Water Quality and Stream Invertebrate Analysis

For Cottle Creek, Nanaimo, BC

Report Submitted by:

RMOT 306: Environmental Monitoring Students

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Submitted to:

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Executive Summary

At Vancouver Island University (VIU) in Nanaimo, BC, the Dream Team, consisting of three students have spent two months (October and November 2021) collecting samples and measurements to monitor Cottle Creek under the supervision of Owen Hargrove, a professor of the RMOT program at VIU. Cottle Creek extends from Linley Valley and emptying into Departure Bay near the Pacific Biological Station (PBS). The data collected during this monitoring project will be used by Fisheries and Oceans Canada (FOC), previously known as the Department of Fisheries and Oceans (DFO), as well as by the City of Nanaimo and any future monitoring by students at VIU.

Two sampling events occurred at four sites along Cottle Creek on October 27, 2021, and again on November 24, 2021. This monitoring project includes hydrology measurements, water quality, and stream invertebrate community analysis. At each site on October 27, 2021, field measurements were obtained for dissolved oxygen and temperature. Six samples were also collected during both sampling events to be analyses at the VIU Laboratory, conducting tests for pH, conductivity, turbidity, alkalinity, hardness, nitrates, and orthophosphates. A total of nine samples were collected during both sampling events and sent to ALS Laboratories in Vancouver, BC. Three of the samples for each of the following characteristics: general water quality, nutrient analysis, and total metals analysis were collected and sent to Vancouver. The general water quality and chemistry parameters fall within BC water quality guidelines for aquatic life, although the stream invertebrate analysis suggested a low site rating when assessed.

The week before the first sampling event, there was some heavy rain fall causing water levels to rise and increase discharge and velocity at all four sites The week before the second sampling event was also very stormy, meteorologists referred to this rainstorm as an “atmospheric river” and this caused massive flooding across southern BC and Vancouver Island, ultimately causing the second sampling event to be postponed until November 24, 2021. That heavy rain led to a change in water quality parameters compared to the data obtained on October 27, 2021.

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Introduction

Project Overview and Background

This project was an environmental monitoring project of Cottle Creek located in Nanaimo, BC. The project included field measurements and sampling, laboratory analyses and ALS (Australian Laboratory Services) analyses. The first sampling event took place on October 27, 2021, where a field probe was used, stream measurements, water quality sampling and biological sampling was completed. The second sampling event took place on November 24, 2021, where stream measurements, water quality and biological sampling was completed. Water quality and stream invertebrate communities have been monitored since 2012 and was compared to current data. The results have contributed to Cottle Creek's monitoring record.

Cottle Creek is located on the East side of Vancouver Island in Nanaimo, BC. The creek begins just west of Linley Valley Cottle Lake Park and flows east until it curves south before emptying into Departure Bay, near DFO's Pacific Biological Station (Figure.1). Cottle Creek has a total length of 3.4 km, not including the length of Cottle Lake which is located between Site 1 and Site 2.

Figure 1. Map of Cottle Creek and surrounding area (Regional District of Nanaimo, 2021)

Historical Review

The area around Cottle Creek was composed of a mix of coniferous and broadleaf trees such as coastal Douglas fir (*Pseudotsuga taxifolia*), western red cedar (*Thuja plicata*), bigleaf maple (*Acer macrophyllum*), cascara (*Rhamnus purshiana*), and arbutus (*Arbutus menziesii*). There were various types of shrubs and ferns in the surrounding area of Cottle Creek, such as dull Oregon grape (*Mahonia* species), salmonberry (*Rubus spectabilis*), western skunk cabbage (*Lysichiton americanum*), broad-leaved stonecrop (*sedum spathulifolium*), sword fer (*Polystichum munitum*), bracken fern (*Pteridium aquilinum*), and deer fern (*Blechnum spicant*). The forested and marshy land around Cottle Creek was primarily in the form of a city park by the same of Linley Valley Cottle Lake Park that is owned by the City of Nanaimo. There was some privately owned residential land surrounding the park. Further downstream closer to Departure Bay, the land use around Cottle Creek was primarily residential family-style homes

making up neighbourhoods. There was more infrastructure such has roads and bridges in these neighbourhoods.

Potential Environmental Concerns

Within the confines of Linley Valley Cottle Creek Park, there were some potential environmental concerns that were spotted during the initial survey of the sample sites. Near Site 1, there was a culvert running underneath Landalt Road, which could potentially have an environmental impact (Appendix C). Near Site 2, there were two abandoned vehicles that could potentially pose environmental impacts (Appendix H, I). Along the creek there were various forms of litter and waste found in the form of tires, wrappers, and beverage containers/aluminum cans, which could pose threat to the environment. There could also be a risk of contamination from residential and city infrastructure along the creek, for example, construction, or wastewater runoff.

Project Objectives

Cottle Creek's environmental monitoring project two main objectives: determine the health and to contribute to the monitoring records of the creek. To assess the abiotic and biotic components of the ecosystem, water samples were analysed for water quality parameters, nutrients, and total metals. Stream invertebrate samples were also collected and analysed, and a wetted cross-sectional profile was constructed for each site to observe the changes in water level. Surface flow velocity and discharge were also calculated to determine any risks or recent changes in bank integrity due to erosion, affecting the ecosystem. The results of this project can be used by Department of Fisheries and Oceans and the City of Nanaimo for any future projects involving Cottle Creek.

Site Safety and Hazard Assessment

Safety was the top priority when conducting an environmental monitoring project. There were several hazards that were identified during the preliminary assessment of the field sites (Table 1). Safety procedure that was taken during field work included contacting instructor Owen Hargrove when arriving and departing the sites. When out in the field, it was also important to keep a look out for wild animals as there are some black bears (*Ursus americanus*), raccoons (*Procyon lotor*) and cougars (*Felis concolor*) that roam in the Departure Bay area. Proper and fitting clothing and footwear were worn. COVID-19 protocols were also followed accordingly during the field and lab components of this environmental monitoring project.

Table 1. Site access and identified physical hazards.

Site	**1**	**2**	**3**	**4**
Access	Steep hill	Mostly level trail	Moderate hill	Road
Hazards	Slips, trips, falls, rocks, logs, bushes	Slips, trips, falls, rocks, bushes, protruding roots	Slips, trips, falls, rocks, bushes	Traffic, slips, trips, falls, rocks, bushes, jump down to get into stream

Methods

Sampling Stations

Locations

A total of four sampling sites were determined for this project (Figure 2). The sites were selected based on the location of previous sampling sites on Cottle Creek and ease of access. All the sites were in UTM zone 10U. Site 1 was located at 427993mE 5452190mN, Site 2 was located at 428879mE 5452245mN, Site 3 was located at 430283mE 5451860mN, and Site 4 is located at 430582mE 5451415mN (Figure 2). The distance from Site 1 to Site 2 was 900m, Site 2

to Site 3 was 1.66km, and Site 3 to Site 4 was 613m. Site 1 and Site 2 were 111m above sea level, Site 3 was 80m above sea level, and Site 4 was 25m above sea level.

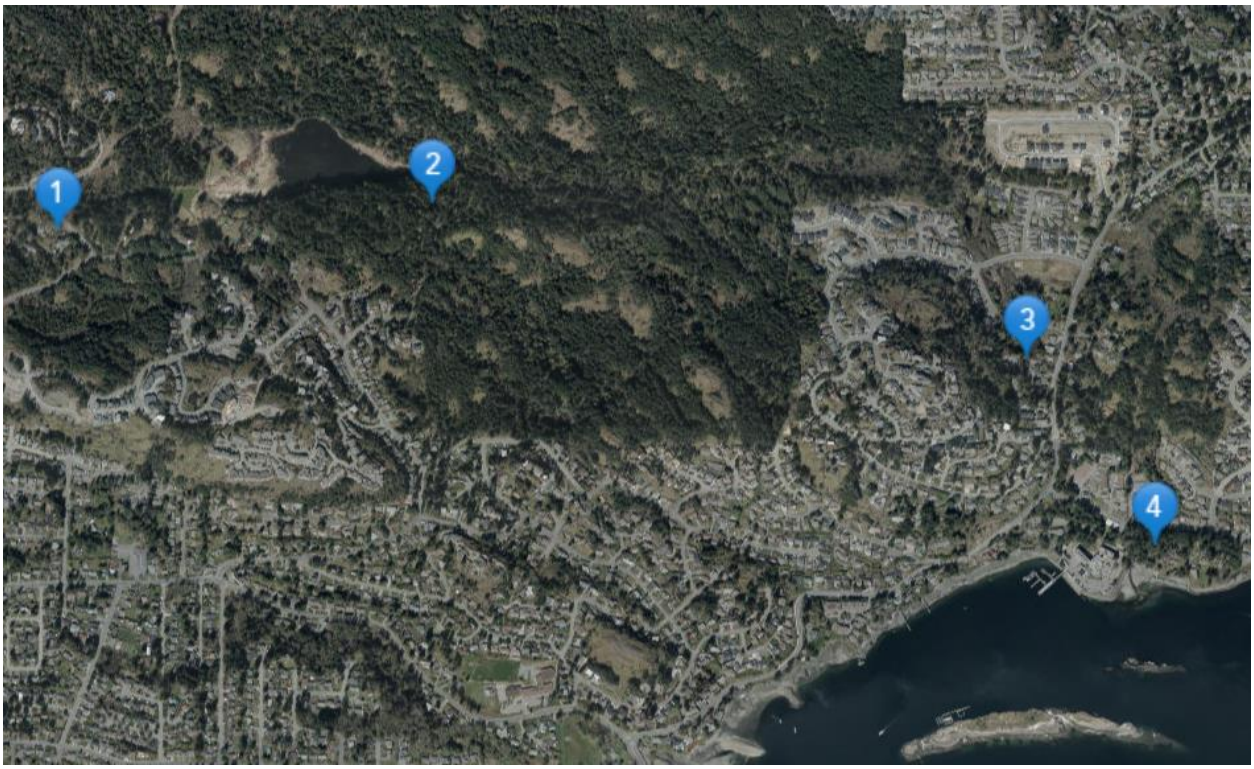

Figure 2. Map of sampling site locations, Cottle Creek Nanaimo, BC

Sampling Frequency

The results obtained from all sites was compared to each-other and between the two sampling dates. The laboratory analysis completed by VIU students was compared to ALS laboratory analysis results. The results were interpreted and compared to the values recorded for each parameter to the "British Columbia Approved Water Quality Guidelines: Aquatic Life, Wildlife & Agriculture" summarized by the Ministry of Environment & Climate Change Strategy Water Protection & Sustainability Branch (2021).

Table 2. Stream measurements, water quality and stream invertebrate sampling completed at each site along Cottle Creek. The symbol "A" indicates sampling completed on October 27, 2021; the symbol "B" indicates sampling completed on November 24, 2021.

Sample Site	Stream Measurements	VIU Laboratory Analyses	ALS Analyses	Stream Invertebrates
1	A, B	A, B	A	A
2	A, B	A, B	B	-
3	A, B	A, B	A, B	A
4	A, B	A, B	A, B	A

Basic Hydrology

Field Measurements

A cross-sectional profile of a stream provides an idea of how much water passes through the channel, mixing oxygen, nutrients, and providing the necessary means for life to many freshwater stream organisms. Water surface velocity was measured using the float method from 3 meters apart. The time it took for a ping pong ball to travel 3 m was used to determine the average velocity of 3 measurements. The bank-full width and depth was measured as well as the wetted width and depth. The wetted depth cross-sectional area (m^2) divided by the velocity (m/s). was used to calculate discharge (m^3/s). These were measured with a measuring tape for width and a measuring pole for depth. Depth measurements were obtained in recorded intervals across the stream, and width measurements were performed.

Water Quality

Field Measurements

Water quality parameters such as water temperature (◦C) and dissolved oxygen (percent saturation and mg/L) were measured in the field using a YSI electronic probe. The probe was placed in the stream until the temperature and dissolved oxygen stabilised. The YSI electronic

probe was used only during the first sampling event in October. The YSI device was calibrated ahead of time.

Water Sample Collection

A total of 15 water samples were collected during each sampling event. There were nine samples that were sent to ALS Laboratory, these containers used to collect water were below the surface of the water. The cap remained sealed until the entire bottle was below the surface of the water, no rinsing was necessary for the sterile, sealed sample bottles. The other six sample containers had to be rinsed three times each with the stream water in the field. The sample itself was obtained by filling the bottle with water below the surface. The first sampling event included a replicate and field blank sample from Site 2, the second round of sampling included a replicate and field blank sample from Site 1.

VIU Laboratory Analyses

At the VIU Laboratory, the samples were analysed for various water quality parameters. A DR 2800 HACH Spectrophotometer was used to measure nutrient concentrations of orthophosphate (PO_4^-) and nitrate (NO_3^-) (mg/L). Titrations were performed to measure alkalinity and hardness of the water samples. A Nephelometric turbidity metre was used to measure turbidity (units were measured in nephelometric turbidity units, NTU). A conductivity metre was used to measure conductivity (μS/cm), and a pH metre was used to measure pH.

ALS Laboratory Analyses

The nine water samples collected during each sampling event included a total of three samples for general water quality parameters analyses, three nutrient analyses, and three total metals analyses. The samples were collected in sterile containers supplied by ALS Laboratory in Vancouver, BC. Results for these samples were obtained roughly ten days post shipping to the laboratory.

Quality Assurance / Quality Control

To promote quality assurance and quality control, each sample container used for VIU laboratory analyses was rinsed three times with stream water on site before the actual sample was taken. This was to confirm that any cleaning materials or any possible contamination was rinsed out of the container before the samples were collected. The samples were also stored in a fridge (at most 4^{o}C) and analysed within four days for any nutrient or pH results. The following of proper sampling procedures, including minimal air bubbles in the samples preserves integrity of the samples.

Stream Invertebrate Communities

Invertebrate Sample Collection

Samples of stream invertebrates were collected from Cottle Creek and subsequently analysed in the laboratory at Vancouver Island University from Sites 1, 3 and 4. The samples were collected with a Hess sampler in the riffles, 70% ethanol solution was added to the sample for preservation.

VIU Laboratory Analyses

Upon beginning of analyses, the contents of the stream invertebrate samples were emptied into a plastic tray and sorted into petri dishes based on morphological characteristics. The invertebrates were then examined under a dissecting microscope, and they were counted and recorded for further analyses. The results of these counts allowed for site specific rating of water quality and the calculation of the Shannon-Wiener Index of Diversity, and the Simpson Index of Dominance.

Quality assurance / Quality Control

The methods of quality assurance/quality control for stream invertebrate sample collection involved the usage of clean, pre-labelled containers and 70% ethanol solution. The

samples were then sealed with tape to prevent the entering or escaping of any substance or organisms. The analysis of the sample occurred the same day as sample collection.

Results and Discussion

General Field Conditions

Hydrology

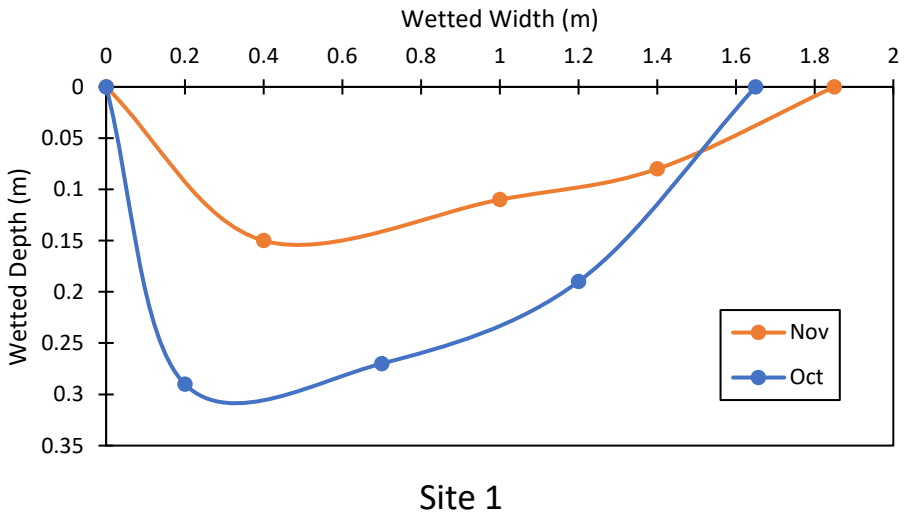

Figure 3. Wetted cross-sectional profile facing up-stream at Site 1 along Cottle Creek (figure 2), measurements recorded on October 27, 2021, and November 24, 2021.

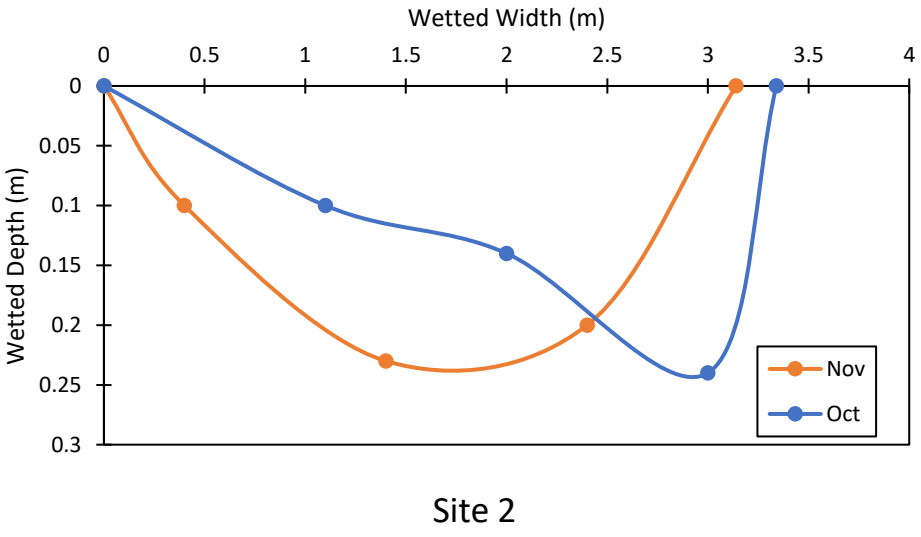

Figure 4. Wetted cross-sectional profile for Site 2 facing down-stream along Cottle Creek (figure 2), measurements recorded on October 27, 2021, and November 24, 2021.

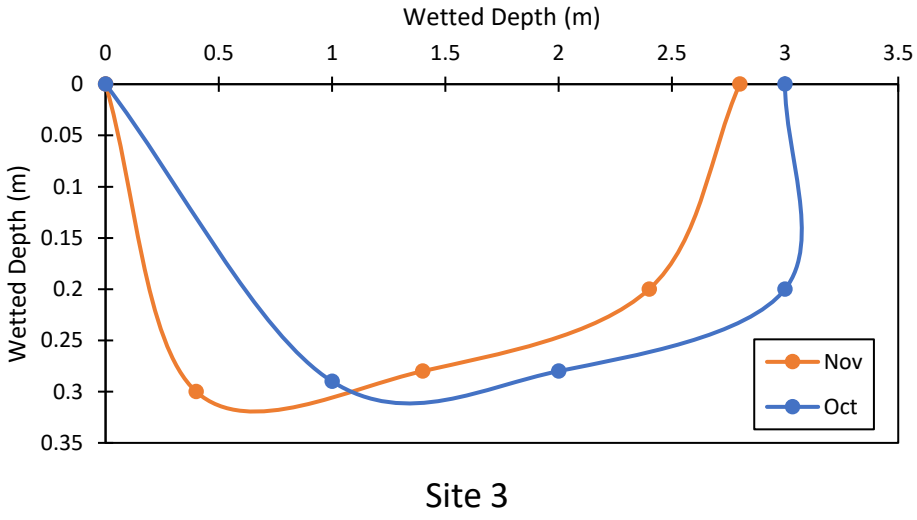

Figure 5. Wetted cross-sectional profile for Site 3, facing up-stream along Cottle Creek (figure 2), measurements recorded on October 27, 2021, and November 24, 2021.

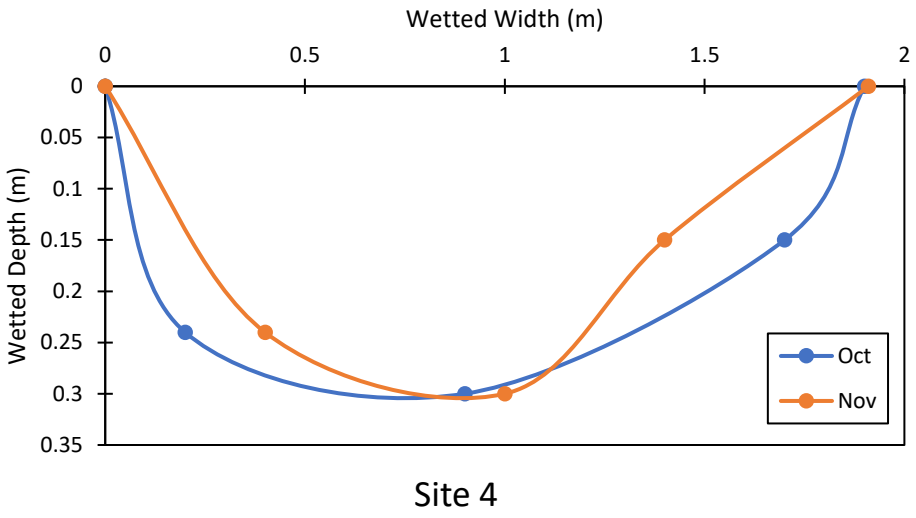

Figure 6. Wetted cross-sectional profile for Site 4, facing up-stream along Cottle Creek (figure 2), measurements recorded on October 27, 2021, and November 24, 2021.

Table 3. Cross-sectional area, Velocity, corrected velocity, discharge values calculated for 4 sites along Cottle Creek. "A" indicates the value calculated on October 27, 2021, and "B" indicates the value calculated on November 24, 2021.

Site	**Cross-sectional area ($\mathbf{m^2}$)**	**Average Surface Velocity ($\mathbf{m/s}$)**	**Corrected average water velocity ($\mathbf{k = 0.85}$) ($\mathbf{m/s}$)**	**Discharge (Area*Velocity) ($\mathbf{m^3/s}$)**
1 (A/B)	0.412/0.203	0.178/0.298	0.151/0.253	0.062/0.051
2 (A/B)	0.534/0.565	0.337/0.374	0.286/0.318	0.153/0.180
3 (A/B)	0.768/0.728	0.433/1.46	0.368/1.24	0.283/0.903
4 (A/B)	0.437/0.433	0.503/1.23	0.427/1.04	0.187/0.454

Water carries sediments and disrupts the benthic surface. The velocity and volume of water that travels down the stream will cause erosion of the stream bed and the banks. The

surface velocity is what was measured, therefore, in table 3, a correction factor was multiplied to the average surface velocity to find the average water column velocity. Discharge is related to catchment size, climate, soil type and vegetation, and the slope of the land. Storms (potential reason for differences between the 2 sampling days. Peak flows depend on rainfall patterns and catchment characteristics. On the west coast of BC, the streams tend to have measurements for peak annual discharge in winter. The outside turns become eroded the water was visibly cutting under the bank. On the inside turns there was more cobble and sediments due to deposition. This is evident in the Cross-sectional profiles (figures 3-6).

Figure 3 represents the two wetted measurements of Site 1. Closer to the zero mark on the x axis, it is evident that the bank there is subject to erosion, whereas the other bank is more subject to sediment deposition, although the channel is relatively straight along the sampling location. The sediment was cobble and this site, based on the profile of the stream and the invertebrate community, although with no mayflies (Ephemeroptera) present in the sample, indicates that there could be some habitat loss. The evidence also suggest that this part of the creek had an average water column velocity of 0.151 m/s and 0.253 m/s and had a discharge of 0.062 m^3/s and 0.051 m^3/s during the sampling events (Table 3). Site 1 had the slowest and least amount of water flowing out of all four sampling locations.

Figure 4 represents the two wetted measurements of site 2, taken in October and November respectively. Site 2 is located at the downstream mouth of Cottle Lake and was measured in a turn. The inside of the turn was roughly 1.9 m along on the x-axis and was subject to mainly deposition of sediments, with less of a riparian zone and more of a cobble island. The outside turn was more likely subject to heavy erosion creating a deeper pool on the edge of the bank. The average water column velocity was calculated to be 0.286 m/s and 0.318 m/s, which made site 2 one of the slower sites along the creek, this could be due to being slightly downstream of the lake. The average discharge of was calculated to be 0.153 m^3/s and 0.180 m^3/s (Table 3). Site 2 had the second least volume of water flowing through per second for the four sampling locations.

Figure 5 represents the measurements at Site 3 in October and November respectively. The site was in a straight part of the channel and just upstream was skunk cabbage and other plants. The sediment was cobble, but it was not overly loose. Just downstream was a stretch of riffles. There was some evidence of erosion along the sides of the banks, but nothing too extreme. Site 2 had the highest discharge value and the fastest average water column velocity compared to all four sites. The velocity was calculated to be 0.368 m/s and 1.24 m/s, and the discharge was calculated to be 0.283 m^3/s and 0.903 m^3/s. This site also had the highest percent saturation of oxygen, but it did not seem to be the best habitat for aquatic life, such as fish or invertebrates.

Figure 6 represents the measurements at Site 4 in October and November respectively. Site 4 was the deepest site with the most evidence of erosion. The site is located on a turn with the 0 on the x axis was the outside of the turn and was subject to erosion. The inside of the turn was shallower and was subject to deposition of cobble sediments. Site 4 had the fastest average water column velocity in October, calculated to be 0.427 m/s, and the second fastest velocity calculated to be 1.04 m/s in November. The discharge, however, was the second most the four sampling locations, calculated to be 0.187 m^3/s and 0.454 m^3/s.

Potential sources of error for the hydrology measurements include rounding errors in calculations and measurements; could be improved with more accurate measuring of widths, depths, and velocities. A more accurate cross-sectional profile could provide more details of erosion and pooling. These factors can directly affect mayfly habitat, and those of which that are more sensitive to changes in habitat.

WATER QUALITY

FIELD MEASUREMENTS

Table 4. summary of in field water quality measurements using an electronic probe (percent saturated dissolved oxygen, concentration of dissolved oxygen, and temperature) measured on October 27, 2021, at all four sites along Cottle Creek.

Site	DO (% Saturation)	DO (mg/L)	Temperature (℃)
1	101.9	11.58	9.7
2	79.2	9.02	9.6
3	96.3	10.93	9.7
4	105	11.96	9.6

The field measurements included dissolved oxygen (DO) in percent saturation and mg/L and temperature in degrees Celsius. Oxygen enters an aquatic ecosystem via diffusion from the atmosphere and photosynthesis. In a stream, the water velocity helps to mix the oxygen in the water to sustain a high concentration of DO. In table 4, it was evident that at all sites, oxygen levels remain high, the only exception was Site 2, which is located just downstream from Cottle Lake, this could explain the reduction in oxygen. Temperature was also measured to obtain an *in-situ* temperature, which was constant among all four sites. The field measurements using an electronic probe (YSI) was only completed during the first sampling event as it was not available for the second sampling event. We can assume similar oxygen concentrations and a slight decrease in temperature between the two sampling events. In sites one and four, the percent saturation was measured quite high (101.9% and 105%) compared to the sites two and three (79.2% and 96.3%) because there was a lot of algae or cyanobacteria activity in those areas. Shampoo looking bubbles were observed on sites one and four more than the sites two and three. It is safe to assume that the bubbles were a result of a photosynthetic activity as the excess oxygen gas is escaping the water.

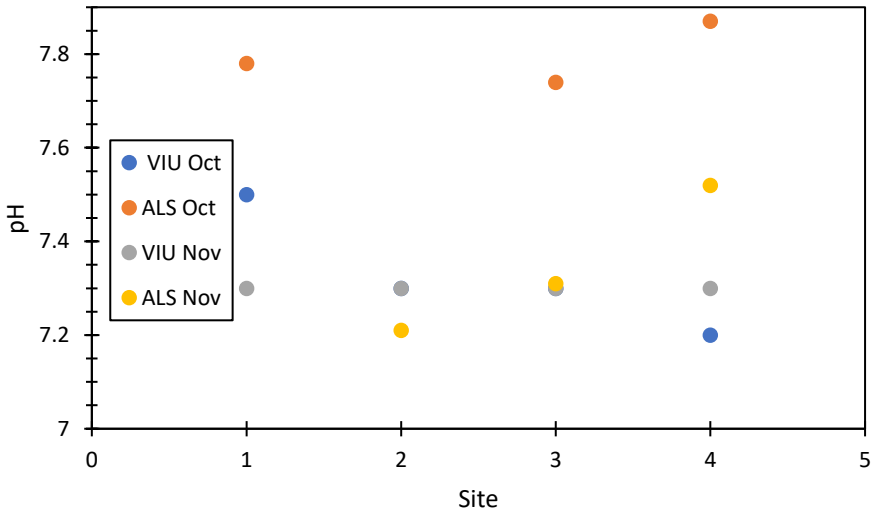

Figure 7. pH (measured in pH units) results from samples obtained at Cottle Creek on October 27, 2021, and November 24, 2021. The results are from both the VIU Laboratory and ALS Laboratory.

pH is the measure of how acidic a solution is depending on the concentration of hydrogen ions (H^+). The solutions' pH is measured on a scale of 0 to 14 with numbers lower than 7 being more acidic, and higher numbers being more basic, while 7 is considered neutral. It is measured on a logarithmic scale meaning that small changes in pH can pose a huge impact because the concentrations of H^+ ions change by the factor of every tenth power. For example, 10^{-1} is pH of 1 and 10^{-2} is pH of 2. In addition, higher concentrations of H^+ affect the bioavailability of metals by dissolving them, whereas the metals precipitate under alkaline conditions. PH for the first (October) and the second (November) rounds of sampling suggest consistent results along the four sites. Negligibly higher pH was recorded after the second sampling event, although it was expected to be lower due to the reaction of carbon dioxide and rainwater in the atmosphere. The mean pH of the first and second round of samples were 7.32 and 7.33 respectively and site 1 had the highest pH for both rounds due to the increased photosynthetic activity in this area.

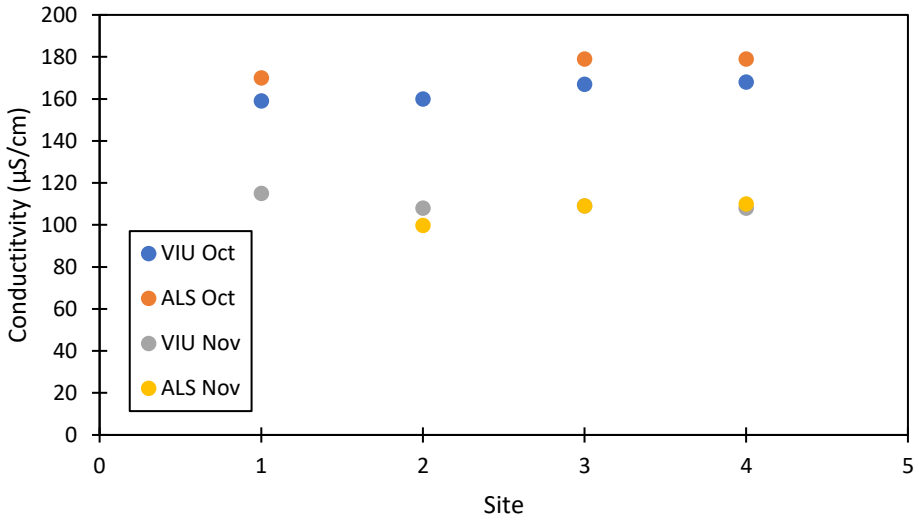

Figure 8. Conductivity (measured in µS/cm) results from samples obtained at Cottle Creek on October 27, 2021, and November 24, 2021. The results are form both the VIU Laboratory and ALS Laboratory.

Conductivity is the relative amount of electricity conducted via water. The more dissolved ions present in a sample, the higher the expected conductivity. It is correlated with total dissolved solids (TDS) and in coastal BC lakes and streams, it is expected to have a value less than 150 µS/cm. The samples from October 27, 2021, were higher in conductivity around 152-179 µS/cm for all four sites. The samples from November 24, 2021, were lower in conductivity around 99-115 µS/cm. The heavy rainfall between the first and second sampling event could have led to a higher discharge and water velocity, washed away some of the dissolved ions.

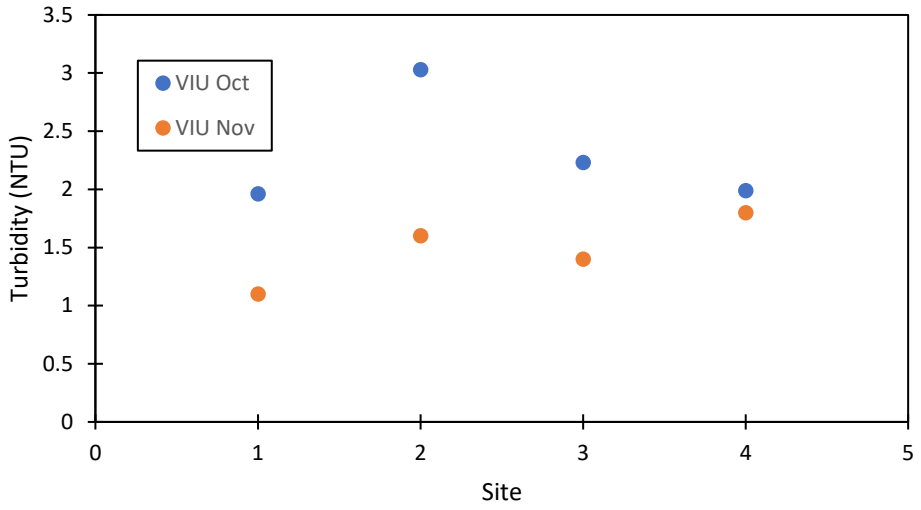

Figure 9. Turbidity (measured in NTU) results from samples obtained at Cottle Creek, on October 27, 2021. The results are from the VIU Laboratory.

Turbidity is the measure of total suspended solids (TSS), it is measured in Nephelometric Turbidity Units (NTU), reflecting the "cloudiness" of a water sample using a spectrophotometer, specifically a nephelometer. This machine measures the scattering of light by the suspended solids through the sample. The results from the first sampling event measured higher turbidity than the second sampling event. These results are most likely due to the rainfall as the rainwater washed most of the suspended solids away. Site 2 had an increase in turbidity of 2.76 NTU, possibly due to the lake and its productivity.

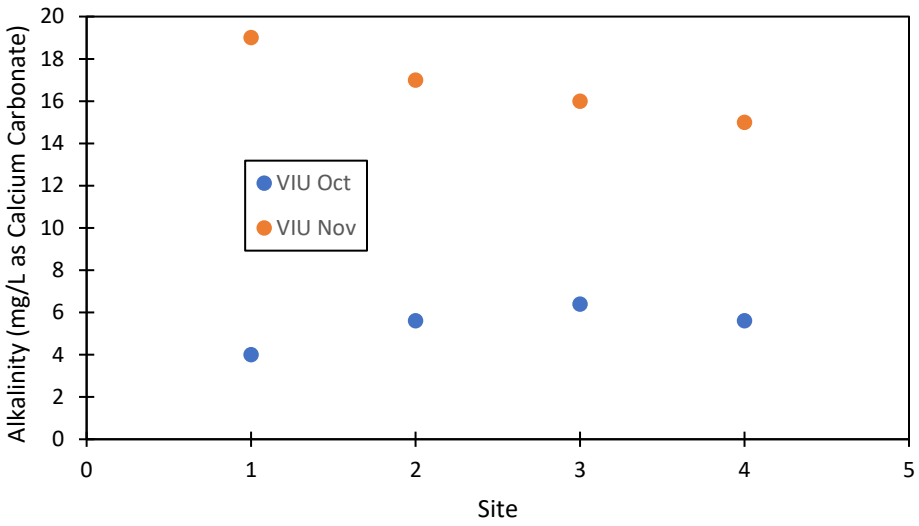

Figure 10. Alkalinity (measured in mg/L as $CaCO_3$) results from samples obtained at Cottle Creek on October 27, 2021, and November 24, 2021. The results are from the VIU Laboratory.

Alkalinity reflects the buffering capacity of a water sample. A higher alkalinity reflects the ability to resist pH changes. It is measured in mg/L as $CaCO_3$ which represents the bicarbonate equilibrium and depends on the presence of carbonate rock such as limestone, in the sediments and area surrounding the stream. In coastal BC lakes and streams, it is expected to obtain results less than 20 mg/L as $CaCO_3$, which was the case. The alkalinity from the first sampling event was quite a bit lower than the second sampling event suggesting that possibly the rain had increased the acid neutralizing capacity of Cottle Creek.

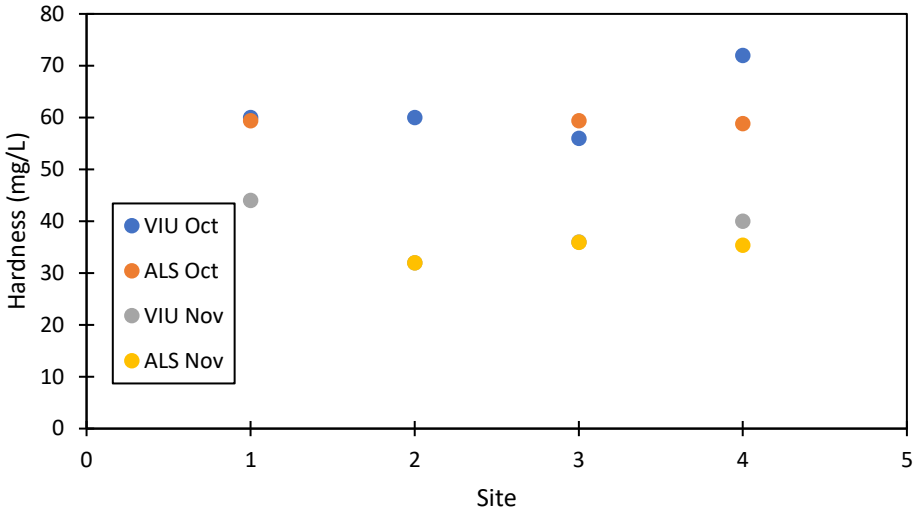

Figure 11. Hardness (measured in mg/L) results from samples obtained at Cottle Creek on October 27, 2021, and November 24, 2021. The results are from both the VIU Laboratory and ALS Laboratory.

Hardness is the measurement of the divalent cations Ca^{2+} and Mg^{2+} dissolved in water. The higher the hardness, the higher alkalinity and conductivity. Water is considered soft when there is less than 60 mg/L as $CaCO_3$, and water is considered hard when there is more than 120 mg/L $CaCO_3$. The hardness measured on October 27, 2021, ranging from 52-72 mg/L, which then decreased on November 24, 2021, ranging from 32-52 mg/L. The results suggest that Cottle Creek had soft water.

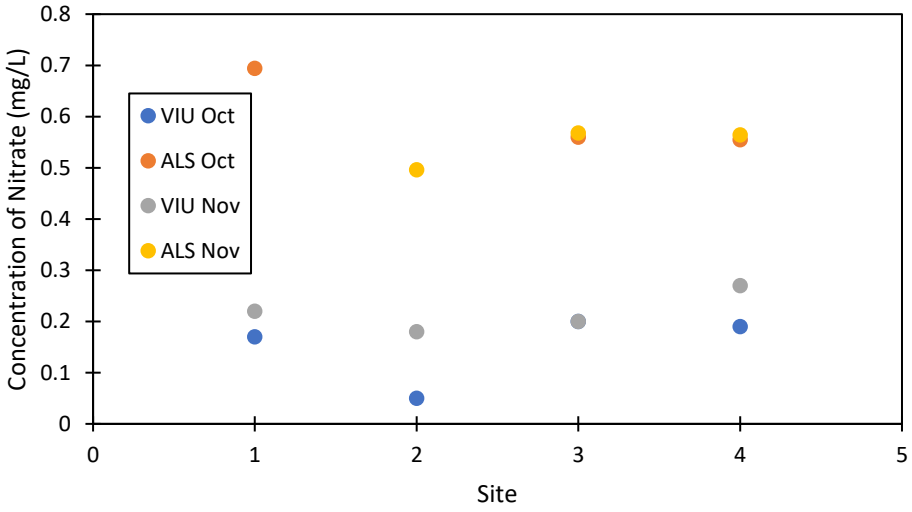

Figure 12. NO_3^- (measured in mg/L) results from samples obtained at Cottle Creek on October 27, 2021, and November 24, 2021. The results are from both the VIU Laboratory and ALS Laboratory.

Nitrate reduction test is conducted to determine if there is an enzyme called nitrate reductase present in water. Many kinds of bacteria have different ways of reducing NO_3 to NO_2 to nitrogenous gases. While some bacteria, have the ability to reduce NO_3 all the way to nitrogenous gases, while others only reduce it to NO_2 as they may lack the necessary nitrate reductase enzymes to fully reduce nitrate to its gas form. First and second line of samples tested at VIU Laboratory yielded means of 0.12 and 0.20 respectively. Results from the first, third, and fourth sites are measured 0.17, 0.19, and 0.20 respectively for the first line of samples. Test results from ALS also shows a higher reductase activity meaning VIU results are consistent with ALS Laboratories' results. Second line of samples are evenly distributed, however, showed an overall higher reductase activity than the first. The reason for that would be due to the heavy rainfall prior to the second round of sampling. ALS results also yielded higher reduction probably due to the fact that it took quite some time delivering the samples bottles to the laboratory. Reductase activity must have continued during that time period.

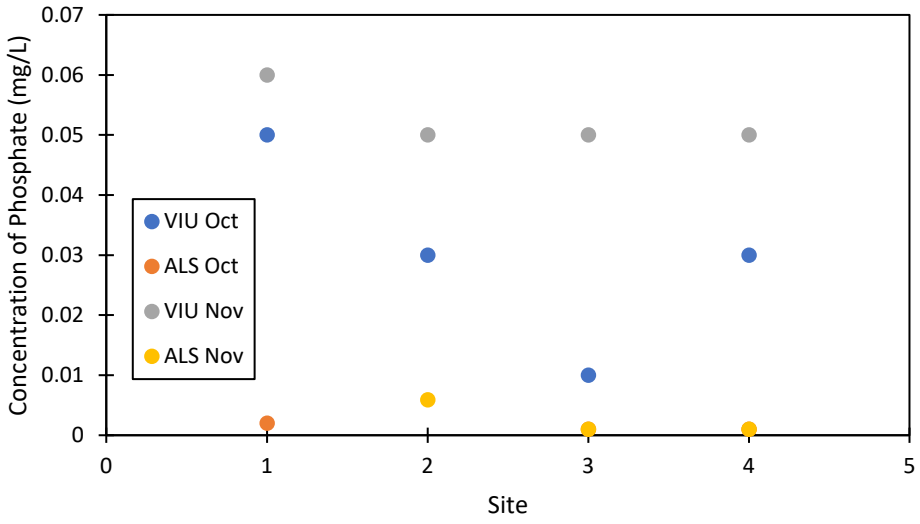

Figure 13. PO_4^{3-} (measured in mg/L) results from samples obtained at Cottle Creek on October 27, 2021, and November 24, 2021. The results are from both the VIU Laboratory and ALS Laboratory.

Phosphorus, specifically orthophosphates are typically very limited in aquatic ecosystems, and is an important factor of productivity. Phosphates can enter waterways through the weathering of minerals and particulate organic materials. They can also enter these systems through agriculture, fertilizers, and sewage/septic run-off leachate, which can result in the eutrophication of the contaminated waterway. Results obtained from the VIU laboratory were measured the same day as the sample collection, whereas the results from ALS laboratories were measured after a period of time, which could explain the difference measured by both laboratories. Results were consistent for the first and second round of samples, however, there is an increase in mean observed in the second round of samples. The mean stands at 0.030 in the first round but 0.055 in the second round. This change was expected after the heavy rainfall a week prior to the scheduled sampling date. The heavy rain provided the kinetic energy needed for the sewage/septic run-off leachate to fall into the creek.

ALS Laboratory Analyses

Table 5. Summary of total metals analysis conducted by ALS Laboratory. Samples collected on October 27, 2021, are indicated by "A" and samples collected on November 24, 2021, are indicated by "B".

Site	1 (A)	2 (B)	3 (A, B)	4 (A, B)
Aluminum, Al (mg/L)	0.0417	0.0691	0.0520, 0.0612	0.0497, 0.0580
Arsenic, As (mg/L)	0.00024	0.00019	0.00026, 0.00020	0.00026, 0.00018
Barium, Ba (mg/L)	0.00431	0.00230	0.00326, 0.00201	0.00310, 0.00209
Boron, B (mg/L)	0.071	0.037	0.078, 0.054	0.076, 0.053
Calcium, Ca (mg/L)	16.0	8.71	16.0, 9.83	15.8, 9.58
Copper, Cu (mg/L)	0.00068	0.257	0.00126, 0.00145	0.00125, 0.00136
Iron, Fe (mg/L)	0.571	-	0.442, 0.177	0.407, 0.183
Magnesium, Mg (mg/L)	4.72	2.50	4.72, 2.76	4.71, 2.79
Manganese, Mn (mg/L)	0.0332	0.0209	0.0248, 0.0145	0.0155, 0.0160
Potassium, K (mg/L)	0.448	0.361	0.519, 0.323	0.518, 0.323
Rubidium, Rb (mg/L)	0.00049	0.00041	0.00066, 0.00033	0.00064, 0.00034

Selenium, Se (mg/L)	0.000050	-	0.000065, -	0.000058, 0.000059
Silicon, Si (mg/L)	6.03	5.13	5.48, 5.66	5.45, 5.82
Sodium, Na (mg/L)	10.2	7.01	11.5, 7.16	11.4, 7.42
Strontium, Sr (mg/L)	0.0650	0.0354	0.0603, 0.0350	0.0608, 0.0352
Sulfur, S (mg/L)	1.52	1.82	1.76, 1.90	1.78, 2.04
Titanium, Ti (mg/L)	0.00209	0.00338	0.00325, 0.00270	0.00286, 0.00258
Vanadium, V (mg/L)	0.00052	0.00054	0.00080, 0.00083	0.00078, 0.00085

The increased water levels could be a factor regarding the decreased concentration in most metal ions between the two sampling events. Metals can be toxic depending on concentration, route of exposure, and duration of exposure. While some metals are toxic in low doses, others are only toxic in high doses. While low doses of some metals do not pose a threat to aquatic organisms for a short time, long term exposure might cause serious consequences such as loss of limb in future progeny. PH is also an important factor to metal toxicity because acidic conditions dissolve metals, therefore, increase their concentration. Basic conditions, on the other hand, induce low concentrations of metals because metals precipitate in alkaline conditions.

Comparison to Past Years

This year's data is mostly consistent with the previous years' data with insignificant differences among metal concentrations. In general, the metal concentrations stayed below the

harmful levels due to the softness of the water along Cottle Creek. PH range seems to be quite diverse for all the past years; however, the average value is consistent and around 7.

Comparison to Guidelines

According to the freshwater aquatic life guidelines, aluminum concentration should be around 0.05 mg/L for short term average. However, the concentrations are increasing over the 0.05 mg/L after the first set of samples. Long term maximum is 0.1 mg/Land as long as the dissolved aluminum concentration does not pass concentrations of 0.1 mg/L for an extended amount of time, the stream will stay healthy in sites two, three, and four. Arsenic, barium, and boron metal concentrations are below the long-term average guidelines. Freshwater aquatic life is tolerant to arsenic until its concentration reaches 5.0 mg/L for long-term average. Boron concentrations need to be lower than 1.2 mg/L for the long-term average, which has a maximum of 0.078 mg/L at the third site. Ca and Mg concentrations are below the threshold levels as Cottle Creek's hardness test results determined that the creek has soft water in general. Cu, Fe, and Mn concentrations are all at safe levels. Safe levels for Cu and Mn are 2.0 mg/L and 0.825 mg/L respectively, which the test results show concentrations below these values. For iron, total numbers should exceed 1.0 mg/L, however, dissolved amount safe threshold is standing at 0.35 mg/L. Since the test results did not differentiate between dissolved and total amounts, we will assume the results given represents the total amounts, therefore, Fe is also below the harmful levels. Salinity toxicity can determine the toxicity of Na ions in the freshwater in which 23 g/kg is considered as toxic when the water temperature is around 10℃ and the pH is 7.8. Test results for Na is showing maximum 11.5 mg/L, which was found in samples from site 3. Rb, Se, Sr, Ti, and V metals are found in very low concentrations, therefore, they are harmless to freshwater aquatic life in Cottle Creek. Potassium is in low levels so it will not be posing any threat to aquatic life.

Stream Invertebrate Communities

The laboratory analysis of the stream invertebrates from Site 1, Site 3, and Site 4 along Cottle Creek revealed that there was a larger number of pollution tolerant species, than pollution intolerant species (figure 14). There was some variation between each of the three

sites in terms of abundance, density, and overall site assessment rating, but in general the results from all three sites were similar (appendix). Since most of the species found were category 2 and category 3 species, it suggests that there is likely some pollution that has occurred in Cottle Creek, for these categories of species to be present in such quantities.

Abundance / Density

Each site was different in terms of the abundance and density of invertebrates. Site 1 had a total of 40 organisms, and a density of 444 organisms per square metre. Site 3 had a total of 32 organisms, and a density of 356 organisms per square metre. Site 4 had a total of 60 organisms, and a density of 667 organisms per square metre (appendix). In terms of species categories, Site 1 and Site 3 had mostly category 3 species, while Site 4 had mostly category 2 species. Only Site 1 had any category 1 species, while Sites 3 and 4 did not have any (figure 14).

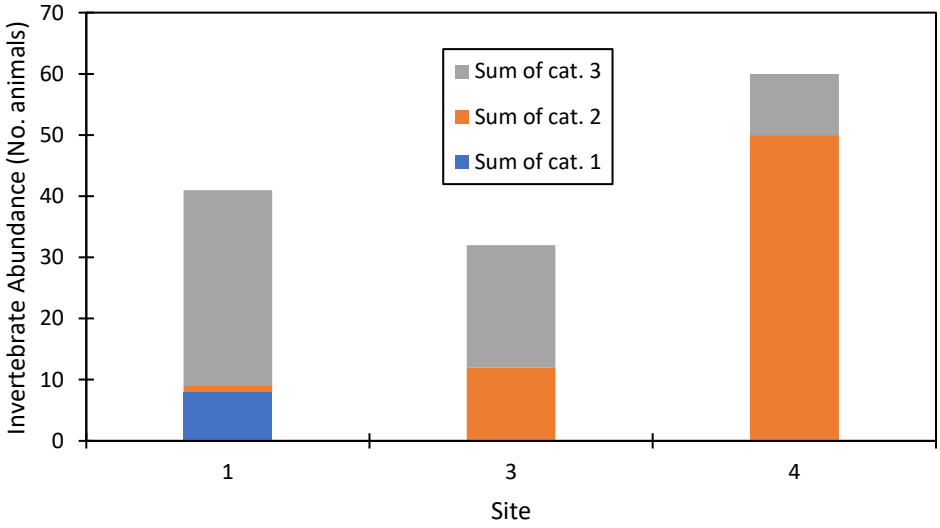

Figure 14. Abundance of stream invertebrate categorized by site and pollution tolerance categories 1 through 3 obtained on October 27, 2021, at Cottle Creek, Nanaimo, BC (Figure 2 for site location information).

Diversity, Dominance, Site Ratings

Differences were observed between the three sites in terms of species diversity, dominance, and overall site ratings. Site 1 had the most diversity based on the Shannon-Weiner

diversity index of 0.618, Site 4 had the second most with a diversity index of 0.575, and Site 3 had the least amount of diversity with an index of 0.513 (table 6). The site with the most dominance was Site 3, with a Simpson Index of Dominance 0.513 of with the aquatic (oligochaete) worm being the most dominant species. The second most dominant site was Site 4, with an index of 0.618 with the amphipods being the dominant species. Site 1 was the least dominant with an index of 0.631, with the aquatic (oligochaete) worm as the dominant species (table 6). The site ratings between the three sites were similar. Site 1 had an average rating of 1.5, Site 3 had an average rating of 1.25, and Site 4 also had an average rating of 1.25. Each site has an overall rating of poor since none of them had an average rating of at least two (table 7).

Table 6. Shannon-Weiner Index of Diversity and Simpson Dominance Index calculation tables and equation calculation for all four sites along Cottle Creek in Nanaimo, BC on October 27, 2021. Stream invertebrate assessment sheets found on pages … of appendix

Site 1					
Common name	**Column C**	$\boldsymbol{p_i}$ **(C / T)**	$\boldsymbol{\ln p_i}$	$\boldsymbol{p_i \cdot \ln p_i}$	$\boldsymbol{(pi)^2}$
Caddisfly Larva	1	0.025	-3.689	-0.092	0.000625
Stonefly Nymph	6	0.150	-1.897	-0.284	0.0225
Cranefly Larva	1	0.025	-3.689	-0.092	0.000625
Aquatic Worm	27	0.675	-0.393	-0.265	0.455
Midge Larva	5	0.125	-2.079	-0.259	0.0156
Total	40	1		-0.994	0.495
Shannon-Weiner Index of Diversity	$H = \frac{-\sum_{i=1}^{S}(p_i \cdot \ln p_i)}{\ln S} = \frac{-(-0.99415)}{1.609438} = 0.618$				
Simpson Dominance Index	$D = \frac{1 - \sum_{i=1}^{S}(p_i)^2}{1 - S^{-1}} = \frac{0.505}{0.8} = 0.631$				

Site 3					
Amphipod	12	0.375	-0.981	-0.368	0.141
Aquatic worm	20	0.625	0.020	0.012	0.391
Total	32	1		-0.356	0.531
Shannon-Weiner Index of Diversity	$H = \frac{-\sum_{i=1}^{S}(p_i \cdot \ln p_i)}{\ln S} = \frac{-(-0.35567)}{0.693147} = 0.513$				
Simpson Dominance Index	$D = \frac{1-\sum_{i=1}^{S}(p_i)^2}{1-S^{-1}} = \frac{0.46875}{0.5} = 0.513$				
Site 4					
Alderfly larva	1	0.017	-4.075	-0.069	0.000289
Clam, Mussel	8	0.133	-2.017	-0.268	0.0177
Cranefly larva	1	0.017	-4.075	-0.069	0.000289
Amphipod	40	0.666	-0.406	-0.270	0.444
Aquatic worm	9	0.15	-1.897	-0.284	0.0225
Pouch and pond snails	1	0.017	-4.075	-0.069	0.000289
Total	60	1		-1.031	0.484
Shannon-Weiner Index of Diversity	$H = \frac{-\sum_{i=1}^{S}(p_i \cdot \ln p_i)}{\ln S} = \frac{-(-1.03103)}{1.791759} = 0.575$				
Simpon Dominance Index	$D = \frac{1-\sum_{i=1}^{S}(p_i)^2}{1-S^{-1}} = \frac{0.515388}{0.833333} = 0.618$				

Table 7. Summary of site rating according to stream invertebrate assessment survey sheets found on pages … of appendix, counted and calculated on October 27, 2021.

Site	Average Site Rating
1	1.5
3	1.25
4	1.25

Comparison to Past Years

While there are some differences compared to past years in terms of species abundance and diversity, the general trend is that category 2 and category 3 species are the most abundant in Cottle Creek. There appears to be a potential increase in pollution due to the lower numbers of category 1 species compared to past years. The overall site assessment ratings were also lower compared to past years, which suggests that the overall health of Cottle Creek is declining rather than improving (VIU 2019, VIU 2018, VIU 2017).

Conclusions and Recommendations

Based on the results of this study, there have been some recommendations made to help in future monitoring projects. The riparian zone is one area that should be studied more along Cottle Creek. The Riparian zone is what helps to protect the stream banks from erosion, providing woody or leafy habitats for invertebrates. It is suggested based on field observations and hydrology results that there is much erosion that has occurred and therefore, should be monitored. Continuing the monitoring of stream invertebrates to see if there is a change in the number of organisms in each category and the general health of the creek. It is also recommended to compare overall site assessment ratings with past years, to observe if the overall health is improving or declining. Continuing monitoring for water quality assessments as well as metal concentrations is important to see if pollution, contamination and/or eutrophication occurs at any of the sites. Take immediate action if the overall quality of the creek worsens.

Acknowledgements

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Appendix A. Abandoned car near sampling site 2, October 20, 2021, Cottle Creek, Nanaimo BC.

Appendix B. Caution sign near sampling site 2 on October 20, 2021, Cottle Creek, Nanaimo BC.

Appendix C. Culvert at sampling site 1 on October 20, 2021, Cottle Creek, Nanaimo, BC.

Appendix D. Path down to sampling site 1 on October 20, 2021, Cottle Creek, Nanaimo BC.

Appendix E. Pool at sampling site 1 on October 20, 2021, Cottle Creek, Nanaimo BC.

Appendix F. Riffle at sampling site 1 on October 20, 2021, Cottle Creek, Nanaimo BC.

Appendix G. Sampling site 2 on October 20, 2021, Cottle Creek, Nanaimo BC.

Appendix H. Sampling site 3 on October 20, 2021, Cottle Creek, Nanaimo BC.

Appendix I. Sampling site 4 on October 20, 2021, Cottle Creek, Nanaimo BC.

Appendix J. Second abandoned car near sampling site 2 on October 20, 2021, Cottle Creek, Nanaimo BC.

Appendix K. Sign for Cottle Creek near sampling site 1 on October 20, 2021, Nanaimo BC.

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name: Cottle Creek		Date: Oct 27, 2021
Station Name: Site 1		Flow status: Low
Sampler Used: Hess	Number of replicates 1	Total area sampled (Hess, Surber = 0.09 m^2) x no. replicates 0.09 m^2

Column A Pollution Tolerance	Column B Common Name	Column C Number Counted	Column D Number of Taxa
Category 1 Pollution Intolerant	Caddisfly Larva (EPT)	EPT1 1	EPT4 1
	Mayfly Nymph (EPT)	EPT2	EPT5
	Stonefly Nymph (EPT)	EPT3 6	EPT6 1
	Dobsonfly (hellgrammite)		
	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		C1 7	D1 2
Category 2 Somewhat Pollution Tolerant	Alderfly Larva		
	Aquatic Beetle		
	Aquatic Sowbug		
	Clam, Mussel		
	Cranefly Larva	1	1
	Crayfish		
	Damselfly Larva		
	Dragonfly Larva		
	Fishfly Larva		
	Amphipod (freshwater shrimp)		
	Watersnipe Larva		
Sub-Total		C2 1	D2 1
Category 3 Pollution Tolerant	Aquatic Worm (oligochaete)	27	1
	Blackfly Larva		
	Leech		
	Midge Larva (chironomid)	5	1
	Planarian (flatworm)		
	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite		
Sub-Total		C3 32	D3 2
TOTAL		CT 40	DT 5

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

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

CT: **40**

DENSITY: Invertebrate density per total area sampled:

		From page 1		
40	÷	**0.09**	m^2 =	**444** / m^2

PREDOMINANT TAXON:
Invertebrate group with the highest number counted (in Col. C)

S1: **Aquatic worm**

SECTION 2 - WATER QUALITY ASSESSMENTS

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

Good	Acceptable	Marginal	Poor
>22	22-17	16-11	<11

3 x D1 + 2 x D2 + D3

3 x **2** + 2 x **1** + **2** =

S2: **10**

EPT INDEX: Total number of EPT taxa.

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

EPT4 + EPT5 + EPT6

1 + **0** + **1** =

S3: **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

(**1** + **0** + **6**) / **40** =

S4: **0.18**

SECTION 3 - DIVERSITY

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

5

PREDOMINANT TAXON RATIO INDEX: Number of invertebrate in the **predominant taxon** (S1) divided by CT.

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

Col. C for S1 / CT

27 / **40** =

S5: **0.68**

SECTION 4 - OVERALL SITE ASSESSMENT RATING

SITE ASSESSMENT RATING: Assign a rating of 1-4 to each index (S2, S3, S4, S5), then calculate the average.

Assessment Rating	
Good	4
Acceptable	3
Marginal	2
Poor	1

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

Average Rating
Average of R1, R2, R3, R4
1.5

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name: Cottle Creek		Date: Oct 27, 2021
Station Name: Site 3		Flow status: Low
Sampler Used: Hess	Number of replicates 1	Total area sampled (Hess, Surber = 0.09 m^2) x no. replicates 0.09 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
Pollution Intolerant	Dobsonfly (hellgrammite)		
	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		C1 0	D1 0
Category 2	Alderfly Larva		
	Aquatic Beetle		
	Aquatic Sowbug		
	Clam, Mussel		
	Cranefly Larva		
	Crayfish		
Somewhat Pollution Tolerant	Damselfly Larva		
	Dragonfly Larva		
	Fishfly Larva		
	Amphipod (freshwater shrimp)	12	1
	Watersnipe Larva		
Sub-Total		C2 12	D2 1
Category 3	Aquatic Worm (oligochaete)	20	2
	Blackfly Larva		
	Leech		
	Midge Larva (chironomid)		
Pollution Tolerant	Planarian (flatworm)		
	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite		
Sub-Total		C3 20	D3 2
TOTAL		CT 32	DT 3

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

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

CT: **32**

DENSITY: Invertebrate density per total area sampled:

32 ÷ 0.09 m^2 = **356** / m^2 (From page 1)

PREDOMINANT TAXON:

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

S1: **Aquatic worm**

SECTION 2 - WATER QUALITY ASSESSMENTS

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

Good	Acceptable	Marginal	Poor
>22	22-17	16-11	<11

3 x D1 + 2 x D2 + D3

3 x 0 + 2 x 1 + 2 = **4**

S2: **4**

EPT INDEX: Total number of EPT taxa.

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

EPT4 + EPT5 + EPT6

0 + 0 + 0 = **0**

S3: **0**

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 + 0) / 32 = **0**

S4: **0**

SECTION 3 - DIVERSITY

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

3

PREDOMINANT TAXON RATIO INDEX: Number of invertebrate in the **predominant taxon** (S1) divided by CT.

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

Col. C for S1 / CT

20 / 32 = **0.63**

S5: **0.63**

SECTION 4 - OVERALL SITE ASSESSMENT RATING

SITE ASSESSMENT RATING: Assign a rating of 1-4 to each index (S2, S3, S4, S5), 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 **2**

Average Rating
Average of R1, R2, R3, R4
1.25

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name: Cottle Creek		Date: Oct 27, 2021
Station Name: Site 4		Flow status: Low
Sampler Used: Hess	Number of replicates 1	Total area sampled (Hess, Surber = 0.09 m^2) x no. replicates 0.09 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
Pollution Intolerant	Dobsonfly (hellgrammite)		
	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		C1 0	D1 0
Category 2	Alderfly Larva	1	1
	Aquatic Beetle		
	Aquatic Sowbug		
	Clam, Mussel	8	1
	Cranefly Larva	1	1
Somewhat Pollution Tolerant	Crayfish		
	Damselfly Larva		
	Dragonfly Larva		
	Fishfly Larva		
	Amphipod (freshwater shrimp)	40	1
	Watersnipe Larva		
Sub-Total		C2 50	D2 4
Category 3	Aquatic Worm (oligochaete)	9	1
	Blackfly Larva		
	Leech		
	Midge Larva (chironomid)		
	Planarian (flatworm)		
Pollution Tolerant	Pouch and Pond Snails	1	1
	True Bug Adult		
	Water Mite		
Sub-Total		C3 10	D3 2
TOTAL		CT 60	DT 6

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

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

CT: **60**

DENSITY: Invertebrate density per total area sampled:

60 ÷ From page 1: 0.09 m^2 = **667** / m^2

PREDOMINANT TAXON:

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

S1: **Amphipod**

SECTION 2 - WATER QUALITY ASSESSMENTS

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

Good	Acceptable	Marginal	Poor
>22	22-17	16-11	<11

3 x D1 + 2 x D2 + D3

3 x 0 + 2 x 4 + 2 = S2: **10**

EPT INDEX: Total number of EPT taxa.

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

EPT4 + EPT5 + EPT6

0 + 0 + 0 = S3: **0**

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 + 0) / 60 = S4: **0**

SECTION 3 - DIVERSITY

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

6

PREDOMINANT TAXON RATIO INDEX: Number of invertebrate in the **predominant taxon** (S1) divided by CT.

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

Col. C for S1 / CT

40 / 60 = S5: **0.67**

SECTION 4 - OVERALL SITE ASSESSMENT RATING

SITE ASSESSMENT RATING: Assign a rating of 1-4 to each index (S2, S3, S4, S5), 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 **2**

Average Rating
Average of R1, R2, R3, R4
1.25

Analytical Results

Sub-Matrix: Water (Matrix: Water)				Client sample ID	Millstone River Site 5	Cottle Creek Site 1	Cottle Creek Site 3	Cottle Creek Site 4	----
				Client sampling date / time	27-Oct-2021 09:50	27-Oct-2021 12:45	27-Oct-2021 09:30	27-Oct-2021 10:30	----
Analyte	CAS Number	Method	LOR	Unit	VA21C4104-006	VA21C4104-007	VA21C4104-008	VA21C4104-009	--------
					Result	Result	Result	Result	----
Physical Tests									
conductivity	----	E100	2.0	µS/cm	93.7	170	179	179	----
hardness (as CaCO3), from total Ca/Mg	----	EC100A	0.50	mg/L	32.8	59.4	59.4	58.8	----
pH	----	E108	0.10	pH units	7.61	7.78	7.74	7.87	----
Anions and Nutrients									
ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	0.0124	0.0588	0.0167	0.0103	----
nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	0.295	0.694	0.560	0.555	----
nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	0.0013	0.0026	0.0014	0.0013	----
nitrogen, total	7727-37-9	E366	0.030	mg/L	0.560	1.07	0.845	0.797	----
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	0.0013	0.0020	<0.0010	<0.0010	----
phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	0.0254	0.0139	0.0096	0.0087	----
Total Metals									
aluminum, total	7429-90-5	E420	0.0030	mg/L	0.539	0.0417	0.0520	0.0497	----
antimony, total	7440-36-0	E420	0.00010	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	----
arsenic, total	7440-38-2	E420	0.00010	mg/L	0.00038	0.00024	0.00026	0.00026	----
barium, total	7440-39-3	E420	0.00010	mg/L	0.0109	0.00431	0.00326	0.00310	----
beryllium, total	7440-41-7	E420	0.000020	mg/L	<0.000020	<0.000020	<0.000020	<0.000020	----
bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	<0.000050	<0.000050	<0.000050	----
boron, total	7440-42-8	E420	0.010	mg/L	0.029	0.071	0.078	0.076	----
cadmium, total	7440-43-9	E420	0.0000050	mg/L	0.0000071	<0.0000050	<0.0000050	<0.0000050	----
calcium, total	7440-70-2	E420	0.050	mg/L	9.06	16.0	16.0	15.8	----
cesium, total	7440-46-2	E420	0.000010	mg/L	0.000032	<0.000010	<0.000010	<0.000010	----
chromium, total	7440-47-3	E420	0.00050	mg/L	0.00118	<0.00050	<0.00050	<0.00050	----
cobalt, total	7440-48-4	E420	0.00010	mg/L	0.00044	<0.00010	<0.00010	<0.00010	----
copper, total	7440-50-8	E420	0.00050	mg/L	0.00202	0.00068	0.00126	0.00125	----
iron, total	7439-89-6	E420	0.010	mg/L	0.838	0.571	0.442	0.407	----
lead, total	7439-92-1	E420	0.000050	mg/L	0.000255	<0.000050	<0.000050	<0.000050	----
lithium, total	7439-93-2	E420	0.0010	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	----
magnesium, total	7439-95-4	E420	0.0050	mg/L	2.46	4.72	4.72	4.71	----
manganese, total	7439-96-5	E420	0.00010	mg/L	0.0516	0.0332	0.0248	0.0155	----
molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.000056	<0.000050	<0.000050	<0.000050	----
nickel, total	7440-02-0	E420	0.00050	mg/L	0.00100	<0.00050	<0.00050	<0.00050	----

Analytical Results

Sub-Matrix: Water
(Matrix: Water)

Analyte	CAS Number	Method	LOR	Unit	Client sample ID	Millstone River Site 5	Cottle Creek Site 1	Cottle Creek Site 3	Cottle Creek Site 4	----
					Client sampling date / time	27-Oct-2021 09:50	27-Oct-2021 12:45	27-Oct-2021 09:30	27-Oct-2021 10:30	----
						VA21C4104-006	VA21C4104-007	VA21C4104-008	VA21C4104-009	--------
						Result	Result	Result	Result	----
Total Metals										
phosphorus, total	7723-14-0	E420	0.050	mg/L		<0.050	<0.050	<0.050	<0.050	----
potassium, total	7440-09-7	E420	0.050	mg/L		0.440	0.448	0.519	0.518	----
rubidium, total	7440-17-7	E420	0.00020	mg/L		0.00071	0.00049	0.00065	0.00064	----
selenium, total	7782-49-2	E420	0.000050	mg/L		0.000062	0.000050	0.000065	0.000058	----
silicon, total	7440-21-3	E420	0.10	mg/L		4.20	6.03	5.48	5.45	----
silver, total	7440-22-4	E420	0.000010	mg/L		<0.000010	<0.000010	<0.000010	<0.000010	----
sodium, total	17341-25-2	E420	0.050	mg/L		5.86	10.2	11.5	11.4	----
strontium, total	7440-24-6	E420	0.00020	mg/L		0.0507	0.0650	0.0603	0.0608	----
sulfur, total	7704-34-9	E420	0.50	mg/L		1.72	1.52	1.76	1.78	----
tellurium, total	13494-80-9	E420	0.00020	mg/L		<0.00020	<0.00020	<0.00020	<0.00020	----
thallium, total	7440-28-0	E420	0.000010	mg/L		<0.000010	<0.000010	<0.000010	<0.000010	----
thorium, total	7440-29-1	E420	0.00010	mg/L		<0.00010	<0.00010	<0.00010	<0.00010	----
tin, total	7440-31-5	E420	0.00010	mg/L		<0.00010	<0.00010	<0.00010	<0.00010	----
titanium, total	7440-32-6	E420	0.00030	mg/L		0.0255	0.00209	0.00325	0.00286	----
tungsten, total	7440-33-7	E420	0.00010	mg/L		<0.00010	<0.00010	<0.00010	<0.00010	----
uranium, total	7440-61-1	E420	0.000010	mg/L		0.000010	<0.000010	<0.000010	<0.000010	----
vanadium, total	7440-62-2	E420	0.00050	mg/L		0.00228	0.00052	0.00080	0.00078	----
zinc, total	7440-66-6	E420	0.0030	mg/L		0.0031	<0.0030	<0.0030	<0.0030	----
zirconium, total	7440-67-7	E420	0.00020	mg/L		<0.00020	<0.00020	<0.00020	<0.00020	----

Please refer to the General Comments section for an explanation of any qualifiers detected.

Chain of Custody (COC) / Analytical Request Form

COC Number: 20 - 935357

Canada Toll Free: 1 800 668 9878

Page of

ALS www.alsglobal.com

Report To — Contact and company name below will appear on the final report

Company:	Vancouver Island University
Contact:	Owen Hargrave
Phone:	(250) 538 - 7556
Company address below will appear on the final report	
Street:	900 5th Street
City/Province:	Nanaimo B.C.
Postal Code:	V9R 5R5

Invoice To

Same as Report To	☑ YES	☐ NO
Copy of Invoice with Report	☑ YES	☐ NO
Company:		
Contact:		

Project Information

ALS Account # / Quote #:	
Job #:	
PO / AFE:	
LSD:	
ALS Lab Work Order # (ALS use only):	

Reports / Recipients

Select Report Format: ☐ PDF ☑ EXCEL ☐ EDD (DIGITAL)

Merge QC/QCI Reports with COA ☐ YES ☐ NO ☐ N/A

☐ Compare Results to Criteria on Report - provide details below if box checked

Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax: Owen.hargrave@viu.ca

Email 2:

Email 3:

Invoice Recipients

Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax: Owen.hargrave@viu.ca

Email 2:

Oil and Gas Required Fields (client use)

AFE/Cost Center:		PO#	
Major/Minor Code:		Routing Code:	
Requisitioner:			
Location:			
ALS Contact:		Sampler:	

Turnaround Time (TAT) Requested

☑ Routine [R] if received by 3pm M-F - no surcharges apply

☐ 4 day [P4] if received by 3pm M-F - 20% rush surcharge minimum

☐ 3 day [P3] if received by 3pm M-F - 25% rush surcharge minimum

☐ 2 day [P2] if received by 3pm M-F - 50% rush surcharge minimum

☐ 1 day [E] if received by 3pm M-F - 100% rush surcharge minimum

☐ Same day [E2] if received by 10am M-S - 200% rush surcharge. Additional fees may apply to rush requests on weekends, statutory holidays and non-routine tests

AFFIX ALS BARCODE LABEL HERE (ALS use only)

Date and Time Required for all E&P TATs: dd-mmm-yy hh:mm am/pm

For all tests with rush TATs requested, please contact your AM to confirm availability.

Analysis Request — Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (ALS use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Number of Containers	General WQ	Nutrients	Total Metals	Samples on Hold	Extended Storage Required	Suspected Hazard (see notes)
	Richards Creek Site 1	26/10/21	11:45	Water	3	1	1	1			
	Richards Creek Site 3	26/10/21	10:08	Water	3	1	1	1			
	Richards Creek Site 4	26/10/21	10:36	Water	3	1	1	1			
	Millstone River Site 1	27/10/21	14:00	Water	3	1	1	1			
	Millstone River Site 3	27/10/21	12:00	Water	3	1	1	1			
	Millstone River Site 5	27/10/21	09:50	Water	3	1	1	1			
	Cottle Creek Site 1	27/10/21	12:45	Water	3	1	1	1			
	Cottle Creek Site 3	27/10/21	09:30	Water	3	1	1	1			
	Cottle Creek Site 4	27/10 21	10:30	Water	3	1	1	1			

Environmental Division
Vancouver
Work Order Reference
VA21C4104
Telephone: +1 604 253 4188

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System? ☐ YES ☐ NO

Are samples for human consumption/ use? ☐ YES ☐ NO

Notes / Specify Limits for result evaluation by selecting from drop-down below (Excel COC only)

SAMPLE RECEIPT DETAILS (ALS use only)

Cooling Method: ☐ NONE ☐ ICE ☑ ICE PACKS ☐ FROZEN ☐ COOLING INITIATED

Submission Comments identified on Sample Receipt Notification: ☐ YES ☐ NO

Cooler Custody Seals Intact: ☐ YES ☐ N/A Sample Custody Seals Intact: ☐ YES ☐ N/A

INITIAL COOLER TEMPERATURES °C FINAL COOLER TEMPERATURES °C: 10 13

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (ALS use only)			FINAL SHIPMENT RECEPTION (ALS use only)		
Released by: O. Hargrave	Date: 2021/10/27	Time: 15:59	Received by:	Date:	Time:	Received by: JA	Date: 28/10/2021	Time: 11:55am

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

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 specified on the back page of the white - report copy.

1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

Analytical Results

Sub-Matrix: Water
(Matrix: Water)

Analyte	CAS Number	Method	LOR	Unit	Client sample ID	Richards Creek Site 1	Richards Creek Site 2	Richards Creek Site 3	Cottle Creek Site 3	Cottle Creek Site 4
					Client sampling date / time	24-Nov-2021 12:40	24-Nov-2021 12:20	24-Nov-2021 12:15	24-Nov-2021 09:50	24-Nov-2021 10:15
						VA21C6350-001	VA21C6350-002	VA21C6350-003	VA21C6350-004	VA21C6350-005
						Result	Result	Result	Result	Result
Physical Tests										
conductivity	----	E100	2.0	µS/cm		79.9	93.7	98.4	109	110
hardness (as CaCO3), from total Ca/Mg	----	EC100A	0.50	mg/L		28.0	34.1	35.2	35.9	35.4
pH	----	E108	0.10	pH units		7.19	7.30	7.32	7.31	7.52
Anions and Nutrients										
ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L		0.0137 RRV	0.0121 RRV	0.0115 RRV	0.0108 RRV	0.0087 RRV
nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L		0.277	0.319	0.361	0.568	0.564 HTO
nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L		<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
nitrogen, total	7727-37-9	E366	0.030	mg/L		0.465	0.552	0.586	0.743	0.736
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L		0.0014	0.0020	0.0074	<0.0010	<0.0010
phosphorus, total	7723-14-0	E372-U	0.0020	mg/L		0.0101	0.0374	0.0211	0.0059	0.0072
Total Metals										
aluminum, total	7429-90-5	E420	0.0030	mg/L		0.184	1.04	0.353	0.0612	0.0580
antimony, total	7440-36-0	E420	0.00010	mg/L		<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
arsenic, total	7440-38-2	E420	0.00010	mg/L		0.00017	0.00048	0.00029	0.00020	0.00018
barium, total	7440-39-3	E420	0.00010	mg/L		0.00818	0.0168	0.0110	0.00201	0.00209
beryllium, total	7440-41-7	E420	0.000020	mg/L		<0.000020	<0.000020	<0.000020	<0.000020	<0.000020
bismuth, total	7440-69-9	E420	0.000050	mg/L		<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
boron, total	7440-42-8	E420	0.010	mg/L		0.011	0.012	0.012	0.054	0.053
cadmium, total	7440-43-9	E420	0.0000050	mg/L		0.0000080	0.0000290	0.0000102	<0.0000050	<0.0000050
calcium, total	7440-70-2	E420	0.050	mg/L		8.77	10.6	10.9	9.83	9.58
cesium, total	7440-46-2	E420	0.000010	mg/L		<0.000010	0.000042	0.000013	<0.000010	<0.000010
chromium, total	7440-47-3	E420	0.00050	mg/L		<0.00050	0.00180	0.00067	<0.00050	<0.00050
cobalt, total	7440-48-4	E420	0.00010	mg/L		0.00014	0.00059	0.00023	<0.00010	<0.00010
copper, total	7440-50-8	E420	0.00050	mg/L		0.00174	0.00514	0.00332	0.00145	0.00136
iron, total	7439-89-6	E420	0.010	mg/L		0.233	1.18	0.409	0.177	0.183
lead, total	7439-92-1	E420	0.000050	mg/L		0.000070	0.000381	0.000132	<0.000050	<0.000050
lithium, total	7439-93-2	E420	0.0010	mg/L		<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
magnesium, total	7439-95-4	E420	0.0050	mg/L		1.47	1.85	1.95	2.76	2.79
manganese, total	7439-96-5	E420	0.00010	mg/L		0.0359	0.0691	0.0229	0.0145	0.0160
molybdenum, total	7439-98-7	E420	0.000050	mg/L		0.000052	0.000163	0.000129	<0.000050	<0.000050

Analytical Results

Sub-Matrix: Water
(Matrix: Water)

Analyte	CAS Number	Method	LOR	Unit	Client sample ID	Richards Creek Site 1	Richards Creek Site 2	Richards Creek Site 3	Cottle Creek Site 3	Cottle Creek Site 4
					Client sampling date / time	24-Nov-2021 12:40	24-Nov-2021 12:20	24-Nov-2021 12:15	24-Nov-2021 09:50	24-Nov-2021 10:15
						VA21C6350-001	VA21C6350-002	VA21C6350-003	VA21C6350-004	VA21C6350-005
						Result	Result	Result	Result	Result
Total Metals										
nickel, total	7440-02-0	E420	0.00050	mg/L		<0.00050	0.00197	0.00102	<0.00050	<0.00050
phosphorus, total	7723-14-0	E420	0.050	mg/L		<0.050	<0.050	<0.050	<0.050	<0.050
potassium, total	7440-09-7	E420	0.050	mg/L		0.374	0.476	0.499	0.323	0.323
rubidium, total	7440-17-7	E420	0.00020	mg/L		0.00048	0.00084	0.00052	0.00033	0.00034
selenium, total	7782-49-2	E420	0.000050	mg/L		<0.000050	0.000103	0.000120	<0.000050	0.000059
silicon, total	7440-21-3	E420	0.10	mg/L		4.26	5.87	5.19	5.66	5.82
silver, total	7440-22-4	E420	0.000010	mg/L		<0.000010	0.000012	<0.000010	<0.000010	<0.000010
sodium, total	17341-25-2	E420	0.050	mg/L		4.06	4.75	4.76	7.16	7.42
strontium, total	7440-24-6	E420	0.00020	mg/L		0.0270	0.0332	0.0379	0.0350	0.0352
sulfur, total	7704-34-9	E420	0.50	mg/L		2.59	3.56	3.39	1.90	2.04
tellurium, total	13494-80-9	E420	0.00020	mg/L		<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
thallium, total	7440-28-0	E420	0.000010	mg/L		<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
thorium, total	7440-29-1	E420	0.00010	mg/L		<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
tin, total	7440-31-5	E420	0.00010	mg/L		<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
titanium, total	7440-32-6	E420	0.00030	mg/L		0.00820	0.0475	0.0155	0.00270	0.00258
tungsten, total	7440-33-7	E420	0.00010	mg/L		<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
uranium, total	7440-61-1	E420	0.000010	mg/L		<0.000010	0.000045	0.000018	<0.000010	<0.000010
vanadium, total	7440-62-2	E420	0.00050	mg/L		0.00077	0.00351	0.00154	0.00083	0.00085
zinc, total	7440-66-6	E420	0.0030	mg/L		<0.0030	0.0049	<0.0030	<0.0030	<0.0030
zirconium, total	7440-67-7	E420	0.00020	mg/L		<0.00020	<0.00020	<0.00020	<0.00020	<0.00020

Please refer to the General Comments section for an explanation of any qualifiers detected.

Analytical Results

Sub-Matrix: Water
(Matrix: Water)

Analyte	CAS Number	Method	LOR	Unit	Client sample ID	Cottle Creek Site 2	Millstone River Site 1	Millstone River Site 3	Millstone River Site 5	----
					Client sampling date / time	24-Nov-2021 13:30	24-Nov-2021 14:30	24-Nov-2021 13:30	24-Nov-2021 12:30	----
						VA21C6350-006	VA21C6350-007	VA21C6350-008	VA21C6350-009	--------
						Result	Result	Result	Result	----
Physical Tests										
conductivity	----	E100	2.0	µS/cm		99.7	34.0	83.1	94.9	----
hardness (as CaCO3), from total Ca/Mg	----	EC100A	0.50	mg/L		32.0	12.8	29.8	33.0	----
pH	----	E108	0.10	pH units		7.21	6.99	7.16	7.44	----
Anions and Nutrients										
ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L		0.0252 MV	<0.0050	0.0194	0.0180	----
nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L		0.496	0.148	0.377	0.419	----
nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L		0.0022	<0.0010	0.0018	0.0016	----
nitrogen, total	7727-37-9	E366	0.030	mg/L		0.709	0.218	0.533	0.621	----
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L		0.0069	<0.0010	0.0037	0.0036	----
phosphorus, total	7723-14-0	E372-U	0.0020	mg/L		0.0079	<0.0020	0.0132	0.0144	----
Total Metals										
aluminum, total	7429-90-5	E420	0.0030	mg/L		0.0691	0.0362	0.210	0.246	----
antimony, total	7440-36-0	E420	0.00010	mg/L		<0.00010	<0.00010	<0.00010	<0.00010	----
arsenic, total	7440-38-2	E420	0.00010	mg/L		0.00019	<0.00010	0.00030	0.00029	----
barium, total	7440-39-3	E420	0.00010	mg/L		0.00230	0.00221	0.00703	0.00902	----
beryllium, total	7440-41-7	E420	0.000020	mg/L		<0.000020	<0.000020	<0.000020	<0.000020	----
bismuth, total	7440-69-9	E420	0.000050	mg/L		<0.000050	<0.000050	<0.000050	<0.000050	----
boron, total	7440-42-8	E420	0.010	mg/L		0.037	0.014	0.024	0.026	----
cadmium, total	7440-43-9	E420	0.0000050	mg/L		<0.0000050	<0.0000050	<0.0000050	0.0000062	----
calcium, total	7440-70-2	E420	0.050	mg/L		8.71	3.51	8.40	9.30	----
cesium, total	7440-46-2	E420	0.000010	mg/L		<0.000010	<0.000010	0.000011	0.000011	----
chromium, total	7440-47-3	E420	0.00050	mg/L		<0.00050	<0.00050	0.00062	0.00072	----
cobalt, total	7440-48-4	E420	0.00010	mg/L		<0.00010	<0.00010	0.00019	0.00022	----
copper, total	7440-50-8	E420	0.00050	mg/L		0.00106	0.00093	0.00138	0.00176	----
iron, total	7439-89-6	E420	0.010	mg/L		0.257	0.047	0.476	0.481	----
lead, total	7439-92-1	E420	0.000050	mg/L		<0.000050	<0.000050	0.000059	0.000109	----
lithium, total	7439-93-2	E420	0.0010	mg/L		<0.0010	<0.0010	<0.0010	<0.0010	----
magnesium, total	7439-95-4	E420	0.0050	mg/L		2.50	0.977	2.14	2.37	----
manganese, total	7439-96-5	E420	0.00010	mg/L		0.0209	0.00131	0.0310	0.0290	----
molybdenum, total	7439-98-7	E420	0.000050	mg/L		<0.000050	<0.000050	<0.000050	0.000057	----
nickel, total	7440-02-0	E420	0.00050	mg/L		<0.00050	<0.00050	0.00051	0.00060	----

Analytical Results

Sub-Matrix: Water (Matrix: Water)				Client sample ID	Cottle Creek Site 2	Millstone River Site 1	Millstone River Site 3	Millstone River Site 5	----
				Client sampling date / time	24-Nov-2021 13:30	24-Nov-2021 14:30	24-Nov-2021 13:30	24-Nov-2021 12:30	----
Analyte	CAS Number	Method	LOR	Unit	VA21C6350-006	VA21C6350-007	VA21C6350-008	VA21C6350-009	--------
					Result	Result	Result	Result	----
Total Metals									
phosphorus, total	7723-14-0	E420	0.050	mg/L	<0.050	<0.050	<0.050	<0.050	----
potassium, total	7440-09-7	E420	0.050	mg/L	0.361	0.115	0.386	0.527	----
rubidium, total	7440-17-7	E420	0.00020	mg/L	0.00041	<0.00020	0.00053	0.00054	----
selenium, total	7782-49-2	E420	0.000050	mg/L	<0.000050	<0.000050	0.000069	0.000052	----
silicon, total	7440-21-3	E420	0.10	mg/L	5.13	3.61	4.26	4.63	----
silver, total	7440-22-4	E420	0.000010	mg/L	<0.000010	<0.000010	<0.000010	<0.000010	----
sodium, total	17341-25-2	E420	0.050	mg/L	7.01	1.56	5.01	6.01	----
strontium, total	7440-24-6	E420	0.00020	mg/L	0.0354	0.0151	0.0710	0.0676	----
sulfur, total	7704-34-9	E420	0.50	mg/L	1.82	0.99	1.96	2.11	----
tellurium, total	13494-80-9	E420	0.00020	mg/L	<0.00020	<0.00020	<0.00020	<0.00020	----
thallium, total	7440-28-0	E420	0.000010	mg/L	<0.000010	<0.000010	<0.000010	<0.000010	----
thorium, total	7440-29-1	E420	0.00010	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	----
tin, total	7440-31-5	E420	0.00010	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	----
titanium, total	7440-32-6	E420	0.00030	mg/L	0.00338	0.00165	0.00976	0.0117	----
tungsten, total	7440-33-7	E420	0.00010	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	----
uranium, total	7440-61-1	E420	0.000010	mg/L	<0.000010	<0.000010	<0.000010	<0.000010	----
vanadium, total	7440-62-2	E420	0.00050	mg/L	0.00054	<0.00050	0.00111	0.00138	----
zinc, total	7440-66-6	E420	0.0030	mg/L	<0.0030	<0.0030	<0.0030	<0.0030	----
zirconium, total	7440-67-7	E420	0.00020	mg/L	<0.00020	<0.00020	<0.00020	0.00026	----

Please refer to the General Comments section for an explanation of any qualifiers detected.

ALS Environmental

www.alsglobal.com

Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

Affix ALS barcode label here (lab use only)

COC Number: 17 - 764594

Page 1 of 1

Report To	Contact and company name below will appear on the final report	Report Format / Distribution	Select Service Level Below - Contact your AM to confirm all E&P TATs (surcharges may apply)
Company:	Vancouver Island University	Select Report Format: PDF ✓ EXCEL EDD (DIGITAL)	Regular [R] ✓ Standard TAT if received by 3 pm - business days - no surcharges apply
Contact:	Owen Hargrave	Quality Control (QC) Report with Report: YES NO	4 day [P4-20%]
Phone:	(250) 538-7556	Compare Results to Criteria on Report - provide details below if box checked	3 day [P3-25%]
	Company address below will appear on the final report	Select Distribution: ✓ EMAIL MAIL FAX	2 day [P2-30%]
Street:		Email 1 or Fax: Owen.hargrave@viu.ca	1 Business day [E - 100%]
City/Province:		Email 2	Same Day, Weekend or Statutory holiday [E2 -200%] (Laboratory opening fees may apply)
Postal Code:		Email 3	Date and Time Required for all E&P TATs: dd-mmm-yy hh:mm
Invoice To	Same as Report To YES NO	Invoice Distribution	For tests that can not be performed according to the service level selected, you will be contacted.
	Copy of Invoice with Report YES NO	Select Invoice Distribution: ✓ EMAIL MAIL FAX	Analysis Request
Company:		Email 1 or Fax: Owen.hargrave@viu.ca	
Contact:		Email 2	

Project Information		Oil and Gas Required Fields (client use)	
ALS Account # / Quote #:		AFE/Cost Center:	PO#:
Job #:		Major/Minor Code:	Routing Code:
PO / AFE:		Requisitioner:	
LSD:		Location:	
ALS Lab Work Order # (lab use only):		ALS Contact:	Sampler:

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	NUMBER OF CONTAINERS	General Water Quality	Nutrients	Total Metals	SAMPLES ON HOLD	SUSPECTED HAZARD (see Special Instructions)
	Richards Creek Site 1	24-Nov-21	12:40	water	3	1	1	1		
	Richards Creek Site 2	24-Nov-21	12:20	water	3	1	1	1		
	Richards Creek Site 3	24-Nov-21	12:15	water	3	1	1	1		
	Cottle Creek Site 3	24-Nov-21	09:50	water	3	1	1	1		
	Cottle Creek Site 4	24-Nov-21	10:15	water	3	1	1	1		
	Cottle Creek Site 2	24-Nov-21	13:30	water	3	1	1	1		
	Millstone River Site 1	24-Nov-21	14:30	water	3	1	1	1		
	Millstone River Site 3	24-Nov-21	13:30	water	3	1	1	1		
	Millstone River Site 5	24-Nov-21	12:30	water	3	1	1	1		

Environmental Division Vancouver
Work Order Reference
VA21C6350

Telephone: +1 604 253 4188

Drinking Water (DW) Samples[1] (client use)	Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)	SAMPLE CONDITION AS RECEIVED (lab use only)
Are samples taken from a Regulated DW System? YES NO		Frozen SIF Observations Yes No
Are samples for human consumption/ use? YES NO		Ice Packs ✓ Ice Cubes Custody seal intact Yes No
		Cooling Initiated
		INITIAL COOLER TEMPERATURES °C: FINAL COOLER TEMPERATURES °C: 12.2

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by: O. Hargrave	Date: 2021/11/24	Time:	Received by:	Date:	Time:	Received by:	Date: NOV 25/21	Time: 11:30

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.