Cottle Creek: Environmental Monitoring Report

Prepared for RMOT 306

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VIU 2020

Table of Contents

List of Tables & Figures

Tables

Figures

Executive Summary

This report contains information and data obtained by four students of the Bachelor of Natural Resource Protection program at Vancouver Island University in Nanaimo, BC. The project was part of the curriculum for the course RMOT 306: Environmental Monitoring. Cottle Creek has been sampled by several times over the years for previous classes, providing an ample amount of background data and information on the stream. The purpose of the continued sampling of Cottle Creek is to determine overall stream health and its ability to support different ecosystems and various organisms. Samples were collected from the four sampling stations in October and November, and then analyzed in the lab for water quality and invertebrate populations. Hydrological measurements were also taken at each of the 4 sites. ALS data was also taken and analyzed at an outside lab to provide information on the nutrient and metal content in the water. Data collected during this study indicates that Cottle Creek does not have ideal water quality, with most of the results falling in the moderate to acceptable range of the water quality guidelines. Invertebrate presence indicated that the stream is relatively unhealthy in some particular areas, but this could be due to the agricultural and domestic land use near these sampling stations. It has been concluded by this report that due to the fact that two new sampling sites were chosen this year, continual monitoring and sampling of the stream should continue in order to get the best picture of the health of the stream. All raw data has been compiled into the appendix of this report.

1.0 Introduction

1.1 Project Overview

The purpose of this project is to conduct a stream survey of Cottle Creek in Nanaimo, BC. The survey will be conducted by four VIU students over the course of several weeks, with sampling to be conducted on October 27th-28th and November 17th-18th, 2020. Cottle Creek splits into three separate arms on its journey though Nanaimo down to the ocean. It passes through Cottle Lake and Lost Lake and covers approximately 4.5km^2 (Bolland et al 2013). In conducting a survey of Cottle Creek we are able to compile data about the environmental condition of the creek and its ability to support healthy and diverse ecosystems.

1.2 Historical Review

Cottle Creek has been surveyed by RMOT students at VIU for many years, providing a database of information on the health and wellness of the stream. The creek is surrounded by a diverse range of habitats, from undeveloped parkland to urban developments. The park surrounding Cottle Lake and parts of Cottle Creek covers about 59 hectares. The park boasts walking and hiking trails and bird sanctuaries. Historically the area was fairly undeveloped but has seen a large push in urban advancement in recent years (Bolland et al 2013). The riparian area of the creek in its natural state includes a heavy vegetation presence including Salal, several species of ferns, and the regionally invasive Himalayan Blackberry. Access to the creek is difficult in non-park designated areas, often surrounded by private housing and fences.

1.3 Potential Environmental Concerns

Potential environmental concerns for Cottle Creek are many. Due to the amount of urban development happening around the creek there is potential for water contamination from construction equipment, sedimentation, destruction of riparian and fish habitat, run-off from new roads and wastewater systems, as well as changes to the creek made by homeowners who have the creek running through their property. The creek flows out into Departure Bay through a large storm drainage culvert which provides opportunity for contaminants to enter the creek system through rainwater drainage systems.

1.4 Project Objectives

While conducting our proposed assessment on Cottle Creek, our project objective is to determine the environmental conditions of the creek. Doing so will allow us to get a better understanding of the health of the river and what kind of life it can support. Our project will be compared to previous years research and data from the same creek to be able to support a long-term study of the creek. There are four sites we are collecting our data from, two in the upper Cottle creek and two in the lower Cottle creek portions. All four locations will be tested for the General Hydrology, Water Quality, and Invertebrates. Only three of the sites (Rock City Rd., Linley Rd., and Nottingham Drive) will have Hess sampling done on site to collect invertebrate data. We will analyze all our samples at Vancouver Island University. The results we collect will help us determine the overall health of the creek.

2.0 Methods

2.1 Sampling Stations & Habitat Characteristics

To gain the best possible scope of the environmental condition of Cottle Creek, four different sampling stations were chosen that represented a large area of Cottle Creek and ranged into the upper and lower sections of the creek to encompass as much area as possible. Each of the 4 sites were chosen for ease of access to the samplers and sample equipment, as well as for keeping safety in mind for ease of site access. Another factor included in the decision process was finding areas that had suitable waterflow and stream composition for conducting studies as many other areas were overgrown with heavy riparian vegetation and would have rendered sampling very difficult for lack of easy access.

The site locations selected were subjected to water quality and stream invertebrate diversity assessments. Basic hydrological information such as discharge and flow rates were collected and recorded at each site.

2.1.2 Locations

Site 1 had a very easy access point via a parking lot for Cottle Lake Park off of Rock City Road , with a well established trail network leading around the park and providing excellent accessability to Cottle Creek. A nearby groundskeeping operation with cleared land and sign of manure fertilization on the land near the stream provided an excellent opportunity for investigation into potential fertilization runoff into the watershed. A horse stable was also located nearby, close to the stream. Public access in the area showcased other anthroprogenic impacts affecting the stream, such as off leash dogs trampling through riparian area or directly into stream. Lower flows in the area made it ideal for conducting analysis, especially invertebrate sampling.

Site 2 was located right off of Linley Road in a residential neighbourhood, which provided excellent access to the creek and ease of carrying equipment down to the low, flat creek side. The creek meandered slowly through this area, with a few straight reaches that were perfect for conducting hydrology. The creek here also showcased a pebble stream bed composition which provided excellent invertebrate sampling opportunities along more calm runs in the creek. Some large and small woody debris was also present for instream composition diversity.

Site 3 was located right next to Cottle Creek public park, with maintained trails accessible all along the fenced riverside path walkway. Here, there were many other storm inflow pipes entering into Cottle Creek from other areas, which provided a network of braided channels and a wide grassy floodplain area, with lots of large woody debris present and dead snags nearby. This site was an excellent choice for conducting assessments as it has a deep pool after a bridge crossing, which provided excellent surveying for invertebrates and potential resident cutthroat trout. This site was also harder for public to access right down onto the stream, which provided an excellent ecological comparison to site #1 where public access into the stream is substantially easier.

Site 4 had a very easy access point, with parking available right beside Stephenson Point Road with a short walk down to the creek side. The site had a very open canopy and was easy to walk around and maneuver equipment and a straight stretch before an outlet pipe provided an excellent place to conduct hydrology measurements. This site was in the lowest reach of Cottle Creek before it emptied into Departure Bay and conducting an analysis at the very end of the waterbody was necessary to measure the accumulation of the whole watershed and any minerals or chemicals draining into the last possible point before emptying into the ocean. This access point was also very close to a major road with a steep slope draining into the creek, so a potential for roadway runoff into the creek wanted to be measured. A large fitness center also backs the edge of the building right onto the creek bank.

2.1.3 Sampling Frequency

Sampling frequency occurred twice over the course of the project length, once on October 28, 2020, and another three weeks later on November 17, 2020. The two sampling times showcased differences in environmental conditions between lower flow conditions in the stream during October and higher flow conditions during November for a variety and diversity comparison between two different ecological conditions.

2.1.4 Monitoring Areas

For the proposed study, assessments conducted were basic hydrological measurements, water quality analysis, and stream invertebrate diversity.

2.2 Hydrology

Hydrological measurements that were taken at each site during each sampling period included stream bed composition, forest canopy cover %, gradient, stream velocity, and stream discharge. Stream velocity was calculated using the timed float method with a water container over a 10m length at 25%, 50%, and 75% channel width for average stream velocity. Discharge was calculated using wetted width and depth measurements at the same 25%, 50%, and 75% channel widths. Gradient was determined using a clinometer looking upstream. Stream bed composition and forest canopy cover % were visually estimated with agreeance amongst the other observers. All measurements were conducted using sticks and measuring tapes.

Table 1. Non-water Hydrological Measurements

Station #	Stream Bed Composition	Forest Canopy Cover (%)	Stream Gradient (%)
1	Gravel, fines	50	1.0
2	Gravel, cobbles, fines, bedrock	45	0.5
3	Fines, silt, SWD	25	1.0
4	Cobble, gravel, bedrock, silt	10	0.5

2.3 Water Quality

Parameters measured included water temperature, dissolved oxygen, conductivity, pH, turbidity, alkalinity, hardness, nitrate, and phosphorus. The ALS analysis included general water quality parameters, nutrient analyses, and total metal scans. Water temperature and dissolved oxygen were measured directly in the field using a YSI probe; all other measurements were collected using labelled water collection containers and analyzed back at the VIU and ALS labs. In the VIU lab, HACH kits and conductivity & pH probes were used to conduct analyses.

All results from analyses conducted were compared to the freshwater limits for sustaining aquatic life set out by the British Columbia Ministry of Environment. Results from both sampling sessions were compared to each other for differences in environmental conditions over the study period. All guideline limits for sustaining aquatic life were taken from RISC, 1998.

2.3.1 Quality Control & Quality Assurance

Proper gloves and sterile protection equipment were worn when sampling and conducting analyses to ensure no contamination is achieved. In between HACH kit and probe testing, all probes were rinsed with distilled water to neutralize any other samples, and HACH kit cells were rinsed and dried with Kim-wipes to ensure sterility. All wastewater was disposed into proper wastewater containers after testing. All water samples were stored in refrigerators at 4°C prior to sampling at a maximum holding time of 4 days to reduce biochemical activity that could alter chemical parameters. 1 trip blank and one replicate sample were taken at each site to ensure no cross contamination had occurred during transport back to labs (RISC 1997). Proper safety gear and masks were worn in lab and field settings as per VIU COVID-19 safety plan.

2.4 Stream Invertebrate Diversity

3 samples were taken at each of the 3 sites indicated for invertebrate sampling (sites 2, 3, 4) allowing for a total of 9 invertebrate samples per sampling session. Samples were collected using a Hess sampler, and invertebrates were collected into labelled sample jars for live transport back to the VIU lab for analysis within a few days of the sampling day. Once at the lab,

genera and taxa of invertebrates were separated by similarity using compound microscopes with tweezers and petri dishes. Ethanol alcohol was also used to euthanize invertebrates to make sampling and counting easier when back in the lab settings. All invertebrates found were recorded on the Pacific Streamkeepers datasheets with the aid of identification keys. A Shannon-Weiner Diversity Index was calculated for each sampling site for each sampling period as a comparative tool to indicate stream health. Invertebrate sampling results were compared against the two sampling sessions to look at differences in invertebrate population numbers and composition for observations in changes in stream health.

Table 2. Site 2 Invertebrate Counts

Invertebrate	Amount of invertebrate	Comparison
Caddisfly Larva	109	Oct/28/20: 01 Nov/18/20: 108
Mayfly Nymph	32	Oct/28/20: 15 Nov/18/20: 17
Stonefly Nymph	17	Oct/28/20: 05 Nov/18/20: 12
Gilled snail	06	Oct/28/20: 01 Nov/18/20: 05
Aquatic worm	04	Oct/28/20: 01 Nov/18/20: 03
Aquatic spider	02	Oct/28/20: 00 Nov/18/20: 02
Planarian (flatworm)	N/A	Oct/28/20: N/A Nov/18/20: N/A
Amphipod	N/A	Oct/28/20: N/A Nov/18/20: N/A
Damselfly Larva	N/A	Oct/28/20: N/A Nov/18/20: N/A
Clam/mussel	N/A	Oct/28/20: N/A Nov/18/20: N/A
Leech	N/A	Oct/28/20: N/A Nov/18/20: N/A

Table 3. Site 2 Shannon-Weiner Index Rating

Assessment	Rating	Assessment	Rating October	Rating November
Good	4	Pollution Tolerance index	4	3
Acceptable	3	EPT index	2	2
Marginal	2	EPT to total ratio	4	4
Poor	1	Predominant taxon ratio	3	2
		Total	3.25	2.75

The completion of both invertebrate samples concluded that for site 2 the location is acceptable to assessment standards. The stream is relatively unhealthy but acceptable. The Shannon-Weiner calculation rating was 3.25 in October and 2.75 in November. The results of the calculation lead us to determine the sub-total number of taxa found in each tolerance category was 17-24, the total number of EPT taxa was 3-4, the EPT to total ratio index was .91-.93, and the predominant taxon ratio index was .53-.73. This indicates that the location was acceptable. Refer to Appendix for full calculations.

The completion of both invertebrate samples concluded that for site 3 the location is marginal to assessment standards. The stream is unhealthy. The Shannon Weiner calculation was 2 in October and 2.25 in November. This indicates that the site is marginal. The results of the calculation lead us to determine the sub-total number of taxa found in each tolerance category was 12-15, the total number of EPT taxa was 2, the EPT to total ratio index was .48-.33, and the predominant taxon ratio index was .45-.55. This indicates that the location was marginal. Refer to Appendix for full calculations.

Table 4. Site 3 Invertebrate Counts

Invertebrate	Amount of invertebrate	Comparison
Caddisfly Larva	05	Oct/28/20: 01 Nov/18/20: 04
Mayfly Nymph	01	Oct/28/20: 01 Nov/18/20: 00
Stonefly Nymph	13	Oct/28/20: 00 Nov/18/20: 13
Gilled snail	N/A	Oct/28/20: N/A Nov/18/20: N/A
Aquatic worm	33	Oct/28/20: 11 Nov/18/20: 22
Aquatic spider	N/A	Oct/28/20: N/A Nov/18/20: N/A
Planarian (flatworm)	08	Oct/28/20: 04 Nov/18/20: 04
Amphipod	30	Oct/28/20: 23 Nov/18/20: 07
Damselfly Larva	N/A	Oct/28/20: N/A Nov/18/20: N/A
Clam/mussel	01	Oct/28/20: 01 Nov/18/20: 00
Leech	01	Oct/28/20: 00 Nov/18/20: 01

Table 5. Site 3 Shannon-Weiner Index Rating

Assessment	Rating	Assessment	Rating October	Rating November
Good	4	Pollution Tolerance index	2	2
Acceptable	3	EPT index	2	2
Marginal	2	EPT to total ratio	1	2
Poor	1	Predominant taxon ratio	3	3
		Total	2	2.25

The completion of both invertebrate samples concluded that for site 4 the location is acceptable to assessment standards. The stream is relatively unhealthy but acceptable. The Shannon Weiner calculation was 2.25 in October and 3.50 in November. This indicates that the site is acceptable. The results of the calculation lead us to determine the sub-total number of taxa found in each tolerance category was 17-23, the total number of EPT taxa was 3-6, the EPT to total ratio index was .19-.49, and the predominant taxon ratio index was .49-.51. This indicates that the location was acceptable. Refer to Appendix for full calculations.

Table 6. Site 4 Invertebrate Counts

Invertebrate	Amount of invertebrate	Comparison
Caddisfly Larva	61	Oct/28/20: 58 Nov/18/20: 03
Mayfly Nymph	23	Oct/28/20: 13 Nov/18/20: 10
Stonefly Nymph	44	Oct/28/20: 07 Nov/18/20: 37
Gilled snail	N/A	Oct/28/20: N/A Nov/18/20: N/A
Aquatic worm	24	Oct/28/20: 17 Nov/18/20: 07
Aquatic spider	N/A	Oct/28/20: N/A Nov/18/20: N/A
Planarian (flatworm)	02	Oct/28/20: 02 Nov/18/20: 00
Amphipod	67	Oct/28/20: 62 Nov/18/20: 05
Damselfly Larva	07	Oct/28/20: 07 Nov/18/20: 00
Clam/mussel	10	Oct/28/20: 10 Nov/18/20: 00
Leech	N/A	Oct/28/20: N/A Nov/18/20: N/A

Table 7. Site 4 Shannon-Weiner Index Rating

Assessment	Rating	Assessment	Rating October	Rating November
Good	4	Pollution Tolerance index	3	4
Acceptable	3	EPT index	2	3
Marginal	2	EPT to total ratio	1	4
Poor	1	Predominant taxon ratio	3	3
		Total	2.25	3.50

As a part of the biological complex of our waters, for all mayflies are aquatic in their developmental stages, these insects find their most important place in human economy and interest. They are an important link in converting microscopic food organisms and vegetable detritus into units large enough and of proper character to be of value to our predatory fishes (B.D., 1953).

The invertebrates discovered in Cottle Creek consisted mostly of Caddisfly Larva. Caddisflies indicate that the environment has little pollution. According to Dohet 2002, the ubiquitous character (Caddisfly) and the capacity to be affected by environmental perturbations in many different types of aquatic systems as well as providing a wide spectrum of responses to environmental stresses. This bio indicator represents low pollution in the stream because Caddisflies are proven to be intolerant to pollution. Caddisflies were the most plentiful invertebrate in the results of the invertebrate testing with the Hess sampler for site 2, Upper Cottle, Linley road and site 4, Lower Cottle, Stephenson point road.

Site 3, Lower Cottle, Nottingham drive was the outlier with only 05 documented caddisflies and 01 mayfly totaled for both October and November combined. The potential problems related to the low quantity of Caddisfly Larva at this site is the location of the site. The site has thick sediment and flooding evident, as well as drainage from every direction displaying marshy attributes. The site had low conductivity and low velocity and this evidence is consistent with the invertebrates, and lack thereof, influencing the unhealthy stream ecosystem.

As a part of the biological complex of our waters, for all mayflies are aquatic in their developmental stages, these insects find their most important place in human economy and interest. They are an important link in con- verting microscopic food organisms and vegetable detritus into units large enough and of proper character to be of value to our predatory fishes (B.D., 1953).

2.4.1 Quality Assurance & Quality Control

One sample from each site was counted twice by 2 team members to ensure counting was correct to include variation amongst different counters. Data entries were verified for each counter to ensure info being recorded for final Shannon-Weiner Index calculations was correct. Proper safety gear and masks were worn in lab and field settings as per VIU COVID-19 safety plan.

3.0 Results & Discussion

3.1 VIU Water Quality Results

The temperatures recorded for each site during both sampling events were within the water quality guidelines for sustaining freshwater life, which is +/- 1ºC of the outside air temperature. Outside air temperatures were checked with records logged by Environment Canada on both sampling days, October 18th, 2020 and November 18th, 2020.

Dissolved oxygen was well within normal limits for sustaining aquatic life on both sampling sessions, however the dissolved oxygen was overall much lower at the sampling sites on the second session in November; dissolved oxygen concentration decreased by 4 mg/L at most sites, however remaining in the acceptable range of 4.0-8.0 mg/L (RISC 1998) (figure 1). Heavy rains were experienced during the November sampling session, which most likely accounted for the lower dissolved oxygen as the water was washed with much debris and sediment. Additionally, turbidity increased at some stations as much as 3-7X from the October session to the November session, which can also be accounted for by the heavy winter rain in November which brought much more sediment into the stream. However, turbidity remained within acceptable guideline levels.

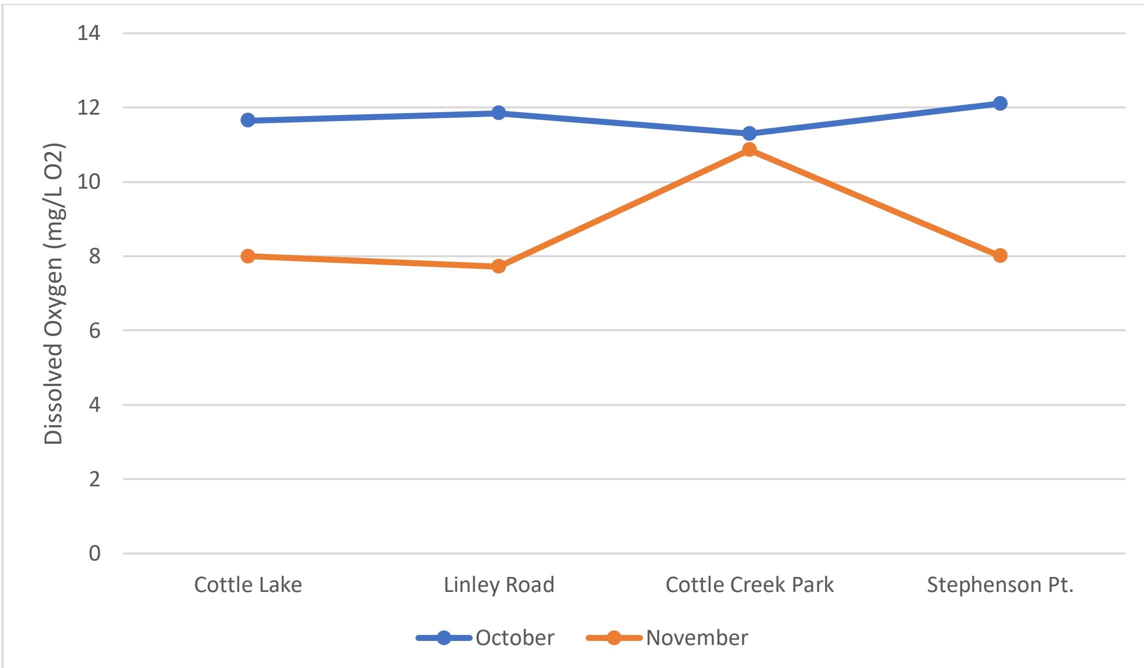


Figure 1: Cottle Creek dissolved oxygen changes, October-November 2020

PH levels remained around the same levels between October and November samplings, close to 9.0 for most sites. Most sites were slightly basic, and above the acceptable guideline of 9.0, with sites 1-3 above pH 9.0 in the first October sampling. With the heavy rains brought in November however, all sites experienced a pH drop down to more acidic levels due to the increased acidity of the additional rainwater being added into the system. Most of the sites experienced a pH shift down within the acceptable range of 6.5-9.0 (RISC 1998).

Conductivity ranged from 100-170 µS/cm between both sampling events, which is a typical range of a BC coastal stream (RISC 1998). An anomaly we experienced was a conductivity of 351 µS/cm for site #2 at Linley Road in October 2020 (app.), however we interpreted the result as a human made error as the conductivity in November was within similar ranges to the other sites sampled.

The changes in alkalinity observed during our stream sampling periods were diverse and broad, especially in the sites located further up in the water shed. Sites #1 and #2 were within the acceptable alkalinity range of 0-20 mg/l $CaCO_3$ during the first sampling session, and after the second sampling session with heavy rains, both sites were above the acceptable range into 25-30 mg/L (figure 2). However, in the lower sites the results contrasted the upper sites as alkalinity stayed the same or decreased significantly, as in site #4. The mass fluctuations in alkalinity can be accounted for by the heavy rainfalls experienced in November, with the additions of minerals and bases being washed off banks and runoff into the stream.

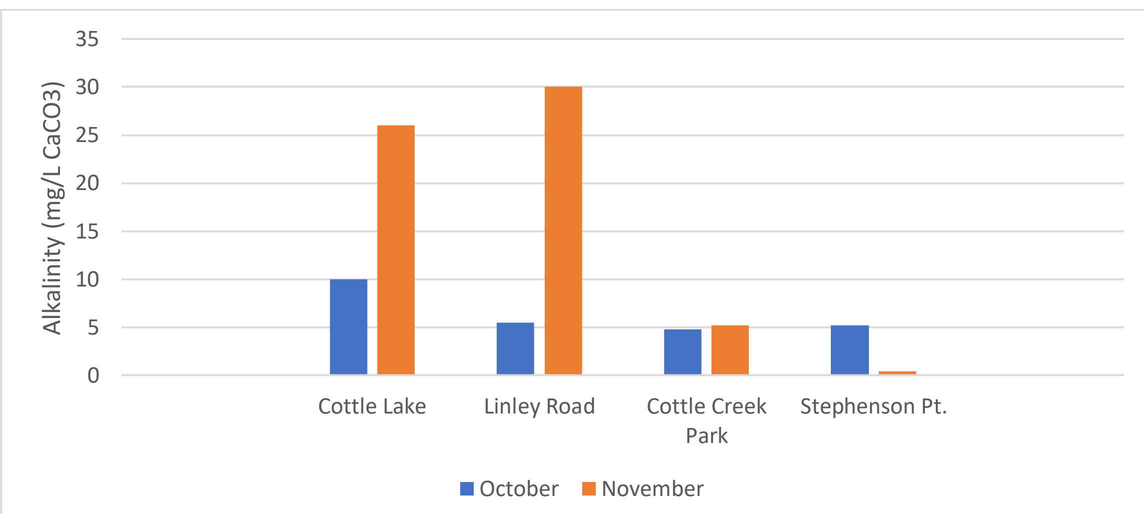


Figure 2: Cottle Creek alkalinity changes, October-November 2020

Hardness levels examined at all the sites showed that in October all 4 sites were within the recommended levels of 60-120 mg/L $CaCO_3$ (RISC 1998). During November, the sites experienced a massive decrease in hardness levels, with all sites falling below the acceptable lowest range of 60 mg/L (figure 3). The additional rain in November introduced a lot of naturally soft rainwater into the system, which dramatically lowered the hardness to dangerous levels; soft water increases the toxicity of metals, especially to aquatic life forms living in stream systems (RISC 1998).

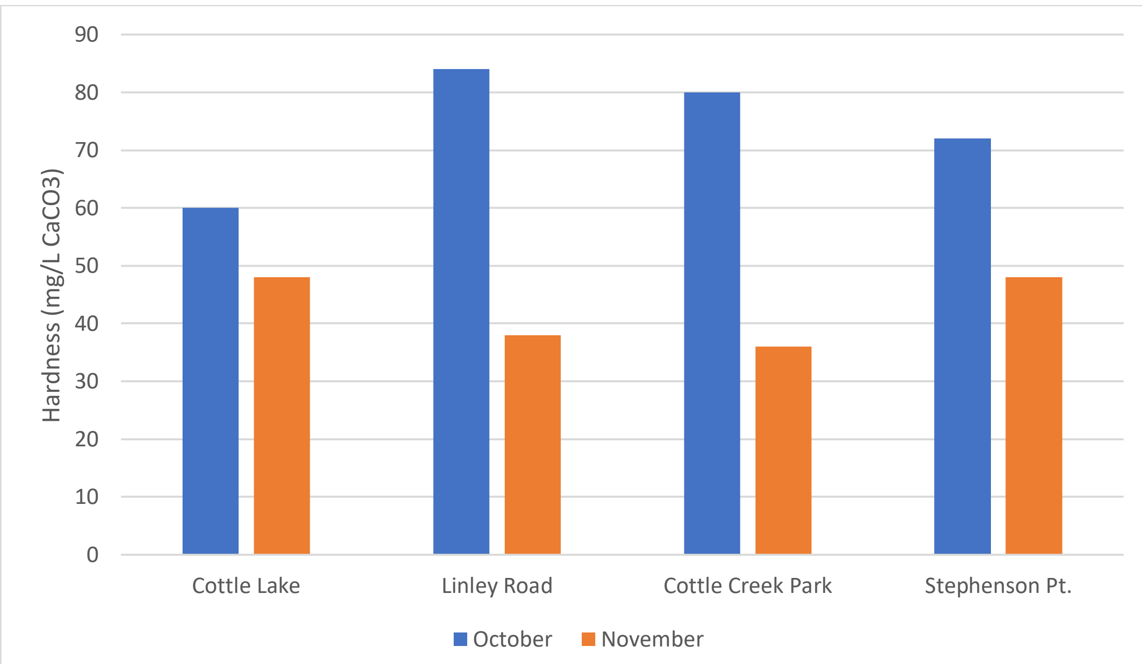


Figure 3: Cottle Creek hardness changes, October-November 2020

Nitrate levels remained well within acceptable ranges during both sampling periods, with the highest recording between the two samplings coming in less than 2 mg/L NO_3. A small increase in the amount of nitrate was noted at all sites during the November sampling session, again most likely from the increased rainfall and washing of excess nutrients into the stream from cliff banks, riparian areas, and nearby land in the water shed.

Lastly, phosphorus levels were found to be naturally high in Cottle Creek between both sampling sessions, as results were all well over the acceptable range of 0.005-0.015 mg/L PO_4^{3-} for aquatic life (RISC 1998). In particular, site #1 experienced a massive increase in phosphorus during the November sampling session to levels above 1.2 mg/L (figure 4). This site was located near a horse stable and large flat sloping grasslands, which may have experienced runoff from the nearby surrounding areas into the creek from the rain-washing nutrients into the system. Phosphorus is the limited nutrient in freshwater, and in excessive cases can cause eutrophication (RISC 1998), however that is experienced more in lake systems. The phosphorus levels experienced were still relatively low, with the highest recording being only just above 1 mg/L, so the findings were declared non substantial as no imminent problems were found for an increase of phosphorus in running water systems.

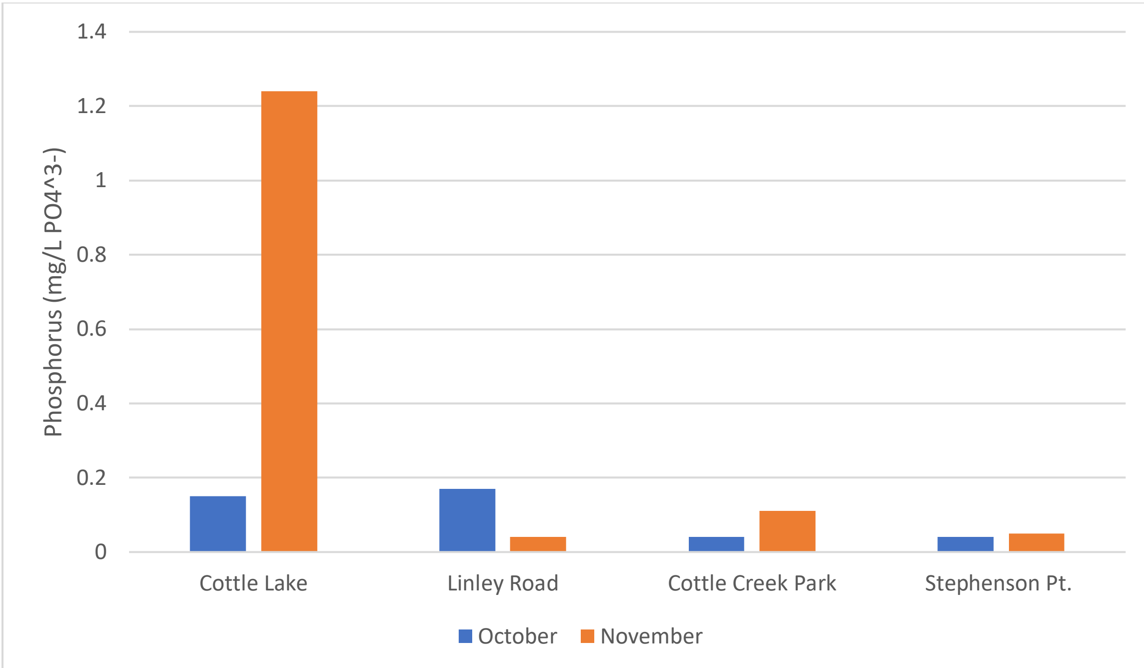


Figure 4: Cottle Creek phosphorus changes, October-November 2020

3.2 ALS Water Quality Results

All ALS results were compared with water quality guidelines put forth by the BC Ministry of Environment (RISC 1998). During both sampling events, all sites experienced levels of aluminum exceeding aquatic life guidelines (table 1). Site #1 was higher than the recommended limit of 0.1 mg/L for both sampling sessions in October and November, whereas sites #2 and #4 only exceeded the guideline in the second sampling session in November, most likely due to the high rain input. Iron levels in Cottle Creek also experienced spikes between the 2 sampling sessions, including a level detected over limit at site #1 in the uppermost reach of the stream (table 1). The other sites experienced an increase in iron levels too, but nowhere near the limit of 1.0 mg/L. Additionally, calcium levels during both sampling events were relatively high at sites, with results from every site coming back over the recommended level of ~8.0 mg/L (table 1). The guidelines recommended that calcium levels above 8.0mg/L indicate low acid sensitivity in fresh water, which is the water's ability to neutralize acid levels (RISC 1998). Based on all the high calcium levels, Cottle Creek has low acid sensitivity. All other metal analysis levels were below minimum detection limit or within the guidelines for aquatic life.

Table 8. ALS metal toxicity results exceeding guidelines

	Parameter					
	Aluminum		**Iron**		**Calcium**	
	0.1 mg/L		**1.0 mg/L**		**~8.0 mg/L**	
Station	Oct-20	Nov-20	Oct-20	Nov-20	Oct-20	Nov-20
Cottle Lake (Site #1)	0.245	0.429	0.891	1.09	16	9.79
Linley Road (Site #2)	0.0173	0.27	0.221	0.561	14.9	8.72
Stephenson Pt. (Site #4)	0.02	0.288	0.204	0.56	17.4	9.66

4.0 Conclusions & Recommendations

This environmental monitoring project was conducted at Cottle Creek water system in the fall of 2020. All of the sites came back with moderate to acceptable stream health. The four sites varied in substrate from silty to bedrock. Canopy cover was a range of 10% - 50%. Gradient for all of the stream was between 0.5-1.0. Invertebrates in three of the locations were considered to be acceptable and one to be moderate. Looking at the findings of the water quality and hydrology these results were expected. At most of the sites the pH and the dissolved oxygen came in above guideline standard but not by much. At the Linley Road site, the phosphorus levels were 0.02 mg/L $PO4^{3-}$ above the guideline standard. This is believed to be caused by the abundance of agriculture right beside the waterway.

The recommendations from this study would be to continuously monitor these sites for future changes in water quality. Due to the two new sites we collected from compared to previous years there will need to be more data collection to conclusively say those sites are negatively being affected from urban development and agriculture. The deterioration of stream health might be shown if studies continue over the years and possibly due to urban development and agriculture around those waterways. The encroaching urban developments and agriculture will continue to deplete riparian areas and contribute to runoff of unwanted substances into the stream. If a record is continuously being recorded there can be documentation for years to come for future comparison.

5.0 Acknowledgements

These acknowledgements are to the people who helped with the project of the Cottle Creek Environmental Monitoring Project in the fall of 2020. An important part of the project came from ALS Environmental for analyzing the water samples in their lab. Without this data we wouldn’t have been able to get some of the crucial information for our report. We would like to acknowledge all of the students and professors from previous years for providing continuous data of the Cottle Creek water system so it can be continuously monitored. Most of all we would like to thank Owen Hargrove and Michael Lester for the help providing report materials, field equipment and laboratory assistance. Both always were flexible with time in the lab and always were available for any questions we had. The lab was always set up with the equipment we needed to be able to complete report.

6.0 References

B.D., B. 1953. The Mayflies, or Ephemeroptera of Illinois. Urbana, Illinois. Illinois Natural History Survey

Bolland A, Krenz D, Peake B, Sinitsin C. 2013. Cottle creek: environmental monitoring program final report. Prepared for RMOT 306 Environmental Monitoring. 38p.

Dohet, A. 2002. Are Caddisflies an ideal group for the biological assessment of water quality in streams? Keltern: Nova Supplement Enterprise.

Environment Canada. 2020. Daily Data Report: Nanaimo A, British Columbia. October 2020 & November 2020. <climate.weather.gc.ca/historical_data/search_historic_data_e.html> Accessed Nov. 24, 2020

Resources Information Standards Committee (RISC). 1997. Guidelines for Designing and Implementing a Water Quality Monitoring in BC. Ministry of Environment, Lands and Parks, Victoria, BC

Resources Information Standards Committee (RISC). 1998. Guidelines for Interpreting Water Quality Data. Ministry of Environment, Lands and Parks Victoria, BC.

7.0 Appendix Index

Site Map

Figure 1: Cottle Creek Sample Station Locations

1) Upper Cottle, Rock City Road

2) Upper Cottle, Linley Road

3) Lower Cottle, Nottingham Drive

4)Lower Cottle, Stephenson Point Road

VIU Water Quality Analysis Results Table

Table 1. Site 1 October Water Quality Results

Parameter	Units	Value	Guideline
pH	Unitless	9.60	6.5-9.0
Conductivity	uS/cm	174	No Guideline
Turbidity	NTU	7.28	=/< 50
Alkalinity	mg/L $CaCO_3$	10	0-20
Hardness	mg/L $CaCO_3$	60	60-120
Nitrate	mg/L NO_3	0.05	Max 200, avg. ~40
Phosphorus	mg/L PO_4^{3-}	0.15	0.005-0.015
Temperature	^oC	11.20	+/- 1^{o}C Natural Level
Dissolved Oxygen	mg/L O_2	11.65	4.0-8.0

Table 2. Site 1 November Water Quality Results

Parameter	Units	Value	Guideline
pH	Unitless	9.1	6.5-9.0
Conductivity	uS/cm	103	No Guideline
Turbidity	NTU	7.57	=/< 50
Alkalinity	mg/L $CaCO_3$	26	0-20
Hardness	mg/L $CaCO_3$	48	60-120
Nitrate	mg/L NO_3	1.09	Max 200, avg. ~40
Phosphorus	mg/L PO_4^{3-}	1.24	0.005-0.015
Temperature	^oC	9	+/- 1^{o}C Natural Level
Dissolved Oxygen	mg/L O_2	8.0	4.0-8.0

Table 3. Site 2 October Water Quality Analysis Results

Parameter	Units	Value	Guideline
pH	Unitless	10.0	6.5-9.0
Conductivity	uS/cm	351	No Guideline
Turbidity	NTU	1.76	=/< 50
Alkalinity	mg/L $CaCO_3$	5.50	0-20
Hardness	mg/L $CaCO_3$	84	60-120
Nitrate	mg/L NO_3	0.35	Max 200, avg. ~40
Phosphorus	mg/L PO_4^{3-}	0.17	0.005-0.015
Temperature	^oC	10.70	+/- 1^oC Natural Level
Dissolved Oxygen	mg/L O_2	11.85	4.0-8.0

Table 4. Site 2 November Water Quality Analysis Results

Parameter	Units	Value	Guideline
pH	Unitless	9.4	6.5-9.0
Conductivity	uS/cm	98	No Guideline
Turbidity	NTU	7.9	=/< 50
Alkalinity	mg/L $CaCO_3$	30	0-20
Hardness	mg/L $CaCO_3$	38	60-120
Nitrate	mg/L NO_3	0.39	Max 200, avg. ~40
Phosphorus	mg/L PO_4^{3-}	0.04	0.005-0.015
Temperature	^oC	16.20	+/- 1^oC Natural Level
Dissolved Oxygen	mg/L O_2	7.72	4.0-8.0

Table 5. Site 3 October Water Quality Analysis Results

Parameter	Units	Value	Guideline
pH	Unitless	9.10	6.5-9.0
Conductivity	uS/cm	171	No Guideline
Turbidity	NTU	1.16	=/< 50
Alkalinity	mg/L $CaCO_3$	4.80	0-20
Hardness	mg/L $CaCO_3$	80	60-120
Nitrate	mg/L NO_3	0.35	Max 200, avg. ~40
Phosphorus	mg/L PO_4^{3-}	0.04	0.005-0.015
Temperature	^oC	10.70	+/- 1^oC Natural Level
Dissolved Oxygen	mg/L O_2	11.30	4.0-8.0

Table 6. Site 3 November Water Quality Analysis Results

Parameter	Units	Value	Guideline
pH	Unitless	7.1	6.5-9.0
Conductivity	uS/cm	101	No Guideline
Turbidity	NTU	5.13	=/< 50
Alkalinity	mg/L $CaCO_3$	5.20	0-20
Hardness	mg/L $CaCO_3$	36	60-120
Nitrate	mg/L NO_3	0.33	Max 200, avg. ~40
Phosphorus	mg/L PO_4^{3-}	0.11	0.005-0.015
Temperature	^oC	11.20	+/- 1^oC Natural Level
Dissolved Oxygen	mg/L O_2	10.86	4.0-8.0

Table 7. Site 4 October Water Quality Analysis Results

Parameter	Units	Value	Guideline
pH	Unitless	9.0	6.5-9.0
Conductivity	uS/cm	162	No Guideline
Turbidity	NTU	3.17	=/< 50
Alkalinity	mg/L $CaCO_3$	5.20	0-20
Hardness	mg/L $CaCO_3$	72	60-120
Nitrate	mg/L NO_3	0.10	Max 200, avg. ~40
Phosphorus	mg/L PO_4^{3-}	0.04	0.005-0.015
Temperature	^oC	11.3	+/- 1^oC Natural Level
Dissolved Oxygen	mg/L O_2	12.11	4.0-8.0

Table 8. Site 4 November Water Quality Analysis Results

Parameter	Units	Value	Guideline
pH	Unitless	8.2	6.5-9.0
Conductivity	uS/cm	107	No Guideline
Turbidity	NTU	6.31	=/< 50
Alkalinity	mg/L $CaCO_3$	0.4	0-20
Hardness	mg/L $CaCO_3$	48	60-120
Nitrate	mg/L NO_3	1.78	Max 200, avg. ~40
Phosphorus	mg/L PO_4^{3-}	0.05	0.005-0.015
Temperature	^oC	15.10	+/- 1^oC Natural Level
Dissolved Oxygen	mg/L O_2	8.01	4.0-8.0

ALS Data Results

Client Sample ID			Cottle Creek- Site 1	Cottle Creek- Site 2	Cottle Creek- Site 4	Cottle Creek - site 1	Cottle Creek - site 2	Cottle Creek - site 4
Date Sampled			27-Oct-2020	27-Oct-2020	27-Oct-2020	17-Nov-2020	17-Nov-2020	17-Nov-2020
Time Sampled			12:00	12:30	12:40	10:55	11:10	11:30
ALS Sample ID			VA20B9454-004	VA20B9454-005	VA20B9454-006	VA20C1169-004	VA20C1169-005	VA20C1169-006
Analyte	Lowest Detection Limit	Units	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water
Physical Tests (Matrix: Water)								
conductivity	2.0	µS/cm	184	167	186	123	109	117
hardness (as CaCO3), from total Ca/Mg	0.60	mg/L	56.0	55.5	63.2	34.3	33.0	36.2
pH	0.10	pH units	7.72	7.77	7.93	7.34	7.34	7.45
Anions and Nutrients (Matrix: Water)								
ammonia, total (as N)	0.0050	mg/L	0.0072	<0.0050	<0.0050	0.0074	0.0090	0.0077
nitrate (as N)	0.0050	mg/L	0.437	0.200	0.360	0.635	0.665	0.815
nitrite (as N)	0.0010	mg/L	0.0026	<0.0010	0.0011	0.0019	0.0020	0.0022
nitrogen, total	0.030	mg/L	0.866	0.454	0.606	0.975	0.940	1.11
phosphate, ortho-, dissolved (as P)	0.0010	mg/L	0.0031	<0.0010	0.0016	<0.0010	<0.0010	0.0014
phosphorus, total	0.0020	mg/L	0.0219	0.0054	0.0060	0.0265	0.0164	0.0175
Total Metals (Matrix: Water)								
aluminum, total	0.0030	mg/L	0.245	0.0173	0.0200	0.429	0.270	0.288
antimony, total	0.00010	mg/L	0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
arsenic, total	0.00010	mg/L	0.00055	0.00019	0.00022	0.00052	0.00027	0.00027
barium, total	0.00010	mg/L	0.00442	0.00226	0.00255	0.00500	0.00290	0.00328
beryllium, total	0.000020	mg/L	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020
bismuth, total	0.000050	mg/L	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
boron, total	0.010	mg/L	0.041	0.094	0.104	0.026	0.050	0.054
cadmium, total	0.0000050	mg/L	0.0000061	<0.0000050	<0.0000050	0.0000101	<0.0000050	<0.0000050
calcium, total	0.050	mg/L	16.0	14.9	17.4	9.79	8.72	9.66

cesium, total	0.000010	mg/L	0.000039	<0.000010	<0.000010	0.000033	0.000010	0.000011
chromium, total	0.00050	mg/L	0.00055	<0.00050	<0.00050	0.00089	0.00056	0.00061
cobalt, total	0.00010	mg/L	0.00020	<0.00010	<0.00010	0.00031	0.00017	0.00019
copper, total	0.00050	mg/L	0.00218	<0.00050	0.00088	0.00275	0.00152	0.00218
iron, total	0.010	mg/L	0.891	0.221	0.204	1.09	0.561	0.560
lead, total	0.000050	mg/L	0.000228	<0.000050	<0.000050	0.000337	0.000082	0.000097
lithium, total	0.0010	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
magnesium, total	0.0050	mg/L	3.92	4.44	4.83	2.40	2.72	2.93
manganese, total	0.00010	mg/L	0.0566	0.0126	0.0126	0.0994	0.0409	0.0441
molybdenum, total	0.000050	mg/L	0.000059	<0.000050	<0.000050	0.000075	<0.000050	0.000052
nickel, total	0.00050	mg/L	0.00058	<0.00050	<0.00050	0.00068	<0.00050	<0.00050
phosphorus, total	0.050	mg/L	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
potassium, total	0.050	mg/L	0.539	0.478	0.492	0.506	0.487	0.518
rubidium, total	0.00020	mg/L	0.00074	0.00075	0.00067	0.00067	0.00057	0.00069
selenium, total	0.000050	mg/L	0.000060	<0.000050	0.000067	0.000076	0.000055	0.000057
silicon, total	0.10	mg/L	6.21	4.90	5.31	4.43	5.18	5.17
silver, total	0.000010	mg/L	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
sodium, total	0.050	mg/L	14.7	10.9	11.8	9.60	6.85	7.45
strontium, total	0.00020	mg/L	0.0605	0.0613	0.0664	0.0376	0.0362	0.0394
sulfur, total	0.50	mg/L	2.18	1.13	1.44	1.76	1.72	1.78
tellurium, total	0.00020	mg/L	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
thallium, total	0.000010	mg/L	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
thorium, total	0.00010	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
tin, total	0.00010	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
titanium, total	0.00030	mg/L	0.0155	0.00087	0.00096	0.0270	0.0181	0.0214
tungsten, total	0.00010	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
uranium, total	0.000010	mg/L	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
vanadium, total	0.00050	mg/L	0.00111	<0.00050	<0.00050	0.00162	0.00140	0.00160
zinc, total	0.0030	mg/L	<0.0030	<0.0030	<0.0030	0.0053	<0.0030	<0.0030
zirconium, total	0.00020	mg/L	<0.00020	<0.00020	<0.00020	<0.00020	0.00020	0.00023

October Shannon-Weiner Calculations

Table 9. Cottle Creek Site #2 Shannon-Weiner Diversity Index Oct 2020

Common Name	Column C	pi(C/T)	ln(pi)	pi*ln(pi)
Caddisfly Larva	5	0.0735	-2.610	-0.192
Mayfly Nymph	21	0.3088	-1.175	-0.363
Stonefly Nymph	36	0.5294	-0.636	-0.337
Gilled Snail	1	0.0147	-4.220	-0.062
Culcidae	1	0.0147	-4.220	-0.062
Aquatic Worm	1	0.0147	-4.220	-0.062
Clam	1	0.0147	-4.220	-0.062
Cranefly Larva	1	0.0147	-4.220	-0.062
Aquatic Spider	1	0.0147	-4.220	-0.062
TOTAL	68	1		-1.264

Shannon-Weiner Diversity Index:
`=-(-1.264)/LN(9)

0.575

Table 10. Cottle Creek Site #3 Shannon-Weiner Diversity Index Oct 2020

Common Name	Column C	pi(C/T)	ln(pi)	pi*ln(pi)
Caddisfly Larva	1	0.023809524	-3.738	-0.089
Mayfly Nymph	1	0.023809524	-3.738	-0.089
Scud	23	0.547619048	-0.602	-0.330
Aquatic Worm	11	0.261904762	-1.340	-0.351
Riffle Beetle	1	0.023809524	-3.738	-0.089
Clam	1	0.023809524	-3.738	-0.089
Flatworm	4	0.095238095	-2.351	-0.224
TOTAL	42	1		-1.261

Shannon-Weiner Diversity Index:
`=-(-1.261)/LN(7)

0.648

Table 11. Cottle Creek Site #4 Shannon-Weiner Diversity Index Oct 2020

Common Name	Column C	pi(C/T)	ln(pi)	pi*ln(pi)
Caddisfly Larva	3	0.025	-3.697	-0.092
Mayfly Nymph	13	0.107	-2.231	-0.240
Stonefly Nymph	7	0.058	-2.850	-0.165
Damselfly Larvae	7	0.058	-2.850	-0.165
Scud	62	0.512	-0.669	-0.343
Clam	10	0.083	-2.493	-0.206
Flatworm	2	0.017	-4.103	-0.068
Aquatic Worm	17	0.140	-1.963	-0.276
TOTAL	121	1		-1.553

Shannon-Weiner Diversity Index:
`=-(-1.553)/LN(6)

0.867

INVERTEBRATE SURVEY FIELD DATA SHEET (October)

Stream Name: Cottle Creek	Date: Oct. 28, 2020
Station Name: Site #2	Flow status: 0.10 m^3/s

Sampler Used:	Number of replicates	Total area sampled (Hess, Surber = 0.09 m^2) x no. replicates
Hess	3	0.27 m^2

Column A Pollution Tolerance	Column B Common Name	Column C Number Counted	Column D Number of Taxa
Category 1	Caddisfly Larva (EPT)	5	2
	Mayfly Nymph (EPT)	21	1
	Stonefly Nymph (EPT)	36	1
	Dobsonfly (hellgrammite)		
Pollution Intolerant	Gilled Snail	1	1
	Riffle Beetle		
	Water Penny		
	Culcidae	1	1
Sub-Total		64	6
Category 2	Alderfly Larva		
	Aquatic Beetle		
	Aquatic Sowbug		
	Clam, Mussel	1	1
	Cranefly Larva	1	1
	Crayfish		
Somewhat Pollution Tolerant	Damselfly Larva		
	Dragonfly Larva		
	Fishfly Larva		
	Amphipod (freshwater shrimp)		

	Water snipe Larva		
Sub-Total		2	2
Category 3	Aquatic Worm (oligochaete)	1	1
	Blackfly Larva		
	Leech		
	Midge Larva (chironomid)		
	Planarian (flatworm)		
Pollution Tolerant	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite		
	Aquatic Spider	1	1
Sub-Total		2	2
TOTAL		68	10

INVERTEBRATE SURVEY INTERPRETATION SHEET

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell **CT**: 68

DENSITY: Invertebrate density per total area sampled:

From page 1

68 ÷ 0.27 m^2 = 252 / m^2

PREDOMINANT TAXON:
Invertebrate group with the highest number counted (in Col. C): 36

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

3x6+2x2+2

24

EPT INDEX: Total number of EPT taxa.

Good	Acceptable	Marginal	Poor	EPT4 + EPT5 + EPT6	4
>8	5-8	2-4	0-1	2+1+1	

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

Good	Acceptable	Marginal	Poor	(EPT1 + EPT2 + EPT3) / CT	0.91
0.75-1.0	0.50-0.74	0.25-0.49	<0.25	5+21+36/68	

SECTION 3 - DIVERSITY

TOTAL NUMBER OF TAXA: Total number of taxa from cell **DT**: 10

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

Good	Acceptable	Marginal	Poor	Col. C for S1 / CT	0.53
<0.40	0.40-0.59	0.60-0.79	0.80-1.0	36/68	

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	4
EPT Index	2
EPT To Total Ratio	4
Predominant Taxon Ratio	3

Average Rating
Average of R1, R2, R3, R4
3.25

L

INVERTEBRATE SURVEY FIELD DATA SHEET (October)

Stream Name: Cottle Creek		Date: Oct. 28, 2020	
Station Name: Site #3		Flow status: 0.076 m^3/s	
Sampler Used: Hess	Number of replicates 3	Total area sampled (Hess, Surber = 0.09 m^2) x no. replicates 0.27 m^2	

Column A Pollution Tolerance	Column B Common Name	Column C Number Counted	Column D Number of Taxa
Category 1	Caddisfly Larva (EPT)	1	1
	Mayfly Nymph (EPT)	1	1
	Stonefly Nymph (EPT)		
	Dobsonfly (hellgrammite)		
Pollution Intolerant	Gilled Snail		
	Riffle Beetle	1	1
	Water Penny		
Sub-Total		3	3
Category 2	Alderfly Larva		
	Aquatic Beetle		
	Aquatic Sowbug		
	Clam, Mussel	1	1
	Cranefly Larva		
	Crayfish		
Somewhat Pollution Tolerant	Damselfly Larva		
	Dragonfly Larva		
	Fishfly Larva		
	Amphipod (freshwater shrimp)	23	1
	Watersnipe Larva		

Sub-Total		24	2
Category 3	Aquatic Worm (oligochaete)	11	1
	Blackfly Larva		
	Leech		
	Midge Larva (chironomid)		
Pollution Tolerant	Planarian (flatworm)	4	1
	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite		
Sub-Total		15	2
TOTAL		42	7

INVERTEBRATE SURVEY INTERPRETATION SHEET

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell **CT**: 42

DENSITY: Invertebrate density per total area sampled:

From page 1

42 ÷ 0.27 m^2 = 155.56 / m^2

PREDOMINANT TAXON:

Invertebrate group with the highest number counted (in Col. C): 23

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

3x3+2x2+2

15

EPT INDEX: Total number of EPT taxa.

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

EPT4 + EPT5 + EPT6

1+1+0

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+1+0/42

0.048

SECTION 3 - DIVERSITY

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

7

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

23/42

0.55

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	2
EPT Index	2
EPT To Total Ratio	1
Predominant Taxon Ratio	3

Average Rating
Average of R1, R2, R3, R4
2

INVERTEBRATE SURVEY FIELD DATA SHEET (October)

Stream Name: Cottle Creek		Date: Oct. 28, 2020	
Station Name: Site #4		Flow status: 0.13 m^3/s	
Sampler Used: Hess	Number of replicates 3	Total area sampled (Hess, Surber = 0.09 m^2) x no. replicates 0.27 m^2	

Column A Pollution Tolerance	Column B Common Name	Column C Number Counted	Column D Number of Taxa
Category 1	Caddisfly Larva (EPT)	3	1
	Mayfly Nymph (EPT)	13	1
	Stonefly Nymph (EPT)	7	1
	Dobsonfly (hellgrammite)		
Pollution Intolerant	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		23	3
Category 2	Alderfly Larva		
	Aquatic Beetle		
	Aquatic Sowbug		
	Clam, Mussel	10	1
	Cranefly Larva		
	Crayfish		
Somewhat Pollution Tolerant	Damselfly Larva	7	1
	Dragonfly Larva		
	Fishfly Larva		
	Amphipod (freshwater shrimp)	62	1
	Watersnipe Larva		
Sub-Total		79	3

Category 3	Aquatic Worm (oligochaete)	17	1
	Blackfly Larva		
	Leech		
	Midge Larva (chironomid)		
Pollution Tolerant	Planarian (flatworm)	2	1
	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite		
Sub-Total		19	2
TOTAL		121	8

INVERTEBRATE SURVEY INTERPRETATION SHEET

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell **CT**: 121

DENSITY: Invertebrate density per total area sampled:

121 ÷ 0.27 (From page 1) m^2 = 448 / m^2

PREDOMINANT TAXON:

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

62

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

3x3+2x3+2

17

EPT INDEX: Total number of EPT taxa.

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

EPT4 + EPT5 + EPT6

1+1+1

3

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

3+13+7/121

0.19

SECTION 3 - DIVERSITY

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

8

PREDOMINANT TAXON RATIO INDEX: Number of invertebrates 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

62/121

0.51

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	3
EPT Index	2
EPT To Total Ratio	1
Predominant Taxon Ratio	3

Average Rating

Average of R1, R2, R3, R4

2.25

October Hydrology Analysis Tables

Table 12. Site 1 Hydrology Measurements

Transect #	Wetted Width (m)	Depth 25% (m)	Depth 50% (m)	Depth 75% (m)	Average Transect Depth (m)
1	0.80	0.10	0.20	0.10	0.13
2	0.70	0.10	0.20	0.10	0.13
3	1.1	0.30	0.10	0.20	0.20
Average Wetted	0.87	[redacted]	[redacted]	[redacted]	0.15

Float #	Distance Travelled (m)	Time (seconds)	Velocity (m/s)
1 (25%)	10	25.30	0.40
2 (50%)	10	25.80	0.39
3 (75%)	10	26.50	0.38
Average Velocity	[redacted]	[redacted]	0.39

Discharge: Q=VxA
Q= 0.39x(0.87x0.15)
Q=0.05 m^3/s

Table 13. Site 2 Hydrology Measurements

Transect #	Wetted Width (m)	Depth 25% (m)	Depth 50% (m)	Depth 75% (m)	Average Transect Depth (m)
1	2.70	0.22	0.24	0.16	0.21
2	3.20	0.10	0.13	0.13	0.12
3	1.30	0.24	0.19	0.18	0.20
Average Wetted	2.40	[redacted]	[redacted]	[redacted]	0.18

Float #	Distance Travelled (m)	Time (seconds)	Velocity (m/s)
1 (25%)	10	38.29	0.26
2 (50%)	10	58.26	0.17
3 (75%)	10	32.64	0.30
Average Velocity	[redacted]	[redacted]	0.24

Discharge: Q=VxA
Q= 0.24x(2.4x0.18)
Q=0.10 m^3/s

Table 14. Site 3 Hydrology Measurements

Transect #	Wetted Width (m)	Depth 25% (m)	Depth 50% (m)	Depth 75% (m)	Average Transect Depth (m)
1	0.90	0.16	0.19	0.20	0.18
2	0.80	0.22	0.24	0.21	0.22
3	1.50	0.20	0.25	0.23	0.23
Average Wetted	1.10	[redacted]	[redacted]	[redacted]	0.21

Float #	Distance Travelled (m)	Time (seconds)	Velocity (m/s)
1 (25%)	10	31.70	0.32
2 (50%)	10	28.08	0.36
3 (75%)	10	33.15	0.30
Average Velocity	[redacted]	[redacted]	0.33

Discharge: Q=VxA
Q= 0.33x(1.1x0.21)
Q= 0.076 m^3/s

Table 15. Site 4 Hydrology Measurements

Transect #	Wetted Width (m)	Depth 25% (m)	Depth 50% (m)	Depth 75% (m)	Average Transect Depth (m)
1	1.90	0.10	0.18	0.10	0.13
2	2.37	0.16	0.27	0.20	0.21
3	2.67	0.13	0.14	0.10	0.12
Average Wetted	2.31	[redacted]	[redacted]	[redacted]	0.15

Float #	Distance Travelled (m)	Time (seconds)	Velocity (m/s)
1 (25%)	10	29.14	0.34
2 (50%)	10	25.53	0.39
3 (75%)	10	25.67	0.39
Average Velocity	[redacted]	[redacted]	0.37

Discharge: Q=VxA
Q= 0.37x(2.31x0.15)
Q= 0.13 m^3/s

November Shannon-Weiner Calculations

Table 16. Cottle Creek Site #2 Shannon-Weiner Diversity Index Nov 2020

Common Name	Column C	pi(C/T)	ln(pi)	pi*ln(pi)
Caddisfly Larva	108	0.73	-0.315	-0.230
Mayfly Nymph	17	0.115	-2.163	-0.249
Stonefly Nymph	12	0.081	-2.513	-0.204
Gilled Snail	5	0.0338	-3.387	-0.114
Culcidae	1	0.0068	-4.997	-0.034
Aquatic Worm	3	0.02	-3.912	-0.078
Aquatic Spider	2	0.0135	-4.305	-0.058
TOTAL	148	1		-0.967

Shannon-Weiner Diversity Index:
`=-(-0.967)/LN(7)

0.497

Table 17. Cottle Creek Site #3 Shannon-Weiner Diversity Index Nov 2020

Common Name	Column C	pi(C/T)	ln(pi)	pi*ln(pi)
Caddisfly Larva	4	0.078431373	-2.546	-0.200
Stonefly Nymph	13	0.254901961	-1.367	-0.348
Scud	7	0.137254902	-1.986	-0.273
Aquatic Worm	22	0.431372549	-0.841	-0.363
Leech	1	0.019607843	-3.932	-0.077
Flatworm	4	0.078431373	-2.546	-0.200
TOTAL	51	1		-1.460

Shannon-Weiner Diversity Index:
`=-(-1.460)/LN(6)

0.815

Table 18. Cottle Creek Site #4 Shannon-Weiner Diversity Index Nov 2020

Common Name	Column C	pi(C/T)	ln(pi)	pi*ln(pi)
Caddisfly Larva	58	0.492	-0.710	-0.349
Mayfly Nymph	10	0.085	-2.468	-0.209
Stonefly Nymph	37	0.314	-1.160	-0.364
Damselfly Larvae	1	0.008	-4.771	-0.040
Scud	5	0.042	-3.161	-0.134
Aquatic Worm	7	0.059	-2.825	-0.168
TOTAL	118	1		-1.264

Shannon-Weiner Diversity Index:
`=-(-1.264)/LN(6)

0.705

INVERTEBRATE SURVEY FIELD DATA SHEET (November)

Stream Name: Cottle Creek		Date: Nov.18, 2020	
Station Name: Site #2		Flow status: 0.96 m^3/s	
Sampler Used: Hess	Number of replicates 3	Total area sampled (Hess, Surber = 0.09 m^2) x no. replicates 0.27 m^2	

Column A Pollution Tolerance	Column B Common Name	Column C Number Counted	Column D Number of Taxa
Category 1	Caddisfly Larva (EPT)	108	1
	Mayfly Nymph (EPT)	17	1
	Stonefly Nymph (EPT)	12	1
	Dobsonfly (hellgrammite)		
Pollution Intolerant	Gilled Snail	5	1
	Riffle Beetle		
	Water Penny		
	Culcidae	1	1
Sub-Total		143	5
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)		
	Water snipe Larva		
Sub-Total			
Category 3	Aquatic Worm (oligochaete)	3	1

Y

Pollution Tolerant	Blackfly Larva		
	Leech		
	Midge Larva (chironomid)		
	Planarian (flatworm)		
	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite		
	Aquatic Spider	2	1
Sub-Total		5	2
TOTAL		148	7

INVERTEBRATE SURVEY INTERPRETATION SHEET

SECTION 1 - ABUNDANCE AND DENSITY

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

148

DENSITY: Invertebrate density per total area sampled:

From page 1

148 ÷ 0.27 m^2 = 548 / m^2

PREDOMINANT TAXON:

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

108

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

3x5+2x0+2

17

EPT INDEX: Total number of EPT taxa.

Good	Acceptable	Marginal	Poor

EPT4 + EPT5 + EPT6

3

>8	5-8	2-4	0-1	1+1+1	

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

Good	Acceptable	Marginal	Poor	(EPT1 + EPT2 + EPT3) / CT	
0.75-1.0	0.50-0.74	0.25-0.49	<0.25	108+17+12/148	0.93

SECTION 3 - DIVERSITY

TOTAL NUMBER OF TAXA: Total number of taxa from cell **DT**: 7

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

Good	Acceptable	Marginal	Poor	Col. C for S1 / CT	
<0.40	0.40-0.59	0.60-0.79	0.80-1.0	108/148	0.73

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	3
EPT Index	2
EPT To Total Ratio	4
Predominant Taxon Ratio	2

Average Rating
Average of R1, R2, R3, R4
2.75

INVERTEBRATE SURVEY FIELD DATA SHEET (November)

Stream Name:	Cottle Creek	Date:	Nov.18, 2020
Station Name:	Site #3	Flow status:	$0.44\ m^3/s$

Sampler Used:	Number of replicates	Total area sampled (Hess, Surber = $0.09\ m^2$) x no. replicates
Hess	3	0.27 m^2

Column A Pollution Tolerance	Column B Common Name	Column C Number Counted	Column D Number of Taxa
Category 1	Caddisfly Larva (EPT)	4	1
	Mayfly Nymph (EPT)		
	Stonefly Nymph (EPT)	13	1
	Dobsonfly (hellgrammite)		
Pollution Intolerant	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		17	2
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)	7	1
	Watersnipe Larva		
Sub-Total		7	1
Category 3	Aquatic Worm (oligochaete)	22	2
	Blackfly Larva		
	Leech	1	1

Pollution Tolerant	Midge Larva (chironomid)		
	Planarian (flatworm)	4	1
	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite		
Sub-Total		27	4
TOTAL		51	7

INVERTEBRATE SURVEY INTERPRETATION SHEET

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell **CT**: 51

DENSITY: Invertebrate density per total area sampled:

From page 1

51 ÷ 0.27 m^2 = 188.89 / m^2

PREDOMINANT TAXON:

Invertebrate group with the highest number counted (in Col. C): 22

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

3x2+2x1+4

12

EPT INDEX: Total number of EPT taxa.

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

EPT4 + EPT5 + EPT6

1+0+1

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

4+0+13/51

0.33

SECTION 3 - DIVERSITY

TOTAL NUMBER OF TAXA: Total number of taxa from cell **DT**: 7

PREDOMINANT TAXON RATIO INDEX: Number of invertebrates 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

22/49

0.45

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	2
EPT Index	2
EPT To Total Ratio	2
Predominant Taxon Ratio	3

Average Rating
Average of R1, R2, R3, R4
2.25

INVERTEBRATE SURVEY FIELD DATA SHEET (November)

Stream Name:	Cottle Creek	Date:	Nov.18, 2020
Station Name:	Station #4	Flow status:	1.90 m^3/s

Sampler Used: Hess	Number of replicates: 3	Total area sampled (Hess, Surber = 0.09 m^2) x no. replicates: 0.27 m^2

Column A Pollution Tolerance	Column B Common Name	Column C Number Counted	Column D Number of Taxa
Category 1	Caddisfly Larva (EPT)	58	2
	Mayfly Nymph (EPT)	10	2
	Stonefly Nymph (EPT)	37	2
	Dobsonfly (hellgrammite)		
Pollution Intolerant	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		105	6
Category 2	Alderfly Larva		
	Aquatic Beetle		
	Aquatic Sowbug		
	Clam, Mussel		
	Cranefly Larva		
	Crayfish		
Somewhat Pollution Tolerant	Damselfly Larva	1	1
	Dragonfly Larva		
	Fishfly Larva		
	Amphipod (freshwater shrimp)	5	1
	Water snipe Larva		
Sub-Total		6	2

Category 3	Aquatic Worm (oligochaete)	7	1
	Blackfly Larva		
	Leech		
	Midge Larva (chironomid)		
Pollution Tolerant	Planarian (flatworm)		
	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite		
Sub-Total		7	1
TOTAL		118	9

INVERTEBRATE SURVEY INTERPRETATION SHEET

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell **CT**: 118

DENSITY: Invertebrate density per total area sampled:

118 ÷ 0.27 (From page 1) m² = 437.04 / m²

PREDOMINANT TAXON:

Invertebrate group with the highest number counted (in Col. C): 58

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

3x6+2x2+1 = 23

EPT INDEX: Total number of EPT taxa.

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

EPT4 + EPT5 + EPT6

2+2+2 = 6

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

58+10+37/118

0.89

SECTION 3 - DIVERSITY

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

9

PREDOMINANT TAXON RATIO INDEX: Number of invertebrates 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

58/118

0.49

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	4
EPT Index	3
EPT To Total Ratio	4
Predominant Taxon Ratio	3

Average Rating
Average of R1, R2, R3, R4
3.5

November Hydrology Analysis Tables

Table 19. Site 1 Hydrology Measurements

Transect #	Wetted Width (m)	Depth 25% (m)	Depth 50% (m)	Depth 75% (m)	Average Transect Depth (m)
1	1.0	0.13	0.22	0.13	0.16
2	1.10	0.20	0.35	0.20	0.25
3	1.18	0.60	0.20	0.40	0.40
Average Wetted	1.09	[redacted]	[redacted]	[redacted]	0.27

Float #	Distance Travelled (m)	Time (seconds)	Velocity (m/s)
1 (25%)	10	22.8	0.44
2 (50%)	10	21.8	0.46
3 (75%)	10	23.2	0.43
Average Velocity	[redacted]	[redacted]	0.44

Discharge: Q=VxA
Q= 0.44x(1.09x0.27)
Q= 0.13 m^3/s

Table 20. Site 2 Hydrology Measurements

Transect #	Wetted Width (m)	Depth 25% (m)	Depth 50% (m)	Depth 75% (m)	Average Transect Depth (m)
1	2.7	0.23	0.26	0.24	0.24
2	3.6	0.26	0.28	0.34	0.29
3	2.4	0.19	0.33	0.40	0.31
Average Wetted	2.9	[redacted]	[redacted]	[redacted]	0.29

Float #	Distance Travelled (m)	Time (seconds)	Velocity (m/s)
1 (25%)	10	8.23	1.22
2 (50%)	10	8.77	1.14
3 (75%)	10	9.50	1.05
Average Velocity	[redacted]	[redacted]	1.14

Discharge: Q=VxA
Q= 1.14x(2.9x0.29)
Q= 0.96 m^3/s

Table 21. Site 3 Hydrology Measurements

Transect #	Wetted Width (m)	Depth 25% (m)	Depth 50% (m)	Depth 75% (m)	Average Transect Depth (m)
1	2.4	0.42	0.29	0.27	0.33
2	1.03	0.37	0.42	0.40	0.40
3	1.48	0.46	0.43	0.24	0.38
Average Wetted	1.64	[redacted]	[redacted]	[redacted]	0.37

Float #	Distance Travelled (m)	Time (seconds)	Velocity (m/s)
1 (25%)	10	15.32	0.65
2 (50%)	10	12.15	0.82
3 (75%)	10	13.76	0.73
Average Velocity	[redacted]	[redacted]	0.73

Discharge: Q=VxA
Q= 0.73x(1.64x0.37)
Q= 0.44 m^3/s

Table 22. Site 4 Hydrology Measurements

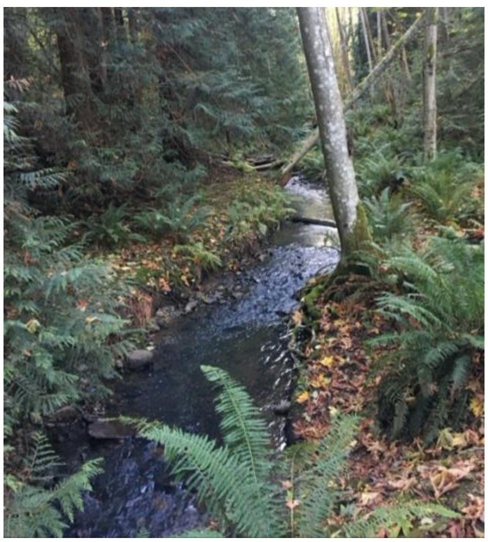
Transect #	Wetted Width (m)	Depth 25% (m)	Depth 50% (m)	Depth 75% (m)	Average Transect Depth (m)
1	2.6	0.36	0.44	0.27	0.36
2	3.5	0.39	0.46	0.27	0.37
3	3.2	0.27	0.35	0.23	0.28
Average Wetted	3.1	[redacted]	[redacted]	[redacted]	0.34

Float #	Distance Travelled (m)	Time (seconds)	Velocity (m/s)
1 (25%)	10	5.52	1.81
2 (50%)	10	5.66	1.77
3 (75%)	10	5.38	1.86
Average Velocity	[redacted]	[redacted]	1.81

Discharge: Q=VxA
Q= 1.81x(3.1x0.34)
Q= 1.90 m^3/s

Photos

Site #1: Upper Cottle (0428331mE, 545224mN). Plant life includes many deciduous trees with a mixture of coniferous. The leaf debris is potentially very slippery in addition to the wet bridges (2) and the stairway down to the site. The stairway is engineered with grips for shoe ware and a railing. The site is approximately 5 minutes from the parking lot, the rest is well built trail.



Site #2: Upper Cottle (0430133mE, 5451971mN). The plant life around this site consists of coniferous and deciduous trees. Leaf litter and wet sword fern create a potentially slippery surface to work on. The site has extremely accessible excess and being careful of slips and trips is the biggest hazard for this site.

Site #3: Lower Cottle (0430561mE, 5451389mN). The plant life surrounding this site is thicker brush and shrubs, along with coniferous and deciduous trees. The branches the group will be working in are eye level therefore conducting data collection may require eye protection.

Site #4: Lower Cottle (0430561mE, 5451389mN). The plant life around this site is primarily deciduous trees and long grass. The rocks surrounding the site add to the slipping risk. This site has good access.

Mariah, Olivia, and Riley taking invertebrate samples on November 18, 2020. (Photo by Cassidy)