Cottle Creek Final Assessment 2018

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Submitted to:
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Executive Summary - (Kayla)

Vancouver Island University students were involved in a continuous water monitoring project on Cottle Creek located in Nanaimo, BC. Students have been monitoring Cottle Creek annually since 2012. Cottle Creek is surrounded by residential areas, busy roadways and public parks and the creek is intercepted between sites 1 and 2 by Cottle Lake. The purpose of this project was to assess the health of Cottle Creek and suggest possible sources of pollutants and recommend solutions.

Students were involved in taking several samples from four different sites along the creek, including hydrology, water quality, microbiology and stream invertebrates. Samples were taken on October 29th and November 20th, 2018. Samples were sent to ALS laboratories in Vancouver and additional samples were analyzed by students in the VIU lab. Basic water quality parameters were measured, and ALS performed a nutrient analyses and a total metal scan. Some measurements were recorded in situ. In addition, students conducted stream invertebrate sampling during the first sampling period. Students made sure to follow quality assurance and quality control measures, by taking replicates, control samples, properly sterilizing equipment, etc.

Due to the heavy rainfall during the week of the first sampling, the discharge was recorded as higher at all 4 sites in comparison to the second sampling period. This initial rainfall of the season may have affected some water quality parameters, including turbidity.

Microbiology samples, of 100ml, were taken at each site to determine the fecal coliform colonies count at each site. Site one had a moderate amount of fecal coliform

colonies at 38% per 100ml. Site two and three had low amounts of fecal coliform colonies. Site two was at 5% and site three at 7%. Site four had the highest amounts of fecal coliforms at 60% and the replicate for site four at 68%. The reasons regarding such high fecal coliform counts for site four is unknown.

There is some concern to the amount of impact the creek may be facing due to human activity, the microbiology results for fecal coliform were very high, especially at site 4, the invertebrate ratings were low and there were some metals that exceeded guidelines. However, water quality results from both VIU and ALS meet the water quality guidelines, except for the few outliers.

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1.0 Introduction - (Karlee)

1.1 Project Overview

This is an informative report about the environmental monitoring project on Cottle Creek, located on Vancouver Island in North Nanaimo, British Columbia. Basic hydrology, water quality, microbiology and invertebrate parameters were measured to determine the overall health of the stream. Cottle Creek is 4.5km long and has three tributaries; Upper Cottle Creek, North Cottle Creek and Lower Cottle Creek. Upper Cottle headwater begins at Arrowsmith Road and flows north-east into Cottle Lake. The North Cottle headwaters flow from Lost Lake into the northernmost bay of Cottle Lake. Lower Cottle tributary is funneled out of Cottle Lake and then runs to Departure Bay where it drops off a small shelf before entering the Pacific Ocean (NALT 2017). This project had four sampling sites. Site 1 was located at the headwaters of the Upper Cottle Tributary at Arrowsmith Road. Site 2 was located at the east end of Cottle Lake where the tributary for Lower Cottle began. Site 3 and 4 were sampled along the Lower Cottle. This project was developed and conducted by three RMOT students, at Vancouver Island University, for the Environmental Monitoring course taught by Dr. Eric Demers. Data from this report will be used by the Regional District of Nanaimo (RDN), Department of Fisheries and Oceans (DFO), the City of Nanaimo and Nanaimo and Area Land Trust (NALT).

1.2 Historical Review

Several ecosystems are located throughout Cottle Creek's residing areas; from old growth forests to dry cliff and grasslands to wetlands. Cottle Creek is dominated by mature Douglas Fir forests that are home to several flora and fauna species. Raptors, salamanders, native frogs, deer, waterfowl and migratory songbirds are some of the few species that inhabit these areas (NALT 2017). Upper and North Cottle Creek flow into Cottle lake which is located in the protected areas of Linley Valley. Linley Valley consists of 145 acres of protected area and is surrounded by 250 acres of protected crown land. This is the largest undeveloped area in the City of Nanaimo (NALT 2017). Cottle Creek supports non-anadromous salmonid species, Coastal Cutthroat Trout (*Oncorhynchus clarki clarki*). Pacific salmon do not reside in Cottle Creek due to the inaccessibility of the steep drop at the mouth of the creek (RDN 2012).

1.3 Potential Environmental Concerns

Cottle Creek is located in an area of high urban development. Even though a large part of Cottle Creek is surrounded by 428 acres of protected land, urban development is still a concern to the overall health of Cottle Creek (City of Nanaimo 2018). Development areas, especially on the steep slopes located near Cottle Creek, create risks such as erosion issues, management to contain storm water and groundwater seepages. Erosion, pesticide use, and fertilizers can leach into groundwater and drain into Cottle Creek causing serious health effects to all ecosystems. Logging, removal of vegetation and ground disturbances could create effects in bank stability, increase turbidity, and alter fish rearing habitats. Physical and chemical stability of Cottle Creek is crucial in maintaining ecosystems, as well as, habitat and species populations.

1.4 Project Objectives

The project's objective was to monitor the overall health of Cottle Creek by surveying environmental factors at four sites. The data collected was reviewed with previous years data to determine any environmental concerns or trends. Each site was examined using hydrology, water quality, microbiology and invertebrate collection procedures to determine the presence of pollution and overall health of the stream. Regional District of Nanaimo (RDN), Department of Fisheries and Oceans (DFO), the City of Nanaimo and Nanaimo and Area Land Trust (NALT) all are interested in receiving long term data collection and sampling on Cottle Creek.

2.0 Methods - (Kayla)

2.1 Sampling Stations

Four sites were sampled along Cottle Creek (Figure 1), as a part of an environmental monitoring project done by the Resource Management and Protection students at Vancouver Island University, under the guidance of Dr. Eric Demers. Two sampling events were conducted, the first on October 29th and the second on November 20th, 2018. At each station, several different parameters were tested including basic hydrology, water quality, stream invertebrates and microbiology. A result of having four sampling sites allowed students to hypothesize possible sources of pollutants and give a more accurate evaluation of the health of the stream.

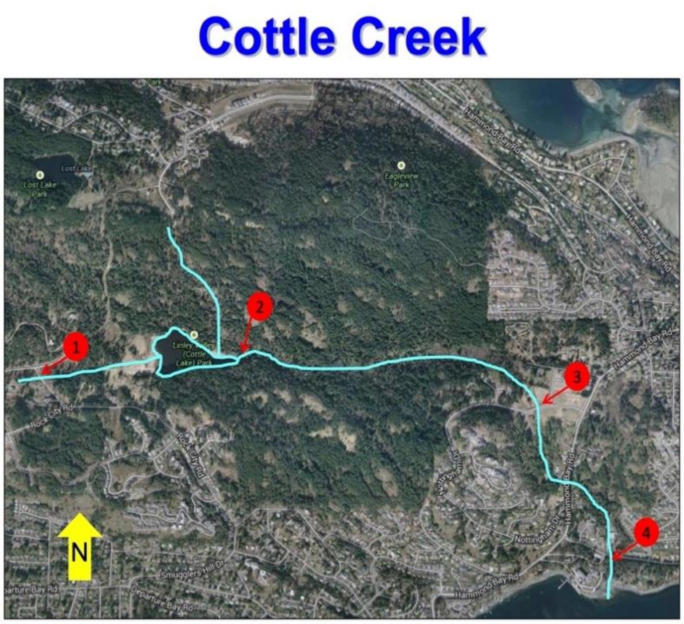

Figure 1: Map of the Four Sampling Sites Along Cottle Creek in Nanaimo, BC.

2.1.1 Locations and Habitat Characteristics

Site #1

Site 1 is situated between Landalt and Arrowsmith Road on the west side of the intersection. This side was chosen because it was easier to access, minimizing safety hazards. At site 1, a culvert directs water downstream, towards Cottle Lake. This area of the creek lays between Arrowsmith Road in the north and residential houses in the south. It is possible that run off from the road, as well as the yards (i.e., fertilizers) may be leaching down into the stream. There is a manmade metal and wooden dam-like structure across the creek, that is slowing the flow down. Miscellaneous items were found littering the creek and surrounding area, including a tire and a pile of black plastic fencing material. The creek is surrounded by dense riparian coverage consisting of mainly red alder and big leaf maple and there is lots of large woody debris. The substrate composition consists mainly of cobble, gravel and fines.

Site #2

Site 2 is located at the eastern end of Cottle Lake, where the start of Lower Cottle Creek originates. This site is located in the protected area of Linley Valley and has well developed trails for easy public access. There is a bridge that crosses the beginning of Lower Cottle Creek that links the two trails around Cottle Lake together. There is a buildup of large woody debris at the outlet of the lake that forms a natural dam, which controls the amount of water entering the stream. There is also thick vegetation of salmonberry, sword fern and grasses that surrounds the area and provide stability to the banks as well as offer riparian cover for fish and wildlife. Since this site is located in a public park, human impacts may be a concern due to high amounts of visitors. At the boundary of the park there is a small recreational farm elevated above the stream/ lake which could be a threat due to pollution, bacteria and fecal matter leaking into the groundwater and leaching into the water system. The substrate composition consists mainly of gravel and fines.

Site #3

Site 3 runs underneath a bridge on Nottingham Drive, in a residential area. Surrounding the creek are houses and a busy roadway. This site has small amounts of large woody debris and little canopy cover, mostly consisting of red alder. Its substrate composition is cobble, gravel and fines. It is possible that chemicals and other toxic substances may be leaching into the steam via residential lawns and the roadway.

Site #4

Site 4 lies south of Stephenson Point Road. We chose to conduct our sampling just south of the road, approximately 3 m from the culvert. This area of the creek has a steep gradient and there were even a few waterfalls further downstream. Like many of the other sites, site 4 is also surrounded by busy roads and residential houses. Substrate composition at site 4 consisted of cobble and large boulders and the area had good canopy cover providing shade by western red cedars and big leaf maples.

2.1.2 Sampling Frequency

Two sampling periods were conducted, the first event on October 29th, and the second on November 20th, 2018. The purpose of this was to account for the data during the low flow season versus the high flow/rainy season. Water quality, microbiology and stream invertebrate samples were taken at all 4 sites. However, stream invertebrate sampling and microbiology were only conducted during the first set of sampling. ALS and VIU water samples were collected and analyzed at all sites. And hydrology was also taken at sites 1 and 4.

2.2 Basic Hydrology

Basic hydrology methods were used to calculate flow during both the sampling periods at sites 1 and 4. Bank-full wetted width, depth, flow and discharge were recorded. The float method was used be used by dropping a ping pong ball and timing the 3 m distance travelled. This was done 5 times and an average flow rate was calculated. Wetted width was measured using a measuring tape and wetted depth was taken 7 times along the width using a metre stick and an average depth was determined. Discharge was calculated by multiplying the flow area (width x depth) by the average velocity. Hydrology measurements were taken during both the sampling periods in the same location to compare the seasonal changes.

2.3 Water Quality

2.3.1 Field Measurements and Water Sample Collection

Dissolved oxygen and water temperature were taken using a Polaris Oxyguard electronic probe and recorded in situ to the nearest 0.1°C. In addition, water samples were taken properly to prevent any contaminants from altering the samples. This was achieved by using clean containers and rinsing them 3 times before use. The ALS bottles and Whirl Pak came pre-sterilized and were not rinsed beforehand. Specific preservatives were added to each ALS bottles after filling them with water, and containers were inverted to mix the solutions. Each container was properly sealed, labeled and documented. Since several different samples were taken, each sample was collected starting downstream working upstream to prevent kicking up any sediments and possibly contaminating other samples. The same probe was used during both sampling periods to ensure accuracy. All samples were kept in coolers with ice packs to preserve them during transport, and later stored in a fridge at ~4°C, before conducting tests.

2.3.2 VIU Laboratory Analyses

Tests were conducted in the VIU Laboratory prior to collection. Students tested for pH, turbidity, alkalinity, hardness, nitrate, phosphate and conductivity. All samples were tested including a replicate sample for site 4. Nitrate and phosphate tests were conducted on the control sample to see if any contaminants entered the samples during transportation or storage. Conductivity was conducted using a Pinpoint Conductivity Metre. Oakton pHTestr 10 pH was used to determine the pH of the samples. Turbidity was measured using a Portable TurbidMeter to the nearest 0.01 NTU. Alkalinity was conducted using the digital titration method. Hardness was measured using the HACH HA-4P test kit. Phosphate and nitrate were determined by using the Spectrophotometer Method.

2.3.3 ALS Laboratory Analyses

In addition to the parameters measured directly by the students, three water samples were collected per station and sent to ALS laboratories in Vancouver. Specific preservatives were added to the bottles after collection. All samples were sent to Vancouver after collection and transported in coolers. ALS was able to determine the basic water quality parameters including conductivity, alkalinity and pH, as well as a nutrient analyses and a total metal scan.

2.3.4 Quality Assurance/Quality Control

Samples were taken from the same location in each site during both sampling periods. Students ensured that any possible contamination was minimized by rinsing gear 3 times prior to use and collecting samples from a downstream to upstream direction. One replicate was taken and 1 control sample was included. The control sample underwent testing in the lab to ensure no contaminants entered the samples during transportation or storage. One set of water samples were analyzed by VIU students in the lab, while another set of samples were sent to ALS labs. This allowed students compare results and consider margins of error.

2.3.5 Data Analyses, Comparison to Guidelines

Once all the data was collected VIU results were compared to ALS results. This helped determine if there were any possible flaws during the testing. To determine if the water quality of Cottle Creek offered habitable conditions for aquatic life, students compared the *Guidelines for Interpreting Water Quality Data* (Ministry of Environment & Climate Change Strategy 2018) to the results. If any water quality parameters were above or below the stated guidelines for aquatic life, it was evident that there was some concern for aquatic organisms and fish such as cutthroat trout who may inhabit the creek. Both VIU and ALS water quality results were compared to the guidelines, and assumptions were made as to where pollutant sources may be coming from. In addition, recommendations were made to give insight as to how the water quality of Cottle Creek could potentially be improved.

2.4 Microbiology

2.4.1 Water Sample Collection

Unlike the other samples, microbiology was only conducted once during the one month period. All 4 sites were sampled using sterile 100-ml Whirlpak bags which were labeled beforehand.

2.4.2 VIU Laboratory Analyses

Tests were conducted by following the *Total Coliforms and E.coli Membrane Filtration Method*, by the USEPA (2003). Samples were filtered through a 47mm membrane (45μm pore size), and transferred to a petri dish where they were laid over a pad of the same size, soaked in m-ColiBlue24 broth. Samples were incubated for a period of 24h at 35°C. Once they were done incubating, both fecal coliforms and non-fecal coliforms were counted by students using microscopes, to the nearest 1 CFU/100 ml.

2.4.3 Quality Assurance/ Quality Control

To ensure that quality assurance standards were met, students sterilized all equipment and wore gloves. Tweezers that were used to transfer the pre-sterilized pads were soaked in ethanol and put under flame. Students used m-ColiBlue24 broth which has already undergone quality control measures in the industry, to ensure there is was no contamination.

2.5 Stream Invertebrate Communities

2.5.1 Invertebrate Sample Collection

Triplicate samples were taken to analyze stream invertebrates using a Hess sampler. All 4 sites were sampled for stream invertebrates, during the first sampling period. Samples were collected from downstream working upstream, and students filled a container with sediment and invertebrates, which were labeled and stored in a fridge. No preservatives were added and all invertebrates were kept alive for studying in the lab.

2.5.2 VIU Laboratory Analyses

Once the samples were brought into the lab, jars were opened and invertebrates found floating on the top were picked out and placed in petri dishes to view under dissecting microscope. The rest were spread out on a large tray and distilled water was added, making it easier to pick out invertebrates and place them under the microscope. Once all invertebrates were collected; species, number of taxa and totals were calculated for each site following *The Streamkeepers Handbook* (1995). Each species of invertebrates was placed into one of three categories, pollution intolerant, somewhat pollution tolerant and pollution tolerant species. All EPT taxa were noted.

2.5.3 Quality Assurance/ Quality Control

Quality assurance was obtained by ensuring all species were accounted for properly with the use of invertebrate identification keys. Dr. Eric Demers assisted students who were having trouble identifying different species. In addition, triplicate samples were taken at all 3 sites to ensure accurate results.

2.5.4 Data Analyses

With the information collected from the lab analyses, the Shannon-Wiener index was calculated to determine the health of the stream. Another calculation was made and *The Streamkeepers Handbook* (1995), was used as a reference. Each site shows the overall site assessment rating based on a 1-4 scale, 1 being poor, 2 marginal, 3 acceptable and 4 being good. Rows separated category 1 (pollution intolerant), category 2 (somewhat pollution tolerant) and category 3 (pollution tolerant) invertebrates. Totals of species found in the sample were documented including the number of different taxa. Once all the data was calculated, the numbers were transferred into equations that gave several site ratings including pollution tolerance index, EPT index, EPT to total ratio index and predominant taxon ratio. Once these calculations were determined an average was calculated to give the final site assessment rating.

3.0 RESULTS AND DISCUSSION

3.1 General Field Conditions - (Kayla)

During the first sampling date on October 29th the weather was clear and sunny as the sampling was being conducted. Due to the heavy rainfall during the week prior to sampling, both sites had a high discharge. The water at site 1 appeared to be especially turbid due to the upwelling of sediments after the initial heavy rainfall of the season.

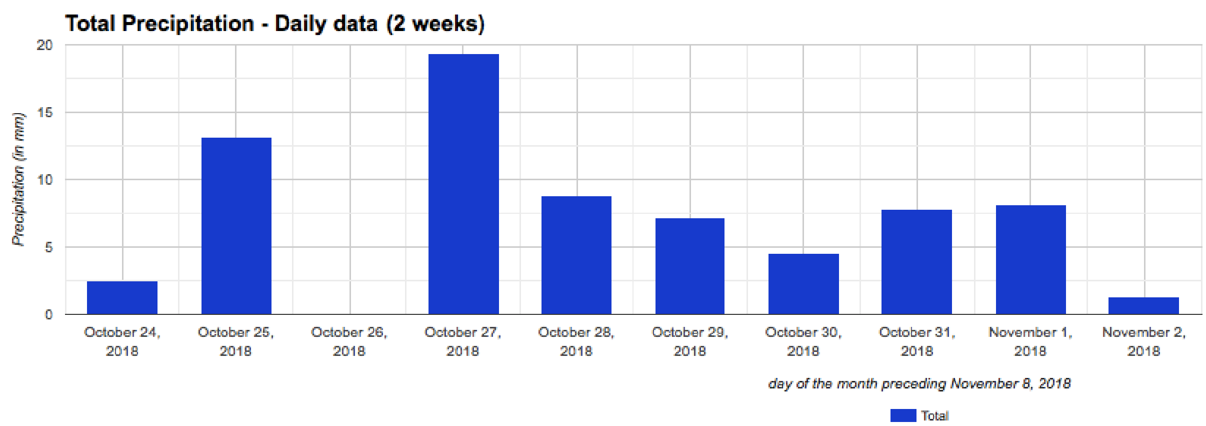

Figure 2: 10 Day Forecast of Precipitation in Nanaimo during the First Sampling Period on October 29, 2018 (Nanaimo Weather Stats 2018).

During the second sampling period on November 20th, the weather was partly cloudy. During the week leading up to the second sampling date it was relatively dry and the expected rainfall did not come (Figure 3). We suspect this may have had an effect on some parameters including hydrology and turbidity. All sites were accessible, and students exercised safety in and around the water.

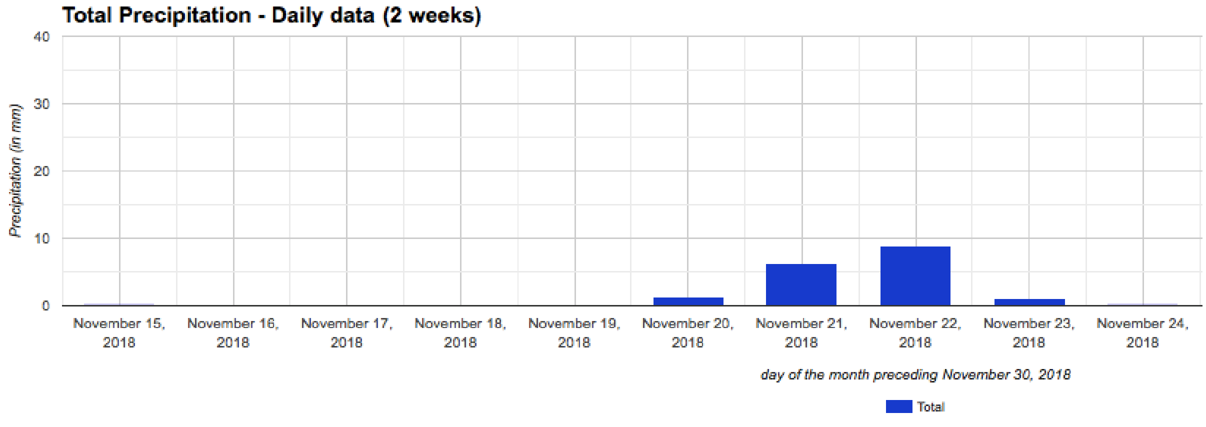

Figure 3: 10 Day Forecast of Precipitation in Nanaimo during the Second Sampling Period on November 20th, 2018 (Nanaimo Weather Stats 2018).

3.1.1 Hydrology

Students were expecting that flow was going to increase during the second sampling period due to the increase rainfall. However, this was not the case, and it was noted that flow, wetted width, wetted depth and discharge were higher during the first sampling period (Table 1). It was concluded that this was due to the heavy rainfall that occurred during the week prior to October 28th. This early rainfall may have temporarily increased the discharge of Cottle Creek and flushed the water through the system which may have been relatively stagnant over the summer months.

Table 1: Hydrology Measurements Taken at Sites 1 and 4 During Both Sampling Periods.

Sampling Date and Site Number	Flow (m/s)	Wetted Width (m)	Wetted Depth (m)	Discharge (m3/s)
October 23 Site 1	6.31	3.7	0.119	2.79
October 23 Site 4	5.17	4	0.163	3.37

November 20 Site 1	5.8	2.0	0.072	0.83
November 20 Site 4	2.03	3.9	0.106	0.84

3.2 Water Quality - (Jenna)

3.2.1 Field Measurements

Dissolved oxygen, stream temperature and percent saturation were collected from all four sites on October 29, 2018 (Table 2). It should be noted that on October 29th, Cottle Creek had high flow due to the amount of rain that had fallen in the days leading up to our first sample period. This may have influence the data collected in the field. In comparison with a 2014 Cottle Creek Assessment (Kee et al. 2014) and a 2016 Cottle Creek Assessment (McDonald et al. 2016), the temperatures and the amount of dissolved oxygen that we recorded are average for that time of year (Ware and Rundle 2012; McDonald et al. 2016). The amount of dissolved oxygen also meets the requirements for all life stages, according to the government of BC water quality guidelines (Ministry of Environment & Climate Change Strategy 2018).

Table 2: First sample results for water temperature, percent saturation and dissolved oxygen at all 4 sites.

Parameter	Units	Site 1	Site 2	Site 3	Site 4
Water Temperature	Celcius	8.92	8.9	9.6	9.5
Dissolved Oxygen	mg/L	11.2	8.2	9.6	11.2
Saturation	%	97	71	93	98

During our second sample period on November 20, 2018, we collected data using the same procedure used in the first sampling period (water temperature, dissolved oxygen and percent saturation) at each site (Table 3). Nothing of great concern was observed from these results. The temperature decreased from the first sample period due to the changes that occur with the cooler air temperatures. Due to the decrease in temperature, we observed an increase in in dissolved oxygen.

Table 3: Second sample results for water temperature, percent saturation and dissolved oxygen at all four sites.

Parameter	**Units**	**Site 1**	**Site 2**	**Site 3**	**Site 4**
Water Temperature	Celsius	6.8	6.7	6.8	6.6
Dissolved Oxygen	mg/L	11.6	9.9	11.1	11.7
Saturation	%	93	96	91	96

3.2.2 VIU Laboratory Analyses

Phosphate

Phosphate is the most limiting nutrient in freshwater. Too little can cause a waterbody to be oligotrophic and too much can cause eutrophication. The phosphate criteria for aquatic life from the British Columbia Water Quality Guidelines (Ministry of Environment, Lands and Parks 1997) is 0.005-0.015 mg/L. We measured all of our phosphate tests in mg/L. Cottle Creek has phosphate levels that exceed the criteria for aquatic life (Table 4). The VIU lab analyses results for phosphate during both sample periods were compared to the results from the ALS lab (Appendix B). The results differ slightly because ALS’s results are slightly lower than the VIU results. However, both phosphate results exceed the criteria for aquatic life. The exact source contributing to higher phosphorus levels are unknown. Potential inputs could be from a number of sources due to the fact that the creek runs through a variety of habitats in a largely urban environment.

Nitrate

Nitrate is the second most limiting nutrient in freshwater and, like phosphate, too much can cause eutrophication. The British Columbia Water Quality Guidelines (Ministry of Environment, Lands and Parks 1997) has a maximum limit of 200 mg/L for nitrate. For the first sample period, after testing in the VIU lab, results appeared to be far below the maximum limit (Table 4), these results were compared to the first set of ALS results (Appendix B). The ALS results showed higher amounts of nitrogen for the first sample period, which lead us to believe that an error was made in the VIU lab when analyzing nitrogen from the first sample period. As for the second sample period, nitrogen results were much closer to the second ALS results (Appendix B). All the results were within the guidelines.

Acidity (pH)

Acidity, also known as pH, is the measurement of hydrogen ions in a body of water. It is measured on a scale of 0-14, 0 being extremely basic and 14 being extremely acidic. Aquatic life requires a pH range of 6.5-9.0 (Ministry of Environment, Lands and Parks 1997) and even the smallest changes in pH can be a significant impact on aquatic life. For both sample periods, pH levels were within the guidelines for aquatic life and between the two sample periods there was no more than a 0.5 change in pH levels (Table 4). When compared to the ALS results for pH (Appendix B), the results only differ slightly from the VIU results, some site and sample period results are the same and some are different but none differ more than 0.7.

Conductivity

Conductivity is the measure of total ion concentration in water and it is measured in microsiemens per cm (µS/cm), BC's coastal streams unusually measure less than 100 µS/cm although there is no actual criteria standards for conductivity (Ministry of Environment, Lands and Parks 1997). After both sample periods and after analyzing our samples through the VIU lab, we got a range of readings (Table 4); for the first sample period we got 162-186 µS/cm and for the second sample period we got 137-173 µS/cm, this is considered high conductivity for the coast. When the VIU results were compared with the results from ALS (Appendix B), they were around the same but the results from ALS were always around 10 µS/cm above the VIU ratings, so still a high concentration of ions for a BC coastal stream. This could be a concern for Cottle Creek but further testing would be required to pinpoint the pollutant input source responsible for the increased conductivity, pollutant sources could be from a number of things i.e. roadways or urban effluents (Ministry of Environment, Lands and Parks 1997).

Turbidity

Turbidity is the measure of how much organic matter (silt, clay, micro-organisms, etc.) is suspended in water and it is measured in nephelometric turbidity units (NTU). There isn't a specific minimum and maximum limit for turbidity but rather an increase maximum that differs according to the average turbidity rating of a particular stream (Ministry of Environment, Lands and Parks 1997). During the first sample period, there had been high rainfalls, causing Cottle Creek to fill up quite suddenly. With its high flow the surrounding watershed contributed runoff and lots of unexpected minerals and nutrients. There was also a slight drop in the creek at station 1 (Appendix A) directly above where we were sampling, this added to the “stir up” of particles in the water. With stating those points, it explains why during our first sample event, at site 1, there was an enormous rating for turbidity (Table 4). The rest of the sites were around the same measurements, although site 3 is higher than site 2 and 4, this was unexpected since it looked to be the clearest site on that day, this could also have been a VIU lab error. During the second sample period, water levels had dropped; there hadn’t been very much rainfall between the first and second sample periods. This may have been the reason for the lower turbidity results; the water was flowing slower and therefore less organic materials were being stirred up in the water.

Hardness

Hardness is the measure of divalent cations (mostly magnesium and calcium ions) in water and is measured in mg/L. The Guidelines for Interpreting Water Quality Data (Ministry of Environment, Lands and Parks 1997) states that if water has a rating less than 60 mg/L it is considered soft water and if water has a rating over 120 mg/L it is considered hard water, the area in between is acceptable for all uses. The results that we got form both sample periods through the VIU lab are all in the acceptable guidelines (Table 4). ALS had results (Appendix B) that were generally 5-10 mg/L less than the results from the VIU lab but these results were still between soft and hard water and therefore acceptable.

Alkalinity

Alkalinity is the measure of a stream's capability to neutralize acids and therefore corresponds with pH. Levels less than 20 mg/L would mean that a stream has a low sensitivity to acids, while 0-10 mg/L means a stream is highly sensitive and this is typical for BC's coastal streams (Ministry of Environment, Lands and Parks 1997). Between both our first and second sample periods, at all four sites, we got a range of results from 46-60 mg/L (Table 4), this is uncommonly high for the coast. When compared to past Cottle Creek survey reports (McDonald et al. 2016) and (Kee et al. 2014) it seems that Cottle Creek normally has a high amount of alkalinity. This isn't a concern, it just means that Cottle Creek is less susceptible to acidification, which is a good thing, it wouldn't be a concern unless alkalinity results were in the 100's.

Table 4: VIU water quality results for both sample periods for all four sites, plus the replicate taken at site four and the trip blank.

Parameter	Sample Dates	Site 1	Site 2	Site 3	Site 4	Replicate	Trip Blank
Phosphate (mg/L)	Oct. 29, 2018	0.07	0.07	0.02	0.03	0.03	0.03
	Nov. 20, 2018	0.03	0.02	0.12	0.02	0.01	0.01
Nitrate (mg/L)	Oct. 29, 2018	0.03	0.04	0.19	0.04	0.04	0.06
	Nov. 20, 2018	0.42	0.12	0.46	0.43	0.34	0.03
Acidity (pH)	Oct. 29, 2018	7.0	7.3	7.0	6.9	6.9	n/a
	Nov. 20, 2018	7.2	7.2	7.4	7.4	7.4	n/a
Conductivity (μS)	Oct. 29, 2018	186	183	173	162	165	n/a
	Nov. 20, 2018	173	139	137	148	146	n/a

Turbidity (NTU)	Oct. 29, 2018	34.9	3.37	6.34	3.79	3.89	n/a
	Nov. 20, 2018	1.77	3.18	1.15	2.00	1.62	n/a
Hardness (mg/L)	Oct. 29, 2018	84	84	84	76	76	n/a
	Nov. 20, 2018	72	72	64	60	60	n/a
Alkalinity (mg/L)	Oct. 29, 2018	58.4	60.8	57.2	49.6	50.4	n/a
	Nov. 20, 2018	58.0	47.2	46.8	46.0	50.8	n/a

3.2.3 ALS Total Metals

The ALS results for total nutrients and physical properties have already been discussed in previous sections so I won't discuss them in this section but you can find the lab results in the appendix. Table 5 displays the 10 metals that actually read above their lowest detection limit in Cottle Creek, the other metals that were tested for were too little to detect by ALS however they can be seen in the appendix. All metals were measured in milligrams per litre mg/L.

The ALS results for total metals are standard, except for iron during the first sample period at site 1 and manganese also during the first sample period at site 1 (Table 5). This abnormal increase of metals could be due to the high rainfalls that caused Cottle Creek to flow rapidly and therefor "stir up" sediment, it's very possible that sediment got mixed in with our water samples and when ALS tested the samples they could have been getting unreliable results from the sediment in the samples. We also hypothesized that the metal dam-like structure that was present in the creek (Appendix A), directly above where we were sampling at site 1 could have contributed metal into the water but this hypothesis is weak because we did not get high iron or manganese results during the second sample.

Although results for iron from the first sample at site 1 are above the guidelines for aquatic life on a short term basis, which is 1 mg/L (Ministry of Environment. 2008), I don't think these results are a concern because when we sampled the second time, results were lower and they met the guidelines. As for the abnormally high manganese result that we got for the first sample period at site 1, the results are actually still under the aquatic life, wildlife and agriculture guideline criteria, which explains that, for short term exposure, with taking hardness results into consideration (84 mg/L at site 1 during the first sample period) and using a short formula, the maximum limit for manganese would be 1.466 mg/L at site 1 during the first sample period (Ministry of Environment & Climate Change Strategy. 2018). The manganese results just meet the guidelines. During the second sample period the results went down to 0.0569 mg/L, so this isn't a concern.

Table 5: Results from the ALS laboratory for total metals, during both sample periods, at sites 1,2 and 4. In total 31 metals were tested for but this chart only shows the 10 metals that actually read above their lowest detection limit.

Metal	**Sample Date**	**Site 1**	**Site 2**	**Site 4**
Aluminum (Al)	Oct. 29, 2018	0.81	<0.20	<0.20
	Nov. 20, 2018	<0.20	<0.20	<0.20
Barium (Ba)	Oct. 29, 2018	0.017	<0.010	<0.010
	Nov. 20, 2018	<0.010	<0.010	<0.010
Calcium (Ca)	Oct. 29, 2018	21.5	19.6	17.8

	Nov. 20, 2018	18.4	13.9	15.1
Iron (Fe)	Oct. 29, 2018	7.37	0.702	0.493
	Nov. 20, 2018	0.471	0.792	0.315
Magnesium (Mg)	Oct. 29, 2018	6.28	5.61	5.00
	Nov. 20, 2018	5.52	4.01	4.29
Manganese (Mn)	Oct. 29, 2018	1.42	0.0498	0.0438
	Nov. 20, 2018	0.0569	0.0501	0.0199
Silicon (Si)	Oct. 29, 2018	8.85	4.13	4.42
	Nov. 20, 2018	7.31	4.00	5.09
Sodium (Na)	Oct. 29, 2018	12.4	14.1	13.2
	Nov. 20, 2018	11.3	9.9	10.2
Strontium (Sr)	Oct. 29, 2018	0.0896	0.0840	0.0712
	Nov. 20, 2018	0.0743	0.0561	0.0565
Titanium (Ti)	Oct. 29, 2018	0.053	0.011	0.012
	Nov. 20, 2018	<0.010	<0.010	<0.010

3.3 Microbiology - (Karlee)

3.3.1 VIU Laboratory Analysis

Each site had fecal coliforms present in the microbiology samples (Table 6). Total Coliform ranged from 595-1150 colonies per 100ml and fecal coliforms units ranged from 30-494 colonies per 100ml. Site 4 had the greatest amount of fecal coliforms present; 60% fecal coliform and the replicate of site 4 had 68% fecal coliforms. Reasons for such a high fecal coliform count for site 4 is unknown. Site 1 had a substantial amount of fecal coliform, at 34%, compared to site 2 and 3. Site 2 and 3 both had low levels of fecal coliform; Site 2 at 5% and site 3 at 7%.

Table 6: Coliforms present in Cottle Creek. Sample taken Oct 29, 2018.

Sample	Total Coliform	Fecal Coliform	% Fecal Coliform	Non- Coliform
Site 1	1150	393	34%	757
Site 2	595	30	5%	565
Site 3	818	61	7%	757
Site 4	615	373	60%	242
Site 4 (Replicate)	726	494	68%	232

3.4 Stream Invertebrate Communities - (Jenna)

Figure 4 shows that on average across all three sites, invertebrate samples consisted mostly of amphipods (category 2), aquatic worms and midge larva (category 3), these invertebrates are somewhat tolerant / tolerant to pollution, therefore can survive in poor quality water. We found a few category 1 invertebrates (caddisfly larva, mayfly nymphs and stonefly nymphs) at sites 1 and 4 however category 2 and 3 invertebrates dominated the results.

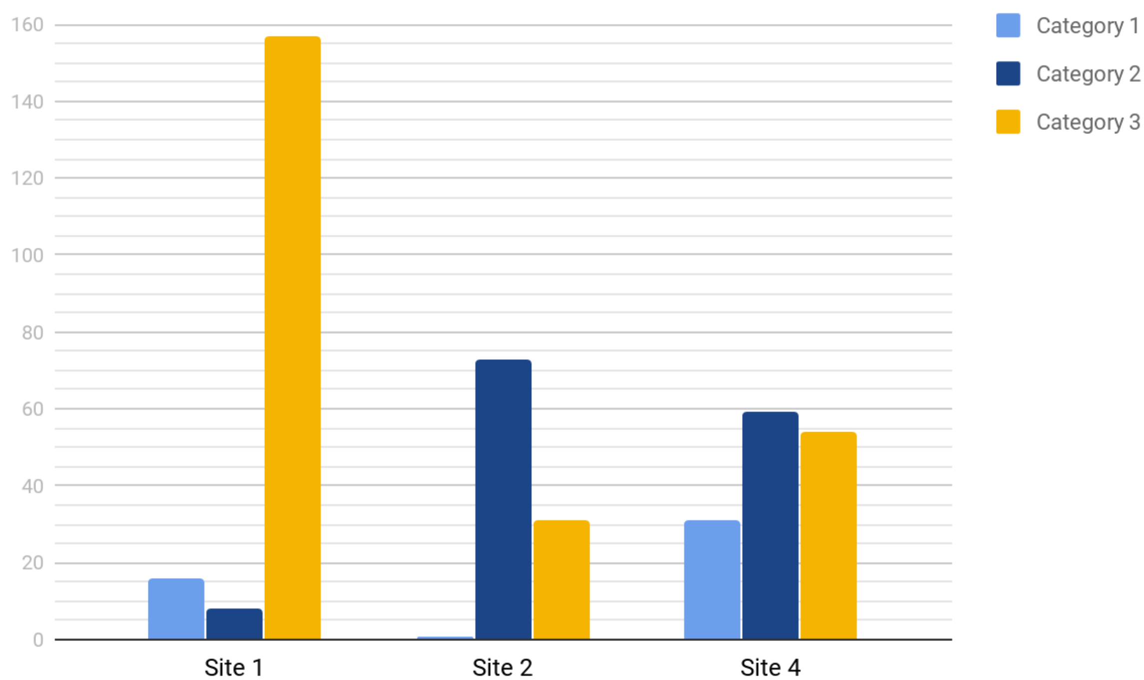

Figure 4: Bar graph showing the amount of category 1 invertebrates (pollution sensitive), category 2 invertebrates (somewhat pollution tolerant) and category 3 invertebrates (pollution tolerant) at sites 1, 2 and 4 (we didn't sample for invertebrates at site 3) during the first sample period.

3.4.1 Abundance / Density

The density of invertebrates for sites 1, 2 and 4 was calculated separately using an abundance and density spreadsheet (Appendix D) the total number of organisms found was divided by the total area sampled (0.27m^2). Site one had a density rating of 655.6 animals per m^2, site two was 385.19 animals per m^2 and site four was 533.34 animals per m^2, which represent the total density of animals per square metre.

3.4.2 Diversity, Site ratings

Diversity was measured by the amount of invertebrate taxa found at each site, this was also recorded on the provided spreadsheet (Appendix D). At site 1 there was a total amount of 16 different taxa found (Table 7), the invertebrates were from categories 1, 2 and 3. At site 2 we found a total of 4 invertebrate taxa (Table 8) but this time the invertebrates found were only from categories 2 and 3. At site 4 we found a total of 10 invertebrate taxa (Table 9) from categories 1, 2 and 3.

Table 7: Results from site 1 for number of individual invertebrate found and the number of taxa found using the hess sampler and taking triplicate samples.

Common Name	**# of Individuals Found**	**# of Taxa**
Caddisfly Larva	4	2
Mayfly Nymph	1	1
Stonefly Nymph	11	2
Cranefly Larva	4	2
Amphipod	4	1
Aquatic Worm	89	4
Blackfly Larva	1	1
Midge Larva	64	2
Pouch and Pond Snails	3	1

Table 8: Results from site 2 for number of individual invertebrate found and the number of taxa found using the hess sampler and taking triplicate samples.

Common Name	**# of Individuals Found**	**# of Taxa Found**
Amphipod	73	2
Aquatic Worm	29	1
Leech	2	1

Table 9: Results from site 4 for number of individual invertebrate found and the number of taxa found using the hess sampler and taking triplicate samples.

Common Name	**# of Individuals Found**	**# of Taxa Found**
Caddisfly Larva	2	1
Mayfly Nymph	9	1
Stonefly Nymph	20	1
Clam, Mussel	1	1
Cranefly Larva	1	1
Damselfly Larva	1	1
Amphipod	56	1
Aquatic Worm	54	3

4.0 Conclusions and Recommendations - (Karlee)

The 2018 Cottle Creek Monitoring Project showed differences in habitat quality between each site. The results of the data showed that the overall health of the stream was moderate, the low invertebrate ratings and the high amounts of fecal coliforms found indicate that Cottle Creek has poor health, while the water quality results from both VIU and ALS indicate that for the most part Cottle Creek meets the government of BC standard guidelines for water quality, excluding iron that was above guidelines and.

Our recommendations are to continue with annual monitoring of Cottle Creek. Basic hydrology studies, water quality assessment, microbiology and stream invertebrate sampling are recommended to be maintained in future studies to determine long term and short term trends. Also, we recommended that more in depth monitoring be conducted to determine the source causing high levels of fecal coliform in site 4. At site 1, we observed large amounts of garbage that was blocking the flow of the stream. We recommend that a cleanup be assessed to remove the barriers and garbage blocking stream flow. As well, we recommend that further studies be conducted at site 1 to find the source of the high levels of iron. We observed the high levels of iron move through the stream from site 1 to site 2, in between sampling periods and we predict that the iron will continue flowing through the stream.

Past projects monitored and sampled from North Cottle has recently been removed from a required sampling site. We recommend that water quality and invertebrate monitoring continue on North Cottle Creek since it flows out of Lost Lake, which is located in a residential area. By monitoring North Cottle Creek, a database can continue being built to determine if this area is impacting the health of the stream.

5.0 Acknowledgments - (Karlee)

We would like to acknowledge the following, who helped with the production of this environmental report. First, we would like to acknowledge Dr. Eric Demers for his contribution and guidance throughout this project. Support that he gave was providing the equipment for field sampling and laboratory analysis and providing us with feedback on the overall construction of the final report. We would also like to acknowledge Kim Ives who helped in the set up and take down of the laboratory equipment.

6.0 References

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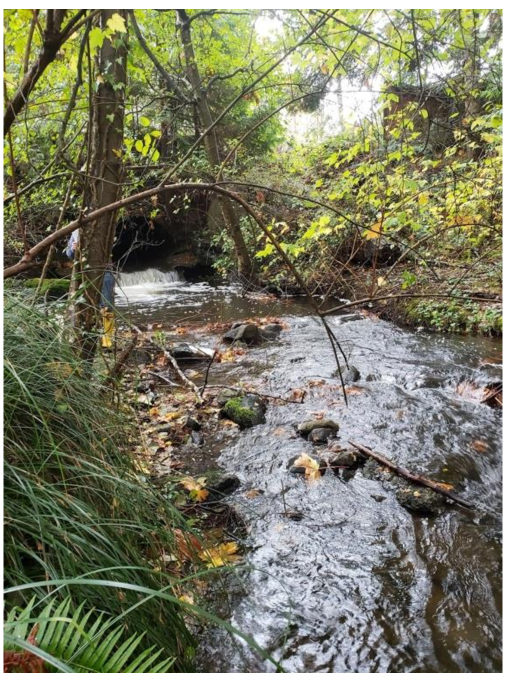
7.0 Appendix

Appendix A: Sampling Site Pictures

Site 3: Lower Cottle at Nottingham Drive.



Site 4: Lower Cottle at Stephenson Point Road.


Site 2: Lower Cottle Tributary at East end of Cottle Lake.


Site 1: Metal structure in the upper Cottle tributary at Arrowsmith Road.

Appendix B: ALS Results

Table 1: All of the ALS results (physical tests, nutrients, metals) from the first sample period, Oct. 29, 2018.

Client Sample ID			COTTLE CREEK - STATION 1	COTTLE CREEK - STATION 2	COTTLE CREEK - STATION 4
Date Sampled			29-Oct-2018	29-Oct-2018	29-Oct-2018
Time Sampled			12:00	12:00	12:00
ALS Sample ID			L2190536-4	L2190536-5	L2190536-6
Parameter	Lowest Detection Limit	Units	Water	Water	Water
Physical Tests (Water)					
Conductivity	2.0	uS/cm	192	189	171
Hardness (as CaCO3)	0.50	mg/L	79.6	72.2	65
pH	0.10	pH	7.63	7.42	7.80
Anions and Nutrients (Water)					
Ammonia, Total (as N)	0.0050	mg/L	0.0122	0.0139	<0.0050
Nitrate (as N)	0.0050	mg/L	0.221	0.265	0.527

Nitrite (as N)	0.0010	mg/L	<0.0010	<0.0010	<0.0010
Total Nitrogen	0.030	mg/L	0.982	0.598	0.804
Orthophosphate-Dissolved (as P)	0.0010	mg/L	0.0059	0.0011	<0.0010
Phosphorus (P)-Total	0.0020	mg/L	0.105	0.0173	0.0146
N:P	N/A	N/A	9.4	34.6	55.1
Total Metals (Water)					
Aluminum (Al)-Total	0.20	mg/L	0.81	<0.20	<0.20
Antimony (Sb)-Total	0.20	mg/L	<0.20	<0.20	<0.20
Arsenic (As)-Total	0.20	mg/L	<0.20	<0.20	<0.20
Barium (Ba)-Total	0.010	mg/L	0.017	<0.010	<0.010
Beryllium (Be)-Total	0.0050	mg/L	<0.0050	<0.0050	<0.0050
Bismuth (Bi)-Total	0.20	mg/L	<0.20	<0.20	<0.20
Boron (B)-Total	0.10	mg/L	<0.10	<0.10	<0.10
Cadmium (Cd)-Total	0.010	mg/L	<0.010	<0.010	<0.010

Calcium (Ca)-Total	0.050	mg/L	21.5	19.6	17.8
Chromium (Cr)-Total	0.010	mg/L	<0.010	<0.010	<0.010
Cobalt (Co)-Total	0.010	mg/L	<0.010	<0.010	<0.010
Copper (Cu)-Total	0.010	mg/L	<0.010	<0.010	<0.010
Iron (Fe)-Total	0.030	mg/L	7.37	0.702	0.493
Lead (Pb)-Total	0.050	mg/L	<0.050	<0.050	<0.050
Lithium (Li)-Total	0.010	mg/L	<0.010	<0.010	<0.010
Magnesium (Mg)-Total	0.10	mg/L	6.28	5.61	5.00
Manganese (Mn)-Total	0.0050	mg/L	1.42	0.0498	0.0438
Molybdenum (Mo)-Total	0.030	mg/L	<0.030	<0.030	<0.030
Nickel (Ni)-Total	0.050	mg/L	<0.050	<0.050	<0.050
Phosphorus (P)-Total	0.30	mg/L	<0.30	<0.30	<0.30
Potassium (K)-Total	2.0	mg/L	<2.0	<2.0	<2.0
Selenium (Se)-Total	0.20	mg/L	<0.20	<0.20	<0.20

Silicon (Si)-Total	0.10	mg/L	8.85	4.13	4.42
Silver (Ag)-Total	0.010	mg/L	<0.010	<0.010	<0.010
Sodium (Na)-Total	2.0	mg/L	12.4	14.1	13.2
Strontium (Sr)-Total	0.0050	mg/L	0.0896	0.0840	0.0712
Thallium (Tl)-Total	0.20	mg/L	<0.20	<0.20	<0.20
Tin (Sn)-Total	0.030	mg/L	<0.030	<0.030	<0.030
Titanium (Ti)-Total	0.010	mg/L	0.053	0.011	0.012
Vanadium (V)-Total	0.030	mg/L	<0.030	<0.030	<0.030
Zinc (Zn)-Total	0.0050	mg/L	0.0057	<0.0050	<0.0050

Table 2: All of the ALS results (physical tests, nutrients, metals) from the second sample period, Nov. 20, 2018.

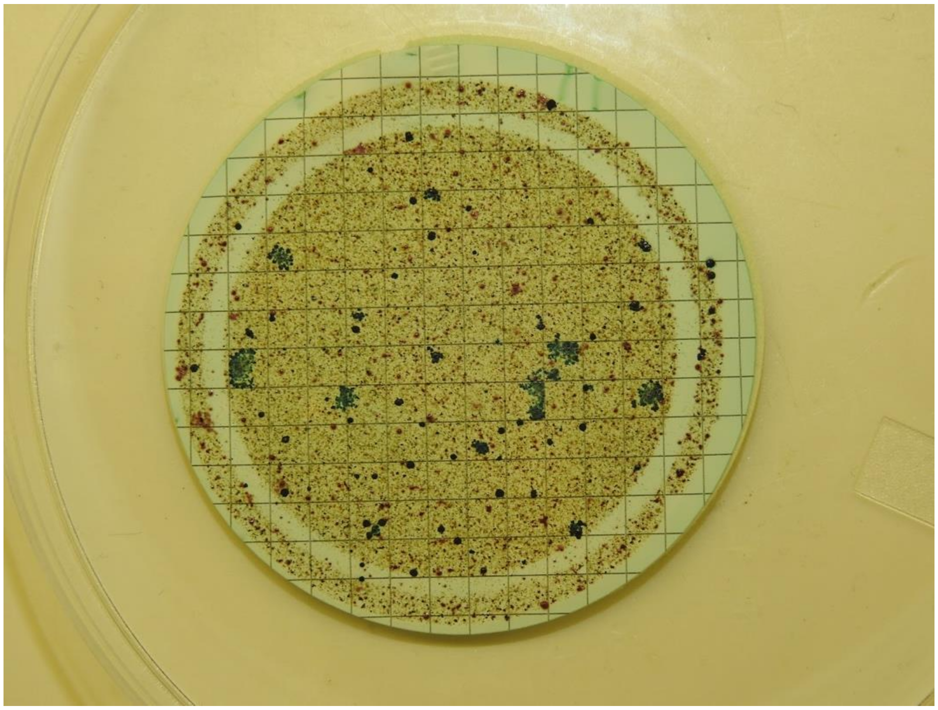
Client Sample ID			COTTLE CREEK-STATION 1 (CC1)	COTTLE CREEK-STATION 2 (CC2)	COTTLE CREEK-STATION 4 (CC4)
Date Sampled			20-Nov-2018	20-Nov-2018	20-Nov-2018
Time Sampled			12:30	12:45	16:15
ALS Sample ID			L2200252-4	L2200252-5	L2200252-6

Parameter	Lowest Detection Limit	Units	Water	Water	Water
–					
Physical Tests (Water)					
Conductivity	2.0	uS/cm	182	157	157
Hardness (as CaCO3)	0.50	mg/L	68.6	51.2	55.4
pH	0.10	pH	7.98	7.77	7.97
Anions and Nutrients (Water)					
Ammonia, Total (as N)	0.0050	mg/L	0.0128	0.0182	<0.0050
Nitrate (as N)	0.0050	mg/L	0.276	0.151	0.395
Nitrite (as N)	0.0010	mg/L	<0.0010	0.0016	<0.0010
Total Nitrogen	0.030	mg/L	0.577	0.424	0.602
Orthophosphate-Dissolved (as P)	0.0010	mg/L	0.0034	0.0026	0.0012
Phosphorus (P)-Total	0.0020	mg/L	0.0098	0.0127	0.0065
N:P	N/A	N/A	58.9	33.4	92.6

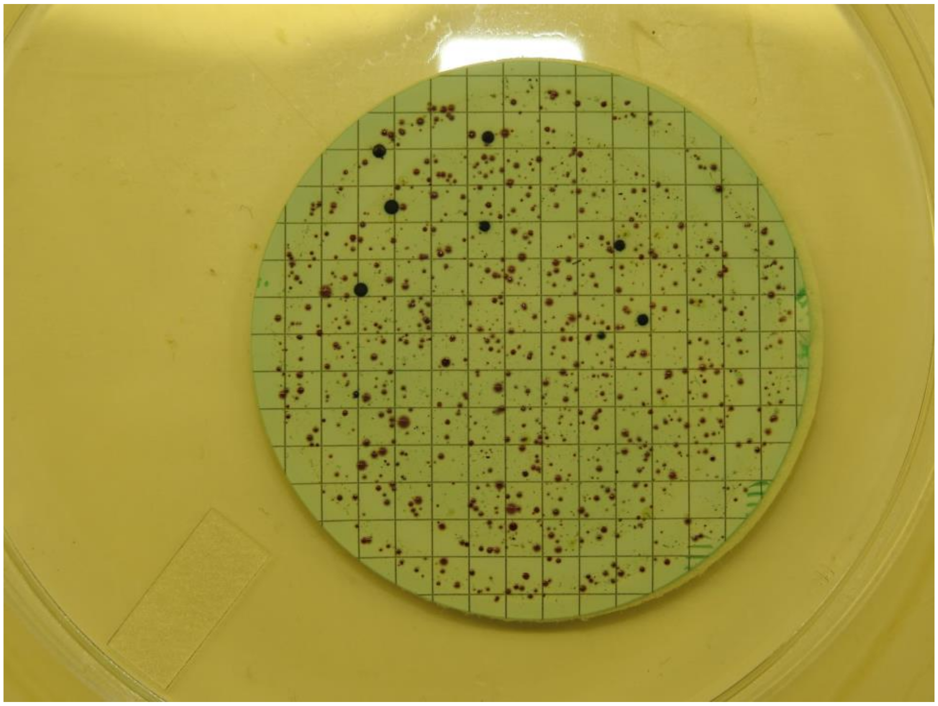
Total Metals (Water)					
Aluminum (Al)-Total	0.20	mg/L	<0.20	<0.20	<0.20
Antimony (Sb)-Total	0.20	mg/L	<0.20	<0.20	<0.20
Arsenic (As)-Total	0.20	mg/L	<0.20	<0.20	<0.20
Barium (Ba)-Total	0.010	mg/L	<0.010	<0.010	<0.010
Beryllium (Be)-Total	0.0050	mg/L	<0.0050	<0.0050	<0.0050
Bismuth (Bi)-Total	0.20	mg/L	<0.20	<0.20	<0.20
Boron (B)-Total	0.10	mg/L	<0.10	<0.10	<0.10
Cadmium (Cd)-Total	0.010	mg/L	<0.010	<0.010	<0.010
Calcium (Ca)-Total	0.050	mg/L	18.4	13.9	15.1
Chromium (Cr)-Total	0.010	mg/L	<0.010	<0.010	<0.010
Cobalt (Co)-Total	0.010	mg/L	<0.010	<0.010	<0.010
Copper (Cu)-Total	0.010	mg/L	<0.010	<0.010	<0.010
Iron (Fe)-Total	0.030	mg/L	0.471	0.792	0.315
Lead (Pb)-Total	0.050	mg/L	<0.050	<0.050	<0.050
Lithium (Li)-Total	0.010	mg/L	<0.010	<0.010	<0.010
Magnesium (Mg)-Total	0.10	mg/L	5.52	4.01	4.29

Manganese (Mn)-Total	0.0050	mg/L	0.0569	0.0501	0.0199
Molybdenum (Mo)-Total	0.030	mg/L	<0.030	<0.030	<0.030
Nickel (Ni)-Total	0.050	mg/L	<0.050	<0.050	<0.050
Phosphorus (P)-Total	0.30	mg/L	<0.30	<0.30	<0.30
Potassium (K)-Total	2.0	mg/L	<2.0	<2.0	<2.0
Selenium (Se)-Total	0.20	mg/L	<0.20	<0.20	<0.20
Silicon (Si)-Total	0.10	mg/L	7.31	4.00	5.09
Silver (Ag)-Total	0.010	mg/L	<0.010	<0.010	<0.010
Sodium (Na)-Total	2.0	mg/L	11.3	9.9	10.2
Strontium (Sr)-Total	0.0050	mg/L	0.0743	0.0561	0.0565
Thallium (Tl)-Total	0.20	mg/L	<0.20	<0.20	<0.20
Tin (Sn)-Total	0.030	mg/L	<0.030	<0.030	<0.030
Titanium (Ti)-Total	0.010	mg/L	<0.010	<0.010	<0.010
Vanadium (V)-Total	0.030	mg/L	<0.030	<0.030	<0.030
Zinc (Zn)-Total	0.0050	mg/L	<0.0050	<0.0050	<0.0050

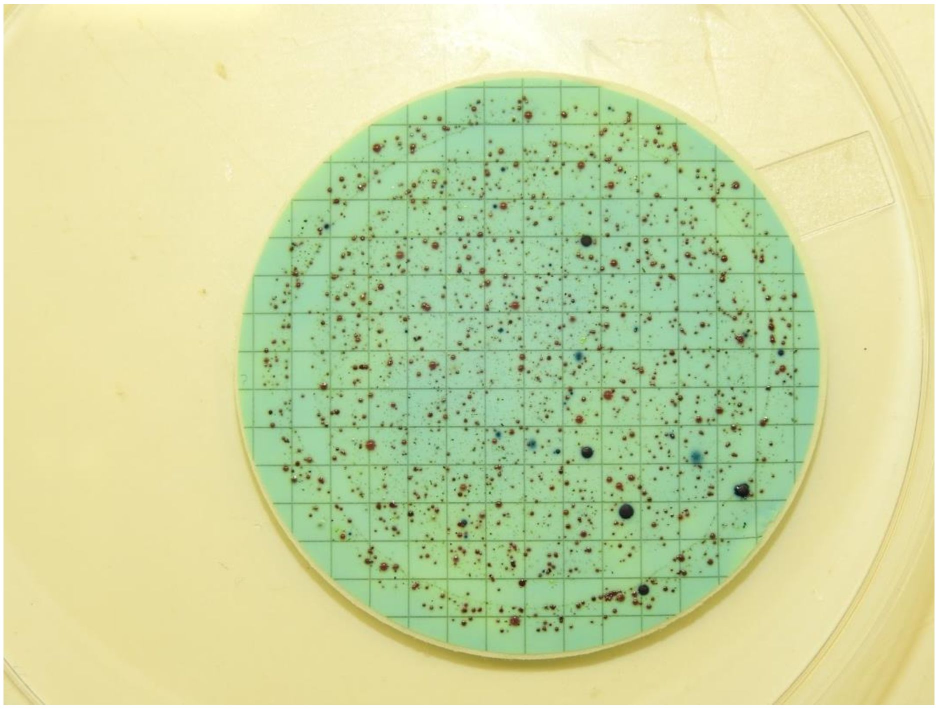
Appendix C: Microbiology Coliform Colonies (Pictures and Data)



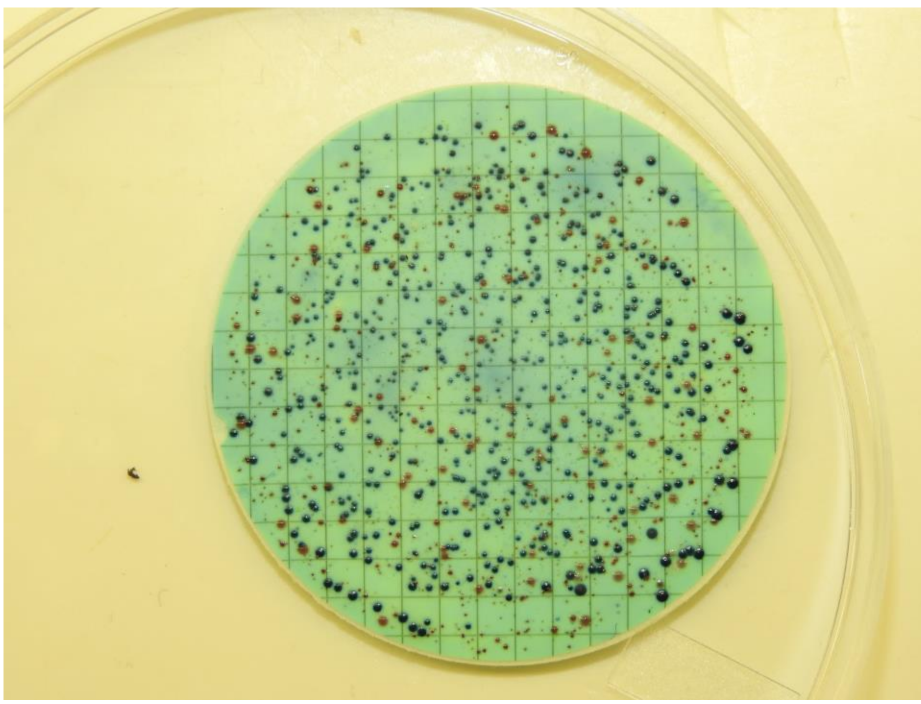
Site 1: 1150 CFU/100ml; 34% Fecal Coliform. Sample taken October 29, 2018.



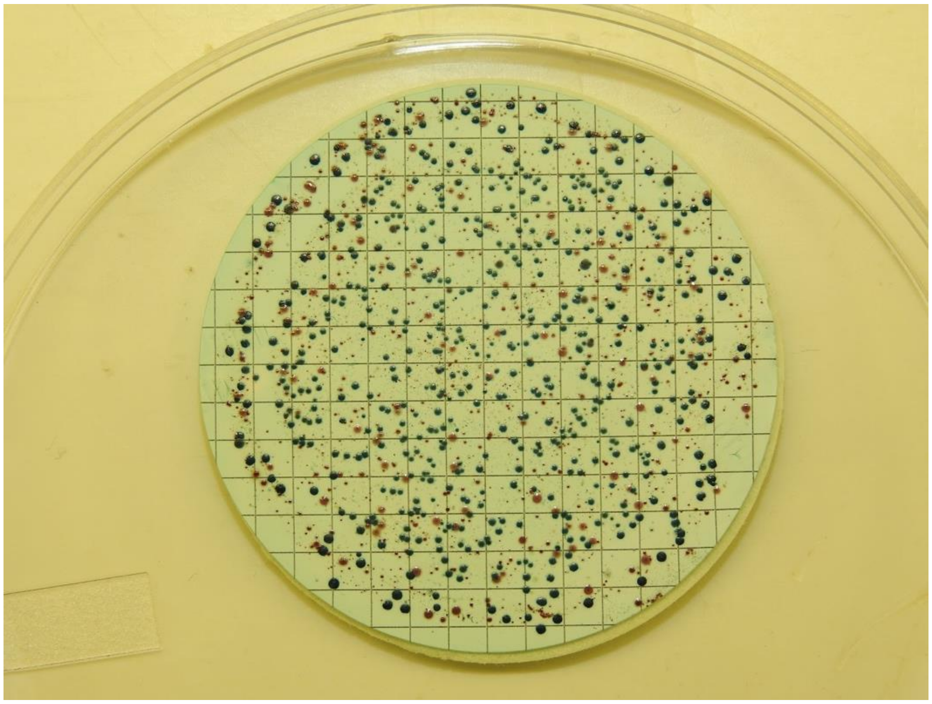
Site 2: 595 CFU/100ml; 5% Fecal Coliform. Sample taken October 29, 2018.



Site 3: 818 CFU/100ml; 7% Fecal Coliform. Sample taken October 29, 2018.



Site 4: 615 CFU/100ml; 60% Fecal Coliform. Sample taken October 29, 2018.



Site 4 (Replicate): 726 CFU/ 100ml; 68% Fecal Coliform. Sample taken October 29, 2018.

Table 1: Coliform Counts for Site 1 Microbiology. Oct 29, 2018

Random Square #	Red	Blue	Clear
1	7	5	0
2	5	1	0
3	7	0	0
4	6	0	0
5	10	1	0
6	8	15	0

7	7	0	0
8	11	2	0
9	11	3	0
10	3	12	0
Total	75	39	0
Average	7.5	3.9	0
CFU/ 100ml	757	393	0

Table 2: Coliform Counts for Site 2 Microbiology. Oct 29, 2018

Random Square #	Red	Blue	Clear
1	6	0	0
2	7	0	0
3	6	0	0
4	7	0	0
5	6	1	0
6	2	0	0

7	3	1	0
8	8	0	0
9	4	1	0
10	7	0	0
Total	56	3	0
Average	5.6	0.3	0
CFU/ 100ml	565	30	0

Table 3: Coliform Counts for Site 3 Microbiology. Oct 29 2018

Random Square #	Red	Blue	Clear
1	8	2	0
2	12	0	0
3	9	1	0
4	7	0	0
5	3	0	0
6	9	1	0

7	6	1	0
8	11	0	0
9	7	0	0
10	3	1	0
Total	75	6	0
Average	7.5	0.6	0
CFU/ 100ml	757	61	0

Table 4: Coliform Counts for Site 4 Microbiology. Oct 29, 2018

Random Square #	Red	Blue	Clear
1	2	4	0
2	1	5	0
3	0	4	0
4	2	3	0
5	3	1	0
6	3	5	0

7	6	2	0
8	2	6	0
9	3	4	0
10	2	3	0
Total	24	37	0
Average	2.4	3.7	0
CFU/ 100ml	242	373	0

Table 5: Coliform Counts for Site 4 (Replicate) Microbiology. Oct 29, 2018

Random Square #	Red	Blue	Clear
1	5	2	0
2	0	7	0
3	4	4	0
4	0	7	0
5	5	0	0
6	0	7	0

7	3	7	0
8	2	5	0
9	3	3	0
10	1	7	0
Total	23	49	0
Average	2.3	4.9	0
CFU/ 100ml	232	494	0

Appendix D: Invertebrate Data Sheets

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name: Cottle Creek		Date: 31-10-2018	
Station Name: Stn 1		Flow status: Fast	
Sampler Used: Hess	Number of replicates 3	Total area sampled (Hess, Surber = 0.09 m²) x no. replicates 0.27m²	

Column A Pollution Tolerance	Column B Common Name	Column C Number Counted	Column D Number of Taxa
Category 1	Caddisfly Larva (EPT)	EPT1 4	EPT4 2
	Mayfly Nymph (EPT)	EPT2 1	EPT5 1
	Stonefly Nymph (EPT)	EPT3 11	EPT6 2
	Dobsonfly (hellgrammite)		
Pollution Intolerant	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		C1 16	D1 5
Category 2	Alderfly Larva		
	Aquatic Beetle		
	Aquatic Sowbug		
	Clam, Mussel		
	Cranefly Larva	4	2
	Crayfish		
Somewhat Pollution Tolerant	Damselfly Larva		
	Dragonfly Larva		
	Fishfly Larva		
	Amphipod (freshwater shrimp)	4	1
	Watersnipe Larva		
Sub-Total		C2 8	D2 3
Category 3	Aquatic Worm (oligochaete)	89	4
	Blackfly Larva	1	1
	Leech		
	Midge Larva (chironomid)	64	2
	Planarian (flatworm)		
Pollution Tolerant	Pouch and Pond Snails	3	1
	True Bug Adult		
	Water Mite		
Sub-Total		C3 157	D3 8
TOTAL		CT 177	DT 16

Site 1: Invertebrate species count and taxonomic diversity count.

STATION #1

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell **CT**: CT 177

DENSITY: Invertebrate density per total area sampled:

177 ÷ From page 1 0.27 m^2 = 655.6 / 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 5 + 2 x 3 + 8 = S2 29

EPT INDEX: Total number of EPT taxa.

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

EPT4 + EPT5 + EPT6

2 + 1 + 2 = S3 5

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 + 1 + 11) / 177 = S4 0.090

SECTION 3 - DIVERSITY

TOTAL NUMBER OF TAXA: Total number of taxa from cell **DT**: 16

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

89 / 177 = S5 0.503

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 4
EPT Index	R2 3
EPT To Total Ratio	R3 1
Predominant Taxon Ratio	R4 3

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

Site 1: Invertebrate survey interpretation sheet with abundance and density rating, predominant taxa, water quality assessment, diversity rating and an overall assessment.

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name: Cottle Creek		Date: Oct. 31st, 2018
Station Name: #2		Flow status: Flowy
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)	EPT1	EPT4
	Mayfly Nymph (EPT)	EPT2	EPT5
	Stonefly Nymph (EPT)	EPT3	EPT6
	Dobsonfly (hellgrammite)		
Pollution Intolerant	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		C1	D1
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)	26+31+16	2
	Watersnipe Larva		
Sub-Total		C2 73	D2 2
Category 3	Aquatic Worm (oligochaete)	6+8+15	1
	Blackfly Larva		
	Leech	1+1	1
	Midge Larva (chironomid)		
	Planarian (flatworm)		
Pollution Tolerant	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite		
Sub-Total		C3 31	D3 2
TOTAL		CT 104	DT 4

Site 2: Invertebrate species count and taxonomic diversity count.

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell **CT**: CT 104

DENSITY: Invertebrate density per total area sampled:

From page 1

104 ÷ 0.27 m^2 = 385.19 / 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 2 + 2 = S2 6

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) / 104 = S4 0

SECTION 3 - DIVERSITY

TOTAL NUMBER OF TAXA: Total number of taxa from cell **DT**: 4 | 4

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

73 / 104 = S5 0.70

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

Site 2: Invertebrate survey interpretation sheet with abundance and density rating, predominant taxa, water quality assessment, diversity rating and an overall assessment.

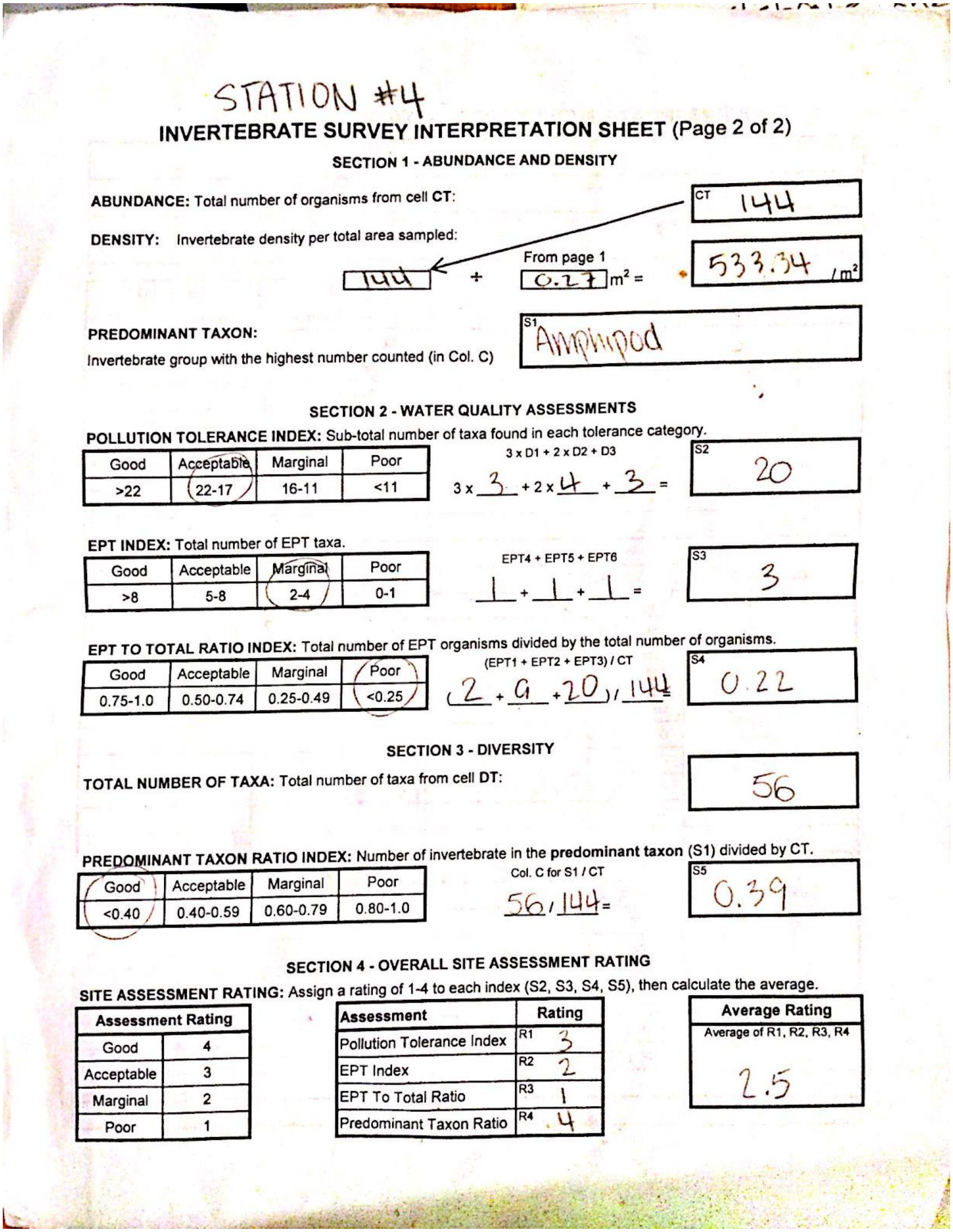
INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name: Cattle Creek		Date: Oct 31, 2018
Station Name: #4		Flow status:
Sampler Used: Hess	Number of replicates	Total area sampled (Hess, Surber = 0.09 m^2) x no. replicates triplicate 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)	EPT1 2	EPT4 1
	Mayfly Nymph (EPT)	EPT2 9	EPT5 1
	Stonefly Nymph (EPT)	EPT3 20	EPT6 1
	Dobsonfly (hellgrammite)		
Pollution Intolerant	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		C1 31	D1 3
Category 2	Alderfly Larva		
	Aquatic Beetle		
	Aquatic Sowbug		
	Clam, Mussel	1	1
	Cranefly Larva	1	1
	Crayfish		
Somewhat Pollution Tolerant	Damselfly Larva	1	1
	Dragonfly Larva		
	Fishfly Larva		
	Amphipod (freshwater shrimp)	56	1
	Watersnipe Larva		
Sub-Total		C2 59	D2 4
Category 3	Aquatic Worm (oligochaete)	54	3
	Blackfly Larva		
	Leech		
	Midge Larva (chironomid)		
	Planarian (flatworm)		
Pollution Tolerant	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite		
Sub-Total		C3 54	D3 3
TOTAL		CT 144	DT 10

limpet 2

Site 4: Invertebrate species count and taxonomic diversity count.



STATION #4

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell **CT**: CT 144

DENSITY: Invertebrate density per total area sampled:

144 ÷ From page 1 0.27 m² = 533.34 /m²

PREDOMINANT TAXON: S1 Amphipod

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

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 3 + 2 x 4 + 3 = S2 20

EPT INDEX: Total number of EPT taxa.

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

EPT4 + EPT5 + EPT6

1 + 1 + 1 = S3 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

(2 + 9 + 20) / 144 = S4 0.22

SECTION 3 - DIVERSITY

TOTAL NUMBER OF TAXA: Total number of taxa from cell **DT**: 56

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

56 / 144 = S5 0.39

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 3
EPT Index	R2 2
EPT To Total Ratio	R3 1
Predominant Taxon Ratio	R4 4

Average Rating

Average of R1, R2, R3, R4

2.5

Site 4: Invertebrate survey interpretation sheet with abundance and density rating, predominant taxa, water quality assessment, diversity rating and an overall assessment.