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Water Quality, Microbiology & Stream Invertebrate Assessment for Cottle Creek Nanaimo, BC

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Executive Summary

A proposal was put forward and accepted to sample four locations within Cottle Creek, located in Nanaimo, British Columbia. Cottle Creek water shed covers 4.5 km^2 and consists of three main tributaries. The creek itself runs through Linley Valley Park and is a water source for various fish, bird, mammal, and reptile and amphibian species. Recent development surrounding the watershed has raised concerns regarding impact to stream health. Concerns include excess sedimentation due to bank erosion, water quality and overall stream condition. The purpose of this report is to conduct physical, chemical and biological testing to verify if parameters fall within guidelines and whether stream health has been impacted. Data collected will be compared to the most recent study in 2013. Two sampling events took place. The first occurred October 28, 2014 and the second occurred on November 29, 2014.

Velocity decreased from event one to event two. This is due to a storm that occurred during sampling event one. Overall wetted width and depth increased from sampling event one to sampling event two.

Dissolved Oxygen results from both events fell within the required guidelines for aquatic health. As temperature dropped between the two sampling events we saw and increase in dissolved oxygen. PH levels remained consistent over both events. PH levels fell within aquatic guidelines ranging from pH 7- pH 8. Conductivity levels increased downstream for both events. Cottle creek was classified through alkalinity testing as a low sensitive with good acid neutralizing capabilities. Turbidity levels were high during sample event one but decreased over time. Sample station three contained high turbidity levels for both events.

Nutrient and Anion testing revealed high nitrogen levels during sample event one, as runoff decreased so did nitrogen levels. Nitrogen levels obtained during sample event two revealed typical levels. Levels for phosphorus remained low for both events. Phosphorus is a limited nutrient in this watershed.

Metal testing conducted by a laboratory in Richmond, British Columbia concluded that there was no excess of metals existing in the watershed and all counts fell under the required guidelines.

Invertebrate testing yielded low capture rates. EPT taxa were predominant in two of the three stations sampled. Biology testing revealed the creek to be of a marginal to acceptable classification.

1.0 Introduction

A proposal was set forth to conduct an environmental monitoring project for Cottle Creek Nanaimo, BC. The project was accepted and sampling began in October of 2014 and concluded in November 2014. The project team consisted of four undergraduate students from Vancouver Island University, acting under direct supervision of Dr. Eric Demers, instructor of RMOT 306 Environmental Monitoring. The project focused on the scientific study of water quality, microbiology and steam invertebrates to determine existing as well as potential environmental hazards that may lead to the degradation of the creek and surrounding ecosystem. A total of four sample stations were used for the study, at various locations throughout the stream .

1.1 Historical Overview

Cottle Creek flows through Linely Valley, a wilderness park located between Rock City Road and Hammond Bay road (Figure 1). The creek consists of three tributaries, Upper Cottle creek from the headwaters towards Rutherford Road to Cottle Lake; North Cottle Creek from Lost Lake to Cottle Creek and Lower Cottle Creek from Cottle Lake to Departure Bay. The watershed covers 4.5 km^2 (City of Nanaimo, 1999). The creek itself, at this time of year is small at some locations, almost completely dried up. Flow is slow. The creek runs through a dense forest and contains high concentrations of organic matter such as leaf litter and woody debris. Primary surrounding vegetation includes Douglas fir *(Pseudotsuga menziesii)*, western red cedar (*Thuja plicata)*, arbutus *(Arbutus unedo)*, salal (*Gaultheria shallon)*, salmonberry (*Rubus spectabilis)*, huckleberry (*Gaylussacia brachycera)*, Himalayan blackberry *(Rubus armeniacus)* and various fern species (*Pteridophyta sp.)*. The creek bed is primarily composed of silt, sand, gravel and cobble. Due to an impassable drop into Departure Bay, no anadromous salmon species exist in the watershed (City of Nanaimo, 1999). The creek contains a resident cutthroat trout *(Oncorhynchus clarkii)* population and an invasive pumpkin seed (Lepomis gibbosus) population. Additionally, the surrounding forest is home to a diverse range of amphibians, reptiles, birds and mammals (City of Nanaimo, 1999).

1.2 Potential Environmental Hazards

Linley Valley is a relatively large portion of undeveloped forest in which Cottle Creek runs through. Each year, urban development increases and adds pressure to the watershed. Developers have been clearing steep slopes, which in return has increased both the stream bank erosion and sedimentation into the system. A previous study of the creek conducted in

2013, showed high phosphorus levels (Bolland et al., 2013). This can most likely be attributed to fertilizer use and urban runoff. Developers' visions include, along with the building of new properties in the area to provide new trails, stonework, bridges and walkways surrounding Cottle Creek (Cottle Creek Estates, 2014). This poses potential threats to the creek by increasing foot traffic, removal of surrounding vegetation, and possible blockages impeding flow. A culvert located under Landalt Road in place to prevent flooding, has created a barrier completely restricting fish movement. City bylaws in place have created a 15 m riparian buffer zone (City of Nanaimo, 1999). However, construction and clear-cutting without erosion control measures are negatively impacting the creek, forest and organisms within the ecosystem.

2.0 Project Objectives

The project objectives for the assessment of Cottle Creek in Nanaimo, BC were to examine the environmental condition of the creek and compare this year's data to previous years to identify any existing problems that may be occurring. We conducted an analysis of Cottle Creek at four different locations within the city of Nanaimo. The analysis included water quality testing, which tested for contaminants in the water; hydrology testing, which established the flow and discharge of the creek; microbiology where we measured for coliform bacteria, and, also conducted an analysis of stream invertebrates. Analysing the species composition within the creek helped determine the overall health of the water. The purpose of the testing was to verify if there are any environmental areas of concern that need immediate action from government agencies in Nanaimo. The test samples collected from Cottle Creek were sent to the ALS lab in Burnaby, BC and were analysed. The obtained results were examined to determine the actual environmental health and condition of Cottle Creek. By continuing with the long-term analysis of Cottle Creek, its health and environmental condition will be monitored for many years to come, and the results will be of interest to government agencies, such as the Department of Fisheries and Oceans Canada.

3.0 Sampling Methods and Analytical Procedure

3.1 Site Locations and Characteristics

Four Bachelor of Natural Resource Protection (BNRP) students enrolled in Dr. Eric Demers 306 Environmental Monitoring Course conducted this project. Four stations have been selected along the Cottle Creek watershed to conduct water quality, microbiology and stream invertebrate assessments.

Site # 1 (Figure 1), is located off Landalt road, which is the upper section of Cottle Creek. Sampling took place west, upstream from the road (Table 1). The sample site is a large flat area, making it possible to conduct water quality and invertebrate sampling. There was one concern present in this location, regarding the water level and foliage during testing times. Since it was early fall the flow of the creek was relatively low and many leaves were beginning to descend into the creek. This affected visibility for collecting invertebrate samples. The substrate at this site was mainly cobble and gravel, and the surrounding vegetation included a high percentage of Red Cedar (*Thuja plicata*) and Sword Ferns (*Polystichum munitum*).

Site #2 (figure 1), is located 100m downstream from Burma Road, which is a part of the northern Cottle Creek watershed. The flow at this site is extremely low so we were unable to conduct stream invertebrate sampling. A potential danger for this site is the large amount of rotten trees that are present and easily pushed over. During the testing there was always potential risk of having a rotten tree fall on a crew member. Extra precautions and due diligence were taken by all crew members regarding this risk. The substrate in this part of the stream was primarily cobble and vegetation consisted of mostly small shrubs and trees.

Site #3 (figure 1), is located on Nottingham drive which is in the lower section of Cottle Creek. The sample site is north, upstream of the bridge crossing. The sample site is small, but has high visibility and is a fairly flat marshland. There is a small rock face that must be scampered down in order to reach the site. The rocks, when wet, were slippery and posed a danger to crewmembers. All members took responsibility to remember to wear proper footwear with grips or wader boots. The flow of the creek was fairly high, especially during the second sampling event, as some heights were recorded over 75 cm. The wetted heights of this area of the creek made it difficult to collect invertebrate samples. However samples were collected approximately 1-2 meters downstream from the sample site under the bridge in the shallower, coarser substrate. The site is described as a low lying area so most of the vegetation consisted of marsh grasses, shrubs and alder trees lining the banks. The substrate in this area was fine silt, clay and mud. The substrate changed briefly as it entered the culvert into cobble and gravel.

Site #4 (figure 1), is located off Stephenson Point road, 150 m from Hammond Bay road to the bridge crossing. The sample site is upstream from the bridge crossing. There was a small incline to access the sample site, otherwise the site was safe and there were minimal dangers. The flow of the creek was moderately faster than that of the rest of the sample sites. The vegetation of the site was mostly shrubs and overhanging trees. The substrate consisted mostly of cobble and the odd boulder.

Table 1: Cottle Creek, Nanaimo BC. Sample Stations, Locations and Directions. Lat/ Long coordinates and UTM coordinates used to access exact sampling area. Map containing sample locations located on the following page.

Station No.	RDN Station ID	Site Description	Directions	Lat/Long	UTM
Cottle Creek Station 1	E290476	Cottle Creek @Landalt Road	From Departure Bay Rd, turn onto Rock City Rd, L on Landalt Rd. Cottle Ck crosses Landalt, and Sample upstream (west) of road.	49° 13'5.398"N 123° 59'22.280"W	0427941 5452180
Cottle Creek Station 2	E290474	North Cottle Creek 100m Downstream from Burma Rd	From Hammond Bay, Rd, turn onto Malaspina, than L onto Laguna way, R onto Lost Lake Rd and L onto Burma Rd. Hike down trail to you cross small creek. This is north Cottle Creek. Sample 5m downstream of bridge.	49° 13.334'N 123° 58.844'W	0428587 5452624
Cottle Creek Station 3	E290473	Cottle Creek @ Nottingham	Going north on Hammond Bay Rd turn onto the second Nottingham Drive. After about 150 m you will cross Cottle Creek. Sample upstream of where road Crosses (North).	49° 13' 1.221"N 123° 57'30.919"W	0430192 5452022
Cottle Creek Station 4	E290475	Cottle Creek @ Stephenson Pt RD	Going north on Hammond bay Rd, turn R onto Stephenson Point Rd, after about 150 m you will cross Cottle Creek. Sample upstream of road.	49° 12'41.207"N 123° 57'11.402" W	Not Given

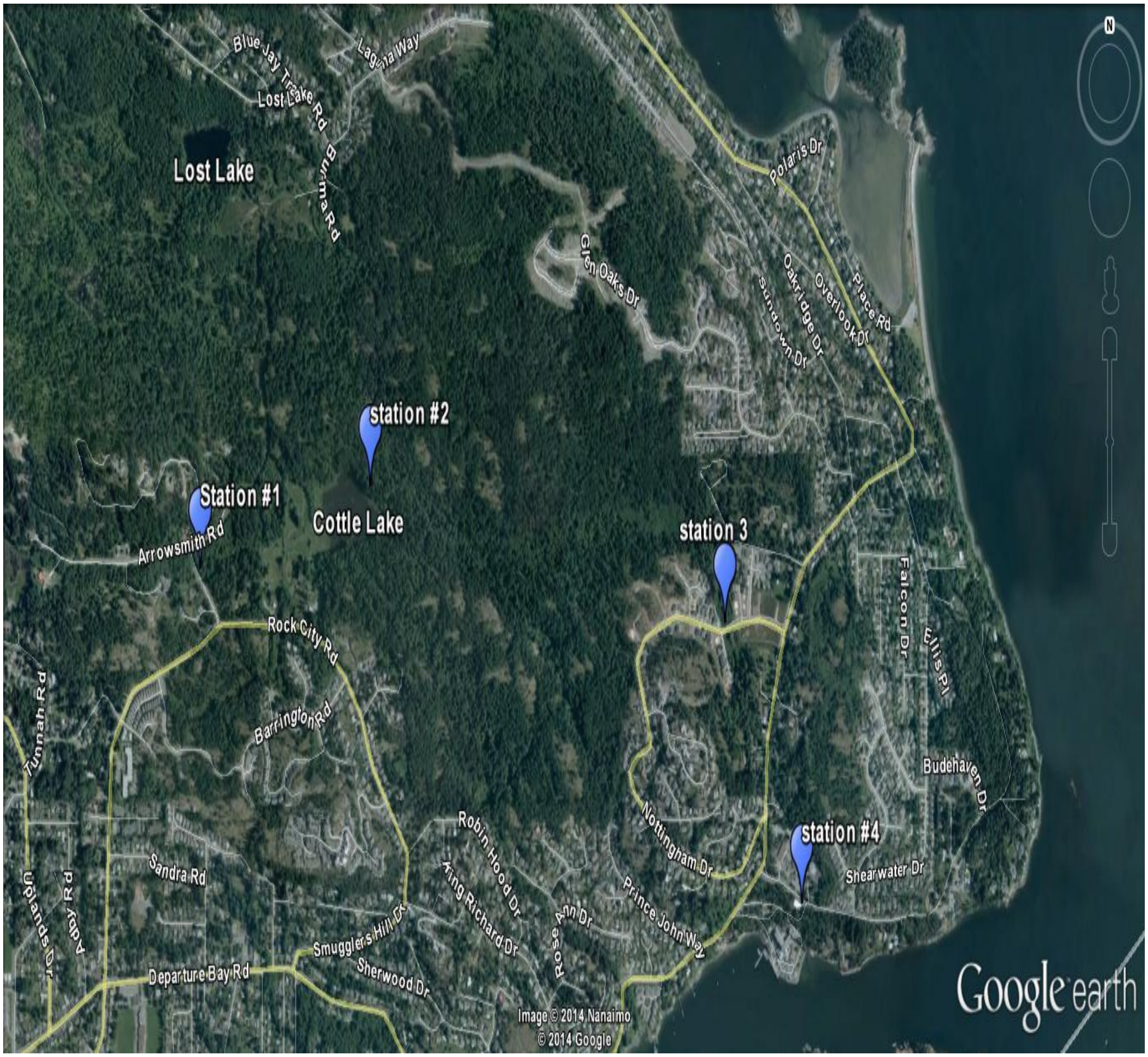

Figure 1: Cottle Creek sample stations 1, 2, 3, 4 located in Nanaimo, BC. for events one and two Site Map. Water flow flows downstream from sample station one to sample station four where it discharges into Departure Bay. Please see table on previous page for site description and locations

3.2 Sampling Frequency

Sampling for this proposed project took place on October 28th, 2014 and November 19th, 2014. There were two main sampling events; one at low water flow and one at high water flow. The samples taken were measured for water quality, toxicity, hydrology, and stream invertebrates. After each sampling event the samples were stored in a cooler and then transferred to a refrigerator overnight before the samples were analyzed.

Quality control and assurance were taken in each sampling exercise and event. Before each sampling event we took care to ensure the instructor knew when we conducted and finished at all of our sites. Upon our first sampling event, each site was assessed for possible dangers and hazards and it was taken into consideration of each team member to ensure that we all had the proper gear.

3.3 Hydrology

Hydrology was conducted at sites 1, 3, and 4, as all of these sites had the most relative water flow. Other basic measurement such as wetted channel width, bank full channel width, and wetted height, were taken at all sites on both sampling dates. During our first sampling date the water level was quite low, which is ideal as you can compare it to later, higher, water levels. It was expected that water levels would increase in the stream on the second sampling event due to rainfall and runoff, however with minimal effluent the water level increased only slightly.

The flow in the creek was conducted by two crewmembers using a measuring tape and a floating fishing bobber. The team members stood 5 meters apart (measured out using the measuring tape) within the sites boundaries, and using a stopwatch measured the amount of time it took the floating bobber to float 5 meters downstream. The measurements were recorded 5 times in order to reach an accurate average time.

3.4 Water Quality

Water quality was conducted during both testing dates and was only collected at sites 1,2 and 4. When it came time for lab analysis a field blank was assessed in order to compare with all results collected. There were 3 sample bottles collected, in order to package and send to ALS for results. There was a 1Litre white plastic bottle, a 250ml white plastic bottle and a 250ml amber glass bottle; there was one of each bottle for each sample location that was being tested for ALS results. Another bottle, which was rinsed 3 times was also collected, but used in the Vancouver Island University lab for different analysis such as coliform. Once the samples were collected on site they were placed in a cooler then transferred to a refrigerator by the end of the day. Here the samples only sat for approximately 2 days and then were taken to the Vancouver Island University Laboratory for analysis and to be shipped to the ALS laboratories in Vancouver. All of the samples will be compared to the *Guidelines for Interpreting Water Quality* to see if the samples collected meet the government guidelines for “safe, drinkable” water. All crewmembers thoroughly followed the *Ambient freshwater and effluent sampling* *manual* during field work for both sampling times and in the laboratory. A replicate and a blank were also used in water quality analysis for quality assurance and control purposes.

Electronic probes were used in the field as well as in the lab to test for pH, turbidity, conductivity, temperature as well as dissolved oxygen. Further testing in the laboratory included hardness, alkalinity, nitrate, phosphate, and coliform filtration. All of the necessary equipment will be provided in the lab and in the field in order to conduct our experiment and analyze results properly.

3.5 Microbiology

The microbiology tests were only conducted on the first sample date and only on sites 1, 3 and 4. During our first sample set the water level was quite low, making it difficult to collect an accurate sample at site number 2. Proper equipment and safety procedures to conduct this test were used both in the field and at the Vancouver Island laboratory. Quality assurance and control were used in this procedure during collection and analysis. Whirl packs were used on site at the stream to collect the sample and then carefully transported in a cooler and stored in a fridge until analysis. During laboratory analysis, tools that were used were consistently sterilized and hands were washed. One replicate was taken for quality assurance and control methods. Once the test was conducted the results were placed in a pitri dish and placed in an incubator for 24-36 hours and then analyzed. The test conducted in the laboratory was used to identify the total fecal coliform in the water sample. When the fecal coliform dots on the pitri dish were counted they were compared to the *Guidelines for Interpreting Water Quality of*

British Columbia Government to ensure that the water in the creek is safe for human consumption.

3.6 Stream Invertebrates

Sampling for stream invertebrates was conducted at sites 1, 3, and 4 during the first sample date. The first sampling date was early in the fall and the water flow was relatively low and made it easier for invertebrate testing. A Hess sampler was used in the stream in order to collect the invertebrate species. There were a total of 4 small plastic containers that were filled and collected at each site in order to bring back to the Vancouver Island University Lab and analyze. The purpose of the test is to be able to identify the diversity of freshwater benthic macro invertebrates in Cottle Creek.

The containers were transported back to Vancouver Island University in a cooler in order to be analyzed in the lab. Using a dissection microscope, the containers were dumped into trays and then sorted through to separate different invertebrate species into their taxa. Using the *Pacific Stream keepers Procedures*, the invertebrates were identified and counted and then placed in tally records on the stream keeper's sheet. All necessary safety requirements were taken in the course of our experiment and the invertebrates were not held any longer than a day and animal care was addressed throughout the process.

4.0 Results and Discussion

4.1 Field Conditions

During the sampling events, Cottle Creek site levels ranged from low wetted height with little velocity to moderate to high wetted height and velocity. The water levels were expected to be lower in the first sampling event however there was an unexpected rainfall that elevated the water levels exceeding normal conditions. Due to the rainfall, water conditions were similar between the two events (table 2).

During the first event, due to an unexpected storm, sampling turned into a two day event. Due to unsafe working conditions the crew was required to finish sampling the next day. High amounts of precipitation resulted in elevated water levels. Station two however, had low velocity and the lowest depth during both events making sampling difficult. As for the second sampling event, due to previous rainfall, the creek levels were higher than the first sample (table 2). Additionally, for the second sampling event, the crew was able to obtain all samples in one day as weather permitted.

Ambient temperatures throughout the two sampling events were normal. During event one, the temperature was 9.6°C; and during event two, the temperature was 5.2°C (table 2).

4.2 Water Quality

4.2.1 Field Measurements

Parameters measured in the field included wetted width, channel width, overall depth, velocity, temperature, and dissolved oxygen. Velocity, depth, and temperature had varied results due to the amount of rainfall and runoff that took place in the two sampling events (table 2).

Velocity was taken at all stations during event one. During event two, velocity measurements were excluded at station two due to limited water depth and debris. Measurements for velocity were taken by timing a bobber as it travelled 5 m downstream. These tests were completed 5 times at each site and the average was calculated. It was expected that velocity would decrease for sampling event two. Although water levels were higher during event two, due to a storm, velocity was higher during event one. This is reflected in our results as velocity decreased at stations three and four and only minimally increased at station one during event two (table 2).

Water temperature was measured with an electronic probe in the field. A difference in water temperature between the two sampling events was to be expected. Sampling event two took place a month after sampling event one, therefore water temperature due to time of year was cooler (table 2).

Dissolved oxygen in the watershed can be directly correlated to temperature. As temperature decreases, dissolved oxygen will increase. This is a result of fewer bacteria, consuming oxygen in the system. This trend was verified as we saw dissolved oxygen increase during sampling event two. For sampling event number one, the results for dissolved oxygen ranged from 9.9 to 11.4 mg/L. The results for sampling event number two ranged from 11.4 to 12.6 mg/L (table 2). Dissolved oxygen results from both events fell within the guidelines for aquatic life (Ministry of Environment et al., 1999).

*Table 2 Physical parameters measured for all stations within Cottle Creek Nanaimo, BC. Samples were obtained during both events (Oct 27, 28 and Nov. 18). Parameters measured include temperature, wetted width, channel width, channel depth, channel velocity and dissolved oxygen. *s represents station number. DO represents dissolved oxygen*

Sampling Event and Stations	***Temperature (Celsius)***	***Wetted Width(m)***	***Channel Width(m)***	***Avg. Channel Depth (m)***	***Avg. Velocity (Sec)***	***DO(mg/L)***
Oct 27* S1	*9.6*	*3.1*	*7.4*	*0.048*	*25.18*	*11.4*
Oct 28 *S2	*11.7*	*1.3*	*2.1*	*0.073*	*14.42*	*9.9*
Oct 28 *S3	*10.7*	*4.6*	*6.9*	*0.596*	*27.10*	*10.5*
Oct 27 *S4	*10.3*	*3.1*	*4.2*	*0.164*	*17.44*	*11.2*
Nov 18 *S1	*6.8*	*3.2*	*5.5*	*0.053*	*28.27*	*11.7*
Nov 18 *S2	*6.6*	*1.10*	*3.0*	*0.045*	*N/A*	*11.4*
Nov 18 *S3	*6.4*	*3.34*	*8.0*	*0.618*	*1.22.52*	*11.8*
Nov 18 *S4	*6.0*	*3.2*	*4.75*	*0.18*	*9.85*	*12.6*

4.2.3 VIU Lab analysis

Percentage hydrogen (pH) was determined in the lab for all four stations during both sampling events. The results from sampling event number one and two were neutral and met the guidelines for aquatic life (Ministry of Environment, 1999). In sampling event number one, station two had the highest pH of 8.04 while station one had the lowest pH of 7.3 (table 3). The trend we expected to see was that station four would have the highest level of pH as it is located the furthest downstream. When analyzing our ALS results, we see this to be true. A collaboration error most likely occurred in the field. Sampling event two yielded similar results to that of sampling event one. Station number two had the highest pH of 7.43 and station number four had a pH of 7.33 (table 3). When analyzing results obtained from the ALS lab in Burnaby, BC we see that station one had a pH of 7.83 and station four had the highest pH reading of 7.88 (table 4). This is the trend we expected to see.

Conductivity was measured for all stations during both events in the VIU lab. Conductivity is a measure of relative electricity conducted by the water and is a product of ion concentration. According to the *BC Guidelines for Interpreting Water Quality Data*, coastal streams have a value that is equal to 100 µS/cm (Ministry of Environment et al. 1999). As conductivity is a measure of ions, we expected the greatest amount to be found at station four. VIU laboratory analysis found this to be true for sampling event number one but not for sampling event number two (table 3). Station number one was the highest for sampling event number two. ALS laboratory results reveal that during both events, station four had the highest conductivity which is consistent with the expected trend. It is probably due to human induced error or a collaboration error that the VIU Laboratory analysis did not yield the same results as the ALS laboratory.

Turbidity refers to the relative clarity of the water. It is believed that due to bank erosion from construction this may be an issue as excess sediment enters the system. Stations one, three, and four are found close to urban development whereas station two is found within Linely

Valley Park. Due to a large amount of rainfall during event one, Turbidity was expected to be higher than event two. Station three had the highest reading of nephelometric turbidity units, (NTUs) during the first and the second sampling event. In the first sampling event the turbidity reading was recorded as 8.32 NTUs and the second sampling event had reading of 7.19 NTUs (table 3). Station three did not have a well-developed riparian area. In other areas the riparian area acts as a filter trapping some of the sediment runoff, this is not the case here. Additionally, site three is exposed to a manmade culvert that impedes flow. As sediment comes downstream it gets backed up at this site as water is channelled through the culvert. High water and flooding are two factors that can also contribute to the excess sedimentation at this station. This culvert can also be attributed to the stations high water depths and minimal velocity. Slow velocity correlates to turbidity as sediments are not being pushed downstream.

Alkalinity is used to measure how affectively a water body can neutralize acidic components. Alkalinity depends on the levels of Ca^{2+} and Mg^{2+}, if there is a high concentration of these elements alkalinity will increase. According to the *BC Water Quality Guidelines* watersheds are classified as; high sensitivity 0-10 mg/L, moderate sensitivity 10-20 mg/L, and low sensitivity is anything >20 mg/L. Alkalinity was determined in the lab for all four stations during both events. During sampling event one Alkalinity levels varied. The lowest reading occurred at station two with a reading of 24 NTU’s while the highest reading occurred with the station one replicate at 56 NTU’s (table 3). For sample event two the results were similar. Station one yielded the highest results with 34 NTU’s whereas station three had the lowest results with 18 NTU’s (table 3). On average, during both sampling events the watershed was classified as low sensitivity, meaning it has good acid neutralizing capabilities.

Nitrate (NO_3^-) and Phosphate (PO_4^{3-}) were both determined in the lab for all stations during both events. Excessive levels of phosphate and nitrogen when meeting the required ratio will lead to eutrophication. According to the *BC Water Quality Guidelines*, the typical levels of nitrogen is <.30 mg/L for freshwater systems (Ministry of the Environment, 1998). In the results for the first sampling event, all the levels fell within the guidelines except for station two which had a nitrogen level of 1.50 mg/ L (table 3). Even though this is higher than the guidelines the nitrogen dropped to <0.01 during sample event two (table 3). ALS laboratory results varied and are a result of human induced error in the VIU lab.

As for phosphate, according to the *BC Water Quality Guidelines* typical levels of <0.01 mg/L means oligotrophic, 0.01-0.03 mg/L is oligotrophic and > 0.03 mg/L is eutrophic. The highest result for sampling event number 1 was station 4 with a reading of 0.05 mg/L (table 3). During the second sampling event almost all the phosphorous levels were lower than MDL (minimal detection limit). These readings could have resulted the first time due to miscalculations or calibration issues.

Hardness was measured in the lab to determine the softness or the hardness of the water. Hardness of the water will depend on the levels of Ca^{2+} and Mg^{2+}. If the water is hard, the creek will have increased levels of alkalinity and conductivity. If the water is soft, metals become more toxic. According to the *BC Water Quality Guidelines*, typical levels of soft water are <60 mg/L $CaCO_3$ and hard water is >120 mg/L $CaCO_3$. The results for the first sampling event ranged from 40-60 mg/L $CaCO_3$; which means that the water in Cottle Creek is soft (table 3). The results in the second sampling ranged from 35-62 mg/L $CaCO_3$, which indicates little change in the hardness of the water, and therefore the water is still soft.

Table 3: Chemical parameters measured in the Vancouver Island University laboratory for sample events one and two for all stations located within Cottle Creek, Nanaimo, BC. Water quality parameters measured include conductivity, turbidity, hardness, nitrate, phosphate and alkalinity.

Stations and Events	**pH**	**Conductivity (µS/cm)**	**Turbidity (NTU)**	**Hardness (mg/L $CaCO_3$)**	**Nitrate (mg/L)**	**Phosphate (mg/L)**	**Alkalinity (mg/L)**
Oct 29 S1	7.3	109	6.64	60.0	0.11	0.05	44.0
Oct 29 Rep	7.69	124	11.4	60.0	0.10	0.02	56.0
Oct 29 S2	8.04	128	3.69	40.0	1.50	<0.01	24.4
Oct 29 S3	7.83	118	8.32	57.0	0.10	0.04	56.0
Oct 29 S4	8.0	142	6.14	58.0	0.39	0.05	33.64
Nov 19 S1	7.32	149	2.43	62.0	<0.01	0.29	34.0
Nov 19 S2	7.43	96	2.26	40.0	<0.01	0.10	27.3
Nov 19 Rep	7.38	94	1.85	35.0	0.25	0.27	33.4
Nov 19 S3	7.26	104	7.19	43.0	<0.01	0.15	18.0
Nov 19 S4	7.33	112	0.77	42.0	<0.01	0.14	29.0

4.2.4 VIU Microbiology

Microbiology samples were obtained during the first sampling event. Samples were collected from all four stations. These tests confirm the presence or absence of fecal coliforms in the creek. The test for fecal bacteria indicates bacteria such as E.coli, which display’s the colour blue on the bacterial plate. For non-fecal matter samples, the colour red is displayed on the bacterial plate. The results determined that the lower stations of the creek had the highest concentration of fecal matter. Station 1, only had a fecal matter concentration of 18 total colonies. Station 2 had the highest result of fecal matter with a reading of up to 202 fecal colonies (table 4). This particular section of the creek is located within a park which has a popular dog walking trail, and therefore has greater potential of animals defecating in the creek. Stations 3 and 4 had a relatively similar result. Station 3 resulted in 121 fecal colonies and station 4 resulted in 90 fecal colonies (table 4). These two stations are in close proximity to urban development. The increase of human activity and dog activity can result in higher coliforms due to the creek being defecated in.

Table 4: Microbiology testing for Cottle Creek, Nanaimo, BC. During both sampling events collected at all four stations. Bacterial plates were counted for both (blue) fecal matter and (red) non-fecal matter.

Stations	**Red (Non-Fecal Matter) (CPU/100ml)**	**Blue (Fecal Matter) (CPU/100ml)**
Station 1	303	18
Station 2	242	202
Station 3	221	121
Station 4	191	90

4.2.5 Quality Assurance/ Quality Control

Quality assurance and quality control measures were taken out in the field for every sampling event. All sampling bottles were properly rinsed three times before sample collection. The chances of contamination of any coliform collecting bags were eliminated through proper sample collecting practices. Trip blanks were taken and recorded properly for further lab analysis. Chain of custody and continuity of samples was exhibited. Replicates were taken, recorded, and analyzed. Proper labelling and storage was completed. All samples were placed into a cooler and kept cold. Once sampling was completed all samples were transported from the cooler to the refrigerator by the crew.

One main issue that was a regular occurrence was completing velocity testing. The bobber was constantly getting caught on the heavy debris during the five trials of velocity at all stations except station 3. Station 3 had the least amount of debris, but had the slowest velocity. This issue was attempted to be fixed by trying different areas within the boundaries of the sample area, but was unsuccessful.

4.2.6 ALS Results

Water samples collected were sent to the ALS lab located in Burnaby BC. Water samples were obtained from sites one, two and four during the first sampling event. Samples were collected from sites one and four during the second sampling event. Parameters tested included physical tests such as conductivity hardness and pH. Anion and nutrient level testing and total metal counts were also analysed.

Conductivity measured during the first sampling event yielded consistent results over the three stations. A trend that was expected and seen was that sample station four had the highest level of conductivity (table 5). Station four is located the furthest downstream so it was expected this area would contain the highest amount of dissolved ions. During sampling event two we saw conductivity levels drop at station one (table 6). This is because runoff from high amounts of precipitation during sampling event one resulted in high ion concentration. As water levels receded during event two so did the conductivity. This was not the case with station four as conductivity levels rose during event two. This may be due to high levels of ions being concentrated at the downstream portion before entering the Ocean at Departure Bay (Table 6).

Hardness levels revealed that Cottle Creek contains soft water. Metals found in soft water as opposed to hard water have higher toxicity levels. Results obtained remained consistent with conductivity in that during sampling event two levels dropped in station one but rose in station four (table 6). The reasoning for this is similar to that given for hardness in that a build-up of divalent cations occurred at station four before discharge into Departure Bay.

Levels of pH remained constant through all stations during both sampling events. The lowest pH value was recorded at station two during event one with a pH value of 7.60 (table 5). The highest value was recorded during event two at station four with a 7.88 pH (table 6). These results reveal neutral pH levels that fall within the guidelines for aquatic life (Ministry of Environment et al. 1998).

Table 5 Physical tests conducted by ALS Laboratories in Richmond, BC for stations one, two and four during sample event one in Cottle Creek, Nanaimo BC. Parameters tested include Conductivity, hardness and pH.

Physical Tests	**Station #1**	**Station #2**	**Station #4**
Conductivity	151	133	166
Hardness	59.3	41.7	62.6
pH	7.81	7.60	7.87

Table 6 Physical tests conducted by ALS Laboratories in Richmond, BC for stations one and four during sample event two in Cottle Creek, Nanaimo, BC. Parameters tested include conductivity, hardness and pH.

Physical Tests	**Station 1**	**Station 4**
Conductivity	139	181
Hardness (as CaCO3)	50.9	72.7
pH	7.83	7.88

One concern expressed by a previous study was high phosphorus levels (Bolland et al., 2013). Phosphorus is the most limiting nutrient in water and excessive levels can result in eutrophication. Much of the development of an urban subdivision is occurring above Cottle Lake. Excessive phosphorus levels due to run off, could result in eutrophication of Cottle Lake. The results obtained reveal that the system is in fact phosphorus limited and far from the red field ratio required to produce eutrophication (table 7, table 8).

Nitrogen levels are typically found to be less than 0.30 mg/L in fresh water systems. During sampling event one, we see results to exceed the typical levels. Station two had the highest value of Nitrogen with 1.88 mg/L (table 7). Station two is located within Linely Valley. Due to high rainfall during event one, elevated amounts of organic matter entered the system resulting in abnormal Nitrogen levels. During sample event two, we see nitrogen levels decrease close to typical levels (table 8). Both stations sampled in event two exceeded typical levels minimally with the highest value found at station four at 0.682 mg/L (table 7). Because phosphorus is limited, eutrophication is unlikely.

Table 7 Anion and nutrient testing, conducted by ALS Laboratories in Richmond, BC for stations one, two and four during sampling event number one with in Cottle Creek, Nanaimo, BC.

Anions and Nutrients	**Station 1**	**Station 2**	**Station 4**
Ammonia, Total (as N)	0.0186	0.0058	0.0114
Nitrate (as N)	0.463	1.71	0.756
Nitrite (as N)	0.0068	0.0010	0.0032
Total Nitrogen	0.859	1.88	1.02
Orthophosphate-Dissolved (as P)	0.0043	0.0036	0.0015
Phosphorus (P)-Total	0.0157	0.0085	0.0101
TN:TP	55	221	101

Table 8 Anion and nutrient testing, conducted by ALS Laboratories in Richmond, BC for stations one and four during sampling event two in Cottle Creek, Nanaimo, BC.

Anions and Nutrients	**Station 1**	**Station 4**
Ammonia, Total (as N)	0.0131	0.0061
Nitrate (as N)	0.240	0.477
Nitrite (as N)	0.0023	0.0019
Total Nitrogen	0.574	0.682
Orthophosphate-Dissolved (as P)	0.0018	0.0015
Phosphorus (P)-Total	0.0176	0.0055
TN:TP	32.6	124.0

The ALS laboratory also measured for total metals found at each site. As discussed previously, metals may be of a concern as soft water is present and metals found within this type of water hold higher toxicity levels. The most toxic metals as they pertain to aquatic life are cadmium (Cd), copper (Cu), mercury (Hg), lead (Pb) and zinc (Zn). When examining both sampling events, all of the previous mentioned metals are not only within the guidelines but in fact under the minimum detection limit of the instruments used for laboratory analysis. Mercury was not measured (table 9, table 10). The only metals that were detected were magnesium (Mg), calcium (Ca), iron (Fe), silicon (Si) and sodium (Na). These metals occur naturally in the environment and do not exceed normal levels, therefore are no concern to the aquatic environment.

Table 9 Total metal analysis conducted by ALS Laboratories in Richmond, BC for stations one two and four during sample event one within Cottle Creek, Nanaimo BC.

Total Metals	**Station 1**	**Station 2**	**Station 4**
Aluminum (Al)-Total	<0.20	<0.20	<0.20
Antimony (Sb)-Total	<0.20	<0.20	<0.20
Arsenic (As)-Total	<0.20	<0.20	<0.20
Barium (Ba)-Total	<0.010	<0.010	<0.010
Beryllium (Be)-Total	<0.0050	<0.0050	<0.0050
Bismuth (Bi)-Total	<0.20	<0.20	<0.20
Boron (B)-Total	<0.10	<0.10	<0.10
Cadmium (Cd)-Total	<0.010	<0.010	<0.010
Calcium (Ca)-Total	16.0	11.8	17.1
Chromium (Cr)-Total	<0.010	<0.010	<0.010
Cobalt (Co)-Total	<0.010	<0.010	<0.010
Copper (Cu)-Total	<0.010	<0.010	<0.010
Iron (Fe)-Total	0.619	0.206	0.451
Lead (Pb)-Total	<0.050	<0.050	<0.050
Lithium (Li)-Total	<0.010	<0.010	<0.010
Magnesium (Mg)-Total	4.73	2.98	4.82
Manganese (Mn)-Total	0.0876	0.0088	0.0300
Molybdenum (Mo)-Total	<0.030	<0.030	<0.030
Nickel (Ni)-Total	<0.050	<0.050	<0.050
Phosphorus (P)-Total	<0.30	<0.30	<0.30
Potassium (K)-Total	<2.0	<2.0	<2.0
Selenium (Se)-Total	<0.20	<0.20	<0.20
Silicon (Si)-Total	5.61	5.98	5.68
Silver (Ag)-Total	<0.010	<0.010	<0.010
Sodium (Na)-Total	8.6	11.3	10.1
Strontium (Sr)-Total	0.0666	0.0418	0.0556
Thallium (Tl)-Total	<0.20	<0.20	<0.20
Tin (Sn)-Total	<0.030	<0.030	<0.030
Titanium (Ti)-Total	<0.010	0.011	<0.010
Vanadium (V)-Total	<0.030	<0.030	<0.030
Zinc (Zn)-Total	<0.0050	<0.0050	<0.0050

Table 10 Total metal analysis conducted by ALS laboratories in Richmond, BC for stations one and four during sampling event two within Cottle Creek, Nanaimo BC.

Total Metals	**Station 1**	**Station 4**
Aluminum (Al)-Total	<0.20	<0.20
Antimony (Sb)-Total	<0.20	<0.20
Arsenic (As)-Total	<0.20	<0.20
Barium (Ba)-Total	<0.010	<0.010
Beryllium (Be)-Total	<0.0050	<0.0050
Bismuth (Bi)-Total	<0.20	<0.20
Boron (B)-Total	<0.10	<0.10
Cadmium (Cd)-Total	<0.010	<0.010
Calcium (Ca)-Total	19.6	13.9
Chromium (Cr)-Total	<0.010	<0.010
Cobalt (Co)-Total	<0.010	<0.010
Copper (Cu)-Total	<0.010	<0.010
Iron (Fe)-Total	0.424	0.245
Lead (Pb)-Total	<0.050	<0.050
Lithium (Li)-Total	<0.010	<0.010
Magnesium (Mg)-Total	5.79	3.94
Manganese (Mn)-Total	0.0523	0.0203
Molybdenum (Mo)-Total	<0.030	<0.030
Nickel (Ni)-Total	<0.050	<0.050
Phosphorus (P)-Total	<0.30	<0.30
Potassium (K)-Total	<2.0	<2.0
Selenium (Se)-Total	<0.20	<0.20
Silicon (Si)-Total	7.48	6.18
Silver (Ag)-Total	<0.010	<0.010
Sodium (Na)-Total	10.2	9.2
Strontium (Sr)-Total	0.0791	0.0497
Thallium (Tl)-Total	<0.20	<0.20
Tin (Sn)-Total	<0.030	<0.030
Titanium (Ti)-Total	<0.010	<0.010
Vanadium (V)-Total	<0.030	<0.030
Zinc (Zn)-Total	<0.0050	<0.0050

5.0 Invertebrate Communities

On October 28, 2014, four samples were obtained using a Hess sampler at three locations within Cottle Creek. During the sample week the watershed received a significant amount of rainfall producing higher than average water depth and flow. This made sampling difficult and the results obtained may not be a true reflection of invertebrate density and richness. Additionally, during sampling an invasive fish species; pumpkin seed *(Lepomis gibbosus)* was captured. This fish was not known to exist in the watershed previously and may be having a negative impact on invertebrate populations.

5.1 Total Density, Richness and Diversity

Sample station one yielded a total capture of 22 invertebrates. Invertebrates will fall into one of three specialized categories dependant on the water quality necessary for species survival. The three categories include pollution intolerant, somewhat pollution tolerant and pollution tolerant. Pollution intolerant species captured at station one totalled 4, somewhat pollution tolerant species totalled 7 and pollution tolerant species yielded 11 (figure 2). From these results we can conclude that pollution tolerant species thrive in this section of the creek. Total invertebrate density per total area sampled was 61 m^2 with the predominant taxon being aquatic worm (*oligochaete)*. Pollution tolerant species are an indicator of poor overall stream health. This sample site lies outside of Linely Valley in a populated urban area. Runoff from this area may be a factor contributing to poor site conditions.

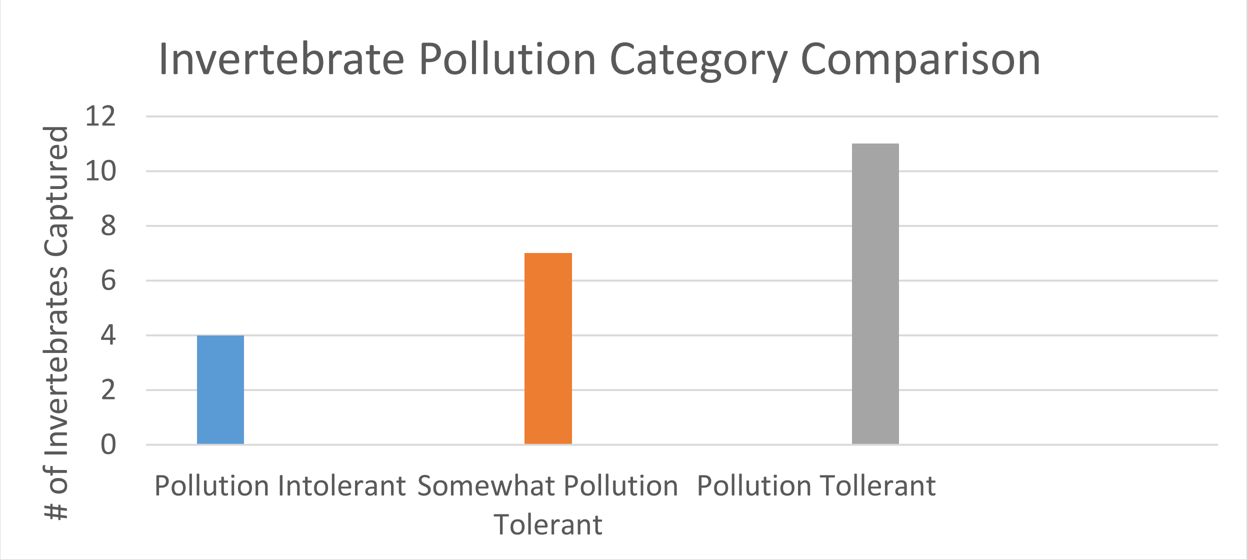

Figure 2 Invertebrate Pollution Category Comparison obtained from sample station one during sampling event one within Cottle Creek, Nanaimo BC. Invertebrate survey field data sheets can be found within the appendix.

Sample station three yielded a total capture of 94 invertebrates. Pollution intolerant species made up 68 percent of this total with 64 captured. All 64 pollution intolerant species captured were those of the EPT taxa. A high number of EPT taxa species indicates good overall stream health. Somewhat pollution tolerant species totalled 17, while pollution tolerant species totalled 13 (Figure 3). Invertebrate density per total area sampled was 252 m^2 with the predominant taxon being stonefly nymph (EPT). Sampling at this station was particularly difficult as water levels were above waist deep.

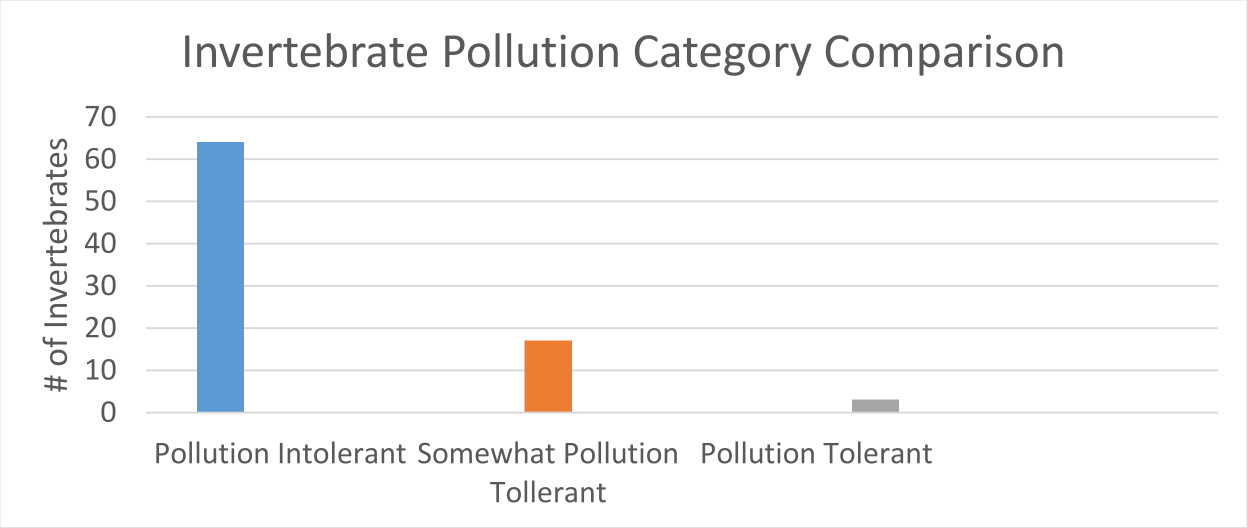

Figure 3 Invertebrate Pollution Category Comparison obtained from sample site three during sampling event one within Cottle Creek, Nanaimo BC. Invertebrate survey field data sheets can be found within the appendix.

Sample station number four yielded 24 EPT taxa species out of a total of 30 captured. Pollution tolerant species captured was 4 while no pollution tolerant species were captured (figure 4). The large amount of pollution intolerant species captured indicates overall good water quality at this site. Invertebrate density per total area sampled was 83 m^2 while the predominant taxon was mayfly nymph (EPT).

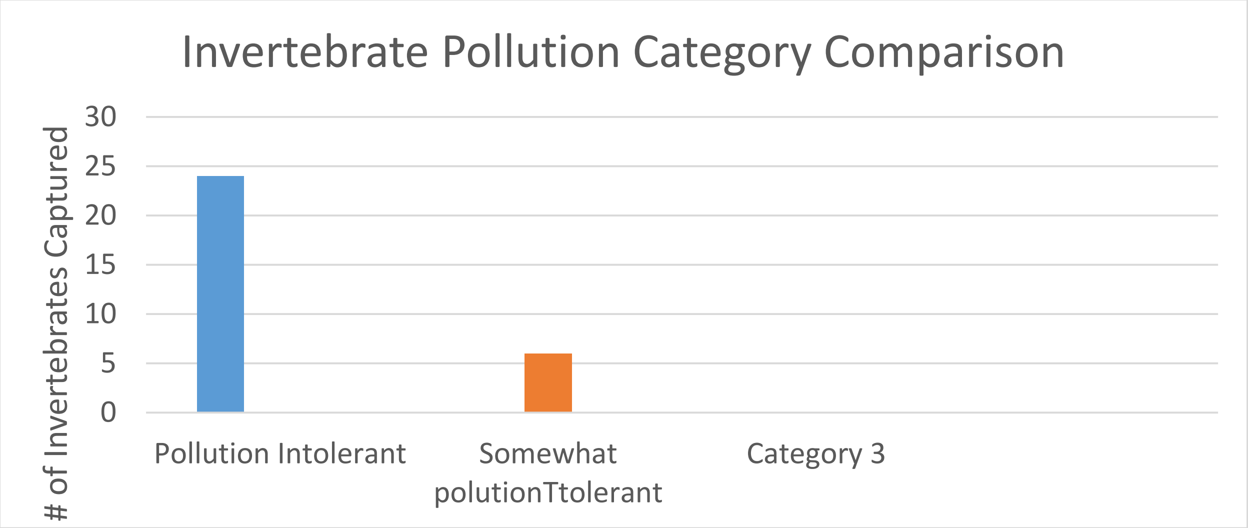

Figure 4 Invertebrate pollution category comparison obtained from sample site four during sampling event one within Cottle Creek, Nanaimo BC. Invertebrate field data sheets can be found within the appendix

In total 146 invertebrates were captured over the three sample sites. Pollution intolerant species totalled 92 while somewhat pollution tolerant species totalled 30 and pollution tolerant species totalled 24 (Figure 5). As mentioned previously, high numbers of pollution intolerant species indicates good overall stream health. Because creek water levels were high, capture was difficult. I believe at lower conditions capture rates would be higher either supporting the high capture rate of EPT taxon species or contradicting it.

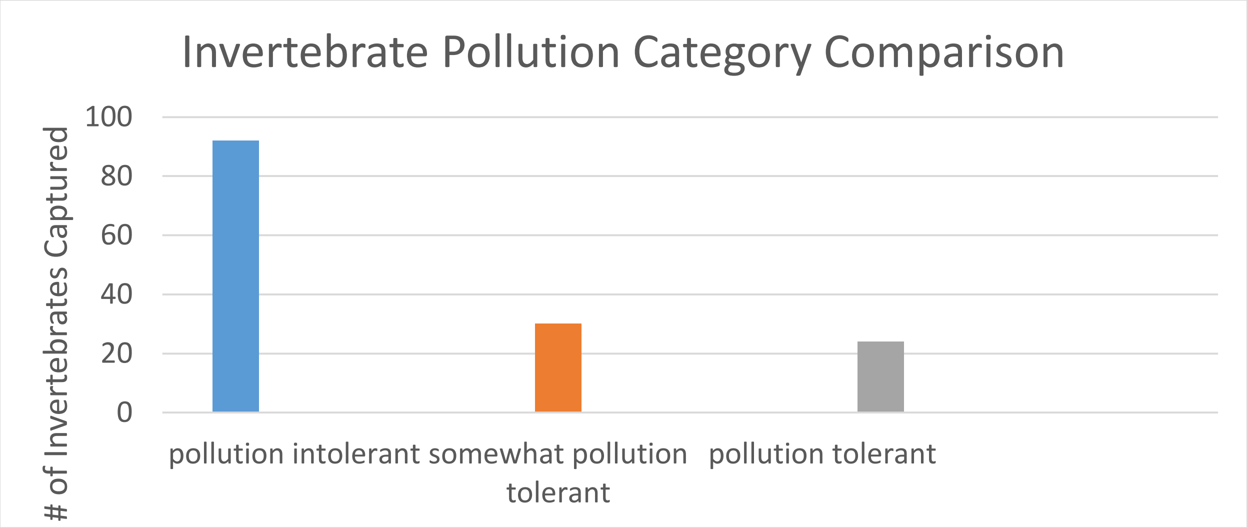

Figure 5 Invertebrate pollution category comparison obtained from an average obtained from sites one, three and four during sampling event one within Cottle Creek, Nanaimo BC. Invertebrate field data sheets can be found within the appendix

5.6 Taxa Richness and Diversity, Site Assessment

When obtaining an overall site assessment rating, four different index categories must be analyzed. The pollution tolerance index is obtained by using the number of invertebrate taxa captured in each category (pollution intolerant, somewhat pollution tolerant, and pollution tolerant). The pollution tolerance index is a means of measuring stream quality based on indicator organisms and their pollution tolerance levels. Site one and four received a marginal assessment rating while site three received a good assessment rating.

The EPT index is measured by adding up the total amount of EPT taxa. The EPT index of water quality is based on the abundance of three pollution-sensitive orders of invertebrates. All sites sampled received a marginal rating. Although a high number of EPT taxon species were captured in comparison to non-EPT taxon the number of taxa of these species was low resulting in a marginal EPT index.

The EPT to total ration index is calculated by adding the total number of EPT organisms divided by the total number of organisms. Site one received a poor assessment as 4 EPT organisms were captured out of 22 total organisms. Site three received a good assessment rating, out of 94 total organisms 64 were EPT taxon. Site four received an acceptable site assessment, where 24 EPT taxon were captured out of a possible 30 organisms.

The predominant taxon ratio index is a measure of the number of invertebrates in the predominant taxon divided by the total number of invertebrates caught. Sample site one and four received acceptable ratings whereas sample site three received a marginal rating.

Once assessment ratings are obtained for the four pre-mentioned indexes an average rating can be calculated. Site one received a marginal overall rating whereas site three and four received acceptable ratings.

5.7 Quality assurance Quality Control

At each station, four samples were obtained by the same individual using a Hess sampler for each sample. The collector began downstream and worked upstream to reduce variability. Once collected the samples remained closed and continuity was exhibited until counts were taken. Counts were double checked to ensure numbers were correct.

6.0 Conclusion and Recommendations

6.1 Conclusion

Results obtained after two sampling events indicate that the Cottle Creek watershed is a healthy ecosystem. Physical and chemical parameters tested were within the guidelines. Biological testing of stream macro invertebrates indicated marginal to acceptable health. As mentioned previous, due to high water conditions biological monitoring was highly variable. It is tough to distinguish whether the results are due to water quality or poor habitat conditions. Additionally the introduction of the invasive pumpkin seed *(Lepomis gibbosus)*, may have had adverse effects on macro invertebrate populations. Phosphate levels have dropped since the previous study was conducted and are not of concern this year. Turbidity levels were high during the first sampling event due to high water runoff caused by large amounts of precipitation. Station three had high turbidity levels during both events. This is due to a manmade obstruction running under Nottingham Road resulting in a backup of sediment. Microbiology testing revealed fecal bacteria counts to exist at significant levels within the watershed. This was especially evident at site two located within Linely Valley. Fecal bacteria counts are high at this site due to the amount of mammals utilizing the park.

6.2 recommendations

It is recommended that a monitoring program for this watershed be conducted annually. Although no anadromous salmon species utilize the creek many birds, mammals, amphibians and reptiles are reliant on the water course for survival. Additionally, as the surrounding development expands developers may become complacent not adhering to guidelines set forth by legislation and environmental effects monitoring plans.

7.0 Acknowledgements

We would like to acknowledge Dr. Eric Demers, instructor of RMOT 306 Environmental Monitoring for overseeing this valuable project. We would also like to acknowledge Vancouver Island University and the sponsoring committees for providing the finding required for this project to be successful.

8.0 References

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Appendix A Sample Site Photographs

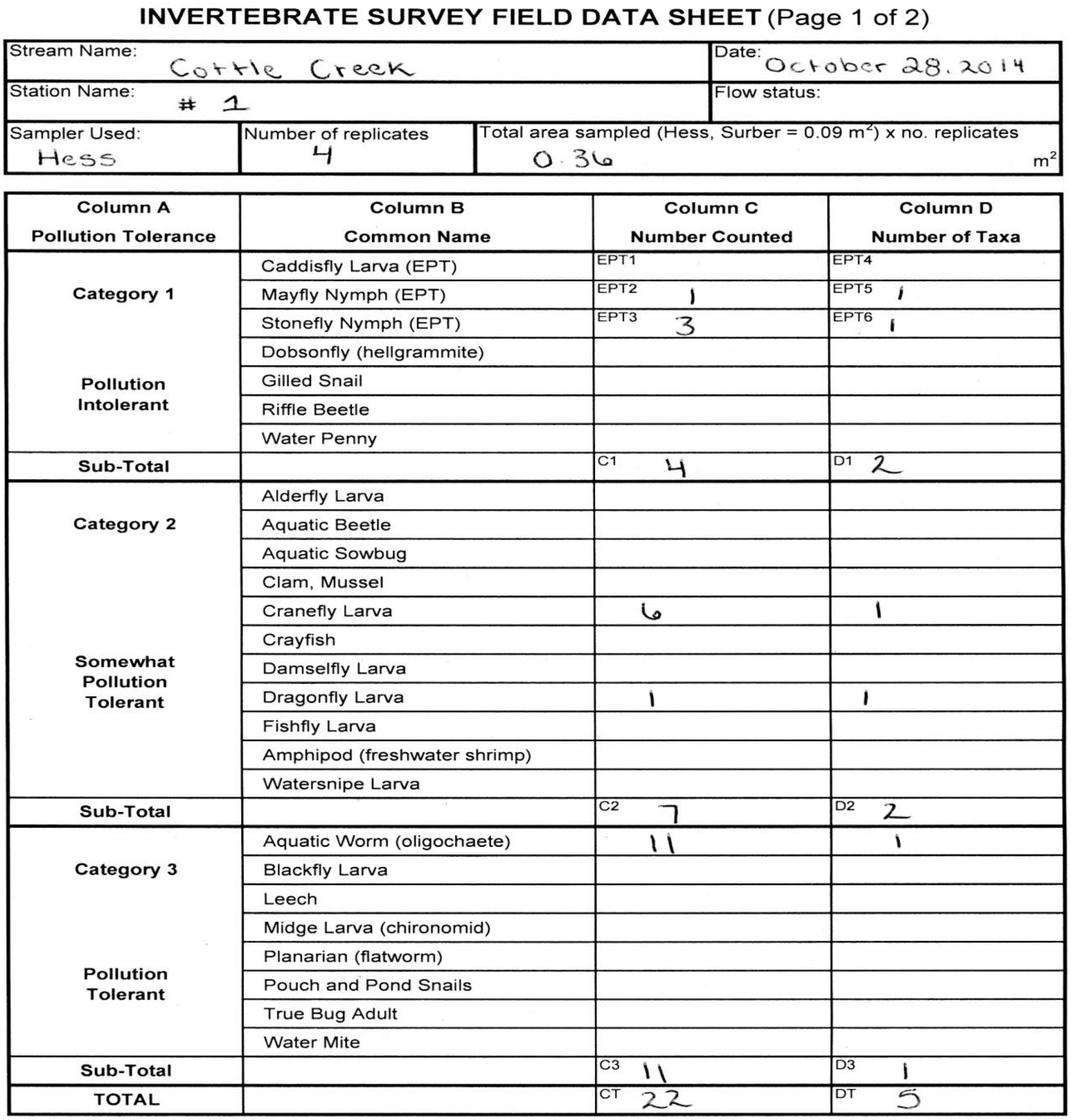
Figure 6: Sample Site #1 Cottle Creek, Nanaimo BC, @Landalt Road (October 15, 2014). From Departure Bay Rd, turn onto Rock City Rd, L on Landalt Rd. Cottle Ck crosses Landalt, and Sample upstream (west) of road.

Figure 7: Sample Site #2 North Cottle Creek 100m Downstream from Burma Rd (October 15, 2014). From Hammond Bay, Rd, turn onto Malaspina, than L onto Laguna way, R onto Lost Lake Rd and L onto Burma Rd. Hike down trail to you cross small creek. This is north Cottle Creek. Sample 5m downstream of bridge.

Figure 8: Sample Site #3 Cottle Creek @ Nottingham (October 15, 2014). Going north on Hammond Bay Road turn onto second Nottingham Drive. After about 150 m you will cross Cottle Creek. Sample upstream where road crosses (north.

Figure 9: Sample Site # 4 Cottle Creek @ Stephenson Pt RD (October 15, 2014). Going north on Hammond Bay Road turn right onto Stephenson Point Road. After about 150 m you will cross Cottle Creek. Sample upstream from road

Appendix B: Invertebrate Survey Field Data Sheets



INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name: Cottle Creek

Date: October 28. 2014

Station Name: # 1

Flow status:

Sampler Used: Hess

Number of replicates 4

Total area sampled (Hess, Surber = 0.09 m^2) x no. replicates 0.36 m^2

Column A Pollution Tolerance	Column B Common Name	Column C Number Counted	Column D Number of Taxa
Category 1 Pollution Intolerant	Caddisfly Larva (EPT)	EPT1	EPT4
	Mayfly Nymph (EPT)	EPT2 1	EPT5 1
	Stonefly Nymph (EPT)	EPT3 3	EPT6 1
	Dobsonfly (hellgrammite)		
	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		C1 4	D1 2
Category 2 Somewhat Pollution Tolerant	Alderfly Larva		
	Aquatic Beetle		
	Aquatic Sowbug		
	Clam, Mussel		
	Cranefly Larva	6	1
	Crayfish		
	Damselfly Larva		
	Dragonfly Larva	1	1
	Fishfly Larva		
	Amphipod (freshwater shrimp)		
	Watersnipe Larva		
Sub-Total		C2 7	D2 2
Category 3 Pollution Tolerant	Aquatic Worm (oligochaete)	11	1
	Blackfly Larva		
	Leech		
	Midge Larva (chironomid)		
	Planarian (flatworm)		
	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite		
Sub-Total		C3 11	D3 1
TOTAL		CT 22	DT 5

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell **CT**: S1 22

DENSITY: Invertebrate density per total area sampled:

S1 22 ÷ 0.36 m² = S2 61.1 /m²

PREDOMINANT TAXON:
Invertebrate group with the highest number counted (Col. C) S3 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	17-22	[✓ 11-16]	<11

3 x D1 + 2 x D2 + D3

3 x 2 + 2 x 2 + 1 = S4 11

EPT INDEX: Total number of EPT taxa.

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

EPT4 + EPT5 + EPT6

0 + 1 + 1 = S5 2

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

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

(EPT1 + EPT2 + EPT3) / CT

(0 + 1 + 3) / 22 = S6 0.18

SECTION 3 - DIVERSITY

TOTAL NUMBER OF TAXA: Total number of taxa from cell **DT**: S7 5

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

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

Col. C for S3 / CT

11 / 22 = S8 0.5

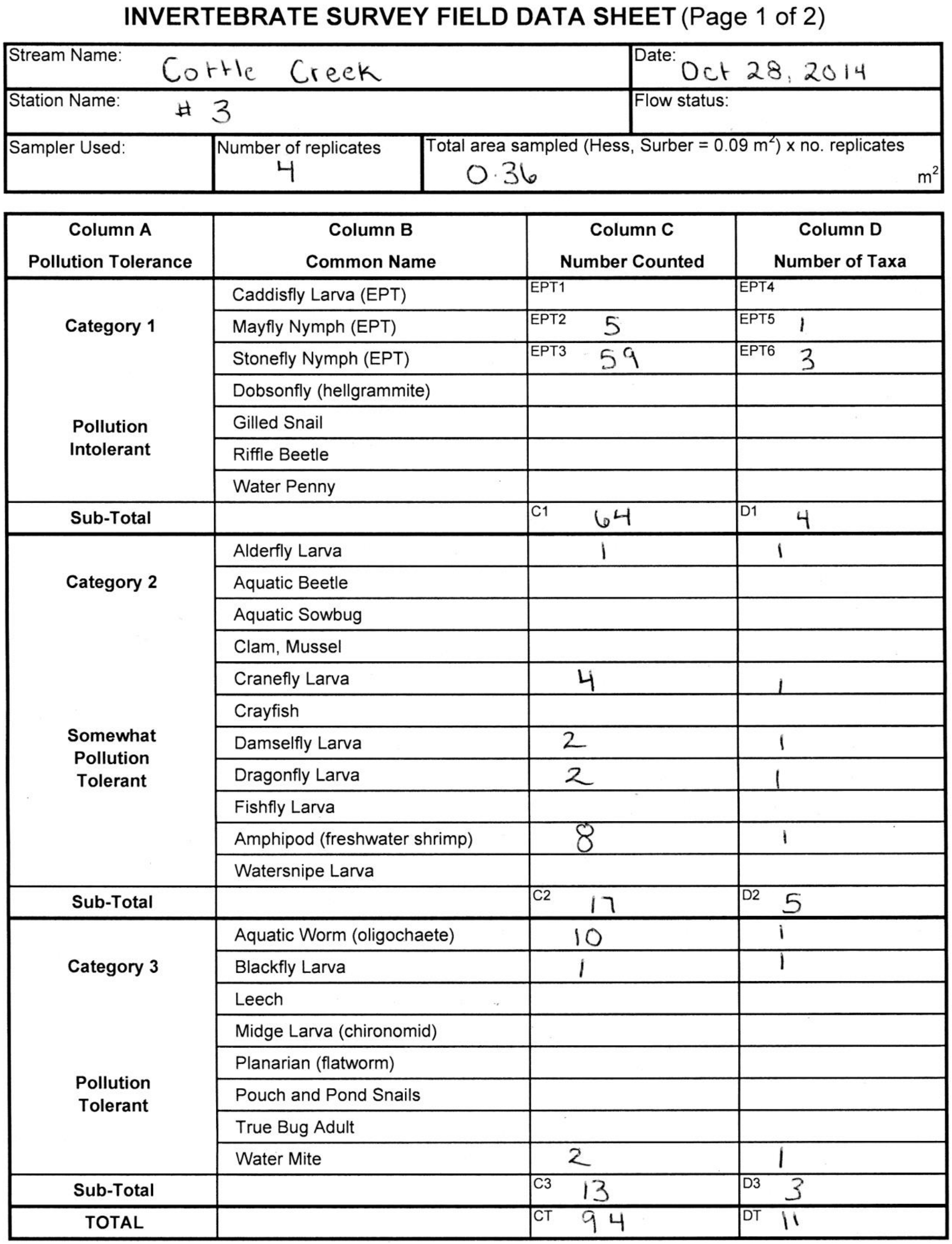
SECTION 4 - OVERALL SITE ASSESSMENT RATING

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

Assessment Rating	
Good	4
Acceptable	3
[✓ Marginal]	[✓ 2]
Poor	1

Assessment	Rating
Pollution Tolerance Index	R1 2
EPT Index	R2 2
EPT To Total Ratio	R3 1
Predominant Taxon Ratio	R4 3

Average Rating
Average of R4, R5, R6, R8 2



INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name: Cottle Creek		Date: Oct 28, 2014
Station Name: # 3		Flow status:
Sampler Used:	Number of replicates 4	Total area sampled (Hess, Surber = 0.09 m^2) x no. replicates 0.36 m^2

Column A Pollution Tolerance	Column B Common Name	Column C Number Counted	Column D Number of Taxa
Category 1	Caddisfly Larva (EPT)	EPT1	EPT4
	Mayfly Nymph (EPT)	EPT2 5	EPT5 1
	Stonefly Nymph (EPT)	EPT3 59	EPT6 3
	Dobsonfly (hellgrammite)		
Pollution Intolerant	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		C1 64	D1 4
Category 2	Alderfly Larva	1	1
	Aquatic Beetle		
	Aquatic Sowbug		
	Clam, Mussel		
	Cranefly Larva	4	1
	Crayfish		
Somewhat Pollution Tolerant	Damselfly Larva	2	1
	Dragonfly Larva	2	1
	Fishfly Larva		
	Amphipod (freshwater shrimp)	8	1
	Watersnipe Larva		
Sub-Total		C2 17	D2 5
Category 3	Aquatic Worm (oligochaete)	10	1
	Blackfly Larva	1	1
	Leech		
	Midge Larva (chironomid)		
Pollution Tolerant	Planarian (flatworm)		
	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite	2	1
Sub-Total		C3 13	D3 3
TOTAL		CT 94	DT 11

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name: Cottle Creek

Date: Oct 28, 2014

Station Name: # 4

Flow status:

Sampler Used:

Number of replicates 4

Total area sampled (Hess, Surber = 0.09 m^2) x no. replicates 0.36 m^2

Column A Pollution Tolerance	Column B Common Name	Column C Number Counted	Column D Number of Taxa
	Caddisfly Larva (EPT)	EPT1	EPT4
Category 1	Mayfly Nymph (EPT)	EPT2 15	EPT5 1
	Stonefly Nymph (EPT)	EPT3 9	EPT6 1
	Dobsonfly (hellgrammite)		
Pollution Intolerant	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		C1 24	D1 2
	Alderfly Larva		
Category 2	Aquatic Beetle		
	Aquatic Sowbug		
	Clam, Mussel		
	Cranefly Larva	1	1
	Crayfish		
Somewhat Pollution Tolerant	Damselfly Larva		
	Dragonfly Larva		
	Fishfly Larva		
	Amphipod (freshwater shrimp)	5	1
	Watersnipe Larva		
Sub-Total		C2 6	D2 2
	Aquatic Worm (oligochaete)		
Category 3	Blackfly Larva		
	Leech		
	Midge Larva (chironomid)		
	Planarian (flatworm)		
Pollution Tolerant	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite		
Sub-Total		C3 0	D3 0
TOTAL		CT 30	DT 4

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell **CT**: S1 30

DENSITY: Invertebrate density per total area sampled:

S1 30 ÷ 0.36 m² = S2 83.3 /m²

PREDOMINANT TAXON: Invertebrate group with the highest number counted (Col. C) S3 may fly nymph

SECTION 2 - WATER QUALITY ASSESSMENTS

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

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

3 x D1 + 2 x D2 + D3

3 x 2 + 2 x 2 + 4 = S4 14

EPT INDEX: Total number of EPT taxa.

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

EPT4 + EPT5 + EPT6

0 + 1 + 1 = S5 2

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

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

(EPT1 + EPT2 + EPT3) / CT

(0 + 15 + 4) / 30 = S6 0.63

SECTION 3 - DIVERSITY

TOTAL NUMBER OF TAXA: Total number of taxa from cell **DT**: S7 4

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

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

Col. C for S3 / CT

15 / 30 = S8 0.50

SECTION 4 - OVERALL SITE ASSESSMENT RATING

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

Assessment Rating	
Good	4
Acceptable	3
Marginal	2
Poor	1

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

Average Rating

Average of R4, R5, R6, R8

3