Water Quality Assessment of the C.W. Young Channel of the Englishman River, Parksville, British Columbia

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Executive Summary

The Englishman River is a historically valuable river located on southeastern side of central Vancouver Island near the city of Parksville. This 40km river is not only an important fish bearing river, but it also supplies the city of Parksville and surrounding area with drinking water. The Englishman River presents much ecological and cultural importance to Vancouver Island residents as fisheries in the area have played an important role in the livelihood of residents for thousands of years. In 1992, an enhanced spawning channel was developed off the Englishman River to support successful spawning and rearing of Pacific salmon, this channel is known as the C.W. Young channel. With increased local development and urbanization, a notable decline in fish stocks has been observed. This decline has influenced many organizations to appraise and conduct monitoring projects on the Englishman River and the C.W. Young channel. Since 2008, Vancouver Island University students have been continuously monitoring the C.W. Young channel to assess the overall health of the channel and the Englishman River as a whole. This year's environmental monitoring project on the C.W. young channel was conducted by undergraduate students Madison Benton, Steve Egan, AJ Johnston and Curtis Ripmeester of the Natural Resource Protection program supervised by Dr. Eric Demers. Hydrology, microbiology and stream invertebrate samples were obtained on two different sampling events (October 30, 2019, November 20, 2019) at 5 pre-determined sampling sites with established procedures to maintain consistencies with previous environmental monitoring projects. Samples were later analyzed at the Vancouver Island University lab and AIS lab in Burnaby, BC to ensure accuracy with analysis. The results were compared to the BC's Water Quality Guidelines for aquatic life which supports that the C.W. Young channel is relatively healthy. Our results are consistent with previous monitoring projects on the C.W. Young channel verifying that the channel continues to be a relatively healthy and productive ecosystem that supports an abundance of terrestrial and aquatic life.

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1.0 Introduction

1.1 Background

The Englishman River is one of British Columbia's most valuable coastal rivers, it is located on Vancouver Island near the City of Parksville. The Englishman River (Water Region 4) flows from the headwaters located on Mt. Arrowsmith (1819m) into the Strait of Georgia in the Salish Sea, just north of Craig Bay with a total drainage area of 324km^2 (RDN 2019b). The headwaters found on Mt. Arrowsmith are Arrowsmith Lake, Hidden Lake and Fishtail Lake (RDN 2019b). During the late 1990's, Arrowsmith Dam was established on Arrowsmith Lake to support municipal water demand and conserve water to support the Englishman River during dry summer months. More than 50% of the water stored in Arrowsmith Lake is to supply the Englishman River (OOW 2019). The Englishman River has 5 tributaries that drain into the main stem; the South Englishman River, Moriaty Creek, Morrison Creek, Swain Creek and Shelley Creek (RDN 2019b). Local fisheries have played an important role in the livelihood of Vancouver Island residents for thousands of years; including recreational, commercial and First Nation's fisheries. Wild salmon serve as a vital source of food and economic security as well as cultural and spiritual significance; West Coast communities have always had a strong allegiance with Pacific salmon (DFO 2005). Historically, this watershed maintained all 5 species of Pacific salmon; Chum, Coho, Sockeye, Chinook and Pink along with observations of Steelhead, Cutthroat and Rainbow trout (Decker et al. 2002). In 2005, the Englishman River Regional Park (figure 1) was established to conserve and maintain the riparian and forested areas along the

Englishman River (RDN 2019a). This project was initiated by the Regional District of Nanaimo who partnered with the Province of BC, Nature Trust of BC, Nature Conservancy of Canada and Ducks Unlimited Canada. This 207-hectare park offers kilometres of hiking and biking trails, wildlife viewing and world class fishing (RDN 2019a) although with increased development and logging, a notable decline in fish stocks has been observed. Potential environmental impacts on the Englishman River are a result of urbanization near the watershed. With agricultural and residential areas nearby, there are potential risks of water contamination from agricultural run-off, including fecal contaminated water and fertilizers as well as potential contamination from nearby septic systems, stormwater and road run-off (Decker et al 2002). Management of Pacific Salmon has progressively become more challenging due to a multitude of direct and indirect variants and environmental impacts (DFO 2005) which is what lead to the creation of the *C.W. Young Channel*.

In 1992, a spawning channel was created and funded by Timberwest on the Englishman River to support returning Coho salmon *(Onchorhynchus kisutch)* and encourage successful spawning and rearing of juveniles (Decker et al. 2002). Since then, the channel has been lengthened and modified and has received funding from additional organizations such as Fisheries and Oceans Canada. Historically the channel was known as the *Timberwest Channel* however, today this channel is known as the *C.W. Young Channel*. This enhanced ecosystem was carefully constructed to create habitat units that would create security and refuge for Coho salmon during the spawning and overwintering season (Decker et al. 2002). During the fall, when Pacific salmon are returning to their natal river, specifically the Englishman River, conditions can be harsh and relentless leaving the success rate of juveniles very low. Overwintering survival rate is directly correlated with habitat quality (Decker et al. 2002) The *C.W. Young Channel* was constructed with a valve intake that is connected to the main stem of the Englishman River, this authorizes control over the water levels, turbidity and other factors that allow the channel to be relatively consistent. Ample information and data have been collected on the importance of side-channel habitats and the specific factors that can influence the success rate of spawning salmon, this includes factors related to the river directly and surrounding environments. The C.W. Young channel has a very low gradient, approximately <2% and is composed of a variety of substrates from silt, fines and gravel to larger cobble and boulders, with each sampling site consisting of different substrates. The Englishman River Regional Park is a dense secondary forest that consists of Big leaf maple trees, Douglas fir trees, Western hemlock trees and a variety of shrubs and aquatic, wetland plants (RDN 2019a) which help to create cover and filter and decelerate runoff before entering waterways (MacGregor et al. 2016).

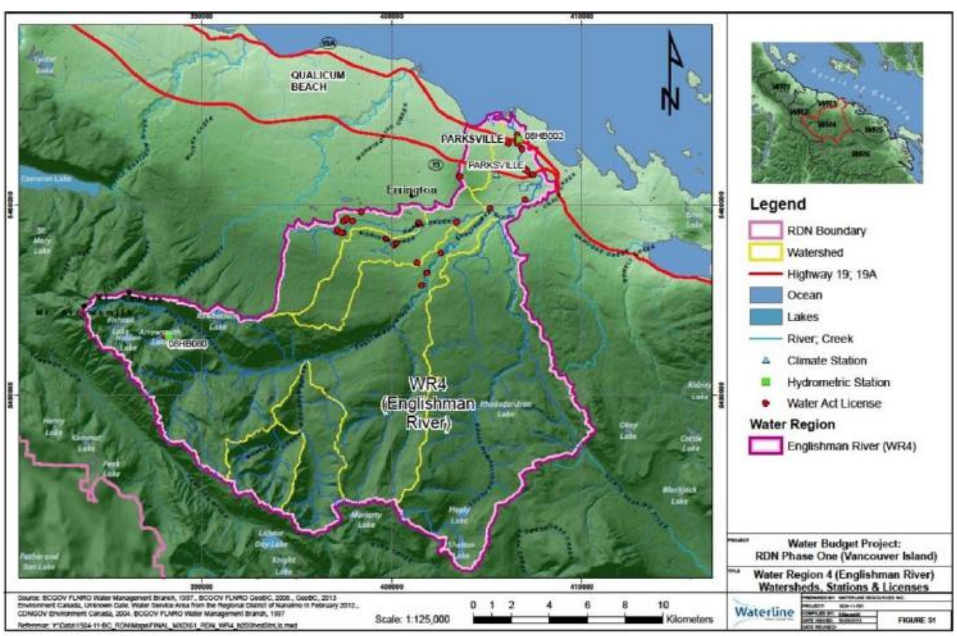

Figure 1: Water region 4 map. Englishman River (and tributaries) from headwaters to Strait of Georgia (RDN 2019).

1.2 Project Overview

The Englishman River is a river of ecological and cultural importance, it has been studied for many years and has been classified as a river of special concern. Since 2008, students from Vancouver Island University (VIU) have conducted an annual environmental monitoring project to assess the health of the C.W. Young Channel, an enhanced spawning channel that was created in 1992 to support salmon returning the Englishman River. Madison Benton, Stephen Egan, AJ Johnston and Curtis Ripmeester, four undergraduate students of the Bachelor of Natural Resource Protection program at VIU, conducted a monitoring project to asses water quality, microbiology and stream invertebrate health of the C.W. Young channel; supervising the 2019 project was Dr. Eric Demers.

Two sampling events occurred on October 30 and November 20, 2019 with expectations of sampling during a low and high flow period to compare variations in water quality. During each event, the team obtained water samples from 5 recognized sampling sites that have been established since the continuous monitoring project began in 2008. Water quality analysis will be conducted at the VIU lab by Benton, Egan, Johnston and Ripmeester as well as the ALS lab in Burnaby, BC. Stream invertebrate samples were also collected at sites 1, 3, 4 using a Hess sampler which were brought back to the VIU lab for analysis. By continuing to conduct annual sampling on the C.W. Young channel, we can monitor and assess the overall ecosystem health and acknowledge imminent changes within the river. Due to increased activity, development and urbanization it is crucial to appraise and monitor important aquatic ecosystems to ensure proper management and conservation for years to come.

3.0 Proposed Environmental Sampling and Analytical Procedures

3.1 Proposed Environmental Sampling and Analytical Procedures

3.1.1 Location and Habitat Characteristics

This assessment is a part of a long-term environmental monitoring project on the C.W Young channel. This environmental monitoring project has been continuous since 2008 and the yearly results go towards building a cohesive long-term environmental assessment. To maintain consistency with previous procedures, the project continued with the established protocols, locations, and sampling intervals. This is necessary for validity, due to potential changes in environment and possible environmental trends it is crucial the yearly projects can be replicated.

The selection of the five locations was based on certain characteristics. These characteristics are important because the five sample sites have to best represent the C.W Young channel, therefore, the sites were chosen based on; the distance from channel head water, canopy cover, water flow, and site substrate. Other contributing factors include site accessibility and crew safety.

The five locations were visited on October 16, 2019 and initial assessment data was collected. The five sites will be subject to three environmental monitoring assessments which are water quality, microbiology, and stream invertebrate biodiversity. The combination of the three helped assess the overall health of the C.W. Young channel.

The five locations begin at the head water of the C.W. Young Channel and continue downstream until the channel meets the Englishmen River. The site numbers and locations are displayed in figure 1. The sites are spaced out enough along the channel to ensure that the channel is being best represented.

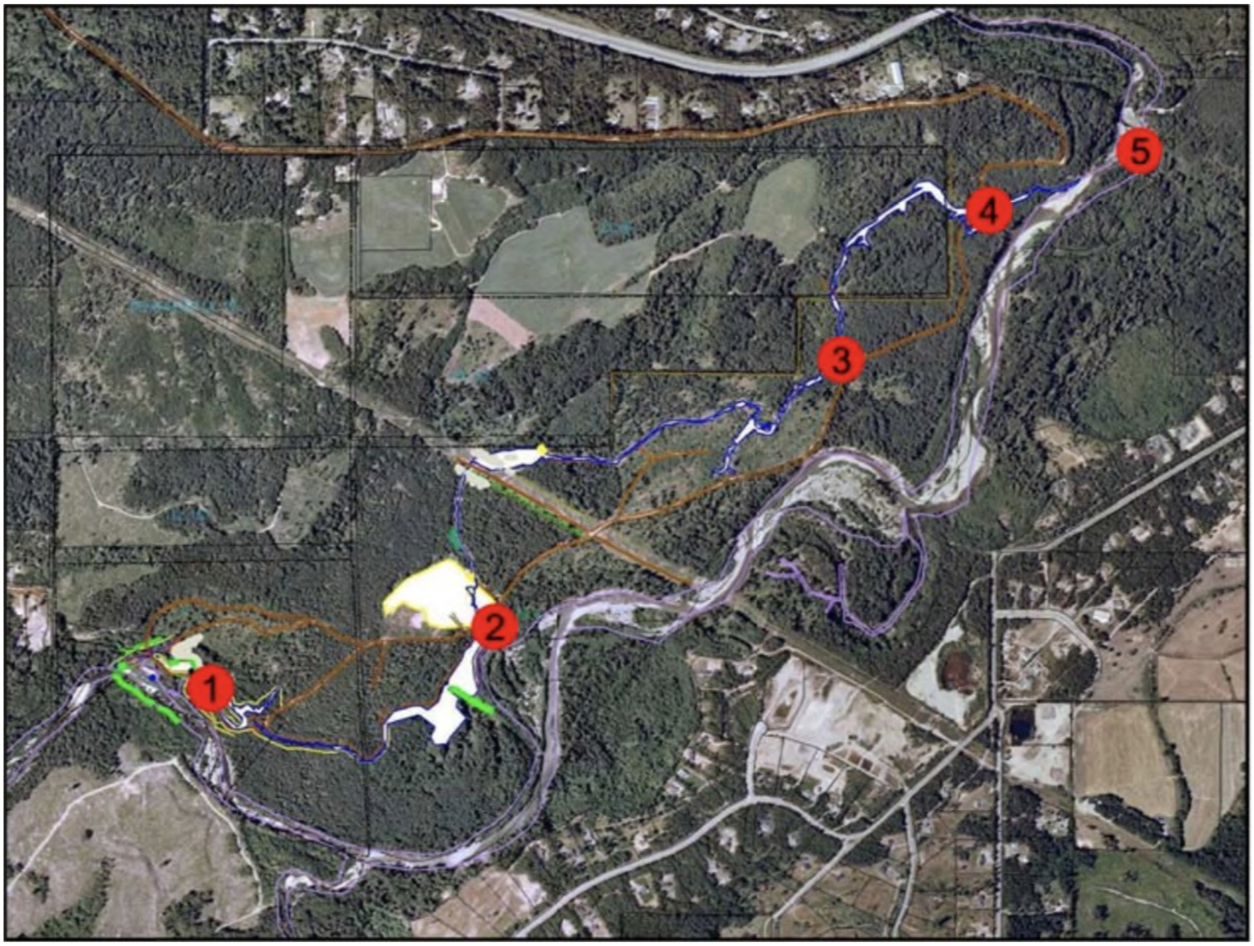

Figure 2: Environmental Assessment Sites Locations along the C.W. Young Channel

The first site is located at the beginning of the C.W. Young channel (UTM 10 U 0405267mE 5459846mN). Site #1 contains the outflow pipe for the channel, the outflow pipe creates a deep pool, because of this the sampling took place 5 meters down from the outflow pipe. The substrate at this location consists of (80%) course gravel and (20%) slit. The gradient downstream of the outflow pipe is <1˚. The canopy coverage was (<10%) and contains Red Alder (*Alnus rubara*) and Big Leaf Maple (*Acer marcophyllum)*, the riparian zone consisted of the same tree species but includes numerous grasses and shrubs. The entrance into this site is steep and slippery, caution will be taken when entering and exiting the site.

Site #2 is located (UTM 10 U 0406143mE 5459962mN) where the access road crosses the channel and is 1250m downstream of site #1. The sampling station is 3 meters downstream of the metal culvert which runs under the access road. The gradient of this site is comparable to site #1 but the water has more flow at this location and could be considered a riffle. However, the substrate of this location is quite different and consists of course gravel (60%), cobble (20%), boulders (10%) and large woody debris (10%). The canopy cover is (<30%) and is comprised of Douglas firs (*Pseudotsuya menziesii)* and Western Red Cedars (*Thuja plicata)*, the riparian zone consists mostly of salal (*Gaultheria shallon).*

The third site (UTM 10U 0407089mE 5460663mN) is located 2900m downstream of site #1 and is found ~ 50m west of the access road. The sample station is 3 meters downstream of the bend in the channel. The gradient of site #3 is low and resulting in slow water flow. The canopy is limited to (<10%) and is comprised of Big Leaf Maples and Western Red Cedars. There is a large open meadow that consumes most of the riparian zone which consists of various grasses, downstream of the bend the riparian switches to salal and other shrubs. The sample station substrate consisted of coarse gravel (30%), cobble (30%), large woody debris (20%), and fines/slit (20%). The large meadow could be susceptible to flooding in high water conditions, therefore, accessibility could be more difficult for the crew.

Site #4 (UTM 10U 0407495mE 5461056mN) is located 3800m downstream of site #1. The site is unique from the rest as it has a metal footbridge in it, this footbridge has a water level measurement on the side and is used to monitor water level in channel. The metal footbridge creates a drop resulting in a cascade and isn't suitable for sampling, therefore, the sample station will be 5 meters downstream of the bridge. The canopy covered is (~40%) consisting of Douglas firs and Maple trees. The sample station substrate is mostly large cobble (50%), coarse gravel (20%), Boulders (20%) and fines/slit (10%). The surrounding riparian zone has sword ferns, salal, and salmonberry shrubs. There is a large pool located upstream of the bridge, if the water level was to increase it could make sampling this site more difficult.

The last sample station site #5 is located on the Englishmen River and is downstream of the outflow of the channel. Site #5 (UTM 10U 0407805mE 5461177mN) has no canopy coverage as the confluence of the channel and river is very open. The riparian zone is dominated by willow. The Englishmen substrate is very different from the C.W. Young channel and consists of cobble (80%), boulders (5%), and course gravel (15%).

3.1.2 Sampling Frequency

There were two dates that field sampling occurred on. The field sampling dates were October 30, 2019 and November 20, 2019. Each of the dates had predetermined sampling procedures (Table 1). The first sampling date included water quality, microbiology, and stream invertebrate sampling. The majority of the sampling was done on the first date due to the possibility of significant alterations in water conditions. If the water level were to increase some of the sample stations will become unsamplable. Stream invertebrates were sampled at stations 1, 3, and 4. At each of the stream invertebrate sample stations 4 replicate samples were taken all 4 samples were combined as one during lab analyst.

Table 1: Water quality and stream invertebrate sampling activities conducted at each station on the C.W. Young Channel and Englishman River. The symbols "A" or "B" indicate whether samples / measurements were taken during the October 30, 2019 (A) or November 20, 2019 (B) sample events.

Water Quality Schedule					
Station	**Field Measurements**	**VIU Analyses**	**ALS Lab Analyses**	**Microbiology**	**Stream Invertebrates**
1	A, B	A, B	A, B	A	A
2	A, B	A, B	A, B	A	--
3	A, B	A, B	--	A	A
4	A, B	A, B	A, B	A	A
5	A, B	A, B	--	A	--

3.3 Water Quality

3.3.1 Field Measurements

A YSI 556 MPS electronic probe was used to test dissolved oxygen (mg/L), conductivity (μs/cm), and water temperature (˚C). Further analyst was conducted at VIU and ALS laboratory facilities of all other parameters.

3.3.2 Water Sample Collection

Two sampling events were conducted, the first of the two was done on October 30th, 2019 and the second was on November 20th, 2019. The alternating sample dates was to sample low flow and high flow events, with two sets of samples taken at each station on both dates. The proper measures were taken to ensure that there was no contamination of the water samples during sampling. This involved sampling being done starting at the furthest downstream site and sequentially continuing upstream. At each sample station the water sample was taken mid-stream below the surface with the sampler wearing nitrile gloves. Each sample bottle was rinsed three times to eliminate any possible contaminations. All samples were stored in a cooler and were analyzed within 12 hours after sampling at Vancouver Island University.

3.3.3 Vancouver Island University Analysis

The water samples that have been acquired were analyzed at a laboratory at VIU's Nanaimo Campus. The samples taken from all five sample stations arrived at VIU within 12 hours. Analyses was conducted to test total suspended solids (TSS), total alkalinity (mg/L

$CACO_3$), total hardness (mg/L $CACO_3$), nitrate (mg/L NO_3^-), and reactive phosphate (mg/L PO_4^{3-}).

3.3.4 ALS Laboratory Analysis

The water samples acquired from sample stations 1, 2, and 4 were stored and shipped in a Styrofoam cooler kept at approximately 4ºC to ALS laboratories in Vancouver, BC. ALS laboratories obtained the shipment within 48 hours of initial sample time. ALS laboratories conducted tests on the following; conductivity, pH, total hardness, nutrients (ammonia, nitrite, nitrate, orthophosphate and total phosphorus), and total metals (31 metals).

3.3.5 Quality Assurance/ Quality Control

To maintain accuracy in our assessment samples were acquired from the same sample stations on both sample events. The environmental assessment of the C.W. Young channel is ongoing, therefore, to keep consistency the sample stations stayed identical to the previous sample years (2008-2019). To ensure no contamination of the samples occurred, 1 field blank and 1 trip blank were included on each sample event for quality control. These two quality control samples were included in the VIU lab analysis.

3.3.6 Data Analysis

The result from both ALS and VIU laboratories were compiled and cross-referenced to the Water Quality Guidelines for Freshwater Aquatic Organisms. It was determined that the water parameters are being met and the C.W. Young channel has the adequate amount of aquatic life properties. The stream invertebrates were organized, categorized, and counted. The results were recorded onto a stream survey

3.4 Microbiology

All sites were sampled for coliforms at the first sampling event on October 16, 2019. Sites 1-5 contained both fecal and non-fecal coliforms (table 5) Colony forming units (CFU) per 100 ml ranged from 222-453 in our samples which is must higher range then previous results from 2017. Site 1 contained the highest number of total coliforms, and site 2 contained the lowest number of total coliforms. Sites 2 and 3 showed the highest percentages of fecal coliform. In addition, percentage of coliforms is much higher than when measured in 2017. The increase in coliform counts may be correlated to increased flow during sampling events between the two years. Most notably within our assessment is the increase in total coliform counts found within site 1. High coliform counts within this system would be expected due to the large amount of recreational acvtvity occurring near the stream. Main causes of coliform at these sites is likely a result of horses, dogs, wildlife and human activities. Water quality guidelines state that in order for human consumption, no CFU per 100 ml should be present (RISC, 1998). In the case of the C.W. Youngs Channel and the Englishman River it is important that proper water treatment is maintained for nearby residents and communities.

Table 2: Coliform counts from sampling event 1 on October 16, 2019

Microbiology	Total Coliform	Fecal Coliform	Non-coliform	% Fecal
Site 1	453	50	41	11.04
Site 2	222	71	50	31.98
Site 3	322	101	50	31.37
Site 4	292	40	30	13.70
Site 5	233	41	71	17.60

3.5 Stream Invertebrates

Invertebrate samples were taken on October 16th, 2019 at stations 1,3 and 4; four replicates were taken at each site. A total of 613 invertebrates were collected from the samples and analyzed in the lab. Species and taxa were separated and recorded onto data sheets for each site (Appendix). Overall the mayfly nymph was the most predominant species at all three sites. Site 5 showed the most organisms of all three sites with a total of 339 invertebrates, while site had the least totaling only 28 invertebrates. Overall site ratings were made on a scale of 1-4, 1 being poor and 4 being good (tables 6,7,8). This calculation was made based on the averages of results for population tolerance index, EPT index, EPT to total ratio, and predominant taxa ratio. The average of overall site ratings is 3.17 of which is between acceptable and good.

3.5.1 Total Invertebrate Density

Total density was calculated from result for total number of invertebrates within samples in correlation with amount of area sampled and number of replicates. Density of invertebrate varied from 77.8 inverts per square meter to 941.7 inverts per square meter; average density for the three sites was 567.6 invertebrates per square meter. Site 4 showed the highest density while site 1 showed the lowest; in contrast site 1 scored the highest overall assessment rating. This is likely due to the better predominant taxa ratio and EPT to total ratio.

3.5.2 Invertebrate Taxon Richness and Diversity

All sites had good pollution tolerance indexes due to high number of taxa within the pollutant tolerant insects. In addition, all sites show acceptable Ephemeroptera, Plecoptera, and Trichoptera (ETP) index. Due to the higher number of total invertebrates found in site 5, it represented a low score for ETP to total ratio. Site 3 recorded a poor rating for predominant taxon ratio due to the large number of mayflies found within the sample; over 80 % of the invertebrates discovered within this sample were mayfly nymphs (table 7). The predominance of mayfly nymphs is present in data from these same sites dating back several years.

Shannon-Wiener Diversity index was calculated for all three sites and number of species recorded was similar between site. Sites 1 and 3 recorded 7 different species, while site 4 recorded 8 different species. Shannon-Wiener Diversity index ranges from 0-1, 1 meaning high species diversity and 0 meaning low. Our samples ranged from 0.82 at site 1, 0.35 at site 3 and 0.66 at site 4. Site 3 has the lowest species diversity due the predominance of mayfly as mentioned prior. Overall the samples represent an average Shannon-Wiener Diversity index of 0.61.

Table 3: Site 1 Invertebrate assessment summary from C.W. Young channel

Assessment	Rating (rating value)
Total invertebrates collected	28
Total Taxa	10
Pollution Tolerance Index	23 (good)
EPT Index	6 (acceptable)

EPT to total ratio	0.61 (acceptable)
Predominant taxa ratio	0.32 (good)
OVERALL ASSESMENT RATING (1-4)	**3.5 (good)**

Table 4: Site 3 Invertebrate assessment summary from C.W. Young channel

Assessment	Rating (rating value)
Total invertebrates collected	246
Total Taxa	14
Pollution Tolerance Index	32 (good)
EPT Index	7 (acceptable)
EPT to total ratio	0.88 (good)
Predominant taxa ratio	0.84 (poor)
OVERALL ASSESMENT RATING (1-4)	**3 (good)**

Table 5: Site 4 Invertebrate assessment summary from C.W. Young channel

Assessment	Rating
Total invertebrates collected	339
Total Taxa	12
Pollution Tolerance Index	25 (good)
EPT Index	5 (acceptable)
EPT to total ratio	0.49 (marginal)
Predominant taxa ratio	0.48 (acceptable)
OVERALL ASSESMENT RATING (1-4)	**3 (good)**

4.0 Results and Discussion

4.1. General Field Conditions

An initial site visit of the five sites along the C.W. Young Channel occurred on October 16, 2019. During this site visit, access and familiarity with the five sample sites was established. This visit occurred during a low flow event with a discharge level of 5 cubic meters per second on the main stem of the Englishman River (Government of Canada 2019). The First sampling event occurred on October 30, 2019. The C.W. Young Channel was again experiencing a low flow event on this date with little rain in the previous days. The discharge level in the main stem of the Englishman was 4.5 cubic meters per second which aligns with many of the sample results in the following sections. The second sampling event occurred on November 20, 2019 and took place during a high flow event. The Englishman River saw discharge levels of 22.5 cubic meters per second at the time of the second sampling event. In the previous days to November 20, the Englishman watershed experienced a significant rain event. On November 17, the Englishman saw a drastic increase in water levels with a discharge of 43 cubic meters per second (Government of Canada 2019). The C.W. Young Channel was affected by this rain event although the water level remained relatively similar to the first sample day as it is flow controlled with a valve at the top of the channel. The turbidity, and thus many of the other water quality parameters reflected this high flow event. The results in the following sections reflect the field conditions observed on the days the site visits occurred on.

4.1.1 Hydrology

Hydrology measurements were made at site 3 on both sample dates so that a comparison could be made to explain water quality results (Table 2). Site 3 was selected for hydrology measurements as this reach consists of a glide that is representative of much of the C.W. Young Channel. There is also good access to the banks of the stream, so it was a safe location to conduct stream measurements on both sample dates. Measurements that were taken included wetted width, three wetted depths across the stream, and velocity measurements. The field measurements taken were then used to calculate a discharge level for each of the sample dates. Our results differed from our expectations for discharge levels between the two sample dates (Table 2). As the second sample event took place during a high flow event, discharge was expected to be higher on this date. This was not the case however as discharge was calculated to be slightly higher on the first sample date during the low flow event. There are several reasons that these unsuspected results may have occurred. The first is that the stream substrate and depth varies throughout site 3 and although we attempted to measure at the same location it is possible the measurements were taken at slightly different locations. This may have caused varying measurements and also the unsuspected discharge results. Another reason for our unexpected results is that the C.W. Young Channel is flow controlled. The main stem of the Englishman saw a significant increase in discharge between the two sample events, but the C.W. Young Channel is regulated by a valve at the top of the channel. As the second sample date occurred during a high flow event, it is possible that the flow of the channel was altered due to debris blocking the inflow pipe. There are several possible reasons for the slightly lower discharge levels on the second sample date.

Table 6: Hydrology comparison between sample event one and two

Sample Date	Wetted Width (cm)	Wetted Depths (cm)	Average Depth (cm)	Average Velocity (m/s)	Discharge (m^3/s)
Oct. 30, 2019	420	43, 49, 36	43	0.418	0.755
Nov. 20, 2019	460	35, 38, 47	40	0.355	0.653

4.2 Water Quality

4.2.1 Field Measurements

Dissolved oxygen (mg/L), water temperature (°C) and air temperature (°C) were measured on both of the sample dates. These parameters were measured with an Oxyguard Handy Polaris electronic probe. Dissolved oxygen and water temperature were measured at each of the five sample sites on both sample events (Figure 3).

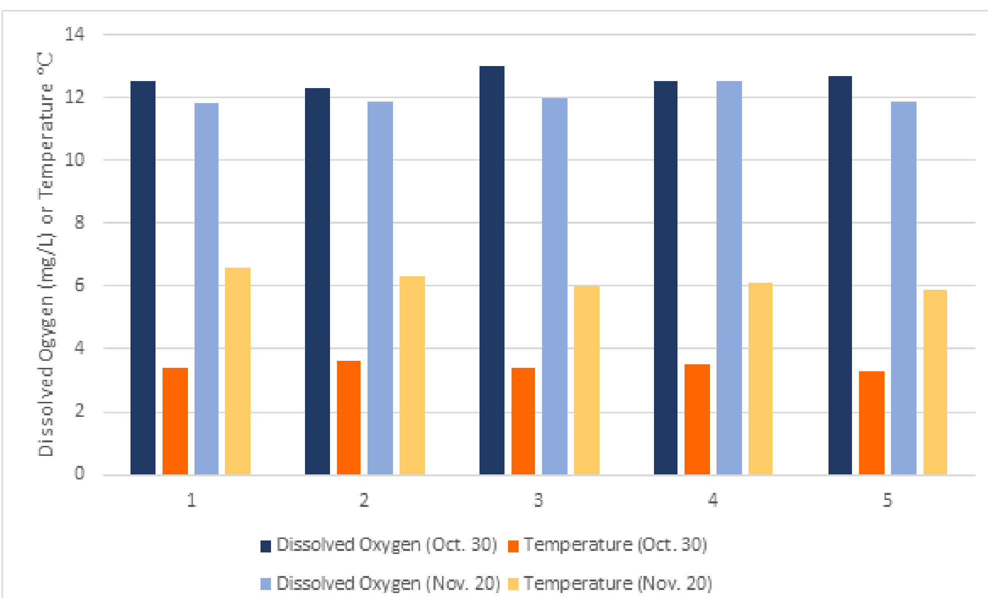

Figure 3: Dissolved oxygen and water temperature comparison between Oct. 30 and Nov. 20

The results of the dissolved oxygen and water temperature measurements aligned with expectations. The water was an average 3.5ºC on October 30th when sampling occurred. Along with these cool water temperatures, high dissolved oxygen levels were measured. All five sites resulted in greater than 12 mg/L of dissolved oxygen. These cool water temperatures are due to several days of clear skies and cool air temperatures prior to October 30th. The air temperature while sampling occurred on October 30th was 4ºC. The second sampling event, on November 20th, saw slightly higher water temperatures and slightly lower dissolved oxygen levels. The water temperature was about 2ºC higher on November 20th than October 30th with an average of 6ºC. The dissolved oxygen measurements averaged just less than 12 mg/L which is slightly lower than on October 30th. These results were expected as a significant rain event on November 17th and warmer air temperatures brought up the water temperature. The air temperature when sampling occurred on November 20th was 8ºC.

Dissolved oxygen is very closely related to water temperature. As water temperature decreases, water is more capable of holding oxygen in a dissolved form. This means that a decrease in water temperature will result in an increase in the amount of dissolved oxygen present. Appropriate levels of dissolved oxygen are necessary for aquatic species to survive. These appropriate levels are outlined in the Guidelines for Interpreting Water Quality Data (Resource Inventory Committee 1998). Both of the sample events water temperature results were several degrees below the maximum temperature guidelines for all salmonid activities. The maximum average weekly water temperature for salmonid spawning is 8-10ºC. The dissolved oxygen levels measured in the C.W. Young Channel were significantly above the minimum level required for aquatic life. The minimum mean monthly level of dissolved oxygen for fish in all life stages other than buried embrio or alevin is 8 mg/L. The lowest level of dissolved oxygen that was measured between the two sample dates was 11.9 mg/L. With excellent water temperature and dissolved oxygen levels, the C.W. Young Channel provides excellent habitat for salmonids and other aquatic species.

4.2.2 VIU Laboratory Analysis

Within 12 hours of sampling on October 30th, water quality parameters were tested, and invertebrate samples were analyzed in a Vancouver Island University (VIU) Laboratory (table3). Water quality parameters were tested again within 12 hours of the November 20th sampling event in the VIU laboratory (table 4). The water quality parameters that were tested after both of the sampling events were turbidity, conductivity, pH, alkalinity, hardness, nitrate and phosphate. Microbiology testing and invertebrate analysis took place only after the October 30th sampling event.

Table 7: VIU Laboratory Water Quality Results from October 30, 2019

	Site 1	Site 1 (duplicate)	Site 2	Site 3	Site 4	Site 5	Field Blank
Turbidity (NTU)	1.41	1.31	1.06	0.97	1.7	1.2	
Conductivity (µs/cm)	69	69	68	68	76	70	
pH	7.8	7.6	7.5	7.9	8	7.9	
Alkalinity (mg/L $CaCO_3$)	19.5	20.8	20.5	22.2	26.5	21	
Hardness (mg/L $CaCO_3$)	29	28	27	27	33	31	
Nitrate (mg/L NO_3-)	0.18	0.09	0.14	0.07	0.18	0.06	0.03

Phosphate (mg/L PO_4^{3-})	0.05	0.03	0.05	0.06	0.11	0.02	0.02

Table 8: VIU Laboratory Water Quality Results from November 20, 2019

	Site 1	Site 1 (duplicate)	Site 2	Site 3	Site 4	Site 5	Field Blank
Turbidity (NTU)	2.82	2.31	3.14	3.75	3.60	3.60	
Conductivity (µs/cm)	50	54	51	62	69	76	
pH	8.5	8.4	8.4	8.0	8.7	8.6	
Alkalinity (mg/L $CaCO_3$)	17.0	16.8	16.2	16.3	21.1	20.2	
Hardness (mg/L $CaCO_3$)	23	26	20	23	24	22	
Nitrate (mg/L NO_3-)	0.34	0.29	0.29	0.29	0.40	0.25	0.04
Phosphate (mg/L PO_4^{3-})	0.06	0.04	0.05	0.07	0.10	0.07	0.04

4.2.2.1 Turbidity

Turbidity is a measure of the relative clarity of water and is influenced by the amount of suspended solids present in the water. Turbidity is measured in Nephelometric Turbidity Units (NTU's). A HACH 2100 Portable Turbidimeter which measures to the nearest 0.01 NTU was used to measure turbidity in the VIU laboratory. This instrument passes light through water samples to determine the density of suspended solids to come up with an NTU reading. Upon completion of this testing, it was determined that there were higher turbidity levels during the second sampling event than the first. The first sampling event saw an average of 1.3 NTU between the five sample sites (figure 4). The second sampling event resulted in more than double the turbidity in almost all of the sites with an average of 3.2 NTU. Based on the water quality guidelines, both events displayed healthy turbidity levels. The guidelines state that a 5 NTU increase in turbidity for water with a background level of less than 50 NTU is the maximum level for aquatic life (Resource Inventory Committee 1998). A 1.9 NTU increase was the average change in turbidity between sample event one and two with the largest increase of 2.78 NTU at site 3. The reason turbidity is a valuable water quality parameter to monitor is that it is directly related to bacteria levels in water which affects human and fish health. Significant increases in turbidity can disrupt the respiratory organs of aquatic species and lead to poor health. Turbidity also decreases aquatic plant growth as sunlight is less available and this affects many aquatic species up the food chain (Resource Inventory Committee 1998). Turbidity is an important water quality parameter to monitor and based on the results from the two sample events, the C.W. Young Channel has healthy turbidity levels.

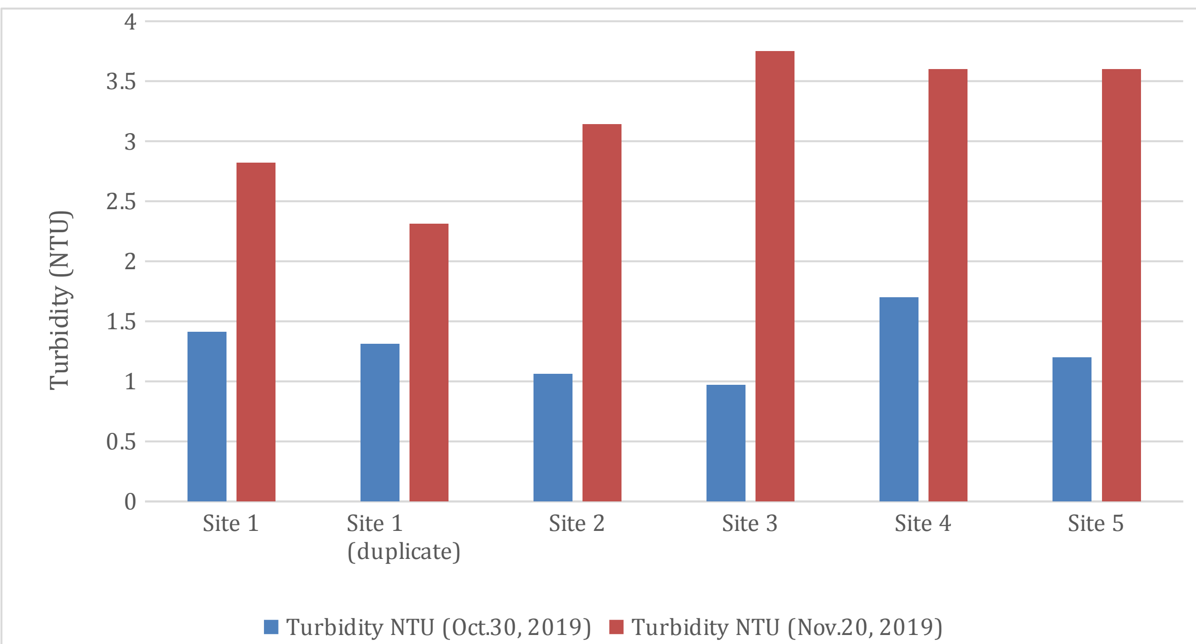

Figure 4: Turbidity results from sample event one and two

4.2.2.2 Conductivity

Conductivity refers to water's ability to pass electrical currents through it. As water passes through a watershed it collects positively and negatively charged ions as it comes in contact with the substrate. The more ions that are present in the water, the more capable it is to pass electrical currents through it. Conductivity in measured in micro siemens per centimeter (µs/cm). Coastal waters in British Columbia typically have conductivity levels of 100 µs/cm or less. The results from conductivity testing on water samples from the C.W. Young Channel align with these suspected levels. The average conductivity level from the first sample event was 70 µs/cm and the average from the second event was 62 µs/cm. The second sampling event saw slightly lower conductivity levels at all of the sites except site 5 was slightly higher than the first sampling event (figure 5). These results were expected as the second sampling event took place during a high flow event causing the ions in the water to be more dilute than during a low flow event. Conductivity is a useful water quality parameter to measure as it can identify sources of pollution in water. Many sources of pollution cause a significant increase in the level of ions in water and this can be displayed in increased conductivity levels. There is not a water quality guideline for conductivity, but the results align well with previous years data (Demers 2016). Many years of similar conductivity results points to the fact that this is a healthy and consistent stream.

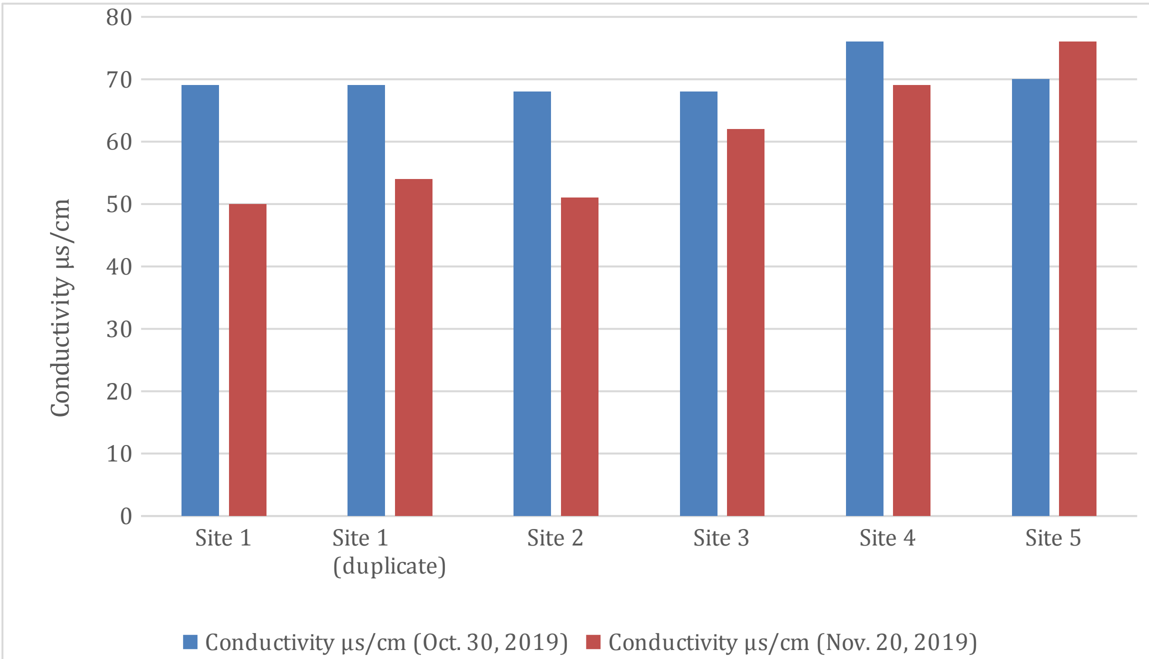

Figure 5: Conductivity results from sample event one and two

4.2.2.3 pH and Alkalinity

pH refers to the concentration of hydrogen ions in a substance. Substances with high levels of hydrogen ions are considered basic and have a pH between 7 and 14. pH values of 7 or under are considered acidic. All pH levels between the two sample days ranged from 7.5 to 8.7 (figure 6). All sample results fell within the pH guideline of 6.5-9 for aquatic life (Resource Inventory Committee 1998). Coastal streams typically have low pH levels of 5.5 to 6.5 meaning the C.W. Young Channel displayed high a pH for a coastal watershed. pH levels were slightly higher in samples taken on the second sample event than the first. These results are comparable to previous years data although they are slightly higher than average (Demers 2016).

Alkalinity refers to water's ability to neutralize acids. Alkalinity is associated with the density of ions in water, in particular, the presence of carbonates. Water that has high ion concentrations is more capable of neutralizing acids. Water with an alkalinity of 10 mg/L or less is considered sensitive and is common in coastal areas. An alkalinity of 10-20 mg/L is considered moderate sensitivity and greater than 20 mg/L is considered low sensitivity. Test results from the C.W. Young Channel conclude that this water has moderate to low sensitivity with values ranging from 16.2-26.5 mg/L (figure 6). The first sample event saw higher alkalinity values with an average of 21.75 mg/L between the sites. The average between the five sample sites was 17.93 mg/L on the second sample event. These results accurately represent the high flow event on November 20 with more dilute ion concentrations.

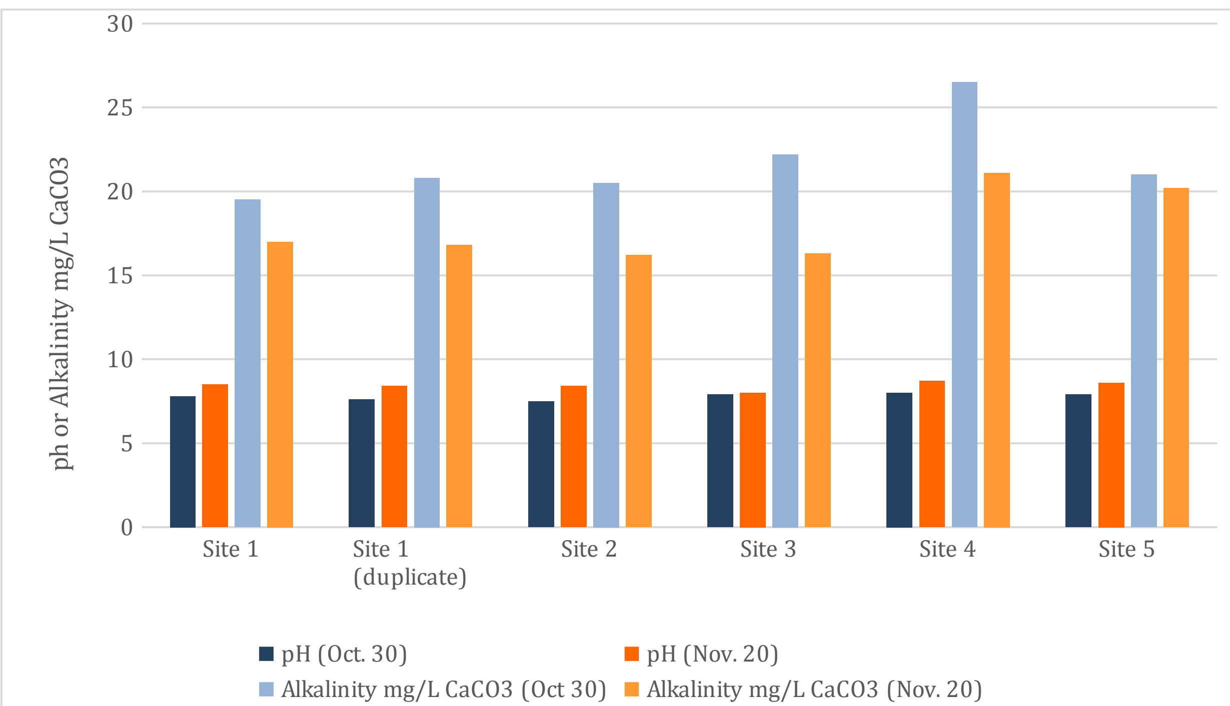

Figure 6: pH and Alkalinity results from sample event one and two

4.2.2.4 Hardness

Hardness is a measure of divalent cations in water, in particular, Magnesium and Calcium. Hardness is closely related to alkalinity and conductivity in that they all are a measure of ion concentration in water. An increase in one parameter typically means an increase in each parameter. This was the case with the results from the two sample events on the C.W. Young Channel. All three parameters saw slight decreases between the first and second sample events. These results were expected as the second sample event was during a high flow event in which ions are present in lower concentrations due to dilution. Hardness is important primarily because it affects the toxicity of metals in water. Lower hardness causes heavy metals to be more toxic as there are less ions in the water. There are no water quality guidelines for hardness, however, hardness affects the guidelines of several heavy metals such as copper, zinc or lead. A hardness measure of 60 mg/L $CaCO_3$ or less is considered soft water and a measure of 120 mg/L $CaCO_3$ is considered hard water. With an average hardness of 26 mg/L $CaCO_3$ between the five sample sites and the two sample events, the water of the C.W. Young Channel is considered soft water (Figure 7).

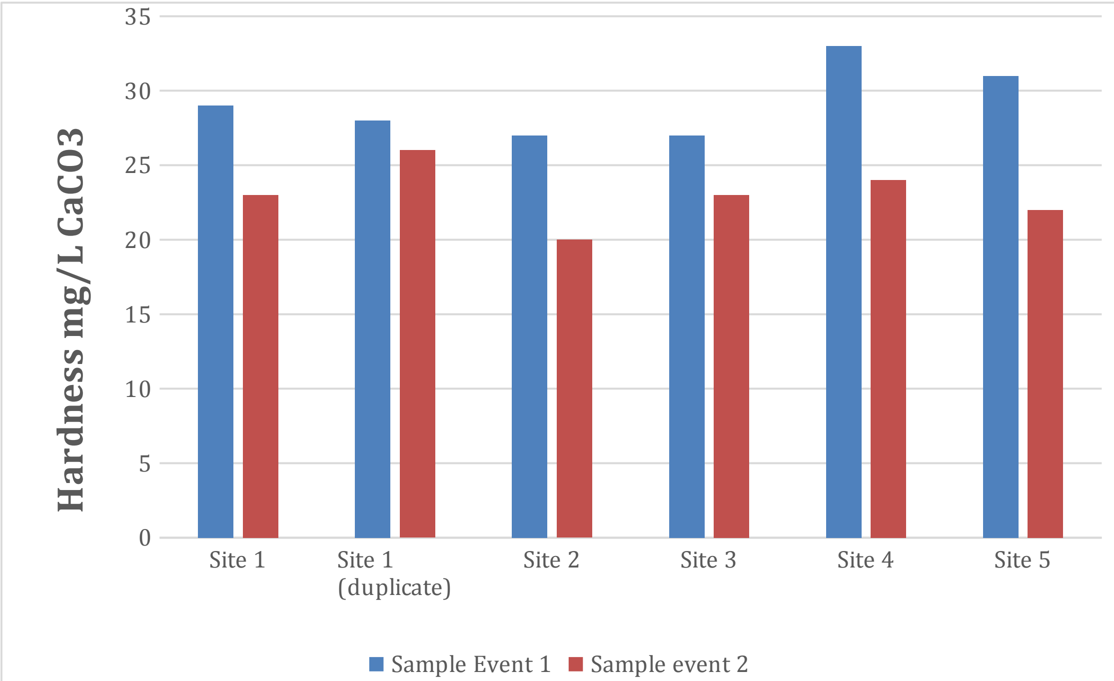

Figure 7: Hardness results from sample event one and two

4.2.2.5 Nitrate and Phosphate

Nitrate (NO_3^-) is the primary source of nitrogen used by aquatic primary producers and is the most essential nutrient for growth. Due to human activities, nitrogen levels in aquatic ecosystems can easily become imbalanced. Sewage outfalls, agricultural fertilizers and explosives are some of the major human caused nitrogen inputs to aquatic ecosystems. When nitrogen levels increase, eutrophication may occur. Eutrophication refers the increased growth of primary producers when nutrient levels are at optimal levels. Eutrophication can cause increased turbidity and bacteria levels, deceased dissolved oxygen and the mortality of native fish species. Without the influence of human activities, most freshwater has nitrate levels less than 0.3 mg/L NO_3^-. The average Nitrate levels were significantly below this limit during the first sample event but averaged 0.31 mg NO_3^- during the second sample event (Figure 8). This result is not concerning as the aquatic guideline for aquatic life is 200 mg/L NO_3^- (Resource Inventory Committee 1998).

The other essential nutrient that was measured from the C.W. Young Channel water samples is phosphate (PO_4^{3-}), the most common form of phosphorus used by aquatic species. Phosphate can also be influenced by human activities and cause eutrophication. Eutrophication is the most extreme when the nutrient level ratio is 16 parts nitrogen for every one-part phosphorus. Phosphate is naturally the most limiting nutrient and therefore, human caused additions can significantly alter an ecosystem. Similarly, to nitrate, agricultural fertilizers, manure, sewage and industrial effluent are human sources of phosphate. There is no water quality guideline for phosphate but the guideline for total phosphorus is 0.005 to 0.015 mg/L (Resource Inventory Committee 1998). Water with phosphate levels less than 0.01 mg/L is considered oligotrophic meaning there are low nutrient levels. Phosphate levels between 0.01 and 0.03 mg/L are considered mesotrophic and greater than 0.03 mg/L is eutrophic. There was a slight increase in phosphate levels during the second event compared to the first event. The average phosphate level between the five sample sites during the first sample event was 0.053 mg/L and during the second sample event was 0.065 mg/L figure 8). Both sample events resulted in eutrophic phosphate levels causing the suspicion that a human source may be inputting phosphate into the C.W. Young Channel. Based on the results of the two sample events, the C.W. Young Channel is nitrogen limited.

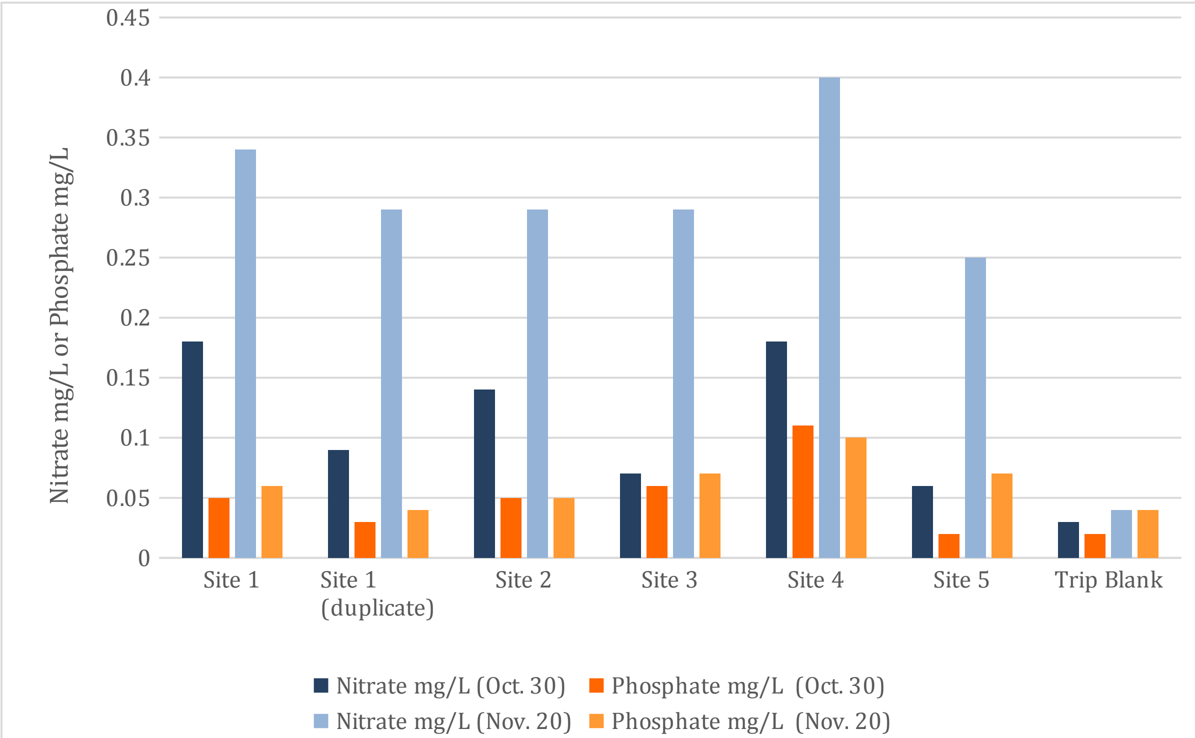

Figure 8: Nitrate and Phosphate results from sample event one and two

4.2.3 ALS Laboratory Analysis

Water samples were collected from sites 1, 2, 4 on October 30th and November 20th, 2019. The samples were then set to the ALS lab in Burnaby, B.C. Results returned from the ALS lab analysis were then summarized into a table format with sample sites and both sampling events. Water quality guidelines for aquatic life were included in the table (table 9). ALS laboratory acquires the conditions and equipment to conduct very accurate results. In comparison with our results from the VIU lab analysis regarding water quality and the ALS results we can determine any errors or less precise results due to our methods.

Physical water tests including the parameters of conductivity, hardness, and pH from our VIU lab analysis show some deviations from that of the ALS results for sites 1,2,4. Conductivity measurements from our VIU lab results with relatively similar with the most variation observed during sampling event one. VIU results from sampling event 1 at sites 1,2 and 3 were 2-4 µs/cm lower than the ALS results. Hardness measurements tended to be slightly higher in our analysis then that of the ALS results. The greatest variation was seen on site 1 with a difference of 2.6 mg/L. Measurements of pH were higher in the VIU analysis at sampling event 2. At sites 1,2 and 3 our measurements showed an approximate increase of 1 pH. Overall the physical water parameters tested were comparable between the two-lab analysis which represents relative quality in our methods and equipment used. The slight deviations between the two lab results is likely due more advanced equipment with higher accuracy.

Nutrient and anion measurements analyzed from ALS results represent expected trends. All measurements obtained are within B.C. water quality guidelines except for phosphorus. The first sampling event on October 30, 2019 measured an average total phosphorus of 0.0038 mg/L, water quality guidelines suggest that less than 0.01 is to be considered oligotrophic (RISC 1998). Results from our second sampling event showed an increase deposit of phosphorus due to higher flow. Measurements showed an average increase of 0.0132 mg/L of total phosphate between sampling events. This increase brought total phosphates to an average of 0.017 mg/L between sites 1,2 and 4 on November 20th, 2019.

B.C. water quality guidelines were compared to ALS results for all parameters. All total metals within the water indicate measurements within the guidelines, with the exception of aluminum; guidelines fall below the minimum detection limits for some parameters and would require further testing. Aluminum was highest at sites 2 and 4 within our second sampling event on November 2019. B.C. Water quality guidelines state a maximum of 0.1 mg/L for aquatic life. Measurement from site 2 and 4 exceeded the guidelines at 0.24 mg/L and 0.21 mg/L. This trend and comparison with previous years suggests the remaining sites have potential to exceed the guideline as well even though it is not represented in our results; the minimum detection limit for aluminum is 0.2 mg/L. The increase shown in aluminum during our high flow sampling is likely due the increase of runoff from industrial and urban areas entering the stream; this deposit of aluminum is consistent with previous years. High calcium levels are also recognized within the first sampling event, these high levels of base elements give the stream a low sensitivity to acidification. Calcium levels were noticeably lower in the second sampling event due to dilution from the increased flow.

Table 9: ALS laboratory results for water samples collected at 3 stations on the C. W. Young Channel on October 30, 2019 and November 20, 2019. All values are recorded in mg/L unless stated otherwise. Additional notes are provided below the table.

	Guidelines	Oct1,30/19			Nov,20/19		
Physical Tests (Water)		Site 1	Site 2	Site 4	Site 1	Site 2	Site 4
Conductivity		72.5	72.7	80.9	51.6	52.0	65.0
Hardness (as CaCO3)	<60 (Soft)	26.4	26.5	30.5	19.9	20.3	26.1
pH	6.5-9	7.44	7.41	7.49	7.42	7.36	7.47
Anions and Nutrients (Water)							
Ammonia, Total (as N)	19.7[a]	<0.0050	<0.0050	<0.0050	<0.0050	0.0087	0.0149
Nitrate (as N)		0.0860	0.0739	0.0846	0.137	0.145	0.190
Nitrite (as N)	0.06[b]	<0.0010	<0.0010	0.0011	<0.0010	<0.0010	<0.0010
Total Nitrogen		0.157	0.178	0.186	0.291	0.325	0.390
Orthophosphate-Dissolved		<0.0010	<0.0010	<0.0010	0.0026	0.0020	0.0028
Phosphorus (P)-Total	0.01-0.025	0.0029	0.0040	0.0044	0.0101	0.0278	0.0131
		54.1	44.5	42.3			
Total Metals (Water)							
Aluminum (Al)-Total	0.1[c]	<0.20	<0.20	<0.20	<0.20	0.24	0.21
Antimony (Sb)-Total	0.009	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Arsenic (As)-Total	0.005	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Barium (Ba)-Total	1	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Beryllium (Be)-Total	0.00013	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Bismuth (Bi)-Total		<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Boron (B)-Total	1.2	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Cadmium (Cd)-Total	0.00017[d]	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Calcium (Ca)-Total		9.03	9.04	9.67	6.57	6.68	7.91
Chromium (Cr)-Total	0.01	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Cobalt (Co)-Total	0.11	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Copper (Cu)-Total	0.003	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Iron (Fe)-Total	1	<0.030	0.203	0.101	0.158	0.272	0.268
Lead (Pb)-Total	0.018[e]	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Lithium (Li)-Total	0.75	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Magnesium (Mg)-Total		0.93	0.97	1.54	0.86	0.89	1.54
Manganese (Mn)-Total	0.8706[f]	<0.0050	0.0072	<0.0050	<0.0050	0.0073	0.0073
Molybdenum (Mo)-Total	2	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Nickel (Ni)-Total	0.25[g]	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Phosphorus (P)-Total		<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium (K)-Total		<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Selenium (Se)-Total	0.002	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Silicon (Si)-Total		2.74	2.92	3.13	3.14	3.24	3.57
Silver (Ag)-Total	0.0001	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Sodium (Na)-Total		4.0	3.9	3.9	2.7	2.7	2.9
Strontium (Sr)-Total		0.0391	0.0384	0.0388	0.0272	0.0282	0.0319
Thallium (Tl)-Total	0.0008	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Tin (Sn)-Total	0.000022	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Titanium (Ti)-Total		<0.010	0.010	<0.010	<0.010	0.013	<0.010
Vanadium (V)-Total	0.05	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Zinc (Zn)-Total	0.033[h]	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050

Note:

BC Water Quality Guidelines summarized from:

https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/waterquality/water-quality-guidelines/approved-wqgs/wqg_summary_aquaticlife_wildlife_agri.pdf

https://www2.gov.bc.ca/assets/gov/environment/natural-resource-stewardship/nr-laws-policy/risc/guidlines_for_interpreting_water_quality_data.pdf

https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/waterquality/water-quality-guidelines/bc_env_working_water_quality_guidelines.pdf

a) Ammonia concentration varies depending on pH and water temperature
b) Nitrate guideline applied for water tested with chloride levels <2 mg/L
c) Aluminum guideline applicable for water tested with pH > 6.5
d) Cadmium guideline of 0.00017 mg/L from {2.718 ^ [1.03 × ln(hardness) - 5.274]} / 1000 (When Hardness = 30)
e) Lead guideline of 0.018 mg/L calculate from {2.718 ^ [1.273 × ln(hardness) - 1.46]} / 1000 (when Hardness = 30)
f) Manganese guideline of 0.8706 mg/L calculated from 0.01102 x (hardness) + 0.54 (when Hardness = 30)
g) Nickel guideline of 0.25 when Hardness < 60 mg/L
h) Zinc guideline of 0.33 mg/L when Hardness < 90 mg/L

4.2.4 Quality Assurance/Quality Control

Several measures were taken to meet quality control and quality assurance standards throughout water quality analysis. Prior to any sampling samplers approached each site from the downstream side in order not to disturb the substrate above sampling areas. All containers for water samples were properly labeled and rinsed three times prior to any sampling; except for the provided sterile ALS containers. Containers and hands were kept clean throughout sampling and transportation. Samples were placed in sterile coolers with ice packs for preservation in the field. Once sampling was completed samples were immediately taken back the lab for analysis. In the lab the team was equipped with lab coats and gloves. All containers and equipment used for testing were rinsed 3 times with distilled water before use.

One replicate sample and one trip blank were taken on each sampling event. Trip blank samples were provided by Dr. Demers. These samples consisted of a sterile container filled with distilled water; they remained in the cooler for the duration of the field work at each sampling event. Replicate samples were taken at site 1 on both events. Analyses were done on the replicate and blank samples alongside remaining samples and results were compared (See Table 7 and 8). ALS lab samples were transported in properly labelled containers in a cooler and accompanied by chain of custody forms to the lab in Burnaby, B.C. ALS is a recognized quality laboratory with trained professionals and advanced equipment. The results collected from ALS were compared with our VIU lab results to further ensure quality of our methods and procedures used.

5.0 Conclusion and Recommendations

In conclusion, after conducting a thorough assessment of the C.W. Young channel based on hydrology, microbiology and stream invertebrates' samples obtained on 2 separate sampling events, it has been determined that the channel is a relatively healthy and successful ecosystem. Our results are consistent with previous environmental monitoring projects on the C.W. Young channel verifying that the channel continues to be an advantageous habitat for spawning salmon. We compared our results with the BC Water Quality Guidelines and determined that most of our water quality results were within the parameters that support aquatic life. One exception being aluminum, our results indicated that the aluminum level was exceeding the BC Water Quality Guidelines. These results are consistent with previous reports and can potentially be a product of industrial run-off. Sample events 1 and 2 differed in terms of turbidity, this is a result of heavy rainfall that occurred prior to our second sampling event this is also correlated with higher nitrate levels observed during the second sampling event.

The analyzation of fecal and non-fecal coliforms was exceeding the water guidelines for drinking water, it is not recommended that the water in the C.W. Young channel be consumed without being treated. The overall stream invertebrate assessment determined a rating of 3 indicating a "good" rating value. The predominance of Mayfly found in the invertebrate samples affected the diversity in sites 3 and 4. Our Shannon-Weiner diversity index average was 0.61 which is "moderate". It has been determined that the overall health of the C.W. Young channel is favorable however, it is important to continue with annual environmental assessment to maintain good ecosystem health and acknowledge imminent changes within the watershed.

6.0 Acknowledgments

We would like to thank Dr. Eric Demers for guiding us and for providing the necessary knowledge and skills to complete this environmental assessment of the C.W. Young Channel. A special thanks to Regional District of Nanaimo for allowing site access. Thank you to Vancouver Island University, specifically, the Resource Management Officer Technology (RMOT) and Science-Biology departments for providing the necessary laboratory and field equipment. Finally, thank you to ALS for the in-depth analysis of our samples with precise and accurate results.

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8.0 Appendix

Figure A1: Site #1, Located in the C.W. Young Channel

Figure A2: Site #2, Located in the C.W. Young Channel

Figure A3: Site #3, Located in the C.W. Young Channel

Figure A4: Site #4, Located in the C.W. Young Channel

Figure A5: Site #5, Located in the Englishman River

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name: ENGLISHMAN RIVER (CW YOUNG CHANNEL)		Date: OCTOBER 30, 2019
Station Name: STATION 1		Flow status:
Sampler Used: HESS	Number of replicates 4	Total area sampled (Hess, Surber = 0.09 m^2) x no. replicates 0.09 m^2

Column A Pollution Tolerance	Column B Common Name	Column C Number Counted	Column D Number of Taxa
Category 1	Caddisfly Larva (EPT)	EPT1 4	EPT4 2
	Mayfly Nymph (EPT)	EPT2 9	EPT5 2
	Stonefly Nymph (EPT)	EPT3 4	EPT6 2
	Dobsonfly (hellgrammite)		
Pollution Intolerant	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		C1 17	D1 6
Category 2	Alderfly Larva		
	Aquatic Beetle		
	Aquatic Sowbug		
	Clam, Mussel		
	Cranefly Larva	1	1
	Crayfish		
Somewhat Pollution Tolerant	Damselfly Larva		
	Dragonfly Larva		
	Fishfly Larva		
	Amphipod (freshwater shrimp)		
	Watersnipe Larva		
Sub-Total		C2 1	D2 1
Category 3	Aquatic Worm (oligochaete)	4	1
	Blackfly Larva		
	Leech	1	1
	Midge Larva (chironomid)	5	1
	Planarian (flatworm)		
Pollution Tolerant	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite		
Sub-Total		C3 10	D3 3
TOTAL		CT 28	DT 10

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell **CT**: CT 28

DENSITY: Invertebrate density per total area sampled:

28 ÷ From page 1 0.36 m^2 = 77.8 $/m^2$

PREDOMINANT TAXON:
Invertebrate group with the highest number counted (in Col. C) S1 Mayfly Nymph.

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 6 + 2 x 1 + 3 = S2 23
18 2 3

EPT INDEX: Total number of EPT taxa.

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

EPT4 + EPT5 + EPT6

2 + 2 + 2 = S3 6

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

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

(EPT1 + EPT2 + EPT3) / CT

(4 + 9 + 4) / 28 = S4 0.61

SECTION 3 - DIVERSITY

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

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

9 / 28 = S5 0.32

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 3
Predominant Taxon Ratio	R4 4

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

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name: Englishman River - CWY		Date: Oct. 20/2019
Station Name: Station 3		Flow status:
Sampler Used: Hess	Number of replicates 4	Total area sampled (Hess, Surber = 0.09 m²) x no. replicates 0.09 m²

Column A Pollution Tolerance	Column B Common Name	Column C Number Counted	Column D Number of Taxa
Category 1	Caddisfly Larva (EPT)	EPT1 1	EPT4 1
	Mayfly Nymph (EPT)	EPT2 206	EPT5 3
	Stonefly Nymph (EPT)	EPT3 10	EPT6 3
	Dobsonfly (hellgrammite)		
Pollution Intolerant	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		C1 217	D1 7
Category 2	Alderfly Larva		
	Aquatic Beetle		
	Aquatic Sowbug		
	Clam, Mussel		
	Cranefly Larva	10	3
	Crayfish		
Somewhat Pollution Tolerant	Damselfly Larva		
	Dragonfly Larva		
	Fishfly Larva		
	Amphipod (freshwater shrimp)	2	1
	Watersnipe Larva		
Sub-Total		C2 12	D2 4
Category 3	Aquatic Worm (oligochaete)	15	2
	Blackfly Larva		
	Leech		
	Midge Larva (chironomid)	2	1
	Planarian (flatworm)		
Pollution Tolerant	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite		
Sub-Total		C3 17	D3 3
TOTAL		CT 246	DT 14

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell **CT**: CT 246

DENSITY: Invertebrate density per total area sampled:

246 ÷ ~~0.09~~ 0.36 m² = 683.33 /m²

From page 1

PREDOMINANT TAXON:
Invertebrate group with the highest number counted (in Col. C) S1 Mayfly ~~Larva~~ Nymph.

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 7 + 2 x 4 + 3 = S2 32

21 8

EPT INDEX: Total number of EPT taxa.

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

EPT4 + EPT5 + EPT6

1 + 3 + 3 = S3 7

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

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

(EPT1 + EPT2 + EPT3) / CT

(1 + 206 + 10) / 246 = S4 0.882

SECTION 3 - DIVERSITY

TOTAL NUMBER OF TAXA: Total number of taxa from cell **DT**: 14

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

206 / 246 = S5 0.837

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 4
Predominant Taxon Ratio	R4 1

Average Rating
Average of R1, R2, R3, R4
3

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name: Englishman River (C.W. Young Channel)	Date: October 20, 2019
Station Name: Station 4	Flow status:
Sampler Used: HESS · Number of replicates: 4	Total area sampled (Hess, Surber = 0.09 m^2) x no. replicates: 0.09 m^2

Column A Pollution Tolerance	Column B Common Name	Column C Number Counted	Column D Number of Taxa
Category 1	Caddisfly Larva (EPT)	EPT1	EPT4
	Mayfly Nymph (EPT)	EPT2 158	EPT5 3
	Stonefly Nymph (EPT)	EPT3 9	EPT6 2
	Dobsonfly (hellgrammite)		
Pollution Intolerant	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		C1 167	D1 5
Category 2	Alderfly Larva		
	Aquatic Beetle		
	Aquatic Sowbug		
	Clam, Mussel		
	Cranefly Larva	14	2
	Crayfish		
Somewhat Pollution Tolerant	Damselfly Larva		
	Dragonfly Larva		
	Fishfly Larva		
	Amphipod (freshwater shrimp)	7	1
	Watersnipe Larva		
Sub-Total		C2 21	D2 3
Category 3	Aquatic Worm (oligochaete)	72	1
	Blackfly Larva	1	1
	Leech		
	Midge Larva (chironomid)	76	1
Pollution Tolerant	Planarian (flatworm)		
	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite	2	1
Sub-Total		C3 151	D3 4
TOTAL		CT 339	DT 12

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell **CT**: CT 339

DENSITY: Invertebrate density per total area sampled:

From page 1

339 ÷ 0.36 m^2 = 941.7 / m^2

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

S1 Mayfly Nymph

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 + 4 =
15 6

S2 25

EPT INDEX: Total number of EPT taxa.

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

EPT4 + EPT5 + EPT6

0 + 3 + 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

(0 + 158 + 9) / 339 =

S4 0.49 ~~158.03~~

SECTION 3 - DIVERSITY

TOTAL NUMBER OF TAXA: Total number of taxa from cell **DT**: 12

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

158 / 339 =

S5 0.47

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 2
Predominant Taxon Ratio	R4 3

Average Rating
Average of R1, R2, R3, R4
3