Water Quality and Stream Invertebrate Assessment of the C.W. Young Channel, Englishman River, B.C, Fall 2022

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Executive Summary

The purpose of this study is to present an holistic evaluation of water quality, invertebrate health, and general site conditions for the C.W. Young side channel. In addition, this study adds to the long-term monitoring efforts as part of Vancouver Island University's RMOT program.

The Englishman River (ER) of which the C.W. Young stems from, is an important salmon-bearing stream with all five species of anadromous salmon utilizing the river and side channels for spawning, rearing, and overwintering. Along with its ecological significance, the Englishman River Water Region is a drinking-water source for much of Parksville and as such, annual environmental monitoring efforts are of economic and social importance to this region. Most recent environmental concerns in this area pertain to the rise in commercial and residential development surrounding the ER watershed, as this has been attributed to observable changes in run-off patterns and an increase in sediment-loading. Additionally, recent years of unprecedented drought has led to low summer water levels, resulting in poor salmon stock and conflict with how best to utilize resources stemming from the ER watershed.

As part of a longitudinal study, the same five sites previously surveyed along the side channel were assessed for this year's study within the same timeframe. The first survey took place in late-October with the second taking place in mid-November as previous groups had done. During each sampling event, general site conditions, field measurements for water quality, and water sample collections for further analyses were taken and recorded in accordance with the B.C. Government's "Ambient Freshwater and Effluent Sampling" guideline. Water samples were analysed both at the Vancouver Island University (VIU) lab by the study group, and at ALS Labs in Burnaby, BC as a means of comparison. The results were compared to BC's Water Quality Guidelines for Aquatic Life to establish stream/invertebrate health.

Upon analyses of the results, it was determined that most of the values fell well within guideline parameters and were similar to previous years. The one outlier was aluminum, which tested above acceptable levels and has been documented as exceeding the guidelines in previous reports due to the possibility of industrial run off. Nonetheless, our results suggest that the C.W Young is a relatively

healthy and successful ecosystem that continues to be a supportive and appropriate habitat for salmon populations and other life.

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2.0 Introduction

2.1 Project Overview

The project is part of a comprehensive environmental monitoring program on the C.W Young Side Channel constructed off of the Englishman River Regional Park located southwest of Parksville, BC. Two environmental sampling events took place during the low-flow conditions in late October, and during the normally high-flow period in mid-November. Analyses of water quality and stream invertebrate communities help to illustrate present-day stream health and serve as a continuation of data collected from previous surveys beginning in 2008. Short-term assessment in conjunction with ongoing long-term monitoring efforts allow for the detection of any current or potential threats to stream health, as well as detection of any potential cumulative impacts from land use surrounding the watershed or otherwise.

The Englishman River (ER) water region (WR4-ER) of which C.W. Young resides is located on the Eastern side of Vancouver Island and is the second largest water region within the RDN covering an area of approximately 322 km^2. The ER watershed has several main tributaries: South Englishman River, Morrison Creek, Shelley Creek, and Centre Creek (Nelitz et al., 2007). From the headwaters at Mount Arrowsmith (08HB080 Fig 1), the ER runs a total length of 28 km and discharges into the Georgia Strait; an arm of the Salish Sea between Vancouver Island and the adjacent mainland coast of BC (Decker et al., 2003). The ER is influenced by heavy fall and winter rain which peak from October through to April with lower precipitation from April to May leading to decreased flows and ultimately low summer flow from June to September. The ER is therefore a primarily rain-driven hydrological system (Whitfield et al., 2002). The C.W. Young Side Channel, where we will be conducting our surveys, is a small, low gradient stream (0.5%) located 7km upstream from the ER estuary and is approximately 5.2 km long. Flow is derived from groundwater upwelling and controlled diversions from the mainstem.

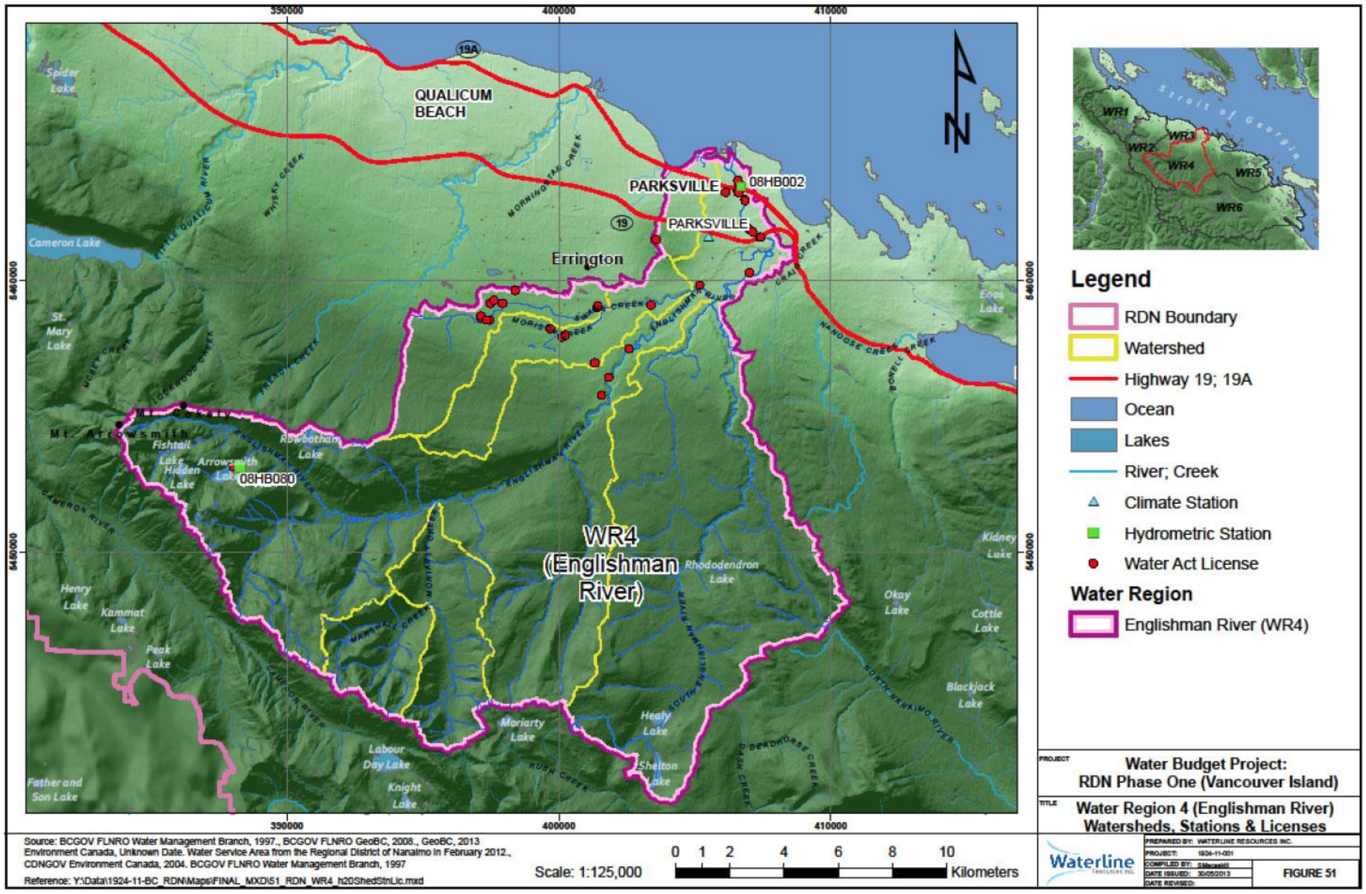

Figure 51: WR4 (ER) – Watersheds, Stations, & Licenses.

Figure 1*. Map of the Englishman River Watershed (Regional District of Nanaimo 2013).*

2.2 Historical Review

The Englishman River is one of the most significant salmon bearing streams on the central east coast of Vancouver Island, where all five species of anadromous salmon along with cutthroat and rainbow trout can be found (McCulloch, 2006). Anadromous length of the river is 15.8 km, beyond which a barrier at Englishman River Falls prevents salmon from passing. As a response to a decline in fish populations, the BC Government in 2000 designated the ER Watershed as a sensitive stream under the *Fish Protection Act*. The watershed has also since been included in the UNESCO Mount Arrowsmith Biosphere Reserve.

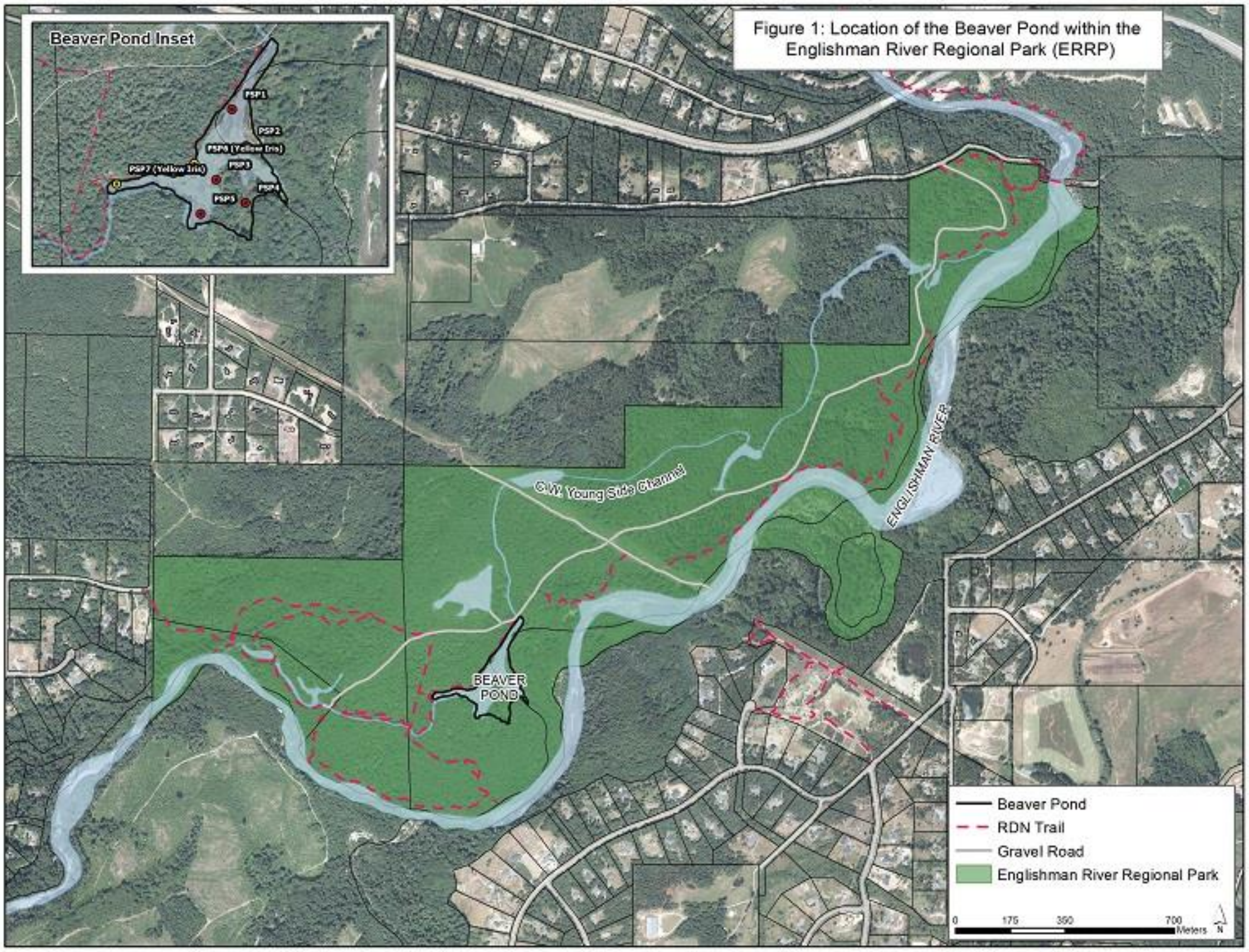

Figure 2. *Map of C.W. Young Side Channel within Englishman River Regional Park (MVIHES, 2020).*

Recognition of side-channels as important refuge from unfavorable wintering conditions in main stem habitats paired with an observed decline in fish stock led to significant off-channel development beginning in 1992 with the creation of the TimberWest (now C.W. Young) and Weyerhaeuser (Nature

Trust). These artificial side-channels were found over time to be preferred wintering habitat in the Englishman River system and further efforts to provide habitat similar to those found in highly-productive spawning sites has been undertaken over the years. Improvements include the installation of a surface water intake and the addition of large woody debris in order to provide structurally-complex habitat. The C.W. Young channel contains roughly 80% rearing pool and 20% spawning habitat, and now provides a place for spawning, rearing, and overwintering for coho salmon and accounts for 15-25% of coho smolt production within the watershed (Gaboury, 2003).

The C.W. Young Channel has previously been tested by Regional District of Nanaimo, Department of Fisheries and Oceans, British Columbia Conservation Foundation, and Vancouver Island University (VIU) Students enrolled in an Environmental Monitoring class.

2.3 Environmental Concerns

During the last fifty-plus years roughly 90% of the landbase in the ER watershed has been logged and is now dominated by second-growth coniferous forest, although the ER is technically located within the Coastal Douglas Fir and Coastal Western Hemlock biogeoclimatic zones. Most of the ER is privately owned by various timber companies, however the ER Provincial Park Conservation Area spans 207 hectares and ER Provincial park 97 ha. Clear-cut logging and subsequent loss of forest cover has led to slope instability along many riparian zones within the ER watershed. Furthermore, commercial and residential development including road construction and various infrastructure projects around ER channels has contributed to observed alterations in run-off patterns, and increased sediment loading. Drought conditions in recent years have led to low summer water levels, resulting in poor salmon stock and conflict with how best to utilize the resources stemming from the ER watershed (Decker et al., 2003). A study conducted by Weston et al., in January of 2013 determined that the Lower Englishmen

River floodplain is vulnerable to expected changes in precipitation and temperature likely to be experienced in the next 80 years as a result of global climate change.

3.0 Project Objectives

The primary objective is to sample the water quality and invertebrate health of the C.W. Young Channel of the Englishman River to contribute to long term monitoring efforts. By defining the general description of this site's environmental conditions we can provide useful information on the present conditions to compare to previous years. This year's data will be unique in that we are currently experiencing a drought. By examining the interactions between short and long term trends we can better understand this site's biodiversity, the effects of anthropogenic and natural disturbances and impacts of stressors (Haase et al. 2022).

4.0 Methods

4.1 Environmental Sampling and Analytical Procedures

4.1.1 Location and Habitat Characteristics

Following previous surveys of the C.W. Young channel, five prior sites were assessed and chosen as they have been laid out in the past (RMOT-306 2014). These five monitoring sites have been established beginning in 2008 and revisited by prior students yearly to be monitored as it is an important salmonid spawning and rearing area. By following past monitoring sites and protocol it allows for the trends of the environment within this stream to be identified through short- or long-term comparisons.

The five sites were visited on October 14th, 2022, to identify any possible changes in the site locations in which it had been determined that all sites were suitable and had not undergone drastic changes. It is important to replicate data for the five sites because these sites have been chosen in the past based upon canopy cover, water flow, site substrate, and accessibility. Therefore, these sites when sampled together best represent the channel in its entirety. Two environmental monitoring assessments being water quality and stream invertebrate biodiversity were conducted throughout the sites to assess the overall health of the C.W Young channel.

The five sites (Figure 3) that were sampled begin at the head water of the C.W. Young channel and continue downstream until the outflow into the main stem Englishman River.

Figure 3. *Map of the C.W. Young Channel Sampling Sites.*

Site 1 (Figure 3) is located at the headwaters of the C.W. Young channel where the outflow pipe is located (UTM 10 U 0405267mE 5459846mN). The location for sampling will take place roughly 1 meter downstream of the outflow pipe, although this can be slightly dependent on discharge levels. Characteristics of the site include a shallow pool with a very low gradient (<1%). At higher flows, the water level can rise and create deeper sections throughout. Substrate within the site is predominantly fines and silt (40%) with large boulders (30%) and coarse gravel making up the rest (30%). Riparian vegetation includes large alder (*Alnus rubra*) and big leaf maples (*Acer macrophyllum*) along with a variety of grasses and black berry bushes. The large trees named provide a relatively sparse canopy.

Site 2 (Figure 3) is located 1.25km downstream of Site 1 at the culvert (10U 0406143mE 5459962mN). The access road crosses the channel at this point and the sampling location will be 3 meters downstream of the culvert. This site location is within a riffle although holding a similar gradient to site #1 as there is no significant change. The substrate within this site contains mainly coarse gravel (60%), with cobble (20%), boulders (10%) and fines/silt (10%) making up the remaining material. Overhead canopy is slightly denser than that of Site 1 due to the number of Douglas Fir (*Pseudotsuga menziesii*) and western red cedar (*Thuja plicata*). The riparian area includes various grasses along with salal (*Gaultheria shallon*).

Site 3 (Figure 3) is 2.9km downstream from Site 1 and roughly 50m west of the access road (UTM 10U 0407089mE 5460663mN). Location for sampling within this site is roughly 4m downstream of the prominent bend. Sampling will take place in the middle of the channel. The site includes a similar low gradient as Site 1 and Site 2. The canopy is relatively open with a few maples and cedars spread without. The riparian zone consists of a wetland. Substrate within the site is mainly gravel (40%) and small woody debris (30%). Some large woody debris (20%) and fines (10%) make up the remaining material.

Site 4 (Figure 3) is located 3.8km downstream from Site 1 and the sampling point is 3m upstream from the steel footbridge (UTM 10U 0407495mE 5461056mN). The sampling location is at the outflow of a marsh that leads into a cascade. The canopy cover is considered moderate and is predominantly maple and Douglas fir. The substrate within the site is composed of large cobble (50%), boulders (15%), fines/silt (25%) and coarse gravel (10%). The riparian zone is made up of predominantly salmonberry and sword fern.

Site 5 (Figure 3) is located at the outflow of the C.W. Young channel into the Englishman River (UTM 10U 0407805mE 5461177mN). The site is made up of majority cobble (65%) with boulders (15%), gravel (10%) and fines (10%) making up the remaining material. Little canopy cover is within the site due to the wide stretch of the main stem Englishman River. The Riparian area includes various grasses and shrubs along with alders and some Douglas Fir.

4.1.2 Sampling Frequency

Field sampling occurred on two separate dates. The dates were October 26, 2022 and November 16, 2022. Both of the dates had predetermined sampling procedures as decided between team members as seen in (Table 1). VIU water samples will be collected at each site for both of the sites. ALS water samples will be taken at only three sites (Sites 2, 3, and 4). Both dates included the water quality samples and stream invertebrate sampling. Stream invertebrates were sampled at sites 1, 3, and 4. And at each stream invertebrate sample site, 3 replicate samples were taken and then combined together for one lab analysis.

Table 1. *Water quality and stream invertebrate sampling activities conducted at each site on the C.W. Young Channel. Symbol "1" indicates sampling events on October 26, 2022. Symbol "2" indicates sampling events on November 16, 2022.*

Site	Field Measurements	VIU Analysis	ALS Analysis	Stream Invertebrates
1	1,2	1,2	N/A	1,2
2	1,2	1,2	1,2	N/A
3	1,2	1,2	1,2	1,2
4	1,2	1,2	1,2	1,2
5	1,2	1,2	N/A	N/A

4.2 Water Quality

4.2.1 Field Measurements

An Oxyguard Polaris D/O meter was used to test dissolved oxygen (mg/L) and water temperature. And measurements of pH were also taken at each site during both of the events. Other samples that were unable to be analyzed in the field were brought back to be analyzed at either VIU or at ALS Laboratories in Vancouver, British Columbia. These measurements included:

- Turbidity,
- Alkalinity,
- Hardness,
- Nitrates,
- Phosphates,
- Nutrients,
- Total metals.

All samples were stored in a cooler with ice packs to keep samples at ~4°C prior to arriving at the labs.

4.2.2 Water Sample Collection

Water samples were collected over two separate dates: October 26, 2022, and November 16, 2022. The separate sampling days were done to cover a low flow and high flow event. Field notes were kept throughout the process to document date, time, weather, and location along with the analysis taken and sampler name. Proper measures were taken to ensure that there was no contamination of the water samples during sampling events. The B.C. Government's "Ambient Freshwater and Effluent Sampling" guideline was consulted throughout the sampling to ensure proper measures were followed. Measures taken included sampling from the furthest downstream site to prevent any contamination from flowing into other sites. Sampling then continued upstream to the headwaters of the C.W. Young Channel. At each station, bottles were rinsed and then samples were taken mid-stream below the surface. All samples were immediately labeled and placed into a cooler with ice packs to be transported to VIU within 12 hours for analysis at Vancouver Island University.

4.2.3 Vancouver Island University Analysis

Water samples that were acquired at each site during the two sampling periods were returned to VIU's Nanaimo Campus to be analyzed. These samples arrived at VIU within 12 hours of being taken. Analyses were conducted to test the total suspended solids (TSS), alkalinity (mg/L CaCO3), hardness (mg/L CaCO3), nitrate (mg/L NO3), and reactive phosphate (mg/L PO4).

4.2.4 ALS Laboratory Analysis

The water samples acquired from sites 2, 3, and 4 were stored in a cooler with ice packs in the field and then once arriving at VIU within 12 hours, were transported to another cooler and kept at ~4°C and shipped to ALS Laboratories in Vancouver, BC. ALS obtained the shipment of samples within 48 hours of initial sample time for both sampling events. ALS conducted physical tests for conductivity, hardness, and pH. An analysis for Anions and Nutrients was also conducted (total ammonia, nitrate, nitrite, total nitrogen, dissolved phosphate, and total phosphate. And lastly metals were analyzed for 31 different metals.

4.2.5 Quality Assurance / Quality Control

During the two sampling events, samples were taken at the same locations within each site. This was to maintain the most accurate sampling regimes possible. Keeping the same sites on the C.W. Young channel as previous environmental assessments that have been completed allows for consistency of data to be kept year to year (2008-2022).

4.2.6 Data Analyses, Comparison to Guidelines

The results from the analysis done at the VIU and ALS laboratories were compiled and compared to past studies of the C.W. Young channel along with both the provincial and federal water quality guidelines for the protection of aquatic life. Stream invertebrates were sampled and compiled for a Shannon-Weiner Diversity Index which was formulated based upon the results, to assess the overall health of the habitat and diversity within the C.W. Young channel.

5.0 Stream Invertebrate Communities

Our team took samples of Macrobenthic invertebrates, which are the most widely used organism for biological monitoring, as they are diverse and easy to sample. By comparing our data from previous years we can see how the overall ecosystem health has progressed at the sites in the C.W Young Channel of the Englishman River.

5.1 Invertebrate Sample Collection

In October during the low flow and in November during the (normally) high flow we sampled sites 1, 3 and 4. This was to ensure continuity of data and that a variation of habitat types were used for accurate representation. We used a Hess Sampler to collect invertebrates, which covers $0.9m^2$ of stream substrate. Selecting a site requires adequate water velocity and a downstream approach. Once in position, students disturb the substrate for 1 minute by hand. It is ideal to select suitable substrate that allows for invertebrate habitat, such as sediments, with some gravel and rocks. The combined content of three samples from each site was emptied into plastic containers and stored in a cooler for transport.

5.1.2 VIU Laboratory Analyses

In the VIU lab, organisms were sorted in shallow trays using tweezers, eye-droppers and petri-dishes. We used a microscope to identify and organize each organism by taxa and enter it into field survey data sheets provided through the Pacific Streamkeeper's procedures. The presence or absence of specific pollution tolerant taxa and abundance, richness and diversity combined give us a site assessment rating. The diversity of species is calculated using the Shannon-Wiener index.

5.1.3 Quality Assurance / Quality Control

To ensure quality assurance we took 3 replicate samples from Site 1, 3 and 4. To ensure quality control each sample was filled with 70% ethanol and put in a pre-labelled sterile plastic container for transport to VIU's lab in a cooler. The Hess sampler was cleaned and inspected prior to each use. In the lab some identified species were confirmed by Mike and Owen to ensure no false results occurred.

5.1.4 Data Analyses

The site's richness and diversity are calculated using the Shannon-Wiener Index. An overall site assessment rating is calculated using the Pacific Stream Keeper Invertebrate Survey Field Data sheet. This uses total density (number per m^2), total number of taxonomic groups, predominant taxonomic group, EPT index, pollution tolerance, EPT to Total Ratio Index and predominant taxon ration index. Due to the reliability of collecting invertebrates from the C.W Young Channel this is a very accurate way to compare stream health from previous years.

6.0 Results and Discussion

6.1 General Field Conditions

The initial site assessment occurred on October 14, 2022. Conditions were warm and dry as the region had experienced an extended period of drought leading up to and including the study, where the average temperature for that area was observed to be 16.4 °C (The Weather Network, 2022). The first sampling event began at 08:15 on October 26, 2022. Sites one through five were visited in reverse-order (beginning with site #5 and ending with site #1) due to order of access from the main gate located at the Allsbrook Road trailhead. The average air temperature was observed to be 10.2 °C (The Weather Network, 2022), and no rain fell during this period. The Englishman River area had been experiencing unseasonably dry conditions during that fall resulting from an extended period of drought, which resulted in dry conditions throughout the entirety of the study. The second sampling event began at 08:25 on November 16, 2022, and followed the same sampling methodology as the first sampling session. During this session an average air temperature of 4.8 °C was observed (The Weather Network, 2022). Like the assessment on October 26, 2022, there occurred no rainfall at any point during the sampling. Throughout the 21-day period between the first and second sampling events, only 36.6 mm of precipitation was reported to have fallen in the Parksville Area (The Weather Network, 2022).

The above mentioned dates were initially selected to capture low and high flow events in the C.W Young Channel of the Englishman River, however the effects caused by the ongoing drought at the time of the study did not allow for a significantly varied comparison, as the data in the report will show. Nevertheless, the data captured will be useful for a long-term study of the overall health of the C.W Young Channel when compared to past and future studies of this ongoing project.

6.1.1 Hydrology

The hydrological data taken at all 5 sampling sites (wherever possible) during both sampling events included wetted width (m), bank full width (m), average velocity (avg/sec), and maximum depth (cm). Limitations in field staff availability during the second sampling event coupled with safety issues in accessing certain areas of the field study resulted in the duplication of some data for certain parameters, namely wetted width and bank full width, as is identified in tables 1 and 2 below.

Table 2: *Hydrological Measurements from stations 1-5 on the C.W Young Channel taken on October 26, 2022.*

Station	Wetted Width (m)	Bank Full (m)	Flow (m/s)	Depth (cm)
1	6.9	8.2	0.09	50
2	4.1	7.9	0.32	55
3	4.2	9.4	0.12	56
4	14.95	14.95	0.11	60
5	24.2	4.39	0.40	45

Table 3: *Hydrological Measurements from stations 1-5 on the C.W Young Channel taken on November 16, 2022.*

Station	Wetted Width (m)	Bank Full (m)	Flow (m/s)	Depth (cm)
1	6.9	8.2	0.12	50
2	4.1	7.9	0.38	55
3	4.2	9.4	0.17	56
4	14.95	14.95	0.14	37
5	24.2	4.39	0.28	50

As previously mentioned, certain data was duplicated between sampling stations due to field staff availability and site safety issues during the second sampling event. Resultantly, some of the data presented may only be accurate and/or reflective of the conditions present during the first sampling session on October 26, 2022. However, throughout the entirety of the study, extended drought conditions affecting the region and consequently the C.W Channel of the Englishman River demonstrated similar conditions during both sampling events, as the rainfall that would be normally typical in that region at that time was well-below average. The variable data that was able to be captured during each sampling event, namely average flow and maximum depth, does support this, as there are no significant differences at any of the five stations relating to either measurement during either sampling event. In fact, as is the case for stations one, two, and three, maximum depths were observed to be identical across both sampling events. Similarly, velocities at these stations did not deviate more than 0.06 m/s each across either sampling event, suggesting that flow rates remained relatively constant across the 21-day study period.

6.2 Water Quality

6.2.1 Field Measurements

At all five stations, temperature (°C) and dissolved oxygen D.O, mg/L) were taken using an “Oxyguard Polaris” field meter across both sampling events occurring on October 26, 2022, and November 16, 2022. However, during the first sampling event, the meter malfunctioned at station two, and as such no field data was collected during that event for those parameters, as can be shown below in Tables 3 and 4.

Table 4: *Field measurements for temperature and dissolved oxygen from stations 1-5 on the C.W Young Channel taken on October 26, 2022.*

Station	Temperature (°C)	Dissolved Oxygen (mg/L)
1	6.1	17.0
2	Data Unavailable	Data Unavailable
3	5.4	13.3
4	5.6	11.3
5	8.1	10.2

Table 5: *Field measurements for temperature and dissolved oxygen from stations 1-5 on the C.W Young Channel taken on November 16, 2022.*

Station	Temperature (°C)	Dissolved Oxygen (mg/L)

1	2.1	18.1
2	2.8	16.4
3	2.7	17.8
4	4	16.8
5	3	17.6

Data from all five stations demonstrates that temperature decreased between each sampling event (excluding station two), ranging from a minimum 1.5 °C to a maximum of a 5.1 °C variance. Resultantly, dissolved oxygen increased at all five stations, as would be expected due to the correlation between dissolved oxygen content and temperature fluctuation. Based on these trends it would therefore be reasonable to expect that dissolved oxygen at station two would have also increased between sampling events, had the equipment not malfunctioned. There were no significant reductions or spikes observed, which would be expected with the recorded ambient air temperatures taken at the time each sampling event.

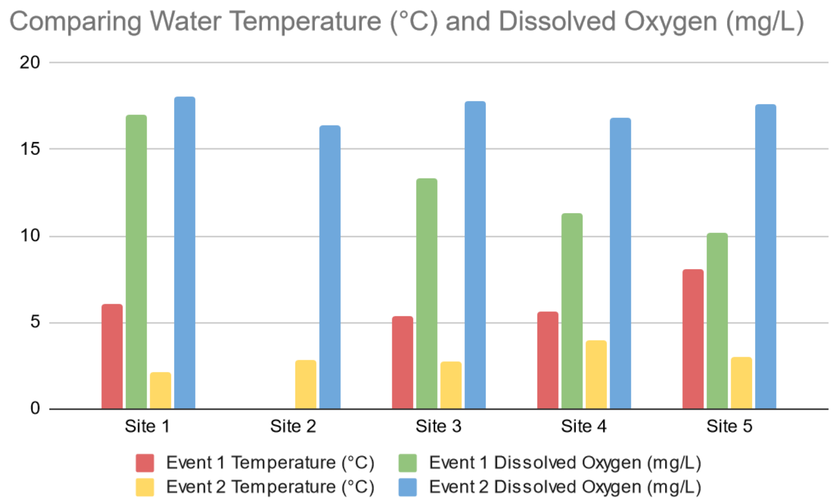

Figure 4: Graph of temperature and dissolved oxygen levels at 5 sites from 2 sampling events. There is no data for Event 1, Site 2 Temperature and D.O.

The "British Columbia Approved Water Quality Guidelines" for the protection of freshwater aquatic life indicates that the long-term chronic water quality guidelines for all life stages of aquatic life other than buried embryos or alevins in the water column have a minimum concentration of 8 mg/L, while buried embryos and alevins have a minimum concentration of 11 mg/L, suggesting that all five stations measured in the C.W Young Channel during both sampling events has acceptable dissolved oxygen levels to support aquatic life (British Columbia Approved Water Quality Guidelines, 2021). Regarding temperature, and specifically pertaining to streams with unknown fish distributions (the guidelines of which will be referenced here since a fish inventory was not conducted as part of this study), the maximum daily temperature should not exceed 19 °C, with an hourly rate of change not to exceed 1°C thereof (British Columbia Approved Water Quality Guidelines, 2021). Based on these results, all five stations measured have acceptable temperatures for the protection of freshwater aquatic life for streams with unknown fish distribution. This is an important distinction, since these numbers err on the side of caution and are not specific to any one species, meaning that these numbers generalize the overall protection of a broader variety of freshwater aquatic species. However, during the second sampling event, Coho Salmon (*Oncorhynchus kisutch)* were observed within the Englishman River near station one, and, according to the "British Columbia Approved Water Quality Guidelines" for the protection of freshwater aquatic life, require an optimum temperature range of 4.4-12.8 °C for spawning, 4.0-13.0 °C for incubation, 9.0-16.0 °C for rearing, and 7.2-15.6 °C for migration (British Columbia Approved Water Quality Guidelines, 2021). Since these salmon were observed on November 16, 2022 near station one, the date of which coincides with the typical spawning period, temperatures though not optimal were acceptable at that station when considering the temperature range specified within the British Columbia Water Quality Guidelines for Temperature and spawning Coho salmon.

When average temperature and dissolved oxygen readings are compared to previous years assessments done within the C.W Young Channel, it is apparent that, as figure 2 below will demonstrate, significant variability in temperature was observed, though not in dissolved oxygen. Since these studies took place during similar times of the year across each study period one would expect not to see any major fluctuations in the data, however, as mentioned in the case of temperature, this appears not to be the case. Speculations may be made as to why this is, and may include causes such as equipment malfunction, and scrutiny of the outlier studies should be made in order to ascertain the cause of these fluctuations.

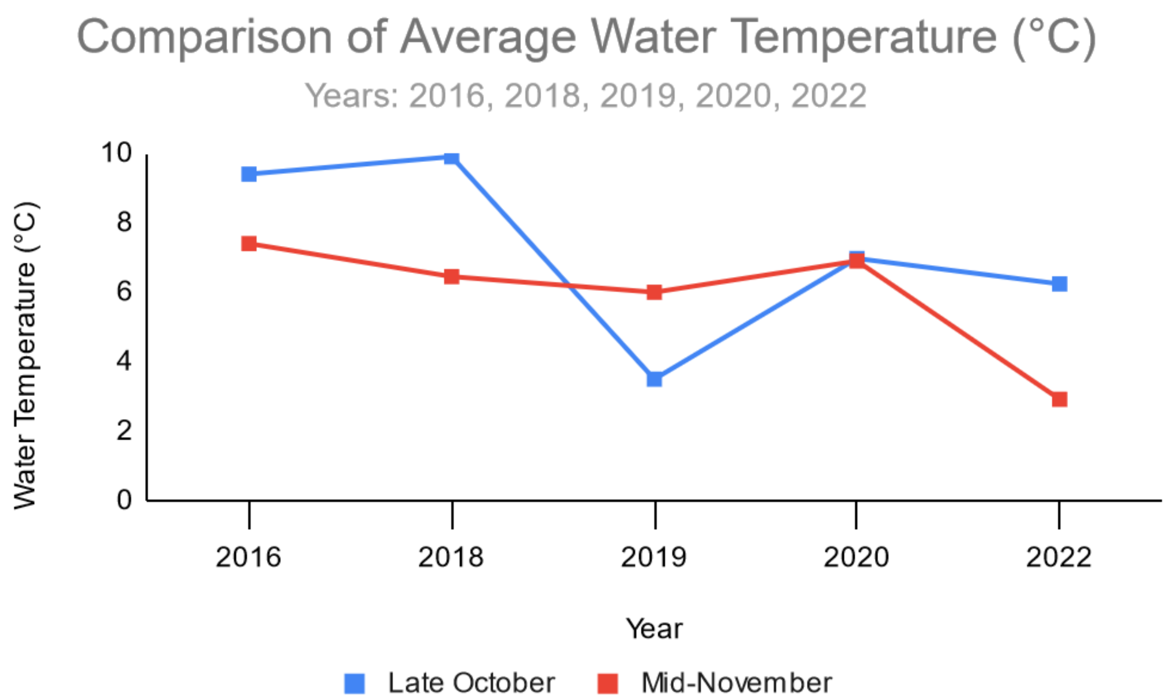

Figure 5: Water temperature (°C) measured during two sampling events in the C.W. Young Channel. Points show average temperature from five sampling stations. Sampling events were conducted in late October (blue) and mid-November (red) each year.

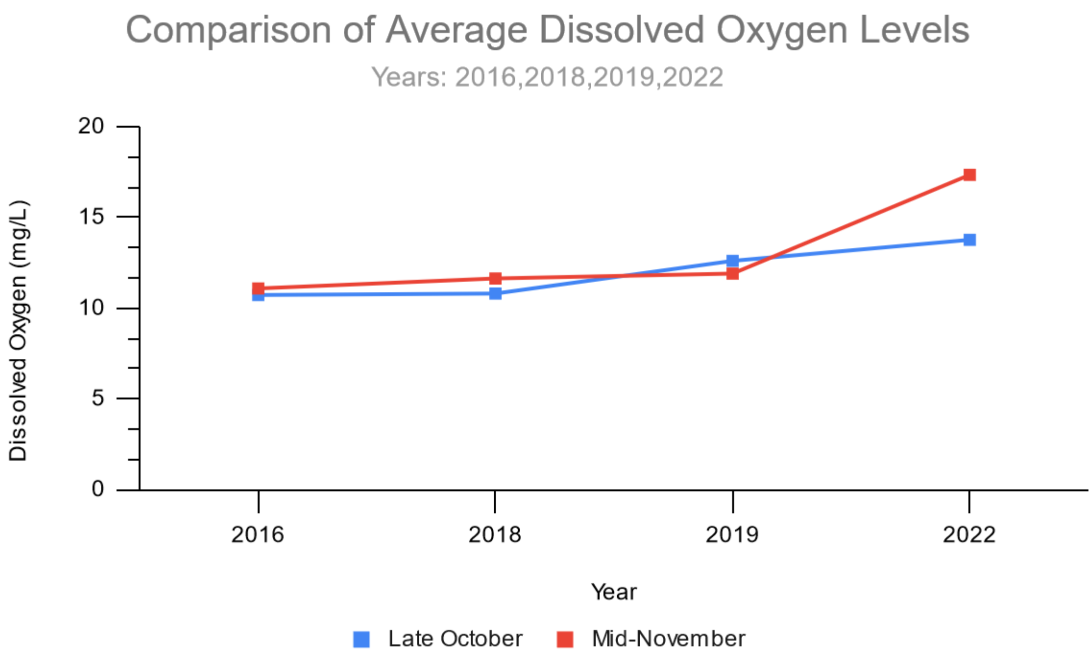

Figure 6: Dissolved oxygen concentrations (mg/L) measured during two sampling events in 2008-2015 in the C.W. Young Channel. Points show average concentrations from five sampling stations. Sampling events were conducted in late October (blue) and mid-November (red) each year.

6.2.2 VIU Laboratory Analyses

Individual samples were collected at all five stations during both sampling events, occurring on October 26, 2022, and November 16, 2022, and were then analyzed at VIU. Samples were collected in clean 1L HDPE bottles using best sampling practices, and were kept cool in-between collection and analyses. In both events, samples were collected and analyzed the same day. Trip blanks were also collected during both events, however in the interests of time and equipment availability were not analyzed at VIU. The types of analyses that were performed included Alkalinity (mg/L), pH, Hardness (mg/L), Turbidity (NTU), Conductivity (µS/cm), Nitrites (mg/L), and Phosphates (mg/L), and is summarized in tables 5 and 6 below.

***Table 6:** Water Quality Results for the C.W Young Channel, sampled and analyzed October 26, 2022.*

Parameter	Site #1	Site #2	Site #3	Site #4	Site #5	Water Quality Guidelines
Alkalinity (mg/L)	28.2	31.0	34.6	35.2	22.3	>20
pH	7.9	7.5	8.0	8.1	Unavailable	6.5-9.0
Hardness (mg/L)	64	60	52	56	56	<60 (soft water)
Turbidity (NTU)	8.46	1.38	0.47	3.11	1.17	<9.4
Conductivity (µS/cm)	119	135	141	128	141	<100
Nitrates (mg/L)	0.78	0.08	0.17	0.12	0.07	<200 (avg. 40)
Phosphates (mg/L)	0.64	0.03	0.03	0.02	0.02	5-15 µg/L

Table 7: *Water Quality Results for the C.W Young Channel, sampled and analyzed November 16, 2022.*

Parameter	Site #1	Site #2	Site #3	Site #4	Site #5	Water Quality Guidelines
Alkalinity (mg/L)	11.5	19.8	32	4	17.8	>20
pH	8.5	8.7	8.6	8.6	8.5	6.5-9.0
Hardness (mg/L)	40	46	60	48	39	<60 (soft water)
Turbidity (NTU)	0.69	3.78	0.64	1.25	1.21	<9.4
Conductivity (µS/cm)	90	87	101	99	89	<100
Nitrates (mg/L)	0.09	0.16	0.11	0.10	0.08	<200 (avg. 40)
Phosphates (mg/L)	0.02	0.02	0.03	0.02	0.03	5-15 µg/L

6.2.2.1 pH and Alkalinity

The British Columbia Approved Water Quality Guidelines indicate that, for the protection of aquatic life, pH should not exceed a range of 6.5-9.0 (British Columbia Approved Water Quality Guidelines, 2021). Both chronic and acutely lethal effects may be observed when pH does fluctuate outside of this range. Though pH samples were analyzed in a lab environment several hours after the samples were collected (with the exception of site five on October 26, 2022), all samples did fall within this acceptable range, averaging 7.88 for the first sampling event on October 26, 2022, and 8.58 for the second sampling event on November 16, 2022. Of the two sampling events, pH remained the most consistent among all five stations during the second sampling event.

Alkalinity, which is the measure of the ability of a waterbody to neutralize acids, averaged 30.26 mg/L while ranging from 22.3 mg/L to 35.2 mg/L during the first sampling event, and averaged 17.02 mg/L while ranging from 4.0 mg/L to 32.0 mg/L during the second sampling event. Because of the significant variability of results between sampling events, different interpretations relating to sensitivity and vulnerability to acidification may be made on the study sites of the C.W Young Channel based on the time of year that these samples were collected. The samples collected on October 26, 2022 indicate that the sample sites have a low sensitivity to acidification, whereas the samples collected on November 16, 2022 indicate a moderate to high sensitivity to acidification (RISC 1998). Figure 4 demonstrates both pH and alkalinity throughout each site on each sampling event.

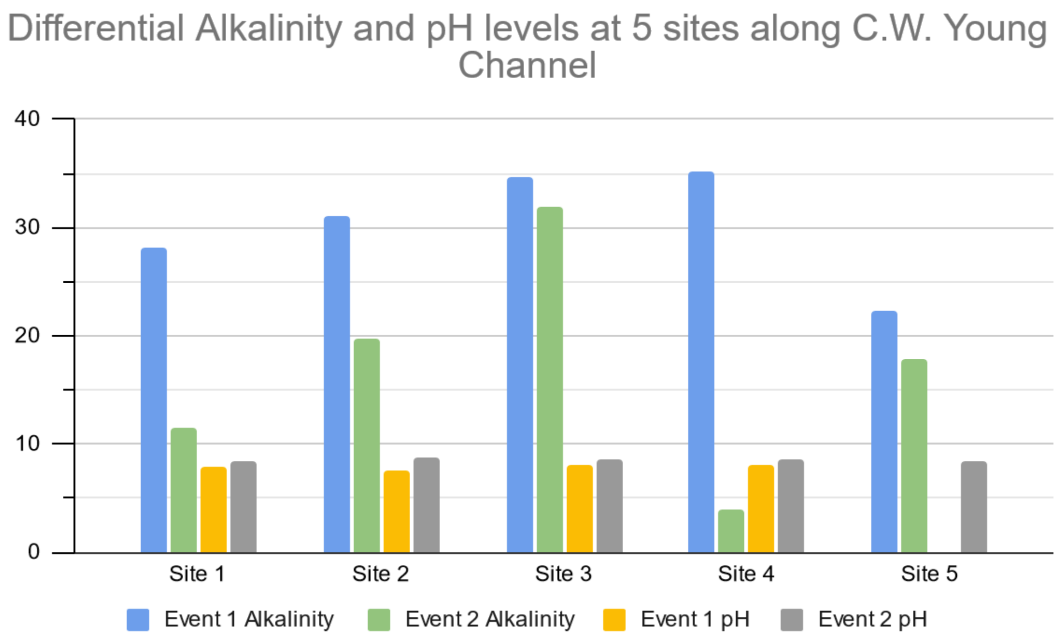

Figure 7: Alkalinity and pH values at five sites in the C.W Young Channel, taken on October 26, 2022 (event 1), and November 16, 2022 (event 2).

6.2.2.2 Turbidity and Conductivity

Turbidity, which is the measure of the relative clarity of a liquid, proved to be highly-variable between sites during both sampling events. Higher turbidity can be associated with a number of causal factors including increased precipitation, substrate disturbance, or erosion resulting in the deposit of suspended solids resulting in decreased water clarity. The highest recorded turbidity reading was at site one on October 26, 2022, with a value of 8.46 NTU. This reading may be an outlier from a statistically useful perspective however, as it falls well-above the average for either sampling event at any of the five stations. In any case, turbidity readings taken on October 26, 2022, fluctuated between 0.47 NTU and 8.46 NTU at each sampling site, averaging 2.92 NTU for that sampling event, and fluctuated between

0.64 NTU and 3.78 NTU when sampled on November 16, 2022, averaging 1.51 NTU for that sampling event, as figure 5 illustrates.

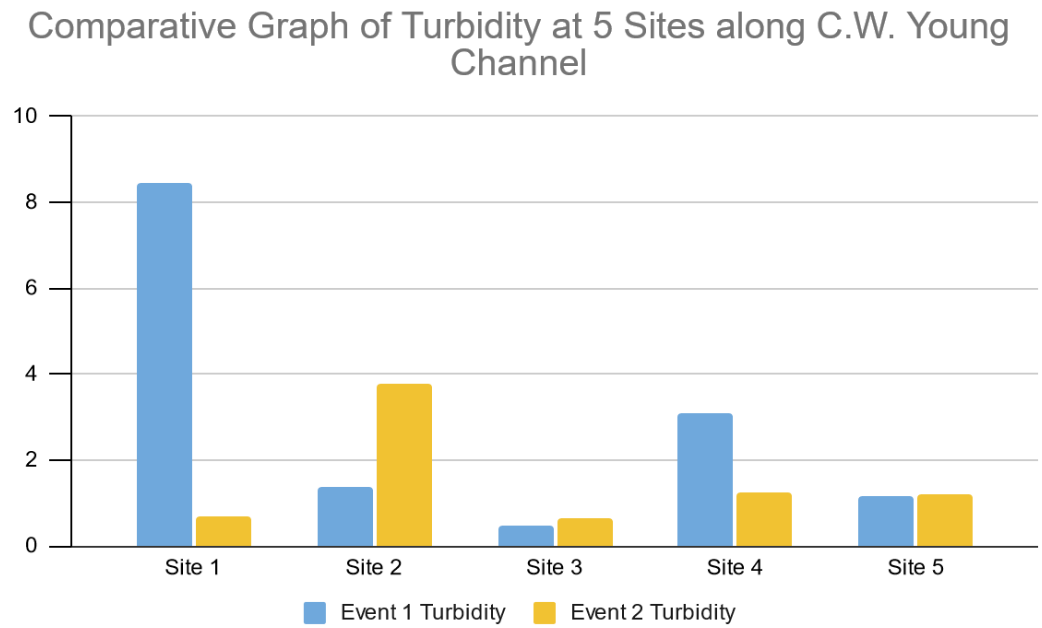

Figure 8: Comparative Graph of Turbidity at 5 sites along C.W. Young Channel.

Turbidity guidelines for the protection of aquatic life suggest that an increase of 5 NTU's above background will begin to have detrimental effects on aquatic life (RISC, 1998). In order to determine what the average background for the C.W Young Channel is, data from previous assessments dating back to 2016 are considered when determining average background NTU's for both low and high-flow study periods in the C.W Young Channel, as identified in Figure 6. Note that it must also be considered that, due to the Covid-19 pandemic, there exists a data gap spanning a two-year period where no data was obtained due to the public health restrictions in place at that time. Average turbidity readings taken in late October were 3.63 NTUs in 2016, 1.43 NTUs in 2018, and 1.3 NTUs in 2019. Therefore, 2.92 NTUs as recorded in late October for this study do not fall outside the 5 NTU background limit specified in the guidelines, and would be acceptable for the protection of aquatic life. Similarly, average turbidity readings taken in mid November were 2.68 NTUs in 2016, 1.34 NTUs in 2018, and 3.2 NTUs in 2019. Resultantly, the average turbidity recorded in 2022 at 1.51 NTUs also does not exceed the 5 NTU tolerance, meaning that, from an aquatic health perspective, results from the 2022 study do fall within acceptable guidelines for the protection of aquatic life relating to turbidity.

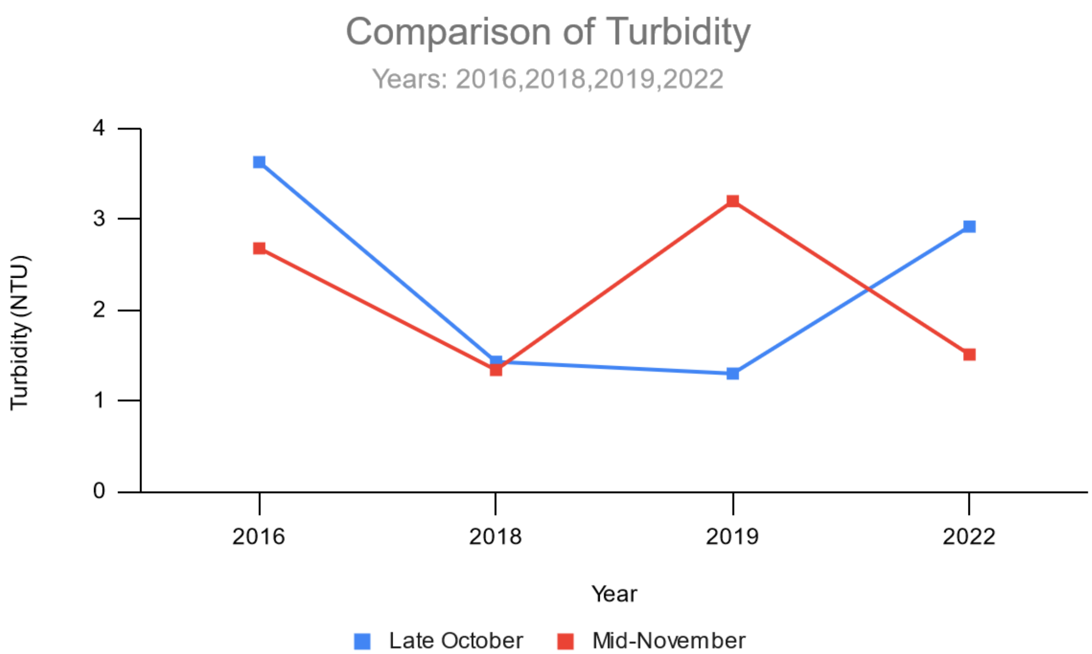

Figure 9: Turbidity levels (NTU) measured during two sampling events in the C.W. Young Channel. Points show average turbidity from 5 sampling stations. Sampling events were conducted in late October (blue) and mid-November (red) each year.

When considering conductivity in the C.W Young Channel, all five stations experienced a decrease in measurements between sampling events in late October and mid November. Conductivity, which is the relative amount of electricity that can be conducted by water (and is expressed in microSiemens), is directly related to the ion content of the waterbody being measured. Thus, a higher concentration of ions equates to a greater measure of conductivity. Conductivity can be affected by precipitation from dilution, which could explain the reduction in readings between studies. There is no prescribed tolerance for conductivity and freshwater life, however coastal lakes and streams in B.C present an average of <150 µS/cm, meaning that all five stations in the C.W Young Channel demonstrated normal levels relating to conductivity during both sampling events.

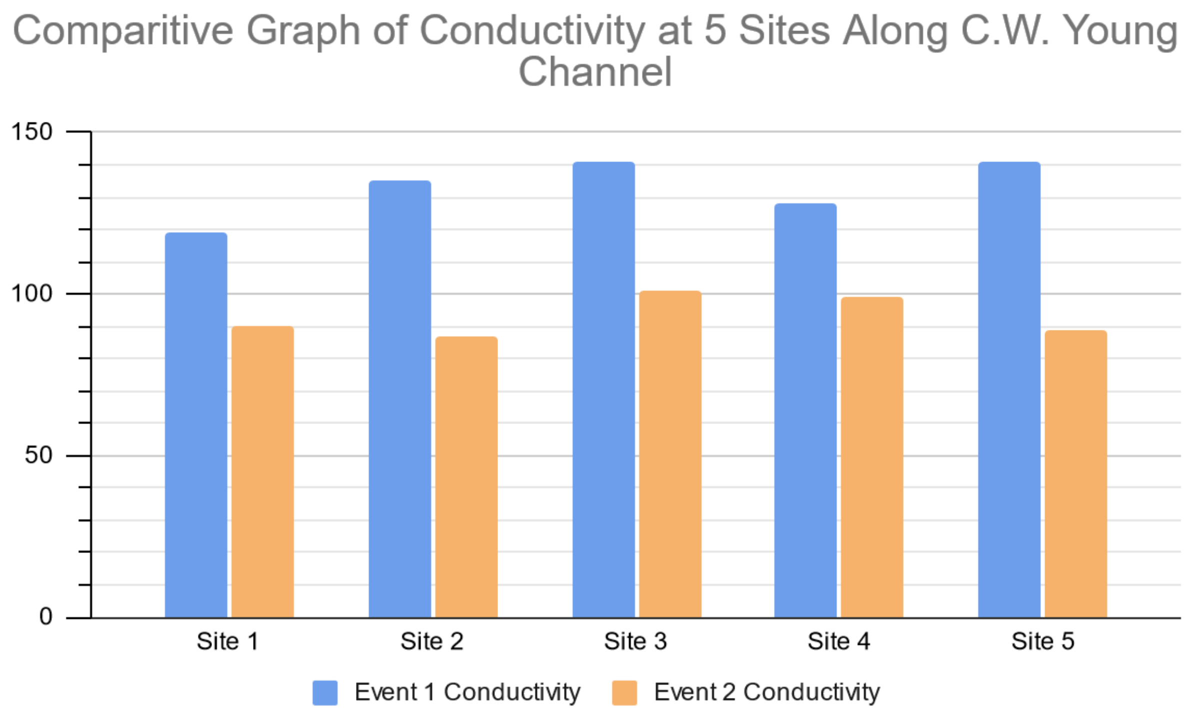

Figure 10: Comparative Graph of Conductivity at 5 sites Along C.W Young Channel.

6.2.2.3 Hardness

Hardness measured at all five stations during both sampling events in the C.W Young Channel fell within a narrow range of 39 mg/L to 64 mg/L. These values, with the exception of site one during the first sampling event in late October, fall within the 60 mg/L guideline indicative of soft water (RISC, 1998). This indicates that, from a hardness perspective, the C.W Young Channel is acceptable for aquatic life (figure 7).

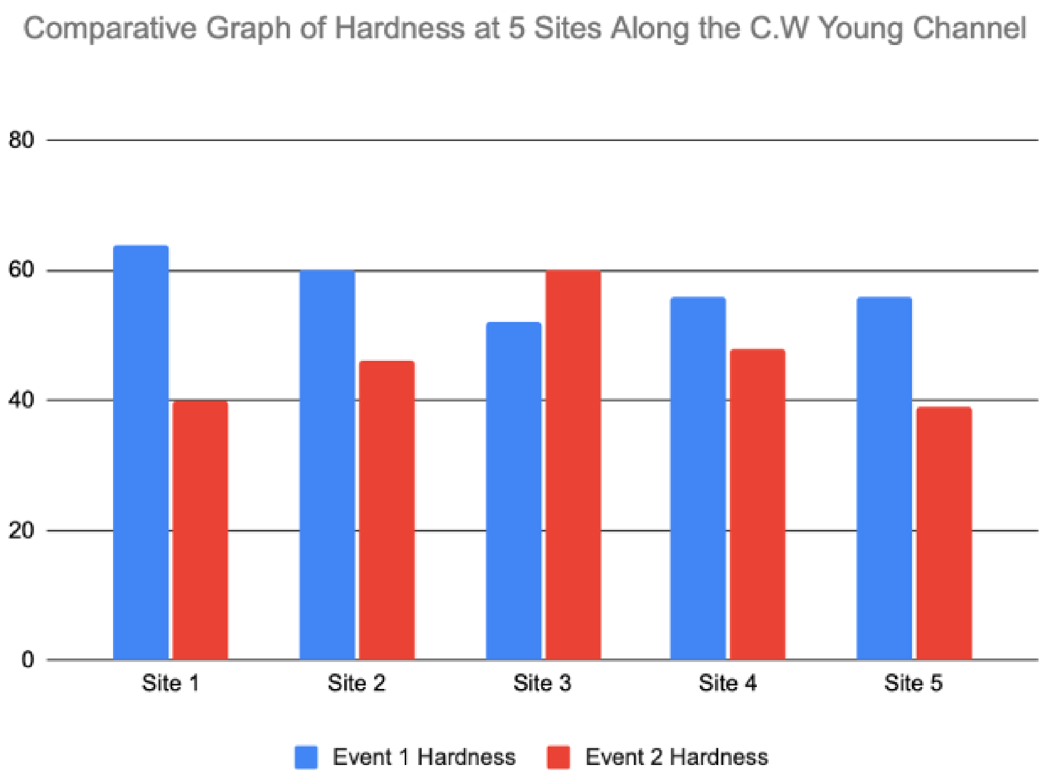

Figure 11: Comparative Graph of Hardness at 5 sites Along the C.W Young Channel.

Though soft water is more susceptible to metal toxicity, the metal analysis results received from ALS (which will be touched on later in this report) show a negligible concentration of metals of any type observed within the C.W Young Channel during this study period.

When comparing hardness to previous assessments dating back to 2016, it appears that values have increased overtime, especially between 2019 and 2022 as figure 8 will show, though the averages still fall within the 60 mg/L tolerance to be considered soft water and therefore acceptable for aquatic life.

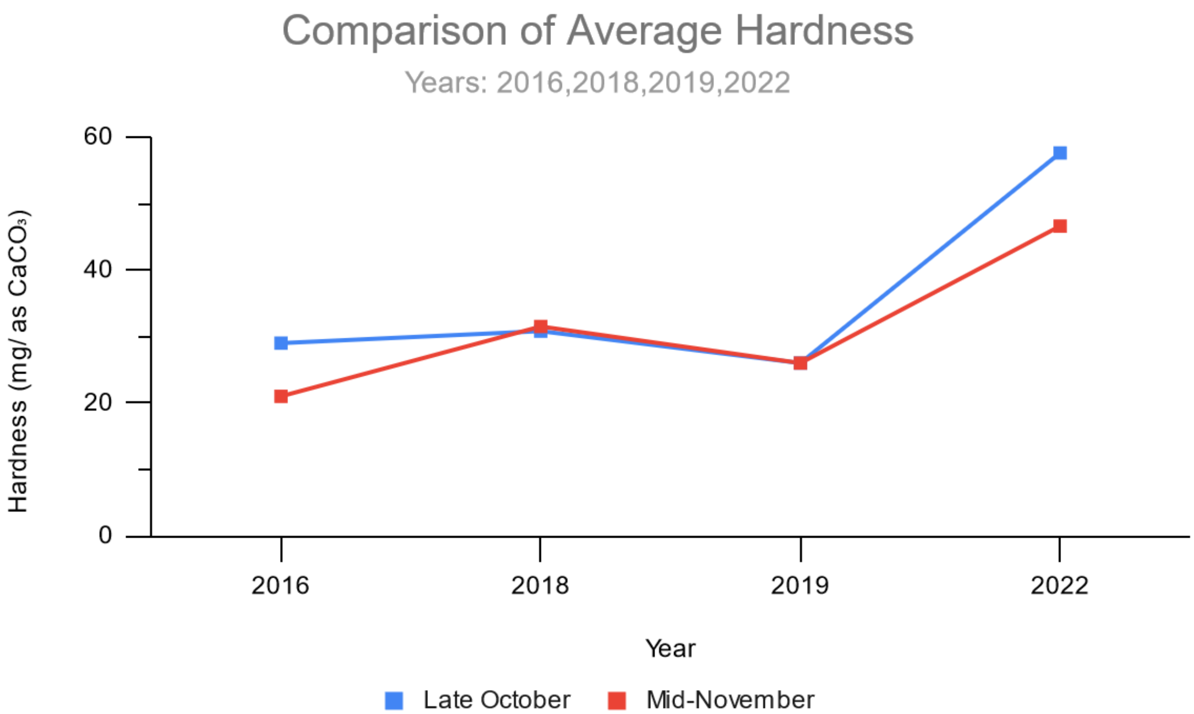

Figure 12: Comparison of Average Hardness at the C.W Young Channel.

6.2.2.4 Nitrates and Phosphates

Nitrates (NO3) are the primary form of nitrogen used by (in this case) aquatic plants and are therefore essential for growth. Nitrates are added to water bodies through natural processes such as weathering and erosion, or through anthropogenic processes such as agricultural runoff or sewage deposits. Excess nitrate loading into water bodies can result in advanced eutrophication, which can have negative effects on a waterbody that may include premature aging. Most freshwater in B.C that has not been affected by anthropogenic processes have nitrate concentrations below 0.3 mg/L (British Columbia Approved Water Quality Guidelines, 2021). At all five stations measured during both sampling events, nitrate levels fell below the 0.3 mg/L tolerance, with the exception of station one during the October 26, 2022 sampling event, which measured 0.78 mg/L. This measurement very likely was caused by the presence of a beaver dam located just upstream of the sampling location at station one, since the deposit of waste and feces from beaver activity could explain the spike in nitrates at only this location. This theory is likely supported due to the fact that the beaver dam had been removed prior to the second sampling event, where nitrate levels were measured at 0.09 mg/L. These results would then suggest that the C.W Young Channel are not affected from anthropogenic inputs of nitrates at any of the five sites studied, and are consequently within range to be acceptable for aquatic life.

Phosphate (PO_4^{3-}) is the main form of phosphorus and is another nutrient essential for aquatic plant life. It is also the most limiting nutrient in freshwater, and excessive phosphate levels can result in eutrophication which can have negative effects on a waterbody. Phosphates have similar sources as nitrates, and therefore must be controlled by reducing or eliminating any anthropogenic inputs. Typically speaking, freshwater environments can be categorized into three distinct classifications based on their productivity relating to their phosphate levels: oligotrophic environments have <0.01 mg/L measured phosphates, mesotrophic environments fall between 0.01-0.03 .g/L, and eutrophic environments fall above 0.03 mg/L. As with nitrates, all stations during both sampling events with the exception of station one during the October 26, 2022 sampling event fell within similar concentrations, which would again be explained by the presence of the beaver dam located at this station. Based on these measurements, the C.W Young Channel can be classified as a eutrophic, or medium-productivity environment.

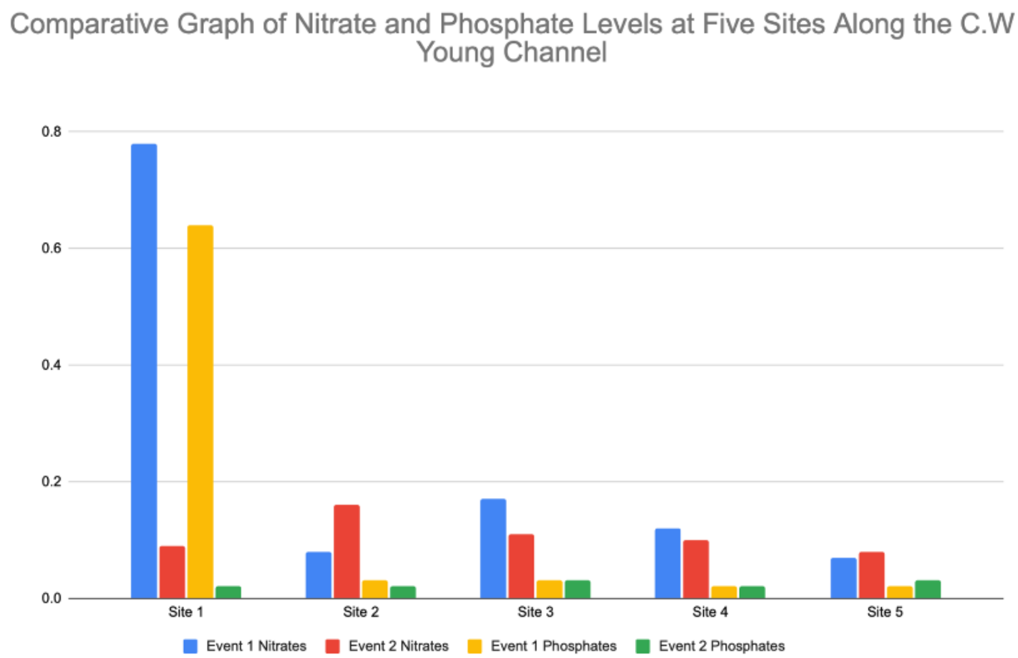

Figure 13: Comparative Graph of Nitrate and Phosphate Levels at Five Stations Along the C.W Young Channel.

6.2.3 ALS Laboratory Analyses

Water samples were collected at sites two, three, and four, during both sampling events on October 26, 2022, and on November 16, 2022, and submitted to ALS Laboratories in Vancouver, B.C. Sample bottles were provided beforehand, including appropriate sampling containers and preservatives for the collection of water to be analyzed for metals and anions, and best sampling practices were used throughout the collection. Samples were packed in a cooler and shipped to ALS, and after analyses the results were provided back to the group, and are summarized below in table 7. Testing at ALS was conducted for pH, Hardness (mg/L), Conductivity (µS/cm), and anions including Nitrates (mg/L) and Phosphates (mg/L), in order to compare results to those sampled for and analyzed at VIU. Additionally, ALS performed analyses on a suite of total metals, since VIU lacked the ability to do so. Metal samples were preserved with nitric acid immediately after sample collection, in order to maintain sample integrity during transport to ALS.

Conductivity results between VIU and ALS were similar, with no result deviating >20 μS/cm between stations during either sampling event. Hardness saw the greatest variation between results, with five sample sites demonstrating at least a 13 mg/L difference in results. This could be caused by sensitivity of equipment or sample quality degradation, though the results are similar enough to be useful from an analytical perspective. pH values remained relatively consistent between VIU's and ALS's analyses. VIU's results for pH fluctuated from 7.5 to 8.1 during the first sampling event, and fluctuated from 8.6 to 8.7 during the second sampling event. ALS' results for pH fluctuated from 7.17 to 7.16 during the first sampling event, and from 8.6 to 8.7, all of which are acceptable for aquatic life.

Samples for anions and nutrients (phosphates especially) showed the greatest variability between VIU and ALS laboratory analyses; results of phosphates that were analyzed at VIU and demonstrated that the C.W Young Channel would be considered mesotrophic (0.01-0.03 g/L), would actually be considered oligotrophic, or low productivity (<0.01 mg/L). This may have been caused by sample degradation during shipping, but regardless still demonstrates that the overall productivity of the C.W Young Channel is still for the time being free from anthropogenic eutrophication.

The results from the metals suite analyzed by ALS suggests that Aluminum is the only parameter that exceeds the acceptable water quality guidelines of 0.1 mg/L (dissolved) for short-term exposure, and 0.05 mg/L for long-term exposure. Sites three and four, sampled on October 26, 2022, contained 0.112 mg/L and 0.133 mg/L total aluminum respectively, and site 2 sampled on November 16, 2022, contained 0.148 mg/L aluminum, all of which exceed acceptable guidelines and is consistent with previous years studies. Possible explanations for these exceedances include industrial activities occurring in and around the C.W Young Channel, the deposit of waste and garbage within the Englishman River, and historical contamination from logging and fishing activities within the area.

***Table 8**: Results of Analysis from ALS Laboratories for 5 stations along C.W Young Channel.*

Results Summary VA22C6261								
Project								
Report To	Owen Hargrove, Vancouver Island University							
Date Received	27-Oct-2022 12:00							
Issue Date	07-Nov-2022 12:36							
Amendment	0							
Client Sample ID			Englishman River -Site 2	Englishman River -Site 3	Englishman River -Site 4	Englishman River Site 2	Englishman River Site 3	Englishman River Site 4
Date Sampled			26-Oct-2022	26-Oct-2022	26-Oct-2022	16-Nov-2022	16-Nov-2022	16-Nov-2022
Time Sampled			9:40	9:10	8:50	9:11	8:56	8:42
ALS Sample ID			VA22C6261-007	VA22C6261-008	VA22C6261-009	VA22C8006-004	VA22C8006-005	VA22C8006-006
Analyte	Lowest Detection Limit	Units	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water
Physical Tests (Matrix: Water)								
conductivity	2	µS/cm	142	132	135	99.3	97.6	105
hardness (as CaCO3), from to	0.5	mg/L	41.9	39.2	42.6	31.2	31.1	37.4
pH	0.1	pH units	7.39	7.42	7.53	7.18	7.17	7.26
Anions and Nutrients (Matrix: Water)								
ammonia, total (as N)	0.005	mg/L	0.0065	0.0106	0.0077	<0.0050	0.0075	0.008
nitrate (as N)	0.005	mg/L	0.0126	<0.0050	0.0355	0.0565	0.0502	0.0833
nitrite (as N)	0.001	mg/L	0.0012	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
nitrogen, total	0.03	mg/L	0.08	1.5	0.132	0.173	0.103	0.139
phosphate, ortho-, dissolved (a	0.001	mg/L	<0.0010	0.001	<0.0010	<0.0010	<0.0010	<0.0010
phosphorus, total	0.002	mg/L	0.0092	0.334	0.0094	0.0034	0.0048	0.0043
Total Metals (Matrix: Water)								
aluminum, total	0.003	mg/L	0.0207	0.112	0.133	0.148	0.0448	0.0496
antimony, total	0.0001	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
arsenic, total	0.0001	mg/L	0.00012	0.00015	0.0002	0.00017	0.00014	0.00015
barium, total	0.0001	mg/L	0.00814	0.00793	0.00768	0.00696	0.00616	0.00654
beryllium, total	0.00002	mg/L	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020
bismuth, total	0.00005	mg/L	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
boron, total	0.01	mg/L	0.019	0.017	0.016	0.012	0.012	0.012
cadmium, total	0.000005	mg/L	<0.0000050	0.0000332	<0.0000050	0.0000112	0.0000113	<0.0000050
calcium, total	0.05	mg/L	14.3	13.4	13.6	10.6	10.6	11.9
cesium, total	0.00001	mg/L	<0.000010	<0.000010	0.00001	0.000012	<0.000010	<0.000010
chromium, total	0.0005	mg/L	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
cobalt, total	0.0001	mg/L	<0.00010	<0.00010	0.0001	0.00011	<0.00010	<0.00010
copper, total	0.0005	mg/L	0.00053	0.00134	0.00075	0.00091	0.00088	0.00147
iron, total	0.01	mg/L	0.1	0.208	0.27	0.28	0.118	0.129
lead, total	0.00005	mg/L	<0.000050	0.000054	0.000051	0.000078	0.000053	0.000322
lithium, total	0.001	mg/L	0.0039	0.0039	0.0035	0.0034	0.0033	0.0031
magnesium, total	0.005	mg/L	1.5	1.39	2.11	1.14	1.13	1.88
manganese, total	0.0001	mg/L	0.00586	0.00658	0.00857	0.00908	0.00421	0.00448
molybdenum, total	0.00005	mg/L	0.000109	0.000115	0.00012	0.000101	0.000124	0.00012
nickel, total	0.0005	mg/L	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
phosphorus, total	0.05	mg/L	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
potassium, total	0.05	mg/L	0.183	0.217	0.242	0.157	0.162	0.224
rubidium, total	0.0002	mg/L	0.00023	0.00032	0.0003	0.00028	0.00021	0.00023
selenium, total	0.00005	mg/L	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	0.000063
silicon, total	0.1	mg/L	2.51	2.51	3.02	2.77	2.64	3.22
silver, total	0.00001	mg/L	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
sodium, total	0.05	mg/L	9.8	8.64	8.48	5.83	6.14	6.08
strontium, total	0.0002	mg/L	0.0713	0.0665	0.0653	0.0525	0.0514	0.0546
sulfur, total	0.5	mg/L	<0.50	<0.50	<0.50	<0.50	0.54	0.63
tellurium, total	0.0002	mg/L	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
thallium, total	0.00001	mg/L	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
thorium, total	0.0001	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
tin, total	0.0001	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.00019
titanium, total	0.0003	mg/L	0.00067	0.00563	0.00647	0.00666	0.00145	0.00234
tungsten, total	0.0001	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
uranium, total	0.00001	mg/L	<0.000010	<0.000010	0.000029	0.000011	<0.000010	0.000023
vanadium, total	0.0005	mg/L	<0.00050	0.0006	0.00102	0.00079	<0.00050	0.0006
zinc, total	0.003	mg/L	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	0.0046

6.2.4 Quality Assurance / Quality Control

Replicate samples in the form of trip blanks were taken during each sampling event, in order to demonstrate that sample integrity during both field sampling and lab analysis was maintained. Samples were taken of distilled water, and were sealed in bottles identical to those used for actual samples taken during each sampling event. Unfortunately, due to challenges in available laboratory analysis time at VIU , on top of the expenses associated with shipping multiple samples to ALS, blank samples were not analyzed and are therefore not included in this report.

All samples taken were collected using best sampling practices. Samples were taken using clean nitrile gloves and were changed in-between stations. Clean 1L HDPE sample bottles were provided for the water analysis, and sterile bottles were provided by ALS for the metals analyses. Samples were individually labeled to identify where and when each sample came from, and a chain-of-custody form was filled prior to submission to ALS. Samples were transported to and from VIU in coolers to be kept at 4 °C.

ALS is a professionally-accredited laboratory, and as such is required to maintain a high standard of quality in their analyses. Testing methodologies, including any notes, deviations, or information otherwise relevant to the results are included in the final report of analysis provided by ALS. In both reports, the data ,et ALS Data Quality Objectives, however recommended holding times were exceeded between sample collection date and analysis. ALS also recommended that pH be collected in the field, as the holding time for pH is quite narrow.

7.0 Stream Invertebrates Communities

On Oct. 26th 2022, Zoe, Alysia, Kiran and Jake sampled sites 1, 3 and 4 using the Hess sampler for a combined total number of 56 invertebrates and total Taxa of 16. The water level of the stream was much lower than usual as we were experiencing a drought. Normally, salmon would be spawning in the channel at this time, but none were observed. On Nov. 16th 2022, combined sites 1, 3 and 4, the total number of invertebrates was 50 with a total Taxa of 11. We expected to collect less invertebrates in November due to temperature decrease and possible predation by salmonids. We only observed 1 salmonid near Site 1 in the C.W Young Channel, but in the main Englishman River, we observed a large group of Coho with some Cutthroat.

A notable difference between the sampling results is that no larva were found in the Nov. 16th collection. The dominant invertebrates were the scuds (amphipods) and mayflies for both sampling events (Figure x.). The average assessment rating for the sites was between 2 and 2.5. The backstop for this rating comes from the Stream Keepers Survey Sheet which designates a 2 as 'marginal'.

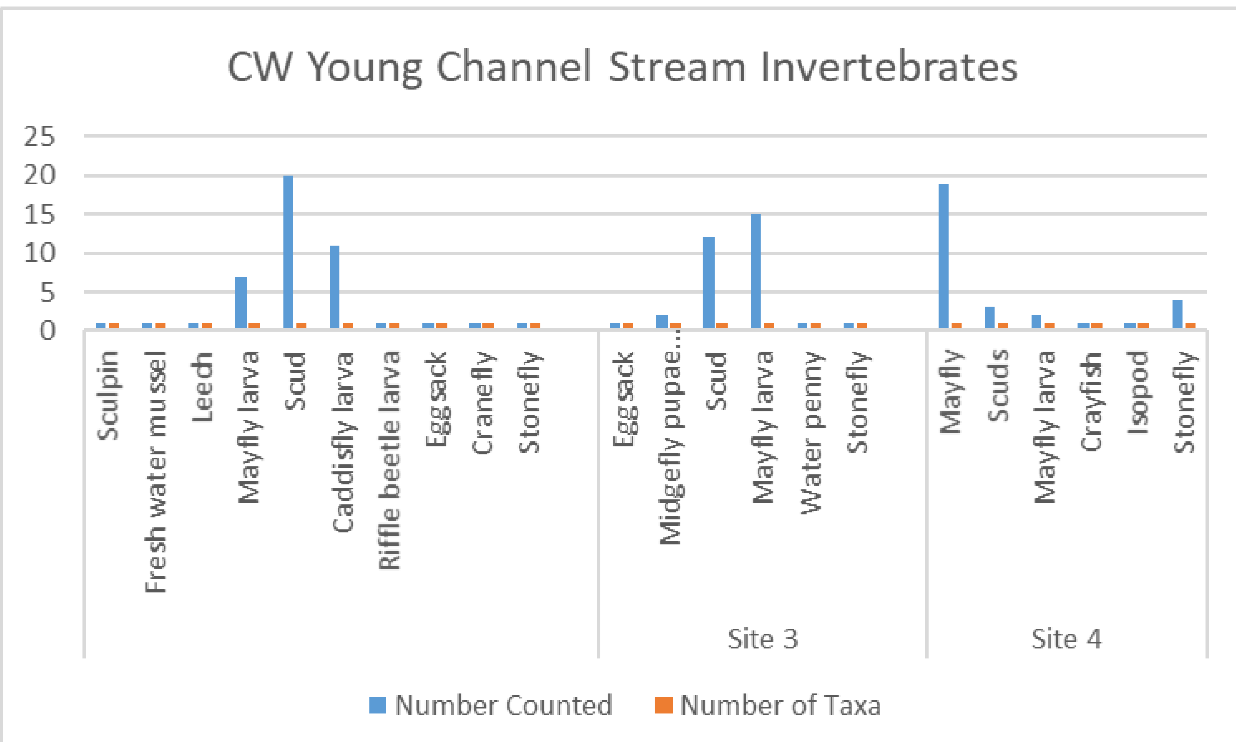

Figure 14*. Number of counted stream invertebrates and number of Taxa in the C.W Young Channel on Oct. 26th and Nov. 16th 2022.*

7.1.1 Total Density

The Three sites were reasonably similar in density. Site 1 had the highest count with 42 invertebrates for an overall density of 155.56/m2. Site 3 had the second highest with 31 invertebrates total and a density of 114.81 m2. Site 4 had the lowest number of organisms at 30 with a density of 111.11 m2 (Appendix 3).

7.1.2 Taxon Richness and Diversity

Using the Shannon-Wiener index the diversity was calculated for each site, with 1 being excellent diversity and 0 being no diversity. Site 1 had an index of 0.707 with 8 total Taxa. Site 3 had an index of 0.666 with 4 total Taxa. Site 4 had an index of 0.772 and a total Taxa of 4. These numbers reflect the totals taken from our notebooks, rather than that of the Stream Keepers Survey, which did not have options for egg sacs and pupae remnants that were included in the diversity index calculations. Interesting observations from the Stream Keepers Survey data sheets were that although Site 5 had the lowest number of organisms it had the highest overall assessment rating. This could be inferred by the EPT to total ratio, which was on the higher end, with a rating of 4 (good). Site 1, which had the highest number of organisms had the lowest overall assessment rating. This is due to the EPT to total ratio being low with a score of 1 (poor) (Appendix 3).

Invertebrates are useful bio-indicators of overall stream health. In 2016 the C.W Young Channel had an overall assessment rating average between 2.25 and 3.25. In 2017 the average was 3.08. In 2019 the assessment rating was 3.5. In 2020 the assessment rating was between 3.25 and 1.75. Our average assessment rating of 2.25, which in comparison to the average of previous years, is somewhat lower. A visual representation of this can be found below (Figure X.) When you consider the drought that occurred this rating does not seem unusual. What could have affected our rating is that only 2 students had waders and with repeated sampling their hands became numb and not able to effectively disturb sediment to collect invertebrates. My recommendation for future sampling is to use a kick method to ensure thorough sampling in cold weather conditions.

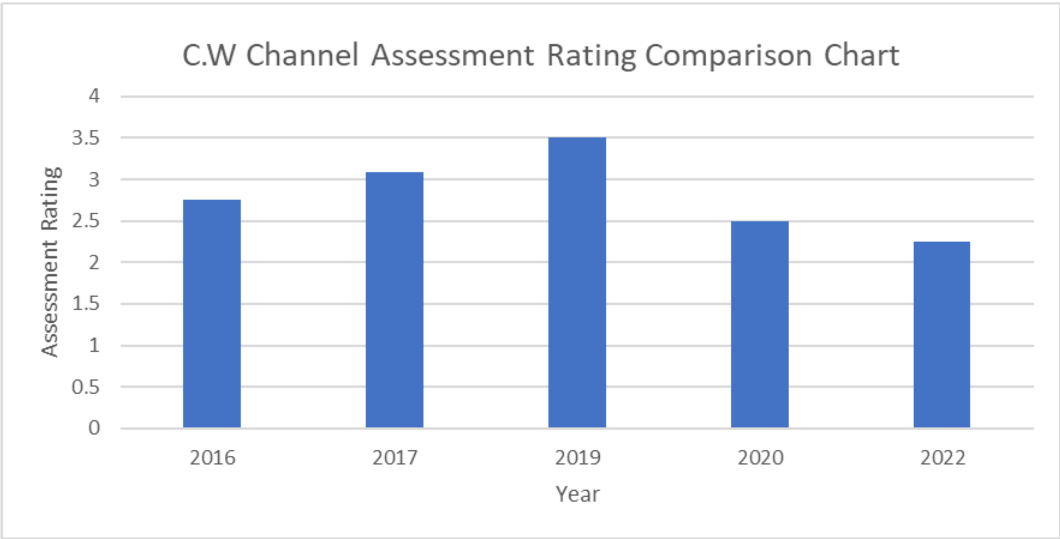

Figure 15*: Average assessment rating of the C.W Young Channel from 2016 to 2022.*

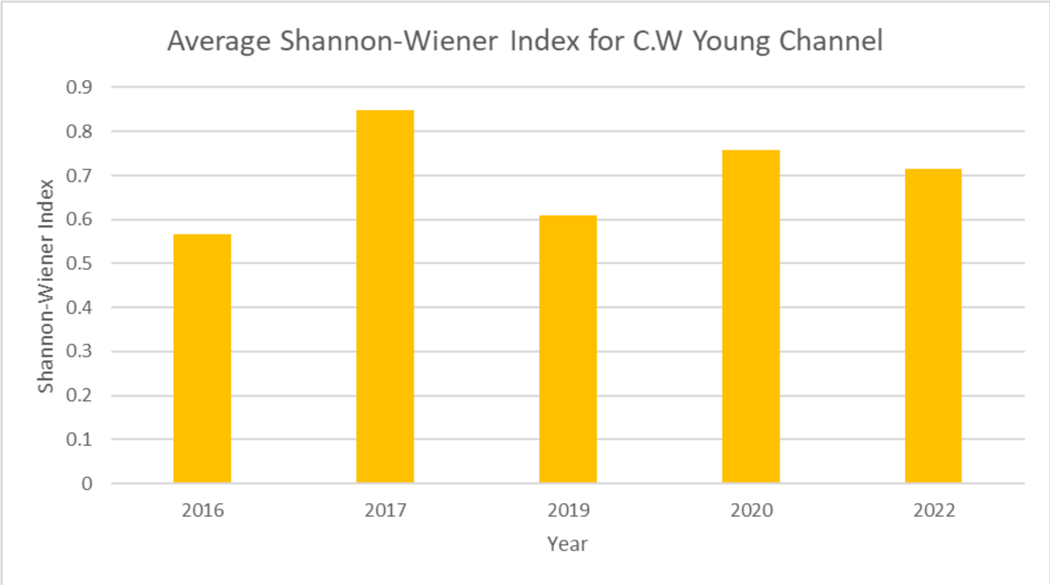

Figure 16: *Average Shannon-Wiener index for C.W Young Channel from 2016 to 2022.*

8.0 Conclusions and Recommendations

Through the assessment of the C.W. Young channel water quality and stream invertebrates which were sampled on 2 separate dates, it has been determined that the stream is a relatively healthy and successful ecosystem. Our results continue with the consistency shown in previous assessments of the C.W. Young channel. This clarifies that the channel continues to be a supportive habitat for the spawning salmon that return to it each year. Results were compared to past environmental monitoring projects, and the BC Water Quality Guidelines. When comparing water quality to the guidelines, it was determined that most of our results were well within the parameters set forth. The one outlier was aluminum, which has been documented as exceeding the guidelines in previous reports due to the possibility of industrial run off. Between the two sampling dates, results remained very similar, with only the temperature dropping slightly. This was probably due to the ongoing drought conditions being experienced.

The overall stream invertebrate assessment rating for this year's sampling events averaged out was 2.25 which indicates “marginal”. Which is slightly lower than that of the past year's results. Our Shannon-Weiner diversity index average was 0.715, which is consistent with previous years results.

Overall, it has been determined that the health of C.W. Young channel is favorable, however some results, such as the site rating and the high presence of aluminum are not. Potential environmental concerns can change year to year, therefore it is important to continue data collection on the C.W. Young channel. One area that should be monitored is site 1, where a beaver continually blocks the channel, causing flow issues in the sites/stream. Due to global warming there are more frequent and severe weather events taking place that contribute to the changing the environment surrounding the stream. In regards to salmonid populations, this produces challenging conditions. Therefore, it could be looked into the effects that releasing pulse flows of water from the intake valve could have on the ecosystem/aquatic life when there are drought conditions. It is recommended that continued studies take place on this channel to monitor changes and to allow for both preventative and reactive measures to allow for suitability for aquatic life to survive.

9.0 Acknowledgements

The authors would first like to acknowledge that this survey was undertaken on the traditional land of the K'ómoks and Snaw-naw-as first nations. Furthermore, a thank-you goes out to past students who have provided past reports to lay the groundwork for how the survey was conducted and the ability to compare data year to year. A thank-you goes to Owen Hargrove and the Vancouver Island University's Science-Biology departments for supplying the equipment needed both in the field and in the lab. And lastly, a thank-you to ALS for examining our water quality samples and providing accurate results.

10.0 References

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11.0 Appendices

Appendix A: Photographs of Sampling Sites

Figure 1: Site #1 of the C.W Young Channel. Note the beginnings of a beaver dam being constructed upstream of the outlet during the first sampling event.

Figure 2: Site #2 of the C.W Young Channel, facing downstream of the culvert.

Figure 3: Site #3 of the C.W Young Channel, facing upstream.

Figure 3: Site #4 of the C.W Young Channel, facing upstream.

Figure 5: Site #5 of the Englishman River, facing upstream.

3.1 Invertebrate Survey Data Sheet for Site 1.

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name: CW Young Channel		Date: Oct 26 + Nov 16 2022
Station Name: Site 1		Flow status: Valve controlled - low
Sampler Used: Hess	Number of replicates: 3	Total area sampled (Hess, Surber = 0.09 m²) x no. replicates: 0.27 m²

Column A Pollution Tolerance	Column B Common Name	Column C Number Counted	Column D Number of Taxa
Category 1	Caddisfly Larva (EPT)	EPT1 11	EPT4 1
	Mayfly Nymph (EPT)	EPT2 7	EPT5 1
	Stonefly Nymph (EPT)	EPT3 1	EPT6 1
	Dobsonfly (hellgrammite)		
Pollution Intolerant	Gilled Snail		
	Riffle Beetle	1	1
	Water Penny		
Sub-Total		C1 19	D1 3
Category 2	Alderfly Larva		
	Aquatic Beetle		
	Aquatic Sowbug		
	Clam, Mussel	1	1
	Cranefly Larva	1	1
	Crayfish		
Somewhat Pollution Tolerant	Damselfly Larva		
	Dragonfly Larva		
	Fishfly Larva		
	Amphipod (freshwater shrimp)	20	1
	Watersnipe Larva		
Sub-Total		C2 22	D2 3
Category 3	Aquatic Worm (oligochaete)		
	Blackfly Larva		
	Leech	1	1
	Midge Larva (chironomid)		
Pollution Tolerant	Planarian (flatworm)		
	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite		
Sub-Total		C3 1	D3 1
TOTAL		CT 42	DT 8

3.2 Invertebrate Survey Site Assessment Sheet for Site 1.

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

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

DENSITY: Invertebrate density per total area sampled:

42 ÷ 0.27 m^2 = 155.56 / m^2 (From page 1)

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

SECTION 2 - WATER QUALITY ASSESSMENTS

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

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

3 x D1 + 2 x D2 + D3

3 x 3 + 2 x 3 + 1 = S2 13

EPT INDEX: Total number of EPT taxa.

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

EPT4 + EPT5 + EPT6

1 + 1 + 1 = S3 3

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

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

(EPT1 + EPT2 + EPT3) / CT

(11 + 7 + 1) / 42 = S4 0.21

SECTION 3 - DIVERSITY

TOTAL NUMBER OF TAXA: Total number of taxa from cell DT: 8

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

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

Col. C for S1 / CT

20 / 42 = 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 2
EPT Index	R2 2
EPT To Total Ratio	R3 1
Predominant Taxon Ratio	R4 3

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

3.3 Invertebrate Survey Data Sheet for Site 3.

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name: CW Young Channel		Date: Oct 26 + Nov 16 2022
Station Name: Site 3		Flow status: Valve controlled - low
Sampler Used: Hess	Number of replicates: 3	Total area sampled (Hess, Surber = 0.09 m²) x no. replicates: 0.27 m²

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 15	EPT5 1
	Stonefly Nymph (EPT)	EPT3 1	EPT6 1
	Dobsonfly (hellgrammite)		
	Gilled Snail		
	Riffle Beetle		
	Water Penny	1	1
Sub-Total		C1 17	D1 3
Category 2 Somewhat Pollution Tolerant	Alderfly Larva		
	Aquatic Beetle		
	Aquatic Sowbug		
	Clam, Mussel		
	Cranefly Larva		
	Crayfish		
	Damselfly Larva		
	Dragonfly Larva		
	Fishfly Larva		
	Amphipod (freshwater shrimp)	12	1
	Watersnipe Larva		
Sub-Total		C2 12	D2 1
Category 3 Pollution Tolerant	Aquatic Worm (oligochaete)		
	Blackfly Larva		
	Leech		
	Midge Larva (chironomid)	2	1
	Planarian (flatworm)		
	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite		
Sub-Total		C3 2	D3 1
TOTAL		CT 31	DT 5

3.4 Invertebrate Survey Site Assessment Sheet for Site 3.

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell CT: CT 31

DENSITY: Invertebrate density per total area sampled:

31 ÷ 0.27 m^2 = 114.81 / m^2 (From page 1)

PREDOMINANT TAXON:
Invertebrate group with the highest number counted (in Col. C): S1 15 mayfly

SECTION 2 - WATER QUALITY ASSESSMENTS

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

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

3 x D1 + 2 x D2 + D3

3 x 3 + 2 x 1 + 1 = S2 12

EPT INDEX: Total number of EPT taxa.

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

EPT4 + EPT5 + EPT6

0 + 1 + 1 = S3 2

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

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

(EPT1 + EPT2 + EPT3) / CT

(0 + 15 + 1) / 31 = S4 0.52

SECTION 3 - DIVERSITY

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

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

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

Col. C for S1 / CT

15 / 31 = S5 0.48

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

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

3.5 Invertebrate Survey Data Sheet for Site 4.

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name: CW Young Channel		Date: Oct 26 + Nov 16 2022
Station Name: Site 4		Flow status: Valve controlled - low
Sampler Used: Hess	Number of replicates: 3	Total area sampled (Hess, Surber = 0.09 m^2) x no. replicates 0.27 m^2

Column A Pollution Tolerance	Column B Common Name	Column C Number Counted	Column D Number of Taxa
Category 1	Caddisfly Larva (EPT)	EPT1	EPT4
	Mayfly Nymph (EPT)	EPT2 21	EPT5 1
	Stonefly Nymph (EPT)	EPT3 4	EPT6 1
	Dobsonfly (hellgrammite)		
Pollution Intolerant	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		C1 25	D1 2
Category 2	Alderfly Larva		
	Aquatic Beetle		
	Aquatic Sowbug		
	Clam, Mussel		
	Cranefly Larva		
	Crayfish	1	1
Somewhat Pollution Tolerant	Damselfly Larva		
	Dragonfly Larva		
	Fishfly Larva		
	Amphipod (freshwater shrimp)	3	1
	Watersnipe Larva		
Sub-Total		C2 4	D2 2
Category 3	Aquatic Worm (oligochaete)		
	Blackfly Larva		
	Leech		
	Midge Larva (chironomid)		
	Planarian (flatworm)		
Pollution Tolerant	Pouch and Pond Snails		
	True Bug Adult	1	1
	Water Mite		
Sub-Total		C3 1	D3 1
TOTAL		CT 30	DT 5

3.6 Invertebrate Survey Site Assessment Sheet for Site 4.

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

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

DENSITY: Invertebrate density per total area sampled:

30 ÷ 0.27 m^2 = 111.11 / m^2 (From page 1)

PREDOMINANT TAXON: S1 21 mayfly

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

SECTION 2 - WATER QUALITY ASSESSMENTS

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

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

3 x D1 + 2 x D2 + D3: 3 x 2 + 2 x 2 + 1 = S2 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 = S3 2

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

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

(EPT1 + EPT2 + EPT3) / CT: (0 + 21 + 4) / 30 = S4 0.83

SECTION 3 - DIVERSITY

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

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

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

Col. C for S1 / CT: 21 / 30 = S5 0.7

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

Average Rating
Average of R1, R2, R3, R4
2.5