DATA REPORT

Water Quality and Stream Invertebrate Assessment

for the C.W. Young Channel, Englishman River, BC,

(Fall 2010)

Report prepared by:

Students of Vancouver Island University RMOT 306 (Environmental Monitoring)

Simon Johnson, Brennan Krantz, Kris Taekema

and

Dr. Eric Demers (Vancouver Island University)

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1. Background

This report documents a water quality and stream invertebrate assessment conducted on the C.W. Young Channel, Englishman River, BC, during November 2010.

This study was undertaken by 3rd year undergraduate students attending the Environmental Monitoring (RMOT 306) course at Vancouver Island University (VIU), offered as part of the Bachelor of Natural Resources Protection (Simon Johnson, Brennan Krantz and Kris Taekema). Students worked under the supervision of the course instructor, Dr. Eric Demers (Vancouver Island University). This report was compiled by Dr. Eric Demers based on a student group report.

VIU students contributed approximately 35 student-hours to this project, including site visits, project proposal, field sampling, laboratory analyses, and oral and written presentations. Dr. Eric Demers contributed approximately 10 hours for project management and report compilation.

Logistical support was provided by the Regional District of Nanaimo (RDN) and Fisheries and Oceans Canada (DFO). Funding for field expenses and analytical processing of water samples was provided by the Regional District of Nanaimo, the Living Rivers - Georgia Basin / Vancouver Island program, and Fisheries and Oceans Canada. ALS Laboratory (Burnaby, BC) provided reduced rates on their analytical services for this project.

2. Introduction

The C.W. Young Channel is located on the northern bank of the Englishman River on Vancouver Island, BC, within Englishmen River Regional Park. It is approximately 7 km upstream from the Englishman River Estuary in Parksville Bay and begins just below the Morison Creek confluence (Hawkes et al., 2008). The channel is approximately 4,100 metres long and provides off-channel and pond habitat for spawning and rearing Pacific salmon and trout. The entire channel is dependent on surface flow from the Englishmen River.

This report documents a water quality and stream invertebrate assessment conducted on the C.W. Young Channel, Englishman River, BC, during November 2010.

Specific objectives for this study of the C.W. Young Channel included:

- establish 5 water quality sampling stations;
- obtain field measurements of water quality at the 5 sampling stations during two sampling events (early and late November 2010);
- obtain water samples from each sampling station during two sampling events (early and late November 2010) for detailed laboratory analyses; and,
- collect stream invertebrate samples at 3 sampling stations during one sampling event (early November 2010) for analysis at Vancouver Island University.

3. Methods

3.1. Study Site

This project was conducted at the C.W. Young Channel located along the Englishman River (Figure 1). The original C.W. Young Channel was constructed in 1992 by Fisheries and Oceans Canada (DFO). In 2007, the C.W. Young Channel was lengthened by another 2 km, with the outlet of the channel a few hundred metres upstream of the Top Bridge Crossing. This brought the total length of constructed side channel habitat in the Englishman River to 4,100 m (Hawkes et al., 2008). The channel was built to provide resident and anadromous salmonids with new spawning and juvenile rearing habitat.

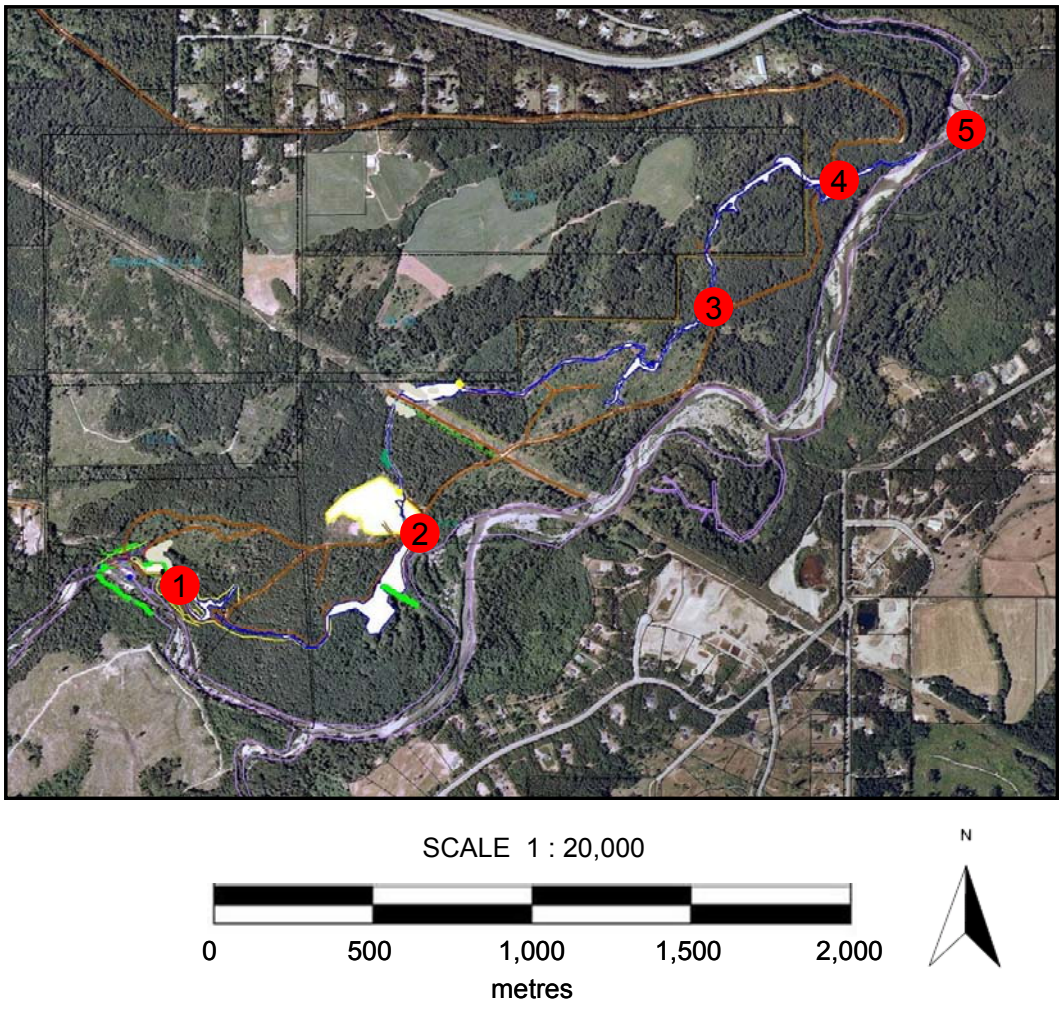

Figure 1. Approximate location of the sampling stations used for water quality and stream invertebrate assessments on the C.W. Young Channel, during November 2010. The C.W. Young Channel and Englishman River are outlined in blue and purple, respectively. Access roads are outlined in brown. Table 1 provides details of the specific location of each station. Table 2 details the sampling activities conducted at each station. This map was obtained from Hawkes et al. (2008). Map scale is approximated.

3.1.1. Sampling Stations

Five stations were established on the C.W. Young Channel and Englishman River, during November 2010 (Tables 1 and 2; Figure 1). The location of each station was chosen to provide adequate coverage for the length of the C.W. Young Channel. Stations were numbered from the upstream end to the downstream end of the channel. All stations were easily accessed via foot paths or access road crossings. Station 1 was located one metre downstream of the steel valve at the upstream entrance into the channel and served as a reference station for initial conditions at channel entry. Stations 2-4 were located at intervals along the channel. Station 5 was located on the main stem Englishman River, near the channel outlet. This station served as a reference to compare spatial changes that occur within the channel and in the main river channel.

Table 1. Description of the sampling stations used for water quality and stream invertebrate assessments on the C.W. Young Channel and Englishman River, during November 2010.

Station	Distance from Upstream End (m)	General Location
1	0	Upstream channel entrance, 1 m downstream of steel pipe valve
2	1,250	Road crossing, start of 2007 channel extension
3	2,900	Channel section near access road
4	3,800	3 m upstream of steel sill structure
5	N/A	Main stem Englishman River, near channel outlet

3.1.2. Sampling Schedule

Field sampling was conducted on 2 and 23 November 2010. For this study, samples were collected for water quality analyses, microbiology and stream invertebrate assessment. Table 2 lists the specific activities conducted at each station during each sampling event. Microbiology and stream invertebrate assessments were only completed during the early November event. Photographs showing site conditions and sampling activities are included in Appendix 1.

3.2. Water Quality

3.2.1. Field Measurements

Water quality sampling events were conducted on 2 and 23 November 2010. At each sampling station, field measurements of water temperature (to the nearest 0.01 ^{o}C), dissolved oxygen (to the nearest 0.01 mg/L), conductivity (to the nearest 1 µSiemens/cm) and pH (to the nearest 0.01 pH unit) were obtained with a YSI 556 MPS electronic probe. The electronic probe was placed directly in the channel water.

Table 2. Water quality and stream invertebrate sampling activities conducted at each station on the C.W. Young Channel and Englishman River, during November 2010. The symbols "A" or "B" indicate whether samples / measurements were taken during the early or late November sampling events, respectively.

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

Note: [1] Basic hydrological measurements were only collected at station 2 during the early November sampling event.

[2] A duplicate sample was collected at station 2 during the early November sampling event for analysis at the VIU Laboratory.

Basic hydrological measurements were taken at station 2 on 2 November 2010. Water velocity (in m/s) was measured along a 5-m stream length. A water-filled ping-pong ball was dropped slightly upstream of the stream length and allowed to float downstream through the stream length. A stopwatch was used to measure the travel time of the ball between the upstream and downstream ends of the stream length. The average travel time from 5 passes was used to calculate average water velocity.

Stream wetted widths were measured with a metered tape to the nearest 0.1 m, and wetted depths were measured (along the same wetted widths) with a meter stick to the nearest 0.01 m. Total cross-sectional areas (in m^2) were calculated as the sum of the areas of cross-section polygons. Stream discharge (in m^3/s) was obtained as the product of mean water column velocity and cross sectional area.

3.2.2. Water Sampling

During each sampling event, two sets of water samples were collected for laboratory analyses: one set was transported for analysis at Vancouver Island University (VIU), and another set was shipped for analysis by ALS Laboratory, in Burnaby, BC.

Water samples for analysis at VIU were collected from all stations (Table 2). At each station, a clean pre-labelled 500-ml plastic bottle was rinsed 3 times and then used to collect a water sample (Table 3). A duplicate sample was collected at station 4 during the early November sampling event for analysis at the VIU Laboratory. Samples were obtained while standing on the stream bank or within the stream channel by immersing the containers just below the water surface while facing upstream. Care was taken not to disturb the bottom sediments. All water

samples were kept in a cooler and stored at approximately 4°C. Laboratory analyses were conducted at VIU within 48 hours of sampling.

Samples for analysis by ALS Laboratory were collected from stations 1-4 during both sampling events (Table 2). At each station, water samples were collected in three clean laboratory-supplied and pre-labelled sample containers (Table 3). All samples were obtained while standing on the stream bank or within the stream channel by directly immersing the containers just below the water surface while facing upstream. Care was taken not to disturb the bottom sediments. Samples for analysis of nutrients and total metals were preserved with laboratory-supplied sulphuric acid and nitric acid, respectively. Bottles with preservatives were inversed five times for adequate mixing. All water samples were stored in a cooler on site, and shipped with ice packs within 48 hours for laboratory analyses at ALS Laboratory.

Quality control samples (trip blanks) were also included during both sampling events for analysis at the VIU Laboratory. The trip blank was prepared at the VIU Laboratory and consisted of distilled water placed in a 500-ml plastic bottle. The trip blank bottle was transported to the sampling stations, but remained unopened. The field blank was prepared by transferring 500 ml of distilled water into a plastic bottle while in the field.

Table 3. Sampling containers and preservatives used for water quality samples taken at the C.W. Young Channel and Englishman River during November 2010. All containers and preservatives for analysis by ALS Laboratory were provided by ALS Laboratory, Burnaby, BC.

Analytical Parameters	Container	Preservative	Analysed by
Total alkalinity, turbidity	500 ml plastic	None	VIU
Conductivity, pH, total hardness	1 L plastic	None	ALS Laboratory
Nutrients	250 ml amber glass	Sulphuric acid	ALS Laboratory
Total metals	250 ml plastic	Nitric acid	ALS Laboratory

3.2.3. VIU Laboratory Analyses

Water samples transported to Vancouver Island University were analysed for total alkalinity and turbidity. Total alkalinity (as $CaCO_3$) was measured to the nearest 0.1 mg/L using the HACH AL-DT digital titration method. Turbidity was measured to the nearest 1 FAU (Formazin attenuation units) using a HACH DR2000 Spectrophotometer (Method 8006).

3.2.4. ALS Laboratory Analyses

Water samples submitted for external analyses were processed as per ALS Laboratory standard analytical procedures. The analytes were: conductivity, total hardness, pH, nutrients (ammonia, nitrite, nitrate, orthophosphate and total phosphorus), and total metals (31 metals).

3.2.5. Quality Assurance / Quality Control

Throughout this study, measures were taken to ensure that potential contamination of water samples was minimized. This included using only clean and rinsed containers, preserving samples as prescribed by the analytical laboratory, and storing collected samples in well-labelled containers. Duplicate sampling provided an estimate of the overall precision associated with the field technique and laboratory analysis.

3.2.6. Data Analyses – Comparison with Applicable Guidelines

Water quality results were compared with the applicable provincial water quality guidelines for the protection of freshwater life. The BC Water Quality Guidelines are the maximum allowable concentration (for potential acute effects) and the 30-day average concentration (for potential chronic effects). All guidelines were obtained from the BC Ministry of Environment, Water Protection Division (http://www.env.gov.bc.ca/wat/wq/).

It is important to note that for some metal parameters, analytical detection limits were above applicable guidelines. These include aluminium, antimony, arsenic, cadmium, chromium, cobalt, copper, lead, nickel, selenium, silver, thallium and vanadium. For these metals, measured values reported to be below method detection limits cannot be assumed to be below the applicable guidelines.

3.3. Microbiology

3.3.1. Field Sampling

Water samples for total and fecal coliform enumeration were collected from each sampling station on 2 November 2010 (Table 2). At each station, a sterile pre-labelled 120-ml Whirl-Pak® bag was used to collect a 100-ml water sample by directly immersing the bag by hand just below the water surface while facing upstream. All samples were stored in a cooler with ice packs and transported within 48 hours to Vancouver Island University for laboratory analysis.

3.3.2. Laboratory Analyses

In the laboratory, water samples were tested for total coliform and fecal coliform (*Escherichia coli* or *E. coli*) using the m-coliBlue24 membrane filtration method (Millipore Corporation). A 25-ml volume of sample water was filtered through a 47-µm membrane filter (marked with 3-mm gridlines) using a vacuum pump. The filtration apparatus was then rinsed with approximately 5 ml of sterile water. A filtration blank was also completed with 25 ml of sterile water using the same filtration procedures. Each membrane filter (including the blank) was then transferred to a Petri plate containing an absorbent pad saturated with m-ColiBlue24 broth. All membrane filters were incubated at 37°C for 20 hours (until bacterial colonies were clearly visible).

Upon completion of the incubation period, membrane filters were then examined for bacterial colonies under a dissection microscope (16X magnification). A red or blue colony represents a

total coliform "positive" result (Table 4). A blue colony specifically represents an *E. coli* "positive" result. A clear or white colony represents a total coliform negative result.

All colonies present on a membrane filter were counted and expressed as CFU (colony forming units) per 100-ml of sample water.

Table 4. Possible outcomes of the m-coliBlue24 membrane filtration method.

Bacteria Type	Positive Result	Negative Result
Total coliform	Red or blue colony	Clear or white colony No colony
E. coli	Blue colony only	Non-blue colony

3.4. Stream Invertebrates

3.4.1. Sampling Stations

Stream invertebrate samples were collected from stations 1, 3 and 4 on 2 November 2010 (Table 1; Figure 1). The sampling stations were selected based on hydrological characteristics, apparent substrate uniformity, space available for replicate samples, safety and site access. At the time of sampling, all stations consisted of shallow riffles (water depth ~10-25 cm), with water velocity of ~0.25-1.0 m/s, and primarily sand and gravel substrate.

3.4.2. Invertebrate Sampling

At each station, three replicate samples (triplicates) were obtained using a Hess sampler and procedures as per the Pacific Streamkeepers procedures (Taccogna and Munro 1995). Each site was approached by walking from downstream. The cylindrical, 34-cm diameter Hess sampler was hand-pressed into the substrate to isolate a circular 0.09-m^2 sampling area. All stones and debris 5 cm or larger within the sampling area were held under water in front of the collecting net and rubbed gently by hand to dislodge invertebrates. Cleaned stones and debris were then placed downstream of the sampling area. The streambed was then gently agitated to a depth of 5 cm to loosen any remaining invertebrates. The content of the collecting net was then transferred in a 125-ml plastic sample jar. The net was carefully inspected to ensure all content was transferred into the sample jar. Samples were stored in a cooler and transported to Vancouver Island University, where laboratory analyses were completed within 24 hours of sampling.

3.4.3. VIU Laboratory Analyses

Laboratory procedures and identification also followed the Pacific Streamkeepers procedures (Taccogna and Munro 1995). The triplicate samples from each station were combined into a single composite sample per station. The contents of all invertebrate sample jars from a station were poured into a shallow white tray. Invertebrates were sorted into apparent taxonomic

groups. Identification to the appropriate taxonomic level (as prescribed by the Pacific Streamkeepers procedures) was confirmed using a dissecting microscope. The number of invertebrates and the number of distinguishable subgroups within each broad taxonomic group were recorded on a Pacific Streamkeeper Invertebrate Survey Field Data Sheet. From these records, various useful metrics were calculated for each station, including: total density (number per m^2), total number of taxonomic groups, predominant taxonomic group, Pollution Tolerance Index, EPT (Ephemeroptera-Plecoptera-Trichoptera) Index, EPT to Total Ratio Index, Predominant Taxon Ratio Index, and overall Site Assessment Rating.

4. Results

The discharge measurement (Table 5) and field observations for the C.W. Young Channel suggests that water level was near bankfull during both sampling events.

Average air temperature during the 10-day period prior to each sampling event was 9.4°C and 0.4 °C for the early and late November sampling events, respectively (data for Nanaimo Airport retrieved from http://climate.weatheroffice.gc.ca). Total rainfall during the 10-day period prior to the early November sampling event was 39 mm. Total precipitation during the 10-day period prior to the late November sampling event included 24 mm of rain and 32 cm of snow, with 24 cm of snow on 19 November 2010.

4.1. Water Quality

4.1.1. Field Measurements and VIU Laboratory Analyses

Water temperature averaged 8.2°C and 1.5°C during the early and late November sampling events, respectively (Table 5). The decrease in water temperature reflected a concurrent decrease in air temperature between sampling events. During both sampling events, all dissolved oxygen levels were above the minimum guideline of 9.0 mg/L for early fish life stages (RISC 1998). Overall, dissolved oxygen concentrations were >93% saturation. Unusually high dissolved oxygen concentrations obtained at stations 1-3 and 5 during late November likely resulted from inappropriate placement of the probe in highly turbulent water.

Conductivity ranged from 37 to 70 µS/cm and generally increased as expected from upstream to downstream within the C.W Young Channel (Table 5). Conductivity increased by an average of 22 µS/cm within station between sampling events. This pattern was opposite from observations in previous years (VIU 2009, 2010), when conductivity usually declined between sampling events due to dilution effect from increased discharge. Water pH ranged from 6.09 to 7.06 during this study, and there was an average increase of 0.3 pH units between sampling events.

Total alkalinity ranged averaged 14.2 and 20.7 mg/L during the early and late November sampling events, respectively (Table 5). Overall, total alkalinity was near or below 20 mg/L during both sampling events, indicating "moderate" to "low acid sensitivity" as defined by RISC (1998).

Turbidity ranged averaged 4.0 and 5.2 FAU during the early and late November sampling events, respectively (Table 5).

A comparison of the water quality results from the duplicate samples taken at station 4 during the early November sampling event indicates that most values were within ±5% of each other.

Table 5. Field measurements and laboratory results (VIU Laboratory) for water samples taken from five stations on the C.W. Young Channel and Englishman River during November 2010. Discharge measurements were only collected at station 2 during the early November sampling event. VIU Laboratory results for station 4 during the early November sampling event represent the average of duplicate samples.

		Field Measurements				VIU Laboratory	
Station	**Discharge (m^3/s)**	**Temperature (^oC)**	**Dissolved Oxygen (mg/L)**	**Conductivity (µS/cm)**	**pH**	**Total Alkalinity (mg/L $CaCO_3$)**	**Turbidity (FAU)**
			2 November 2010				
1		7.93	12.63	40	6.09	14.0	4
2	0.66	8.02	11.81	39	7.06	13.6	4
3		8.43	11.43	41	6.21	15.2	4
4		8.35	11.73	51	6.43	16.8	5
5		8.14	12.01	37	6.41	11.6	3
			23 November 2010				
1		1.00	21.00	63	6.94	20.4	6
2		0.90	19.40	63	6.78	23.6	8
3		2.00	18.00	61	6.72	18.0	1
4		2.40	12.50	70	6.73	23.2	6
5		1.30	18.70	59	6.72	18.4	5

4.1.2. ALS Laboratory Analyses

Water quality results from ALS Laboratories were compared to the BC Provincial water quality guidelines for the protection of aquatic life (Table 6).

The conductivity measurements from ALS Laboratories were consistent with the field measurements obtained with the electronic probe and differed by <4%.

Total hardness followed similar trends as conductivity, namely a general increase from upstream to downstream stations and an increase between sampling events. Total hardness was below or near 60 mg/L during both sampling events, indicating "soft water" as defined by RISC (1998).

Field measurements of pH (range: 6.09-7.06) were generally lower and more variable than the ALS Laboratories results (range: 7.11-7.64). This discrepancy possibly reflects improper calibration, differences in air space content among sampling containers and/or time elapsed between sampling and laboratory analysis. Consistent with field measurements, there was an average increase of 0.4 pH units between sampling events.

All nutrient levels were below applicable guidelines and/or below detection limits. Total ammonia was below or near detection limit (i.e., <0.005 mg/L) during both sampling events. Nitrate concentrations increased between the early (average: 0.027 mg/L) and late November sampling events (average: 0.056 mg/L). The highest nitrate levels were observed at station 4 during both sampling events (0.036 and 0.066 mg/L, respectively). Nitrite levels were below detection limit during this study (i.e., <0.001 mg/L).

Orthophosphate was mainly below or near detection limit (i.e., ≤0.0015 mg/L) during the early November sampling event, but increased slightly during the late November sampling event when levels reached 0.0013-0.0021 mg/L. Total phosphorus levels were variable, but decreased slightly between the early (average: 0.0098 mg/L) and late November sampling events (average: 0.0076 mg/L). Overall, total phosphorus levels were mainly within or near the low range typical of "oligotrophic" (<0.010 mg/L) waters as defined by RISC (1998).

All metal concentrations were below the applicable water quality guidelines and/or below detection limits, except aluminium at stations 1, 3, and 4 during the early November sampling event. Total metal analyses measure the combined amount of metals dissolved in water and bound to particles. In general, dissolved metals are more bio-available (hence toxicologically available) than metals that are bound to particles. It is unclear whether the observed elevated aluminium represented dissolved metals or metals bound to suspended particles.

Table 6. Laboratory results (ALS Laboratory) for water samples taken from 4 stations at the C.W. Young Channel during 2 and 23 November 2010. All values are expressed in mg/L unless specified otherwise. The values enclosed in boxes exceeded at least one of the applicable water quality guidelines. See additional notes on the next page.

	BC Water Quality Guidelines [a]		2 November 2010				23 November 2010			
	BC Max	BC 30-day Mean								
Variable	mg/L	mg/L	1	2	3	4	1	2	3	4
General/Physical										
Conductivity (µS/cm)			40.4	40.1	39.7	49.7	64.3	63.8	62.7	71.3
Hardness, Total			16.9	17.0	17.4	22.5	23.5	22.6	22.3	25.9
pH (pH units)	6.5 - 9.0		7.26	7.20	7.11	7.28	7.57	7.58	7.58	7.64
Nutrients										
Ammonia-N	9.73 [b]	1.87 [b]	<0.0050	<0.0050	0.0088	0.0069	<0.0050	0.0054	0.0073	0.0095
Nitrate (as N)	31.3	3	0.0257	0.0233	0.0213	0.0357	0.0550	0.0523	0.0504	0.0658
Nitrite (as N)	0.06 [c]	0.02 [c]	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Ortho Phosphate (as P)			<0.0010	<0.0010	0.0015	0.0012	0.0015	0.0013	0.0015	0.0021
Total Phosphorus			0.011	0.007	0.0116	0.0096	0.0061	0.0055	0.0056	0.0093
Total Metals										
Aluminum (Al) [m]	0.10 [d]	0.05 [d]	0.29	<0.20	0.26	0.25	<0.20	<0.20	<0.20	<0.20
Antimony (Sb) [m]	0.02		<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Arsenic (As) [m]	0.005		<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Barium (Ba)	5	1	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Berylium (Be)	0.0053		<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Bismuth (Bi)			<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Boron (B)	1.2		<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Cadmium (Cd) [m]	0.00001 [e]		<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Calcium (Ca)			5.60	5.63	5.67	6.72	7.77	7.46	7.30	7.84
Chromium (Cr) [m]	0.001 [f]		<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Cobalt (Co) [m]	0.11	0.004	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Copper (Cu) [m]	0.004 [g]	0.002 [g]	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Iron (Fe)	1.0		0.246	0.237	0.325	0.312	0.132	0.147	0.158	0.220
Lead (Pb) [m]	0.008 [h]	0.004 [h]	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Lithium (Li)	0.87	0.096	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Magnesium (Mg)			0.72	0.70	0.80	1.39	0.98	0.95	0.99	1.53
Manganese (Mn)	0.73 [i]	0.68 [i]	0.005	0.007	0.010	0.009	0.005	0.006	0.009	0.010
Molybdenum (Mo)	2	1	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Nickel (Ni) [m]	0.025 [j]		<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Phosphorus (P)			<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium (K)	373		<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Selenium (Se) [m]		0.002	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Silicon (Si)			2.74	2.63	2.78	3.19	3.09	2.99	3.00	3.37
Silver (Ag) [m]	0.0001 [k]	0.00005 [k]	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Sodium (Na)			<2.0	<2.0	<2.0	2.2	3.7	3.5	3.4	3.4
Strontium (Sr)			0.020	0.021	0.021	0.024	0.033	0.031	0.030	0.031
Thallium (Tl) [m]	0.0003		<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Tin (Sn)			<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Titanium (Ti)	2		0.015	0.01	0.014	0.012	<0.010	<0.010	<0.010	<0.010
Vanadium (V) [m]	0.006		<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Zinc (Zn)	0.033 [l]	0.0075 [l]	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050

Table 6. (Continued)

NOTES:

Results are expressed as mg/L except for pH and conductivity.
"<" means less than the detection limit.

[a] BC Water Quality Guidelines (WQG) compiled from
http://www.env.gov.bc.ca/wat/wq/wq_guidelines.html
http://www.env.gov.bc.ca/wat/wq/BCguidelines/working.html

[b] Total ammonia guideline is dependent on water temperature and pH of tested water.

[c] Nitrite guideline is for chloride concentration < 2 mg/L.

[d] Aluminum guidelines for pH ≥ 6.5.

[e] The maximum cadmium guideline is $0.001 * 10^{\{0.86 [\log(\text{hardness})] - 3.2\}}$ mg/L.

[f] Chromium guideline is for the more toxic Chromium VI.

[g] The maximum copper guideline is 0.001 * [0.094(hardness) + 2] mg/L.
The 30-day mean copper guideline is for hardness < 50 mg/L.

[h] The maximum lead guideline is $0.001 * e^{\{1.273 [\ln(\text{hardness})] - 1.46\}}$ mg/L.
The 30-day mean lead guideline is $0.001 * [3.31 + e^{\{1.273 [\ln(\text{hardness})] - 4.704\}}]$ mg/L.

[i] The maximum manganese guideline is 0.01102 * (hardness) + 0.54 mg/L.
The 30-day mean manganese guideline is 0.0044 * (hardness) + 0.605 mg/L.

[j] Nickel guideline is for hardness < 60 mg/L.

[k] Silver guidelines are for hardness < 100 mg/L.

[l] Zinc guidelines are for hardness < 90 mg/L.

[m] Analytical detection limits were above applicable guidelines for these metals.

4.2. Microbiology

All samples collected from the C.W. Young Channel and Englishman River contained some coliform bacteria (Table 7). Total coliform counts were generally constant between stations, with a range of 240-280 CFU / 100 ml. The proportion of total coliform made up of *E. coli* bacteria was also relatively constant between stations (range: 11-28%). Overall, the observed total coliform levels were similar to a study conducted at the C.W. Young Channel during Fall 2008 (<300 CFU / 100 ml) (VIU, 2009). However, no *E. coli* bacteria were observed during the Fall 2008 study.

The filtration blank completed with sterile water did not produce any bacterial colonies.

Table 7. Total coliform and *E. coli* counts from water samples taken at five stations on the C.W. Young Channel and Englishman River on 2 November 2010. All values are expressed as number of bacteria per 100 ml. No samples were collected on 23 November 2010.

Station	Total Coliform	*E. coli*	% *E. coli*
1	280	48	17.1%
2	256	32	12.5%
3	252	28	11.1%
4	240	68	28.3%
5	276	40	14.5%
Filtration blank	0	0	–

4.3. Stream Invertebrates

A total of 934 stream invertebrates representing 11 broad taxonomic groups were counted at three stations on the C.W. Young Channel on 2 November 2010 (Table 8; Figure 2; Appendix 2). Animal density was high at all stations (1,063-1,237 animals/m^2). Overall, stonefly and mayfly nymphs were the most common taxonomic group encountered.

Site assessment ratings ranged from 3.0-3.5 suggesting "acceptable" to "good" invertebrate community abundance and diversity. The consistent representation of pollution-sensitive mayfly nymphs, stonefly nymphs and caddisfly larvae (EPT taxa: 83-91% of total abundance) indicates generally "favourable" environmental conditions.

Table 8. Abundance and density of stream invertebrates obtained from triplicate samples taken on 2 November 2010 at three stations on the C.W. Young Channel. Overall site assessment ratings are also provided for each station (out of a maximum rating of 4.00). Invertebrate Survey Field Data Sheets are included in Appendix 2. No samples were collected on 23 November 2010.

Pollution Tolerance	Invertebrate Taxa	Station 1	Station 3	Station 4
Category 1 Pollution Intolerant	Caddisfly Larva	5	20	18
	Mayfly Nymph	47	78	127
	Stonefly Nymph	228	163	115
Category 2 Somewhat Pollution Intolerant	Aquatic Sowbug	0	0	1
	Cranefly Larva	0	10	3
	Dragonfly Larva	0	1	0
	Scud (amphipod)	42	0	0
Category 3 Pollution Tolerant	Aquatic Worm (oligochaete)	12	15	45
	Leech	0	0	2
	Pouch and Pond Snails	0	0	1
	Water Mite	0	0	1
	Total Abundance	334	287	313
	Density (number / m^2)	1,237	1,063	1,159
	Site Assessment Rating	3.00	3.50	3.50

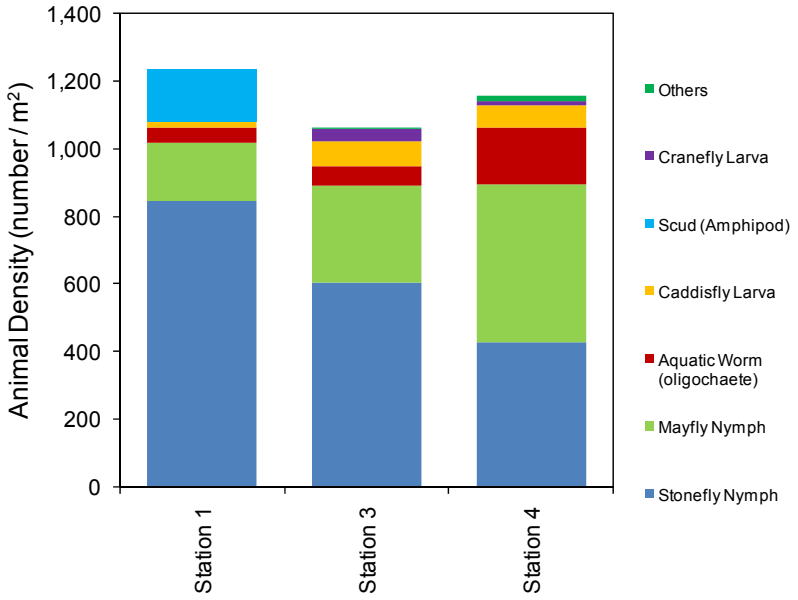

Figure 2. Density of stream invertebrates obtained from triplicate samples taken on 2 November 2010 at three stations on the C.W. Young Channel. The "Other" category includes leech, aquatic sowbug, dragonfly larva, pouch and pond snail, and water mite. Data are summarized in Table 8 and Invertebrate Survey Field Data Sheets are included in Appendix 2.

5. Acknowledgements

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7. Appendices

APPENDIX 1. Photographs showing site conditions at each sampling station on the C.W. Young Channel.

Photo 1. Downstream view of the C.W. Young Channel near station 2 on 20 October 2010.

Photo 2. Downstream view of the C.W. Young Channel near station 3 on 20 October 2010.

APPENDIX 1. (Continued)

Photo 3. Upstream view of the C.W. Young Channel near station 4 on 2 November 2010.

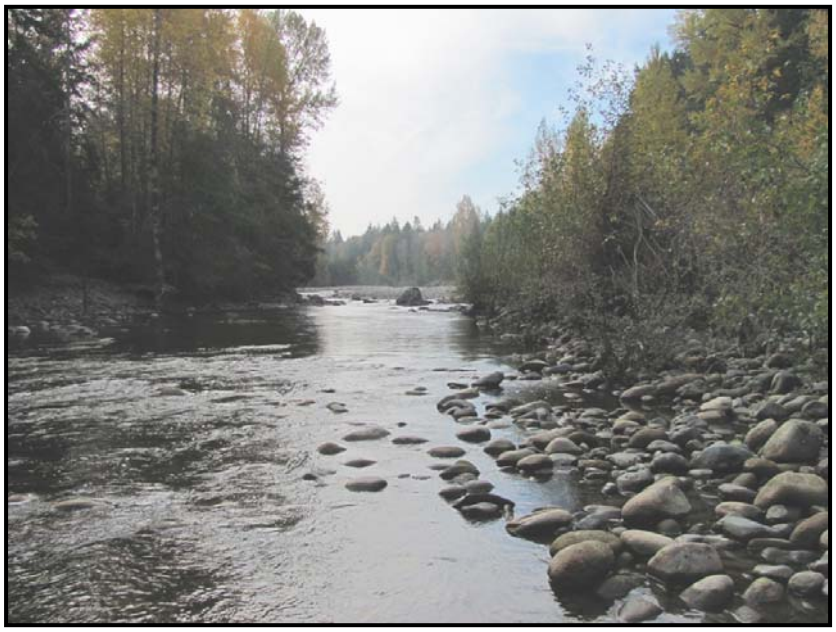

Photo 4. Upstream view of the Englishman River near the confluence with the C.W. Young outlet (station 5) on 20 October 2010.

APPENDIX 2. Invertebrate Survey Field Data Sheet completed for triplicate stream invertebrate samples collected at stations 1, 3 and 4 on the C.W. Young Channel during 2 November 2010.

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name: CW Young		Date: 2 November 2010
Station Name: **Station 1**		Flow status: Moderate
Sampler Used: Hess	Number of replicates 3	Total area sampled (Hess, Surber = 0.09 m^2) x no. replicates 0.09 x 3 = 0.27 m^2

Column A Pollution Tolerance	Column B Common Name	Column C Number Counted	Column D Number of Taxa
Category 1	Caddisfly Larva (EPT)	5	1
	Mayfly Nymph (EPT)	47	2
	Stonefly Nymph (EPT)	228	3
Pollution Intolerant	Dobsonfly (hellgrammite)		
	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		280	6
Category 2	Alderfly Larva		
	Aquatic Beetle		
	Aquatic Sowbug		
	Clam, Mussel		
	Cranefly Larva		
Somewhat Pollution Tolerant	Crayfish		
	Damselfly Larva		
	Dragonfly Larva		
	Fishfly Larva		
	Scud (amphipod)	42	1
	Watersnipe Larva		
Sub-Total		42	1
Category 3	Aquatic Worm (oligochaete)	12	2
	Blackfly Larva		
	Leech		
	Midge Larva (chironomid)		
Pollution Tolerant	Planarian (flatworm)		
	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite		
Sub-Total		12	2
TOTAL		334	9

APPENDIX 2. (Continued)

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell **CT**: 334

DENSITY: Invertebrate density per square metre:

334 ÷ 0.27 = 1237

PREDOMINANT TAXON:

Invertebrate group with the highest number counted (Col. C): Stonefly Nymph (EPT)

SECTION 2 - WATER QUALITY ASSESSMENTS

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

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

3 x D1 + 2 x D2 + D3

3 x 6 + 2 x 1 + 2 = 22

EPT INDEX: Total number of EPT taxa.

Good	Accpetable	Marginal	Poor
>8	5-8	2-5	0-1

EPT4 + EPT5 + EPT6

1 + 2 + 3 = 6

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

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

(EPT1 + EPT2 + EPT3) / CT

(5 + 47 + 228) / 334 = 0.84

SECTION 3 - DIVERSITY

TOTAL NUMBER OF TAXA: Total number of taxa from cell **DT**: 9

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

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

Col. C for S3 / CT

228 / 334 = 0.68

SECTION 4 - OVERALL SITE ASSESSMENT RATING

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

Assessment Rating	
Good	4
Accpetable	3
Marginal	2
Poor	1

Assessment	Rating
Pollution Tolerance Index	3
EPT Index	3
EPT To Total Ratio	4
Predominant Taxon Ratio	2

Average Rating
3.00

APPENDIX 2. (Continued)

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name: CW Young		Date: 2 November 2010
Station Name: **Station 3**		Flow status: Moderate
Sampler Used: Hess	Number of replicates 3	Total area sampled (Hess, Surber = 0.09 m^2) x no. replicates 0.09 x 3 = 0.27 m^2

Column A Pollution Tolerance	Column B Common Name	Column C Number Counted	Column D Number of Taxa
Category 1 **Pollution Intolerant**	Caddisfly Larva (EPT)	20	2
	Mayfly Nymph (EPT)	78	3
	Stonefly Nymph (EPT)	163	3
	Dobsonfly (hellgrammite)		
	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		261	8
Category 2 **Somewhat Pollution Tolerant**	Alderfly Larva		
	Aquatic Beetle		
	Aquatic Sowbug		
	Clam, Mussel		
	Cranefly Larva	10	4
	Crayfish		
	Damselfly Larva		
	Dragonfly Larva	1	1
	Fishfly Larva		
	Scud (amphipod)		
	Watersnipe Larva		
Sub-Total		11	5
Category 3 **Pollution Tolerant**	Aquatic Worm (oligochaete)	15	3
	Blackfly Larva		
	Leech		
	Midge Larva (chironomid)		
	Planarian (flatworm)		
	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite		
Sub-Total		15	3
TOTAL		287	16

APPENDIX 2. (Continued)

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell **CT**: 287

DENSITY: Invertebrate density per square metre:

287 ÷ 0.27 = 1063

PREDOMINANT TAXON:

Invertebrate group with the highest number counted (Col. C): 163

SECTION 2 - WATER QUALITY ASSESSMENTS

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

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

3 x D1 + 2 x D2 + D3

3 x 8 + 2 x 5 + 3 = 37

EPT INDEX: Total number of EPT taxa.

Good	Accpetable	Marginal	Poor
>8	5-8	2-5	0-1

EPT4 + EPT5 + EPT6

2 + 3 + 3 = 8

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

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

(EPT1 + EPT2 + EPT3) / CT

(20 + 78 + 163) / 287 = 0.91

SECTION 3 - DIVERSITY

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

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

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

Col. C for S3 / CT

163 / 287 = 0.57

SECTION 4 - OVERALL SITE ASSESSMENT RATING

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

Assessment Rating	
Good	4
Accpetable	3
Marginal	2
Poor	1

Assessment	Rating
Pollution Tolerance Index	4
EPT Index	3
EPT To Total Ratio	4
Predominant Taxon Ratio	3

Average Rating
3.50

APPENDIX 2. (Continued)

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name: CW Young		Date: 2 November 2010
Station Name: **Station 4**		Flow status: Moderate
Sampler Used: Hess	Number of replicates 3	Total area sampled (Hess, Surber = 0.09 m^2) x no. replicates 0.09 x 3 = 0.27 m^2

Column A Pollution Tolerance	Column B Common Name	Column C Number Counted	Column D Number of Taxa
Category 1 **Pollution Intolerant**	Caddisfly Larva (EPT)	18	1
	Mayfly Nymph (EPT)	127	2
	Stonefly Nymph (EPT)	115	3
	Dobsonfly (hellgrammite)		
	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		260	6
Category 2 **Somewhat Pollution Tolerant**	Alderfly Larva		
	Aquatic Beetle		
	Aquatic Sowbug	1	1
	Clam, Mussel		
	Cranefly Larva	3	2
	Crayfish		
	Damselfly Larva		
	Dragonfly Larva		
	Fishfly Larva		
	Scud (amphipod)		
	Watersnipe Larva		
Sub-Total		4	3
Category 3 **Pollution Tolerant**	Aquatic Worm (oligochaete)	45	1
	Blackfly Larva		
	Leech	2	1
	Midge Larva (chironomid)		
	Planarian (flatworm)		
	Pouch and Pond Snails	1	1
	True Bug Adult		
	Water Mite	1	1
Sub-Total		49	4
TOTAL		313	13

APPENDIX 2. (Continued)

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell **CT**: 313

DENSITY: Invertebrate density per square metre:

313 ÷ 0.27 = 1159

PREDOMINANT TAXON:

Invertebrate group with the highest number counted (Col. C): Mayfly Nymph (EPT)

SECTION 2 - WATER QUALITY ASSESSMENTS

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

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

3 x D1 + 2 x D2 + D3

3 x 6 + 2 x 3 + 4 = 28

EPT INDEX: Total number of EPT taxa.

Good	Accpetable	Marginal	Poor
>8	5-8	2-5	0-1

EPT4 + EPT5 + EPT6

1 + 2 + 3 = 6

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

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

(EPT1 + EPT2 + EPT3) / CT

(18 + 127 + 115) / 313 = 0.83

SECTION 3 - DIVERSITY

TOTAL NUMBER OF TAXA: Total number of taxa from cell **DT**: 13

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

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

Col. C for S3 / CT

127 / 313 = 0.41

SECTION 4 - OVERALL SITE ASSESSMENT RATING

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

Assessment Rating	
Good	4
Accpetable	3
Marginal	2
Poor	1

Assessment	Rating
Pollution Tolerance Index	4
EPT Index	3
EPT To Total Ratio	4
Predominant Taxon Ratio	3

Average Rating
3.50