RICHARDS CREEK VIU STUDENT MONITORING PROGRAM 2013

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Executive Summary

The 2013 Environmental Monitoring project for Richards Creek in the Cowichan Valley was conducted by four Vancouver Island University (VIU) students for the class RMOT 306; a core component of the Natural Resource Protection Bachelor program. The sampling program is a continuation of previous years sampling by other VIU students and the DFO officials who initiated projects in this creek in previous years. The focus of environmental monitoring in this location is to assess stream health in relation to suitability for aquatic life such as historic salmonid populations, and potential pollution threats by resources use such as farming, which occurs adjacent to parts of the creek.

The sampling occurred on two separate days, October 28th and November 18th 2013. Hydrology measurements taken at three of the four stations on both days showed that there was a higher discharge rate during the second sampling event. This produced flushing in the lower reaches of the creek, which removed duckweed and decreased conductivity.

Microbiology samples taken at all four sampling stations on October 28th showed coliform to be present at all of the sites and in very high numbers in the lowest reach of the stream where the water slows.

Invertebrate sampling was also conducted on October 28th from the first three stations of the creek. Healthy insect populations were found and will be later discussed in the report, based on the stream keeper's guide for these communities.

Water samples were taken for both VIU and ALS laboratories on both sampling days. Samples from three stations were sent to ALS, and samples from four stations plus a duplicate was analyzed by students at the VIU lab. During the first event, iron values were found by ALS to be

above the provincial guidelines to support aquatic life; by the second event, iron levels were found to be below limits. The stream pH measured at VIU for all stations during the first sampling event was lower than the provincial recommendation of 6.5, but had gone up to acceptable limits by the second event.

Phosphorus input from surrounding farms is a cause for concern, especially within the downstream reaches of this creek. On the first sampling day, station four had eutrophic levels, and on the second day the last two stations had eutrophic levels.

If healthy fish populations are to return to this creek, more restorative work will need to be conducted so the environment is more stable and conducive to juvenile fish and spawning. Though the creek results overall were healthy, fish may not travel through the lower reaches because of eutrophication. Perhaps with enough people conducting this kind of monitoring, as well as more solutions being sought, Coho salmon will spawn in Richards Creek again.

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1 INTRODUCTION

1.1 PROJECT OVERVIEW

This project was carried out between the dates of October 16th and November 20th, 2013, by four, 3rd year Bachelor of Natural Resource Management students enrolled at Vancouver Island University, under the direction of RMOT 306: environmental monitoring professor, Eric Demers.

Two separate data collection dates occurred on October 21st and November 18th. We looked at chemical, biological and physical measurements that included: water quality samples, stream macro invertebrates, water matrix microbiology samples, and hydrologic features for flow and velocity. Between the two sampling dates we saw low stream flows transitioning to high stream flows.

Work completed for this environmental monitoring project has provided information necessary for a continuation of data collected by previous year's Bachelor degree students. This project was directed towards gathering creek information for monitoring, assessing and identifying actual and potential environmental impacts to Richards Creek from surrounding agricultural and residential land use.

Richards Creek stretches across approximately 9.2 km of land along the Somenos basin. The creek originates from Crofton Lake and empties into Somenos Lake (south east of Crofton Lake) near the city of Duncan, British Columbia, Canada (Dorey M, 2011).

1.2 HISTORICAL REVIEW

For a number of years Richards Creek has been modified by natural and anthropogenic sources; such as, beavers constructing dams, and farmers modifying the surrounding landscape for

agriculture. A 2005 water quality report for the Somenos Basin (Guimond S, 2005) speaks of three important historical events occurring:

1. Records from the 1950's show that it is likely that diversion of the Cowichan River in 1956 has contributed to flooding of Richards Creek

2. In 1983, Richards Creek was excavated to prevent flooding to farmer's fields and to improve salmonid habitat

3. In 2003 six water quality sites were set up along the creek by BC government officials and VIU students have conducted monitoring from them intermittently ever since

Four of the six sites have been sampled for this project to continue the water quality data studies.

In the year 2008, the Crofton Dam underwent restorations to improve flows in Richards Creek to enhance fish habitat (Citizen, 2008). The project consisted mainly of summer flow augmentation performed by the Department of Fisheries and Oceans (DFO).

1.3 Potential Environmental Concerns

Potential environmental concerns for Richards Creek include excessive nutrient runoff from nearby agricultural lands, such as pasture and fertilizer runoff. Our report follows trends of past reports that shown an overabundance of nutrients in downstream reaches, relatively low water gradients, and summer flows. All these factors have resulted in hypoxic water conditions in some lower reaches of the stream. Reduced salmonid habitat is also a large concern for this creek. Low dissolved oxygen levels, turbidity, and acidic water all adversely affect salmonid habitat.

Along this creek there are currently no observed major point source impacts; i.e., there are no mills or factories disposing effluent directly into the water. The leading impact source is likely from the farmland that the creek travels through in the form of field run off from things such as manure,

fertilizers, or pesticides. An excessive respiration process is occurring in the lower stream reaches. This may be caused by fertilizers encouraging algae bloom and duckweed growth which is capping the water surface, coupled with lack of riparian buffers in farmland areas to provide more oxygen to the water. Other potential contributors to pollution come from aging septic systems, car runoff, and litter.

2 PROJECT OBJECTIVES

The main objective for this project was to conduct environmental monitoring of Richards Creek in the Duncan/North Cowichan area as part of a continued environmental monitoring program. Though streams are ever-changing, we looked at current factors that helped offer insights about Richards Creek as it relates to the ultimate goal of a healthy sustainable ecosystem. Our analysis was based on technical work that has provided a description of environmental conditions in Richards Creek. This work, compared with past results and environmental standards set by the British Columbia Ministry of the Environment for water quality has set the stage for discussion points in the resulting report.

This creek has been studied for many years, mainly by VIU students from 2008-2012, and we have continued to build on the results of the previous monitoring efforts. We monitored the creek in four different locations; at each location we collected samples and data for hydrology, water quality, microbiology, and stream invertebrates. With the data collected, we performed analysis based on BC Government standards and past reports to determine the relative health of the stream. The results may be used by multiple agencies such as Vancouver Island University, The City of North Cowichan, the British Columbia Conservation Foundation, and the Department of Fisheries and Oceans Canada. Some of the agencies listed provided funding for this project since it began in 2008.

3 METHODS

3.1 SAMPLING STATIONS

3.1.1 Locations

Richards Creek is located on Vancouver Island within the municipalities of Duncan and North Cowichan. The Crofton Lake reservoir that regulates creek flow is controlled by the Cowichan Valley Regional district (CVRD). The creek originates at Crofton Lake and drains into Somenos Lake, which is a part of the Somenos Basin (Figure 1). The upstream half of Richards Creek runs through woodland and residential areas and the downstream half passes through agricultural land.

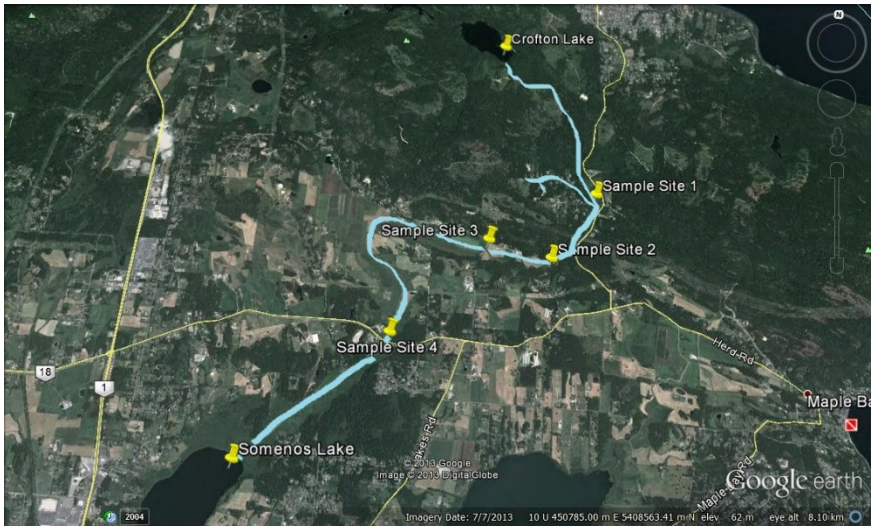

Figure 1. Sampling station locations along Richards Creek (embellished) which originates at Crofton Lake and drains into Somenos Lake (Google Earth, 2013). The sampling sites shown here were used for water quality, invertebrate, and hydrology and microbiology assessments. Sampling took place in October and November 2013. Table 1 (below) further describes directions to the sites.

All sampling site locations are numbered from upstream (station1) to downstream (station4) and sampling was conducted sequentially starting at station1. All sites were located close to public access areas from bridges and road crossings. Site one is located off of Escarpment Way, site two is at the end of Rice Road, site three is on Richards Trail, and site four is at a large bridge crossing on Herd Road. UTM Coordinates and site descriptions are provide in table 1.

Table 1: UTM Coordinates and sample site geographic description for all 4 sampling sites used for water quality, invertebrate, hydrology and microbiology assessments October to November, 2013 at Richards Creek.

Sample Site	Easting	Northing	Description
1	452505	5409496	Approximately 20 meters NW from Escarpment Way. (From Herd Road turn on Osborne, then Escarpment Way)
2	451904	5408588	End of Rice Road, Approximately 15 meters North down a driveway toward Innisvale Farm
3	451344	5408779	Richards Trail/Richard creek intercept at East end of Pastula Farm, Approximately 20 m East of the culverted road crossing through farmers' fields by an old wooden bridge
4	450251	5407632	Herd Road/Richards Creek Intercept, Approximately 10 meters from Herd Road at Mays Road at road bridge

3.1.2 **Habitat Characteristics**

Bank and in-stream habitat is variable for each sampling location. Sites one and two are located in an area with gentle slopes and a wider area of forested riparian vegetation, whereas sites three and four pass through almost flat, brushy, and open agricultural land. Canopy cover, vegetation, in-stream cover, in-stream bed material and slope were recorded and are listed in table 2.

Table 2: Habitat characteristics for each of the four stations observed during October and November 2013 sampling events.

nd* There is no data due to the stream being covered in duckweed and too murky to make these observations.

	Station1	Station 2	Station 3	Station 4
Ecosystem Type	Forested area	Forested Area	Agricultural Fields	Agricultural Fields
Riparian Vegetation	Salmonberry, sword fern, big leaf maple, red alder Western red cedar.	English ivy, big leaf maple, Douglas fir, Western red cedar	Himalayan blackberry red alder, hardhack	red alder, Douglas fir, big leaf maple, red osier dogwood, Nootka rose, hardhack, Himalayan blackberry, sedges and rushes.
In-stream cover	20%	5%	70%	5%
Canopy Cover	90%	90%	75%	0%

Large woody debris (LWD)	5%	5%	5%	nd*
Small Woody debris	20%	10%	10%	nd*
Substrate	10% clay, 0%sand, 10%gravel, 5%coble, 5%boulder	40% silt and sand, 50% cobble, and 10% boulder	30% silt and sand, 20% boulder, and 50% cobble	nd*

3.1.3 Sampling Frequency

Water quality testing was conducted twice at each of the four sampling locations on Richards Creek. The first sampling event took place on October 21st and the second event took place on November 18th. Microbiology and invertebrate sampling occurred during the first sampling event (in triplicate) at stations 1, 2, and 3. Lab analysis for the invertebrate sampling and first round of water quality sampling occurred on Wednesday October 30th. The second round of water quality data was analyzed on Wednesday November 20th. Hydrology measurements were taken at both events for Stations 1, 2 and 3. Vegetation profiles, substrate and woody debris presence was recorded during the first sampling event.

3.2 Basic Hydrology

Stream profile and water velocity was used to evaluate the flow rates of Richards Creek at stations 1, 2 and 3 during both sampling events. Equipment included a pop can (half filled with water), measuring tape, measuring stick, and a stop watch. Stream profile was measured by determining the wetted width to the nearest 0.1 m, and water depths to the nearest 0.01m. To determine velocity we dropped the can into the channel and measured the time it took to travel over the course of 2 m. The average time of 3 attempts was used for more accurate results and sampling was conducted in accordance with (BC MOE). Discharge in m^2/s was then calculated for both events using the product of profile and velocity.

3.3 WATER QUALITY

3.3.1 Field Measurements

Field measurements for temperature and dissolved oxygen were taken on site with an YSI 556 MPS electronic probe placed directly into the stream channel. Temperature was taken to the nearest 0.01◦C and to the dissolved oxygen 0.01 mg/L at each site.

3.3.2 Water Sample Collection

Samples were taken by submersing a bottle in the water with the opening facing upstream with the sampler standing along the side. We approached the midstream sample site from downstream carefully so bottom sediments were not disturbed. We will began sampling at the most upstream stream site (Station 1) and proceed downstream until we reach station 4.

One trip blank accompanied us on the sampling days and a duplicate was taken at station 3. At all stations we collected 1 sample for VIU laboratory analysis; at stations 1, 3 and 4 we collected 3 different samples for ALS laboratory analysis. All samples were kept at 4°C in a fridge until the analysis was conducted.

3.3.3 VIU Laboratory Analysis

At the VIU lab under the guidance of Eric Demers, Sara Greenway and John Morgan, we used various equipment to determine: pH using a pH meter, conductivity to the nearest µS/cm, hardness as $CaCO_3$ to the nearest o.o1 mg/L , total alkalinity to the nearest mg/L using the HATCH AL-DT digital titration method, phosphate to the nearest mg/L using HATCH method no. 8048, nitrate to the nearest mg/L using HATCH method 8192, (Both tests nitrate and phosphorus used a spectrometer) and turbidity to the nearest 0.01 NTU(Nephelometric Turbidity Units) using a HATCH 2100Portable Turbidimeter.

3.3.4 ALS Laboratory Analysis

Eric Demers submitted our labeled samples with the appropriate chain of custody via courier to ALS Laboratory in Burnaby BC via a cooler shipment. They provided us data for conductivity, pH, hardness, alkalinity), nutrients (ammonia, nitrate, nitrite, orthophosphate, total phosphorus), and total metals. Many of these tests had to be qualified due to the holding time between sampling and analysis being over the guideline recommended times.

3.3.5 Quality Assure/Quality Control

Various measures were used to ensure the events and analysis maintained quality assurance and control, they are listed in the bulleted points below:

- A trip blank was be used for each sampling day.
- Filtration blanks were used when conducting VIU laboratory analysis of coliforms.
- A duplicate water sample from station 3 was included in each sample batch submitted to the VIU lab.
- All bottles that arrived from the ALS laboratory were clean and was not rinsed before samples were taken.
- We adhered to procedures and standards set by the Province of British Columbia outlined in various manuals such as RISC Guidelines for Interpreting Water Quality (RISC, 2004), British Columbia Ministry of the Environment Water Quality Guidelines ((BC, MOE, 2013), A Compendium of Working Water Quality Guidelines for British Columbia (N. K. Nagpal, 2006) and The Streamkeepers Handbook: a Practice Guide to Stream and Wetland Care (Munro, 1995) to collect, test and analyze all samples.
- Many of the tests we are conducting as students is also conducted by an accredited laboratory and the results compared.

- Samples were stored in a cooler at 4°C. The temperature was verified on the chain of custody upon arrival to each of the labs. Samples were kept in a fridge until such a time as we were able to analyze them.
- Sample holding times will affect results, we did our best to meet requirements, however, some of the samples ran outside of the recommended holding time. The data is qualified in the report.
- All Excel formulas used for data is verified as correct with Eric Demers before submitting the final report.

3.4 MICROBIOLOGY

Water samples for Microbiology were gathered at the first sampling events in sterile 120mL Whirl-Pac sampling bags from stations 1, 2, 3, and 4 and analyzed kept on ice until analysis could begin at the VIU laboratory. The test is called the M-coliBlue24 membrane filtration method and producing colony forming units (CFUs) of coliform. 100 mL of water was filtered through a 45om membrane filter with a vacuum pump. M-ColiBlue24 broth is added to a pad the filtered particles were placed on, then incubated for growth, so a total and fecal coliform count could be performed. A filtration blank was used for quality assurance.

3.5 STREAM INVERTEBRATES

We sampled the stream invertebrates in the afternoon of Monday Oct. 28th, 2013. We sampled at stations 1, 2, and 3 using the Hess Sampler. At each station we collected three different samples, with a total of nine samples all together. At each location we made sure that the samples were of similar substrate, we approached from downstream, and always in riffles.

We kept the samples in separate clean, and pre-labelled containers, and kept them cold (4◦C) so they would be alive until transported and analyzed at VIU. On Wednesday Oct. 30, 2013 we

counted the combined the containers taken at each station and did an overall count, to produce three invertebrate field data sheets.

For accuracy and quality assurance measures we used two people to count the same samples and checked each other's work. We used Excel for our calculations and confirmed with our instructor that we have the proper formulae in place on the spreadsheets. We followed the Pacific Stream Keepers Procedures (Munro, 1995) during sampling and when analyzing the samples.

4 RESULTS AND DISCUSSION

4.1 GENERAL FIELD CONDITIONS

The first sampling event occurred on Monday October 28th 2013, and the second sampling event occurred on Monday, November 18th 2013. The weather on October 28th was cloudy with partial sun, and no rainfall. On November 18th the weather was overcast, and it had been raining steadily before, during and after the sampling events. This could have influenced water quality results, and hydrology measurements.

WATER QUALITY

4.1.1 Field Measurements

The wetted width of station 1 increased from 1.8m in the first sampling event to 2.2m in the second sampling event; station 2 increased from 3.25m to 3.6m and station 3 increased marginally from 3.67m to 3.7m (Table #). Wetted depth measurements correlated closely to the changes seen in wetted width. Station 1 had a wetted depth increase from 0.172m at the first sampling event to 0.227m at the second sampling event. There is an increase of 1.3 times in wetted depth and a 1.2 times increase in wetted width over both sampling events at station 1. Wetted depth decreased from 0.122m to 0.055m at the second sampling site. This change could be the result of an error in the field. The second measurement may not have been taken at the same location as the first sampling event. Changes in stream bed topography would obscure the results. Wetted depth at station three remained relatively the same at 0.258m during the first event and 0.247 at the second event.

Table 3: Hydrology measurements taken at stations 1 to 3 on October 28th, 2013 and November 19 2013 show and increase in Discharge rates between the two events.

	Hydrology measurements for Richards Creek 2013

	RICHARDS CREEK- STATION 1	RICHARDS CREEK- STATION 2	RICHARDS CREEK- STATION 3		RICHARDS CREEK- STATION 1	RICHARDS CREEK- STATION 2	RICHARDS CREEK- STATION 3
Date	October 28th	October 28th	October 28th		November 18th	November 18th	November 18th
Wetted width (m)	1.8	3.45	3.67		2.2	3.6	3.7
Average Wetted Depth (m)	0.172	0.122	0.258		0.227	0.055	0.247
Flow Rate (m^2/S)	0.04	0.07	0.13		0.07	0.06	0.27

In correlation with the increase of wetted width and depth, stream flow rate also increased. Station 1 measured 0.04m^2/s during the first sampling event and increased to 0.07 m^2/s at the second sampling event. Station 2 remained relatively the same, but overall decreased from 0.07 m^2/s to 0.06 m^2/s. Station 3 had the largest increase in water volume from 0.13 m^2/s to 0.27 m^2/s. An increase in wetted width, depth and flow rate was expected over the course of the two sampling events because of annual rainfall changes. Monthly precipitation data collected from The Weather Network for Duncan, BC over the last 30 years shows that average rainfall increases from 84mm in October to 141mm in November (The Weather Network, 2013). Rainfall data from Duncan Weather shows that for October 2013, total precipitation was 6.4mm and November was 106.2mm (The Weather Network, 2013). This difference in rainfall compared to the average indicates that October was an unusually dry month this year. Overall, the wetted width, depth and flow rate increased in November.

4.1.2 **VIU Laboratory Analysis**

The water samples taken on the two event days were analyzed by the student team in the laboratory at VIU, under the direction of Eric Demers. Several parameters were tested including dissolved oxygen, nitrate, phosphorus, alkalinity and turbidity.

From the samples taken on October 28th, it was found that the pH taken in the field was below the provincial guidelines of 6.5-9.0 for the first sampling event. The pH for the samples taken on November 19th were within the guidelines.

Upon looking over data from the first sampling event and comparing it to temperature and other trends, we discovered that our field probe had been giving us false readings and were forced to discard the dissolved oxygen data for day 1 of sampling. On Nov 19th, the dissolved oxygen was found to be much higher and fell within the guidelines for embryos for stations 1-3, while station 4 had now fallen into the guidelines to support fish.

Turbidity guidelines are variable throughout the province, though it was found that our turbidity for the first sampling events were quite low compared to the turbidity of our second sampling events. This is most likely due to the rainfall experienced between the samplings dates and a higher amount of runoff from the surrounding landscape.

It was found that both sampling events tested for alkalinity had a low acid sensitivity, with both dates having alkalinity values well above the provincial guidelines for low acid sensitivity. For hardness, sites 1 and 2 samples from the first event were considered soft water, while sites 3 and 4 were roughly in the middle of being considered soft and hard water. On the second sampling date, the samples of all sites were considered hard water. These tests will be less accurate than the lab tests since we used a smaller portion of sample and multiplied our results.

The guidelines for nitrate were well above the amounts that were found to be in the samples that the VIU student team tested in the lab. The guideline is 200mg/and highest result any sample obtained was 0.91 mg/L during sample event two.

Phosphorus from both sample batches was found to be within the limits for eutrophic waters.

4.1.3 **ALS Laboratory Analysis**

ALS Results were compared to the British Columbia water quality guidelines for Aquatic life and are presented in Table 4. Most of the parameters tested were within the guidelines. More precise tests would be required for a few of the parameters tested, such as cadmium and copper, the maximums for those are below the detection limits for the tests we ordered. The only guideline breech according to the ALS results was at station 4 on the first sampling day; it had an iron hit of 1.07mg/L, and the limit is 1.0mg/L. On the second sampling day, the iron at station 4 was down to 0.615mg/L, which is within the guidelines for aquatic life.

Conductivity increased at stations 1 and 3 (compared to the first sampling event), and decreased at station 4, presumably due to more flushing occurring around that area as the discharge rates had increased.

The pH for both sampling days ranged from 7.19-7.85. Though this is within guidelines, these samples were not tested within the recommended time, therefore the VIU lab measurements may be more accurate.

Hardness was registered as soft water for all stations. Due to the precision of the lab tests, these measurements are more likely to be true than our less precise VIU lab tests for hardness.

The total phosphorus count for station 4 on October 28th, and station 3 and 4 on November 18th registered as eutrophic water. The Redfield ratio for both days is presented in the table below shows that phosphorus input is in excess of the 16:1 required ratio for balanced growth.

Table 4: The Redfield ration calculated from the dividing the total nitrogen from the total phosphorus on 2013 sampling days at Richards Creek.

Sampling days	Redfield Ratio N:P

	Station 1	Station3	Station 4
October 28	1:32	1:31	1:04
November 18	1:23	1:21	1:10

Table 5: ALS Laboratory results for Richards Creek stations 1, 3 and 4 samples compared to the British Columbia Guidelines for Aquatic Life. Highlighted values exceed limits or are cause for concern. (Next page)

BRITISH COLUMBIA WATER QUALITY GUIDELINES			ALS Results					
			28-Oct-13			18-NOV-13		
Parameter	**Guideline (mg/L)**	**Note**	RICHARDS CREEK-STATION 1	RICHARDS CREEK-STATION 3	RICHARDS CREEK-STATION 4	RICHARDS CREEK - STATION1	RICHARDS CREEK - STATION3	RICHARDS CREEK - STATION4
pH	6.5 - 9.0		7.62	7.72	7.19	7.85	7.83	7.49
Conductivity			86.5	120	335	149	183	245
Hardness	<60	Soft water	34.1	47.2	48.2	49.2	50.2	51.2
	>120	Hard water						
Ammonia (NH_3)	Variable	Varies with temperature and pH See Tables in Reference	0.0068	0.0058	0.299	0.0108	0.0073	0.252
Nitrite (NO_2^-)	0.06		<0.0010	<0.0010	0.0094	<0.0010	0.0023	0.0218
Nitrate (NO_3^-)	200		0.0151	0.0989	0.129	0.338	0.543	0.785
Total Phosphorus (P)	<0.010	Oligotrophic						
	0.010 - 0.025	Mesotrophic	0.0072	0.0101	0.430	0.0203	0.0374	0.152
	≥0.025	Eutrophic	Oligo	Meso	Eutro	Meso	Eutro	Eutro
Aluminum (Al)	0.3	≥50 mg/L						
	0.1	When pH ≥ 6.5 When pH <6.5, see Reference	<0.20	<0.20	<0.20	<0.20	<0.20	0.27
	Variable							
Antimony (Sb)	0.02		<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Arsenic (As)	0.005		<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Barium (Ba)	5		<0.010	<0.010	0.022	0.011	0.012	0.017
Beryllium (Be)	0.0053		<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Boron (B)	1.2		<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Cadmium (Cd)	Variable	10 ^ [0.86 x LOG(hardness) - 3.2) / 1000	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Calcium (Ca)	≤4	High acid sensitivity						
	4 to 8	Moderate acid sensitivity	10.7	14.0	31.5	16.9	20.3	29.8
	>8	Low acid sensitivity						
Chromium (Cr)	0.001	For the more toxic Chromium VI	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Cobalt (Co)	0.11		<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Copper (Cu)	Variable	[0.094 x (hardness) + 2] / 1000	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Iron (Fe)	1		0.316	0.148	1.07	0.252	0.221	0.615
Lead (Pb)	Variable	(0.2108 x (hardness) ^ 1.293) / 1000	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Lithium (Li)	0.87		<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Manganese (Mn)	Variable	0.01102 x (hardness) + 0.54	0.0536	0.0103	0.372	0.0756	0.0170	0.123
Molybdenum (Mo)	2		<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Nickel (Ni)	0.025	When hardness ≤60 mg/L						
	0.065	When hardness = 60 - 120 mg/L	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
	0.11	When hardness = 120 - 180 mg/l When hardness >180 mg/L						
	0.15							
Selenium	0.002		<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Silver (Ag)	0.0001	When hardness ≤100 mg/L						
	0.003	When hardness >100 mg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Zinc (Zn)	0.033	When hardness ≤ 90 mg/L						
	Variable	When hardness > 90 mg/L, [0.75 x (hardness - 90) + 33] / 1000	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0092

4.1.4 **Quality Control**

Instrument blanks were used when conducting VIU laboratory analysis of coliforms. The Blank registered 2 red CFU's, and no blue (E.Coli) CFUs giving us a reasonable degree accuracy for these tests.

We used our trip blank to check the tests for phosphorus and nitrate and registered hits of 0.05 (first sampling event) and 0.09 (second sampling event) for total nitrogen and 0.03 (first sampling event) and 0.09 (second sampling event) for total phosphorus CFUs giving us a reasonable degree accuracy for these tests.

A duplicate water sample from station 3 was included in each sample batch submitted to ensure accuracy. The results produced were similar for all tests.

All Samples were kept in cooler, and a 4^0C temperature was maintained to ensure the validity of the samples. The temperature of the samples at 4°C was verified on the respective chain of custody, upon arrival to each of the labs. Samples were kept in a fridge until we could analyze them. The deadlines for all samples were adhered to as best as was possible. All the ALS samples were analyzed after their deadline, this was qualified in the ALS report. All excel formulas used to analyze data were verified as correct with Eric Demers before submitting the report.

4.1.5 **Microbiology**

There was Coliform present in all the samples taken from Richards Creek. Station 1 had the second greatest count, with total CFUs of 829, while station 4 registered an 1802 CFUs. Stations 2 and 3 were relatively low. Though they weren't plentiful, all samples contained some E. coli bacteria, individuals on drinking water permits for this creek would do well to treat their water before consumption.

Table 6: Coliform counts for water samples taken at stations 1, 2, 3 and 4 in October and November 2013. The values expressed are Coliform forming units, or CFUs per 100 mL of water sample.

Microbiology					
Colony Units	Station 1	Station 2	Station 2	Station 4	Blank
Red	827	64	176	1776	0
Blue (E. coli)	2	2	5	26	2
Total	829	66	181	1802	2

4.2 STREAM INVERTEBRATE COMMUNITIES

4.2.1 Total Density

The team conducted the stream invertebrate samples on Oct. 28th; the first sampling day. The total density for the stream invertebrates for the first station was 15 animals/m^2 while the second station was 13 animals/m^2, then finally in station 3 it was 20 animals/m2 (Table #). Therefore the density for Richards's creek is considered to be good, with station 3 being the best in density. The reason that could be is, at station 3 there was a high amount of phosphorus being added from the surrounding farm land.

4.2.2 Taxon Richness and Diversity

In station 1 the taxon diversity was 15, with 3 different taxon from Mayflies, 5 from Craneflies, and 3 from the Aquatic Worms. Caddisfly, Stonefly, Amphipod, and midge larva had just 1 taxon represented in each (Table#). Station 2 had more taxon diversity within category 1, but the overall taxon was slightly less than the first station, having 13 taxon in total. The mayflies had 2 different taxon, Stonefly had 3, and the Dobsonfly also had 3. The Caddisfly, Cranefly, Aquatic Worm, Midge Larva, and Water mite all had 1 taxon each. For station 3 there was a relatively larger diversity with a total of 20 taxon, with most falling into category 1. There were 2 taxon seen for Caddisflies, 5 for Mayflies, 3 for Stoneflies, 3 for Dobsonflies, and 2 for Aquatic Worms. Only one taxon was represented for Cranefly, Amphipod, Leech, Midge Larva, and Water Mite

(Table #). Station 3 was found to have the best taxon richness and diversity out of all sites sampled for invertebrates.

5 CONCLUSIONS

Richards Creek appears to be a relatively healthy stream when the data for the stream invertebrate and water quality samples are analyzed and compared to the guidelines for the province. There are some issues however with eutrophication due to farm land run off in the surrounding area as evidenced by the high Redfield ratios. The iron content may also be cause for concern as may be the pH during certain times of the years since our data showed these variables to be outside recommended guidelines. The good news is that the water is good place for invertebrates, the issues we can work may be preventing salmon from spawning in the creek.

6 RECOMMENDATIONS

There are a number of initiatives that would benefit the health of Richards Creek. Reclaiming some of the farmland to make it into wetlands again and provide a natural buffer to possible pollutants. This will help with the eutrophication by introducing a natural filtration system. Wetlands would also help solve the issue of flooding in the Somenos basin. Also, there should be repeated studies done on the creek in the future to maintain the data on the stream health, and if any more issues arise, it would be easier to figure out the factor leading to the problems.

Eutrophic waters are not a desirable place for salmonids to spawn, perhaps more mitigation efforts need to be done. Somenos basin acts as a natural reservoir when water tables are high in the winter season. If Somenos Lake reaches capacity due to anthropologic inputs, farmers and urban residents could experience property flooding.

With continued efforts to improve the health of this stream, potential problems may not occur. With so many people depending on this water body, it is likely work will continue and the issues presented in this report will one day be resolved.

7 ACKNOWLEDGEMENTS

We would like to acknowledge the expertise of Eric Demers, Sara Greenway and John Morgan for helping us analyze the samples. Data from past groups that worked on this creek made this project more interesting, so special mention is due to prior students from Vancouver Island University as well as DFO and BCCF employees. Funding for this project was made possible by Vancouver Island University, and with reduced rates from ALS Environmental Testing Lab in Burnaby BC.

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9 APPENDIX

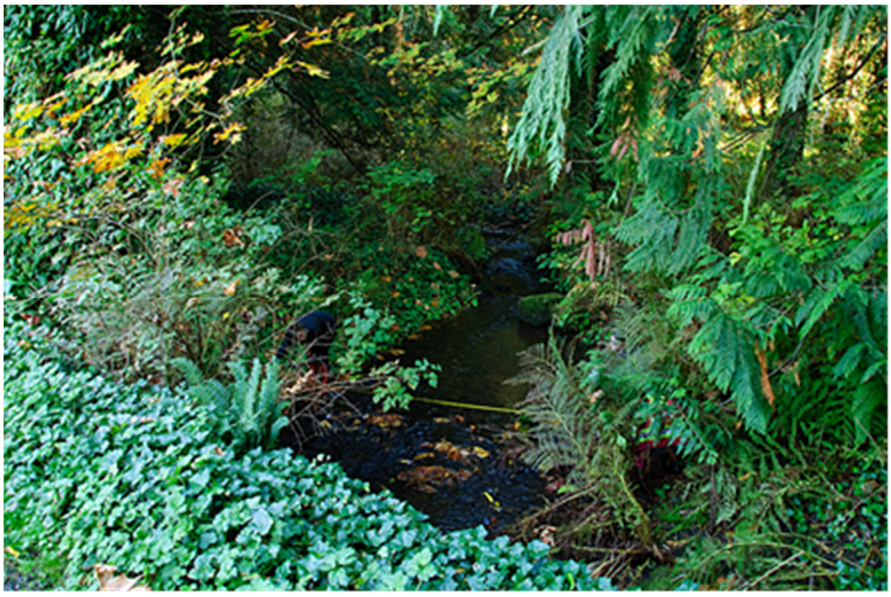
Hydrology Excel File

	Hydrolgy measurements for Richards Creek 2013						
	RICHARDS CREEK-STATION 1	RICHARDS CREEK-STATION 2	RICHARDS CREEK-STATION 3		RICHARDS CREEK-STATION 1	RICHARDS CREEK-STATION 2	RICHARDS CREEK-STATION 3
Date	October 28th , 2013				November 18th 2013		
Wetted width	1.8	3.45	3.67		2.2	3.6	3.7
Wetted depth 25%	0.12	0.13	0.335		0.18	0.06	0.2
Wetted depth 50%	0.205	0.135	0.25		0.24	0.06	0.2
Wetted depth 75%	0.19	0.1	0.19		0.26	0.045	0.34
Float time **T** (s)	11.72	10.52	12.26		12.77	5.33	5.68
Float distance **L** (m)	2	2	2		2	2	2
Surface Velocity **Vs** (m^3/s)	0.171	0.190	0.163		0.1567	0.3750	0.3523

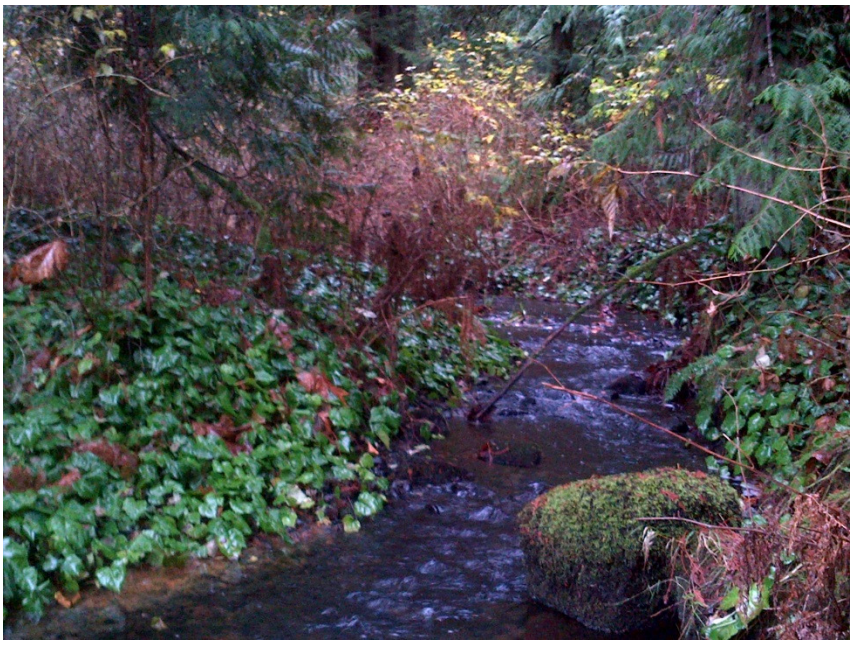
Site Photos

Habitat Characteristics for Site One (Photograph Taken by Mel Demkiw).

Habitat Characteristics for Site Two (Photograph Taken by Lynnea Parker).



Habitat Characteristics for Site Three (Photograph Taken by Mel Demkiw)



Habitat Characteristics for Site Four (Photograph Taken by Lynnea Parker).

ALS RESULTS For First Sampling day

Project	ENVIRONMENTAL MONITORING COURSE
Report To	Eric Demers, Vancouver Island University
ALS File No.	L1386524
Date Received	01-Nov-13 10:40
Date	09-Nov-13

RESULTS OF ANALYSIS

Sample ID	RICHARDS CREEK-STATION 1	RICHARDS CREEK-STATION 3	RICHARDS CREEK-STATION 4
Date Sampled	28-OCT-13	28-OCT-13	28-OCT-13
Time Sampled	15:00	16:47	17:00
ALS Sample ID	L1386524-1	L1386524-2	L1386524-3
Matrix	Water	Water	Water
Physical Tests			
Conductivity	86.5	120	335
Hardness (as CaCO3)	34.1	47.2	104
pH	7.62	7.72	7.19
Anions and Nutrients			
Ammonia, Total (as N)	0.0068	0.0058	0.299
Nitrate (as N)	0.0151	0.0989	0.129
Nitrite (as N)	<0.0010	<0.0010	0.0094
Total Nitrogen	0.227	0.315	1.62
Orthophosphate-Dissolved (as P)	<0.0010	0.0021	0.184
Phosphorus (P)-Total	0.0072	0.0101	0.430
Total Metals			
Aluminum (Al)-Total	<0.20	<0.20	<0.20
Antimony (Sb)-Total	<0.20	<0.20	<0.20
Arsenic (As)-Total	<0.20	<0.20	<0.20
Barium (Ba)-Total	<0.010	<0.010	0.022
Beryllium (Be)-Total	<0.0050	<0.0050	<0.0050
Bismuth (Bi)-Total	<0.20	<0.20	<0.20
Boron (B)-Total	<0.10	<0.10	<0.10
Cadmium (Cd)-Total	<0.010	<0.010	<0.010
Calcium (Ca)-Total	10.7	14.0	31.5
Chromium (Cr)-Total	<0.010	<0.010	<0.010
Cobalt (Co)-Total	<0.010	<0.010	<0.010
Copper (Cu)-Total	<0.010	<0.010	<0.010
Iron (Fe)-Total	0.316	0.148	1.07
Lead (Pb)-Total	<0.050	<0.050	<0.050
Lithium (Li)-Total	<0.010	<0.010	<0.010
Magnesium (Mg)-Total	1.81	2.97	6.16
Manganese (Mn)-Total	0.0536	0.0103	0.372
Molybdenum (Mo)-Total	<0.030	<0.030	<0.030
Nickel (Ni)-Total	<0.050	<0.050	<0.050
Phosphorus (P)-Total	<0.30	<0.30	0.37
Potassium (K)-Total	<2.0	<2.0	4.8
Selenium (Se)-Total	<0.20	<0.20	<0.20
Silicon (Si)-Total	3.56	5.22	7.44
Silver (Ag)-Total	<0.010	<0.010	<0.010
Sodium (Na)-Total	4.0	5.5	25.1
Strontium (Sr)-Total	0.0320	0.0473	0.133
Thallium (Tl)-Total	<0.20	<0.20	<0.20

Tin (Sn)-Total	<0.030	<0.030	<0.030
Titanium (Ti)-Total	0.012	<0.010	0.016
Vanadium (V)-Total	<0.030	<0.030	<0.030
Zinc (Zn)-Total	<0.0050	<0.0050	<0.0050

ALS RESULTS For Second Sampling day

Project	ENVIRONMENTAL MONITORING COURSE
Report To	Eric Demers, Vancouver Island University
ALS File No.	L1395801
Date Received	23-Nov-13 13:50
Date	04-Dec-13

RESULTS OF ANALYSIS

Sample ID	RICHARDS CREEK - STATION1	RICHARDS CREEK - STATION3	RICHARDS CREEK - STATION4	Units	Detection Limit
Date Sampled	18-NOV-13	18-NOV-13	18-NOV-13		
Time Sampled	13:17	14:00	15:15		
ALS Sample ID	L1395801-1	L1395801-2	L1395801-3		
Matrix	Water	Water	Water		
Physical Tests					
Conductivity	149	183	245	uS/cm	2.0
Hardness (as CaCO3)	54.0	68.6	96.2	mg/L	0.50
pH	7.85	7.83	7.49	pH	0.10
Anions and Nutrients					
Ammonia, Total (as N)	0.0108	0.0073	0.252	mg/L	0.0050
Nitrate (as N)	0.338	0.543	0.785	mg/L	0.0050
Nitrite (as N)	<0.0010	0.0023	0.0218	mg/L	0.0010
Total Nitrogen	0.471	0.798	1.56	mg/L	0.050
Orthophosphate-Dissolved (as P)	<0.0010	0.0251	0.108	mg/L	0.0010
Phosphorus (P)-Total	0.0203	0.0374	0.152	mg/L	0.0020
Total Metals					
Aluminum (Al)-Total	<0.20	<0.20	0.27	mg/L	0.20
Antimony (Sb)-Total	<0.20	<0.20	<0.20	mg/L	0.20
Arsenic (As)-Total	<0.20	<0.20	<0.20	mg/L	0.20
Barium (Ba)-Total	0.011	0.012	0.017	mg/L	0.010
Beryllium (Be)-Total	<0.0050	<0.0050	<0.0050	mg/L	0.0050
Bismuth (Bi)-Total	<0.20	<0.20	<0.20	mg/L	0.20
Boron (B)-Total	<0.10	<0.10	<0.10	mg/L	0.10
Cadmium (Cd)-Total	<0.010	<0.010	<0.010	mg/L	0.010
Calcium (Ca)-Total	16.9	20.3	29.8	mg/L	0.050
Chromium (Cr)-Total	<0.010	<0.010	<0.010	mg/L	0.010

Cobalt (Co)-Total	<0.010	<0.010	<0.010	mg/L	0.010
Copper (Cu)-Total	<0.010	<0.010	<0.010	mg/L	0.030
Iron (Fe)-Total	0.252	0.221	0.615	mg/L	0.050
Lead (Pb)-Total	<0.050	<0.050	<0.050	mg/L	0.010
Lithium (Li)-Total	<0.010	<0.010	<0.010	mg/L	0.10
Magnesium (Mg)-Total	2.89	4.33	5.28	mg/L	0.0050
Manganese (Mn)-Total	0.0756	0.0170	0.123	mg/L	0.030
Molybdenum (Mo)-Total	<0.030	<0.030	<0.030	mg/L	0.050
Nickel (Ni)-Total	<0.050	<0.050	<0.050	mg/L	0.30
Phosphorus (P)-Total	<0.30	<0.30	<0.30	mg/L	2.0
Potassium (K)-Total	<2.0	<2.0	<2.0	mg/L	0.20
Selenium (Se)-Total	<0.20	<0.20	<0.20		
Silicon (Si)-Total	5.77	6.61	6.74	mg/L	0.050
Silver (Ag)-Total	<0.010	<0.010	<0.010	mg/L	0.010
Sodium (Na)-Total	7.8	8.7	12.7	mg/L	2.0
Strontium (Sr)-Total	0.0542	0.0776	0.124	mg/L	0.0050
Thallium (Tl)-Total	<0.20	<0.20	<0.20	mg/L	0.20
Tin (Sn)-Total	<0.030	<0.030	<0.030	mg/L	0.030
Titanium (Ti)-Total	<0.010	<0.010	0.013	mg/L	0.010
Vanadium (V)-Total	<0.030	<0.030	<0.030	mg/L	0.030
Zinc (Zn)-Total	<0.0050	<0.0050	0.0092	mg/L	0.0050

VIU Lab and Field Measurements Day 1

Sample ID	RICHARDS CREEK-STATION 1	RICHARDS CREEK-STATION 1	RICHARDS CREEK-STATION 3	QC.RICHARDS CREEK-STATION 3 DUPLICATE	RICHARDS CREEK-STATION 4	QC.RICHARDS CREEK-TRIP BLANK
Date Sampled	28-OCT-13	28-OCT-13	28-OCT-13	28-Oct-13	28-OCT-13	
Time Sampled	15:00	16:01	16:47	16:48	17:00	
Matrix	Water	Water	Water	Water	Water	Water
Physical Tests						
Temperature (Field) (◦C)	n/a	10.1	9.4	9.4	9.4	
Dissolved Oxygen (Field) (mg/L)	n/a	4.7	4.7	4.7	0.81-0.68	Instrument malfunction
Conductivity (µS/cm)	71	92	102	103	301	
Hardness (as CaCO3) (mg/L)	51.3	51.3	68.4	68.4	102.6	
pH	6.43	6.47	6.49	6.48	6.07	
Turbidity (NTUs)	1.16	0.81	0.78	1.14	3.58	
Alkalinity (mg/L)	30	35.6	40.4	39.2	54	
Microbiology						Filter Blank
Red (CFUs)	827	64	176		1776	2
Blue (CFUs)	2	2	5		26	0
Total (CFUs)	829	66	181		1802	
Anions and Nutrients						

						Blanks
Nitrate (as N)	0.06	0.19	0.18	0.16	0.11	0.05
Orthophosphate-Dissolved (as P)	0.07	0.07	0.13	0.08	0.92	0.03

VIU Lab and Field Measurements Day 2

Sample ID	RICHARDS CREEK-STATION 1	RICHARDS CREEK-STATION 2	RICHARDS CREEK-STATION 3	QC.RICHARDS CREEK-STATION 3 DUPLICATE	RICHARDS CREEK-STATION 4	QC.RICH CREEK-T BLANK
Date Sampled	18-Nov-13	18-Nov-13	18-Nov-13	18-Nov-13	18-Nov-13	
Time Sampled	13:17	13:35	14:00	14:02	15:15	
Matrix	Water	Water	Water	Water	Water	Water
Physical Tests						
Temperature (Field)(◦C)	7.5	7.3	8.3	8.3	6.6	
Dissolved Oxygen (Field) (mg/L)	11.6	12.8	12.4	n/a	5.36	
Conductivity (Lab) (µS/cm)	112	126	143	143	175	
Hardness (as CaCO3) (mg/L)	153.9	171	188.1	153.9	171	
pH	7.45	7.6	7.7	7.73	6.9	
Turbidity (NTUs)	1.59	3.19	2.35	1.53	4.11	
Alkalinity (mg/L)	52	37.6	51.6	50	60.8	
Anions and Nutrients						Blank
Nitrate (as N)	0.57	0.67	0.77	0.91	0.73	0.09
Orthophosphate-Dissolved (as P)	0.06	0.14	0.23	0.29	0.5	0.09

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name:	Richards Creek	Date:	october 30th 2013
Station Name:	1	Flow statu	

Sampler Used:	Number of replicate	Total area sampled (Hess, Surber = 0.09 m^2) x no. rep	
Hess	3	0.27	m^2

Column A	Column B	Column C		Column D	
Pollution Tolerance	Common Name	Number Counted		Number of Taxa	
Category 1	Caddisfly Larva (EPT)	EPT1	4	EPT4	1
	Mayfly Nymph (EPT)	EPT2	31	EPT5	3
	Stonefly Nymph (EPT)	EPT3	4	EPT6	1
Pollution Intolerant	Dobsonfly (hellgrammite)				
	Gilled Snail				
	Riffle Beetle				
	Water Penny				
Sub-Total		C1	39	D1	5
Category 2	Alderfly Larva				
	Aquatic Beetle				
	Aquatic Sowbug				
Somewhat Pollution Tolerant	Clam, Mussel				
	Cranefly Larva		5		5
	Crayfish				
	Damselfly Larva				
	Dragonfly Larva				
	Fishfly Larva				
	Amphipod (freshwater shrimp)		4		1
	Watersnipe Larva				
Sub-Total		C2	9	D2	6
Category 3	Aquatic Worm (oligochaete)		13		3
	Blackfly Larva				
	Leech				
Pollution Tolerant	Midge Larva (chironomid)		4		1
	Planarian (flatworm)				
	Pouch and Pond Snails				
	True Bug Adult				
	Water Mite				
Sub-Total		C3	17	D3	4
TOTAL		CT	65	DT	15

NVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell **CT**: S1 CT = 65

DENSITY: Invertebrate density per total area sampled:

S1: 65 ÷ 0.27 m2 = S2: 241 / m^2

PREDOMINANT TAXON: Invertebrate group with the highest number counte S3: 31

SECTION 2 - WATER QUALITY ASSESSMENTS

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

Good	Acceptable	Marginal	Poor	3 x D1 + 2 x D2 + D3	S4
>22	17-22	11-16	<11	3 x 5 + 2 x 6 + 4 =	31

EPT INDEX: Total number of EPT taxa.

Good	Acceptable	Marginal	Poor	EPT4 + EPT5 + EPT6	S5
>8	5-8	2-4	0-1	1 + 3 + 1 =	5

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

Good	Acceptable	Marginal	Poor	(EPT1 + EPT2 + EPT3) / CT	S6
0.75-1.0	0.50-0.74	0.25-0.49	<0.25	(4 + 31 +4) /65=	0.6

SECTION 3 - DIVERSITY

TOTAL NUMBER OF TAXA: Total number of taxa from cell **DT**: S7: 15

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

Good	Acceptable	Marginal	Poor	Col. C for S3 / CT	S8
<0.40	0.40-0.59	0.60-0.79	0.80-1.0	31 / 65 =	0.48

SECTION 4 - OVERALL SITE ASSESSMENT RATING

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

Assessment Rating	
Good	4
Acceptable	3
Marginal	2
Poor	1

Assessment	Rating	
Pollution Tolerance In	4	R1
EPT Index	3	R2
EPT To Total Ratio	3	R3
Predominant Taxon R	3	R4

Average Rating
Average of R4, R5, R6, R8
3.25

ner Diversity Index Table for Richards

Common	Column (	pi (C/T)	ln (pi)	pi*ln
Caddisfly	4	0.06	-2.79	-0.
Mayfly Ny	31	0.48	-0.74	-0.
Stonefly N	4	0.06	-2.79	-0.
Cranefly L	5	0.08	-2.56	-0.
Amphipoc	4	0.06	-2.79	-0.
Aquatic W	13	0.20	-1.61	-0.
Leech				
Midge Lar	4	0.06	-2.79	-0.
Water Mite				
Total	65	1.0	-16.07	-1.5
H	0.801			

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name:	Richards Creek	Date:	october 30th 2013
Station Name:	2	Flow statu	

Sampler Used:	Number of replicate	Total area sampled (Hess, Surber = 0.09 m^2) x no. rep	
Hess	3	0.27	m^2

Column A	Column B	Column C		Column D	
Pollution Tolerance	Common Name	Number Counted		Number of Taxa	
Category 1	Caddisfly Larva (EPT)	EPT1	1	EPT4	1
	Mayfly Nymph (EPT)	EPT2	25	EPT5	2
	Stonefly Nymph (EPT)	EPT3	16	EPT6	3
Pollution Intolerant	Dobsonfly (hellgrammite)		6		3
	Gilled Snail				
	Riffle Beetle				
	Water Penny				
Sub-Total		C1	48	D1	9
Category 2	Alderfly Larva				
	Aquatic Beetle				
	Aquatic Sowbug				
Somewhat Pollution Tolerant	Clam, Mussel				
	Cranefly Larva		1		1
	Crayfish				
	Damselfly Larva				
	Dragonfly Larva				
	Fishfly Larva				
	Amphipod (freshwater shrimp)				
	Watersnipe Larva				
Sub-Total		C2	1	D2	1
Category 3	Aquatic Worm (oligochaete)		3		1
	Blackfly Larva				
	Leech				
Pollution Tolerant	Midge Larva (chironomid)		1		1
	Planarian (flatworm)				
	Pouch and Pond Snails				
	True Bug Adult				
	Water Mite		1		1
Sub-Total		C3	5	D3	3
TOTAL		CT	54	DT	13

NVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell **CT**: S1 CT 54

DENSITY: Invertebrate density per total area sampled:

S1 54 ÷ 0.27 m2 = S2 200 / m^2

PREDOMINANT TAXON: S3

Invertebrate group with the highest number counte 25

SECTION 2 - WATER QUALITY ASSESSMENTS

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

Good	Acceptable	Marginal	Poor	3 x D1 + 2 x D2 + D3	S4
>22	17-22	11-16	<11	3 x 3 + 2 x 1 + 3 =	32

EPT INDEX: Total number of EPT taxa.

Good	Acceptable	Marginal	Poor	EPT4 + EPT5 + EPT6	S5
>8	5-8	2-4	0-1	1 + 2 + 3 =	6

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

Good	Acceptable	Marginal	Poor	(EPT1 + EPT2 + EPT3) / CT	S6
0.75-1.0	0.50-0.74	0.25-0.49	<0.25	(1 + 23 + 16 / 54=	0.78

SECTION 3 - DIVERSITY

TOTAL NUMBER OF TAXA: Total number of taxa from cell **DT**: S7 13

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

Good	Acceptable	Marginal	Poor	Col. C for S3 / CT	S8
<0.40	0.40-0.59	0.60-0.79	0.80-1.0	25 / 54 =	0.46

SECTION 4 - OVERALL SITE ASSESSMENT RATING

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

Assessment Rating	
Good	4
Acceptable	3
Marginal	2
Poor	1

Assessment	Rating	
Pollution Tolerance In	4	R1
EPT Index	3	R2
EPT To Total Ratio	4	R3
Predominant Taxon R	3	R4

Average Rating: Average of R4, R5, R6, R8 = 3.5

ner Diversity Index Table for Richards Cr

Common	Column (	pi (C/T)	ln (pi)	pi*ln (pi)
Caddisfly	1	0.02	-3.99	-0.074
Mayfly Ny	25	0.46	-0.77	-0.357
Stonefly N	16	0.30	-1.22	-0.360
Dobsonfly	6	0.11	-2.20	-0.244
Cranefly L	1	0.02	-3.99	-0.074
Aquatic W	3	0.06	-2.89	-0.161
Leech				
Midge Lar	1	0.02	-3.99	-0.074
Water Mit	1	0.02	-3.99	-0.074
Total	54	1.0	-23.03	-1.417
H	0.68			

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name:	Richards Creek	Date:	october 30th 2013
Station Name:	3	Flow statu	

Sampler Used:	Number of replicate	Total area sampled (Hess, Surber = 0.09 m^2) x no. rep	
Hess	3	0.27	m^2

Column A	Column B	Column C		Column D	
Pollution Tolerance	Common Name	Number Counted		Number of Taxa	
Category 1	Caddisfly Larva (EPT)	EPT1	77	EPT4	2
	Mayfly Nymph (EPT)	EPT2	53	EPT5	5
	Stonefly Nymph (EPT)	EPT3	62	EPT6	3
Pollution Intolerant	Dobsonfly (hellgrammite)		6		3
	Gilled Snail				
	Riffle Beetle				
	Water Penny				
Sub-Total		C1	198	D1	13
Category 2	Alderfly Larva				
	Aquatic Beetle				
	Aquatic Sowbug				
Somewhat Pollution Tolerant	Clam, Mussel				
	Cranefly Larva		2		1
	Crayfish				
	Damselfly Larva				
	Dragonfly Larva				
	Fishfly Larva				
	Amphipod (freshwater shrimp)		9		1
	Watersnipe Larva				
Sub-Total		C2	11	D2	2
Category 3	Aquatic Worm (oligochaete)		27		2
	Blackfly Larva				
	Leech		2		1
Pollution Tolerant	Midge Larva (chironomid)		1		1
	Planarian (flatworm)				
	Pouch and Pond Snails				
	True Bug Adult				
	Water Mite		2		1
Sub-Total		C3	32	D3	5
TOTAL		CT	241	DT	20

NVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell **CT**: S1 CT 241

DENSITY: Invertebrate density per total area sampled:

S1 241 ÷ 0.27 m2 = S2 892.5926 / m^2

PREDOMINANT TAXON: S3

Invertebrate group with the highest number counte 77

SECTION 2 - WATER QUALITY ASSESSMENTS

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

Good	Acceptable	Marginal	Poor	3 x D1 + 2 x D2 + D3	S4
>22	17-22	11-16	<11	3 x 13 + 2 x 2 +5 =	48

EPT INDEX: Total number of EPT taxa.

Good	Acceptable	Marginal	Poor	EPT4 + EPT5 + EPT6	S5
>8	5-8	2-4	0-1	2 +5 +3 =	10

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

Good	Acceptable	Marginal	Poor	(EPT1 + EPT2 + EPT3) / CT	S6
0.75-1.0	0.50-0.74	0.25-0.49	<0.25	(77 +53 +62) / 241=	0.80

SECTION 3 - DIVERSITY

TOTAL NUMBER OF TAXA: Total number of taxa from cell **DT**: S7 20

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

Good	Acceptable	Marginal	Poor	Col. C for S3 / CT	S8
<0.40	0.40-0.59	0.60-0.79	0.80-1.0	77 / 241 =	0.32

SECTION 4 - OVERALL SITE ASSESSMENT RATING

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

Assessment Rating	
Good	4
Acceptable	3
Marginal	2
Poor	1

Assessment	Rating	
Pollution Tolerance In	4	R1
EPT Index	4	R2
EPT To Total Ratio	4	R3
Predominant Taxon R	4	R4

Average Rating	
Average of R4, R5, R6, R8	
	4

ner Diversity Index Table for Richards Cr

Common	Column (	pi (C/T)	ln (pi)	pi*ln (pi)
Caddisfly	77	0.32	-1.14	-0.365
Mayfly Ny	53	0.22	-1.51	-0.333
Stonefly N	62	0.26	-1.36	-0.349
Cranefly L	2	0.01	-4.79	-0.040
Amphipoc	9	0.04	-3.29	-0.123
Aquatic W	27	0.11	-2.19	-0.245
Leech	2	0.01	-4.79	-0.040
Midge Lar	1	0.00	-5.48	-0.023
Water Mit	2	0.01	-4.79	-0.040
Total	235	1.0	-29.35	-1.5570
H	0.71			