Departure Creek

Environmental Monitoring Project Final Report

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Executive Summary

This project involves the environmental monitoring of Departure Creek in Nanaimo B.C during Fall 2012. The project was performed by three students enrolled in the RMOT 306 "Environmental Monitoring" course at Vancouver Island University. The data collected from this assessment will be added to the information collected from previous monitoring of this watershed in order to gain a comprehensive view of the creek's health and to observe any changes over time. We sampled four sites located along an approximately 1700-metre stretch upstream from where Departure Creek empties into Departure Bay. We performed two separate sampling events: the first sample was taken to represent low flow conditions on October 31st, 2012 and the second sample was taken to represent high flow on November 21st, 2012. Departure Creek was determined to have variable flow depending on the site location and the timing of the sampling event; this is due to the significant gradient increase from the outflow to the uppermost sampling site. Increased rainfall also significantly increased the water depth with an increased depth at almost all sites during the second event. We tested several parameters including; water quality, hydrology, microbiology and invertebrate sampling. During both sampling events water quality samples were taken at each of the four sites. Some of these samples were analyzed in the lab to determine the levels of nitrate, phosphate, turbidity, hardness, and alkalinity at each site. Other samples were sent off to the ALS laboratory to determine the levels of metals, nutrients and general parameters. The ALS results were also used to compare nutrient levels with those determined in the lab. Excluding some of our nitrogen and phosphate results the ALS results closely mirrored the results we determined in the lab. The ALS results did show that while the majority of the metals and nutrients found in

the stream either met the guidelines for aquatic life or scored below the detectable limit, the Aluminum levels were consistently above the guidelines in sites 2 and 3 as well Iron levels were consistently higher than the guidelines in site 3. Some water quality parameters were determined in the field; PH, Dissolved Oxygen, conductivity and temperate were measured directly at each of the sampling using a YSI meter model 555.

During the first sampling event we obtained invertebrate samples on the first three of the four sites using a Hess sampler. We found that enough invertebrates were present for the creek to be in the marginal to acceptable range, with the healthiest site being site three which is inside the Woodstream Park. During the first sampling event we also collected a water sample in a sterile Whirl-Pak bag that we used to conduct coliform plate tests. These tests showed that there were high levels of fecal coliforms in each of the three tested sites which are expected due to the high concentration of deer and other residential pets in the area. Using all of these parameters we were able to determine that at this time this area of the Creek is generally healthy with parameters within the guidelines to support aquatic life including the Coho (Oncorhynchus kisutch) and Pink salmon (*Oncorhynchus gorbuscha*) that use the Creek for spawning.

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1. Introduction

1.1 Project Overview

This report is an assessment of the current state of Departure Creek in Nanaimo, BC, based on water quality, hydrology, microbiology and invertebrate sampling. The area of Departure Creek that we monitored is a 1700-m stretch upstream from where the creek empties into Departure Bay. This Project was performed by three VIU students enrolled in the environmental monitoring class in the Resource Management Officer Technology program. The sampling process occurred during two separate sampling events. The first was on October 31st 2012, which represented low flow, and the second was on November 21st, which represented high flow. During both sampling events hydrology and water quality were measured at all four of our sampling sites. During the first event Invertebrate and microbiology samples were taken at three of the four sample sites. The results from this project will be added to the results collected from previous years.

1.2 Historical Overview

Departure Bay Creek is a small creek that runs through Country Club and the Departure Bay residential neighborhoods of Nanaimo and drains into Departure Bay. Departure Creek originates as two small creeks: Keighly Creek, which begins at Nanaimo Golf and Country Club, and Joseph Creek, which begins in a residential part of the Country Club neighborhood. The area surrounding Departure Creek has historically been used as a single-family residential neighborhood. The creek drains an area of approximately three square kilometers through the City of Nanaimo. The creek's location and tributaries are shown in Figure 1 below.

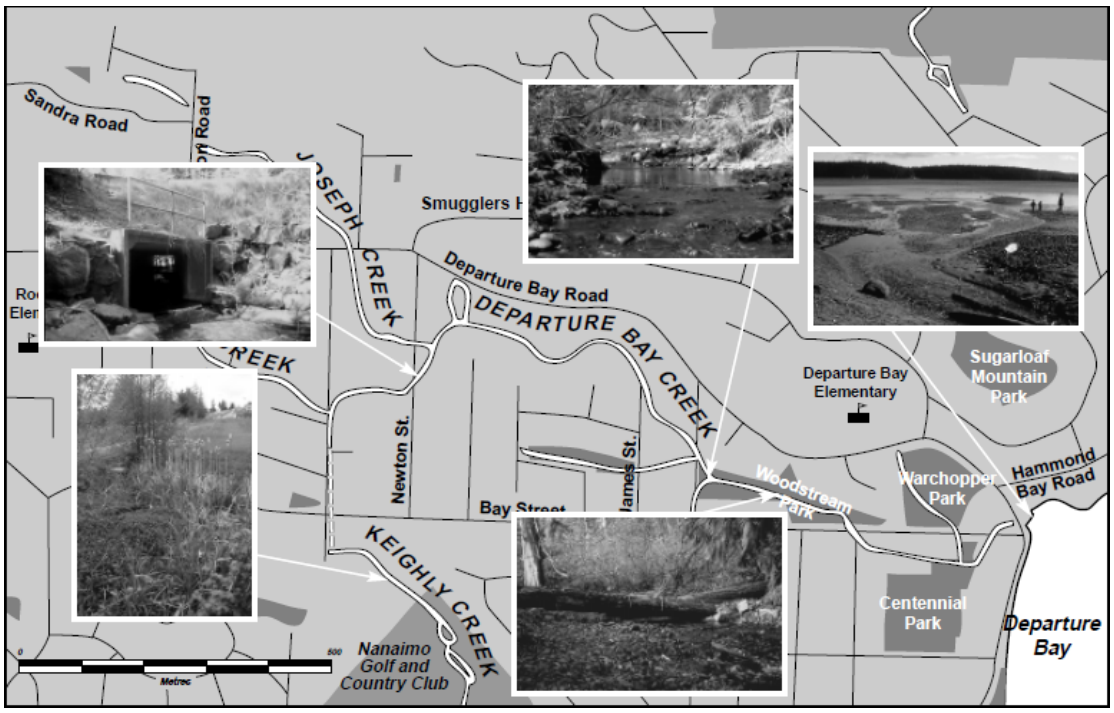


Figure 1. Map of Departure Creek showing its location and main tributaries (City of Nanaimo, 1998).

1.3 Potential Environmental Issues

We found several environmental concerns while performing our monitoring that could impact the creek's health. The fact that the creek runs through a dense residential area led to a number of concerns regarding possible contaminations including fertilizer and pesticide runoff from gardens, oil and gas contamination from car washing and driveways as well as from the roads and the nearby gas station. There was also the danger of litter and other garbage entering the stream from the residences or from hikers moving through Woodstream Park. There were other possible issues in the area such as fecal contamination from dogs and deer, improper disposal of chemicals into storm drains, erosion (increased runoff from paved surfaces), and silt covering area used for salmon spawning. The fact that the stream begins near a golf course could also be a point source that increased concern for fertilizer, pesticide and garbage contamination.

2. Project Objectives

To monitor and evaluate water and habitat quality of Departure Creek in Nanaimo BC, as part of a continuous environmental monitoring program. This Creek is known to be local habitat for salmon species including Pink *(Oncorhynchus gorbuscha)* and (*Oncorhynchus kisutch*) Coho. This process of water quality testing and bio-monitoring will hopefully contribute to maintaining the wildlife habitat of the Creek.

3. Methods

3.1 Sampling Stations

This study focused on 4 stations along an approximately 1700-metre stretch of Departure Creek upstream from where the creek empties into Departure Bay. Sites were numbered from 1 (furthest upstream) to 4 (closest to the ocean) in accordance with the numbering system used in previous years. A map showing the approximate location of the sites is shown in Figure 2. Site 1 was located immediately upstream from Neyland Road. Its substrate consisted of small cobblestones and sandy areas, and there was 50% canopy coverage of the stream by deciduous trees, grass and blackberries. Site 2 was located immediately downstream of Newton Street. Its substrate consisted of medium sized boulders, large cobblestones and small sandy areas. There was 100% canopy cover consisting of mixed tree species including Douglas fir (*Pseudotsuga menziesii*), Yellow Cedar (*Thuja occidentalis*), Red Alder (*Alnus rubra)* and many types of ferns and other plants. Site 3 was located inside Woodstream Park and its substrate consisted of small and medium sized gravel, with around 100% canopy coverage consisting of a variety of deciduous trees including Birch (*Betula nigra*)*,* Red Alder (*Alnus rubra*), and Big Leaf Maple (*Acer macrophyllum*) with the forest floor being covered in a variety of different fern species. Site 4 was the furthest downstream of the sites and was located immediately upstream of Departure Bay Road. The creek bed substrate consisted of small boulders and cobble with no canopy cover; however, the banks of the Creek were covered in small alder (*Alnus rubra*), blackberries *(Rubus ursinus*) and tall grass. All sites were located close to residential areas with sites 1, 2 and 4 being located immediately beside roads. The sampling locations were recorded using GPS coordinates in order to keep the sampling sites consistent for next year (Table 1).

Each site was tested for general water quality during both sampling events by both VIU and ALS, and for metal contamination and nutrient levels by ALS alone. Microbial and invertebrate sampling was performed at Sites 1, 2 and 3 during the first sampling event.

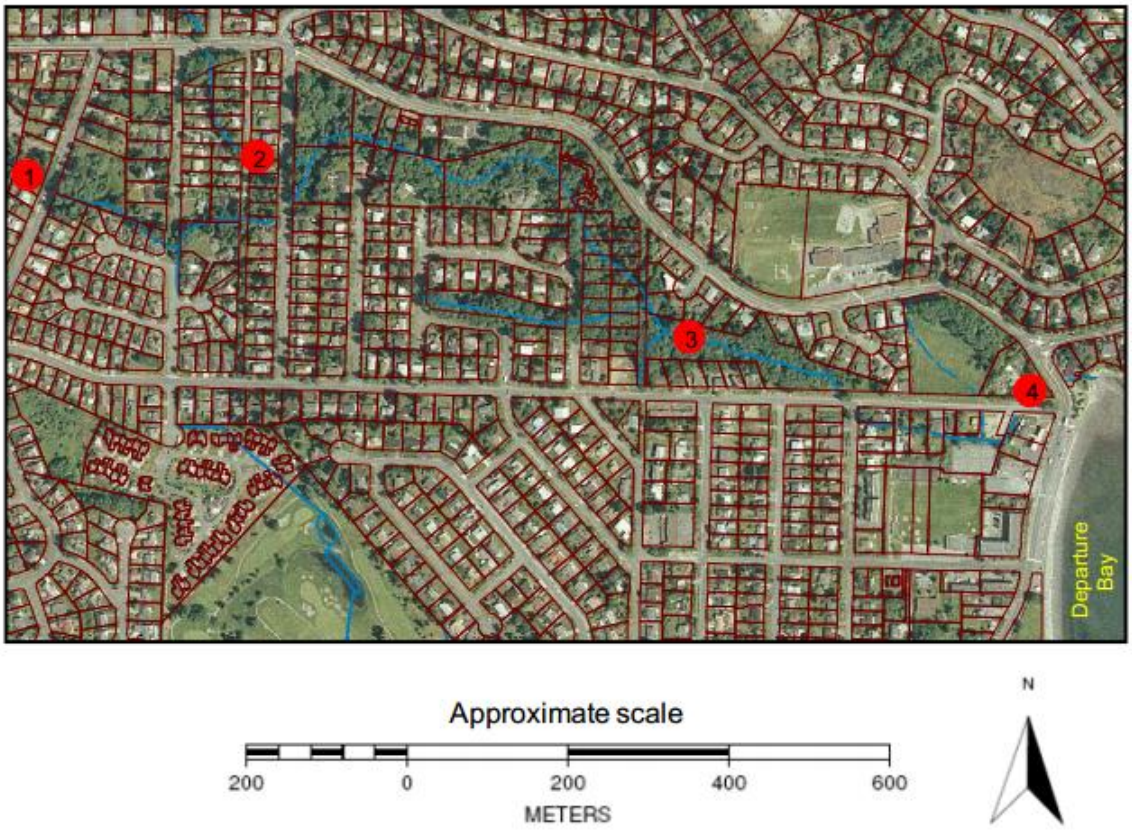


Figure 2. Site map of Departure Creek in Nanaimo BC, showing the four sampling locations (Demers, 2007). Note that our Site 2 was located on the opposite side of the street.

Table 1. UTM Coordinates of Sampling Sites

	Zone	Easting	Northing
Site 1	10	428050	5451104
Site 2	10	428388	5451081
Site 3	10	428911	5450913
Site 4	10	429313	5450826

3.2 Basic Hydrology

Each site was monitored during each sampling event to determine flow rate, average depth, and discharge. The flow was determined by measuring a five-metre section of the Creek with a measuring tape and then determining the amount of time needed for a ping pong ball to travel this distance. We repeated this test three times to obtain an average velocity. The depth of the stream was measured with a meter stick at three evenly spaced points along the width of the stream. The cross-sectional area and discharge were then calculated.

3.3 Water Quality, Field measurements

Water Quality analysis occurred during both sampling events on October 31st and November 21st. The values for Conductivity, Hardness, pH, and Dissolved Oxygen were determined directly in the field using a MPS 555 YSI meter. The YSI meter was placed into the running water and held there until a constant value was determined. Although hardness and conductivity are able to be measured in a lab setting, we decided to measure these parameters in the field in order to improve the quality control of the measurements. Table 2 summarizes the methods used in collecting the various types of water quality parameters.

Table 2. Water Quality Tests performed on Departure Creek

Parameter	**Method**
Stream flow	Collected in field using float method
Stream discharge	
Water temperature	Collected in field using YSI probe
Dissolved oxygen	
Conductivity	
pH	
Turbidity	Water samples collected in VIU bottles; analyzed in VIU lab
Alkalinity	
Hardness	
Nitrate	
Phosphate	
General water quality parameters	Water samples collected in ALS bottles; shipped by courier to ALS lab in Vancouver
Nutrient analyses	
Total metal scan	

3.4 Water Quality, VIU Laboratory Analysis

Several parameters of water quality from both sampling events were measured in the lab at Vancouver Island University including nitrate, phosphate, hardness, alkalinity, and turbidity. We used several HACH kits and a spectrophotometer to obtain the results. Nitrate and Phosphate were measured using a HACH spectrometer 2800, hardness was measured using the HACH kit HA-71A, Alkalinity was determined using a HACH digital Titrator, and turbidity was measured with a HACH 2100P Turbidimeter. A variety of quality assurance measures were used while collecting the samples including wearing gloves, working downstream to upstream, rinsing bottles three times prior to collecting the samples, and performing the lab analysis as soon as possible. Lab analysis was done the day after the first sampling event and within 24 hours of the

second sampling event. We also used a field blank and a replicate sample at Site 1 to improve quality control.

3.5 ALS Laboratory Water Analysis

During each sampling event, three water samples from each of sites 1, 2 and 3 were collected and sent to ALS laboratories for analysis. A general water parameter sample was collected in a sterile 1 L white plastic container with no preservative. A total metals sample was collected in a 250 mL white plastic acid-washed container and preserved with nitric acid. Finally, a nutrient sample was collected in a 250 mL amber glass container and preserved with sulphuric acid. Quality assurance was maintained by pre-labeling containers prior to sampling, maintaining a chain of custody form, and placing preservatives in the sample bottles immediately after collection. Quality control was provided by sending the samples to an accredited lab.

3.6 Water Quality Data Analysis, Comparison to Guidelines

Both the results from the water quality samples analysed in the VIU lab and the samples sent to ALS laboratories were compared to the provincial guidelines for aquatic life. The water quality results from the VIU laboratory were also compared with the results compiled by the ALS laboratories to identify any significant discrepancies between the two sets of results. This year's results were also compared with last year's findings in order to see how Departure Creek may have changed over the year (See Appendix 5).

3.7 Coliform plate test

During the first sampling event on October 31, we took samples from sites 1, 2 and 3 to determine the microbial aspect of the creek using sterile 100 mL Whirk-Pak bags and performing a coliform plate test at the VIU laboratory. The plate test was performed using the m-ColiBlue 24 membrane filtration method (Millipore Corporation). Before testing the sample we performed a filtration blank by passing 50ml of distilled water through a 47-µm membrane filter, marked with 3-mm gridlines, using a vacuum pump. The membrane filter was then transferred to a m-ColiBlue24 saturated absorbent pad inside a sterile petri dish. This process was repeated with each of our three samples with the vacuum pump being washed with distilled water three times between each use. The petri dishes were then incubated at 37^{o}C for 24 hours. The Colony Forming Units (CFUs) were counted within 24hrs after being removed from incubation. They were viewed using a dissecting microscope at 16X magnification.

3.8 Stream Invertebrates

During the first sampling event on October 31st we took invertebrate samples from site numbers 1, 2 and 3 using a Hess sampler. The invertebrates collected were preserved with a 70% alcohol solution. The invertebrate samples were then taken to the VIU laboratory where they were counted and analysed. The analysis of each site determined the predominant taxon, pollution tolerance index, EPT index, and the total number of taxa. These factors were then used to assess the overall health of that site.

Based on these results we found that site 1 and 2 were very similar and near the marginal to acceptable range for both the EPT index and the overall site assessment. This pattern changed

in site 3 when the Shannon-Weiner Diversity Index increased. Also, in site 3 the overall site assessment and the EPT index increased into the acceptable range. This is expected due to the fact that site 3 is located inside a park and is therefore more protected and isolated from possible contamination. In order to maintain quality control and assurance three samples from slightly different areas of the stream bed were taken in order to compensate for variation in substrate composition and water flow rates. One sample from each site was analysed by each member of the group in order to remove any biased analysis or mistakes from one person.

4. Results and Discussions

4.1 Water Quality:

The first sampling event took place on October 31, 2012. This was supposed to be our low water sampling event, but due to unusually high precipitation levels prior and during this time it actually looks more like our high water event. The weather conditions on sampling day one were overcast with moderate to heavy rainfall, strong winds from the southeast and an ambient temperature of 7°C. The second sampling took place on November 21, 2012. This was supposed to represent the high water sampling event. The weather was partially cloudy with sunny breaks and a slight breeze and the ambient temperature was 8°C. Field measurements that were taken on site included dissolved oxygen, pH and water temperature with some similarities noticed between the sampling events.

The dissolved oxygen results from sample 1 showed some variance with a low of 9.33mg/L at site 1 and a high of 9.8mg/L at site 3. During sample 2, dissolved oxygen had a low of 9.5mg/L at site 1 and a high of 9.88mg/L at site 3. These results were the same as in event number 1 with site 3 being the high and site 1 being the low. The pH showed little variance between sites during the first sample event with site 1 having the low of 7.94 and site 3 having the high of 8.04. For the second sample event pH levels were at their lowest at site 4 with a reading of 7.58 and their greatest at site 2 with a reading of 8.07. This differs from the first sampling event where site 1 had the lowest levels and site 3 had the highest readings.

Temperature varied by less than 0.3°C at sample 1 with the low coming from site 4 measured at 11.3°C and the high of 11.58°C coming from site 1. Temperatures during the second sampling event was its lowest at site 4 at 8.86°C and highest at site #1 reading 9.76°C, these were the

same results as sample 1 with the lowest temperature coming from site 4 and the highest coming from site 1. Temperature levels were expected to decrease from sample 1 to sample 2 due to colder ambient air temperatures and they did so. It should be noted that D.O. readings at both events gave ranges that are within the Ministry of Environment guidelines of 9.0mg/L with the exception of the lowest reading during the second sample event which was 8.86mg/L. The pH was well within the MOE guidelines of 6.5-9.0 and temperature at both events were also within the Ministry of Environment guideline criteria.

4.2 VIU Lab Analyses

Other water quality parameters were measured in the lab at VIU and they consisted of conductivity, turbidity, alkalinity, hardness, phosphates and nitrates (see Tables 3 and 4 for results). Conductivity was consistent in both sampling events in that site 2 had the greatest measurements, then site 3, site 4 and site 1 having the smallest measurements of $\mu S/cm^3$. The greatest turbidity came from sample 1 which showed NTU levels being higher at every test site than that of sample 2. This could be due in part to the large amount of rainfall that occurred during this sample time and was washing materials into the water and giving higher than normal readings.

All Alkalinity site measurements for both sample events read greater than 20mg/L. This is the opposite of coastal BC lakes/streams which measures less than 20mg/L meaning Departure Creek has a high alkaline water body that is not as susceptible to acidification as most coastal BC lakes and streams. The water hardness in Departure Creek measures closest to a soft water level of less than 60mg/L. Sample 1 had an average measurement of 47mg/L which is well

below the soft water parameters while sample 2's average measurements were 69mg/L just above the soft water limits but well below the hard water parameter of 120mg/L.

Phosphate results were conflicting substantially with that of ALS results and the field blank did indicate some kind of cross contamination in sample 2. Sample 1 results seemed to be correct and all measured with in low-range testing of the HACH Spectrophotometers, but sample 2 had to all be measured using the high range test of the HACH kit with the exception of site 3. It should be noticed that both ALS and VIU lab results still indicated a eutrophic water system. For nitrates our results and those from ALS also conflicted, in sample 1 our replicate indicated that all parameters were reliable except nitrate, but then the field blank did not indicate any contamination. During sample 2, site 1 replicates indicate that all parameters were reliable except nitrate and the field blank indicated phosphate contamination. Even with possible contamination of phosphate or nitrate in the samples both ALS and VIU lab results indicate a eutrophic water system.

Table 3. Water Quality Results From Sample Event #1 Taken From Departure Creek (October 31, 2012) and Performed at VIU.

Site	Site #1	Site #1 Replicate	Site #2	Site #3	Site #4	Blank
Alkalinity(mg/L)	73	62	127	106	94	9
Hardness(mg/L)	43	43	55	45	44	<MDL
Turbidity (NTU)	1.78	1.71	2.09	4.05	3.59	0.19
Nitrate(mg/L)	2.13	0.75	0.26	1.89	over	0.05
Phosphate(mg/L)	0.07	0.07	0.08	0.08	0.01	0.02
Conductivity(µs/cm³)	133	133	203	164	159	5
DO(mg/L)	9.33	9.33	9.66	9.8	9.77	7.3
pH	7.94	7.94	8.22	8.04	7.61	7.15
Temperature(c°)	11.58	11.58	11.39	11.34	11.30	/

Table 4. Water Quality Results From Sample Event #2 Taken From Departure Creek (November 21, 2012) and Performed at VIU.

Site	Site #1	Site #1 Replicate	Site #2	Site #3	Site #4	Blank
Alkalinity(mg/L)	26.8	29.6	55.6	50.8	53.2	1.6
Hardness(mg/L)	48	47	77	76	74	<MDL
Turbidity (NTU)	0.98	1.02	1.59	1.23	2.43	0.25
Nitrate(mg/L)	68	32	68	56	61	18
Phosphate(mg/L)	2.04	10.7	16.1	0.43	2.17	23.5
Conductivity(µs/cm³)	148	148	221	211	207	/
DO(mg/L)	9.5	9.5	9.76	9.88	9.6	/
pH	7.62	7.62	8.07	7.64	7.58	/
Temperature(c°)	9.76	9.74	9.44	9.88	8.86	/

4.3 Hydrological Measurements

As previously mentioned, our first sampling event on Oct. 31 was supposed to be the low flow sample event, but due to heavy rainfall before and during the event flow rates were faster in 3 of the four test sites during the low flow sample than the high flow sample performed on Nov 21. It was only site 1 that had a more decreased rate of 0.86m/sec during the low flow event compared to the high flow event at site 1 with an increased rate of 0.98m/sec. This could be because sites 2, 3 and 4 are more downstream and received more water from terrestrial run-off and other sources of input therefore increasing flow as water amounts accumulated (see Figures 3, 4, 5 & 6).

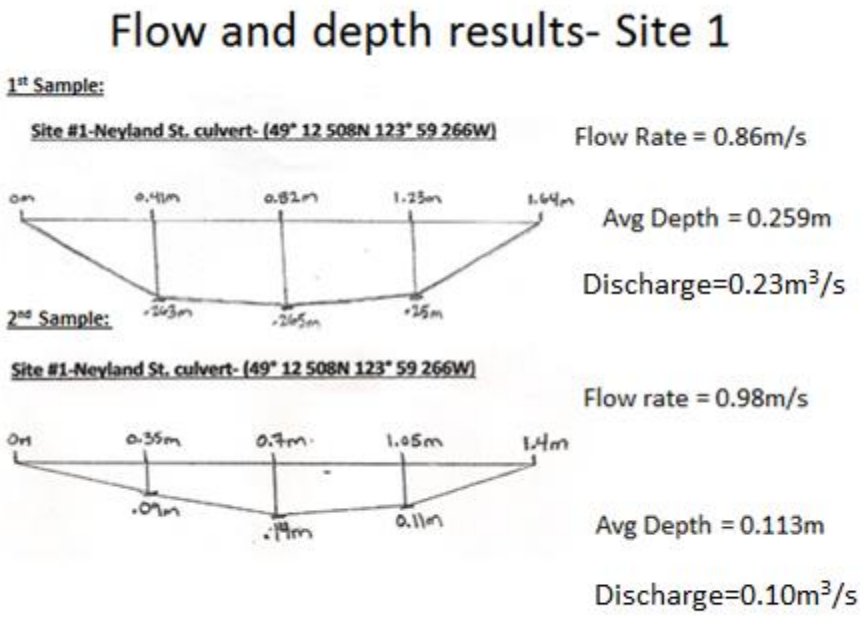


Figure 3. Flow and Depth Results of Departure Cr. From Site #1 of the 1st Sample Event (Oct. 31, 2012) and the 2nd Sample Event (Nov. 21, 2012).

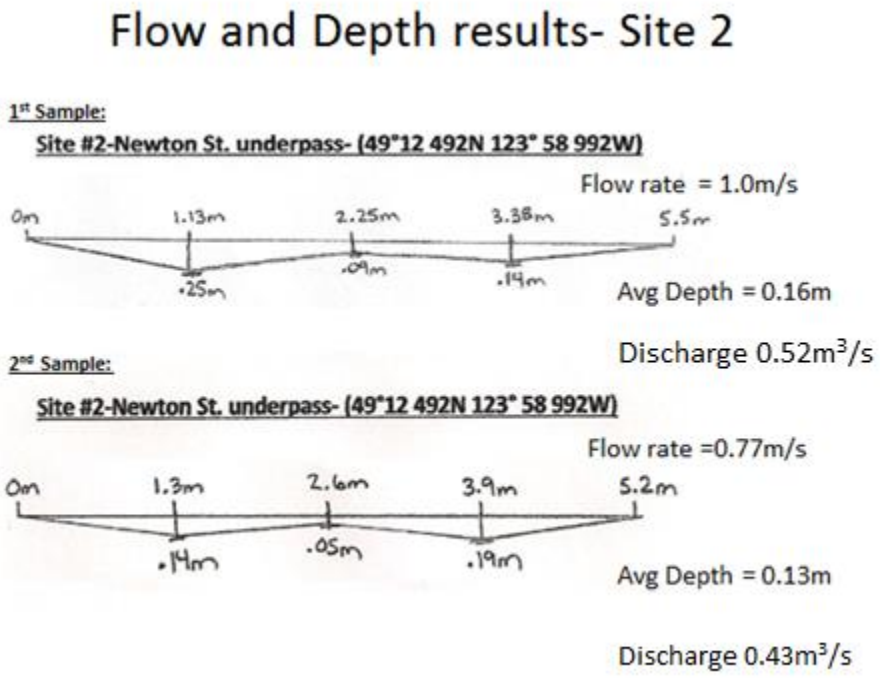


Figure 4. Flow and Depth Results of Departure Cr. From Site #2 of the 1st Sample Event (Oct. 31, 2012) and the 2nd Sample Event (Nov. 21, 2012).

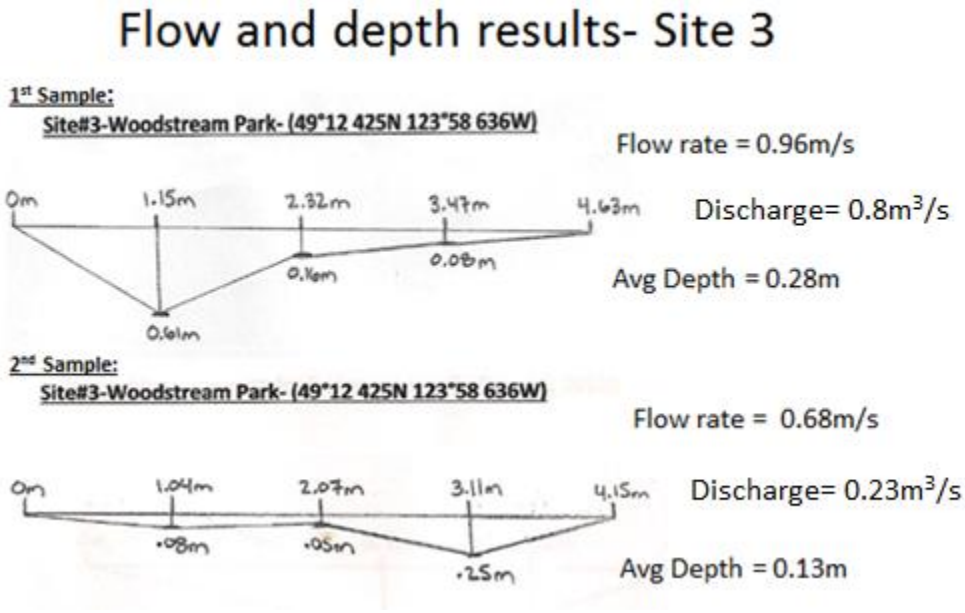


Figure 5. Flow and Depth Results of Departure Cr. From Site #3 of the 1st Sample Event (Oct. 31, 2012) and the 2nd Sample Event (Nov. 21, 2012).

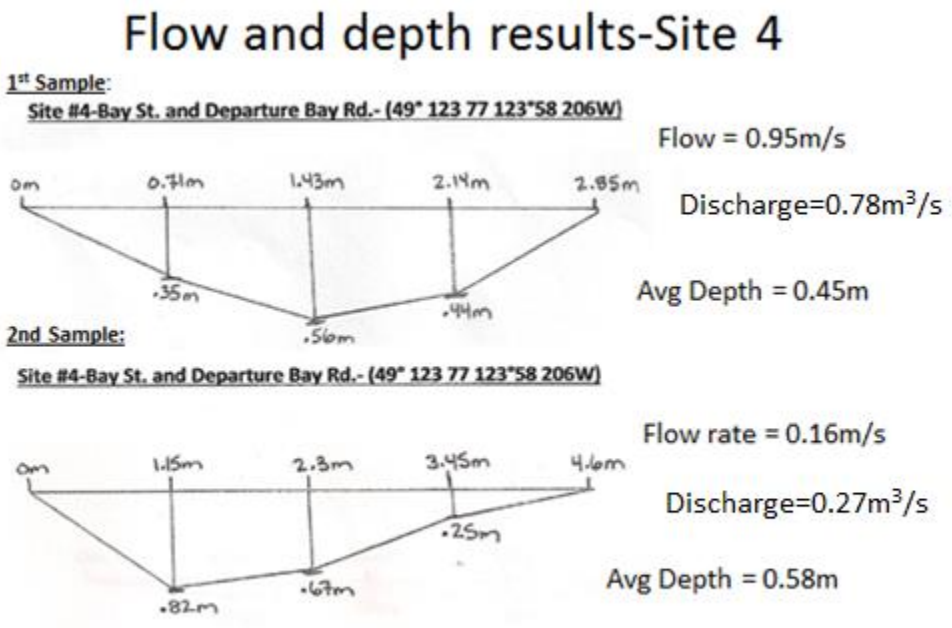


Figure 6. Flow and Depth Results of Departure Cr. From Site #4 of the 1st Sample Event (Oct. 31, 2012) and the 2nd Sample Event (Nov. 21, 2012).

A microbiology analysis was also performed at the VIU lab on water samples taken from the first three sites on the 1st sampling event of Oct. 31 only (see Figure 7). Results concluded that fecal coliforms were high in Departure Creek and this could be due to a large, local population of deer and many household pets from surrounding residences excreting around the creek, and the large amount of rainfall carrying it into the water system.

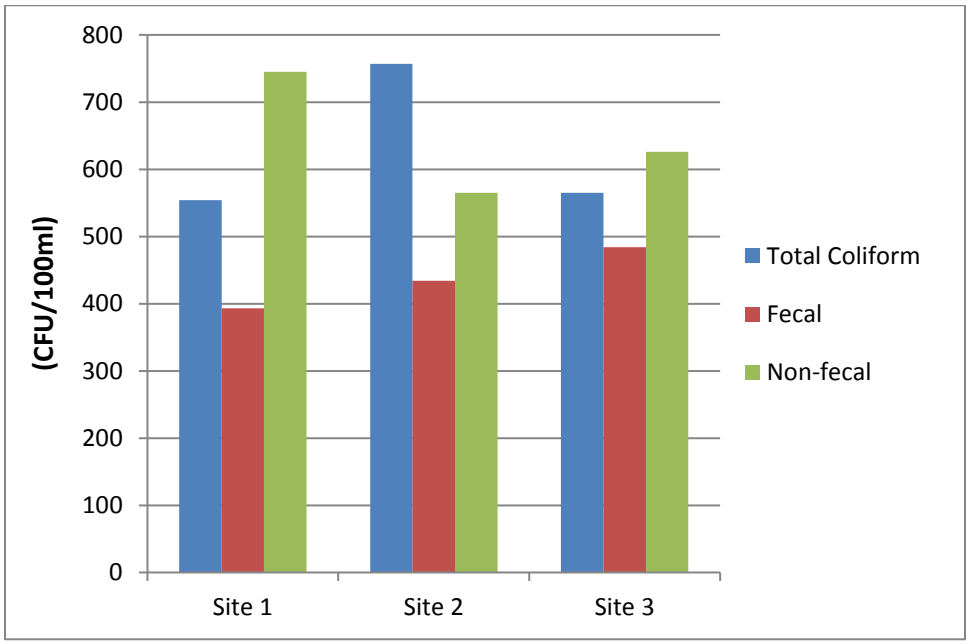


Figure 7. Coliform Levels Detected during Microbiology Analyses of Departure Cr. (October 31, 2012) performed at VIU

4.4 ALS Analyses:

Samples for the ALS Labs were collected on the first event on October 31, 2012 and also on the second event on November 21, 2012. Samples collected from both events were taken from sites 1, 2 and 3. A lot of the metals we sampled for either had no provincial water quality guidelines or have guidelines for amounts that were too small for ALS to detect.

For both of the sampling events the provincial guidelines were met for Barium, Beryllium, Boron, Cobalt, Lithium, Manganese, Molybdenum and zinc. Provincial guidelines were exceeded for Aluminum at sites 2 and 3 during both sampling events as well as Iron at site 3 during the first sampling event. Aluminum amounts exceeding the guidelines can cause embryo deformation in fish, particularly at low pH which was not present in the sample sites. Aluminum is a common natural metal, with surface water values ranging from 0.012 to 2.25 mg/L (Health Canada, 1998). The total iron concentration of 1.05 mg/L at Site 3 is slightly above the guideline of 1.0 mg/L. It has been noted that high iron concentrations can change aquatic communities, causing sensitive species to be replaced by more tolerant species (See Appendix 4).

4.5 Quality Assurance/Quality Control

Quality Assurance is the planning of systematic activities that are implemented by us in a test so that quality requirements for that test will be fulfilled; some of those activities are as follows:

- Wear protective gloves
- Rinsing of all VIU sample bottles a minimum of 3 times
- Worked downstream to upstream
- DO, pH, Conductivity and Temperature tested directly in the field
- Maintained a chain of custody for ALS Laboratories
- Pre-labeled all containers prior to field sampling
- Water quality parameters were determined the same day (event 1) or the next day (event 2)
- Invertebrate samples immediately preserved with alcohol

Quality Control is the observation techniques and activities used to fulfill requirements for quality and they consisted of:

- Having field blanks
- Water quality replicates for site #1
- Filtration blank for coliform count
- 3 replicate invertebrate samples were taken from each site
- 1 invertebrate sample from each site was processed by each group member
- Water quality and nutrient samples were sent to ALS Labs for a comparison to our field and lab results

4.6 Stream Invertebrate Communities

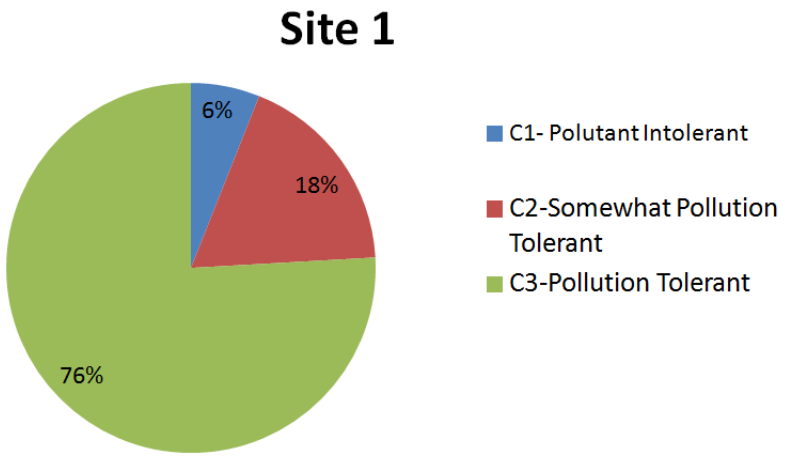
Invertebrates were sampled only during the first sampling event on October 31, and only at sites 1, 2 and 3. Results of the sampling indicated that stream health improved as it travelled away or downstream from the Nanaimo golf and Country Club from which it originated (see table 5).

Table 5. Overall Site Assessment and EPT Index from Invertebrate Sampling of Departure Creek Performed on October 31, 2012 According to the Stream Keeper's Guide

	Overall Site Assessment	EPT Index
Site #1	2.5- (marginal to acceptable)	3-(marginal)
Site #2	2.25-(just above marginal)	3-(marginal)
Site #3	3.25-(just above acceptable)	6-(acceptable)

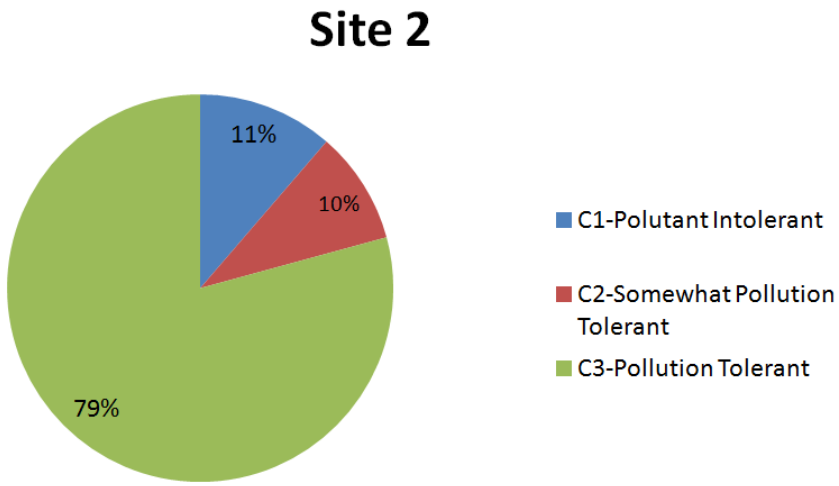
The ratio of pollution tolerant and intolerant invertebrates is compared at all three sampling sites in Figures 8-10.

The density of pollution tolerant and intolerant invertebrates is compared at all three sampling sites, and again it should be noticed how the density of pollution tolerant species decreases significantly from upstream site 1 to downstream site 3 (Figures 8-10).



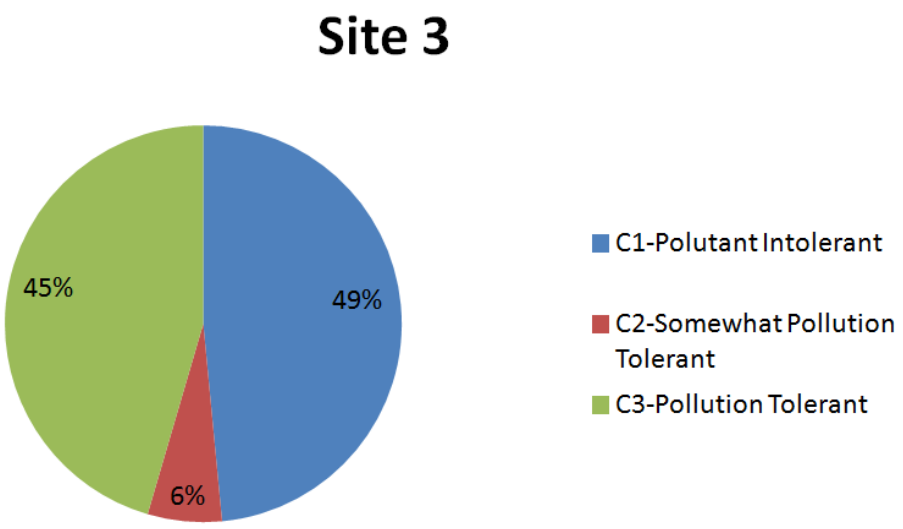
Overall Site Assessment: 2.5 (marginal to acceptable)
EPT index: 3 (marginal)
Shannon-Weiner Diversity Index: 0.567

Figure 8. Invertebrate pollution tolerant categories of taxa according to the stream keeper's guide of invertebrates sampled at site #1 on Oct. 31, 2012 on Departure Creek.



Overall Site Assessment: 2.25 (just above marginal)
EPT index: 3 (marginal)
Shannon-Weiner Diversity Index: 0.583

Figure 9. Invertebrate pollution tolerant categories of taxa according to the stream keeper's guide of invertebrates sampled at site #2 on Oct. 31, 2012 on Departure Creek.



Overall Site Assessment: 3.25 (just above acceptable)
EPT index: 6 (acceptable)
Shannon-Weiner Diversity Index: 0.651

Figure 10. Invertebrate pollution tolerant categories of taxa according to the stream keeper's guide of invertebrates sampled at site #3 on Oct. 31, 2012 on Departure Creek

4.7 Taxon Richness and Diversity:

As previously mentioned stream health appeared to improve downstream this was confirmed when we sampled for invertebrates. This again is supported by the overall richness of taxon and the diversity of pollution indicator species of invertebrates found at each sample site. Our first site had 63 pollution tolerant individuals coming from 10 different taxon (see Table 6), Site 2 then had 42 pollution tolerant individuals coming from 9 different taxon and finally Site 3 only had 15 pollution tolerant individuals coming from 5 different taxon (see Table 7). It was in site 3 as well where for the first time there were a larger number of pollution intolerant individuals then pollution tolerant individuals. The Shannon-Weiner Diversity Index also indicates that site #3 had the highest diversity when compared with sites 1 and 2. (See appendix 3)

5. Conclusions and Recommendations

Departure Creek is generally healthy for an urban stream. Physical parameters such as temperature, pH and dissolved oxygen are suitable for all stages of salmon life. Higher-than-expected alkalinity and calcium values indicate that the creek is resistant to acidification, which is a positive sign for the survival of salmon eggs and young. Metal analysis indicated that iron levels slightly exceeded the guideline at site 3 during the first sampling event and that aluminum levels slightly exceeded the guidelines in site 2 and 3 during both sampling events. Invertebrate sampling revealed the creek to be in the marginal to acceptable range habitat for aquatic life. The invertebrate community became more diverse and sensitive further downstream. High levels of both fecal and total coliforms were found at all three sites tested, indicating fecal contamination by mammals. All sites experienced high nutrient levels particularly nitrate and phosphate during both sampling events.

Our recommendations include two main goals: educating residents and improving the monitoring program. During sampling, we observed litter and dog waste near the stream. Last year's report recommended installing more garbage cans on the trails, but this does not appear to have happened yet (Koch, Lattanzi and Gordon, 2011). Residents need to be more aware of how chemicals from lawns and storm drains wash into the watershed and affect the salmon and other species. The RMOT student sampling reports are an excellent source of information about Departure Creek, but they only cover a specific period from late October to November. Sampling is needed at different times of the year to determine seasonal trends in water quality. Additional research is needed on nutrient runoff from the

golf course. Demers and Wright (2007) found that the golf course runoff contains at least ten times as much ammonia and phosphorus as the other sampling sites. None of the student projects have sampled this runoff.

6. References

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Appendix 1: Sampling Site Photos

Site 1: Upstream of Neyland Road

View looking upstream at Site 1; October 18, 2012.

View from the right-hand bank when looking upstream November 21, 2012.

Site 2: Downstream of Newton Street

Looking downstream at Site 2; October 18, 2012.

View from right-hand bank when looking downstream November 21, 2012.

Site 3: Woodstream Park Bridge

View looking downstream at Site 3; October 18, 2012.

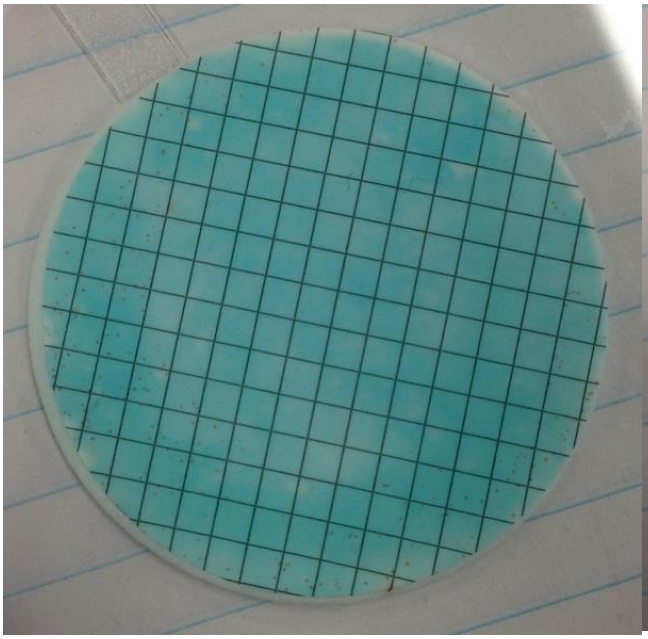
View from opposite bank; November 21, 2012. Note the large logs that have appeared in the stream during the past month.

Site 4: Departure Bay Road

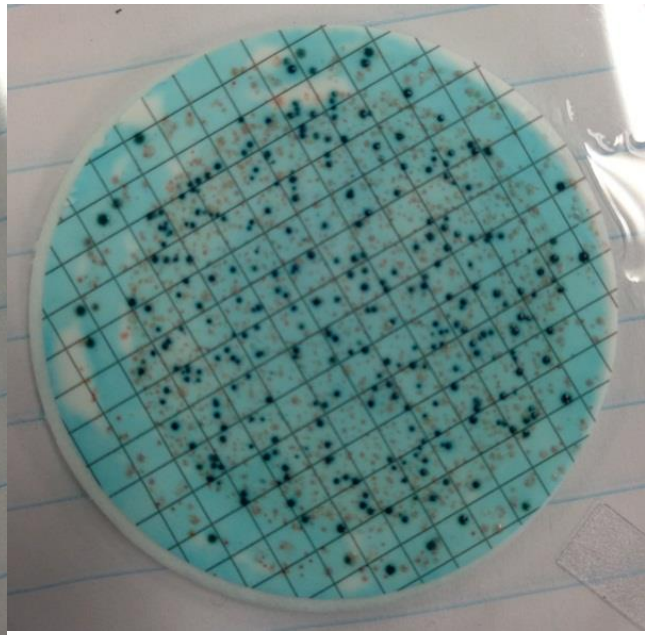
View looking downstream from the culvert on Bay St. (near the corner of Bay St. and Departure Bay Rd.); October 18, 2012.

Downstream view from same location showing marker pole; November 21, 2012.

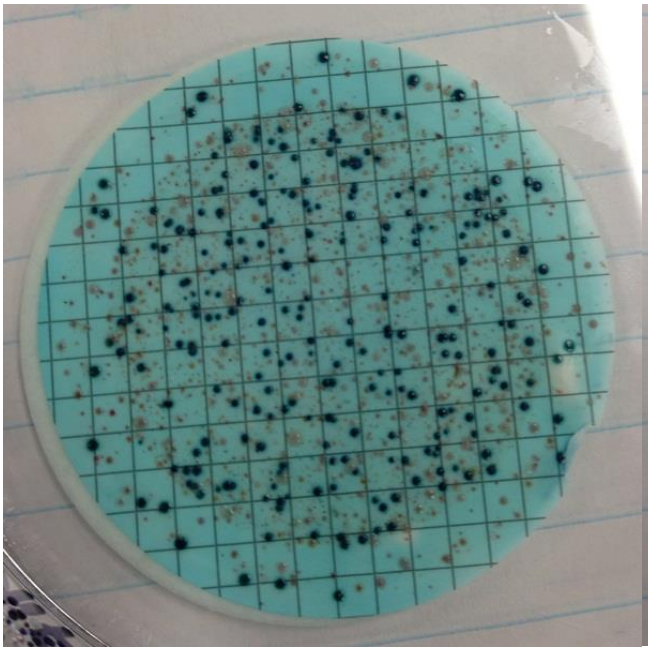
Appendix 2: Coliform Plate Photos



Filtration Blank



Site 1 Coliform Plate (50 mL filtered)



Site 2 Coliform Plate (50 mL filtered)

Site 3 Coliform Plate (50 mL filtered)

Appendix 3: Detailed Invertebrate Results

Table 6. Invertebrate results for Site 1. Triplicate samples were taken with a Hess Sampler on October 31, 2012. Total area sampled was 0.27 m^2.

Pollution Tolerance	Common Name	Number Counted	Number of Taxa
Category 1 Pollution Intolerant	Caddisfly Larva (EPT)	1	1
	Mayfly Nymph (EPT)	1	1
	Stonefly Nymph (EPT)	3	1
Subtotal		**5**	**3**
Category 2 Somewhat Pollution Tolerant	Aquatic Sowbug	3	1
	Cranefly Larva	3	1
	Damselfly Larva	2	1
	Amphipod (freshwater shrimp)	7	1
Subtotal		**15**	**4**
Category 3 Pollution Tolerant	Aquatic Worm (oligochaete)	50	5
	Blackfly Larva	2	1
	Midge Larva (chironomid)	2	1
	Planarian (flatworm)	3	1
	Pouch and Pond Snails	4	1
	Water Mite	2	1
Subtotal		**63**	**10**
TOTAL		**83**	**17**

Table 7. Interpretation and Rating of Invertebrate Data from Site 1.

Section 1: Abundance / Density	**Result**
Abundance	83
Density	307.4/m2
Predominant Taxon	Aquatic Worm (oligochaete)
Section 2: Water Quality	
Pollution Tolerance Index	27 (Good)
EPT Index	3 (Marginal)
EPT to Total Ratio Index	0.06 (Poor)
Section 3: Diversity	
Total Number of Taxa	17
Predominant Taxon Ratio Index	0.6 (Marginal)
Section 4: Overall	
Site Assessment Rating	2.5 (Marginal to Acceptable)

Table 8. Invertebrate results for Site 2. Triplicate samples were taken with a Hess Sampler on October 31, 2012. Total area sampled was 0.27 m^2.

Pollution Tolerance	Common Name	Number Counted	Number of Taxa
Category 1 Pollution Intolerant	Caddisfly Larva (EPT)	0	0
	Mayfly Nymph (EPT)	1	1
	Stonefly Nymph (EPT)	5	2
Subtotal		**6**	**3**
Category 2 Somewhat Pollution Tolerant	Aquatic Sowbug	2	1
	Amphipod (freshwater shrimp)	3	1
Subtotal		**5**	**2**
Category 3 Pollution Tolerant	Aquatic Worm (oligochaete)	30	5
	Blackfly Larva	5	1
	Midge Larva (chironomid)	2	1
	Pouch and Pond Snails	2	1
	Water Mite	3	1
Subtotal		**42**	**9**
TOTAL		**53**	**14**

Table 9. Interpretation and Rating of Invertebrate Data from Site 2.

Section 1: Abundance / Density	**Result**
Abundance	53
Density	196.3/m2
Predominant Taxon	Aquatic Worm (oligochaete)
Section 2: Water Quality	
Pollution Tolerance Index	22 (Acceptable)
EPT Index	3 (Marginal)
EPT to Total Ratio Index	0.11 (Poor)
Section 3: Diversity	
Total Number of Taxa	14
Predominant Taxon Ratio Index	0.566 (Marginal)
Section 4: Overall	
Site Assessment Rating	2.25 (Marginal to Acceptable)

Table 10. Invertebrate results for Site 3. Triplicate samples were taken with a Hess Sampler on October 31, 2012. Total area sampled was 0.27 m^2.

Pollution Tolerance	Common Name	Number Counted	Number of Taxa
Category 1 Pollution Intolerant	Caddisfly Larva (EPT)	4	1
	Mayfly Nymph (EPT)	4	3
	Stonefly Nymph (EPT)	8	2
Subtotal		**16**	**6**
Category 2 Somewhat Pollution Tolerant	Aquatic Beetle	2	2
Subtotal		**2**	**2**
Category 3 Pollution Tolerant	Aquatic Worm (oligochaete)	12	3
	Midge Larva (chironomid)	2	1
	Water Mite	1	1
Subtotal		**15**	**5**
TOTAL		**33**	**13**

Table 11. Interpretation and Rating of Invertebrate Data from Site 3.

Section 1: Abundance / Density	**Result**
Abundance	33
Density	122.2/m2
Predominant Taxon	Aquatic Worm (oligochaete)
Section 2: Water Quality	
Pollution Tolerance Index	27 (Good)
EPT Index	6 (Acceptable)
EPT to Total Ratio Index	0.485 (Marginal)
Section 3: Diversity	
Total Number of Taxa	13
Predominant Taxon Ratio Index	0.36 (Good)
Section 4: Overall	
Site Assessment Rating	3.25 (Acceptable to Good)

Appendix 4: ALS Water Quality Results

Table 12. Water Quality Results From Sample Event #1 Taken From Departure Cr. (October 31, 2012) and Performed by ALS Labs.

Metal	Site 1	Site 2	Site 3	Provincial Guideline (mg/L)	Meets Guideline?
Aluminum (Al)	<0.20	0.27	0.68	0.1 when pH > 6.5	No, Exceeds guideline at sites 2 & 3. Test not sensitive enough for site 1.
Antimony (Sb)	<0.20	<0.20	<0.20	0.02	Test not sensitive enough
Arsenic (As)	<0.20	<0.20	<0.20	0.005	Test not sensitive enough
Barium (Ba)	<0.010	0.017	0.015	5	Yes
Beryllium (Be)	<0.0050	<0.0050	<0.0050	0.0053	Yes
Bismuth (Bi)	<0.20	<0.20	<0.20	N/A	N/A
Boron (B)	<0.10	<0.10	<0.10	1.2	Yes
Cadmium (Cd)	<0.010	<0.010	<0.010	0.00002 calc from hardness	Test not sensitive enough
Calcium (Ca)	11.6	16.2	13.1	Low < 4, Med 4-8, High > 8	Low Acid Sensitivity
Chromium (Cr)	<0.010	<0.010	<0.010	0.001	Test not sensitive enough
Cobalt (Co)	<0.010	<0.010	<0.010	0.11	Yes
Copper (Cu)	<0.010	<0.010	<0.010	0.006	Test not sensitive enough
Iron (Fe)	0.201	0.434	1.05	1.0	No, Site 3 exceeds guideline
Lead (Pb)	<0.050	<0.050	<0.050	0.026 calc from hardness	Test not sensitive enough
Lithium (Li)	<0.010	<0.010	<0.010	0.87	Yes
Magnesium (Mg)	3.06	4.41	3.62	N/A	N/A
Manganese (Mn)	0.0222	0.0420	0.0839	0.998 calc from hardness	Yes
Molybdenum (Mo)	<0.030	<0.030	<0.030	2	Yes
Nickel (Ni)	<0.050	<0.050	<0.050	0.025 when hardness < 60	Test not sensitive enough
Potassium (K)	<2.0	2.1	<2.0	N/A	N/A
Selenium (Se)	<0.20	<0.20	<0.20	0.002	Test not sensitive enough
Silicon (Si)	4.48	4.20	4.27	N/A	N/A
Silver (Ag)	<0.010	<0.010	<0.010	0.0001 when hardness < 100	Test not sensitive enough
Sodium (Na)	8.2	20.0	15.4	N/A	N/A
Strontium (Sr)	0.0560	0.0805	0.0630	N/A	N/A
Thallium (Tl)	<0.20	<0.20	<0.20	N/A	N/A
Tin (Sn)	<0.030	<0.030	<0.030	N/A	N/A
Titanium (Ti)	0.010	0.019	0.049	N/A	N/A
Vanadium (V)	<0.030	<0.030	<0.030	N/A	N/A
Zinc (Zn)	0.0200	0.0150	0.0180	0.033 when hardness < 90	Yes

Table 13. Water Quality Results From Sample Event #2 Taken From Departure Cr. (November 21, 2012) and Performed by ALS Labs.

Metal	Site 1	Site 2	Site 3	Provincial Guideline (mg/L)	Meets Guideline?
Aluminum (Al)	0.22	0.23	<0.20	0.1 when pH > 6.5	No, Exceeds guideline at sites 2 & 3. Test not sensitive enough for site 1.
Antimony (Sb)	<0.20	<0.20	<0.20	0.02	Test not sensitive enough
Arsenic (As)	<0.20	<0.20	<0.20	0.005	Test not sensitive enough
Barium (Ba)	<0.010	0.017	0.013	5	Yes
Beryllium (Be)	<0.0050	<0.0050	<0.0050	0.0053	Yes
Bismuth (Bi)	<0.20	<0.20	<0.20	N/A	N/A
Boron (B)	<0.10	<0.10	<0.10	1.2	Yes
Cadmium (Cd)	<0.010	<0.010	<0.010	0.00002 calc from hardness	Test not sensitive enough
Calcium (Ca)	13.9	19.2	17.8	Low < 4, Med 4-8, High > 8	Low Acid Sensitivity
Chromium (Cr)	<0.010	<0.010	<0.010	0.001	Test not sensitive enough
Cobalt (Co)	<0.010	<0.010	<0.010	0.11	Yes
Copper (Cu)	<0.010	0.010	<0.010	0.006	Test not sensitive enough
Iron (Fe)	0.505	0.559	0.213	1.0	yes
Lead (Pb)	<0.050	<0.050	<0.050	0.026 calc from hardness	Test not sensitive enough
Lithium (Li)	<0.010	<0.010	<0.010	0.87	Yes
Magnesium (Mg)	3.76	5.19	4.89	N/A	N/A
Manganese (Mn)	0.113	0.108	0.0224	0.998 calc from hardness	Yes
Molybdenum (Mo)	<0.030	<0.030	<0.030	2	Yes
Nickel (Ni)	<0.050	<0.050	<0.050	0.025 when hardness < 60	Test not sensitive enough
Potassium (K)	<0.30	<0.30	<0.30	N/A	N/A
Selenium (Se)	<2.0	<2.0	<2.0	0.002	Test not sensitive enough
Silicon (Si)	<0.20	<0.20	<0.20	N/A	N/A
Silver (Ag)	5.87	5.36	5.34	0.0001 when hardness < 100	Test not sensitive enough
Sodium (Na)	<0.010	<0.010	<0.010	N/A	N/A
Strontium (Sr)	9.2	17.7	17.0	N/A	N/A
Thallium (Tl)	0.0592	0.0866	0.0794	N/A	N/A
Tin (Sn)	<0.20	<0.20	<0.20	N/A	N/A
Titanium (Ti)	<0.030	<0.030	<0.030	N/A	N/A
Vanadium (V)	0.015	0.017	<0.010	N/A	N/A
Zinc (Zn)	<0.030	<0.030	<0.030	0.033 when hardness < 90	Yes

Appendix 5: Comparing water quality results with previous years

Table 14. 1st sampling event. Comparison of our results to the past years results

Parameter measured	Our results are overall:
Alkalinity	Slightly higher
Hardness	Lower
Turbidity	Higher
Nitrate	Higher
Phosphate	Lower
Conductivity	Lower
DO	Slightly higher
PH	Higher
Temp	higher

Table 15. 2nd Sampling event. Comparison of our results to the past years results

Parameter measured	Our results are overall
Alkalinity	lower
Hardness	lower
Turbidity	lower
Nitrate	higher
Phosphate	lower
Conductivity	lower
DO	Slightly higher
PH	higher
Temp	higher

In both cases the temp, pH, DO, and nitate levels are all higher in our results then the results from the 2011 report, whereas Conductivity, phosphate, and hardness were all lower. This may indicate that the Creek has become slightly less healthy due to the decrease in conductivity and hardness, however the DO results were higher in our year which should indicate a healthier system. Therefore the results are too inconsistent and incomprehensive to make any definite claims about the change in the Creek's health over the last year.