Holland Creek Environmental Monitoring

Water Quality and Invertebrate Population Assessment

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RMOT 306

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Executive Summary

Holland Creek is located in Ladysmith, British Columbia on Vancouver Island and runs approximately 12km before emptying into Ladysmith Harbour. This is a productive fish bearing stream with Chum Salmon (*Oncorhynchus keta*), Coho (*Oncorhynchus kisutch*), Cutthroat Trout (*Oncorhychus clarkii*) and Rainbow Trout (*Oncorhynchus mykiss*). There are numerous manmade structures that limit the passage of anadromous fish species to the lower 2.3 kilometers, such as the impassible falls, upper and lower colliery dams and the chicken ladder dam. This stream is one of the main drinking water sources for the town of Ladysmith and as such its health is of great importance to everyone in the area. A significant restoration and water monitoring project was started in 2004 by Department of Fisheries and Oceans, Coastal BC, the Pacific Salmon Foundation, Timber West, the Town of Ladysmith, and many volunteers.

This is the second year the Bachelor of Natural Resource Protection (BNRP) program has done water quality monitoring on Holland Creek. Two sampling events took place, one during low flow in October and the other during high flow in November. Water quality analysis was conducted both by VIU students and ALS Laboratories in Vancouver, British Columbia. Microbiology, stream invertebrate populations and hydrology were also measured at each of the 4 sites selected in Holland Creek Walking Trail (Figure 3).

This year's monitoring program found the stream to be extremely sensitive, but in generally good health. Benthic invertebrate populations increased dramatically, but at the cost of a lowered EPT index score as much of the population growth was within the group of category 3 pollution intolerant species. The overall assessment based on the

EPT index was positive, but it will be important to keep track of population trends in the future to ensure 2012's marginalization of category 1 species does not continue.

Water quality results showed a stream generally within suggested guideline parameters, but with minor issues regarding acidity. The second sampling event analyzed by ALS showed 2 sites slightly below the suggested pH range, but this was conflicted by field measurements made with a YSI. Alkalinity measurements were extremely low, averaging 10 mg Ca²+/L, the upper limit for high acid sensitivity (RISK,1998).

Iron levels during the first event were found to be above BC water guidelines for aquatic life on one occasion, though it was at a site that exhibited a large amount of variation in all readings as a result of nearby tributary streams. The overall impact of this result is negligible however, as parameters at the next site downstream were back with guidelines and the spike in iron levels was not detected during the second event. Aluminum levels were also uncharacteristically high during the first event, peaking at the same site where high iron levels were detected (Appx 6.2).

Acknowledgements

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1.0 Introduction

1.1 Project Overview

BS consulting of Vancouver Island University (VIU) and the RMOT 306 Environmental Monitoring class conducted a stream survey on Holland Creek located in the town of Ladysmith, British Columbia. The study took place between October 31st and November 21st 2012 (Table 1) and monitored 4 locations pre-determined by 2011 Resource Management Officer Technology students from the Vancouver Island University (Figure 3).

Samples from each site were analyzed for water quality, microbiology, invertebrate populations and hydrology. Information was also collected on overall environmental conditions, biological health and environmental issues to examine human influence from development and use of Holland Creek area. Water quality, coliform testing, invertebrate sampling and hydrology were performed at all 4 locations during low flow (October) sampling event, while only water quality and hydrology testing was completed during high flow (November) sampling event. Data collected during this project will be used in continuation with the data collection from past years to provide Fisheries and Oceans Canada with a baseline report on the stream health and rehabilitation status of Holland Creek.

1.2 Historical Review

The Holland Creek watershed covers an area of 28 square kilometers and originates West of Ladysmith in the Coronation Mountains (Coastal BC, 2004). The watershed as a whole has been put through a significant amount of stress over the last 100 years. The area has been heavily logged in the past which has left what was once stable and productive fish habitat flashy and degraded. Human encroachment and the proximity to the town of Ladysmith have also significantly affected the quality of the stream. A substantial amount of effort has been put into the stream since 2004; the introduction of large log spurs (Figure 1), the reworking or removal of gravel bars and log jams, and the building of new side channels have all significantly improved the habitat for spawning fish. This work was done by Ladysmith Sportsman's club and consultant Dave Clough, who began the restoration process in 2004, which has made the stream adequate for spawning salmon.



Figure 1. Example of log spur placement used by Dave Clough Consulting to increase fish cover and alter channel bed. (Coastal BC,2004)

The Holland Creek Fish Habitat Enhancement Project was funded with the help of Department of Fisheries and Oceans, Coastal BC, the Pacific Salmon Foundation, Timber West, the Town of Ladysmith, and private donors. Holland Creek is now a fish bearing stream with annual Coho Salmon (*Oncorhynchus kisutch*) and Chum Salmon (*Oncorhynchus keta*) runs, as well as Cutthroat Trout (*Oncorhynchus clarkii*) and Rainbow Trout (*Oncorhynchus Mykiss*) populations located at multiple locations within the watershed.

On the stream's 12km run to Ladysmith Harbour there are numerous manmade structures that limit anadromous fish to the bottom 2.3 kilometers such as the impassible falls, upper and lower colliery dams and the chicken ladder dam. Since the enhancement project Holland Creek escapement numbers are on the rise, with approximately 10,500 Chum salmon, 75 Coho salmon and 25 Steelhead. A portion of the creek runs through Holland Creek Trail which is 5.9 kilometers of heavily forested area complete with an extensive network of walking paths, and bridges throughout. All 4 sampling sites for this project are within the Holland Creek Trail system, sites 2-4 are located alongside populated areas of Ladysmith, while site 1 is slightly further inland (Figure 3). The Holland Creek watershed has various deciduous and non-deciduous tree species consisting mainly of Red Cedar (*Thuja plicata*), Douglas Fir (*Pseudosuga menziesii*), Red Alder (*Alnus rubra*), along with high amounts of Salal (*Ericaceae*) and sword ferns (*Polystichum munitum*).



The Town of Ladysmith Trail Guide

Figure 2. Map of trails throughout the Holland Creek watershed. (Town of Ladysmith, 2010)

1.3 Potential Environmental Concerns

With the proximity to Ladysmith and the town's continuous growth there is going to be continued environmental concerns associated with non-point source effluent entering the Holland Creek watershed. These include urban development, logging, recreational use, storm drains and road runoff. This concentration of anthropogenic sources has the potential to cause large increases in the levels of nutrients such as nitrates and phosphorus, both of which can cause significant damage. Numerous newly formed small tributary streams were noted being cut into the riparian zone hillside due largely to this excess runoff, which significantly altered our readings at one monitoring site. The flashy nature of this creek has in the past forced the City of Ladysmith to use the water of Stocking Lake as a drinking water source, as the sporadically high turbidity and increased coliform counts have made Holland Creek water unfit for consumption (Town of Ladysmith,2010)

2.0 Methods

2.1 Overview

Environmental sampling was completed at four pre-determined location along Holland Creek in Ladysmith, British Columbia (Figure 3). This is the second year of sampling by RMOT students on Holland Creek. Parameters tested included microbiology, invertebrate diversity and water quality testing in an effort to determine the environmental concerns associated with Holland Creek.

Sampling occurred two times once during low flow on October 31st 2012 and the second sampling event occurred November 21st/22nd, 2012. Water Quality was measured at each of the four sample sites during both sampling events and replicate samples were taken at site 3 during sampling event one and site 1 during sampling event two. Three additional samples were collected at sites 2, 3, 4 during both sampling events to be analyzed by ALS Laboratories in Vancouver, British Columbia. Hydrology measurements were taken at all four sample sites during both October low flow sampling event and November high flow sampling event. Microbiology tests were conducted during the first sampling event at all 4 site locations but were not tested for

during the second sampling event. Invertebrate sampling was done with the Hess sampler at sites 2, 3, 4 during the first sampling event but was not conducted during the second event (Table 1).

	Date	Site 1	Site 2	Site 3	Site 4
Watan	Oct 31 2012	1:30 pm	12:30 pm	10:30 am	11:10 am
Quality	Nov 21/22 2012	3:00 pm	3:30 pm	4:25 pm	10:00am (Nov 22)
Invertebrate Sampling	Oct 31 2012		12:45 pm	10:40 am	11:20 am

Table 1. Date and time of each sampling event

2.2 Sample Site Locations



(Figure 3) Approximate location of the sampling stations used for water quality and stream invertebrate assessments on Holland Creek during October-November 2012

Sample site 1 was located 800m along the Holland Creek walking trail and is accessed from Mackie Road. Samples were collected beside the wooden foot bridge

crossing the creek. Large boulders are present at this site along with cobble-gravel substrates. Vegetation in the surrounding area is dense with both deciduous and non-deciduous tree species, mainly Red Cedar (*Thuja plicata*), Douglas Fir (*Pseudosuga menziesii*), Red Alder (*Alnus rubra*). The total canopy cover over the stream is approximately 35%. (Figure 4)



Figure 4. Sample site 1. Photo taken by Braeden Lattanzi

Sample site 2 was located 300m along the Holland Creek walking trail and is accessed from Mackie Road. Samples were collected in lower flow areas near the side of the stream. Recent landscaping by the city has added new fir trees to the bank, while large amounts of Salal, deciduous and non-deciduous trees are also scattered along the river. The canopy cover in this area is approximately 15%. Large boulders are present at this site along with cobble-gravel substrates (Figure 5).



Figure 5. Sample site 2. Photo taken by Braeden Lattanzi

Sample site 3 is located approximately 100m upstream of the overpass and accessible from the parking lot on Dogwood Drive. Approximately 150m along the Holland Creek Lower Loop with large deciduous and non-deciduous growing throughout with approximately 45% canopy cover. There are no large boulders at this site but mostly cobble and small gravel substrates. This site looked to be the most productive area for Chum salmon spawning during water quality monitoring, likely due to its low gradient and optimal substrate size.



Figure 6. Sample site 3. Photo taken by Braeden Lattanzi

Site 4 is located 200m down the Holland Creek Lower Loop & accessed from the parking lot on Dogwood Drive, roughly 100m downstream of the overpass. Approximately 55% canopy with deciduous and non-deciduous cover the stream has deep undercut banks and large woody debris. This site has many burned in trails leading to the river and it looks like there is a lot of human traffic leading to the streams edge. This part of the creek has large boulders spread throughout the area but is mainly small gravel substrates (Figure 7).



Figure 7. Location of sample site 4. 2011. File corruption prevented use of 2012 photo. Taken by Stephanie Righi.

2.3 Hydrology

Discharge measurements were taken at all 4 sampling sites during low flow October monitoring and high flow November monitoring. Discharge was determined by measuring the wetted width across the creek and depth measurements at 25, 50, 75 percent across the stream. A 10m measurement along the creek was conducted and a ping pong ball was dropped 5 times at the upstream end of the 10 meters. The length of time it took for the ping pong ball to travel the 10m interval was then used to calculate water velocity. The cross sectional areas obtained by previous width and depth measurements were then multiplied by the velocity to estimate the discharge rate for each section of the creek. Field water quality measurements taken during these sampling events included dissolved oxygen, pH, conductivity and temperature and were done using an YSI pro200. One sample bottle along with a field blank and replicate sample were collected and analyzed at Vancouver Island University laboratories for each of the stations at both low and high flow sampling events. Parameters measured during these sampling events were alkalinity, hardness, total nitrate (NO3-), and total phosphate (PO43-). Additionally, 3 samples were taken at site 2, 3, 4 to be sent to ALS laboratories in Vancouver, British Columbia to test for pH, total suspended solids, alkalinity, total metals and nutrients. Quality control and quality assurance were taken into account during all monitoring events following the MOE aquatic monitoring guidelines.

2.4 Microbiology

Water samples to test for total coliforms and fecal coliforms were collected in sterile whirl packs while in the field. 50 ml from each site was then filtered through a 0.45 µm membrane using a vacuum pump. Once filtered, the membrane was then transferred onto a petri dish containing a pad soaked in m-ColiBlue24 broth before being incubated at approximately 37 degree Celsius for 48 hrs The sample was then analyzed and counted for colony forming units (CFU) and the data was tallied. Fecal coliform units had a bluish colour, non-fecal coliforms had a red colour and noncoliform bacteria had a clear to crème colour. Microbiology testing took place during the low flow October 31st sampling period but not during the high flow November sampling period. Quality assurance measures were taken by using gloves during collection and analysis, as well as using alcohol on forceps and burning off to sterilize during filtration.

2.5 Water Quality

3 water samples were collected and analyzed by ALS private laboratories in Vancouver, BC and by students working on Holland creek in the Vancouver Island University laboratories. Numerous steps were taken to ensure minimal sample contamination; all sample containers were pre-labeled and rinsed 3-5 times before water collection, gloves were worn at all times and samples were collected below the surface water level after approaching from downstream. Field blanks and trip blanks were used to verify that there was no contamination during sampling and transportation.

Sample preservation during transport to ALS private laboratories was achieved by adding sulphuric acid to the water sample measuring metals in order to keep them dissolved, while nitric acid was added to the sample to be analyzed for nutrient levels in order to prevent the losses of organic compounds. Water samples that are to be analyzed by Vancouver Island University students are conductivity, pH, total hardness, phosphate, nitrate, total alkalinity and turbidity. These parameters will be tested to the BC aquatic life guidelines to determine if they are within acceptable parameters

2.6 Stream Invertebrate Communities

Macro-invertebrate population sampling took place during the low flow October sampling event from sites 3 and 4. Duplicate samples were taken at each site in order to account for the variance in abundance and distribution that is commonly found in freshwater environments. A Hess sampler was used to contain and collect the organisms and a brush was then used to remove any cobble to ensure no invertebrates were lost. Once the larger cobble was removed, the remaining substrate was disturbed for 60 seconds and any invertebrates present were washed down into the collection jar.

The jar was then emptied into a tray and the large pieces of debris were rinsed and removed in the field, upon completion all specimens were preserved in a prelabeled jar with 70% ethanol for future sorting by taxonomy in the labs at VIU. This information was then used to calculate abundance, density, predominant taxon, pollution tolerance index, EPT index, EPT to total ratio index, diversity and overall site assessment rating.

3.0 Results and Discussion

3.1 General Field Conditions

The first sampling event took place on October 31st in a substantial amount of precipitation. 11.2mm of rain fell between 2pm and 7pm, only exacerbating the already muddy conditions resulting from 35mm of rainfall the previous day. Ambient temperature was 10.2 °C. The second event took place on November 21st when the ambient temperature had dropped to 4.9 °C, while 4.9mm of precipitation fell. (Weather Office, 2012)

3.2 Water Quality

3.2.1 Field Measurements

Four water quality parameters were measured while in the field; dissolved oxygen, temperature, conductivity and pH. Conductivity at was fairly consistent across sampling events and stations, with the exception of station 3 during the first event. While the other sites' conductivity measured between 16-22 µs/cm over both events, on October 31st site 3 was found to have a conductivity reading of 36 µs/cm when tested in the field and 45.3 µs/cm when analyzed by ALS (appx.-table 5). This anomaly in the water quality was reflected later by multiple parameters, as site 3's hardness, phosphorus, aluminum, silicon, sodium and turbidity varied greatly from the other stations. We believe this to be result of small tributary streams that had recently formed nearby as a result of significant October rainfall following an abnormally dry September. The second event was taken during high flow and showed no noticeable trend at station 3, making it likely that the increased flow on Nov 21 diluted the incoming runoff to normal levels.

Dissolved oxygen readings were well within guidelines for invertebrates, fish and fish embryos. Over both events the dissolved oxygen ranged from 11.1-11.9 mg/L, while anything over 9 mg/L is suitable for even the most sensitive life in coastal streams (ie. fish embryos)(Appx table 9).

Water temperature readings at each station were stable in relation to each other, but as expected dropped slightly over the two sampling trips. Temperature during the first event ranged from 6.5-6.7 °C, while the second event ranged from 4.7-5.1 °C.(appx table 8)

PH was tested both in the field and by ALS; field measurements found it to be within range (6.5-9) at all but the 3rd site during the first sampling event when it was measured 6.3 (other sites ranged from 6.7-7.3). This was contradicted by ALS analysis that found all sites within range during the first event, and sites 2 and 3 below range during the second event. While this difference stands out initially, the largest discrepancy between ALS and field readings was 1, with ALS's reading during event 2 at site 3 was 6.35 and field measurements were 7.35; this caused site 3 to drop below guidelines by 0.15.(Appx table 4)

Hydrological data was taken during both events at 3 sites. It was our intention to monitor flow rate at the same sites during both trips, but the drastic increase in flow during the second event made unsafe to enter the water at site 2 (Tables 2, 3). Because of this, we had difficulty interpreting the data in the manner that we had intended.

Event 1						
Site number	Average Depth (m)	Wetted Width (m)	Cross sectional area (m²)	Average Velocity (m/sec)	Flow Rate (m³/sec)	
2	0.21	6.8	1.43	0.43	0.61	
3	0.22	7.2	1.58	0.16	0.25	
4	0.18	9.7	1.75	0.19	0.33	

Table 2. Hydrological data during event 1

	Event 2					
Site Number	Average Depth (m)	Wetted Width (m)	Cross sectional area (m ²)	Average Velocity (m/sec)	Flow Rate (m³/sec)	

1	0.58	12.0	6.9		
3	0.55	14.2	7.81	0.79	6.17
4	0.42	15.1	6.34	0.93	5.9

Table 3. Hydrological data during event 2

3.2.2 VIU Laboratory Analysis

6 water quality parameters were measured using VIU analysis equipment; nitrate, total phosphorus, alkalinity, turbidity, hardness. All parameters were then compared to the guidelines set out by the Resources Information Standards Committee (1998) or the BC Ministry of Environment's Water Quality Guidelines Reports (2003).

Nitrate analysis of event 1 samples ranged from 0.08-0.15 mg/L, and 0.03-0.04 mg/L during the second. Both readings are positive in nature, as the maximum guideline is 200mg/L or an average of 40mg/L. Surface water in British Columbia averages <0.3mg/L (RISK,1998), so this reading is on par with expected results. Overall it bodes well for the watershed as a whole, as its close proximity to Ladysmith and numerous storm water drains feeding into can often cause a spike in nitrates from anthropogenic sources (Appx table 2).

Phosphorus readings were overwhelmingly in the eutrophic range (>0.025mg/L) at all stations through both events, with the exception of site 2 during event 1. Site 2 readings during both events were over 50% lower than at other stations, falling into the mesotrophic range (0.010-0.025mg/L)(RISK,1998) during event 1 with a reading of 0.02mg/L. All other sites ranged from 0.07-0.19 mg/L (Appx table 3).

Alkalinity testing found Holland Creek to have a moderate to high sensitivity to acid inputs. Across both events, results ranged from 8-12.4 mg Ca²+/L. Guidelines have the high acid sensitivity range as 0-10 mg Ca²+/L, while 10-20 mg Ca²+/L is described as moderate sensitivity (RISK, 1998). No broad trends between sites were found (Appx table 6).

Turbidity readings between sites were fairly consistent with the exception of the previously mentioned anomalous site 3 during event 1. During both events turbidity showed a slight trend of increasing at each station moving downstream, although this progression is distorted by a reading of 6.17 NTU at site 3, while the other sites ranged from 1.23-2.5 NTU during the first event. Event 2 readings stabilized significantly, with no deviation between readings more than 0.07 NTU. Instead, event 2 unexpectedly had a significantly lower average turbidity reading (0.38 NTU) despite greatly increased flow. This may be a result of October precipitation being the first noteworthy rainfall since the beginning of summer, introducing a high amount of loose soil and substrate into the stream which lowered and stabilized over time (Appx table 7).

Hardness averaged 9.75 mg CaCO3/L during event 2, and 10.25 during event 2 (Appx table 10). This is including the comparably high reading from site 3(14 mg/L vs 8,8,9 mg/L at S1,S2, S4 respectively), which unexpectedly carried over between sampling events, unlike any of the other high readings from site 3. Overall, the water with the Holland Creek watershed is extremely soft, with <60 mg/L being the upper limit for soft water (RISK,1998)

3.2.3 ALS Laboratory Analysis

During both events, separate samples were taken from sites 2, 3 and 4 with the goal of having more advanced analysis done by ALS. 3 samples from each station were taken; one for total metals, one for anions and nutrients and one for general water quality parameters. Certain tests overlapped with the laboratory work done at VIU (conductivity, hardness, pH, nitrates and phosphates) which offered the opportunity to compare results.

The results of the physical tests (conductivity, hardness, pH) were fairly consistent with those obtained from VIU analysis. The abnormal readings from the VIU analysis of site 3 were reflected in those from ALS, though at slightly different quantities; conductivity at sites 2, 3 and 4 according to VIU analysis was 16, 36 and 20 µs/cm respectively, ALS results showed 18.9, 45.3 and 22.3 µs/cm (Table 4). Despite this, there was only an average of 15% difference found. This slight variance in readings continues through measurements of hardness and pH, though the discrepancies are not nearly as pronounced. Event 2's physical test results when compared to VIU analysis was accurate with regards to conductivity and pH, but hardness showed deviations too high for the VIU measurement to be considered precise. Event two also showed a pH reading below acceptable guidelines at site 2 and 3 by 0.22 pH and 0.15 pH respectively.

The next section of analysis done by ALS was anions and nutrients. Ammonia, nitrate, nitrite, orthophosphate and phosphorus was tested, though only nitrate and phosphorus readings were above detectable limits. Nitrate and phosphate readings

from both events deviated too much from the VIU samples, which as a result cannot be considered accurate. ALS readings were found to be well within acceptable guidelines for aquatic life.

The level of 31 separate metals were tested for each event, with 11 of 35 being above detectable limits during event 1, and only 5 of 31 during event 2 (Appx 6.2). Site 3 showed an iron level 2.09 mg/L, well above both other sites (avg of 0.293 mg/L) and the acceptable guideline of 1mg/L. Aluminum and iron were the only metals found to be above acceptable limits during the first sampling event (Table 4). Aluminum, barium, calcium, magnesium, manganese, silicon, sodium, strontium, titanium and zinc also showed elevated levels at site 3, though as said before, all were within acceptable parameters.

Total metals were much lower overall during the second sampling event (Table 5), which is likely related to increased flow and thus increased dilution. Only calcium, iron, magnesium, silicon, and strontium were above detectable limits, none of which were higher than acceptable guidelines. The correlation between site 3 and increased metal concentration was not present during the second event, although there was a clear trend pointing to a slow increase in metal concentration at each site further downstream. Based on the readings of site 2 and 4, this trend may well have been present during the first event, but the abnormal readings of site 3 prevent any confirmation.

	HOLLAND CREEK STN 2	HOLLAND CREEK STN 3	HOLLAND CREEK STN 4	Water Quality Guidelines (maximum allowable level)
DATE	31-OCT- 12	31-OCT-12	31-OCT-12	
TIME OF SAMPLE	12:30 pm	10:30 am	11:10 am	
Physical Tests				
Conductivity	18.9	45.3	22.3	
Hardness (as CaCO3)	7.68	17.9	9.07	
рН	6.78	7.12	6.94	6.5-9.0
Anions and Nutri	ents			
Nitrate (as N)	0.158	0.171	0.168	200 mg/L
Phosphorus (P)-Total	0.0166	0.0666	0.019	<0.010- Oligotrophic 0.010-0.025- Mesotrophic ≥0.025- Eutrophic
Total Metals				
Aluminum (Al)-Total	<mark>0.33</mark>	<mark>1.99</mark>	<mark>0.37</mark>	0.1 when pH >6.5
Barium (Ba)-Total	<0.010	0.016	<0.010	1 mg/L
Calcium (Ca)-Total	2.29	5.39	2.74	 ≤4- High acid sensitivity 4 – 8- Moderate acid sensitivity >8- Low acid sensitivity
Iron (Fe)-Total	0.254	<mark>2.09</mark>	0.332	1 mg/L
Magnesium (Mg)-Total	0.48	1.08	0.54	
Manganese (Mn)-Total	0.0127	0.0501	0.0154	0.65mg/L (at avg hardness of 10)
Silicon (Si)-Total	2.58	4.55	2.71	
Sodium (Na)-Total	<2.0	3.5	<2.0	
Strontium (Sr)-Total	0.0129	0.0423	0.0165	
Titanium (Ti)-Total	<0.010	0.091	0.014	
Zinc (Zn)-Total	<0.0050	0.0088	<0.0050	0.033mg/L (when hardness <90)

Table 4. Condensed ALS results from event 1 showing only parameters above detectable limits.Highlighted are results above water quality guidelines.

	HOLLAND CREEK STN 2	HOLLAND CREEK STN 3	HOLLAND CREEK STN 4	Water Quality Guidelines (maximum allowable level)
DATE	21-NOV-12	21-NOV-12	21-NOV- 12	
TIME OF SAMPLE	15:00	16:00	17:00	
Physical Tests				
Conductivity	16.7	19.3	20.2	
Hardness (as CaCO3)	6.27	7.15	7.54	
рН	<mark>6.28</mark>	<mark>6.35</mark>	6.95	6.5-9.0
Anions and Nut	rients			
Nitrate (as N)	0.0417	0.0507	0.0616	200mg/L
Phosphorus (P)-Total	0.0041	0.0039	0.0052	<0.010- Oligotrophic 0.010-0.025- Mesotrophic ≥0.025- Eutrophic
Total Metals				
Calcium (Ca)-Total	1.88	2.17	2.3	 ≤4- High acid sensitivity 4 – 8- Moderate acid sensitivity >8- Low acid sensitivity
Iron (Fe)-Total	0.056	0.06	0.059	1 mg/L
Magnesium (Mg)- Total	0.38	0.42	0.44	
Silicon (Si)-Total	2.48	2.55	2.56	
Strontium (Sr)-Total	0.0102	0.0122	0.0127	

 Table 5. Condensed ALS results from event 2 showing only parameters above detectable limits.

 Highlighted are results above water quality guidelines.

3.3 Benthic Macroinvertibrate Communities

Invertebrate, and more specifically EPT populations were found to be healthy and surprisingly stable throughout the 3 sites (2,3,4) where sampling took place on October 31st, 2012. 330 total invertebrates were counted from the samples taken, made up of 9 different species (Table 7). Predominant taxon throughout site 2 was midge larva (chironomid), while at sites 3 and 4 it was aquatic worms (oligochaete)(Appx 6.2). While somewhat concerning

because they are of category 3 pollution tolerance, the ratio of their abundance to the other taxon received a rating of 4, denoted as "good" using this style of interpretation. (Table 6).



Table 6. EPT Index ratings

Figure 8. Pollution tolerance distribution

In comparison to last year's sampling trips, the density of animals was found to have significantly increased, but with only one more species present in 2012; density per square meter ranged from 533-727 (Appx 6.2), while last year it ranged from 226-348.

The overall site assessment for all 3 was found to be 3.25 (Table 6), with a rating of 4 being the maximum rating ("good") and 3 being "acceptable" using this system. The site assessment rating in 2012 was slightly lower than the previous, but had much less variability overall; in 2011 it ranged from 2.75-3.75 and averaged 3.375 (Demers et al, 2012), while in 2012 it was 3.25 at all sites monitored.

The invertebrate population has clearly increased over the past year, and the overall health of it has remained reasonably stable. The main concern for Holland creek is the EPT to

Total Population ratio, which was the lowest scoring quality during the site assessment, with a rating of 2 ("marginal")(Figure 8).

Pollution Tolerance	Species	Site 2	Site 3	Site 4
Category 1	Caddisfly Larva	10	9	7
	Mayfly Nymph	12	20	15
	Stonefly Nymph	12	13	26
Category 2	Cranefly Larva	2	5	5
	Damselfly Larva	15	14	1
	Crayfish	1	0	0
Category 3	Aquatic Worm	20	25	39
	Blackfly Larva	0	3	2
	Midge Larva	24	20	36

Table 7.. Individual species abundance by pollution tolerance

3.4 Microbiology

Coliform counts in Holland Creek look to have drastically declined in the past year. Sites 2, 3 and 4 were tested during event 1 and an average of 296 CFU/100ml was found (Appx table 11). Being in such close proximity to the town of Ladysmith, as well as having significant dog walking trails throughout the watershed, the presence of coliform was expected. Compared to last year's samples however, which ranged from 498-2098 CFU/100ml (site 2 was found to have 10,000+ CFU/100ml, but human error is suspected)(Demers et al, 2012), 296 CFU/100ml is a significant improvement. Of the 282.4 CFU detected at site 2, 17.8% were fecal coliform. Sites 3 and 4 had 333 and 272.2 CFU detected, 27% and 22% of which respectively, were found to be fecal coliform.

4.0 Conclusions and Recommendations

It is clear after this monitoring project that the past improvements to fish habitat have benefited the salmon runs considerably, as the stream again supports a significant chum run, as well as a minor Coho Run. The introduction of numerous log spurs along the length of the stream have worked to narrow and deepen channels, resulting in many more pools essential to the rearing of juveniles and the protection of adult fish of all species. The newly constructed side channels have yet to make their intended impact, as very few fish were observed in them during out monitoring trips. We feel however that this is temporary and will improve over time as vegetation both in, and at streamside grows to make it more suitable habitat.

Water quality readings were generally within guidelines for aquatic life in BC. As outlined in previous sections, site 3 during event 1 provided multiple unique readings in comparison to the other sites. We believe this to be a result of numerous small streams originating from the roadside and draining into the stream in the vicinity of the testing site. Higher overall flow seems to have mitigated this to some degree as parameters were much closer to the other sites during the 2nd sampling event. This will need to be monitored closely in the future during low flow periods, as the volume of water in the creek during the summer may not always be sufficient to dilute metal concentration to acceptable levels. We feel it would be beneficial to the watershed as a whole if streams that can be traced back to the roadside are monitored for contaminants, as preliminary findings point to non-point source pollution; though we do recognize that funding likely will not allow for this.

Invertebrate counts showed the area to be in good health, and had a surprisingly uniform ratio of Category 1, 2 & 3 species across the separate sites. Aquatic worms and midge larva were the most common species, but were not found in alarming abundance. EPT species were found to be in good abundance. Compared to the previous year, the ratio of EPT to Total invertebrates was lower, though a drastic increase in overall abundance of all other species mitigates these concerns to some degree. Being only the second year of monitoring, there is still much more monitoring necessary before a reliable baseline can be established, and thus we recommend the long term monitoring of trends with regards to EPT ratio.

With Holland Creek being a continued source of municipal water as well as valuable fish habitat, it is of the utmost importance monitoring of water volume drawn is continued. Ladysmith's recent tax credit initiatives aimed at lowering water consumption are a step in the right direction, and we hope to hear of similar programs being established in the future.

5.0 References

CoastalBC. 2004. Holland Creek Fish Habitat Enhancement Program http://www.coastalbc.com/fish/st402holland.htm

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6.0 Appendix

6.1 Tables

Station #	UTM Northing	UTM Easting	Distance (m) Ladysmith <u>Harbour</u>	General Location
1	5425763	439234	2,700	Wooden bridge, 600 m upstream of trail access at Mackie Road
2	5426167	439247	2,300	Between Lower and Upper Colliery Dams, 200 m upstream of trail access at Mackie Road
3	5425625	440718	450	100 m upstream of the Dogwood Drive crossing
4	5425635	440948	210	100 m downstream of the Dogwood Drive crossing

Table 1. Description of the sampling stations used for water quality and stream invertebrate

 assessments on Holland Creek during October-November 2012. All northing and easting coordinates

 were approximated with Google Earth and are based on zone 10U.

Site Number	Nitrate (mg/L)		
	Event 1	Event 2	
1	0.15	0.03	
2	0.08	0.04	
3	0.14	0.04	
4	0.13	0.04	

Table 2

Site Number	Phosph	norus (mg/L)
	Event 1	Event 2
1	0.07	0.13
2	0.02	0.06
3	0.10	0.18
4	0.11	0.19

Table 3

Site Number	рН		
	Event 1	Event 2	
1	7.3	7.18	
2	7.1	7.13	
3	6.3	7.35	
4	6.7	7.09	

Table 4

Site Number	Conductivity (μs/cm)		
	Event 1	Event 2	
1	16	17	
2	16	17	
3	36	20	
4	20	21	

Table 5

Site Number	Alkalinity (mg Ca ² +/L)		
	Event 1	Event 2	
1	8	10	
2	9.6	11	
3	12.4	10	
4	9.6	9.6	

Table 6

Site Number	Turbio	dity (NTU)
	Event 1	Event 2
1	1.23	0.33
2	1.59	0.39
3	6.17	0.40
4	2.5	0.40

Table 7

Site Number	Temperature(°C)		
	Event 1	Event 2	
1	6.7	5.1	
2	6.5	4.7	
3	6.6	4.8	
4	6.5	4.7	

Table 8

Site Number	Dissolved	Oxygen(mg/L)
	Event 1	Event 2
1	11.8	11.1
2	11.6	11.3
3	11.8	11.3
4	11.9	11.2

Table 9

Site	Hardness (mg/L)		
Number	Event 1	Event 2	
1	8	9	
2	8	9	
3	14	13	
4	9	10	

Table 10

Site Number	Coliform		
	Total Coliform	Fecal Coliform	Non-Coliform
2	282.4	50.4	80.7
3	333	90.8	60.5
4	272.2	60.5	70.6

Table 11

6.2 ALS Results

Event 1

	HOLLAND CREEK STN 2	HOLLAND CREEK STN 3	HOLLAND CREEK STN 4
DATE	31-OCT-12	31-OCT-12	31-OCT-12
TIME OF SAMPLE	12:30 pm	10:30 am	11:10 am
	-		
Physical Tests			
Conductivity	18.9	45.3	22.3
Hardness (as CaCO3)	7.68	17.9	9.07
рН	6.78	7.12	6.94
Anions and Nutrie	nts		
Ammonia, Total (as N)	<0.0050	<0.0050	<0.0050
Nitrate (as N)	0.158	0.171	0.168
Nitrite (as N)	<0.0010	<0.0010	<0.0010
Orthophosphate- Dissolved (as P)	<0.0010	<0.0010	<0.0010
Phosphorus (P)-Total	0.0166	0.0666	0.019
Total Metals			
Aluminum (Al)-Total	0.33	1.99	0.37
Antimony (Sb)-Total	<0.20	<0.20	<0.20
Arsenic (As)-Total	<0.20	<0.20	<0.20
Barium (Ba)-Total	<0.010	0.016	<0.010
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	2.29	5.39	2.74
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	0.254	2.09	0.332
Lead (Pb)-Total	<0.050	<0.050	<0.050
Lithium (Li)-Total	<0.010	<0.010	<0.010

Magnesium (Mg)-Total	0.48	1.08	0.54
Manganese (Mn)-Total	0.0127	0.0501	0.0154
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	<0.30
Potassium (K)-Total	<2.0	<2.0	<2.0
Selenium (Se)-Total	<0.20	<0.20	<0.20
Silicon (Si)-Total	2.58	4.55	2.71
Silver (Ag)-Total	<0.010	<0.010	<0.010
Sodium (Na)-Total	<2.0	3.5	<2.0
Strontium (Sr)-Total	0.0129	0.0423	0.0165
Thallium (Tl)-Total	<0.20	<0.20	<0.20
Tin (Sn)-Total	<0.030	<0.030	<0.030
Titanium (Ti)-Total	<0.010	0.091	0.014
Vanadium (V)-Total	<0.030	<0.030	<0.030
Zinc (Zn)-Total	<0.0050	0.0088	<0.0050

Event 2

	HOLLAND CREEK STN 2	HOLLAND CREEK STN 3	HOLLAND CREEK STN 4
DATE	21-NOV-12	21-NOV-12	21-NOV-12
TIME OF SAMPLE	15:00	16:00	17:00
Physical Tests			
Conductivity	16.7	19.3	20.2
Hardness (as CaCO3)	6.27	7.15	7.54
рН	6.28	6.35	6.95
Anions and Nutrien	ts		
Ammonia, Total (as N)	<0.0050	<0.0050	<0.0050
Nitrate (as N)	0.0417	0.0507	0.0616
Nitrite (as N)	<0.0010	<0.0010	<0.0010
Orthophosphate-Dissolved (as P)	<0.0010	<0.0010	<0.0010
Phosphorus (P)-Total	0.0041	0.0039	0.0052
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	<0.010
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	1.88	2.17	2.3
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	0.056	0.06	0.059
Lead (Pb)-Total	<0.050	<0.050	<0.050
Lithium (Li)-Total	<0.010	<0.010	<0.010
Magnesium (Mg)-Total	0.38	0.42	0.44
Manganese (Mn)-Total	<0.0050	<0.0050	<0.0050
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	<0.30
Potassium (K)-Total	<2.0	<2.0	<2.0
Selenium (Se)-Total	<0.20	<0.20	<0.20
Silicon (Si)-Total	2.48	2.55	2.56
Silver (Ag)-Total	<0.010	<0.010	<0.010
Sodium (Na)-Total	<2.0	<2.0	<2.0
Strontium (Sr)-Total	0.0102	0.0122	0.0127
Thallium (Tl)-Total	<0.20	<0.20	<0.20
Tin (Sn)-Total	<0.030	<0.030	<0.030
Titanium (Ti)-Total	<0.010	<0.010	<0.010
Vanadium (V)-Total	<0.030	<0.030	<0.030
Zinc (Zn)-Total	<0.0050	<0.0050	<0.0050

6.3 Invertebrate Survey Field Data Sheets

Stream Name:	Holland	d Creek			Date:		Oct 31	, 2012
Station Name:	Stat	Station 2 Flow status: Medium					ium	
Sampler Used:	Number of replicates	Total area sa	ampled	(Hess,	Surber = 0	.09 m²) :	x no. re	plicates
Hess Sampler	2			:				0.18 'm²
Column A	Column B			Colur	nn C		Colun	nn D
Pollution Tolerance	Common Nam	ne	Nu	mber	Counted	N	umber	of Taxa
	Caddisfly Larva (EPT)	0	EPT1	10		EPT4	3	
Category 1	Mayfly Nymph (EPT)		EPT2	12		EPT5	2	
	Stonefly Nymph (EPT)		EPT3	12		EPT6	2	
	Dobsonfly (hellgrammite	;)						1
Pollution	Gilled Snail		0					
Intolerant	Riffle Beetle							2
	Water Penny				- A de la Color			
Sub-Total			C1	34	778-11-0	D1	7	
	Alderfly Larva							
Category 2	Aquatic Beetle							
18	Aquatic Sowbug							2
	Clam, Mussel							
	Cranefly Larva	2		2	2		1	
	Crayfish			1			1	
Somewhat	Damselfly Larva			1:	5		1	
Tolerant	Dragonfly Larva							
	Fishfly Larva							
	Amphipod (freshwater s	hrimp)						
	Watersnipe Larva				-			
Sub-Total			C2	18		D2	3	
	Aquatic Worm (oligocha	ete)		2	0		1	
Category 3	Blackfly Larva				1			
41 ⁶⁴	Leech							
	Midge Larva (chironomi	d)		2	4		1	2
Dellection	Planarian (flatworm)							
Tolerant	Pouch and Pond Snails				19			
	True Bug Adult							
	Water Mite		11 - H					
Sub-Total			C3	44		D3 2		
TOTAL			СТ	96		DT	12	

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDAN	CE: Tota	al number of or	ganisms from cell CT:				S1
DENSITY:	Inverte	brate density p	per total area sampled:				90 S2
	S1	96	÷	0.18	'm²	=	533/ m ²
PREDOMIN	IANT T/	AXON:		S3	31		e
Invertebrate	aroup v	with the highes	t number counted (Col. C)		М	idge Lar	rva (chironomid)

SECTION 2 - WATER QUALITY ASSESSMENTS

EPT4 + EPT5 + EPT6

3+ 2+2 =

(EPT1 + EPT2 + EPT3) / CT

(10+12 +12) / 96=

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 7+ 2 x 3+ 2 =	2

EPT INDEX: Total number of EPT taxa.

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

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

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

SECTION 3 - DIVERSITY

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

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	24/96 =	0.25

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 Index	4
EPT Index	3
EPT To Total Ratio	2
Predominant Taxon Ratio	4

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

	0.25	
_	0.35	
	2	

7

29

S5

S6

S7		
	12	

INVERTE	BRATE SURVEY	FIELD	DATA SH	IEET (Pa	ige 1 of	2)
Stream Name:	Holland	Date:	31-Oct-12			
Station Name:	Site 3				Medium	
Sampler Used:	Number of replicates	Total area sa	ampled (Hess	s, Surber = 0.	.09 m²) x n	o. replicates
	2				0.18 m ²	
Column A	Column B		Column C			
Pollution Tolerance	Common Nan	ne		Counted	Number of Taxa	
	Caddisfly Larva (EPT)					2
Category 1	Mayfly Nymph (EPT)		EP12 20		EPIS	3
	Stonefly Nymph (EPT)		EP13 13		EPI6	2
	Dobsonfly (hellgrammit	e)				
Pollution	Gilled Snail					
Intolerant	Riffle Beetle					
	Water Penny					
Sub-Total			C1 36		D1 7	
	Alderfly Larva					
Category 2	Aquatic Beetle					
	Aquatic Sowbug					
	Clam, Mussel					
	Cranefly Larva		Ę	5		1
	Crayfish					
Somewhat	Damselfly Larva		1	4		1
Tolerant	Dragonfly Larva					
	Fishfly Larva					
	Amphipod (freshwater s	shrimp)				
	Watersnipe Larva					
Sub-Total			C2 19		D2 2	
	Aquatic Worm (oligoch	aete)	2	5		2
Category 3	Blackfly Larva		3			1
	Leech					
	Midge Larva (chironomid)		20			1
	Planarian (flatworm)					
Pollution	Pouch and Pond Snails					
TOTETAIL	True Bug Adult					
	Water Mite					
Sub-Total			C3 48		D3	4
TOTAL			CT 103		DT 13	

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)									
SECTION 1 - ABUNDANCE AND DENSITY									
ABUNDANC	E: Total num	ber of organis	sms from cell	CT:			S1		
	Invertebrate	doncity por t	tal area cam	nlod			103		
DENSITT.	S1 1	03	Jiai alea Salii	pieu.			S2		
			<u>.</u>		0.18 m^2	=		$572/m^2$	
					0.10 111			572/111	
PREDOMIN	ANT TAXON	•			S3				
Invertebrate	group with the	e highest nur	nber counted	(Col. C)		Aquatic Wor	m (oligochae	ete)	
		SECT	ION 2 - WAT			INTS			
			ub-total numb	er of taxa fou	nd in each to	lerance cater	10rv		
Good	Acceptable	Marginal	Poor	3 x	D1 + 2 x D2 +	D3	S4		
> 22	17.00	11 16	-11						
>22	17-22	11-10	<11	31	x 7+ 2 x2 +4	=	29		
EPT INDEX:	Total numbe	er of EPT taxa	a.				05		
Good	Acceptable	Marginal	Poor	EP	14 + EP15 + EP	S5			
>8	5-8	2-4	0-1		2+ 3+ 2 =		7		
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	(9+20 + 13) /103=		0.35			
			SECTI	ON 3 - DIVE	SITY				
							S7		
TOTAL NUN	IBER OF TA	XA: Total nui	mber of taxa						
							13		
PREDOMIN	ANT TAXON	RATIO INDE	X: Number o	f invertebrate	in the predo	minant taxo	n (S3) divide	d by CT.	
Good	Acceptable	Marginal	Poor		ol. C for S3 / C		58		
<0.40	0.40-0.59	0.60-0.79	0.80-1.0	25/ 103=			0.24		
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.									
Assessme	ent Rating		Assessment	:	Rating		Average	Rating	
Good	4		Pollution Tol	erance Index	4		Average of R	4, R5, R6, R8	
Acceptable	3		EPT Index		3				
Marginal	2		EPT To Tota	l Ratio	2		3 25		
Poor	1		Predominant	Taxon Ratio	4		0.20		

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name:	eam Name: Holland Creek					Date: Oct. 31, 2012			
Station Name:	Sta		Flow status: Medium						
Sampler Used: Hess	Number of replicates 2	Total area :	sampled (Hess, Surber = 0).09 m²) >	k no. replicates 0.18 'm²			
Column A	Column B			Column C		Column D			
Pollution Tolerance	Common Nar	ne	Nur	nber Counted	Nu	Number of Taxa			
	Caddisfly Larva (EPT)		EPT1	7	EPT4	2			
Category 1	Mayfly Nymph (EPT)	EPT2	15	EPT5	2				
8	Stonefly Nymph (EPT)		EPT3	26	EPT6	3			
	Dobsonfly (hellgrammite	e)							
Pollution	Gilled Snail								
Intolerant	Riffle Beetle								
	Water Penny					5 ¹⁰ 3			
Sub-Total			C1	48	D1	7			
	Alderfly Larva								
Category 2	Aquatic Beetle								
	Aquatic Sowbug								
	Clam, Mussel								
	Cranefly Larva		5		1				
	Crayfish								
Somewhat	Damselfly Larva			1		1			
Tolerant	Dragonfly Larva			5					
100 States Presidenti States Presidenti 100 States Presidenti States Presidenti	Fishfly Larva			2					
	Amphipod (freshwater s	shrimp)							
	Watersnipe Larva								
Sub-Total	-		C2	6	D2	2			
	Aquatic Worm (oligochaete)			39		2			
Category 3	Blackfly Larva			2		1			
	Leech					10 KK			
	Midge Larva (chironomi	d)		36		1			
	Planarian (flatworm)								
Tolerant	Pouch and Pond Snails								
	True Bug Adult	9		· · ·					
	Water Mite								
Sub-Total			C3	77	D3	4			
TOTAL			СТ	131	DT	13			

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

APUNDANCE: Total number of organisms from cell CT								
ADONDANO		our or organie		.			ŭ 131	
DENSITY:	Invertebrate density per total area sampled:							
	131		÷	0.18 'm ²		=	s2 727 / m ²	
							5. 	
PREDOMIN	ANT TAXON:				\$3			
Invertebrate group with the highest number counted (Col. C) 'Aquatic V							orm (oligochaete)	
		SEC	TION 2 - WAT	TER QUALITY	ASSESSME	NTS		
POLLUTION	I TOLERANC	E INDEX: Su	b-total numbe	er of taxa found	d in each tole	rance catego	ory.	
Good	Acceptable	Marginal	Poor	3 x	D1 + 2 x D2 + D	03	S4	
>22	17-22	11-16	<11	3 x 7	+ 2 x 2 +	- 4 =	29	
							e en	
EPT INDEX:	Total number	r of EPT taxa						
Good	Acceptable	Marginal	Poor	EP.	T4 + EPT5 + EP	Т6	S5	
>8	5-8	2-4	0-1		2 + 2+ 3 =		7	
EPT TO TO	TAL RATIO IN	NDEX: Total	number of EP	T organisms d	ivided by the	total numbe	r 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	(7+	15 + 26) /13	1=	0.37	
			SECT	ION 3 - DIVER	SITY			
TOTAL NUM	BER OF TA	XA: Total nur	nber of taxa fr	rom cell DT :			S7	
	<i>IX</i>						13	
PREDOMIN	ANT TAXON	RATIO INDE	X: Number of	invertebrate ir	n the predom	inant taxon	(S3) divided by CT.	
Good	Acceptable	Marginal	Poor	c	col. C for S3 / CT		S8	
<0.40	0.40-0.59	0.60-0.79	0.80-1.0		39 / 131=		0.29	
		E						
		SECTIO	ON 4 - OVER	ALL SITE ASS	SESSMENT R	ATING		
SITE ASSES	SMENT RAT	ING: Assian	a rating of 1-4	4 to each index	(S4, S5, S6,	S8), then c	alculate the average.	
Assessm	ent Rating	l	Assessmen	t	Rating		Average Rating	
Good	4		Pollution Tol	erance Index	4		Average of R4, R5, R6, R8	
Acceptable	3		EPT Index		3		3.25	
Marginal	2		EPT To Tota	I Ratio	2	SI.	0.20	
Poor	1		Predominant	t Taxon Ratio	4			