Water Quality and Stream Invertebrate Assessment for the Millstone River Project Proposal

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EXECUTIVE SUMMARY (Taylor)

The Millstone is used for recreational activities, education and by Coho salmon for spawning grounds so its health is of the utmost importance. The purpose of this field study was to collect data, analyse the data and use the results to assess the overall health of the Millstone watershed. This field study on the Millstone River was conducted in the fall of 2020, samples were taken over two collection days, the 28th of October, and the 17th of November. The reason for this was to collect data during low flow and high flow days to get the most accurate analysis of overall stream health. As the water levels change drastically as rainfall and run off comes into the water system. It was found that data collected on each sampling day was slightly different, but what was drastically different was our lab results in comparison to the results ALS lab found. It was determined that having lesser quality equipment and less experience performing these testing procedures was a factor in this large difference. Because of this the research group decided to rely more heavily on the ALS data when concluding the results. The group concluded that the Millstone River is moderately healthy as an ecosystem. Within the collection of data, our group could not take samples from certain sites due to safety concerns when it was on high flow days. The data did show that at specific test sites conductivity and Ph was higher and invertebrate types yielded more aquatic worms. This was representative of mild pollution present.

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INTRODUCTION (John)

An environmental monitoring survey was conducted where water quality and invertebrate assessment was tested on the Millstone River. The Survey and assessment were conducted by 3 Bachelors of Natural Resource Protection students from Vancouver Island University. The Millstone River survey was conducted to gather data and analyze water quality, and invertebrate sampling to determine overall health of all five sites.

Some background information and history of the Millstone River. The Millstone River is located in Nanaimo BC, The Millstone River is the most urbanized major watershed in region 5. Overall, the Millstone River has a total elevation gain of 75 meters. The river originates from just west of Mount Benson and Lucid Lake and flows to the Nanaimo harbour. The river consists of 16 tributaries, and 8 lakes such as Westwood lake, McGarrigle Creek and Divers Lake. The Millstone River is 14km in length. The most well-known area of the Millstone River runs through a 36-hectare municipal park in Nanaimo BC called Bowen Park. The watershed covers an area of approximately 100 square kilometers. Within Region 5 (Nanoose to South Wellington) there are four major watersheds. The first is Nanoose Creek, the second major watershed is Bonell Creek, the third is the Chase River and the final major watershed is the Millstone River (Nanaimo, 2008).

In 2007, a collaboration with multiple funding partners and stewardship partners, a side channel was constructed to allow coho salmon, rainbow trout, and cutthroat trout to pass Deadman Falls. This barrier was impassable for the coho until the side channel was built. The general construction took 4 months to complete; the side channel stretches 800 meters past the main waterfall in Bowen park. The stream had gravel substrate and cobble added to the stream in certain sections to increase the roughness and improve fish migration. This allows the spawning coho to make their way up the watershed with ease. There were also multiple stumps and fallen logs added to low gradient areas of the Millstone River to create cover for spawning salmon.

The Millstone River not only offers a viable spawning habitat for coho salmon but also offers the general public many benefits such as recreational benefits, educational benefits, economic benefits, and community benefits. Throughout Bowen park, the side channel also offers interpretive signs along the trail that provide education about the salmon and other wildlife to the general public. This is a great example of a community and educational benefit (Nanaimo, 2008).

Figure 1 - Google Map of Millstone River Sites 1-5

METHODS (Derek)

Sampling Program

Locations and Habitat Characteristics

The Millstone River and its tributaries has been monitored by the RMOT 306 class at Vancouver Island University every fall since 2008. Each year students have sampled basic hydrology, water quality, microbiology, and invertebrates at the same five locations. In order to ensure consistency, we also performed our sampling at those same five locations which allowed data to be compared to previous years in order to measure the health of the river, and whether it is improving, declining, or remaining consistent.

The five locations are easily accessible and propose no significant safety issues. Each site also offers a variety of riparian vegetation and land use, from farming to park land to urban areas. This allows for a broader overall view of the health of the river. Note that from 2008 through 2015 a sixth site was monitored at the Pryde Vista Golf Course, but it was removed from the testing schedule in 2016 for unknown reasons. In order to remain consistent, we will did not monitor this site.

The five sites that we will be monitored are as follows. The locations can be seen marked on the map in Figure 1.


Figure 2 - Site 1 location

Site 1: Benson Creek, which flows into Brannen Lake from the south west, and is a tributary of the Millstone River. The testing location is on the south side of the bridge on Biggs Road where it crosses Benson Creek, next to the parking lot of Camp Caillet. The site has a dense riparian area but is quite close to the campground and agricultural areas. The water here is relatively shallow and slow moving.


Figure 3 - Site 2 location

Site 2: Millstone River just south east of Brannen Lake, also on Biggs Road where it crosses the river. The sampling site is just north of the bridge, less than a kilometer east of site 1. This site is surrounded on all sides by agricultural areas, but again has a dense riparian area. The water is again shallow, but with a stronger currant.


Figure 4 - Site 3 location

Site 3: Millstone River at the junction of Maxey Road and Durnin Road on the southwest side of the bridge crossing. This area is rural residential with private yards on either side of the river. Again, this allows for a dense riparian area. The water here is deeper than either of the two previous sites. Upstream it is flowing quite fast, but in our sampling site it is relatively slow.


Figure 5 - Site 4 location

Site 4: Millstone River, located inside Bowen Park at the downstream outlet of the duck pond in the side channel. The easiest area to access, the side channel, as discussed in the introduction, is used for salmon spawning and therefore of particular interest to the study. Very shallow, but somewhat swift, water running out of the duck pond. Good riparian coverage, by design.


Figure 6 - Site 5 location

Site 5: Millstone River, at the end of Barsby Avenue. This area has seen the most changes since 2008 as it used to be undeveloped by now there are multiple apartment buildings and condos being built. The construction is still ongoing but will not provide any obstacles to accessing the site. Also, due to an increased homeless presence in Nanaimo it is possible to encounter refuse, human waste, or drug paraphernalia in the area and therefore caution must be taken. This is the widest, deepest, and fastest area of the river included in the study. The riparian area is still quite dense at the test site, which is located just east of the footbridge at the end of the street leading into Barsby Park.

Sampling Frequency

We sampled each location twice for this project. The first test was conducted on October 28, 2020. The second was on November 17, 2020. Basic hydrology was measured at all five sites on October 28 and again on November 17. However, due to safety concerns some aspects were not measured on the second visit. See below for more details. Stream invertebrates were measured at sites 1, 2, and 4 on October 28 and at sites 3 and 4 on November 17 via a Hess sampler. Microbiology was not be measured at VIU this year due to COVID-19 safety protocols in the laboratory. Samples were also sent to the ALS lab for analysis from sites 1, 2, and 4 for October 28 and from sites 3, 4, and 5 for November 17.

Basic Hydrology

Basic hydrology was measured at all sites and included the following data: full bank width, wetted width, velocity, crown canopy, percent cover, dominant cover, water depth, and substrate type. Average water velocity was measured over a distance of 5m three times. Wetted depths were measured at 25%, 50%, and 75% of the wetted width. Due to safety concerns, depths and velocity were not measured on November 17.

Water Quality

Field Measurements

The following measurements were made in the field using a YSI electronic probe, provided by VIU: water temperature (^{o}C) and dissolved oxygen (mg/L).

Water Sample Collection

For tests that required water samples to be collected in the field and then transported to either the VIU or ALS lab for analysis the sample was collected as near to the center of the river as safely possible. To ensure no contamination the following steps were taken: the sample collector was wearing latex or nitrile gloves; the samples were taken from below the surface of the water; when multiple samples were collected from the same site, the collector started downstream and moved upstream with each consecutive sample; sample bottles were rinsed three times before the final sample was collected. Once all samples were collected, they were transported to VIU in a cooler packed with ice.

VIU Laboratory Analyses

The laboratory in building 370 room 204 on the VIU campus was used to analyze the water quality tests that could not be performed in the field. Measurements taken in the lab included: pH, conductivity (µs/cm), turbidity (NTU), total alkalinity (mg/L as $CaCO_3$), hardness (mg/L as $CaCO_3$), nitrate (mg/L NO_3) and phosphorus (mg/L PO_4^{3-}). We were unable to test phosphorus for Site 1 on October 28 as the test sample was contaminated before the test could be conducted. The full results are found in appendix 2.

ALS Laboratory Analyses

Three samples were sent to the ALS laboratory in Vancouver, BC for each testing day. The samples were shipped by VIU in a Styrofoam cooler containing ice to maintain integrity. The samples arrived within 48 hours of being taken. Tests performed measured the conductivity, hardness, pH, anions, nutrients, and total metals. The samples sent to ALS were from the same sites as the samples tested VIU in order to compare results.

Quality Assurance / Quality Control

To ensure accurate results, samples were taken from the same locations for both VIU and ALS lab analysis. As noted previously, to ensure no contamination the following steps were taken: the sample collector was wearing latex or nitrile gloves; the samples were taken from below the surface of the water; when multiple samples were being collected from the same site, the collector started downstream and moved upstream with each consecutive sample; sample bottles were rinsed three times before the final sample was collected.

A field blank (distilled water) to ensure no environmental contamination affects test results was taken from the lab on both days. On October 28, testing revealed no issues with the field blank. However, on November 17 it was discovered that a possible issue occurred during the phosphorus testing of the distilled water. It is suspected that the sample bottle was not fully cleaned before being filled with the distilled water. No issues were detected during any other tests using the distilled water.

Microbiology

Due to COVID-19 restrictions around the lab, microbiology was not tested this year.

Stream Invertebrate Communities

Stream invertebrate samples were gathered in the field and analyzed at the VIU lab. The information gathered will provide information on the overall health of the river ecosystem. The sites were selected based on the water levels at time of sampling in order to ensure both safety as well as proper sample gathering.

Invertebrate Sample Collection

Invertebrates were gathered using a standard Hess sampler. Triplicate samples were collected at each sampling site on October 28 while duplicate samples were taken on November 17. Samples were stored in labelled jars, with as much debris as possible removed and ethanol added before sealing to be transported to the lab. Samples were collected from sites 1, 2, and 4 on October 28 and from sites 3 and 4 on November 17.

VIU Laboratory Analyses

In the VIU laboratory the samples were counted under a dissecting microscope using identification keys and recorded on Pacific Streamkeepers' data sheets. All team members took part in the sample counting.

Quality Assurance

As stated above, to ensure no contamination the following steps were taken: the sample collector was wearing latex or nitrile gloves; the samples were taken from below the surface of the water; when multiple samples were being collected from the same site, the collector started downstream and moved upstream with each consecutive sample; sample bottles were rinsed three times before the final sample was collected.

RESULTS AND DISCUSSION (Derek)

Basic Hydrology

Aspects such as full bank width, crown canopy, and substrate remained consistent at each site between the first and second visits. Due to a large amount of rainfall in the days leading up to the second visit, the wetted width, depth, and velocity all changed. As mentioned above, safety concerns prevented us from measuring depth and velocity on November 17, but we were able to measure the change in wetted width at all sites. The following table demonstrates how this measurement changed. The full results are located in appendix 1.

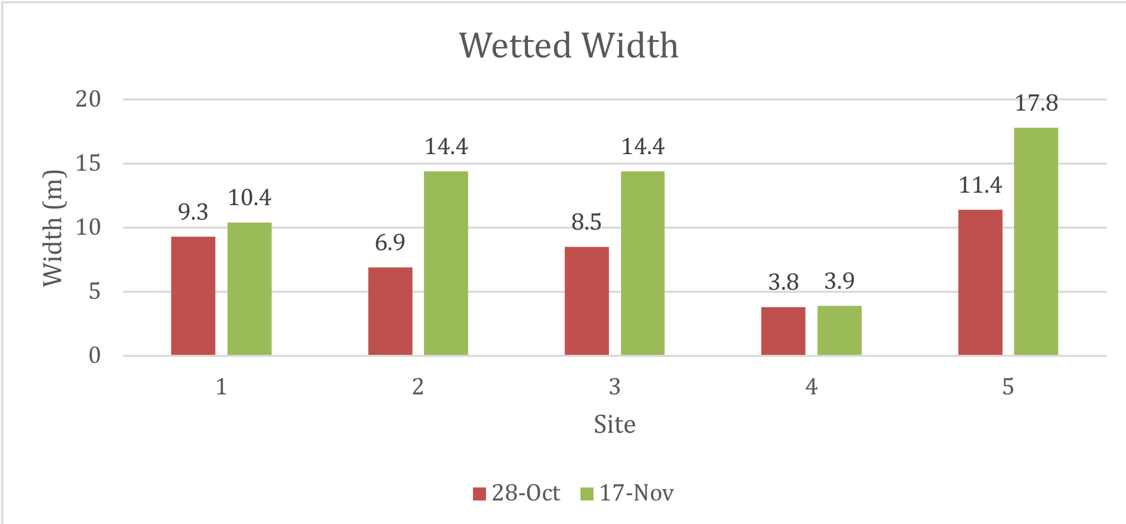

Figure 7 - Wetted width for all sites over both visits

Water Quality

Field Measurements

Temperature

The temperature at four out of five sites was significantly lower on November 17 than it was on October 28 after the large rainfall events of the previous days. Site 1 recorded a higher temperature on November 17. This outlier could be due to user error and not waiting long enough for the measurement to stabilize.

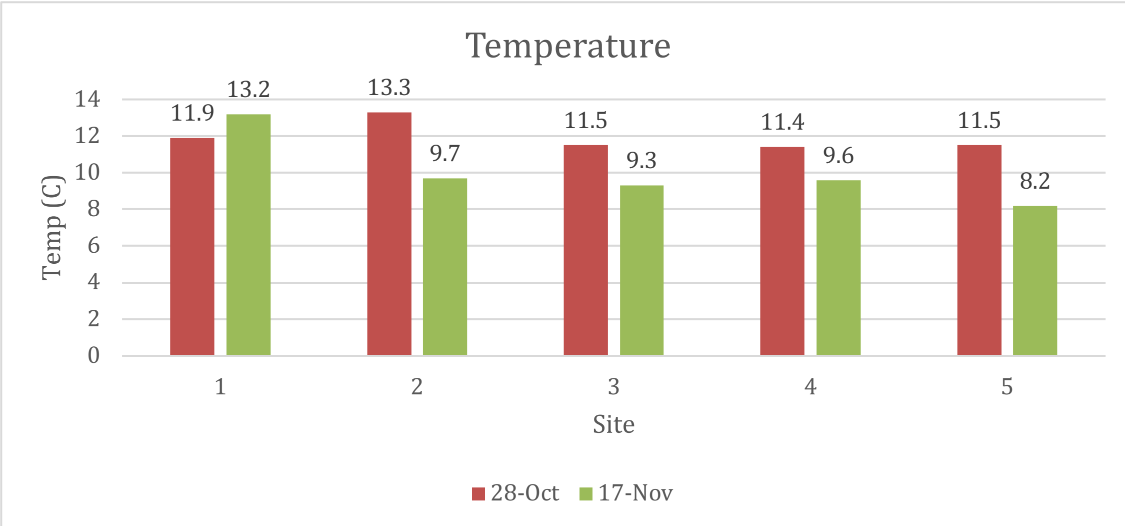

Figure 8 - Temperature for all sites over both visits

Dissolved Oxygen

Dissolved oxygen remained consistent between the two sampling dates and did not appear to be affected by the increased flow after the rain events.

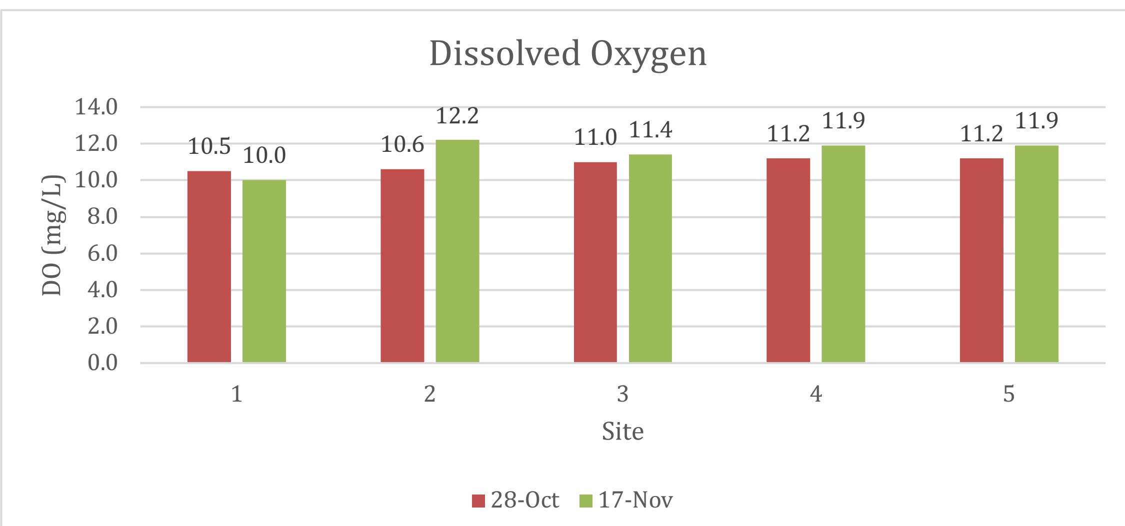

Figure 9 - Dissolved oxygen for all sites over both visits

Laboratory Analyses Results Comparison

The following charts compare the results of the VIU analysis to the ALS analysis for all metrics measured by both labs. This comparison shows the difference in accuracy between a professional laboratory with highly experienced staff and sophisticated equipment and a team of students who are still learning. While some measurements were quite close, others are very different. Therefore, when comparing the results to the Guidelines for Interpreting Water Quality Data we will be using the ALS test results as it is to be assumed that they are more accurate. The full ALS results can be found in appendix 3.

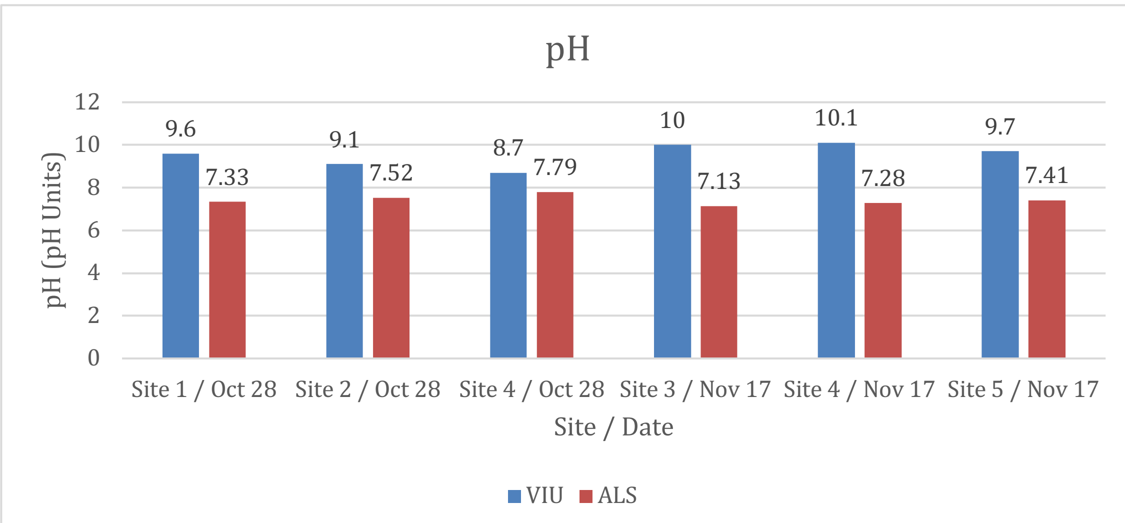

Figure 10 - Comparison of results from VIU and ALS for pH

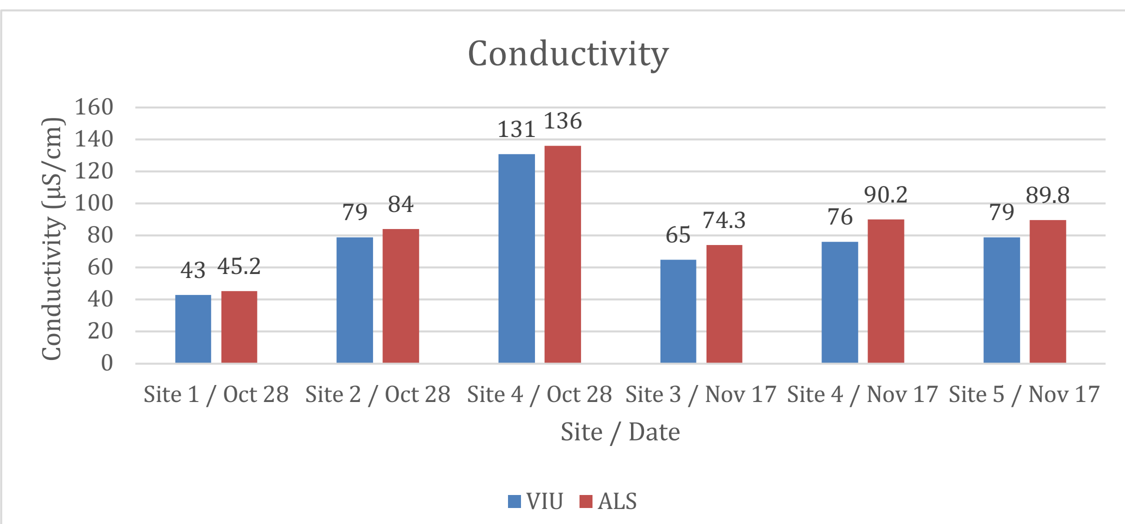

Figure 11 - Comparison of results from VIU and ALS for conductivity

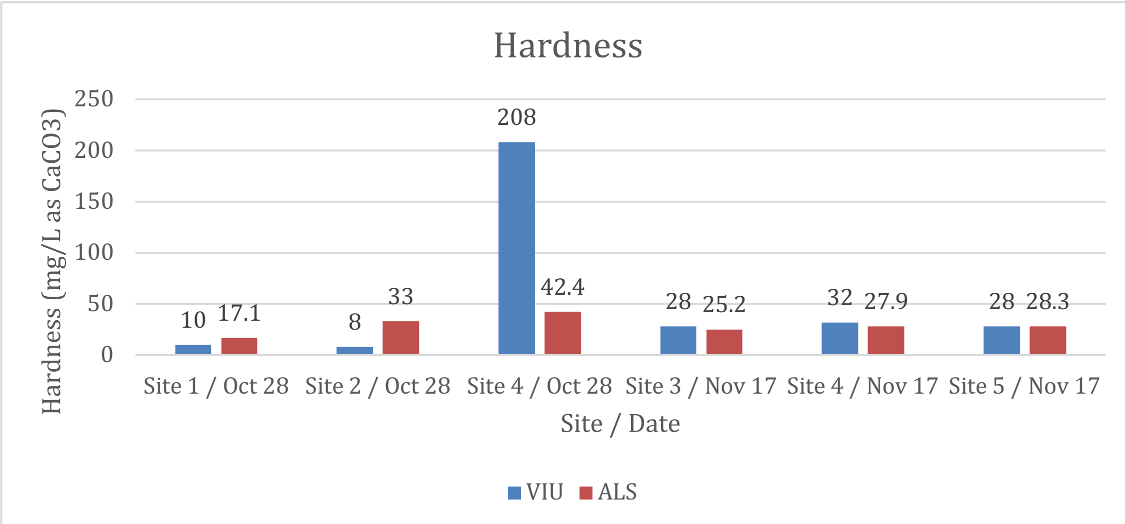

Figure 12 - Comparison of results from VIU and ALS for hardness

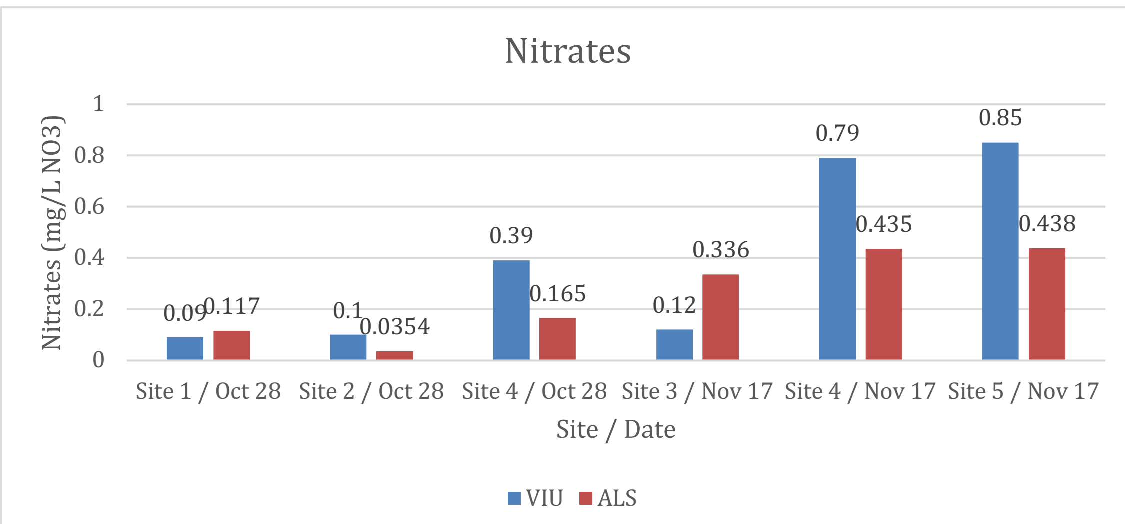

Figure 13 - Comparison of results from VIU and ALS for nitrates

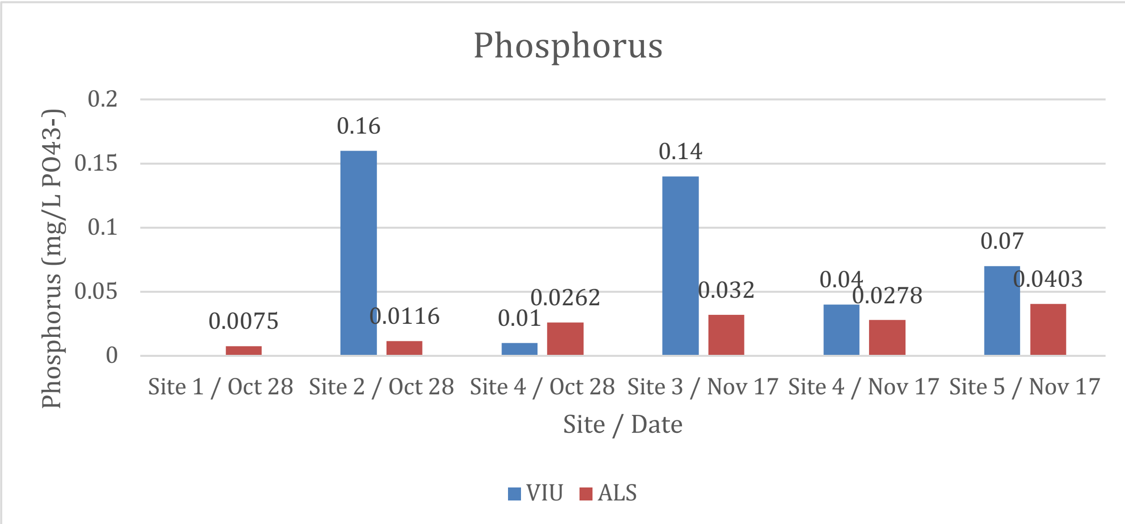

Figure 14 - Comparison of results from VIU and ALS for phosphorus

Comparison to Guidelines

The following is a comparison of the results of the tests performed at ALS to the Guidelines for Interpreting Water Quality Data (Ministry 1998) in order to study the health of the river. For any measurements in which ALS results are available we are using them as it is assumed to be more accurate as it was done by professionals as compared to the results obtained by VIU students who are just learning the process. Only analytes with measurable guidelines are observed. Any analytes in which the results were below detectable levels are also omitted.

Table 1 - Comparison of ALS results to guidelines for October 28

Analyte	***Units***	***Site 1***	***Site 2***	***Site 4***	***Guidelines***	***Observations***
Temperature	ºC	11.9	13.3	11.4	8-19	within guidelines
pH	pH units	7.33	7.52	7.79	6.5 – 9.0	within guidelines
Dissolved Oxygen	mg/L	10.5	10.6	11.2	9-11	within guidelines
nitrate (as N)	mg/L	0.117	0.0354	0.165	<200	within guidelines
phosphorus, total	mg/L	0.0075	0.0116	0.0262	0.005 – 0.015	site 4 exceeds guidelines
aluminum, total	mg/L	0.0492	0.0698	0.134	<0.1	site 4 exceed guidelines
copper, total	mg/L	0.00101	0.00088	0.00116	<0.002 (at <50 mg/L hardness)	within guideliness

Table 2 - Comparison of ALS results to guidelines for November 17

Analyte	*Units*	*Site 3*	*Site 4*	*Site 5*	*Guidelines*	*Observations*
Temperature	ºC	9.3	9.6	8.2	8-19	within guidelines
pH	pH units	7.13	7.28	7.41	6.5 – 9.0	within guidelines
Dissolved Oxygen	mg/L	11.4	11.9	11.9	9-11	exceeds guidelines
nitrate (as N)	mg/L	0.336	0.435	0.438	<200	within guidelines
phosphorus, total	mg/L	0.0320	0.0278	0.0403	0.005 – 0.015	exceeds guidelines
aluminum, total	mg/L	0.640	0.520	0.939	<0.1	exceeds guidelines
cadmium, total	mg/L	0.0000057	0.0000052	0.0000124	<0.00002 at 30 mg/L hardness	within guidelines
copper, total	mg/L	0.00209	0.00198	0.00270	<0.002 (at <50 mg/L hardness)	exceeds guidelines

Based on the above observations, the rainfall event of the days preceding the November 17 collection had an impact on many aspects of the Millstone River. Specifically, the amount of some metals increased to the point that they rose above the recommended guidelines. AS well, both temperature and dissolved oxygen were affected by the deeper and faster moving waters.

Stream Invertebrates

Data Analyses

Multiple metrics are used to analyze the health of the stream based on invertebrates. Calculations were made to determine: the abundance and density of invertebrates; the predominant taxon; water quality assessments based on the pollution tolerance index, EPT index, and EPT to total ratio index; diversity based on the total number of taxa and the predominant taxon ratio index; and an overall site assessment rating based on the above calculations. As well, the Shannon-Wiener Diversity Index was calculated in order to estimate the health of the ecosystem. This index measures the uncertainty in predicting the taxa in which a randomly selected invertebrate will belong to. The higher the value, the higher the uncertainty which indicates that there is a large diversity. A smaller number, meaning it is more certain to predict which taxa the individual belongs to, indicates fewer taxa. The following tables and graphs summarize these findings. The full data and interpretation sheets are found in appendix 4. The Shannon-Weiner Diversity Index tables are in appendix 5.

Table 3 - Abundance and density of stream invertebrates for all samples

		SECTION 1 - ABUNDANCE AND DENSITY	
SITE	**PREDOMINANT TAXON**	**ABUNDANCE**	**DENSITY**
Site 1 / Oct 28	Caddisfly Larva (EPT)	56	207.407
Site 2 / Oct 28	Aquatic Worm (oligochaete)	51	188.889
Site 4a / Oct 28	Mayfly Nymph (EPT)	101	374.074
Site 3 / Nov 17	Aquatic Worm (oligochaete)	258	1433.333
Site 4b / Nov 17	Mayfly Nymph (EPT)	145	805.556

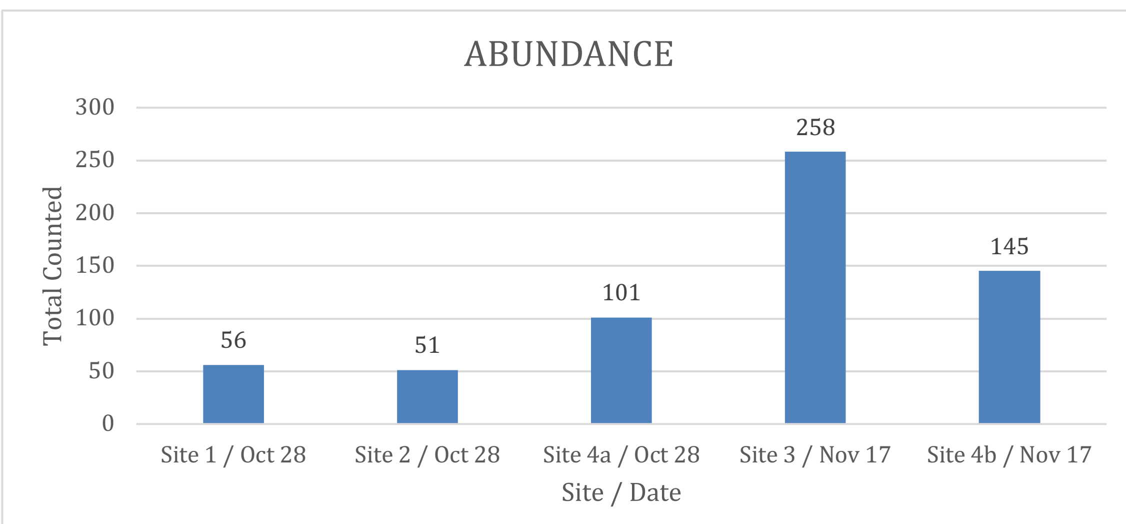

Figure 15 - Abundance of stream invertebrates for all samples

Table 4 - Water quality assessments of stream invertebrates for all samples

SITE	SECTION 2 - WATER QUALITY ASSESSMENTS		
	POLLUTION TOLERANCE INDEX	EPT INDEX	EPT TO TOTAL RATIO INDEX
Site 1 / Oct 28	17	4	0.643
Site 2 / Oct 28	14	1	0.333
Site 4a / Oct 28	13	3	0.634
Site 3 / Nov 17	21	3	0.465
Site 4b / Nov 17	18	4	0.586

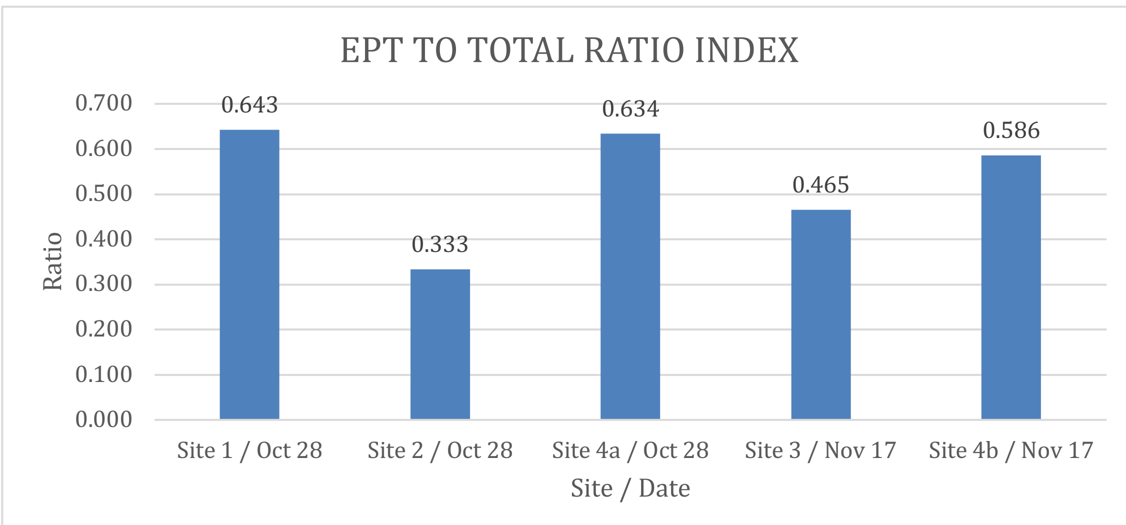

Figure 16 - EPT to total ratio of stream invertebrates for all samples

Table 5 - Diversity of stream invertebrates for all samples

SITE	SECTION 3 - DIVERSITY	
	TOTAL NUMBER OF TAXA	PREDOMINANT TAXON RATIO INDEX
Site 1 / Oct 28	9	0.357
Site 2 / Oct 28	7	0.353
Site 4a / Oct 28	6	0.495
Site 3 / Nov 17	11	0.419
Site 4b / Nov 17	8	0.441

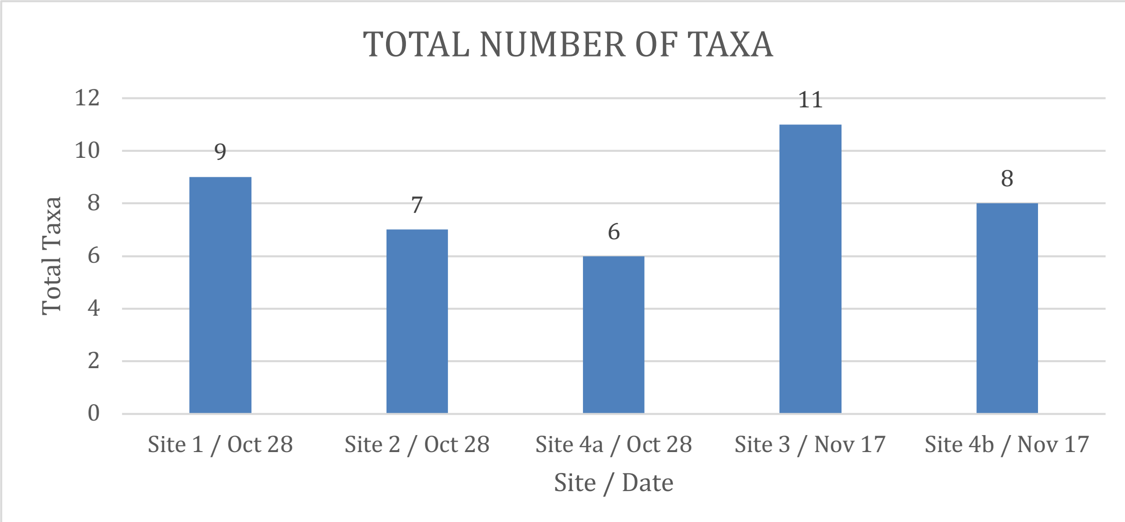

Figure 17 - Total number of taxa of stream invertebrates for all samples

Table 6 - Overall site assessment rating of stream invertebrates for all samples

SITE	SECTION 4 - OVERALL SITE ASSESSMENT RATING				
	POLLUTION TOLERANCE INDEX	EPT INDEX	EPT TO TOTAL RATIO INDEX	PREDOMINANT TAXON RATIO INDEX	AVERGAE RATING
Site 1 / Oct 28	3	2	3	4	3
Site 2 / Oct 28	2	1	2	4	2.25
Site 4a / Oct 28	2	2	3	3	2.5
Site 3 / Nov 17	3	2	2	3	2.5
Site 4b / Nov 17	3	2	3	3	2.75

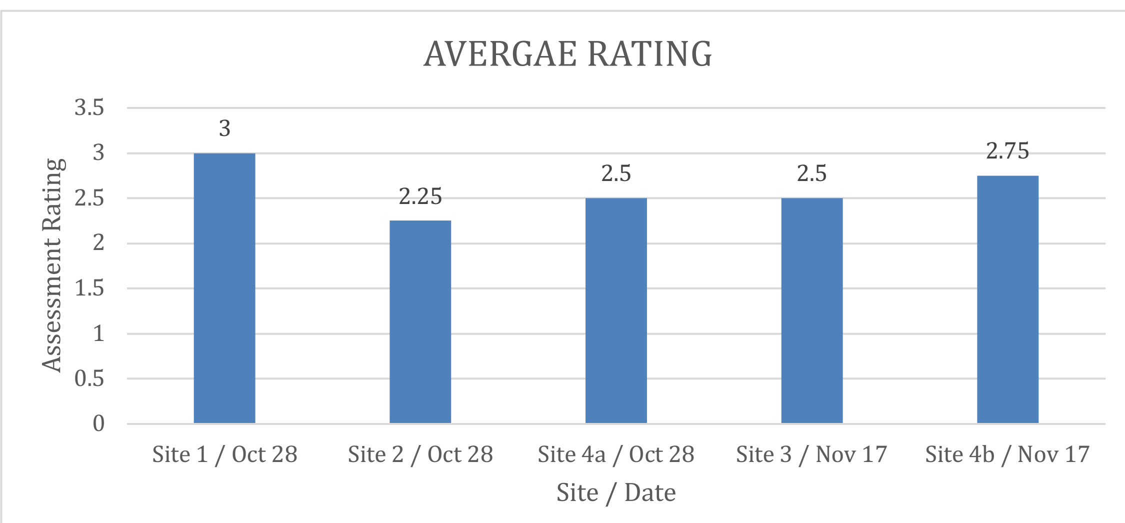

Figure 18 - Average site assessment rating of stream invertebrates for all samples

Table 7 - Shannon-Weiner Diversity Index of stream invertebrates for all samples

SITE	SHANNON-WEINER DIVERSITY INDEX
Site 1 / Oct 28	0.841
Site 2 / Oct 28	0.642
Site 4a / Oct 28	0.826
Site 3 / Nov 17	0.756
Site 4b / Nov 17	0.726

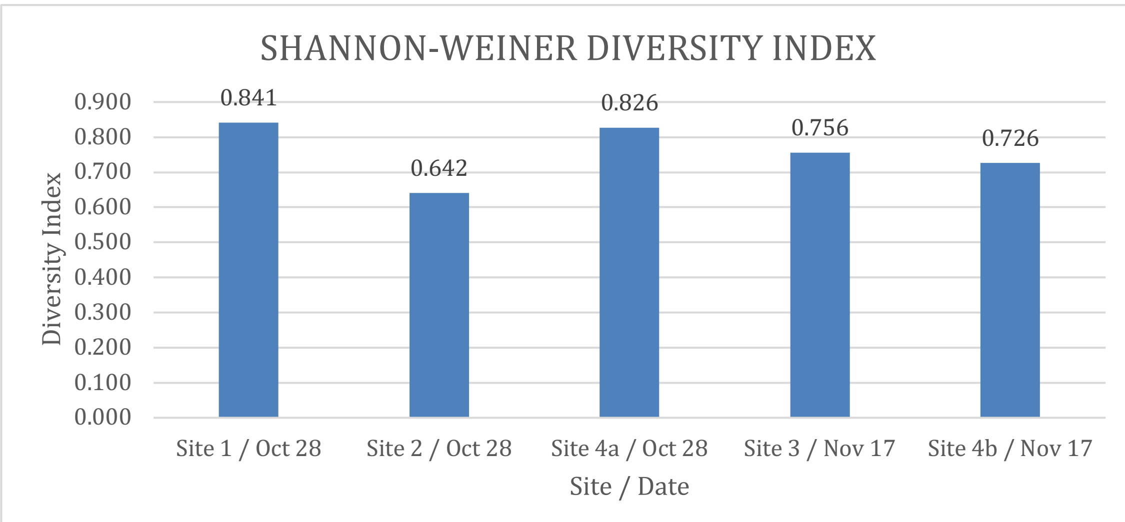

Figure 19 - Shannon-Weiner Diversity Index of stream invertebrates for all samples

Based on the results of the stream invertebrate analysis and calculations, the overall site assessment rating is moderate to acceptable. When we look at the Shannon-Weiner Diversity Index it shows that a randomly selected individual will be unpredictable 72-84% of the time, with one outlier of 64%, which indicates a high level of diversity.

CONCLUSION AND RECOMMENDATION (John)

Overall, the Millstone River is a moderately healthy system. The results from ALS as well as our group results for water quality indicate a healthy river. However, there is one site that tested unusually high for both conductivity and inverts sampling. The Hess sampler results indicate a high level of pollution present in the water. Site #4 was the only notable site that had significant differences in both invert and water samples. Our group collected well over 200 aquatic worms at site #4. It was discussed in our group that this large number of aquatic worms is due to a pollutant nearby or run off from a nearby duck pond. Furthermore, the conductivity results of site #4 came back very high. The conductivity as well as the ALS results for minerals and metals indicate that the stream health at site #4 is poor. The group concluded that the overall environmental health of the Millstone River is moderately to very healthy.

There are two recommendations that our group came up with for future stream surveys. As a group we discussed that our group had some unfortunate time constraints. All three members of the group work part time, this makes it somewhat difficult to keep a consistent sampling time. Some of the designated days our group would be testing and collecting samples near the afternoon and evening. It would be interesting to consider the possibility of having a uniform and standardized sampling time, location, and methods used. For example, if the MIllstone River survey becomes uniform across the board from sampling locations, sampling times IE only sample in the evening or morning.

The last recommendation would be to somehow address the significant difference in the VIU and ALS samples. As ALS is a very reputable company our groups numbers and data in comparison to ALS are significantly different. Some samples we tested back at VIU compared to those that are tested at ALS came back with a staggering difference in some categories. Therefore, somehow making the VIU samples more accurate or closer the ALS results would be ideal for future groups. The group concluded that the differences from ALS results are due to several factors such as contamination, provided testing equipment is not as accurate as ALS, and mishandling of water samples.

REFERENCES

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Nanaimo, City of. (2008). Millstone River side-channel. <https://www.civicinfo.bc.ca/practices_innovations/nanaimo_ubcm_lib2> Accessed October 20, 2020.

APPENDICES

Appendix 1 – Basic Hydrology

Site 1

Bankfull Channel Width	10.4 m
Wetted Width (Oct 28)	9.3 m
Wetted Width (Nov 17)	10.4 m
Wetted Depths (Oct 28)	0.28 m, 0.68 m, 0.50 m
Wetted Depths (Nov 17)	n/a
Avg. Velocity (Oct 28)	0.2 m/s
Avg. Velocity (Nov 17)	n/a
Riparian Land Use (L)	Residential
Vegetation Type (L)	Bush
Vegetation Depth (L)	2 m
Riparian Land Use (R)	Residential
Vegetation Type (R)	Deciduous
Vegetation Depth (R)	10+ m
Substrate Fines	45%
Substrate Gravel	10%
Substrate Cobble	5%
Substrate Boulders	40%
Substrate Bedrock	0%
Instream Cover	8%
Instream Cover Composition	Boulders
Canopy Cover	10%

Site 2

Bankfull Channel Width	7.5 m
Wetted Width (Oct 28)	6.9 m
Wetted Width (Nov 17)	14.4 m
Wetted Depths (Oct 28)	0.07 m, 0.08 m, 0.04 m
Wetted Depths (Nov 17)	n/a
Avg. Velocity (Oct 28)	n/a
Avg. Velocity (Nov 17)	n/a
Riparian Land Use (L)	Agricultural
Vegetation Type (L)	Deciduous
Vegetation Depth (L)	5 m
Riparian Land Use (R)	Agricultural
Vegetation Type (R)	Deciduous
Vegetation Depth (R)	5 m
Substrate Fines	20%

Substrate Gravel	30%
Substrate Cobble	50%
Substrate Boulders	0%
Substrate Bedrock	0%
Instream Cover	15%
Instream Cover Composition	Overhanging Vegetation
Canopy Cover	15%

Site 3

Bankfull Channel Width	14.5 m
Wetted Width (Oct 28)	8.5 m
Wetted Width (Nov 17)	14.4 m
Wetted Depths (Oct 28)	0.05 m, 0.05 m, 0.05 m
Wetted Depths (Nov 17)	n/a
Avg. Velocity (Oct 28)	1.06 m/s
Avg. Velocity (Nov 17)	n/a
Riparian Land Use (L)	Residential
Vegetation Type (L)	Bush & Deciduous
Vegetation Depth (L)	5 m
Riparian Land Use (R)	Residential
Vegetation Type (R)	Bush
Vegetation Depth (R)	3 m
Substrate Fines	5%
Substrate Gravel	35%
Substrate Cobble	60%
Substrate Boulders	0%
Substrate Bedrock	0%
Instream Cover	50%
Instream Cover Composition	Instream Vegetation, Overhanging Vegetation, Undercuts
Canopy Cover	10%

Site 4

Bankfull Channel Width	4.3 m
Wetted Width (Oct 28)	3.8 m
Wetted Width (Nov 17)	3.9 m
Wetted Depths (Oct 28)	0.17 m, 0.20 m, 0.21 m
Wetted Depths (Nov 17)	0.20 m, 0.27 m, 0.25 m
Avg. Velocity (Oct 28)	0.7 m/s
Avg. Velocity (Nov 17)	n/a
Riparian Land Use (L)	Park
Vegetation Type (L)	Deciduous & Coniferous

Vegetation Depth (L)	10+ m
Riparian Land Use (R)	Park
Vegetation Type (R)	Deciduous & Coniferous
Vegetation Depth (R)	10+ m
Substrate Fines	15%
Substrate Gravel	30%
Substrate Cobble	40%
Substrate Boulders	15%
Substrate Bedrock	0%
Instream Cover	30%
Instream Cover Composition	Large Woody Debris, Instream Vegetation, Overhanging Vegetation
Canopy Cover	50%

Site 5

Bankfull Channel Width	17.8 m
Wetted Width (Oct 28)	11.4 m
Wetted Width (Nov 17)	17.8 m
Wetted Depths (Oct 28)	0.50 m, 0.65 m, 0.40 m
Wetted Depths (Nov 17)	n/a
Avg. Velocity (Oct 28)	1.5 m/s
Avg. Velocity (Nov 17)	n/a
Riparian Land Use (L)	Residential
Vegetation Type (L)	Bush & Deciduous
Vegetation Depth (L)	7 m
Riparian Land Use (R)	Residential
Vegetation Type (R)	Bush & Deciduous
Vegetation Depth (R)	10 m
Substrate Fines	10%
Substrate Gravel	30%
Substrate Cobble	50%
Substrate Boulders	10%
Substrate Bedrock	0%
Instream Cover	20%
Instream Cover Composition	Large Woody Debris, Instream Vegetation, Overhanging Vegetation, Boulders, Undercuts
Canopy Cover	50%

Appendix 2 – VIU Lab Results

Site 1

Analyte	Units	Oct 28	Nov 17
Water Temp	ºC	11.9	13.2
Dissolved Oxygen	mg/L	10.5	10.0
pH	pH Units	9.6	n/a
Conductivity	µS/cm	043	n/a
Turbidity	NTU	5.35	n/a
Total Alkalinity	mg/L as $CaCO_3$	13.6	n/a
Hardness	mg/L as $CaCO_3$	10	n/a
Nitrates	mg/L NO_3	0.09	n/a
Phosphorus	mg/L PO_4^{3-}	n/a	n/a

Site 2

Analyte	Units	Oct 28	Nov 17
Water Temp	ºC	13.3	9.7
Dissolved Oxygen	mg/L	10.6	12.2
pH	pH Units	9.1	n/a
Conductivity	µS/cm	079	n/a
Turbidity	NTU	0.94	n/a
Total Alkalinity	mg/L as $CaCO_3$	24.8	n/a
Hardness	mg/L as $CaCO_3$	8	n/a
Nitrates	mg/L NO_3	0.10	n/a
Phosphorus	mg/L PO_4^{3-}	0.16	n/a

Site 3

Analyte	Units	Oct 28	Nov 17
Water Temp	ºC	11.5	9.3
Dissolved Oxygen	mg/L	11.0	11.4
pH	pH Units	n.a	10
Conductivity	µS/cm	n/a	065
Turbidity	NTU	n/a	6.49
Total Alkalinity	mg/L as $CaCO_3$	n/a	20.0
Hardness	mg/L as $CaCO_3$	n/a	28
Nitrates	mg/L NO_3	n/a	0.12
Phosphorus	mg/L PO_4^{3-}	n/a	0.14

Site 4

Analyte	Units	Oct 28	Nov 17
Water Temp	ºC	11.4	9.6

Dissolved Oxygen	mg/L	11.2	11.9
pH	pH Units	8.7	10.1
Conductivity	µS/cm	131	076
Turbidity	NTU	7.25	10.5
Total Alkalinity	mg/L as $CaCO_3$	43.2	22.9
Hardness	mg/L as $CaCO_3$	208	32
Nitrates	mg/L NO_3	0.39	0.79
Phosphorus	mg/L PO_4^{3-}	0.01	0.04

Site 5

Analyte	Units	Oct 28	Nov 17
Water Temp	^oC	11.5	8.2
Dissolved Oxygen	mg/L	11.2	11.9
pH	pH Units	n/a	9.7
Conductivity	µS/cm	n/a	079
Turbidity	NTU	n/a	13.3 NTU
Total Alkalinity	mg/L as $CaCO_3$	n/a	22.6
Hardness	mg/L as $CaCO_3$	n/a	28
Nitrates	mg/L NO_3	n/a	0.85
Phosphorus	mg/L PO_4^{3-}	n/a	0.07

Appendix 3 – ALS Lab Results

October 28

Analyte	Units	Site 1	Site 2	Site 4
Physical Tests (Matrix: Water)				
conductivity	µS/cm	45.2	84.0	136
hardness (as CaCO3), from total Ca/Mg	mg/L	17.1	33.0	42.4
pH	pH units	7.33	7.52	7.79
Anions and Nutrients (Matrix: Water)				
ammonia, total (as N)	mg/L	<0.0050	<0.0050	0.0118
nitrate (as N)	mg/L	0.117	0.0354	0.165
nitrite (as N)	mg/L	<0.0010	<0.0010	0.0020
nitrogen, total	mg/L	0.279	0.261	0.416
phosphate, ortho-, dissolved (as P)	mg/L	<0.0010	<0.0010	0.0085
phosphorus, total	mg/L	0.0075	0.0116	0.0262
Total Metals (Matrix: Water)				
aluminum, total	mg/L	0.0492	0.0698	0.134
antimony, total	mg/L	<0.00010	<0.00010	<0.00010
arsenic, total	mg/L	0.00012	0.00030	0.00028
barium, total	mg/L	0.00304	0.00376	0.0132
beryllium, total	mg/L	<0.000020	<0.000020	<0.000020
bismuth, total	mg/L	<0.000050	<0.000050	<0.000050
boron, total	mg/L	0.027	0.027	0.035
cadmium, total	mg/L	<0.0000050	<0.0000050	<0.0000050
calcium, total	mg/L	4.80	9.07	11.9
cesium, total	mg/L	<0.000010	<0.000010	<0.000010
chromium, total	mg/L	<0.00050	<0.00050	<0.00050
cobalt, total	mg/L	<0.00010	0.00011	0.00012
copper, total	mg/L	0.00101	0.00088	0.00116
iron, total	mg/L	0.023	0.181	0.333
lead, total	mg/L	<0.000050	0.000060	0.000083
lithium, total	mg/L	<0.0010	<0.0010	<0.0010

magnesium, total	mg/L	1.25	2.52	3.06
manganese, total	mg/L	0.00082	0.0277	0.0264
molybdenum, total	mg/L	<0.000050	<0.000050	0.000056
nickel, total	mg/L	<0.00050	<0.00050	<0.00050
phosphorus, total	mg/L	<0.050	<0.050	<0.050
potassium, total	mg/L	0.131	0.268	0.505
rubidium, total	mg/L	<0.00020	0.00034	0.00055
selenium, total	mg/L	<0.000050	<0.000050	<0.000050
silicon, total	mg/L	3.79	2.96	3.57
silver, total	mg/L	<0.000010	<0.000010	<0.000010
sodium, total	mg/L	2.04	3.95	9.33
strontium, total	mg/L	0.0206	0.0362	0.0900
sulfur, total	mg/L	1.21	1.46	1.98
tellurium, total	mg/L	<0.00020	<0.00020	<0.00020
thallium, total	mg/L	<0.000010	<0.000010	<0.000010
thorium, total	mg/L	<0.00010	<0.00010	<0.00010
tin, total	mg/L	<0.00010	<0.00010	<0.00010
titanium, total	mg/L	0.00056	0.00399	0.00650
tungsten, total	mg/L	<0.00010	<0.00010	<0.00010
uranium, total	mg/L	<0.000010	<0.000010	<0.000010
vanadium, total	mg/L	<0.00050	<0.00050	0.00085
zinc, total	mg/L	<0.0030	<0.0030	<0.0030
zirconium, total	mg/L	<0.00020	<0.00020	<0.00020

November 17

Analyte	Units	Site 3	Site 4	Site 5
Physical Tests (Matrix: Water)				
conductivity	µS/cm	74.3	90.2	89.8
hardness (as CaCO3), from total Ca/Mg	mg/L	25.2	27.9	28.3
pH	pH units	7.13	7.28	7.41
Anions and Nutrients (Matrix: Water)				
ammonia, total (as N)	mg/L	0.0082	0.0100	0.0075
nitrate (as N)	mg/L	0.336	0.435	0.438

nitrite (as N)	mg/L	0.0016	0.0025	0.0026
nitrogen, total	mg/L	0.599	0.726	0.758
phosphate, ortho-, dissolved (as P)	mg/L	0.0035	0.0046	0.0054
phosphorus, total	mg/L	0.0320	0.0278	0.0403
Total Metals (Matrix: Water)				
aluminum, total	mg/L	0.640	0.520	0.939
antimony, total	mg/L	<0.00010	<0.00010	<0.00010
arsenic, total	mg/L	0.00047	0.00034	0.00046
barium, total	mg/L	0.00824	0.0122	0.0120
beryllium, total	mg/L	<0.000020	<0.000020	<0.000020
bismuth, total	mg/L	<0.000050	<0.000050	<0.000050
boron, total	mg/L	0.024	0.023	0.024
cadmium, total	mg/L	0.0000057	0.0000052	0.0000124
calcium, total	mg/L	6.78	7.68	7.68
cesium, total	mg/L	0.000035	0.000025	0.000053
chromium, total	mg/L	0.00140	0.00102	0.00189
cobalt, total	mg/L	0.00047	0.00031	0.00064
copper, total	mg/L	0.00209	0.00198	0.00270
iron, total	mg/L	0.994	0.740	1.38
lead, total	mg/L	0.000182	0.000182	0.000342
lithium, total	mg/L	<0.0010	<0.0010	0.0012
magnesium, total	mg/L	2.01	2.13	2.22
manganese, total	mg/L	0.0536	0.0429	0.0687
molybdenum, total	mg/L	<0.000050	0.000050	0.000056
nickel, total	mg/L	0.00096	0.00081	0.00134
phosphorus, total	mg/L	<0.050	<0.050	<0.050
potassium, total	mg/L	0.469	0.664	0.626
rubidium, total	mg/L	0.00076	0.00080	0.00096
selenium, total	mg/L	<0.000050	<0.000050	<0.000050
silicon, total	mg/L	4.36	4.28	4.86
silver, total	mg/L	<0.000010	<0.000010	<0.000010
sodium, total	mg/L	4.16	5.74	5.64
strontium, total	mg/L	0.0399	0.0464	0.0452
sulfur, total	mg/L	1.34	1.45	1.42
tellurium, total	mg/L	<0.00020	<0.00020	<0.00020
thallium, total	mg/L	<0.000010	<0.000010	<0.000010

thorium, total	mg/L	<0.00010	<0.00010	<0.00010
tin, total	mg/L	<0.00010	<0.00010	<0.00010
titanium, total	mg/L	0.0325	0.0283	0.0517
tungsten, total	mg/L	<0.00010	<0.00010	<0.00010
uranium, total	mg/L	<0.000010	<0.000010	0.000016
vanadium, total	mg/L	0.00268	0.00220	0.00382
zinc, total	mg/L	<0.0030	<0.0030	0.0048
zirconium, total	mg/L	0.00027	0.00039	0.00039

Appendix 4 – Invertebrate Data Sheets

Site 1 – October 28

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name: Millstone River		Date: 28-Oct-20
Station Name: Site 1		Flow status: low
Sampler Used: Hess	Number of replicates 3	Total area sampled (Hess, Surber = 0.09 m^2) x no. replicates 0.27 m^2

Column A Pollution Tolerance	Column B Common Name	Column C Number Counted	Column D Number of Taxa
Category 1	Caddisfly Larva (EPT)	20	2
	Mayfly Nymph (EPT)	6	1
	Stonefly Nymph (EPT)	10	1
	Dobsonfly (hellgrammite)		
Pollution Intolerant	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		36	4
Category 2	Alderfly Larva		
	Aquatic Beetle		
	Aquatic Sowbug		
	Clam, Mussel		
	Cranefly Larva		
	Crayfish		
Somewhat Pollution Tolerant	Damselfly Larva		
	Dragonfly Larva		
	Fishfly Larva		
	Amphipod (freshwater shrimp)		
	Watersnipe Larva		
Sub-Total		0	0
Category 3	Aquatic Worm (oligochaete)	19	4
	Blackfly Larva		
	Leech		
	Midge Larva (chironomid)	1	1
	Planarian (flatworm)		
Pollution Tolerant	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite		
Sub-Total		20	5
TOTAL		56	9

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell **CT**: **56**

DENSITY: Invertebrate density per total area sampled:

56 ÷ 0.27 (From page 1) m^2 = **207.4074** / m^2

PREDOMINANT TAXON:
Invertebrate group with the highest number counted (in Col. C): **Caddisfly Larva (EPT)**

SECTION 2 - WATER QUALITY ASSESSMENTS

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

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

3 x D1 + 2 x D2 + D3

3 x 4 + 2 x 0 + 5 = **17**

EPT INDEX: Total number of EPT taxa.

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

EPT4 + EPT5 + EPT6

2 + 1 + 1 **4**

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

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

(EPT1 + EPT2 + EPT3) / CT

(20 + 6 + 10) / 56 **0.642857143**

SECTION 3 - DIVERSITY

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

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

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

Col. C for S1 / CT

20 / 56 **0.357142857**

SECTION 4 - OVERALL SITE ASSESSMENT RATING

SITE ASSESSMENT RATING: Assign a rating of 1-4 to each index (S2, S3, S4, S5), then calculate the average.

Assessment Rating	
Good	4
Acceptable	3
Marginal	2
Poor	1

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

Average Rating
Average of R1, R2, R3, R4
3

Site 2 – October 28

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name:	Millstone River	Date:	28-Oct-20
Station Name:	Site 2	Flow status:	low
Sampler Used: Hess	Number of replicates: 3	Total area sampled (Hess, Surber = 0.09 m^2) x no. replicates: 0.27 m^2	

Column A	Column B	Column C	Column D
Pollution Tolerance	**Common Name**		
Category 1 Pollution Intolerant	Caddisfly Larva (EPT)	17	1
	Mayfly Nymph (EPT)	0	0
	Stonefly Nymph (EPT)	0	0
	Dobsonfly (hellgrammite)		
	Gilled Snail	1	1
	Riffle Beetle		
	Water Penny		
Sub-Total		18	2
Category 2 Somewhat Pollution Tolerant	Alderfly Larva		
	Aquatic Beetle		
	Aquatic Sowbug		
	Clam, Mussel	1	1
	Cranefly Larva	1	1
	Crayfish		
	Damselfly Larva		
	Dragonfly Larva		
	Fishfly Larva		
	Amphipod (freshwater shrimp)	11	1
	Watersnipe Larva		
Sub-Total		13	3
Category 3 Pollution Tolerant	Aquatic Worm (oligochaete)	18	1
	Blackfly Larva		
	Leech		
	Midge Larva (chironomid)	2	1
	Planarian (flatworm)		
	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite		
Sub-Total		20	2
TOTAL		51	7

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell **CT**: **51**

DENSITY: Invertebrate density per total area sampled:

From page 1

51 ÷ 0.27 m^2 = 188.8889 / m^2

PREDOMINANT TAXON:
Invertebrate group with the highest number counted (in Col. C): Aquatic Worm (oligochaete)

SECTION 2 - WATER QUALITY ASSESSMENTS

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

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

3 x D1 + 2 x D2 + D3

3 x 2 + 2 x 3 + 2 = **14**

EPT INDEX: Total number of EPT taxa.

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

EPT4 + EPT5 + EPT6

1 + 0 + 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

(EPT1 + EPT2 + EPT3) / CT

(17 + 0 + 0) / 51 = **0.333333333**

SECTION 3 - DIVERSITY

TOTAL NUMBER OF TAXA: Total number of taxa from cell **DT**: **7**

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

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

Col. C for S1 / CT

18 / 51 = **0.352941176**

SECTION 4 - OVERALL SITE ASSESSMENT RATING

SITE ASSESSMENT RATING: Assign a rating of 1-4 to each index (S2, S3, S4, S5), then calculate the average.

Assessment Rating	
Good	4
Acceptable	3
Marginal	2
Poor	1

Assessment	Rating
Pollution Tolerance Index	2
EPT Index	1
EPT To Total Ratio	2
Predominant Taxon Ratio	4

Average Rating

Average of R1, R2, R3, R4

2.25

Site 4 – October 28

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name:	Millstone River	Date:	28-Oct-20
Station Name:	Site 4	Flow status:	low

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

Column A	Column B	Column C	Column D
Pollution Tolerance	**Common Name**		
Category 1	Caddisfly Larva (EPT)	14	2
	Mayfly Nymph (EPT)	50	1
	Stonefly Nymph (EPT)	0	0
Pollution Intolerant	Dobsonfly (hellgrammite)		
	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		64	3
Category 2	Alderfly Larva		
	Aquatic Beetle		
	Aquatic Sowbug		
Somewhat Pollution Tolerant	Clam, Mussel		
	Cranefly Larva		
	Crayfish		
	Damselfly Larva		
	Dragonfly Larva		
	Fishfly Larva		
	Amphipod (freshwater shrimp)	21	1
	Watersnipe Larva		
Sub-Total		21	1
Category 3	Aquatic Worm (oligochaete)	12	1
	Blackfly Larva		
	Leech		
Pollution Tolerant	Midge Larva (chironomid)	4	1
	Planarian (flatworm)		
	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite		
Sub-Total		16	2
TOTAL		101	6

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell **CT**: **101**

DENSITY: Invertebrate density per total area sampled:

101 ÷ 0.27 (From page 1) m^2 = 374.0741 / m^2

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

SECTION 2 - WATER QUALITY ASSESSMENTS

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

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

3 x D1 + 2 x D2 + D3
3 x 3 + 2 x 1 + 2 = **13**

EPT INDEX: Total number of EPT taxa.

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

EPT4 + EPT5 + EPT6
2 + 1 + 0 **3**

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

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

(EPT1 + EPT2 + EPT3) / CT
(14 + 50 + 0) / 101 **0.633663366**

SECTION 3 - DIVERSITY

TOTAL NUMBER OF TAXA: Total number of taxa from cell **DT**: **6**

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

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

Col. C for S1 / CT
50 / 101 **0.495049505**

SECTION 4 - OVERALL SITE ASSESSMENT RATING

SITE ASSESSMENT RATING: Assign a rating of 1-4 to each index (S2, S3, S4, S5), then calculate the average.

Assessment Rating	
Good	4
Acceptable	3
Marginal	2
Poor	1

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

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

Site 3 – November 17

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name:	Millstone River	Date:	17-Nov-20
Station Name:	Site 3	Flow status:	high
Sampler Used: Hess	Number of replicates: 2	Total area sampled (Hess, Surber = 0.09 m^2) x no. replicates: 0.18 m^2	

Column A	Column B	Column C	Column D
Pollution Tolerance	**Common Name**		
Category 1	Caddisfly Larva (EPT)	36	1
	Mayfly Nymph (EPT)	63	1
	Stonefly Nymph (EPT)	21	1
Pollution Intolerant	Dobsonfly (hellgrammite)		
	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		120	3
Category 2	Alderfly Larva		
	Aquatic Beetle		
	Aquatic Sowbug		
Somewhat Pollution Tolerant	Clam, Mussel		
	Cranefly Larva	1	1
	Crayfish		
	Damselfly Larva	1	1
	Dragonfly Larva		
	Fishfly Larva		
	Amphipod (freshwater shrimp)	28	2
	Watersnipe Larva		
Sub-Total		30	4
Category 3	Aquatic Worm (oligochaete)	108	4
	Blackfly Larva		
	Leech		
Pollution Tolerant	Midge Larva (chironomid)		
	Planarian (flatworm)		
	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite		
Sub-Total		108	4
TOTAL		258	11

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell **CT**: **258**

DENSITY: Invertebrate density per total area sampled:

258 ÷ 0.18 (From page 1) m^2 = **1433.333** / m^2

PREDOMINANT TAXON: Invertebrate group with the highest number counted (in Col. C): **Aquatic Worm (oligochaete)**

SECTION 2 - WATER QUALITY ASSESSMENTS

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

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

3 x D1 + 2 x D2 + D3

3 x 3 + 2 x 4 + 4 = **21**

EPT INDEX: Total number of EPT taxa.

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

EPT4 + EPT5 + EPT6

1 + 1 + 1 = **3**

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

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

(EPT1 + EPT2 + EPT3) / CT

(36 + 63 + 21) / 258 = **0.465116279**

SECTION 3 - DIVERSITY

TOTAL NUMBER OF TAXA: Total number of taxa from cell **DT**: **11**

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

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

Col. C for S1 / CT

108 / 258 = **0.418604651**

SECTION 4 - OVERALL SITE ASSESSMENT RATING

SITE ASSESSMENT RATING: Assign a rating of 1-4 to each index (S2, S3, S4, S5), then calculate the average.

Assessment Rating	
Good	4
Acceptable	3
Marginal	2
Poor	1

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

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

Site 4 – November 17

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name:	Millstone River	Date:	17-Nov-20
Station Name:	Site 4	Flow status:	high
Sampler Used: Hess	Number of replicates: 2	Total area sampled (Hess, Surber = 0.09 m^2) x no. replicates: 0.18 m^2	

Column A Pollution Tolerance	Column B Common Name	Column C	Column D
Category 1	Caddisfly Larva (EPT)	15	2
	Mayfly Nymph (EPT)	64	1
	Stonefly Nymph (EPT)	6	1
Pollution Intolerant	Dobsonfly (hellgrammite)		
	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		85	4
Category 2	Alderfly Larva		
	Aquatic Beetle		
	Aquatic Sowbug		
Somewhat Pollution Tolerant	Clam, Mussel		
	Cranefly Larva		
	Crayfish		
	Damselfly Larva		
	Dragonfly Larva	1	1
	Fishfly Larva		
	Amphipod (freshwater shrimp)	9	1
	Watersnipe Larva		
Sub-Total		10	2
Category 3	Aquatic Worm (oligochaete)	50	2
	Blackfly Larva		
	Leech		
Pollution Tolerant	Midge Larva (chironomid)		
	Planarian (flatworm)		
	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite		
Sub-Total		50	2
TOTAL		145	8

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell **CT**: **145**

DENSITY: Invertebrate density per total area sampled:

From page 1

145 ÷ 0.18 m^2 = **805.5556** / m^2

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

Mayfly Nymph (EPT)

SECTION 2 - WATER QUALITY ASSESSMENTS

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

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

3 x D1 + 2 x D2 + D3

3 x 4 + 2 x 2 + 2 = **18**

EPT INDEX: Total number of EPT taxa.

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

EPT4 + EPT5 + EPT6

2 + 1 + 1 **4**

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

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

(EPT1 + EPT2 + EPT3) / CT

(15 + 64 + 6) / 145 **0.586206897**

SECTION 3 - DIVERSITY

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

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

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

Col. C for S1 / CT

64 / 145 **0.44137931**

SECTION 4 - OVERALL SITE ASSESSMENT RATING

SITE ASSESSMENT RATING: Assign a rating of 1-4 to each index (S2, S3, S4, S5), then calculate the average.

Assessment Rating	
Good	4
Acceptable	3
Marginal	2
Poor	1

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

Average Rating

Average of R1, R2, R3, R4

2.75

Appendix 5 – Shannon-Weiner Diversity Index

Site 1 – October 28

Common Name		Column C	pi(C/T)	ln(pi)	pi*ln(pi)
Caddisfly Larva (EPT)		20	0.357	-0.447	-0.160
Mayfly Nymph (EPT)		6	0.107	-0.970	-0.104
Stonefly Nymph (EPT)		10	0.179	-0.748	-0.134
Aquatic Worm (oligochaete)		19	0.339	-0.469	-0.159
Midge Larva (chironomid)		1	0.018	-1.748	-0.031
TOTAL (T)		56	1.000		-0.588
S		5			
H		**0.841**			

Site 2 – October 28

Common Name		Column C	pi(C/T)	ln(pi)	pi*ln(pi)
Caddisfly Larva (EPT)		17	0.425	-0.372	-0.158
Gilled Snail		1	0.025	-1.602	-0.040
Clam, Mussel		1	0.025	-1.602	-0.040
Cranefly Larva		1	0.025	-1.602	-0.040
Aquatic Worm (oligochaete)		18	0.450	-0.347	-0.156
Midge Larva (chironomid)		2	0.050	-1.301	-0.065
TOTAL (T)		40	1.000		-0.499
S		6			
H		**0.642**			

Site 4 – October 28

Common Name		Column C	pi(C/T)	ln(pi)	pi*ln(pi)
Caddisfly Larva (EPT)		14	0.139	-0.858	-0.119
Mayfly Nymph (EPT)		50	0.495	-0.305	-0.151
Amphipod (freshwater shrim		21	0.208	-0.682	-0.142
Aquatic Worm (oligochaete)		12	0.119	-0.925	-0.110
Midge Larva (chironomid)		4	0.040	-1.402	-0.056
TOTAL (T)		101	1.000		-0.577
S		5			
H		**0.826**			

Site 3 – November 17

Common Name		Column C	pi(C/T)	ln(pi)	pi*ln(pi)
Caddisfly Larva (EPT)		36	0.140	-0.855	-0.119
Mayfly Nymph (EPT)		63	0.244	-0.612	-0.150
Stonefly Nymph (EPT)		21	0.081	-1.089	-0.089
Cranefly Larva		1	0.004	-2.412	-0.009
Damselfly Larva		1	0.004	-2.412	-0.009
Amphipod (freshwater shrim		28	0.109	-0.964	-0.105
Aquatic Worm (oligochaete)		108	0.419	-0.378	-0.158
TOTAL (T)		258	1.000		-0.639
S		7			
H		**0.756**			

Site 4 – November 17

Common Name		Column C	pi(C/T)	ln(pi)	pi*ln(pi)
Caddisfly Larva (EPT)		15	0.103	-0.985	-0.102
Mayfly Nymph (EPT)		64	0.441	-0.355	-0.157
Stonefly Nymph (EPT)		6	0.041	-1.383	-0.057
Dragonfly Larva		1	0.007	-2.161	-0.015
Amphipod (freshwater shrim		9	0.062	-1.207	-0.075
Aquatic Worm (oligochaete)		50	0.345	-0.462	-0.159
TOTAL (T)		145	1.000		-0.565
S		6			
H		**0.726**			