Benthic Macro-Invertebrate Biomonitoring Study

Bighill Springs Creek, Cochrane, Alberta
Research Target Area: Environmental – Water



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The source of the funds for this Aquatic Invertebrate study in Bighill Springs Creek, Cochrane, Alberta, came from a ‘Research Legacy Fund’ established for the late Dr. Richard Pharis, Professor of Botany, Department of Biological Sciences, University of Calgary. Vivian Pharis, Vice-President of the BCPS has been an ambassador of environmental preservation for most of her life, and realized the importance of aquatic and terrestrial invertebrate studies for Bighill Creek and valley as an important adjunct research to water quality analysis conducted for the society by Dr. Ymene Fouli from 2017-2020. Working with Dr. Mary Reid, Professor, Department of Biological Science, Faculty of Science, University of Calgary, Vivian Pharis able to divert funds from her late husband’s research into a Summer Fellowship through the Department of Biological Science, Faculty of Science, University of Calgary.

Upon my graduation (B.Sc. Environmental Science (Honours), multifaceted departments, Faculty of Science, University of Calgary, in June 2019, I was selected by the BCPS Board of Directors to conduct studies of aquatic invertebrates in Bighill Springs Creek at Cochrane, Alberta. I acknowledge the close mentorship of BCPS Board members, Vivian Pharis and Dr. Ken Stevenson (Professor Emeritus of Biochemistry, Department of Biological Science, Faculty of Science, University of Calgary) throughout this study and Final Report preparation.

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1.0 Introduction:

River ecosystems are woven throughout Alberta, and the way we choose to interact with them is vital for the prosperity of our land and water ways. They can be very complex systems, and can differ in a variety of parameters, such as, physical, chemical and biological (Bunn & Arthington, 2002). Understanding the flow and connection between these parameters can help to prosper a better understanding of waterways. This can then contribute to the maintenance of healthy ecosystems that benefit both natural and urban environments.

Bighill creek is a spring fed perennial stream a part of the South Saskatchewan River Basin. The creek initiates its flow north of the town of Cochrane A.B., flowing through a variety of land uses before entering the Bow river in the middle of the town. Within Bighill Creek's watershed there are many resource extraction developments, including gravel mining, petroleum drilling and fracking (Seewalt, 2017; Lafarge, 2017; Alberta Energy Regulator, 2016; Energy Resources Conservation Board, 2009). Springs have been located along the length of Bighill Creek, however the exact locations of all springs are as yet unknown. This aquatic insect study focuses on the last 13km reach of the stream before it enters the Bow River.

Biomonitoring analysis techniques were performed to assess the water quality in Bighill Creek, specifically, aquatic benthic invertebrate analysis. Benthic is the zone along the bottom of a body of water, which can hold a large diversity of invertebrates dependent on the biotic and abiotic components present (Raina et al., 2019). Benthic invertebrates have proven to be a successful biomonitoring community as they are abundant, relatively long lived, well documented around the world, have low seasonal movement, and vary in their sensitivity to pollutants (Hodkinson & Jackson, 2005). Therefore, looking at abundance and diversity of invertebrate communities can give valuable indications of water quality, and habitat functionality.

This study has examined the activity of a specific community of invertebrates recognized as the Ephemeroptera, Plecoptera and Trichoptera (EPT) community. Studies have shown decreases in EPT community to be correlated with increases in anthropogenic activity as well as cattle access lands (Martins et al., 2017; Davis et al., 2003). This community consists of invertebrates from the Ephemeroptera (Mayflies), Plecoptera (Stoneflies) and Trichoptera (Caddisflies) orders. The EPT community can provide a strong indication of water quality because they consist of very intolerant taxa (Chun et al., 2017). Studies suggest that increases in organic pollutions, heavy metals, and toxic chemicals, inversely decreases the EPT community (Hilsenhoff, 1988; Hauver & Lamberti, 1996; Johnson et al, 1993). All the taxa within the EPT community have been given a tolerance index number (from 0-10, with 0 being least tolerant) based on their susceptibility to increases in pollutants (Hilsenhoff, 1988; Hauver & Lambert, 1996; Johnson et al, 1993)(Table 2). Pre-existing knowledge of the EPT community and tolerance values will be incorporated in this study to provide indications of water quality in Bighill Creek.

Many variables can affect the abundance and diversity of benthic macroinvertebrates, and therefore when assessing the invertebrate communities, it is important to look at both chemical and physical variables. This includes things in their habitat such as, stone size, interstitial material, allochthonous and autochthonous food sources, structure of the stream, dissolved oxygen, and various organic compounds (Carter & Pappas, 2012). Therefore, this report will include measurements on reach characteristics, and water chemistry, to support the findings of the benthic macroinvertebrates. All these features affect the invertebrates in different ways by affecting the type of habitat the invertebrates have adapted to live in (Carter & Pappas, 2012). Examining these features and the invertebrate community will help determine sources of disturbance and lead to properly implemented solutions to conserve and preserve Bighill creek.

This study uses Canadian Aquatic Biomonitoring Network (CABIN) protocols. CABIN is a national aquatic biomonitoring program that has created in-depth protocols to be followed, creating consistency in sampling and collection of biomonitoring data. This approach allows scientist and researchers across Canada to collect, manage, and assess data at a synoptic scale. Samples were also submitted to the Squencing the Rivers for Envioronmnental Assessment and Monitoring (STREAM) program, for eDNA metabarcoding. The STREAM program is a partnership amongst Living Lakes Canada, World Wildlife Fund Canada, Environment and Climate Change Canada and Dr. Mehrdad Hajibabaei of the University of Guelph. Through this program community-based projects, such as this one, are being used to amass a library of environmental DNA (eDNA) from major watersheds throughout Canada.

2.0 Methods:

2.1 Site

The study area consists of 11 sites located along the last 13km of Bighill Creek, prior to its convergence with the Bow River. Sites are arranged in numeric order with Site 1 being furthest downstream, and Site 11 being furthest upstream (Figure 1). Sites 1 – 6 are located within the town of Cochrane with the dominant surrounding land use being residential (Table 4). Sites 7- 11 are upstream of Site 1-6 and located outside of major residential or urban areas, where the dominant surrounding land use is ranch land, or light recreational land (Table 4). Site 1 is in the Bow river, directly at the confluence with Bighill Creek (Figure 2). Site 2 is approximately 100m upstream of Site 1, on the east side of a disc golf park (Figure 3). Site 3 is located approximately 900m upstream of Site 2, in a residential park off Glenpatrick road (Figure 4). Site 4 is approximately 1 km upstream of Site 3 in the picnic area by Cochrane Ranche (Figure 5). Site 5 is 800m upstream of Site 4 on Cross Piston Trail, within a nature reserve (Figure 6). Site 6 is 2km upstream of Site 5 on the boundary of the nature reserve and Bighill Creek Preservation Society's stewardship reserve (Figure 7). Site 7 is 1 km upstream of Site 6, on private land ownership approximately 20m upstream of the boundary of Bighill Creek Preservation Society stewardship reserve (Figure 8). Site 8 is 1 km upstream of Site 7 within the same private lands that are mainly used for grazing (Figure 9). Site 9 is 5 km upstream of Site 8, located in the Bighill Springs Provincial park at the confluence with the influent from the Bighill Springs and influent from local springs located further north (Figure 10). Site 10 is approximately 0.5km upstream from Site 9 in the Bighill Springs Provincial park, and < 1km from the Bighill Springs source (Figure 11). Site 11 is 2 km upstream from Site 9 on the North side of Bighill Springs provincial park, and on the south side of Highway 567 (Figure 12).

This aquatic invertebrate study was preformed over a five-month time period from May-September, 2019. Sites 1, 2, 4 and 6 were sampled in May and June, then Site 3, 5, 7, 8, 9, 10 and 11 were added and sampled in July and September. Site 1 was removed from sampling in July and September in order to take more samples directly from Bighill Creek. At each site, aquatic macro-invertebrate samples were taken along with reach characteristics, and water samples. Procedures for collection and processing of samples followed the Canadian Aquatic Biomonitoring network guidelines (Carter & Pappa, 2012).

2.2 Analysis

2.2.1. Aquatic Invertebrates:

Samples were collected from the riffle environment within in the stream, in a reach area that was determined at six times the bankfull width. Aquatic invertebrates were collected using the kick-net method with a 400micro meter D-net. Sediment was disturbed for a period of three minutes while moving in a zig-zag pattern upstream within the reach area. All the specimen inside the net were collected and preserved with 95% ethanol. Samples were identified to family level using techniques outlined by the West Virginia Department of Environmental Protection and An Introduction to the Aquatic Insects of North America (Bouchard et al., 2004; Merrit & Cummins, 1984). Descriptive statistics were performed where applicable. Additionally, total abundance, percent EPT and a Shannon-Wiener index (H') was calculated for every sample using excel version 1908 (Build 11929.20300). The Shannon-Wiener index is calculated using information theory and looks at predicting the uncertainty of a given outcome; see formula below. The higher the H' value, the greater the predicted diversity.

Shannon- Wiener Index (H')
H'= $-\boldsymbol{\Sigma pi * \ln(pi)}$
Pi = the fraction of the total number of individuals in the community belonging to species

2.2.2 eDNA Collection and Processing

In September, 2019, 12 samples were collected for eDNA processing. Samples were collected from Sites 2-11, with 2 replicates at Site 2 and 10. Samples were collected using the same techniques as CABIN, however decontamination of all equipment was preformed prior to taking samples at each sampling site. For the decontamination a 1:10 dilution bleach solution was used. A thorough scrub of all equipment was performed prior to the collection of each sample, and then decontaminated with the bleach solution. A new pair of nitrile gloves was worn for each sample. Samples were placed into 500mL polypropylene straight sided sample jars to the halfway point, and the remaining half was filled with 95% denatured ethanol. It was important that the final concentration of denatured ethanol is 50% or higher. Samples were kept on ice until shipped to the Centre for Biodiversity Genomics at the University of Guelph. The Hajibabaei Lab performed eDNA analysis on the samples, providing BCPS with a presence/absence report on aquatic macroinvertebrates (Hajibabaei Lab, 2019).

2.2.3 Reach Characteristics:

Reach characteristics consists of the following measurements: wetted width, instream stone size, percent embeddedness of stones, percent macrophyte cover, canopy cover, velocity, and depth. Wetted width was measured as the width from bank to bank at the waters edge. The stone count was conducted by walking up the reach of the study area in a zig-zag pattern and measuring every rock that touched the toe of my right foot, for a total off 100 stones. The intermediate axis of each stone was measured (Figure 13). Percent embeddedness was measured by picking up the stone and recording how much of the stone was buried in interstitial material, this was done for every 10^{th} stone during the intermediate axis measurements, for a total of 10 measurements. Stone measurements could not be preformed at Site 11 due to depth and lack of rocks. Percent macrophyte coverage was recorded as approximate macrophyte coverage within the reach area. Canopy cover was recorded as a percentage based on how much canopy cover was present directly above the reach area that was sampled. Percent canopy cover was approximated from the center of the reach area. Velocity was calculated by using a meter stick to measure flowing water depth and depth of stagnation. These two measurements were taken at ¼ distance from shore, ½ the distance from shore and ¾ distance from shore then calculated using the formula outlined below. Depth was recorded as the average of the three flowing water depth measurements.

Velocity (m/s) = $\sqrt{(2(\Delta D) * g)}$

ΔD = the difference between flowing water depth and depth of stagnation

g= acceleration due to gravity ($9.81 m/s^2$)

2.2.4 Water chemistry:

Water chemistry measurements were collected in July, and September. At each site, temperature, pH, electrical conductivity (EC), and dissolved oxygen (DO) were recorded using a multimeter probe (YSI Environmental, 556 Multiparameter System). Water samples were collected at Site 2, 6, 7, 10 and 11, for further analyses by Dr. Ymène Fouli. Other water chemistry data was collected at various sites throughout Bighill Creek in a more extensive study by Dr. Ymène Fouli in 2017 and 2019 (Fouli, 2018). All water and soil samples collected were sent to Maxxam Analytics (4000-19th Street NE, Calgary, AB T2E 6G8) for analyses of physical, chemical, and biological parameters.

<u>3.0 Results</u>

3.1 Macro-invertebrates:

This study identified 12 orders and 58 families within Bighill Creek. Values did not fluctuate greatly between months. The highest total abundance was collected in July at Site 7 (N=765), and the lowest was in July at Site 5 (N= 68) (Figure 23). The highest EPT abundance was in July at Site 8 (N=371), and the lowest (N=3) was in July at Site 11 (Table 1). The highest percent EPT (83%) was found in May at Site 6, and the lowest (1.3%) was in July at Site 11 (Figure 15 and 24). The highest diversity (H=2.37) was found in May at Site 4, and the lowest (H=0.83) was found in July at Site 2 (Figures 16 and 24).

3.1.2 May:

Sites located further upstream from the confluence with the Bow river have an increasing trend in total abundance numbers, percent EPT, and diversity. Based on the four sites that were sampled in May, Site 6 had the highest total abundance numbers (N=313), and highest percent EPT(83%), while Site 1 had the lowest total abundance numbers (N=79) and lowest percent EPT (19%)(Figure 14 and 15). Site 1 also had the lowest Shannon Wiener index (H=0.96)(Figure 16). The highest Shannon Wiener index was at Site 4 (H= 2.37) (Figure 16). The lowest tolerant family found was the Rhyacophilidae (Green Sedge Caddis). The highest abundance of Rhyacophilidae was found at Site 6 (n=49)(Figure 17). The site with the highest Chironomidae (Non-biting midge) count (N=103) was at Site 2, and the lowest Chironomidae count (N=2) was at Site 6 (Figure 17). There was no record of Hydrachnidia (aquatic mites) found in any of the sites in May.

3.1.3 June:

Sites sampled in June showed an increasing trend in total abundance, percent EPT and diversity further upstream from the confluence. The highest total abundance (N=373) was at Site 6 and the lowest (N=116) was ate Site 1 (Figure 18). Percent EPT was lowest at Site 2 (32%) and highest at Site 4 (63.4%) (Figure 19). Diversity was highest at Site 2 (H=2.31) and lowest at Site 1 (H=1.46) (Figure 20). The lowest tolerant family found was the Rhyacophilidae. The highest abundance of Rhyacophilidae was found at Site 6 (n=40) (Figure 21). Site 1 had the highest Chironomidea (N=58) and Site 4 had the lowest (N=1) (Figure 21). Site 4 and 6 had Hydrachnidia present, with a total count of 1 and 2 respectively (Figure 22).

3.1.4 July:

Total abundance and diversity in July show a positive trend as sites move further upstream, away from the confluence. Highest total abundance is at Site 7 (N=765), and lowest total abundance is at Site 5 (N=68) (Figure 23). The highest diversity is recorded at Site 9 and 11 (H=2.0), and the lowest diversity (H=0.83) is recorded at Site 2 (Figure 25). Percent EPT shows a negative trend as sites move further upstream from confluence (Figure 24). The lowest percent EPT was recorded at Site 11 (1.3%), and the highest (78.5%) was recorded at Site 2 (Figure 24). The lowest tolerant family found was the Rhyacophilidae. The highest abundance of Rhyacophilidae was found at Site 10 (n=34) (Figure 26). The site with the highest Chironomidae count (n=94) is at Site 9 and the site with the lowest Chironomidae count (N=5) is at Site 5 (Figure 26.) Hydrachnidia are present at Site 3, 4, 7, 8, 9, 10 and 11 (Figure 27). The highest Hydrachnidia count is at Site 10 (N=204), and the lowest (N=2) is at Site 4 (Figures 27).

3.1.5 Sept eDNA:

Throughout all of the samples, 20 orders, 85 families, 137 genera and 148 species of invertebrates were identified (Hajibabaei Lab, 2019). Every Site (Sites 2-11) had EPT species present (Hajibabaei Lab, 2019). Total Diversity (including fish) was highest at Site 2 with a total of 63 different species present (Figure 29). The lowest diversity was found at Site 6, with a total of 23 species present. The highest %EPT was at Site 8 (37%), the lowest was at Site 9 (15%) (Figure 28). Rhyacophilidae and Chironomidae were present at all 10 sites, but abundance was undetectable. Hydrachnidia were detected at Site 2, 3, 4, 7, 9, and 11 (Hajibabaei Lab, 2019).

3.2 Reach Characteristics:

Sites vary between 2.5m to 6.2m in wetted width (Site 11 and 8 respectively), Site 1 is an outlier (89m) (Table 4). Site 10 had the highest canopy cover (~50%), then Site 4, 5 and 6 (~25%), the rest of the sites showed little to no canopy cover (Table 4). Macrophyte coverage also varied across sites and throughout the summer. Sites 1, 6, 8, and 9 showed little to no macrophyte coverage throughout the whole summer, while Site 11 had consistently the highest macrophyte coverage (~100%) throughout both months (Table 4). Site 11 has the greatest depth (>100cm) (excluding Site 1 as an outlier) and Site 6 has the lowest depth (15.67cm) (Table 4). The average stone size varied between 1.6cm, at Site 9, and 7.8cm at Site 3 (Table 5). In May and June the highest velocity was at Site 1 (V=~4-7m/s) (Table 6). However, with Site 1 as an outlier, Site 6 consistently had the highest velocity throughout the study period, with the highest velocity recorded in July (V=0.85 m/s)(Table 6). The lowest velocity throughout the study period was at Site 11 in September (V=0.13 m/s)(Table 6).

3.3 Water Chemistry:

Phosphorus was highest in July at Site 10 at 0.11mg/L for total phosphorus, and 0.083mg/L dissolved (Table 8). Phosphorus was lowest at Site 4 both in July and September (Table 8 and 9). In July total phosphorus was 0.021, dissolved was 0.029, and in September total phosphorus was 0.030, while dissolved was 0.017. Dissolved nitrate was highest in September at Site 10 at 13mg/L (Table 9). The lowest nitrogen concentration was at Site 7 at 0.055mg/L (Table 9). Potential hydrogen (pH) was highest at Site 5 in September at 8.58, and lowest in July at Site 2 with a measurement of 7.98. Dissolved oxygen (DO) was highest in September near Site 8 at 17.8 mg/L (Table 9), and lowest in July at Site 11 at 0.112 mg/L (Table 8).

4.0 Discussion:

Comparisons of samples provide no noticeable trends or differences in variation temporally, but differences were identified spatially. As this is the first year of the study, it is difficult to predict whether differences will be noticed between May – September in any given year. However, it does suggest that habitat state has a greater influence on invertebrate communities when compared to temporal variation.

In the first two months, there was an increasing trend in diversity, abundance, percent EPT, and Rhyacophilidae taxa as sites moved further upstream. This is interesting because the further upstream the samples were taken, sites had lower anthropogenic impacts. To see if these trends would persist, more sites were added in July and September. This revealed a consistently strong increasing trend in diversity, but the trend in abundance became weaker and the trend in percent EPT became negative. Because there is a consistent positive trend in diversity and abundance this gives good indication of increasing health further upstream (Broszeit et al., 2017).

Diversity levels showed consistently increasing trends the further upstream samples were taken. Any Shannon Wiener index value between 1.5 – 3.5 is considered normal for natural habitats (Magurran, 2004). Only a few sites showed values below 1.5, and two sites had values below one. The sites that showed values below one was Site 1 and Site 2, both these sites have a suitable habitat for invertebrates but are the furthest downstream sites tested during the entire summer. This decrease in diversity could be used to speculate that there are decreases in the water quality with increasing human presence. Montane Cordillera invertebrates such as these, have been seen to be affected by nitrogen and phosphorus levels reaching as little as 0.21 mg/L and 0.02 mg/L respectfully (Chambers et al., 2012). Other studies have shown this negative correlation, where an increase in human activity leads to a decrease in invertebrate community health (Sciera et al., 2008). These values are low when compared to other river systems in Alberta where the Shannon Wiener index average is 1.98 (Canadian Aquatic Biomonitoring Network, 2019).

Increasing abundance can indicate good water quality, but only if diversity levels remain high. If diversity levels drop and the environment becomes dominated by only a few taxa, this can indicate serious problems in the water column (Broszeit et al., 2017). In Bighill Creek these two variables increase together, this is a very good indication of pristine water quality (Broszeit et al., 2017).

Percent EPT varied throughout the summer, which is consent with the organism's life cycles (Winkelmann & Koop, 2007). Usually the lowest numbers are seen in late June or early July, when many EPT are emerging into their terrestrial stage (Winkelmann & Koop, 2007). However, when compared to other sites throughout Alberta, EPT numbers in Bighill creek rank on the lower end (Table 11). Due to the EPT community having a 1-3 year aquatic life span, it is important to track these numbers for at least 3 years, to disclose natural variations in their population (Winkelmann & Koop, 2007).

The negative trend in percent EPT community appears to be correlated to habitat. After the June sample, 6 more sites were added to the study, giving greater diversity amongst reach characteristics. Sites 1, 9 and 11 became outliers with respect to reach characteristics. Site 1 was sampled in the Bow River, which is substantially bigger than Bighill creek, with respect to width, depth, rocks, sediment, discharge and many characteristics that deviate from that of a stream. This may be why we see the lowest diversity at in the Bow River: not only does it have many tributaries that can bring with it all kinds of different water quality sources, it also has a very competitive environment that will decline healthy biodiversity like those found in the refuge waters of Bighill creek (Broszeit et al., 2017).

When we take into account the stream characteristics that were measured, Site 9 and 11 do not have favourable conditions for the EPT community (Table 4). This may be why there is a drop in percent EPT at these sites. Site 9 and 11 both have small or no stones, low DO, and low velocity. Site 9 has no macrophyte coverage while Site 11 has 100% macrophyte coverage (Table 4). Stone size has been positively correlated with abundance and diversity of Ephemeroptera, Plecoptera and Trichoptera, because stones provide shelter and stability for these invertebrates (Jacobsen, 2005). Therefore, the small stone sizes at these two sites preclude for high numbers of EPT (Somerfield et al., 2018). As well, sensitive, pollution intolerant taxa within the EPT community tend to have complex biological structures that require high levels of DO, and neutral pH levels (Hodkinson & Jackson, 2005). If oxygen levels are high enough, macrophyte coverage can support increases in macro invertebrates by providing surface area for invertebrates to cling to, and in some cases, a food source (Lusardi et al., 2018; Feio et al., 2017). Variations in macrophyte cover have been correlated with changes in invertebrate communities but can also attribute to stone size (Feio et al., 2017). While macrophyte coverage is high at Site 11, stones are absent. Therefore, this may prompt increases in some invertebrate communities, but for the EPT community specifically, stones are often necessary. Some other sites have high macrophyte coverage and high EPT numbers, but these sites also have many stones, higher DO levels and a more neutral pH. While Site 9 and 11 may not be favourable habitats for the EPT community, they both prosper high diversity, which is a positive sign of a healthy aquatic environment (Broszeit et al., 2017). Site 10 also has a lower percent EPT community, relative to other sites further downstream, but it maintains favorable reach characteristics for the EPT community to thrive. This may also signal changes in water chemistry compared to other sites. Site 10 is very close to Bighill Springs, therefore it is receiving a strong groundwater signal, which often has higher salinity (Goldschmidt, 2016, and Fouli, 2018).

Site 10 is unique because of increased aquatic mite counts. The mite counts in July at Site 10 were ten times higher than the second largest sample size at Site 9 (n=20). Mites have been correlated with spring habitats because they prefer high salinity environments often supplied by groundwater (Goldschmidt, 2016). Recently, mites have proven to be a good bioindicator of ground water health because they are sensitive to changes in their environment, especially those linked to pastures, and mechanical activity (Goldschmidt, 2016). This data has been used to show positive correlations in mite population and spring health (Goldschmidt, 2016). Many studies done in Europe have correlated a decline in mite populations with an increase in environmental degradation (Sabatino et al., 2003;

Miccoli et al., 2013). There is increasing research in North America that links a decline in mite populations to changes in climate and anthropogenic pressures (Goldschmidt, 2016). The aquifers of Bighill Creek are higher in saline and lower in nitrogen and phosphorus than the main creek (Fouli, 2018). This provides favorable habitat characteristics for aquatic mites and may be the reason for increased populations of these taxa at sites near the springs.

To look at specific families within the EPT community, the Rhyacophilidae were examined because they are a very sensitive family within the Trichoptera order, with a tolerance value of zero (Bouchard et al., 2004). This is the least tolerant value taxa found in all the samples. Finding high Rhyacophilidae in healthy spring fed streams is consistent with previous research (Sun et al., 2019). This organism's numbers are consistently highest at Sites 6, and 10. These are the two most forested sites and have a good riffle environment for Rhyacophilidae to cling to the rocks. These sites are also very protected sites, as Site 6 is on the boundary of BCPS's stewardship reserve, and Site 10 is within the Bighill Springs Provincial Park.

Chironomidae is a family within the Diptera order and while they are commonly known as a great food source for other organisms, they have a high tolerance value and can persist in environments under greater stress (Bouchard et al., 2004). It is interesting to see the negative relationship between Chironomidae and Rhyacophilidae (Figure 17, 21, and 26). Where Chironomidae numbers are high, Rhyacophilidae numbers tend to be low, supporting accurate interpretations of the data in these areas.

The University of Guelph's findings support the findings in this aquatic invertebrate study (Hajibabaei Lab, 2019). The eDNA gives us institutional recognition of the invertebrates we have found in Bighill Creek. While the eDNA results do not give us total abundance, it will be vital in helping to document the many important organisms inhabiting Bighill Creek. The varying trends could possibly prompt further analysis in order to depict outliers and trends.

5.0 Conclusion:

Overall, this aquatic invertebrate study has shown that Bighill Creek has a healthy aquatic environment, with high diversity, and a pristine ground water source. The invertebrate community, however, shows signs of declining water quality linked to increasing human disturbances. This trend is particularly indicated from sampling within Cochrane townsites.

Most aquatic insects have a life span between 1-3 years and may shows signs of fluctuation within their cycles. All invertebrates are in their aquatic state in late August to early September. Therefore, it is advisable to continue annually sampling in the fall for 3-6 years in order to detect natural variations that may reveal overtime. Having a more robust data set would also permit more thorough inferential statistics to be performed.

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Figures:

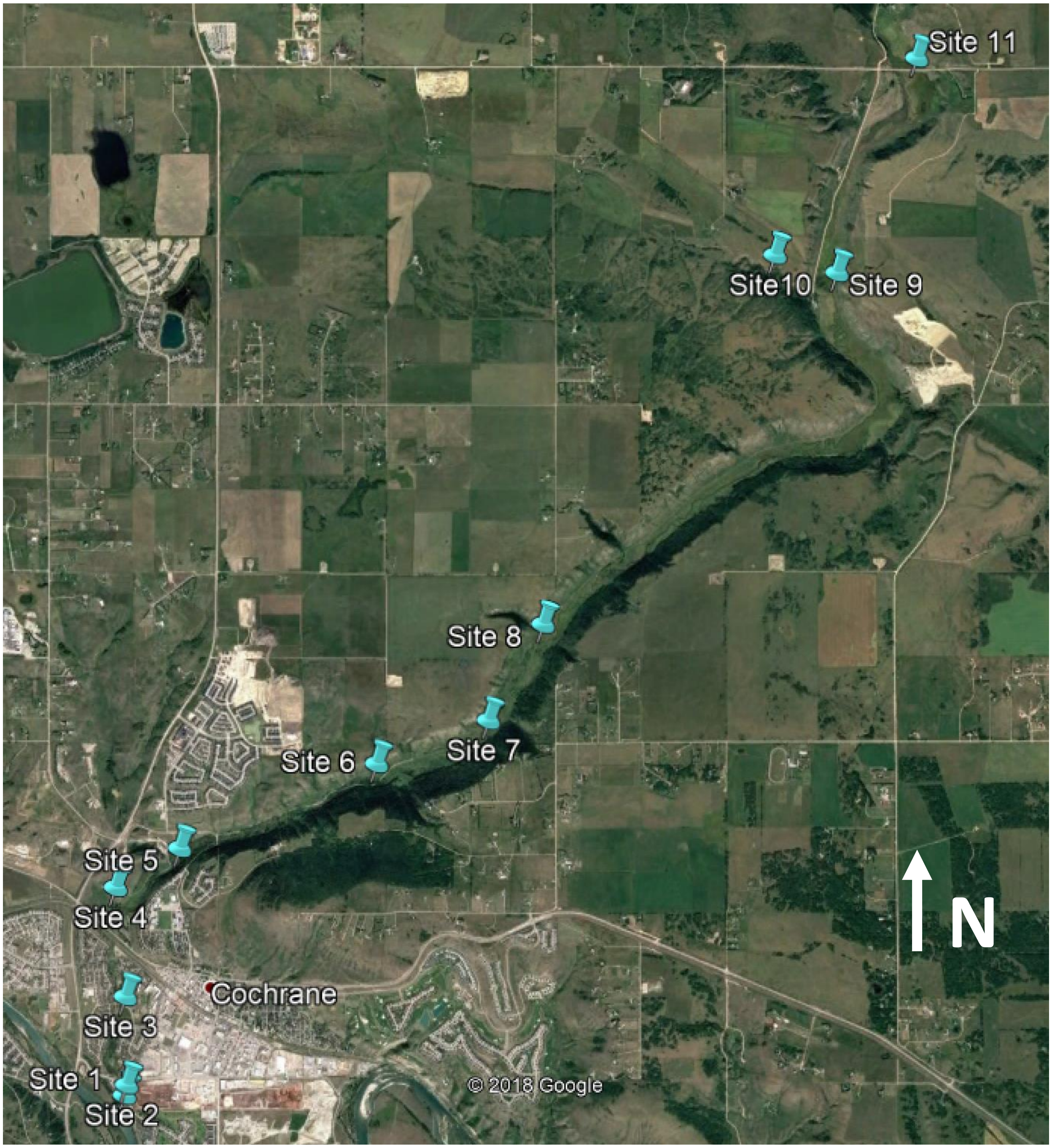


Figure 1. Site locations along Bighill Springs Creek.

(a) (b) (c)

Figure 2. Pictures of Site 1, taken in May, looking upstream (a), downstream (b), south bank (c)

 (a)
 (b)

 (c)

 (d)

Figure 3. Pictures of Site 2, taken in May, looking upstream (a), downstream (b), east bank (c) and west bank (d)


(a)


(b)


(c)

Figure 4. Pictures of Site 3, taken in October, looking upstream (a), downstream (b), standing on east bank facing west (c)

 (a)  (b)

 (c)

 (d)

Figure 5. Pictures of Site 4, taken in May, looking upstream (a), downstream (b), west bank (c) and east bank (d)

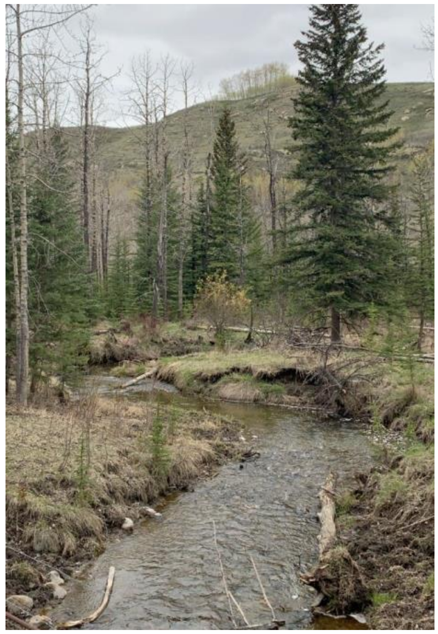
(a)

(b)

(c)

Figure 6. Pictures of Site 5, taken in July, standing on south bank looking upstream (a), downstream (b), and west bank (c).

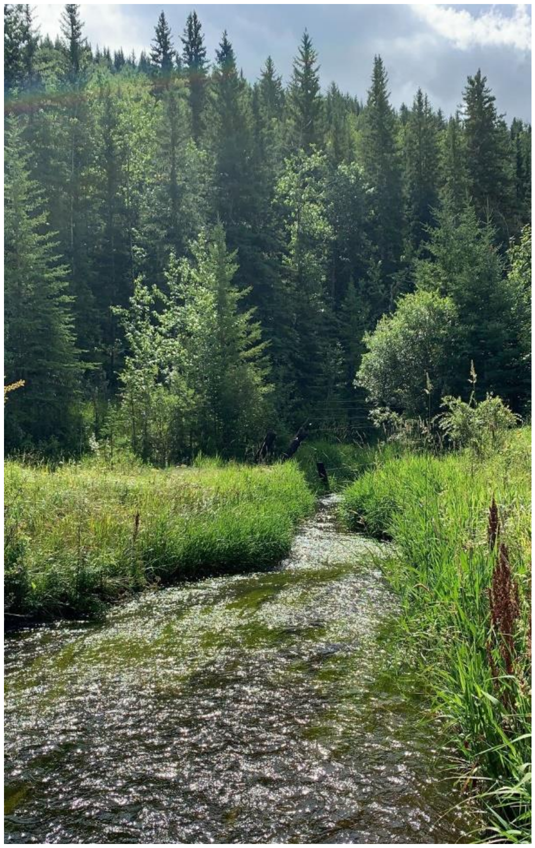

(a)


(b)


(c)


(d)

Figure 7. Pictures of Site 6, taken in May, looking upstream on other side of bridge(a), downstream (b), west bank (c), and east bank (d).

 (a)  (b)

 (c)

Figure 8. Pictures of Site 7, taken in July, looking upstream (a), downstream (b), and east bank (c).

 (a)

(b)

 (c)

Figure 9. Pictures of Site 8, taken in July, looking at the west bank (a), birds eye view (b), and east bank (c).

 (a)  (b)

Figure 10. Pictures of Site 9, taken in July, looking at the east bank (a), and benthic substrate (b)

Figure 11. Pictures of Site 10, taken in July, looking upstream (a), downstream (b) north bank (c), facing north (d), and intermittent sediment (e).


(a)

(b)


(c)

Figure 12. Pictures of Site 11, taken in July, looking upstream (a), downstream (b) and west bank (c).

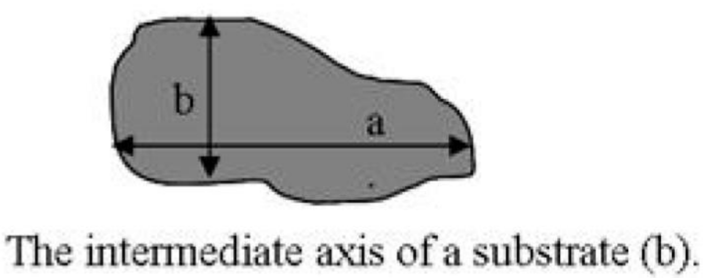


Figure 13. Shows where intermediate axis of a stone is, which is the measurement taken for all the stone measurements in this study.

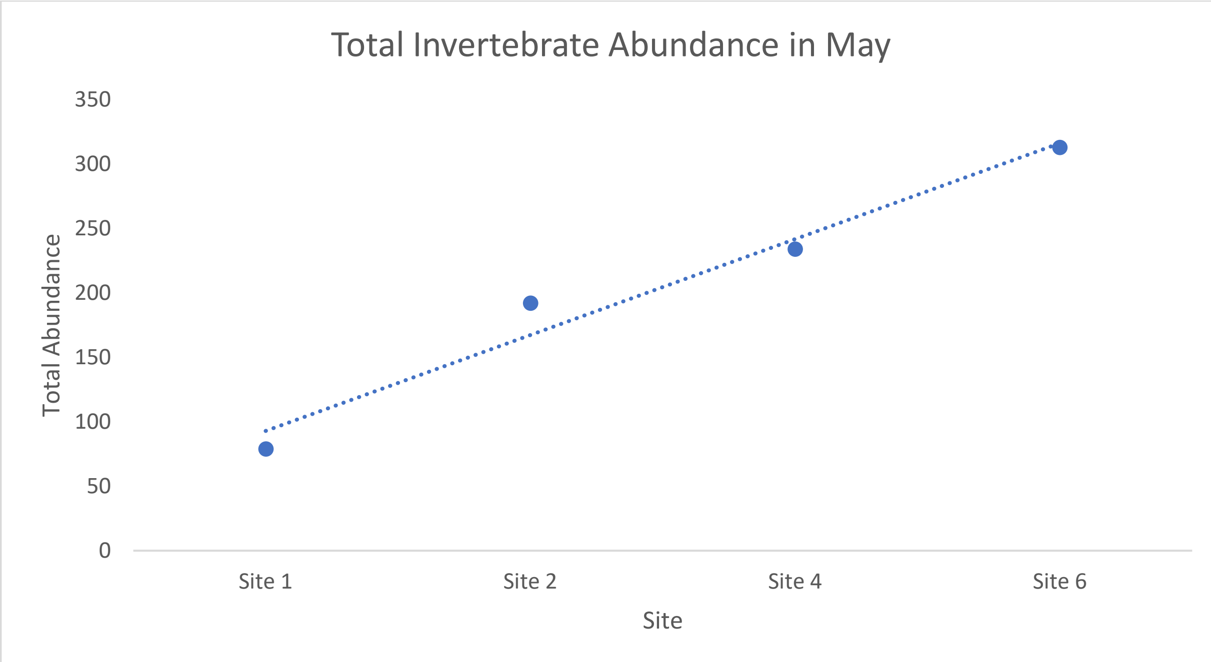


Figure 14. Total invertebrate abundance is the sum of all macro benthic invertebrates collected at each site for the month of May. This figure is displayed left to right as sites closest to Bow confluence (on the left) to furthest away/upstream (on the right).

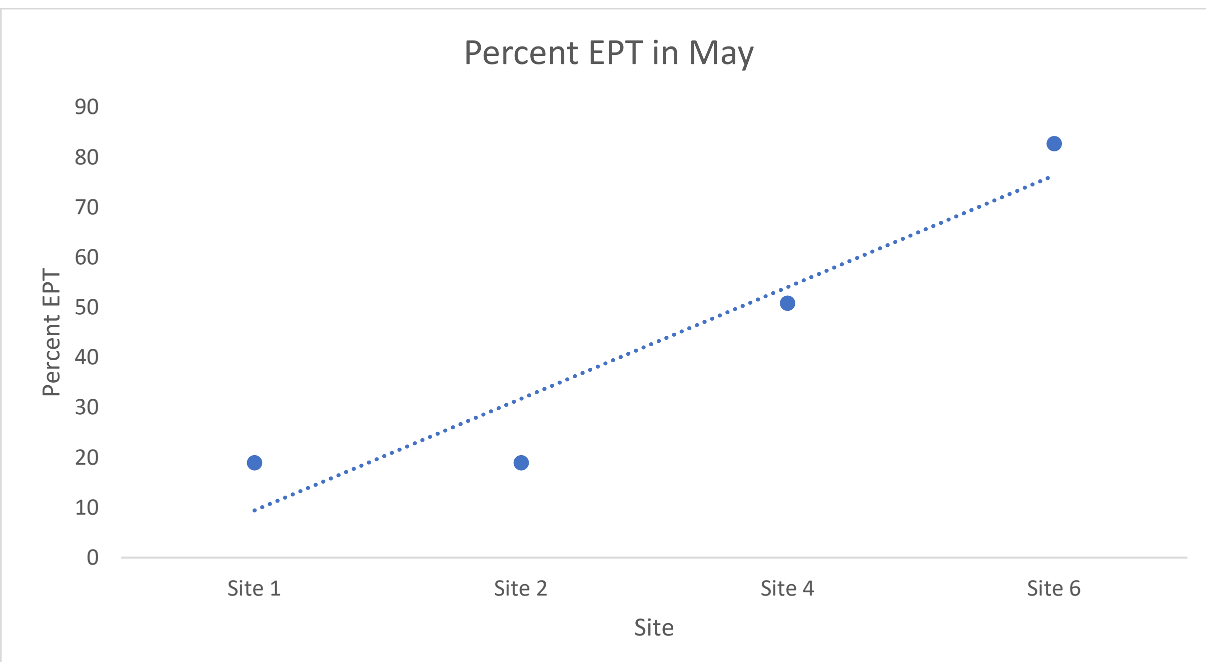


Figure 15. Percent of EPT community (including all families from the orders, Ephemeroptera, Plecoptera, and Trichoptera, commonly known as Mayflies, Stoneflies, and Caddisflies) divided by total abundance count, calculated at each site. This data is from sites sampled in the month of May and is displayed left to right as sites closest to Bow confluence to furthest away.

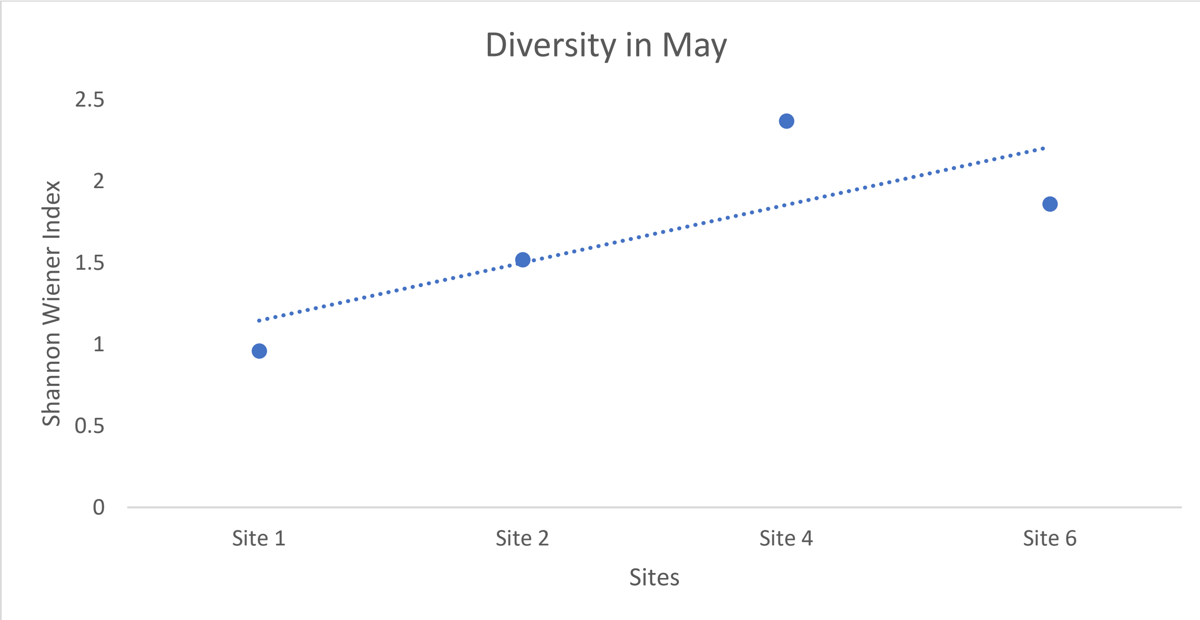


Figure 16. Shannon Wiener Index calculated for each site in the month of May. Sites are organized as closest site to Bow river confluence on the left to furthest away from confluence upstream on the right.

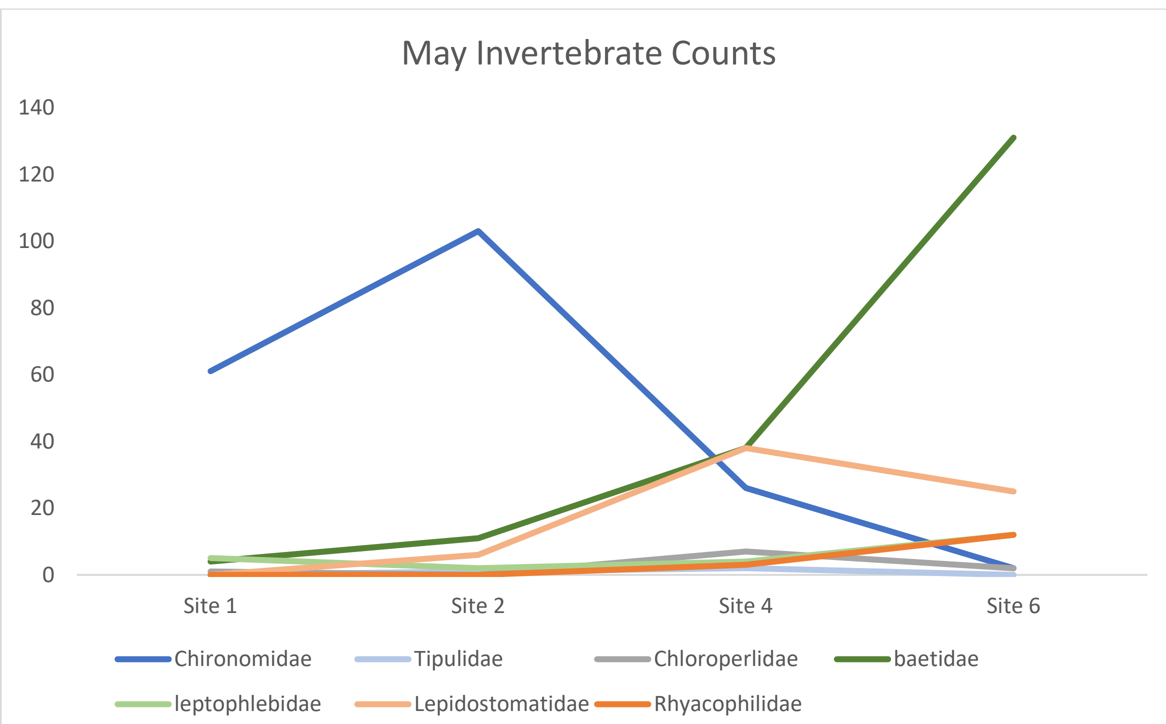


Figure 17. Shows total counts of seven key invertebrate families at each site sampled in May. The families in blue are apart of the Diptera (True Fly) order, grey is apart of the Plecoptera (Stone fly) order, green is apart of the Ephemeroptera (May fly) order and orange is apart of the Trichoptera (Caddis fly) order. This data is displayed left to right as sites closest to Bow confluence to furthest away.

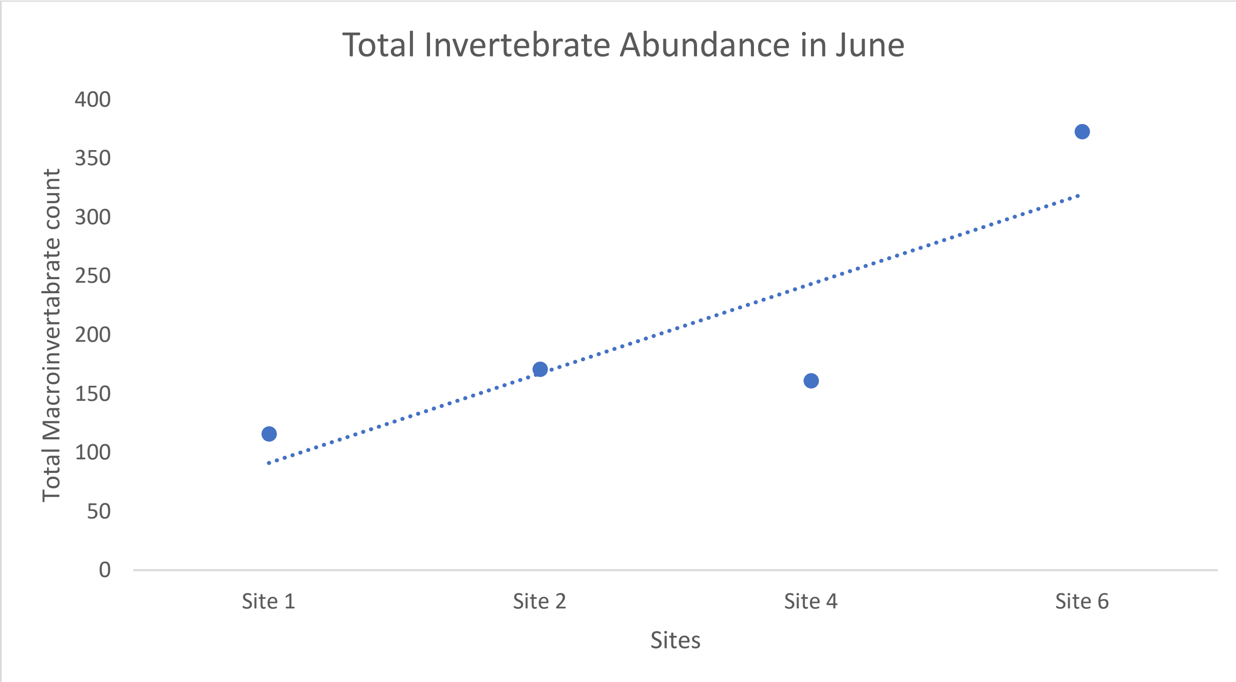


Figure 18. Total invertebrate abundance is the sum of all macro benthic invertebrates collected at each site for the month of June. This figure is displayed left to right as sites closest to Bow confluence (on the left) to furthest away/upstream (on the right).

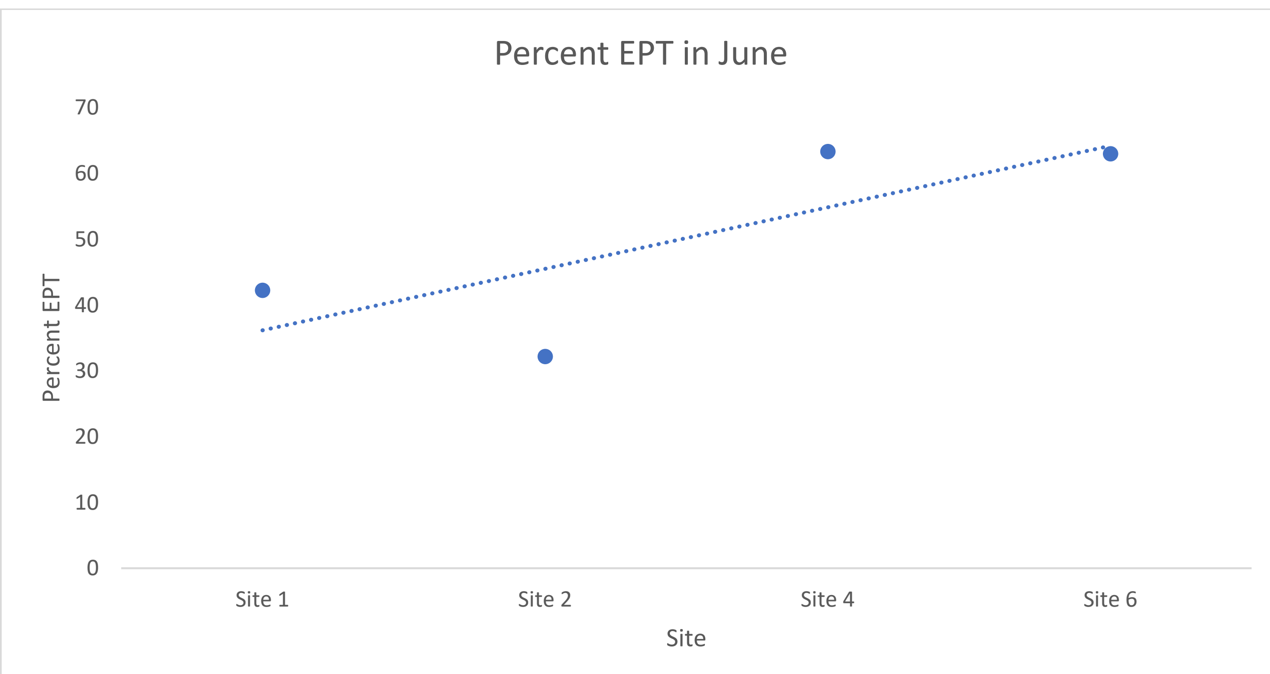


Figure 19. Percent of EPT community (including all families from the orders, Ephemeroptera, Plecoptera, and Trichoptera, commonly known as Mayflies, Stoneflies, and Caddisflies) divided by total abundance count, calculated at each site. This data is from sites sampled in the month of June and is displayed left to right as sites closest to Bow confluence to furthest away.

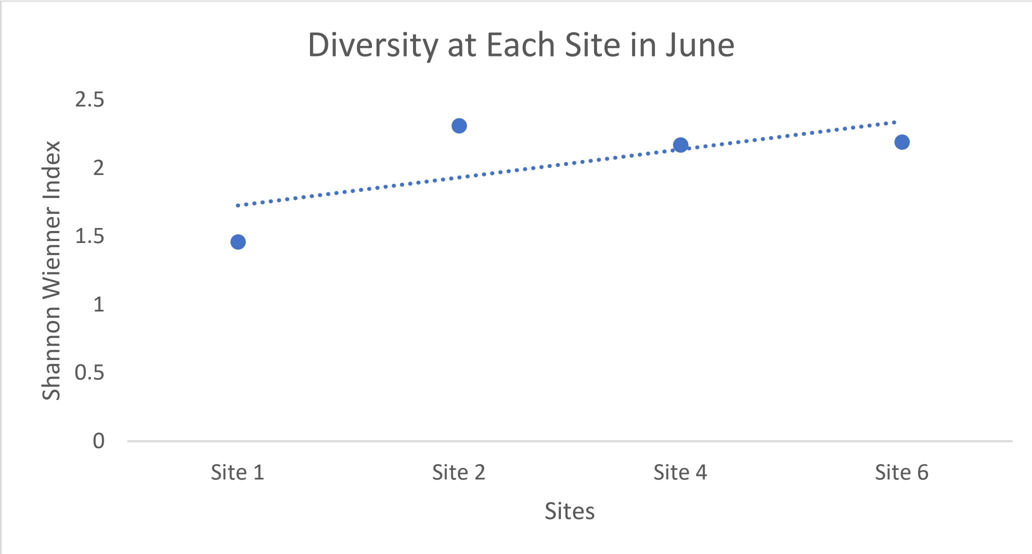


Figure 20. Shannon Wiener Index calculated for each site in the month of June. Sites are organized as closest site to Bow river confluence on the left to furthest away from confluence upstream on the right.

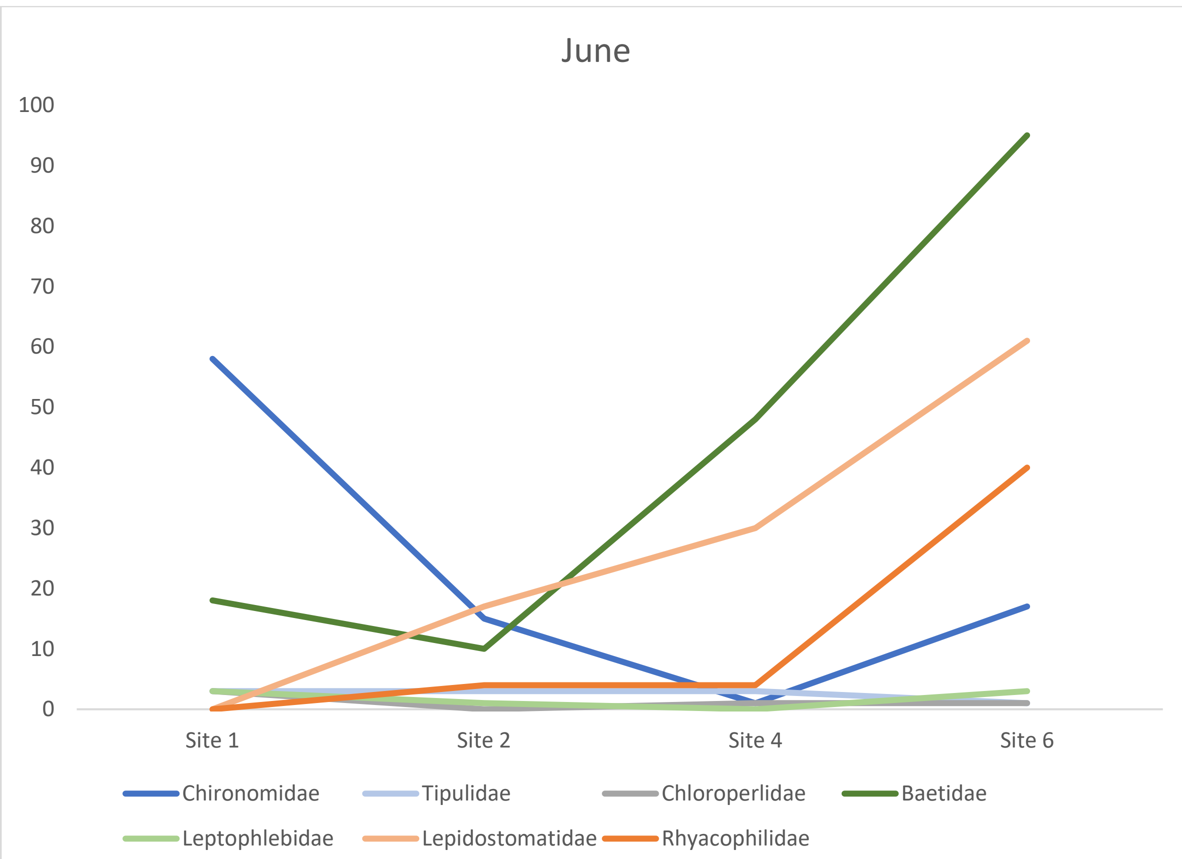


Figure 21. Shows total counts of seven key invertebrate families at each site sampled in June. The families in blue are apart of the Diptera (True Fly) order, grey is apart of the Plecoptera (Stone fly) order, green is apart of the Ephemeroptera (May fly) order and orange is apart of the Trichoptera (Caddis fly) order. This data is displayed left to right as sites closest to Bow confluence to furthest away.

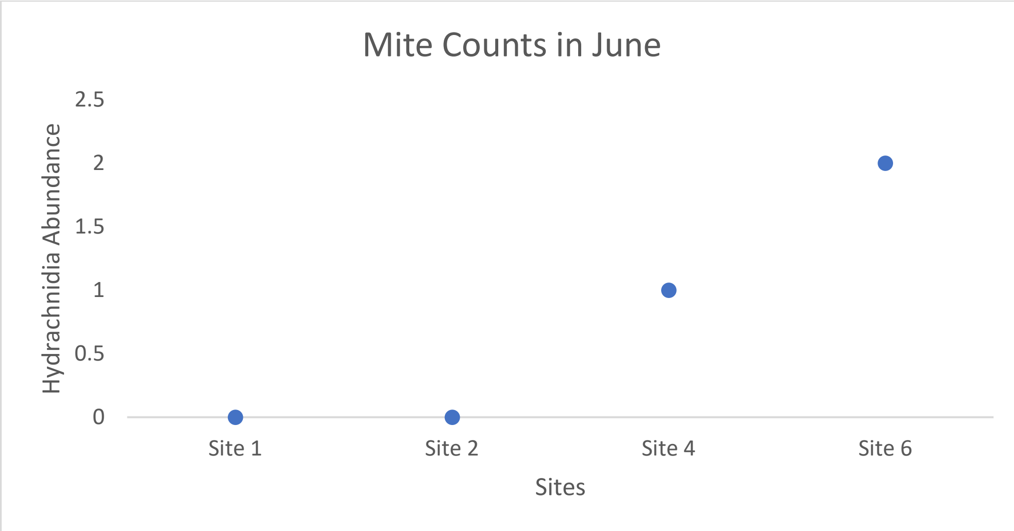


Figure 22. Hyrdachnidia (aquatic mite) counts at 4 sites in June.

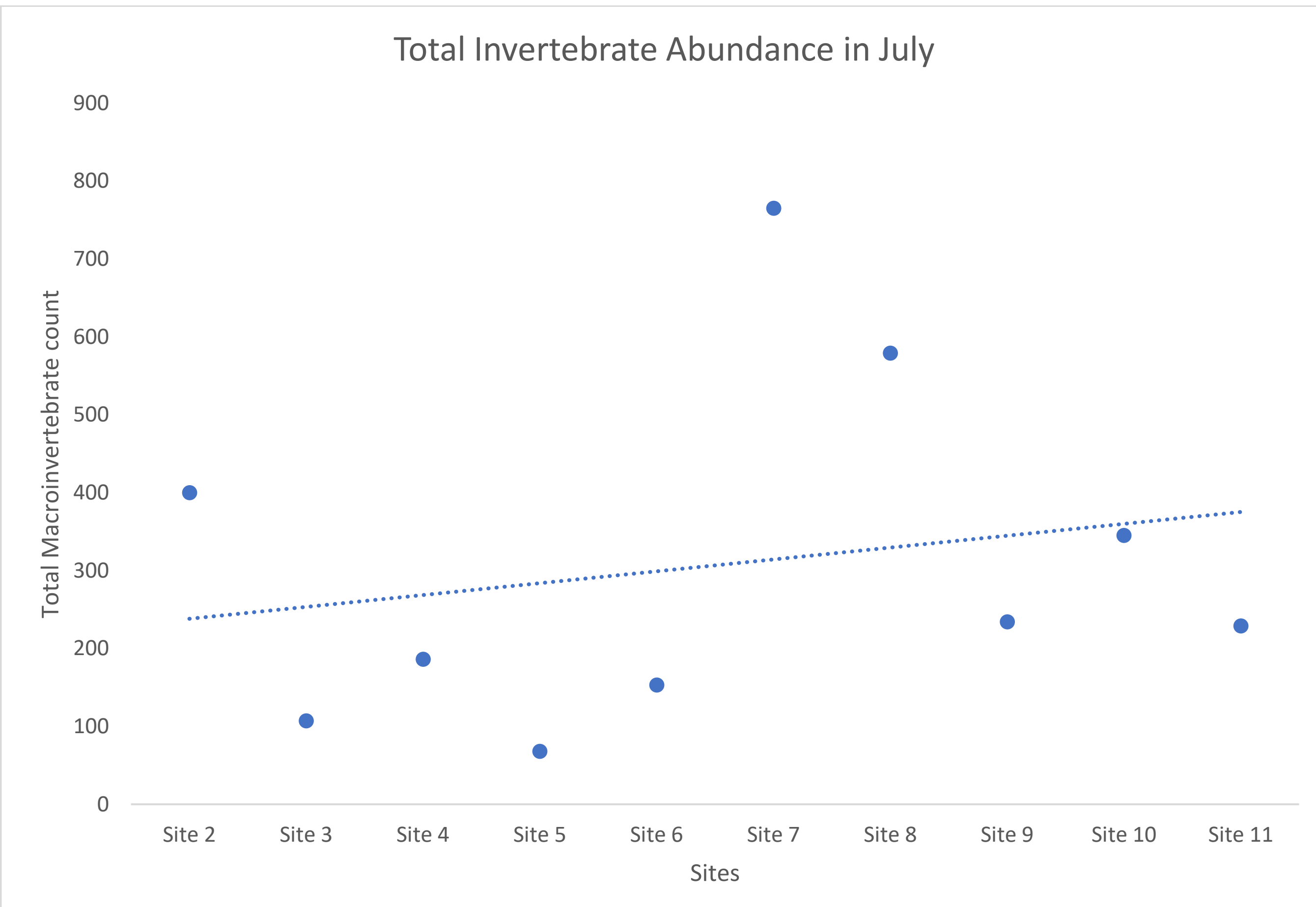


Figure 23. Total invertebrate abundance is the sum of all macro benthic invertebrates collected at each site in the month of July. This figure is displayed left to right as sites closest to Bow confluence (on the left) to furthest away/upstream (on the right).

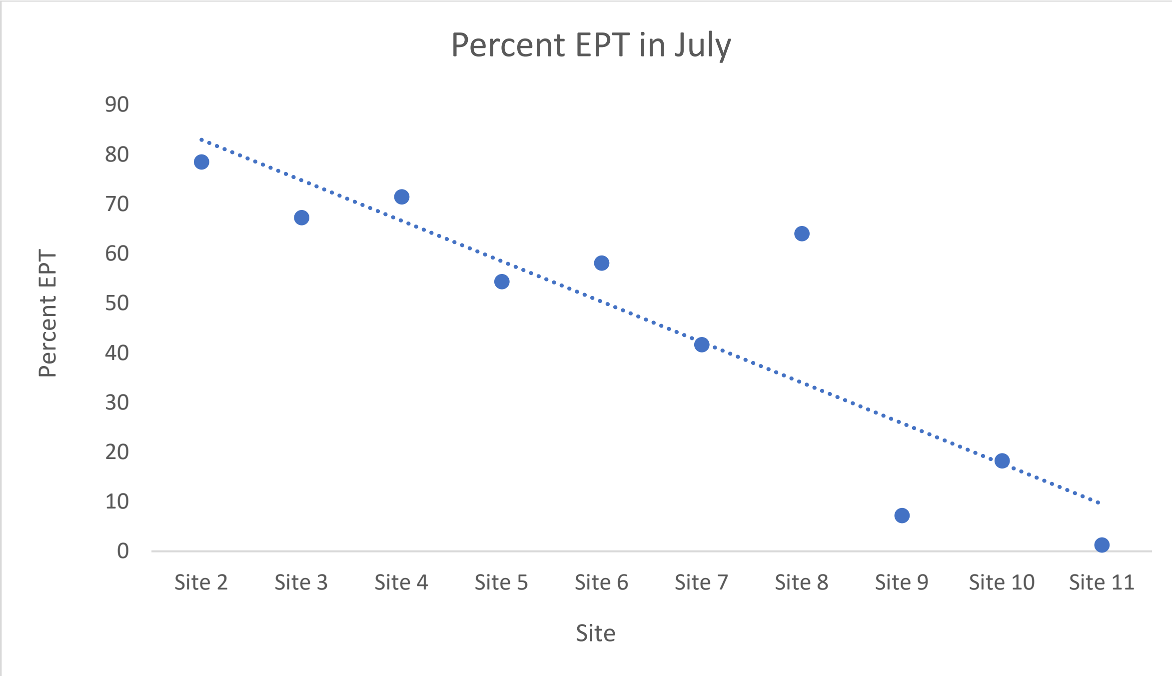


Figure 24. Percent of EPT community (including all families from the Orders, Ephemeroptera, Plecoptera, and Trichoptera, commonly known as Mayflies, Stoneflies, and Caddisflies) divided by total abundance count, calculated at each site. This data is from sites sampled in the month of July and is displayed left to right as sites closest to Bow confluence to furthest away.

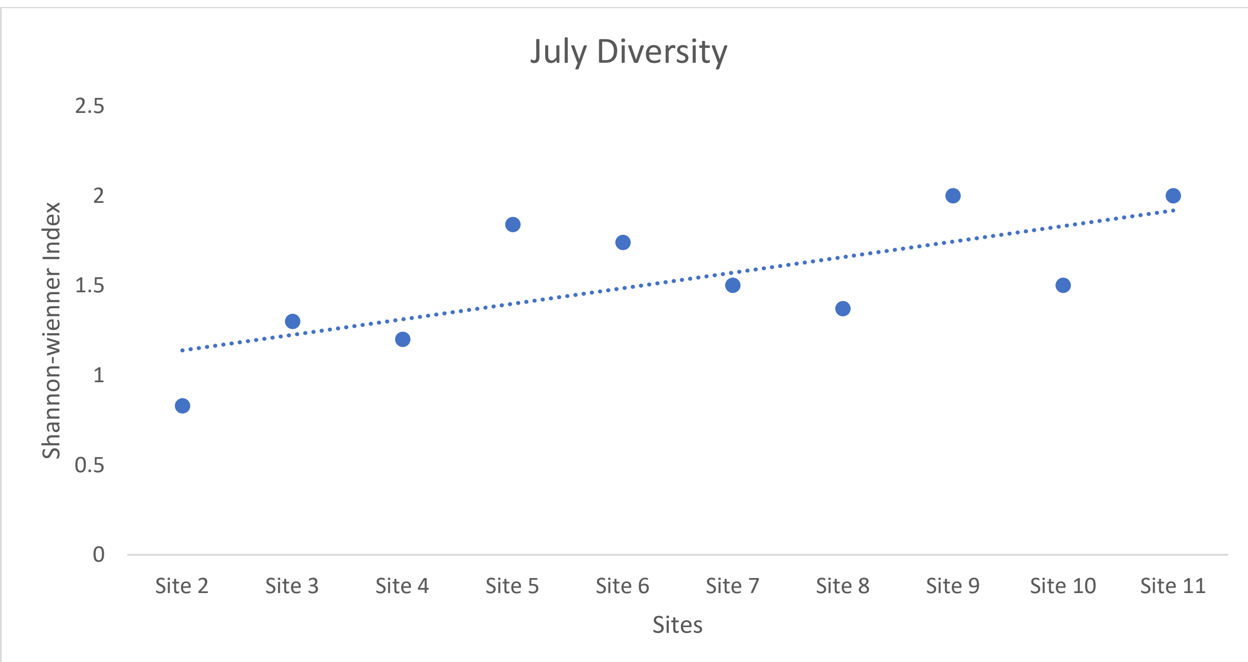


Figure 25. Shannon Wiener Index calculated for each site in the month of July. Sites are organized as closest site to Bow river confluence on the left to furthest away from confluence upstream on the right.

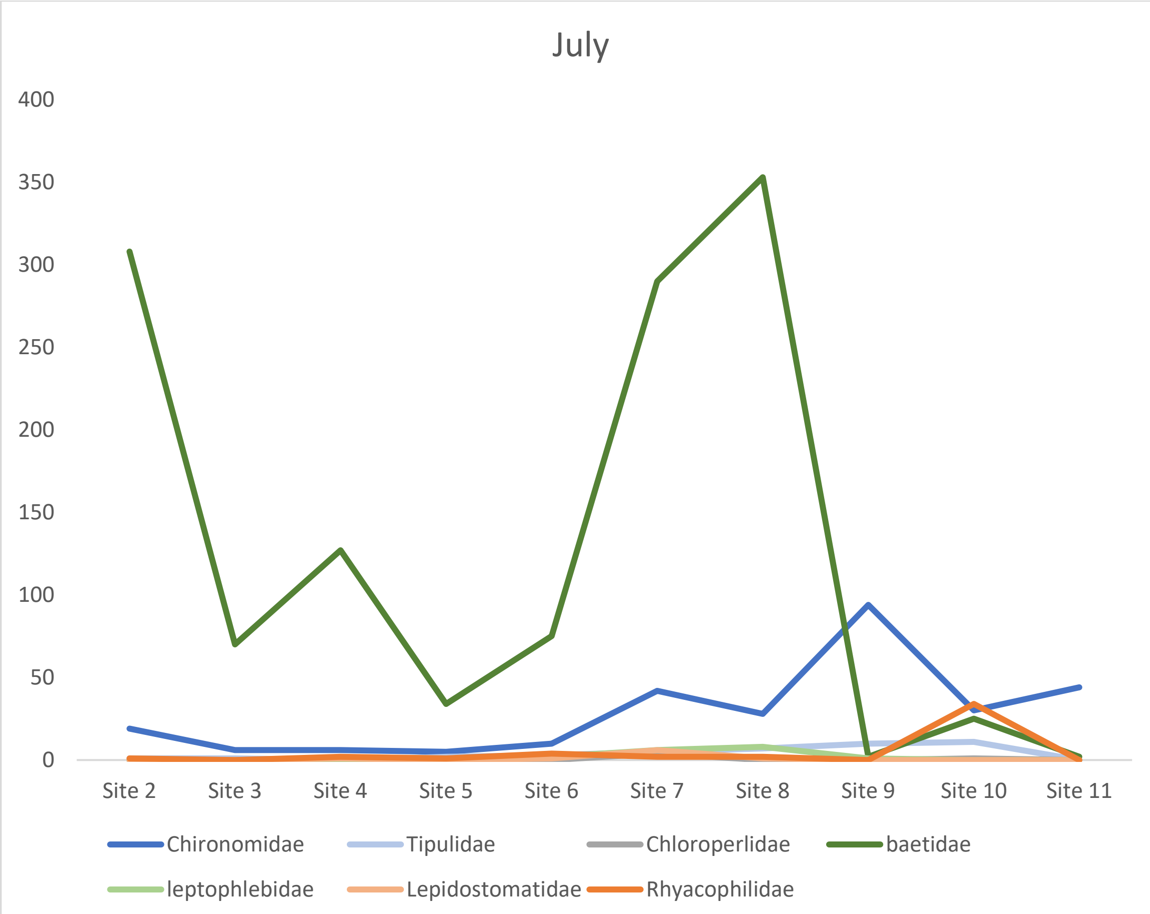


Figure 26. Shows total counts of seven key invertebrate families at each site sampled in July. The families in blue are apart of the Diptera (True Fly) order, grey is apart of the Plecoptera (Stone fly) order, green is apart of the Ephemeroptera (May fly) order and orange is apart of the Trichoptera (Caddis fly) order.

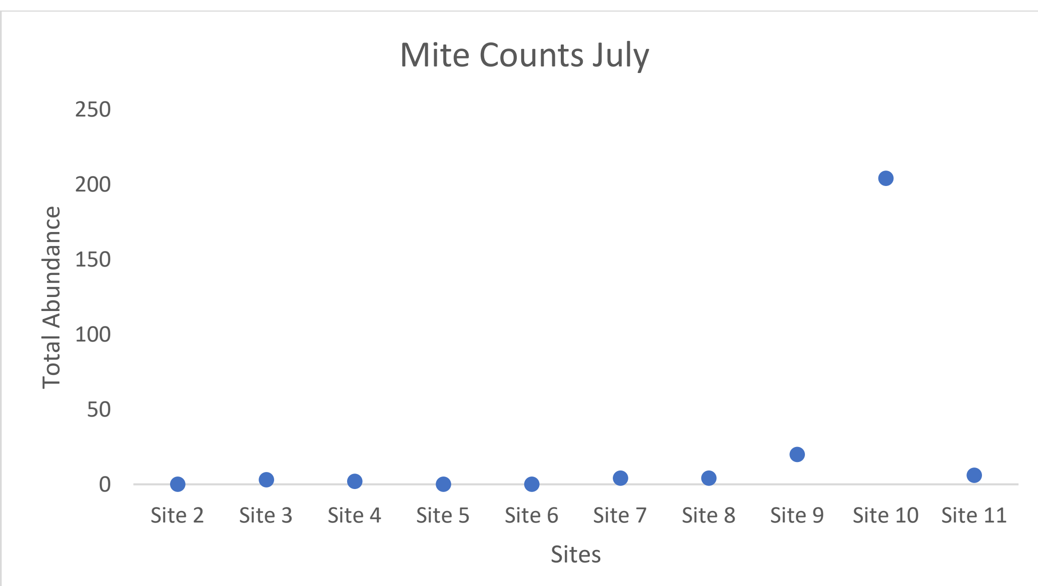


Figure 27. Hyrdachnidia (aquatic mite) count at 10 sites in July.

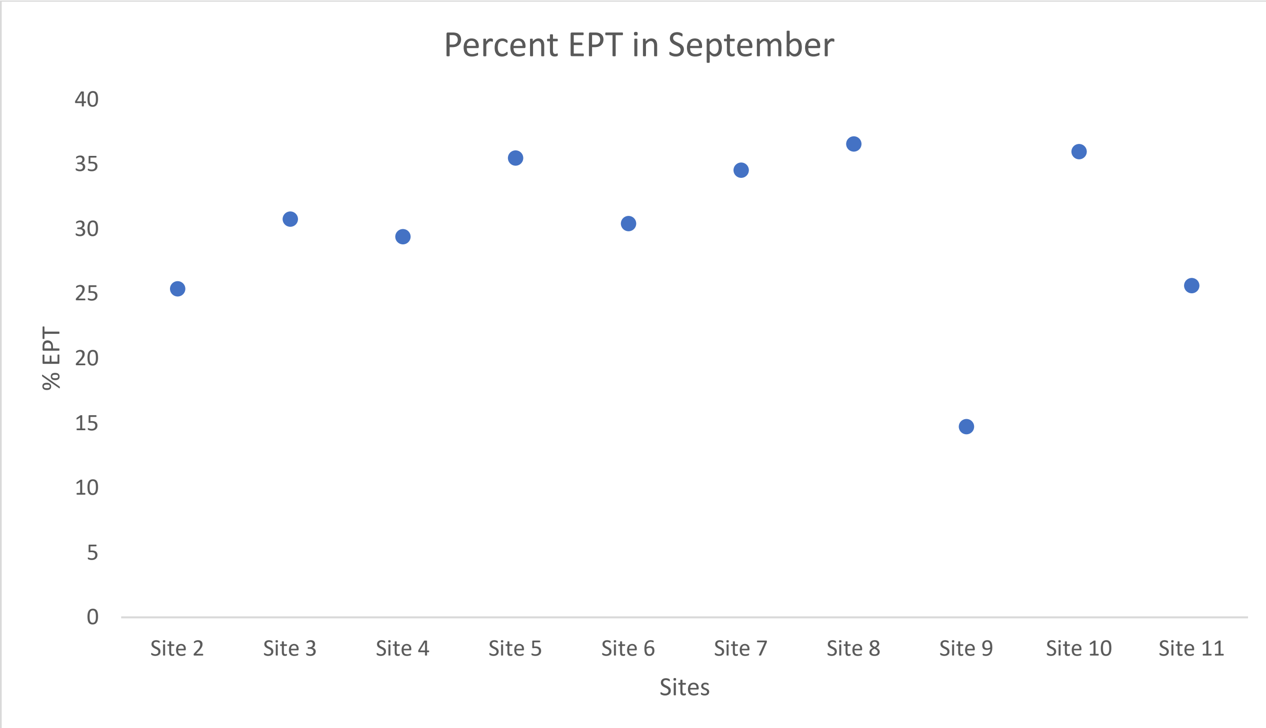


Figure 28. Percent of EPT community (including all Species from the Orders, Ephemeroptera, Plecoptera, and Trichoptera, commonly known as Mayflies, Stoneflies, and Caddisflies) divided by total amount of Species present at each site. This data is from sites sampled in the month of September and is displayed left to right as sites closest to Bow confluence (Site 2) to furthest away (Site 11).

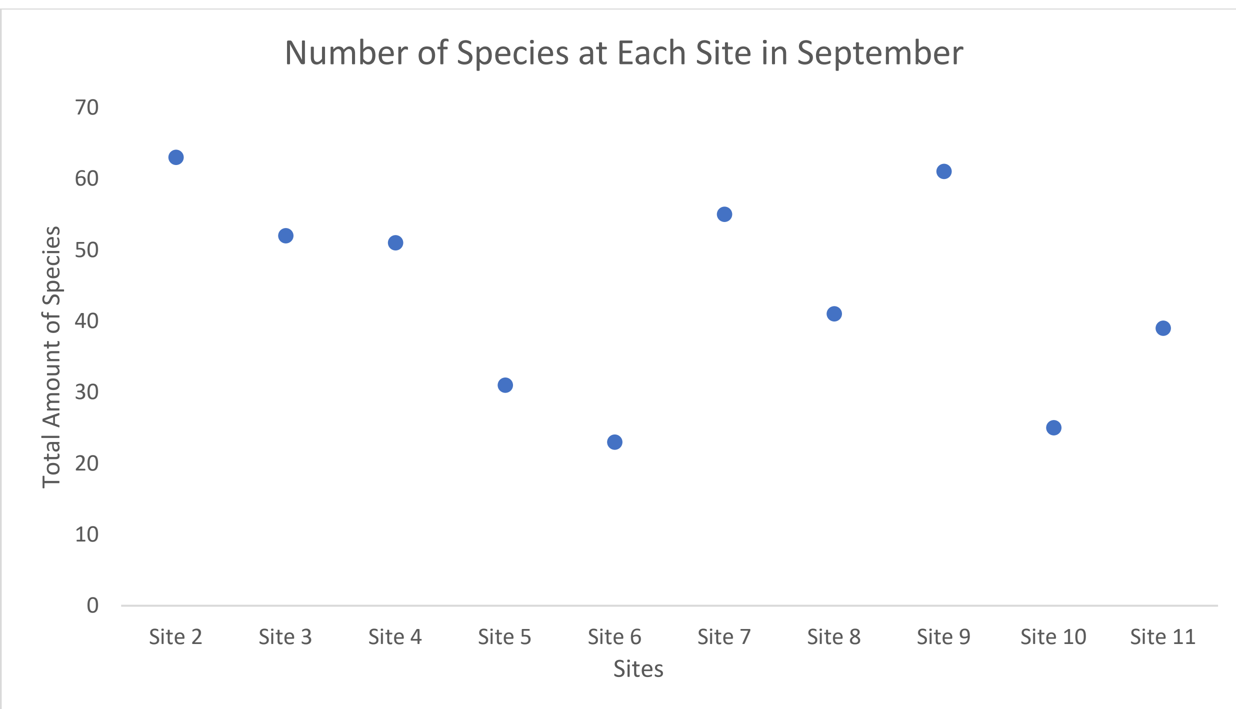


Figure 29. The total number of all the species at each site is used here to display biodiversity differences at each site.

Tables:

Table 1. Aquatic invertebrate counts at 11 sites in Bighill creek collected in May, June, July and September. Identification is separated out by order (in bold) and is identified down to family level. Where invertebrates are present, the numbers are bolded and where invertebrate counts are above 100, the numbers are highlighted.

Site	Site 1				Site 2						Site 3		Site 4					
Date	May		June		May		June		July	September	July	September	May		June		July	September
Environment	Riffle	Pool	Riffle	Pool	Riffle	Pool	Riffle	Pool	Riffle	Riffle	Riffle	Riffle	Riffle	Pool	Riffle	Pool	Riffle	
Plecoptera (Stonefly)																		
Chloroperlidae (Green Stonefly)	**1**	0	**3**	0	0	0	0	0	0		0		**7**	0	**1**	**2**	**1**	
Perlidae (Golden Stonefly)	**1**	0	0	0	0	0	0	0	**1**		**1**		0	0	0	0	0	
Nemouridae (Spring Stonefly)	0	0	0	0	0	0	0	0	0		0		0	0	0	0	0	
Trichoptera (Caddis-Fly)																		
Brachycentridae (Humpless case maker Caddis)	0	0	0	0	0	0	0	0	**1**		0		0	0	0	0	0	
Leptoceridae (Long horned caddis)	0	0	0	0	0	0	0	0	0		0		0	0	0	0	0	
Rhyacophilidae (Free-living caddis)	0	0	0	0	0	**3**	**4**	0	**1**		**1**		**12**	**3**	**4**	**1**	**2**	
Lepidostomatidae (Case-maker caddis)	0	0	0	**2**	**6**	0	**17**	**5**	0		0		**38**	**12**	**30**	**42**	**1**	
Empty Case	0	0	0	**3**	0	0	**9**	**17**	0		0		**10**	0	**14**	**13**	0	
Hydropsychidae (Net spinning caddis)	**1**	0	0	0	**12**	**8**	**13**	0	**2**		0		**8**	**2**	**3**	**4**	0	
Hydroptilidae Pupa (Micro caddis)	0	0	0	0	0	0	0	0	0		0		0	0	**1**	0	**1**	
Psychomyiidae (Net tube caddis)	0	0	0	0	0	0	0	0	0		0		0	0	0	0	0	
Philopotamidae (Fingernet Caddis)	0	0	0	0	0	0	0	0	0		0		0	0	0	0	1	

Polycentropodidae (Tube maker caddis)	0	0	0	0	0	0	0	0	0		0		0	0	0	0	0	
Odontoceridae (Mortarjoint casemaker)	0	0	0	0	0	0	0	0	0		0		0	0	0	0	0	
Ephemeroptera (Mayfly)																		
Baetidae (Small minnow mayfly)	**4**	0	**18**	0	**11**	**1**	**10**	**1**	**308**		**34**		**38**	**7**	**48**	**8**	**127**	
Leptophlebidae (Pronggilled mayfly)	**5**	0	**3**	0	**2**	0	**1**	0	0		0		**4**	**1**	0	0	0	
Heptageniidae (Flat headed mayfly)	**3**	0	0	0	0	0	0	0	0		**1**		**1**	0	**1**	0	0	
Ephemerelidae (Spiny crawler mayfly)	0	0	**25**	**1**	**3**	**1**	**1**	0	**1**		0		**1**	0	0	0	0	
Hemiptera (True Bug)																		
Nymph	0	0	**2**	0	0	**3**	**5**	**2**	0		0		**1**	0	**2**	**7**	0	
Ant	0	0	0	0	0	0	**1**	0	0		0		0	0	0	**1**	0	
Corixidae (Water boatmen)	0	0	0	0	0	0	0	0	0		0		0	0	0	0	0	
Coleoptera (Beetle)																		
Elmidae larva (Riffle beetle)	**1**	0	**1**	**3**	**27**	**26**	**21**	**5**	**30**		**4**		**31**	**5**	**6**	**15**	**26**	
Elmidae adult (Riffle beetle)	0	0	**3**	0	**13**	**4**	**55**	**4**	**19**		**6**		**10**	0	**25**	**1**	**3**	
Dytiscidae (Diving beetle)	0	0	0	0	0	0	0	0	**1**		**1**		0	0	0	0	0	
Haliplidae (Water beetle)	0	0	0	0	0	0	0	0	0		0		0	0	0	0	0	
Haliplidae Larvae (Water beetle)	0	0	0	0	0	0	0	0	0		0		0	0	0	0	0	
Hydrophilidae (Water scavenger beetle)	0	0	0	0	0	0	0	0	0		0		0	0	0	0	0	
Diptera (True Fly)																		

Chironomidae (Non-biting midge)	**61**	**24**	**58**	**6**	**103**	**123**	**15**	**9**	**19**		**5**		**26**	**69**	**1**	**34**	**6**	
Pediciidae (Crane fly)	**2**	0	0	0	**2**	0	0	0	**1**		**2**		0	0	0	0	0	
Tipulidae (Crane fly)	0	0	**3**	0	**1**	0	**3**	0	**1**		**7**		0	**2**	**3**	**1**	0	
Empididae (Dance fly)	0	0	0	0	0	0	**1**	0	0		0		0	0	0	**4**	**2**	
Simuliidae (Black fly)	0	0	0	0	0	0	0	0	0		0		0	0	0	0	0	
Ephydridae (Shore fly)	0	0	0	0	0	0	0	0	0		0		0	0	0	0	0	
Ptychopteridae (Phantom crane fly)	0	0	0	0	0	0	0	0	0		0		0	0	0	0	0	
Psychodidae (Drain fly)	0	0	0	0	0	0	0	0	0		0		0	0	0	0	0	
Oligochaeta																		
Lumbriculida (Non-segmented aquatic worm)	0	**4**	0	0	**6**	**9**	0	0	0		0		**32**	**10**	0	0	0	
Hirudinea (Leech)	0	0	0	0	0	0	0	0	**1**		0		0	0	0	0	0	
Nematod (Roundworm)																		
Ascaridida	0	0	0	**4**	0	0	**4**	**12**	**13**		0		**1**	0	**5**	**19**	**3**	
Amphipoda																		
gammaridae (Side-swimmers)	0	**1**	0	**1**	**5**	**1**	**1**	0	0		**2**		**2**	**1**	**3**	**1**	**9**	
Megaloptera																		
Sialidae (Alderfly)	0	0	0	0	**1**	0	0	**1**	0				0	0	0	**1**	0	
Cladocera																		
Daphnia (Water flea)	0	**5**	0	**8**	0	**5**	**2**	**6**	0		0		**12**	**22**	**11**	**109**	0	
Hydrachnidia (Aquatic mite)																		
Pionidae	0	0	0	0	0	0	0	0	0		0		0	**3**	**1**	**2**	**3**	
Sperchonidae	0	0	0	0	0	0	0	0	0		0		0	**4**	0	0	0	
Laversiidae	0	0	0	0	0	0	0	0	0		0		0	0	0	0	0	
Hydrovolziidae	0	0	0	0	0	0	0	0	0		0		0	0	0	0	0	
Nymphs	0	0	0	0	0	0	0	0	0		0		0	0	0	0	0	
Mollusks																		

Hydrobiidae (Mud snail)	0	0	0	0	0	0	**3**	0	**1**		0		0	0	0	0	0	
Planorbidae	0	0	0	0	0	0	0	0	0		0		0	**2**	0	**1**	0	
Sphaeriidae (Pea clam)	0	0	0	0	0	**3**	**5**	0	0		0		0	**1**	**2**	**1**	0	
Conchostraca (Clam shrimp)	0	0	0	0	0	0	0	**1**	0		0		0	**5**	0	**3**	0	
Lymnaeidae (Pond snail)	0	0	0	0	0	0	0	0	0		0		0	0	0	0	0	
Physidae (Bladder snail)	0	0	0	0	0	0	0	0	0		0		0	0	0	0	0	
Bithyniidae (freshwater snail)	0	0	0	0	0	0	0	0	0		**1**		0	0	0	0	0	
Odonata (Dragon fly)																		
Gomphidae (Club tail dragon fly)	0	0	0	0	0	0	0	0	0		**1**		0	0	0	0	0	
Aeshnidae (Darner dragon fly)	0	0	0	0	0	0	0	0	0		0		0	0	0	0	0	
Spongilla (Freshwater sponge)																		
Hydra Hymanae	0	0	0	0	0	0	0	0	0		**2**		0	0	0	0	0	

Site	Site 5		Site 6						Site 7		Site 8		Site 9		Site 10		Site 11	
Date	July	September	May		June		July	September	July	September	July	September	July	September	July	September	July	September
Environment	Riffle	Riffle	Riffle	Pool	Riffle	Pool	Riffle	Riffle	Riffle	Riffle	Riffle	Riffle	Riffle	Riffle	Riffle	Riffle	Riffle	Riffle
Plecoptera (Stonefly)																		
Chloroperlidae (Green Stonefly)	0		**2**	0	**1**	0	0		**4**		0		**1**		**1**		0	
Perlidae (Golden Stonefly)	**1**		0	0	0	0	0		**8**		0		**6**		**2**		0	
Nemouridae (Spring Stonefly)	0		0	0	0	0	0		0		0		0		0		0	

Trichoptera (Caddis-Fly)																		
Brachycentridae (Humpless case maker Caddis)	0		**28**	0	0	0	0		0		**2**		**3**		0		0	
Leptoceridae (Long horned caddis)	0		**1**	0	0	0	0		0		0		0		0		0	
Rhyacophilidae (Free-living caddis)	**1**		**49**	0	**40**	0	4		**2**		**2**		0		**34**		0	
Lepidostomatidae (Case-maker caddis)	0		**25**	**3**	**61**	**4**	**1**		**6**		**1**		0		0		0	
Empty Case	0		**10**	0	**34**	0	0		0		0		0		0		0	
Hydropsychidae (Net spinning caddis)	0		0	0	0	0	0		0		0		**3**		0		0	
Hydroptilidae Pupa (Micro caddis)	0		0	0	0	0	0		0		0		0		0		0	
Psychomyiidae (Net tube caddis)	0		0	0	0	0	0		0		0		0		0		0	
Philopotamidae (Fingernet Caddis)	0		0	0	0	0	4		**2**		**2**		0		**1**		0	
Polycentropodidae (Tube maker caddis)	0		0	0	0	0	1		**1**		0		0		0		0	
Odontoceridae (Mortarjoint casemaker)	0								0		0		0		0		**1**	
Ephemeroptera (Mayfly)																		

Baetidae (Small minnow mayfly)	**34**		**131**	0	**95**	0	**75**		**290**		**353**		**2**		**25**		**2**	
Leptophlebidae (Pronggilled mayfly)	0		**12**	0	**3**	0	**2**		**6**		**8**		**1**		0		0	
Heptageniidae (Flat headed mayfly)	**1**		**1**	**1**	**1**	0	0		0		0		0		0		0	
Ephemerelidae (Spiny crawler mayfly)	0		0	0	0	0	**2**		0		**3**		**1**		0		0	
Hemiptera (True Bug)																		
Nymph	0		0	0	0	0	0		0		**7**		0		0		0	
Ant	0		0	0	0	0	0		0		**1**		0		0		0	
Corixidae (Water boatmen)	0		0	0	**1**	0	0		0		0		**1**		0		**16**	
Coleoptera (Beetle)																		
Elmidae larva (Riffle beetle)	**4**		**30**	0	**19**	**2**	**32**		**321**		**124**		**3**		0		**1**	
Elmidae adult (Riffle beetle)	**6**		**16**	0	**62**	0	**7**		**46**		**13**		**2**		0			
Dytiscidae (Diving beetle)	**1**		0	0	0	0	0		0		**4**		0		0		**4**	
Haliplidae (Water beetle)	0		0	0	0	0	0		0		0		0		0		**33**	
Haliplidae Larvae (Water beetle)	0		0	0	0	0	0		0		0		0		0		**4**	
Hydrophilidae (Water	0		0	0	0	0	0		0		0		0		0		**1**	

scavenger beetle)																		
Diptera (True Fly)																		
Chironomidae (Non-biting midge)	**5**		**2**	**3**	**17**	**10**	**10**		**42**		**28**		**94**		**30**		**44**	
Pediciidae (Crane fly)	**2**		**4**	0	0	0	**3**		0		0		0		0		0	
Tipulidae (Crane fly)	**7**		0	**1**	**17**	0	**2**		**5**		**7**		**10**		**11**		0	
Empididae (Dance fly)	0		0	0	**1**	0	**1**		0		**8**		0		0		0	
Simuliidae (Black fly)	0		0	0	0	0	0		**15**		0		**24**		0		**1**	
Ephydridae (Shore fly)	0		0	0	0	0	0		0		0		0		0		0	
Ptychopteridae (Phantom crane fly)	0		0	0	0	0	0		0		0		0		0		0	
Psychodidae (Drain fly)	0		0	0	0	0	0		1		0		0		0		0	
Oligochaeta																		
Lumbriculida (Non-segmented aquatic worm)	0		**1**	0	0	0			0		0		**6**		0			
Hirudinea (Leech)	0		0	0	0	0	0		**1**		0		0		0		0	
Nematod (Roundworm)																		
Ascaridida	0		0	**1**	**4**	0	**1**		0		0		**2**		**2**		**3**	
Amphipoda																		
gammaridae (Side-swimmers)	**2**		0	0	0	0	0		**8**		**6**		**45**		0		**87**	
Megaloptera																		
Sialidae (Alderfly)			0	0	0	0	0		0		0		0		0		0	
Cladocera																		

Daphnia (Water flea)	0		0	0	**4**	0	**1**		0		0		**7**		**18**		**4**	
Hydrachnidia (Aquatic mite)																		
Pionidae	0		0	0	**2**	0	**2**		**4**		**4**		**20**		**2**		0	
Sperchonidae	0		0	0	0	0	0		0		0		0		**173**		**5**	
Laversiidae	0		0	0	0	0	0		0		0		0		**3**		**1**	
Hydrovolziidae	0		0	0	0	0	0		0		0		0		**2**		0	
Nymphs	0		0	0	0	0	0		0		0		0		**24**		0	
Mollusks																		
Hydrobiidae (Mud snail)	0		0	0	**1**	**2**	**1**		**1**		**3**		0		**2**		0	
Planorbidae	0		**1**	0	**3**	**7**	0		0		0		0		0		**2**	
Sphaeriidae (Pea clam)	0		0	0	**7**	**1**	**4**		0		**2**		**2**		**3**		0	
Conchostraca (Clam shrimp)	0		0	0	0	0	0		2		0		0		**11**		0	
Lymnaeidae (Pond snail)	0		0	0	0	0	0		0		0		0		0		**12**	
Physidae (Bladder snail)	0		0	0	0	0	0		0		0		0		0		**7**	
Bithyniidae (freshwater snail)	**1**		0	0	0	0	0		0		**1**		**1**		**1**		0	
Odonata (Dragon fly)																		
Gomphidae (Club tail dragon fly)	**1**		0	0	0	0	0		0		0		0		0		0	
Aeshnidae (Darner dragon fly)	0		0	0	0	0	0		0		0		0		0		**1**	
Spongilla (Freshwater sponge)																		

Hydra Hymanae	**2**		0	0	0	0	0		0		0		0		0		0	

Table 2. Shows the tolerance values of families within the Plecoptera (stonefly), Trichoptera (Caddis-fly) and Ephemeroptera (Mayfly) orders.

Plecoptera (Stonefly)	Tolerance Value
Chloroperlidae (Green Stonefly)	1
Perlidae (Golden Stonefly)	1
Nemouridae (Spring Stonefly)	2
Trichoptera (Caddis-fly)	
Brachycentridae (Humpless case-maker caddis)	1
Leptoceridae (Long horned caddis)	4
Rhyacophilidae (Free-living Caddis)	0
Lepidostomatidae (Case-maker caddis)	1
Hydropsychidae (Net spinning caddis)	4
Hydroptilidae Pupa (micro caddis)	4
Psychomyiidae (Net tube caddis)	2
Philopotamidae (Fingernet caddis)	3
Polycentropodidae (Tube maker caddis)	6
Odontoceridae (Mortarjoint casemaker)	0
Ephemeroptera (Mayfly)	
Baetidae (Small minnow mayfly)	4
Leptophlebidae (Pronggilled mayfly)	2
Heptageniidae (Flat headed mayfly)	4
Ephemerelidae (Spiny crawler mayfly)	1

Table 3. Sample site locations and directions.

Site	Lat/Long (WGS 84 Web Mercator)	Directions
Site 1	51°10'47.9''N 114 °28'49.6''W	In Bow River, 50m downstream from confluence with Bighill Creek.

Site 2	51 °10'51.1''N 114 °28'49.2''W	In Bighill Creek, approximately 100m upstream from confluence with Bow River.
Site 3	51°11'18.5''N 114°28'49.9'' W	Enter residential park off of Glenpatrick Drive (not Glenpatrick **Road**). There is a foot path that starts directly across from a ball diamond/rodeo park. Take this path down past the tennis courts. Stick to the right until you come across a bridge. Sample location is in riffle on the downstream side of the bridge.
Site 4	51 °11'52.4''N 114 °28'55.0''W	Picnic area in Cochrane's Farmers Market. Travel north up the gravel path from the parking lot. Walk down gravel path until the bridge and turn left down path before crossing the bridge. You will see the historical education boards on the west side of the creek and the sample site is located approximately 50m downstream from the boards.
Site 5	51°12'04.7''N 114°28'22.9'' W	Enter Range Road 42 A by heading North down 4th ave, park approximately 400m down the dirt road (right before crossing the first bridge). Enter at Cross Piston trail and walk South along the path approximately 500m until at bridge. You should be able to see the Cochrane Recreation Centre across the valley. Sample site is located in the riffle on the upstream side of the bridge.
Site 6	51 °12'31.0''N 114 °26'45.1''W	Continue down Range Road 42 A until at entrance to BCPS Steward Land. Park on South side of Bridge, and enter the Nature Reserve on the downstream side of bridge. Sample location is in riffle on the downstream side of the bridge.
Site 7	51 °12'44.50''N 114 °25'49.56'' W	Enter off of Ranch Rd. Park in front of Lyse and Mike's house and walk North down path until you reach the creek, follow Boothby fence parameter and cross to North side of fence when safety permits. Sample upstream of fence where the old bridge has been removed.

Site 8	51°13’14.4’’N 114°25’22.4’’W	Once at Site 7, cross the creek, and continue walking along the old public access road. Walk about 1km until at the next location where the bridge has been removed (you can see metal and wood remanence from the bridge). Sample site is located in creek where the bridge has been removed.
Site 9	51 °14’50.69’’N 114 °22’53.65’’W	Enter site by parking in Bighill Springs Provincial Parking lot. You have to cross over a small bridge when entering the parking lot, once on foot, go back to this bridge and follow the creek downstream until at confluence with flow from the local upper springs. Sample site is located just down stream (~5m) of the confluence.
Site 10	51°15’09.5’’N 114°23’26.7’’W	Enter by parking in Bighill Spring Provincial Parking lot. Follow path on the North side of the parking lot, walking upstream until at the end of the park, where the fence is. Sample site is located in the riffle on the North side of the fence.
Site 11	51 °16’12.59” N 114 °22’15.04” W	Enter off of Highway 567, park just inside the turn off to Bighill Springs Provincial Park (Range Rd 34 A). Walk East on the South side of Highway 567 until at the creek, then cross to South side of fence and access Site approximately 200m downstream of Highway 567.

Table 4. Site characteristics.

Site	Land Use	Riparian Vegetation	Canopy Cover	Macrophyte Coverage	Width	Average Depth (cm)
Site 1	North bank has walking trail, daytime picnic area and residential housing. South bank is 75% deciduous trees, 25% shrubs.	South bank mostly deciduous trees with some conifers, grass and shrubs.	0%	0%	89	NA

Site 2	Paved walking/bicycling trail, day-time picnic area, and residential housing near by.	Small Coniferous, deciduous, and grass.	0	~5% macrophyte cover in May and June. Macrophyte coverage increased to ~ 25%-50% in July.	4.2	35
Site 3	community park, tennis courts, playground area, bridge crossing just upstream of site and multiple gravel paths	Mostly deciduous trees, shrubs and grasses.	~25%	25%-50% macrophyte coverage.	3.2	19.67
Site 4	Day time picnic area, with mix of open fields for playing games and treed areas.	West bank has mostly grass while east bank has mix of grasses, shrubs, deciduous and coniferous trees	0	~5% macrophyte cover in May and June. Macrophyte coverage increased to ~ 25%-50% in July.	3.1	21
Site 5	recreation path running parallel to stream, mountain biking, deep groves, erosion, and foot bridge. Major residential development within 500m up stream of site.	Heavily forested, mainly pines/spruces, lots of shrubs and grass.	~25%	10%-20% macrophyte coverage.	5.0	24.3

Site 6	Located inside nature reserve 20m downstream from dirt road and bridge.	Both sides are forested with deciduous and coniferous trees, some shrubs and grasses	~25%	Little to no macrophyte coverage during all sample times.	3.6	15.67
Site 7	Little human activity, small foot paths, little bare ground.	Pastureland, with mainly grasses.	0%	~5% macrophyte coverage in May and June samples. ~25% macrophyte coverage in July sample.	3.2m	20
Site 8	Little human activity, old public road that has been grown over with grasses	Mostly grasses with sporadic deciduous trees.	0%	No macrophyte coverage.	6.2	25
Site 9	Little to no human activity within a few hundred meters of the site. There is a provincial park approximately 0.5 km up stream	Pastureland, with mainly grasses, a few shrubs and broadleaf plants.	0%	No macrophyte coverage.	4.9m	32
Site 10	Site located in provincial park. Banks of stream for a buffer of approximately 10m have severe ground compaction from	Forested area, mostly coniferous, some small shrubs.	~50%	~25% macrophyte coverage.	3.3	16.3

	human made walking paths on the west side of the creek, some erosion along the side of the creek bed.					
Site 11	Approximately 50m downstream from highway where stream passes under highway through culvert.	Pastureland, mostly grasses, some broadleaf plants.	0%	Macrophyte coverage ~100%	2.5	>100

Table 5. Show the average stone size at each site, measured at intermediate axis (n=100), and the average percent embeddedness of the stones (n=10).

Site	Pebble Size (cm)	Percent Embeddedness
1	NA	NA
2	5.5	55%
3	7.8	33%
4	7.1	58%
5	3.5	28%
6	5.3	40%
7	5.4	30%
8	6.3	35%
9	1.6	45%
10	5.9	43%
11	NA	NA

Table 6. Velocity measurements during sampling time at each site. Recordings are an average of 6 measurements.

Site	Velocity (m/s)			
	May	June	July	September
Site 1	~4.0-7.0	~4.0-7.0	NA	NA
Site 2	0.44	0.51	0.70	0.72
Site 3	NA	NA	0.62	0.59
Site 4	0.39	0.54	0.65	0.58
Site 5	NA	NA	0.58	0.64
Site 6	0.54	0.55	0.85	0.74
Site 7	0.39	NA	0.79	0.59
Site 8	NA	NA	0.68	0.60
Site 9	0.25	NA	0.50	0.25
Site 10	NA	NA	0.30	0.21
Site 11	NA	NA	0.15	0.13

Table 7. Water chemistry measurements, taken during September 5th 2019, at each sample site, including pH, temperature, dissolved oxygen. All measurements are an average of 3 replicates.

Site	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Electrical Conductivity Corrected (μs/cm)
Site 2	15.09	9.09	11.50	2112.75
Site 3	14.95	10.06	14.20	1004.00
Site 4	14.24	9.01	13.33	2001.25
Site 5	14.57	9.30	15.30	981.00
Site 6	14.41	6.10	15.32	964.75
Site 7	13.90	8.85	13.66	944.75
Site 8	15.14	8.31	14.70	950.00
Site 9	11.90	9.65	9.20	932.00
Site 10	5.70	5.44	10.99	1543.25
Site 11	13.20	7.75	5.87	597.00

Table 8. Water Chemistry samples from July 15th, 2019.

Site	Total Phosphorus (mg/L)	Dissolved Phosphorus (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Dissolved Nitrate (mg/L)	Nitrate plus Nitrite (mg/L)	Total Ammonia (mg/L)
Site 11	0.065	0.058	0.58	0.20	0.058	0.069
Site 10	0.11	0.083	0.66	4.6	1.0	0.021
Site 9	0.066	0.046	0.66	0.84	0.19	0.086
Site 8	0.027	0.026	0.41	3.5	0.80	0.044
Site 7	0.040	0.025	0.84	0.055	<0.014	0.042
Site 6	0.021	0.029	0.95	0.19	0.044	0.035
Site 2	0.082	0.029	0.98	0.54	0.12	0.037

Table 9. Chemistry samples from September 5th, 2019.

Site	Total Phosphorus (mg/L)	Dissolved Phosphorus (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Dissolved Nitrate (mg/L)	Nitrate plus Nitrite (mg/L)	Total Ammonia (mg/L)
Site 11	0.035	0.022	0.85	0.12	0.027	0.049
Site 10	<0.0030	<0.0030	<0.050	13	2.9	<0.015
Site 9	0.032	0.018	0.68	3.3	0.74	0.029
Site 8	0.0055	0.0044	0.35	12	2.6	0.028
Site 7	0.034	0.016	0.74	1.6	0.37	0.033
Site 6	0.030	0.017	0.61	1.4	0.33	0.028
Site 2	0.017	0.0078	0.67	1.2	0.27	0.020

Table 10. Shannon Wiener Index for each site.

Month	Site	Index
May	1	0.96
May	2	1.52
May	4	**2.37**
May	6	1.86
June	1	1.46
June	2	2.31

June	4	2.17
June	6	2.19
July	2	**0.83**
July	3	1.3
July	4	1.2
July	5	1.84
July	6	1.78
July	7	1.5
July	8	1.37
July	9	2.0
July	10	1.5
July	11	2.0

Table 11. Data collected from CABIN database on 19 surrounding rivers and creeks.

		EPT	non-EPT	Total abundance	%EPT	Shannon Wienner Index
2010	Ghost River at Richard's Road	2490.85	490.87	2981.72	83.53735	1.58
2010	Jumping Pound Creek at Cochrane	1549.92	899.91	2449.83	63.26643	2.48
2010	Kananaskis River at Nakiska Junction	17950	1800	19750	90.88608	1.5
2010	Oldman River at Olin Creek	2046.05	584.54	2630.59	77.77913	2.02
2010	Oldman River below Dam	10966.6	1799.96	12766.56	85.90098	1.57
2010	WaiparousCk	1494.03	399.93	1893.96	78.88393	1.82
2010	Waterton@Pkb	835.42	254.7	1090.12	76.6356	2.01
2015	Louise Creek	1357.89	289.46	1647.35	82.42875	2
2017	Hidden Creek	1900	253.34	2153.34	88.23502	2.07
2018	Hidden Creek	6	231	237	2.531646	1.4
2017	Corral Creek	3700.01	1550.02	5250.03	70.47598	2.06
2018	Corral Creek	405	1065	1470	27.55102	1.86
2017	Katherine Creek	4285.74	285.73	4571.47	93.74971	2.26

2018	Katherine Creek	4542.87	385.74	4928.61	92.17345	2.04
2017	Helen Creek	5500	860	6360	86.47799	1.96
2018	Helen Creek	4271.45	628.59	4900.04	87.17174	2
2018	Skoki Creek	3928.58	628.59	4557.17	86.20657	2.36
2018	Helen Creek	5700	440	6140	92.83388	1.6
2012	Boom Creek	2287.5	1662.5	3950	57.91139	2.45
	Average	4178.43944	793.2711	4971.711	79.00583	1.98

Sample Photos:


Hydropsychidae – Trichoptera (Caddisfly)


Leptophlebidae – Ephermeroptera (Mayfly)


Simuliidae – Diptera (True Fly)


Trichoptera sealed case prior to emergence


Elmidae - Coleoptera (Beetle)


Pionidae (Top) Sperchonidae (Left), Laversiidae (Right) - Hydrachnidia (Aquatic mite).