Canadian Aquatic Benthic Invertebrate Network (CABIN):

Virginia River, South Brook, and Broad Cove Brook

St. John's, Mount Pearl, St. Phillip's

A look into aquatic biomonitoring and the establishment of new CABIN reference sites in the Northeast Avalon Region.

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Executive Summary

Three rivers were selected in the Northeast Avalon region to be sampled for benthic macroinvertebrates using methods and protocol designed by the Canadian Aquatic Benthic Invertebrate Network (CABIN) program. The purpose of sampling was to identify the abundances and diversities of species present at these sites in order to collect baseline data for use as a reference in future biomonitoring programs. The data collected is presented graphically as a demonstration of how a future interpretive model can be applied.

This report documents the baseline sampling program developed through a partnership between NAACAP and the NL Department of Environment and Conservation (ENVC) Water Resources Management Division. This article is to be used as a tool on which to base future biomonitoring efforts when more reference data would be collected and new test sites would be assessed. Interpretations may only be made through the future sampling and comparison of several test sites and additional reference sites associated with adequate baseline data. No interpretations or conclusions were made on the actual environmental health of the three reference sites in this study. This report also serves the purpose of generating knowledge on the subject of biodiversity and its use in determining the environmental health of aquatic ecosystems.

Acknowledgements

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Introduction

Biological diversity or "biodiversity" is a measure of the variety of species or genotypes present in an ecosystem. In addition, it can also represent the variety of ecosystems present within a specified area (Environment Canada, 2009). Generally, the overall richness of biological diversity in any specified geographic area relates to the overall health of the area, since the healthier an ecosystem the more types of animal and plant species are going to thrive in it. Additionally, species depend on other species for survival, whether they be a direct food source, or whether they promote other types of positive environmental factors, such as increasing the fertility of a habitat such as soil, or increasing the amount of oxygen present in water. Thus, the more species present, the more likely that an ecosystem is going to thrive optimally, and the more likely the ecosystem will be able to adapt to future changes (US EPA, 2009).

In an aquatic riverine ecosystem, biodiversity includes not only the different species of vertebrates, such as fish, amphibians, birds and mammals, but also the plants and invertebrates present in the system, such as various species of insects and their larvae, and different species of worms. In particular, insect larvae are helpful in determining the health of river ecosystems, since many species of insects begin their lives in the mud and sediment found at the bottom. These larvae are known as benthic macroinvertebrates.

Under normal circumstances, given adequate habitat conditions and that certain water quality parameters are met, many species of insect larvae occur in abundance all year long (Environment Canada, 2009). Adverse water quality conditions will affect the growth cycles and health of some more sensitive species of insects. Thus, if certain species of insects are found to be missing or less abundant in sampled river sediments, then it could indicate that the water is polluted or otherwise adversely affected by an outside factor. Additionally, some insects are more tolerant of aquatic toxins and will increase in abundance in polluted conditions (Environment Canada, 2009).

These basic concepts helped to form the foundation for Environment Canada's Canadian Aquatic Biomonitoring Network (CABIN) program, initiated by the National Water Research Institute (NWRI). The focus of CABIN is to develop a Canada-wide database of benthic macroinvertebrates for the purpose of integrating a reliable biological component into an ecological assessment designed for the monitoring of wadeable streams. This is an important step in determining the health of a flowing aquatic environment because, prior to CABIN, assessments typically only encompassed chemical and physical methods (Reynoldson, *et al.*, 2009).

In the fall of 2008, three sites were chosen by the provincial Department of Environment and Conservation Water Resources Division and by Northeast Avalon ACAP (NAACAP) within the Northeast Avalon region to sample for benthic macroinvertebrates under the nationally standardized CABIN protocol. These sites will be the first of several more benthic macroinvertebrate reference locations to be chosen in the years to come. Data from these reference stations will be catalogued in the national data bank with stations having similar metadata characteristics. Eventually, test sites will be selected in areas where water quality is believed to be impaired, and the collection of benthic macroinvertebrates will be compared to the expected reference site collection.

Study Area

Three rivers were selected in the Northeast Avalon region, in and around the City of St. John's: The Virginia River, South Brook, and Broad Cove Brook (*Figures 1 – 4*). A reach of each river were chosen for sampling. They represented pristine reference sites, which were expected to have a typical distribution and healthy abundances of macroinvertebrate species. A reference site should also represent an area that has not been exposed to toxins or disturbances that can disrupt water and sediment quality resulting in reduced biodiversity. An ideal reference site would not have been previously impacted by human activity.

The sampling site of the Virginia River was located in the headwaters, which was located in a boggy area upstream of a large residential housing development in the Airport Heights neighborhood. This shallow section was essentially undisturbed by human activities, and had riffle, pool, and straight run habitats. From here, the Virginia River flows downstream around Airport Heights and under Torbay Road, where it eventually flows southward through St. John's and into Quidi Vidi Lake.

The section of South Brook sampled was located immediately adjacent to the Southlands, a relatively new residential development southwest of Mount Pearl. South Brook flows from its undisturbed headwaters a few kilometers upstream of the sampling site, along the northeast edge of the Southlands residential development, and downstream where it meets the Waterford River at Bowering Park in St. John's. Except for a notable ATV crossing site just upstream, the section sampled was relatively undisturbed and served as an appropriate reference site for the purposes of this study. This section was just downstream of a culvert and provided a variety of riffle, pool and straight run habitats.

The site chosen on Broad Cove Brook receives water from both the Windsor Lake watershed and as well as from Little Power's Pond just upstream. At this point, the stream has traveled through a few small areas of low-density housing and near several roads. Although there is some development in this area, such as the construction of a new baseball diamond further upstream, and the potential for residential lawn and road runoff near the sample site, this upstream location was considered to have minimal impact from nearby development. The section of river selected had a fairly deep straight run upstream, and some riffle and pooling areas at the end, although the riparian zone was not as well developed here. Downstream of this site, Broad Cove Brook flows through the town of

St. Phillip's mostly alongside Thorburn Road and flows into the beach at Broad Cove, Conception Bay.

According to criteria established in the CABIN protocol (Environment Canada, 2009), all three sites selected for sampling are considered to be adequate reference sites for the purposes of this report because they are all located upstream of most or all existing developments. Additionally, all three rivers pass through more developed areas downstream, and so the sites become good references in case any test sites are eventually chosen in impacted regions.

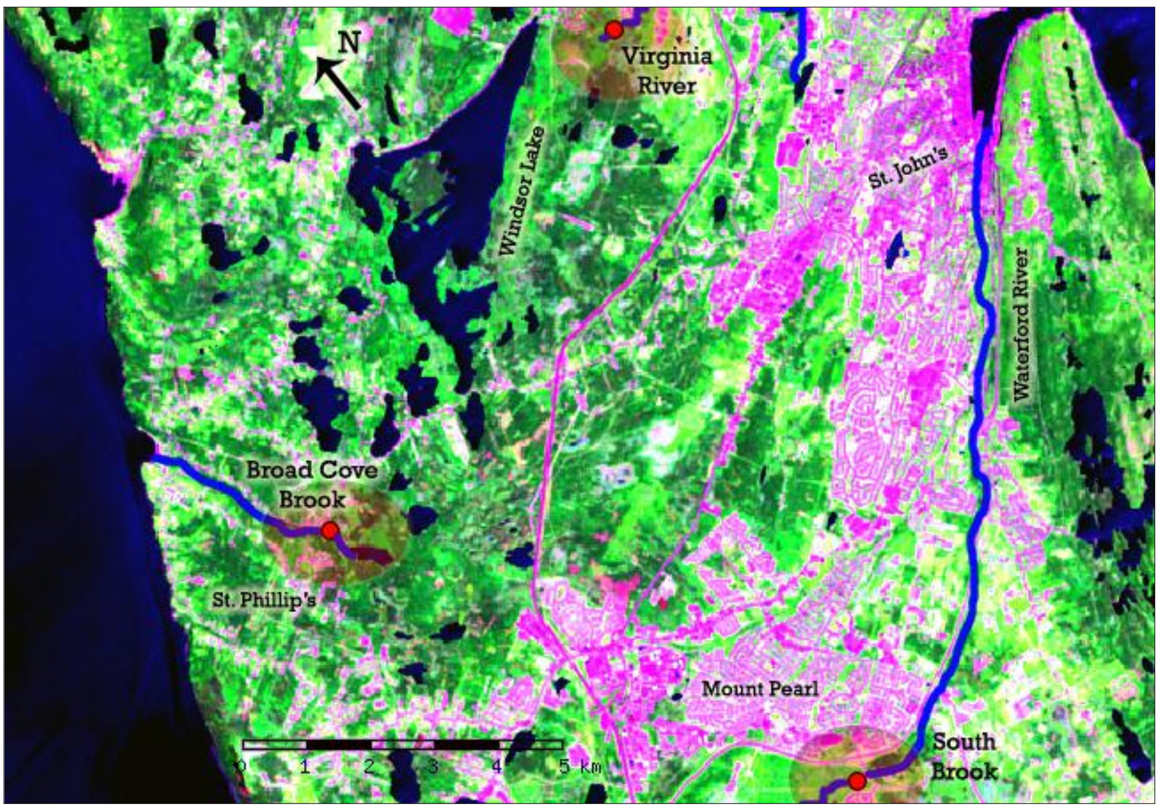

Figure 1: *Satellite image of study area and sampling sites (red dots) showing Virginia River (top), South Brook (bottom right), and Broad Cove Brook (left) in relation to developed areas (purple), and less developed areas (green shades). The rivers of interest are highlighted in blue. Edited from GeoBase©, 2009.*

Figure 2: *Bird's-eye view aerial photo of the Virginia River sample site. The highlighted area represents the general vicinity of the river. Edited from Microsoft Bing Maps©, 2009.*

Figure 3: *Bird's-eye view aerial photo of the South Brook sample site. The highlighted area represents the general vicinity of the river. Microsoft Bing Maps©, 2010.*

Figure 4: *Bird's eye view aerial photo of the Broad Cove Brook sample site. The highlighted area represents the general vicinity of the river. Edited from Microsoft Bing Maps©, 2009.*

Biology

Healthy stream habitats are complex and diverse. Ideally there would be a wide range of plant and animal species that would all co-exist with one another, either peacefully or competitively, and the complexity of species as a whole would, in return, contribute to the continued health of the ecosystem. There also would exist an established food chain within this ecosystem, in which species would depend on other species for food, either directly or indirectly. For example, some species of aquatic plants provide oxygen and food sources enabling certain insect species to survive, and these aquatic insects are in turn an important food source for animals like fish.

Insect larvae and other types of aquatic benthic macroinvertebrates are effective indicators of water quality and habitat integrity (Reynoldson, *et al.*, 2009). Table 1 lists the names and biological classifications of various types of benthic macroinvertebrates that are commonly observed in benthic samples. They are categorized based on their relative sensitivities to environmental stress or change.

Table 1: *List of some common benthic macroinvertebrates found in the samples categorized by their relative sensitivities to environmental stress or change.*

Sensitive		Facultative		Tolerant	
Common name	*Rank*	*Common name*	*Rank*	*Common name*	*Rank*
Mayfly	Order: Ephemeroptera	Dragonfly and Damselfly	Order: Odonata	Fly and Midge	Order: Diptera
Stonefly	Order: Plecoptera	Scud	Order: Amphipoda	Freshwater Worm	Phylum: Annelida
Caddisfly	Order: Trichoptera	Net-Spinning Caddisfly	Family: Hydropsychidea	Flatworm	Phylum: Platyhelminthe
Beetle	Order: Coleoptera			Nematode	Phylum: Nemata

- Benthic macroinvertebrates **sensitive** to environmental changes and stress are the best indicators of good water and habitat quality.
- **Facultative** organisms appear in both pristine habitats and adversely impacted ones, although other than for representing diversity, their numbers are not as indicative as the more tolerant and the more sensitive species.
- Benthic macroinvertebrates **tolerant** to environmental changes and stresses are considered to be able to tolerate and sometimes thrive in most habitat types and in different degrees of water quality.

Most midge larvae have a fairly high tolerance to habitat diversity. One reason for their resilience is that the larvae, sometimes known as bloodworms, often contain elevated levels of oxygen-rich hemoglobin, which allows them to survive in just about any type of habitat condition (US EPA, 2009). It is important to note that while Chironomids have been known to survive in a range of environmental conditions, and thus can be abundant when compared to other less tolerant organisms in similar conditions (SWCSMH, 2006), they do not necessarily indicate poor water quality. A healthy balance of Chironomids to an abundance of numerous types of other benthic macroinvertebrates is generally an indicator of good aquatic health; whereas an overabundance of this type of organism when compared with a lower population of other, more sensitive fauna might indicate adverse environmental conditions in the system. Additionally, some particular species will show deformities related to particular toxins in the water (US EPA, 2009), but because of the way the CABIN program is designed the site assessment only relies on the biodiversity and abundances of aquatic benthic macro-organisms instead of the condition individual invertebrates are in.

Methodology

The methods used in collecting the data followed the standardized sampling protocol established by the CABIN program as outlined in the Canadian Aquatic Biomonitoring Network Field Manual (BC Ministry of Environment, 2009; Reynoldson, *et al.*, 2009). The fieldwork began after the three reference sites were established and metadata about each site had been recorded, such as the nomenclature codes for the watershed basin, the river names, the sampling dates, the eco-region, the stream order, the latitude and longitude, etc.

Once the metadata had been collected the site assessment could begin, and first involved collecting data about the stream habitat and surrounding riparian zone. This included determining the reach characteristics (*i.e.* straight-run, pools, riffles, etc); measuring the stream-bank and river width; creating a hand-drawn and labeled diagram of the sample site; photographing all aspects of the site; measuring the stream velocity; determining the stream gradient (slope) and depth; classifying the extent of canopy coverage and identifying the predominant riparian vegetation; and identifying the predominant aquatic vegetation present as either macrophyte or periphyte.

Next the actual sampling could begin. First water samples were taken to be sent to a lab to be analysed for various water quality parameters such as metals and nutrients, and *in-situ* testing of parameters such as pH, temperature, dissolved oxygen, turbidity, and specific conductivity were performed with a Hydrolab® Datasonde multiparameter monitoring sonde. The benthic macroinvertebrate sampling followed immediately after, and involved the collection of live organisms through stirring up the substrate with the technician's boots and letting it flow directly into a specially designed kick-net oriented downstream of the disturbance. After three minutes of collecting, the sample, now trapped in a bottle at the end of the net, was carefully transferred to a sieve where the sediment was washed off the live sample and the leaves and detritus were carefully picked clean of invertebrates. The benthic organisms and remaining debris were subsequently transferred to a properly labeled bottle containing 95% ethanol, which preserved the sample, and was later sent to an accredited taxonomist, who identified the species present and recorded their abundance.

The last step was to characterize the composition of the stream bed by performing a random pebble count. This helped to determine whether there was suitable habitat for a range of aquatic organisms by selecting one hundred stones from the bottom of the sample reach and measuring their median diameters. The result showed the predominant sizes of stones on the riverbed and indicated whether there would be many organisms expected in the substrate. Typically, the more cobbles, pebbles and boulders found, the more invertebrates would be expected to live there, and likewise, this number would decrease with increasing sand and silt (BC Ministry of Environment, 2009).

Once the results from the taxonomy lab were received, they were analysed in terms of species richness (number of biological families present in a sample), and the abundance of particular types of sensitive organisms, such as Ephemeroptera, Plecoptera, Trichoptera, and Coleoptera (referred collectively in this report as EPT/C) was noted.

Results and Discussion

Water Quality Results

Four standard water variables were determined *in-situ* at each sample: pH, temperature, specific conductance (SpC), and dissolved oxygen (DO). The following graph (*Figure* 5) shows the results of the *in-situ* water quality testing for each river. The numerical data for these samples are included in Appendix A. At the time of sampling, the basic water quality results show that each parameter was at or near expected background levels for that site, thus making it suitable for the purposes of collecting reference data. A brief discussion of these results is as follows:

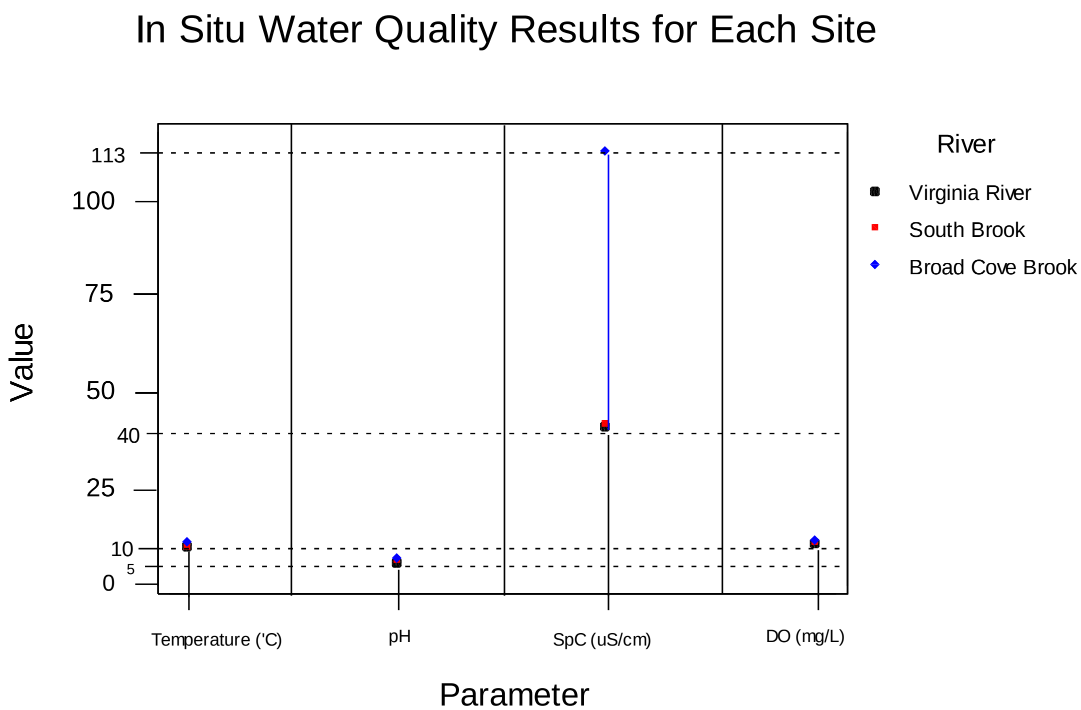

Figure 5: *At-a-glance basic water quality results for temperature (°C), pH, specific conductance (SpC, µS/cm), and dissolved oxygen (DO, mg/L) for each river.*

The temperatures recorded at each site are typical of small streams in the mid-fall season, and ranged from 9.0°C in South Brook to 10.3°C in Broad Cove Brook. Temperature can fluctuate depending on the amount of shade cover and sunlight reaching the water and with the ambient outside air temperature, but overall these temperatures represent a healthy range of natural river water for that time period.

The levels of pH recorded at each site were relatively low, with the lowest being at the Virginia River site at a value of 4.91. The highest recorded was 5.85 at the Broad Cove Brook site. Despite these low values, river water found in boggy areas within the Northeast Avalon region are expected to be acidic due to the presence of vegetative and peat tannins in the water (Environment Canada, 2006). The more developed an area is, the less bogs there are and so pH generally increases as rivers flow downstream. In the case of Broad Cove Brook, although development is fairly sparse in the upper reaches, the river flows through some less boggy, residential areas; so as expected, it has the highest of the pH values recorded at each sample site.

The parameter that experienced larger variability among the sample sites was the specific conductance (SpC). The SpC was quite low in the Virginia River and South Brook sites, ranging from 40.4 µS/cm to 41.6 µS/cm respectively, but was higher in Broad Cove Brook at a value of 113.1 µS/cm. Generally, relatively unimpacted river water within the Northeast Avalon region will show a value of less than 150 µS/cm, and often closer to about 40 µS/cm, however uncontaminated headwaters sites have also been observed in other monitoring programs to have normal values of somewhat higher than 150 µS/cm as well (Ficken, 2006, 2008, 2009) such is the case in the Waterford River (Ficken, 2006, 2008). It is possible that Broad Cove Brook may have a natural tendency to exhibit slightly higher levels of SpC, or salty runoff containing fertilizers from adjacent lawns just upstream. This interpretation is speculative because the data needed to establish this is outside the scope of this report. The important point is that Broad Cove Brook still displays a relatively low value of SpC, and is, thus, still useful as a reference site.

The levels of dissolved oxygen (DO) for all the sites fell within a healthy range for aquatic life. A DO value of more than 7mg/L is generally considered adequate (CCME, 2006), and the values recorded in each river at the time of sampling ranged from 9.7 mg/L in the Virginia River, to 10.9 mg/L in Broad Cove Brook.

Biological Analysis

The collection of benthic macroinvertebrates provided background information on the types of species found in the reference sites at that particular time of year. The ratios and counts of tolerant to intolerant species are displayed in the following graphs (*Figures 6 – 7*). The preliminary data from this study will be added to a catalogue of reference data being collected across Canada as part of the CABIN monitoring program. Reference site data will be grouped together based on ecological similarities of sites, and CABIN models will be developed so that future test site data can be compared to the reference models.

Figure 6 (*below*) shows the abundances of the most important orders of benthic macroinvertebrates at each sample site. The taxa count for each type of benthic macroinvertebrate collected for each sample site is contained in Appendix B. It should be noted, however, that due to the late sampling date, it was possible that the biological data collected did not accurately represent the normal status of the biological communities sampled with regards to richness and abundances.

Figure 7 (*below*) shows the richness and also various percentages of tolerant to sensitive organisms, including the percentage of facultative fauna, relative to the total count per sample site. The orders Plecoptera (Stoneflies), Ephemeroptera (Mayflies), Trichoptera (Caddisflies), and Coleoptera (Aquatic Beetles) make up the basis of the %EPT/C parameter. A percentage for Diptera was also shown because it made up for most of the tolerant organisms.

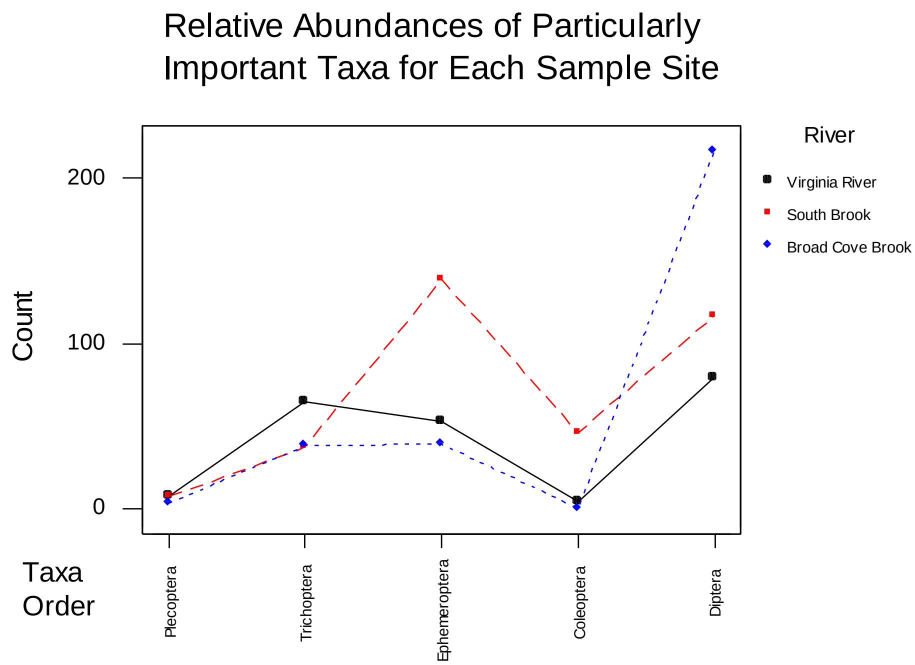

Figure 6: *Taxonomy count of particularly important orders of aquatic benthic invertebrates for each river showing the relative abundance of each type per sample site.*

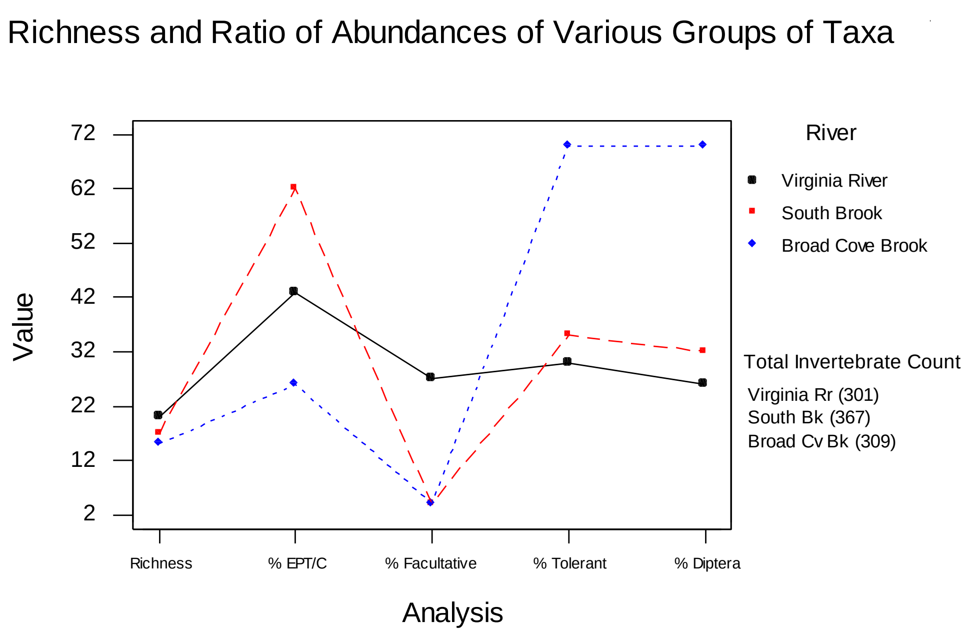

Figure 7: *Results of various analyses on diversity of specific orders and classifications of benthic macroinvertebrates collected at each sampling site, including total invertebrate count*

Accounting for Errors

The methods of analyses used in this type of bioassessment have been known to have errors, as they are not always suited for every type of habitat at all latitudes. It is also known that the ecological conditions at natural boggy headwaters can affect biodiversity (Mandaville, 2002), due to the low nutrient content and pH, among other natural parameters relating to bogs (Environment Canada, 2006). For example, midges (Chironomids) are known to thrive in these conditions (Health Canada, 2009), while other invertebrates find them less favorable and could possibly be present in lower quantities. Additionally, since the samples were collected in late October, it was also possible that the biological communities could have been diminished naturally due to the lateness of the season, also giving a less than representative result (CABIN Manual, 2009).

Conclusions and Recommendations

The activities outlined in this report pertaining to the nationally accepted CABIN program illustrate an appropriate method for devising a local benthic macroinvertebrate sampling program, and for properly collecting biological samples and interpreting the data. In this case, the activities are related specifically to sampling new reference sites to establish baseline information regarding ecological conditions relatively unaffected by human activity, such as land development. The reference data collected will be of value in upcoming biomonitoring sessions within the Northeast Avalon region.

It is recommended that data continues to be collected from many reference sites across the province during the next year or two, representing a wide geographic range and a variety of eco-regions, following CABIN protocol. Once this data has been uploaded to Environment Canada’s reference collection catalogue, and the Atlantic Canada CABIN reference model has been finalized, the focus in ensuing years will shift to sampling test (potentially impacted) sites. Finally, aquatic ecosystem health will be analyzed and interpreted by comparing data from test sites to the reference collection model.

References and Resources

- BC Ministry of Environment, 2009. *Canadian Aquatic Biomonitoring Network Field Manual*. British Columbia Ministry of Environment, Science and Information Branch. Retrieved from: http://www.llbc.leg.bc.ca/public/PubDocs/bcdocs/455724/CABIN_field_manual.pdf

- CCME Canadian Council of Ministers of the Environment, 2006. *Canadian water quality guidelines for the protection of aquatic life. Updated.* In: Canadian environmental quality guidelines, 1999. Winnipeg, MN: Canadian Council of Ministers of the Environment.

- Environment Canada, 2006. *The Canadian Wetland Classification System*. Retrieved from: http://www.qc.ec.gc.ca/faune/atlasterreshumides/html/classification_e.html

- Environment Canada, 2009. *Canadian Aquatic Biomonitoring Network (CABIN)*. Retrieved from: http://cabin.cciw.ca/Main/cabin_about.asp?Lang=en-ca

- Escolar, J., Mercer, A., Urpeth, H., 2009. *Assessment of Global Vision International's Impact on Water Quality in the Bosque Protector Yachana – Preliminary Report*. Global Vision International. Retrieved from: http://www.scribd.com/doc/17611955/Amazon-Benthic-Report-April-2009

- Ficken, D. (2006). *Monitoring and examination of water quality in an urban watershed: The Waterford River Drainage Basin; Paradise, Mount Pearl, St. John's.* St. John's, NL, Northeast Avalon ACAP Inc. http://www.naacap.ca

- Ficken, D. (2006). *Regional Watershed Survey: Nut Brook Drainage Basin, St. John's Stream analysis of a river system in a local industrial Zone*. St. John's, NL, Northeast Avalon ACAP Inc. http://www.naacap.ca

- Ficken D. (2008). *Road Salt Loading Study: Waterford River, Leary's Brook and Virginia River. Northeast Avalon Urban Region*. St. John's, NL, Northeast Avalon ACAP Inc. http://www.naacap.ca

- Ficken D. (2009). *A Comprehensive Study of Water Quality: Nut Brook / Kelligrews River Watershed*. St. John's, NL, Northeast Avalon ACAP Inc. http://www.naacap.ca

- Ficken D. (2009). *Results of baseline sampling in Logy Bay Middle Cove Outer Cove (07/27/09)*. St. John's, NL, Northeast Avalon ACAP Inc.

- Health Canada, 2009. *Environmental and Workplace Health: Guidelines for Canadian Recreational Water Quality: Nuisance Organisms*. Health Canada. Retrieved from: http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/guide_water-1992-guide_eau/section4-eng.php

- Hedrick, J., Ras, L., 2001. *Determination of Aquatic Impacts Resulting from Valley Fill Construction*. Research, Environmental, and Industrial Consultants Inc. Cool Ridge, West Virginia. Retrieved from: http://wvmdtaskforce.com/proceedings/02/Hedrick.pdf

- Hilsenhoff, W., 1987. *An improved biotic index of organic stream pollution*. The Great Lakes Entomologist, 20(1), 31 – 36.

- Hilsenhoff, W., 1988. *Rapid field assessment of organic pollution with a family-level biotic index*. The North American Benthological Society, 7(1), 65 – 68. Retrieved from: http://www.homepage.montana.edu/~wwwbi/staff/kerans/bio439/hilsenhoff.pdf
- Green, J., Swietlik, W., 2000. *A Stream Condition Index for West Virginia Wadeable* Streams. Prepared by Tetra Tech Inc., Owings Mills, MD for US EPA. Retrieved from: http://www.wvdep.org/Docs/536_WV-Index.pdf
- Mandaville, S., 2002. *Benthic Macroinvertebrates in Freshwater – Taxa Tolerance Values, Metrics, and* Protocols. Soil & Water Conservation Society of Metro Halifax. Retrieved from: http://www.chebucto.ns.ca/ccn/info/Science/SWCS/H-1/tolerance.pdf
- Reynoldson, T., Logan, C., Pascoe, T., Thompson, S., (2009). *CABIN (Canadian Aquatic Biomonitoring Network) Benthic Invertebrate Field and Lab Manual*. National Water Research Institute, Environment Canada.
- SWCSMH, 2006. *Family Chironomidae (Midge Flies)*. Soil & Water Conservation Society of Metro Halifax. Retrieved from: http://www.chebucto.ns.ca/ccn/info/Science/SWCS/ZOOBENTH/BENTHOS/xiii.html
- SWCSMH, 2008. *Chemical vs. Biological monitoring in limnology*. Soil & Water Conservation Society of Metro Halifax. Dartmouth, NS. Retrieved from: http://www.halifax.ca/Commcoun/hecc/documents/_0108100519_001.pdf
- SWCSMH, 2008. *Taxa Tolerance Values*. Soil & Water Conservation Society of Metro Halifax. Dartmouth, NS. Retrieved from: http://www.chebucto.ns.ca/ccn/info/Science/SWCS/ZOOBENTH/BENTHOS/tolerance.html#Chironomidae
- US EPA, 2009. *Biological Indicators of Watershed Health – Biological Integrity*. U.S. Environmental Protection Agency. Retrieved from: http://www.epa.gov/bioiweb1/html/biointeg.html
- US EPA, 2009. *Detroit River – Western Lake Erie Basin Indicator Project. Indicator: Chironomid Abundance and Deformities*. U.S. Environmental Protection Agency, Large Lakes and Rivers Forecasting Research Branch. Retrieved from: http://www.epa.gov/med/grosseile_site/indicators/chironomids.html
- Zimmerman, M., 1993. *The use of the biotic index as an indication of water quality*. Department of Biology, Lycoming College. Williamsport, Pennsylvania. Retrieved from: http://www.ableweb.org/volumes/vol-5/6-zimmerman.pdf

Appendix A

Metadata for each sample location and water quality results from *in-situ* Minisonde sampling.

Metadata and in-situ water quality results for the Virginia River.

Variable	**Value**
Site Code	NF02ZM0098
Name	Virginia River
Basin	Virginia River
Stream Order	1
Eco-Region	Maritime Barrens
Eco-Zone	Boreal Shield
Sampling Device	Kick Net
Protocol	CABIN - Wadeable Streams
Date	30-Oct-08
Sample(s) Taken	1
Kick Time (Min)	3
Kick Distance (m)	
Mesh Size (µ.m)	400
Description	Narrow stream in a wooded area passing through tall grasses near a large subdivision
Latitude & Longitude	47.59889 & -52.75472
Altitude	570
Taxonomist	Community Group
ID Date	3/24/2009
Certifications	2007 - OBBN Order/Family Training
Sampling Crew	Joanne Sweeney Dan Ficken

Temperature ('C)	9.15
pH	4.91
Specific Conductivity (uS/cm)	40.4
Dissolved Oxygen (mg/L)	9.74

Metadata and in-situ water quality results for South Brook

Variable	Value
Site Code	NF02ZM0185
Name	South Brook @ Headwaters
Basin	South Brook
Stream Order	1
Eco-Region	Maritime Barrens
Eco-Zone	Boreal Shield
Sampling Device	Kick Net
Protocol	CABIN - Wadeable Streams
Date	28-Oct-08
Sample(s) Taken	1
Kick Time (Min)	3
Kick Distance (m)	
Mesh Size (µ.m)	400
Description	15 meters downstream from culvert, 5 meters upstream of pedestrian footbridge
Latitude & Longitude	47.49361 & -52.85056
Altitude	554
Taxonomist	Community Group
ID Date	3/27/2009
Certifications	2007 - OBBN Order/Family Training
Sampling Crew	Joanne Sweeney Dan Ficken

Temperature ('C)	9.02
pH	5.64
Specific Conductivity (uS/cm)	41.6
Dissolved Oxygen (mg/L)	10.51

Metadata and in-situ water quality results for Broad Cove Brook

Variable	Value
Site Code	NF02ZM0020
Name	Broad Cove Brook
Basin	Broad Cove Brook
Stream Order	3
Eco-Region	Maritime Barrens
Eco-Zone	Boreal Shield
Sampling Device	Kick Net
Protocol	CABIN - Wadeable Streams
Date	29-Oct-08
Sample(s) Taken	1
Kick Time (Min)	3
Kick Distance (m)	
Mesh Size (µ.m)	400
Description	Narrow stream flows through wooded area between two residential streets.
Latitude & Longitude	47.59806 & -52.88139
Altitude	367
Taxonomist	Community Group
ID Date	3/11/2009
Certifications	2007 - OBBN Order/Family Training
Sampling Crew	Joanne Sweeney Dan Ficken

Temperature ('C)	10.34
pH	5.85
Specific Conductivity (uS/cm)	113.1
Dissolved Oxygen (mg/L)	10.87

Appendix B – **Taxonomy of organisms collected for each sample site (no species-level available).**

Taxonomy of benthic macroinvertebrates collected at the Virginia River site.

Phylum	Class	Order	Family	Genus	Mean Count	Raw Count	More common (fishing) name, possible animal type
Nemata					13.33	2	Unsegmented Worm (Nematode)
Annelida	Oligochaeta				40	6	Earthworm (or Freshwater Worm)
Platyhelminthes	Turbellaria				26.66	4	Flatworm
Arthropoda	Malacostraca	Amphipoda			426.66	64	Scud
Chelicerata	Arachnida	Hydracarina			13.33	2	Water Mite
Arthropoda	Insecta	Plecoptera			20	3	Stonefly
Arthropoda	Insecta	Trichoptera			106.66	16	Caddisfly
Arthropoda	Insecta	Diptera	Chironomidae		480	72	Midge
Arthropoda	Insecta	Coleoptera	Elmidae		6.66	1	Riffle Beetle
Arthropoda	Insecta	Ephemeroptera	Heptageniidae		93.33	14	Flat-Headed or Stream Mayfly
Arthropoda	Insecta	Trichoptera	Hydroptilidae		66.66	10	Micro or Purse-Case Caddisfly
Arthropoda	Insecta	Plecoptera	Nemouridae		13.33	2	Spring or Brown Stonefly
Arthropoda	Insecta	Diptera	Tipulidae		6.66	1	Crane Fly
Arthropoda	Insecta	Ephemeroptera	Baetidae	Baetis	6.66	1	Baetis Mayfly (Blue-Winged Olive)
Arthropoda	Insecta	Trichoptera	Philopotamidae	Chimarra	20	3	Little Black Sedge Caddisfly
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Ephemerella	13.33	2	Pale Morning Dun Mayfly
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Hydropsyche	100	15	Spotted-Sedge Caddisfly (Net-Spinning)
Arthropoda	Insecta	Trichoptera	Hydroptilidae	Hydroptila	13.33	2	Micro-caddisfly
Arthropoda	Insecta	Plecoptera	Perlodidae	Isoperla	13.33	2	Yellow Sally Stonefly
Arthropoda	Insecta	Diptera	Empididae	Neoplasta	6.66	1	Dancefly (Midge)
Arthropoda	Insecta	Trichoptera	Polycentropodidae	Neureclipsis	13.33	2	Little Red Twillight Sedge Caddisfly
Arthropoda	Insecta	Coleoptera	Elmidae	Optioservus	20	3	Optioservus Riffle Beetle
Arthropoda	Insecta	Trichoptera	Hydroptilidae	Oxyethira	193.33	29	Cream or Brown Micro-caddisfly
Arthropoda	Insecta	Ephemeroptera	Leptophlebiidae	Paraleptophlebia	233.33	35	Blue Quill Mayfly
Arthropoda	Insecta	Diptera	Ceratopogonidae	Probezzia	33.33	5	Biting Midge
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Rhithrogena	6.66	1	Red Quill Mayfly
Arthropoda	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila	20	3	Green Sedge Caddisfly

Taxonomy of benthic macroinvertebrates collected at the South Brook site.

Phylum	Class	Order	Family	Genus	Mean Count	Raw Count	More common (fishing) name, possible animal type
Nemata					5	2	Unsegmented Worm (Nematode)
Annelida	Oligochaeta				20	8	Earthworm (or Freshwater Worm)
Arthropoda	Malacostraca	Amphipoda			5	2	Scud
Chelicerata	Arachnida	Hydracarina			22.5	9	Water Mite
Arthropoda	Insecta	Ephemeroptera	Baetidae		35	14	Small Mayfly
Arthropoda	Insecta	Diptera	Chironomidae		282.5	113	Midge
Arthropoda	Insecta	Coleoptera	Elmidae		10	4	Riffle Beetle
Arthropoda	Insecta	Ephemeroptera	Leptophlebiidae		12.5	5	Prong-Gilled Mayfly
Arthropoda	Insecta	Diptera	Simuliidae		2.5	1	Blackfly
Arthropoda	Insecta	Plecoptera	Capniidae	Allocapnia	7.5	3	Tiny Winter Black Stonefly
Arthropoda	Insecta	Diptera	Athericidae	Atherix	5	2	Watersnipe Fly
Arthropoda	Insecta	Ephemeroptera	Baetidae	Baetis	150	60	Baetis Mayfly (Blue-Winged Olive)
Arthropoda	Insecta	Plecoptera	Chloroperlidae	Haploperla	10	4	Green Stonefly
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Hydropsyche	5	2	Spotted-Sedge Caddisfly (Net-Spinning)
Arthropoda	Insecta	Trichoptera	Hydroptilidae	Hydroptila	62.5	25	Micro-caddisfly
Arthropoda	Insecta	Trichoptera	Lepidostomatidae	Lepidostoma	20	8	Little Plain Brown Sedge Caddisfly
Arthropoda	Insecta	Coleoptera	Elmidae	Optioservus	105	42	Optioservus Riffle Beetle
Arthropoda	Insecta	Ephemeroptera	Leptophlebiidae	Paraleptophlebia	15	6	Blue Quill Mayfly
Arthropoda	Insecta	Diptera	Ceratopogonidae	Probezzia	5	2	Biting Midge
Arthropoda	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila	5	2	Green Sedge Caddisfly

Taxonomy of benthic macroinvertebrates collected at the Broad Cove Brook site.

Phylum	Class	Order	Family	Genus	Mean Count	Raw Count	More common (fishing) name, possible animal type
Arthropoda	Malacostraca	Amphipoda			5.71	2	Scud
Chelicerata	Arachnida	Hydracarina			2.85	1	Water Mite
Arthropoda	Insecta	Plecoptera			8.57	3	Stonefly
Arthropoda	Insecta	Trichoptera			22.85	8	Caddisfly
Arthropoda	Insecta	Ephemeroptera	Baetidae		2.85	1	Small Mayfly
Arthropoda	Insecta	Diptera	Chironomidae		611.42	214	Midge
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae		5.71	2	Spiny Crawler Mayfly
Arthropoda	Insecta	Ephemeroptera	Heptageniidae		28.57	10	Flat-Headed or Stream Mayfly
Arthropoda	Insecta	Trichoptera	Hydroptilidae		2.85	1	Micro or Purse-Case Caddisfly
Arthropoda	Insecta	Trichoptera	Leptoceridae		5.71	2	Long-Horned Caddisfly
Arthropoda	Insecta	Ephemeroptera	Leptophlebiidae		2.85	1	Prong-Gilled Mayfly
Arthropoda	Insecta	Diptera	Athericidae	Atherix	8.57	3	Watersnipe Fly
Arthropoda	Insecta	Ephemeroptera	Baetidae	Baetis	14.28	5	Baetis Mayfly (Blue-Winged Olive)
Arthropoda	Insecta	Trichoptera	Philopotamidae	Chimarra	68.57	24	Little Black Sedge Caddisfly
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Ephemerella	57.14	20	Pale Morning Dun Mayfly
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Hydropsyche	20.00	7	Spotted-Sedge Caddisfly (Net-Spinning)
Arthropoda	Insecta	Trichoptera	Lepidostomatidae	Lepidostoma	5.71	2	Little Plain Brown Sedge Caddisfly
Arthropoda	Insecta	Odonata	Gomphidae	Ophiogomphus	5.71	2	Club Tail Dragonfly
Arthropoda	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila	2.85	1	Green Sedge Caddisfly

Appendix C – Results of biological assessment for each sample site

Workings for the Virginia River site.

Insect Type (12)	Total Count	Sensitivity Rating
Coleoptera	4	Excellent
Plecoptera	7	Excellent
Trichoptera	65	Excellent
Ephemeroptera	53	Excellent
Odonata	0	Facultative
Hydropsychidae	15	Facultative
Amphipoda	64	Facultative
Hydracarina	2	Facultative
Nemata	2	Poor
Annelida	6	Poor
Platyhelminthes	4	Poor
Diptera	79	Poor

Total count	**Richness**
301	20
Biodiversity Ratio	**% Total D**
6.64	26
Total Facultative	**% Total tolerant**
81	30
Total Tolerant	**% Total facultative**
91	27

Workings for the South Brook site.

Insect Type	Total Count	Sensitivity Rating	Total count	Richness
Plecoptera	7	Excellent	367	17
Trichoptera	37	Excellent		
Coleoptera	46	Excellent	**Biodiversity Ratio**	**% Total D**
Ephemeroptera	139	Excellent	4.63	32
Amphipoda	2	Facultative	**Total Facultative**	**% Total tolerant**
Odonata	0	Facultative	13	35
Hydropsychidae	2	Facultative		
Hydracarina	9	Facultative	**Total Tolerant**	**% Total facultative**
			128	4
Nemata	2	Poor		
Annelida	8	Poor		
Diptera	117	Poor		

Workings for the Broad Cove Brook site.

Insect Type	Total Count	Sensitivity Rating	Total count	Richness
Plecoptera	3	Excellent	309	15
Trichoptera	38	Excellent		
Ephemeroptera	39	Excellent	**Biodiversity Ratio**	**% Total D**
			4.85	70
Odonata	2	Facultative		
Hydropsychidae	7	Facultative	**Total Facultative**	**% Total tolerant**
Amphipoda	2	Facultative	12	70
Hydracarina	1	Facultative		
			Total Tolerant	**% Total facultative**
Diptera	217	Poor	217	4