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February 3, 2010
File: 9299

Department of Transportation and Public Works
1672 Granville Street
Johnson Building, 3rd Floor
Halifax, NS B3J 3Z8

Attention: Mr. Chris Moir

Dear Mr. Moir:

Reference: Biological, and Supporting Water Quality Studies, Woodens River Watershed, 2009

At the request of Nova Scotia Department of Transportation and Public Works (NSTPW), Jacques Whitford Stantec Limited (Stantec) undertook biological, and supporting water quality studies in the Woodens River watershed. The purpose of the work was to assess general environmental quality (as represented by water chemistry), and the biological condition of selected lakes (as represented by the benthic invertebrate communities present in the spring, and observations of brook trout spawning areas in the fall). Benthic invertebrate community structure has been shown to be a good indicator of the level of stress placed on aquatic ecosystems as a result of lake acidification (Stephenson et al. 1994). As such, comparisons of benthic invertebrate communities between lakes can provide information about the overall biological condition of the lakes. In addition, in the fall of 2009 a salmonid spawning assessment was completed for two streams feeding into Hubley Big Lake. The spawning survey is an indicator of the potential recruitment of brook trout.

The benthic invertebrate study results and spawning survey information are intended to complement ongoing studies related to the presence of PCB contamination in Five Island Lake, and the general population status of brook trout (*Salvelinus fontinalis*) in the Woodens River watershed.

BACKGROUND

The Associated Metal and Electronic Salvage Yard, in the community of Five Island Lake, was in operation for approximately 25 years before being closed by the Nova Scotia Department of Environment (NSDOE) in late 1989, and designated an Orphan Site. As a result of certain operating practices, site contamination was widespread, including polychlorinated biphenyl (PCB), metals, and dioxin and furan impacts in soil and groundwater on site and sediment and surface water in the Woodens River watershed, especially in the adjacent Five Island Lake. Concentrations of PCB in the tissues of fish from Five Island Lake were first measured in 1994, and were found to exceed levels considered safe for human consumption. This condition persists to the present day, although fish in other nearby lakes are considered to be safe for consumption.

Following the finding of PCB in fish tissue, the recreational fisheries in the Woodens River watershed were designated catch and release only. At recent public meetings, some members of the public have asked to have portions of the fishery released from this restriction. At the same time, however, concern about the ability of the fish populations to withstand exploitation have been identified, due to the low productivity of the lakes, the acidity of the water, and anecdotal evidence regarding reduced mayfly hatches in some of the lakes. Declining mayfly hatches may signal biological change in the lakes due to acidification, and mayflies are an important food resource for brook trout.

SCOPE OF STUDY

This letter provides the results of an investigation of littoral (near-shore) benthic invertebrate communities present in selected lakes in the Woodens River watershed, and the findings from a fall brook trout spawning survey.

Benthic invertebrates were collected from Five Island, Hubley Big, Long, Ben Miller, Albert Bridge, and Gates lakes (Figure 1). Benthic invertebrates were sampled shortly after ice-out in the spring of 2009. Samples were collected using a kick-and-sweep net technique, and were sieved and sorted in the field using a sieve mesh size of 0.5 mm (500 µm). Approximately 100 invertebrates were captured from each of five sampling stations within each lake in order to characterize the invertebrate assemblages present. Benthic invertebrates were identified to genus or species where possible.

Brook trout spawning habitat was surveyed along the entire length of two streams: Fleck Brook and Five Island Lake Run, both of which feed Hubley Big Lake. The streams were assessed for existing redds and for potential spawning habitat, as well as for supporting fish habitat types.

Water samples were collected from each lake (as a mid-lake surface grab sample) during the spring benthic sampling and from both streams (as grab samples) during the fall spawning survey. Water samples were submitted for analysis of trace elements and general chemistry parameters (including laboratory-measured pH). Additionally, temperature, specific conductivity, total dissolved solids (TDS), salinity, dissolved oxygen (DO) and pH were measured in the field at each sample location using a YSI model 556 handheld multimeter.

METHODS

Benthic Invertebrate Community Study:

Lake sampling began with the selection of sampling stations from a map of the lake. In each lake basin, a compass rose was established near the centre, with transects intersecting the shore at the eight major compass points. Sampling stations were identified by randomly selecting a number between 1 and 360. The compass rose was then rotated clockwise by this number of degrees. Islands and points of land were disregarded in this process. Five sampling stations were then selected randomly from the eight compass points, the remaining three stations providing redundancy should any of the five selected stations prove impossible to sample (for example, a vertical drop at the shore to a depth of >1 m).

Benthic macroinvertebrates were collected from each of the littoral zone stations using a kick-and-sweep net technique. A 30-cm triangular sweep net (0.5 mm mesh openings) was worked back and forth as the operator kicked at the benthic substrate to dislodge sand, gravel, and organic debris. All material captured in the net was transferred to a sieve box (also 0.5 mm mesh) and sieved to remove fine particulate matter. The contents of the sieve box were then transferred to white-painted baking trays and floated in a small quantity of lake water in order to identify living benthic invertebrates. Individual invertebrates were captured using tweezers or eyedroppers, and preserved in 70% isopropyl alcohol. Approximately 100 individual organisms were collected at each of the five sites within each lake.

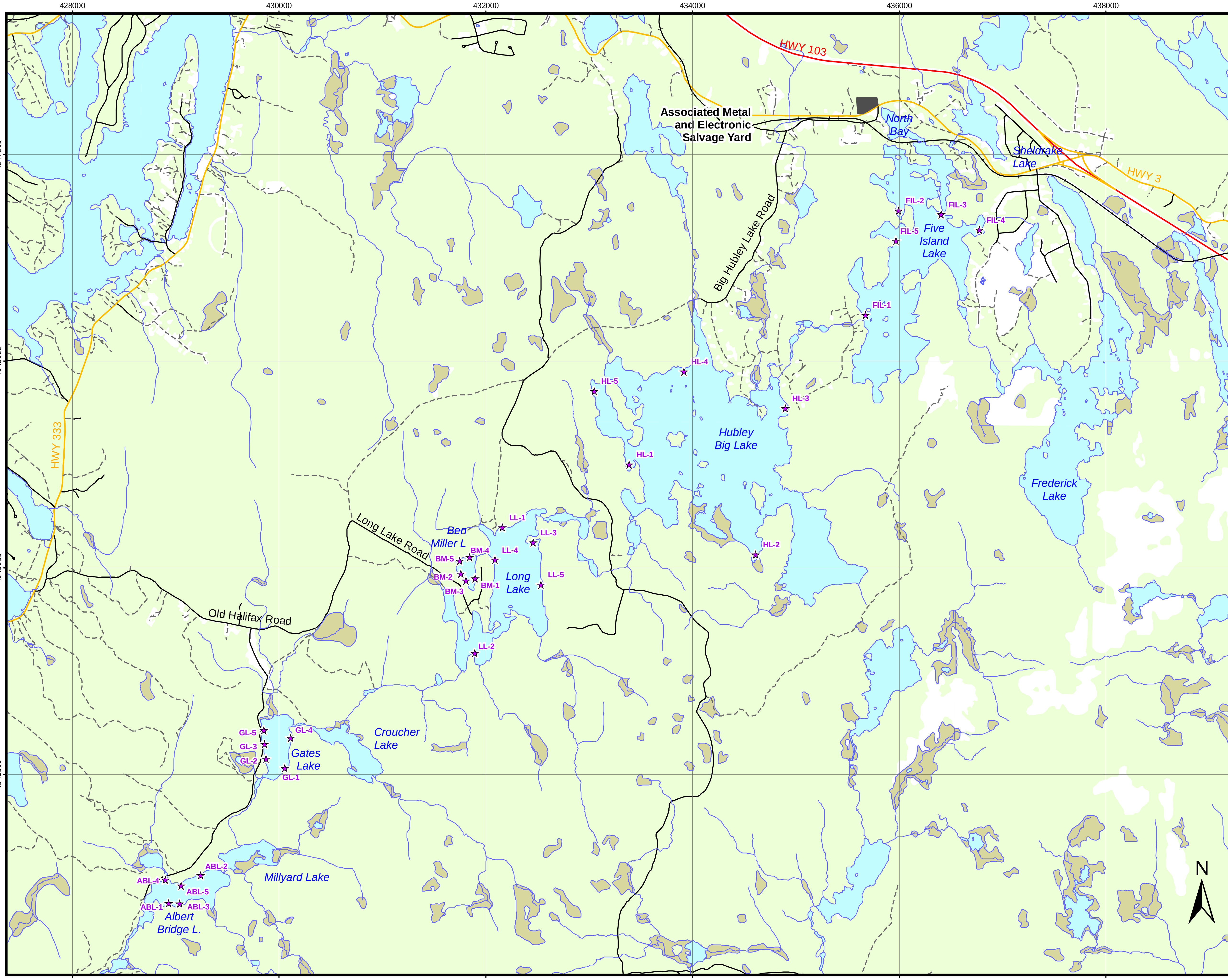


Figure 1

Nova Scotia Transportation & Infrastructure Renewal

Benthic Invertebrate Sample Locations

Map Features

- Benthic Invertebrate Sampling Locations
- Watercourse
- Utility Line
- Major Highway
- Collector Highway
- Paved Road
- Unpaved Road
- Rail
- Waterbody
- Wetland

Forestry

- Cleared
- Forested

0 0.5 1 2
Kilometers

Map Parameters
Projection: UTM-NAD83-Z20
Scale 1:35,000
Date: September 15th, 2009
Project No.: 09299.12

Stantec

Water samples were collected at the centre of each lake and analysed for general water chemistry and trace element parameters. Water temperature, pH, conductivity, dissolved oxygen, total dissolved solids and salinity were measured at the same location.

At the end of sample collection each day, the samples were transported to the Stantec office, and were refrigerated prior to submission for benthic invertebrate identification and water quality analysis.

Brook Trout Spawning Habitat Survey

The brook trout spawning habitat survey was based on methods described by Imhof in "Spawning Survey Methodology" (1997). The survey began by setting up survey areas with fixed start and end points for reproducibility. This was accomplished through the use of a coordinate based system and used the inlet and outlet of adjoining lakes as physical landmarks. The survey was completed near the anticipated end of the spawning season as this would give the greatest number of redds, while still allowing for visual identification through the disturbance of the substrate.

Once a redd was identified a waypoint was taken using a Nomad DGPS unit accurate to <1m. The location as well as placement within the stream was noted (e.g., left bank, center, right bank); multiple redds within close proximity (<10 m) were counted and noted with the one set of coordinates. An overall habitat survey of each stream was completed using field sheets derived from NBDNR/DFO stream survey forms. Fish habitat (*i.e*., spawning, rearing, migration, *etc*.) was assessed along the length of both streams. The assessment included: stream type, substrate class and abundance, embeddedness, stream bank stability and vegetation, as well observations on the presence of aquatic macrophytes and algae.

Water samples were collected at the first identified redd closest to Hubley Big Lake (*i.e.*, the most downstream redd) and were analysed for general water chemistry and trace element parameters. Water temperature, pH, conductivity, dissolved oxygen, total dissolved solids and salinity were measured at the same location *in situ* using a YSI model 556 handheld multimeter.

RESULTS AND DISCUSSION

The benthic invertebrate community data can be found in Attachment 1. Water quality data from field measurements can be found in Attachment 2. The laboratory certificates for chemical analysis can be found in Attachment 3. Values for general chemistry and metal parameters expressed as concentrations were log10-transformed prior to statistical analysis in order to ensure normality and homogeneity of variance.

Water Quality Data

The lake water quality can be characterized as generally good, although generally acidic, and highly dilute, with laboratory-measured conductivity values ranging from 21 µS/cm in Ben Miller Lake to 110 µS/cm in Five Island Lake. Concentrations of total organic carbon (TOC) in the water are considered moderate, ranging from 3.1 mg/L in Ben Miller Lake, to 6.0 mg/L in Albert Bridge Lake.

The pH values measured in the field ranged from 4.68 (Hubley Big Lake) to 5.57 (Ben Miller Lake). Laboratory reported pH values had a similar range (4.81 in Gates Lake to 5.60 in Ben Miller Lake). The pH values of dilute water samples are susceptible to drift, and therefore the field-measured values are considered to be more representative of actual field conditions.

Major ion chemistry (i.e., calcium, magnesium, sodium, potassium, sulphate, chloride and alkalinity) of the lakes confirms the highly dilute character of the water. Calcium concentrations, which generally reflect local geological conditions (*i.e.*, granitic bedrock and thin overburden soils), range from 0.6 mg/L in Ben Miller Lake to 2.0 mg/L in Five Island Lake. None of the lakes contain high concentrations of sulphate, indicating that the lakes are not being significantly influenced by weathering of sulphide minerals within their watersheds. Overall, the sulphate concentrations are rather low (generally less than 3 mg/L). Sodium concentrations, which can be affected by external factors including proximity to roads and major highways (due to road salting), or salt spray (near the ocean) showed considerable influence of human activity, ranging from 2.7 mg/L in Ben Miller Lake to 16 mg/L in Five Island Lake. Ben Miller Lake is remote from paved roads, and the sodium concentration in this lake presumably reflects a low level of oceanic aerosol deposition. In contrast, Five Island Lake is down-gradient of Route 103, a major four-lane highway, and sodium values in the remaining lakes generally appear to lie on a gradient of dilution consistent with their locations in the overall Woodens River watershed.

The chemical data are paradoxical as Ben Miller Lake, despite having the most dilute water, also has the highest pH of the sampled lake set. Generally, one would expect the most dilute lake to have the highest sensitivity to acid deposition and lowest pH. Deposition of sea salt has been shown to exacerbate acidification of lakes in granitic terrain in Scotland and Norway (Ferrier et al. 2001). Inputs of sea-salt occur in conjunction with storms, as these events release large amounts of aerosol and salty spray into the atmosphere, which may subsequently be deposited on land. Since chloride is very mobile in soils, chloride concentrations in streams and lochs show large variation over time. The cations in the sea-salts, mainly sodium and magnesium, are not as mobile in soils as chloride since both cations participate in ion exchange reactions. In acidified soils the incoming sodium and magnesium exchange in part for inorganic aluminum and hydrogen ions, resulting in decreased pH and alkalinity of the runoff water. Aluminum ions in water can also act as a virtual acid, since the precipitation of aluminum minerals (primarily gibbsite, with a fundamental chemical formula of $Al(OH)_3$) removes base (OH^-) ions from the water, shifting the pH balance towards acidity.

Episodic acidification due to sea-salt deposition has been documented in studies from Loch Dee in Galloway (Langan, 1987), Norway (Hindar et al., 1994) and Maine, USA, (Heath et al., 1992) and was demonstrated experimentally at Sogndal, Norway (Wright et al., 1988). The same effect can be expected as a result of road salt deposition in watersheds. Therefore it is possible that the chemical signal of road salt application observed in Five Island, Hubley Big, Long, Albert Bridge and Gates Lakes is also partly responsible for the acidification of those lakes. A direct comparison with the pH of Ben Miller Lake would suggest that this acidification could have a magnitude of up to -0.8 pH units.

Also related and of concern are the very low calcium concentrations (0.6 to 2.0 mg/L) recorded in the Woodens River watershed lakes. A side-effect of acidification that has been identified recently throughout softwater regions of eastern North America and Europe is the depletion of calcium by ion exchange from watershed soils (Jeziorski et al. 2008). This depletion can also be exacerbated by elevated salt loadings. Low availability of calcium can limit the survival and distribution of sensitive species including crustacean zooplankton such as *Daphnia* spp., and can limit the recovery of lakes even after acid loadings are reduced (Jeziorski et al. 2008). One lake referenced in the study by Jeziorski et al. (2008) is a Nova Scotia lake (Little Wiles Lake) having a calcium concentration of 1.5 mg/L and a pH of around 5.6. Little Wiles Lake was shown to have experienced declining calcium concentrations, with a concurrent loss of *Daphnia* spp., although the lake pH appears to have remained stable. The cascading ecological effects of losing key species from the zooplankton community are difficult to predict.

Trace element chemistry also reflects the highly dilute character of the waters, with many elements including antimony, arsenic, beryllium, bismuth, boron, chromium, cobalt, copper, lead, molybdenum, nickel, selenium, silver, thallium, tin, titanium and vanadium being non-detectable in most or all samples. The remaining trace elements including barium, iron, manganese, strontium, uranium and vanadium generally met CCME water quality guideline values for the protection of freshwater aquatic life (where such exist). Exceptions included total aluminum, which ranged from 135 to 219 µg/L; and total cadmium, which ranged from 0.021 to 0.063 µg/L. These values, which exceed CCME guidelines for the protection of freshwater aquatic life, are likely signals of watershed acidification.

The water chemistry of the Woodens River watershed exhibits patterns that should be cause for concern with respect to acidity, as well as present or eventual depletion of calcium from watershed soils. Ben Miller Lake, which is minimally exposed to road salting activities, had the highest pH of the lakes tested, yet it also had the lowest calcium concentration. The elevated sodium concentrations in the remaining lakes are clearly a result of road salting activities, which will be most intense in the Five Island Lake sub-watershed, which is traversed by Highway 103, as well as other roads. High salt (sodium chloride) loadings to watershed soils can exacerbate acidification of lake and stream water, a process that appears to be occurring. The calcium concentration in Five Island Lake (2.0 mg/L), which is somewhat higher than the calcium concentrations in downstream lakes, and considerably higher than in Ben Miller Lake (0.6 mg/L) may signal exchange of calcium for sodium in watershed soils, a process which, while increasing calcium concentrations in lake water in the short term, will eventually lead to calcium depletion as the exchangeable reservoir of soil calcium becomes depleted.

Benthic Invertebrate Data

The Woodens River watershed samples yielded a list of 89 taxa (see Attachment 1). The lake samples yielded a rather uniform benthic community throughout the study area. The Chironomidae (non-biting midges) were the most diverse group with 20 taxa recorded. The next highest diversity was found in the Odonata (damsel and dragon-flies) with 17 taxa recorded. This variety of odonates was not surprising considering the samples came from shoreline habitats. Only six types of mayflies were recorded, but these were common throughout with the exception of the burrowing mayfly, *Hexagenia rigida*, which was found in only one sample. Sample LL-4 from Long Lake exhibited the most riverine community as it contained Elmidae (riffle beetles), a leptophlebiid mayfly, leuctrid stoneflies and *Diplectrona modesta*, a trichopteran (caddisfly) not found elsewhere. These are taxa that might be expected in a more typical stream sample, but can also be found along exposed lake shorelines where wave action substitutes for current.

Rather surprisingly given the water chemistry results, the amphipod *Hyalella azteca* was found at every station in every lake. *Hyalella* has been identified elsewhere in both field studies and in experimental work as an acid-sensitive organism (Stephenson and Mackie, 1986; Stephenson et al. 1994), although mayflies appeared to be more sensitive, although less reliable indicators. Mayflies encountered included *Caenis diminuta*, *Eurylophella* sp., *Hexagenia rigida*, *Stenacron interpunctatum*, *Habrophlebia vibrans* and *Leptophlebia cupida*. Of these, *Leptophlebia* was the most common and abundant (found in all samples), followed by *Eurylophella* (found in all but three samples). Stephenson et al. (1994) found *Eurylophella* and *Stenacron* to be less frequently encountered in acidifying lakes in Ontario, whereas *Leptophlebia* was relatively tolerant of acidity. In contrast, *Caenis* was found at all five stations in Ben Miller Lake, while *Hexagenia* was found in only one sample, from Albert Bridge Lake, and *Habrophlebia* was found in only one sample, from Long Lake.

Mollusks, which have a high requirement for calcium in order to develop their shells, were represented only by fingernail clams (Sphaeriidae). Two taxa (*Musculium lacustre* from two sites in Ben Miller Lake and one site in Five Island Lake; and *Pisidium* sp. from sites in Five Island, Gates, Hubley Big and Long lakes) were reported. While *Pisidium* is known to be relatively acid-tolerant, it is surprising to find *Musculium lacustre* in these environments.

The benthic invertebrate communities were statistically assessed based on the presence or absence of species at each sampling station within each lake. If a species was not present within the lake (*i.e*., absent at all five stations) it was given a value of 0. If a species was present at each of the five sampled locations it was given a value of 5. The benthic invertebrate community data were then evaluated using non-metric multidimensional scaling (NMDS). NMDS is a nonparametric ordination technique that can be used to explore similarities and differences between benthic communities, and to identify fundamental structures and relationships in the data.

Firstly, the benthic invertebrate abundance data (based on presence or absence, with values of 0 to 5) were compared using a Spearman (nonparametric) correlation matrix to measure the overall likeness between the assemblages captured in each sample. The resulting correlation matrix was then submitted to NMDS with results visualized in a two-dimensional plot. This approach was chosen as it allows the representation of the overall relationships of a complex data set, such as benthic invertebrate community survey data, with minimal loss of information. The NMDS ordination plot for the Woodens River watershed benthic invertebrate data is shown in Figure 2. Based on this figure, it is apparent that the benthic invertebrate assemblage of Ben Miller Lake is distinct from the assemblages in all other lakes (as visualized by the distance between lake pairs in NMDS Dimension 1), and that the remaining five lakes display a similar gradient between Five Island Lake and Albert Bridge Lake on NMDS Dimension 2.

Potential physical causes for these observations were explored by examining correlations and performing a linear regression analysis. Pearson correlation analysis was considered between both NMDS Dimension 1 and Dimension 2 scores and the following parameters (Table 1):

- temperature (°C);
- conductivity (µS/cm);
- pH (units);
- general water chemistry parameters (generally mg/L); and
- concentrations of metal in water (generally µg/L).

The highest correlation coefficients were generally observed for NMDS Dimension 1 scores with the highest value encountered with pH ($r = -0.983$). The following parameters also had correlation coefficients with NMDS Dimension 1 scores with absolute values stronger than 0.70: conductivity, chloride, total organic carbon (TOC), calcium, magnesium, potassium, sodium, aluminum, barium, cadmium, iron, manganese, strontium, uranium, and zinc. For NMDS Dimension 2, there were no particularly strong ($r > 0.70$) correlation coefficients. Sulfate had the strongest correlation coefficient ($r = -0.675$), followed by hardness, nitrate and magnesium, each with correlation coefficients with absolute values slightly greater than 0.50; however, these signals are weak, and it is possible that factors other than water chemistry may account for the differences between benthic invertebrate communities in NMDS Dimension 2.

Reference: **Biological and Supporting Water Quality Studies, Woodens River Watershed, 2009**

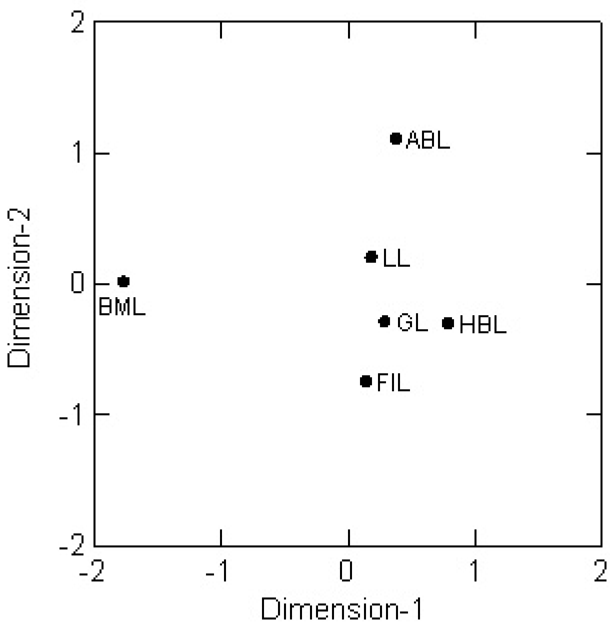


Figure 2. Ordination Plot for Benthic Invertebrate Community Survey. Lakes Include Albert Bridge Lake (ABL); Ben Miller Lake (BML); Five Island Lake (FIL); Gates Lake (GL); Hubley Big Lake (HBL); and Long Lake (LL).

Table 1. Pearson Correlation Coefficients Between Water Quality Parameters and Benthic Invertebrate Community NMDS Scores.

Parameters	Units	Dimension 1	Dimension 2
Temperature	°C	-0.202	0.497
Conductivity	µS/cm	**0.713**	-0.487
pH	units	**-0.983**	0.041
Total Dissolved Solids	g/L	0.273	0.020
Dissolved Oxygen	mg/L	0.399	-0.499
Hardness (as $CaCO_3$)	mg/L	0.621	-0.546
Nitrate	mg/L	0.417	-0.507
Chloride	mg/L	**0.847**	-0.358
Total Organic Carbon	mg/L	**0.818**	0.399
Sulfate	mg/L	0.324	-0.675
Calcium	mg/L	**0.720**	-0.465
Magnesium	mg/L	**0.701**	-0.503
Potassium	mg/L	**0.939**	-0.250
Sodium	mg/L	**0.841**	-0.366
Aluminum	µg/L	**0.865**	-0.300
Barium	µg/L	**0.879**	-0.322
Cadmium	µg/L	**0.770**	-0.380

Table 1. Pearson Correlation Coefficients Between Water Quality Parameters and Benthic Invertebrate Community NMDS Scores.

Parameters	Units	Dimension 1	Dimension 2
Iron	µg/L	**0.886**	-0.356
Lead	µg/L	0.532	0.127
Manganese	µg/L	**0.792**	-0.434
Strontium	µg/L	**0.877**	-0.335
Uranium	µg/L	**0.973**	0.050
Zinc	µg/L	**0.864**	-0.376

Note:
Highlighted values (bold font) indicate a correlation coefficient higher than (absolute) 0.70.

Correlations were also examined between the presence of predominant benthic invertebrate and NMDS Dimension 1 and 2 scores (Figure 3, Table 2). The following taxa had Spearman correlation coefficients that exceeded an arbitrary “r” value of 0.70 for either dimension: Dimension 1: *Psectrocladius*, *Muscilium lacustre*, *Pseudochironomus*, *Procladius*, *Heterotrissocladius*, *Djalmabatista*, *Aeshna*, *Haliplus*, and *Limnesia*; for Dimension 2: *Stenelmis crenata*, *Chironomus*, *Polypedilum*, *Basiaesha janata*, *Pisidium*, *Somatochlora*, *Dicrotendipes*, *Cricotopus*, and *Tipula*.

Three of the four taxa that correlated positively with Dimension 1 scores were found predominantly in Albert Bridge and Hubley Big lakes. Four of the five taxa that correlated negatively with Dimension 1 scores were predominantly found in Ben Miller Lake. Additionally, all three taxa that correlated positively with Dimension 2 scores were found predominantly in Albert Bridge Lake and Long Lake, whereas those that correlated negatively were found in Five Island Lake and Hubley Big Lake. These observations corroborate the ordination plot (Figure 2) and the benthic community structure of these lakes.

Table 2. Spearman Correlation Coefficients Between Benthic Invertebrate Community Data and NMDS Scores.

Taxa	Dimension 1	Dimension 2
Stenelmis crenata	-0.031	**-0.772**
Haliplus	**0.845**	0.068
Chironomus	0.338	**-0.778**
Dicrotendipes	0.278	**0.802**
Polypedilum	0.353	**-0.794**
Pseudochironomus	**-0.845**	-0.304
Cricotopus	0.207	**0.828**
Heterotrissocladius	**-0.878**	-0.098
Psectrocladius	**-0.802**	-0.401
Djalmabatista	**0.778**	0.338
Procladius	**-0.841**	-0.116
Tipula	0.207	**0.828**
Aeshna	**0.778**	0.338
Basiaeshna janata	0.293	**-0.878**
Somatochlora	0.207	**-0.828**
Limnephilus	**0.928**	0.377
Muscilium lacustre	**-0.845**	-0.304
Pisidium	0.278	**-0.833**

Notes:
Highlighted values (bold font) indicate a correlation coefficient higher than (absolute) 0.70.

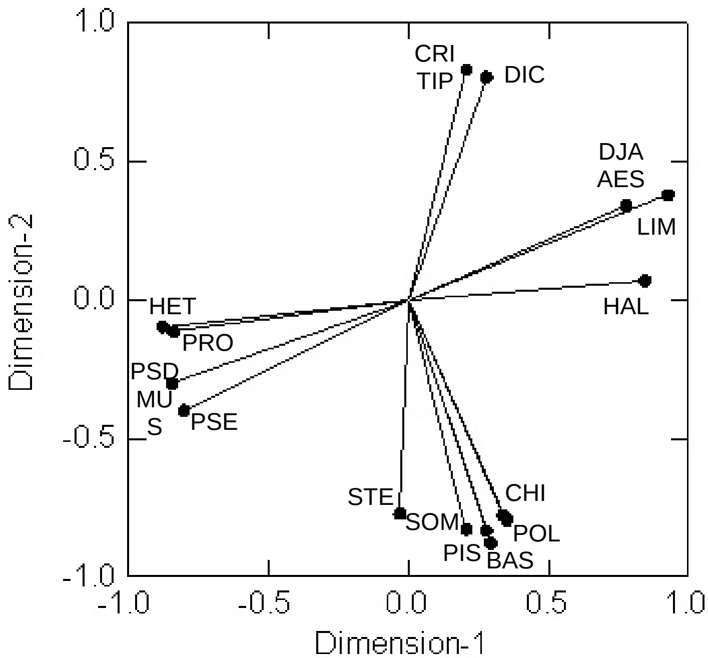


Figure 3 Spearman Correlation Coefficients for Benthic Community Survey according to NMDS Dimension Scores. Label Identification for Dimension 1: *Psectrocladius* (PSE); *Musculium lacustre* (MUS); *Pseudochironomus* (PSD); *Procladius* (PRO); *Heterotrissocladius* (HET); *Djalmabatista* (DJA); *Aeshna* (AES); *Haliplus* (HAL); and *Limnesia* (LIM). For Dimension 2: *Stenelmis crenata* (STE); *Chironomus* (CRI); *Polypedilum* (POL); *Basiaesha janata* (BAS); *Pisidium* (PIS); *Somatochlora* (SOM); *Dicrotendipes* (DIC); *Cricotopus* (CRI); and *Tipula* (TIP).

The littoral benthic invertebrate community structures of lakes within the Woodens River watershed show that Ben Miller Lake is distinct from the other lakes. Higher incidence of the fingernail clam *Musculium lacustre*, and the chironomids *Psectrocladius*, *Pseudochironomus* and *Procladius* was noted in Ben Miller Lake, whereas *Dicrotendipes*, *Cricotopus*, and *Tipula* were mostly observed in Albert Bridge and Long lakes, and *Stenelmis crenata*, *Chironomus*, *Polypedilum*, *Basiaesha janata*, *Pisidium*, and *Somatochlora* in Five Island and Hubley Big lakes. Differences in benthic invertebrate community structure between Ben Miller Lake and the other lakes were found to correlate with several water chemistry parameters including pH (which was higher in Ben Miller Lake), as well as TOC, major ions, and trace elements (which were generally lower in Ben Miller Lake).

Fish Habitat and Brook Trout Spawning Bed Survey

Fleck Brook

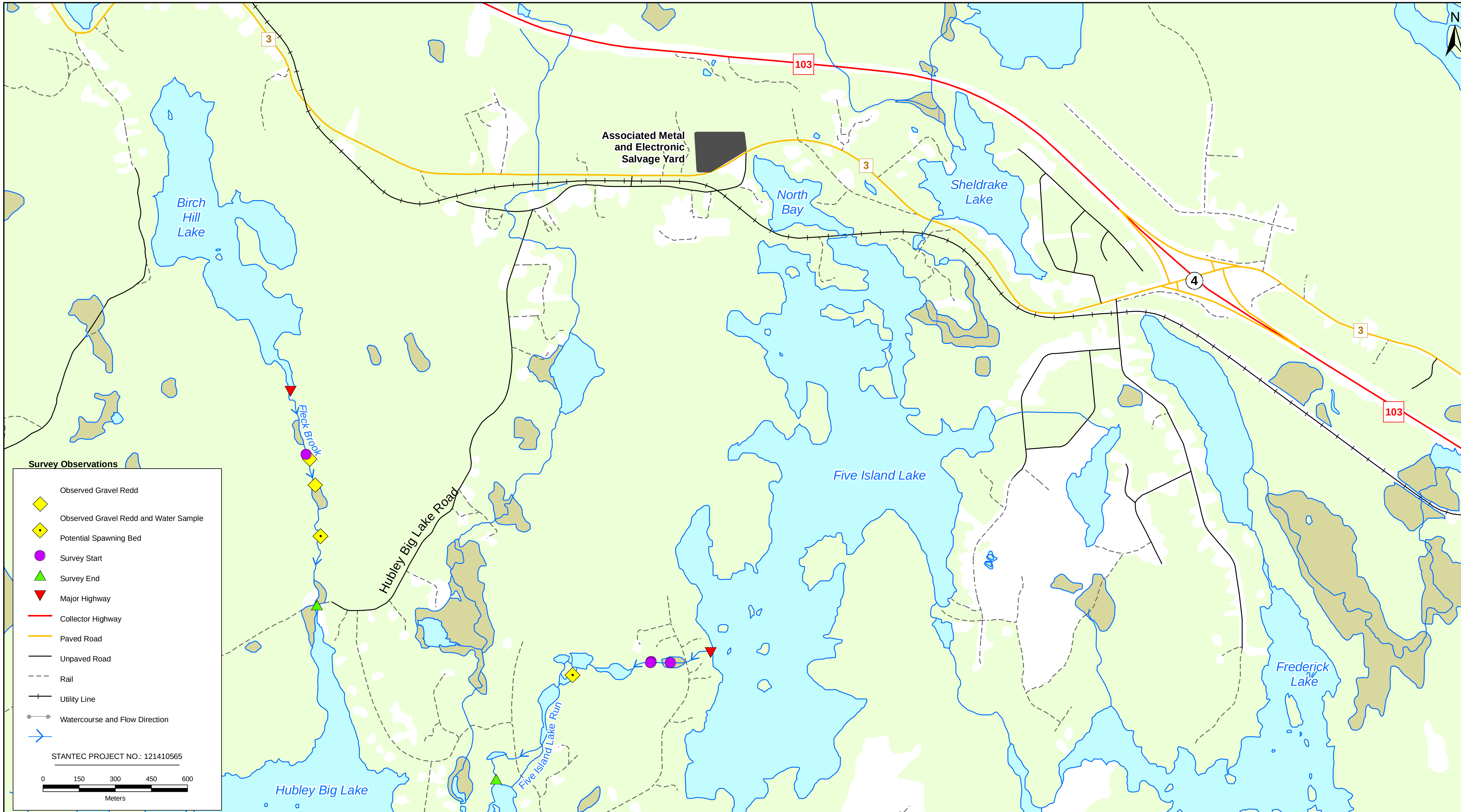
A perennial stream that runs relatively straight from north to south, Fleck Brook drains Birch Hill Lake and feeds Hubley Big Lake, encompassing several wetlands along its stream banks. Substrate along the 875 m section of stream surveyed varied from boulder to fine organic material, with several areas supporting gravel beds.

At the time of the survey, the downstream reach of Fleck Brook was a flat run surrounded by wetland with stream banks that were minimally entrenched, stable and covered with sphagnum moss and overhanging woody vegetation (Photo 1, Attachment 4). The stream was widest and deepest in this downstream area, with the brook varying from 3 m to 5 m in width and supporting mean depths of 0.75 m to 1.0 m. The low velocity through this section of brook allowed settling of organic material and fines that covered 50% of the rocky substrate composed of equal parts boulder, gravel and sand. This organic material provided substrate for the growth of submerged aquatic plants (*i.e.*, macrophytes), while the boulders provided an appropriate surface for aquatic algae growth. The wetland tannins stained the water brown, and made the streambed difficult to see in the larger, deeper stillwaters. One redd was observed within this section and a sample for water quality analysis was taken at the location of the redd (Photo 2, Attachment 4; Figure 4). The redd was characterized by cleared gravel in an area suspected of receiving ground water input (Photo 3, Attachment 4).

The second surveyed reach (the midsection of Fleck Brook) was located north of the heavy wetland coverage and provided different fish habitat. The brook narrowed through this area and slope increased (Photo 4, Attachment 4), except in one wetland area where the brook widened into a slow-moving flat. The substrate of the 1.5 m wide brook in the second surveyed reach was dominated by boulders. With the stronger velocity resulting from the increased slope and decreased width, coverage by fines was reduced to approximately 30% of the substrate within this section. A forest canopy developed in this survey section and lead to increased shading and riparian vegetation dominated by deciduous forest species and minimal overhanging vegetation. Algae remained present on the large substrate and submergent macrophytes were noted as well. Three redds and a few areas of potential spawning habitat were observed within this section, including within the slower moving flat (Photo 5, Attachment 4).

The third and most upstream section of the surveyed portion of Fleck Brook was shorter in length than the two previous sections and included the riffle immediately below Birch Hill Lake (Photo 6, Attachment 4). Bounded by deciduous forest on stable banks, the canopy cover over the brook remained low due to the width of the watercourse. At nearly 4 m wide, the depths varied from 0.15 m to 0.4 m. This area supported increased water velocities and larger substrate, but had fewer areas of potential spawning habitat than the remainder of the brook.

The water quality in Fleck Brook in November 2009 was generally good. The field-measured pH was 6.33, similar to the lab-measured value of 6.35. Cation concentrations were dominated by sodium (12 mg/L), which was considerably more concentrated than the calcium concentration (1.3 mg/L). Similarly, the chloride concentration (19 mg/L) overwhelmed the concentrations of other major anions including sulphate and bicarbonate (both non-detectable). The aluminum concentration (225 µg/L) was the highest value recorded in either the spring or fall surveys. Overall, the water quality of Fleck Brook shows strong influence of road salt. It is unclear what the water quality may be in the spawning gravels during the incubation while brook trout eggs and fry are developing, prior to emergence in the spring.



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C. Shupe

PREPARED BY:

Transportation and
Infrastructure Renewal

FIVE ISLAND LAKE FISH HABITAT

Stream and Spawning Bed Survey (Nov. 24, 2009)

FIGURE NO.: 4

Stantec

Hubley
Big Lake

Five Island Lake Run

A perennial stream that meanders towards the east, Five Island Lake Run drains Five Island Lake and feeds Hubley Big Lake. The watercourse encompasses several ponds or stillwaters between the two lakes. Substrate along the 1,300 m section of stream surveyed varied from boulder to fine organic material, with few observed areas of gravel substrate.

At the time of the survey, the downstream extent of Five Island Lake Run was dominated by riffles running over rock and boulder substrate (Photo 7, Attachment 4). The watercourse was surrounded by deciduous forest and the stream banks were stable and covered with overhanging woody-stemmed vegetation. Minimal undercutting was observed and was limited to bends within the run. A road crosses the run at its widest section approximately 80m upstream of Hubley Big Lake. Wet widths in this area of the survey varied between 15 m and 20 m, and the average depth was 0.2 m. The shallow water depth allowed the boulder and rock substrate to be exposed above water throughout much of the lower reach of Five Island Run. Submerged vegetation and algae were present along this section. There was no spawning habitat observed within the area downstream or immediately upstream of the road.

The second surveyed reach of Five Island Lake Run (the midsection) encompassed the stillwater pond area (Photo 8, Attachment 4). While the ponds themselves were not assessed due to poor substrate visibility (heavily stained, deep water), the runs between the ponds were included in the survey. A redd was observed within one of these short runs (Photo 9, Attachment 4). The runs connecting the ponds varied in width: the area in which the redd was observed was 10 m wide and 0.4 m deep. The substrate consisted of boulders, rock, rubble and patches of gravel and sand. The larger substrate was 35% to 50% embedded with gravel and sand. Stream banks were stable although moderately undercut. A deciduous forest canopy provided partial shade to the run while the riparian community of grasses and woody vegetation added to the 30% stream cover. Submerged vegetation and algae remained present within the runs and were anticipated to be plentiful within the ponds during the growing season. A water sample was taken for chemical analysis at the location of the observed redd (see Figure 4).

The third (upstream) section of the surveyed portion of Five Island Lake Run differed significantly from the previous two segments. The run narrowed to 6 m, contained smaller substrate in areas, became more entrenched, and exhibited flow characteristics that alternated between runs, riffles and pools leading to the outlet of Five Island Lake (Photos 10 and 11, Attachment 4). The primary substrate was rock measuring 18 cm to 46 cm, followed in dominance by a mixture of boulder and rubble which was surrounded by gravel that embedded the larger substrate (embeddedness was less than 20%). Riparian vegetation was composed of an equal mix of grasses, shrubs and deciduous trees on a stable stream bank with moderate undercutting. An area of wetland was observed adjacent to the stream approximately 100 m downstream of Five Island Lake; potential spawning habitat was recorded in this area and at the head of a pool 50 m downstream from the wetland. The 0.75 m deep pool was observed to have multiple areas of clear gravel, but could not be confirmed as a redd at the time of the survey. A large open-bottomed culvert is present upstream of the wetland, approximately 75 m downstream of Five Island Lake. Above the culvert the stream gradient steepens, the run narrows, velocities increase and no additional spawning habitat was observed.

The water quality in Five Island Lake Run in November 2009 was moderate. The field-measured pH was 6.15, higher than the lab-measured value of 5.55. Cation concentrations were dominated by sodium (15 mg/L), which was considerably more concentrated than the calcium concentration (1.8 mg/L). Similarly, the chloride concentration (28 mg/L) overwhelmed the concentrations of other major anions including sulphate (2 mg/L) and bicarbonate (non-detectable). The aluminum concentration was 174 µg/L. Overall, the water quality of Five Island Lake Run shows strong influence of road salt. It is unclear what the water quality may be in the spawning gravels during the incubation while brook trout eggs and fry are developing, prior to emergence in the spring.

Summary

The brook trout spawning habitat and stream survey carried out in November 2009 confirmed that both Fleck Brook and Five Island Lake Run support diverse fish habitat typically used by multiple fish species at various life stages. Potential brook trout spawning habitat and cleared gravel redds were observed and their locations recorded during the survey. Specific sites may be used by spawning fish as the result of an interaction between several variables including: unique characteristics in the sorting of the substrate; certain particle size distributions; groundwater discharge; specific channel form and type; and natural or human discharges of certain chemicals into the stream (Imhof 1997). The stream survey also confirmed connectivity between Hubley Big Lake and both Birch Hill and Five Island Lakes. During extremely low flow periods, fish passage in the downstream reach of Five Island Lake may be prohibited but clear fish passage is anticipated to occur during the majority of the year.

Water quality in both Fleck Brook and Five Island Lake Run shows strong influence of road salt application higher in the watershed. It is not clear what the water quality will be in the spawning gravels over the winter and during the spring snow melt period, when acid deposition held in the snowpack tends to be released in a pulse coinciding with the early melt events, and the effects of road salt application will be most pronounced. On the one hand, low pH values and aluminum ions released by acidity and displaced by road salt application could be toxic to developing fish larvae; on the other hand, the high concentrations of sodium and displaced calcium ions can provide a measure of mitigation for high aluminum concentrations.

CONCLUSIONS

The water quality and benthic invertebrate communities of lakes in the Woodens River watershed show clear evidence of watershed acidification, and ecological responses to this acidification. Some of the watershed acidification appears to be attributable to high road salt loadings, which may also be responsible for leaching calcium from watershed soils, a process that will eventually lead to calcium depletion. Long term depletion of calcium will add to the stress experienced by fish and benthic invertebrate populations from acidification, and will cause population declines. Brook trout (*Salvelinus fontinalis*) appear to be using both Five Island Lake Run and Fleck Brook as spawning habitat, with very specific sites in both streams supporting redds during the 2009 spawning survey. Water quality conditions in the spawning gravels during the late winter and early spring period will be an important determinant of the survival of eggs and larval fish, and consequently the recruitment of juvenile brook trout into the populations of the Woodens River system.

RECOMMENDATIONS

Based on the findings of this study, we recommend the following:

1. Maintain catch and release fishing for brook trout in the Woodens River watershed until sufficient information is available on the status and sustainability of brook trout populations in this system.
2. Undertake a non-lethal sampling program to estimate population size and demographics of brook trout populations in selected lakes in the Woodens River watershed.
3. Conduct more regular monitoring of water quality in the Woodens River watershed to establish seasonal trends, and in particular to better understand chemical conditions within the spawning gravels during the winter and spring period.
4. If chemical conditions within the spawning gravels appear likely to cause stress or mortality to developing eggs and larvae of brook trout, investigate the survival of larval fish in known spawning areas.

LIMITATIONS

This report has been prepared for Nova Scotia Department of Transportation and Public Works. The report may not be used by any other person or entity without the express written consent of Nova Scotia Department of Transportation and Public Works and Stantec Consulting Ltd.

Any uses that a third party makes of this report, or any reliance on decisions made based on it, are the responsibility of such third parties. Stantec Consulting Ltd. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made, or actions taken, based on this report.

The information and conclusions contained in this report are based upon work undertaken by trained professional and technical staff in accordance with generally accepted engineering and scientific practices current at the time the work was performed. Conclusions and recommendations presented in this report should not be construed as legal advice.

The conclusions presented in this report represent the best technical judgment of Stantec Consulting Ltd. based on the data obtained from the work. The conclusions are based on the site conditions observed by Stantec Consulting Ltd. at the time the work was performed at the specific testing and/or sampling locations, and can only be extrapolated to an undefined limited area around these locations. Due to the nature of the investigation and the limited data available, Stantec Consulting Ltd. cannot warrant against undiscovered environmental liabilities.

If any conditions become apparent that differ significantly from our understanding of conditions as presented in this report, we request that we be notified immediately to reassess the conclusions provided herein.

Reference: **Biological and Supporting Water Quality Studies, Woodens River Watershed, 2009**

This report was prepared by Annick St-Amand, Ph.D. and Julianne Sullivan, M.Sc., and was reviewed by Malcolm Stephenson, Ph.D.

STANTEC CONSULTING LTD.

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Attachments

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ATTACHMENTS

TABLE 1-1 **Benthic Invertebrate Community Survey**
2009 Woodens River Watershed Fisheries Resource Study
Jacques Whitford Project NSD. 09299.12

		STATION	Albert Bridge Lake					Ben Miller Lake					Five Island Lake					Gates Lake					Hubley Big Lake					Long Lake				
		REPLICATE	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
		DATE	19-Apr-09	19-Apr-09	19-Apr-09	19-Apr-09	19-Apr-09	18-Apr-09	18-Apr-09	18-Apr-09	18-Apr-09	18-Apr-09	17-Apr-09	17-Apr-09	17-Apr-09	17-Apr-09	17-Apr-09	17-Apr-09	17-Apr-09	17-Apr-09	17-Apr-09	17-Apr-09	17-Apr-09	17-Apr-09	17-Apr-09	17-Apr-09	17-Apr-09	19-Apr-09	19-Apr-09	19-Apr-09	19-Apr-09	19-Apr-09
ANNELIDA:OLIGOCHAETA	LUMBRICULIDAE:	*Lumbriculus variegatus*	2	1	2	3	2		1	1	1	1	6	1	8	4	3	9	3		6	1	3	3	1	2	4	2	4	1	2	2
ACARI:	ARRENURIDAE:	*Arrenurus*							1																							
	LIMNESIIDAE:	*Limnesia*																											1			
	LIMNOCHARIDAE:	*Limnochares*				1			5	3	4																					
	SPERCHONTIDAE:	*Sperchon*							3		1	1																				
CRUSTACEA:AMPHIPODA	HYALELLIDAE:	*Hyalella azteca*	15	15	2	15	11	14	5	14	8	3	26	13	36	28	16	1	6	9	6	20	18	27	11	17	1	21	14	2	31	28
INSECTA:COLEOPTERA	DYTISCIDAE:	*Agabus*	1																													
		Liodessus fuscatus													1				1		1											
		Neoporus carolinus		2	2	13	9	6	11	10	15	7	5	1			3	3	2	6			15	13	7	5	13	6		12	5	
		Neoporus undulatus																2														
	ELMIDAE:	*Promoresia tardella*																													1	
		Stenelmis crenata											1		1		1	1								1						1
	GYRINIDAE:	*Dineutus*										1																				
		Gyrinus					1				1	3											1	2								
	HALIPLIDAE:	*Haliplus*					1																1	1	2							
DIPTERA:	CERATOPOGONIDAE:							1	1	1					1									1						1		
	CHIRONOMINAE:	*Chironomus*														2								1			2					
		Dicrotendipes	1	1														2											14			3
		Glyptotendipes													3																	
		Micropsectra			1									1	1													1				
		Microtendipes				4	8	1							1						1					7	1	3		1		1
		Polypedilum												1	2			11					1	3			1			3		
		Pseudochironomus							8	1	3	1				1																
		Stenochironomus																								1						
		Stictochironomus											1																			
		Tanytarsus																						8								
		Tribelos			2	8	11			2	1		2	9			8		1	9		2	4	14		3	23	9	6	30		3
	ORTHOCLADIINAE:	*Brillia*					2																									
		Corynoneura																													1	
		Cricotopus	1																													1
		Heterotrissocladius				2		1				2		1		2						1		1							3	3
		Nanocladius	1	1																												
		Psectrocladius	3					5		8		7	2	1		4		2	1			2		1							2	1
		Zalutschia	11	2	3	2	8		5					4	4	11	2	4	2	4	2	14		2	2	1	1		4	5	6	4
	TANYPODINAE:	*Clinotanypus*											1																			
		Djalmabatista	1	3		1	1																2	7								
		Natarsia		1	4		1					1	2		3		2	1	1	1	2				1	2	1	2		1	8	2
		Procladius						1	1	3	1		1		2					1							5			3	1	4
	TABANIDAE:	*Chrysops*				1																										
	TIPULIDAE:	*Tipula*			1																										1	
EPHEMEROPTERA:	CAENIDAE:	*Caenis diminuta*	7				4	3	4	7	3	28	2								1							5	28	11		
	EPHEMERELLIDAE:	*Eurylophella*	2	9	24	4	12	2	5			4	9	18	3	2	16	7	24	14	19		11	13	16	26	12	31	8	14	19	19
	EPHEMERIDAE:	*Hexagenia rigida*	2																													
	HEPTAGENIIDAE:	*Stenacron interpunctatum*		1	4	1									4		7	4	2	1								3				
	LEPTOPHLEBIIDAE:	*Habrophlebia vibrans*																													1	
		Leptophlebia cupida	61	38	46	34	22	35	42	58	52	49	20	37	14	9	15	52	20	36	29	71	36	12	56	23	32	47	13	38	35	27
HEMIPTERA:	CORIXIDAE:	*Sigara*						1			1	3										1										
	NOTONECTIDAE:	*Notonecta*			1	1	1	1	1		1			2											2		1			1		
LEPIDOPTERA:	CRAMBIDAE:	*Eoparagyractis*					1																									
		Paraponyx				1																										
MEGALOPTERA:	CORYDALIDAE:	*Nigronia serricornis*		1											3	2	1															
	SIALIDAE:	*Sialis*			3		2			1	1	1		4	2			2	1	1		1	1						1			2
ODONATA	AESHNIDAE:	*Aeshna*			1	1																					2					
		Basiaeshna janata															1			1						1						
		Boyeria vinosa												1																		
	COENAGRIONIDAE:	*Argia*	1		1		1						3			1	1		1	1					1	2	1	1				
		Chromagrion conditum				1								1																		
		Enallagma spp.	2	7			2	2	4	2	4		4						5	2	3	5	2		1	2		2		1		1
		Ischnura verticalis		2	1	2	7			2				3													1		1	8	1	
	CORDULIIDAE:	*Helocordulia uhleri*																								1	1			1		
		Somatochlora														1							1									
		Tetragoneuria cynosura																										1				
	GOMPHIDAE:	*Gomphus (Gomphus) sp.*																1	1	4							2		1			
		Gomphus (Gomphus) exilis	2	1		4	2		1			1	2	1	1	1	2		1		3									1		
		Hagenius brevistylus	1																													
	LESTIDAE:	*Lestes vigilax*																							1							
	LIBELLULIDAE:	*Celithemis ?eponina*							1						1				2		1					1						
	MACROMIIDAE:	*Didymops transversa*		1			1										1									1						
		Macromia illinoiensis													1																	
PLECOPTERA	NEMOURIDAE:	*Prostoia*	2	14	14		5						6	5	1	5	2	2	42	14	28	1			2	2	2	8		19	18	6
	LEUCTRIDAE:	*Leuctra tenella*																													12	
	PERLIDAE:	*Acroneuria lycorias*													2	2	2															
	PERLODIDAE:	*Isoperla transmarina*																			1											
TRICHOPTERA:	HYDROPSYCHIDAE	*Diplectrona modesta*																													1	
	HYDROPTILIDAE:	*Hydroptila*			1																											
	LEPIDOSTOMATIDAE:	*Lepidostoma*																													1	
	LEPTOCERIDAE:	*Oecetis*																												1		
	LIMNEPHILIDAE:	*Limnephilus*	2	2	1	2	2	1					1			2			2		2	2	2	1		2	4		1	8	2	
		Pycnopsyche				1	1						1					2	2		6										1	
	MOLANNIDAE:	*Molanna*											1															1				
	PHRYGANAEIDAE:	*Agrypnia*						1				1															1					
		Banksiola				3			1																							
		Ptilostomis	2			1	1	1		1	2			1	1	1							1									1
	POLYCENTROPIDAE:	*Polycentropus*	1	4		1	4	5	1	2				1					1	2	3	1					2	1	7			
	SERICOSTOMATIDAE:	*Agarodes*	1								1		3			1																1
MOLLUSCA:BIVALVIA:	SPHAERIIDAE:	*Muscilium lacustre*						6			1				9																	
		Pisidium														8	1			2	1		1			4			2			
		TOTAL TAXA	22	19	19	24	27	18	19	16	18	17	21	20	24	19	18	17	21	17	18	13	16	17	13	20	22	17	15	21	21	19
		TOTAL NUMBERS	122	106	114	107	123	87	101	116	101	114	99	106	105	87	84	106	121	108	115	122	100	110	103	104	113	144	105	162	152	110

TABLE 2-1 **In Situ Water Quality Results, April 2009**
2009 Woodens River Watershed Fisheries Resource Study
Jacques Whitford Project NSD. 09299.12

Lake	Date	Temperature (°C)	Specific Conductivity (uS/cm)	TDS (g/L)	Salinity (ppt)	DO (%)	DO (mg/L)	pH
Hubley Lake	17-Apr-09	6.84	22	0.014	0.01	101.7	12.41	4.68
Five Island Lake	17-Apr-09	6.31	30	0.020	0.01	100.0	12.35	4.82
Long Lake	19-Apr-09	7.38	19	0.012	0.01	71.7	8.61	4.74
Ben Miller Lake	18-Apr-09	8.26	6	0.004	0.00	84.0	9.83	5.57
Albert Bridge Lake	19-Apr-09	8.68	16	0.010	0.01	90.1	10.55	4.82
Gates Lake	17-Apr-09	9.39	17	0.001	0.01	96.6	11.00	4.82

Maxxam Job #: A944179
Report Date: 2009/04/24

Jacques Whitford Limited
Client Project #: SD09299.12/Z9100
Project name: FIVE ISLAND LAKE WATERSHED
Your P.O. #: NSD016300
Sampler Initials:

RESULTS OF ANALYSES OF WATER

Maxxam ID		CG0691	CG0692		CG0693		CG0694		CG0695	CG0696	CG0696		
Sampling Date		4/17/2009 16:00	4/17/2009 12:00		4/17/2009 16:00		4/17/2009 12:00		4/17/2009 16:00	4/17/2009 12:00	4/17/2009 12:00		
COC Number		B 60816	B 60816		B 60816		B 60816		B 60816	B 60816	B 60816		
	Units	**FIVE ISLAND LAKE**	**HUBLEY LAKE**	**RDL**	**BML**	**RDL**	**LONG LAKE**	**QC Batch**	**ALBERT BRIDGE LAKE**	**GL**	**GL Lab-Dup**	**RDL**	**QC Batch**
Calculated Parameters													
Anion Sum	me/L	0.820	0.560	N/A	0.110	N/A	0.440	1792877	0.350	0.370		N/A	1793062
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	ND	ND	1	ND	1	ND	1792843	ND	ND		1	1793058
Calculated TDS	mg/L	52	37	1	11	1	30	1792880	24	25		1	1793065
Carb. Alkalinity (calc. as CaCO3)	mg/L	ND	ND	1	ND	1	ND	1792843	ND	ND		1	1793058
Cation Sum	me/L	0.860	0.620	N/A	0.180	N/A	0.520	1792877	0.440	0.460		N/A	1793062
Hardness (CaCO3)	mg/L	8	6	1	3	1	5	1793060	4	4		1	1793060
Ion Balance (% Difference)	%	2.38	5.08	N/A	24.1	N/A	8.33	1792876	11.4	10.8		N/A	1793061
Langelier Index (@ 20C)	N/A	NC	NC		NC		NC	1792878	NC	NC			1793063
Langelier Index (@ 4C)	N/A	NC	NC		NC		NC	1792879	NC	NC			1793064
Nitrate (N)	mg/L	0.09	0.07	0.05	ND	0.05	0.08	1792979	ND	ND		0.05	1792979
Saturation pH (@ 20C)	N/A	NC	NC		NC		NC	1792878	NC	NC			1793063
Saturation pH (@ 4C)	N/A	NC	NC		NC		NC	1792879	NC	NC			1793064
Inorganics													
Total Alkalinity (Total as CaCO3)	mg/L	ND	ND	5	ND	5	ND	1794420	ND	ND	ND	5	1794420
Dissolved Chloride (Cl)	mg/L	27	18	1	4	1	15	1794432	12	13	13	1	1794432
Colour	TCU	66	73	30	39	5	74	1794446	78	77	78	30	1794446
Nitrate + Nitrite	mg/L	0.09	0.07	0.05	ND	0.05	0.08	1794449	ND	ND	ND	0.05	1794449
Nitrite (N)	mg/L	ND	ND	0.01	ND	0.01	ND	1794451	ND	ND	ND	0.01	1794451
Nitrogen (Ammonia Nitrogen)	mg/L	ND	ND	0.05	ND	0.05	ND	1794598	ND	ND		0.05	1794598
Total Organic Carbon (C)	mg/L	4.3	4.6	0.5	3.1	0.5	5.0	1797286	6.0	5.6		0.5	1797286
Orthophosphate (P)	mg/L	ND	ND	0.01	ND	0.01	ND	1794448	ND	ND	ND	0.01	1794448
pH	pH	5.49	4.99	N/A	5.60	N/A	4.90	1797762	4.82	4.81		N/A	1797762
Reactive Silica (SiO2)	mg/L	2.7	2.7	0.5	2.8	0.5	2.6	1794441	2.3	2.4	2.4	0.5	1794441
Dissolved Sulphate (SO4)	mg/L	3	2	2	ND	2	ND	1794440	ND	ND	ND	2	1794440
Turbidity	NTU	0.8	0.7	0.1	0.6	0.1	0.6	1798226	0.8	0.5		0.1	1798226
Conductivity	uS/cm	110	76	1	21	1	66	1797764	55	58		1	1797764

ND = Not detected
NC = Non-calculable
RDL = Reportable Detection Limit
Lab-Dup = Laboratory Initiated Duplicate
QC Batch = Quality Control Batch

Attachment 4: Five Island Lake (SD09299.12) Brook Trout Spawning Habitat and Stream Survey November 2009

Photo 1: Fleck Brook - downstream reach

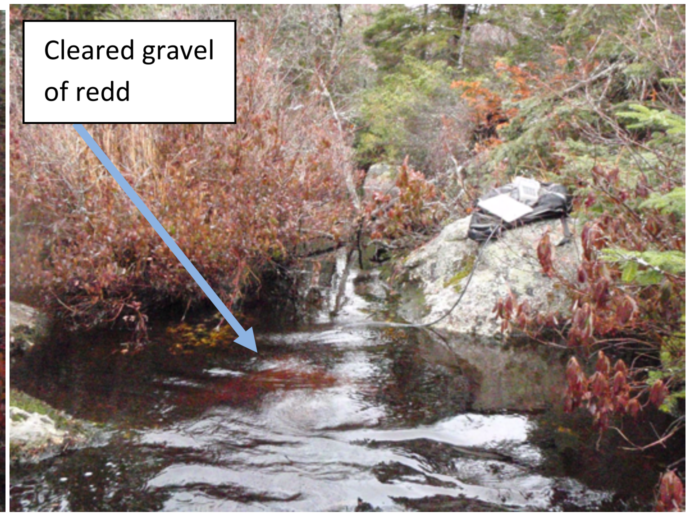

Photo 2: Fleck Brook observed redd (water quality site)

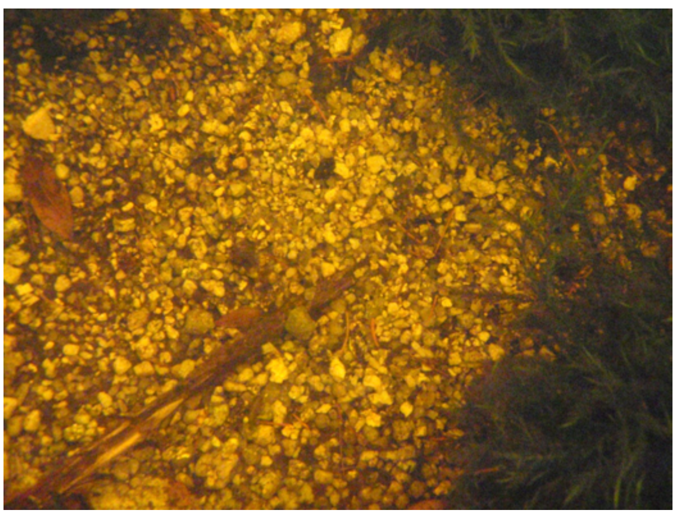

Photo 3: Fleck Brook – cleared gravel of redd

Photo 4: Fleck Brook – second (midstream) surveyed reach

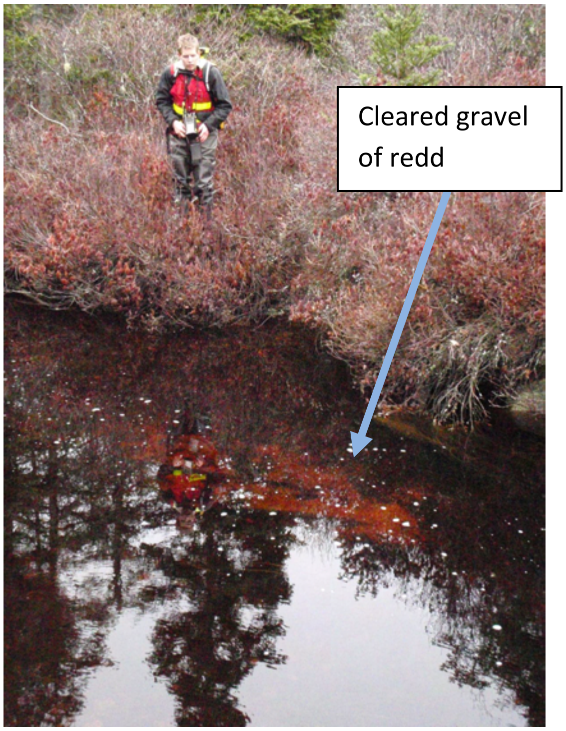

Photo 5: Fleck Brook observed redd

Photo 6: Fleck Brook – upstream reach at Birch Hill Lake

Photo 7: Five Island Lake Run – downstream reach

Photo 8: Five Island Lake Run – second (midstream) surveyed reach (stillwater ponds)

Attachment 4: Five Island Lake (SD09299.12) Brook Trout Spawning Habitat and Stream Survey November 2009

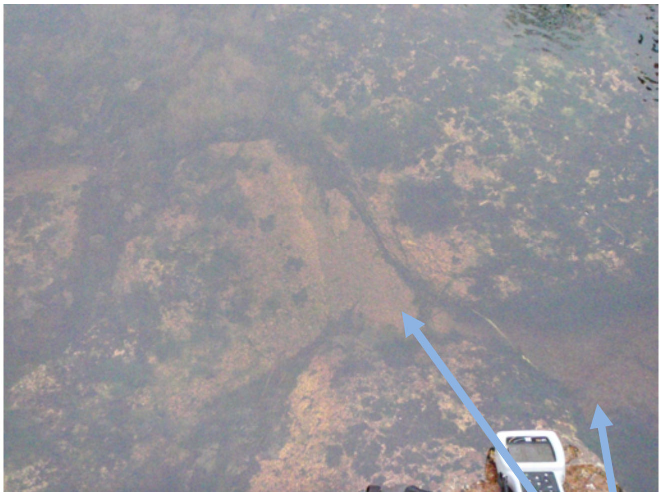

Photo 9: Five Island Lake Run – observed redd (water quality site)

Photo 10: Five Island Lake Run – upstream reach

Photo 11: Five Island Lake Run – upstream reach at Five Island Lake