BIOASSESSMENT OF STREAMS IN THE EAST INTERLAKE USING BENTHIC MACROINVERTEBRATE AND ASSOCIATED HABITAT DATA 2006 TO 2010

A Report Prepared
for

East Interlake Conservation District

by

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ABSTRACT

In Manitoba, watershed management and water quality assessments have become priority for many conservation districts. Methods using aquatic macroinvertebrates as bio-indicators have proven valuable for assessing effects on aquatic systems. A field-based study was initiated in the fall of 2006 to characterize the benthic macroinvertebrate fauna for the purpose of assessing biological condition in the East Interlake Conservation District. The program was refined in 2007 and continued until 2010, where biological sampling was conducted in Grassmere Creek, Parks Creek, Wavey Creek, Netley Creek, Fish Lake Drain, Icelandic River, Washow Bay Creek, and east Fisher River.

The majority of the macroinvertebrate sampling was completed using a kicknet sampler; a tall Ekman was used at two sites where wading was precluded because of water depth and/or velocity. Habitat assessments were conducted at all sites using field-based measurements. *In situ* water quality measurements were collected at all sampling sites during 2009 and 2010.

The land use type for the majority of the stream sites was agricultural; a few sites were located in mixed forest or residential/commercial areas. Aquatic habitat diversity was relatively low and canopy cover was minimal. Riparian areas were typically comprised of reed canary grass. Aquatic macrophytes and algae were present at many sites. Clay was the dominant substrate, occasionally covered with a layer of unconsolidated or flocculent organic material. Mean channel ratios, and maximum water depths and velocities varied between sites and years.

In situ water quality parameters were measured in 2009 and 2010. Most sites were relatively well-oxygenated and above the most stringent water quality objectives for the protection of cool-water aquatic life. The only exceptions were Fisher River and Washow Bay Creek where DO was lower in 2009 than in other streams. The pH of the streams was somewhat alkaline and consistent with the Manitoba water quality guideline for the protection of aquatic life. In 2009, there was some indication of spatial variability in the Fisher River. As is typical for lotic environments (i.e., flowing water), turbidity varied between years and across sites during the same sampling event. Overall, specific conductance was similar across sites within each of the streams during the same sampling period.

The overall mean abundance of benthic macroinvertebrates collected in kicknet samples during 2006 to 2010 was 4,569 individuals. Overall, insects dominated the invertebrate community in abundance (61%), with non-insect taxa comprising 39% of the overall

total. The opposite trend was observed at Grassmere, Parks, and Wavy creeks where the non-insect taxa dominated the community. Of the non-insects, the main groups were: Annelida (aquatic worms), Crustacea (mainly amphipods), though Bivalvia (clams) and Gastropoda (snails) were also present. Insecta mainly consisted of Ephemeroptera (mayflies 22%) and Chironomidae (midges 21%).

Mean invertebrate richness was 22 families. Hill's effective richness showed that only 5 out of the 22 families dominated the invertebrate community and of those the most common families were Hyalellidae (amphipod), Baetidae (small minnow mayfly), and Chironomidae. The mean EPT (Ephemeroptera, Plecoptera, Trichoptera) richness was 6 families, although the prevalence of was dominated by Ephemeroptera. EPT: C ratio values varied between years and sites, with the dominant trend of a fairly balanced community. Mean diversity and evenness values indicated however the streams were low in diversity and the families were intermediately distributed amongst a few groups. Water quality ratings derived from a family biotic index ranged from fair to fairly poor, with an overall rating of fairly poor, indicating that substantial organic pollution is likely.

In general, the invertebrates collected from these streams were in the mid to highly tolerant range for organic pollution, and the community metrics indicated low diversity with the majority of organisms belonging to the same few groups. Based on the bioassessment of the benthic macroinvertebrates and supporting habitat variables, it was determined that the 'fairly poor' biological condition of the eight streams examined within the EICD is likely due to anthropogenic causes.

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1.0 INTRODUCTION

In Manitoba, watershed management and water quality assessments have become priority for many conservation districts. Traditionally, methods for water quality assessments have relied solely on the compilation of physical and chemical measures. To supplement these monitoring techniques, methods using aquatic macroinvertebrates as indicators of biological condition and productivity have proven valuable for assessing effects on aquatic systems. Benthic macroinvertebrates are common, generally abundant and diverse, relatively sedentary (compared to fish), and are an ecologically important part of the food web. These attributes, plus being relatively easy organisms to sample, make them useful and effective bio-indicators (Environment Canada 2010).

The primary objective of this study was to produce a characterization of the benthic macroinvertebrate fauna in streams located in the East Interlake Conservation District (EICD) for the purpose of assessing biological condition. The program was initiated in 2006, and was refined in 2007 where sampling was conducted at 3 sites in each of 8 streams. From 2007 to 2010, biological sampling was conducted in Grassmere Creek, Parks Creek, Wavey Creek, Netley Creek, Fish Lake Drain, Icelandic River, Washow Bay Creek, and east Fisher River (Figure 1). The majority of benthic macroinvertebrate sampling was completed using a kicknet sampler. In 2006, a tall Ekman grab was used to sample benthic invertebrates in non-wadeable reaches of the Icelandic River and Washow Bay Creek. Habitat assessments were conducted at all sites using field-based measurements. *In situ* water quality measurements were also collected at all sampling sites during 2009 and 2010.

This report presents the benthic macroinvertebrate and supporting habitat data collected between 2006 and 2010 from selected streams within the EICD, Manitoba. Also presented is a synthesis of five years of biological data to assess the biological condition of eight of the streams located in the East Interlake. The invertebrate communities associated with each stream are described and compared using descriptors such as abundance, relative proportion (%), taxonomic richness (number of invertebrate families and number of EPT families), effective richness, EPT: Chironomidae ratio; and indices of diversity, evenness, and organic pollution tolerance. This document is intended to act as a resource tool for continued watershed management and water quality improvements.

2.0 METHODS

2.1 FIELD SAMPLING

Benthic invertebrate sampling sites were selected to characterize a range of aquatic habitat types to represent natural (e.g., intact riparian vegetation and non-channelized) and channelized (e.g., denuded riparian, straightened, deepened reaches). Initially, sites were selected within 1 km of existing water quality stations. The majority of sites were wadeable, where the stream could be sampled using a kicknet across the channel from bank to bank. Where water levels were too high to cross the channel, kicknet sampling was confined to the stream margin to a maximum of 1 meter water depth. Where waters were too deep and/or fast, benthic grabs were collected using a tall-Ekman grab sampler. The benthic invertebrate surveys were conducted using a semi-qualitative rapid bioassessment approach modified and implemented based on several resources, namely the Canadian aquatic biomonitoring network (CABIN) and the Ontario benthos biomonitoring network: (OBBN). Other methodology-related resources considered were Hughes (2001), Plafkin *et. al.* (1989) and Bailey *et. al.* (2004).

Sampling dates were as follows: 02, 03, 11 and 19 October 2006; 26-27 September 2007; 23-24 and 27 October 2008; 13-15 October 2009; and 04-07 October 2010. In 2006, 55 benthic invertebrate samples were collected from streams within the EICD at Grassmere Creek, Parks Creek, Wavey Creek, Netley Creek, Willow Creek, Fish Lake Drain, and east Fisher River. Samples were also collected in 3 reaches of the Icelandic River and Washow Bay Creek (Figure 1). From 2007 to 2010, the program was limited to 24 kicknet samples i.e., 3 samples collected at 3 sites in each of Grassmere Creek, Parks Creek, Wavey Creek, Netley Creek, Fish Lake Drain, Icelandic River, Washow Bay Creek, and east Fisher River (Figure 1).

Locations of benthic invertebrate sampling sites were recorded as UTM coordinates (Universal Transverse Mercator NAD 83) using a hand-held Garmin eTrex® GPS; these units were used to navigate back to the same coordinates in each consecutive year. Supporting habitat variables were documented at all of the sampling sites. *In situ* water quality measures were taken using a hand-held Analite and YSI meters; or a Horiba meter. The same methodologies were employed in all years, except in 2006 to 2008 embeddedness, bankfull width and *in situ* water quality measures were not recorded. The detailed field sampling protocol and list of equipment used for data collection is located in Appendix 1.

2.2 LABORATORY PROCEDURES

Benthic invertebrate samples were processed in the laboratory at North/South Consultants Inc. in Winnipeg, Manitoba. The sample sorting and identification protocol, with the QAQC standards for each is outlined in Appendix 2. All animals were enumerated and identified to the lowest reliable taxonomic level, usually family, using keys from Clifford (1991), Merritt and Cummins (1996), Peckarsky *et. al.* (1990), and Smith (2001). Scientific names follow the Integrated Taxonomic Information System classification (ITIS 2011). Invertebrate samples are archived in 70% ethanol at North/South should further processing or analysis be required.

2.3 DATA ANALYSIS

Total invertebrate abundance (number of individuals ± SD), abundance of major groups (number of individuals ± SD), and taxon proportion (percentage abundance) were calculated from individual invertebrate sample results. Community metrics were also calculated for each stream. These included taxonomic richness, EPT richness, effective richness, EPT to Chironomidae ratio, heterogeneity, evenness, and the family biotic index.

Taxonomic richness was determined at the family level and is a count of the different invertebrate families identified in a sample. EPT richness is a count of the different families belonging to the orders: Ephemeroptera, Plecoptera, and Trichoptera. Effective richness (based in Hill's effective richness) provides an indication of the number of families that are contributing to the majority of the community represented in a sample. For example, if total richness = 28 and effective richness = 8, then of the 28 families identified in the sample, 8 taxa are considered dominant.

EPT to Chironomidae ratio (EPT: C ratio) compares the number of mayflies, stoneflies, and caddisflies to the number of chironomids. The EPT are comparatively more sensitive to environmental stress than many chironomids. A ratio value close to 1 suggests an even distribution among the four groups and a low ratio value suggests an unbalanced shift in the community towards more highly tolerant organisms.

Heterogeneity (based on Gini-Simpson's Diversity Index) quantifies biodiversity and is the chance that one invertebrate will be different than the next invertebrate when picked from a sample of invertebrates. If this number is close to 1, then most of the invertebrate groups are different; which means invertebrate diversity is high.

Evenness (based on Shannon –Weaver's Equitability Index) is the relationship between the numbers of invertebrates within each invertebrate group in a sample. If the number is close to one, then most invertebrate groups are similar in number, which means the total number of invertebrates is evenly distributed among all of the different invertebrates groups.

The family biotic index (based on the modified Hilsenhoff's FBI) is based on the proportion of individual family tolerance values and the individual abundance of each family in a sample.

Family tolerance values range from 0 (very intolerant) to 10 (highly tolerant) and are based on the expected response of individuals to organic pollution (Mandeville 2002). A water quality rating derived from Hilsenhoff's 1988 FBI table is based on the mean FBI value for each stream.

From the 2006 data, Willow Creek, Icelandic River reaches 1 and 3, and Washow Bay Creek reach 1 were removed from the five-year summary analysis (2006 to 2010). Rationale is as follows: Willow Creek was not re-sampled/re-visited; a different sampling device and habitat was sampled in the reach 1 of both Icelandic River and Washow Bay Creek; and results from invertebrate samples collected in the reach 3 of Icelandic River were inconsistent with respect to overall abundance and taxonomic composition are therefore considered an outlier.

3.0 RESULTS

3.1 SUPPORTING HABITAT VARIABLES

Twelve habitat variables were measured in the field for each of the stream sites (Table 1). These included type of hydraulic habitat sampled, channel morphology, percent canopy cover, dominant riparian vegetation, dominant aquatic macrophyte or percent coverage, dominant algal type or coverage, dominant and subdominant substrate type, substrate embeddedness, bankfull width (m), wetted width (m), channel ratio (wetted:bankfull), maximum water depth, and surface water velocity (m/s) (Table 1).

The land use type for the majority of the stream sites was agricultural, and included farmsteads, livestock pasture/grazing land, crop land, and hayland (Table 1). In some cases cattle had direct access to the stream (e.g., Fisher River FR KN-2 and Icelandic River IR KN-2) where impacts included heavy grazing, trampling of bank and riparian vegetation, and disturbance of channel substrate with concurrent suspension of sediments into the watercourse. A few sites were located in mixed forest (e.g., Wavey Creek) or residential/commercial areas (e.g., Grassmere Creek and Fish Lake Drain) (Table 1).

Aquatic habitat diversity was relatively low at most sites; the majority was channelized and had few meanders (Table 1). Canopy cover was also minimal, as most sites were denuded of woody vegetation. The banks and riparian areas of majority of the sites were inundated with reed canary grass (*Phalaris arundinacea*). Aquatic macrophytes were present at some sites, with *Potamogeton* sp. being the most common type. Algae were also present at many sites, with some sites having abundant amounts of attached and filamentous.

Substrate type varied among sites, with clay as the dominant substrate component (Table 1). Some sites were described as having an unconsolidated flocculent layer on top of a more consolidated clay substrate. Some sites had hard substrates such as sand, gravel, and some boulder; and Wavey Creek (near sites KN-2 and KN-3) had artificial riffle sections (Table 1).

Bankfull and wetted widths were measured in 2009 and 2010 in order to compare the flow conditions during time of sampling to high flow conditions (Table 1). Channel ratio values varied between sites and years. The mean wetted width was 43% of bankfull channel in 2009, with values ranging between 18% (Parks Creek) and 71% (Wavey Creek). In 2010 the mean wetted channel was 63%, with values ranging from 29% (Parks Creek) to 81% (Washow Bay Creek). Maximum water depths and velocities also varied between sites and years. The overall mean water depth was 0.7m and mean water velocity was 0.24 m/s. (Table 1).

Appendix 3 presents 1-page summary sheets for each of the stream locations as a quick reference for basic site information and photographs.

3.2 WATER QUALITY

The *in situ* water quality measures: water temperature (ºC), dissolved oxygen (DO mg/L), pH, turbidity (NTU), and specific conductance (µS/cm) are presented in Table 2. Since instantaneous measurements of water quality variables are likely to change due to short term, localized influences, these data were used as general habitat information and for possible use to relate to biological condition.

In general, most sites were relatively well-oxygenated and above the most stringent water quality objectives for the protection of cool-water aquatic life during all sampling events (Williamson 2002). DO was lower in the Fisher River and to a lesser extent in Washow Bay Creek in October 2009 than in other streams (Table 2).

The pH of the streams was somewhat alkaline and was consistently within the Manitoba water quality guideline for the protection of aquatic life (6.5-9.0) (Table 2). As observed for DO, pH was relatively similar across sites within each of the streams, although there was some indication of spatial variability for the Fisher River in October 2009. A fairly wide range of turbidity conditions (5 – 106 NTU) were observed over the course of the field program (Table 2).

As is typical for lotic environments, turbidity varied between 2009 and 2010 in the streams and some exhibited spatial differences across sites during the same sampling event. Overall, specific conductance was similar across sites within each of the streams during the same sampling period (Table 2).

Specific conductance was notably higher in the Icelandic and Fisher rivers and in Washow Bay Creek in 2010 compared to the other streams, whereas the reverse was observed in 2009 (Table 2).

3.3 BENTHIC MACROINVERTEBRATES

The overall mean abundance for invertebrates collected in kicknet samples from 2006 to 2010 was 4,569 individuals (±1,301SE) with mean numbers ranging between 659 (Grassmere Creek) and 8,205 (Wavey Creek) (Table 3). Overall, insects dominated the invertebrate community in abundance (61%), with non-insect taxa comprising 39% of the overall total (Table 3). The opposite trend was observed at Grassmere, Parks and Wavy creeks where the non-insect taxa dominated the community (Figure 2; Table 3). Of the non-insects, the main group was Crustacea (mainly amphipods), though Annelida (aquatic worms), Bivalvia (clams) and Gastropoda (snails) were also present (Figure 3; Table 3). Insecta mainly consisted of Ephemeroptera (mayflies 22%) and Chironomidae (midges 21%) (Figure 3; Table 3).

Mean number of invertebrate taxa (total richness) was 22 families (±2SE), with richness values ranging between 17 (Grassmere Creek) and 28 (Icelandic River) (Figure 4; Table 3). Despite the range in total richness values, Hill's effective richness showed that only 5 out of the 22 families dominated the invertebrate community. However, only three families are notably more abundant; where Hyalellidae (amphipod), Baetidae (small minnow mayfly), and Chironomidae were the most dominant families collected in the streams (Appendix 4).

The mean EPT richness was 6 families (±1SE), with richness values ranging between 3 (Parks Creek) and 9 (Wavey Creek and Icelandic River) (Figure 4). Total EPT comprised 25% of the total invertebrate community; although the prevalence of all three orders was dominated by Ephemeroptera (Table 3). Within Ephemeroptera, Baetidae was the most common mayfly, though Caenidae, Ephemeridae, Heptageniidae, Isonychiidae, Leptophlebiidae, and Tricorythidae were also collected in small numbers at some sites (Appendix 4). Very few Plecoptera (stoneflies) were recorded; only a small number of Chloroperlidae was collected from one site in the Icelandic River in 2010. Similarly of the Trichoptera (caddisflies), very few Hydropsychidae, Heliopsychidae, Hydroptilidae, Leptoceridae, Limnephilidae, and Phryganeidae were collected (Appendix 4).

Mean ratio of EPT to Chironomidae was 3.12 (±1.19SE), with ratio values ranging from 0.20 (Fisher River) to 7.84 (Washow Bay Creek) (Figure 5; Table 3). EPT: C ratio values varied considerably between years and sites. Large numbers of Ephemeroptera were recorded from Washow Bay Creek (2006) and Grassmere Creek (2007); which exaggerated the overall EPT: C ratio for these stream sites (Figure 5). These high numbers of Ephemeroptera are inconsistent with expected results and the otherwise lower values in all other years and sites. Care should be used when using these values for rating water quality assessment for those sites in particular. With the exception of Fisher River, the overall trend indicated a fairly balanced community with respect to EPT: C. However, the overall diversity of Ephemeroptera is low and dominated by Baetidae; a ubiquitous group with general habitat requirements and in the mid-range of tolerance values derived for organic pollution.

Diversity values (Gini-Simpson's Diversity Index) ranged from 0.25 (Icelandic River) to 0.42 (Grassmere Creek) (Table 3). Mean diversity (0.33 ±0.02SE) and evenness (0.52 ±0.02SE) values indicated that streams had a low diversity; and the taxa were only intermediately distributed amongst the invertebrate groups (Figure 6). Family biotic index values (modified Hilsenhoff's FBI) ranged from 5.27 (Icelandic River) to 6.78 (Parks Creek), with an overall mean index value of 6.14 (±0.23SE) (Table 3; Figure 7). Water quality ratings ranged from fair to fairly poor, with an overall rating of fairly poor, indicating that substantial organic pollution is likely (Table 4; Figure 7).

4.0 DISCUSSION

Based on the bioassessment of the benthic macroinvertebrates in conjunction with habitat variables of eight streams within the EICD, it was determined that these waterbodies are subject to negative impacts, and the impacts are likely due to anthropogenic causes (i.e., human intervention). Many of the invertebrates collected from these streams were in the mid- to highly tolerant range for organic pollution, and the community metrics indicated low diversity with the majority of organisms belonging to the same few groups.

The predominant agricultural and urban land use practices, and the watercourse manipulations that facilitate these land uses, are suspected of being the major contributor of disturbance to these streams. These manipulations are not unique to this region, and are known to negatively impact the quality of aquatic environments and associated habitats. Stresses resulting from these manipulations typically include loss of diversity in stream morphology (i.e., meanders removed by channel re-alignment and straightening), loss of diversity in stream hydraulics (i.e., pool, riffle, run sequences reduced to straight runs), loss of diversity in substrate (i.e., cobbles and gravels eliminated by the deposition of fine sediments), and degradation of riparian corridor (i.e., natural vegetation removed, replaced, mowed, trampled, and/or grazed). These factors, and their resultant consequences on the aquatic environment, can affect the numbers and diversity of macroinvertebrates, which in turn affects higher trophic level organisms in the watercourse (e.g., fish).

Agricultural land use practices in the East Interlake Conservation District are relatively diverse (e.g., compared to the Red River Valley). Nonetheless, fertilizer, insecticide, herbicide, and fungicide use, particularly in the R.M.s of Fisher, Bifrost, St. Andrews, and Springfield, have been reported as relatively high compared to other (western) portions of the Interlake (Manitoba Agriculture 2003). Additionally, since the fall of 2004, the Interlake region has experienced several, successive years of normal to above-normal precipitation, primarily as rainfall during the growing season. It is possible that the consequential soil saturation, surface pooling, and eventual overland run-off have mobilized some of the applied and natural nutrients, and pesticides from the land into the water courses. This may have resulted in exacerbating water quality problems by the introduction of these substances that are harmful to the health of aquatic organisms.

Water quality within stream courses could likely see improvement through the combined implementation of sustainable land and water management. From the perspective of water management, this would require the retention of the region’s remaining wetlands and small permanent lakes to function as natural water storage basins. This water management practice would slow and likely reduce accumulations of dissolved nutrients and pesticides into the region’s major watercourses. Restricting livestock access to the riparian corridor of any water course (i.e., via controlled grazing and off-channel watering) could reduce the degradation of the vegetation that provides a physical filter to the sediment-borne nutrients and pesticides resulting from overland runoff. Riparian vegetation also functions as a binding medium (i.e., roots) for bank stabilization to control bank erosion. In-stream water management, such as construction of riffles in the long, straight hydraulic ‘runs’ that are known or suspected to be fish-bearing, would increase hydraulic diversity, and could improve the aquatic habitat for resident species. Caution must be exercised in the design of such structures to ensure that fish stranding does not occur under low- flow conditions.

Furthermore, land use that supports the persistence of perennial vegetation on the landscape (e.g., forage and forage seed production; managed grazing) is likely to positively affect the aquatic environment. Perennial vegetation can function to reduce artificial nutrient and pesticide application and their potential introduction to stream courses (as compared to the greater levels of application necessary for crop production), improve soil pore structure by reducing overland runoff through improved water infiltration and plant utilization, and reduce soil erosion resulting from droplet and/or horizontal flow forces.

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