Lake Manitoba and Lake St. Martin Outlet Channel Project

Benthic Invertebrate Investigations

REPORT

Prepared for Manitoba Infrastructure · March 2019
By North/South Consultants Inc. · 83 Scurfield Blvd. · Winnipeg, MB · R3Y 1G4

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2018

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A Draft Report Prepared for

Manitoba Infrastructure and Transportation

By:

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EXECUTIVE SUMMARY

Flood events in 2011 and 2014 emphasized the need for better water level regulation on Lake Manitoba and Lake St. Martin. Consequently, the Province of Manitoba has committed to enhancing the outlet capacities to better regulate water levels on both lakes and improve flood protection for the people of Manitoba. The Lake Manitoba and Lake St. Martin Outlet Channel Project (the Project) was initiated subsequent to the 2011 flood event and, to date, has included a feasibility assessment, analysis of alternate routes, and the preliminary engineering to construct a diversion channel between Lake Manitoba and Lake St. Martin and a second channel from Lake St. Martin to Lake Winnipeg.

The Project will require an environmental assessment (EIS) pursuant to *The Environment Act* and *CEAA 2012*, and will also need regulatory approvals pursuant to the *Fisheries Act* and the *Navigation Protection Act*. The environmental assessment process is underway for the Project, and includes the collection of baseline data to describe the existing environment, assess impacts, and provide the basis for future monitoring programs. The EIS and the application for approval under the *Fisheries Act* will require a thorough description of existing aquatic habitat and biota in the vicinity of the channels. Although benthic invertebrate data has been collected near the inlet and outlet of the Lake Manitoba Outlet Channel (LMOC; AEE Technical services 2016), no benthic invertebrate data has been collected in the immediate vicinity of the Lake St. Martin Outlet Channel (LSMOC) inlet in Lake St. Martin or its outlet in Sturgeon Bay. This report provides a summary of methods and results of a benthic invertebrate sampling program conducted near the LSMOC inlet and outlet during fall 2018.

Benthic invertebrate sampling occurred on October 26 at Lake St. Martin and on October 7 and 12 in Sturgeon Bay. Invertebrate and substrate samples were collected from one site in Lake St. Martin and from two sites in Sturgeon Bay. Substrates were similar between the two water bodies, and were comprised largely of clays and silts. Invertebrate densities were much greater in Sturgeon Bay than Lake St. Martin, and community composition differed between the two waterbodies. Insects, primarily chironomids and ephemeropterans, comprised the majority (92%) of the invertebrate community in Lake St. Martin. In contrast, non-insect groups including annelids and bivalves comprised the majority (95%) of the invertebrate community in Sturgeon Bay. The invasive Zebra Mussel (*Dreissena polymorpha*) and Spiny Water Flea (*Bythotrephes longimanus*) were captured in Sturgeon Bay during this study. This is believed to be the first documented occurrence of either species in southern Sturgeon Bay.

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1.0 INTRODUCTION

Widespread record flooding throughout southern Manitoba during 2011 led to water levels in Lake Manitoba and Lake St. Martin that were several feet higher than desirable, resulting in significant damage to hundreds of properties, restricted road access to several communities, and long-term evacuation of four First Nations communities in the vicinity of Lake St. Martin. Heavy precipitation during winter 2013/2014 and spring 2014 again elevated water levels in Lake Manitoba and Lake St. Martin, resulting in a second flood event in areas around Lake Manitoba and Lake St. Martin.

The 2011 and 2014 flood events emphasized the need for better water level regulation on Lake Manitoba and Lake St. Martin. Consequently, the Province of Manitoba has committed to enhancing the outlet capacities to better regulate water levels on both lakes and improve flood protection for the people of Manitoba. The Lake Manitoba and Lake St. Martin Outlet Channel Project (the Project) was initiated subsequent to the 2011 flood event and, to date, has included a feasibility assessment, analysis of alternate routes, and the preliminary engineering to construct a diversion channel between Lake Manitoba and Lake St. Martin and a second channel from Lake St. Martin to Lake Winnipeg (Figure 1).

The Lake Manitoba Outlet Channel (LMBOC) will work with the existing Fairford River Water Control Structure to help regulate water levels and mitigate flooding on Lake Manitoba. The Lake St. Martin Outlet Channel (LSMOC) will also provide flood protection by mitigating increased inflows from operation of the Fairford River Water Control Structure, as well as additional inflows from the planned outlet from Lake Manitoba. Together, the two proposed channels will also assist in mitigating the adverse effects related to operation of the existing flood protection structure in Manitoba (Figure 2).

The Project will require an environmental assessment pursuant to *The Environment Act* and *CEAA 2012*, and will also need regulatory approvals pursuant to the *Fisheries Act* and the *Navigation Protection Act*. The environmental assessment process is underway for the Project, and is being led by Manitoba Infrastructure (MI). North/South Consultants Inc. (NSC) has been contracted by MI to provide technical expertise and collect baseline data to describe the existing environment, assess impacts, and provide the basis for future monitoring programs.

Although the benthic invertebrate communities occurring in southern Sturgeon Bay were characterized during environmental monitoring conducted to assessment of the 2011 and 2014 flood events (NSC 2016) and some information has been collected near the LMOC inlet to Lake St. Martin (AAE Tech Services 2016), no information is available to describe benthic communities in Lake St. Martin in the area near the LSMOC outlet. This report provides a summary of methods and results for benthic invertebrate sampling conducted in Sturgeon Bay and Lake St. Martin during fall 2018. The objective of the program was to provide contemporary data to describe benthic invertebrate communities near the LSMOC inlet and outlet.

2.0 METHODS

2.1 FIELD METHODS

The lone benthic site sampled in Lake St. Martin was selected based on proximity to the LSMOC outlet and included three replicate stations. Benthic sites in Sturgeon Bay were selected based on proximity to the LSMOC inlet (SB-01) and on proximity to sites sampled during 2011 and 2013 (SB-02; NSC 2016). Five replicates were collected at Sturgeon Bay sites. In both waterbodies, each replicate station consisted of five individual grabs (subsamples) randomly collected around the boat that were combined to provide a single composite sample.

Supporting habitat variables were measured at each sampling site to link aquatic habitat characteristics with the invertebrate communities in Lake St. Martin and Sturgeon Bay. These included sampling site location (Garmin GPSMAP®78 handheld receiver); water temperature (surface; handheld alcohol thermometer ± 0.5°C; water transparency (Secchi disk) and water/sampling depth (handheld depth sounder). An additional grab sample was collected in each replicate station to characterize the sediments in terms of particle size, texture analysis, and carbon content.

Benthic invertebrates and sediment were sampled using a petite Ponar benthic grab sampler (0.023 m^2 opening). To minimize disturbance to organisms and sediment, the grab sampler was slowly lowered until it rested on the bottom, then triggered to close and raised to the surface. Each benthic grab sample was rinsed through a 500 µm mesh sieve bucket, transferred into labelled jars, and fixed in 10% formalin solution. Grab samples collected for sediment analysis were sub-sampled with a 5 cm diameter core tube (0.002 m^2 surface area) to provide at least 100 mL of sediment for analysis.

Invertebrate samples were delivered to the NSC laboratory (Winnipeg, MB) for processing (sorting and identification). Samples were processed in accordance with the laboratory protocol provided in Appendix 1. Benthic sediment samples were shipped to ALS Laboratories (Saskatoon) for particle size, texture, and carbon analyses.

2.2 LABORATORY METHODS

The benthic grab samples were rinsed with water through a 500 µm brass test sieve and sorted under a 3X magnifying lamp. Invertebrates were removed from the sample matrix and transferred to 70% ethanol for taxonomic identification. Invertebrates were identified to lowest practical level, with the exception of the following: Ephemeroptera, Plecoptera, and Trichoptera (EPT) were each identified to genus; Chironomidae (C) to family; and zooplankton to order. Invertebrate identification and enumeration was performed by an invertebrate taxonomy expert, with a 100x magnification stereomicroscope. Scientific names followed the Integrated Taxonomic Information System classification (ITIS 2017).

Benthic sediment samples were shipped to ALS (Saskatoon) for particle size, texture, and carbon analyses.

2.3 DATA ANALYSIS

Benthic grab catches were converted to invertebrate density (individuals/m^2) using the following:

$$\text{Benthic Density} = (\#) / (a_{grab} / 5_{subsamples})$$

where:

\# = number of individuals and

a_{grab} = area of grab sampler (0.023 m^2).

The following metrics were calculated for each replicate sample: total density, densities and relative proportions of major invertebrate taxa (non-Insecta, Annelida, Bivalvia, Gastropoda, zooplankton, Amphipoda; Insecta, Coleoptera, Hemiptera, Ephemeroptera, Plecoptera, Trichoptera, Chironomidae, other Diptera, EPT, and Oligochaeta + Chironomidae), EPT:C ratio, and taxonomic richness (total and EPT).

A suite of metrics were used to quantify and characterize the invertebrate communities in Sturgeon Bay and Lake St. Martin in terms of abundance, composition, and diversity. Taxonomic richness is a measure of diversity and is the total number of taxa in a habitat (or sample). Simpson's diversity index was also used to quantify diversity as it provides more information about community structure than abundance or richness alone. Simpson's diversity index is a measure of diversity which takes into account the number of species present, as well as the relative abundance of each species. Simpson's diversity index values (probabilities) range from zero (low diversity) to one (high diversity). Simpson's evenness index is calculated from the Simpson's diversity index and is a measure of the relative abundance of the different taxa making up the richness of a habitat (or sample). Evenness values range from zero (no evenness) to one (complete evenness). Simpson's Index (D) was calculated as follows:

$$D = \left(\frac{\sum n(n-1)}{N(N-1)}\right)$$

Where:

n = the total number of organisms of a particular species; and

N = the total number of organisms of all species.

From D, Simpson's Diversity Index was then calculated as 1 – D. Simpson's Equitability (ED; evenness) was calculated from D as follows:

$$ED = (1/\left(\frac{\sum n(n-1)}{N(N-1)}\right)/D)$$

Where:

n = the total number of organisms of a particular species;

N = the total number of organisms of all species; and

D = Simpson's Index.

3.0 RESULTS

3.1 FIELD PROGRAM

Field investigations during fall 2018 were hampered substantially by unseasonably cold weather and consequent ice formation on Lake St. Martin. The occurrence of thick ice (7-8 cm) along the shore of Lake St. Martin prevented access to the lake on October 18, but air temperature in subsequent days was sufficiently warm for the ice to melt, allowing for a field campaign to be conducted on October 25 and 26. Benthic sampling occurred on October 26.

Similarly, fall field investigations in Sturgeon Bay were hampered by high wind conditions. Benthic invertebrate sampling occurred on October 12 and 17, 2018.

3.2 LAKE ST. MARTIN

3.2.1 Sediments

Mean water depth for the sediment sampling site located in Lake St. Martin was 1.6 m (Table 1; Figure 3). Substrates were characterized on site as being comprised of silts and clays with an abundance of bivalve shells (Table 1). Particle size analysis indicated that, on average, the sediments at the site were comprised predominantly of clay (71%) and silt (9%), but also contained 20% sand (Table 2; Figure 5). Texture analysis characterized the sediments as silt loam (Table 2). Carbon comprised 11.8% on average of the sediment mass for samples from Lake St. Martin. Inorganic carbon and organic carbon comprised 3.72% and 7.37% of the sediment mass, respectively (Table 2; Figure 6).

3.2.2 Benthic Macroinvertebrates

The mean total density for benthic invertebrates collected at the Lake St. Martin sampling location was 897 /m^2, with replicate values ranging from 649 to 1,255 /m^2 (Table 3; Figure 7). Collected benthos were comprised primarily of insect organisms (95%); non-insects comprised only 5% of invertebrates collected (Table 4). Non-insects were comprised predominantly of amphipods (Hyalellida: scuds; Figure 8). Annelids (Oligochaeta: aquatic worms) comprised a smaller proportion of the non-insects collected (Figure 8). The insect component was comprised of chironomids (midges) and ephemeropterans (Ephemeridae: burrowing mayflies) (Figure 9). EPT density was 153 /m^2 (Table 3; Figure 10) and comprised 16.7% of the invertebrate catch (Table 4).

Taxonomic richness (Family level) was 5 (Table 5; Figure 11), and EPT richness (Family level) was 2 (Table 5). Invertebrate diversity and evenness were moderate at the Lake St Martin sampling site (Table 5; Figure 12).

3.3 STURGEON BAY

3.3.1 Sediments

Mean water depths for the two sites site located in Sturgeon Bay were 5.8 m (SB-01) and 6.8 m (SB-02; Table 1; Figure 4). Substrates at both sites were characterized as being comprised of silts and clays (Table 1). Particle size analysis indicated that, on average, the sediments at the SB-01 were comprised predominantly of silt (66.5%), but also included 19.4% clay and 14.1% sand (Table 2; Figure 5). Similarly, sediments at SB-02 were comprised predominantly of silt (57.2%), but contained very little sand (1.9%) and more clay (41.1%) than at SB-01 (Table 2; Figure 5). Texture analysis characterized the sediments at SB-01 as silt loam and silty clay loam or silty clay at SB-02 (Table 2). Carbon comprised 7.20% and 6.39% on average of the sediment mass for samples from SB-01 and SB-02, respectively (Table 2). Inorganic carbon and organic carbon comprised 1.69% and 5.52% of the sediment mass at SB-01 and 1.65% and 4.74% at SB-02, respectively (Table 2; Figure 6). Inorganic comprised approximately the same proportion of the sample at both sites (1.69% and 1.65%), but proportion of organic carbon was slightly higher at SB-01 (5.52%) than SB-02 (4.74%; Table 2; Figure 6).

3.3.2 Benthic Macroinvertebrates

Mean total density for benthic invertebrate samples collected in Sturgeon Bay was 14,411 /m^2, with mean site values ranging from 13,615 to 15,208/m^2 (Table 6; Figure 7). Collected benthos were comprised primarily of non-insect organisms (79.4%); insects comprised 20.6% of invertebrates collected (Table 7). The non-insect component was comparable at both Sturgeon Bay sites and was comprised predominantly of annelids (Oligochaeta: aquatic worms) and bivalves. Gastropods comprised the remainder of the non-insects collected (Figure 8). The bivalve catch was comprised primarily of fingernail clams (Pisidiidae; 98% of bivalves), but a small number of Zebra Mussels (*Dreissena polymorpha*) were also documented from both sites (Appendix 2). The insect component was comparable between the two sampling sites, and was comprised of chironomids (midges) and tricopterans (Leptoceridae: long horned caddisflies). Ephemeropterans comprised a small portion of the catch (Ephemeridae: burrowing mayflies (Figure 9). Mean EPT density was 338/m^2 (Table 6) but varied considerably between the two sites; Mean EPT density at SB-01 was more than double that observed at SB-02 (Figure 10). EPT invertebrates comprised 2.5% of the invertebrate catch (Table 7).

Taxonomic richness (Family level) was 8.7 (Table 8; Figure 11), and EPT richness (Family level) was 1.8 (Table 8). Invertebrate diversity and evenness were moderate at both Sturgeon Bay sites, and displayed greater diversity than that observed at Lake St Martin (Table 8; Figure 12).

3.3.3 Aquatic Invasive Species

Aquatic invasive species that recently have entered Lake Winnipeg include the Zebra Mussel and the Spiny Water Flea (*Bythotrephes longimanus*). Both are known to occur in the north basin of the lake (Invasive Species Council of Manitoba; Jansen et al. 2017) but have not been reported from Sturgeon Bay during previous biological investigations (NSC 2016). In this study, Zebra mussels were collected from one replicate at SB-01 (n = 4) and from four replicates at SB-02 (n = 98; Table 9; Figure 4).

Although not a benthic organism, 12 Spiny Water Fleas were captured with the ponar sampler at a single replicate sample grab at SB-01 (SB-01-R4; Table 6). These are the first documented occurrences of both species within southern Sturgeon Bay.

4.0 REFERENCES

AAE Tech Services Inc. 2016. Fisheries and Aquatic Habitat Baseline Assessment. Lake Manitoba Outlet Channel Route Options. A report prepared for M. Forster Enterprises for Submission to Manitoba Infrastructure. 192 p

Invasive Species Council of Manitoba. https://invasivespeciesmanitoba.com/site/index.php?page=aquatic-species. Accessed 12 March 2019.

ITIS (INTEGRATED TAXONOMIC INFORMATION SYSTEM) 2017. Available online: http://www.itis.gov/

North/South Consultants Inc. 2016. Volume 4 - Habitat. Lake St. Martin Emergency Outlet Channel Assessment of Effects and Development of Offsetting. A report prepared for Manitoba Infrastructure and Transportation by North/South Consultants Inc. August 2016. 148 pp.

North/South Consultants Inc. 2017. Bathymetric data collection at Fairford River, Pinemuta Lake, Lake St. Martin and Sturgeon Bay. Data collection of behalf of Manitoba Infrasturucture.

Jansen, W, G. Gill, and B.J. Hann. 2017. Rapid geographic expansion of spiny water flea (*Bythotrephes longimanus*) in Manitoba, Canada, 2009-2015. June 2017 Aquatic Invasions 12(3). DOI: 10.3391/ai.2017.12.3.03

TABLES

Table 1. Location and associated habitat data for sediment and benthic invertebrate samples collected from Lake St. Martin and Sturgeon Bay, fall 2018.

Waterbody	Site [1]	Location [2]		Date	Water Temperature (°C)	Water Depth [3] (m)	Secchi Depth (m)	Predominant Substrate
		Easting	Northing					
Sturgeon Bay	SB-01-R1	574903	5752166	12-Oct-18	3	5.8	-	clay/silt
	SB-01-R2	575570	5751876	12-Oct-18	3	6.0	-	clay/silt
	SB-01-R3	575479	5751857	12-Oct-18	3	5.9	-	clay/silt
	SB-01-R4	575134	5751916	12-Oct-18	3	5.8	-	clay/silt
	SB-01-R5	574935	5752008	12-Oct-18	3	5.7	-	clay/silt
Sturgeon Bay	SB-02-R1	571729	5757271	17-Oct-18	3	6.8	0.45	clay/silt
	SB-02-R2	571841	5757175	17-Oct-18	3	7.0	0.45	clay/silt
	SB-02-R3	571872	5757307	17-Oct-18	3	6.9	0.45	clay/silt
	SB-02-R4	572031	5757340	17-Oct-18	3	6.7	0.45	clay/silt
	SB-02-R5	572004	5757186	17-Oct-18	3	6.8	0.45	clay/silt
Lake St. Martin	LSM-01-R1	555656	5737316	26-Oct-18	3	1.4	0.80	silt/clay/shells
	LSM-01-R2	555532	5737291	26-Oct-18	3	1.7	0.80	silt/clay/shells
	LSM-01-R3	555581	5737124	26-Oct-18	3	1.6	0.80	silt/clay/shells

1 - site locations illustrated on Figures 3 and 4

2 - UTM coordinates; NAD83, Zone 14U

3 - water depth at Site SB-02 not measured in field; depths presented were derived from bathymetric data collected during fall 2017 (NSC 2017)

Table 2. Summary statistics for total organic and inorganic carbon, predominant texture, and sediment composition (%) for sediment samples collected at benthic sites in Sturgeon Bay and Lake St. Martin, fall 2018.

Site	Total Carbon (%)	Inorganic Carbon (%)	Total Organic Carbon (%)	Inorganic Carbon (%) [1]	Texture	Particle Size (% composition)		
						Clay (<2 μm)	Silt (2 μm – 0.05 mm)	Sand (0.05 -2.0 mm)
SB-01								
SB-01-R1	6.99	1.67	5.32	13.90	silt loam	19.2	71.6	9.2
SB-01-R2	7.31	1.67	5.64	13.90	silt loam	22.4	67.7	9.9
SB-01-R3	7.33	1.68	5.65	14.00	silt loam	13.0	63.5	23.5
SB-01-R4	7.24	1.73	5.51	14.40	silt loam	25.8	64.1	10.1
SB-01-R5	7.15	1.68	5.47	14.00	silt loam	16.7	65.6	17.7
Mean	7.20	1.69	5.52	14.04	-	19.4	66.5	14.1
SD [2]	0.14	0.03	0.14	0.21	-	5.0	3.3	6.3
Minimum	6.99	1.67	5.32	13.90	-	13.0	63.5	9.2
Maximum	7.33	1.73	5.65	14.40	-	25.8	71.6	23.5
SB-02								
SB-02-R1	6.31	1.64	4.67	13.70	silty clay loam	39.7	58.7	1.6
SB-02-R2	6.67	1.71	4.96	14.30	silty clay	50.0	48.0	2.0
SB-02-R3	6.44	1.64	4.80	13.60	silty clay loam	37.3	59.7	3.0
SB-02-R4	6.08	1.62	4.46	13.50	silty clay	42.7	56.4	<1.0
SB-02-R5	6.45	1.65	4.80	13.80	silty clay loam	35.6	63.3	1.1
Mean	6.39	1.65	4.74	13.78	-	41.1	57.2	1.9
SD	0.22	0.03	0.19	0.31	-	5.7	5.7	0.8
Minimum	6.08	1.62	4.46	13.50	-	35.6	48.0	1.1
Maximum	6.67	1.71	4.96	14.30	-	50.0	63.3	3.0
LSM-01								
LSM-01-R1	9.93	3.30	6.63	27.50	silt loam	5.3	66.2	28.5
LSM-01-R2	10.90	3.61	7.29	30.10	silt loam	8.3	71.8	19.9
LSM-01-R3	12.40	4.24	8.20	35.40	silt loam	12.0	75.6	12.4
Mean	11.08	3.72	7.37	31.00	-	8.5	71.2	20.3
SD	1.24	0.48	0.79	4.03	-	3.4	4.7	8.1
Minimum	9.93	3.30	6.63	27.50	-	5.3	66.2	12.4
Maximum	12.40	4.24	8.20	35.40	-	12.0	75.6	28.5

1 - as a $CaCO_3$ equivalent; 2 - standard deviation

Table 3. Density (#/m^2) of invertebrate groups from benthic samples collected in Lake St. Martin, fall 2018.

Sampling Site	LSM-01			Summary				
	LSM-01-R1	LSM-01-R2	LSM-01-R3	Mean	SD	SE	Min	Max
Total Invertebrates								
	788	649	1255	897	318	183	649	1255
Insecta vs Non-Insecta								
Non-Insecta	35	9	121	55	59	34	9	121
Insecta	753	641	1134	843	259	149	641	1134
Major Groups								
Oligochaeta	0	0	17	6	10	6	0	17
Amphipoda	26	0	78	35	40	23	0	78
Bivalvia	0	0	0	0	0	0	0	0
Gastropoda	0	0	0	0	0	0	0	0
Chironomidae	537	459	718	571	133	77	459	718
Ephemeroptera	69	139	251	153	92	53	69	251
Plecoptera	0	0	0	0	0	0	0	0
Trichoptera	0	0	0	0	0	0	0	0
Other Taxa	156	52	190	133	72	42	52	190
EPT	69	139	251	153	92	53	69	251

Table 4. Proportion of invertebrate groups (% of total) from benthic samples collected in Lake St. Martin, fall 2018.

Sampling Site	LSM-01			Summary				
	LSM-01-R1	LSM-01-R2	LSM-01-R3	Mean	SD	SE	Min	Max
Insecta vs Non-Insecta								
Non-Insecta	4.4	1.3	9.7	5.1	4.2	2.4	1.3	9.7
Insecta	95.6	98.7	90.3	94.9	4.2	2.4	90.3	98.7
Major Groups								
Oligochaeta	0.0	0.0	1.4	0.5	0.8	0.5	0.0	1.4
Amphipoda	3.3	0.0	6.2	3.2	3.1	1.8	0.0	6.2
Bivalvia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gastropoda	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chironomidae	68.1	70.7	57.2	65.3	7.1	4.1	57.2	70.7
Ephemeroptera	8.8	21.3	20.0	16.7	6.9	4.0	8.8	21.3
Plecoptera	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Trichoptera	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Taxa	19.8	8.0	15.2	14.3	5.9	3.4	8.0	19.8
EPT	8.8	21.3	20.0	16.7	6.9	4.0	8.8	21.3

Table 5. Community metrics for invertebrate groups from benthic samples collected in Lake St. Martin, fall 2018.

Sampling Site	LSM-01			Summary				
	LSM-01-R1	LSM-01-R2	LSM-01-R3	Mean	SD	SE	Min	Max
EPT:C Ratio	0.13	0.30	0.35	0.26	0.12	0.07	0.13	0.35
Total Richness (Family-level)	5	5	8	6.0	1.7	1.0	5.0	8.0
EPT Richness (Family-level)	1	2	2	1.7	0.6	0.3	1.0	2.0
Simpson's Diversity Index	0.49	0.46	0.63	0.53	0.09	0.05	0.46	0.63
Simpson's Evenness Index	0.39	0.37	0.34	0.37	0.03	0.02	0.34	0.39

Table 6. Density (#/m^2) of invertebrate groups from benthic samples collected in Sturgeon Bay, fall 2018.

Sampling Site	SB-01					SB-02					Summary				
	SB-01-R1	SB-01-R2	SB-01-R3	SB-01-R4	SB-01-R5	SB-02-R1	SB-02-R2	SB-02-R3	SB-02-R4	SB-02-R5	Mean	SD	SE	Min	Max
Total Invertebrates															
	18629	20637	9868	14751	12154	11357	10163	12933	6821	26801	14411	5991	1895	6821	26801
Insecta vs Non-Insecta															
Non-Insecta	15582	16421	6380	11253	8033	9765	8553	11253	5003	24931	11717	5898	1865	5003	24931
Insecta	3047	4216	3489	3497	4120	1593	1610	1679	1818	1870	2694	1086	343	1593	4216
Major Groups															
Oligochaeta	11807	10258	3636	7341	5194	5938	5263	4969	1645	15166	7122	4108	1299	1645	15166
Amphipoda	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bivalvia	2458	4986	2121	2597	1870	3082	3082	5436	3082	8241	3695	1973	624	1870	8241
Gastropoda	1073	1177	623	1212	935	606	208	658	190	1385	807	416	132	190	1385
Chironomidae	2666	3601	3194	2943	3532	1437	1385	1368	1697	1731	2355	923	292	1368	3601
Ephemeroptera	69	130	156	173	346	0	17	52	17	0	96	109	34	0	346
Plecoptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	312	485	139	381	242	156	208	260	104	139	242	121	38	104	485
Other Taxa	242	0	0	104	35	139	0	190	87	139	93	85	27	0	242
EPT	381	615	294	554	589	156	225	312	121	139	338	189	60	121	615

Table 7. Proportion of invertebrate groups (% of total) from benthic samples collected in Sturgeon Bay, fall 2018.

Sampling Site	SB-01					SB-02					Summary				
	SB-01-R1	SB-01-R2	SB-01-R3	SB-01-R4	SB-01-R5	SB-02-R1	SB-02-R2	SB-02-R3	SB-02-R4	SB-02-R5	Mean	SD	SE	Min	Max
Insecta vs Non-Insecta															
Non-Insecta	83.6	79.6	64.6	76.3	66.1	86.0	84.2	87.0	73.4	93.0	79.4	9.2	2.9	64.6	93.0
Insecta	16.4	20.4	35.4	23.7	33.9	14.0	15.8	13.0	26.6	7.0	20.6	9.2	2.9	7.0	35.4
Major Groups															
Oligochaeta	63.4	49.7	36.8	49.8	42.7	52.3	51.8	38.4	24.1	56.6	46.6	11.3	3.6	24.1	63.4
Amphipoda	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bivalvia	13.2	24.2	21.5	17.6	15.4	27.1	30.3	42.0	45.2	30.7	26.7	10.7	3.4	13.2	45.2
Gastropoda	5.8	5.7	6.3	8.2	7.7	5.3	2.0	5.1	2.8	5.2	5.4	1.9	0.6	2.0	8.2
Chironomidae	14.3	17.4	32.4	20.0	29.1	12.7	13.6	10.6	24.9	6.5	18.1	8.4	2.6	6.5	32.4
Ephemeroptera	0.4	0.6	1.6	1.2	2.8	0.0	0.2	0.4	0.3	0.0	0.7	0.9	0.3	0.0	2.8
Plecoptera	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Trichoptera	1.7	2.3	1.4	2.6	2.0	1.4	2.0	2.0	1.5	0.5	1.7	0.6	0.2	0.5	2.6
Other Taxa	1.3	0.0	0.0	0.7	0.3	1.2	0.0	1.5	1.3	0.5	0.7	0.6	0.2	0.0	1.5
EPT	2.0	3.0	3.0	3.8	4.8	1.4	2.2	2.4	1.8	0.5	2.5	1.2	0.4	0.5	4.8

Table 8. Community metrics for invertebrate groups from benthic samples collected in Sturgeon Bay, fall 2018.

Sampling Site	SB-01					SB-02					Summary				
	SB-01-R1	SB-01-R2	SB-01-R3	SB-01-R4	SB-01-R5	SB-02-R1	SB-02-R2	SB-02-R3	SB-02-R4	SB-02-R5	Mean	SD	SE	Min	Max
EPT:C Ratio	0.14	0.17	0.09	0.19	0.17	0.11	0.16	0.23	0.07	0.08	0.14	0.05	0.02	0.07	0.23
Total Richness (Family-level)	10	7	7	8	8	9	8	11	9	10	8.7	1.3	0.4	7.0	11.0
EPT Richness (Family-level)	2	2	2	2	2	1	2	2	2	1	1.8	0.4	0.1	1.0	2.0
Simpson's Diversity Index	0.56	0.66	0.71	0.68	0.70	0.64	0.63	0.68	0.68	0.59	0.65	0.05	0.02	0.56	0.71
Simpson's Evenness Index	0.23	0.42	0.49	0.39	0.42	0.30	0.34	0.29	0.35	0.24	0.35	0.09	0.03	0.23	0.49

Table 9. Summary of aquatic invasive species captured in Sturgeon Bay during fall, 2018.

Site	Zebra Mussel	Spiny Water Flea
SB-01		
SB-01-R1	4	-
SB-01-R4	-	12
SB-02		
SB-02-R2	16	-
SB-02-R3	38	-
SB-02-R4	4	-
SB-02-R5	40	-
Total	102	12

FIGURES

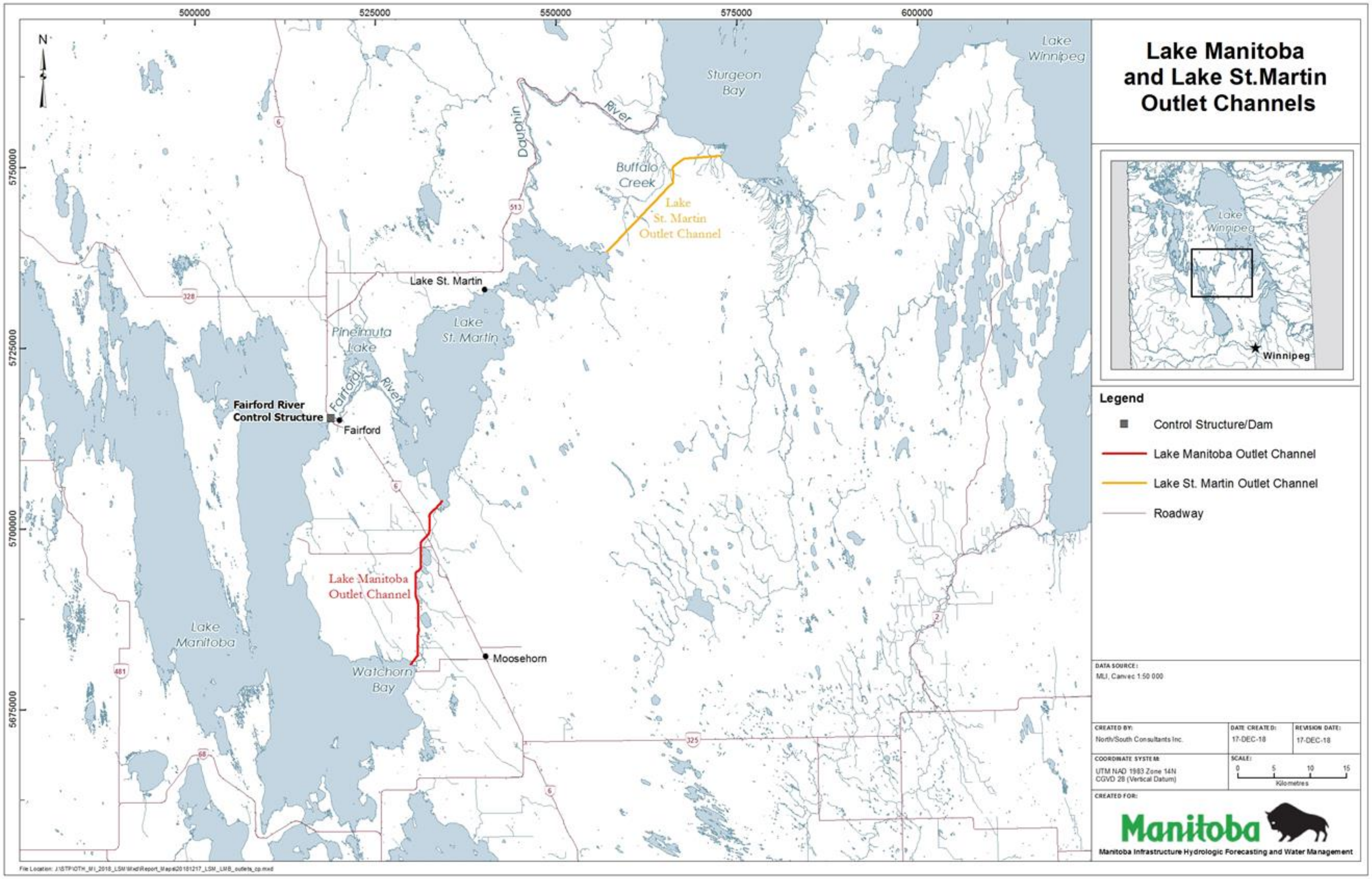

Figure 1. Location of the proposed Lake Manitoba and Lake St. Martin Outlet Channels in central Manitoba.

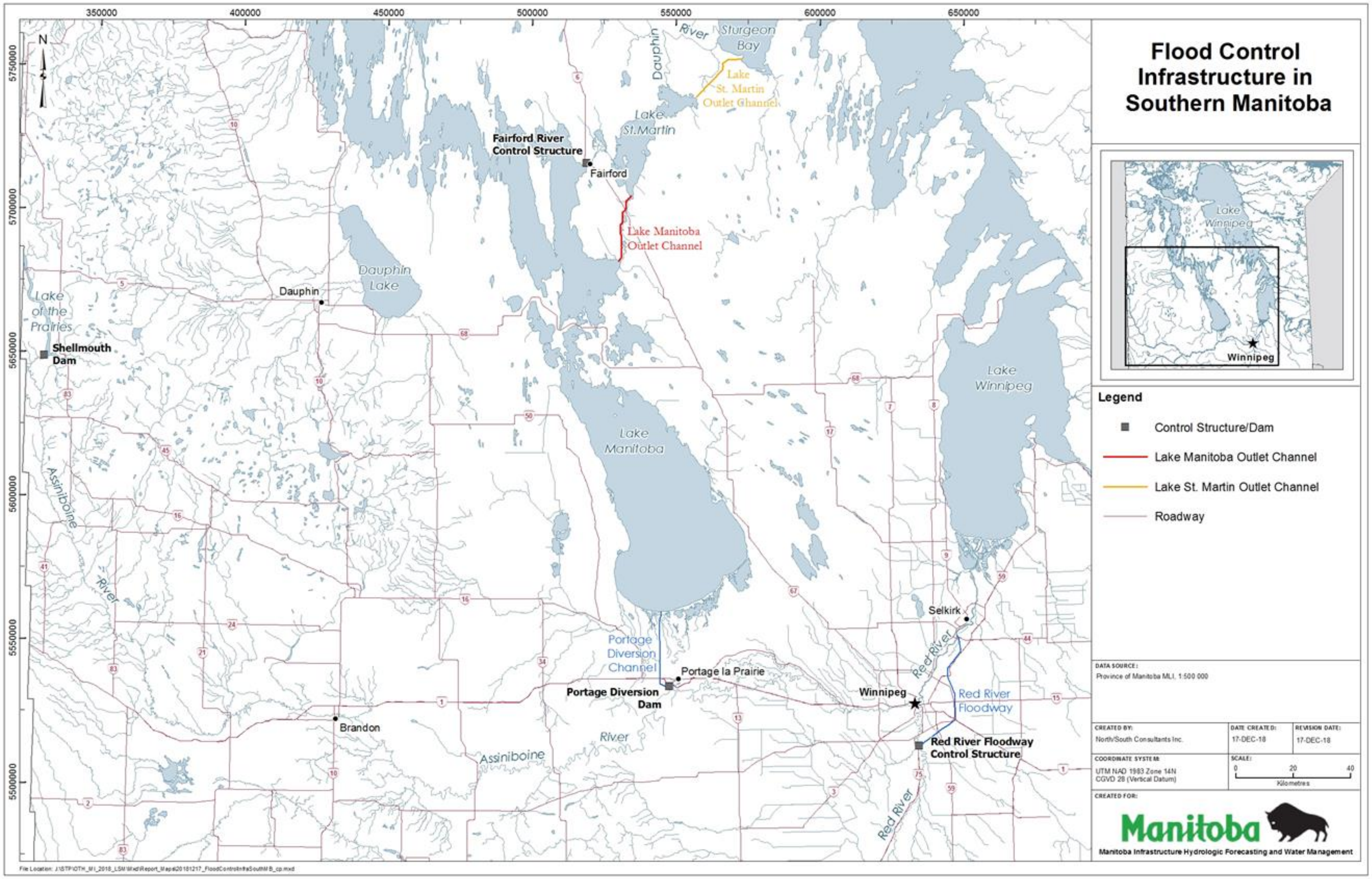

Figure 2. Location of key components of the provincial flood control system in southern Manitoba.

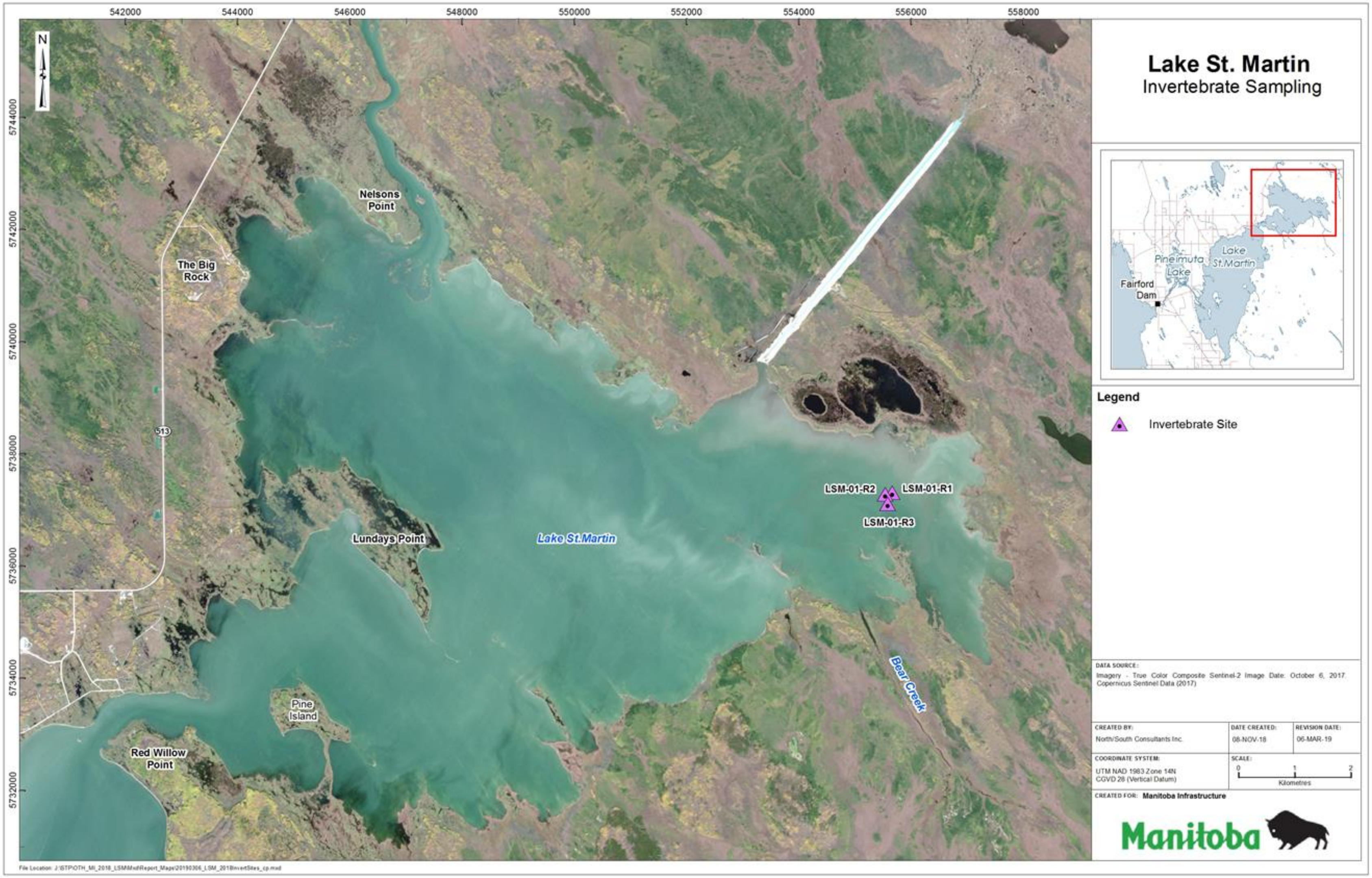

Figure 3. The location of benthic macroinvertebrate sampling sites in Lake St. Martin, fall 2018.

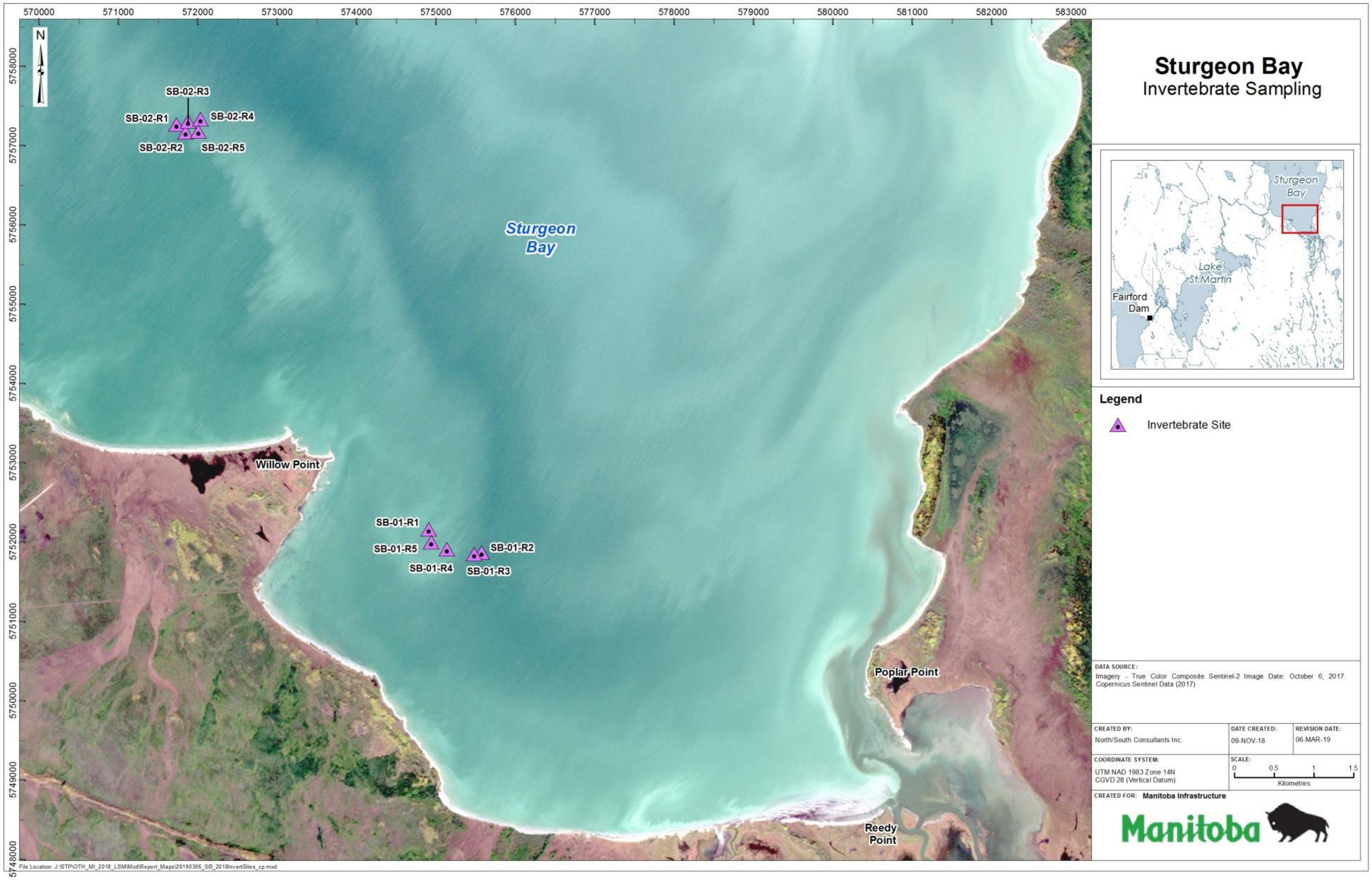

Figure 4. The location of benthic macroinvertebrate sampling sites in Sturgeon Bay, fall 2018.

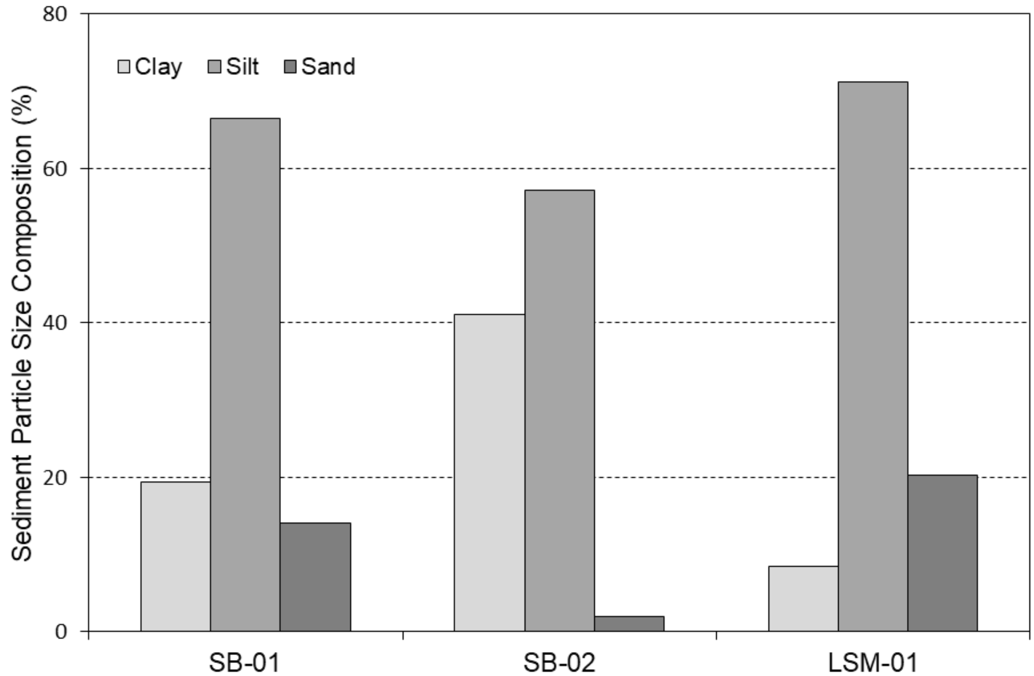

Figure 5. Sediment particle size composition of the substrate collected in Sturgeon Bay and Lake St. Martin, fall 2018.

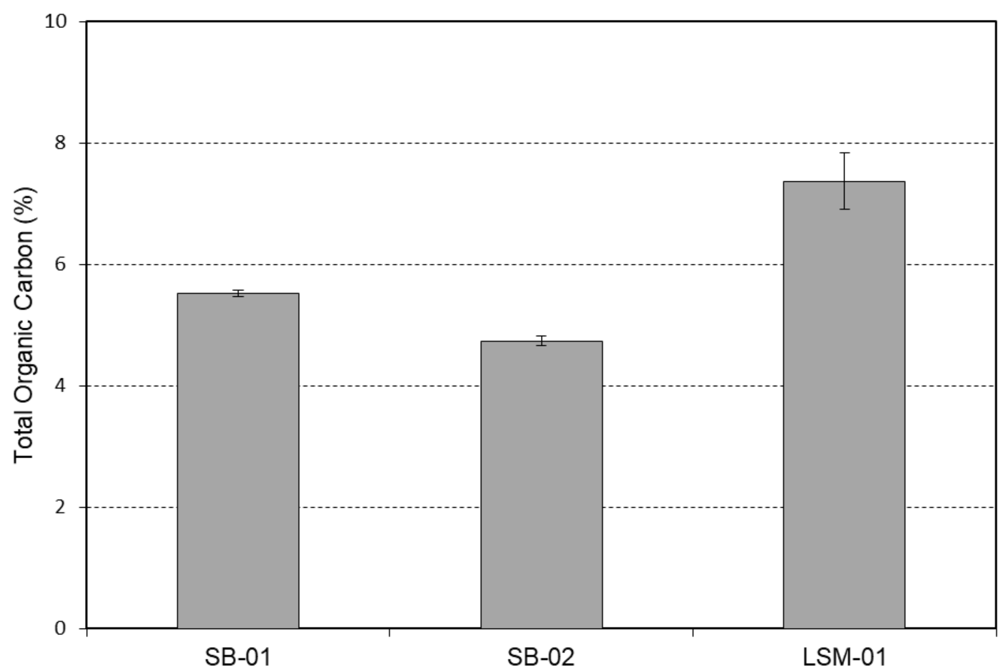

Figure 6. Organic carbon content (mean % ± SE) of substrate in Sturgeon Bay and Lake St. Martin, fall 2018.

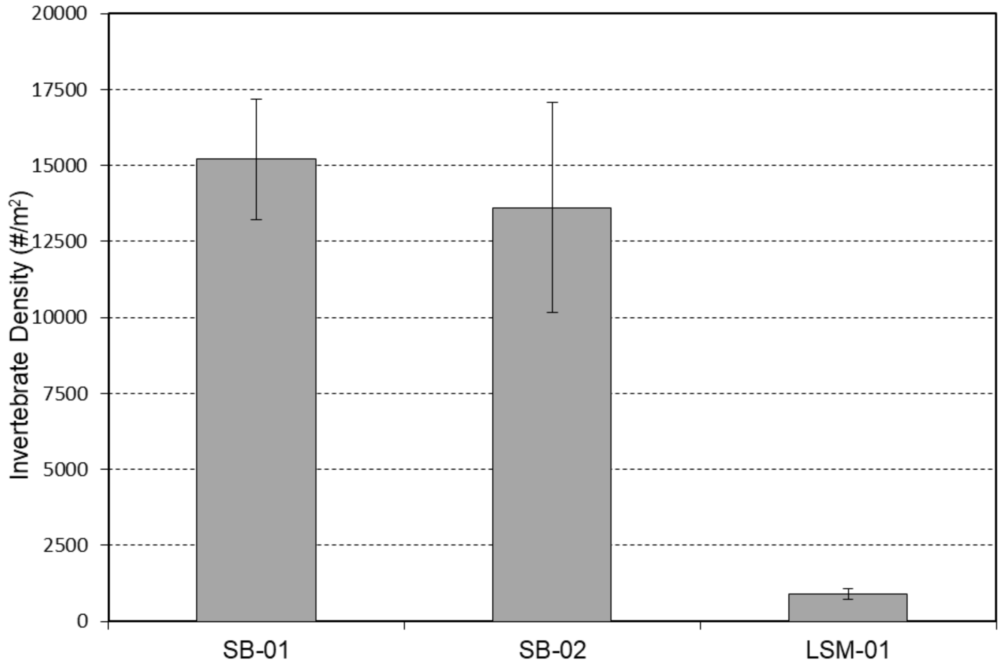

Figure 7. Density of invertebrates (total; mean ± SE) in benthic samples collected in Sturgeon Bay and Lake St. Martin, fall 2018.

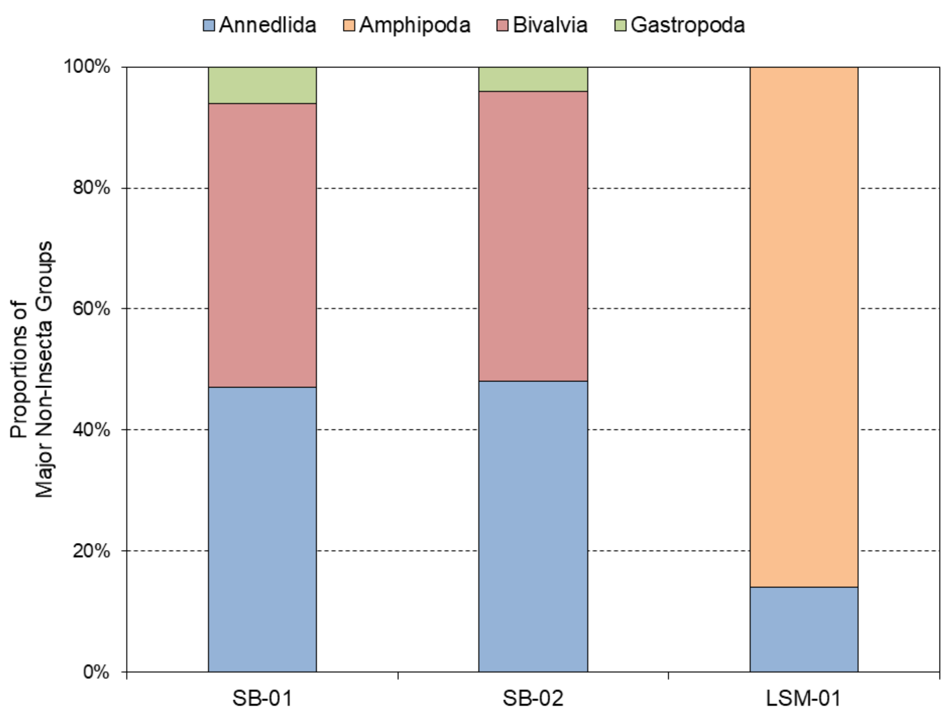

Figure 8. Proportions of the major non-Insecta groups in benthic samples collected in Sturgeon Bay and Lake St. Martin, fall 2018.

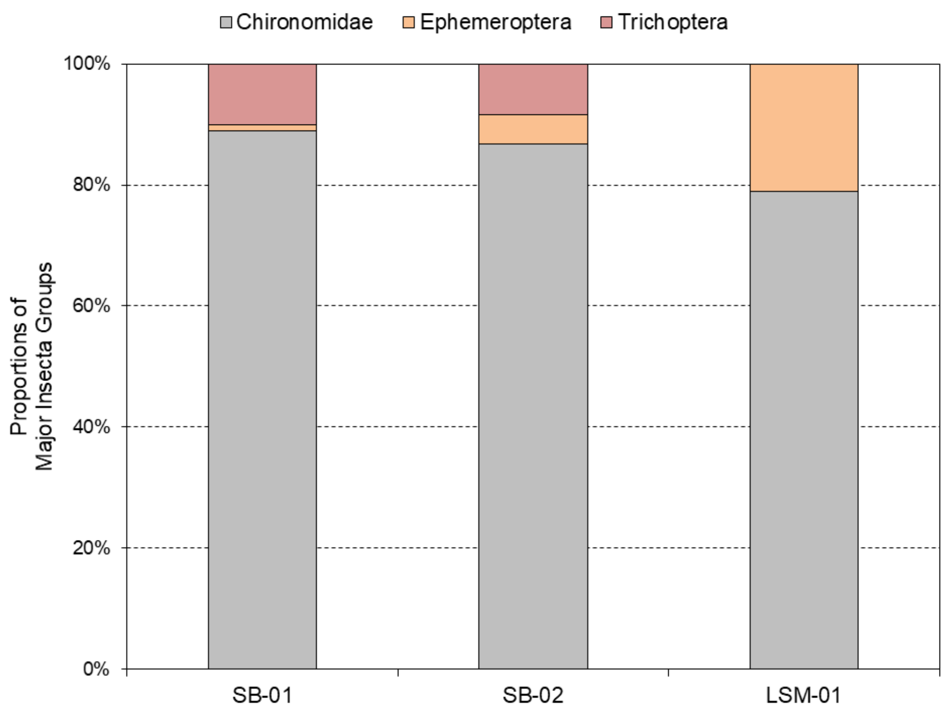

Figure 9. Proportions of the major Insecta groups in benthic samples collected in Sturgeon Bay and Lake St. Martin, fall 2018.

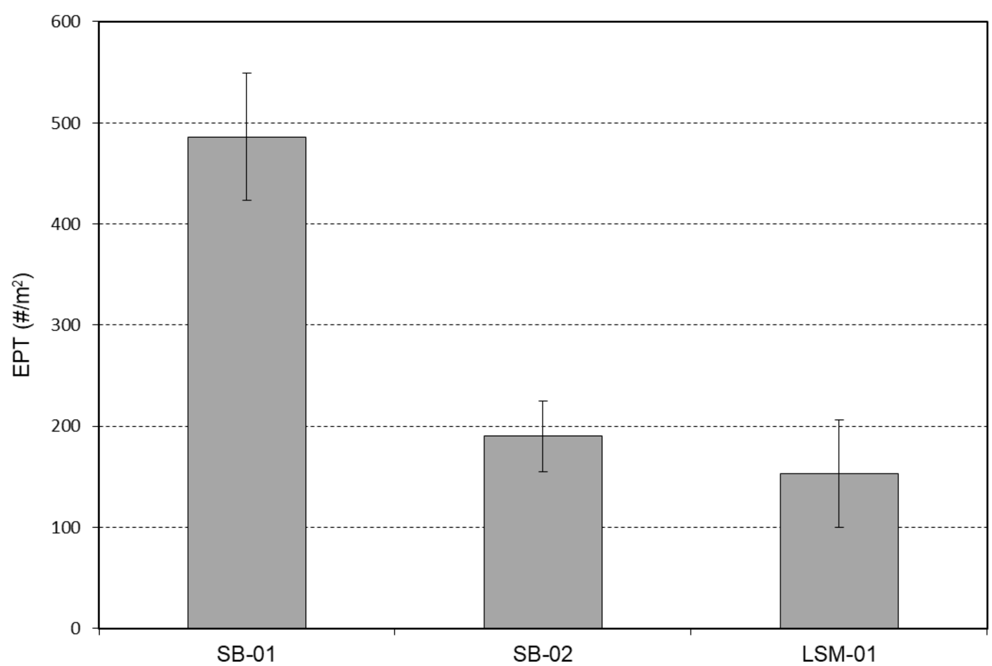

Figure 10. EPT density (combined; mean ± SE) in benthic samples collected in Sturgeon Bay and Lake St. Martin, fall 2018.

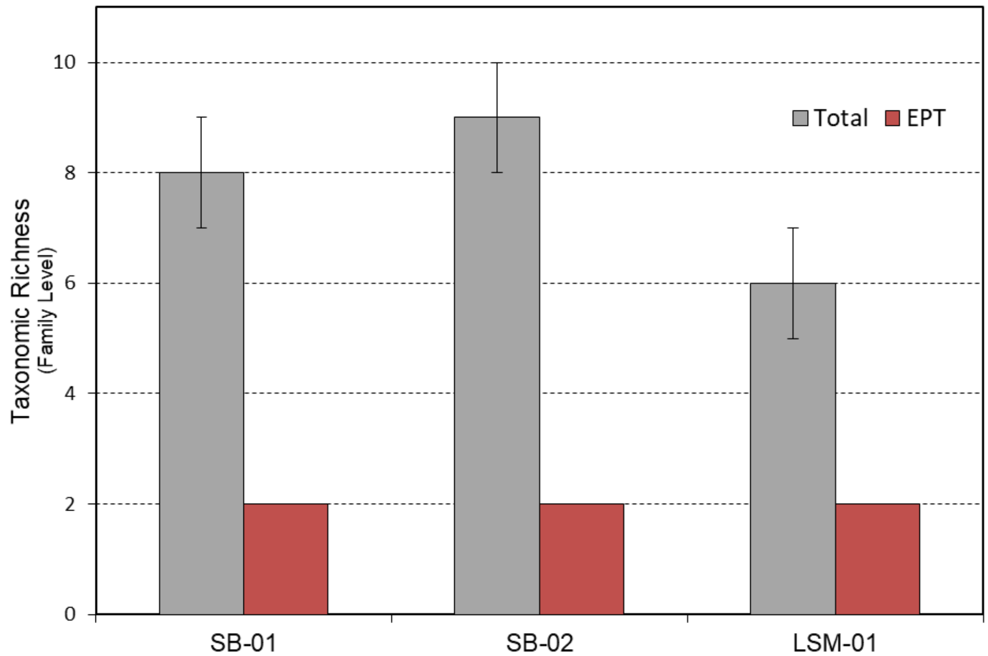

Figure 11. Taxonomic richness (family-level; mean ± SE) in benthic samples collected in Sturgeon Bay and Lake St. Martin, fall 2018.

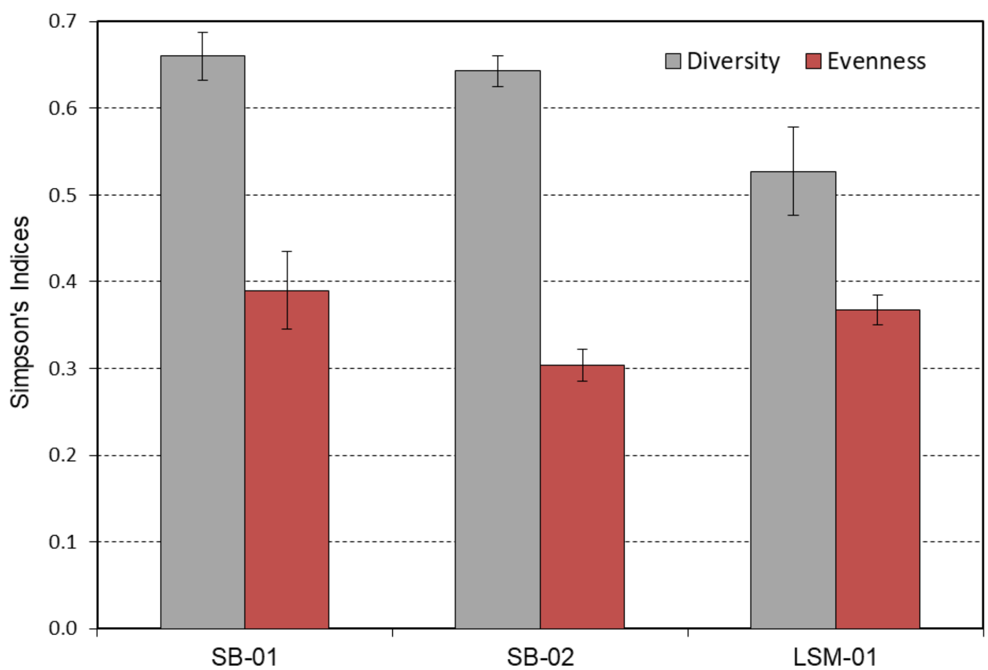

Figure 12. Simpson's Diversity and Evenness indices (mean ± SE) in benthic samples collected in Sturgeon Bay and Lake St. Martin, fall 2018.

APPENDIX 1. INVERTEBRATE LABORATORY PROTOCOL

Detailed sample processing protocols are developed on a by-project-basis depending on the specific needs of each client. The following provides an overview of standard QA/QC procedures employed for each project.

Large &/or Rare Search for Samples Requiring Sub-Sampling

- Sample is washed and sieved using appropriate sized mesh (250 µm mesh for drift and Hess; 500 µm mesh for benthic);
- Entire sample is scanned for large &/or rare invertebrates in an appropriately sized tray. This scan is conducted on a per sample basis to avoid under-representing taxa that tend to occur singly or in few numbers that may be missed as a result of sub-sampling;
- Large organisms tend to occur in small numbers (e.g., Belostomatidae, crayfish); these organisms are rare in relation to the overall number of organisms in the sample being processed. Based on the overall number of organisms in the sample, if an organism tends to occur rarely with respect to the rest of the organisms in the sample, this organism is removed (or more, if >1) and retained in a separate vial for taxonomic identification;
- Large &/or rare organisms are not included in the split correction and this is indicated clearly on the bench sheet. It is noted that there is a separate vial containing large &/or rare organisms.

Sample Processing

Sub-Sampling

- Most samples are sub-sampled (unless requested by the client) to decrease processing time. A minimum of 300 organisms processed ensures the inclusion of more rare taxa and permits comparisons of richness among sites;
- The entire sample is examined in a large tray and estimate the number of splits necessary to produce the appropriate number of aliquots needed to achieve a 300-organism target;
- If a sample contains >300 organisms, large &/or rare invertebrates and any small fish are removed from the whole sample before sub-sampling (see above);
- When >300 organisms are present, the sample is split into halves. In order to reduce any bias created by the mixing/splitting process, the well-cleaned and mixed sample is split using a 1.0 or 4.0 L [specific to sample volume] Folsom Plankton Splitter. Each sub-sample is subsequently sorted until at least 300 animals are counted. When the 300-organism count is achieved part way through a sub-sample, the remainder of this fraction is sorted so that a known fraction is sorted. All splitting information is recorded on the bench sheet;
- In sparse samples (i.e., containing ~300 animals or less), the entire sample is processed;
- To be counted, a specimen must have enough intact body parts to permit its identification to the targeted level, and it must have a head (this prevents a body and detached head from being counted as two animals);
- Larval exuviae (exoskeleton remains), and empty shells (snails and clams) and cases (caddisflies) are not counted in the 300-organism count. If there are no “live” molluscs in the

sample, a few empty shells are set aside for identification; these are placed into vial with the large &/or rare specimens; ▯ All taxa, including terrestrial invertebrates, are included in the 300-organism count for the drift net samples;

- All taxa, except for terrestrial invertebrates, are included in the 300-organism count for the Hess samples. ▯ The taxa Porifera, Nemata, Copepoda, Cladocera, Rotifera, Platyhelminthes, Ostracoda, and nonaquatic (terrestrial) taxa are not included in the 300 organism count for the benthic macroinvertebrate samples.

Sorting Samples

- Sorting aquatic samples involves removing aquatic macroinvertebrates from organic and inorganic materials within each sample;
- All sorting is conducted with a 10x stereomicroscope for drift and Hess samples; and a 3x desktop magnifier for benthic samples;
- All sorted samples are checked by a 2nd laboratory technician (QA/QC technician);
- Any additional invertebrates collected during the QA/QC process are combined with the original sample, but counted separately;
- Sorting efficiency must be ≥ 95%. The QA/QC technician checks on a tray-by-tray basis so that the sample is handled as few times as possible; the QA/QC technician will sort any remaining invertebrates from the tray and record the number of missed invertebrates per tray;
- The QA/QC technician will also check the bench sheet data to ensure it matches the sample data; and
- Sorted invertebrate samples are stored in 70% ethanol prior to delivery to the taxonomist.

Verification of Taxonomic Identification

- NSC taxonomists regularly communicate with external taxonomic specialists to ensure accuracy and consistency.

Sample Identifications

- Samples are identified to the appropriate taxonomic level by an in-house or external taxonomist with 100x stereomicroscope;
- Invertebrates are identified to lowest practical level: Ephemeroptera, Plecoptera, and Trichoptera to genus; Chironomidae to family, and zooplankton to order; Ten percent (10%) of the in-house identifications are randomly selected and sent to an external taxonomy specialist for QA/QC. The accuracy of the sample subset is assessed for identification and enumeration; all unknown invertebrates are sent to an external specialist; incorrect identifications and/or enumeration discrepancies are noted on the laboratory datasheet; and
- The target overall accuracy level for in-house invertebrate identifications and enumeration is 95% at the Family level and 90% at the Genus level. Corrected identifications and

enumeration values received from the external taxonomist are used in place of in-house data discrepancies. If the average error rate of audited samples is outside the target, the entire project must be re-identified by someone other than the original taxonomist.

Data Processing

- Data from field books and laboratory bench sheets are entered into an MS Excel® data template;
- Data templates specify the Project Name, Study Area, Site Location/Description, GPS coordinates (Global Positioning System), Site Label, Sampling Date, Time of Day, Gear Type, Sieve Mesh Size in Field/Laboratory, Presence or Absence of Vegetation/Algae, Water Temperature, Water Depth, Velocity, Substrate Type, Number of Splits, Taxonomic List, Life Stage, and Enumeration List;
- A 2nd and 3rd technician sequentially verify all entered data and formulae to original field book and laboratory bench sheets (i.e., verification is done twice) and a final verification is conducted by the project biologist and/or report author.

APPENDIX 2. INVERTEBRATE DATA

Appendix 2. Invertebrate counts for samples collected in Lake St. Martin and Sturgeon Bay, fall 2018.

Taxon	Sturgeon Bay					Sturgeon Bay					Lake St. Martin		
	SB-02-R1	SB-02-R2	SB-02-R3	SB-02-R4	SB-02-R5	SB-01-R1	SB-01-R2	SB-01-R3	SB-01-R4	SB-01-R5	LSM-01-R1	LSM-01-R2	LSM-01-R3
Annelida													
Oligochaeta	686	608	574	190	1752	1364	1185	420	848	600	-	-	2
Hirudinea	12		20	10	8	12				4	-	-	-
Crustacea													
Amphipoda													
Hyalellidae	-	-	-	-	-	-	-	-	-	-	3	-	9
Arachnida													
Acari	4	-	2	-	8	16	-	-	12	-	1	1	3
Mollusca													
Bivalvia													
Dreissena polymorpha	-	16	38	4	40	4	-	-	-	-	-	-	-
Pisidiidae	356	340	590	352	912	280	576	245	300	216	-	-	-
Gastropoda - unidentified	2	4	20		8	-	-	-	4	-	-	-	-
Hydrobiidae	16	4	30	16	56	112	104	40	100	96	-	-	-
Valvatidae	50	16	20	6	72	12	32	32	36	12	-	-	-
Viviparidae	2	-	6	-	24	-	-	-	-	-	-	-	-
Insecta - Ephemeroptera													
Caenidae													
Caenis	-	-	-	-	-	-	-	-	-	-	-	2	7
Ephemeridae													
Hexagenia	-	2	6	2	-	8	15	18	20	40	8	14	22
Insecta - Tricoptera													
Leptoceridae	18	24	30	12	16	36	56	16	44	28	-	-	-
Insecta - Diptera													
Chaoboridae	-	-	-	-	-	-	-	-	-	-	17	5	18
Chironomidae	166	160	158	196	200	308	416	369	340	408	62	53	83
Total Invertebrates	1312	1174	1494	788	3096	2152	2384	1140	1704	1404	91	75	144