ROCHE

Victory Nickel Inc.

Baseline Study – Aquatic Environment Monitoring Program

O/Ref: 51516-100

Minago Project

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August 2012

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1 Introduction

Victory Nickel Inc. in conjunction with Roche Ltd undertook the fisheries studies in the fall of 2011 as part of the Environmental Baseline Study (EBS) required under the Environment Act License (EAL) No. 2981. The EAL calls for a Comprehensive Monitoring Program consisting of fish and related assessment and water quality monitoring.

The Minago Project is located in the Thompson Nickel Belt off PTH 6, approximately 225 km south of Thompson and 100 km north of Grand Rapids, Manitoba, Canada.

The purpose of the Comprehensive Monitoring Program (CMP) is to comply with Clause 28 and Schedule B of the EAL No. 2981. Under this Clause, Victory Nickel Inc. is required to undertake an environmental monitoring program beginning the fall of 2011. The CMP which is part of the EBS is limited to water quality, sediment quality, fish survey, benthic communities, and fish tissue analysis and stream flow measurements. Where applicable, the CMP components followed the components identified in the Federal Environmental Effects Monitoring Program (EEM) with particular interest in the Oakley Creek and the Minago watersheds. In addition to the 2011 fall program, VNI will undertake additional baseline studies for 2012 and beyond in order to capture transitory fish utilization; understand early life stage use and resident populations; and to understand top trophic level fish (such as whitefish and walleye) spawning periods in the immediate watersheds.

For the 2012 campaigns, efforts will be made to meet the EEM program requirements and at the same time meeting the EAL No. 2981 conditions.

The EBS results together with operational environmental monitoring data will be used to determine effects in aquatic ecosystems caused by Metal Mine Effluent and the effectiveness of environmental mitigation measures. The overall objectives of CMP and EEM are to evaluate the effects of mine effluent on fish, fish habitat which might affect fisheries resources, water and sediment quality and benthic invertebrate communities.

Since Victory Nickel is not operational, the EEM and the CMP focused on biophysical monitoring studies limited to fish surveys for determining baseline conditions. Indicators of fish population health and fish tissue analysis; benthic invertebrate community survey; water and sediment quality assessment complemented the EBS data provided in the EIS.

The planned CMP also complies with Conditions 4 (a), 4 (b), 4 (c) and 4 (d) as stipulated in Schedule B of the Environment Act License.

2 Environmental Baseline Studies for Comprehensive Monitoring Program

The Environmental Baseline Studies that took place in the fall of 2011 were scoped out to the requirements of Clause 28 and Schedule B of the EAL to meet the following objectives:

- To establish the baseline condition for the fish community in Oakley Creek and the Minago River (Condition 4 (a));
- To ensure that the utilization of Oakley Creek and the Minago River by transitory species is understood and characterized (Condition 4 (b));
- To validate whether or not the fish community is impacted by the change in flows (Condition 4 (c)); and
- To determine the maximum in-stream flow requirements for fish habitat (Condition 4 (d)).

The EBS included a Fish Resources and Habitat Survey; a Surface Water Assessment including Quality and Flow; Sediment Sampling in surface water bodies as stipulated in Condition 5 in Schedule B; and Benthic Invertebrate and Periphyton Sampling in water bodies as per Condition 5 in Schedule B.

The stations that were targeted during the 2011 CMP are outlined below:

- Oakley Creek (2 stations, upstream and downstream of future discharge point);
- Minago River (2 stations, upstream and downstream of future discharge point);
- William River (2 stations, upstream and downstream of the future discharge point (upstream and downstream of the confluence point with Oakley Creek));
- Limestone Bay (1 station, at the mouth of William River);
- Hill Lake (1 station, where Minago River flows into the Lake);
- Drunken Lake (1 station, where Minago River flows into the Lake);
- Cross Lake (1 station, where Minago River flows into the Lake).

The Oakley Creek (upstream and downstream of future discharge point) and the Minago River (upstream and downstream of future discharge point) will serve as the EEM monitoring stations and the EAL No. 2981 monitoring stations. It is important to mention for the 2011 fall program, VNI objective is to comply with the EAL conditions and future campaigns will incorporate EEM requirements.

The locations of the ten (10) stations for the Local Study Areas (LSA) and Regional Study Areas (RSA) are shown on Map 2.1 and the sampling effort described in Table 2.1

2.1 Fish Community and Habitat Assessment

The 2011 Fish Community and Habitat Assessment Program will complement the previous Baseline Studies conducted for Environmental Impact Statement (EIS). The Local and Regional Study Areas established during the previous Baseline Studies of 2006, 2007 and 2008 have been included in the Fall Comprehensive Monitoring Program. The 2011 CMP program provides additional information on transitory species utilization of Oakley Creek and the Minago River systems.

The main aquatic habitats observed within the study areas were characterized in order to establish functions such as spawning, migration, feeding, etc. and to evaluate how those habitats are used by the various fish species occurring in the areas.

One of the approaches was to determine (as part of the 2011 fall EBS program) whether field sampling will be occurring within the whitefish spawning period. To ascertain this, gill nets were set up at Hill Lake - near where the Minago enters the Lake; and Limestone Bay - near the William River outlet. Best efforts were made to set up the gill nets over areas that whitefish might have been honing in. The objective is to strengthen the EIS fish data collected in the William and Oakley River and to verify whether top trophic level fish (including whitefish and walleye) are currently accessing these systems – particularly William River.

2.1.1 Objectives of the Fish Resource and Habitat Survey

The objectives of the Fish Resource and Habitat Survey were to:

- Provide a general description of aquatic habitats;
- Determine the composition of the fish communities in the freshwater system by documenting the presence/absence of fish species in water bodies that will likely be affected by the project;
- Determine the basic biological characteristics of major fish populations including abundance, and condition coefficient (mass/length ratio, etc.), and
- Determine the metal concentrations in muscle tissues of specimens of the major fish populations.

2.1.2 Approach / Method

Scientific fishing and fish habitat characterization was undertaken in the targeted water bodies and streams that could potentially be affected by the mining discharges activities. For this reason, ten (10) fishing stations were strategically selected within the Local Study Area (LSA) and the Regional Study Area (RSA) to assess potential future impacts downstream and upstream of future discharges. The selected watersheds and related monitoring and sampling stations are given on Map 2.1 with detailed descriptions of the various activities as given in Table 2.1. These stations and activities were selected to best monitor and sample for fish surveys, benthic invertebrates' enumeration, water quality, sediments assessment, fish tissue assessment and hydrological investigations.

In addition, according to information provided by Victory Nickel Inc., water temperature monitoring instrumentation together with data loggers will be installed in 2012 to give early warning with respect to potential spawning in the Oakley Creek and Minago River.

Small hoop nets, bait traps or bow nets were used in small streams while in larger water bodies, experimental nets and bait traps will be used instead. For the 2012 campaigns, VNI will determine if electro-fish and/or seine techniques can be applied particularly for the Minago River and Oakley Creek watersheds. Fish specimens captured were counted and individual species were identified.

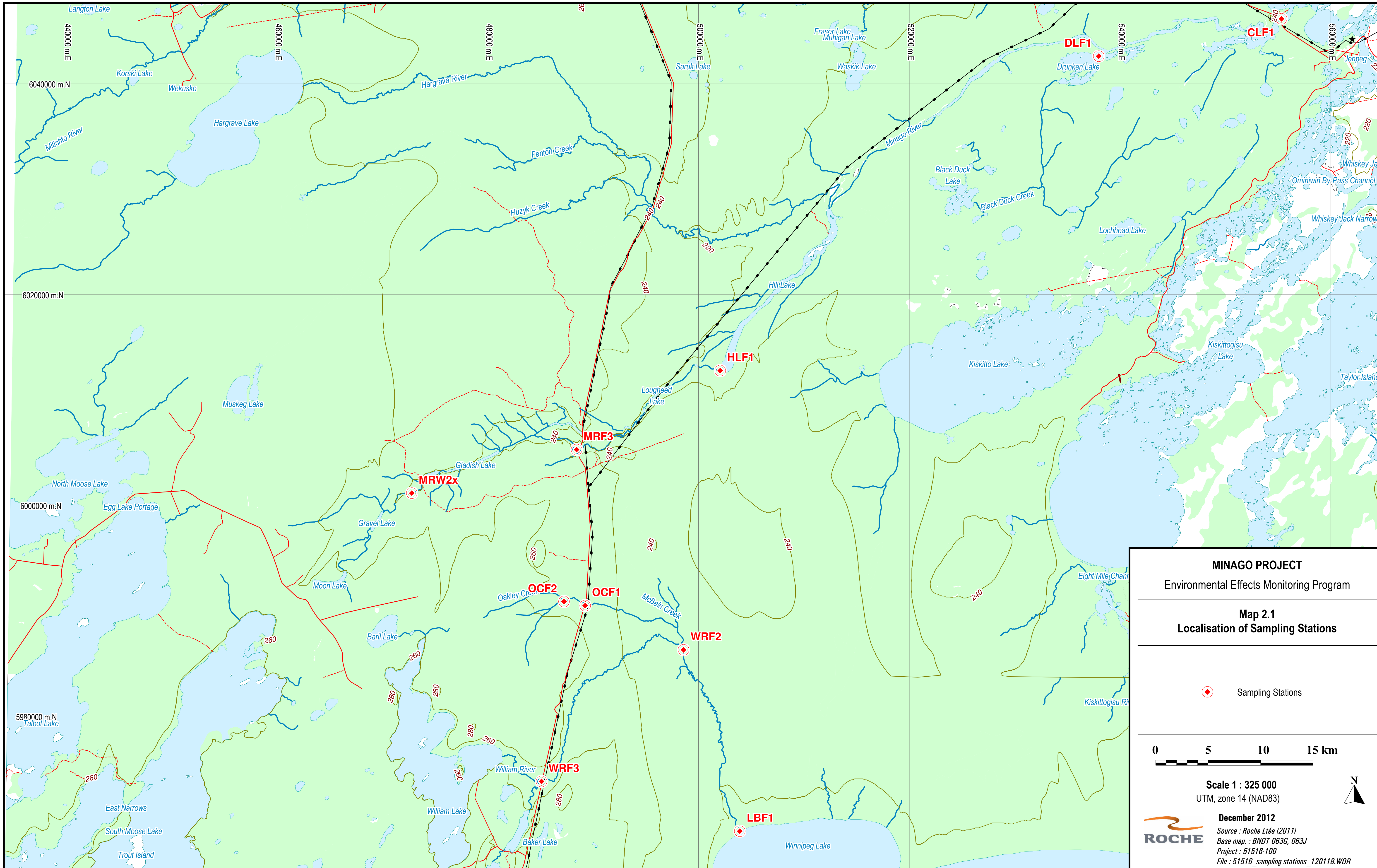
MINAGO PROJECT
Environmental Effects Monitoring Program
Map 2.1
Localisation of Sampling Stations
Sampling Stations
0 5 10 15 km
Scale 1 : 325 000
UTM, zone 14 (NAD83)
N
December 2012
ROCHE
Source : Roche Ltée (2011)
Base map. : BNDT 063G, 063J
Project : 51516-100
File : 51516_sampling stations_120118.WOR
CLF1
DLF1
HLF1
MRF3
MRW2x
OCF2
OCF1
WRF2
WRF3
LBF1
440000 m.E
460000 m.E
480000 m.E
500000 m.E
520000 m.E
540000 m.E
560000 m.E
6040000 m.N
6020000 m.N
6000000 m.N
5980000 m.N
Langton Lake
Korski Lake
Wekusko
Hargrave Lake
Mitishto River
Hargrave River
Fenton Creek
Huzyk Creek
Saruk Lake
Fraser Lake
Muhigan Lake
Waskik Lake
Minago River
Drunken Lake
Jenpeg
Black Duck Lake
Black Duck Creek
Lochhead Lake
Whiskey Jack Narrows
Ominiwin By-Pass Channel
Hill Lake
Kiskitto Lake
Kiskittogisu Lake
Taylor Island
Lougheed Lake
Muskeg Lake
Gladish Lake
North Moose Lake
Egg Lake Portage
Gravel Lake
Moon Lake
Oakley Creek
McBain Creek
Baril Lake
Eight Mile Chann
Kiskittogisu Ri
Talbot Lake
East Narrows
South Moose Lake
Trout Island
William River
William Lake
Baker Lake
Winnipeg Lake

Table 2.1 Sampling Effort for the Program of Fall 2011

	Stations	Coordinates UTM (NAD83)	Fishing Techniques: Bait Traps	Fishing Nets	Electric Fishing	Fyke Net	Fish tissue	Habitat Characterization: Benthic invertebrates	Water Quality (*in situ*)*	Sediment Quality	Hydrology
Minago River Watershed	**Minago River**										
	MRF3	488350 6005312	3	1	1	1	8	x	x	x	x
	MRW2x	472490 6001214	4	1			5	x	x	x	x
	Hill Lake										
	HLF1	502096 6012951	3	1			10		x	x	
	Drunken Lake										
	DLF1	538498 6042781	3	1			10		x	x	
	Cross Lake										
	CLF1	555475 6046181	3	1			5		x	x	
William River Watershed	**Oakley Creek**										
	OCF1	489284 5990513			2	1	2	x	x	x	x
	OCF2	487465 5990964	5	1			0	x	x	x	x
	William River										
	WRF3	485224 5973748	7	1			0	x	x	x	x
	WRF2	498504 5986512	5	1			2	x	x	x	x
	Limestone Bay										
	LBF1	503896 5969237	3	1			9		x	x	
TOTAL			36	9	3	2	51	6	10	10	6

* Reported elsewhere

The total length and weight of each specimen captured were recorded. For all specimens captured with the experimental fish nets, the sex and sexual maturity parameters were determined. The presence of any lesions, tumours, parasites or other abnormalities was also noted.

For top trophic level and herbivorous species of interest for subsistence and commercial fishing downstream of the proposed project discharges were be observed as part of this program. The muscle tissues of these species were also analysed. Fifty (50) of these fish specimens from small, medium and large size specimens from the various stations were sampled and analyzed for total metals. A full ICP-MS metals and metalloids scan was undertaken on the samples collected. Key parameters of interest included As, Cd, Pb, Ni, Se and Hg. The fish flesh was analysed for metals as per Canadian Guideline for Chemical Contaminants and Toxins in Fish and Fish Products. Selenium concentrations will be of particular importance for analysis as this metal tends to accumulate in fish muscle tissues. Similarly, there will be a focus on the analysis of nickel concentrations since the Minago Project will be a Nickel mine.

In addition to sampling of all fish and determining length, weight and sex, as part of the CMP and subject to sufficient numbers of two (2) species of fish (20 males and 20 females) additional end points (liver and gonads) would be undertaken. The two species may be potentially classified as the sentinel species for the future EEM program. It is important to note that this was undertaken for the upstream and downstream sites on the Minago River (MRW2x and MRF2) and Oakley Creek (OCF1 and OCF2). The EEM program calls for species that would occur within the influence of the effluent discharge and tend not to migrate. The primary objective was to characterize and identify one sentinel species as a forage species.

2.1.3 Fish Habitat Characterization

Each sampling and monitoring station was characterized to evaluate its potential for fish habitat using the following parameters:

- Water depth (all stations, at the fishing station);
- Stream width (streams);
- Substrate characterization (all stations);
- Water velocity (qualitative; streams);
- Nature of flow (streams);
- Width at the high water mark (streams);
- Mapping of the aquatic vegetation (all stations);
- Mapping of the covers in streams (overhanging trees, boulders, wood debris, undercut bank, etc.);
- Secchi disk water transparency measurements (water body); and
- Surface water and sediment quality data.

Flow measurements were taken at all stations located along Minago River, Oakley Creek and William River to provide a quantitative evaluation of water velocity and flow.

In addition to the parameters stated above, representative reaches, both upstream and downstream (Oakley Creek (OCF1 and OCF2); and MRW2x and MRF2), of the proposed effluent discharge locations were surveyed so that they could be revisited over time to document any changes. These reaches are within the area anticipated to be effected – more immediately downstream of the proposed discharges. This was done for the sites depicted in Table 2.1. VNI understands that continued sampling of these sites will need to occur if there is to be any determination of change arising from flows. VNI would like to reiterate that these current sites may not coincide with future site selection under EEM. The ongoing fish monitoring is occurring prior to EEM coming into effect and if a determination is already made regarding any effects of increased flow under EAL 2981 then there may not be the need to potentially monitor multiple sites for the same watershed.

The surveyed reaches and related habitat characterization data, photo documentation together with data collected during low flows and again after the spring freshet will be available to establish baseline conditions prior to the start of discharging groundwater from de-watering activities.

2.2 Sediment Quality

At each station, three (3) representative samples were collected, including the top five (5) centimetres of sediment which were used for total metal analysis. Sediment samples were analysed for the following parameters:

- pH;
- Total sulphur;
- Particle size distribution;
- Total metals (Hg, Ag, As, Ba, Cd, Co, Cr, Cu, Sn, Mn, Mo, Ni, Pb, Se, Zn, Al, Sb, Be, B, Ca, Fe, Mg, K, Na, V);
- Total organic carbon;
- Hydrocarbons (C_{10}-C_{50}) and total oil and grease;
- Loss on ignition.

Particle size distribution was done using six categories, from clay (less than 0.0032 mm) to stones (larger than 14 mm). Samples were analyzed by Maxxam Analytics in Quebec City, QC. A proper QA/QC program was also implemented to ensure quality of analyses and reliability of results (duplicates, ghost samples, etc.). The results are given in Appendix II.

2.3 Benthic Invertebrate Community

In order to address the requirements of the *Metal Mining Effluent Regulations* (MMER), the Aquatic Monitoring Program included a benthic invertebrate community survey. This study is based on the *Metal Mining Guidance Document for Aquatic Environmental Effects Monitoring* issued by Environment Canada in 2002. As part of this program, an initial characterization, which set the bases for the following periodic monitoring phases to come (i.e., subsequent surveys), was completed in 2008 by Roche Ltd and others prior to 2008 and is fully depicted in the EIA Report issued in May 2010 by VNI. The same approach (same methods, sampling plan, sampling stations, sample sizes, period of the year, etc.) will be adopted for the following monitoring phases.

2.3.1 Objectives

- Determine the actual specific composition of the benthic community living in the freshwater system (i.e., document the presence/absence of benthic families in water bodies that will likely be affected by the project and in a reference area that won't be affected);
- Determine the basic biological characteristics of the benthic community in the different areas (total invertebrate density, taxonomic richness, Simpson's diversity index, Bray-Curtis index); and,
- Initiate a sampling plan that will allow determination of differences (if any) between exposure areas and reference area during the operation and post-closure phases of the project.

2.3.2 Approach / Method

The design of the benthic invertebrate survey is site-specific and the sampling program design selected to achieve this study is the "control-impact design". Following this plan, a sampling campaign was undertaken in water bodies that will likely be affected by the mining activities (hereafter called "exposure area"), and in a water body with similar environmental characteristics as the exposure areas, but that will not be affected by the mining activities (hereafter called "reference area"). The "control-impact design" will allow detecting differences between discrete exposure and reference areas. In the present case, sampling stations are located upstream (reference) and downstream (potentially to be impacted) of the future location of the final effluent. To have a more precise description, all stations that will be used as part of this Benthic Invertebrate Communities Assessment Program have also been used for the Surface Water and Sediment Quality Program.

For each replicate station sampled, some explicative parameters connected to invertebrate habitats were measured according to *Metal Mining Guidance Document for Aquatic Environmental Effects Monitoring* and specific to the benthic characterization among which morphometric measurements (water depth) and riparian zone characteristics (riparian vegetation and canopy cover). Also related to the characterization of the benthic community is the description of the substrate (Boudreault *et al.*, 1984), as well as the Surface Water and Sediment Quality Program which took place at those same stations. Section 2.2.3 .refers to *in situ* measurements of specific physicochemical parameters while Section 2.3 depicts which parameters were analysed as part of the Sediment Quality Program. Surface Water Quality Assessment was outside the scope of this report.

In each sampling areas (2), two replicate stations were sampled. These stations were distributed to cover most of the given area and met the criteria of a minimal surface of 10 m x 10 m and a distance from the other stations of at least 20 m. Each replicate station was sampled by collecting two samples at random;

a sample corresponding to one grab (approximately 0.05 m²). A Ponar grab (for lakes) and a Surber net (for streams) allowed the collection of benthic organisms (Figure 2.1).

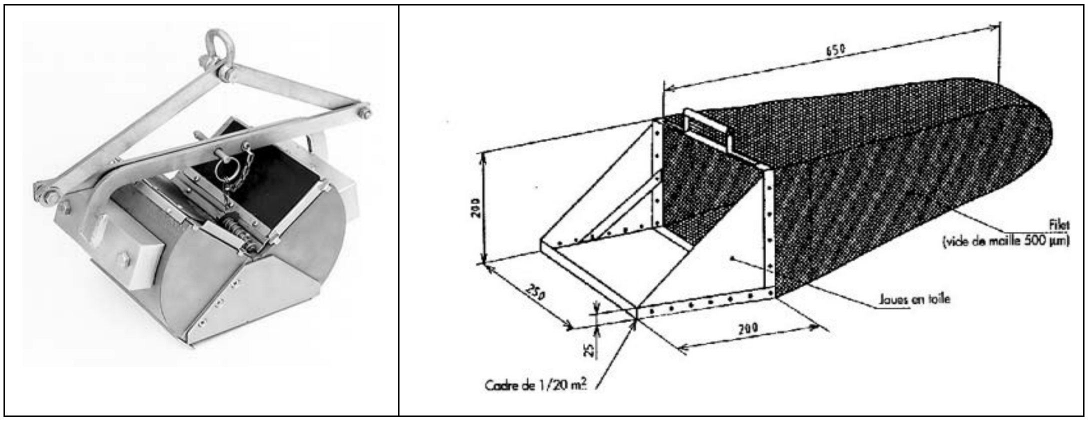

Figure 2.1 Ponar Grab and Surber Net

Each sample was washed over a 500 µm strainer. Organisms were then stored in a 7% formaldehyde solution and sent for analysis. Once arrived to Laboratoires SAB Inc., organisms were transferred in a 70% alcohol solution with glycerine for preservation until their identification was done up to the genus level at the laboratory.

Les laboratories SAB Inc. sorted, sub-sampled, identified and counted all the organisms in each sample. A reference collection was build-up using some specimens from all observed taxa. Such a collection was build up for consistency in taxonomic identifications between surveys. Further details on methods and the associated QA/QC program is depicted in Appendix III.

Specific measures were taken into account for the assessment of biological characteristics of the benthic invertebrate community:

- All the specimens from the Phylum Nematoda were treated as one group (as if they were at genus level);
- All Oligochaeta fragments found were excluded from the analysis, because of the difficulty to relate each fragment to a single individual and to identified at Family level; and,
- An abundance of 1 was fixed for the Spongillidae colony as it was indicated by the letter ‘C’ in the original table elaborated by Laboratoires SAB Inc.

2.3.2.1 Taxonomic Richness

The taxonomic richness corresponds to the total amount of taxa to which collected individuals belong (Environment Canada, 2011). Except for Nematoda, the genus level was used for calculation. The arithmetic mean, standard deviation, median as well as minimal and maximal values were calculated for the whole study area using taxonomic richness values measured at each station.

2.3.2.2 Density and Relative Abundance

For each taxa, the density was calculated using the mean amount of invertebrates and the sampled area (1 grab = 0.05 m^2). The total density (all taxa) was also calculated for each sampling station. The arithmetic mean, standard deviation, median as well as minimal and maximal values were calculated for the whole study area using values measured at each station.

The relative abundance of the taxa at each station was calculated by dividing one taxa's density by the total density.

2.3.2.3 Simpson's Diversity Index

Simpson's diversity index uses both abundance and taxonomic richness values. It is calculated using the following formula:

$$D = 1 - \sum_{i=1}^{S} (p_i)^2$$

with *D* corresponding to Simpson's diversity index, *S* being the total amount of taxa at the station and p_i being the relative abundance of the i^{th} taxa at the station.

Simpson's diversity index ranges from 0 to 1. A community with only one taxa would score 0 while a community showing an infinite number of taxa all being equally abundant would score 1. The maximal value which can be obtained is proportional to the number of taxa (for example, 4 taxa with a relative abundance of 25%, *D* = 0.75 and 5 taxa with a relative abundance of 20%, *D* = 0.8).

Simpson's diversity index were calculated for each sampling station. The arithmetic mean, standard deviation, median as well as minimal and maximal values were calculated for the whole study area using values measured at each station.

2.3.2.4 Bray-Curtis Distance

Bray-Curtis distance is used to measure the differences among the sampling stations. It is calculated using the following formula:

$$B - C = \frac{\sum_{i=1}^{n} |y_{i1} - y_{i2}|}{\sum_{i=1}^{n} (y_{i1} + y_{i2})}$$

with *B – C* representing the Bray-Curtis distance between two stations, y_{i1} being the density of the *i* taxa at station 1, y_{i2} being the density of *i* taxa at station 2 and *n* the total number of taxa observed at both stations.

As part of this study, the Bray-Curtis distance was calculated between stations' taxonomic composition. Bray-Curtis distance ranges from 0 to 1. If the taxonomic composition of one station is totally identical to the taxonomic composition of the other station, therefore it equals 0. As the composition differs between two stations, the distance increases.

2.3.2.5 EPT/EPT+Chironomid Ratio

The EPT/EPT+Chironomid Ratio is an indicator of the health of each site. The ratio of EPT (Ephemeroptera, Plecoptera and Trichoptera taxa) to chironomids is a common ratio that measures the abundance of the two groupings and indicates the balance in benthic community diversity. A healthy community should have a high proportion of EPT individuals relative to chironomids. The proportions of chironomids generally rise with increasing pollution, replacing the more sensitive EPT species. Therefore, since EPT taxa are known to be mostly intolerant and the family Chironomidae (at least as a whole; Moisan, 2006) is generally considered tolerant and often dominates polluted situations, the ratio of EPT taxa to the total of EPT + Chironomidae should be lower as the environment gets more polluted. This family is considered as pollution resistant (Moisan 2006). Most of its species can resist to lower dissolved oxygen level and some can even survive where oxygen content is so low it cannot be detected (Thorp and Covich 1991). Moreover, the blood of some Chironomidae contains a specific type of haemoglobin which is efficient at low oxygen content (Thorp and Covich 1991, Wetzel 2001).

3 Results

3.1 Fish Community and Habitat

3.1.1 Fish Habitat

The main physicochemical characteristics of fish habitats where experimental fishing took place are shown in Table 3.1. Water depth ranges from 0.59 to 4.35 m; sun light was able to reach the bottom at most fishing stations. At all stations, aquatic plant communities or aquatic vegetation and ligneous debris were observed; percentage cover varied from less than 5% to 10% (Table 3.2). Substrate was made essentially of silt and coarse sand (Section 3.2).

Table 3.1 Basic Physicochemical Characteristics for Various Sampling Stations

	Station	Temperature °C		Dissolved Oxygen (O_2) %		Dissolved Oxygen (O_2) (mg/l)		pH		Conductivity µS/cm		Turbidity NTU	
	Year	2008	2011	2008	2011	2008	2011	2008	2011	2008	2011	2008	2011
	Month	May	Oct	May	Oct	May	Oct	May	Oct	May	Oct	May	Oct
Minago River Watershed	MWR2X	9,0	5,0	88,4	82,0	10,20	10,45	7,76	7,94	300	284	-	3,76
	MRF2	7,2	-	54,5	-	6,57	-	7,52	-	125	-	-	-
	MRF3	6,8	9,7	83,2	88,4	10,27	10,07	7,53	7,75	134	229	-	1,62
	CLF1	4,2	4,8	91,7	97,6	11,91	12,53	7,85	8,04	178	164	-	21,56
	DLF1	-	9,7	-	86,0	-	9,79	-	7,86	-	159	-	13,25
	HLF1	8,1	9,8	91,8	87,7	10,85	9,99	7,68	7,86	152	212	-	1,06
William River Watershed	LBF	5,0	3,7	94,8	89,3	12,10	11,80	7,98	8,05	240	193	-	19,11
	WRF1	7,4	-	95,7	-	11,50	-	8,22	-	360	-	-	-
	WRF2	6,7	6,4	93,9	93,2	11,49	11,46	8,20	7,88	260	224	-	8,06
	WRF3	6,6	1,3	84,8	89,4	10,35	12,60	8,27	8,48	290	286	-	3,35
	OCF1	3,1	4,7	81,1	92,9	10,83	11,93	7,65	7,93	230	246	-	0,32
	OCF2	5,9	4,5	73,0	86,1	9,16	11,1	7,68	7,91	290	260	-	0,62

Table 3.2 Fish Habitat Characterization

Stations	Coordinates UTM NAD83	Date	Water depht (m)	Stream width (m)	Secchi disk (m)	Water velocity (m^2/s)	Nature of flow	Substrate characterisation	Width at the high water mark (m)	Aquatic Vegetation (AV)	AV Dimension (approximation)	AV Cover % (approximation)	AV Type	Comments
MINAGO RIVER WATERSHED														
Minago River														
MRF3	488350 6005312	2011-10-14	1 (Net)	-	1	4,71	Basin	Si, roots, AV, Co	-	• Left Bank, upstream • At fishing site: extended	20 m wide to 50-60 m wide by 500 m length	50%	• Deep AV • emergent vegetation, 80-100%	• Type of AV was different from the other sites • Extended cover up to 100 m upstream the bridge
MRW2x	472490 6001214	2011-10-16	0,8 max:1,10	15 to 17	0,8 max:1,10	0,9	Channel	Co, Pe, Si, Om, AV	45-47	No		10 -15 %	• 10% AV • < 5 % ligneous debris	• Upstream presence of a beaver dam • stream gauging downstream
Hill Lake														
HLF1	502096 6012951	2011-10-14	1,8 (Net)	-	1,8	-	Lake	Bl, Co, R, (Si on banks)	N/O	• Extended near sampling site • Extended on right bank	•100 m x 100 m •300 m x 20 m	25 to 30%	• Weak AV • some ligneous debris on shore	No easy access to the AV, only airborn description
Drunken Lake														
DLF1	538498 6042781	2011-10-15	2,10 (Net)	-	0,62	-	Lake	Sa, Si, R	N/O	Yes, wild rice	40 m x 8 m x 1,0 m depth	20%	• Very weak AV • 1 % ligneous debris	•AV in a small cove
Cross Lake														
CLF1	555475 6046181	2011-10-20	4,35 (Net)	-	0,43	-	Lake	Si, Cl (Center); Si, Sa, Gr (banks)	N/O	Sparse, north side of the bridge	75 m x 6 m	40%	Weak, little aquatic vegetation close to shore, some ligneous debris < 1 %	• Turbid water
WILLIAM RIVER WATERSHED														
Oakley Creek														
OCF1	489284 5990513	2011-10-19	0,20 - 0,8 mean:0,40	6,16 to 9; stream gauging	0,20 - 0,8 mean:0,40	0,82	Basin, Rapid, Ledge	Basin: R, Gr, Si, Pe, Cl Rapid: Bl, R, Co Ledge: R, Co (limestone)	10-12.5	Basin: 2 areas Some aquatic vegetation in a small and calm arm of the stream	1) 15 m x 3 m 2) 10 m x 2 m	40%	• 40% AV • < 5% ligneous debris	• Sucession of 3 facies, basin downstream of the road, rapid and ledge • Stream gauging at ledge
OCF2	487465 5990964	2011-10-17	1,4 to 2,05	3,3 to 4,5	1,4 to 2,05	0,3	Channel	Om, Si, Av	Peatland approx. 100 m on RB, LB approx. 75 m; presence of woodland	Pretty much everywhere, sometimes at the foot of the banks and sometimes in the middle of the stream	approx. 0,8 m wide on each riverbank	40%	• 40% AV • 10% Ligneous debris	• Channel in peatland • Emergent vegetation on banks and presence of aquatic vegetation
William River														
WRF3	485224 5973748	2011-10-19	0,59 (Net) 0,82	15 to 25	0,59 (Net) 0,82	1,26	Channel	Si, Sa, Cl (traces), R, Co, Pe (20 to 25%)	18 to 28	In the middle and on river banks	-	25 to 30%	• 25 to 30% vegetation • 25% ligneous debris	• Max water depth was found under the bridge
WRF2	498504 5986512	2011-10-16	1,20 - 1,88	15,5 to 18	1,20 - 1,88	2,97	Channel	Si, Cl, roots	19 to 21.5	Both river banks	2 m wide on each riverbank	20 to 30%	• 20 to 30 % vegetation • < 5 % ligneous debris	• Current was too strong for Secchi disk measurments
Limestone Bay														
LBF1	503896 5969237	2011-10-18	1,85 - 2,0	20	0,51	-	Channel	OM (mostly ligneous), few to very few Si	N/O	N/O	N/O	N/O	< 10% ligneous debris	Fishing nets were deployed in the river that feed the bay, actual site was without water caused by strong NO winds two days earlier (water retreat of 600 m in the bay)

N/O: Not Observed
AV: Aquatic Plant Community
HWL High Water Level

Bl: Block, **Cl:** Clay, **Co**: Cobble, **Gr:** Gravel, **Pe:** Pebble, **Sa:** Sand, **Si:** Silt, **Om:** Organic Matter, **R:** Rock

RB/LB: Right bank /Left bank

3.1.2 Fish Community

A total of 121 fishes were captured by experimental fishing (fishing nets, fyke nets, bait traps and electrofishing) at the ten stations (Table 3.3). Fish specimens were captured at all stations but one, WRF3, where both fishing net and bait traps (7) were unsuccessful. Among all captured specimens, 84 were from the Minago River watershed and 37 from the William River watershed (Tables 3.4 and 3.5). Twelve species were identified as follows: the northern pike was the most abundant species with 59 individuals captured; yellow perch (18); and brook stickleback (17; Table 3.3). Photos 3.1 to 3.10 show some of the species captured at each station.

In comparison with past results presented in the EIA report, four new species were identified, namely, rock bass (*Ambloplites rupestris*); burbot (*Lota lota*); sauger (*Stizostedion canadense*) and cisco (*Coregonus artedi*). Considering that experimental fishing took place in mid-October, one could have expected that lake whitefish (*Coregonus clupeaformis*) would have been captured during the program. In the study area, lake whitefish is known to spawn in the fall, mostly in October; historical data was the main reason why fishing took place at that time. Limestone Bay is considered a spawning sanctuary for whitefish in the fall (and walleye in the spring; Manitoba Water Stewardship, pers. comm.).

Experimental gillnets are considered to be the best sampling method for capturing whitefish (including cisco, which was captured as part of this study) and October is a good month to confirm the presence or absence of whitefish in the study area (Manitoba Water Stewardship, pers. comm.). However, timing could have been a factor considering that spawning period varies from year to year depending on various conditions and therefore one could not confirm the absence of whitefish.

Table 3.3 Fisheries Survey – Results by Species and Stations

	HLF1	DLF1	MRF3	MRW2	WRF2	WRF3	LBF1	CLF	OCF1	OCF2	**Total**
Brook Stickleback									15	2	**17**
Burbot				1							**1**
Cisco		3									**3**
Golden Shiner								1			**1**
Northern Pike	12	11	8	4	2		14	6	2		**59**
Rainbow Smelt								1			**1**
Rock Bass	1										**1**
Sauger		1									**1**
Sucker sp.										1	**1**
Walleye		8									**8**
White sucker	5	1		1			1	2			**10**
Yellow Perch		13						5			**18**
Total	**18**	**37**	**8**	**6**	**2**	**0**	**15**	**15**	**17**	**3**	**121**

Table 3.4 Fisheries Results - Minago River Watershed

	Common name	Scientific name	Lenght (mm)	Weight (g)	Sex	Maturity	Fishing technique
HLF-1							
1	Northern Pike	*Esox lucius*	690	1970	M	3	Net
2	Northern Pike	*Esox lucius*	655	1900	F	3	Net
3	Northern Pike	*Esox lucius*	735	2890	M	3	Net
4	Northern Pike	*Esox lucius*	1035	5070	F	3	Net
5	Northern Pike	*Esox lucius*	465	580	F	3	Net
6	Northern Pike	*Esox lucius*	485	640	M	3	Net
7	Northern Pike	*Esox lucius*	560	940	M	3	Net
8	Northern Pike	*Esox lucius*	460	620	F	3	Net
9	Northern Pike	*Esox lucius*	435	460	M	3	Net
10	Northern Pike	*Esox lucius*	370	280	F	2	Net
11	Rock Bass	*Ambloplites rupestris*	8,9	22	-	-	Net
12	Walleye	*Sander vitreus*	580	1570	F	3	Net
13	Walleye	*Sander vitreus*	515	1620	F	4	Net
14	White Sucker	*Catostomus commersoni*	430	1070	M	4	Net
15	White Sucker	*Catostomus commersoni*	430	880	F	4	Net
16	White Sucker	*Catostomus commersoni*	420	950	M	4	Net
17	White Sucker	*Catostomus commersoni*	465	1250	F	4	Net
18	White Sucker	*Catostomus commersoni*	200	90	I	1	Net
MRF-3							
19	Northern Pike	*Esox lucius*	295	150	F	2	Net
20	Northern Pike	*Esox lucius*	245	40	M	3	Net
21	Northern Pike	*Esox lucius*	375	320	M	3	Net
22	Northern Pike	*Esox lucius*	395	430	M	3	Net
23	Northern Pike	*Esox lucius*	340	230	M	3	Net
24	Northern Pike	*Esox lucius*	320	230	F	2	Net
25	Northern Pike	*Esox lucius*	325	210	F	3	Net
26	Northern Pike	*Esox lucius*	149	19,0	I	1	Fyke net
MRW-2x							
27	Burbot	*Lota lota*	320	160	M	3	Net
28	Northern Pike	*Esox lucius*	265	110	M	3	Net
29	Northern Pike	*Esox lucius*	260	100	F	2	Net
30	Northern Pike	*Esox lucius*	250	85	M	3	Net
31	Northern Pike	*Esox lucius*	280	130	M	3	Net
32	White Sucker	*Catostomus commersoni*	245	170	M	3	Net
DLF-1							
33	Cisco	*Coregonus artedi*	340	410	M	3	Net
34	Cisco	*Coregonus artedi*	260	180	I	1	Net
35	Cisco	*Coregonus artedi*	155	30	I	1	Net
36	Northern Pike	*Esox lucius*	235	50	I	1	Net
37	Northern Pike	*Esox lucius*	510	800	M	3	Net
38	Northern Pike	*Esox lucius*	515	740	F	3	Net
39	Northern Pike	*Esox lucius*	480	690	F	3	Net
40	Northern Pike	*Esox lucius*	420	450	F	2	Net
41	Northern Pike	*Esox lucius*	405	410	F	3	Net
42	Northern Pike	*Esox lucius*	510	810	M	3	Net
43	Northern Pike	*Esox lucius*	585	1230	M	3	Net
44	Northern Pike	*Esox lucius*	750	2830	M	3	Net
45	Northern Pike	*Esox lucius*	910	4910	F	3	Net
46	Northern Pike	*Esox lucius*	~580	-	-	-	Net
47	Sauger	*Sander canadensis*	245	140	M	3	Net
48	Walleye	*Sander vitreus*	435	900	M	3	Net
49	Walleye	*Sander vitreus*	435	710	M	3	Net
50	Walleye	*Sander vitreus*	515	1520	M	3	Net
51	Walleye	*Sander vitreus*	395	610	M	3	Net
52	Walleye	*Sander vitreus*	335	360	M	3	Net
53	Walleye	*Sander vitreus*	430	830	M	3	Net
54	Walleye	*Sander vitreus*	305	270	I	1	Net
55	Walleye	*Sander vitreus*	290	240	I	1	Net
56	White Sucker	*Catostomus commersoni*	445	1140	F	3	Net
57	Yellow Perch	*Perca flavescens*	265	275	F	3	Net
58	Yellow Perch	*Perca flavescens*	195	8,5	I	1	Net
59	Yellow Perch	*Perca flavescens*	232	165	F	3	Net
60	Yellow Perch	*Perca flavescens*	245	180	F	3	Net
61	Yellow Perch	*Perca flavescens*	170	72	F	3	Net
62	Yellow Perch	*Perca flavescens*	151	51	F	2	Net
63	Yellow Perch	*Perca flavescens*	103	30	I	1	Net
64	Yellow Perch	*Perca flavescens*	95	25	I	1	Net
65	Yellow Perch	*Perca flavescens*	113	28	I	1	Net
66	Yellow Perch	*Perca flavescens*	100	21	I	1	Net
67	Yellow Perch	*Perca flavescens*	105	21	I	1	Net
68	Yellow Perch	*Perca flavescens*	98	20	I	1	Net
69	Yellow Perch	*Perca flavescens*	105	23	I	1	Net
CLF-1							
70	Golden Shiner	*Notemigonus crysoleucas*	129	20,09	-	-	Net
71	Northern Pike	*Esox lucius*	830	2830	F	3	Net
72	Northern Pike	*Esox lucius*	625	1560	F	3	Net
73	Northern Pike	*Esox lucius*	586	1400	F	3	Net
74	Northern Pike	*Esox lucius*	535	800	M	3	Net
75	Northern Pike	*Esox lucius*	527	730	M	3	Net
76	Northern Pike	*Esox lucius*	480	610	F	3	Net
77	Rainbow Smelt	*Osmerus mordax*	98	5,60	-	-	Net
78	White Sucker	*Catostomus commersoni*	406	770	M	3	Net
79	White Sucker	*Catostomus commersoni*	403	770	F	3	Net
80	Yellow Perch	*Perca flavescens*	225	113	M	3	Net
81	Yellow Perch	*Perca flavescens*	189	75	F	3	Net
82	Yellow Perch	*Perca flavescens*	193	72	M	3	Net
83	Yellow Perch	*Perca flavescens*	160	59	I	1	Net
84	Yellow Perch	*Perca flavescens*	115	16,2	I	1	Net

Table 3.5 Fisheries Results - William River Watershed

	Common name	Scientific name	Lenght (mm)	Weight (g)	Sex	Maturity	Fishing technique
WRF-2							
1	Northern Pike	*Esox lucius*	232	80	F	3	Net
2	Northern Pike	*Esox lucius*	360	240	F	3	Net
WRF-3							
	-	-	-	-	-	-	Net/Bait trap
LBF-1							
3	Northern Pike	*Esox lucius*	700	2290	M	3	Net
4	Northern Pike	*Esox lucius*	692	1980	M	3	Net
5	Northern Pike	*Esox lucius*	513	890	F	3	Net
6	Northern Pike	*Esox lucius*	415	440	M	3	Net
7	Northern Pike	*Esox lucius*	397	372	M	3	Net
8	Northern Pike	*Esox lucius*	405	435	M	3	Net
9	Northern Pike	*Esox lucius*	335	212	M	3	Net
10	Northern Pike	*Esox lucius*	329	223	F	3	Net
11	Northern Pike	*Esox lucius*	271	130	I	1	Net
12	Northern Pike	*Esox lucius*	288	150	M	3	Net
13	Northern Pike	*Esox lucius*	223	75	M	3	Net
14	Northern Pike	*Esox lucius*	218	73	M	3	Net
15	Northern Pike	*Esox lucius*	237	88	F	2	Net
16	Northern Pike	*Esox lucius*	234	92	M	3	Net
17	White Sucker	*Catostomus commersoni*	421	950	F	3	Net
OCF-1							
18	Brook Stickleback	*Culaea inconstans*	45	0,82	No sex and maturity identification		Electric
19	Brook Stickleback	*Culaea inconstans*	48	0,78			Electric
20	Brook Stickleback	*Culaea inconstans*	45	0,60			Electric
21	Brook Stickleback	*Culaea inconstans*	55	1,14			Electric
22	Brook Stickleback	*Culaea inconstans*	47	0,68			Electric
23	Brook Stickleback	*Culaea inconstans*	39	0,42			Electric
24	Brook Stickleback	*Culaea inconstans*	39	0,30			Electric
25	Brook Stickleback	*Culaea inconstans*	46	0,77			Electric
26	Brook Stickleback	*Culaea inconstans*	32	0,24			Electric
27	Brook Stickleback	*Culaea inconstans*	42	0,59			Electric
28	Brook Stickleback	*Culaea inconstans*	38	0,39			Electric
29	Brook Stickleback	*Culaea inconstans*	48	0,83			Electric
30	Brook Stickleback	*Culaea inconstans*	43	0,56			Electric
31	Brook Stickleback	*Culaea inconstans*	40	0,50			Electric
32	Brook Stickleback	*Culaea inconstans*	36	0,35			Electric
33	Northern Pike	*Esox lucius*	164	23,79	I	1	Fyke net
34	Northern Pike	*Esox lucius*	162	23,40	I	1	Electric
OCF-2							
35	Brook Stickleback	*Culaea inconstans*	50	1,03	No sex and maturity identification		Bail trap
36	Brook Stickleback	*Culaea inconstans*	55	1,17			Bail trap
37	Sucker sp.	*Catostomus sp.*	58	1,77			Bail trap

3.1.3 Fish Tissue Metal Content Analysis

Fish tissue metal content was analyzed for arsenic, lead, mercury, nickel and selenium. Laboratory Certificates are provided in Appendix I. Northern pikes, white suckers and ciscoes were used for this analysis. The results indicate that for arsenic, lead, nickel and selenium, concentrations are in compliance with the Canadian Food Inspection Agency (CFIA) guideline (if any) and, in some cases, were below the detection limit. On the other hand, mercury content found in fish tissues exceeded the CFIA criteria of 0.5 mg/kg as shown in Table 3.6. In the Minago River Watershed, 9.8% of samples exceeded the CFIA criteria for mercury. Exceedances for mercury were only found in Hill Lake (3) and Drunken Lake (1); values ranged from 0.02 to 3.83 mg/kg. In the William River Watershed, there were no exceedances indicated for the mercury; values ranged from 0.02 to 0.21 mg/kg.

In the 2008 Fisheries Program done by Roche, tissue samples were collected in order to evaluate total metal content (As, Pb, Se, Ni and Hg) in 20 specimens. Tissue samples were collected from four walleyes, seven northern pikes, three white suckers, four longnose suckers and two yellow perches. Metal concentrations for arsenic, selenium and lead were always below the detection limit of 0.2 and 0.1 mg/kg, respectively. However, twenty-five percent (25%) of all sample fishes showed mercury concentrations above the CFIA criteria. Measured mercury concentrations varied from 0.06 to 1.6 mg/kg.

The concentration of mercury in fish varies with species, age, size, and environmental conditions. Older, larger fish generally have a higher concentration of mercury in their tissues than younger, smaller fish. Fish that feed on other fish such as walleye and northern pike tend to have more mercury in their tissues than fish that feed on insects or plankton such as whitefish and goldeye.

The *Guidelines for the Consumption of Recreationally Angled Fish in Manitoba* were developed so that the nutritional benefits of consuming fish can be achieved without exceeding safe concentrations of mercury. According to these guidelines, and based on median values measured for each watershed in the study area (Table 3.6), which are of 0.12 mg/kg in the Minago River watershed and 0.06 mg/kg in the William River watershed, both would be considered as within Consumption Category 1 (less than or equal to 0.2 µg/g of mercury in fish fillet; Manitoba Water Stewardship, 2012).

Photo 3.1 Station HLF1 - *Catostomus commersoni*

Photo 3.2 Station HLF1 – *Ambloplites rupestris*

Photo 3.3 Station DLF1 – *Sander vitreus*

Photo 3.4 Station DLF1 – *Coregonus artedi*

Photo 3.5 Station CLF1 – *Esox lucius*

Photo 3.6 Station CLF1 – *Osmerus mordax*

Photo 3.7 Station MRW2x – *Lota lota*

Photo 3.8 Station OFC1 – *Esox lucius* and *Culaea inconstans* (small fishes)

Photo 3.9 Station LBF1 – *Esox lucius*

Photo 3.10 Station OFC1 – *Culaea inconstans*

Table 3.6 Fish Tissue Metal Content Analysis

Parameters	Units	Method detection limit	CFIA Critera[1]	Minago River Watershed																								
Sample characteristics																												
Certificate of analysis number	-			52475-01	52475-01	52475-01	52475-01	52475-01	52475-01	52475-01	52475-01	52475-01	52475-01	52475-02	52475-02	52475-02	52475-02	52475-02	52475-02	52475-02	52475-02	52475-02	52475-02	52475-03	52475-04	52475-04	52475-04	52475-04
Laboratory sample number				P31388	P31413	P31414	P31415	P31416	P31417	P31418	P31419	P31420	P31421	P31422	P31423	P31424	P31425	P31426	P31427	P31428	P31429	P31430	P31431	P31451	P31432	P31433	P31434	P31435
Sample number				HLF1-1	HLF1-4	HLF1-7	HLF1-9	HLF1-12	HLF1-13	HLF1-14	HLF1-15	HLF1-16	HLF1-17	DLF1-1	DLF1-2	DLF1-5	DLF1-6	DLF1-9	DLF1-10	DLF1-12	DLF1-13	DLF1-14	DLF1-15	CLF1-1	CLF1-4	CLF1-6 (mean)	CLF1-7 (mean)	CLF1-8
Date of sampling				14-10-11	14-10-11	14-10-11	14-10-11	14-10-11	14-10-11	14-10-11	14-10-11	14-10-11	14-10-11	15-10-11	15-10-11	15-10-11	15-10-11	15-10-11	15-10-11	15-10-11	15-10-11	15-10-11	15-10-11	20-10-11	20-10-11	20-10-11	20-10-11	20-10-11
Location				**Hill Lake**										**Drunken Lake**										**Cross Lake**				
Fish characteristics																												
Species	-	-		ESLU	ESLU	ESLU	ESLU	ESLU	CACO	CACO	CACO	CACO	CACO	ESLU	ESLU	ESLU	ESLU	ESLU	ESLU	COAR	COAR	COAR	CACO	ESLU	ESLU	ESLU	CACO	CACO
Sex	-			M	F	F	M	F	M	F	M	F	I	I	M	F	F	M	F	M	I	I	F	F	M	F	M	F
Maturity	-			3	3	3	3	2	4	4	4	4	1	1	3	2	3	3	3	3	1	1	3	3	3	3	3	3
Lenght	mm			690	1035	465	560	370	430	430	420	465	200	235	510	420	405	750	910	340	260	155	445	830	535	480	406	403
Weight	g			1970	5070	580	940	280	1070	880	950	1250	90	50	800	450	410	2830	4910	410	180	30	1140	2830	800	610	770	770
Metal and metaloids																												
Arsenic	mg/kg	0.01	3.5	0.059	0.027	0.057	0.024	0.033	0.030	0.036	0.051	0.076	0.052	0.041	0.033	0.019	0.022	0.063	0.060	0.036	0.114	0.115	0.029	0.061	0.031	0.042	0.050	0.020
Lead	mg/kg	0.1	0.5	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1
Mercury	mg/kg	0.010	0.5	0.580	3.83	0.320	0.750	0.110	0.080	0.110	0.050	0.063	0.020	0.120	0.270	0.150	0.140	1.02	0.400	0.040	0.080	0.060	0.070	0.240	0.200	0.125	0.085	0.070
Nickel	mg/kg	0.5	-	< 0,5	< 0,5	< 0,5	< 0,5	< 0,5	< 0,5	< 0,5	< 0,5	< 0,5	< 0,5	< 0,5	< 0,5	< 0,5	< 0,5	< 0,5	< 0,5	< 0,5	< 0,5	< 0,5	< 0,5	< 0,5	< 0,5	< 0,5	< 0,5	< 0,5
Selenium	mg/kg	0.2	-	< 0,2	< 0,2	< 0,2	< 0,2	0.2	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	0.3	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	0.2

Parameters	Units	Method detection limit	CFIA Critera[1]	Minago River Watershed (next)													Descriptive statistics								
																	N	N>LD	Min	Med	Max	Mean	SD	CV (%)	% over criteria
Sample characteristics																									
Certificate of analysis number	-			52475-05	52475-05	52475-05	52475-05	52475-06	52475-04	52475-04	52475-05	52475-05	52475-05	52475-05	52475-05	52475-05									
Laboratory sample number				P31458	P31459	P31460	P31461	P31462	P31440	P31441	P31452	P31453	P31454	P31455	P31456	P31457									
Sample number				MRW2X-1	MRW2X-2	MRW2X-3	MRW2X-4	MRW2X-5	MRF2-1	MRF2-2	MRF-2-3	MRF-2-4	MRF-2-5	MRF-2-6	MRF-2-7	MRF2VE11									
Date of sampling				16-10-11	16-10-11	16-10-11	16-10-11	16-10-11	15-10-11	15-10-11	15-10-11	15-10-11	15-10-11	15-10-11	15-10-11	14-10-11									
Location				**Minago River**																					
Fish characteristics																									
Species	-	-		ESLU	ESLU	ESLU	ESLU	CACO	ESLU	ESLU	ESLU	ESLU	ESLU	ESLU	ESLU	ESLU									
Sex	-			M	F	M	M	M	F	M	M	M	M	F	F	I									
Maturity	-			3	2	3	3	3	2	3	3	3	3	2	3	1									
Lenght	mm			265	260	250	280	245	295	245	375	395	340	320	325	149									
Weight	g			110	100	85	130	170	150	40	320	430	230	230	210	19.0									
Metal and metaloids																									
Arsenic	mg/kg	0.01	3.5	0.029	0.032	0.024	0.023	0.099	0.038	0.079	0.041	0.042	0.049	0.020	0.037	0.015	38	38	0.015	0.038	0.115	0.045	0.025	0.551	0.0
Lead	mg/kg	0.1	0.5	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	38	0	0.0	< 0,1	< 0,1	< 0,1	-	-	0.0
Mercury	mg/kg	0.010	0.5	0.140	0.370	0.320	0.220	0.120	0.070	0.110	0.080	0.060	0.130	0.040	0.100	0.070	38	38	0.02	0.12	**3.83**	0.28	0.63	2.20	9.8
Nickel	mg/kg	0.5	-	< 0,5	< 0,5	< 0,5	< 0,5	< 0,5	< 0,5	< 0,5	< 0,5	< 0,5	< 0,5	< 0,5	< 0,5	< 0,5	38	0	0.0	< 0,5	0.0	< 0,5	-	-	0.0
Selenium	mg/kg	0.2	-	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	38	3	0.2	0.2	0.3	0.2	-	-	0.0

Parameters	Units	Method detection limit	CFIA Critera[1]	William River Watershed													Descriptive statistics								
																	N	N>LD	Min	Med	Max	Mean	SD	CV (%)	% over criteria
Sample characteristics																									
Certificate of analysis number	-			52475-04	52475-04	52475-04	52475-04	52475-03	52475-03	52475-03	52475-03	52475-03	52475-03	52475-03	52475-03	52475-06									
Laboratory sample number				P31436	P31437	P31438	P31439	P31442	P31443	P31444	P31445	P31446	P31447	P31448	P31449	P31464									
Sample number				OCF1-VE-1	OCF1-PE-16	WRF2-1	WRF2-2	LBF1-1 (mean)	LBF1-3	LBF1-4	LBF1-6	LBF1-7	LBF1-8	LBF1-13	LBF1-14	LBF1-15 (mean)									
Date of sampling				19-10-11	19-10-11	16-10-11	16-10-11	18-10-11	18-10-11	18-10-11	18-10-11	18-10-11	18-10-11	18-10-11	18-10-11	18-10-11									
Location				**Oakley Creek**		**William River**		**Limestone Bay**																	
Fish characteristics																									
Species	-	-		ESLU	ESLU	ESLU	ESLU	ESLU	ESLU	ESLU	ESLU	ESLU	ESLU	ESLU	ESLU	CACO									
Sex	-			I	I	F	F	M	F	M	M	M	F	F	M	F									
Maturity	-			1	1	3	3	3	3	3	3	3	3	2	3	3									
Lenght	mm			164	162	360	232	700	513	415	405	335	329	237	234	421									
Weight	g			23.8	23.4	240	80	2290	890	440	435	212	223	88	92	950									
Metal and metaloids																									
Arsenic	mg/kg	0.01	3.5	0.021	0.016	0.032	0.065	0.073	0.040	0.042	0.027	0.053	0.050	0.032	0.041	0.036	13	13	0.016	0.040	0.073	0.041	0.016	0.403	0.0
Lead	mg/kg	0.1	0.5	< 0,1	0.2	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	13	1	0.2	0.2	0.2	0.2	-	-	0.0
Mercury	mg/kg	0.010	0.5	0.060	0.070	0.120	0.020	0.210	0.110	0.030	0.080	0.030	0.020	0.030	0.050	0.100	13	13	0.020	0.060	0.210	0.072	0.054	0.755	0.0
Nickel	mg/kg	0.5	-	< 0,5	< 0,5	< 0,5	< 0,5	< 0,5	< 0,5	< 0,5	< 0,5	< 0,5	< 0,5	< 0,5	< 0,5	< 0,5	13	0	0	< 0.5	< 0.5	<0,5	-	-	0.0
Selenium	mg/kg	0.2	-	< 0,2	< 0,2	< 0,2	< 0,2	0.2	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	0.2	13	2	0.2	0.2	0.2	0.2	-	-	0.0

[1] Canadian Food Inspection Agency Guidelines for Contaminants and Toxins in Fish and Fish Products (2007).

(grey box) Exceed CFIG Critera

ESLU = *Esox lucius* (Northern pike)

CACO = *Catostomus commersoni* (White sucker)

COAR = *Coregonus artedi* (cisco)

3.2 Sediment Quality

The physicochemical characteristics of the sediment samples are given in Table 3.7 (Laboratory Certificates are presented in Appendix II). Relevant sediment guidelines for the Minago Project include the *Canadian Sediment Quality Guidelines for the Protection of Aquatic Life* (CCME, 2002).

The *Canadian Sediment Quality Guidelines for the Protection of Aquatic Life*, which includes the Interim Freshwater Quality Guidelines (ISQGs) and the Probable Effect Levels (PELs), provide a flexible interpretive tool for evaluating the toxicological significance of sediment chemistry data, as well as for prioritizing actions and management decisions (CCME, 2002). Sediment chemical concentrations below the ISQGs are not expected to be associated with any adverse biological effects; however, concentrations above the PELs are expected to be frequently associated with adverse biological effects. Chemical concentrations between the ISQGs and PELs represent the range in which effects are occasionally observed. These two values provide practical means to characterize sites as of minimal, potential, or significant toxicological concern in order to focus further investigations.

The results show that particle size distribution was dominated by silt (0.0032 to 0.08 mm) with 49.6% followed by 27.5% of coarse sand (0.160 to 2.5 mm) and, in a smaller proportion, fine sand (0.080 to 0.160 mm) with 12.4%. Although surface water pH was basic as shown in Table 3.1; sediment pH on the other hand was acidic to neutral-basic (6.6 – 8.2) with a neutral mean of 7.3 ±0.5. Total organic carbon content in sediments ranges from 0.5 to 31 % with a mean value of 10.7 ± 9.8 %. Highest values were observed in the Minago River, Hill Lake, Limestone Bay and Oakley Creek, indicating a potential deleterious effect on benthic invertebrates according to Hyland *et al*. (2000).

In 2006, the average total organic carbon (TOC) content at the sampling stations in Oakley Creek ranged from a minimum of 4.5% to a maximum of 17.7%, which is similar to what was observed in 2011. In 2008, at Minago, TOC values were in most cases under 4% and sediment quality did not appear to be a limiting factor for the viability of benthic communities. Limestone Bay and Oakley Creek had TOC concentrations ranging from 19.4 to 23.3%.

Total organic carbon (TOC) has a major influence on both the chemical and biological processes that take place in sediments. The amount of organic carbon influences the redox potential in sediments, thus regulating the behaviour of other chemical species such as metals. Since organic matter is a primary source of food for benthic organisms, it is important in maintaining a viable ecosystem. However, too much organic matter can lead to the depletion of oxygen in the sediments and overlying water, which can have a deleterious effect on benthic and fish communities (Hyland *et al*., 2000).

Metals and metalloids content in sediments exceeded the ISQGs for chromium (37.3 mg/kg) at 6 out of 10 stations and the PELs for lead (91.3 mg/kg) at one station (CLF-1). In 2008, chromium contents were exceeding the CCME criteria only at MRF3. At that station, chromium was still of concern in 2011. Total chromium also exceeded ISQGs in 2006 and 2007; average chromium levels were higher than the ISQGs at OCW-1, OCW-2, OCW-3 and MRW-1 in 2006 while in 2007, chromium concentration exceeded the ISQGs at MRW2 only.

As explained in the EIA report issued in May 2010, chromium exists in two oxidation states in aquatic systems: hexavalent Cr (i.e., Cr^{6+}) and trivalent Cr (i.e., Cr^{3+}). Independent assessments of the potential for toxicity of Cr^{6+} and Cr^{3+} in the Canadian environment were carried out according to the *Canadian Environmental Protection Act* (CEPA) and showed that dissolved and soluble forms of Cr^{6+} may have a harmful effect on the environment (Government of Canada, 1994). However, for Cr^{3+}, the CEPA assessment reported that it was not possible to determine whether dissolved and soluble forms were entering the Canadian environment according to the above conditions (Government of Canada, 1994).

The majority of the data used to derive ISQGs and probable effects levels (PELs) for Cr are from studies on field-collected sediments that measured concentrations of Cr, along with concentrations of other chemicals, and associated biological effects, as compiled in the Biological Effects Database for Sediments (BEDS) (Environment Canada, 1998). In most studies that evaluated the distribution of Cr in the environment, only total Cr was measured; little information was provided on the species of Cr present in the sediment. However, results of recent studies in Canada and other countries, indicate that Cr^{6+} is the dominant form in the dissolved phase, whereas nearly all of the Cr in sediments (excluding that immediately below the sediment–water interface with overlying aerobic waters) is likely present in the any given site cannot be predicted conclusively from the physicochemical characteristics of the sediments or the attributes of endemic organisms (Environment Canada, 1998).

No previous exceedance of lead content was previously reported in the EIA report. Since only one sample showed concentration higher than what was recorded at all the other stations, possible cross-contamination is probable.

Table 3.7 Sediment Quality

Parameters	Units	Method detection limit	Manitoba Water Quality Standards, Objectives and Guidelines (Williamson, 2002)[1] Tier II: Water Quality Objectives	Tier III: Water Quality Guidelines - Freshwater Aquatic Life	Canada: Surface water quality criteria for the protection of aquatic life (CCME) [2]	Canada - CCME [3] Sediment Quality Guidelines for the protection of aquatic life: Interim freshwater sediment quality guidelines (ISQGs)	Probable Effect Level (PEL)	Stations – Minago River Watershed: MRW2x	MRF3	CLF1	DLF1	HLF1	William River Watershed: LBF1	WRF3	WRF2	OCF1	OCF2	Descriptive statistics: N	N>LD	Min	Med	Max	Mean	SD	CV (%)	% over criteria
Station characteristics																										
Sampling site								Minago River	Minago River	Cross Lake	Drunken Lake	Hill Lake	Limestone Bay	William River	William River	Oakley Creek	Oakley Creek									
Certificate of analysis number								P30822	P30892	P30895	P30894	P30893	P30900	P30898	P30899	P30897	P30896									
Sample number								MRW2x	MRF-2	CLF-1	DLF-1	HLF-1	LBF-1	WRF-1	WRF-2	OCF-1	OCF-2									
Date of sampling								2011-10-17	2011-10-13	2011-10-20	2011-10-15	2011-10-14	2011-10-18	2011-10-19	2011-10-15	2011-10-17	2011-10-18									
UTM (Nad83, Zone 14) East								472487	488350	555217	538454	502122	503939	485184	498511	489287	487441									
UTM (Nad83, Zone 14) North								6001200	6005312	6046016	6042796	6012943	5969147	5973787	5986566	5990512	5990957									
***In situ* measurements (Surface water)**																										
Depth of the station	meters	-	-	-	-	-	-	0,88	0,25	4,35	2,10	1,80	1,84	0,59	1,88	0,31	1,43	10	-	0,3	1,6	4,4	1,5	1,2	78%	0%
Sample collection depth	meters	-	-	-	-	-	-	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	10	-	0,2	0,2	0,2	0,2	0,0	0%	0%
Dissolved oxygen	mg/l	-	Varies 3,0 to 6,5[A]	-	<5,5-9,5[B]	-	-	10,45	10,07	12,53	9,79	9,99	11,80	12,60	11,46	11,93	11,1	10	-	9,8	11,3	12,6	11,2	1,1	9%	0%
Dissolved oxygen	%	-	-	-	-	-	-	82,0	88,4	97,6	86,0	87,7	89,3	89,4	93,2	92,9	86,1	10	-	82,0	88,9	97,6	89,3	4,4	5%	0%
Water temperature	°C	-	-	-	narrative[C]	-	-	5,0	9,7	4,8	9,7	9,8	3,7	1,3	6,4	4,7	4,5	10	-	1,3	4,9	9,8	6,0	2,9	49%	0%
Conductivity	µS/cm	-	-	-	-	-	-	284	229	164	159	212	193	286	224	246	260	10	-	159,0	226,5	286,0	225,7	44,9	20%	0%
pH	pH units	-	6,5 - 9,0	-	6,5 - 9,0[D]	-	-	7,94	7,75	8,04	7,86	7,86	8,05	8,48	7,88	7,93	7,91	10	-	7,8	7,9	8,5	8,0	0,2	3%	0%
Turbidity	NTU	-	-	-	-	-	-	3,76	1,62	21,56	13,25	1,06	19,11	3,35	8,06	0,32	0,62	10	-	0,3	3,6	21,6	7,3	8,0	110%	0%
Particle size distribution (Sediments)																										
< 0,0032 mm clay	%	-	-	-	-	-	-	15,1	7,7	0,4	0,0	3,7	0,8	29,6	23,4	24,1	7,6	10	-	0,0	7,7	29,6	11,2	11,1	98%	0%
0,0032 to 0,080 mm silt	%	-	-	-	-	-	-	66,4	62,5	9,3	45,7	32,2	6,8	54,6	64,4	32,5	53,5	10	-	6,8	49,6	66,4	42,8	21,9	51%	0%
0,080 to 0,160 mm fine sand	%	-	-	-	-	-	-	8,6	13,5	12,2	12,5	14,5	13,9	7,2	8,5	0,7	18,4	10	-	0,7	12,4	18,4	11,0	4,9	45%	0%
0,160 to 2,5 mm coarse sand	%	-	-	-	-	-	-	9,7	16,1	58,5	40,1	42,2	76,4	8,2	3,6	38,0	17,0	10	-	3,6	27,5	76,4	31,0	24,1	78%	0%
2,5 mm to 14 mm gravel	%	-	-	-	-	-	-	0,2	0,2	12,8	1,7	5,1	2,1	0,4	0,1	4,5	3,5	10	-	0,1	1,9	12,8	3,1	3,9	127%	0%
>14 mm stones	%	-	-	-	-	-	-	0,0	0,0	6,8	0,0	2,3	0,0	0,0	0,0	0,2	0,0	10	-	0,0	0,0	6,8	0,9	2,2	235%	0%
Organic compounds (Sediments)																										
pH	pH units	-	-	-	-	-	-	6,80	6,60	8,24	6,84	6,93	7,47	7,60	7,54	7,67	6,91	10	-	6,6	7,2	8,2	7,3	0,5	7%	0%
Total organic carbon	mg/kg	500	-	-	-	-	-	120 000	97 000	5 100	43 000	230 000	310 000	29 000	27 000	66 000	140 000	10	10	5100,0	81500,0	310000,0	106710,0	97945,4	92%	0%
Total organic carbon	%							12,0	9,7	0,5	4,3	23,0	31,0	2,9	2,7	6,6	14,0	10	10	0,5	8,2	31,0	10,7	9,8	92%	0%
Total sulphur	mg/kg	100	-	-	-	-	-	1 600	1 000	< 100	900	3 500	1800	600	300	1 200	5 100	10	9	300,0	1200,0	5100,0	1777,8	1553,8	87%	0%
Total sulphur	%	0,01	-	-	-	-	-	0,16	0,10	< 0,01	0,09	0,35	0,18	0,06	0,03	0,12	0,51	10	9	0,0	0,1	0,5	0,2	0,2	87%	0%
oil and total grease	mg/kg	100 - 200 - 300	-	-	-	-	-	190	270	< 100	130	770	< 300	590	150	270	590	10	8	130,0	270,0	770,0	370,0	243,5	66%	0%
Hydrocarbons $C_{10}C_{50}$	mg/kg	80 -100 - 200	-	-	-	-	-	< 100	< 200	< 100	< 100	400	400	150	< 100	< 100	< 200	10	3	150,0	400,0	400,0	316,7	144,3	46%	0%
Loss by ignition (dry weight) (550°C)	% (g/g)	0,2	-	-	-	-	-	8,9	6,0	0,8	4,1	8,6	7,8	4,2	4,4	7,5	9,8	10	10	0,8	6,8	9,8	6,2	2,8	45%	0%
Metals and metalloids (Sediments)																										
Aluminium	mg/kg	20	-	-	-	-	-	16 000	21 000	6 400	13 000	11 000	1 600	14 000	14 000	13 000	4 700	10	10	1600,0	13000,0	21000,0	11470,0	5754,2	50%	0%
Antimony	mg/kg	2	-	-	-	-	-	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	10	0	< 2	< 2	< 2	< 2	-	-	0%
Arsenic	mg/kg	2	-	-	-	5,9	17	2	5	< 2	3	2	< 2	2	2	2	< 2	10	7	2,0	2,0	5,0	2,6	1,1	44%	0%
Baryum	mg/kg	5	-	-	-	-	-	120	150	43	99	90	43	100	95	110	79	10	10	43,0	97,0	150,0	92,9	32,6	35%	0%
Beryllium	mg/kg	0,5	-	-	-	-	-	0,7	1,0	< 0,5	0,6	0,5	< 0,5	0,6	0,7	0,6	< 0,5	10	7	0,5	0,6	1,0	0,7	0,2	24%	0%
Boron	mg/kg	5	-	-	-	-	-	14	17	5	9	24	9	11	10	11	11	10	10	5,0	11,0	24,0	12,1	5,2	43%	0%
Calcium	mg/kg	30	-	-	-	-	-	22 000	29 000	28 000	10 000	43 000	18 000	48 000	39 000	39 000	23 000	10	10	10000,0	28500,0	48000,0	29900,0	12096,4	40%	0%
Cadmium	mg/kg	0,2	-	-	-	0,6	3,5	<0.2	<0.2	<0.2	0,2	0,3	< 0,2	<0.2	<0.2	<0.2	<0.2	10	2	0,2	0,3	0,3	0,3	0,1	28%	0%
Chromium	mg/kg	2	-	-	-	37,3	90	***48***	***60***	27	***43***	34	6	***44***	***42***	***40***	15	10	10	6,0	***41,0***	***60,0***	***35,9***	16,0	45%	60%
Cobalt	mg/kg	2	-	-	-	-	-	12	17	6	12	9	< 2	11	12	11	4	10	9	4,0	11,0	17,0	10,4	3,8	36%	0%
Copper	mg/kg	1	-	-	-	35,7	197	20	21	15	24	28	6	21	19	18	7	10	10	6,0	19,5	28,0	17,9	6,9	39%	0%
Iron	mg/kg	10	-	-	-	-	-	25 000	40 000	13 000	21 000	21 000	4 200	23 000	23 000	21 000	10 000	10	10	4200,0	21000,0	40000,0	20120,0	9686,7	48%	0%
Lead	mg/kg	5	-	-	-	35,0	91,3	11	16	**280**	12	14	< 5	11	11	11	< 5	10	8	11,0	11,5	**280,0**	45,8	94,7	207%	10%
Magnesium	mg/kg	10	-	-	-	-	-	11 000	18 000	7 400	6 200	17 000	3 900	17 000	19 000	13 000	4 700	10	10	3900,0	12000,0	19000,0	11720,0	5868,1	50%	0%
Manganese	mg/kg	2	-	-	-	-	-	510	1 000	170	410	310	300	360	910	720	310	10	10	170,0	385,0	1000,0	500,0	281,9	56%	0%
Mercury	mg/kg	0,05	-	-	-	0,17	0,486	< 0,05	< 0,05	< 0,05	0,06	0,10	< 0,05	< 0,05	< 0,05	< 0,05	0,12	10	3	0,1	0,1	0,1	0,1	0,0	33%	0%
Molybdenum	mg/kg	2	-	-	-	-	-	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	10	0	< 2	< 2	< 2	< 2	-	-	0%
Nickel	mg/kg	1	-	-	-	-	-	30	39	28	28	25	4	31	28	27	9	10	10	4,0	28,0	39,0	24,9	10,5	42%	0%
Potassium	mg/kg	10	-	-	-	-	-	2 400	3 500	1 400	2 600	2 000	270	2 700	2 700	2 200	510	10	10	270,0	2300,0	3500,0	2028,0	1019,5	50%	0%
Selenium	mg/kg	10	-	-	-	-	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	10	0	< 10	< 10	< 10	< 10	-	-	0%
Silver	mg/kg	2	-	-	-	-	-	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	10	0	< 2	< 2	< 2	< 2	-	-	0%
Sodium	mg/kg	10	-	-	-	-	-	190	320	130	210	220	68	180	230	180	83	10	10	68,0	185,0	320,0	181,1	73,9	41%	0%
Tin	mg/kg	5	-	-	-	-	-	< 5	< 5	< 5	< 5	14	< 5	< 5	< 5	< 5	< 5	10	1	<5	<5	14,0	<5	-	-	0%
Vanadium	mg/kg	5	-	-	-	-	-	35	46	20	37	29	< 5	36	35	32	9	10	9	9,0	35,0	46,0	31,0	10,8	35%	0%
Zinc	mg/kg	5	-	-	-	123	315	65	89	28	69	89	16	54	59	58	29	10	10	16,0	58,5	89,0	55,6	24,8	45%	0%

Bold - italic Value exceeding Criteria for the protection of aquatic life - Sediments (ISQGs)

[Shaded] Probable Effect Level (PEL) - Sediments (ISQGs)

[1] Williamson, D.A. 2002 draft. Manitoba Water Quality, Standards, Objectives, and Guidelines. Manitoba Conservation Report No. *2002-11*, Manitoba Conservation.
[2] Canadian Council of the Ministers of Environment. 2006. Canadian Guidelines for the Protection of Environment.
[3] Canadian Council of the Ministers of Environment. 2002. Canadian Sediment Quality Guidelines for the Protection of Aquatic Life.

aa Substance has been re-evaluated since CCREM 1987 + Appendixes. Either a new guideline has been derived or insufficient data existed to derive a new guideline.
Dissolved oxygen for warm-water biota:
early life stages = 6 mg/L
other life stages = 5,5 mg/L
for cold-water biota: early life stages = 9,5 mg/L
other life stages = 6,5 mg/L

bb Dissolved oxygen concentrations should not be inferior to the following values:

Temper. °C	Dissoved oxygen concentration – Cold waters: % Saturation	Warm waters: mg/L
0	54	7
5	54	6
10	54	5
15	54	5
20	57	4
25	63	4

In waters inhabited by sensitive biological communities, the presence of an additional physical or chemical stress may necessitate the use of more restrictive limits.
In hypolimnion waters, natural dissolved oxygen concentrations are sometimes smaller than the ones mentioned above. This state should not be aggravated by the addition of biodegradable substances.

cc Temperature:
Thermal Stratification: Thermal additions to receiving waters should be such that thermal stratification and subsequent turnover dates are not altered from those existing prior to the addition of heat from artificial origins.
Maximum Weekly Average Temperature: Thermal additions to receiving waters should be such that the maximum weekly average temperature is not exceeded.
Short-term Exposure to Extreme Temperature: Thermal additions to receiving waters should be such that the short-term exposures to maximum temperatures are not exceeded. Exposures should not be so lengthy or frequent as to adversely affect the important species.

dd Any increase in temperature should not :
- modify water temperature of a river or lake section so that a movement of present or potential aquatic populations becomes predictable;
- alter sensitive areas such as a spawning area;
- kill living organisms near the discharge area.
- Furthermore, the area should not suffer any sharp temperature changes caused, for example, by a sudden warm discharge during the cold season.

3.3 Benthic Invertebrate Community

A total of 132 taxa of benthic invertebrates were identified within the study area by Laboratoires SAB Inc. (Appendix III). Five phyla were identified including Porifera, Nematoda, Mollusca, Annelida and Arthropoda. Results are depicted in Tables 3.8 and 3.9. At each station, all subsamples were used to calculate those results. Station WRF3 is associated with the highest abundance (953 specimens) while OCF2 has the lowest with only 277 specimens.

3.3.1 Taxonomic Richness

The mean taxonomic richness in the entire study area is 47.83 ± 4.17 species by stations (Table 3.8). The lowest value was found at WRF2 (42); similar results were measured at OCF1 and OCF2 with 53 and 51, respectively. In comparison with results gathered in 2008, taxonomic richness values are higher; however, the Simpson's diversity index is more appropriated for such comparison since it also accounts for density.

3.3.2 Density and Relative Abundance (RA)

The mean density was of 9,094.35 ind/m^2 with a very high standard deviation of 35,719.28 ind/m^2 as shown in Table 3.8. As expected, the highest density was found at WRF3 (18,172.80 ind/m^2). Stations OCF1 and OCF2 again showed similar values within the 5,000-6,000 range. The lowest value was found at WRF2 with mean density of 2,793.62 ind/m^2. Within the Minago River watershed, the highest density was found at MRF3 (13,319.79 ind/m^2).

Relative abundances for each species are shown in Table 3.9. The most abundant species considering all stations is the Sphaeriidae *Pisidium* with 38.3% RA at station MRW2X, 21.6% RA at WRF2 and about 15% RA at both Oakley Creek stations; however, it was completely inexistent at MRF3 and almost not present at WRF3. Otherwise, the most abundant species are found in the phylum Arthropoda. The Turbificidae *Limnodrilus* presented the highest relative abundance at station WRF3 with 37.62% RA and 16.04% RA at WRF2, being weakly represented at the other stations. Some genuses, such as *Isocypris* at WRF3 or *Hyallella azteca cx* at MRF3, were almost only identified at one station and were almost inexistent in the other stations. Same for the Trichoptera *Hydroptila* which was present only in Oakley Creek.

In 2008, Sphaeriidae were also well represented at OCF1 with 35.71% RA and at MRF3 with 17.39% RA, but poorly represented at WRF3; similar results were obtained in 2011. Also, Crustaceans RA were as in 2008 almost not represented in most stations while Ephemerides were again the most abundant group among Insects (even if values are significantly higher in 2011). Hydrobiidae was observed at station WRF3 in 2008 with a 19.47% RA, but was not observed at that same station in 2011.

Table 3.8 Descriptive Statistics and Ecological Index – Benthic Invertebrate Community (2011)

General Information						
Stations	MRF3	MRW2X	OCF1	OCF2	WRF3	WRF2
Date	13-10-11	17-10-11	17-10-11	18-10-11	19-10-11	15-10-11
UTM E (NAD83)	488350	472487	489287	487441	485184	498511
UTM N (NAD83)	6005312	6001200	5990512	5990957	5973787	5986566
Total Specimens	698.5	467	319.5	277	953	146.5

Taxonomic Richness	48	44	53	51	49	42
Mean	47.83					
Standard Deviation	4.17					
Median	48.50					
Maximum	53.00					
Minimum	42.00					

Density	13,319.73	8,905.25	6,092.56	5,282.13	18,172.80	2,793.62
Mean	9,094.35					
Standard Deviation	5,719.28					
Median	7,498.90					
Maximum	18,172.80					
Minimum	2,793.62					

Simpson's Diversity Index	0.80	0.81	0.81	0.85	0.82	0.90
Mean	0.83					
Standard Deviation	0.04					
Median	0.82					
Maximum	0.90					
Minimum	0.80					

EPT/EPT+Chironomid Ratio	0.70	0.18	0.77	0.83	0.35	0.55

Bray-Curtis Distance						
STATIONS	MRF3	MRW2X	OCF1	OCF2	WRF3	WRF2
MRF3		0.969	0.975	0.984	0.969	0.966
MRW2X	0.969		0.667	0.726	0.789	0.749
OCF1	0.975	0.667		0.485	0.866	0.723
OCF2	0.984	0.726	0.485		0.899	0.771
WRF3	0.969	0.789	0.866	0.899		0.865
WRF2	0.966	0.749	0.723	0.771	0.865	

Table 3.9 Relative Abundance – Benthic Invertebrate Community

Taxa	STATIONS MRF3	MRW2X	OCF1	OCF2	WRF3	WRF2
	Relative Abundance (%)					
PORIFERA						
Demospongiae						
Spongillidae						
Eunapius fragilis	0,21	0,32	0,16	0,18	0,05	0,34
NEMATODA	0,00	0,00	0,16	0,36	0,21	0,34
MOLLUSCA						
Gastropoda						
Prosobranchia						
Hydrobiidae						
Amnicola limosa	0,00	5,25	0,31	0,00	2,15	3,07
Valvatidae						
Valvata	0,00	0,00	0,16	0,00	0,00	0,00
Pulmonata						
Ancylidae						
Ferrissia	0,07	0,11	0,16	0,00	0,16	3,75
Lymnaeidae						
Galba	0,00	0,00	0,00	0,18	0,00	0,00
Physidae						
Physa	0,00	0,00	0,00	0,00	0,00	0,68
Planorbidae						
Gyraulus	0,00	0,32	0,47	0,36	0,00	0,00
Helisoma anceps	0,00	0,00	0,16	0,36	0,00	0,00
Bivalvia						
Unionidae (juvenile)						
Sphaeriidae						
Pisidium	0,00	**38,33**	15,49	15,16	0,21	21,16
Sphaerium simile	0,00	0,75	0,00	0,00	0,47	0,00
ANNELIDA						
Oligochaeta						
Naididae						
Nais behningi	0,29	0,00	0,00	0,00	0,00	0,00
Nais variabilis	0,07	0,00	0,00	0,00	0,00	0,00
Pristina	0,07	0,00	0,00	0,00	0,00	0,00
Tubificidae						
* Tubificidae (immature w/ capilliform seta)	0,00	0,54	0,00	0,54	0,89	0,00
Limnodrilus	0,00	1,39	0,31	0,18	**37,62**	16,04
Lumbriculidae						
Lumbriculus	0,00	0,00	0,16	1,99	0,00	0,00
Hirudinea						
Glossiphoniidae						
Actinobdella inequiannulata	0,00	0,00	2,66	0,36	0,00	0,34
Glossiphonia complanata	0,00	0,11	0,00	0,72	0,05	0,00
Helobdella stagnalis	0,00	0,00	0,00	1,81	0,00	0,00
Placobdella papillifera	0,00	0,00	0,00	0,18	0,00	0,00
Erpobdellidae						
Erpobdella microstoma	0,00	0,00	0,00	0,00	0,21	0,00
Erpobdella obscura	0,00	0,00	0,31	0,72	0,00	0,00
Erpobdella punctata	0,00	0,00	0,00	0,00	0,31	0,00
ARTHROPODA						
Chelicerata						
Arachnida						
Acari						
Hydryphantidae						
Thyopsis	0,00	0,00	0,00	0,00	0,00	0,34
Hygrobatidae						
Atractides	0,21	0,00	0,00	0,00	0,00	0,00
Hygrobates	0,00	0,00	0,00	0,36	0,00	0,00
Lebertiidae						
Lebertia	0,00	0,00	0,00	0,18	0,00	0,00
Limnesiidae						
Limnesia	0,00	0,00	0,00	0,36	0,00	0,00
Tyrrellia	0,07	0,00	0,00	0,18	0,00	0,00
Mideopsidae						
Mideopsis	0,00	0,54	0,00	0,36	0,21	0,00
Sperchontidae						
Sperchon	1,07	0,00	0,00	0,00	0,00	0,00
Sperchonopsis	0,86	0,00	0,00	0,00	0,00	0,00
Torrenticolidae						
Torrenticola	0,00	0,00	0,00	0,18	0,00	0,00
Unionicolidae						
Neumania	0,00	0,00	0,00	0,36	0,00	0,00
Crustacea						
Copepoda						
Cyclopoida						
Cyclopidae						
Macrocyclops albidus	0,07	0,00	0,00	0,00	0,00	0,34
Ostracoda						
Podocopida						
Candonidae						
Candona	0,00	0,00	0,00	0,18	0,52	0,00
Cyprididae						
Isocypris	0,00	0,00	0,00	0,00	**11,59**	0,34
Malacostraca						
Amphipoda						
Gammaridae						
Gammarus lacustris	0,21	0,00	0,31	0,00	0,16	0,00
Hyalellidae						
Hyalella azteca cx	**27,49**	2,03	0,63	0,18	1,47	3,07
Uniramia						
Insecta						
Odonata						
Anisoptera						
Corduliidae						
Somatochlora	0,07	0,00	0,31	0,18	0,00	0,00
Gomphidae (young stage)	0,00	0,00	0,16	0,00	0,00	0,00
Ophiogomphus	0,00	0,00	0,16	0,00	0,00	0,00
Ephemeroptera						
Baetidae						
Acerpenna pygmaea	**32,93**	0,00	0,00	0,00	0,00	0,00
Baetis	0,21	0,00	0,00	0,00	0,00	0,00
Callibaetis	0,00	1,50	0,00	0,00	0,00	1,37
Caenidae						
Caenis youngi	0,07	0,00	0,00	0,00	0,00	0,00
Caenis	0,29	1,71	**38,65**	11,37	0,68	0,00
Ephemeridae						
Ephemera	0,00	0,00	0,16	0,18	9,08	0,68
Hexagenia	0,07	2,46	2,66	0,00	1,21	8,87
Ephemerellidae						
Eurylophella	0,00	0,11	0,00	1,08	0,00	0,00
Heptageniidae						
Maccaffertium	0,00	0,00	0,00	0,00	0,00	0,68
Leptophlebiidae						
Leptophlebia	4,37	0,11	0,47	0,36	0,00	3,41
Metretopodidae						
Siphloplecton	0,00	0,00	0,47	0,00	0,00	5,12
Plecoptera						
Taeniopterygidae						
Taeniopteryx	0,00	0,00	0,00	0,00	0,00	0,34
Megaloptera						
Sialidae						
Sialis	0,00	0,11	0,00	0,00	0,52	0,00
Hemiptera						
Corixidae						
Hesperocorixa	0,07	0,32	0,00	0,00	0,26	0,68
Sigara	0,07	0,21	0,16	0,00	0,00	1,02

Taxa	STATIONS MRF3	MRW2X	OCF1	OCF2	WRF3	WRF2
	Relative Abundance (%)					
ARTHROPODA (next)						
Trichoptera						
Dipseudopsidae						
Phylocentropus	0,00	0,00	0,00	0,00	0,00	0,34
Hydropsychidae						
Ceratopsyche	4,87	0,00	0,16	0,18	0,00	0,68
Cheumatopsyche	0,43	0,00	0,00	0,00	0,05	0,00
Hydropsyche	0,36	0,00	0,00	0,00	0,00	0,00
Hydroptilidae						
Hydroptila	0,00	0,00	5,16	**30,87**	0,00	0,00
Oxyethira	0,00	0,00	0,94	3,43	0,00	0,00
Lepidostomatidae						
Lepidostoma	0,50	0,00	0,00	0,00	0,00	0,00
Leptoceridae						
Mystacides sepulchralis	0,00	0,00	0,16	0,18	0,16	0,00
Oecetis	0,00	0,11	1,25	0,36	0,42	0,00
Triaenodes melaca	3,65	0,00	0,00	0,18	0,00	0,00
Limnephilidae (young stage)	0,00	0,00	0,16	0,00	0,00	0,00
Anabolia	0,00	0,11	0,31	0,18	0,00	0,00
Limnephilus	0,00	0,21	0,00	0,18	0,00	0,00
Nemotaulius hostilis	0,00	0,21	0,00	0,00	0,00	0,00
Molannidae						
Molanna	0,00	0,00	0,16	0,00	0,00	0,00
Phryganeidae						
Ptilostomis	0,00	0,11	0,16	0,00	0,05	0,00
Polycentropodidae						
Neureclipsis	0,00	0,00	0,00	0,00	0,00	0,68
Nyctiophylax	0,00	0,11	0,00	0,00	0,00	0,00
Polycentropus	0,07	0,11	0,00	0,00	0,00	0,00
Psychomyiidae						
Psychomyia	0,14	0,00	0,00	0,00	0,00	0,00
Lepidoptera						
Crambidae						
Parapoynx	0,00	0,00	0,00	0,00	0,31	0,00
Coleoptera						
Elmidae						
Dubiraphia	0,00	0,32	0,78	2,17	0,00	0,34
Optioservus	0,50	0,00	0,00	0,00	0,00	0,00
Gyrinidae						
Gyrinus parcus	0,00	0,11	0,16	0,00	0,00	0,34
Chrysomelidae						
Donacia	0,00	0,00	0,00	0,00	0,05	0,00
Diptera						
Nematocera						
Ceratopogonidae						
Bezzia \ Palpomyia	0,00	0,54	0,16	1,44	0,31	0,00
Culicoides	0,00	0,11	0,00	0,00	0,73	0,34
Dasyhelea	0,00	0,00	1,41	0,00	0,00	1,02
Probezzia	0,00	**10,06**	8,76	**10,11**	8,18	4,10
Chironomidae (pupa)	0,14	0,00	0,00	0,00	0,00	0,00
Chironomidae (larva)						
Tanypodinae						
Ablabesmyia	0,00	0,00	0,31	0,00	0,31	0,00
Clinotanypus	0,00	0,75	0,00	0,00	1,68	0,00
Conchapelopia \ Helopelopia	3,08	0,21	0,00	0,00	0,16	0,00
Larsia	0,00	0,00	0,63	1,44	0,42	0,00
Procladius	0,00	9,21	4,69	0,00	1,63	0,68
** Thienemannimyia gr (w/ bifid segmented seta)	1,00	0,00	0,31	0,00	0,00	0,00
Chironominae						
Chironomini						
Cryptochironomus	0,00	0,75	1,25	2,89	0,26	0,00
Demicryptochironomus	0,00	0,00	0,00	0,00	0,05	0,00
Dicrotendipes	0,07	0,96	0,47	0,36	0,00	0,34
Einfeldia	0,00	0,00	0,00	0,00	0,94	0,00
Glyptotendipes	0,00	0,00	0,00	0,00	0,00	0,34
Microtendipes	0,07	0,54	0,47	0,54	2,41	0,00
Paralauterborniella	0,00	0,00	0,00	0,00	2,36	0,00
Phaenopsectra flavipes	0,00	1,50	0,00	0,00	0,00	0,00
Polypedilum (Polypedilum)	0,00	0,00	0,00	0,00	0,00	0,68
Polypedilum (Tripodura)	0,00	0,54	0,63	1,26	6,45	2,73
Stictochironomus	0,00	0,43	0,16	0,00	0,00	0,00
Tribelos jucundus	0,00	**15,31**	0,47	1,26	0,26	0,34
Tanytarsini						
Micropsectra	0,43	0,00	0,00	0,00	0,47	0,00
Neostempellina	0,00	0,00	0,00	0,36	0,00	0,00
Paratanytarsus	1,36	0,00	0,00	0,00	0,00	0,00
Rheotanytarsus	2,79	0,00	0,00	0,00	0,00	0,00
Tanytarsus	0,00	0,00	4,38	1,81	0,00	0,34
Orthocladiinae						
Brillia	0,00	0,00	0,00	0,00	0,89	9,22
Cricotopus (Cricotopus)	5,58	0,00	0,00	0,00	0,00	0,00
Epoicocladius	0,00	0,00	0,31	0,00	2,83	0,68
Eukiefferiella						
Heterotrissocladius	0,00	0,00	0,31	0,00	0,31	0,00
Parachaetocladius	0,07	0,00	0,00	0,00	0,00	0,00
Parakiefferiella	0,36	0,00	0,00	0,00	0,00	0,00
Parametriocnemus	0,64	0,00	0,00	0,00	0,05	0,00
Tvetenia	0,93	0,00	0,00	0,00	0,00	0,00
Diamesinae						
Potthastia longimana gr	0,00	0,00	0,31	0,18	0,00	0,00
Dixidae						
Dixa	0,00	0,43	0,00	0,00	0,00	0,00
Dixella	0,00	0,43	0,00	0,00	0,00	0,00
Simuliidae						
Simulium	3,51	0,00	0,00	0,00	0,00	0,00
Tipulidae						
Dicranota	0,00	0,00	0,63	0,18	0,00	0,00
Limnophila	0,00	0,00	0,00	0,00	0,00	2,05
Pilaria	0,00	0,64	0,00	0,00	0,10	1,02
Tipula	0,07	0,00	0,00	0,00	0,00	0,00
Brachycera						
Empididae						
Hemerodromia	0,14	0,00	0,31	1,44	0,00	0,34
Roederiodes	0,21	0,00	0,00	0,00	0,00	0,00
Tabanidae						
Chrysops	0,00	0,00	0,00	0,36	0,05	1,37
Total taxa 132 — Total	**100,00**	**100,00**	**100,00**	**100,00**	**100,00**	**100,00**

Bold values are the maximal relative abundance measured for a specific species.

3.3.3 Simpson's Diversity Index

This index considers both the relative abundance and the taxonomic richness so that it provides with a better picture when taxonomic richness values are similar for two different communities. At the study area level, a mean index of 0.83 ± 0.04 was measured. The highest index, 0.90, was calculated at WRF2 while the lowest was at MRF3 with 0.8. Stations MRW2X and OCF1 scored a similar Simpson's index with 0.81; closely followed by WRF2 with 0.82 and OCF2 with 0.85 as given in Table 3.8.

In 2008, sampling size was only 20% of what was sampled in 2011. Moreover, sampling was done in May in 2008 while it was performed in October in 2011. But still, Simpson's indexes are similar from 2008 to 2011, suggesting that benthic invertebrate communities were somehow stable with regards to density and taxonomic richness (Table 3.10).

Table 3.10 Simpson's Diversity Index and EPT/EPT+Chironomid Ratio – 2008 vs. 2011

	Simpson's Diversity Index		EPT/EPT+Chironomid Ratio	
Stations	**2008**	**2011**	**2008**	**2011**
MRF3	0.80	0.80	0.19	0.70
OCF1	0.82	0.81	0.65	0.77
WRF3	0.85	0.82	0.58	0.35

3.3.4 Bray-Curtis Distance

This index enables the evaluation of the ecological difference (distance) between benthic invertebrate communities based on a reference median density. Values range between 0 and 1. Distance between communities in Oakley Creek, namely OCF1 and OCF2, is as expected the smallest with 0.485 as depicted in Table 3.8, i.e. those communities are the most similar with regards to taxonomic composition and one could have expected such results since both stations are located within the same creek. The largest distances were calculated with MRF3, demonstrating that MRF3 is the one community that differs the most from the others. In 2008, MRF3 was closer to OCF1 and WRF3 than in 2011, having distances of 0.672 and 0.845, respectively.

3.3.5 EPT/EPT+Chironomid Ratio

This ecological indicator helps assessing the relative ecosystem health status by evaluating the diversity balance of the community. The group composed by Ephemeroptera, Plecoptera and Trichoptera is known to be more sensitive to environmental disturbances, mostly contamination, than Chironomids which form a more tolerant group (Moisan, 2006). Therefore, the ratio will be higher if the benthic community is healthier (more EPT than Chironomid). In the study area, values range between 0.18 for MRW2X and 0.83 for OCF2.

Highest values were measured in Oakley Creek and at MRF3. The lowest ratios calculated were for William River and MRW2X. These results suggest communities in William River may be more sensitive than those in Minago River.

Higher values were measured in 2011 than in 2008 at MRF3 and OCF1 while lower values were obtained at WRF3, being still consistent with the hypothesis that the William River watershed may be more sensitive than the Minago River watershed.

4 Conclusions and Recommendations

The objectives of the Aquatic Monitoring Program were:

- To establish the baseline condition for the fish community in Oakley Creek and the Minago River;
- To ensure that the utilization of Oakley Creek and the Minago River by transitory species is understood and characterized;
- To develop and implement a monitoring program for selenium that includes an initial baseline sampling of tissue and sediment at the following sites: Oakley Creek, Minago River, William River, Limestone Bay, Hill Lake, Drunken Lake and Cross Lake;
- To initiate an annual sediment sampling at each of those sites for total metal analysis;
- To assess benthic invertebrate communities in order to provide more knowledge on the habitat used by fish communities and to comply with Canada's *Metal Mining Effluent Regulations* (MMER).

A total of 121 fishes were captured during the Fisheries Survey. The tools used are fishing nets, fyke nets, bait traps and electrofishing.. No fish specimen was captured at WRF3 where both fishing net and bait traps were unsuccessful. Among all captured specimens, 84 were from the Minago River watershed and 37 from the William River watershed. Twelve species were identified and the northern pike was the most abundant species, followed by the yellow perch and the smaller brook stickleback.

In comparison with the 2008 Fisheries Survey, four new species were captured including rock bass (*Ambloplites rupestris*), burbot (*Lota lota*), sauger (*Stizostedion canadense*) and cisco (*Coregonus artedi*). Considering that Fisheries Survey took place in mid-October, one would expect to have lake whitefish (*Coregonus clupeaformis*) in the watershed. However, timing could have been late or early considering that spawning period varies from year to year depending on various conditions and therefore one could not confirm the absence of whitefish.

Fish tissue metal content analyses revealed that arsenic (criteria: 3.5 mg/kg), lead (criteria: 0.5 mg/kg), nickel (none) and selenium (none), concentrations were in compliance with the Canadian Food Inspection Agency (CFIA) guideline and some were below the detection limit. Mercury content found in fish tissues exceeded the CFIA criteria of 0.5 mg/kg. Minago River watershed had 9.8% of samples exceeding the CFIA criteria for mercury while in the William River watershed, there was no exceedance.

The *Guidelines for the Consumption of Recreationally Angled Fish in Manitoba* were developed so that the nutritional benefits of consuming fish can be achieved without exceeding safe mercury concentrations levels. According to those guidelines, both watersheds (William and Minago rivers) would be considered as within Consumption Category 1 (less than or equal to 0.2 µg/g of mercury in fish fillet; Manitoba Water Stewardship, 2012).

Sixty percent (60%) of sediment samples exceeded the ISQGs for chromium and 10% of the samples exceeded the PELs for lead. However, currently, the degree to which Cr will be bioavailable at particular sites cannot be predicted conclusively from the physicochemical characteristics of the sediments or the attributes of endemic organisms (Environment Canada, 1998). Overall, results from the physicochemical characterization of sediments are consistent from 2008 to 2011.

The presence of high concentration of total organic carbon (TOC) in sediments was reported to be naturally occurring in the study area and could represent a limiting factor for aquatic life.

Simpson's Diversity Index were stable from 2008 to 2011, suggesting that benthic invertebrate communities were somehow stable with regards to density and taxonomic richness. The benthic

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