Aquatic Baseline Studies

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Aquatic Baseline Study in the Lalor Lake Area: Fall 2007

Lalor Lake

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AQUATIC BASELINE STUDY IN THE LALOR LAKE AREA:

FALL 2007

Report Prepared for UMA Engineering Ltd.

By

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TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

1.0 INTRODUCTION

North/South Consultants Inc. was retained by UMA Engineering to conduct an aquatic baseline study of Lalor Lake and surrounding waterbodies in the Snow Lake, Manitoba area (Figure 1), for Hudson Bay Minerals Inc. The study objective was to collect baseline information on the aquatic environment in the vicinity of a potential zinc/copper mine near Lalor Lake. A study was designed to collect information on the various components of the aquatic environment, including water quality, sediment quality, phytoplankton, zooplankton, benthic invertebrates, fish communities, metals in fish tissue and fish habitat at Lalor, Maw, Varnson and Tern lakes to support the conduct of an environmental impact assessment, should the decision be made to proceed. A less extensive program, which focused on water and sediment quality, was also conducted at Cook, Squall and Snow Lakes, a small unnamed lake (hereafter referred to as "Unnamed Lake 1") and four low gradient shallow streams.

The following document provides a brief description of the aquatic baseline survey study design, detailed descriptions of sampling and analysis methods, and a description of field observations and analytical results for field studies conducted between September 7 and 15, 2007.

1.1 STUDY AREA

The Study Area for the aquatic baseline study included Lalor, Maw, Varnson, Tern (Figure 2), Cook, Squall and Snow Lakes, Unnamed Lake 1, an unnamed creek (running between Maw and Varnson Lakes, hereafter referred to as "Unnamed Creek 1"), Snow Creek, Tern Creek and a creek flowing between Tern and Ghost Lakes (hereafter referred to as "Tern Ditch") (figures 1 and 3). The Study Area, which is within approximately 10 km of the Town of Snow Lake, is located in the boreal shield ecozone, characterized by a generally cool climate with long cold winters and short warm summers. The vegetation is predominantly coniferous and consists of black spruce, white spruce, tamarack and jack pine while deciduous species include paper birch, trembling aspen and varieties of shrubs. Large areas contain contiguous or isolated wetlands. The bedrock of the area is Precambrian granite (mafic and selfic metavolcanic rocks) overlain with glacial-lacustrine deposits.

2.0 METHODS

The following sections provide detailed descriptions of field sampling methods, parameters measured, laboratory analysis methods, and data analysis methods. Sampling sites were accessed by helicopter and boat. Sampling site locations were recorded as universal transmercator units (UTM) coordinates using a hand-held Garmin eTrex Global Positioning System (GPS) unit. Water depth was measured at each sampling site using a Strike Master Polar Vision hand-held digital sonar SM-5.

2.1 BATHYMETRIC AND SUBSTRATE SURVEYS

2.1.1 Survey Sites

Bathymetric and substrate surveys were conducted in Lalor, Maw, Varnson and Tern Lakes.

2.1.2 Survey Methods

The remote sensing software application QTC VIEW series V (Quester Tangent Corporation) was used to map both the depth and substrate in Lalor, Varnson, and Tern lakes. Depth was manually surveyed in Maw Lake due to its small size. QTC View V is operated in concert with a Sounder Interface Module (Quester Tangent Corporation), a Suzuki ES-2035 (50 kHz) echo sounder (connected to a transducer) and a Trimble Pro XRS differential GPS. QTC View V will rapidly record a series of digitized echo signals to produce a single record, with depth information, along with latitude and longitude with sub-meter precision. Each digitized echo will reflect some degree of distortion caused by the backscatter of an acoustic pulse off different substrate types. The configuration of the sounder parameters in QTC VIEW V was set in order to properly record the first wave of each echo. These include the transmit pulse length (in micro seconds), transmit pulse ring down, depth at end of ring down, attenuate transmit pulse and beam width of the transducer.

Surveys were typically made in broad zig-zag patterns and the track lines were crossed at right angles in certain places as a quality control measure in order to ensure signal types were similar over intersecting points. Areas where the depth was less than approximately 1.3 m were excluded due to limitations associated with the QTC VIEW software settings (minimum depth of 0.8 m) and the physical depth of the transducer in the water (0.5 m).

The majority of Maw Lake was too shallow to effectively operate the QTC system. Therefore, Maw Lake was manually mapped using a hand-held sonar to measure depth and a Garmin eTrex GPS to record location at a number of sites in the lake.

2.1.3 Substrate Composition Validation

Substrate samples were collected at various locations in each lake using an Ekman benthic grab, long metal probing rod, or direct visual observation and qualitatively described in order to provide validation for substrate classification provided during the processing of QTC VIEW V data.

2.2 WATER QUALITY

2.2.1 Sampling Sites

The objective of the water quality sampling programs was to collect *in situ* measurements and samples for analysis in the laboratory at three sites in Lalor, Maw, Varnson, Cook, Snow (narrows area only) and Tern lakes, two sites in Snow Creek, four sites in Squall Lake, and one site in each of Unnamed Lake 1, Unnamed Creek 1, Tern Creek, and Tern Ditch (Table 1 and Figure 4).

2.2.2 Parameters

In situ physical and chemical measurements were collected from each site including:

- pH;
- temperature (°C);
- specific conductance/conductivity (µS\cm);
- turbidity (NTU);
- dissolved oxygen ([DO], mg/L); and
- water depth (m).

Secchi disk depths were also recorded at deep lake sites where the bottom was not visible. Samples of surface water were collected for submission to an accredited analytical laboratory for the parameters indicated in Table 2.

2.2.3 Collection Methods

pH, temperature and conductivity were measured *in situ* using a YSI Model 63 pH/temperature/conductivity meter. Dissolved oxygen was measured using a YSI Model 55A DO meter while turbidity was measured with an Analite 160 Turbidity Meter. Measurements were obtained at 0.5 m intervals at sites where depth was > 1 m or at the surface, mid-depth, and near the bottom at each site where depth was ≤ 1 m.

Secchi disk depth was measured as the average of two measurements: the depth at which a black and white disk lowered into the water from the shady side of the boat was no longer visible; and the depth at which the disk re-appeared when raised from the water column.

Water samples were collected from near the surface at all sites. In addition, samples were collected at depth (0.5 m above the substrate) using a Kemmerer water sampler where *in situ* measurements indicated vertical stratification and depth was sufficient to allow collection of water samples near the sediment-water interface.

Surface water samples were collected by directly submerging sample bottles provided by the analytical laboratory (with the cap on) into the surface water to approximately elbow depth (approximately 30 cm below the surface), removing the cap, allowing the bottle to fill, and retrieving the bottle to the surface. Bottom samples were collected by lowering and filling the Kemmerer at the desired depth, retrieving the sampler to the surface, and transferring the water sample directly into individual sample bottles provided by the analytical laboratory. In the event surface and bottom samples were taken at a site, the sample identification code was followed by the suffix "-S" for surface and "-B" for bottom samples.

Several samples were also collected for analysis of DO in the laboratory to serve as a measure of quality assurance/quality control (QA/QC) for verifying field measurements. Samples were collected from the same depth where an *in situ* measurement of DO was obtained (to provide comparable data) and preserved in accordance with sample processing protocols provided by the analytical laboratory.

Upon collection, preservatives were added to samples as required, as indicated by the analytical laboratory, and the sample bottles were capped and mixed. Samples for analysis of dissolved mercury and dissolved metals/major ions were not filtered in the field and therefore were not preserved (filtering and preservation was done at the analytical laboratory upon receipt of samples). Samples were kept cool and in the dark and shipped to ALS Laboratory Group (Winnipeg, MB) for analysis. All samples were received by the analytical laboratory within the specified 48-hr holding time.

2.2.4 Laboratory Methods

Samples were submitted to ALS Laboratory Group, Winnipeg, MB (an accredited laboratory), for analysis. All analyses were performed using standard methods and laboratory QA/QC procedures.

2.2.5 QA/QC Samples

The water quality sampling program incorporated several QA/QC samples, including collection of triplicate samples and field and trip blanks. Additionally, as indicated below, several samples were collected for laboratory analysis of DO for verification of field measurements.

Triplicate Samples

Triplicate samples were collected in Lalor and Cook Lakes.

Field Blanks

One field blank, labelled as "Ghost Lake" was submitted to the analytical laboratory. Field blanks were prepared by filling one set of sample bottles provided by the analytical laboratory with deionized water (also provided by the analytical laboratory) in the field and treating the blanks in exactly the same manner as actual samples. Field blanks were stored and transported with field samples.

Trip Blanks

One trip blank was submitted to the analytical laboratory during the sampling program. The trip blank was prepared at the analytical laboratory prior to departure for the field program. A full set of sample bottles was filled at ALS Laboratories, Winnipeg, MB with deionized water and preservatives (where appropriate). The trip blank was transported to the field site, using the same handling and transport protocols as for actual samples, and submitted along with samples to the analytical laboratory for analysis. The trip blank was treated similarly to the field blank but the bottles were not opened at any point in the field and thus not exposed to the environment.

Dissolved Oxygen QA/QC Samples

Four samples of surface water (from sites LL-2, ML-2, VL-2, and TL-1) were collected for DO analysis to be conducted at ALS Laboratories. These samples were intended to provide QA/QC for accuracy of the field DO measurements. These samples were stored, transported, and submitted to ALS Laboratories along with the remaining water quality samples.

2.3 SEDIMENT QUALITY

2.3.1 Sampling Sites

Sediment samples were collected for chemical and physical analysis in all lakes and creeks examined in the Study Area. The number and location of sediment quality sites were consistent with

water quality sampling sites (Table 1) except for sites VL-1 and VL-3, where sediment quality was not measured (Figure 5).

2.3.2 Collection Methods

Samples of surficial sediments were collected using an Ekman dredge (0.023 m^2). At the site where a triplicate sample was collected, each grab was separated spatially to ensure that sampling disturbances from one grab did not affect another (i.e., approximately 2 m apart). Acceptable grab samples were retrieved to the surface and water was decanted from the sampler. The upper 5 cm of sediment were sub-sampled with a stainless steel spoon. Sample jars provided by the analytical laboratory were then alternately filled, leaving as little headspace as possible. Samples were kept cool and in the dark and shipped to the analytical laboratory for analysis.

Sampling equipment was rinsed prior to and following sampling at each site or sub-station with water from the sampling site. Qualitative descriptions of the sediments, water depth, and UTM coordinates were recorded at each site.

2.3.3 Parameters

Sediment samples were analysed for metals/metalloids, nutrients, moisture, and particle size.

2.3.4 Laboratory Analysis

All sediment samples were submitted to ALS Laboratories (Winnipeg, MB) for analysis. All analyses were performed using standard methods and laboratory QA/QC procedures.

2.3.5 QA/QC Samples

A QA/QC triplicate sample was taken from the centre of Lalor Lake (LL-2).

2.4 PHYTOPLANKTON

Samples for the enumeration and identification of phytoplankton were collected in conjunction with water quality sampling. Samples were collected from the centre of Lalor (LL-2), Maw (ML-2), Varnson (VL-2), and Tern (TL-1) lakes by directly filling sample bottles provided by the analytical laboratory at approximately 30 cm below the water surface. Samples were then preserved with sufficient quantities of Lugol's solution to form a tea-coloured solution, stored in a dark and cool location, and submitted to ALS Laboratories (Winnipeg, MB) for analysis of algal biomass and taxonomic identification.

2.5 ZOOPLANKTON

2.5.1 Sampling Sites

Samples for the enumeration and identification of zooplankton were collected in conjunction with phytoplankton sampling (i.e., at the same sites).

2.5.2 Collection Methods

Zooplankton samples were collected using a 1.0-m long, 63-µm mesh size conical net, complete with a weighted PVC cod-end attached to a single 0.25-m diameter steel hoop frame. Due to the shallow depths of the lakes in the Study Area, a horizontal tow was performed whereby the net was lowered horizontally at the stern of the boat and pulled along the length of the boat (5.5 m) by a person standing at the bow. Upon retrieval, zooplankton captured in the net were rinsed into the cod-end collecting cup, washed into a labelled sampling jar, and fixed in 10% formalin. Tows were repeated at each site until approximately 100 zooplankton were counted in the sample jar. Samples were then transported to the laboratory at North/South Consultants Inc. in Winnipeg and transferred to 70% ethanol for storage.

2.5.3 Sample Processing and Laboratory Analysis

Zooplankton samples were enumerated and identified to species level where possible by an external taxonomist in Winnipeg, MB. Zooplankton taxonomic references used included: Balcer et al. (1984); Edmondson (1959); Pennak (1978); and Smith and Fernando (1978). Taxonomic names of zooplankton follow the Integrated Taxonomic Information System classification (ITIS 2008). Mature Cladocera and Copepoda were identified to species and enumerated. Immature copepods were classified as immature Cyclopoida or Calanoida. When possible, at least 200 individuals were counted in each sample. Large samples were sub-sampled with a Hensen-Stemple pipette, depending on the density of organisms in each sample. Larger and/or relatively rare specimens were enumerated for the entire sample prior to sub-sampling.

The estimate of abundance for each taxon per tow was calculated as the number of individuals per cubic metre of water (individuals/m^3). Volume of water filtered was estimated by multiplying the net mouth area (= 0.049 m^2) by the sample depth and the number of horizontal tows.

2.6 BENTHIC INVERTEBRATES

2.6.1 Sampling Sites

Six samples were collected for analysis of benthic invertebrate densities and taxonomic identification in each of Lalor, Maw, and Varnson lakes, and three samples were collected from each of Tern Lake and Unnamed Lake 1 (Figure 6). With the exception of Maw Lake which is more

circular, sampling sites were located across the longitudinal axis of each lake to provide a representation of a gradient of habitat conditions.

2.6.2 Collection Methods

Samples of surficial sediment were collected using an Ekman dredge (0.023 m^2). Qualitative descriptions of the sediment and the habitat, UTM coordinates, and water depth were recorded at each site. Each sample was sieved in the boat through a 500 µm mesh, placed in a one litre plastic jar labelled externally and internally, and preserved in 10% formalin. Samples were kept cool and transported to the laboratory at North/South Consultants Inc. for processing.

2.6.3 Sample Processing and Laboratory Analysis

In Winnipeg, samples were sieved using 355 µm mesh, rinsed with water, sorted under a magnifying lamp and transferred to vials containing 70% ethanol. Larger benthic samples (>300 organisms) were divided into subsamples before sorting using a version of the Folsom plankton splitter. For more information on the procedures used to divide benthic samples, please refer to Appendix 1. Invertebrates were counted and identified by an invertebrate taxonomist to Order with exception of Odonata, which were identified to Suborder, and Diptera and Bivalvia, which were identified to Family using the identifications keys of Peckarsky et al. (1990), Clifford (1991), and Merritt and Cummins (1996). Scientific names used throughout this report follow the Integrated Taxonomic Information System (ITIS 2008) classification. Taxonomic names Hydracarina, Sphaeriidae, Diplostraca, and Mysidacea have been changed to Acarina, Pisidiidae, Diplostraca, and Lophogastrida, respectively. Sample processing, taxonomy, and quality assurance were completed in accordance with North/South Consultants Inc. procedures. All nematodes and zooplankton collected were omitted from the analyses.

Benthic invertebrate density was calculated by first correcting for the split fraction and then using the following formula:

$$\text{Individuals}/m^2 = \text{total number of invertebrates in sample (individuals}/0.023\ m^2) \times 43.5$$

2.6.4 QA/QC Samples

Sample processing and invertebrate identification followed the QA/QC procedures outlined in Appendix 2.

2.7 FISH COMMUNITY

2.7.1 Sampling Sites

The fish community was examined in Lalor, Maw, Varnson, and Tern lakes and at a single site in the Unnamed Creek 1.

2.7.2 Collection Methods

Fish collections were attempted using a variety of gear types including:

- standard gang index gill nets consisting of six 22.9 m (25 yd) long by 1.8 m (2 yd) deep panels of 38, 51, 76, 95, 108, and 127 mm (1.5, 2.0, 3.0, 3.75, 4.25, and 5.0 inch) twisted nylon stretched mesh;
- experimental "Swedish" gillnet gangs containing three 10.0 m long by 1.8 m deep panels of 16, 20, and 25 mm twisted nylon stretched mesh;
- vinyl coated round minnow traps; and
- seines.

A minimum of one index gill net and one Swedish gill net was set overnight in each lake depending on the size and depth of the lake. Four minnow traps were also set overnight in each of the lakes. A seine was used to sample Unnamed Creek 1 and to supplement gillnet and minnow trap catches to achieve the sample size required for the examination of metals in fish tissue (see Section 2.8). Fish collections were conducted under scientific collection permit number 45-07 issued by the Manitoba Water Stewardship Aquatic Ecosystem Section.

Fishing effort was distributed evenly throughout each lake. Four minnow traps were placed in various habitats, primarily near shore, and occasionally moved to a new location on the same day. The date and time of deployment and retrieval of gill nets and minnow traps along with UTM coordinates, water depth, depth of sampling gear, and a habitat description were recorded at each site. Locations are shown in Figure 7.

2.7.3 Sample Processing

All captured fish were identified to species, enumerated, measured, and weighed. The sex of each fish was also determined whenever possible.

2.7.4 QA\QC Samples

A small sub-sample of forage fish species captured in each lake was retained for taxonomic verification in the laboratory at North/ South Consultants Inc.

2.8 METAL RESIDUES IN FISH

2.8.1 Sampling Sites

As large-bodied fish were not captured in lakes in the Study Area, concentrations of metals in fish tissues were measured in whole bodies of forage fish collected in Lalor, Maw, Varnson and Tern lakes.

2.8.2 Collection Methods

Fish were collected for the analysis of metal residues during the fish community sampling program described in Section 2.7. The objective of the study was to collect 10 individuals of two large-bodied fish species and submit tissue samples of liver and muscle for analysis of metal residues. However, as large-bodied fish were not captured in any of the lakes, small-bodied species (i.e., forage fish) were retained for analysis. Wherever possible, 20 individual forage fish of two species were collected for analysis for each of Maw, Varnson, Lalor, and Tern lakes.

2.8.3 Sample Processing

Each fish was identified to species, measured (± 0.1 mm), and weighed (± 0.01 g). A ventral incision was made to visually inspect and identify the sex. Individual fish were placed in a labelled Whirlpac® bag and frozen. Laboratory tissue requirements necessitated submission of whole fish rather than samples of liver and muscle for metals analysis. Samples were submitted to Maxxam Analytics Inc. for analysis of metals/metalloids.

2.8.4 Laboratory Analysis

Upon submission to Maxxam Analytics, individual fish were homogenized using a blender and aliquots were digested using nitric acid and peroxide for metals analysis. A separate aliquot of homogenized sample was digested with HNO_3/ HCl and peroxide for analysis of mercury. Metals (except mercury) were analyzed by inductively coupled plasma mass spectrometry (ICPMS) (EPA 6020 modified method). Mercury was analysed by cold vapour atomic absorption (CVAA) (EPA 7471A method). Results were presented as wet weights (w.w.). Note that analytical detection limits varied between samples for the same parameter due to matrix interferences.

2.9 DATA ANALYSIS AND PRESENTATION

2.9.1 Lake Bathymetry and Substrate Mapping

2.9.1.1 Bathymetry

After the collection process, analysis of the acoustic sonar data was conducted using the software QTC IMPACT. The software linked the acoustic survey data and the GPS files to produce geo-

referenced depth data. Geo-referenced depth values were imported into a geographic information system (ESRI ArcGIS®) for mapping.

Once the GPS points were created, a digital shoreline was created of each lake in the Study Area from vector topographic data derived from high-resolution 10 m SPOT panchromatic orthorectified satellite imagery. The shoreline was assigned a depth value of 0 and was then merged with the QTC data. QTC depth values were offset by 0.5 m to correct for the position of the transducer below the water surface. A kriging algorithm was used in ArcGIS® Spatial Analyst to create the contour lines from the geo-referenced depth data. A tolerance distance was set so that the value of each interpolated raster cell was derived from a minimum of five measured depth points. The kriging process produced a continuous depth raster data set which was then converted to a vector depth contour data set. Once the contours were created, they were inspected for anomalies, and a smoothing algorithm was applied (which does not change the data) to produce final contour lines for final cartographic outputs.

2.9.1.2 *Substrate Composition*

The acoustic data set was examined prior to analysis using the full features vector (FFV) editor in IMPACT, and anomalous data were removed. Survey data from Lalor, Varnson, and Tern Lakes along with data collected for a separate project in nearby Bur, Fiddle, and Morris Lakes (Gallagher and Cooley 2008) were analyzed together because the survey settings in QTC VIEW V were similar among the lakes. IMPACT uses Principal Components Analysis (PCA) to reduce 166 variables of the digitized first wave into three principal components. This process allows for easier interpretation of substrate classes. The Automatic Cluster Engine (ACE) was used to classify the PCA-transformed sonar signatures into three natural clusters depicting varying types of lake-bottom substrate. Observation data collected during the survey were used to validate the classes obtained from the unsupervised classification analysis. Once classification was completed, the data set was exported from IMPACT as an ASCII text file complete with geographic coordinates and lake-bed classification information.

ArcGIS® ArcMap was used to map the classified substrate track files. ArcGIS® Spatial Analyst was used to create a raster file, which interpolated a continuous surface of values between the discrete substrate class data points. The raster data set was smoothed using a boundary cleaning algorithm to remove noise relics created by interpolation tool. The interpolated raster substrate map was then converted to a vector polygon file.

2.9.2 Water and Sediment Quality

2.9.2.1 *QA/QC*

Water and sediment quality QA/QC samples (i.e., triplicate samples) were assessed according to standard criteria to evaluate precision and identify potential sample contamination issues (BCMELP 1998). Percent relative standard deviation (PRSD) was calculated for triplicate samples as follows:

PRSD = Standard Deviation (SD) of the triplicate values/Mean of the triplicate values x 100.

Precision of triplicate samples was evaluated using the "rule of thumb" criterion for precision of 18% for triplicate samples (BCMELP 1998). Where one or more of the replicate values were less than five times the analytical detection limit, an analysis of precision was not undertaken, in accordance with guidance provided in BCMELP (1998).

Field and trip blank results were also evaluated for evidence of sample contamination. Values for any parameter that exceeded five times the analytical detection limit were considered to be indicative of sample contamination and/or laboratory error.

Precision of the DO field measurements were assessed by calculating the relative percent mean difference (RPMD) between the laboratory and *in situ* measurements using the formula:

RPMD = (duplicate value 1 – duplicate value 2)/((duplicate value 1 + duplicate value 2)/2) x 100.

Precision of these samples was evaluated using the "rule of thumb" criterion for precision of 25% for duplicate samples (BCMELP 1998).

Additionally, all water and sediment quality data were evaluated qualitatively for potential outliers, and transcription or analytical errors. Where values were encountered that departed considerably from results obtained at the same site during other sampling periods and/or where one replicate sample differed notably from the others, the measurement was flagged as suspect. In these instances, values were verified against analytical laboratory reports for transcription errors and/or requests were made to the analytical laboratory to verify the values through sample reanalysis and/or verification of reporting accuracy.

2.9.2.2 Calculations

In situ and laboratory water quality data were tabulated and several parameters were calculated from these measured values. Calculations included:

Organic Nitrogen: Total Kjeldahl nitrogen (TKN) – ammonia-N.

Total nitrogen (TN): nitrate/nitrite-N + TKN.

Dissolved inorganic nitrogen: ammonia-N + nitrate/nitrite-N

Measurements of dissolved oxygen concentrations were converted to percent saturation values using water temperature measured at each site and their respective elevations.

Light extinction coefficients (K_e) and the depth of the euphotic zone (z_1) (defined as depth at which 1% of surface radiation still remains) were estimated from Secchi disc depths (z_{sd}) using the following relationships:

$K_e = 1.7 / z_{sd}$; and,

$Z_1 = z_{sd} \times 3$ (Cole 1983).

Where means were obtained (e.g., for replicate samples), measurements reported below the analytical detection limits were assigned a value of one half the detection limit.

2.9.2.3 Comparisons to Water and Sediment Quality Objectives and Guidelines

Provincial guidelines and objectives have been generated for many water quality parameters, with the purpose of protecting aquatic biota and wildlife, and various human usages including recreation, drinking, irrigation, and livestock watering. In Manitoba, existing provincial water quality criteria were revised in 2002 (Williamson 2002) and are largely in accordance with national Canadian Council of Ministers of the Environment (CCME) guidelines (CCME 1999).

Water and sediment quality data were compared to the Manitoba Water Quality Standards, Objectives, and Guidelines (MWQSOGs) for the protection of aquatic life (PAL, Williamson 2002), where available, and criteria from other jurisdictions/groups (e.g., CCME), where criteria were not available for Manitoba. A summary of water and sediment quality objectives and guidelines applied for interpretation of data collected in the Lalor Lake Study Area is presented in Appendix 3.

2.9.3 Fish Community

The effort required to capture each species of fish was standardized by calculating the catch-per-unit-effort (CPUE) for each gear type. The total number of each species captured in the Swedish gill nets and minnow traps was divided by the number of hours spent fishing. Swedish gill net CPUE is expressed as the number of fish captured per 30 m net per hour, while minnow trap CPUE is the number of fish captured per hour.

The arithmetic mean and standard deviation, minimum and maximum values of length and weight of fish were calculated. Condition factor (K) was calculated for individual fish after (Ricker 1975) as follows:

$$K = W \times 10^5 / L^3$$

Where W is equal to round weight (g) and L is equal to fork length (mm). Weight-length

relationships were calculated for each species using least squares regression analysis on logarithmically transformed fork lengths and round weights. Weight-length relationships were expressed as follows:

$$Log_{10} W = a + b (Log_{10} L)$$

Where: W = round weight (g);
L = fork length (mm);
a = Y- intercept; and
b = slope of the regression line.

2.9.4 Metal Residues in Fish

Metal residues of whole-bodied forage fish were compared to Manitoba aquatic life tissue residue guidelines for human consumers (Williamson 2002). There are three applicable guidelines as follows:

- Arsenic: 3.5 µg/g;
- Lead: 0.5 µg/g; and
- Mercury: 0.5 µg/g.