Oliver Creek Watershed Assessment Report

LAKEHEAD REGION
CONSERVATION AUTHORITY

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2016

PREPARED BY:

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The Lakehead Region Conservation Authority would like to acknowledge the residents of the Oliver Creek watershed who allowed Lakehead Region Conservation Authority staff access to their property and who were eager to share valuable information about the condition and health of Oliver Creek.

The 2016 Oliver Creek Watershed Assessment was prepared by Scott Drebit, GIS Technician/Planner of the Lakehead Region Conservation Authority. Simon Shankie, Watershed Manager of the LRCA, also provided guidance, input and revisions towards the completion of this report. Gene Kent, Special Projects Coordinator of the LRCA, assisted with identification and sampling of the soils, and completed the section on Geology.

This report has been prepared in-house at the Lakehead Region Conservation Authority for internal purposes to document the condition of the Oliver Creek watershed in 2016.

EXECUTIVE SUMMARY

The Oliver Creek watershed is located within the Municipality of Neebing and Municipality of Oliver Paipoonge. The watershed covers a drainage area of approximately 47.8 square kilometres. Oliver Creek is approximately 29.9 kilometres in length and is a meandering creek, which travels from Oliver Lake into the Kaministiquia River. The gradient is steep in the upper reaches (within the first 2.0 kilometres) then the creek valley gradually widens until a flatter lowland area is reached. The general slope of the watershed is 0.78 percent.

The majority of the Oliver Creek watershed is privately owned land (84.8 percent) and the remainder is Crown land (15.2 percent). The watershed is mainly designated as either Rural or Agricultural land use by the Official Plans of the Municipality of Neebing and Municipality of Oliver Paipoonge.

The surficial geology distribution of the Oliver Creek watershed changes from bedrock (36.9 percent) in the headwaters area of Oliver Lake, to talus slopes (7.4 percent) on the edge of the highlands, with moraine (24.7 percent), glaciolacustrine plain (30.9 percent) immediately southeast of Highway 588 and alluvial (0.1 percent) at the confluence of Oliver Creek at the Kaministiquia River.

The bedrock formation is mostly composed of sedimentary rocks (56.8 percent), but there are also mafic and related intrusive rocks (43.2 percent).

The Oliver Creek watershed is composed of eight different soil types. The most abundant soil type is silt loam, which covers 15.9 square kilometres (35.1 percent) of the watershed. Moderately course sandy loam is the second most abundant, covering 15.7 square kilometres (34.5 percent) of the watershed. Rock is the third most abundant, covering 6.3 square kilometres (13.9 percent) of the watershed. The remaining soil is made up of clay, clay loam, fine sandy loam, silty clay loam and organic, which together cover 7.5 square kilometres (16.5 percent).

The Oliver Creek watershed is located within the boundaries of the Great Lakes and Boreal forest regions. The most common tree species in the watershed are white spruce, jack pine, black spruce, balsam poplar and trembling aspen. There are a variety of other plants present in the watershed including ferns, shrubs, herbs, mosses and lichens.

For this report, eight sample sites located within the Oliver Creek watershed were chosen based on a variety of attributes including: accessibility, physical features, land use designation, and proximity to man-made features that may alter water quality, as

well as headwaters used as a base reference. Site 1 was located near the confluence of the Oliver Creek at the Kaministiquia River. Sites 2, 4, 6 and 7 were located on the main channel. Sites 3 and 5 were located on different tributaries. Site 8 was located at Oliver Lake, the headwaters of the watershed.

At each of the eight sample locations, surface water samples and field measurements were collected on June 14 and July 14, 2016. Surface water samples were analyzed by ALS Laboratory Group for conductivity, total dissolved solids, turbidity, total ammonia, nitrate, nitrite, total phosphorus, *Escherichia coli (E. coli)*, total coliforms and a full metal scan. Field measurements taken using a YSI Pro DSS Multi-Parameter Probe included: water temperature, pH, conductivity, turbidity, oxidation-reduction potential and dissolved oxygen. Field and laboratory results were compared to the Ministry of Environment and Climate Change's *Provincial Water Quality Objectives* (PWQO), 1994 and the *Canadian Water Quality Guidelines for the Protection of Aquatic Life: Summary Table*, produced by the Canadian Council of Resources and Environmental Ministers (CCREM), updated 2012. Parameters that exceeded the PWQOs included: phosphorous, *E. coli*, total coliforms, aluminum and iron.

Phosphorus exceeded the PWQO criterion (0.03 mg/L) at Sites 1, 2 and 3. Phosphorus ranged from <0.003 mg/L (Site 8) to 0.24 mg/L (Site 3). The elevated levels of phosphorous may be due to high clay content in the creek, since phosphorus sorption capacity can increase with clay content.

PWQO criterion for *E. coli* bacteria levels below 100 counts per 100 mL of water are considered safe for swimming and bathing. During the June sampling period, Site 7 (108 counts/100 mL) exceeded the criterion. During the July sampling period, Site 3 (687 counts/100 mL) exceeded the criterion. It was noted at Site 7 that a beaver dam was present upstream and a farm was located upstream of Site 3; however, there were no exceedances of *E.coli* at the farthest downstream sample locations.

As there is no current PWQO for total coliforms, results were compared to the pre-1994 PWQO criterion (1,000 MPN/100 mL). Every site in 2016 for both sampling periods exceeded the criterion with the exception of Site 8. The total coliform concentrations in 2016 ranged from 53 MPN/100mL to >2,420 MPN/100 mL for the watershed.

The PWQO criterion for aluminum is 0.075 mg/L. During the June sampling period all sites were above the criterion except for Sites 7 and 8. During the July sampling period, all sites were above except for Site 8. Aluminum concentrations ranged from 0.016 mg/L (Site 8) to 0.331 mg/L (Site 6). These values are typically associated with fine sediments.

All sites were above the PWQO criterion of 0.30 mg/L for iron during both the sampling periods, with the exception of Site 8. Iron concentrations ranged from 0.028 mg/L (Site

8) to 1.510 mg/L (Site 5) for the watershed. Iron exceedances are common in the region, due to natural sources.

The flora and fauna inventory indicated that the Oliver Creek watershed supports a healthy population of diverse plants and animals. The stream banks were stable and showed little signs of erosion. The one bridge located on East Oliver Lake Road was in good and stable condition and all culverts were also in good condition. The culverts at Sites 2 and 3 (C2 and C3) should be monitored in the future as they appear to be deteriorating.

The Oliver Creek watershed was also assessed using the *Guide to Developing Conservation Authority Watershed Report Cards*, 2011. Using this guideline, surface water quality and forest conditions for the Oliver Creek watershed were used to determine a grade for the watershed. Surface water quality maintained a good rating with minimal exceedances of phosphorus and *E. coli* present within the Oliver Creek watershed. Forest condition scored a good rating with high forest coverage and a low percentage of riparian forest cover. Overall the quality of the Oliver Creek watershed in 2016 was determined to be in good health and graded a B based on the surface water quality and a B based on the forest condition.

At the time of sampling in 2016 the Oliver Creek watershed was considered to be in good health.

Upon completion of the 2016 Oliver Creek Watershed Assessment, the following recommendations have been made for consideration:

- Staff and funding permitting, it is recommended that an update to the 2016 Oliver Creek Watershed Assessment be completed in the next five to ten years.
- Benthic analysis indicates water quality over an extended period of time and should be considered for future watershed assessments.
- Additional sampling should be conducted in the spring to observe the water quality differences between high and low flow seasons.
- A copy of this report should be provided to the Municipality of Oliver Paipoonge and the Municipality of Neebing for reference purposes. The Report should be kept on file at the LRCA Administration Office for review by interested parties.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF MAPS

LIST OF APPENDICES

1 INTRODUCTION

The Oliver Creek watershed is located within the Municipality of Neebing and the Municipality of Oliver Paipoonge as shown on Map M-1: Key Plan Map. Areas regulated by the Lakehead Region Conservation Authority (LRCA) and Municipal boundaries can be found on Map M-2: Regulated Areas.

A watershed can be defined as all the land and water within the confines of a drainage divide. In essence, the Oliver Creek watershed consists of all the surrounding land that naturally drains its streams, wetlands and precipitation runoff into the Kaministiquia River which then flows into Lake Superior.

The headwaters of the main branch is initiated by Oliver Lake, which is within the boundaries of the geographic Township of Scoble in the Municipality of Neebing. The watershed covers a drainage area of approximately 47.8 square kilometres. The prevailing soil type throughout the watershed is silty loam and sandy loam. Most of the watershed is dominated by white spruce, white birch, balsam poplar and trembling aspen. The Oliver Creek runs approximately 29.9 kilometres in length and meanders through poorly defined and flat drainage courses, to well defined valleys.

The goal of this report is to document the conditions of the watershed, especially surface water quality, as observed in June and July of 2016. This information will ultimately be used to develop and maintain programs to sustain a healthy ecosystem consistent with the Natural Hazards and Natural Heritage Policies of the Province of Ontario. The main objectives of this assessment report are to:

- Summarize the physical, biological and socio-economic attributes of the watershed;
- Collect surface water quality data;
- Collect field measurements;
- Conduct an inventory of the forest ecosystem and fauna observed within the watershed;
- Conduct an inventory of soil, streambed substrate and stream bank cover observed within the watershed;
- Document active erosion sites;
- Document the physical condition of all Oliver Creek water crossings (bridges/culverts); and
- Interpret results to record the health status of the watershed

2 BACKGROUND

2.1 Physical Attributes

2.1.1 Topography

Oliver Creek originates in the area southwest of Candy Mountain and Knob Hill. A large Logan diabase sill forms a mesa and topographic high stretching from Stanley Hill southwestward to Oliver Lake. Oliver Creek flows in a northerly direction, joining with the Kaministiquia River approximately 34.0 kilometres upstream from Lake Superior. The highest point in the watershed is approximately 502.7 metres above sea level north of Hunter Lane (308619 N, 5353148 E). The lowest point in elevation can be found near the confluence of the Kaministiquia River and Oliver Creek, at 206.3 metres above sea level (312670 N, 5359560 E). The general slope of the watershed is 0.78 percent. Although the Nor'Wester Mountains form the height of land along the western and southern extremes of the watershed, the northern part of the Oliver Creek watershed consists of a low relief glaciolacustrine lake plain composed of sandy loam deposits (LRCA, 2008). The transition area in between the outcrop ridge and sandy loam soils consists of moraine deposits. Map M-3 illustrates the Oliver Creek watershed topography.

2.1.2 Geology & Soils

2.1.2.1 Bedrock

The Oliver Creek Watershed begins in an area of high elevation bounded by the bedrock
ridges of Candy Mountain and Knob Hill to the east. The southwest edge of the watershed has steep gradients and is bounded by mountains. Most of the watershed area is underlain by Paleo-Proterozoic rocks of the Animikie Group consisting of argillaceous shales of the Rove Formation as well as mudstone, greywacke, argillite and siltstone. These rocks are between 1,600 to 2,200 million years in age. The sedimentary rocks form lowland valleys in the northern portion of the watershed.

Logan Diabase Sills outcrops are found on the southwest side of the watershed. The diabase rocks are about 1,100 million years old, and are both the youngest and hardest (erosion resistant) rocks in the area. These diabase sills form flat top mountains called mesas. The diabase rock, which forms the mesas, were intruded as flat lying magma in between layers of sedimentary rock. The overlying sediments have eroded away over the last billion years leaving the igneous rock exposed along the tops of the mesas. The hard diabase sills form steep talus slopes where erosion has occurred along the edge of the mountains. A broken area of shale regolith can be seen at the base of some of the

mesas; this may form the bedrock interface throughout the watershed. The shale rock and regolith layers are permeable; this means that bedrock source water wells in the area could be affected by groundwater runoff infiltrating into the rock. Figure 1: Rock Formations South of Thunder Bay shows a cross-section of the rock formations which has led to the development of the mesas and valleys in the area south of Thunder Bay. Map M-4 illustrates the Oliver Creek watershed bedrock geology.

2.1.2.2 Surficial Geology & Soils

Most of the underlying sedimentary bedrock in the Oliver Creek Watershed is deeply eroded; the visible geology consists of Holocene Age sediments. The substrates or sediments were laid down as glacial outwash and lake bottom deposits called glaciolacustrine horizons. Map M-5: Surficial Geology is based on the Northern Ontario Engineering Geology Terrain Study (NOEGTS); it details the main types overburden as well as their glacial/fluvial origins. The distribution of surficial layers changes from bedrock (36.9 percent) in the headwaters area of Oliver Creek, to talus slopes (7.4 percent) on the edge of the highlands, with moraine (24.7 percent), glaciolacustrine plain (30.9 percent) immediately southeast of Highway 588 and alluvial (0.1 percent) at the confluence of Oliver Creek at the Kaministiquia River.

The majority of the sediments and soils have been deposited by Oliver Creek and by historical flooding of the area by Glacial Lake Kaministiquia and Glacial Lake Minong. During the time period of 8,000 to 10,000 years ago, thick beds of silt, sand and loam material were deposited on the glacial lake bottom. These lacustrine soils now form the lowlands of the watershed.

Soil logging in this Watershed Assessment Report was completed to test the extent of the NOEGTS soil types; the soil logging was completed using criteria derived from the "Field Guide to the Substrates of Ontario" (MNRF, March 2015). Soil samples were taken and logged using a 1.2 metre soil auger. The depth of the organic layer as well as the depth, composition and characteristics of the A, B and C soil horizons were logged at the eight water sampling sites along Oliver Creek. Map M-6: Soils illustrates the location of the eight soil sampling sites. The majority of soils consist of silty loam with areas of moderately fine loam and minor occurrences of silty clay loam at sites 4 and 5. The provincial layer indicates clay soils in the northern portion of the watershed. Clay soils were not encountered at any of the auger sites 1 to 4; this suggests there may be inconsistencies in the provincial layer.

The soil testing results and photographs of each soil profile are shown in Appendix A: Soil Logging Summary and Photography. The soils do not have a well developed organic layer in the Oliver Creek Watershed. Sites 5 and 6 had a thin organic horizon

averages five to ten centimetres in thickness close to the creek. The "A" horizon soils are generally less than 1 metre in thickness and often transition directly to the "C" horizon, which represents the mineral soils from the last glacial period. Site 1 shows a substrate of a typical moraine. The high percentage of cobbles and sand is typical of ground moraine with some reworking by fluvial processes.

The silty loam and sandy loam underlying the majority of the watershed shown on Map M-6: Soils is a fair characterization of the watershed and has been confirmed by the sampling program.

2.1.3 Climate

The climate of the Oliver Creek watershed is similar to the Thunder Bay region, in that it is a modified continental climate influenced by Lake Superior. From the months of July to March the westerly winds prevail, whereas the easterly winds prevail the remainder of the year (LRCA, 1985). These winds modify the climate of Thunder Bay and the surrounding regions. The mean daily temperatures (degrees Celsius) and precipitation levels (millimetres) were recorded at the Thunder Bay Airport from 1971 to 2000 (Environment Canada, 2016) as shown in Table 2.1-1. This table also summarizes the extreme daily precipitation in millimetres recorded within a 24-hour period and the date it occurred.

Table 2.1-1: Average Monthly Temperature and Precipitation for Thunder Bay, 1971-2000

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temperature												
Daily (degrees Celsius)	-14.8	-12	-5.5	2.9	9.5	14	17.6	16.6	11	5	-3	-11.6
Precipitation												
Total Precipitation (millimetres)	31.3	24.9	41.6	41.5	66.5	85.7	89	87.5	88	62.6	55.6	37.5
Extreme Max. Daily Precipitation (millimetres)	51.6	33.5	41.9	69.3	76.2	49.3	53.8	87.1	131.2	47.8	63	42.7
Date (yyyy /dd)	1956 /20	1951 /26	1957 /14	1954 /30	1971 /24	1947 /04	1973 /27	1973 /19	1977 /08	1968 /09	1973 /21	1948 /05

The average monthly temperatures (degrees Celsius) and precipitation levels (millimetres) were recorded at the Thunder Bay Airport for 2016 (Environment Canada, 2016), as shown below.

Table 2.1-2: Average Monthly Temperature and Precipitation for Thunder Bay, January-July 2016

	Jan	Feb	Mar	Apr	May	June	July
Average Temperature							
Daily (degrees Celsius)	-10.6	-11.0	-3.0	1.1	10.1	14.5	18.6
Precipitation							
Total Precipitation (millimetres)	35.2	41.1	37.9	21.8	51.5	212.7	70.7

The average monthly temperature for the June and July sampling periods was 16.6 degrees Celsius and the average monthly precipitation was 141.7 millimetres. In comparison with the historical data, the 2016 temperature was within 0.8 degrees Celsius of the average for June and July. The 2016 precipitation for June was 127 millimetres higher than the historical average precipitation. The precipitation for July 2015 was 18.3 millimetres less than recorded historical average precipitation. In general, temperatures in June and July were very near normal while received precipitation for June was above average and July was below average.

2.1.4 Hydrology

The Oliver Creek is 29.9 kilometres in length and the watershed covers an area of approximately 47.8 square kilometres, and flows in a general northeasterly direction to its confluence with the Kaministiquia River, approximately 34 kilometres upstream from Lake Superior. The surface water drainage area has been estimated at 2.5 square kilometres and a wetland area of 2.5 square kilometres. There are no provincially significant wetlands within the watershed.

2.2 Biological Attributes

2.2.1 Flora

The Oliver Creek watershed is located within the boundaries of the Great Lakes forest region and the Boreal forest region as shown on the Canada's Forest Regions map (Figure 2). The trees, which comprise the Great Lakes forest region, are primarily white pine, red pine and yellow birch. Although the watershed is geographically located in this forest region, the tree species observed are more indicative of a Boreal forest region, as the trees present are predominantly black spruce, jack pine, white birch and trembling aspen. This discrepancy is likely due to the fact that the watershed is relatively close to the Boreal forest region and mechanisms such as local climate (slope, aspect), site condition (soil characteristics), disturbance regimes and species interaction can affect the species distribution in the area. The coarse scale of the Canada's Forest Regions distribution map is only a basic division of the forest types; there is no discrete line that separates the two zones. Factors such as the ones mentioned above could easily alter forest types, which are located between two zones.

There are a variety of other plant species present in the Oliver Creek watershed including ferns, shrubs, herbs, mosses and lichens. Plant species identified at the sample sites are listed in Appendix B: Common and Scientific Names of Identified Flora and Fauna.

2.2.2 Fauna

The Oliver Creek watershed provides breeding grounds for a variety of wildlife. Species of amphibians, reptiles, and butterflies that have been sighted in the watershed and surrounding area historically and recently are listed below in Table 2.2-1. There is also a complete list of the wildlife observed in the watershed in Appendix B: Common and Scientific Names of Identified Flora and Fauna. The Oliver Creek watershed is part of the Ontario Ministry of Natural Resources and Forestry (OMNRF) Wildlife Management Unit 13 and Fisheries Management Zone 6.

Table 2.2-1 : Common Reptiles, Amphibians, and Butterflies

Species Name	
Common Name	**Scientific Name**
Amphibians and Reptiles	
Blue-Spotted Salamander	*Ambystoma laterale*
Jefferson Salamander	*Ambystoma jeffersonianum*
Snapping Turtle	*Chelydra serpentine*
Western Painted Turtle	*Chrysemys picta bellii*
Eastern Garter Snake	*Thamnophis sirtalis sirtalis*
Eastern Newt	*Notophthalmus viridescens viridescens*
Mudpuppy	*Necturus maculosus*
American Toad	*Anaxyrus americanus*
Boreal Chorus Frog	*Pseudacris maculata*
Gray Tree Frog	*Hyla versicolor*
Green Frog	*Lithobates clamitans*
Mink Frog	*Lithobates septentrionalis*
Northern Leopard Frog	*Lithobates pipiens*
Spring Peeper	*Pseudacris crucifer*
Wood Frog	*Lithobates sylvaticus*
Butterflies	
Juvenal's Duskywing	*Erynnis juvenalis*
European Skipper	*Thymelicus lineola*
Common Branded Skipper	*Hesperia comma*
Long Dash Skipper	*Polites mystic*
Canadian Tiger Swallowtail	*Papilio Canadensis*
Mustard White	*Pieris oleracea*
Cabbage White	*Pieris oleracea*
Clouded Sulphur	*Colias philodice*
Atlantis Fritillary	*Speyeria atlantis*
Northern Crescent	*Phyciodes cocyta*

Table 2.2-1 : Common Reptiles, Amphibians, and Butterflies	
Species Name	
Common Name	**Scientific Name**
Satyr Comma	*Polygonia satyrus*
Mourning Cloak	*Nymphalis antiopa*
Milbert's Tortoiseshell	*Algais milberti*
American Lady	*Vanessa virginiensis*
Painted Lady	*Vanessa cardui*
Red Admiral	*Vanessa atalanta*
White Admiral	*Limenitis arthemis*
Northern Pearly-Eye	*Lethe anthedon*
Common Wood-Nymph	*Cercyonis pegala*
Monarch	*Danaus plexippus*

Source: Ontario Butterfly Atlas & Reptile and Amphibian Atlas, 2015

2.2.3 Species at Risk

Ontario has more than 200 species at risk living in its forests and lakes, all at varying degrees of risk. There are approximately 19 species at risk in the Thunder Bay region that have potential to exist within the Oliver Creek watershed. The surrounding area is considered in addition to the watershed boundary limits, as it is also Boreal forest region, which would allow for movement of individuals in and out of the watershed boundary. Below is a table showing the species at risk in the Thunder Bay region.

Table 2.2-2: Species at Risk		
Species Name		Status of Risk
Common Name	**Scientific Name**	
American White Pelican	*Pelecanus erythrorhynchos*	Threatened
Bald Eagle	*Haliaeetus leucocephalus*	Special Concern
Barn Swallow	*Hirundo rustica*	Threatened
Black Tern	*Chlidonias niger*	Special Concern
Bobolink	*Dolichonyx oryzivorus*	Threatened
Eastern Whip-poor-will	*Antrostomas vociferus*	Threatened
Golden Eagle	*Aquila chrysaetos*	Endangered
Least Bittern	*Ixobrychus exilis*	Threatened
Loggerhead Shrike	*Lanius ludovicianus*	Endangered
Peregrine Falcon	*Falco peregrinus*	Special Concern
Yellow Rail	*Coturnicops noveboracensis*	Special Concern
Lake Sturgeon	*Acipenser fulvescens*	Special Concern
Northern Brook Lamprey	*Ichthyomyzon fossor*	Special Concern
Shortjaw Cisco	*Coregonus zenithicus*	Threatened
American Badger	*Taxidea taxus*	Endangered
Wolverine	*Gulo gulo*	Threatened
Caribou, Boreal population	*Rangifer tarandus*	Threatened
Pitcher's Thistle	*Cirsium pitcheri*	Threatened
Snapping Turtle	*Chelydra serpentina*	Special Concern

Source: Ontario Ministry of Natural Resources and Forestry - Species at Risk in Thunder Bay Region, 2016

2.2.4 Invasive Species

Invasive species are a threat to native plants and animals and can disturb entire ecosystems. They are introduced and spread as a result of movement of people and goods around the world, increased urbanization, improved transportation routes and through recreational activities. Some of the ways invasive species can enter Ontario include:

- All-terrain vehicles
- Aquarium, water garden and pet trades
- Ballast water of ships
- Canals and changes to waterways
- Gardening and landscaping
- Release of live fish and bait
- Transport of topsoil
- Recreational and commercial boating
- Transport of animal carcasses or products made from them
- Transport of raw wood and other forest products

Invasive species that were observed in the Kaministiquia River, Lake Superior or the District of Thunder Bay, Ontario may be present in the Oliver Creek watershed, according to the Canada/Ontario Invasive Species Centre, OMNRF and the Ontario Federation of Anglers and Hunters' Early Detection and Distribution Mapping System, are listed in the table below.

Table 2.2-3 : Invasive Species

Species Name	
Common Name	**Scientific Name**
Chinese Mitten Crab	*Eriocheir sinensis*
Common Reed	*Phragmites australis*
Eurasian Ruffe	*Gymnocephalus cernua*
European Common Reed	*Phragmites australis ssp. australis*
European Flounder	*Platichthys flesus*
Flowering-Rush	*Butomus umbellatus*
Goldfish	*Carassius auratus*
Himalayan Balsam	*Impatiens glandulifera*
Japanese Knotweed	*Reynoutria japonica*
New Zealand Mud Snail	*Potamopyrgus antipodarum*
Purple Loosestrife	*Lythrum salicaria*
Rainbow Smelt	*Osmerus mordax*
Round Goby	*Neogobius melanostomus*
Rusty Crayfish	*Orconectes rusticus*
Spiny Water Flea	*Bythotrephes longimanus*
Three Spine Stickleback	*Gasterosteus aculeatus*
Tubenose Goby	*Proterorhinus marmoratus*

Table 2.2-3 : Invasive Species	
Species Name	
Common Name	**Scientific Name**
White Perch	*Morone Americana*
Yellow Sweet-Clover	*Melilotus officinalis*
Zebra Mussel	*Dreissena polymorpha*

Source: Early Detection & Distribution Mapping System for Ontario, 2015

2.3 Socio-Economic Attributes

2.3.1 Planning & Development Controls

Land Tenure

The majority of the Oliver Creek watershed is privately owned land (84.81 percent). Provincially owned crown land constitutes 15.19 percent. Land ownership in the watershed is illustrated on Map 7: Land Ownership.

Areas of Jurisdiction

The hydrological boundaries of the Oliver Creek watershed fall within the Municipality of Neebing and the Municipality of Oliver Paipoonge. Map 7: Land Ownership, illustrates the location of the Oliver Creek watershed within these areas. Table 2.3-1 below outlines the watershed area within each boundary.

Table 2.3-1: Areas of Jurisdiction within the Oliver Creek Watershed			
Geographic Boundaries	**Total Municipal Area (km^2)**	**Municipal Area within Oliver Creek Watershed (km^2)**	**Municipal Area within Oliver Creek Watershed (%)**
Municipality of Neebing	877.60	29.30	61.22
Municipality of Oliver Paipoonge	350.76	18.56	38.78
Total			**100**

Within the regulated area, the Authority administers the Development, Interference with Wetlands and Alterations to Shorelines and Watercourses O. Reg 180/06 under the Conservations Authorities Act. Areas considered regulated include: Provincially Significant Wetlands and 120 metres adjacent, all watercourses, all land zoned Hazard Land, Use Limitation or Environmental Protection, steep slopes and 15 metres landward and one kilometre lakeward from the 100 year flood level on Lake Superior (i.e. 183.9 metres Geodetic Survey of Canada), as shown on Map 2: Regulated Area. Activities within the approximate regulated area may require a permit from the Authority.

2.3.1.1 Land Use Designation/Zoning

Municipal Official Plans contain long term goals and policies that serve as guidelines for future land use and development. The Oliver Creek watershed is affected by the Municipality of Neebing, and the Municipality of Oliver Paipoonge Official Plan and Zoning by-laws. Land use designations within the Oliver Creek watershed can be found on Map 8: Zoning.

The policies of the Official Plan and all land use designations are implemented through zoning by-laws. Zoning provides an additional level of detail, particularly with respect to the range of permitted uses and any specific conditions which must be satisfied such as buffering, suitable distances between uses and parking requirements.

Within the Municipality of Neebing the Oliver Creek watershed has been zoned as:

- Recreation 1 (S1) Zone
- Rural (R) Zone
- Institutional (I) Zone
- Use Limitation (UL) Zone

The following definitions are taken from the Municipality of Neebing Zoning By-Law No. 860-2010, dated August 2010.

Recreation 1 (S1) Zone

On existing lots of record as of the date of passing of this By-law, no person shall within any Recreation 1 (S1) Zone use any lot or erect, alter or use any building or structure for any purpose except in accordance with the following: Permitted Uses: (1) a recreational dwelling (2) a recreational modular home (3) a guest cottage (4) a bed and breakfast (5) a boat house (6) buildings, structures and uses accessory to the above uses in accordance with Section 2.1.

Rural (R) Zone

No person shall within any Rural (RU) Zone use any lot or erect, alter or use any building or structure for any purpose except in accordance with the following: Permitted Uses: (1) a single dwelling (2) a modular dwelling (3) agricultural use (4) forestry use (5) stables, riding academies (6) watershed management and conservation uses (7) a home occupation (8) a home industry (9) a guest cottage (10) a bed and breakfast (11) mineral exploration(12) wind farms (13) buildings, structures and uses accessory to the above uses in accordance with Section 2.1

Institutional (I) Zone

No person shall within any Institutional (I) Zone use any lot or erect, alter or use any building or structure for any purpose except in accordance with the following: Permitted Uses: (1) a public or private school (2) a cemetery (3) a Federal, Provincial, or Municipal building, garage or office (4) a fire station (5) a church (6) a community hall (7) assembly hall, club or fraternal organization (8) buildings, structures and uses accessory to the above in accordance with Section 2.1 including a restaurant in a community centre.

Use Limitation (UL) Zone

No person shall within any Use Limitation (UL) Zone use any lot or erect, alter or use any building or structure for human habitation. Buildings or structures may be used for the following: Permitted Uses: (1) agricultural use (2) conservation use (3) forestry use (4) watershed management (5) watershed protection (6) public parks (7) outdoor passive recreational uses (8) mineral exploration (9) wind farm (10) dwellings existing on the date of passing of this By-law, and uses, buildings and structures accessory thereto.

Within the Municipality of Oliver Paipoonge the Oliver Creek watershed has been zoned as:

- Paipoonge General Agricultural (PAG) Zone
- Paipoonge Rural (PRU) Zone
- Paipoonge Use Limitation (PUL) Zone

The following definitions are taken from the Municipality of Oliver Paipoonge Zoning By-Law 185-01.

Paipoonge General Agricultural (PAG) Zone

No person shall within any PAG Zone use any lot or erect, alter or use any building or structure for any purpose except in accordance with the following: Permitted Uses: (i) agriculture (ii) forestry (iii) stables, riding academies, dog kennels (iv) watershed management and conservation uses (v) an accessory dwelling unit on a viable farm operation (vi) a staff house on a viable farm operation (vii) a single detached dwelling (viii) an apartment within an accessory building as permitted by subsection (v) above (ix) a home occupation (x) a home industry (xi) buildings, structures and uses accessory to the above uses in accordance with Section 4.1(a).

Paipoonge Rural (PRU) Zone

No person shall within any PRU Zone use any lot or erect, alter or use any building or structure for any purpose except in accordance with the following: Permitted Uses: (i) agriculture (ii) forestry (iii) stables, riding academies, dog kennels (iv) watershed management and conservation uses (v) single detached dwelling (vi) an accessory dwelling to a use listed in (i), (ii), or (iii); (vii) a home occupation (viii) a home industry (ix) buildings, structures and uses accessory to the above uses in accordance with Section 4.1(a).

Paipoonge Use Limitation (PUL) Zone

No person shall within any PUL Zone use any lot for any purpose except in accordance with the following: Permitted Uses: (i) agriculture (ii) conservation (iii) forestry (iv) wildlife management (v) watershed protection (vi) public and private parks (vii) golf course (viii) ski area (ix) other outdoor recreation uses. Other Provisions: No buildings or structures shall be permitted in the Use Limitation (UL) Zone except where such are intended for: (i) flood or erosion control (ii) watercourse protection works (iii) back stabilization projects.

3 METHODS AND MATERIALS

A summary of the sampling techniques used is included in Appendix C: Techniques for Data Collection.

3.1 Site Selection

Eight sites were chosen along the Oliver Creek watershed to assess the overall health of the watershed. Each site was chosen based on its accessibility and its proximity to natural or man-made features that may alter water quality. Site locations can be found on Map M-9: Site Plan.

3.2 Quantitative Assessment

Several parameters were measured to assess surface water quality of Oliver Creek. Surface water samples were collected in laboratory supplied bottles by LRCA staff and summer students and transported on ice, to ALS Laboratory Group, 1081 Barton Street, Thunder Bay, Ontario. An analysis was conducted on the samples to determine conductivity, total dissolved solids (TDS), turbidity, nutrients (ammonia-total nitrogen, nitrate, nitrite and phosphorus), bacteria (*E. coli* and total coliforms) and total metals.

Sampling was conducted on two separate occasions for each site, to enable comparisons and reveal discrepancies. The first data set was collected on June 14, 2016. The second data set was collected on July 14, 2016.

Methodology for water sample collection was based on the Provincial Water Quality Monitoring Network (PWQMN), Ministry of the Environment and Climate Change, protocol. Grab samples were collected away from the stream bank in the main current by wading or by using a reaching pole. Effort was taken to enter the stream downstream of the sampling location in order to disturb as little sediment as possible. Additionally, samples were taken upstream from any water crossings and/or outlet culverts and were taken facing upstream into the current. In cases where current was not detectable (stagnant water) or current was flowing in the opposite direction (influenced by wind direction), samples were still collected facing upstream. Samples were collected at a depth of 0.3 metres below the surface of the water to avoid capturing any floating debris.

ALS Laboratory Group provided five collection bottles for each site to conduct the following tests: routine, nutrient, metal and bacterial analysis. The routine analysis sample bottles and lids were rinsed twice before a true sample was collected. The ALS Laboratory Group pre-charged the nutrient sample bottles with sulfuric acid and the total metals bottles were pre-charged with nitric acid to preserve the samples taken,

and were not rinsed before filling. Bottles for bacterial analysis were also not rinsed as they were pre-charged with sodium thiosulphate preservative and special care was taken not to open the bottle until the true sample was to be filled. All filled sample bottles were transported on ice for delivery to the laboratory.

Field parameters of water temperature, pH, conductivity, dissolved oxygen, salinity, and oxygen reduction potential were measured using an YSI ProDSS multi-parameter water quality sampler at the same time as water sample collection. The following additional field parameters were also measured: air temperature by mercury thermometer, channel width using a measuring-tape reel, channel depth using a weighted measuring tape reel and velocity was measured using a stick, measuring tape, stopwatch and appropriate calculations. Velocity was only measured for water running downstream (not in ponds producing only windblown results). A description of the water quality parameters are attached in Appendix D: Summary of Water Quality Parameters.

3.3 Applicable Criteria

Surface water quality results from the Oliver Creek watershed were compared to applicable criteria published in the *Provincial Water Quality Objectives* (PWQO) by the Ontario Ministry of Environment and Climate Change (MOECC), July 1994. The goal of the PWQO is to "ensure that the surface waters of the province are of the quality which is satisfactory for aquatic life and recreation".

The applicable criteria published in the PWQO water quality guidelines are attached in Appendix E: Water Quality Guidelines. Total Coliform results were compared to the pre-1994 PWQO, as there are no current criteria.

3.4 Qualitative Assessment

Watershed health can also be assessed by qualitative monitoring (i.e. visual inspection). The composition of in-stream substrate, forest soil, stream bank riparian community, shoreline vegetation and condition of the stream bank can all affect water quality. The presence or absence of certain flora and fauna can indicate the status of the watershed to provide suitable habitat. Nine field guides were used to identify terrestrial and aquatic species. Each site was given a Vegetation Type (V-type) allocation based on the *Field Guide to the Forest Ecosystem Classification for Northwestern Ontario* (Sims *et al.* 1997). Sites were assessed based on vegetation that could be seen from the site, with no distinct sample area, using a dichotomous key. It is important to note that these classifications are a general overview of a larger area and no site was exactly the same as another. Differences or inconsistencies between the V-types should be expected. Vegetation Types for each site are attached in Appendix F: Forest Ecosystem

Classification. Common and Latin names of plant species are attached in Appendix D: Common and Scientific Names of Identified Flora and Fauna. Fauna was assessed by identifying the species and number of individuals observed at each site.

An inventory of Oliver Creek water crossings (bridges and culverts) was conducted. Physical dimensions were measured, Universal Transverse Mercator (UTM) coordinates and pictures were taken and general observations were noted including high water marks, stability of fill and any restriction of flow. Culvert and bridge locations can be found on Map M-10: Bridge and Culvert Sites. The bridge and culvert assessments are attached in Appendix G: Culvert Assessments and Appendix H: Bridge Assessments.

3.5 Watershed Report Card Rating

The Conservation Authorities in Ontario have developed the Watershed Report Card (WRC) as a means of reporting and designating watershed health through the use of environmental indicators and to utilize the information to better target programs and measure environmental change. Four resource categories are measured in the Watershed Report Cards, which include surface water quality, forest conditions, wetland conditions, and groundwater quality. The grading system for each resource category is recognized as A-Excellent; B-Good; C-Fair; D-Poor; F-Very Poor.

Surface water quality and forest conditions were identified for the Oliver Creek watershed. The three indicators used to assess surface water quality for the watershed are total phosphorus, *Escherichia coli (E. coli*), and benthic macroinvertebrates (data not available). The average point score of the surface water indicators is used to determine the overall surface water quality grade. No wetland or groundwater data was available for the watershed.

Forest conditions utilize three indicators to determine the grade for the quality of the forest, which include forest coverage, forest interior percentage and percentage of riparian zone forested. Forest cover is the percentage of the watershed that is forested. Forest interior is the area of forest that lies more than 100 metres from a forest edge. Forest riparian zone measures the amount of forest cover within 30 metres adjacent to all open watercourses. Northern Ontario Forest Cover criteria are currently being developed.

Table 3.5-1: 2011 Surface Water Quality Indicator Guidelines						
					Overall Surface Water Quality Grade	
Total Phosphorus (mg/L)	*E. coli* (#100 mL)	Benthic Invertebrates	Point Score	Grade	Final Points	Final Grade
<0.020	0-30	0.00-4.25	5	A	>4.4	A
0.020-0.030	31-100	4.26-5.00	4	B	3.5 - 4.4	B
0.031-0.060	101-300	5.01-5.75	3	C	2.5 - 3.4	C
0.061-0.180	301-1000	5.76-6.50	2	D	1.5 - 2.4	D
>0.180	>1000	6.51-10.00	1	F	<1.5	F

Table 3.5-2: 2011 Forest Conditions Indicator Guidelines						
					Overall Forest Conditions	
% Forest Cover	% Forest Interior	% Riparian Zone Forested	Point Score	Grade	Final Points	Final Grade
>35.0	>11.5	>57.5	5	A	>4.4	A
25.1 - 35.0	8.6 - 11.5	42.6 - 57.5	4	B	3.5 - 4.4	B
15.1 - 25.0	5.6 - 8.5	27.6 - 42.5	3	C	2.5 - 3.4	C
5.0 – 15.0	2.5 - 5.5	12.5 - 27.5	2	D	1.5 - 2.4	D
<5.0	<2.5	<12.5	1	F	<1.5	F

3.6 Materials

Materials used during the assessment included:

- Auger
- Chest waders
- Cooler and ice packs
- Clipboard and observation chart paper
- Dip net
- Digital camera
- Field guides
- Fluorescent orange vests
- Latex gloves
- Measuring tape reel
- Mercury thermometer
- Metre stick
- Writing utensils
- Reaching pole
- Road map
- Sampling bottles and preservative provided by ALS Laboratory Group
- Scissors
- Stick (to measure velocity)

- Stopwatch
- Trimble Geo XH GPS
- YSI Pro DSS metre
- Ziploc bags

Field Guides:

- Field Guide to the Forest Ecosystem Classification for Northwestern Ontario (Sims *et al.*, 1997)
- Terrestrial and Wetland Ecosites of Northwestern Ontario (G. Racey *et al.*, 1996)
- Wetland Plants of Ontario (Newmaster *et al.*, 1997)
- Atlas of the Breeding Birds of Ontario (Cadman *et al.*, 2007)
- Newcomb's Wildflower Guide (Newcomb, 1977)
- Forest Plants of Northeastern Ontario (Legasy *et al.*,1995)
- Bugs of Ontario (Acorn, 2003)
- Shrubs of Ontario (Heimburger & Soper, 1982)
- Trees in Canada (Farrar, 1995)

4 RESULTS

Site photos from each sampling site are attached in Appendix I: Site Photography. The laboratory water quality results and PWQO criteria have been compared and attached in Appendix J: Laboratory Water Quality Results Summary Tables. The original Laboratory Certificates of Analysis and Analytical Reports have been attached in Appendix K: Laboratory Certificates of Analysis and Test Results.

The results for the Oliver Creek watershed are summarized in the tables below for each site.

4.1 Site 1

Site 1 was located near the confluence of Oliver Creek at the Kaministiquia River and was accessed from River Road. The substrate at this site included clay, silt, sand, gravel and boulders. The banks of the shoreline were stable with abundant vegetation in the riparian zone including balsam fir, trembling aspen, white birch, alder, chokecherry and red osier dogwood. Erosion on the banks of the creek downstream of the bridge was apparent. There were only a few visible emergent aquatic plants present at the sample area; however, they were too far away to identify. The soil type present at this site in the "A" Horizon was sand; the "B" Horizon was sandy gravel; the "C" Horizon was cobble.

The laboratory results from the July 14, 2016 sampling period showed that phosphorus exceeded the PWQO criterion (0.03 mg/L) with a value of 0.03 mg/L. Total coliforms, aluminum and iron all exceeded the PWQO guidelines on both June 14, 2016 and July 14, 2016 sampling periods. Total coliforms were above the pre-1994 PWQO criterion (1,000 MPN/100mL) with a value of 1,410 MPN/100mL on June 14, 2016 and >2,420 MPN/100mL on July 14, 2016. Aluminum results exceeded the PWQO criterion (0.075 mg/L) with a value of 0.195 mg/L on June 14, 2016 and 0.201 mg/L on July 14, 2016. Iron exceeded the PWQO criterion (0.3 mg/L) with a value of 0.937 mg/L on June 14, 2016 and 1.290 mg/L on July 14, 2016.

Table 4.1-1: Location References for Site 1	
Location Description	River Road, near Oliver Creek confluence at Kaministiquia River
UTM Coordinates	Northing 5359381 Easting 312614
Altitude/Elevation	212.96 metres above sea level

Table 4.1-2: Field Measurements for Site 1			
Parameter	**Unit**	**Date:** 14-JUN-16 **Time:** 15:00	**Date**: 14-JUL-16 **Time**: 12:05
Water Temperature	°C	15.9	19.9
Conductivity	uS/cm	149.8	169.6
Dissolved Oxygen	mg/L	9.78	8.84
Dissolved Oxygen	%	99.0	97.0
pH		8.08	8.22
Turbidity	NTU	4.5	5.5
Air Temperature	°C	17	19
Total Dissolved Solids	mg/L	97.345	110.219
Channel Width	m	5.1	5.1
Channel Depth	m	0.88	0.71
Velocity	m/s	0.31	0.24

Table 4.1-3: Laboratory Water Quality Results for Site 1				
Parameter	**Unit**	**PWQO Guidelines**	**Date:** 14-JUN-16 **Time:** 15:00	**Date:** 14-JUL-16 **Time:** 12:05
Bacteriological				
Escherichia Coli	MPN/100mL	100	33	37
Total Coliforms	MPN/100mL	1,000 (prior to 1994)	**1410**	**>2420**
Physical				
Conductivity (EC)	uS/cm	N/A	150	170
pH		6.5-8.5	7.84	8.13
Total Dissolved Solids	mg/L	N/A	109	127
Turbidity	NTU	N/A	4.47	5.44
Nutrients and Anions				
Ammonia-N, Total	mg/L	N/A	0.021	<0.020
Un-ionized Ammonia	mg/L	0.2	0.0006	<0.0008
Chloride (Cl)	mg/L	N/A	5.62	5.10
Nitrate-N (NO_3-N)	mg/L	N/A	<0.020	0.072
Nitrite-N (NO_2-N)	mg/L	N/A	<0.010	<0.010
Phosphorus (P)-Total	mg/L	0.03	0.02	**0.03**
Sulfate (SO_4)	mg/L	N/A	8.34	6.65
Metals				
Aluminum (Al)	mg/L	0.075	**0.195**	**0.201**
Cadmium (Cd)	mg/L	0.0001 (0-100 mg/L $CaCO_3$)	0.000046	0.000064
	mg/L	0.0005 (>100 mg/L $CaCO_3$)		
Cobalt (Co)	mg/L	0.0009	0.00016	0.00019
Copper (Cu)	mg/L	0.005 (interim)	0.0037	0.0044
Iron (Fe)	mg/L	0.300	**0.937**	**1.290**
Lead (Pb)	mg/L	0.003 (30- 80 mg/L $CaCO_3$)	0.00015	0.00021
	mg/L	0.005 (>80 mg/L $CaCO_3$)		
Sodium (Na)	mg/L	N/A	3.76	4.24

Bold indicates exceedance above PWQO guidelines

Table 4.1-4: Flora Observed at Site 1			
FEC V-Type: V14 Balsam Fir Mixedwood			
Forest Density / Stream Cover	25% stream cover		
Terrestrial Species			
Trees	**Shrubs**	**Herbs**	**Ferns / Horsetails / Mosses / Grasses**
White Spruce Balsam Fir Trembling Aspen White Birch Balsam Poplar	Chokecherry Red Osier Dogwood Speckled Alder Wild Red Raspberry	Dandelion Rough-Stemmed Goldenrod Cow Vetch	Meadow Horsetail
Aquatic Macrophytes and Algae			
Emergent	-	**Floating Algae**	-
Rooted Floating	-	**Filaments**	-
Submergent	-	**Attached Algae**	-
Free Floating	-	**Slimes or Crusts**	-

Table 4.1-5: Fauna Observed at Site 1	
Fauna Species	
Amphibians	-
Birds	-
Crustaceans	-
Fish	-
Insects	-
Mammals	Chipmunk
Mollusca	-
Reptiles	-

Table 4.1-6: Physical Features Observed at Site 1							
In-stream Substrate							
Bedrock	**Boulder**	**Cobbles**	**Gravel**	**Sand**	**Silt**	**Organic**	**Clay**
-	10%	-	15%	25%	25%	-	25%
Bank Stability/Erosion	Erosion downstream from the sampling site						

4.2 Site 2

Site 2 was located on the north side of Barrie Drive, across from 457 Barrie Drive. The substrate at this site included gravel, cobbles, boulders and bedrock. The banks of the shoreline were stable with abundant vegetation in the riparian zone including white spruce, jack pine, white birch, balsam fir, trembling aspen, willow, red osier dogwood and speckled alder. The soil type present at this site in the "A" Horizon was sandy loam; the "C" Horizon was rock.

The laboratory results from the July 14, 2016 sampling period showed that phosphorus exceeded the PWQO criterion (0.03 mg/L) with a value of 0.03 mg/L. Total coliforms,

aluminum and iron all exceeded the PWQO guidelines on both June 14, 2016 and July 14, 2016 sampling periods. Total coliforms were above the pre-1994 PWQO criterion (1,000 MPN/100mL) with a value of 2,420 MPN/100mL on June 14, 2016 and >2,420 MPN/100mL on July 14, 2016. Aluminum results exceeded the PWQO criterion (0.075 mg/L) with a value of 0.219 mg/L on June 14, 2016 and 0.200 mg/L on July 14, 2016. Iron exceeded the PWQO criterion (0.3 mg/L) with a value of 0.966 mg/L on June 14, 2016 and 1.260 mg/L on July 14, 2016.

Table 4.2-1: Location References for Site 2	
Location Description	North side of Barrie Drive – Across from 457 Barrie Drive
UTM Coordinates	Northing 5357660 Easting 312283
Altitude/Elevation	238.60 metres above sea level

Table 4.2-2: Field Measurements for Site 2			
Parameter	**Unit**	**Date:** 14-JUN-16 **Time:** 14:25	**Date**: 14-JUL-16 **Time**: 11:50
Water Temperature	°C	15.5	19.7
Conductivity	uS/cm	144.4	162.0
Dissolved Oxygen	mg/L	9.49	8.46
Dissolved Oxygen	%	95.0	92.7
pH		7.80	7.92
Turbidity	NTU	4.8	5.6
Air Temperature	°C	16	19
Total Dissolved Solids	mg/L	93.966	105.350
Channel Width	m	3.5	3.5
Channel Depth	m	0.35	0.35
Velocity	m/s	1.11	0.92

Table 4.2-3: Laboratory Water Quality Results for Site 2				
Parameter	**Unit**	**PWQO Guidelines**	**Date:** 14-JUN-16 **Time:** 14:25	**Date:** 14-JUL-16 **Time:** 11:50
Bacteriological				
Escherichia Coli	MPN/100mL	100	68	77
Total Coliforms	MPN/100mL	1,000 (prior to 1994)	**2420**	**>2420**
Physical				
Conductivity (EC)	uS/cm	N/A	143	162
pH		6.5-8.5	7.70	7.89
Total Dissolved Solids	mg/L	N/A	105	122
Turbidity	NTU	N/A	4.90	5.69
Nutrients and Anions				
Ammonia-N, Total	mg/L	N/A	0.035	<0.020
Un-ionized Ammonia	mg/L	0.2	0.0010	<0.0007
Chloride (Cl)	mg/L	N/A	5.19	4.57
Nitrate-N (NO_3-N)	mg/L	N/A	<0.020	0.087
Nitrite-N (NO_2-N)	mg/L	N/A	<0.010	<0.010
Phosphorus (P)-Total	mg/L	0.03	0.02	**0.03**
Sulfate (SO_4)	mg/L	N/A	8.44	6.62
Metals				
Aluminum (Al)	mg/L	0.075	**0.219**	**0.200**

Table 4.2-3: Laboratory Water Quality Results for Site 2				
Parameter	**Unit**	**PWQO Guidelines**	**Date:** 14-JUN-16 **Time:** 14:25	**Date:** 14-JUL-16 **Time:** 11:50
Cadmium (Cd)	mg/L	0.0001 (0-100 mg/L $CaCO_3$)	0.000051	0.000063
	mg/L	0.0005 (>100 mg/L $CaCO_3$)		
Cobalt (Co)	mg/L	0.0009	0.00017	0.00020
Copper (Cu)	mg/L	0.005 (interim)	0.0038	0.0040
Iron (Fe)	mg/L	0.300	**0.966**	**1.260**
Lead (Pb)	mg/L	0.003 (30- 80 mg/L $CaCO_3$)	0.00016	0.00025
	mg/L	0.005 (>80 mg/L $CaCO_3$)		
Sodium (Na)	mg/L	N/A	3.63	3.74

Bold indicates exceedance above PWQO guidelines

Table 4.2-4: Flora Observed at Site 2			
FEC V-Type: V15 White Spruce Mixedwood			
Forest Density / Stream Cover	40% stream cover		
Terrestrial Species			
Trees	**Shrubs**	**Herbs**	**Ferns / Horsetails / Mosses / Grasses**
White Birch Jack Pine White Spruce Trembling Aspen Balsam Poplar Balsam Fir	Speckled Alder Willow Spp. Wild Red Raspberry Red Osier Dogwood Prickly Wild Rose	Cow Vetch Dandelion Red Clover Ox-Eye Daisy Swamp Thistle	
Aquatic Macrophytes and Algae			
Emergent	-	**Floating Algae**	-
Rooted Floating	-	**Filaments**	-
Submergent	-	**Attached Algae**	-
Free Floating	-	**Slimes or Crusts**	-

Table 4.2-5: Fauna Observed at Site 2	
Fauna Species	
Amphibians	-
Birds	-
Crustaceans	-
Fish	-
Insects	-
Mammals	-
Mollusca	-
Reptiles	-

Table 4.2-6: Physical Features Observed at Site 2							
In-stream Substrate							
Bedrock	**Boulder**	**Cobbles**	**Gravel**	**Sand**	**Silt**	**Organic**	**Clay**
50%	20%	15%	15%	-	-	-	-
Bank Stability/ Erosion	Stable / abundant vegetation						

4.3 Site 3

Site 3 was located on the south side of Barrie Drive, beside the driveway to 617 Barrie Drive. The substrate at this site included gravel, sand, silt and clay. The banks of the shoreline were stable with abundant vegetation in the riparian zone including white spruce, willow, pincherry, red osier dogwood, clover and rough-stemmed goldenrod. The soil type present at this site in the "A" Horizon and "B" Horizon was sandy loam.

The laboratory results from the July 14, 2016 sampling period showed that *E. coli* exceeded the PWQO criterion of 100 MPN/100mL with a value of 687 MPN/100mL. It was noted a farm was located upstream. Total coliforms, aluminum, iron and phosphorus all exceeded the PWQO guidelines on both June 14, 2016 and July 14, 2016 sampling periods. Total coliforms were above the pre-1994 PWQO criterion (1,000 MPN/100mL) with a value of >2,420 MPN/100mL on June 14, 2016 and >2,420 MPN/100mL on July 14, 2016. Aluminum results exceeded the PWQO criterion (0.075 mg/L) with a value of 0.105 mg/L on June 14, 2016 and 0.110 mg/L on July 14, 2016. Iron exceeded the PWQO criterion (0.3 mg/L) with a value of 0.712 mg/L on June 14, 2016 and 0.912 mg/L on July 14, 2016. Phosphorus exceeded the PWQO criterion (0.03 mg/L) with a value of 0.16 mg/L on June 14, 2016 and 0.24 mg/L on July 14, 2016.

Table 4.3-1: Location References for Site 3	
Location Description	South side of Barrie Drive, beside the driveway to 617 Barrie Drive
UTM Coordinates	Northing 5357694 Easting 310732
Altitude/Elevation	250.44 metres above sea level

Table 4.3-2: Field Measurements for Site 3			
Parameter	**Unit**	**Date:** 14-JUN-16 **Time:** 14:05	**Date**: 14-JUL-16 **Time**: 11:35
Water Temperature	°C	13.5	16.8
Conductivity	uS/cm	466.3	552
Dissolved Oxygen	mg/L	9.39	7.31
Dissolved Oxygen	%	90.2	76.1
pH		7.77	7.73
Turbidity	NTU	2.5	3.2
Air Temperature	°C	16	19
Total Dissolved Solids	mg/L	303.127	358.935
Channel Width	m	0.8	0.8
Channel Depth	m	0.16	0.3

Table 4.3-2: Field Measurements for Site 3			
Parameter	**Unit**	**Date:** 14-JUN-16 **Time:** 14:05	**Date**: 14-JUL-16 **Time**: 11:35
Velocity	m/s	n/a	n/a

Table 4.3-3: Laboratory Water Quality Results for Site 3				
Parameter	**Unit**	**PWQO Guidelines**	**Date:** 14-JUN-16 **Time:** 14:05	**Date:** 14-JUL-16 **Time:** 11:35
Bacteriological				
Escherichia Coli	MPN/100mL	100	24	**687**
Total Coliforms	MPN/100mL	1,000 (prior to 1994)	**>2420**	**>2420**
Physical				
Conductivity (EC)	uS/cm	N/A	461	552
pH		6.5-8.5	7.93	7.96
Total Dissolved Solids	mg/L	N/A	290	356
Turbidity	NTU	N/A	3.13	3.71
Ammonia-N, Total	mg/L	N/A	0.051	0.037
Un-ionized Ammonia	mg/L	0.2	0.0013	0.0012
Chloride (Cl)	mg/L	N/A	13.9	13.7
Nitrate-N (NO_3-N)	mg/L	N/A	0.027	0.137
Nitrite-N 2-N)	mg/L	N/A	<0.010	<0.010
Phosphorus (P)-Total	mg/L	0.03	**0.16**	**0.24**
Sulfate (SO_4)	mg/L	N/A	23.5	19.4
Metals				
Aluminum (Al)	mg/L	0.075	**0.105**	**0.110**
Cadmium (Cd)	mg/L	0.0001 (0-100 mg/L $CaCO_3$)		
	mg/L	0.0005 (>100 mg/L $CaCO_3$)	0.000073	0.000068
Cobalt (Co)	mg/L	0.0009	0.00057	0.00053
Copper (Cu)	mg/L	0.005 (interim)	0.0030	0.0029
Iron (Fe)	mg/L	0.300	**0.712**	**0.912**
Lead (Pb)	mg/L	0.003 (30- 80 mg/L $CaCO_3$)		
	mg/L	0.005 (>80 mg/L $CaCO_3$)	<0.00005	0.00006
Sodium (Na)	mg/L	N/A	9.13	9.91

Bold indicates exceedance above PWQO guidelines

Table 4.3-4: Flora Observed at Site 3			
FEC V-Type: N/A			
Forest Density / Stream Cover	75% stream cover		
Terrestrial Species			
Trees	**Shrubs**	**Herbs**	**Ferns / Horsetails / Mosses / Grasses**
Balsam Poplar Trembling Aspen White Spruce	Pincherry Willow Spp. Red Osier Dogwood	Red Clover Dandelion Rough-Stemmed Goldenrod White Clover Swamp Thistle	
Aquatic Macrophytes and Algae			
Emergent	-	**Floating Algae**	-
Rooted Floating	-	**Filaments**	-

Table 4.3-4: Flora Observed at Site 3			
Submergent	-	**Attached Algae**	-
Free Floating	-	**Slimes or Crusts**	-

Table 4.3-5: Fauna Observed at Site 3	
Fauna Species	
Amphibians	-
Birds	-
Crustaceans	-
Fish	-
Insects	-
Mammals	-
Mollusca	-
Reptiles	-

Table 4.3-6: Physical Features Observed at Site 3							
In-stream Substrate							
Bedrock	**Boulder**	**Cobbles**	**Gravel**	**Sand**	**Silt**	**Organic**	**Clay**
-	-	-	10%	25%	40%	-	25%
Bank Stability/ Erosion	Stable/ abundant vegetation						

4.4 Site 4

Site 4 was located on the south side of Barrie Drive, approximately 105 metres from 741 Barrie Drive. The substrate at this site included gravel, sand, silt and clay. The banks of the shoreline were stable with abundant vegetation in the riparian zone including white spruce, willow, chokecherry, speckled alder and clover. The soil type present at this site in the "A" Horizon was loamy sand; the "C" Horizon was silty clay loam.

The laboratory results showed that total coliforms, aluminum and iron all exceeded the PWQO guidelines on both June 14, 2016 and July 14, 2016 sampling periods. Total coliforms were above the pre-1994 PWQO criterion (1,000 MPN/100mL) with a value of >2,420 MPN/100mL on June 14, 2016 and >2,420 MPN/100mL on July 14, 2016. Aluminum results exceeded the PWQO criterion (0.075 mg/L) with a value of 0.280 mg/L on June 14, 2016 and 0.226 mg/L on July 14, 2016. Iron exceeded the PWQO criterion (0.3 mg/L) with a value of 0.963 mg/L on June 14, 2016 and 1.200 mg/L on July 14, 2016.

Table 4.4-1: Location References for Site 4	
Location Description	South side of Barrie Drive, approximately 105 metres from 741 Barrie Drive
UTM Coordinates	Northing 5357730 Easting 309619
Altitude/Elevation	250.09 metres above sea level

Table 4.4-2: Field Measurements for Site 4			
Parameter	**Unit**	**Date:** 14-JUN-16 **Time:** 13:30	**Date**: 14-JUL-16 **Time**: 11:20
Water Temperature	°C	15.1	19.4
Conductivity	uS/cm	110.6	120.1
Dissolved Oxygen	mg/L	9.40	7.97
Dissolved Oxygen	%	93.5	86.7
pH		7.63	7.65
Turbidity	NTU	5.2	5.3
Air Temperature	°C	15	
Total Dissolved Solids	mg/L	71.896	78.045
Channel Width	m	3.4	3.4
Channel Depth	m	0.28	0.36
Velocity	m/s	0.40	0.47

Table 4.4-3: Laboratory Water Quality Results for Site 4				
Parameter	**Unit**	**PWQO Guidelines**	**Date:** 14-JUN-16 **Time:** 13:30	**Date:** 14-JUL-16 **Time:** 11:20
Bacteriological				
Escherichia Coli	MPN/100mL	100	58	56
Total Coliforms	MPN/100mL	1,000 (prior to 1994)	**>2420**	**>2420**
Physical				
Conductivity (EC)	uS/cm	N/A	111	121
pH		6.5-8.5	7.64	7.64
Total Dissolved Solids	mg/L	N/A	86	107
Turbidity	NTU	N/A	5.02	5.67
Nutrients and Anions				
Ammonia-N, Total	mg/L	N/A	0.026	<0.020
Un-ionized Ammonia	mg/L	0.2	0.0002	<0.0002
Chloride (Cl)	mg/L	N/A	2.85	2.51
Nitrate-N (NO_3-N)	mg/L	N/A	0.032	0.072
Nitrite-N (NO_2-N)	mg/L	N/A	<0.010	<0.010
Phosphorus (P)-Total	mg/L	0.03	0.02	0.02
Sulfate (SO_4)	mg/L	N/A	23.5	6.69
Metals				
Aluminum (Al)	mg/L	0.075	**0.280**	**0.226**
Cadmium (Cd)	mg/L	0.0001 (0-100 $CaCO_3$)	0.000057	0.000072
	mg/L	0.0005 (>100 mg/L $CaCO_3$)		
Cobalt (Co)	mg/L	0.0009	0.00020	0.00020
Copper (Cu)	mg/L	0.005 (interim)	0.0040	0.0040
Iron (Fe)	mg/L	0.300	**0.963**	**1.200**
Lead (Pb)	mg/L	0.003 (30- 80 mg/L $CaCO_3$)	0.00019	0.00023
	mg/L	0.005 (>80 mg/L $CaCO_3$)		
Sodium (Na)	mg/L	N/A	2.52	2.49

Bold indicates exceedance above PWQO guidelines

Table 4.4-4: Flora Observed at Site 4			
FEC V-Type: N/A			
Forest Density / Stream Cover	10% stream cover		
Terrestrial Species			
Trees	**Shrubs**	**Herbs**	**Ferns / Horsetails / Mosses / Grasses**
White Spruce	Willow spp. Chokecherry Speckled Alder	Red Clover Dandelion Swamp Thistle Cow Vetch Rough-Stemmed Goldenrod	
Aquatic Macrophytes and Algae			
Emergent	-	**Floating Algae**	-
Rooted Floating	-	**Filaments**	-
Submergent	-	**Attached Algae**	-
Free Floating	-	**Slimes or Crusts**	-

Table 4.4-5: Fauna Observed at Site 4	
Fauna Species	
Amphibians	-
Birds	-
Crustaceans	-
Fish	-
Insects	-
Mammals	-
Mollusca	-
Reptiles	-

Table 4.4-6: Physical Features Observed at Site 4							
In-stream Substrate							
Bedrock	**Boulder**	**Cobbles**	**Gravel**	**Sand**	**Silt**	**Organic**	**Clay**
-	-	-	15%	30%	30%	-	25%
Bank Stability/ Erosion	Stable/ abundant vegetation						

4.5 Site 5

Site 5 was located on the west side of C-Line Road, approximately 130 metres from 19 C-Line Road. The substrate at this site included clay, silt, gravel, and cobbles. The banks of the shoreline were stable with abundant vegetation in the riparian zone including trembling aspen, white spruce, balsam fir, red osier dogwood, pincherry, speckled alder and clover. The soil type present at this site in the "A" Horizon was silty clay loam.

The laboratory results showed that total coliforms, aluminum and iron all exceeded the PWQO guidelines on both June 14, 2016 and July 14, 2016 sampling periods. Total coliforms were above the pre-1994 PWQO criterion (1,000 MPN/100mL) with a value of

2,420 MPN/100mL on June 14, 2016 and 2,420 MPN/100mL on July 14, 2016. Aluminum results exceeded the PWQO criterion (0.075 mg/L) with a value of 0.123 mg/L on June 14, 2016 and 0.101 mg/L on July 14, 2016. Iron exceeded the PWQO criterion (0.3 mg/L) with a value of 1.040 mg/L on June 14, 2016 and 1.510 mg/L on July 14, 2016.

Table 4.5-1: Location References for Site 5	
Location Description	West side of C-Line Road, approximately 130 metres from 19 C-Line Road
UTM Coordinates	Northing 5355789 Easting 308729
Altitude/Elevation	283.65 metres above sea level

Table 4.5-2: Field Measurements for Site 5			
Parameter	**Unit**	**Date:** 14-JUN-16 **Time:** 13:00	**Date**: 14-JUL-16 **Time**: 11:00
Water Temperature	°C	15.8	19.9
Conductivity	uS/cm	93	101.4
Dissolved Oxygen	mg/L	8.70	7.43
Dissolved Oxygen	%	87.9	81.6
pH		7.46	7.59
Turbidity	NTU	2.4	2.4
Air Temperature	°C	15	19
Total Dissolved Solids	mg/L	60.515	65.942
Channel Width	m	2.4	2.4
Channel Depth	m	0.3	0.26
Velocity	m/s	0.19	0.30

Table 4.5-3: Laboratory Water Quality Results for Site 5				
Parameter	**Unit**	**PWQO Guidelines**	**Date:** 14-JUN-16 **Time:** 13:00	**Date:** 14-JUL-16 **Time:** 11:00
Bacteriological				
Escherichia Coli	MPN/100mL	100	13	33
Total Coliforms	MPN/100mL	1,000 (prior to 1994)	**2420**	**2420**
Physical				
Conductivity (EC)	uS/cm	N/A	93.2	102
pH		6.5-8.5	7.42	7.55
Total Dissolved Solids	mg/L	N/A	88	92
Turbidity	NTU	N/A	2.59	2.77
Nutrients and Anions				
Ammonia-N, Total	mg/L	N/A	0.026	<0.020
Un-ionized Ammonia	mg/L	0.2	0.0002	<0.0002
Chloride (Cl)	mg/L	N/A	0.16	0.15
Nitrate-N (NO_3-N)	mg/L	N/A	<0.020	<0.020
Nitrite-N (NO_2-N)	mg/L	N/A	<0.010	<0.010
Phosphorus (P)-Total	mg/L	0.03	0.02	0.025
Sulfate (SO_4)	mg/L	N/A	2.74	1.45
Metals				
Aluminum (Al)	mg/L	0.075	**0.123**	**0.101**
Cadmium (Cd)	mg/L	0.0001 (0-100 mg/L $CaCO_3$)	0.000062	0.000070
	mg/L	0.0005 (>100 mg/L $CaCO_3$)		
Cobalt (Co)	mg/L	0.0009	0.00019	0.00021
Copper (Cu)	mg/L	0.005 (interim)	0.0040	0.0030

Table 4.5-3: Laboratory Water Quality Results for Site 5				
Parameter	**Unit**	**PWQO Guidelines**	**Date:** 14-JUN-16 **Time:** 13:00	**Date:** 14-JUL-16 **Time:** 11:00
Iron (Fe)	mg/L	0.300	**1.040**	**1.510**
Lead (Pb)	mg/L	0.003 (30- 80 mg/L $CaCO_3$)	0.00011	0.00014
	mg/L	0.005 (>80 mg/L $CaCO_3$)		
Sodium (Na)	mg/L	N/A	1.67	1.59

Bold indicates exceedance above PWQO guidelines

Table 4.5-4: Flora Observed at Site 5			
FEC V-Type: V15 White Spruce Mixedwood			
Forest Density / Stream Cover	80% stream cover		
Terrestrial Species			
Trees	**Shrubs**	**Herbs**	**Ferns / Horsetails / Mosses / Grasses**
Balsam Poplar Trembling Aspen White Spruce Balsam Fir White Birch	Pincherry Willow spp. Speckled Alder Red Osier Dogwood Wild Red Raspberry	Red Clover Swamp Thistle Cow Vetch Dandelion	
Aquatic Macrophytes and Algae			
Emergent	-	**Floating Algae**	-
Rooted Floating	-	**Filaments**	-
Submergent	-	**Attached Algae**	-
Free Floating	-	**Slimes or Crusts**	-

Table 4.5-5: Fauna Observed at Site 5	
Fauna Species	
Amphibians	-
Birds	-
Crustaceans	-
Fish	-
Insects	-
Mammals	-
Mollusca	-
Reptiles	-

Table 4.5-6: Physical Features Observed at Site 5							
In-stream Substrate							
Bedrock	**Boulder**	**Cobbles**	**Gravel**	**Sand**	**Silt**	**Organic**	**Clay**
-	-	10%	10%	-	40%	-	40%
Bank Stability/ Erosion	Stable/ abundant vegetation						

4.6 Site 6

Site 6 was located on the south side of Candy Mountain Road, approximately 65 metres from Oliver Creek Road. The substrate at this site included clay, silt, gravel, cobbles and boulders. The banks of the shoreline were stable with abundant vegetation in the riparian zone including black ash, white spruce, balsam fir, red osier dogwood, pincherry, speckled alder and rough-stemmed goldenrod. The soil type present at this site in the "A" Horizon was sandy loam and "B" Horizon was loam.

The laboratory results showed that total coliforms, aluminum and iron all exceeded the PWQO guidelines on both June 14, 2016 and July 14, 2016 sampling periods. Total coliforms were above the pre-1994 PWQO criterion (1,000 MPN/100mL) with a value of 2,420 MPN/100mL on June 14, 2016 and 1,730 MPN/100mL on July 14, 2016. Aluminum results exceeded the PWQO criterion (0.075 mg/L) with a value of 0.331 mg/L on June 14, 2016 and 0.262 mg/L on July 14, 2016. Iron exceeded the PWQO criterion (0.3 mg/L) with a value of 0.925 mg/L on June 14, 2016 and 0.343 mg/L on July 14, 2016.

Table 4.6-1: Location References for Site 6

Location Description	South side of Candy Mountain Road, approximately 65 metres from Oliver Creek Road
UTM Coordinates	Northing 5355688 Easting 309852
Altitude/Elevation	276.69 metres above sea level

Table 4.6-2: Field Measurements for Site 6

Parameter	**Unit**	**Date:** 14-JUN-16 **Time:** 12:30	**Date**: 14-JUL-16 **Time**: 10:40
Water Temperature	°C	15	19.1
Conductivity	uS/cm	96.6	96.7
Dissolved Oxygen	mg/L	9.67	8.60
Dissolved Oxygen	%	95.8	93.0
pH		7.79	7.81
Turbidity	NTU	6.1	6.0
Air Temperature	°C	14	18
Total Dissolved Solids	mg/L	62.812	63.160
Channel Width	m	2.9	2.9
Channel Depth	m	0.62	0.65
Velocity	m/s	0.19	0.14

Table 4.6-3: Laboratory Water Quality Results for Site 6

Parameter	**Unit**	**PWQO Guidelines**	**Date:** 14-JUN-16 **Time:** 12:30	**Date:** 14-JUL-16 **Time:** 10:40
Bacteriological				
Escherichia Coli	MPN/100mL	100	23	50
Total Coliforms	MPN/100mL	1000 (prior to 1994)	**2420**	**1730**
Physical				
Conductivity (EC)	uS/cm	N/A	97.1	101
pH		6.5-8.5	7.59	7.71

Table 4.6-3: Laboratory Water Quality Results for Site 6				
Parameter	**Unit**	**PWQO Guidelines**	**Date:** 14-JUN-16 **Time:** 12:30	**Date:** 14-JUL-16 **Time:** 10:40
Total Dissolved Solids	mg/L	N/A	81	78
Turbidity	NTU	N/A	5.84	6.40
Nutrients and Anions				
Ammonia-N, Total	mg/L	N/A	<0.020	<0.020
Un-ionized Ammonia	mg/L	0.2	<0.0002	<0.020
Chloride (Cl)	mg/L	N/A	3.03	2.42
Nitrate-N (NO_3-N)	mg/L	N/A	<0.020	0.030
Nitrite-N (NO_2-N)	mg/L	N/A	<0.010	<0.010
Phosphorus (P)-Total	mg/L	0.03	0.02	0.02
Sulfate (SO_4)	mg/L	N/A	8.35	7.07
Metals				
Aluminum (Al)	mg/L	0.075	**0.331**	**0.262**
Cadmium (Cd)	mg/L	0.0001 (0-100 mg/L $CaCO_3$)	0.000056	0.000063
	mg/L	0.0005 (>100 mg/L $CaCO_3$)		
Cobalt (Co)	mg/L	0.0009	0.00018	0.00018
Copper (Cu)	mg/L	0.005 (interim)	0.0036	0.0036
Iron (Fe)	mg/L	0.300	**0.925**	**1.160**
Lead (Pb)	mg/L	0.003 (30- 80 mg/L $CaCO_3$)	0.00020	0.000024
	mg/L	0.005 (>80 mg/L $CaCO_3$)		
Sodium (Na)	mg/L	N/A	2.42	2.39

Bold indicates exceedance above PWQO guidelines

Table 4.6-4: Flora Observed at Site 6			
FEC V-Type: V2 Black Ash Hardwood and Mixedwood			
Forest Density /Stream Cover	75% stream cover		
Terrestrial Species			
Trees	**Shrubs**	**Herbs**	**Ferns / Horsetails / Mosses / Grasses**
Black Ash Balsam Fir White Spruce White Pine Trembling Aspen	Pincherry Willow spp. Speckled Alder Red Osier Dogwood Wild Red Raspberry	Dandelion Rough-Stemmed- Goldenrod Cow Vetch Red Clover	Interrupted Fern
Aquatic Macrophytes and Algae			
Emergent	-	**Floating Algae**	-
Rooted Floating	-	**Filaments**	-
Submergent	-	**Attached Algae**	-
Free Floating	-	**Slimes or Crusts**	-

Table 4.6-5: Fauna Observed at Site 6	
Fauna Species	
Amphibians	-
Birds	-
Crustaceans	-
Fish	-
Insects	-

Table 4.6-5: Fauna Observed at Site 6	
Fauna Species	
Mammals	-
Mollusca	-
Reptiles	-

Table 4.6-6: Physical Features Observed at Site 6							
In-stream Substrate							
Bedrock	**Boulder**	**Cobbles**	**Gravel**	**Sand**	**Silt**	**Organic**	**Clay**
-	5%	15%	10%	-	35%	-	35%
Bank Stability/Erosion	Stable/ abundant vegetation						

4.7 Site 7

Site 7 was located on the south side of Boundary Drive, approximately 60 metres from 1150 Boundary Drive. The substrate at this site included clay, organic, silt, gravel and cobbles. The banks of the shoreline were stable with abundant vegetation in the riparian zone including white spruce, black spruce, black ash, balsam fir, red osier dogwood, willow and rough-stemmed goldenrod. The soil type present at this site in the "A" Horizon was sandy loam; the "B" Horizon and "C" Horizon was loamy sand.

The laboratory results from the June 14, 2016 sampling period showed that *E. coli* exceeded the PWQO criterion of 100 MPN/100mL with a value of 108 MPN/100mL. It was noted that a beaver dam was present upstream. Aluminum results exceeded the PWQO criterion (0.075 mg/L) with a value of 0.080 mg/L on July 14, 2016. Total coliforms and iron exceeded the PWQO guidelines on both June 14, 2016 and July 14, 2016 sampling periods. Total coliforms were above the pre-1994 PWQO criterion (1,000 MPN/100mL) with a value of 1,730 MPN/100mL on June 14, 2016 and 1,730 MPN/100mL on July 14, 2016. Iron exceeded the PWQO criterion (0.3 mg/L) with a value of 0.343 mg/L on June 14, 2016 and 0.585 mg/L on July 14, 2016.

Table 4.7-1: Location References for Site 7	
Location Description	South side of Boundary Drive, approximately 60 metres from 1150 Boundary Drive
UTM Coordinates	Northing 5351643 Easting 310097
Altitude/Elevation	331.71 metres above sea level

Table 4.7-2: Field Measurements for Site 7			
Parameter	**Unit**	**Date:** 14-JUN-16 **Time:** 11:45	**Date**: 14-JUL-16 **Time**: 10:25
Water Temperature	°C	16	20.1
Conductivity	uS/cm	86.5	81.3
Dissolved Oxygen	mg/L	88.8	7.68
Dissolved Oxygen	%	89.9	84.6

Table 4.7-2: Field Measurements for Site 7			
Parameter	**Unit**	**Date:** 14-JUN-16 **Time:** 11:45	**Date**: 14-JUL-16 **Time**: 10:25
pH		7.45	7.52
Turbidity	NTU	1.4	2.4
Air Temperature	°C	14	18
Total Dissolved Solids	mg/L	54.721	52.483
Channel Width	m	6.1	6.1
Channel Depth	m	0.52	0.75
Velocity	m/s	0.23	0.14

Table 4.7-3: Laboratory Water Quality Results for Site 7				
Parameter	**Unit**	**PWQO Guidelines**	**Date:** 14-JUN-16 **Time:** 11:45	**Date:** 14-JUL-16 **Time:** 10:25
Bacteriological				
Escherichia Coli	MPN/100mL	100	**108**	99
Total Coliforms	MPN/100mL	1000 (prior to 1994)	**1730**	**1730**
Physical				
Conductivity (EC)	uS/cm	N/A	80.2	83.4
pH		6.5-8.5	7.34	7.50
Total Dissolved Solids	mg/L	N/A	55	61
Turbidity	NTU	N/A	1.46	2.74
Nutrients and Anions				
Ammonia-N, Total	mg/L	N/A	<0.020	0.175
Un-ionized Ammonia	mg/L	0.2	<0.0002	0.0021
Chloride (Cl)	mg/L	N/A	2.94	2.15
Nitrate-N (NO_3-N)	mg/L	N/A	<0.020	0.023
Nitrite-N (NO_2-N)	mg/L	N/A	<0.010	<0.010
Phosphorus (P)-Total	mg/L	0.03	0.01	0.01
Sulfate (SO_4)	mg/L	N/A	6.07	5.82
Metals				
Aluminum (Al)	mg/L	0.075	0.064	**0.080**
Cadmium (Cd)	mg/L	0.0001 (0-100 mg/L $CaCO_3$)	0.000023	0.000028
	mg/L	0.0005 (>100 mg/L $CaCO_3$)		
Cobalt (Co)	mg/L	0.0009	<0.00010	0.00013
Copper (Cu)	mg/L	0.005 (interim)	0.0018	0.0018
Iron (Fe)	mg/L	0.300	**0.343**	**0.585**
Lead (Pb)	mg/L	0.003 (30- 80 mg/L $CaCO_3$)	0.00005	0.00010
	mg/L	0.005 (>80 mg/L $CaCO_3$)		
Sodium (Na)	mg/L	N/A	1.93	1.99

Bold indicates exceedance above PWQO guidelines

Table 4.7-4: Flora Observed at Site 7			
FEC V-Type: V16 Balsam Fir – White Spruce Mixedwood / Feathermoss			
Forest Density / Stream Cover	10% stream cover		
Terrestrial Species			
Trees	**Shrubs**	**Herbs**	**Ferns / Horsetails / Mosses / Grasses**
White Spruce Black Ash Black Spruce Trembling Aspen Balsam Fir	Willow Spp. Speckled Alder Red Osier Dogwood	Common Cattail Cow Vetch Swamp Thistle Dandelion Rough-stemmed Goldenrod	
Aquatic Macrophytes and Algae			
Emergent	-	**Floating Algae**	-
Rooted Floating	-	**Filaments**	-
Submergent	-	**Attached Algae**	-
Free Floating	-	**Slimes or Crusts**	-

Table 4.7-5: Fauna Observed at Site 7	
Fauna Species	
Amphibians	-
Birds	-
Crustaceans	-
Fish	-
Insects	Dragonfly
Mammals	-
Mollusca	-
Reptiles	-

Table 4.7-6: Physical Features Observed at Site 7							
In-stream Substrate							
Bedrock	**Boulder**	**Cobbles**	**Gravel**	**Sand**	**Silt**	**Organic**	**Clay**
-	-	5%	15%	-	30%	30%	20%
Bank Stability/ Erosion	Stable/ abundant vegetation						

4.8 Site 8

Site 8 was located on the northeast side of Oliver Lake and was accessed on East Oliver Lake Road, across from 196 East Oliver Lake Road. This site was a good representation of the headwaters of the watershed. The substrate at this site included clay, silt, sand, gravel and cobbles. Along the shore of the sampling area, there was rip rap present with little to no vegetation. The banks of the shoreline on the other side of the road were stable with abundant vegetation in the riparian zone including white spruce, balsam poplar, white birch, willow, speckled alder and clover. The soil type present at this site in the "B" Horizon and "C" Horizon was loamy sand.

The laboratory results showed that the June 14, 2016 and July 14, 2016 samples taken at this site did not exceed the PWQO guidelines for any parameters.

Table 4.8-1: Location References for Site 8	
Location Description	East Oliver Lake Road, at Oliver Lake
UTM Coordinates	Northing 5349812 Easting 309530
Altitude/Elevation	360.70 metres above sea level

Table 4.8-2: Field Measurements for Site 8			
Parameter	**Unit**	**Date:** 14-JUN-16 **Time:** 11:10	**Date**: 14-JUL-16 **Time**: 10:05
Water Temperature	°C	14.5	20.3
Conductivity	uS/cm	73.4	73.6
Dissolved Oxygen	mg/L	10.32	8.59
Dissolved Oxygen	%	101.2	95.0
pH		7.82	7.99
Turbidity	NTU	0.5	0.6
Air Temperature	°C	14	18
Total Dissolved Solids	mg/L	47.718	47.901
Channel Width	m	1.8	1.8
Channel Depth	m	0.37	0.34
Velocity	m/s	0.76	0.77

Table 4.8-3: Laboratory Water Quality Results for Site 8				
Parameter	**Unit**	**PWQO Guidelines**	**Date:** 14-JUN-16 **Time:** 11:10	**Date:** 14-JUL-16 **Time:** 10:05
Bacteriological				
Escherichia Coli	MPN/100mL	100	<1	2
Total Coliforms	MPN/100mL	1,000 (prior to 1994)	53	365
Physical				
Conductivity (EC)	uS/cm	N/A	74.1	76.2
pH		6.5-8.5	7.46	7.75
Total Dissolved Solids	mg/L	N/A	39	48
Turbidity	NTU	N/A	0.46	0.53
Ammonia-N, Total	mg/L	N/A	<0.020	0.106
Un-ionized Ammonia	mg/L	0.2	<0.0002	0.0040
Chloride (Cl)	mg/L	N/A	2.23	1.91
Nitrate-N (NO_3-N)	mg/L	N/A	<0.020	<0.020
Nitrite-N (NO_2-N)	mg/L	N/A	<0.010	<0.010
Phosphorus (P)-Total	mg/L	0.03	0.003	<0.003
Sulfate (SO_4)	mg/L	N/A	8.23	8.36
Metals				
Aluminum (Al)	mg/L	0.075	0.016	0.022
Cadmium (Cd)	mg/L	0.0001 (0-100 mg/L $CaCO_3$)	<0.000005	0.000010
	mg/L	0.0005 (>100 mg/L $CaCO_3$)		
Cobalt (Co)	mg/L	0.0009	<0.00010	<0.00010
Copper (Cu)	mg/L	0.005 (interim)	0.0012	0.0010
Iron (Fe)	mg/L	0.300	0.028	0.043

Table 4.8-3: Laboratory Water Quality Results for Site 8				
Parameter	**Unit**	**PWQO Guidelines**	**Date:** 14-JUN-16 **Time:** 11:10	**Date:** 14-JUL-16 **Time:** 10:05
Lead (Pb)	mg/L	0.003 (30- 80 mg/L $CaCO_3$)	<0.00005	<0.00005
	mg/L	0.005 (>80 mg/L $CaCO_3$)		
Sodium (Na)	mg/L	N/A	1.80	1.82

Bold indicates exceedance above PWQO guidelines

Table 4.8-4: Flora Observed at Site 8			
FEC V-Type: V15 White Spruce Mixedwood			
Forest Density / Stream Cover	0% stream cover		
Terrestrial Species			
Trees	**Shrubs**	**Herbs**	**Ferns / Horsetails / Mosses / Grasses**
White Spruce White Birch Jack Pine White Pine Balsam Poplar	Willow Spp. Speckled Alder Narrow-Leaved Meadowsweet	Red Clover Dandelion	Field Horsetail
Aquatic Macrophytes and Algae			
Emergent	-	**Floating Algae**	-
Rooted Floating	-	**Filaments**	-
Submergent	-	**Attached Algae**	-
Free Floating	-	**Slimes or Crusts**	-

Table 4.8-5: Fauna Observed at Site 8	
Fauna Species	
Amphibians	-
Birds	-
Crustaceans	-
Fish	Minnows
Insects	Water Beatles
Mammals	Red Squirrel
Mollusca	-
Reptiles	Painted Turtle

Table 4.8-6: Physical Features Observed at Site 8							
In-stream Substrate							
Bedrock	**Boulder**	**Cobbles**	**Gravel**	**Sand**	**Silt**	**Organic**	**Clay**
-	-	20%	20%	30%	15%	-	15%
Bank Stability/ Erosion	Stable/ abundant vegetation						

4.9 Watershed Report Card Results

The overall surface water quality for the Oliver Creek watershed maintained a total averaged point score of 3.8. With minimal exceedances for phosphorus and for *E. coli*,

the rating of the surface water quality for the Oliver Creek watershed was determined to have a grade of B.

The forest coverage for the Oliver Creek watershed was 33.9 square kilometres (70.8 percent), interior forest coverage was 18.9 square kilometres (35.9 percent) and the riparian forest cover was 2.9 square kilometres (6.0 percent). These percentages generated a total point score of eleven (average of 3.7) for the forest conditions, which determined a grade of B.

Table 4.9-1: Oliver Creek Watershed Surface Water Indicators and Overall Grade Calculation

Site Number	Average Total Phosphorus (mg/L)	Average *E. coli* (MPN/ 100mL)	Average of Benthic Invertebrates	Total Point Score	Grade	Overall Surface Water Quality Grade Final Points	Grade
1	0.0256	35	N/A	8	B	4	B
2	0.0260	73	N/A	8	B	4	B
3	0.1975	356	N/A	3	D	1.5	D
4	0.0208	57	N/A	8	B	4	B
5	0.0225	23	N/A	9	A	4.5	A
6	0.0202	37	N/A	8	B	4	B
7	0.0095	104	N/A	8	B	4	B
8	0.0015	2	N/A	10	A	5	A

Table 4.9-2: Oliver Creek Watershed Forest Conditions and Overall Grade Calculation

					Overall Forest Conditions	
% Forest Cover	% Forest Interior	% Riparian Zone Forested	Total Point Score	Grade	Final Points	Final Grade
70.8	39.5	6.0	11	B	3.7	B

5 DISCUSSION

The Oliver Creek watershed was sampled at eight different locations, chosen based on accessibility and possible contamination sources, as well as attempting to reach all areas of the watershed. The first sampling period was on June 14, 2016 and the second sampling period on July 14, 2016.

The average air temperature for the June 14, 2016 sampling period was 15.1 degrees Celsius which exceeded the monthly average temperature of 14.5 degrees Celsius for June 2016 as well as the historical average of 14 degrees Celsius for June 1971-2000 in Thunder Bay. The average air temperature for the July sampling period was 18.6 degrees Celsius, which was the same as the monthly average temperature for July 2016 and exceeded the historical average of 17.6 degrees Celsius for July 1971-2000. Precipitation for the month of June totaled 212.7 millimetres, which was above the historical monthly average of 85.7 millimetres for Thunder Bay from June 1971-2000. In July, precipitation totaled 70.7 millimetres, which was below the historical monthly average of 89 millimetres for July 1971-2000. During the June and July sampling period, the sky was mostly overcast.

Water temperatures ranged from 13.5 degrees Celsius to 16.0 degrees Celsius in June and 19.1 degrees Celsius to 20.3 degrees Celsius in July, which can be seen on Figure 3: Oliver Creek Watershed Water Temperature. The stream depths observed ranged from 0.16 metres to 0.88 metres for both June and July. Water levels increased at Sites 1, 5, and 8 and decreased at Sites 3, 4, 6, and 7 between June and July.

All of the eight sample locations were water crossings that required a bridge or culvert to support the road. The only bridge was at Site 8. The bridge was made out of timber beams and did not appear to alter flow in a significant way, or change the natural stream course. Rip rap protection was used along the sides of the bridge and aided in bridge support as well as erosion and sedimentation control from road run-off. Culverts were present at Sites 1, 2, 3, 4, 5, 6 and 7. The culverts at these sites were in good condition and were large enough to withstand increased velocity and water levels from heavy rainfall. The culverts at Site 2 and 3 were starting to rust through on the bottom.

A vegetation assessment was carried out at each site, recording species present within view of each site. A summary of each site is included in Appendix F: Forest Ecosystem Classification. Forest Ecosystem Classification type V-15 White Spruce Mixedwood, was the most common and occurred at Sites 2, 5 and 8. The remaining sites still had a similar mixedwood forest type favouring coniferous species as opposed to hardwood. The dominant tree species within the Oliver Creek watershed included white spruce, balsam poplar, trembling aspen, jack pine and black spruce. The shrub layer was very diverse throughout the watershed, with many species present. Some commonly

observed species in the shrub layer were chokecherry, red osier dogwood, alder, raspberry, and willow species. The ground cover and herb layer included wildflowers typical of disturbed sites, most likely due to the habitat provided by roadsides. The most commonly observed herb and wildflower species included dandelion, ox-eyed daisy, swamp thistle, goldenrod, cow vetch, red and white clover. No invasive plant species or species at risk were seen at the sample sites within the Oliver Creek watershed.

Overall, the stream banks documented within the Oliver Creek watershed were stable. The main soil types were silty loam and sandy loam. Some of the sites were mainly silty but had vegetation right up to the edge of the water, while some had more boulder and cobble. Both types of substrate aid the banks by helping with slope stability and keeping erosion to a minimum.

The PWQO acceptable pH range is 6.5-8.5. The range within the Oliver Creek watershed was 7.45 to 8.22 as illustrated on Figure 4: pH Level at Oliver Creek Sample Sites. The average pH lies within a good water quality range.

Total Dissolved Solids (TDS) can be related to conductivity since the dissolved solids are what conduct an electric current through the water. The more dissolved solids present in a solution, the greater the conductive potential, as there are more ions present to carry the charge. The relationship can be seen in the watershed data when comparing between Figure 5: Conductivity at Oliver Creek Sample Sites and Figure 6: Total Dissolved Solids (TDS) at Oliver Creek Sample Sites, the highest reading for TDS and conductivity were at Site 3, and the lowest readings for both parameters were at Site 8.

As a limiting nutrient to aquatic vegetation, phosphorus is important to monitor in watersheds to avoid excessive vegetation growth, which can lead to lowered dissolved oxygen. Phosphorus exceeded the PWQO of 0.03 mg/L during the June sampling period at Site 3 with a value of 0.16 mg/L. During the July sampling period Sites 1, 2, and 3 were all in exceedance with a range of 0.0311 mg/L to 0.2350 mg/L. The average concentration of phosphorus was 0.03 mg/L for all sites during the June sampling month and 0.0534 mg/L during the July sampling month. The elevated levels of phosphorus could be related to high clay content in the creek, since phosphorus sorption capacity can increase with clay content.

Monitoring of bacterial levels in surface water is often limited to *E. coli*, as this is the most common water-borne pathogen that can cause illness and death. The *E. coli* levels at Site 3 and Site 7 were in exceedance of the PWQO of 100 MPN/100mL. Site 3 had a value of 687 MPN/100mL on July 14, 2016 and Site 7 had a value of 108 MPN/100mL on June 14, 2016. The rest of the sampling sites did not show any exceedances. The presence of *E. coli* in the watershed ranged from <1 to 687 MPN/100mL. The *E. coli* levels are illustrated on Figure 7: Escherichia Coli Bacteria Counts at Oliver Creek

Sample Sites. Presence of *E. coli* indicates a fecal contamination source nearby, but there are instances when fecal contamination occurs and testing does not show *E. coli* are present. It was noted at Site 7 that a beaver dam was present upstream and a farm was located upstream of Site 3; however, there were no exceedances of *E.coli* at the farthest downstream sample locations. Many studies have shown that the presence of farm animals near a stream can significantly influence bacteria counts. *E. coli* could also enter the watershed from leaking residential septic tanks and/or from manure. Total coliforms are among the flora present in the intestinal tract of animals and are often present in much greater numbers than potential pathogens, such as *E. coli*. Therefore, coliforms are easier to isolate and identify within a water sample. In order to better determine the possibility of contamination, total coliforms are measured in surface water as indicators of pathogenic bacteria contamination. No current PWQO exists for total coliforms. Total coliforms exceeded the pre-1994 PWQO of 1,000 MPN/100mL at all the sites with the exception of Site 8 during the June and July sampling period. The highest level of total coliforms present was >2,420 MPN/100mL at Sites 3 and 4 on June 14, 2016 and Sites 1, 2, 3 and 4 on July 14, 2016. Total coliforms ranged from 53 to >2,420 MPN/100mL.

Total ammonia ranged from <0.020 mg/L to 0.175 mg/L. Total ammonia does not have a singular criterion because its speciation between un-ionized and total forms are dependent on pH and temperature parameters. Total ammonia concentrations reported by the laboratory were converted into un-ionized ammonia concentrations using the conversion table provided in the PWQO guidelines. All un-ionized ammonia concentrations in the Oliver Creek watershed were <0.008 mg/L (with PWQO criterion of 0.020 mg/L). These guidelines were put in place for protection from direct toxic effects and do not consider indirect effects due to eutrophication (large algae blooms).

The PWQO criterion of 0.075 mg/L for aluminum was exceeded during the June sampling period at Sites 1, 2, 3, 4, 5 and 6, as well as Sites 1, 2, 3, 4, 5, 6 and 7 during the July sampling period. Aluminum concentrations ranged from 0.016 mg/L at Site 8 on June 14, 2016 to 0.331 mg/L at Site 6 on June 14, 2016. The average concentration of aluminum was 0.167 mg/L for all sites during the June sampling period and 0.1503 mg/L during the July sampling period.

All sites except for Site 8 were above the PWQO criterion of 0.3 mg/L for iron during both the sampling months of June and July, 2016. Iron concentrations ranged between 0.028 mg/L at Site 8 on June 14, 2016 and 1.510 mg/L at Site 5 on July 14, 2016. The average concentration of iron was 0.739 mg/L for the June sampling period and 0.995 mg/L for the July sampling period.

High aluminum and iron levels may be caused by the underlying geology. These metals may naturally dissociate from mineral-rich rocks. The exceedances are likely a result of natural source and are commonly high within the region.

The overall health of the Oliver Creek watershed was determined using the ratings from surface water quality and forest conditions, which were combined to give a grade for the Watershed Report Card. Given the number of exceedances for phosphorus and *E. coli*, the overall health of the Oliver Creek watershed surface water quality has received a rating (B) for its Watershed Report Card rating. The Oliver Creek forest conditions based on forest coverage, forest interior, and riparian zone forested, were determined to also result in a rating of (B). Based on this rating and other observed conditions, the Oliver Creek watershed has been determined to have good overall health.

6 CONCLUSION

The Oliver Creek watershed was determined to be in good condition with minimal evident anthropogenic impacts. Surface water quality at the time of the study was good, with the exceedances of the Provincial Water Quality Objectives being mostly attributed to natural sources. Plant species composition seems characteristic of the boreal forest, with diversity at each site among the overstory, understory and herb layer. A more comprehensive fauna study would give a clear indication of the species and populations present, but at the time of the study, multiple species were observed giving a good representation of a typical boreal forest area. Water levels appeared consistent with previous water markings. Erosion was not typically a concern, as the stream banks were stable. Stream cover was often provided by shrubs and trees growing along the creek banks which also helped prevent erosion. Bridges and culverts were in stable condition with no immediate concern for maintenance.

7 RECOMMENDATIONS

Upon completion of the 2016 Oliver Creek Watershed Assessment, the following recommendations have been made for considerations:

- Staff and funding permitting it is recommended that an update to the 2016 Oliver Creek Watershed Assessment be completed in the next five to ten years.
- Benthic analysis indicates water quality over an extended period of time and should be considered for future watershed assessments.
- Additional sampling should be conducted in the spring to observe the water quality differences between high and low flow seasons.
- A copy of this report should be provided to the Municipality of Neebing and Municipality of Oliver Paipoonge for reference purposes. The report should be kept on file at the LRCA Administration Office for review by interested parties.

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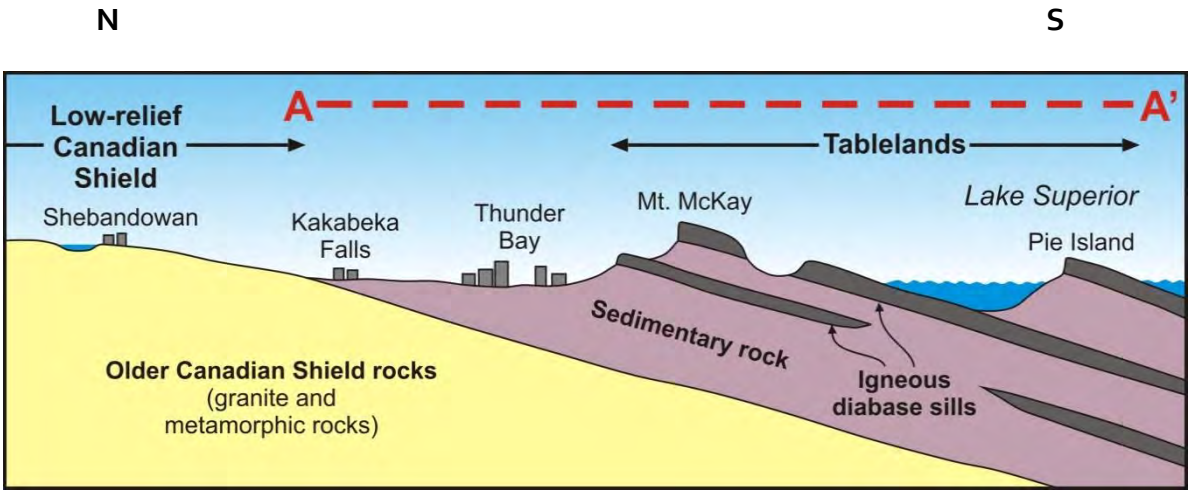
Figures



The Oliver Creek Watershed forms in an erosional valley of soft Animikie Shales bounded to the south by mesas and cuestas of hard Igneous diabase sills.

Figure 1: Rock Formations South of Thunder Bay

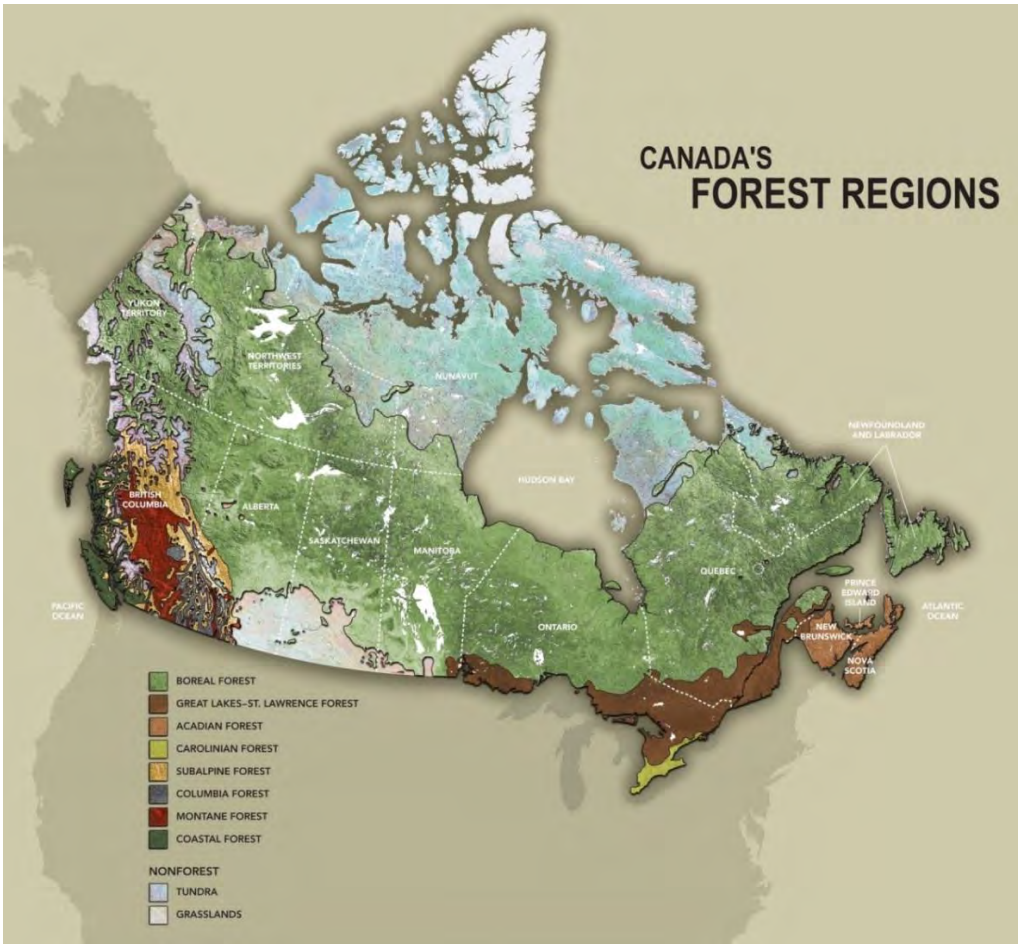


Figure 2: Canada's Forest Regions (Canadian Forest Service, 2013)

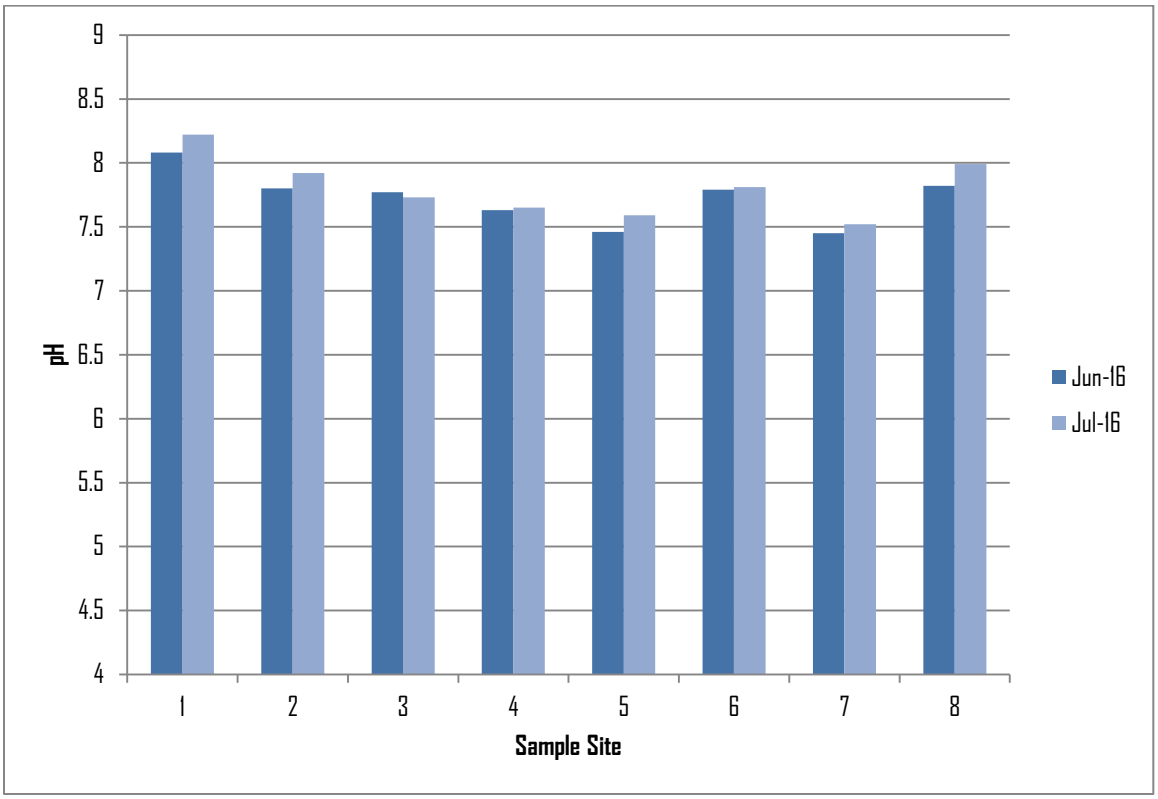


Figure 3: pH Level at Oliver Creek Sample Sites

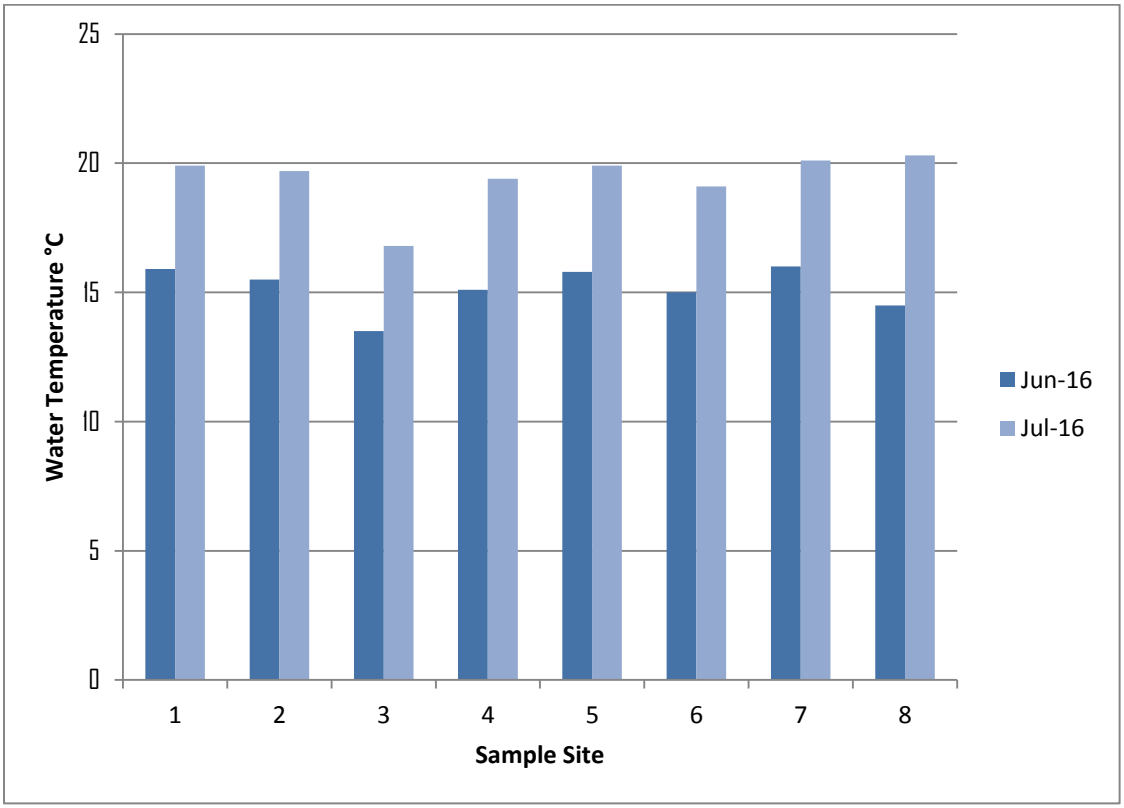


Figure 4: Water Temperature at Oliver Creek Sample Sites

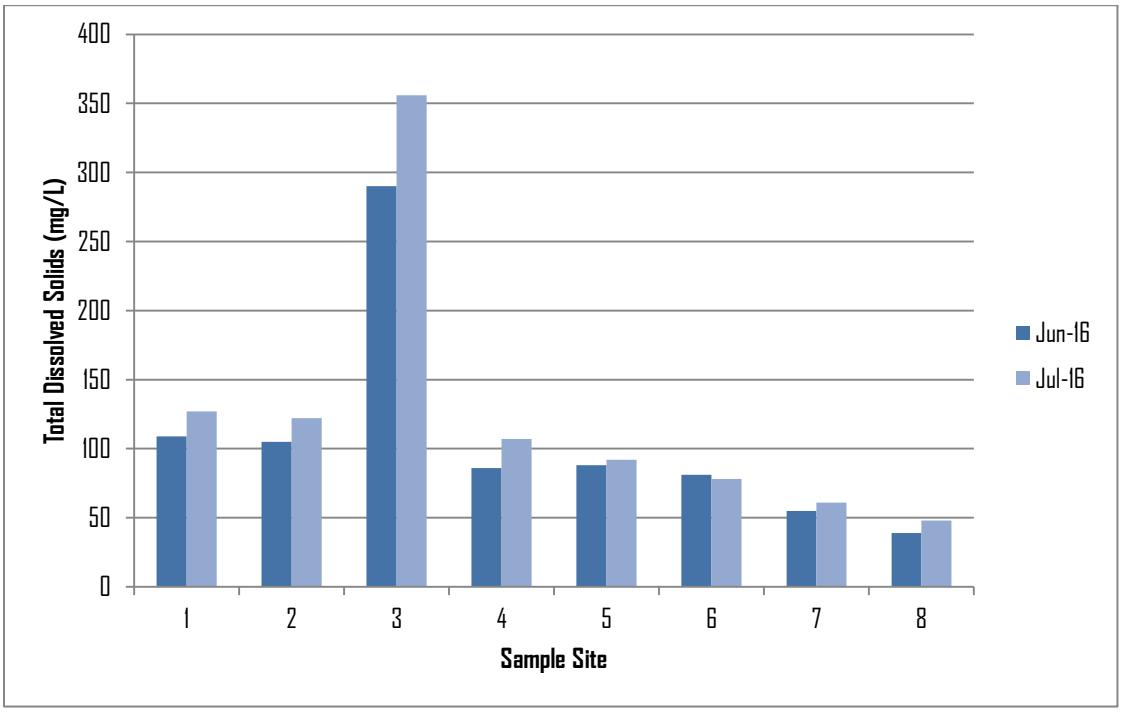


Figure 5: Total Dissolved Solids at Oliver Creek Sample Sites

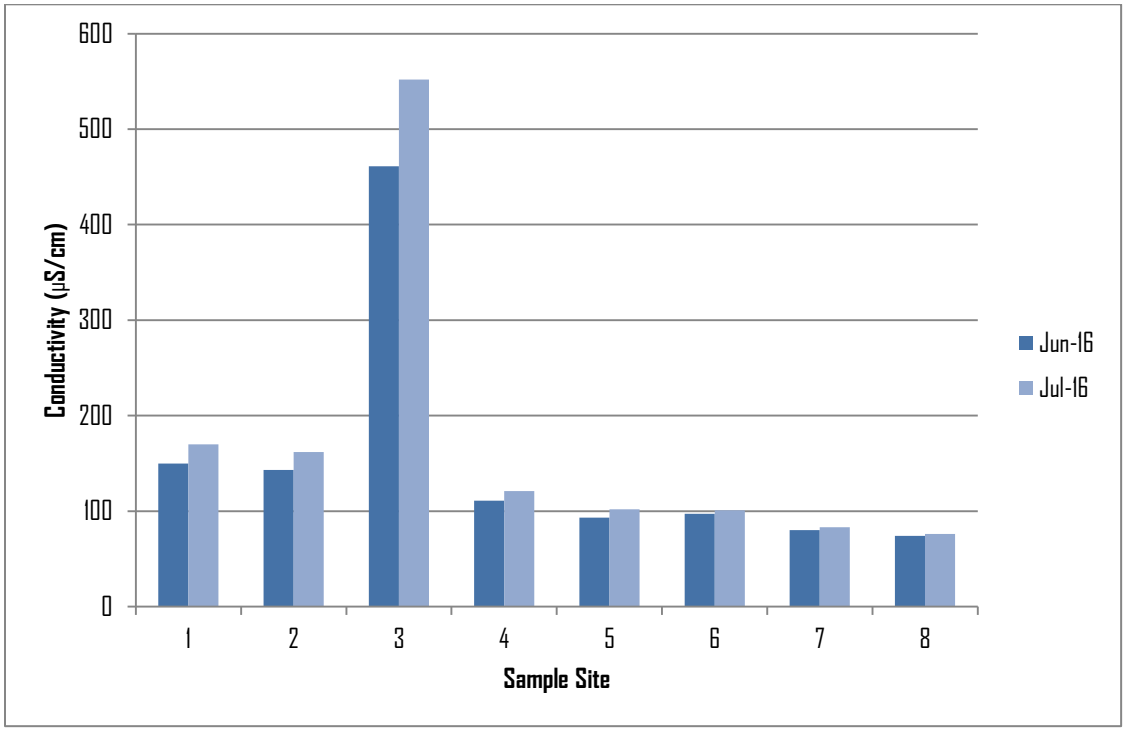


Figure 6: Conductivity at Oliver Creek Sample Sites

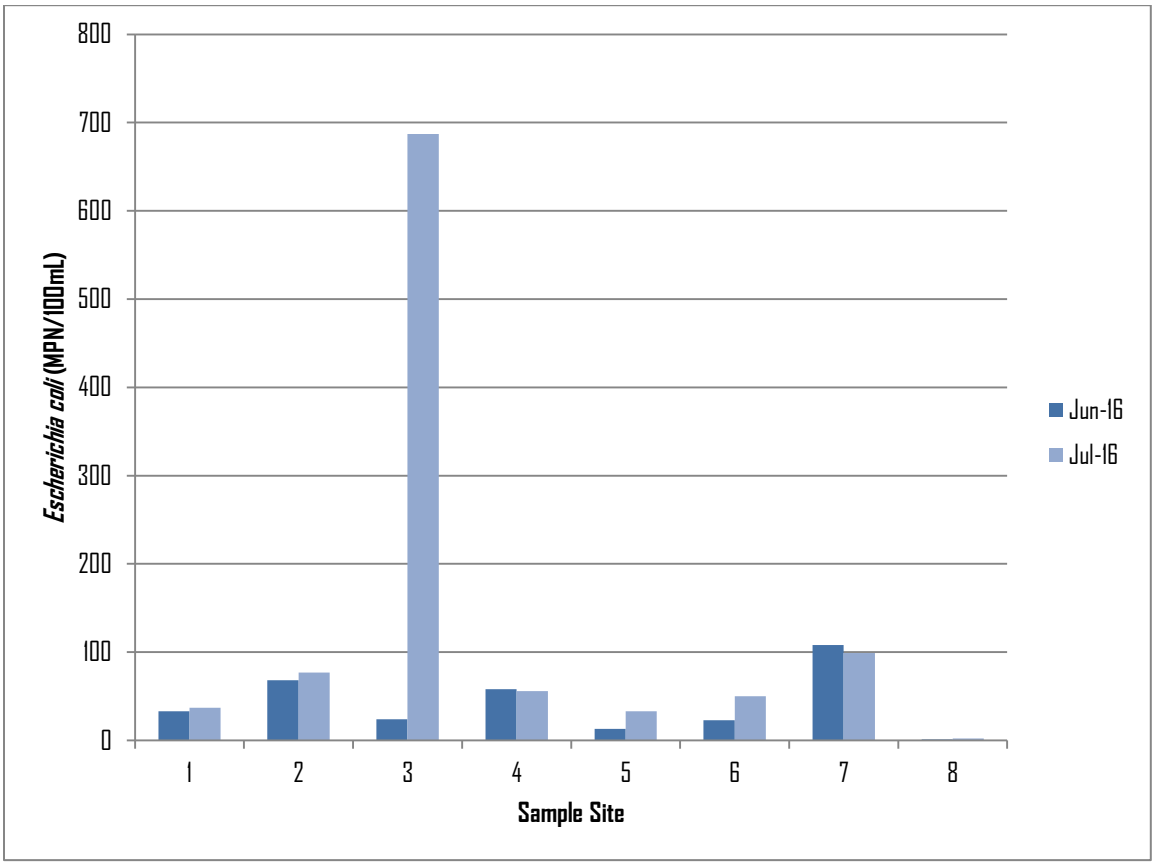


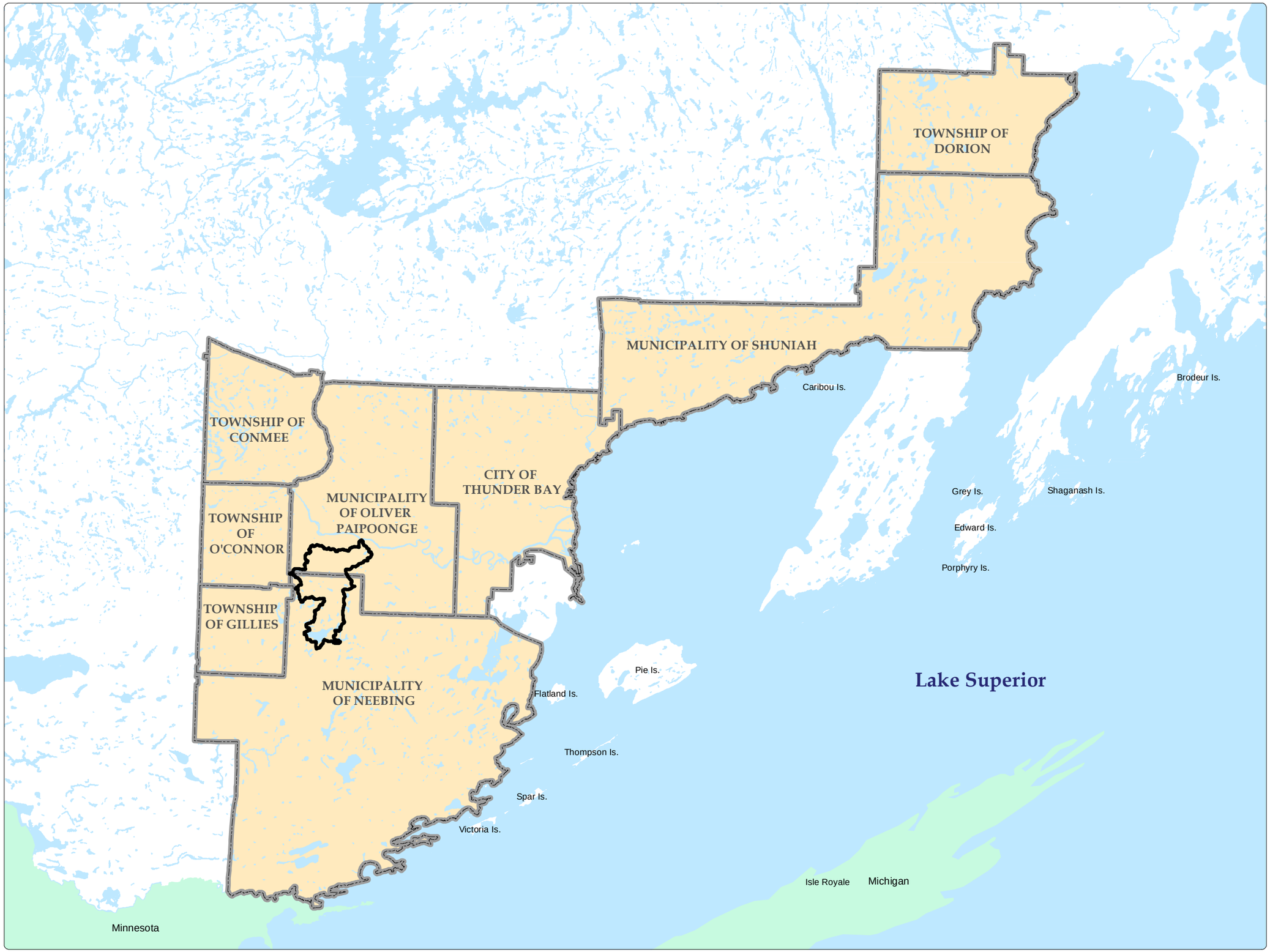
Figure 8: *Escherichia Coli* Bacteria Counts at Oliver Creek Sample Sites

Maps

LAKEHEAD REGION
CONSERVATION AUTHORITY

Oliver Creek Watershed

M-1: Key Plan



N

Legend

- Oliver Creek Watershed
- Municipal Boundary
- LRCA Jurisdiction Boundary
- Water Body

0 10 20 km

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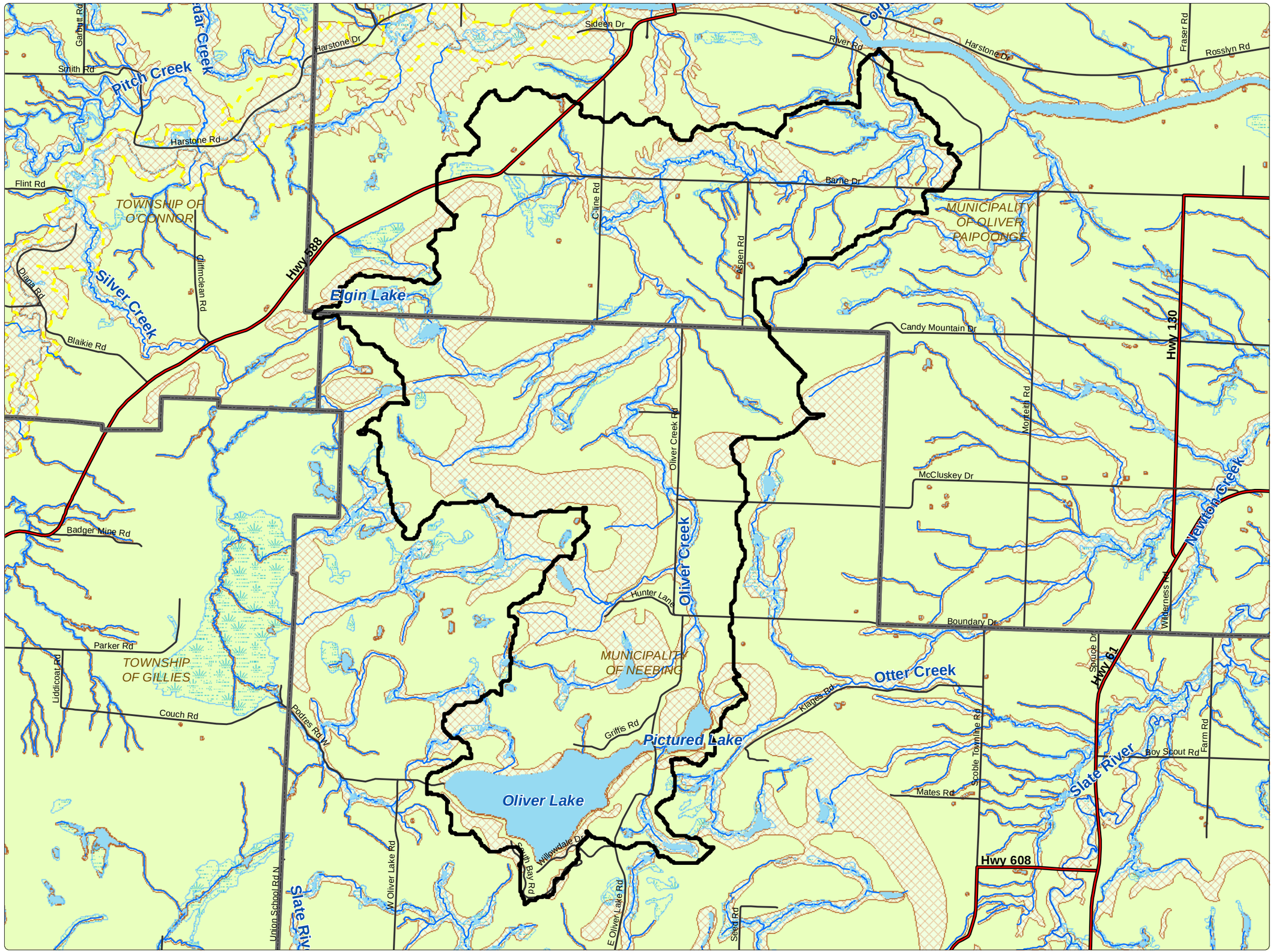
Datum: NAD 83
Projection: UTM Zone 16N
Date: March 2017

LAKEHEAD REGION CONSERVATION AUTHORITY

Oliver Creek Watershed

M-2: Regulated Area



Legend

- Approximate Regulated Area
- Oliver Creek Watershed
- Municipal Boundary
- LRCA Jurisdiction Boundary

Drainage

- Water Body
- Provincially Significant Wetland
- Wetland
- Stream
- River
- Ditch
- Regional Floodline
- 100 Year Floodline
- Identified Spillway
- Fill Line
- Interpolated Floodline
- End of Study Area

Roads

- Highway
- Road
- Street

0 1 2 km

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LAKEHEAD REGION CONSERVATION AUTHORITY

Oliver Creek Watershed

M-3: Topography

N

Legend

- Highest Point in Watershed
- Oliver Creek Watershed

Drainage

- Water Body
- Provincially Significant Wetland
- Wetland
- Stream
- River
- Ditch
- Municipal Boundary

Contour Lines

- 10m Contour Intervals
- 50m Contour Intervals

Roads

- Highway
- Road
- Street

0 1 2 km

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LAKEHEAD REGION CONSERVATION AUTHORITY

Oliver Creek Watershed

M-4: Bedrock Geology

N

Legend

- Oliver Creek Watershed
- Municipal Boundary

Bedrock_Formation

MESOPROTEROZOIC

- 31a, Mafic and related intrusive rocks (Keweenawan age)

PALEOPROTEROZOIC

- 22a, Sedimentary rocks

Drainage

- Water Body
- Provincially Significant Wetland
- Wetland
- Stream
- River
- Ditch

Roads

- Highway
- Road
- Street

0 1 2 km

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LAKEHEAD REGION CONSERVATION AUTHORITY

Oliver Creek Watershed

M-5: Surficial Geology

N

Legend

- Oliver Creek Watershed
- Municipal Boundary

Surficial Geology

- Alluvial
- Bedrock
- Esker/Kame/Outwash plain
- Glaciolacustrine plain
- Moraine
- Organics
- Slope/Talus pile

Surficial Points Features

- QUARRY/MINE WORKINGS
- SAND/GRAVEL PIT
- TALUS

Drainage

- Water Body
- Provincially Significant Wetland
- Wetland
- Stream
- River
- Ditch

Roads

- Highway
- Road
- Street

0 1 2 km

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LAKEHEAD REGION CONSERVATION AUTHORITY

Oliver Creek Watershed

M-6: Soils

N

Legend

- Sampling Sites
- Oliver Creek Watershed
- Municipal Boundary

Drainage

- Water Body
- Provincially Significant Wetland
- Wetland
- Stream
- River
- Ditch

OMAFRA Soils

- Organic (O)
- Clay (c)
- Clay Loam (cl)
- Fine Sandy Loam (fsl)
- Gravel (g)
- Gravelly Sand (gs)
- Gravelly Sand Loam (gsl)
- Medium to Moderately Fine Loam (l)
- Loamy Sand (ls)
- Peaty Phase (pp)
- Rock (r)
- Coarse Sand and Loamy Sand (s)
- Silty Clay Loam (sicl)
- Silt Loam (sil)
- Moderately Coarse Sandy Loam (sl)
- Very Fine Sandy Loam (vfsl)

Roads

- Highway
- Road
- Street

0 1 2 km

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Date: March 2017

LAKEHEAD REGION CONSERVATION AUTHORITY

Oliver Creek Watershed

M-7: Land Ownership

N

Legend

- Oliver Creek Watershed
- Municipal Boundary

Land Ownership

- Crown Land
- Federal Land Indian Reserve
- Private Land

Roads

- Highway
- Road
- Street

Drainage

- Water Body
- Provincially Significant Wetland
- Wetland
- Stream
- River
- Ditch

0 1 2 km

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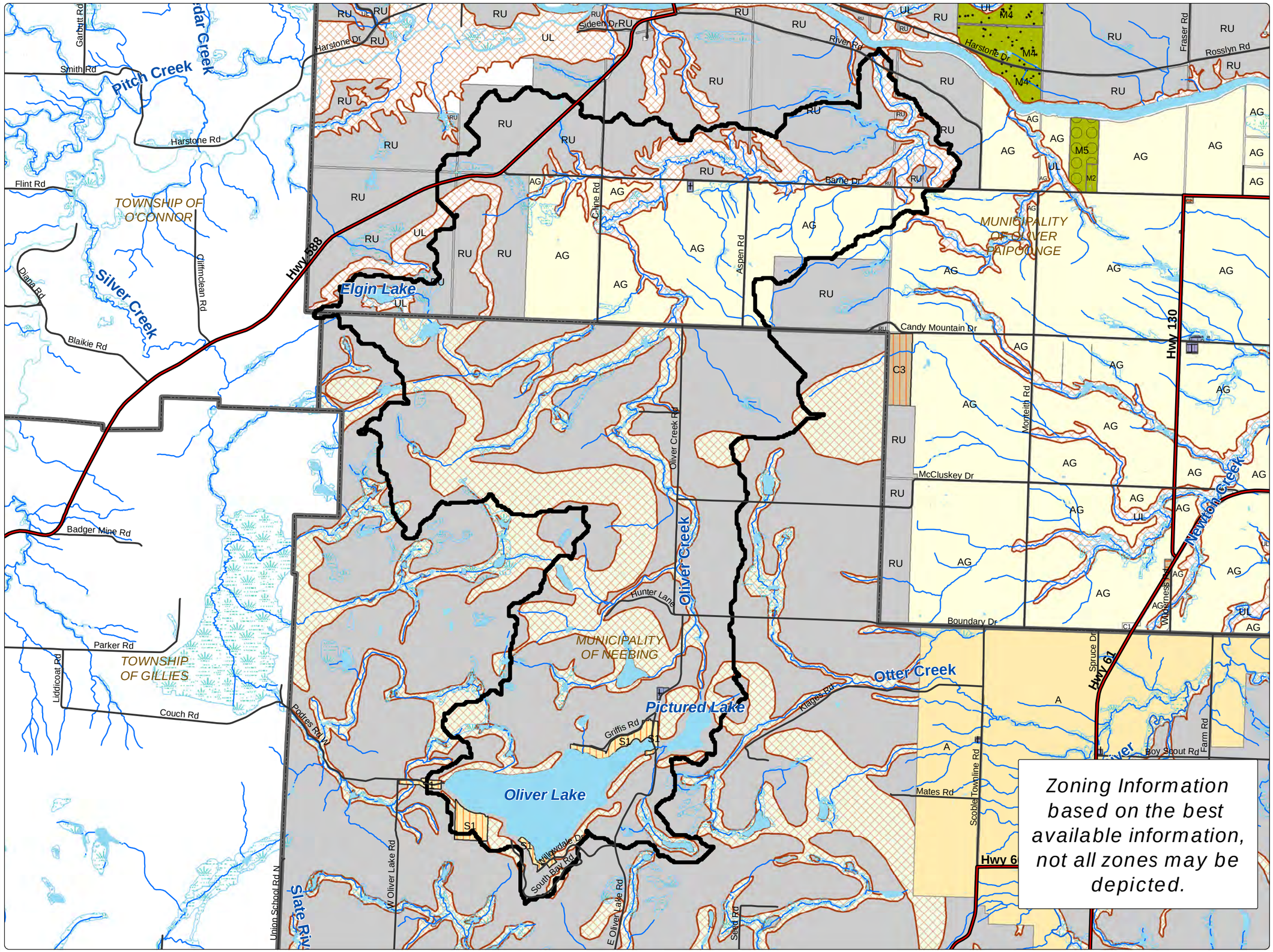
Datum: NAD 83
Projection: UTM Zone 16N
Date: March 2017

LAKEHEAD REGION CONSERVATION AUTHORITY

Oliver Creek Watershed

M-8: Zoning



Zoning Information based on the best available information, not all zones may be depicted.

N

Legend

- Oliver Creek Watershed

Municipality of Neebing Zoning

- A, Agricultural Zone
- I, Institutional Zone
- S1, Recreation 1 Zone
- UL, Use Limitation Zone
- R, Rural

Municipality of Oliver-Paipoonge Zoning

- PAG, Paipoonge General Agriculture
- C2, General Commercial
- C3, Recreation Commercial
- I, Institutional
- M1, Light Industrial
- M2, General Industrial
- M4, Extractive Industrial
- M5, Disposable Industrial
- UL, Use Limitation
- PRU, Paipoonge Rural

Drainage

- Water Body
- Provincially Significant Wetland
- Wetland
- Stream
- River
- Ditch

Roads

- Highway
- Road
- Street

0 1 2 km

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Lakehead Region Conservation Authority
130 Conservation Rd.
Thunder Bay, ON
P7B 6T8

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Datum: NAD 83
Projection: UTM Zone 16N
Date: April 2017

LAKEHEAD REGION CONSERVATION AUTHORITY

Oliver Creek Watershed

M-9: Site Plan

N

Legend

- Sampling Sites
- Oliver Creek Watershed
- Township Boundary
- Household Waste Disposal Site
- Inactive Waste Disposal Site

Drainage

- Water Body
- Wetland
- Provincially Significant Wetland
- Stream
- River
- Ditch

Roads

- Highway
- Road
- Street

0 1 2 km

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LAKEHEAD REGION CONSERVATION AUTHORITY

Oliver Creek Watershed

M-10: Bridge & Culvert Sites

N

Legend

- Confluence
- Bridge
- Culvert
- Oliver Creek Watershed
- Municipal Boundary

Drainage

- Water Body
- Wetland
- Stream
- River
- Ditch

Roads

- Highway
- Road
- Street

0 1 2 km

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Datum: NAD 83
Projection: UTM Zone 16N
Date: March 2017

Appendix A:

Soil Logging Summary and Photography

Appendix A: Soil Logging Summary and Photography

Soil Logging Summary

SITE ID	Organic Layer "O"	"A" Horizon	"B" Horizon	"C" Horizon
OC1		0-10cm Sand (S)	10-70cm Sandy Gravel (SG)	70cm->
cobbles
OC2		0-10cm brown Sandy Loam (SL)		10cm->
Rock (r) shale
OC3		0-30cm Sandy Loam (SL)	30-90cm Sandy Loam (SL) >10% Coarse	
OC4		0-50cm Loamy sand (LS)		50-90cm Silty Clay Loam (SiCl)
OC5	0-15cm Mesic Organic (O)	15-25cm Silty Clay loam (SiCl)		
OC6	0-5cm Organic (O)	5-40cm Sandy Loam (SL)	40-100cm Loam(L)>50% Coarse	
OC7		0-5cm Sandy Loam (SL)	5-60cm Loamy Sand (LS)	60-95cm Loamy Sand (LS)
OC8			0-45cm Loamy Sand (LS)	45-95cm Loamy Sand (LS)

Soil Photography

Site 1

Site 2

Site 2 – Shale Bedrock

Site 3

Site 4

Site 5

Site 6

Site 7

Site 8

Appendix B:

Common and Scientific Names of Identified Flora and Fauna

Appendix B: Common and Scientific Names of Identified Flora and Fauna

Flora	
Common Name	**Scientific (Latin) Name**
Trees	
Apple spp.	*Malus spp.*
Balsam poplar	*Populus balsamifera*
Black ash	*Fraxinus nigra*
Black spruce	*Picea mariana*
Jack pine	*Pinus banksiana*
Tamarack	*Larix laricina*
Trembling aspen	*Populus tremuloides*
White birch	*Betula papyrifera*
White pine	*Pinus strobus*
White spruce	*Picea glauca*
Shrubs	
Beaked hazel	*Corylus cornuta*
Bush honeysuckle	*Diervilla lonicera*
Canada goldenrod	*Solidago canadensis*
Fringed bindweed	*Polygonum cilinode*
Green alder	*Alnus viridis*
Highbush cranberry	*Viburnum trilobum*
Showy mountain-ash	*Sorbus americana*
Mountain maple	*Acer spicatum*
Northern wild black current	*Ribes hudsonianum*
Pin cherry	*Prunus pensylvanica*
Prickly wild rose	*Rosa acicularis*
Red-osier dogwood	*Cornus stolonifera*
Saskatoon (serviceberry)	*Amelanchier alnifolia*
Speckled alder	*Alnus rugosa*
Virginia creeper	*Parthenocissus quinquefolia*
Wild red raspberry	*Rubus idaeus*
Willow spp.	*Salix spp.*
Herbs	
American vetch	*Vicia americana*
Canada anemone	*Anemone canadensis*
Canada goldenrod	*Solidago canadensis*
Common strawberry	*Fragaria virginiana*
Cow parsnip	*Heracleum lanatum*
Cow vetch	*Vivia cracca*
Dandelion	*Taraxacum officinale*

Flora	
Common Name	**Scientific (Latin) Name**
Herbs	
Mullein	*Verbascum thapsus*
Northern bluebell	*Mertensia paniculata*
Large leaved aster	*Aster macrophyllus*
Lupines	*Lupinus albus*
Orange hawkweed	*Hieracium aurantiacum*
Ox-eye daisy	*Leucanthemum vulgare*
Red clover	*Trifolium pratense*
Rose-twisted stalk	*Streptopus amplexifolius*
Rough Bedstraw	*Galium asprellum*
Sweet coltsfoot	*Petasites frigidus*
Swamp thistle	*Cirsium muticum*
Wild Columbine	*Aquilegia canadensis*
Wild Pea	*Lathyrus palustris*
Woodland strawberry	*Fragaria vesca*
Yarrow	*Achillea millefolium*
Yellow hawkweed	*Hieracium pratense*
Ferns/Mosses/Graminoids/Lichens	
Bulrush spp.	*Scirpus spp.*
Common reed	*Phragmites australis*
Dog's tooth lichen	*Peltigera canina*
Horsetail - field	*Equisetum arvense*
Horsetail - swamp	*Equisetum fluviatile*
Horsetail - woodland	*Equisetum sylvaticum*
Lady fern	*Athyrium filix-femina*
Oak fern	*Gymnocarpium dryopteris*
Plume moss	*Ptilium crista-castrensis*
Sedge spp.	*Carex spp.*
Sphagnum spp.	*Sphagnum spp.*
Aquatic Plants	
Common cattail	*Typha latifolia*

Fauna	
Common Name	**Scientific (Latin) Name**
Fish	
Smallmouth bass	*Micropterus dolomieu*
Emerald Shiner	*Notropis atherinoides*
Shiner spp.	*Notropis spp.*
Invertebrates	
Black flies	*Simuliidae spp.*
Eastern tiger swallowtail	*Papilio glaucus*
Midges	*Pseudochironomus spp.*
Mosquitoes	*Culicidae spp.*
Red ants	*Solenopsis spp.*
Spring azure	*Celastrina ladon*
Water spider	*Papilio glaucus*
Water strider	*Gerridae spp.*
Aves	
Canada goose	*Branta canadensis*
Ruffled grouse	*Bonasa umbellus*
Common merganser	*Mergus merganser*
Mammals	
White tail deer	*Odocoileus virginianus*

Appendix C:

Techniques for Data Collection

Appendix C: Techniques for Data Collection

Air Temperature
The air temperature was measured with a basic mercury thermometer.

Channel Width & Depth
The width of the stream was measured using a nylon measuring-tape reel. Channel depth was measured by using a stainless steel meter stick.

Conductivity
Conductivity was measured with the YSI Pro DSS. The accuracy of the reading was ±0.001 mS/cm or ±1.0%; whichever was greater. The readings were recorded once the probe was completely submerged and all readings stabilized. In addition to conductivity readings taken in the field, laboratory analysis of the samples provided a second reading of conductivity which is included within the results.

Dissolved Oxygen
The YSI Pro DSS measured dissolved oxygen for the samples. The readings were recorded once the probe was submerged in the water and all variables were stabilized.

Flora and Fauna Identification
Identification was made in the vicinity of the sample sites, no transects were made. Observations were made approximately 50 metres from either stream edge. Field guides were used to accurately identify species.

Flow
The velocity of river flow at sites was measured using a stick and nylon measuring-tape reel. Distances measured varied depending upon stream obstructions and variable depth. The flow was then calculated using the equation **Q=V*A,** where **Q** is flow/ discharge, **V** is velocity (distance divided by time), and **A** is the cross sectional area of the stream.

Latitude, Longitude, and Elevation
The Universal Transverse Mercator (UTM) coordinates for each site were measured with a Trimble Geo XH 2008 hand held GPS unit.

Location
The sample sites were chosen using a 1:50,000 scale topographic map. The sample sites were also described in terms of road access and road crossings.

pH
The YSI Pro DSS measured pH for the water sample sites. The readings were recorded once the probe was submerged in the water and all the variables were stabilized. A pH reading was also taken during the analysis at the laboratory.

Photographs
Photographs were taken at each site using the Stylus 1030SW shock and water proof camera. Upstream and downstream photographs as well as culvert, bridge, and outstanding litter or erosion photographs were all taken at each site. Substrate photographs were attempted at each site with the waterproof camera.

Surface Water Sampling
Samples were taken at the same position at each site wherever possible. Grab sampling technique was used when conducting surface water sampling. Sample bottles were pre-charged with preservatives, so this did not have to be done in the field. Sample bottles were submerged 15 to 30 centimetres below the surface of the water body and positioned towards the flow of the water source. Samples were kept cool and delivered to ALS Laboratory for analyzing.

Total Dissolved Solids
The total dissolved solids (TDS) were measured in laboratory.

Turbidity
Turbidity of the water was measured with the YSI Pro DSS. The readings were taken after the probe was submerged and all variables on the meter were stabilized.

Water Temperature
Water temperature was measured with the YSI Pro DSS. The readings were taken after the probe was submerged and all variables on the meter were stabilized.

OBBN In-Stream Materials Key

Soil Type
Like stream bed description, soil type on land will impact vegetation and erosion potential. Soil type was categorized based on its grain size using the FEC Manual for North Western Ontario.

Stream Bed Description
The bed description was described by means of a visual scan of the sample site area, with percentages assigned to the appropriate categories of varying grain sizes:

Grain Size	Description
Boulder	> 25.6 cm in diameter
Cobbles	6.4 - 25.6 cm in diameter
Gravel	0.2 – 6.4 cm in diameter
Sand	< 0.2 cm in diameter
Silt	Finer inorganic material than sand
Organic	Mainly organic combination of silt and clay
Clay	Inorganic origin with no apparent structure

Stream Cover

Stream cover describes the vegetation density along the river bank no more than 5 metres from the water's edge. Stream cover was divided into three categories of density:

Description	% Cover
Dense	75-100% shaded by canopy
Partly Open	25-75% shaded by canopy
Open	0-25% shaded by canopy

Appendix D:

Summary of Water Quality Parameters

Appendix D: Summary of Water Quality Parameters

Physical Properties

The abiotic factors of water quality are very influential on aquatic plants and animals and can have a significant impact on the ecosystem. The following physical parameters were measured either in the field or in the laboratory.

Conductivity
Conductivity is the measure of the ability of water to carry an electrical current expressed in micro seimens per centimetre. The reading is used to determine the total dissolved solids (TDS) in the water sample. There is no PWQO for conductivity.

Dissolved Oxygen
Like terrestrial animals, fish and other aquatic species require oxygen to breathe. It is not the mere presence of dissolved oxygen that is important; the gas has to be above a certain concentration in order to sustain life. As well, oxygen is required to decompose organic matter in the stream. Dissolved oxygen levels will be highest if the water is colder, turbulent (a lot of mixing at the air-water interface) and during the day when aquatic plants have had time to produce oxygen during photosynthesis. PWQO's have an acceptable range for dissolved oxygen in water dependent upon temperature. At 20 degrees Celsius the minimum amount of dissolved oxygen is 5 milligrams per litre.

pH
The pH measures the concentration of hydrogen ions in the water based on a logarithmic scale of 0 to 14. Lower pH is acidic (many free hydrogen ions) and higher pH is alkaline (few free hydrogen ions). The pH of water determines the solubility and biological availability of chemicals constituents such as nutrients (eg. nitrogen, phosphorus) and heavy metals (eg. lead, copper). Geology of the watershed can give the river some buffering capacity to resist changes in pH but overall the range has to stay between 6.5 and 8.5 to protect aquatic life.

Temperature
Water temperature is important because it dictates the kind of aquatic life that can live in a stream. Fish, insects, plankton and other aquatic species all have a preferred temperature range. If the temperature goes too far above or below their preferred range, then the number of species will decrease until there is none. Temperature also influences water chemistry which in turn affects biological activity. Chemical reactions generally speed up with warmer temperatures. Temperature is important, as warmer water holds less dissolved oxygen and warmer water will allow bacteria to reproduce and grow more quickly. Temperature can vary depending on the source of the water,

depth and velocity of the stream, sunlight intensity and the amount of shade by the shoreline vegetation.

Total Dissolved Solids

Total dissolved solids (TDS) measure the amount of inorganic salts and small amounts of organic matter that is dissolved in water. The principal constituents are usually calcium, magnesium, sodium, potassium, carbonate, bicarbonate, chloride, sulphate, and nitrate (from agricultural use). Most of these originate from natural geological sources yet high levels may indicate runoff from of road salts, runoff from agricultural and erosion from exposed soil/no stream bank vegetation. There is no PWQO for TDS.

Turbidity

Turbidity is the measure of the relative clarity of water. Turbidity in water is caused by suspended matter such as silt, clay and algae that scatter the sunlight. The diversity of species will be affected by how far the sunlight can penetrate the water column. Fish gills will become clogged with a lot of suspended material, as well the material can settle on top of fish spawning grounds (and their eggs). Highly turbid water will appear murky or dirty. Turbidity will be higher after heavy rainfall, but high levels may also indicate soil erosion.

Nutrients

Like terrestrial plants, aquatic plants and algae require nutrients for growth and productivity. The main nutrients of concern are nitrogen and phosphorus.

Nitrogen

Nitrogen (N) is one of the most common gases in our atmosphere. It makes up approximately 78% of the earth's atmosphere. Like phosphorus, these nutrients are often applied to agricultural crops as fertilizers and having too much in the river can increase plant growth and productivity to unhealthy levels. Nitrogen is constantly being recycled through the environment through decomposition, etc. The most important forms that plants can readily use are ammonia, nitrate (NO_3) and nitrite (NO_2). There are many different ways to report nitrogen so it is necessary to note that the results from ALS Laboratory Group were given in Total ammonia-nitrogen (mg/L), Nitrate-nitrogen (NO_3-N mg/L), and Nitrite-nitrogen (NO_2-N mg/L).

Phosphorus

Total phosphorus gives a measurement of all forms of phosphorus in the water, but the most important form within this measurement is soluble inorganic phosphate (PO_4) or orthophosphate ion (PO_4^{-3}) because it is the fraction utilized by aquatic plants. While phosphorus is essential to life, too much of it will increase algae growth attached to rocks in the river. Excessive growths of attached algae can use up all the dissolved

oxygen leaving other species, like fish, with anoxic (no oxygen) conditions. Nutrient loading may cause a decrease in biodiversity and a decrease in the most ecologically sensitive species. Natural decomposition of organic matter such as leaves, twigs, grass that is washed into the stream during the winter does constitute an important source of nutrients. However, high levels of phosphorus may indicate unnatural sources such as detergent, pesticide and fertilizer runoff from developed watersheds. Milk house waste from dairy farms is also a large source of phosphorus and has become one of the main environmental issues surrounding dairy farming.

Bacteria

Escherichia coli

Escherichia coli (*E. coli*) are naturally found in the intestines of humans and warm-blooded animals. Unlike other bacteria in this family, *E. coli* does not usually occur naturally on plants or in soil and water. The inability of *E. coli* to grow in water combined with its short survival time in water environments means that the detection of *E. coli* in a water system is a good indicator of recent fecal contamination. Potential sources of *E. coli* include: leaking septic systems, runoff from manure storage facilities or wild animal waste (i.e. beavers and Canadian Geese). These bacteria can cause irritation of the skin and eyes when contact is made and can cause gastro-intestinal disorders.

Total Coliforms

Total coliforms are a group of bacteria that are naturally found on plants and in soils, water, and in the intestines of humans and warm-blooded animals. Because total coliforms are widespread in the environment, they can be used as one of the many operational tools to determine the efficacy of a drinking water treatment system. The total coliform group contains various species of the genera *Escherichia, Klebsiella, Enterobacte, Citrobacter, Serratia,* and many others. There is no current PWQO for total coliforms; however, the previous guideline was 1000 MPN per 100 mL.

Metals

Most of the metals listed below are found naturally within the earth's crust and weathering of rock can transport them into surface water. The following is a complete list of the metals analysis performed on the water samples and their qualities.

Aluminum

Aluminum is the most abundant metal on Earth, comprising about 8% of the Earth's crust. It is found in a variety of minerals, such as feldspars and micas, which, with time, weather to clays and exposure is inevitable. High levels of aluminum will put strain on the kidneys of animals when they attempt to excrete it but it is not normally fatal. Aluminum and its compounds are often used in food as additives, in drugs, in consumer

products and in the treatment of drinking water. Aluminum poisoning has been linked to neurological dementia in kidney dialysis patients and, in recent years, its role in Alzheimer's disease, Parkinson's disease and Lou Gehrig's disease. The intake of large amounts of aluminum can also cause anaemia, osteomalacia (brittle or soft bones), glucose intolerance, and cardiac arrest in humans. The PWQO guideline for aluminum varies with pH, the maximum concentration being 75 µg/L.

Antimony

Antimony is a metallic element that is a blue-white colour in its stable form. Acute intoxication is characterized by abdominal pain, vomiting, diarrhea, dehydration, muscular pain, shock, haemoglobinuria, anuria and uraemia. In addition, severe myocardial symptoms and convulsions have been observed with acute doses of antimonials, as well some deaths were attributed to liver necrosis. The maximum concentration of antimony under PWQO guidelines is 20 µg/L.

Arsenic

Arsenic is a natural element abundantly found within the earth's crust. It may be found in some drinking water supplies, including wells. Long-term exposure (over many years or decades) to high levels of arsenic in drinking water may cause thickening and discoloration of the skin; nausea and diarrhea; decreased production of blood cells; abnormal heart rhythm and blood vessel damage, or numbness in the hands and feet. Short term exposure (days/weeks) to very high levels of arsenic can result in abdominal pain, vomiting and diarrhea, muscular cramping or pain, weakness and flushing of skin, skin rash, numbness, burning or tingling sensation on the palms of the hands and soles of the feet, or loss of movement and sensory response. The maximum concentration of arsenic under PWQO guidelines is 5 µg/L.

Barium

Barium is present as a trace element in both igneous and sedimentary rocks. Although it is not found free in nature, barium occurs in a number of compounds. Barium compounds have a wide variety of industrial applications. They are used in the plastics, rubber, electronics and textiles industries. At high concentrations, barium causes strong vasoconstriction by its direct stimulation of arterial muscle, peristalsis due to the violent stimulation of smooth muscle, and convulsions and paralysis following stimulation of the central nervous system. Depending on the dose and solubility of the barium salt, death may occur in a few hours or a few days. There are currently no PWQO guidelines for barium.

Beryllium

Beryllium is a hard grey metal that is extracted from the earth, refined and reduced to a very fine powder. It occurs as a chemical component of certain rocks, coal and oil, soil, and volcanic dust. People exposed to beryllium are at risk of developing serious

debilitating diseases. Chronic beryllium disease (CBD or berylliosis) is a painful scarring of the lung tissue. Less common than CBD, acute (short—term) beryllium disease, causes lung inflammation resembling pneumonia. In severe cases, both diseases may be fatal. The maximum concentration of beryllium under PWQO guidelines depends on hardness. If $CaCO_3$ is >75 mg/L the maximum concentration of beryllium is 1100 µg/L and if the $CaCO_3$ is <75 mg/L the maximum concentration of Beryllium is 11 µg/L.

Bismuth

Bismuth is a brittle metal with a pinkish colour, often found in its native form. Exposure to bismuth at low doses may cause gastrointestinal disorders, low stomach acid, heartburn, bloating, calcification, warts, diarrhea, and gastric ulcers. At large doses it may cause mental confusion, memory problems, tremors, staggering gait, muscle twitching, slurring speech, joint problems, hypoadrenalism, hearing and visual disturbances, hallucinations and coma. There are currently no PWQO guidelines limiting the intake of bismuth.

Boron

Boron is a non-metallic element that is not found in nature in its elemental form but can be found in a number of compounds. Exposure to boron in small doses may cause irritation to the nose, throat and eyes. In larger doses, boron can affect the stomach, liver, kidneys and brain, and may eventually lead to death. The maximum level of boron under PWQO guidelines is 200 µg/L.

Cadmium

Cadmium is an extremely toxic metal even in low concentrations. It is used commercially as a stabilizer in plastic, fungicides for golf courses, television picture tube phosphors, nickel–cadmium batteries, motor oils, and curing agents for rubber. Cadmium poisoning can lead to itai-itai disease, which initiates bone softening, joint pain and kidney failure. The maximum concentration of cadmium under PWQO guidelines is 0.2 µg/L. The interim PWQO guideline states if hardness as $CaCO_3$ is 0-100 the maximum cadmium concentration is 0.1 µg/L and if hardness is >100, the maximum cadmium concentration is 0.5 µg/L.

Calcium

Calcium is the third most abundant metal in the Earth's crust. Calcium is also the most abundant metal in the human body and is the main constituent of bones. Calcium is a dietary requirement and there are no adverse health effects from intake of large doses of calcium. There are currently no PWQO guidelines for calcium.

Chromium

Chromium is a lustrous, hard metal. Chromium (III) is an essential nutrient, but higher intake may cause skin rashes. Chromium (VI) is known to cause various health effects

such as skin rashes, upset stomachs and ulcers, respiratory problems, weakened immune systems, kidney and liver damage, alteration of genetic material, lung cancer and death. The maximum concentration of chromium under PWQO guidelines is 1 µg/L for Chromium (VI) and 8.9 µg/L for Chromium (III).

Cobalt
Cobalt is a hard, lustrous, silver-grey metal and is found in various ores. Health effects resulting from exposure to high concentrations include vomiting and nausea, vision problems, heart problems and thyroid damage. The maximum concentration of cobalt under PWQO guidelines is 0.9 µg/L.

Copper
Copper occurs in nature as a metal and in minerals. Copper is an essential element to human metabolism, although intake at higher doses can cause adverse health effects. Acute copper poisoning health effects include vomiting, diarrhea, jaundice, haemolysis, haemoglobinuria, haematuria, and oliguria. In severe cases, the stool and saliva may appear green or blue. In the terminal phases, anuria, hypotension, and coma precede death. The maximum concentration of copper under PWQO guidelines is 5 µg/L.

Iron
Iron is also an abundant metal found in rock. The precipitation of excessive iron creates an objectionable reddish-brown colour to water. Iron may also stain laundry and plumbing fixtures, produce undesirable tastes in beverages, and promote the growth of certain iron-bacteria, leading to the deposition of a slimy coating in water distribution pipes. The PWQO guideline stipulates that the levels of iron in the water must be below 300 µg/L.

Lead
Lead is a very toxic metal to all forms of life, causing neurological damage and even death. Although natural occurrences can occur from precipitation and the weathering of ores, the majority of lead in watercourses comes from anthropogenic sources. The PWQO requirement for lead varies with different alkalinity as $CaCO_3$ (mg/L). The maximum lead concentration is 25 µg/L.

Lithium
Lithium is a soft, silver-white metal belonging to the alkali metal group of chemical elements. Under standard conditions, it is the lightest metal and the least dense solid element. Like all alkali metals, lithium is highly reactive and flammable. Lithium forms a minor part of igneous rocks, with the largest concentrations in granites. Lithium and its compounds have a range of effects on the human body. For instance, compounds of lithium tend to harm the kidneys and lithium carbonate can affect a person's mental health. There are no current PWQO guidelines for lithium.

Magnesium
Magnesium is very abundant in nature and is found in many minerals. It is a dietary requirement, but too much can lead to muscle weakness, lethargy and confusion. There are no current PWQO guidelines for magnesium.

Manganese
Manganese is a very common compound that can be found everywhere on earth. It is essential for humans to survive, but toxic when concentrations in the body are too high. Manganese can cause Parkinson, lung embolism and bronchitis. There are currently no PWQO guidelines for manganese.

Molybdenum
Molybdenum is a by-product of copper and tungsten mining. It is used as an alloy for various metals and occurs naturally in soil and rock. Potential health impacts associated with molybdenum include neurotoxicity and reproductive toxicity. The maximum concentration of molybdenum under PWQO guidelines is 40 µg/L.

Nickel
Nickel is a compound that occurs in the environment only at very low levels. An uptake of large quantities of nickel may cause higher risks of cancer, respiratory failure, birth defects and heart disorders. The maximum concentration of nickel under PWQO guidelines is 25 µg/L.

Potassium:
Potassium is a soft silvery white metal, which is a key plant element and is found in most fertilizers. Potassium is also a dietary requirement, but many potassium compounds may cause adverse health effects. Such compounds include potassium alum or potassium cyanide. There are currently no PWQO guidelines for potassium.

Selenium
Selenium is one of the rarer elements on the surface of the earth. It occurs naturally in the environment and is also released by human activities. The health effects of various forms of selenium can vary from brittle hair and deformed nails, to rashes, heat, swelling of the skin and severe pains. Selenium poisoning may become so severe in some cases that it can even cause death. The maximum concentration of selenium under PWQO guidelines is 100 µg/L.

Silver
Silver does not react with pure water. It is stable in both water and air. Moreover, it is acid and base resistant, but it corrodes when it comes in contact with sulphur compounds. Silver oxide is harmful upon swallowing, because it irritates the eyes, respiratory tract and skin. Silver nitrate is much more harmful, because it is a strong

oxidant. It causes corrosion, and an oral uptake can lead to vomiting, dizziness and diarrhea. The maximum concentration of silver under PWQO guidelines is 0.1 µg/L.

Sodium
Sodium is a soft, silvery-white, highly reactive metal. It is the sixth most abundant element in the Earth's crust, and exists in numerous minerals such as feldspars, sodalite and rock salt. Sodium has a number of important functions in plants, humans, and animals. In humans, it is involved in controlling the amount of fluid present in cells. An excess or lack of sodium can cause cells to gain or lose water. Either of these changes can prevent cells from carrying out their normal functions. There are currently no PWQO guidelines for sodium.

Strontium
Strontium is a bright silvery metal that is softer than calcium and even more reactive in water. Acute effects of strontium include vomiting and diarrhea if ingested, and may also cause irritation to the skin. Chronic skin contact may cause dermatitis. There are currently no PWQO guidelines for strontium.

Tellurium
Tellurium is a brittle, mildly toxic, rare, silver-white metalloid. It is chemically related to selenium and sulfur. It is occasionally found in native form as elemental crystals. Tellurium is far more common in the universe as a whole than on Earth. When taken internally, tellurium can have harmful effects. It may cause nausea, vomiting, and damage to the central nervous system. One interesting side effect is that it gives a garlicky-odor to the breath. There are currently no PWQO guidelines for tellurium.

Thallium
Thallium is a silvery-grey metal that is very toxic by inhalation, ingestion and skin absorption. It may act as a systemic poison, neurotoxin, and may cause birth abnormalities. It is also a respiratory and eye irritant. The maximum concentration of thallium under PWQO guidelines is 0.3 µg/L.

Tin
Tin is a soft, pliable, silvery-white metal. Acute effects of tin include skin or eye irritation, headaches, stomach aches, dizziness, and breathlessness. Long-term effects include liver damage, malfunctioning of immune systems, chromosomal damage, shortage of red blood cells, and brain damage. There are currently no PWQO guidelines limiting the intake of tin.

Titanium
Titanium is a white-silvery metallic colour and is always found bound to other elements in nature. There are no known health hazards of titanium in water, but it is known to

have adverse health effects in powder form. There are currently no PWQO guidelines for titanium.

Tungsten
Tungsten is a lustrous, silvery-white metal. Acute health effects include irritation to the skin and eyes causing watering and redness. There are no known long-term health effects. The maximum concentration of tungsten under PWQO guidelines is 30 µg/L.

Uranium
Uranium is a hard, dense, malleable, ductile, silver-white, radioactive metal. No harmful radiation effects of natural levels of uranium have been found. However, chemical effects may occur after the uptake of large amounts of uranium, which can cause health effects such as kidney disease. Exposure to uranium radionuclides that form during radioactive decay may cause cancer. The maximum concentration of uranium under PWQO guidelines is 5 µg/L.

Vanadium
Vanadium is a rare, soft, ductile grey-white element found combined in certain minerals and used mainly to produce certain alloys. The uptake of vanadium by humans mainly takes place through foodstuffs, such as buckwheat, soy beans, olive oil, sunflower oil, apples and eggs. Some acute health effects associated with the high intake of vanadium include inflammation of stomach and intestines, sickness and headaches, dizziness, skin rashes, nosebleeds and throat pain. Chronic exposure may cause eye, skin and respiratory problems. The maximum concentration of vanadium under PWQO guidelines is 6 µg/L.

Zinc
Zinc is a lustrous bluish-white metal. Overdoses do not occur very often. Symptoms include nausea, vomiting, dizziness, fevers and diarrhea. The maximum concentration of zinc under PWQO guidelines is 20 µg/L.

Zirconium
Zirconium is a very strong, malleable, ductile, lustrous silver-grey metal. Zirconium and its salts generally have low systemic toxicity. The maximum concentration of Zinc under PWQO guidelines is 4 µg/L.

Appendix E:
Water Quality Guidelines

Appendix E: Water Quality Guidelines

The following are taken from the Ministry of the Environment, Provincial Water Quality Objectives (PWQO), July 1994.

Physical

Alkalinity:
Alkalinity should not be decreased by more than 25% of the natural concentration.

Dissolved Oxygen:
Dissolved oxygen concentrations should not be less than the values specified below for cold water biota (e.g. salmonid fish communities) and warm water biota (e.g. centrarchid fish communities):

Dissolved Oxygen Concentration				
Temperature	Cold Water Biota		Warm Water Biota	
°C	% Saturation	mg/L	% Saturation	mg/L
0	54	8	47	7
5	54	7	47	6
10	54	6	47	5
15	54	6	47	5
20	57	5	47	4
25	63	5	48	4

In waters inhabited by sensitive biological communities, or in situations where additional physical or chemical stressors are operating, more stringent criteria may be required. For example, a sensitive species such as lake trout may require more specific water quality objectives.

In some hypolimnetic waters, dissolved oxygen is naturally lower than the concentrations specified in the above table. Such a condition should not be altered by adding oxygen-demanding materials causing a depletion of oxygen.

pH:
The pH should be maintained in the range of 6.5 – 8.5:

- to protect aquatic life
- both alkaline and acidic waters may cause irritation to anyone using the water for recreational purposes

Temperature:
The natural thermal regime of any body of water shall not be altered so as to impair the quality of the natural environment. In particular, the diversity, distribution and abundance of plant and animal life shall not be significantly changed.

Waste Heat Discharge

1. Ambient Temperature Changes

   The temperature at the edge of a mixing zone shall not exceed the natural ambient water temperature at a representative control location by more than 10°C (18°F). However, in special circumstances, local conditions may require a significantly lower temperature difference than 10°C (18°F). Potential dischargers are to apply to the MOEE for guidance as to the allowable temperature rise for each thermal discharge. This ministry will also specify the nature of the mixing zone and the procedure for the establishment of a representative control location for temperature recording on a case-by-case basis.

2. Discharge Temperature Permitted

   The maximum temperature of the receiving body of water, at any point in the thermal plume outside a mixing zone, shall not exceed 30°C (86°F) or the temperature of a representative control location plus 10°C (18°F) or the allowed temperature difference, whichever is the lesser temperature. These maximum temperatures are to be measured on a mean daily basis from continuous records.

3. Taking and Discharging of Cooling Water

   Users of cooling water shall meet both the Objectives for temperature outlined above and the "Procedures for the Taking and Discharge of Cooling Water" as outlined in the MOEE publication *Deriving Receiving-Water Based, Point-Source Effluent Requirements for Ontario Waters (1994).*

Nutrients

Ammonia (un-ionized):
The amount of un-ionized ammonia should not exceed 20 µg/L.

The percentages of un-ionized ammonia (NH_3) in aqueous ammonia solution for different temperature and pH conditions are listed in the table below. For example, at 20°C and pH of 8.0, a total ammonia concentration of 500 µg/L would give an un-ionized ammonia concentration of 500 x 3.8/100 = 19 µg/L which is less than the un-ionized ammonia Objective of 20 µg/L.

The table below is taken from the PWQO, percentages are rounded to two significant figures. The equations given by may be used to interpolate values between those given in the table:

$f = 1/(10^{pKa-pH} + 1)$, where ***f* is the fraction of NH_3**

pKa = 0.09018 + 2729.92/T, where T = ambient water temperature in Kelvin (K = °C + 273.16)

Results should be converted to percent and rounded to two significant figures. Extrapolations should not be made beyond the ranges of the table.

Note: Under certain temperature and pH conditions, the total ammonia criteria for the protection of aquatic life may be less stringent than the criteria for other beneficial uses (e.g. public water supply).

Percent NH_3 in aqueous ammonia solutions for 0-30 °C and pH 6-10

Temp.	pH								
°C	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0
0	.0083	.026	.083	.26	.82	2.6	7.6	21.	45.
1	.0090	.028	.090	.28	.89	2.8	8.3	22.	47.
2	.0098	.031	.098	.31	.97	3.0	8.9	24.	49.
3	.011	.034	.11	.34	1.1	3.3	9.6	25.	52.
4	.012	.036	.12	.36	1.1	3.5	10.	27.	54.
5	.013	.040	.13	.39	1.2	3.8	11.	28.	56.
6	.014	.043	.14	.43	1.3	4.1	12.	30.	58.
7	.015	.046	.15	.46	1.5	4.4	13.	32.	60.
8	.016	.050	.16	.50	1.6	4.8	14.	34.	61.
9	.017	.054	.17	.54	1.7	5.2	15.	35.	63.
10	.019	.059	.19	.59	1.8	5.6	16.	37.	65.
11	.020	.064	.20	.63	2.0	6.0	17.	39.	67.
12	.022	.069	.22	.68	2.1	6.4	18.	41.	69.
13	.024	.074	.24	.74	2.3	6.9	19.	43.	70.
14	.025	.080	.25	.80	2.5	7.4	20.	45.	72.
15	.027	.087	.27	.86	2.7	8.0	22.	46.	73.

Temp.	pH								
°C	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0
16	.030	.093	.29	.93	2.9	8.5	23.	48.	75.
17	.032	.10	.32	1.0	3.1	9.1	24.	50.	76.
18	.034	.11	.34	1.1	3.3	9.8	26.	52.	77.
19	.037	.11	.37	1.2	3.6	11.	27.	54.	79.
20	.040	.13	.40	1.2	3.8	11.	28.	56.	80.
21	.043	.14	.43	1.3	4.1	12.	30.	58.	81.
22	.046	.15	.46	1.4	4.4	13.	32.	59.	82.
23	.049	.16	.49	1.5	4.7	14.	33.	61.	83.
24	.053	.17	.53	1.7	5.0	14.	35.	63.	84.
25	.057	.18	.57	1.8	5.4	15.	36.	64.	85.
26	.061	.19	.61	1.9	5.8	16.	38.	66.	86.
27	.065	.21	.65	2.0	6.2	17.	40.	67.	87.
28	.070	.22	.70	2.2	6.6	18.	41.	69.	88.
29	.075	.24	.75	2.3	7.0	19.	43.	70.	88.
30	.081	.25	.80	2.5	7.5	20.	45.	72.	89.

The following nitrate and nitrite guidelines are taken from the Canadian Council of Resource and Environment Ministers (CCREM) Canadian water quality guidelines for the protection of aquatic life. Summary table, updated 2012. The information in these guidelines and supporting text is used to complement the Provincial Water Quality Objectives and Interim Objectives.

Phosphorus:
Current scientific evidence is insufficient to develop a firm objective at this time. Accordingly, the following phosphorus concentrations should be considered as general guidelines, which should be supplemented by site-specific studies:

- To avoid nuisance concentrations of algae in lakes, average total phosphorus concentrations for the ice-free period should not exceed 20 µg/L;
- A high level of protection against aesthetic deterioration will be provided by a total phosphorus concentration for the ice-free period of 10 µg/L or less. This should apply to all lakes naturally below this value;
- Excessive plant growth in rivers and streams should be eliminated at a total phosphorus concentration below 30 µg/L.

Bacteriological

Escherichia coli:

The amount of *Escherichia coli* should not exceed 100 counts per 100 mL of water (based on a geometric mean of at least 5 samples).

Based on a recreational water quality guideline published by the Ontario Ministry of Health in 1992, this Ministry of Health guideline was specifically intended for application by the local Medical Officer of Health to swimming and bathing beaches. It is based upon a geometric mean of levels of *E. coli* determined from a minimum of 5 samples per site taken within a given swimming area and collected within a one month period. If the geometric mean *E. coli* level for the sample series at a given site exceeds 100 per 100 mL, the site should be considered unsuitable for swimming and bathing. *E. coli* was selected for the guideline because studies have determined that, among bacteria of the coliform group, *E. coli* is the most suitable and specific indicator of fecal contamination.

An analytical test with a high degree of specificity for *E. coli* regardless of water sample source, requiring no confirmation procedures, and which produces results in 21 hours has been developed and adopted by both the Ministry of Health, and Ministry of Environment and Energy laboratories.

Where testing indicates sewage or fecal contamination, a site-specific judgment must be made as to the severity of the problem and the appropriate course of action.

As of May 1, 1994, MOEE staff has been advised to base all **new** compliance, enforcement and monitoring activities on the *E. coli* test. Some water managers may find it necessary to continue testing for fecal coliforms or total coliforms. For example, where testing at a long term water quality monitoring station requires a continuous record of results using either the fecal or total coliform test to monitor trends in water quality. As a benchmark for the long term monitoring results, the former objectives for fecal coliforms and total coliforms are referenced for your information. For fecal coliforms the objective was 100 counts per 100 ml (based on a geometric mean density for a series of water samples). For total coliforms the objective was 1000 counts per 100 ml (based on a geometric mean density for a series of water samples).

Metals

Aluminum:

Aluminum amounts should not exceed the following:

PH values	Interim PWQO (µg/L)
4.5 to 5.5	15
>5.5 to 6.5	No more than 10 % of natural background
> 6.5 to 9.0	75

Antimony:

The amount of Antimony should not exceed 20 µg/L.

Arsenic:
The amount of Arsenic should not exceed 5 µg/L.

Barium:
There are currently no PWQO guidelines for Barium.

Beryllium:
Beryllium amounts should not exceed the following:

Hardness as $CaCO_3$ (mg/L)	Interim PWQO (µg/L)
< 75	11
>75	1100

Bismuth:
There are currently no PWQO guidelines for Bismuth.

Boron:
The amount of Boron should not exceed 200 µg/L.

Cadmium:
Cadmium amounts should not exceed 0.2 µg/L.

Hardness as $CaCO_3$ (mg/L)	Interim PWQO (µg/L)
0 – 100	0.1
>100	0.5

Calcium:
There are currently no PWQO guidelines for Calcium.

Chromium:
Chromium amounts should not exceed the following:

	Interim PWQO (µg/L)
Hexavalent Chromium (Cr VI)	1
Trivalent Chromium (Cr III)	8.9

Cobalt:
The amount of Cobalt should not exceed 0.9 µg/L.

Copper:
The amount of Copper should not exceed 5 µg/L.

Hardness as $CaCO_3$ (mg/L)	Interim PWQO (µg/L)
0-20	1
>20	5

Iron:
The amount of Iron should not exceed 300µg/L.

Lead:
Lead amounts should not exceed the following:

Hardness as $CaCO_3$ (mg/L)	Interim PWQO (µg/L)
< 30	1
30 to 80	3
> 80	5

Lithium:
There are currently no PWQO guidelines for Lithium.

Magnesium:
There are currently no PWQO guidelines limiting the intake of Magnesium.

Manganese:
There are currently no PWQO guidelines for Manganese.

Molybdenum:
The amount of Molybdenum should not exceed 40 µg/L.

Nickel:
The amount of Nickel should not exceed 25 µg/L.

Potassium:
There are currently no PWQO guidelines for Potassium.

Selenium:
The amount of Selenium should not exceed 100 µg/L.

Silicon:
There are currently no PWQO guidelines for Silicon.

Silver:
The amount of Silver should not exceed 0.1 µg/L.

Sodium:
There are currently no PWQO guidelines for Sodium.

Strontium:
There are currently no PWQO guidelines for Strontium.

Tellurium:
There are currently no PWQO guidelines for Tellurium.

Thallium:
The amount of Thallium should not exceed 0.3 µg/L.

Tin:
There are currently no PWQO guidelines for Tin.

Titanium:
There are currently no PWQO guidelines for Titanium.

Tungsten:
The amount of Tungsten should not exceed 30 µg/L.

Uranium:
The amount of Uranium should not exceed 5 µg/L.

Vanadium:
The amount of Vanadium should not exceed 6 µg/L.

Zinc:
The amount of Zinc should not exceed 20 µg/L.

Zirconium:
The amount of Zirconium should not exceed 4 µg/L.

Appendix F:

Forest Ecosystem Classification

Appendix F: Forest Ecosystem Classification

Site 1: V14 Balsam Fir Mixedwood

Description: An extremely variable mixedwood type. The canopy, comprising mainly balsam fir, may contain a mixture of several species. The understory varies from shrub rich to moderately herb and shrub poor. Usually on deep, fresh to moist, mineral soils but encompassing a wide range of soil and site conditions.

Common Overstory Species (in descending order):
balsam fir, trembling aspen, white birch, white spruce, black spruce, jack pine, balsam poplar, white cedar

Common Understory Species:

Shrubs:	*Abies balsamea, Acer spicatum, Rubus pubescens, Linnaea borealis, Diervilla lonicera, Sorbus decora, Populus tremuloides, Corylus cornuta, Amelanchier* spp., *Rosa acicularis*
Herbs:	*Maianthemum canadense, Aralia nudicaulis, Clintonia borealis, Streptopus roseus, Cornus canadensis, Trientalis borealis, Viola renifolia, Mitella nuda, Aster macrophyllus, Galium triflorum, Coptis trifolia, Petasites palmatus*
Mosses:	*Pleurozium schreberi, Ptilium crista-castrensis, Hylocomium splendens, Plagiomnium cuspidatum*

Forest Floor Cover:

Species	Broadleaf Litter	Moss	Conifer Litter	Wood
Forest Floor Cover (%)	66	12	14	6

Site 2, Site 5, Site 7 and Site 8: V15 White Spruce Mixedwood

Description: A variable mixedwood type with white spruce as the main canopy species. The understory ranges from herb and shrub rich to poor, with balsam fir commonly abundant in the shrub layer. Occurring over a broad range of soil and site conditions but primarily on deep, fresh to moist, mineral soils.

Site 2

Site 5

Site 7

Site 8

Common Overstory Species (in descending order):
White spruce, balsam fir, trembling aspen, white birch, black spruce, balsam poplar, red maple, jack pine

Common Understory Species:

Shrubs:	*Abies balsamea, Acer spicatum, Rubus pubescens, Corylus cornuta, Sorbus decora, Linnaea borealis, Diervilla lonicera, Rosa acicularis, Amelanchier* spp., *Populus tremuloides*
Herbs:	*Aralia nudicaulis, Cornus canadensis, Clintonia borealis, Maianthemum canadense, Streptopus roseus, Trientalis borealis, Galium triflorum, Aster macrophyllus, Mitella nuda, Viola renifolia, Anemone quinquefolia, Petasites palmatus*
Mosses:	*Pleurozium schreberi, Ptilium crista-castrensis, Rhytidiadelphus triquetrus, Plagiomnium, cuspidatum*

Forest Floor Cover:

Cover Type	Broadleaf Litter	Moss	Conifer Litter	Wood
Forest Floor Cover (%)	61	16	13	5

Site 6: V2 Black Ash Hardwood and Mixedwood

Description: Hardwood and mixedwood stands containing black ash in the overstory. The understory is typically dense and floristically diverse. Of limited areal extent; occurring in low-lying locations on deep, moist to wet, usually non-calcareous substrates.

Common Overstory Species (in descending order):
black ash, balsam fir, trembling aspen, white birch, white spruce, cedar, red ash, American ash, balsam poplar

Common Understory Species:

Shrubs:	*Rubus pubescens, Acer spicatum, balsam fir, Ribes triste, Prunus virginiana, Comus stolonifera, Alnus rugosa, Corylus cornuta, Rubus idaeus*
Herbs:	*Viola spp., Mitella nuda, Athyrium filix{emina, Galium trijlorum, Maianthemum canadense, Dryopteris austriaca, Circaea alpina, Streptopus roseus, Aralia nudicaulis, Aster macrophyllus, Trientalis borealis, Equisetum sylvaticum*
Mosses:	*Plagiomnium cuspidatum, Climacium dendroides*

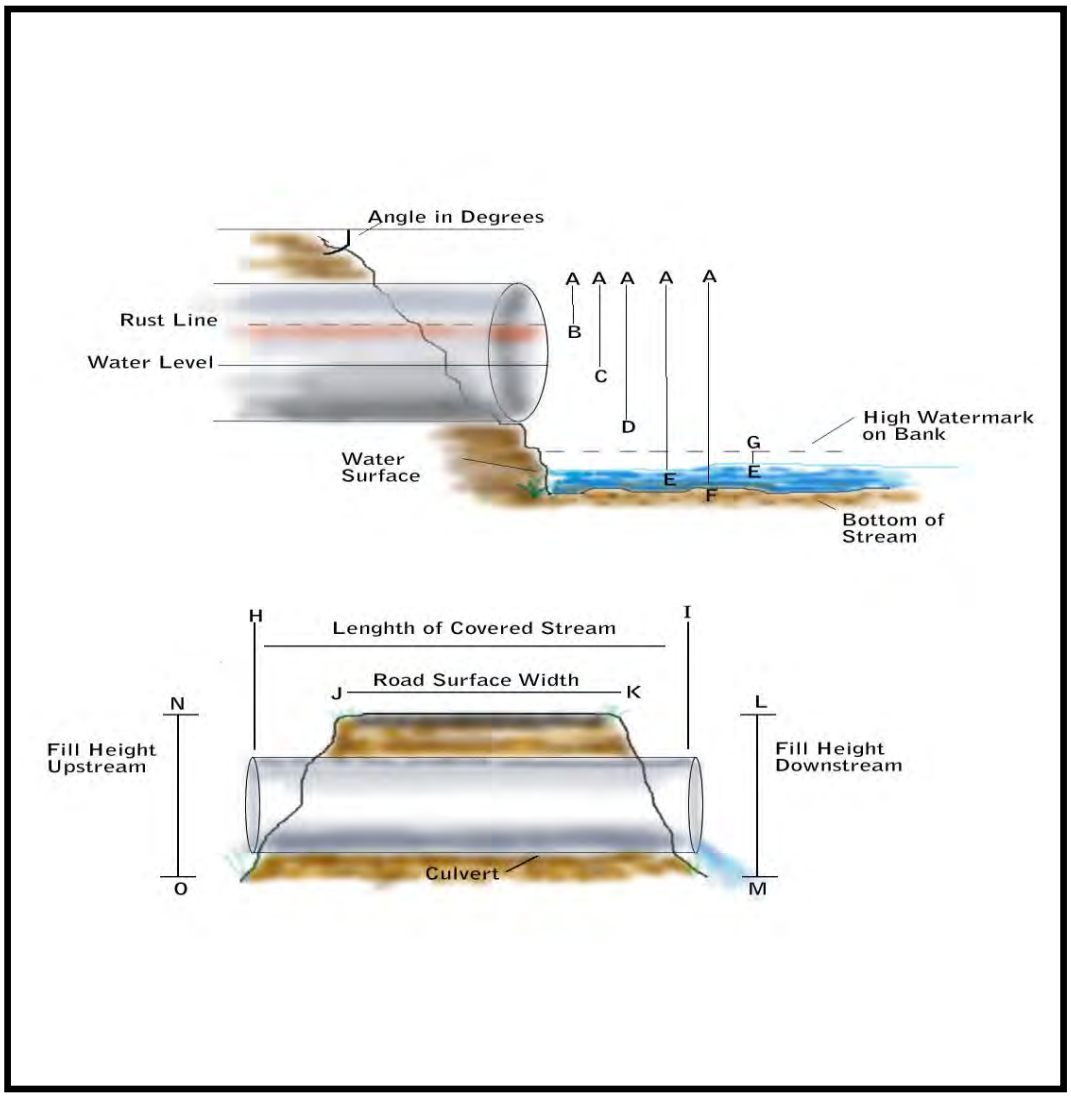
Forest Floor Cover:

Species	Broadleaf Litter	Moss	Humus	Water	Graminoid Litter	Wood
Forest Floor Cover (%)	39	20	12	11	11	6

Appendix G:

Culvert Assessments

Appendix G: Culvert Assessments



Oliver Creek 2016 Culvert Assessments

Culvert Number/ Site Number	**J-K** Road Surface Width (m)	**H-I** Length of Covered Stream (m)	**N-O** Fill Height Upstream (m)	**L-M** Fill Height Downstream (m)		**A-D** Width of Opening (m)	**A-B** Inside Top to Rust Line (m)	**A-C** Inside Top to Water Surface (m)	**A-E** Height Above Outlet Pool (m)	**E-G** Water Surface to High Water Mark (m)	**A-F** Inside Top to Bottom of Stream (m)
C1/Site 1											
Culvert	11.3	21.1	1.05	1.25	Upstream	7.1	2.85	3.35	3.35	0.5	3.86
					Downstream	7.1	2.87	3.24	3.24	0.37	3.75
C2/Site 2											
Culvert	6.8	N/A	N/A	N/A	Upstream	0.8	0.58	N/A	N/A	N/A	N/A
					Downstream	0.8	N/A	N/A	N/A	N/A	N/A
C3/Site 3											
Culvert	7.0	12.5	0.75	N/A	Upstream	1.3	0.77	1.21	1.21	0.44	1.38
					Downstream	1.3	0.62	0.95	0.95	0.33	1.13
C4/Site 4											
Culvert A (East)	7.0	12.7	0.67	0.8	Upstream	1.7	0.69	1.46	1.46	0.77	1.61
					Downstream	1.7	0.65	1.52	1.52	0.87	1.56
Culvert B (West)	7.0	12.7	0.72	0.83	Upstream	1.7	0.50	1.41	1.41	0.91	1.49
					Downstream	1.7	0.56	1.39	1.39	0.83	1.52

Culvert Number/ Site Number	**J-K** Road Surface Width (m)	**H-I** Length of Covered Stream (m)	**N-O** Fill Height Upstream (m)	**L-M** Fill Height Downstream (m)		**A-D** Width of Opening (m)	**A-B** Inside Top to Rust Line (m)	**A-C** Inside Top to Water Surface (m)	**A-E** Height Above Outlet Pool (m)	**E-G** Water Surface to High Water Mark (m)	**A-F** Inside Top to Bottom of Stream (m)
C5/Site 5											
Culvert	7.0	14.0	0.47	0.4	Upstream	1.20	0.82	1.01	1.01	0.19	1.26
					Downstream	1.20	0.85	1.02	1.02	0.17	1.25
C6/Site 6											
Culvert A	7.5	15.6	0.90	0.92	Upstream	0.8	0.77	1.19	1.19	0.42	1.89
					Downstream	0.8	0.65	1.10	1.10	0.45	1.51
Culvert B	7.5	15.6	0.85	0.86	Upstream	0.8	0.78	1.25	1.25	0.47	1.81
					Downstream	0.8	0.72	1.11	1.11	0.39	1.48
C7/Site 7											
Culvert	9.0	19.0	0.48	0.79	Upstream	2.1	N/A	N/A	N/A	N/A	N/A
					Downstream	2.1	0.97	1.37	1.37	0.4	2.05

Culvert 1 / Site 1

Location: River Road, near Oliver Creek confluence at Kaministiquia River.

GPS Coordinates: Northing 5359381 Easting 312614

Description: The large corrugated steel culvert is in excellent condition and seemed large enough to be able to support water flow during times of both high water level and low water level. The water level was relatively low compared to the size of the culvert opening. There is abundant vegetation surrounding the culvert and the banks appear to be stable.

Upstream

Downstream

Culvert 2 / Site 2

Location: North side of Barrie Drive – Across from 457 Barrie Drive.

GPS Coordinates: Northing 5357660 Easting 312283

Description: The corrugated steel culvert has abundant vegetation surrounding the culverts on both sides. There was no water flowing through the culvert during the site visit. The downstream side is perched and the bottom of the upstream side is starting to deteriorate.

Upstream

Downstream

Culvert 3 / Site 3

Location: South side of Barrie Drive, beside the driveway to 617 Barrie Drive.

GPS Coordinates: Northing 5357694 Easting 310732

Description: The corrugated steel culvert is in good condition except the bottom of the upstream side is starting to deteriorate. Vegetation completely covers the culvert on the downstream side

Upstream

Downstream

Culvert 4 / Site 4

Location: South side of Barrie Drive, approximately 105 metres from 741 Barrie Drive.

GPS Coordinates: Northing 5357730 Easting 309619

Description: The two corrugated steel culverts appear to be in excellent condition, except for one end of the culverts on the upstream side is bent inwards on the top. The culverts seemed large enough to be able to support water flow during times of both high water level and low water level. Rip rap was used to prevent erosion around the culverts. There is abundant vegetation surrounding the culverts and the banks appear to be stable.

Upstream

Downstream

Culvert 5 / Site 5

Location: West side of C-Line Road, approximately 130 metres from 19 C-Line Road.

GPS Coordinates: Northing 5355789 Easting 308729

Description: The corrugated steel culvert is in excellent condition and seemed large enough to be able to support water flow during times of both high water level and low water level. The water level was relatively low compared to the size of the culvert opening. There is abundant vegetation surrounding the culvert and the banks appear to be stable.

Upstream

Downstream

Culvert 6 / Site 6

Location: South side of Candy Mountain Road, approximately 65 metres from Oliver Creek Road.

GPS Coordinates: Northing 5355688 Easting 309852

Description: The two corrugated steel culverts are in excellent condition and seemed large enough to be able to support water flow during times of both high water level and low water level. There is abundant vegetation surrounding the culverts and the banks appear to be stable.

Upstream

Downstream

Culvert 7 / Site 7

Location: South side of Boundary Drive, approximately 60 metres from 1150 Boundary Drive.

GPS Coordinates: Northing 5351643 Easting 310097

Description: The corrugated steel culvert appeared to be in excellent condition and seemed large enough to be able to support water flow during times of both high water level and low water level. The water level was backing up on the upstream side due a beaver dam.

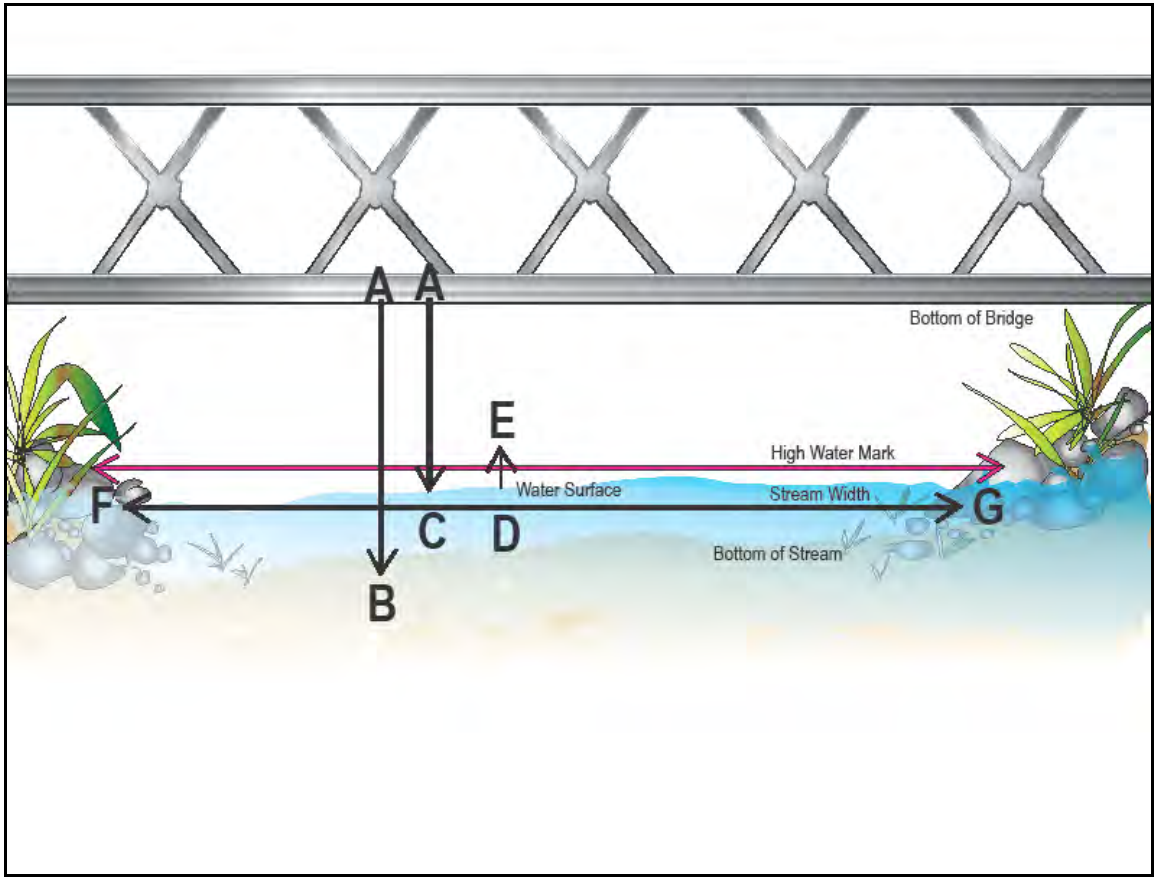
Upstream

Downstream

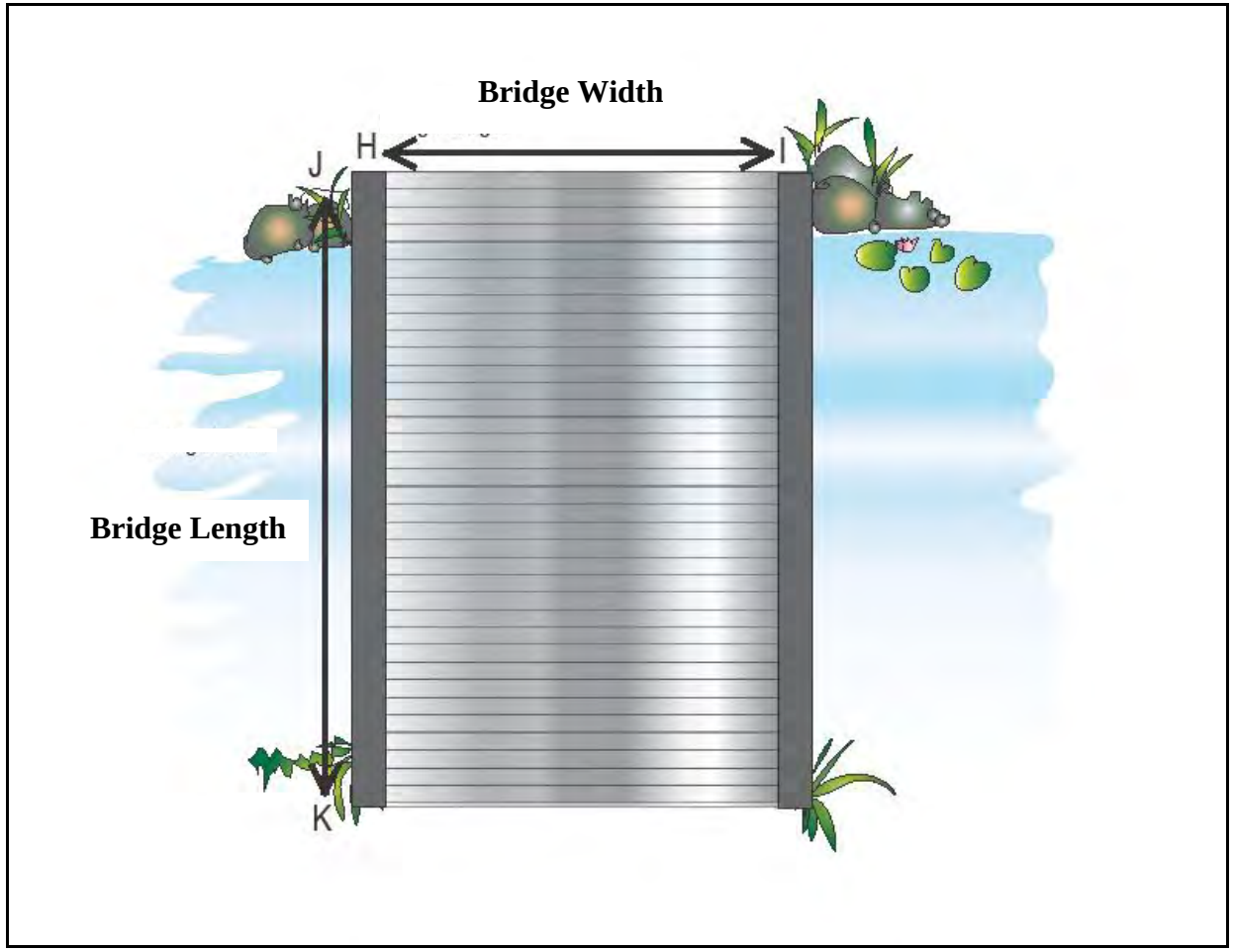
Appendix H:

Bridge Assessments

Appendix H: Bridge Assessments



Bridge Measurement Parameters


Bridge Width
H
I
J
K
Bridge Length

Oliver Creek 2016 Bridge Measurements

Site Number	Bridge Number	**A-C** Bottom of Bridge to Water Surface (m)	**A-B** Bottom of Bridge to Bottom of Stream (m)	**D-E** Outlet Pool Water Surface to Outlet Pool High Water Mark (m)	**F-G** Width of Stream (m)	**H-I** Length of Bridge (m)	**J-K** Width of Bridge (m)
8	1	1.16	1.31	N/A	1.8	8.5	2.4

Bridge 1

Location: East Oliver Lake Road, at Oliver Lake.

GPS Coordinates: Northing 5349812 Easting 309530

Description: This bridge is a single-span structure made out of timber. It was completed in 2010 with a permit issued by the LRCA (33/10). Rip rap protection was placed for erosion control on the banks. The bridge was in very good condition, but regular maintenance should be conducted, as it is a high traffic area.

Upstream

Downstream

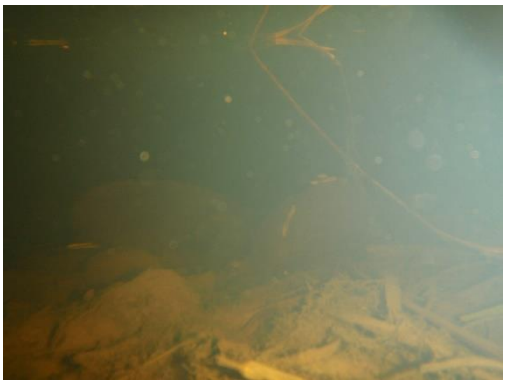
Appendix I:

Site Photography

Appendix I: Site Photography

Site 1 – River Road, near Oliver Creek confluence at Kaministiquia River	
A: Upstream	**B: Downstream**
	
C: Vegetation	**D: Substrate**
	

Site 2 – North side of Barrie Drive – Across from 457 Barrie Drive	
A: Upstream	**B: Downstream**
	
C: Vegetation	**D: Substrate**
	

Site 3 – South side of Barrie Drive, beside the driveway to 617 Barrie Drive	
A: Upstream	**B: Downstream**
	
C: Vegetation	**D: Substrate**
	

Site 4 - South side of Barrie Drive, approximately 105 metres from 741 Barrie Drive	
A: Upstream	**B: Downstream**
	
C: Vegetation	**D: Substrate**
	

Site 5 - West side of C-Line Road, approximately 130 metres from 19 C-Line Road	
A: Upstream	**B: Downstream**
	
C: Vegetation	**D: Substrate**
	

Site 6 - South side of Candy Mountain Road, approximately 65 metres from Oliver Creek Road	
A: Upstream	**B: Downstream**
	
C: Vegetation	**D: Substrate**
	

Site 7 – South side of Boundary Drive, approximately 60 metres from 1150 Boundary Drive	
A: Upstream	**B: Downstream**
	
C: Vegetation	**D: Substrate**
	

Site 8 - East Oliver Lake Road, at Oliver Lake	
A: Upstream	**B: Downstream**
	
C: Vegetation	**D: Substrate**
	

Appendix J:

Laboratory Water Quality Results Summary Tables

Oliver Creek Watershed Assessment 2016
Laboratory Water Quality Results Summary Tables

Laboratory Water Quality Results for June 14, 2016

Parameter	Units	PWQO Criterion	OC1 Oliver Creek - SITE#1 14-Jun-16	OC2 Oliver Creek - SITE#2 14-Jun-16	OC3 Oliver Creek - SITE#3 14-Jun-16	OC4 Oliver Creek - SITE#4 14-Jun-16	OC5 Oliver Creek - SITE#5 14-Jun-16	OC6 Oliver Creek - SITE#6 14-Jun-16	OC7 Oliver Creek - SITE#7 14-Jun-16	OC8 Oliver Creek - SITE#8 14-Jun-16	Average June
Physical Tests											
Conductivity (EC)	(uS/cm)	N/A	150	143	461	111	93.2	97.1	80.2	74.1	151
pH		6.5-8.5	7.84	7.70	7.93	7.64	7.42	7.59	7.34	7.46	7.62
Total Dissolved Solids	(mg/L)	N/A	109	105	290	86	88	81	55	39	107
Turbidity	(NTU)	N/A	4.47	4.9	3.13	5.02	2.59	5.84	1.46	0.46	3.48
Anions and Nutrients											
Alkalinity, Total (as $CaCO_3$)*	(mg/L)	20.3	62.3	58.3	221	44.9	46.7	36.7	31.6	27.1	66.1
Ammonia-N, Total	(mg/L)	N/A	0.021	0.035	0.051	0.026	0.026	<0.020	<0.020	<0.020	0.03
Un-ionized Ammonia (calculated)**	(mg/L)	0.02	0.0006	0.0010	0.0013	0.0002	0.0002	<0.0002	<0.0002	<0.0002	0.0005
Chloride (Cl)	(mg/L)	N/A	5.62	5.19	13.9	2.85	0.16	3.03	2.94	2.23	4.49
Nitrate-N (NO_3-N)	(mg/L)	N/A	<0.020	<0.020	0.027	0.032	<0.020	<0.020	<0.020	<0.020	0.03
Nitrite-N (NO_2-N)	(mg/L)	N/A	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Total Kjeldahl Nitrogen	(mg/L)	N/A	0.56	0.48	0.95	0.48	0.58	0.40	0.30	<0.25	0.54
Phosphorus (P)-Total	(mg/L)	0.03	0.02	0.02	**0.16**	0.02	0.02	0.02	0.01	0.003	0.03
Sulphate (SO_4)	(mg/L)	N/A	8.34	8.44	23.5	8.17	2.74	8.35	6.07	8.23	9.23
Bacteriological Tests											
Escherichia Coli	(MPN/100mL)	100	33	68	24	58	13	23	**108**	<1	41
Total Coliforms	(MPN/100mL)	1000 (prior to 1994)	**1410**	**2420**	**>2420**	**>2420**	**2420**	**2420**	**1730**	53	**1912**
Total Metals											
Aluminum (Al)-Total***	(mg/L)	0.075	**0.195**	**0.219**	**0.105**	**0.280**	**0.123**	**0.331**	0.064	0.016	**0.167**
Antimony (Sb)-Total	(mg/L)	0.02	0.00012	0.0001	0.00011	0.00011	0.00011	<0.00010	<0.00010	0.00016	0.00011
Arsenic (As)-Total	(mg/L)	0.005 (interim)	0.00125	0.00120	0.00125	0.00121	0.00135	0.00099	0.00060	0.00022	0.00101
Barium (Ba)-Total	(mg/L)	N/A	0.0254	0.0226	0.043	0.0205	0.0132	0.0154	0.0116	0.0102	0.0202
Beryllium (Be)-Total****	(mg/L)	0.011 (<75 mg/L $CaCO_3$)	<0.00010	<0.00010		<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	(mg/L)	1.10 (>75 mg/L $CaCO_3$)			<0.00010						
Bismuth (Bi)-Total	(mg/L)	N/A	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Boron (B)-Total	(mg/L)	0.2	0.010	0.010	0.014	<0.010	<0.010	0.010	<0.010	<0.010	0.011
Cadmium (Cd)-Total****	(mg/L)	0.0001 (0-100 mg/L $CaCO_3$)	0.000046	0.000051		0.000057	0.000062	0.000056	0.000023	<0.000005	0.000052
	(mg/L)	0.0005 (>100 mg/L $CaCO_3$)			0.000073						
Calcium (Ca)-Total	(mg/L)	N/A	18.2	17	58.8	12.5	12.5	11.3	8.56	7.49	18.3
Chromium (Cr)-Total	(mg/L)	N/A	0.00061	0.00073	0.00065	0.00077	0.00061	0.0008	0.00026	0.00018	0.00058
Cobalt (Co)-Total	(mg/L)	0.0009	0.0002	0.0002	0.0006	0.0002	0.0002	0.0002	<0.0001	<0.0001	0.0002
Copper (Cu)-Total****	(mg/L)	0.005	0.0037	0.0038	0.0030	0.0040	0.0039	0.0036	0.0018	0.0012	0.0031
Iron (Fe)-Total	(mg/L)	0.3	**0.937**	**0.966**	**0.712**	**0.963**	**1.040**	**0.925**	**0.343**	0.028	**0.739**

Notes:

PWQO - Provincial Water Quality Objectives. **Bold indicates exceedance of PWQO criteria**

* - Alkalinity should not be decreased by more than 25% of the natual conditions (Site 8)

** - indicates criterion is pH and temperature dependent

*** - indicates criterion is pH dependent

**** - indicates criteria are Alkalinity dependent

Oliver Creek Watershed Assessment 2016
Laboratory Water Quality Results Summary Tables

Laboratory Water Quality Results for June 15, 2016

Parameter	Units	PWQO Criterion	OC1 Oliver Creek - SITE#1 14-Jun-16	OC2 Oliver Creek - SITE#2 14-Jun-16	OC3 Oliver Creek - SITE#3 14-Jun-16	OC4 Oliver Creek - SITE#4 14-Jun-16	OC5 Oliver Creek - SITE#5 14-Jun-16	OC6 Oliver Creek - SITE#6 14-Jun-16	OC7 Oliver Creek - SITE#7 14-Jun-16	OC8 Oliver Creek - SITE#8 14-Jun-16	Average June
Total Metals Continued											
Lead (Pb)-Total****	(mg/L)	0.003 (30-80 mg/L $CaCO_3$)	0.00015	0.00016		0.00019	0.00011	0.00020	0.00005	<0.00005	0.00012
	(mg/L)	0.005 (>80 mg/L $CaCO_3$)			<0.00005						
Lithium (Li)-Total	(mg/L)	N/A	0.0016	0.0015	0.0056	0.0014	<0.0010	0.0014	<0.0010	<0.0010	0.0023
Magnesium (Mg)-Total	(mg/L)	N/A	7.23	6.72	24.80	5.58	4.95	5.09	3.94	3.40	7.71
Manganese (Mn)-Total	(mg/L)	N/A	0.0397	0.0372	0.1410	0.0389	0.1190	0.0189	0.025	0.0016	0.0527
Molybdenum (Mo)-Total	(mg/L)	0.004	0.000836	0.000794	0.001390	0.000758	0.00109	0.000552	0.00035	0.000167	0.000742125
Nickel (Ni)-Total	(mg/L)	0.025	0.00218	0.00230	0.00313	0.00238	0.00203	0.00223	0.00086	<0.00050	0.00216
Potassium (K)-Total	(mg/L)	N/A	0.951	0.92	3.600	0.815	0.726	0.742	0.658	0.684	1.1370
Selenium (Se)-Total	(mg/L)	0.1	0.000209	0.000175	0.000357	0.000203	0.000260	0.000153	0.000098	0.000062	0.000190
Silver (Ag)-Total	(mg/L)	0.0001	0.000023	0.000028	0.000012	0.000033	0.00002	0.000034	<0.000010	<0.000010	0.000025
Sodium (Na)-Total	(mg/L)	N/A	3.76	3.63	9.13	2.52	1.67	2.42	1.93	1.80	3.36
Strontium (Sr)-Total	(mg/L)	N/A	0.0423	0.0398	0.1070	0.0324	0.0276	0.0283	0.0208	0.0194	0.0397
Tellurium (Te)-Total	(mg/L)	N/A	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Thallium (Tl)-Total	(mg/L)	0.0003	0.000012	0.000012	<0.000010	0.000015	<0.000010	0.00002	<0.000010	<0.000010	0.000015
Tin (Sn)-Total	(mg/L)	N/A	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Titanium (Ti)-Total	(mg/L)	N/A	0.00418	0.00459	0.00393	0.00517	0.00291	0.00617	0.00147	0.000310	0.0036
Tungsten (W)-Total	(mg/L)	0.03	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Uranium (U)-Total	(mg/L)	0.005	0.000254	0.000248	0.00249	0.000176	0.000186	0.000115	0.000037	<0.000010	0.0005
Vanadium (V)-Total	(mg/L)	N/A	0.00131	0.00131	0.00293	0.00125	0.00109	0.00126	<0.00050	<0.00050	0.00153
Zinc (Zn)-Total	(mg/L)	0.02 (interim)	0.0038	0.0041	<0.0030	0.0045	<0.0030	0.0052	<0.0030	<0.0030	0.0044
Zirconium (Zr)-Total	(mg/L)	0.004	<0.00030	<0.00030	0.00034	<0.00030	0.00032	<0.00030	<0.00030	<0.00030	0.00031

Notes:

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* - Alkalinity should not be decreased by more than 25% of the natual conditions (Site 8)

** - indicates criterion is pH and temperature dependent

*** - indicates criterion is pH dependent

**** - indicates criteria are Alkalinity dependent

Oliver Creek Watershed Assessment 2016
Laboratory Water Quality Results Summary Tables

Laboratory Water Quality Results for July 14, 2016

Parameter	Units	PWQO Criterion	OC1 Oliver Creek - SITE#1 14-Jul-16	OC2 Oliver Creek - SITE#2 14-Jul-16	OC3 Oliver Creek - SITE#3 14-Jul-16	OC4 Oliver Creek - SITE#4 14-Jul-16	OC5 Oliver Creek - SITE#5 14-Jul-16	OC6 Oliver Creek - SITE#6 14-Jul-16	OC7 Oliver Creek - SITE#7 14-Jul-16	OC8 Oliver Creek - SITE#8 14-Jul-16	Average July
Physical Tests											
Conductivity (EC)	(uS/cm)	N/A	170	162	552	121	102	101	83	76	171
pH		6.5-8.5	8.13	7.89	7.96	7.64	7.55	7.71	7.50	7.75	7.77
Total Dissolved Solids	(mg/L)	N/A	127	122	356	107	92	78	61	48	124
Turbidity	(NTU)	N/A	5.44	5.69	3.71	5.67	2.77	6.40	2.74	0.53	4.12
Anions and Nutrients											
Alkalinity, Total (as $CaCO_3$)*	(mg/L)	20.6	74.3	71.4	267	51.3	50.0	38.4	30.8	27.5	76.3
Ammonia-N, Total	(mg/L)	N/A	<0.020	<0.020	0.037	<0.020	<0.020	<0.020	0.175	0.106	0.106
Un-ionized Ammonia (calculated)**	(mg/L)	0.02	<0.0008	<0.0007	0.0012	<0.0002	<0.0002	<0.0002	0.0021	0.0040	0.0012
Chloride (Cl)	(mg/L)	N/A	5.10	4.57	13.70	2.51	00.15	2.42	2.15	1.91	4.06
Nitrate-N (NO_3-N)	(mg/L)	N/A	0.072	0.087	0.137	0.072	<0.020	0.030	0.023	<0.020	0.070
Nitrite-N (NO_2-N)	(mg/L)	N/A	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Total Kjeldahl Nitrogen	(mg/L)	N/A	0.65	0.62	1.07	0.57	0.68	0.46	0.41	0.25	0.59
Phosphorus (P)-Total	(mg/L)	0.03	**0.03**	**0.03**	**0.24**	0.02	0.03	0.02	0.01	<0.003	**0.05**
Sulphate (SO_4)	(mg/L)	N/A	6.65	6.62	19.40	6.69	1.45	7.07	5.82	8.36	7.76
Bacteriological Tests											
Escherichia Coli	(MPN/100mL)	100	37	77	**687**	56	33	50	99	2	130
Total Coliforms	(MPN/100mL)	1000 (prior to 1994)	**>2420**	**>2420**	**>2420**	**>2420**	**2420**	**1730**	**1730**	365	**1561**
Total Metals											
Aluminum (Al)-Total***	(mg/L)	0.075	**0.201**	**0.200**	**0.110**	**0.226**	**0.101**	**0.262**	**0.080**	0.022	**0.150**
Antimony (Sb)-Total	(mg/L)	0.02	0.00015	0.00014	0.00017	0.00014	0.00013	0.00013	<0.00010	<0.00010	0.0001
Arsenic (As)-Total	(mg/L)	0.005 (interim)	0.0019	0.00181	0.00161	0.00181	0.00208	0.00144	0.00096	0.00027	0.0015
Barium (Ba)-Total	(mg/L)	N/A	0.0324	0.0263	0.0524	0.0237	0.0140	0.0163	0.0127	0.0093	0.0234
Beryllium (Be)-Total****	(mg/L)	0.011 (<75 mg/L CaCO3)	<0.00010	<0.00010		<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	(mg/L)	1.10 (>75 mg/L CaCO3)			<0.00010						
Bismuth (Bi)-Total	(mg/L)	N/A	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Boron (B)-Total	(mg/L)	0.2	0.013	0.012	0.018	0.011	<0.010	0.012	<0.010	<0.010	0.0132
Cadmium (Cd)-Total****	(mg/L)	0.0001 (0-100 mg/L $CaCO_3$)	0.000064	0.000063		0.000072	0.000070	0.000063	0.000028	0.000010	0.00005
	(mg/L)	0.0005 (>100 mg/L $CaCO_3$)			0.000068						
Calcium (Ca)-Total	(mg/L)	N/A	21.9	20.0	69.8	14.5	13.9	11.4	9.0	7.4	21.0
Chromium (Cr)-Total	(mg/L)	N/A	0.00077	0.00075	0.00061	0.00077	0.00061	0.00073	0.00032	0.00014	0.00059
Cobalt (Co)-Total	(mg/L)	0.0009	0.00019	0.0002	0.00053	0.0002	0.00021	0.00018	0.00013	<0.00010	0.0002
Copper (Cu)-Total****	(mg/L)	0.005	0.0044	0.0040	0.0029	0.0040	0.0030	0.0036	0.0018	0.0010	0.0031
Iron (Fe)-Total	(mg/L)	0.3	**1.290**	**1.260**	**0.912**	**1.200**	**1.510**	**1.160**	**0.585**	0.043	**0.995**

Notes:

PWQO - Provincial Water Quality Objectives. **Bold indicates exceedance of PWQO criteria**

* - Alkalinity should not be decreased by more than 25% of the natual conditions (Site 8)

** - indicates criterion is pH and temperature dependent

*** - indicates criterion is pH dependent

**** - indicates criteria are Alkalinity dependent

Oliver Creek Watershed Assessment 2016
Laboratory Water Quality Results Summary Tables

Laboratory Water Quality Results for July 14, 2016

Parameter	Units	PWQO Criterion	OC1 Oliver Creek - SITE#1 14-Jul-16	OC2 Oliver Creek - SITE#2 14-Jul-16	OC3 Oliver Creek - SITE#3 14-Jul-16	OC4 Oliver Creek - SITE#4 14-Jul-16	OC5 Oliver Creek - SITE#5 14-Jul-16	OC6 Oliver Creek - SITE#6 14-Jul-16	OC7 Oliver Creek - SITE#7 14-Jul-16	OC8 Oliver Creek - SITE#8 14-Jul-16	Average July
Total Metals Continued											
Lead (Pb)-Total****	(mg/L)	0.003 (30-80 mg/L CaCO3)	0.000214	0.000246		0.000233	0.000136	0.000241	0.000102	<0.000050	0.0002
	(mg/L)	0.005 (>80 mg/L CaCO3)			0.000062						
Lithium (Li)-Total	(mg/L)	N/A	0.002	0.0019	0.0096	0.0017	<0.0010	0.0015	<0.0010	<0.0010	0.0033
Magnesium (Mg)-Total	(mg/L)	N/A	8.42	7.72	29.30	5.93	5.37	4.95	4.12	3.41	8.65
Manganese (Mn)-Total	(mg/L)	N/A	0.0421	0.0428	0.1320	0.0449	0.1460	0.0195	0.0355	0.0032	0.0583
Molybdenum (Mo)-Total	(mg/L)	0.004	0.001240	0.00114	0.001720	0.0011	0.001530	0.000775	0.000441	0.000181	0.0010
Nickel (Ni)-Total	(mg/L)	0.025	0.00294	0.00283	0.00318	0.00275	0.00228	0.00248	0.00105	<0.00050	0.0025
Potassium (K)-Total	(mg/L)	N/A	1.230	1.110	4.860	0.879	0.743	0.796	0.679	0.66	1.370
Selenium (Se)-Total	(mg/L)	0.1	0.000059	0.000084	0.000151	0.000251	0.000226	0.000448	0.000263	0.000253	0.0002
Silver (Ag)-Total	(mg/L)	0.0001	0.000032	0.000028	0.000012	0.000035	0.00002	0.000038	<0.000010	<0.000010	0.00003
Sodium (Na)-Total	(mg/L)	N/A	4.24	3.74	9.91	2.49	1.59	2.39	1.99	1.82	3.5213
Strontium (Sr)-Total	(mg/L)	N/A	0.0507	0.0460	0.1260	0.0359	0.0319	0.0302	0.0229	0.0185	0.0453
Tellurium (Te)-Total	(mg/L)	N/A	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Thallium (Tl)-Total	(mg/L)	0.0003	0.000015	0.000016	<0.000010	0.000029	<0.000010	0.000021	<0.000010	<0.000010	0.0000
Tin (Sn)-Total	(mg/L)	N/A	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Titanium (Ti)-Total	(mg/L)	N/A	0.00484	0.00457	0.00389	0.00446	0.00245	0.00526	0.00163	0.0004	0.0034
Tungsten (W)-Total	(mg/L)	0.03	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Uranium (U)-Total	(mg/L)	0.005	0.000355	0.000338	0.00287	0.000207	0.000184	0.000130	0.000049	0.000011	0.0005
Vanadium (V)-Total	(mg/L)	N/A	0.00196	0.00179	0.00371	0.00163	0.00149	0.00167	0.00090	<0.00050	0.0019
Zinc (Zn)-Total	(mg/L)	0.02 (interim)	0.0039	0.0040	<0.0030	0.0037	<0.0030	0.0040	<0.0030	<0.0030	0.0039
Zirconium (Zr)-Total	(mg/L)	0.004	0.00034	0.00032	0.00033	0.00036	<0.00030	<0.00030	<0.00030	<0.00030	0.0003

Notes:

PWQO - Provincial Water Quality Objectives. **Bold indicates exceedance of PWQO criteria**

* - Alkalinity should not be decreased by more than 25% of the natual conditions (Site 8)

** - indicates criterion is pH and temperature dependent

*** - indicates criterion is pH dependent

**** - indicates criteria are Alkalinity dependent

Appendix K:

Laboratory Certificates of Analysis and Test Results

LAKEHEAD REGION CONSERVATION AUTHORITY
ATTN: Scott Drebit / Gene Kent
130 Conservation Road
P.O. Box 10427
Thunder Bay ON P7B 6T8

Date Received: 15-JUN-16
Report Date: 27-JUN-16 15:41 (MT)
Version: FINAL

Client Phone: 807-344-5857

Certificate of Analysis

Lab Work Order #: L1783692

Project P.O. #: NOT SUBMITTED
Job Reference: OLIVER CREEK
C of C Numbers:
Legal Site Desc:

Brandon Trudell
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	L1783692-1 Grab 14-JUN-16 11:10 OC8 - OLIVER CREEK - SITE #8	L1783692-2 Grab 14-JUN-16 11:45 OC7 - OLIVER CREEK - SITE #7	L1783692-3 Grab 14-JUN-16 12:30 OC6 - OLIVER CREEK - SITE #6	L1783692-4 Grab 14-JUN-16 13:00 OC5 - OLIVER CREEK - SITE #5	L1783692-5 Grab 14-JUN-16 13:30 OC4 - OLIVER CREEK - SITE #4
WATER						
Physical Tests	Conductivity (EC) (uS/cm)	74.1	80.2	97.1	93.2	111
	Hardness (as CaCO3) (mg/L)	32.7	37.6	49.1	51.6	54.2
	pH (pH)	7.46	7.34	7.59	7.42	7.64
	Total Dissolved Solids (mg/L)	39	55	81	88	86
	Turbidity (NTU)	0.46	1.46	5.84	2.59	5.02
Anions and Nutrients	Alkalinity, Total (as CaCO3) (mg/L)	27.1	31.6	36.7	46.7	44.9
	Ammonia, Total (as N) (mg/L)	<0.020	<0.020	<0.020	0.026	0.026
	Chloride (Cl) (mg/L)	2.23	2.94	3.03	0.16	2.85
	Nitrate (as N) (mg/L)	<0.020	<0.020	<0.020	<0.020	0.032
	Nitrite (as N) (mg/L)	<0.010	<0.010	<0.010	<0.010	<0.010
	Total Kjeldahl Nitrogen (mg/L)	<0.25	0.30	0.40	0.58	0.48
	Phosphorus (P)-Total (mg/L)	0.0031	0.0117	0.0169	0.0209	0.0197
	Sulfate (SO4) (mg/L)	8.23	6.07	8.35	2.74	8.17
Bacteriological Tests	Escherichia Coli (MPN/100mL)	<1	108	23	13	58
	Total Coliforms (MPN/100mL)	53	1730	2420	2420	>2420
Total Metals	Aluminum (Al)-Total (mg/L)	0.0163	0.0639	0.331	0.123	0.280
	Antimony (Sb)-Total (mg/L)	0.00016	<0.00010	<0.00010	0.00011	0.00011
	Arsenic (As)-Total (mg/L)	0.00022	0.00060	0.00099	0.00135	0.00121
	Barium (Ba)-Total (mg/L)	0.0102	0.0116	0.0154	0.0132	0.0205
	Beryllium (Be)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Bismuth (Bi)-Total (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Boron (B)-Total (mg/L)	<0.010	<0.010	0.010	<0.010	<0.010
	Cadmium (Cd)-Total (mg/L)	<0.0000050	0.0000232	0.0000563	0.0000623	0.0000568
	Calcium (Ca)-Total (mg/L)	7.49	8.56	11.3	12.5	12.5
	Cesium (Cs)-Total (mg/L)	<0.000010	<0.000010	0.000048	0.000010	0.000043
	Chromium (Cr)-Total (mg/L)	0.00018	0.00026	0.00080	0.00061	0.00077
	Cobalt (Co)-Total (mg/L)	<0.00010	<0.00010	0.00018	0.00019	0.00020
	Copper (Cu)-Total (mg/L)	0.00115	0.00178	0.00362	0.00394	0.00401
	Iron (Fe)-Total (mg/L)	0.028	0.343	0.925	1.04	0.963
	Lead (Pb)-Total (mg/L)	<0.000050	0.000052	0.000203	0.000106	0.000187
	Lithium (Li)-Total (mg/L)	<0.0010	<0.0010	0.0014	<0.0010	0.0014
	Magnesium (Mg)-Total (mg/L)	3.40	3.94	5.09	4.95	5.58
	Manganese (Mn)-Total (mg/L)	0.00161	0.0249	0.0189	0.119	0.0389
	Molybdenum (Mo)-Total (mg/L)	0.000167	0.000350	0.000552	0.00109	0.000758
	Nickel (Ni)-Total (mg/L)	<0.00050	0.00086	0.00223	0.00203	0.00238
	Phosphorus (P)-Total (mg/L)	<0.050	<0.050	<0.050	<0.050	<0.050

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1783692-6	L1783692-7	L1783692-8		
	Description	Grab	Grab	Grab		
	Sampled Date	14-JUN-16	14-JUN-16	14-JUN-16		
	Sampled Time	14:05	14:25	15:00		
	Client ID	OC3 - OLIVER CREEK - SITE #3	OC2 - OLIVER CREEK - SITE #2	OC1 - OLIVER CREEK - SITE #1		
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (EC) (uS/cm)	461	143	150		
	Hardness (as CaCO3) (mg/L)	249	70.1	75.1		
	pH (pH)	7.93	7.70	7.84		
	Total Dissolved Solids (mg/L)	290	105	109		
	Turbidity (NTU)	3.13	4.90	4.47		
Anions and Nutrients	Alkalinity, Total (as CaCO3) (mg/L)	221	58.3	62.3		
	Ammonia, Total (as N) (mg/L)	0.051	0.035	0.021		
	Chloride (Cl) (mg/L)	13.9	5.19	5.62		
	Nitrate (as N) (mg/L)	0.027	<0.020	<0.020		
	Nitrite (as N) (mg/L)	<0.010	<0.010	<0.010		
	Total Kjeldahl Nitrogen (mg/L)	0.95	0.48	0.56		
	Phosphorus (P)-Total (mg/L)	0.162	0.0213	0.0242		
	Sulfate (SO4) (mg/L)	23.5	8.44	8.34		
Bacteriological Tests	Escherichia Coli (MPN/100mL)	24	68	33		
	Total Coliforms (MPN/100mL)	>2420	2420	1410		
Total Metals	Aluminum (Al)-Total (mg/L)	0.105	0.219	0.195		
	Antimony (Sb)-Total (mg/L)	0.00011	0.00010	0.00012		
	Arsenic (As)-Total (mg/L)	0.00125	0.00120	0.00125		
	Barium (Ba)-Total (mg/L)	0.0430	0.0226	0.0254		
	Beryllium (Be)-Total (mg/L)	<0.00010	<0.00010	<0.00010		
	Bismuth (Bi)-Total (mg/L)	<0.000050	<0.000050	<0.000050		
	Boron (B)-Total (mg/L)	0.014	0.010	0.010		
	Cadmium (Cd)-Total (mg/L)	0.0000726	0.0000505	0.0000456		
	Calcium (Ca)-Total (mg/L)	58.8	17.0	18.2		
	Cesium (Cs)-Total (mg/L)	<0.000010	0.000031	0.000028		
	Chromium (Cr)-Total (mg/L)	0.00065	0.00073	0.00061		
	Cobalt (Co)-Total (mg/L)	0.00057	0.00017	0.00016		
	Copper (Cu)-Total (mg/L)	0.00301	0.00383	0.00366		
	Iron (Fe)-Total (mg/L)	0.712	0.966	0.937		
	Lead (Pb)-Total (mg/L)	<0.000050	0.000158	0.000146		
	Lithium (Li)-Total (mg/L)	0.0056	0.0015	0.0016		
	Magnesium (Mg)-Total (mg/L)	24.8	6.72	7.23		
	Manganese (Mn)-Total (mg/L)	0.141	0.0372	0.0397		
	Molybdenum (Mo)-Total (mg/L)	0.00139	0.000794	0.000836		
	Nickel (Ni)-Total (mg/L)	0.00313	0.00230	0.00218		
	Phosphorus (P)-Total (mg/L)	0.193	<0.050	<0.050		

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	L1783692-1 Grab 14-JUN-16 11:10 OC8 - OLIVER CREEK - SITE #8	L1783692-2 Grab 14-JUN-16 11:45 OC7 - OLIVER CREEK - SITE #7	L1783692-3 Grab 14-JUN-16 12:30 OC6 - OLIVER CREEK - SITE #6	L1783692-4 Grab 14-JUN-16 13:00 OC5 - OLIVER CREEK - SITE #5	L1783692-5 Grab 14-JUN-16 13:30 OC4 - OLIVER CREEK - SITE #4
WATER						
Total Metals	Potassium (K)-Total (mg/L)	0.684	0.658	0.742	0.726	0.815
	Rubidium (Rb)-Total (mg/L)	0.00042	0.00049	0.00082	0.00064	0.00080
	Selenium (Se)-Total (mg/L)	0.000062	0.000098	0.000153	0.000260	0.000203
	Silicon (Si)-Total (mg/L)	1.73	2.07	3.50	3.13	3.68
	Silver (Ag)-Total (mg/L)	<0.000010	<0.000010	0.000034	0.000020	0.000033
	Sodium (Na)-Total (mg/L)	1.80	1.93	2.42	1.67	2.52
	Strontium (Sr)-Total (mg/L)	0.0194	0.0208	0.0283	0.0276	0.0324
	Sulfur (S)-Total (mg/L)	2.47	1.83	2.94	1.10	2.72
	Tellurium (Te)-Total (mg/L)	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
	Thallium (Tl)-Total (mg/L)	<0.000010	<0.000010	0.000020	<0.000010	0.000015
	Thorium (Th)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Tin (Sn)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Titanium (Ti)-Total (mg/L)	0.00031	0.00147	0.00617	0.00291	0.00517
	Tungsten (W)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Uranium (U)-Total (mg/L)	<0.000010	0.000037	0.000115	0.000186	0.000176
	Vanadium (V)-Total (mg/L)	<0.00050	<0.00050	0.00126	0.00109	0.00125
	Zinc (Zn)-Total (mg/L)	<0.0030	<0.0030	0.0052	<0.0030	0.0045
	Zirconium (Zr)-Total (mg/L)	<0.00030	<0.00030	<0.00030	0.00032	<0.00030

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1783692-6	L1783692-7	L1783692-8		
	Description	Grab	Grab	Grab		
	Sampled Date	14-JUN-16	14-JUN-16	14-JUN-16		
	Sampled Time	14:05	14:25	15:00		
	Client ID	OC3 - OLIVER CREEK - SITE #3	OC2 - OLIVER CREEK - SITE #2	OC1 - OLIVER CREEK - SITE #1		
Grouping	**Analyte**					
WATER						
Total Metals	Potassium (K)-Total (mg/L)	3.60	0.920	0.951		
	Rubidium (Rb)-Total (mg/L)	0.00140	0.00073	0.00067		
	Selenium (Se)-Total (mg/L)	0.000357	0.000175	0.000209		
	Silicon (Si)-Total (mg/L)	6.49	3.66	3.71		
	Silver (Ag)-Total (mg/L)	0.000012	0.000028	0.000023		
	Sodium (Na)-Total (mg/L)	9.13	3.63	3.76		
	Strontium (Sr)-Total (mg/L)	0.107	0.0398	0.0423		
	Sulfur (S)-Total (mg/L)	8.50	2.62	2.82		
	Tellurium (Te)-Total (mg/L)	<0.00020	<0.00020	<0.00020		
	Thallium (Tl)-Total (mg/L)	<0.000010	0.000012	0.000012		
	Thorium (Th)-Total (mg/L)	<0.00010	<0.00010	<0.00010		
	Tin (Sn)-Total (mg/L)	<0.00010	<0.00010	<0.00010		
	Titanium (Ti)-Total (mg/L)	0.00393	0.00459	0.00418		
	Tungsten (W)-Total (mg/L)	<0.00010	<0.00010	<0.00010		
	Uranium (U)-Total (mg/L)	0.00249	0.000248	0.000254		
	Vanadium (V)-Total (mg/L)	0.00293	0.00131	0.00131		
	Zinc (Zn)-Total (mg/L)	<0.0030	0.0041	0.0038		
	Zirconium (Zr)-Total (mg/L)	0.00034	<0.00030	<0.00030		

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Method Blank	Chloride (Cl)	B	L1783692-1, -2, -3, -5, -6, -7, -8
Matrix Spike	Calcium (Ca)-Total	MS-B	L1783692-1, -2, -3, -4, -5, -6, -7, -8
Matrix Spike	Magnesium (Mg)-Total	MS-B	L1783692-1, -2, -3, -4, -5, -6, -7, -8
Matrix Spike	Sulfate (SO4)	MS-B	L1783692-1, -2, -3, -4, -5, -6, -7, -8
Matrix Spike	Calcium (Ca)-Total	MS-B	L1783692-1, -2, -3, -4, -5, -6, -7, -8
Matrix Spike	Magnesium (Mg)-Total	MS-B	L1783692-1, -2, -3, -4, -5, -6, -7, -8
Matrix Spike	Sodium (Na)-Total	MS-B	L1783692-1, -2, -3, -4, -5, -6, -7, -8
Matrix Spike	Strontium (Sr)-Total	MS-B	L1783692-1, -2, -3, -4, -5, -6, -7, -8
Matrix Spike	Sulfur (S)-Total	MS-B	L1783692-1, -2, -3, -4, -5, -6, -7, -8
Matrix Spike	Total Kjeldahl Nitrogen	MS-B	L1783692-1, -2, -3, -4, -5, -6, -7, -8
Matrix Spike	Total Kjeldahl Nitrogen	MS-B	L1783692-1, -2, -3, -4, -5, -6, -7, -8

Qualifiers for Individual Parameters Listed:

Qualifier	Description
B	Method Blank exceeds ALS DQO. All associated sample results are at least 5 times greater than blank levels and are considered reliable.
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-TITR-TB	Water	Alkalinity	APHA 2320

This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

CL-L-IC-N-TB	Water	Chloride in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

EC-TITR-TB	Water	Conductivity	APHA 2510 B

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

HARDNESS-CALC-TB	Water	Hardness (as CaCO3)	CALCULATION
MET-T-CCMS-TB	Water	Total Metals in Water by CRC ICPMS	EPA 200.2/6020A (mod)

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

NH3-COL-TB	Water	Ammonia by Discrete Analyzer	APHA 4500-NH3 G. (modified)

Ammonia in aqueous matrices is analyzed using discrete analyzer with colourimetric detection.

NO2-IC-N-TB	Water	Nitrite in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

NO3-IC-N-TB	Water	Nitrate in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

P-T-COL-TB	Water	Total Phosphorus by Discrete Analyzer	APHA 4500-P B, F, G (modified)

Phosphorus in aqueous matrices is analyzed using discrete Analyzer with colourimetric detection.

PH-TITR-TB	Water	pH	APHA 4500-H

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

SO4-IC-N-TB	Water	Sulfate in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

TC,EC-QT97-TB	Water	Total Coliform and E.coli	APHA 9223 B

This analysis is carried out using procedures adapted from APHA Method 9223 "Enzyme Substrate Coliform Test". E. coli and Total Coliform are determined simultaneously. The sample is mixed with a mixture of hydrolyzable substrates and then sealed in a multi-well packet. The packet is incubated for 18 or 24 hours and then the number of wells exhibiting a positive response are counted. The final result is obtained by comparing the

Reference Information

positive responses to a probability table.

TDS-TB	Water	Total Dissolved Solids	APHA 2540 C (modified)

Aqueous matrices are analyzed using gravimetry and evaporation

TKN-COL-TB	Water	Total Kjeldahl Nitrogen	APHA 4500-Norg (modified)

Total Kjeldahl Nitrogen in aqueous matrices is analyzed using a discrete analyzer with colourimetric detection.

TURBIDITY-TB	Water	Turbidity	APHA 2130 B-Nephelometer

Aqueous matrices are analyzed using nephelometry with the light scatter measured at a 90” angle.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
TB	ALS ENVIRONMENTAL - THUNDER BAY, ONTARIO, CANADA

Chain of Custody Numbers:

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Chain of Custody (COC) / Analytical Request Form

ALS Environmental
www.alsglobal.com

Canada Toll Free: 1 800 668 9878

L1783692-COFC

COC Number: 14 -

Page 1 of 1

Report To		Report Format / Distribution	Select Service Level Below (Rush Turnaround Time (TAT) is not available for all tests)
Company:	Lakehead Region Conservation Authority	Select Report Format: ☑PDF ☐EXCEL ☐EDD (DIGITAL)	R ☐Regular (Standard TAT if received by 3 pm - business days)
Contact:		Quality Control (QC) Report with Report ☐ Yes ☑No	P ☐Priority (2-4 bus. days if received by 3pm) 50% surcharge - contact ALS to confirm TAT
Address:	130 Conservation Road PO Box 10427	☐Criteria on Report - provide details below if box checked Select Distribution: ☑EMAIL ☐MAIL ☐FAX	E ☐Emergency (1-2 bus. days if received by 3pm) 100% surcharge - contact ALS to confirm TAT E2 ☐Same day or weekend emergency - contact ALS to confirm TAT and surcharge
Phone:	807-344-5857	Email 1 or Fax tammy@lakeheadca.com Email 2 Scott@lakeheadca.com	Specify Date Required for E2,E or P:

Invoice To		Invoice Distribution	Analysis Request
	Same as Report To ☑ Yes ☐ No	Select Invoice Distribution: ☑EMAIL ☐MAIL ☐FAX	Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below
	Copy of Invoice with Report ☑ Yes ☐ No		
Company:		Email 1 or Fax	
Contact:		Email 2	

Project Information		Oil and Gas Required Fields (client use)	
ALS Quote #:	Q56900	Approver ID:	Cost Center:
Job #:	Oliver Creek	GL Account:	Routing Code:
PO / AFE:		Activity Code:	
LSD:		Location:	

ALS Lab Work Order # (lab use only): L1783692 **ALS Contact:** **Sampler:** SD

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Alkalinity, Conductivity, pH	Chloride, Nitrate, Nitrite, Sulphate	TDS, Turbidity	NH3, TKN, TP	Metals, Total & Hardness	TC/EC	Number of Containers
	OC8 - Oliver Creek - Site #8	14-JUN-16	11:10	grab	X	X	X	X	X	X	5
	OC7 - Oliver Creek - Site #7	14-JUN-16	11:45	grab	X	X	X	X	X	X	5
	OC6 - Oliver Creek - Site #6	14-JUN-16	12:30	grab	X	X	X	X	X	X	5
	OC5 - Oliver Creek - Site #5	14-JUN-16	13:00	grab	X	X	X	X	X	X	5
	OC4 - Oliver Creek - Site #4	14-JUN-16	13:30	grab	X	X	X	X	X	X	5
	OC3 - Oliver Creek - Site #3	14-JUN-16	14:05	grab	X	X	X	X	X	X	5
	OC2 - Oliver Creek - Site #2	14-JUN-16	14:25	grab	X	X	X	X	X	X	5
	OC1 - Oliver Creek - Site #1	14-JUN-16	15:00	grab	X	X	X	X	X	X	5

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System? ☐ Yes ☑ No

Are samples for human drinking water use? ☐ Yes ☑ No

Special Instructions / Specify Criteria to add on report (client use)

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐ SIF Observations Yes ☐ No ☒

Ice packs Yes ☒ No ☐ Custody seal intact Yes ☐ No ☐

Cooling Initiated ☒

INITIAL COOLER TEMPERATURES °C			FINAL COOLER TEMPERATURES °C		
8.2					

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by:	Date: June 15/16	Time:	Received By	Date: Jun 15 16	Time: 12:55	Received by:	Date: Jun 15/16	Time: 1:50

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

ALS Form v09 Front/04 January 2014

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a **Regulated Drinking Water (DW) System**, please submit using an **Authorized DW COC form**.

LAKEHEAD REGION CONSERVATION AUTHORITY
ATTN: Scott Drebit
130 Conservation Road
P.O. Box 10427
Thunder Bay ON P7B 6T8

Date Received: 14-JUL-16
Report Date: 28-JUL-16 11:46 (MT)
Version: FINAL

Client Phone: 807-344-5857

Certificate of Analysis

Lab Work Order #: L1798433

Project P.O. #: NOT SUBMITTED
Job Reference: OLIVER CREEK
C of C Numbers:
Legal Site Desc:

Christina Shepherd
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1798433-1	L1798433-2	L1798433-3	L1798433-4	L1798433-5
	Description	Grab	Grab	Grab	Grab	Grab
	Sampled Date	14-JUL-16	14-JUL-16	14-JUL-16	14-JUL-16	14-JUL-16
	Sampled Time	10:05	10:25	10:40	11:00	11:20
	Client ID	OC8 - OLIVER CREEK - SITE #8	OC7 - OLIVER CREEK - SITE #7	OC6 - OLIVER CREEK - SITE #6	OC5 - OLIVER CREEK - SITE #5	OC4 - OLIVER CREEK - SITE #4
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (uS/cm)				102	121
	Conductivity (EC) (uS/cm)	76.2	83.4	101		
	Hardness (as CaCO3) (mg/L)	32.5		48.8	56.7	60.7
	Hardness (as CaCO3)		39.5			
	pH (pH)	7.75	7.50	7.71	7.55	7.64
	Total Dissolved Solids (mg/L)	48	61	78	92	107
	Turbidity (NTU)	0.53	2.74	6.40	2.77	5.67
Anions and Nutrients	Alkalinity, Total (as CaCO3) (mg/L)	27.5	30.8	38.4	50.0	51.3
	Ammonia, Total (as N) (mg/L)	0.106	0.175	<0.020	<0.020	<0.020
	Chloride (Cl) (mg/L)	1.91	2.15	2.42	0.15	2.51
	Nitrate (as N) (mg/L)	<0.020	0.023	0.030	<0.020	0.072
	Nitrite (as N) (mg/L)	<0.010	<0.010	<0.010	<0.010	<0.010
	Total Kjeldahl Nitrogen (mg/L)	0.25	0.41	0.46	0.68	0.57
	Phosphorus (P)-Total (mg/L)	<0.0030	0.0090	0.0204	0.0250	0.0216
	Sulfate (SO4) (mg/L)	8.36	5.82	7.07	1.45	6.69
Bacteriological Tests	Escherichia Coli (MPN/100mL)	2	99	50	33	56
	Total Coliforms (MPN/100mL)	365	1730	1730	2420	>2420
Total Metals	Aluminum (Al)-Total (mg/L)	0.0223	0.0799	0.262	0.101	0.226
	Antimony (Sb)-Total (mg/L)	<0.00010	<0.00010	0.00013	0.00013	0.00014
	Arsenic (As)-Total (mg/L)	0.00027	0.00096	0.00144	0.00208	0.00181
	Barium (Ba)-Total (mg/L)	0.00932	0.0127	0.0163	0.0140	0.0237
	Beryllium (Be)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Bismuth (Bi)-Total (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Boron (B)-Total (mg/L)	<0.010	<0.010	0.012	<0.010	0.011
	Cadmium (Cd)-Total (mg/L)	0.0000102	0.0000275	0.0000627	0.0000700	0.0000723
	Calcium (Ca)-Total (mg/L)	7.37	9.02	11.4	13.9	14.5
	Cesium (Cs)-Total (mg/L)	<0.000010	0.000010	0.000044	<0.000010	0.000040
	Chromium (Cr)-Total (mg/L)	0.00014	0.00032	0.00073	0.00061	0.00077
	Cobalt (Co)-Total (mg/L)	<0.00010	0.00013	0.00018	0.00021	0.00020
	Copper (Cu)-Total (mg/L)	0.00100	0.00182	0.00362	0.00303	0.00397
	Iron (Fe)-Total (mg/L)	0.043	0.585	1.16	1.51	1.20
	Lead (Pb)-Total (mg/L)	<0.000050	0.000102	0.000241	0.000136	0.000233
	Lithium (Li)-Total (mg/L)	<0.0010	<0.0010	0.0015	<0.0010	0.0017
	Magnesium (Mg)-Total (mg/L)	3.41	4.12	4.95	5.37	5.93
	Manganese (Mn)-Total (mg/L)	0.00322	0.0355	0.0195	0.146	0.0449
	Molybdenum (Mo)-Total (mg/L)	0.000181	0.000441	0.000775	0.00153	0.00110

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1798433-6	L1798433-7	L1798433-8		
	Description	Grab	Grab	Grab		
	Sampled Date	14-JUL-16	14-JUL-16	14-JUL-16		
	Sampled Time	11:35	11:50	12:05		
	Client ID	OC3 - OLIVER CREEK - SITE #3	OC2 - OLIVER CREEK - SITE #2	OC1 - OLIVER CREEK - SITE #1		
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (uS/cm)	552	162	170		
	Conductivity (EC) (uS/cm)					
	Hardness (as CaCO3) (mg/L)	295	81.7	89.5		
	Hardness (as CaCO3)					
	pH (pH)	7.96	7.89	8.13		
	Total Dissolved Solids (mg/L)	356	122	127		
	Turbidity (NTU)	3.71	5.69	5.44		
Anions and Nutrients	Alkalinity, Total (as CaCO3) (mg/L)	267	71.4	74.3		
	Ammonia, Total (as N) (mg/L)	0.037	<0.020	<0.020		
	Chloride (Cl) (mg/L)	13.7	4.57	5.10		
	Nitrate (as N) (mg/L)	0.137	0.087	0.072		
	Nitrite (as N) (mg/L)	<0.010	<0.010	<0.010		
	Total Kjeldahl Nitrogen (mg/L)	1.07	0.62	0.65		
	Phosphorus (P)-Total (mg/L)	0.235	0.0320	0.0311		
	Sulfate (SO4) (mg/L)	19.4	6.62	6.65		
Bacteriological Tests	Escherichia Coli (MPN/100mL)	687	77	37		
	Total Coliforms (MPN/100mL)	>2420	>2420	>2420		
Total Metals	Aluminum (Al)-Total (mg/L)	0.110	0.200	0.201		
	Antimony (Sb)-Total (mg/L)	0.00017	0.00014	0.00015		
	Arsenic (As)-Total (mg/L)	0.00161	0.00181	0.00190		
	Barium (Ba)-Total (mg/L)	0.0524	0.0263	0.0324		
	Beryllium (Be)-Total (mg/L)	<0.00010	<0.00010	<0.00010		
	Bismuth (Bi)-Total (mg/L)	<0.000050	<0.000050	<0.000050		
	Boron (B)-Total (mg/L)	0.018	0.012	0.013		
	Cadmium (Cd)-Total (mg/L)	0.0000676	0.0000630	0.0000640		
	Calcium (Ca)-Total (mg/L)	69.8	20.0	21.9		
	Cesium (Cs)-Total (mg/L)	<0.000010	0.000032	0.000030		
	Chromium (Cr)-Total (mg/L)	0.00061	0.00075	0.00077		
	Cobalt (Co)-Total (mg/L)	0.00053	0.00020	0.00019		
	Copper (Cu)-Total (mg/L)	0.00292	0.00400	0.00444		
	Iron (Fe)-Total (mg/L)	0.912	1.26	1.29		
	Lead (Pb)-Total (mg/L)	0.000062	0.000246	0.000214		
	Lithium (Li)-Total (mg/L)	0.0096	0.0019	0.0020		
	Magnesium (Mg)-Total (mg/L)	29.3	7.72	8.42		
	Manganese (Mn)-Total (mg/L)	0.132	0.0428	0.0421		
	Molybdenum (Mo)-Total (mg/L)	0.00172	0.00114	0.00124		

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample ID	L1798433-1	L1798433-2	L1798433-3	L1798433-4	L1798433-5
Description	Grab	Grab	Grab	Grab	Grab
Sampled Date	14-JUL-16	14-JUL-16	14-JUL-16	14-JUL-16	14-JUL-16
Sampled Time	10:05	10:25	10:40	11:00	11:20
Client ID	OC8 - OLIVER CREEK - SITE #8	OC7 - OLIVER CREEK - SITE #7	OC6 - OLIVER CREEK - SITE #6	OC5 - OLIVER CREEK - SITE #5	OC4 - OLIVER CREEK - SITE #4
Grouping / **Analyte**					
WATER					
Total Metals					
Nickel (Ni)-Total (mg/L)	<0.00050	0.00105	0.00248	0.00228	0.00275
Phosphorus (P)-Total (mg/L)	<0.050	<0.050	<0.050	<0.050	<0.050
Potassium (K)-Total (mg/L)	0.660	0.679	0.796	0.743	0.879
Rubidium (Rb)-Total (mg/L)	0.00042	0.00054	0.00080	0.00079	0.00077
Selenium (Se)-Total (mg/L)	0.000059	0.000084	0.000151	0.000251	0.000226
Silicon (Si)-Total (mg/L)	1.76	2.66	4.06	3.99	4.37
Silver (Ag)-Total (mg/L)	<0.000010	<0.000010	0.000038	0.000020	0.000035
Sodium (Na)-Total (mg/L)	1.82	1.99	2.39	1.59	2.49
Strontium (Sr)-Total (mg/L)	0.0185	0.0229	0.0302	0.0319	0.0359
Sulfur (S)-Total (mg/L)	2.74	2.02	2.33	<0.50	1.98
Tellurium (Te)-Total (mg/L)	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Thallium (Tl)-Total (mg/L)	<0.000010	<0.000010	0.000021	<0.000010	0.000029
Thorium (Th)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Tin (Sn)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Titanium (Ti)-Total (mg/L)	0.00040	0.00163	0.00526	0.00245	0.00446
Tungsten (W)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Uranium (U)-Total (mg/L)	0.000011	0.000049	0.000130	0.000184	0.000207
Vanadium (V)-Total (mg/L)	<0.00050	0.00090	0.00167	0.00149	0.00163
Zinc (Zn)-Total (mg/L)	<0.0030	<0.0030	0.0040	<0.0030	0.0037
Zirconium (Zr)-Total (mg/L)	<0.00030	<0.00030	<0.00030	<0.00030	0.00036

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1798433-6	L1798433-7	L1798433-8		
	Description	Grab	Grab	Grab		
	Sampled Date	14-JUL-16	14-JUL-16	14-JUL-16		
	Sampled Time	11:35	11:50	12:05		
	Client ID	OC3 - OLIVER CREEK - SITE #3	OC2 - OLIVER CREEK - SITE #2	OC1 - OLIVER CREEK - SITE #1		
Grouping	**Analyte**					
WATER						
Total Metals	Nickel (Ni)-Total (mg/L)	0.00318	0.00283	0.00294		
	Phosphorus (P)-Total (mg/L)	0.254	<0.050	<0.050		
	Potassium (K)-Total (mg/L)	4.86	1.11	1.23		
	Rubidium (Rb)-Total (mg/L)	0.00205	0.00086	0.00093		
	Selenium (Se)-Total (mg/L)	0.000448	0.000263	0.000253		
	Silicon (Si)-Total (mg/L)	8.85	5.01	5.34		
	Silver (Ag)-Total (mg/L)	0.000012	0.000028	0.000032		
	Sodium (Na)-Total (mg/L)	9.91	3.74	4.24		
	Strontium (Sr)-Total (mg/L)	0.126	0.0460	0.0507		
	Sulfur (S)-Total (mg/L)	7.15	2.19	2.34		
	Tellurium (Te)-Total (mg/L)	<0.00020	<0.00020	<0.00020		
	Thallium (Tl)-Total (mg/L)	<0.000010	0.000016	0.000015		
	Thorium (Th)-Total (mg/L)	<0.00010	<0.00010	<0.00010		
	Tin (Sn)-Total (mg/L)	<0.00010	<0.00010	<0.00010		
	Titanium (Ti)-Total (mg/L)	0.00389	0.00457	0.00484		
	Tungsten (W)-Total (mg/L)	<0.00010	<0.00010	<0.00010		
	Uranium (U)-Total (mg/L)	0.00287	0.000338	0.000355		
	Vanadium (V)-Total (mg/L)	0.00371	0.00179	0.00196		
	Zinc (Zn)-Total (mg/L)	<0.0030	0.0040	0.0039		
	Zirconium (Zr)-Total (mg/L)	0.00033	0.00032	0.00034		

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Method Blank	Iron (Fe)-Total	B	L1798433-2, -3, -4, -5, -6, -7, -8
Method Blank	Manganese (Mn)-Total	B	L1798433-2, -3, -4, -5, -6, -7, -8
Duplicate	Aluminum (Al)-Total	DLHC	L1798433-1
Duplicate	Antimony (Sb)-Total	DLHC	L1798433-1
Duplicate	Arsenic (As)-Total	DLHC	L1798433-1
Duplicate	Aluminum (Al)-Total	DUP-H	L1798433-2, -3, -4, -5, -6, -7, -8
Matrix Spike	Ammonia, Total (as N)	MS-B	L1798433-1, -2, -3, -4, -5, -6, -7, -8
Matrix Spike	Total Kjeldahl Nitrogen	MS-B	L1798433-1, -2, -3, -4, -5, -6, -7, -8
Matrix Spike	Calcium (Ca)-Total	MS-B	L1798433-2, -3, -4, -5, -6, -7, -8
Matrix Spike	Magnesium (Mg)-Total	MS-B	L1798433-2, -3, -4, -5, -6, -7, -8
Matrix Spike	Manganese (Mn)-Total	MS-B	L1798433-2, -3, -4, -5, -6, -7, -8
Matrix Spike	Strontium (Sr)-Total	MS-B	L1798433-2, -3, -4, -5, -6, -7, -8
Matrix Spike	Calcium (Ca)-Total	MS-B	L1798433-2, -3, -4, -5, -6, -7, -8
Matrix Spike	Magnesium (Mg)-Total	MS-B	L1798433-2, -3, -4, -5, -6, -7, -8
Matrix Spike	Manganese (Mn)-Total	MS-B	L1798433-2, -3, -4, -5, -6, -7, -8
Matrix Spike	Sodium (Na)-Total	MS-B	L1798433-2, -3, -4, -5, -6, -7, -8
Matrix Spike	Strontium (Sr)-Total	MS-B	L1798433-2, -3, -4, -5, -6, -7, -8
Matrix Spike	Sulfur (S)-Total	MS-B	L1798433-2, -3, -4, -5, -6, -7, -8

Qualifiers for Individual Parameters Listed:

Qualifier	Description
B	Method Blank exceeds ALS DQO. All associated sample results are at least 5 times greater than blank levels and are considered reliable.
DLHC	Detection Limit Raised: Dilution required due to high concentration of test analyte(s).
DUP-H	Duplicate results outside ALS DQO, due to sample heterogeneity.
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-TITR-VA	Water	Alkalinity Species by Titration	APHA 2320 Alkalinity
This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.			
CL-L-IC-N-TB	Water	Chloride in Water by IC (Low Level)	EPA 300.1 (mod)
Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.			
EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.
This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.			
EC-TITR-TB	Water	Conductivity	APHA 2510 B
This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.			
HARDNESS-CALC-TB	Water	Hardness (as CaCO3)	CALCULATION
MET-T-CCMS-TB	Water	Total Metals in Water by CRC ICPMS	EPA 200.2/6020A (mod)
Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.			
Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.			
NH3-COL-TB	Water	Ammonia by Discrete Analyzer	APHA 4500-NH3 G. (modified)
Ammonia in aqueous matrices is analyzed using discrete analyzer with colourimetric detection.			
NO2-IC-N-TB	Water	Nitrite in Water by IC	EPA 300.1 (mod)
Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.			
NO3-IC-N-TB	Water	Nitrate in Water by IC	EPA 300.1 (mod)
Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.			

Reference Information

P-T-COL-TB	Water	Total Phosphorus by Discrete Analyzer	APHA 4500-P B, F, G (modified)

Phosphorus in aqueous matrices is analyzed using discrete Analyzer with colourimetric detection.

PH-METER-TB	Water	pH	APHA 4500-H-ELECTRODE

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using pH electrode.

SO4-IC-N-TB	Water	Sulfate in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

TC,EC-QT97-TB	Water	Total Coliform and E.coli	APHA 9223 B

This analysis is carried out using procedures adapted from APHA Method 9223 "Enzyme Substrate Coliform Test". E. coli and Total Coliform are determined simultaneously. The sample is mixed with a mixture of hydrolyzable substrates and then sealed in a multi-well packet. The packet is incubated for 18 or 24 hours and then the number of wells exhibiting a positive response are counted. The final result is obtained by comparing the positive responses to a probability table.

TDS-TB	Water	Total Dissolved Solids	APHA 2540 C (modified)

Aqueous matrices are analyzed using gravimetry and evaporation

TKN-COL-TB	Water	Total Kjeldahl Nitrogen	APHA 4500-Norg (modified)

Total Kjeldahl Nitrogen in aqueous matrices is analyzed using a discrete analyzer with colourimetric detection.

TURBIDITY-TB	Water	Turbidity	APHA 2130 B-Nephelometer

Aqueous matrices are analyzed using nephelometry with the light scatter measured at a 90” angle.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
TB	ALS ENVIRONMENTAL - THUNDER BAY, ONTARIO, CANADA
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Chain of Custody (COC) / Analytical Request Form

ALS Environmental
www.alsglobal.com

Canada Toll Free: 1 800 668 9878

L1798433-COFC

COC Number: 14 -

Page 1 of 4

Report To		Report Format / Distribution		Select Service Level Below (Rush Turnaround Time (TAT) is not available for all tests)
Company:	Lakehead Region Conservation Authority	Select Report Format: ☒PDF ☐EXCEL ☐EDD (DIGITAL)		R ☐Regular (Standard TAT if received by 3 pm - business days)
Contact:		Quality Control (QC) Report with Report ☐ Yes ☒ No		P ☐Priority (2-4 bus. days if received by 3pm) 50% surcharge - contact ALS to confirm TAT
Address:	130 Conservation Road	☐Criteria on Report - provide details below if box checked		E ☐Emergency (1-2 bus. days if received by 3pm) 100% surcharge - contact ALS to confirm TAT
	PO Box 10427	Select Distribution: ☑EMAIL ☐MAIL ☐FAX		E2 ☐Same day or weekend emergency - contact ALS to confirm TAT and surcharge
Phone:	807-344-5857	Email 1 or Fax tammy@lakeheadca.com		Specify Date Required for E2,E or P:
		Email 2 Scott@lakeheadca.com		

Invoice To		Invoice Distribution	
	Same as Report To ☑ Yes ☐ No	Select Invoice Distribution: ☑EMAIL ☐MAIL ☐FAX	
	Copy of Invoice with Report ☑ Yes ☐ No	Email 1 or Fax	
Company:		Email 2	
Contact:			

Project Information		Oil and Gas Required Fields (client use)	
ALS Quote #:	Q56900	Approver ID:	Cost Center:
Job #:	Oliver Creek	GL Account:	Routing Code:
PO / AFE:		Activity Code:	
LSD:		Location:	

ALS Lab Work Order # (lab use only): L1798433 **ALS Contact:** **Sampler:** SD

Analysis Request — Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Alkalinity, Conductivity, pH	Chloride, Nitrate, Nitrite, Sulphate	TDS, Turbidity	NH3, TKN, TP	Metals, Total & Hardness	TC/EC	Number of Containers
	OC8 - Oliver creek - Site #8	14-JUL-16	10:05	grab	X	X	X	X	X	X	5
	OC7 - Oliver creek - Site #7	14-JUL-16	10:25	grab	X	X	X	X	X	X	5
	OC6 - Oliver Creek - Site #6	14-JUL-16	10:40	grab	X	X	X	X	X	X	5
	OC5 - Oliver creek - Site #5	14-JUL-16	11:00	grab	X	X	X	X	X	X	5
	OC4 - Oliver Creek - Site #4	14-JUL-16	11:20	grab	X	X	X	X	X	X	5
	OC3 - Oliver Creek - Site #3	14-JUL-16	11:35	grab	X	X	X	X	X	X	5
	OC2 - Oliver Creek - Site #2	14-JUL-16	11:50	grab	X	X	X	X	X	X	5
	OC1 - Oliver Creek - Site #1	14-JUL-16	12:05	grab	X	X	X	X	X	X	5

Drinking Water (DW) Samples[1] (client use)	Special Instructions / Specify Criteria to add on report (client use)
Are samples taken from a Regulated DW System? ☐ Yes ☐ No	
Are samples for human drinking water use? ☐ Yes ☐ No	

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen	☐	SIF Observations	Yes ☐	No ☑	
Ice packs	Yes ☑	No ☐	Custody seal intact	Yes ☐	No ☐
Cooling Initiated	☑				

INITIAL COOLER TEMPERATURES °C		FINAL COOLER TEMPERATURES °C	
17.3	15.1		

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by:	Date: July 14/16	Time:	Received By: JRR	Date: 7-14-16	Time: 1:46	Received by: S.D.	Date: July 14/16	Time: 2:20

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

ALS-FM-0326m v09 Front/04 January 2014

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a **Regulated Drinking Water (DW) System**, please submit using an **Authorized DW COC form.**