2011 Lake System Health Monitoring Program

Year End Report

February 2012

Prepared by
The District Municipality of Muskoka
Planning and Economic Development Department

With Technical Support from the
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Ministry of the Environment

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Introduction

Muskoka is a world-class tourist destination with a large component of the population being seasonal residents with cottages on its many lakes and rivers. With over 8,000 waterbodies and more than 13,500 kilometres of shoreline, Muskoka also attracts almost two million visitors each year.

Continued prosperity in Muskoka depends upon maintaining the natural environment and clean, healthy water that draws people here. For this reason, The District Municipality of Muskoka has an interest in the water quality of all the lakes and rivers within its jurisdiction.

In conjunction with the Ministry of the Environment, Muskoka has undertaken a water quality monitoring program since 1980. In total, 193 sites on 164 lakes are monitored on a rotational basis. These data are collected to support development policy and represent one of the best municipal water quality data sets in Canada.

Muskoka Water Strategy

In January 2003, The District Municipality of Muskoka expanded its recreational water quality program and developed the Muskoka Water Strategy. The Strategy is a framework of integrated and strategic initiatives to protect Muskoka's water resources. Muskoka spearheads the Strategy with the support of the Muskoka Watershed Council and with involvement from a wide variety of organizations, agencies and stakeholders.

The Strategy consists of four broad components:

1. Lake System Health, including lake and watershed monitoring, and improved stormwater management;

2. Communication and community involvement, including the Muskoka Water Web site (www.muskokawaterweb.ca);

3. The Muskoka Watershed Council, which includes initiatives such as the Muskoka Watershed Report Card and Best Practices program (www.muskokaheritage.org/mwc); and

4. Broader Water Initiatives, such as source water protection and watershed inventories.

The Strategy emphasizes the development of relationships and the sharing of resources with other organizations as well as greater community involvement. As the strategy evolves, it will address new water issues or concerns respecting Muskoka's water resources and will provide a structure for future water initiatives.

Lake System Health

Lake System Health is a broad approach to protecting waterbodies that includes recreational water quality monitoring, enhanced development policy, a strong stewardship program, and municipal infrastructure programs. The goal of the Lake System Health Program is to protect lake ecosystems and the social and economic values they provide. The ability of development to occur around a waterbody without substantially damaging the natural environment, habitat and trophic status of the waterbody or other waterbodies within the same watershed is the initial and primary factor in achieving lake health and sustainable development.

Summary of Lake System Health Monitoring Activities

A key component of the Lake System Health Program is good water quality. Water quality has been monitored by Muskoka in conjunction with the Ministry of the Environment for over 30 years and has produced very good long-term data records for many key lakes.

The monitoring program is a field-based program that monitors 193 sites on 164 lakes on a rotational basis. The purpose of the monitoring program is to establish a long-term record of key water quality parameters so that trends in water quality and lake system health can be identified and appropriate management decisions can be made to protect lake water quality.

In collaboration with the Dorset Environmental Science Centre (DESC), Secchi depth (a measure of clarity) and phosphorus concentrations are taken as part of the Provincial Lake Partner Program. DESC also tests for other parameters, such as pH, conductivity, alkalinity, calcium, and nitrogen, so that a more complete understanding of lake chemistry can be achieved. While in the field, Water Quality Technicians also record dissolved oxygen and temperature profiles.

In 2002, a shoreline land use survey was initiated with fifty-five lakes, bays and river segments surveyed to date. These surveys document all man-made structures, condition of the shoreline and general land-use adjacent to the lake. This information is available to lake associations, Area Municipalities and other interested parties for planning purposes.

In 2003, under direction from scientists at DESC and the Ecological Monitoring and Assessment Network (EMAN), a Biological Monitoring Program was developed for lake associations interested in becoming more involved in lake monitoring and broader lake planning. Each year, summer staff are available to train lake residents to undertake volunteer monitoring programs that are based on standard protocols such as PlantWatch, FrogWatch, forest health and benthic analysis. Ongoing support is provided to meet the needs of individual associations.

The objective of the biological monitoring program is to develop a network of monitoring partners to collect a broad range of chemical and biological data, physical lake attributes and shoreline development data that are in a useful form and can be made accessible to individuals, associations, businesses and government agencies.

This report is a snapshot in time and contains a summary of the data collected during the 2011 monitoring season. Water quality parameters, such as phosphorus and dissolved oxygen, vary throughout the year, as well as from year to year. In order to fully understand changes in environmental quality on a particular lake, it is important to track the long-term trends for that lake.

Data sheets for individual lakes that track change over time are available on the Muskoka Water Web (www.muskokawaterweb.ca), by emailing rwillison@muskoka.on.ca, or by calling (705) 645-7393 x203. The 2011 Lake System Health Monitoring Program Data Report contains data sheets for all the lakes monitored in 2011 and can be downloaded from The District Municipality of Muskoka's website at www.muskoka.on.ca/siteengine/activepage.asp?PageID=231. Refer to Figure 5 for an example of a 2011 Lake Data Sheet.

Partners

1) Program Partners

   The District Municipality of Muskoka leads and is responsible for the Lake System Health Monitoring Program. Additional funding and extensive technical support is received from the Water Monitoring Section of the Environmental Monitoring and Reporting Branch of the Ministry of the Environment at the Dorset Environmental Science Centre.

   The District Municipality of Muskoka has entered into an agreement with the Township of Seguin to monitor two additional sites on Lake Joseph and one on Lake Rosseau in order to gain a complete picture of the water quality on these two lakes, which cross municipal boundaries. Muskoka has also coordinated sampling in the Georgian Bay area with the Severn Sound Environmental Association to avoid duplication of effort and to make more effective use of resources.

2) Volunteer Participants

   The following associations and organizations participated in the 2011 Lake System Health Program:

Ontario Stewardship Rangers
Bigwind Lake Cottagers' Assoc.
Gilleach Lake Cottagers
Leonard Lake Stakeholders' Assoc.
Menominee Lake Cottagers' Assoc.
Chub Lake Property Owners' Assoc.
Lake Waseosa Ratepayers' Assoc.
Trillium Lakelands District School Board
Ril Lake Assoc.
Gravenhurst Public Library
Ada Lake Resident
Mary Lake Assoc.
Bella & Rebecca Lakes Cottagers' Assoc.
South Muskoka Lake Community Assoc.
Leech Lake Cottagers' Assoc.
Tawingo College
Montessori School of Huntsville
Portage Bay Water Quality Steering Ctte
Brackenrig Bay (Rosseau) Cottagers
Haliburton Muskoka Childrens' Water Festival
Buck Lake Assoc.
Muldrew Lake Cottagers' Assoc.
Peninsula Lake Assoc.
Pine Lake Ratepayers' Assoc.
Walker & Pell Lakes Assoc.
Lake of Bays Resident – Northolme
Kahshe Lake Ratepayers' Assoc.
Gull and Silver Lakes Residents' Assoc.
Go Home Lake Cottagers
Muskoka Family Focus (Hike for Fathers)
Muskoka Bay Property Owners' Assoc.
Pine Lake Ratepayers' Assoc.

Monitoring Staff

Under the direction of the *Director of Watershed Programs*, two post-secondary students were hired as Water Quality Technicians for a four-month contract, beginning in April and ending in August.

The *Water Quality Technicians* collected water samples for phosphorus testing and analysis of base chemical parameters, measured Secchi depths, and recorded temperature and dissolved oxygen concentrations. The technicians were also responsible for conducting shoreline land use surveys.

A *Biological Monitoring Technician* was hired for a four-month contract beginning in April and ending in August. Activities undertaken by this staff member included:

- Providing volunteer training, primarily on benthic and terrestrial monitoring protocols.
- Providing ongoing support and technical information to volunteers and associations during the monitoring season.
- Bringing the data together and developing a reporting structure for individuals and associations.
- Conducting stewardship workshops and one-on-one site visits for interested organizations and individuals.

The *Watershed Planning Technician* is responsible for supervising summer students, managing all of the monitoring data, and developing watershed and lake specific data reports for public distribution.

Lake System Health Monitoring Program Components

The fieldwork for the 2011 Lake System Health Monitoring Program began in late April and concluded in August. Components of the program included:

- Spring phosphorus sampling conducted in May;
- Water sample collection for base chemical parameters in May;
- Secchi depth measurements collected in May and August;
- Temperature and dissolved oxygen readings collected in May and August;
- Shoreline land use surveys conducted in June and July; and
- Benthic macro-invertebrate sampling from May to August.

Table 1 identifies the lakes sampled in 2011, their location, and the program carried out.

Table 1: Lakes monitored in 2011.

Lake	Lake Number	Municipality	Watershed	Parameter Monitored
Ada	15-1	ML	Lake Joseph	Chem/Benthic
Atkins	140-1	BR	Muskoka River	Phos
Axle	6901-1	LOB	Lake of Bays	Chem
Barron's	225-1	GB	West	Chem
Bass	240-1	ML	Lake Joseph	Chem
Bass	239-1	GR	Sparrow Lake	Phos
Bearpaw	276-1	GR	Morrison Lake	Phos
Bella	319-1	LOB	Lake Vernon	Benthic
Ben	6903-1	GR	Sparrow Lake	Phos
Bigwind	413-1	BR	Muskoka River	Chem/Benthic
Brandy	562-1	ML	Lake Muskoka	Chem
Brooks	590-1	LOB	Dwight Bay	Chem/Shore
Bruce	604-2	ML	Lake Joseph	Chem
Buck	616-1	LOB	Dwight Bay	Chem
Buck	617-1	HT	Lake Vernon	Chem/Benthic
Butterfly	676-1	ML	Lake Joseph	Chem
Camel	702-1	ML	Lake Rosseau	Phos
Cassidy	775-1	ML	Moon River	Phos
Chub	853-2	LOB	Muskoka River	Chem
Chub	7061-1	HT	Mary Lake	Chem/Benthic/Phos
Cognashene Bay	7064-37	GB	West	Chem
Cooper	976-2	LOB	Dwight Bay	Phos
Cornall	988-1	GR	Sparrow Lake	Chem/Phos
Crosson	1049-1	BR	Black River	Chem
Dark	6913-1	ML	Lake Muskoka	Chem/Phos
Deer	1140-1	GR	Lake Muskoka	Chem
Devine	1173-1	HT	Muskoka River	Chem/Phos
Echo	1326-2	LOB	Muskoka River	Phos
Fawn (Deer)	1440-1	BR	Muskoka River	Chem/Phos
Flatrock	7243-1	GB	Musquash River	Chem/Shore
Foote	1524-1	LOB	Lake Vernon	Chem/Phos
Fox	1550-1	HT	Lake Vernon	Phos
Gibson - North	1644-2	GB	Musquash River	Phos
Gibson - South	1644-1	GB	Musquash River	Phos
Gilleach	7042-1	BR	Muskoka River	Benthic
Go Home	1667-7	GB	Musquash River	Benthic
Go Home Bay	7064-38	GB	Musquash River	Chem
Grandview	1723-2	LOB	Muskoka River	Chem
Grindstone	1777-1	LOB	Black River	Chem
Gull	1791-2	GR	Lake Muskoka	Chem/Benthic
Gullfeather (Gull)	1795-1	BR	Black River	Chem
Gullwing	1798-1	ML	Lake Muskoka	Phos

Lake	Lake Number	Municipality	Watershed	Parameter Monitored
Hardup (Poverty)	1863-1	LOB	Dwight Bay	Chem
Healey	1923-1	BR	Muskoka River	Phos
Hesner's (Everness)	1953-1	ML	Moon River	Phos
High	1964-1	ML	Lake Rosseau	Shore
Hoc Roc River	–	GR	Lake Muskoka	Benthic
Joseph - Cox Bay	2460-5	ML	Lake Joseph	Chem
Joseph - Hamer Bay	2460-4	ML	Lake Joseph	Chem
Joseph - Joseph River	2460-8	ML	Lake Joseph	Chem
Joseph - Little Lake Joseph	2660-1	SE	Lake Joseph	Chem
Joseph - Main	2460-6	ML	Lake Joseph	Chem
Joseph - North	2460-11	ML	Lake Joseph	Chem
Joseph - South	2460-10	ML	Lake Joseph	Chem
Kahshe - Grant's Bay	2217-2	GR	Sparrow Lake	Chem
Kahshe - Main	2217-5	GR	Sparrow Lake	Chem/Benthic
Lake of Bays - Dwight Bay	2469-2	LOB	Lake of Bays	Chem
Lake of Bays - Haystack Bay	2469-5	LOB	Lake of Bays	Chem
Lake of Bays - Rat Bay	2469-9	LOB	Lake of Bays	Chem
Lake of Bays - South Muskoka River Bay	2469-11	LOB	Lake of Bays	Chem
Lake of Bays - South Portage Bay	2469-8	LOB	Lake of Bays	Chem
Lake of Bays - Ten Mile Bay	2469-10	LOB	Lake of Bays	Chem
Lake of Bays - Trading Bay	2469-6	LOB	Lake of Bays	Chem
Lake of Bays Stream	–	LOB	Lake of Bays	Benthic
Leech	2529-1	BR	Muskoka River	Benthic/Phos
Leonard	2540-3	ML	Lake Muskoka	Chem/Benthic
Little Go-Home Bay	7064-30	GB	West	Chem
Long's (Utterson)	6926-1	HT	Lake Rosseau	Chem
Longline	6509-1	LOB	Lake of Bays	Chem
Mary	3032-3	HT	Mary Lake	Chem/Benthic
McDonald	7245-1	GB	West	Chem
McRey	7044-1	BR	Muskoka River	Phos
Medora	3171-1	ML	Lake Muskoka	Phos
Menominee	3181-3	LOB	Lake of Bays	Chem/Benthic/Phos
Mirror	7094-2	ML	Lake Muskoka	Shore
Moot	3325-2	LOB	Muskoka River	Chem/Phos
Morrison	3331-1	GR	Morrison Lake	Chem
Muskoka - Muskoka Bay	2465-10	GR	Lake Muskoka	Benthic/Phos
Myers (Butterfly)	3408-1	GB	Moon River	Chem/Shore
Neilson	3441-1	ML	Lake Muskoka	Chem/Phos
Nine Mile	3469-1	ML	Musquash River	Chem
North Bay	7064-18	GB	West	Chem
North Muldrew	4074-1	GR	Morrison Lake	Chem
Nutt (Mud)	4109-1	ML	Lake Rosseau	Chem/Phos
Otter	6916-1	HT	Mary Lake	Phos
Oudaze	4202-1	HT	Lake Vernon	Chem
Oxbow	4213-2	LOB	Dwight Bay	Chem

Lake	Lake Number	Municipality	Watershed	Parameter Monitored
Paint (St. Mary)	5145-4	LOB	Trading Bay	Chem
Pell	6683-1	LOB	Dwight Bay	Chem
Penfold	4307-1	HT	Mary Lake	Chem
Peninsula - East	4309-4	LOB	Mary Lake	Benthic
Pigeon	4365-1	GR	Lake Muskoka	Phos
Pine	4379-1	BR	Muskoka River	Chem
Pine	4378-1	GR	Lake Muskoka	Chem/Benthic
Prospect	4468-1	BR	Sparrow Lake	Chem
Ricketts	6921-1	ML	Lake Joseph	Phos
Ril	4627-2	LOB	Muskoka River	Benthic/Phos
Rose	4696-1	HT	Mary Lake	Phos
Rosseau - Brackenrig Bay	2476-12	ML	Lake Rosseau	Chem/Benthic
Rosseau - East Portage Bay	2476-11	ML	Lake Rosseau	Chem/Shore/Benthic
Rosseau - Main	2476-13	ML	Lake Rosseau	Chem
Rosseau - North	2476-14	SE	Lake Rosseau	Chem
Rosseau - Skeleton Bay	2476-10	ML	Lake Rosseau	Chem
Ryde (Buck)	4750-1	GR	Sparrow Lake	Phos
Silver	4951-2	GR	Lake Muskoka	Chem
Silver	4952-1	ML	Lake Muskoka	Chem
Silversands	4959-1	GB	Moon River	Phos
Six Mile - Cedar Nook Bay	4978-1	GB	West	Chem
Six Mile - Main	4978-4	GB	West	Chem
Six Mile - Provincial Park Bay	4978-5	GB	West	Chem
Sixteen Mile (Long)	4980-1	LOB	Dwight Bay	Chem/Phos
Solitaire	5037-1	LOB	Lake Vernon	Chem
South Bay	5058-17	GB	West	Chem
South Muldrew	5075-1	GR	Morrison Lake	Chem/Benthic
South Nelson	7236-1	LOB	Dwight Bay	Chem
Spence - North	5102-1	BR	Muskoka River	Phos
Stoneleigh	6923-1	BR	Muskoka River	Chem
Tackaberry	7234-1	LOB	Muskoka River	Chem
Tasso	5303-5	LOB	Lake Vernon	Chem
Three Mile	5361-1	GR	Sparrow Lake	Chem/Phos
Tucker	7235-1	HT	Mary Lake	Chem
Turtle (Long Turtle)	5485-1	GR	Morrison Lake	Chem
Vernon - Hunter's Bay	6455-6	HT	Lake Vernon	Phos
Vernon - Main	6455-7	HT	Lake Vernon	Benthic
Wah Wah Taysee	7064-39	GB	West	Chem
Walker	5710-2	LOB	Mary Lake	Benthic
Waseosa	5741-1	HT	Lake Vernon	Chem/Benthic
Wood	5961-1	BR	Muskoka River	Chem/Phos

BR (Bracebridge) **GB** (Georgian Bay) **GR** (Gravenhurst) **HT** (Huntsville) **LOB** (Lake of Bays) **ML** (Muskoka Lakes) **SE** (Seguin)

Chem - Spring Phosphorus & Other Chemical Parameters
Benthic - Benthic Macro-invertebrate Monitoring
Shore - Shoreline Land Use Survey
Phos - Late Summer Hypolimnetic Phosphorus

1) Spring phosphorus sampling and other chemical parameters

Phosphorus is the nutrient that controls the growth of algae in most Ontario lakes. For this reason, an increase in phosphorus in a lake increases the potential for algal blooms. Algal blooms detract from recreational water quality and, in some cases, affect the habitat of coldwater fish species such as Lake trout.

Phosphorus samples are collected in the spring during a period called "spring turnover". Studies have shown that for lakes on the Precambrian Shield, total phosphorus long-term means derived using spring turnover data and whole lake means are not significantly different.[1] In some cases, a sample may be taken after a lake has thermally stratified (see section 3b) but before biological activity has altered the phosphorus concentration in each layer. Studies conducted at the Dorset Environmental Science Centre demonstrate that phosphorus samples taken in April (during turnover), May (late turnover-early stratification) and early June (weakly stratified) are not significantly different.[2]

By sampling spring phosphorus each year it is possible to detect a change in the nutrient status of a lake. Several years of data must be collected before it is possible to determine normal phosphorus levels and between-year differences. It is only at that point that trends in phosphorus can be identified.

Phosphorus is a natural substance required by all living organisms. It enters a lake naturally through sediment and precipitation, which cannot be controlled by human activities. Human inputs of phosphorus to Muskoka's recreational lakes are primarily through septic system seepage and surface runoff from sources such as lawn fertilizer runoff and agricultural runoff. Planning policy targets these activities to reduce human phosphorus inputs. Municipal wastewater will also add phosphorus to a waterbody. However, Muskoka sewage treatment plants all have tertiary treatment with phosphorus reduction technology.

Sampling for spring phosphorus and other chemical parameters in 2011 was conducted between late April and early June. A total of 91 sites were sampled on 72 lakes.

Figure 1 identifies the 72 lakes that were sampled for spring phosphorus, Secchi depth, temperature, dissolved oxygen and other chemical parameters in 2011.

a) *Sampling method*
A composite water sample for spring phosphorus was taken at a depth twice the Secchi depth measurement. Two samples were taken for each lake and these readings were averaged.

b) *Spring phosphorus results*
Figure 2 summarizes the 2011 spring phosphorus results.

Lakes with phosphorus concentrations below 10 micrograms per litre (μg/L) are considered oligotrophic or unenriched. Those with a phosphorus concentration falling between 11 and 20 μg/L are termed mesotrophic or moderately enriched, while lakes with a phosphorus concentration exceeding 20 μg/L are called eutrophic and are

[1] Clark, Bev J. , Paterson, Andrew M. , Jeziorski, Adam and Kelsey, Susan (2010). 'Assessing variability in total phosphorus measurements in Ontario lakes', Lake and Reservoir Management, 26: 1, 63 - 72, First published on: 24 March 2010 (iFirst)
[2] ibid.

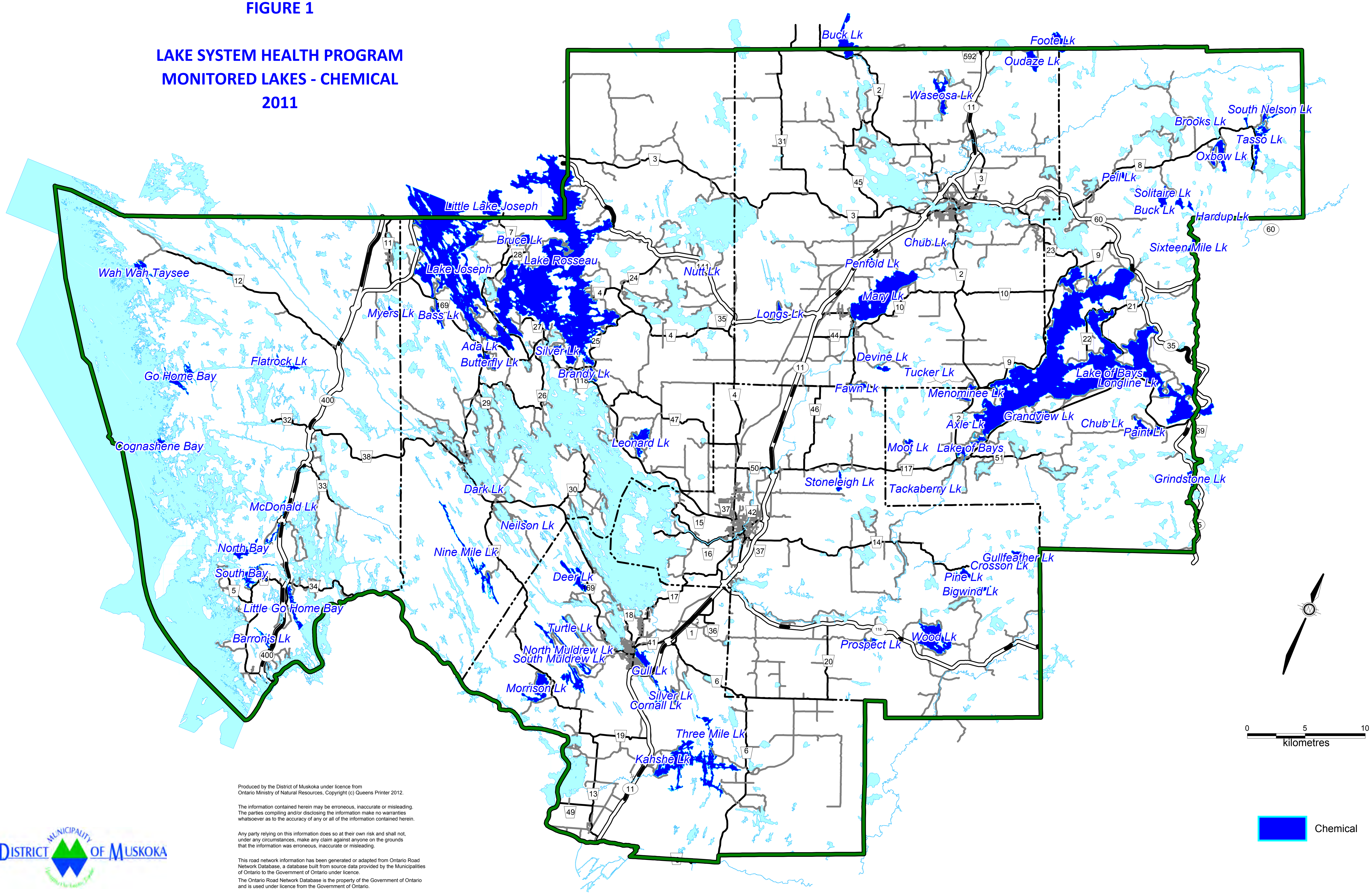
considered enriched. Refer to Appendix 2 for general characteristics of oligotrophic, mesotrophic, and eutrophic lakes.

As recommended in the 2008 report *Review of Long-Term Water Quality Data for the Lake System Health Program* prepared by Gartner Lee Limited, spring phosphorus results were analyzed for bad splits and outliers. A bad split occurs when a greater than 40% variance is found between duplicate samples taken at each site. Where a bad split is found, the higher value is discarded. The average spring phosphorus data was then analyzed to determine the validity of the 2011 measurement in the long term data series for each lake using the methods outlined in the above report. Data points determined to be outliers were excluded from the calculation of a lake's 10-year average.

c) *Other chemical parameters*
Water samples collected in the spring are analyzed for a variety of parameters, including pH, alkalinity, conductivity, dissolved organic carbon, calcium, chloride, colour, sodium, nitrogen, and sulphate. Collection of these data provides information on the chemical characteristics of the lake and can highlight changes in water chemistry. Table 2 gives a definition of each parameter and Appendix 5 contains the chemical data for each lake sampled in 2011.

FIGURE 1

LAKE SYSTEM HEALTH PROGRAM
MONITORED LAKES - CHEMICAL
2011



THE DISTRICT MUNICIPALITY OF MUSKOKA

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Table 2: Chemical water quality parameters monitored in 2011.

Water Quality Parameter	What Is It	Why Measure It	Recommended Limit
Alkalinity (mg/L)	A measure of a lake's "buffering capacity" or its ability to neutralize acids. Alkalinity comes from rocks and soils, salts, plant activities, and industrial wastewater discharges.	It is a measure of a lake's sensitivity to acid inputs, such as rainfall or snowmelt.	Values of 20-200 mg/L are common in freshwater systems; lakes below 10 mg/L are susceptible to acidification.
Calcium (mg/L)	The most commonly found substance in water, normally from bedrock leaching and effluent discharge. An important element for aquatic life and for pH buffering in lakes. It is the main component causing water hardness.	High amounts can cause algae problems and water hardness. Low amounts can cause corrosion, water softness, and affect species diversity.	Water is considered hard at levels above 120 mg/L and soft below 60 mg/L. Muskoka, being on the Canadian Shield, has extremely soft water.
Chloride (mg/L)	A salt compound that results from the combination of gas chlorine and a metal. Small amounts are required for normal cell functions in plant and animal life. Sources include rock, agricultural runoff, industrial wastewater and sewage treatment effluent.	Chloride ion (Cl^-) in lake water is considered an indicator of human activity.	High levels (>250 mg/L) affect fish and aquatic communities.
Colour (TCU)	A shade or tint imparted to water that is often caused by organic materials created when vegetation decays. Lakes with high DOC tend to have more colour.	Dissolved mineral matter, such as iron and manganese, may also produce colour.	Aesthetic objective in drinking water is 5 TCU. Lakes naturally range from 0-300 TCU.
Conductivity (µS/cm)	The ability of water to pass an electric current. It indicates the physical presence of dissolved salts (ions) in the water, such as chloride, sulphate, phosphate, sodium, magnesium, calcium, iron and aluminium. Pure water has low conductivity.	The higher the conductivity, the more dissolved solids are in the water. Conductivity increases with increasing temperature.	Natural waters tend to be between 50-1500 µS/cm.
Dissolved Organic Carbon (DOC) (mg/L)	The most abundant element found in all organisms. In aquatic environments, organic carbon is produced by plant photosynthesis and bacterial growth. Leaching of humic substances and decomposition of plants and animals are other natural sources.	Water high in DOC tends to be more tea-coloured. In addition to natural sources, human-related sources of DOC include agricultural runoff and municipal and industrial effluents.	Aesthetic objective in drinking water is 5 mg/L. Values above 7 mg/L are considered high for recreational use.
Sodium (mg/L)	A highly soluble metal found everywhere in the water environment. Major sources include road salt, agricultural runoff, geological formations and water softeners.	High levels can cause algae problems and can be toxic to aquatic life.	Aesthetic objective in drinking water is 200 mg/L. Levels over 20 mg/L may affect people on sodium-reduced diets.
Nitrate (NO_3) (µg/L)	Nitrate is the primary form of nitrogen used by plants as a nutrient to stimulate growth.	Elevated levels may indicate pollution from sewage or agricultural runoff and can lead to increased algal growth and eutrophication.	Natural levels in surface water are typically less than 1 mg/L (1000 µg/L). Drinking water objective is a maximum of 10 mg/L.
Total Kjeldahl Nitrogen (TKN) (µg/L)	A measure of both ammonia and organic forms of nitrogen. Major sources include sewage treatment plant effluent, agricultural runoff and development.	Excessive amounts contribute to eutrophication of lakes creating algal blooms that can negatively impact aquatic life.	Lakes with high TKN values *and* high TP values may be prone to excessive algae growth.
pH	A measure of the hydrogen ion concentration in water, on a scale of 1 to 14 with 7 being neutral. The lower the pH of water, the more acidic it is. Extreme changes in pH impair the reproduction of aquatic life and species diversity.	The distribution of aquatic organisms and the toxicity of some common pollutants are strongly affected by pH.	Provincial water quality objective is between 6.5 and 8.5. pH values below 5 and above 9 are harmful to organisms.
Sulphate (mg/L)	Sulphate is natural in many minerals but is often derived from acidic deposition (acid rain). High amounts that exceed the buffering capacity of a lake can reduce the pH.	High levels can reduce the pH in a lake by increasing the acidity levels.	Drinking water standard is 500 mg/L.

2) <u>Secchi depth measurements</u>

Secchi depth is a measurement of water clarity. In Muskoka, the major determinant of water clarity may be either natural colour, determined by dissolved organic carbon (DOC) content, or an increase in nutrient input from the surrounding watershed.

A lake may naturally be a brown colour due to high levels of DOC that come from the wetlands in a watershed. DOC colours lakes brown and reduces water clarity, but is not an indication of nutrient enrichment. Examples of lakes with naturally high DOC content include Brandy Lake and Fawn Lake.

Water clarity can also decrease as nutrients from the surrounding watershed enter and enrich the lake, resulting in high levels of suspended sediments or algal growth.

Water clarity can change weekly or yearly as a result of weather, length of winter ice cover, shoreline development, natural seasonal trends or other impacts. However, when the primary determinant of water clarity is a function of nutrient enrichment, a long-term trend that indicates a reduction in water clarity is an indication of reduced water quality.

a) Sampling method

Secchi depth readings were taken once in May and once in August for each lake. Readings were obtained over the deepest part of the lake by lowering the Secchi disc into the water until it disappeared (value A). The disc was then raised until it reappeared (value B). The average of the two values is the Secchi depth reading [(A+B) ÷2].

b) Secchi depth measurement results

Figure 3 summarizes the Secchi depth measurements for 2011.

In general, where a lake is not coloured by DOC, the higher the Secchi depth reading, the clearer the lake and the less nutrients it contains. Lakes with Secchi depth measurements over five metres are considered oligotrophic or unenriched. Those with a Secchi depth measurement falling between three and five metres are termed mesotrophic or moderately enriched, while lakes with a Secchi depth measurement below three metres are called eutrophic and are considered enriched. Refer to Appendix 2 for general characteristics of oligotrophic, mesotrophic, and eutrophic lakes.

In some instances, Secchi depth measurements may be limited by the depth of the lake, resulting in a low Secchi depth reading even though the lake is low in DOC and otherwise clear. For example, although Brackenrig Bay in Lake Rosseau is low in DOC, its Secchi depth measurement is less than three metres because the bay is shallow.

In Georgian Bay, where Zebra mussels and Quagga mussels feed on the phytoplankton, nutrients are transferred from deeper water to the shoreline area resulting in a high density of shoreline aquatic vegetation and high Secchi depth readings in deeper water. In this situation, Secchi depth readings do not provide a true indication of the trophic status of the water body.

Figure 2: 2011 Spring Phosphorus Sampling Results

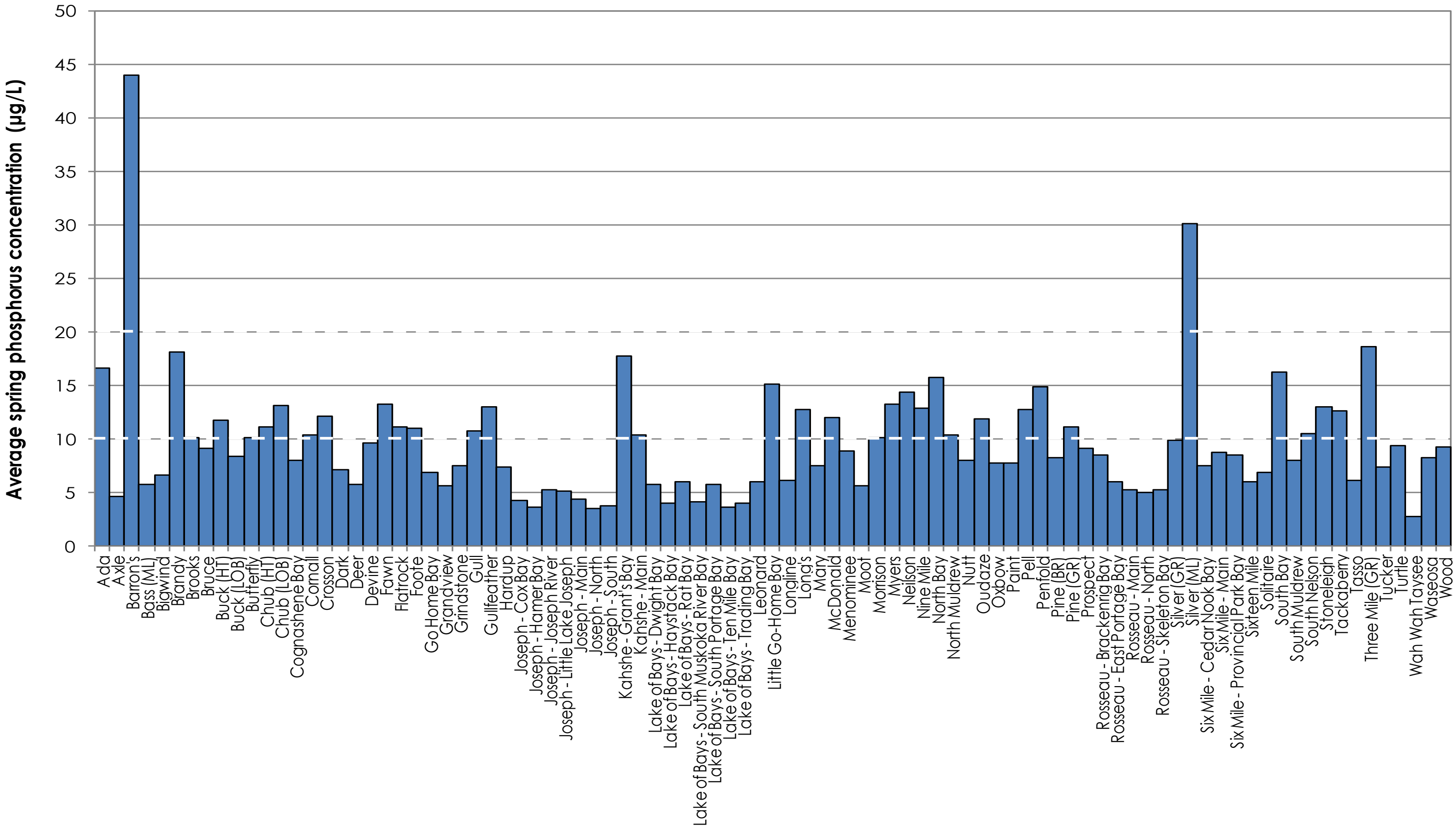
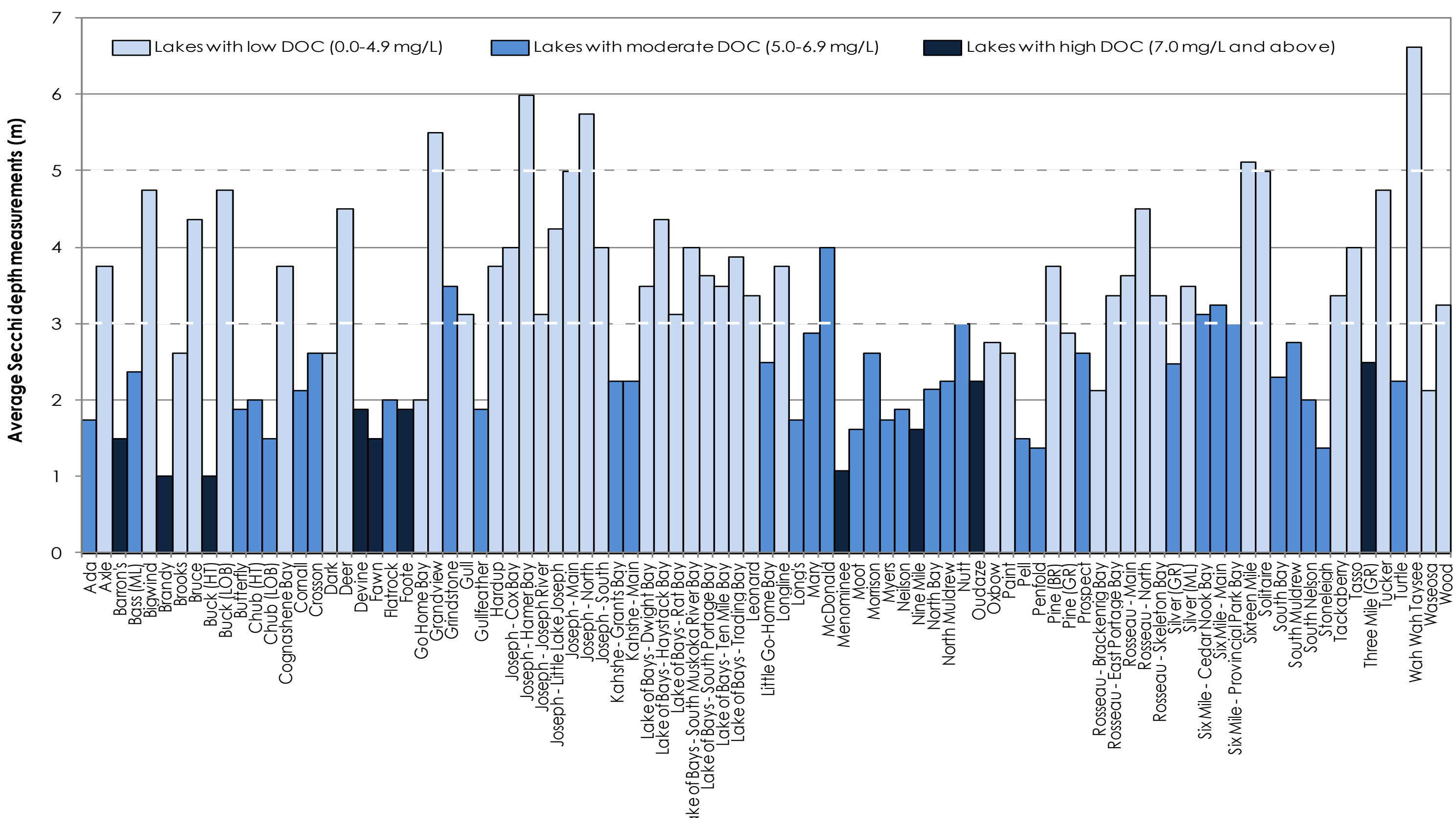


Figure 3: 2011 Secchi Depth Measurements



3) Temperature and dissolved oxygen measurements

Temperature is a measure of the intensity of heat stored in a volume of water. Temperature patterns affect the solubility of many chemical compounds and influences the effects of pollution on aquatic life.

Dissolved oxygen is a measure of the concentration of oxygen dissolved in water. Adequate concentrations of dissolved oxygen are necessary for the survival of fish and other aquatic organisms. Dissolved oxygen concentration is an indicator of a lake's ability to support aquatic life.

Dissolved oxygen levels above 5 milligrams per litre (mg/L) are considered optimal for most aquatic organisms. Most fish cannot survive if levels fall below 3 mg/L. For coldwater species, such as Lake trout, a minimum of 6 mg/L is needed, along with a temperature below 10 °C. Lakes with dissolved oxygen readings below 0.5 mg/L are considered anoxic.

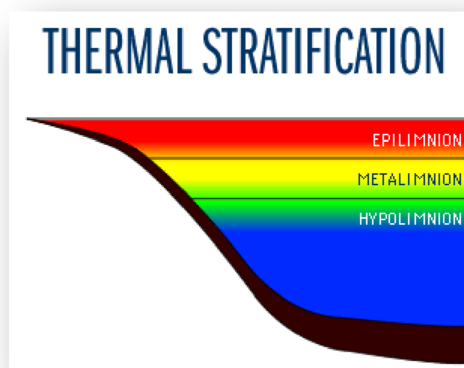
a) Sampling method

Temperature and dissolved oxygen readings were taken once in May and once in August for each lake. Readings were taken with a dissolved oxygen metre (YSI Model 58) with the first reading at 0.5 metres from the surface, the second at 1 metre, and continuing down in one-metre increments to a depth of 10 metres. Readings were then taken in two metre increments to within one metre of the bottom. Values were recorded on the Lake Survey Deck Sheet (Appendix 3).

b) Temperature and dissolved oxygen measurement results

The combination of thermal stratification and biological activity causes characteristic patterns in water chemistry. In the summer, deep lakes stratify with warm water on top and cold water below. Because cold water is more dense than warm water, these two layers do not mix and atmospheric oxygen cannot reach the bottom layer.

In general, the dissolved oxygen concentration in the epilimnion (top layer of water in a lake) remains high throughout the summer because of photosynthesis, which produces oxygen, and diffusion of oxygen from the atmosphere. Conditions in the hypolimnion (the bottom layer of water in a lake) vary with trophic status (see Appendix 2 for characteristics of trophic levels).



In these deep regions of the lake, dissolved oxygen declines during the summer because organisms continue to consume oxygen. In some lakes, the bottom layer may eventually become anoxic (totally devoid of oxygen).

Lakes that are less than nine meters deep are generally too shallow to stratify and remain mixed all year. Smaller lakes that are less than twenty meters deep, like Walker Lake, tend to go anoxic at the bottom of the lake naturally at the end of the summer because the hypolimnion is not large enough to store the oxygen required to support a full season of natural processes. The plant and animal life in these lakes have adapted to this annual variation in available oxygen.

In oligotrophic lakes, low plant growth and increased water clarity allows deeper light penetration. Algae are able to grow deeper in the water column and less oxygen is consumed by decomposition.

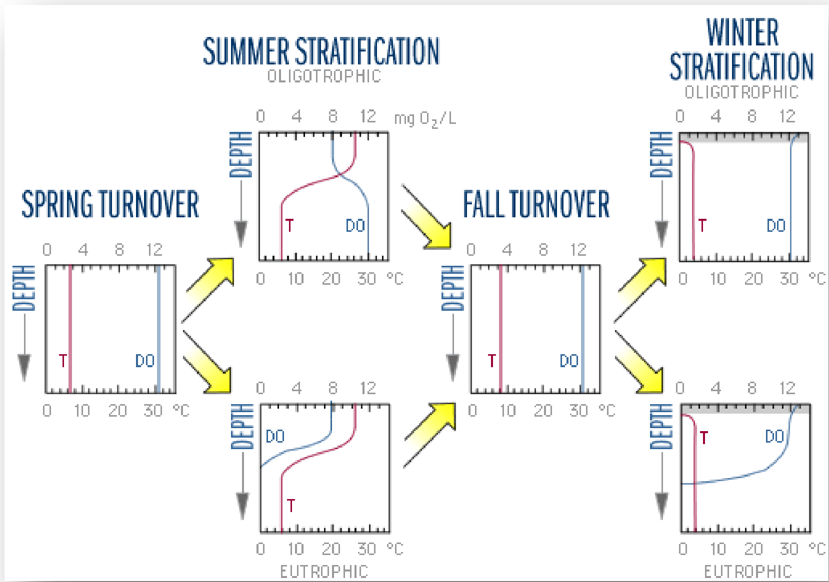
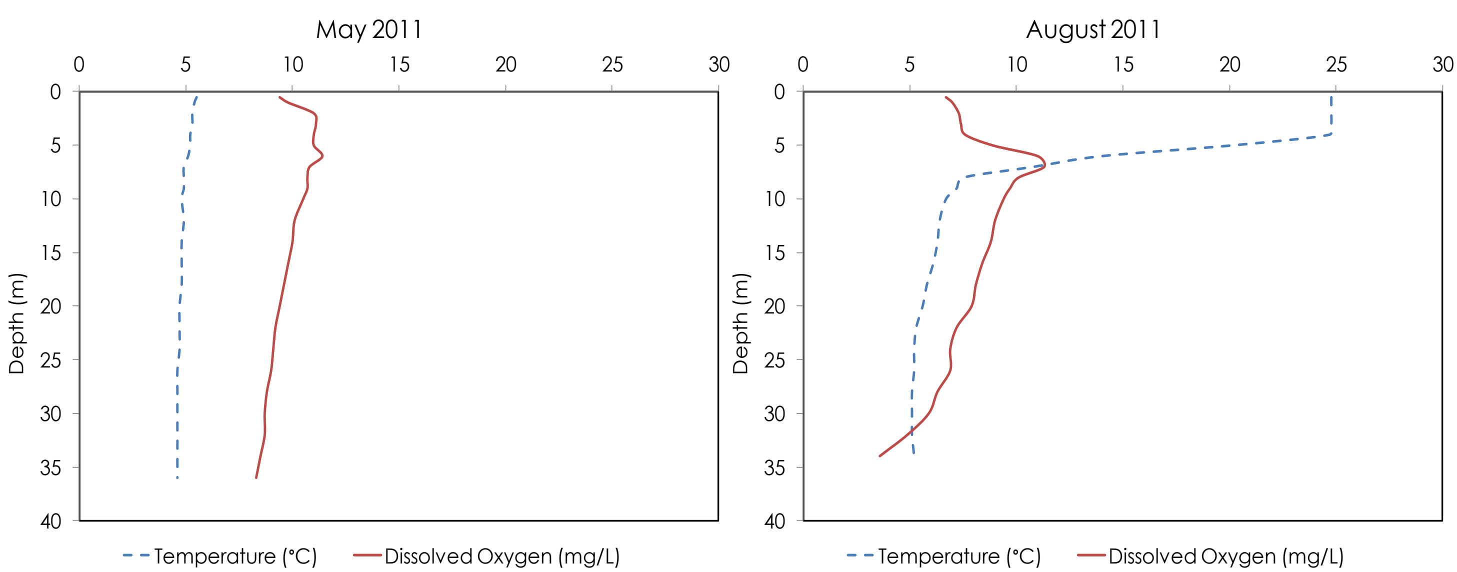


Figure 4: Typical temperature and dissolved oxygen profiles for eutrophic and oligotrophic lakes throughout the year **(adapted from Figure 8-1 in Wetzel, R.G. 1975. Limnology. W.B. Saunders Company).**

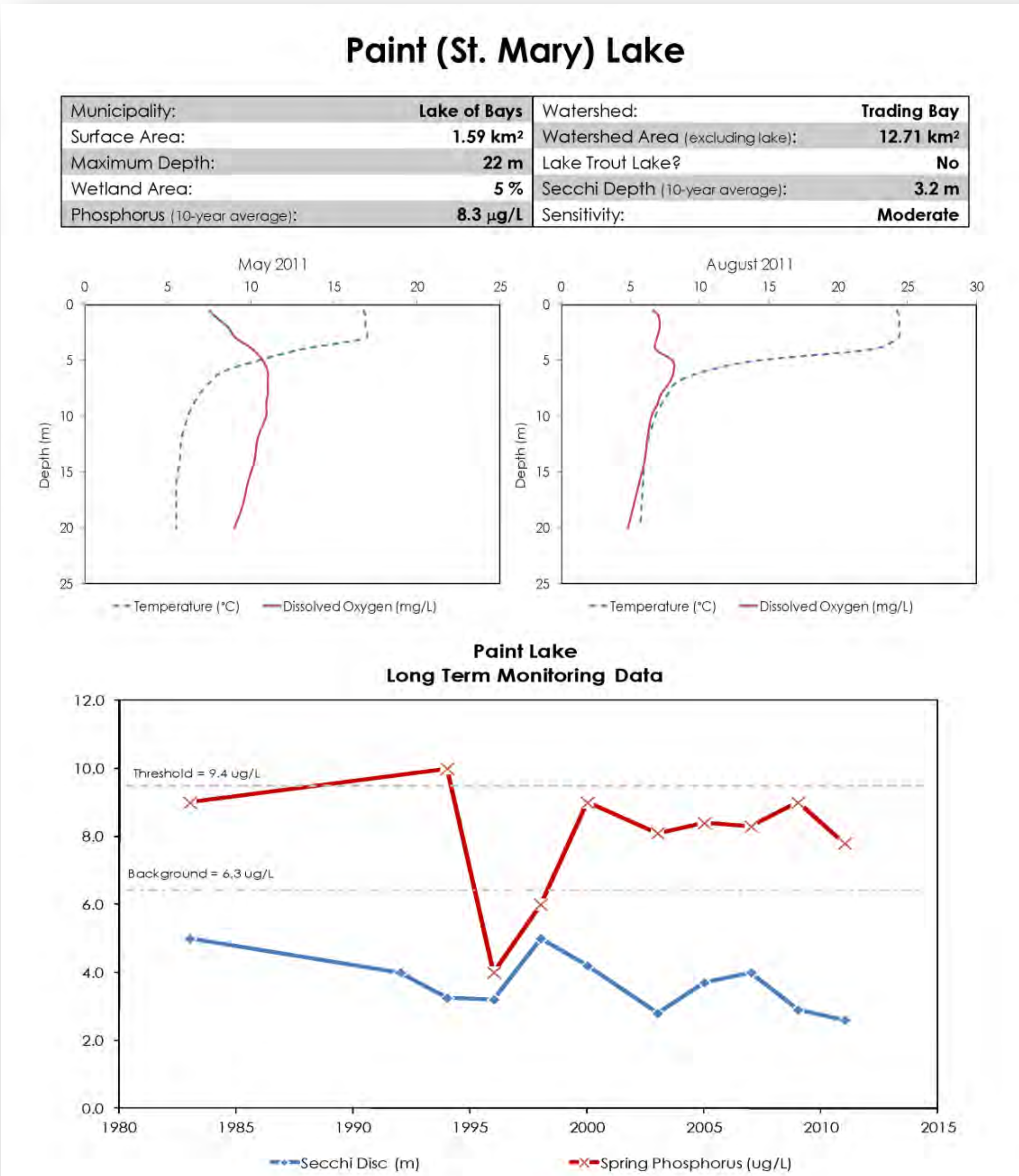
The following is an example of temperature and dissolved oxygen profiles for one lake monitored in 2011. Temperature and dissolved oxygen profiles for each lake monitored in 2011 are available on the Muskoka Water Web at www.muskokawaterweb.ca or in the 2011 Lake System Health Monitoring Program Data Report.

Bigwind Lake



It is evident from the above profiles that there is ample dissolved oxygen in May with approximately 10 mg/L. The temperature is around 5 °C throughout the water column. By August, the water temperature at the surface has risen to almost 25 °C and drops sharply to 6 °C at a depth of approximately 7 meters. This is called the thermocline. At the thermocline, dissolved oxygen concentration increases with the decrease in temperature because cold water holds more oxygen than warm water. Below the thermocline, oxygen is between 5-10 mg/L, making this lake a healthy lake for coldwater fish species such as Lake trout.

Figure 5: Example of a 2011 Lake Data Sheet.



4) Shoreline land use survey

The shoreline land use survey was started in the summer of 2002 to collect data on shoreline vegetation, shoreline structures and the first 20 meters of land around a water body. All of the information gathered will contribute to the growing database of the lakes in Muskoka.

See Appendix 4 for a list of lakes with completed shoreline land use surveys. In 2011, the focus was on lakes that are classified as "Over Threshold" under Muskoka's revised Lake System Health Program. Six lakes were surveyed in 2011, completing the list of Over Threshold lakes.

a) Survey method

Six lakes were surveyed in 2011 (see Table 1 and Figure 7). Field data were collected and entered into a database and graphically mapped using MapInfo Professional.

b) Shoreline land use survey results

Figure 6 is an example of a completed shoreline land use survey map.

Table 3 is a summary of the results of the land use survey for one of the lakes surveyed in 2011. Summaries for these areas are available in the 2011 Lake System Health Monitoring Program Data Report. Completed maps are available from the Muskoka Water Web site at www.muskokawaterweb.ca.

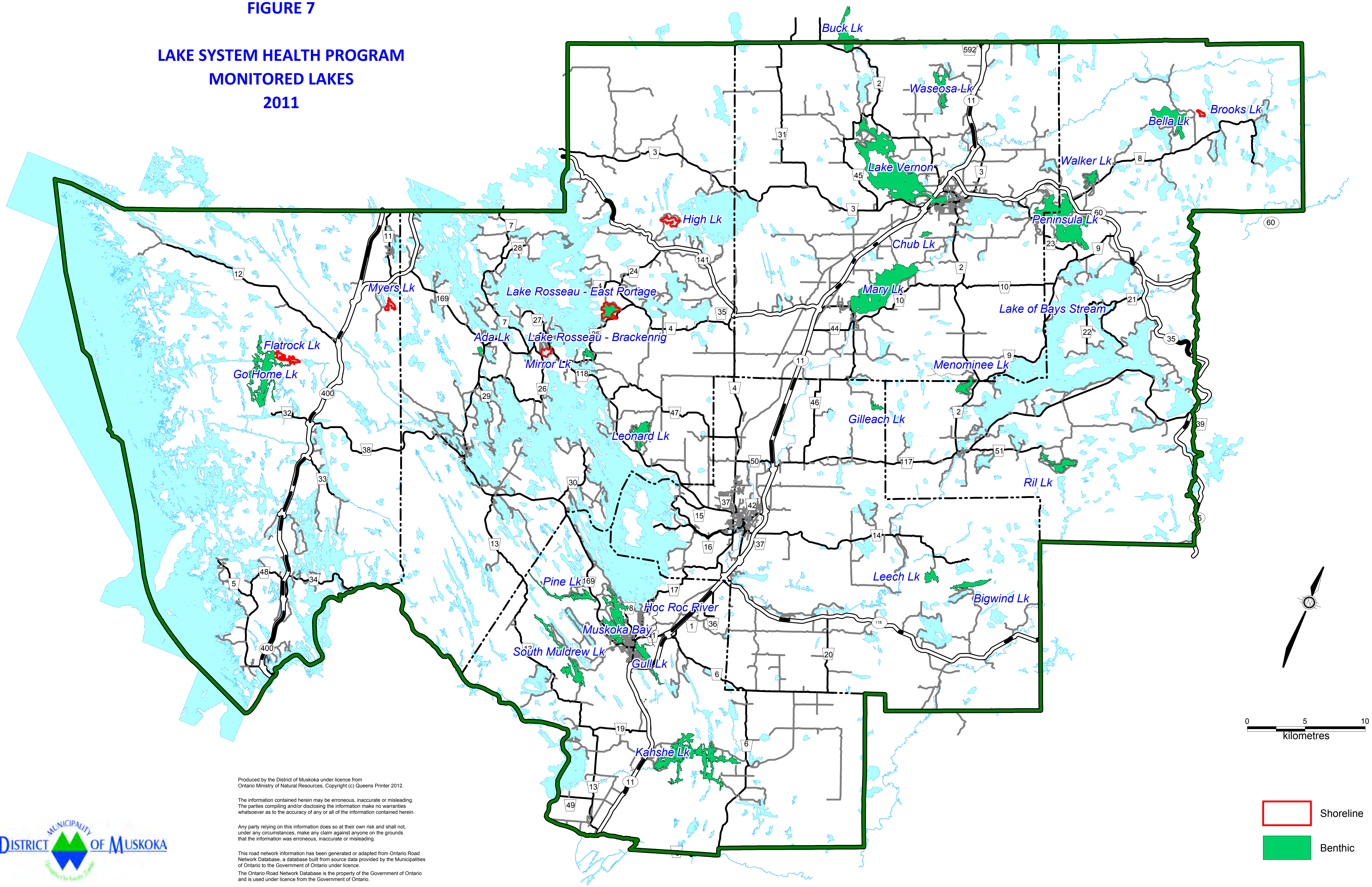
Figure 6: Shoreline survey map for High Lake in Muskoka Lakes.

Table 3: Summary of land use survey data for High Lake in Muskoka Lakes.

Shoreline			**Backlot**			**Structures**	
Type	**Length (m)**	**Percent**	**Type**	**Area (m²)**	**Percent**	**Type**	**Count**
Natural Beach	56.16	0.98	Mixed Forest	47,391.99	41.46	Crib Boathouse	1
Overgrowth	3,248.10	56.54	Thinned Forest	39,698.67	34.73	1 Slip Crib Boathouse	1
Rock	1,764.19	30.71	Rock Barren	10,251.02	8.97	Crib Dock	17
Rapids/Falls	18.35	0.32	Rapids/Falls	320.53	0.28	Floating Dock	18
Shrub	340.00	5.92	Road	4,447.63	3.89	Pole Dock	20
Man Made Beach	233.53	4.06	Buffered Lawn	9,504.90	8.32	Marine Railway	3
Concrete Ramp	13.45	0.23	Unbuffered Lawn	2,684.06	2.35		
Wooden Shore Wall	71.23	1.24					
Total	5,745.01	100.00	**Total**	114,298.90	100.00	**Total**	60
Natural	5,426.80	94.46	**Natural**	57,963.54	50.71		
Altered	318.21	5.54	**Altered**	56,335.26	49.29		

FIGURE 7

LAKE SYSTEM HEALTH PROGRAM
MONITORED LAKES
2011



P:\WATER\WATQUAL\Monitoring Program\2011\Report Maps\MONITORED LAKES 2011 Other 11x17.WOR

5) Biological Monitoring Program

In 2003 Muskoka's existing monitoring program was enhanced with a volunteer biological monitoring program. The Biological Monitoring Technician provided training for lake volunteers and developed a program of ongoing support to meet the needs of individual associations.

The 2011 biological monitoring program focused on the Ontario Benthic Biomonitoring Network (OBBN) benthic monitoring protocol, which supplements existing lake monitoring and shoreline land use data.

a) *Benthic macro-invertebrate sampling method*

The benthic macro-invertebrate sampling protocol required the collection and classification of macro-invertebrates from a variety of developed and undeveloped sites of the near shore environment. The program follows the standard protocol for benthic analysis developed by the Ontario Benthos Biomonitoring Network (OBBN), spearheaded by the Ministry of the Environment through the Dorset Environmental Science Centre.

The Kick and Sweep method was used to collect samples and the Teaspoon method was the sub-sampling method used to collect organisms from within the sample.

b) *Benthic macro-invertebrate sampling results*

In 2011, benthic sampling occurred at 26 sites on 24 lakes and 2 rivers across Muskoka. See Table 1 for a list and Figure 7 for a map of the lakes involved in the 2011 benthic macro-invertebrate sampling program.

Aquatic Invertebrate Data Sheets for each site sampled in 2011 are available in the 2011 Lake System Health Monitoring Program Data Report. They can also be accessed on the Muskoka Water Web site at www.muskokawaterweb.ca. Figure 8 is an example of an Aquatic Invertebrate Data Sheet.

c) *Docktalk program*

In 2011, Muskoka continued to implement a modified Docktalk program initially developed by the Federation of Ontario Cottagers Associations (FOCA) in 2005. This modified program consists of stewardship presentations and workshops given to lake associations and other community organizations and one-on-one site visits to interested shoreline property owners. Stewardship information packages are available to associations wishing to distribute them to their membership, and tabletop displays are available on a variety of topics.

Docktalk information was distributed to a number of associations and displays were set up at the Gravenhurst Public Library featuring topics like natural shorelines, monitoring programs, and species at risk.

Figure 8: Example of an Aquatic Invertebrate Data Sheet.

THE DISTRICT MUNICIPALITY OF MUSKOKA

Aquatic Invertebrate Data Sheet

Mary Lake
Town of Huntsville

Common Name	Site 1									Scientific Name
	2007			2008			2011			
	1	2	3	1	2	3	1	2	3	
Hydras										Coelenterata
Flatworms				1			5	12	9	Turbellaria
Roundworms						4				Nematoda
Aquatic Earthworms	28	30	24	8	5	10	24	26	21	Oligochaeta
Leeches	1			1						Hirudinaea
Sow Bugs	29	19	17	32	8	5	103	192	91	Isopoda
Clams			2				2		7	Pelecypoda
Fairy Shrimp	30	47	45	59	62	48	53	64	120	Amphipoda
Crayfish										Decapoda
Mites				28	10			1	2	Hydracarina
Mayflies		12	8	6	12	20	5		2	Ephemeroptera
Dragonflies	1		2					1	1	Anisoptera
Damselflies			1							Zygoptera
Stoneflies										Plecoptera
True Bugs										Hemiptera
Fishflies & Alderflies	5	4	5		1	2	5	5	4	Megaloptera
Caddisflies	4	17	5	8	5	21	9	24	32	Trichoptera
Aquatic Moths				1						Lepidoptera
Beetles			1					2	3	Coleoptera
Snails & Limpets	4	1	1				10	9	6	Gastropoda
Midges	18	17	17	8	23	30	8	6	12	Chironomidae
Horse & Deer Flies					1					Tabanidae
Mosquitos	1									Culicidae
No-see-ums		2	1			1				Ceratopogonidae
Craneflies						4				Tipulidae
Blackflies										Simuliidae
Misc. True Flies										Misc. Diptera
Total Count	121	149	129	152	127	145	224	342	310	
Number of Taxa	10	9	13	10	9	10	10	11	13	
										Muskoka Average *
Richness	15			15			13			**13**
% EOT	13			17			8			**26**
% Chironimids	13			14			3			**12**
% Predators	6			11			6			**24**
% Shredders	7			9			7			**2**
% Collectors/Gatherers	86			79			83			**69**
Hilsenhoff Index	6.66			6.17			6.86			**5.99**

R = Reference Site

* The Muskoka Average is based on 73 samples collected at 44 reference sites between 2004 to 2008. Reference sites from five mesotrophic and nineteen oligotrophic lakes throughout Muskoka were used.

Over Threshold Classification

The District Municipality of Muskoka classifies lakes based on their sensitivity to phosphorus inputs as an indicator of lake health. Lakes in Muskoka are some of the cleanest and best recreational lakes in Canada. In order to preserve our good water quality, Muskoka has taken a very conservative approach to development around our lakes.

An acceptable threshold for phosphorus has been determined for each lake in Muskoka, as detailed in the report entitled *Recreational Water Quality Management in Muskoka – Technical Review of the Water Quality Model, 2005* prepared by Gartner Lee Limited. The threshold level of a lake is 50% above the predicted background or undeveloped value. This threshold is restrictive because Muskoka believes that action taken when small changes have been identified will protect our good water quality in the future. This threshold value, when compared to measurements of current water quality, serves as an indicator of lake enrichment and the sensitivity of the lake to phosphorus loading.

There are two criteria that must be examined to determine if a lake has exceeded its acceptable threshold for phosphorus. If a lake meets both of these criteria, then it is considered to be Over Threshold:

1. Total phosphorus concentration, as estimated by the Muskoka Water Quality Model, exceeds the "Background + 50%" threshold; and

2. Long-term measured total phosphorus concentration, as determined by Muskoka's Lake System Health Monitoring Program, also exceeds the "Background + 50%" threshold value.

Where a lake is considered over threshold, restrictive planning policy will be implemented as detailed in the *Official Plan of the Muskoka District Area* and Muskoka District will work with the Area Municipality, Lake Ratepayer associations and other interested parties to prepare and implement a Remedial Action Program (RAP) for the lake. The District Municipality of Muskoka will provide technical support and data when a RAP is initiated.

A lake that is Over Threshold will be de-listed only after the 10-year long-term average of total phosphorus is less than the threshold established for the lake and there have been three consecutive phosphorus measurements below its threshold value. In the event that a 10-year review of the model is underway, lakes will not be listed as being Over Threshold nor delisted as no longer being Over Threshold until the model review is complete.

Lakes may approach or exceed their threshold value for phosphorus loading for a variety of reasons, both from human sources and from changes in the natural system. Human sources of phosphorus are attributed to such activities as:

- Nutrient loading from septic systems;

- Use of phosphorus-based cleaning supplies; and

- Loss of native shoreline vegetation, especially the diverse forest environment that has traditionally ringed many of our lakes. As lawns replace trees, fertilizer runoff, stormwater and soil erosion wash higher loads of phosphorus into our lakes.

Some significant recent changes in the natural system have been attributed to climate change. It is unclear at this time what long-term impact climate change will have on our lakes and rivers, although scientists are indicating that they are beginning to see a significant 'climate signal' in a variety of recent lake attributes including recreational lake water quality.

Planning policy can only directly address increases in human produced phosphorus. Development policy adopted by Muskoka and the Area Municipalities is a conservative approach to development that will strengthen our natural systems and may buffer climate change impacts. Several recent studies confirm that protecting, maintaining and enhancing the health and diversity of ecosystems is essential to long-term sustainability of watersheds that will be stressed by the changing climate.

Currently there are thirty-seven (37) lakes or bays that are considered Over Threshold, or have a higher concentration of phosphorus than is considered healthy for that particular lake. Because of the stringent standards established by Muskoka, thirty (30) of the lakes identified as being Over Threshold have a phosphorus concentration of less than 10 µg/L and are considered oligotrophic, meaning they are clear and have good water quality. These high standards have been established because the objective of Muskoka's Lake System Health Program is to maintain our excellent water quality and the natural variation in phosphorus concentration in lakes over time.

Muskoka will continue to monitor these lakes and work with Area Municipalities and Lake Ratepayer associations to address lake-specific issues. In particular, Muskoka will:

1) Implement restrictive development policy for new lot creation and redevelopment of property, as outlined in the Muskoka Official Plan;
2) Undertake shoreline land use surveys;
3) Prepare limits to growth assessments;
4) Provide stewardship advice in conjunction with the Muskoka Watershed Council;
5) Continue to monitor and report on water quality; and
6) Consult with the Ministry of the Environment on water quality issues.

Water Quality Model Review

A review of the Recreational Water Quality Model is currently underway. Areas of interest that will be given special consideration during this review include:

1) Lakes where there is a discrepancy between the modeled and measured phosphorus values, especially those lakes that go anoxic, have high dissolved organic carbon (DOC) readings, or are exceptionally clear;
2) Embayment of large lakes;
3) Lakes where monitoring commenced after the last model review;
4) Potential impacts of climate change; and
5) Changes in natural inputs of phosphorus, particularly atmospheric deposition and wetlands inputs.

The following project was undertaken this summer as part of the Water Quality Model Review:

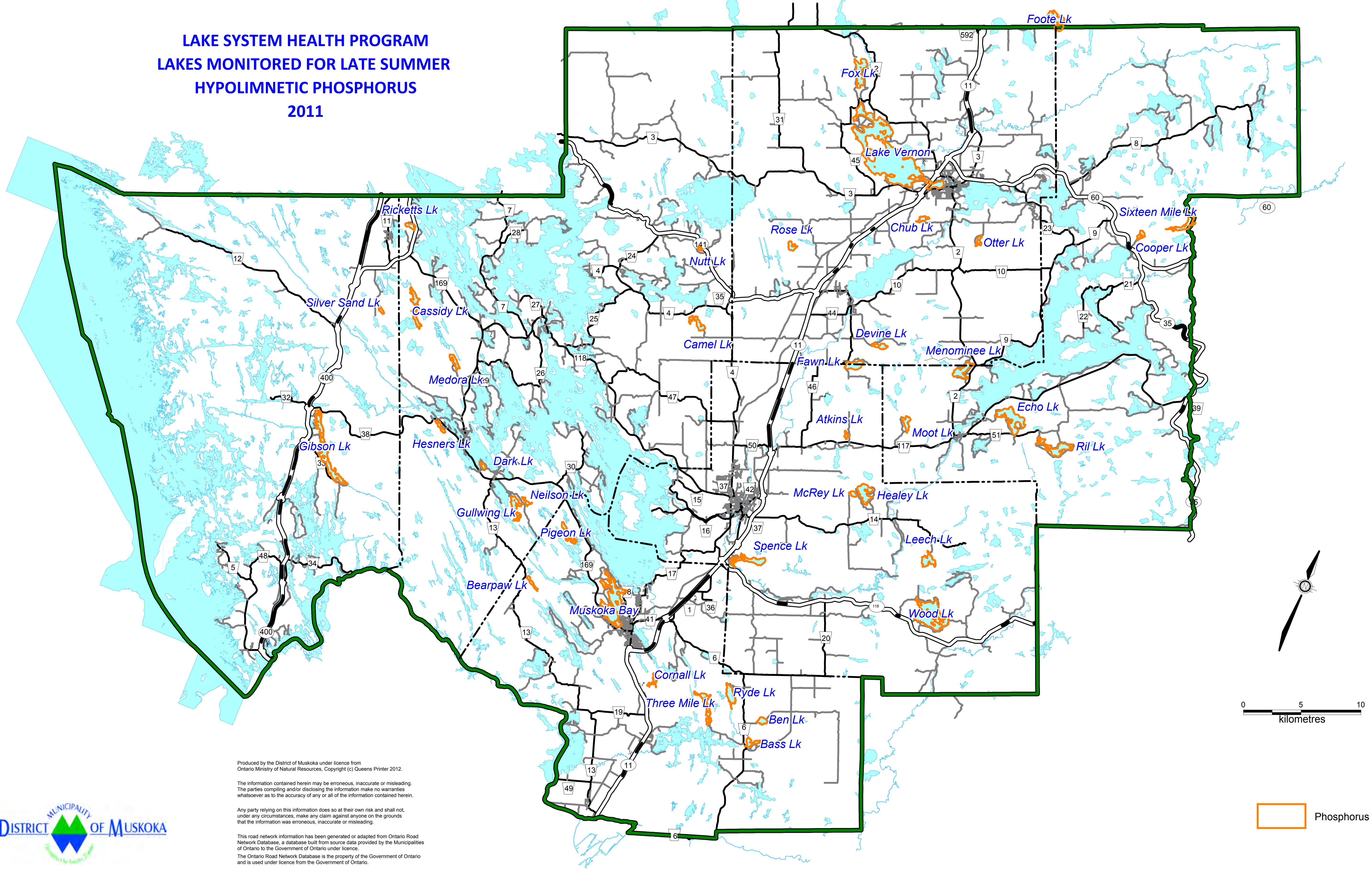
1) <u>Late Summer Hypolimnetic Phosphorus Sampling</u>

   Dissolved oxygen status is used in the water quality model as a surrogate to estimate internal phosphorus loading, since anoxia (dissolved oxygen concentrations below 2 µg/L) in the hypolimnion often triggers the release of nutrients from the sediment, resulting in an increase in the amount of phosphorus in the water column available for uptake by vegetation.

   In lakes that stratify, the dissolved oxygen concentration in the epilimnion (top layer of water in a lake) remains high throughout the summer because of the diffusion of oxygen from the

FIGURE 9

LAKE SYSTEM HEALTH PROGRAM
LAKES MONITORED FOR LATE SUMMER HYPOLIMNETIC PHOSPHORUS
2011



THE DISTRICT MUNICIPALITY OF MUSKOKA

P:\WATER\WATQUAL\Monitoring Program\2011\Report Maps\MONITORED LAKES 2011 Phos 11x17.WOR atmosphere. The hypolimnion (the bottom layer of water in a lake) cannot be replenished with oxygen and may become anoxic.

The purpose of this project was to measure the internal loading through direct measurements of phosphorus in the hypolimnion (1 meter off bottom) of anoxic lakes in late summer. Elevated phosphorus concentrations provide a direct indicator of internal load for the sampled lakes, and can be used to test and refine the relationships between depth, internal load and oxygen status in the water quality model.

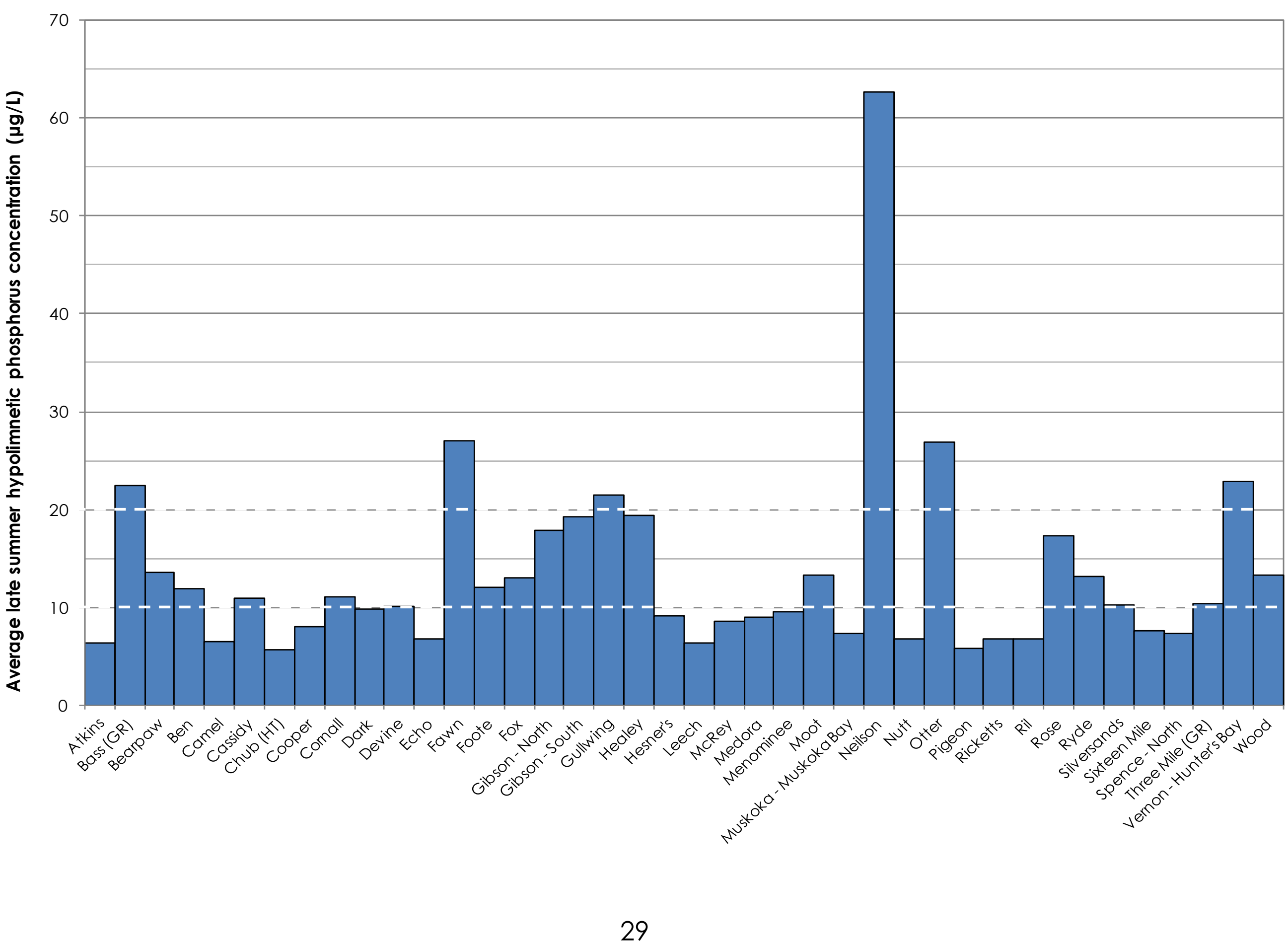
a) *Sampling method*

Forty sites were selected based on depth and severity of anoxia (see Table 1 and Figure 9). Water samples were collected in August one meter off bottom using a Van Dorn horizontal water bottle. Two samples were taken at each site and these readings were averaged.

b) *Late summer hypolimnetic phosphorus results*

Figure 10 summarizes the 2011 late summer hypolimnetic phosphorus results. The data were analyzed for bad splits. A bad split occurs when a greater than 40% variance is found between duplicate samples taken at each site. Where a bad split is found, the higher value is discarded.

Figure 10: 2011 Late Summer Hypolimnetic Phosphorus Sampling Results



Appendix 1

Table of 2011 phosphorus sampling and Secchi depth measurement results

2011 phosphorus sampling and Secchi depth measurement results

Lake Name	Ave Secchi (m)	Ave TP (µg/L)
Ada	1.8	16.6
Axle	3.8	4.6
Barron's	1.5	44.0
Bass (ML)	2.4	5.8
Bigwind	4.8	6.7
Brandy	1.0	18.2
Brooks	2.6	10.2
Bruce	4.4	9.1
Buck (HT)	1.0	11.8
Buck (LOB)	4.8	8.4
Butterfly	1.9	10.2
Chub (HT)	2.0	11.2
Chub (LOB)	1.5	13.1
Cognashene Bay	3.8	8.0
Cornall	2.1	10.4
Crosson	2.6	12.2
Dark	2.6	7.2
Deer	4.5	5.8
Devine	1.9	9.6
Fawn	1.5	13.3
Flatrock	2.0	11.1
Foote	1.9	11.0
Go Home Bay	2.0	6.9
Grandview	5.5	5.6
Grindstone	3.5	7.5
Gull	3.1	10.8
Gullfeather	1.9	13.0
Hardup	3.8	7.4
Joseph - Cox Bay	4.0	4.3
Joseph - Hamer Bay	6.0	3.7
Joseph - Joseph River	3.1	5.3
Joseph - Little Lake Joseph	4.3	5.2
Joseph - Main	5.0	4.4
Joseph - North	5.8	3.5
Joseph - South	4.0	3.8
Kahshe - Grants Bay	2.3	17.8
Kahshe - Main	2.3	10.4
Lake of Bays - Dwight Bay	3.5	5.8
Lake of Bays - Haystack Bay	4.4	4.0
Lake of Bays - Rat Bay	3.1	6.0
Lake of Bays - South Muskoka River Bay	4.0	4.1
Lake of Bays - South Portage Bay	3.6	5.8
Lake of Bays - Ten Mile Bay	3.5	3.7
Lake of Bays - Trading Bay	3.9	4.0
Leonard	3.4	6.0
Little Go-Home Bay	2.5	15.1

Lake Name	Ave Secchi (m)	Ave TP (µg/L)
Longline	3.8	6.2
Long's	1.8	12.8
Mary	2.9	7.5
McDonald	4.0	12.0
Menominee	1.1	8.9
Moot	1.6	5.7
Morrison	2.6	10.2
Myers	1.8	13.3
Neilson	1.9	14.4
Nine Mile	1.6	12.9
North Bay *	2.2	15.8
North Muldrew	2.3	10.4
Nutt	3.0	8.0
Oudaze	2.3	11.9
Oxbow	2.8	7.8
Paint	2.6	7.8
Pell	1.5	12.8
Penfold	1.4	14.9
Pine (BR)	3.8	8.3
Pine (GR)	2.9	11.1
Prospect	2.6	9.1
Rosseau - Brackenrig Bay	2.1	8.5
Rosseau - East Portage Bay	3.4	6.0
Rosseau - Main	3.6	5.3
Rosseau - North	4.5	5.0
Rosseau - Skeleton Bay	3.4	5.3
Silver (GR)	2.5	9.9
Silver (ML)	3.5	30.2
Six Mile - Cedar Nook Bay	3.1	7.5
Six Mile - Main	3.3	8.8
Six Mile - Provincial Park Bay	3.0	8.5
Sixteen Mile	5.1	6.0
Solitaire	5.0	6.9
South Bay *	2.3	16.3
South Muldrew	2.8	8.0
South Nelson	2.0	10.5
Stoneleigh	1.4	13.0
Tackaberry	3.4	12.6
Tasso	4.0	6.2
Three Mile (GR)	2.5	18.6
Tucker	4.8	7.4
Turtle	2.3	9.4
Wah Wah Taysee	6.6	2.8
Waseosa	2.1	8.3
Wood	3.3	9.3

* Data provided by the Severn Sound Environmental Association

Appendix 2

Trophic state of lakes

Trophic state of lakes

The trophic state of a lake is one method of classifying lakes by water quality. There are three broad categories of trophic states: **Oligotrophic**, **Mesotrophic**, and **Eutrophic**. Lakes are categorized based on their nutrient levels and water clarity.

Lakes naturally age, with oligotrophic lakes gradually changing to mesotrophic and then eutrophic lakes over geologic time. Allowing nutrients into the lakes through agriculture, fertilizers, street runoff, effluent discharge, and storm drains can speed up this process.

Trophic Level	Phosphorus Concentration (µg/L)	Secchi Disc Measurement (m)	Characteristics
Oligotrophic	<10	>5	• Are generally clear, deep, and free of weeds and large algae blooms • Are low in nutrients, have low primary production, and do not support large fish populations • May support Lake trout • Watershed usually contains few wetlands
Mesotrophic	11 - 20	3 - 4.9	• Have more nutrients and production than an oligotrophic lake, but not as much as a eutrophic lake • Have some aquatic vegetation and wetland areas that support a wide variety of wildlife • Are able to support a wide variety of fish, e.g. bass
Eutrophic	>21	<2.9	• Are the most productive lakes and tend to be shallow • Normally have larger areas of aquatic vegetation • Generally have large wetland areas in their watersheds • May be subject to algae blooms • Support large fish populations, with rough fish being common • Are susceptible to oxygen depletion in the hypolimnion

Appendix 3

Lake survey deck sheet

2011 Lake Survey Deck Sheet

Lake: ________________________ Date: ________________

Municipality: ________________________ Time: ________________

Weather: __Sunny __Cloudy __Raining __Windy Temp: ____________

Sample Number: ________________ Secchi Depth: ________________

Secchi Colour: Brown Green Composite Depth: ________________

Depth	Temp	DO	Depth	Temp	DO
0.5			26		
1			28		
2			30		
3			32		
4			34		
5			36		
6			38		
7			40		
8			42		
9			44		
10			46		
12			48		
14			50		
16			52		
18			54		
20			56		
22			58		
24			60		

Technicians: ________________ Equipment: ☐ YSI 58 ☐ Other

Notes: i.e.: Directions, Access, or any problems encountered…

Appendix 4

Lakes with completed shoreline land use surveys

Lakes with completed shoreline land use surveys

Waterbody	Municipality	Year
Baxter Lake	Georgian Bay	2006
Bella Lake	Lake of Bays	2002
Bird Lake	Bracebridge	2007
Brandy Lake	Muskoka Lakes	2002
Brooks Lake	Lake of Bays	2011
Bruce Lake	Muskoka Lakes	2005
Clear Lake	Muskoka Lakes	2010
Clearwater Lake	Gravenhurst	2007
Clearwater Lake	Huntsville	2007
Dark Lake	Muskoka Lakes	2007
Flatrock Lake	Georgian Bay	2011
Fox Lake	Huntsville	2003
Go Home Lake	Georgian Bay	2007
Gull Lake	Gravenhurst	2006
High Lake	Muskoka Lakes	2011
Lake Joseph	Muskoka Lakes	2007/2008/2009
Joseph River	Muskoka Lakes	2010
Leech Lake	Bracebridge	2006
Leonard Lake	Muskoka Lakes	2006
Little Long Lake	Muskoka Lakes	2010
Long Lake	Muskoka Lakes	2006
Long's Lake	Huntsville	2006
Longline Lake	Lake of Bays	2007
Loon Lake	Gravenhurst	2004
Mary Lake	Huntsville	2008
McKay Lake	Bracebridge	2006
Medora Lake	Muskoka Lakes	2010
Mirror Lake	Muskoka Lakes	2011
Moon River – Bala Reach	Muskoka Lakes	2009
Muldrew Lake (North & South)	Gravenhurst	2003
Lake Muskoka – Muskoka Bay	Gravenhurst	2007
Muskoka River (confluence to mouth)	Bracebridge	2003
Myers Lake	Georgian Bay	2011
Nutt Lake	Muskoka Lakes	2006

Waterbody	Municipality	Year
Paint Lake	Lake of Bays	2005
Pell Lake	Lake of Bays	2006
Pine Lake	Bracebridge	2005
Rebecca Lake	Lake of Bays	2002
Ril Lake	Lake of Bays	2004
Riley Lake	Gravenhurst	2002
Lake Rosseau – Brackenrig Bay	Muskoka Lakes	2007
Lake Rosseau – East Portage Bay	Muskoka Lakes	2011
Silver Lake	Muskoka Lakes	2006
Six Mile Lake	Georgian Bay	2005
South Bay	Georgian Bay	2003
Spring Lake	Bracebridge	2006
Stewart Lake	Muskoka Lakes	2010
Three Mile Lake	Muskoka Lakes	Surveyed 2004 Updated 2006
Tooke Lake	Lake of Bays	2006
Turtle Lake	Gravenhurst	2004
Twelve Mile Bay	Georgian Bay	2004
Lake Vernon	Huntsville	2002
Walker Lake	Lake of Bays	2006
Lake Waseosa	Huntsville	2002
Wood Lake	Bracebridge	2006

Appendix 5

Table of 2011 chemical data

Table of 2011 chemical data

Lake Name	Date (mm/dd/yyyy)	Alkalinity mg/L	Calcium mg/L	Chloride mg/L	Colour TCU	Conductivity µS/cm	DOC mg/L	Sodium mg/L	NO_3 µg/L	TKN µg/L	pH	Sulphate mg/L
Ada	05/19/2011	11.20	5.74	47.90	47.8	195.0	6.9	28.50	4	435	7.01	3.40
Axle	06/07/2011	0.50	1.06	0.72	15.4	12.6	3.6	0.72	30	208	5.94	2.75
Barron's	06/02/2011	19.70	6.10	28.60	53.6	153.0	9.3	17.70	4	732	7.21	3.60
Bass (ML)	05/19/2011	4.20	2.34	3.99	29.2	33.6	5.3	2.90	58	214	6.67	3.20
Bigwind	04/29/2011	2.29	1.92	0.60	17.2	20.0	3.2	0.93	82	251	6.12	4.05
Brandy	05/13/2011	7.11	2.70	5.45	105.0	44.4	11.2	3.66	20	413	6.58	2.80
Brooks	05/25/2011	8.25	2.96	0.38	7.8	31.4	3.9	0.87	70	255	6.98	4.75
Bruce	05/11/2011	41.00	3.64	3.19	15.6	42.6	3.8	2.37	36	245	7.59	4.55
Buck (HT)	05/17/2011	2.02	1.96	0.74	85.6	18.4	9.3	0.90	76	348	5.97	3.15
Buck (LOB)	05/26/2011	3.87	2.12	0.43	5.6	23.8	3.2	0.74	48	180	6.68	4.15
Butterfly	05/19/2011	9.65	4.34	25.90	33.8	123.0	5.8	16.10	60	317	6.96	3.95
Chub (HT)	05/11/2011	8.51	2.58	2.02	35.8	29.0	5.0	1.57	24	305	6.89	4.00
Chub (LOB)	05/20/2011	1.49	1.50	0.37	49.2	15.2	6.5	0.65	2	370	6.07	3.30
Cognashene Bay	05/30/2011	32.20	11.60	7.05	23.6	109.0	4.7	4.39	104	299	7.50	7.25
Cornall	06/01/2011	8.61	3.54	39.30	55.0	155.0	6.8	23.90	26	419	6.58	2.05
Crosson	06/03/2011	0.52	1.08	0.27	40.4	12.4	5.4	0.56	66	294	5.87	3.25
Dark	05/09/2011	8.59	3.94	6.11	18.6	51.2	4.0	4.01	62	430	7.19	4.45
Deer	06/07/2011	3.10	1.74	1.06	7.2	19.2	3.1	0.93	26	214	6.65	2.80
Devine	05/17/2011	2.29	1.86	0.63	57.6	17.8	7.1	0.88	6	333	6.35	3.05
Fawn	05/11/2011	4.80	1.86	1.35	77.2	19.8	7.8	1.01	86	300	6.60	2.85
Flatrock	06/06/2011	6.36	3.08	7.49	32.6	53.6	5.1	4.75	98	334	6.70	4.65
Foote	05/17/2011	3.22	2.20	0.73	54.2	21.0	7.6	0.94	68	302	6.33	3.25
Go Home Bay	05/30/2011	28.00	10.40	5.76	29.0	96.6	4.6	3.70	140	264	7.33	6.90
Grandview	05/20/2011	8.94	4.18	12.80	5.8	75.6	2.6	6.63	2	279	7.07	4.65
Grindstone	06/07/2011	2.56	2.20	18.10	26.8	80.4	5.5	11.60	2	254	6.44	3.35
Gull	06/02/2011	11.80	4.82	14.40	18.6	91.2	4.7	9.22	60	270	7.00	4.10
Gullfeather	06/03/2011	1.10	1.26	0.40	63.2	12.8	6.8	0.69	50	297	5.95	3.15
Hardup	05/27/2011	3.78	1.94	0.32	18.0	20.6	3.6	0.69	72	258	6.53	3.75
Joseph - Cox Bay	05/10/2011	6.62	4.12	9.84	8.6	64.0	2.8	6.14	92	318	6.93	5.55
Joseph - Hamer Bay	05/10/2011	6.22	4.00	9.18	5.2	60.4	2.6	5.63	124	291	6.86	5.85
Joseph - Joseph River	05/10/2011	6.55	3.80	8.40	15.0	56.8	3.6	5.11	62	284	6.93	5.10
Joseph - Little Lake Joseph	05/10/2011	5.97	3.82	6.10	13.0	48.6	3.2	3.85	80	300	6.81	5.05

Lake Name	Date (mm/dd/yyyy)	Alkalinity mg/L	Calcium mg/L	Chloride mg/L	Colour TCU	Conductivity µS/cm	DOC mg/L	Sodium mg/L	NO_3 µg/L	TKN µg/L	pH	Sulphate mg/L
Joseph - Main	05/10/2011	6.48	3.98	9.36	6.0	61.8	2.6	5.74	120	244	6.89	5.85
Joseph - North	05/10/2011	6.08	3.96	8.98	6.2	59.6	2.4	5.43	128	299	6.82	5.90
Joseph - South	05/10/2011	6.23	4.04	9.45	6.4	61.8	2.6	5.73	106	197	6.92	5.75
Kahshe - Grant's Bay	05/31/2011	4.57	2.04	1.79	47.0	25.2	6.0	1.42	56	338	6.46	2.60
Kahshe - Main	05/31/2011	4.82	2.02	1.79	47.0	25.6	6.0	1.48	40	328	6.52	2.70
Lake of Bays - Dwight Bay	05/18/2011	2.26	2.36	3.03	21.0	31.8	4.0	2.20	170	227	6.44	4.70
Lake of Bays - Haystack Bay	05/18/2011	4.63	2.76	2.95	10.4	34.0	3.0	2.06	102	217	6.64	4.80
Lake of Bays - Rat Bay	05/18/2011	2.77	2.48	2.98	22.8	32.0	4.6	2.20	156	230	6.41	4.30
Lake of Bays - South Muskoka River Bay	05/18/2011	4.35	2.70	3.07	12.6	33.2	3.0	2.18	122	177	6.65	4.65
Lake of Bays - South Portage Bay	05/18/2011	3.85	2.62	2.97	16.6	33.0	4.2	2.17	142	189	6.52	4.25
Lake of Bays - Ten Mile Bay	05/18/2011	3.74	2.66	2.83	11.2	32.6	3.4	2.07	118	148	6.53	4.55
Lake of Bays - Trading Bay	05/18/2011	3.97	2.24	2.24	11.8	29.4	3.3	1.69	106	165	6.59	4.55
Leonard	05/13/2011	2.79	2.34	5.14	18.4	37.8	4.8	3.50	4	208	6.49	4.10
Little Go-Home Bay	06/02/2011	63.20	24.20	21.00	22.0	217.0	5.2	12.40	16	350	7.64	9.55
Longline	05/20/2011	8.02	3.36	2.04	9.2	35.6	3.5	1.32	4	251	7.03	4.60
Long's	05/11/2011	13.70	3.68	21.40	66.4	103.0	6.8	13.80	190	300	7.08	4.50
Mary	05/11/2011	1.95	2.96	6.14	44.6	47.0	5.4	3.94	218	246	5.96	4.50
McDonald	05/24/2011	52.90	20.10	16.40	23.2	189.0	5.4	11.10	44	328	7.59	7.95
Menominee	05/11/2011	-2.14	2.40	8.57	67.0	47.2	7.2	5.15	76	275	4.42	2.90
Moot	04/28/2011	0.92	1.22	0.29	69.0	15.4	6.7	0.56	84	336	5.63	1.60
Morrison	05/03/2011	7.60	3.76	6.37	45.2	48.2	6.9	3.67	84	357	6.76	2.55
Myers	05/24/2011	4.60	2.62	8.79	38.2	50.8	5.4	5.05	48	253	6.60	2.05
Neilson	05/09/2011	0.82	1.18	0.31	56.2	11.6	6.0	0.47	62	300	5.97	1.80
Nine Mile	05/09/2011	3.14	2.04	1.08	80.4	18.2	8.1	0.84	42	390	6.33	1.40
North Bay *	05/03/2011	–	–	–	–	150.0	–	–	22	325	7.51	–
North Muldrew	05/03/2011	7.65	3.96	7.47	49.2	52.0	6.7	4.32	96	305	6.63	2.35
Nutt	05/11/2011	2.10	15.70	3.98	19.8	106.0	5.6	2.96	90	371	6.18	3.60
Oudaze	06/08/2011	5.13	2.58	1.37	52.2	29.2	8.2	1.53	18	509	6.69	4.00
Oxbow	05/25/2011	2.99	2.00	0.96	22.8	8.4	4.5	0.99	84	244	6.60	3.95
Paint	05/26/2011	6.92	2.86	4.14	20.4	43.4	4.3	2.79	2	208	6.91	4.20
Pell	05/25/2011	1.38	1.48	2.10	39.8	22.4	6.0	1.53	62	324	6.13	3.30
Penfold	05/11/2011	5.14	5.68	28.90	53.4	142.0	6.6	18.60	40	361	6.54	4.65
Pine (BR)	05/05/2011	5.04	2.90	0.65	29.8	25.8	4.6	0.94	84	227	6.60	3.95
Pine (GR)	06/01/2011	3.45	1.82	2.16	26.0	23.0	4.8	1.34	8	279	6.39	2.30

Lake Name	Date (mm/dd/yyyy)	Alkalinity mg/L	Calcium mg/L	Chloride mg/L	Colour TCU	Conductivity µS/cm	DOC mg/L	Sodium mg/L	NO_3 µg/L	TKN µg/L	pH	Sulphate mg/L
Prospect	05/05/2011	2.92	2.36	9.84	41.6	52.8	5.0	6.56	136	234	6.26	3.15
Rosseau - Brackenrig Bay	05/16/2011	6.60	3.44	6.23	17.6	51.8	3.9	4.12	100	25	6.90	4.85
Rosseau - East Portage Bay	05/16/2011	6.51	3.38	6.67	13.6	51.8	3.8	4.07	152	194	6.78	4.95
Rosseau - Main	05/16/2011	6.48	3.40	6.52	13.8	52.0	4.2	4.17	138	191	6.86	5.05
Rosseau - North	05/16/2011	5.88	3.02	5.82	18.0	48.4	3.7	3.94	178	230	6.60	4.65
Rosseau - Skeleton Bay	05/16/2011	5.92	–	–	0.4	0.2	1.1	–	–	165	6.74	–
Silver (GR)	05/09/2011	5.86	3.10	2.95	40.6	34.2	5.5	1.73	94	293	6.70	2.95
Silver (ML)	05/16/2011	15.70	6.38	12.20	12.4	88.6	4.4	8.31	2	431	7.24	3.90
Six Mile - Cedar Nook Bay	05/13/2011	29.90	12.60	10.10	25.0	111.0	5.6	5.24	32	288	7.40	5.30
Six Mile - Main	05/13/2011	55.80	22.50	19.20	26.4	201.0	5.6	11.50	46	290	7.68	8.90
Six Mile - Provincial Park Bay	05/13/2011	54.10	22.10	22.10	22.6	203.0	5.9	13.20	12	294	7.75	8.50
Sixteen Mile	05/27/2011	3.19	1.88	0.33	19.4	20.2	3.6	0.71	142	237	6.40	3.60
Solitaire	05/26/2011	3.75	2.12	0.71	4.0	24.0	2.5	0.74	28	153	6.73	4.55
South Bay *	05/03/2011	–	–	–	–	161.0	–	–	36	347	7.55	–
South Muldrew	06/07/2011	7.13	3.52	7.77	45.6	51.2	6.8	4.40	54	321	6.81	2.45
South Nelson	05/25/2011	0.98	1.42	0.27	47.8	16.4	6.9	0.64	132	284	5.78	3.15
Stoneleigh	04/28/2011	0.65	1.60	0.60	60.8	18.8	6.8	0.73	108	316	5.73	2.60
Tackaberry	04/28/2011	2.02	1.26	0.44	12.0	16.6	3.3	0.63	38	258	5.91	2.80
Tasso	05/25/2011	2.44	1.70	0.75	11.0	20.0	2.8	0.76	128	177	6.38	3.95
Three Mile (GR)	05/09/2011	4.77	2.40	2.02	68.4	27.4	7.2	1.70	36	392	6.62	2.75
Tucker	06/03/2011	0.73	1.12	0.32	12.8	13.6	3.3	0.52	24	244	6.07	3.40
Turtle	05/03/2011	12.10	6.64	25.20	32.8	126.0	5.3	14.40	78	303	6.96	3.00
Wah Wah Taysee	05/24/2011	61.10	21.10	7.11	6.0	166.0	2.3	4.31	220	128	7.74	12.10
Waseosa	06/09/2011	4.12	2.42	1.84	31.2	28.6	4.8	1.47	32	260	6.79	4.25
Wood	04/29/2011	3.79	2.56	5.84	21.8	39.0	3.8	3.72	94	218	6.44	3.95

* Data provided by the Severn Sound Environmental Association