2012 Kahshe Lake Steward Report

Kahshe Lake Ratepayers' Association

December 2012

2012 KAHSHE LAKE STEWARD REPORT

Contents

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1.0 Kahshe Lake Stewardship Mandate

The Lake Steward Committee is funded by and reports directly to the Kahshe Lake Ratepayers' Association (KLRA) Board with two main goals:

- Educating the residents and other users of the lake on how to **preserve** and **improve** the quality of the lake and its shoreline.
- Monitoring the environmental quality of the lake and keeping the association members up to date on the results of the testing programs.

The Lake Steward Committee has in the past and currently consists of only one KLRA Board member, the Kahshe Lake Steward. However, some of the sampling requires assistance from additional volunteers for short periods of time to ensure that the long term sampling is maintained.

The Lake Steward also has been designated as a sitting member of a newly created KLRA Conservation Committee, and will attend and participate in that committee as requested.

2.0 History of Environmental Monitoring on Kahshe and Other Muskoka Lakes

Kahshe Lake is being monitored for water quality and biological functioning parameters under two main initiatives as outlined below:

Lake Partner Program

This program is operated by the Ontario Ministry of the Environment (MOE) through the Dorset Environmental Science Centre (DESC). Under this program, water sampling and measurement of water clarity is conducted by the Kahshe Lake Steward every year.

The program consists of the following activities:

- Water clarity measurements
  - Clarity of the water is measured every two weeks during the ice-free period at three locations using a Secchi disc, and these findings are forwarded to the MOE for compilation and comparison with other lakes in Ontario.
- Water quality testing
  - Water is sampled from two locations in May each year and sent to the MOE where it is analyzed for total phosphorous, an indicator of the potential for algal blooms and nutrient enrichment which is termed eutrophication.

Lake System Health Program

This program is one of several components of a larger **Muskoka Water Strategy** which is operated by The District Municipality of Muskoka (DMM), with support from the Muskoka Watershed Council (MWC), the MOE and several other participating agencies.

DMM has undertaken a lake water quality monitoring program in Muskoka since 1980. In January 2003, with the support of the MWC and with involvement from a wide variety of organizations, agencies and stakeholders, DMM expanded its recreational water quality program and developed the **Muskoka Water Strategy**.

The **Muskoka Water Strategy** consists of four broad components:

1. Lake System Health, including lake and watershed monitoring;
2. Communication and community involvement via the Muskoka Water Web site www.muskokawaterweb.ca
3. The MWC, which includes initiatives such as the Muskoka Watershed Report Card and Best Practices program; and,
4. Broader Water Initiatives, such as source water protection and watershed inventories.

The Lake System Health initiative is the most relevant to Kahshe Lake and includes recreational water quality monitoring, water quality-based development initiatives, a 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. This goal is achieved by managing the development on Muskoka lakes in a sustainable manner to ensure that development does not:

- damage the natural environment
- damage the habitat or trophic status of the water body or other water bodies within a watershed

Summary of DMM's Lake System Health Monitoring Activities

Before examining the findings of the DMM Lake System Health Program for Kahshe Lake, it's important to get an overview of the program as it applies to lakes in Muskoka.

Water quality in Muskoka has been monitored by the DMM in conjunction with the MOE for over 30 years and has produced long-term data records for many key lakes.

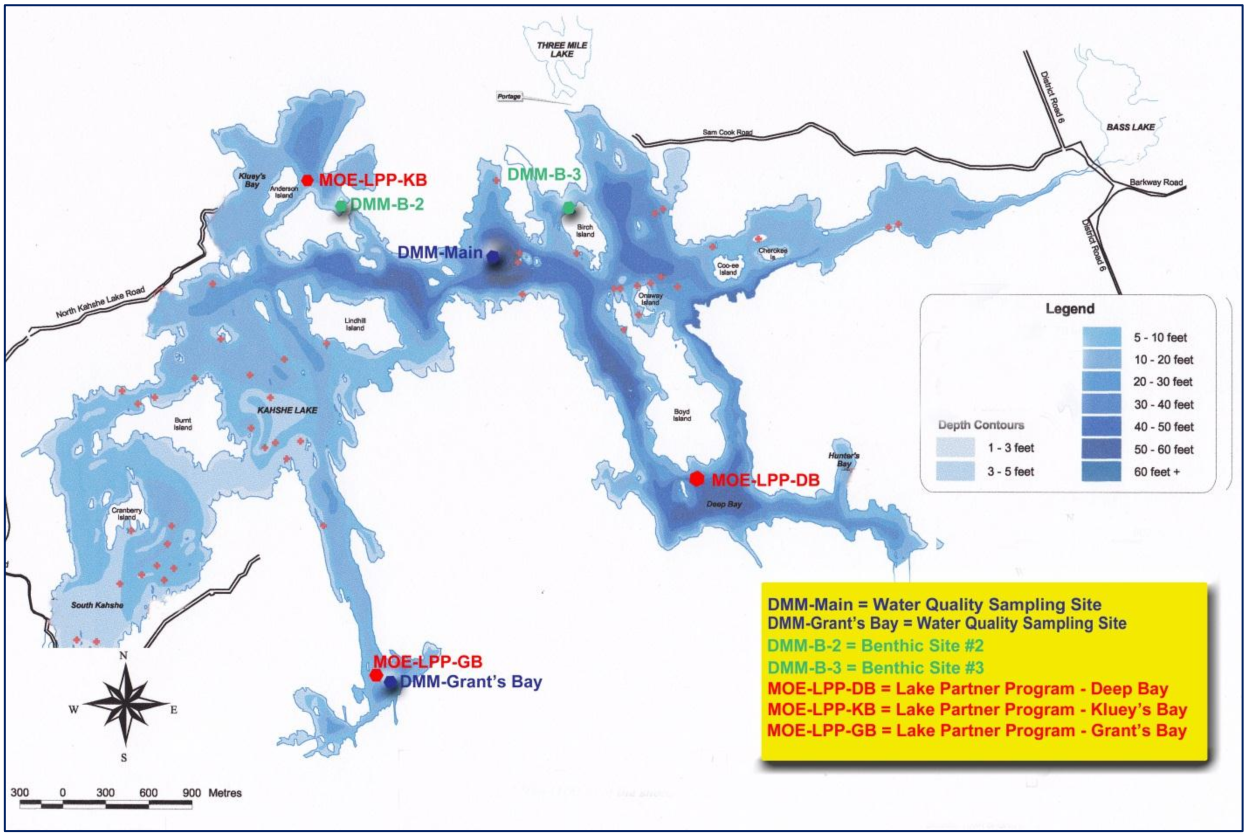
The monitoring program consists of 193 sampling sites on 164 lakes on a rotational basis. To achieve the goal that was identified above, the program was designed to deliver a monitoring program which would establish a long-term record of key water quality parameters so that trends in water quality and lake system health could be identified and appropriate management decisions taken to protect lake water quality. Shown below are the main initiatives of Muskoka's Lake System Health program:

- Samples collected for analysis under the DMM are sent to the MOE's Dorset laboratory, where they are analyzed for total phosphorus and for other parameters, such as pH, conductivity, calcium, and nitrogen.
- DMM staff also take Secchi disc readings and record dissolved oxygen and temperature profiles at several water depths.
- In 2003, a Biological Monitoring Program was developed for lake associations interested in becoming more involved in lake monitoring and broader lake planning.
- Each year, DMM staff are available to train lake residents to undertake volunteer monitoring programs – e.g. Benthic Analysis, PlantWatch, FrogWatch, and forest health.
- Each year, the DMM publishes a Lake System Health Monitoring Year End Report which captures the data collected during the year.
- Data Sheets for individual lakes that track changes in total phosphorus and Secchi depth over time are posted on the Muskoka Water Web site (www.muskokawaterweb.ca)

For Kahshe Lake, the DMM program consists of the following activities which are conducted every other year:

- 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;
- Benthic invertebrate sampling in August.

To give a better perspective on where the sampling for both the MOE Lake Partner Program and the DMM Lake System Health Program is conducted on Kahshe Lake, the locations of water sampling and measurement have been plotted on a map below:



3.0 Reported Findings of Monitoring on Kahshe and Other Muskoka Lakes

While both the MOE, MWC and DMM have web sites where the sampling and analysis data are presented, there is only a limited amount of trend analysis and interpretative information available that is specific to data collected on Kahshe Lake. Here's a brief summary of what each agency has published, and the conclusions which can be drawn from the data.

3.1 MWC Watershed Reports

The MWC's Watershed Report Cards are published every four years, and to date, three report cards have been released (2004, 2007 and 2010), with the next one to be released in 2014. The Report Cards focus *on Indicators of Watershed Health* which were developed in 2002 through a Water Strategy public consultation process.

The key indicators that form the basis of the Report Cards include:

- Water that is Swimable
- Water that is Drinkable
- Water that is Fishable
- Air that is Breathe-able
- Ecosystems that are Healthy
- A Physical Environment that is Sustainable
- Community Values that are Environmentally Sustainable

Based on information provided in the MWC's Report Cards, the Kahshe Lake sub-watershed is 24,533 hectares (ha) in size, and is located within the Severn River Watershed.

Kahshe Lake itself is 8.3 km^2 in area and in addition to this larger lake there are 20 lakes over 8 hectares in size in the sub-watershed.

Approximately 5% the sub-watershed is developed with 76% of the land in the sub-watershed being Crown land. There are no major urban areas within the sub-watershed and rural and shoreline residential development comprises most of the land use.

About 11% of the sub-watershed is protected through provincial parks, crown nature reserves, or local land trusts.

In the most recent 2010 Report Card, the MWC grades assigned to the Kahshe Lake Sub-Watershed were:

Land:	B
Water:	A
Wetland:	—

While this gives a general perspective on the health of the Kahshe Lake Sub-Watershed, it doesn't provide any specific information on Kahshe Lake itself.

3.2 MOE Lake Partner Program

The MOE does not generate a year-end report on their Lake Partner Program. Instead, they provide a web-based link to all of the data generated via this program for use by Lake Stewards and other interested parties.

As the MOE's Lake Partner Program does not include an interpretative report, the remainder of this 2012 analysis has focused on the findings from the DMM's Lake System Health Program.

The analysis has been broken into the following three main components:

- Evaluation of 2011 DMM Year-End Findings - Kahshe Lake Water Quality

- Additional Analysis of Kahshe Lake Water Quality Data, including:
    - a comparison of water quality in Kahshe Lake to results for three up-gradient lakes;
    - a comparison of the DMM findings for total phosphorus and Secchi depth to the MOE's LPP program findings;
    - an analysis of trends over time and predictive relationships among sampling parameters

- Evaluation of the DMM Benthic Monitoring Results for Kahshe Lake

3.3 DMM Lake System Health Monitoring

The DMM year-end summary and data reports provide more interpretative information on trends in water quality and the biological basis for analyzing the tested parameters and interpreting the outcome of the changes that are being seen across Muskoka.

The year-end data sheets for Kahshe Main and Grant's Bay sampling sites show current (2011) results for total phosphorus, Secchi Disc depth, water temperature and dissolved oxygen concentrations with increasing sampling depth. There is also a data sheet which shows the results of the benthic sampling over the years it has been undertaken.

The year-end report provides useful information on how Kahshe Lake total phosphorus and Secchi disc results compare to the results from all monitored lakes in Muskoka. The charts on water quality as presented in the 2011 DMM year-end report are shown below for the Kahshe Lake Main and Grant's Bay locations.

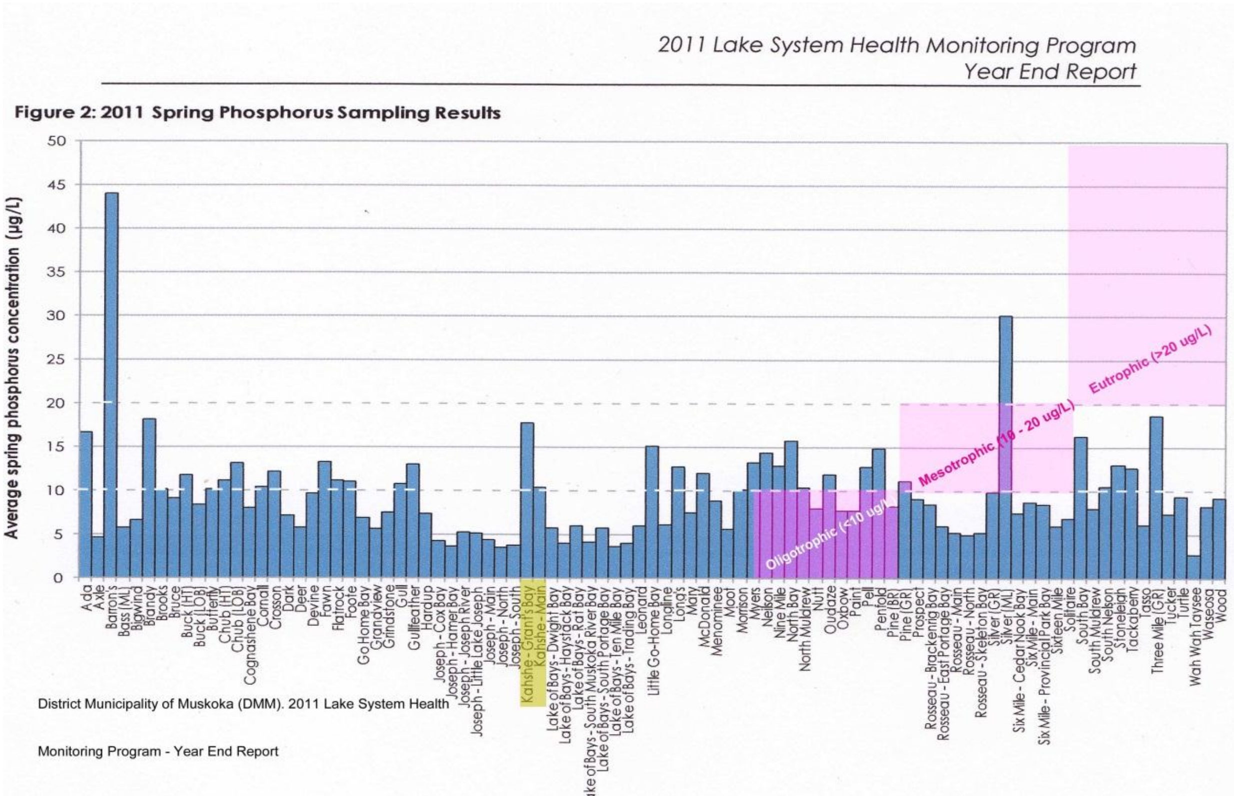
A brief summary of the findings follow each graph. However, before the results are examined, it's important to briefly explain the units which are used in expressing the concentration of total phosphorus and other substances that will be discussed later in this report.

The measurement of total phosphorus is expressed in units of µg/L, which means micrograms per litre of water. As a microgram is one millionth of a gram, and as one litre weighs about 1,000 grams, another way of visualizing the concentrations is as parts of contaminant per billion parts of water. For those not used to counting in billions, one billion has nine zeros – 1,000,000,000.

Given the size of Kahshe Lake (8.3 square kilometres) and assuming an average depth of 6 m, the lake contains approximately 50 billion litres of water. Based on the volume of water in the lake and the fact that a litre of water weighs about 1,000 grams, a concentration of 1 of µg/L or one part per billion is equivalent to dumping about 50 one litre bags of milk (or bottles of wine) into the entire water volume of Kahshe Lake.

The charts that are applicable to Kahshe Lake have been reproduced below:

2011 - Total Phosphorus Results



What does this tell us?

- This chart plots the total phosphorus concentrations of all Muskoka lakes that were sampled in 2011.
- For clarity, the results from the two Kahshe Lake sampling locations have been highlighted in yellow.
- In addition, three shaded areas have been added to show how lakes in Muskoka are rated in terms of total phosphorus concentrations.
    - Lakes with total phosphorus concentrations of < 10 µg/L are referred to as **Oligotrophic**.
    - Lakes with total phosphorus concentrations in the range of 11 - 20 µg/L are termed **Mesotrophic**,
    - Lakes with > 20 µg/L total phosphorus are termed **Eutrophic.**
- Kahshe Lake falls into the Mesotrophic category, and in 2011, the concentrations at the two sites (17.8 and 10.4 µg/L at Grant's Bay and Kahshe Main, respectively) fit that category.
- The DMM summarizes this information as indicating that the lakes in Muskoka are characterized by excellent water quality, with 68% of the lakes having an average of 10 µg/L or less of total phosphorus.
- DMM staff also have concluded that the average total phosphorus concentration for a given lake may vary by as much as ± 10% to 125% (average = 40%) from year to year.

Some Additional Background Information on Total Phosphorus

Because of the main focus of all water sampling on total phosphorus, it's important to understand what it is and why it is an important contaminant.

- Phosphorus is a natural substance required by all living organisms. It enters a lake naturally through sediment and precipitation, and via human activities such as:
  - Nutrient loading from septic systems;
  - Use of phosphorus-based cleaning supplies; and
  - Loss of native shoreline vegetation, especially the diverse forest environment. As lawns replace trees, fertilizer runoff, storm water and soil erosion wash higher loads of phosphorus into our lakes.

- Phosphorus samples are collected in the spring during a period called "spring turnover", as studies have shown that total phosphorus concentrations at this stage of thermal mixing of water bodies is representative of the average of phosphorus concentrations throughout the whole ice-free period.

- After spring turnover, the lake will stratify thermally such that the upper, epilimnetic layers do not mix with the deep hypolimnetic waters. Precipitation and runoff from the watershed of a lake add phosphorus to the epilimnetic waters and the growth of algae is confined to the upper waters of the lake which are illuminated by sunlight. Upon death at year end, algal cells sink to the hypolimnetic waters, where they are decomposed and phosphorus is re-mineralized. Over the course of a year, therefore, phosphorus concentrations will vary with depth and with time.

- The reason for focusing on total phosphorus is that it is typically the best chemical indicator of lake eutrophication or enrichment and has been found to be the best chemical signal as a warning sign for potential algal blooms which detract from recreational water quality, have the potential to release organic toxins, and can affect the habitat of coldwater fish species such as Lake trout.

- In general, Muskoka has two types of lakes: clear water lakes that drain nutrient poor land areas; and brown water lakes that have a significant amount of wetlands in their drainage basin and are high in dissolved organic carbon (DOC) and natural phosphorus.

What does this mean in terms of the potential for algal blooms and concern regarding more intensified development?

- Based on a review of the science, the DMM has opted to conservatively preserve the levels of total phosphorus equated with eutrophication and algal bloom problems based on their predicted background or undeveloped concentrations. The threshold level for total phosphorus in each lake in Muskoka is determined by adding 50% of the background concentration to a background base which was developed through a water quality model.

- The setting of the background base is currently under review and is a complex process whereby relevant parameters which can influence background concentrations are used in a mathematical water quality model that has been developed and refined over several years.

- In the case of Kahshe Lake, the background was set at 9.5 µg/L, resulting in a total phosphorus threshold of 14.2 µg/L – i.e. 9.5 + [0.5*9.5]= 14.2 µg/L.

- As you can see, in 2011, the spring total phosphorus threshold of 14.2 µg/L was exceeded, with a concentration of 17.8 µg/L.

What happens when a total phosphorus threshold is exceeded?

- 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:
  - Total phosphorus concentration, as estimated by the Muskoka Water Quality Model, exceeds the “Background + 50%” threshold; and,

  - The long-term (10-year) measured total phosphorus concentration, as determined by the DMM Program, also exceeds the “Background + 50%” threshold value.

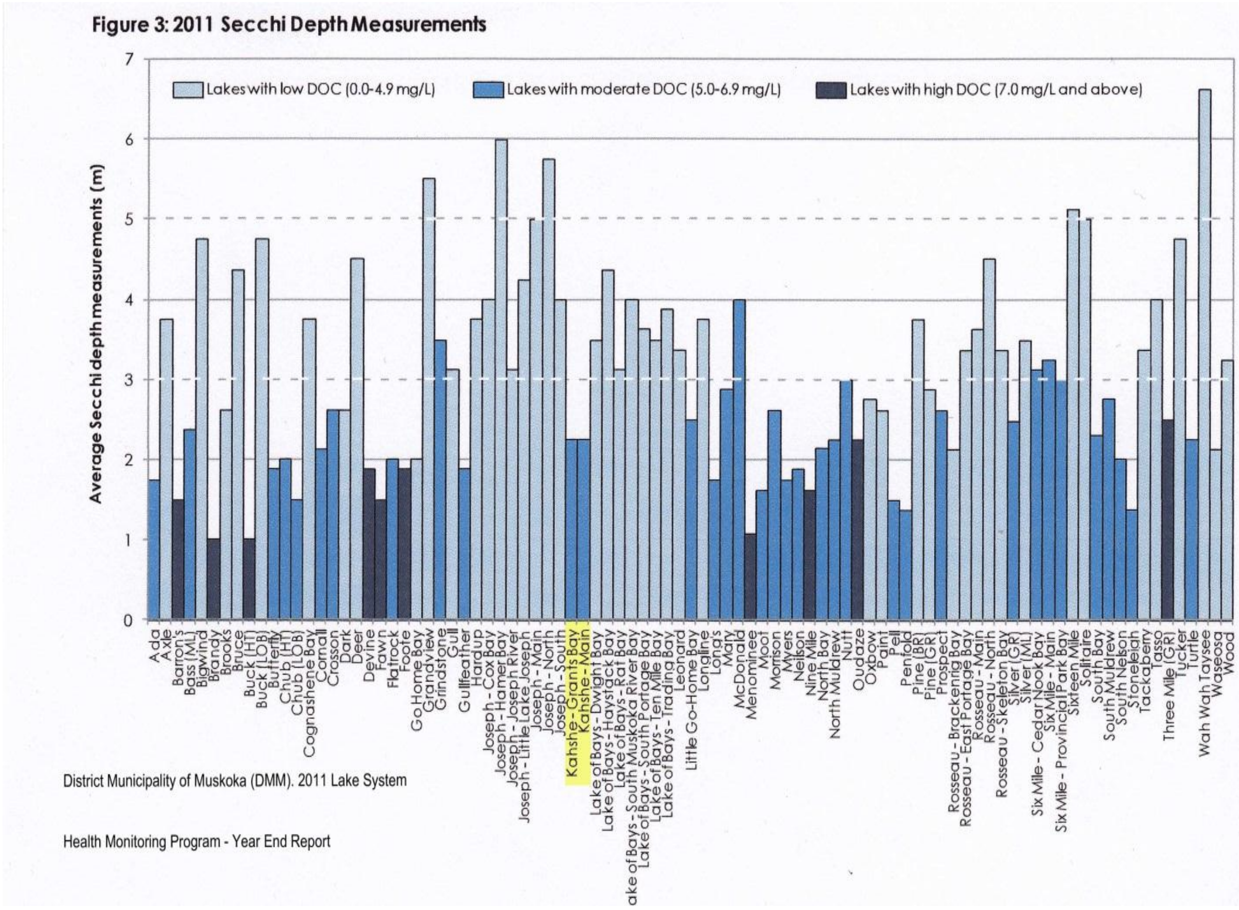
- A lake that is Over Threshold will be de-listed only after the long-term average of total phosphorus is less than the threshold established for the lake and there have been three consecutive phosphorus measurements below its threshold value.

- However, in the event that a 10-year review of the Water Quality Model is underway (which it is), lakes will not be listed as being Over Threshold nor delisted as no longer being Over Threshold until the model review is complete.

- As the DMM’s water quality model review report (Gartner Lee, 2005), is a complicated technical presentation of the model parameters and their influence on total phosphorus concentrations, it is just too detailed to include in this summary. However, it did have an appendix where all of the Muskoka lakes were evaluated in terms of their compliance with the total phosphorus threshold and projected sensitivity to increasing phosphorus concentrations.

- The good news is that Kahshe Lake is listed as being at a level of background + 23% [well below the threshold of background + 50%] and is shown as being low in terms of total phosphorus responsiveness. However, because of limited soil attenuation potential, the mobility rating is high. The combination of these two factors results in a moderate sensitivity classification for Kahshe.

2011-Secchi Depth Results



What does this tell us?

- This chart plots the Secchi depths for all Muskoka lakes that were measured in 2011.
- For clarity, the results from the two Kahshe Lake sampling locations are highlighted in yellow.
- To understand this chart, it's important to consider that water clarity in Muskoka lakes is determined by two factors:
  - The first is dissolved organic carbon (DOC) which colours the water orange-brown. DOC compounds are formed by the decomposition of organic plant matter in wetland areas and concentrations in lake waters are determined by the amount of wetland in the catchment of a lake. The influence of DOC on transparency is entirely natural and cannot be managed to improve water clarity.
  - The second determinant of transparency is the level of the plant pigment chlorophyll *"a"* in the water. This pigment is contained in algae which grow in the water and so the amount of chlorophyll reflects the amount of algae in the water.
- 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.

What does this tell us? Cont'd

- Lakes with Secchi depth measurements over five metres are considered **Oligotrophic** or un-enriched.
- Those with a Secchi depth measurement falling between three and five metres are termed **Mesotrophic** or moderately enriched.
- Lakes with a Secchi depth measurement below three metres are called **Eutrophic** and are considered enriched.
- 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.
- As is apparent from the chart above, Kahshe Lake is rated as a moderate in terms of its DOC levels (degree of tea-colour); however, based on the DMM sampling results for 2011, the depth in terms of clarity is below the 3-5 m typical depth for a Mesotrophic lake and more representative of an Eutrophic lake.

2011-Dissolved Oxygen and Temperature Results

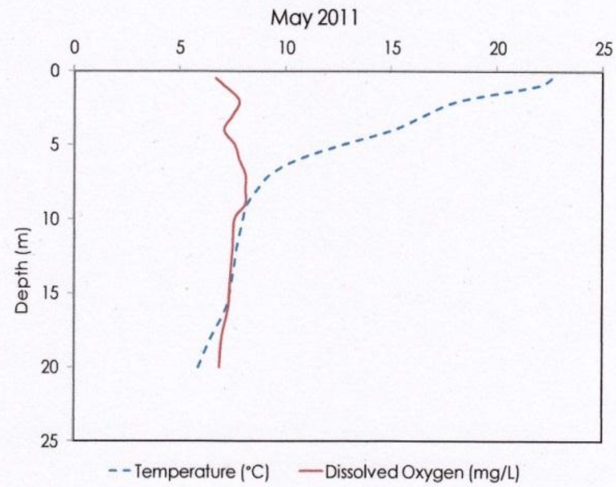
The 2011 results for these two parameters are shown in the Kahshe Lake data sheet which has been taken from the DMM web site and reproduced below.

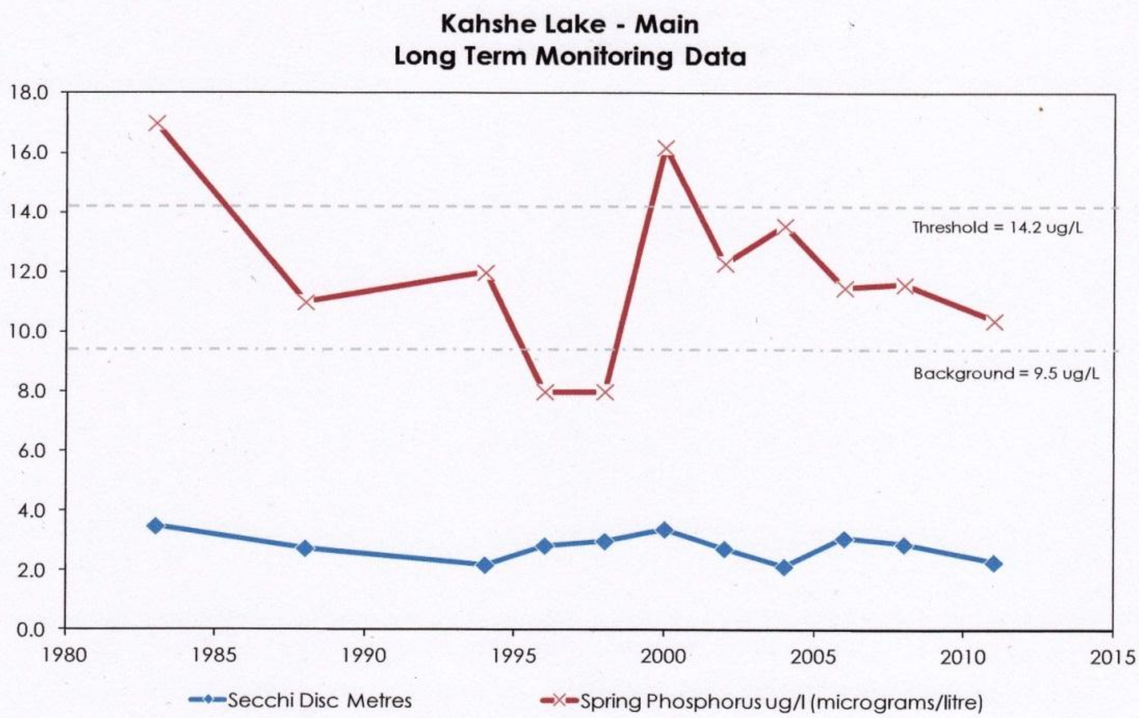
THE DISTRICT MUNICIPALITY OF MUSKOKA

Lake Data Sheet
2011

Kahshe Lake – Main

Municipality:	**Gravenhurst**	Watershed:	**Sparrow Lake**
Surface Area:	**8.3 km²**	Watershed Area (excluding lake):	**32.7 km²**
Maximum Depth:	**20 m**	Lake Trout Lake?	**No**
Wetland Area:	**5 %**	Secchi Depth (10-year average):	**2.6 m**
Phosphorus (10-year average):	**11.9 µg/L**	Sensitivity:	**Moderate**





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What does this tell us?

- Temperature patterns affect the solubility of many chemical compounds and influence the effects of pollution on aquatic life.
- Dissolved oxygen is an indicator of a lake’s ability to support aquatic life.
- Adequate concentrations of dissolved oxygen are necessary for the survival of fish and other aquatic organisms.
- Dissolved oxygen levels above 5 milligrams per litre (mg/L) are considered optimal for most aquatic organisms and 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 ^{o}C.
- Lakes with dissolved oxygen readings below 0.5 mg/L are considered anoxic.
- It is apparent from this sampling in May 2011 that water temperature predictably decreases with depth while the dissolved oxygen concentrations are fairly constant with depth and well within the levels that would support aquatic life at all depths.

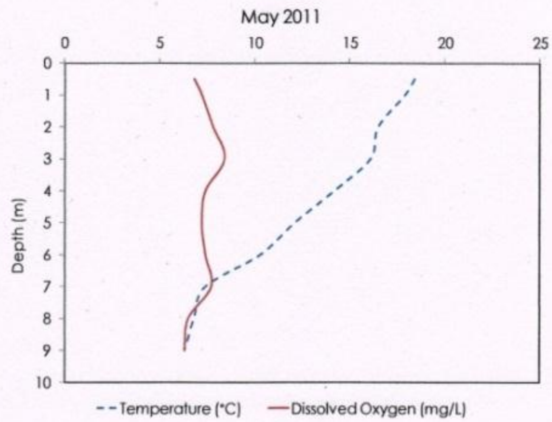
The data for Grant's Bay are similar, although because of a more shallow depth profile, the temperature decrease is not as noticeable as it is in the main sampling location where the water depth is greater than 20 m.

THE DISTRICT MUNICIPALITY OF MUSKOKA

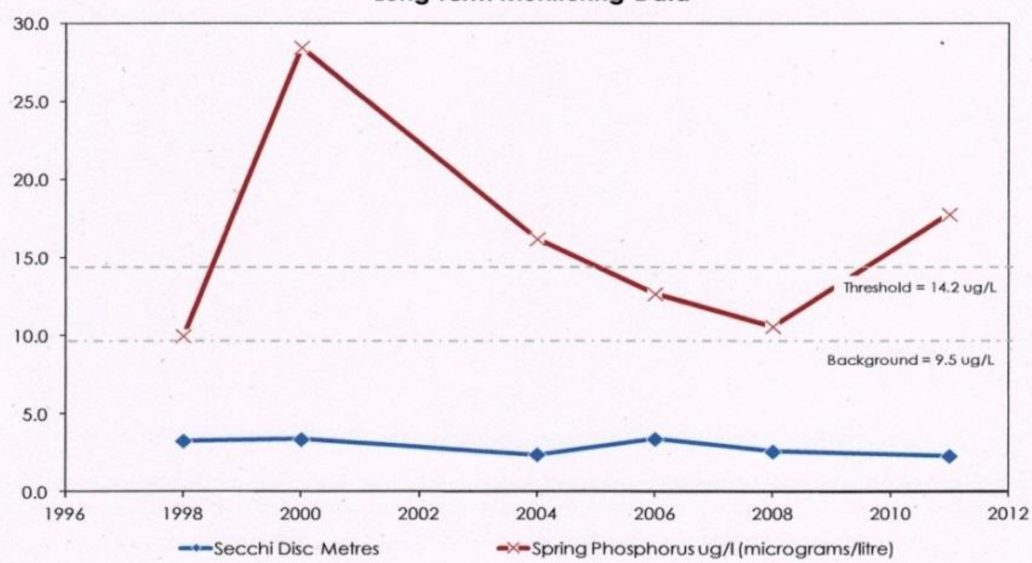
Lake Data Sheet 2011

Kahshe Lake – Grant's Bay

Municipality:	**Gravenhurst**	Watershed:	**Sparrow Lake**
Surface Area:	**8.3 km²**	Watershed Area (excluding lake):	**32.7 km²**
Maximum Depth:	**20 m**	Lake Trout Lake?	**No**
Wetland Area:	**5 %**	Secchi Depth (10-year average):	**2.7 m**
Phosphorus (10-year average):	**14.3 µg/L**	Sensitivity:	**Moderate**



Kahshe Lake - Grant's Bay
Long Term Monitoring Data



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Also shown in each of the data sheets for Kahshe Main and Grant's Bay are the total phosphorus and Secchi depth measurements over the entire period that Kahshe Lake has been monitored by DMM.

I'll discuss these findings in the next section, as they require some additional evaluation of expected variability.

4.0 Additional Analysis of Kahshe Lake Water Quality

As the DMM year-end reports do not provide a detailed discussion of their findings for Kahshe Lake, this report will look more closely at the Kahshe Lake results to ensure that we fully understand what's happening in our lake and how this compares with other lakes that are up-gradient and have the potential to influence our water quality.

To carry out a more detailed analysis of the DMM and MOE data with greater emphasis on Kahshe Lake and three other up-gradient lakes for comparison purposes, all of the DMM data for Kahshe plus Bass, Buck (Ryde) and Sunny Lakes were requested from DMM. These three lakes are within the Kahshe Lake Sub-Watershed and all are up-gradient of Kahshe Lake. Once the entire dataset was obtained, it was merged and aligned to match sampling dates across the years that sampling was carried out. This full set of data is attached as Appendix Table A.

During the course of this investigation into the water quality status of Kahshe Lake, four other water quality analysis reports or presentations were obtained and have proven very beneficial in understanding how water quality on Kahshe Lake compares to other lakes.

These are all available on-line and are listed in order from most recent to oldest below:

Palmer, M. Ontario Ministry of the Environment. *Our Lakes: How Have they Changed Over the Last 25 Years?* Environmental Lecture Series, Muskoka Watershed Council. July 26, 2012. Port Carling, Ontario.

Somers, K., Willison, R. Brouse, J. and Yan, N. 2009. *Muskoka's Water Quality: An Analysis of the Data from Your Lake.* Environmental Lecture Series. November 2009.

Gartner Lee Limited. 2008. *Review of Long Term Water Quality Data for the Lake System Health Program*. Prepared for the District Municipality of Muskoka.

Gartner Lee Limited. 2005. *Recreational Water Quality Management in Muskoka*. Prepared for the District Municipality of Muskoka. June 2005.

Again, because of the complexity of the analyses that have been completed in each of the above references, the material here will show very briefly how the findings from Kahshe Lake compare to the results and conclusions reached in each of the above reference papers/presentations.

For the most part, this has been done this on a chemical-by-chemical basis; however, it became apparent during the analysis that interrelationships between the various analyzed parameters was also important, so in these cases, the report departs from the chemical specific approach.

Given the amount of data available from sampling programs conducted on Kahshe Lake and other lakes in Muskoka that have not been included in the 2011 DMM Year End report or not evaluated by DMM on a lake-specific basis, this analysis was undertaken to answer the following four key questions:

i. How do DMM results for Kahshe Lake compare to results from on nearby up-gradient lakes?

ii. How do DMM results for Kahshe Lake compare to results from MOE's Sampling Program?

ii. How do DMM results for Kahshe Lake compare to results of time-trend and predictive analysis based on the full set of Muskoka data? and,

v. Can any conclusions be drawn based on the results of a large suite of chemical parameters that have been analyzed by DMM over the past 6-8 years but not included in the Year-End report?

4.1 How do DMM results for Kahshe Lake compare to results from nearby up-gradient lakes?

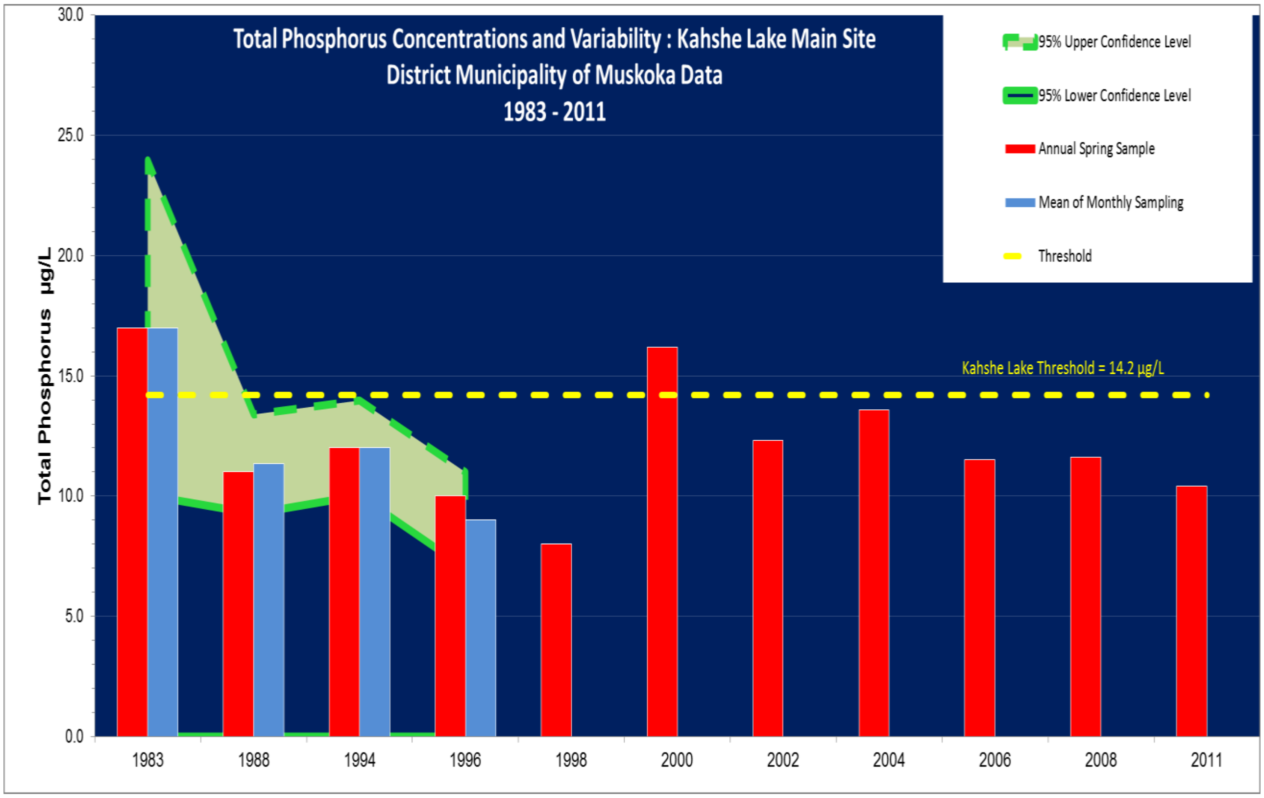
4.1.1 Total Phosphorus

Before making any comparisons among different lakes, it was necessary to determine the variability in the total phosphorus data that has been generated for Kahshe Lake. The first chart looks at the variability in the total phosphorus analytical results from the DMM sampling on Kahshe over the 28 year period from 1983 to 2011. It also shows the total phosphorus threshold level of 14.2 µg/L. When comparing older data to newer data, DMM staff caution that the following factors must be kept in mind:

- Prior to 2001 samples were analyzed by the MOE's main laboratory in Rexdale.
- In 2002, samples started to be analyzed in the MOE's Dorset laboratory and the analysis is 10x more precise. Duplicates also started to be taken.
- In 2003, water samples started to be filtered before they were analyzed to remove any sediment or other material that could influence the results.

As a result of these changes to the laboratory analysis program, the more current data has less variability than the older data. Some of this is likely due to better analytical methods and quality control. When DMM looks at historical data for a lake, they usually look at 2001 to present and before 2001.

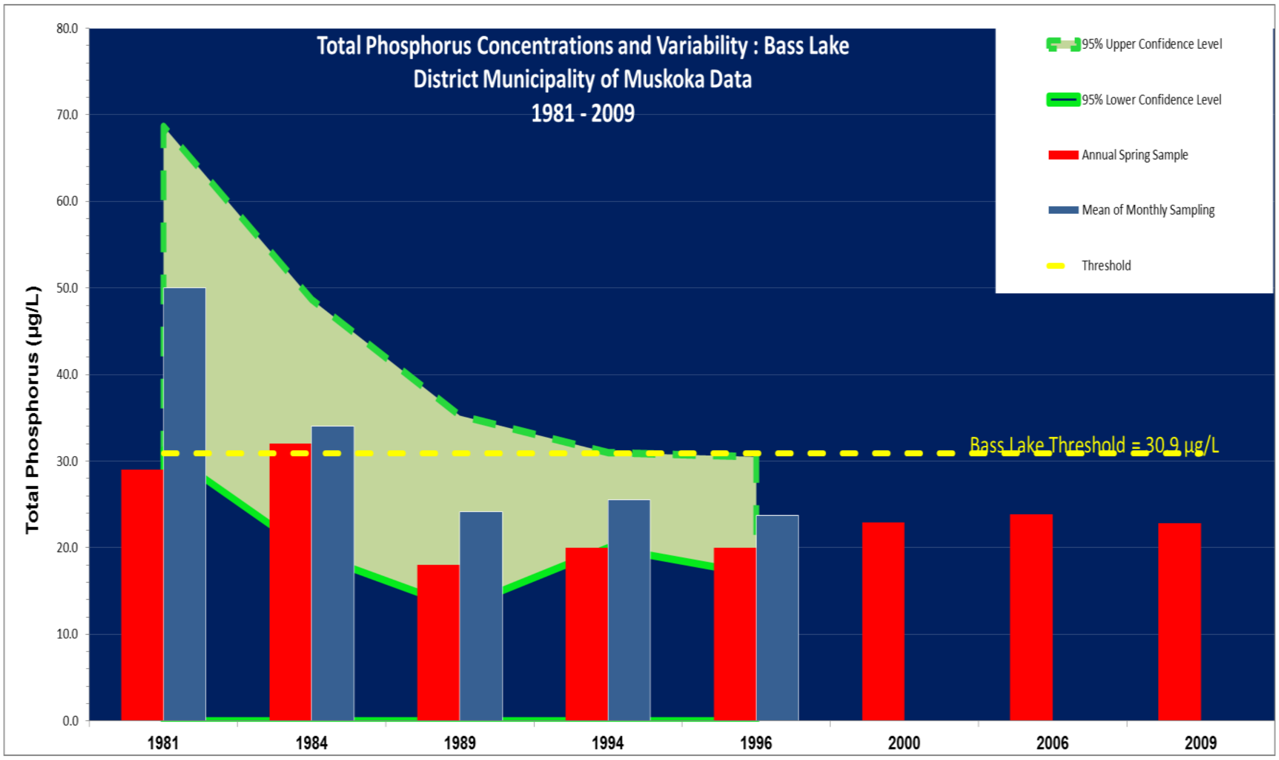
A tabular summary of the data used to prepare this chart can be found in Appendix Table B.



What does this tell us?

- To examine the variability in the total phosphorus data, the spring turnover results were plotted in red. The blue bars represent the average of monthly sampling results for the period up until 1996 when the DMM reduced their sampling to only the spring turnover time.
- The next step was to calculate the variability in the monthly data by via use of the 95% Upper and Lower Confidence Levels of the Confidence Interval.
- Statistically, there is a 95% level of probability (i.e. 95 times out of 100) that the mean of the population would fall between the upper and lower confidence limits.
- The upper and lower limits in total phosphorus values are shown in the green-shaded area.
- Although the statistical analysis could only be performed on the monthly data, these findings appear to be in line with the conclusions reached by the DMM using all total phosphorus sampling data (GLL, 2005a), where it was shown that there is approximately 40% variability in total phosphorus concentrations. This variability needs to be kept in mind in making any comparisons of data from Kahshe Lake with other lakes in our watershed.

The same type of analysis was then run on the total phosphorus data for Bass Lake (data in Appendix Table B) and the results are shown below:

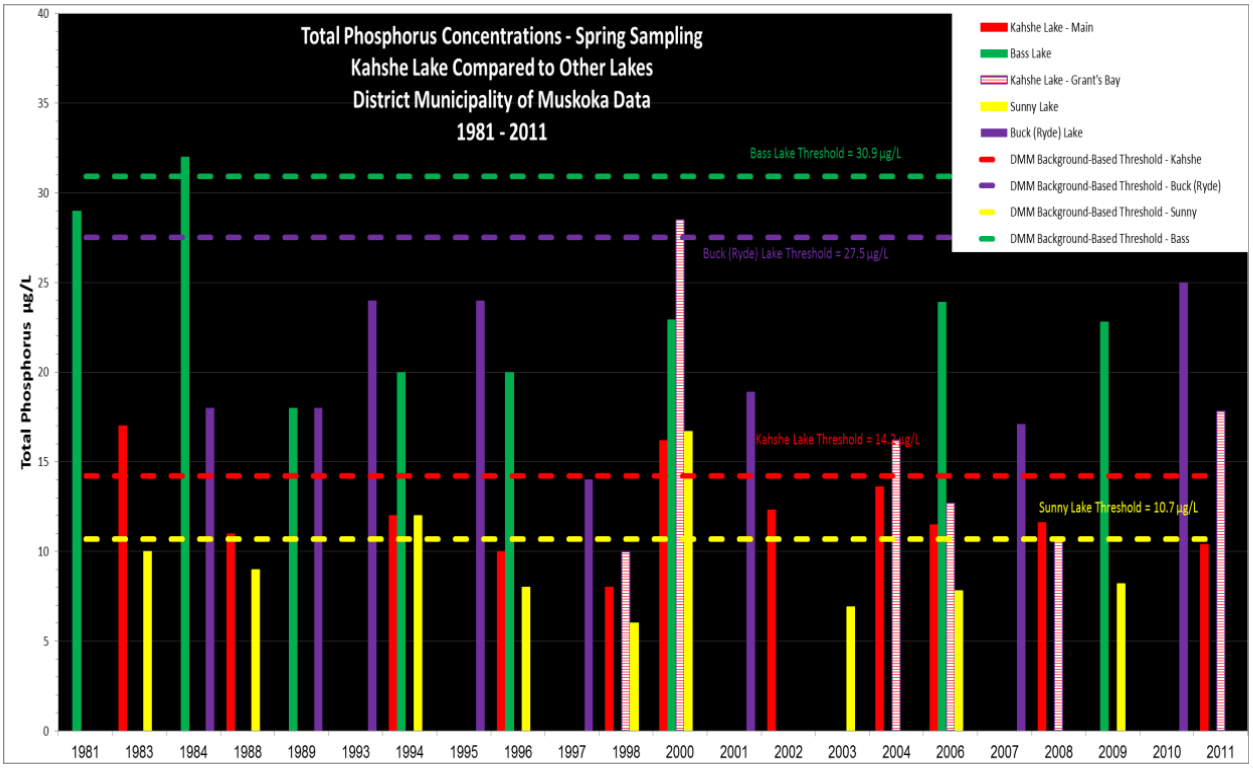


What does this tell us?

- As was the case for Kahshe Lake, there is a significant degree of variability in the Bass Lake data which also needs to be considered in making any comparisons with the total phosphorus concentrations from other lakes and over the sampling time period.
- Irrespective of this variability, it is apparent that that total phosphorus concentrations in Bass Lake are considerably higher than those in Kahshe Lake, and so too is the total phosphorus threshold (30.9 v. 14.2 µg/L).
- This is reflective of the fact that Bass Lake has a larger wetland area, and therefore, it has naturally higher levels of total phosphorus.

The final chart provides a better picture of how the total phosphorus concentrations and respective thresholds vary for the three additional lakes (Bass, Buck/Ryde and Sunny Lake) that have been examined.

A summary of the data used to prepare this comparative chart can be found in Appendix Table C.

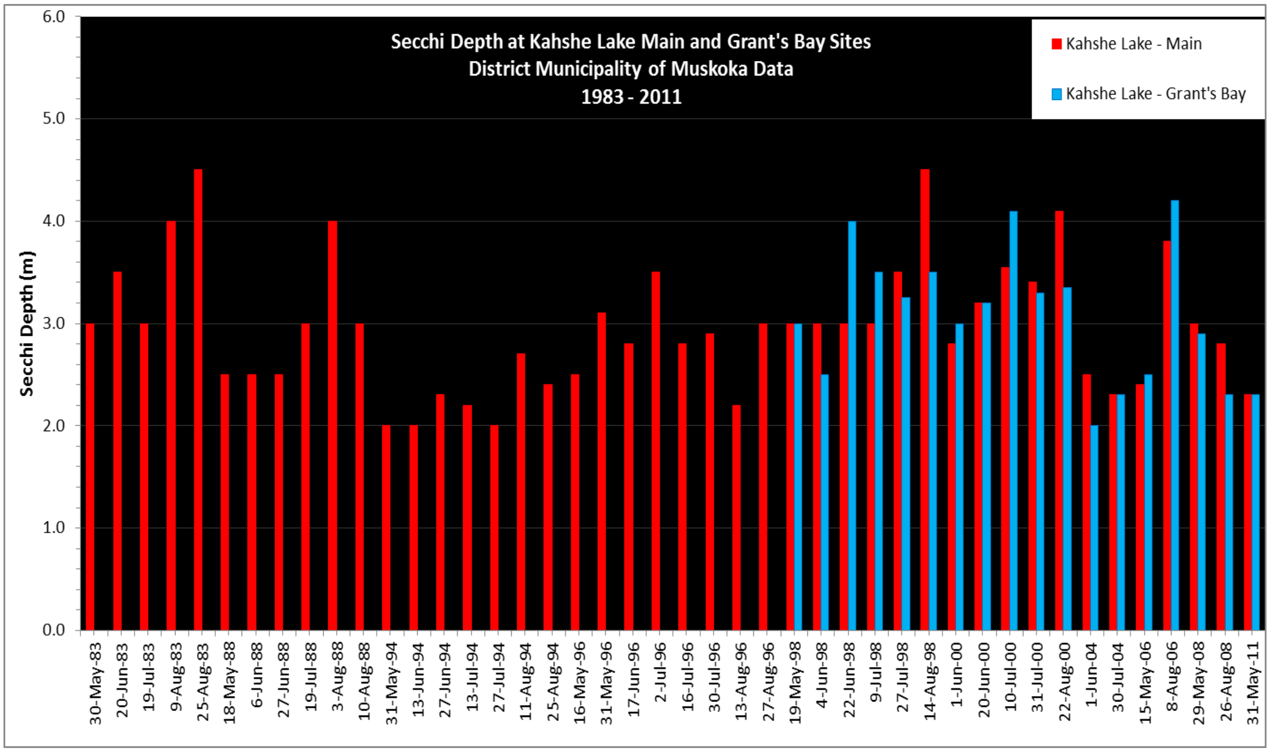


What does this tell us?

- This chart gives a better idea as to how the three up-gradient lakes compare in terms of their total phosphorus concentrations.
- The highest concentrations are found in Bass Lake, with decreasing concentrations in Buck(Ryde), Kahshe and Sunny Lakes.
- The total phosphorus thresholds also are reflective of these concentrations, as the thresholds range from just greater than 10 to over 30 µg/L.
- It should be noted that like Kahshe Lake, all three lakes are rated as being Moderate in terms of sensitivity to phosphorus input above natural background levels, and in all cases this is due to their fairly high sensitivity to mobility of the phosphorus associated with septic seepage through soil and overland flow/erosion which can result from shoreline disturbance.

4.1.2 Secchi Depth

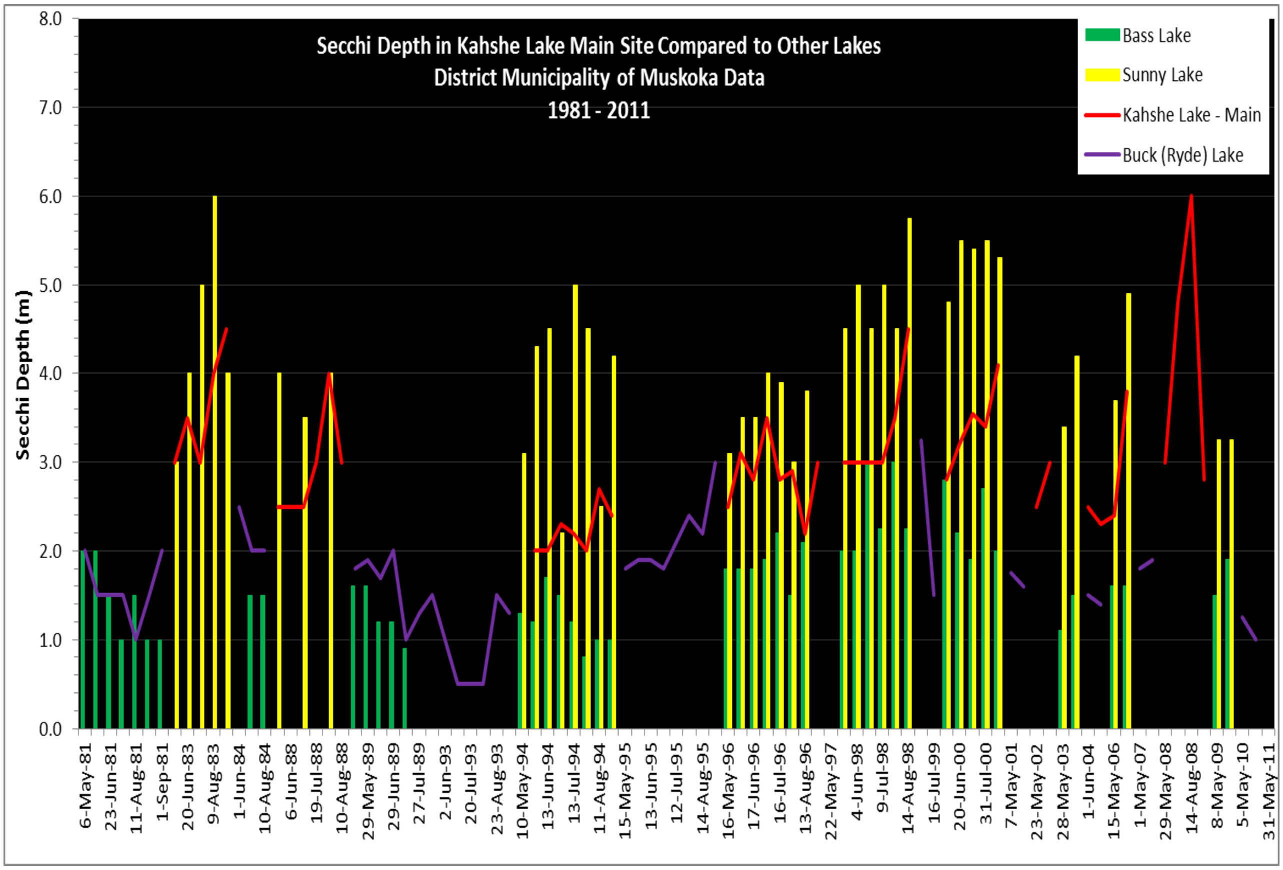
In the first chart, (data in Appendix Table E) the DMM data for the two sites on Kahshe Lake (Main and Grant's Bay) have been plotted over the period from 1983 to 2011. These are the same results as those found in the two DMM Kahshe Lake Data Sheets which were shown earlier, but they show how the two locations compare.



What does this tell us?

- Although Secchi depth measurements were not started in Grant's Bay until 1998, the results show that there is little difference in the Secchi depth over the period when both locations were measured.
- The results also show a fair amount of variability within each year and from year to year over this 28 year measurement history.

The next chart shows how Secchi depth in Kahshe Lake compares to the three other lakes. The full data set used in this chart can be found in Appendix Table F.



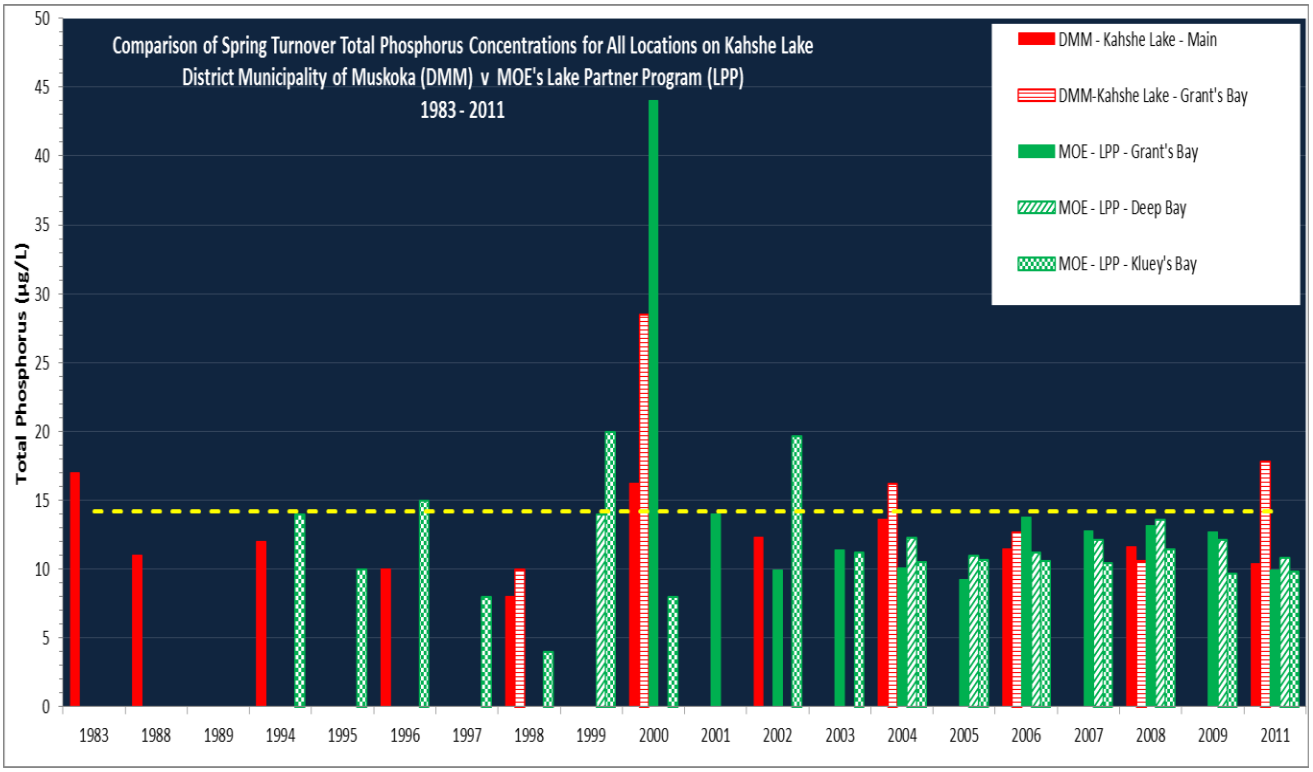
What does this tell us?

- The Secchi depth measurements have been displayed via column and line graphs in this chart to try and make it easier to carry out this comparison.
- While this chart is too busy to pull out any year to year variation, it does give a general picture that shows water clarity to be best (deepest Secchi disc value) in Sunny Lake and lowest in Bass and Buck (Ryde) Lakes, with Kahshe Lake coming in second in terms of clarity.
- These findings are in general agreement with the total phosphorus results, in that Sunny Lake had the lowest total phosphorus and highest clarity while Bass Lake had the highest total phosphorus and lowest water clarity.

4.2 How do DMM results for Kahshe Lake compare to results from MOE's Sampling Program?

4.2.1 Total Phosphorus

As both the DMM and MOE carry out total phosphorus sampling and analysis on Kahshe Lake, the next comparison looks at the results from both programs. The data are presented in Appendix Table D and are charted below:

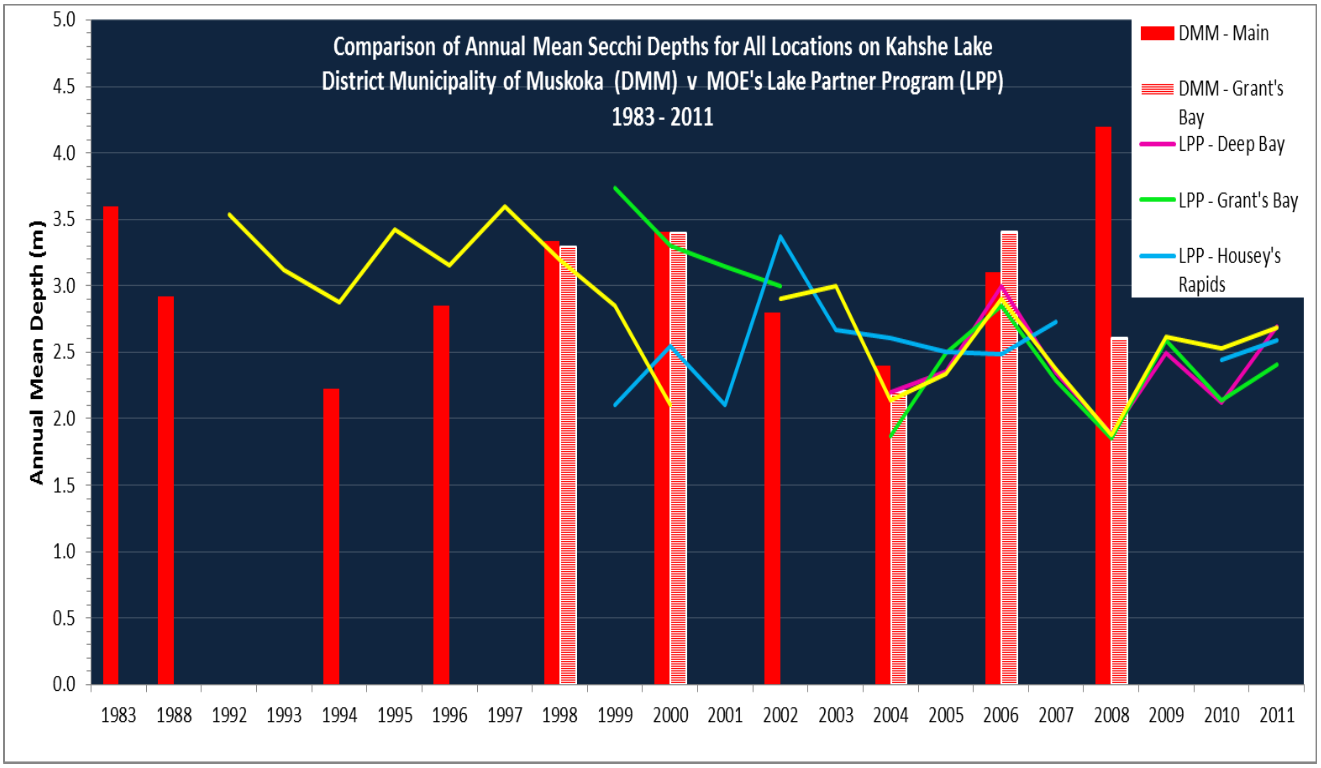


What does this tell us?

- In order to make this comparison of the results for the two sampling program, it was necessary to plot the findings from different types of data. In some cases, the MOE's LPP data represent annual ice-free average results, while in other cases, they represent concentrations for the spring sampling, as in those years, sampling was only conducted once a year.
- In the case of the DMM results, the values shown in the above chart are for the spring sampling period only. However, as shown in the two earlier charts for Kahshe Lake, the spring sampling results typically are representative of seasonal average concentrations.
- Keeping in mind the above differences in the data and the variability that exists within the total phosphorus database, it is apparent that when analysis results for similar sampling dates over the period from 1983 to 2011 are plotted, both programs appear to have generated similar results.
- Even in the year 2000, when all sampling results were elevated above typical findings, the two programs were similar, with the results for Grant's Bay being noticeably elevated.

4.2.2 Secchi Depth

As was the case for total phosphorus, the next comparison was between the Secchi depth results of the DMM and MOE programs. The data are presented in Appendix Table G. The MOE data for total phosphorus and Secchi depth measurements are presented in Appendix Tables P and Q.



What does this tell us?

- As for total phosphorus, the results of the two sampling programs (DMM Secchi depth shown as columns and the MOE's LPP measurements shown as lines) show a considerable degree of variability over the period from 1983 to 2011, but are in general agreement in most years, and on average, are in the range of 2.0 to 3.0 m in depth.

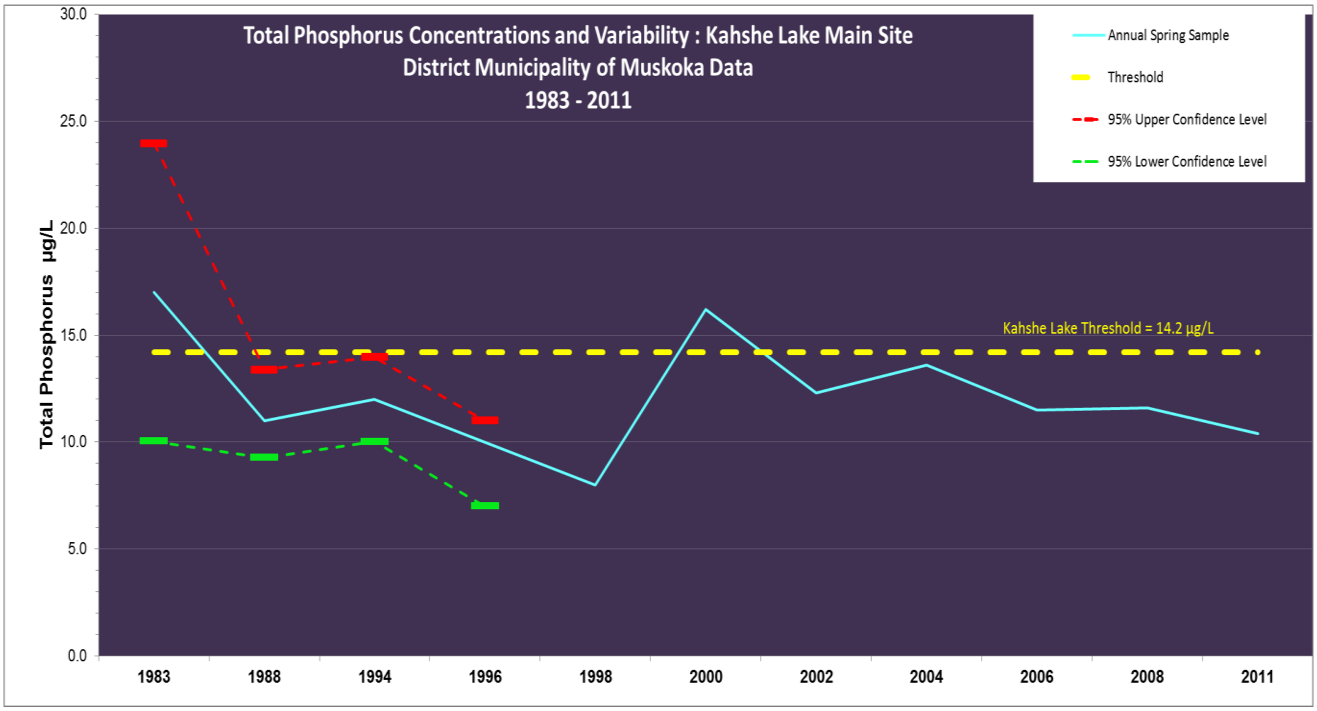
4.3 How do DMM results for Kahshe Lake compare to results of time-trend and predictive relationship analysis based on the full set of Muskoka data?

4.3.1 Total Phosphorus Time-Trend Analysis

This section attempts to determine if the DMM findings from sampling carried out on Kahshe Lake over the past 25 years are showing any 'big picture' trends over time or predictive relationships similar to those that have been found in more intensive research publications/presentations using the entire Muskoka dataset.

However, because of the complexity of the analyses that have been completed in the research studies which are listed in Section 4.0, the analysis was limited to an examination of trends in total phosphorus concentrations, as this is the parameter of greatest concern due to its relationship with water quality impacts due to lake enrichment.

So how do the findings on Kahshe Lake compare with the long term trend analysis carried out by Palmer (2012) and Somers et al. (2009)? The chart below provides some insight on how total phosphorous concentrations in Kahshe Lake have trended over time.



What does this tell us?

- Both of the research studies which used data from all Muskoka lakes concluded that there has been a gradual decrease in total phosphorus concentrations over time. This trend was also substantiated in a more intensive study carried out by the MOE on nine lakes in Muskoka, where sampling was carried out over an almost 30 year period, commencing in the mid-1970s.

- Although the results from Kahshe Lake, which are shown above for the period from 1983 to 2011 have too much variability to confirm that a similar pattern of decreasing total phosphorus concentrations is occurring in Kahshe Lake, this is not unexpected, as the larger data sets available to evaluate long term changes would have a much higher power of analysis.

- However, based on the results for Kahshe Lake, it is encouraging to note that total phosphorus concentrations are definitely not increasing, and with continued analysis, it may be possible to confirm that total phosphorus concentrations are decreasing as in other Muskoka lakes.

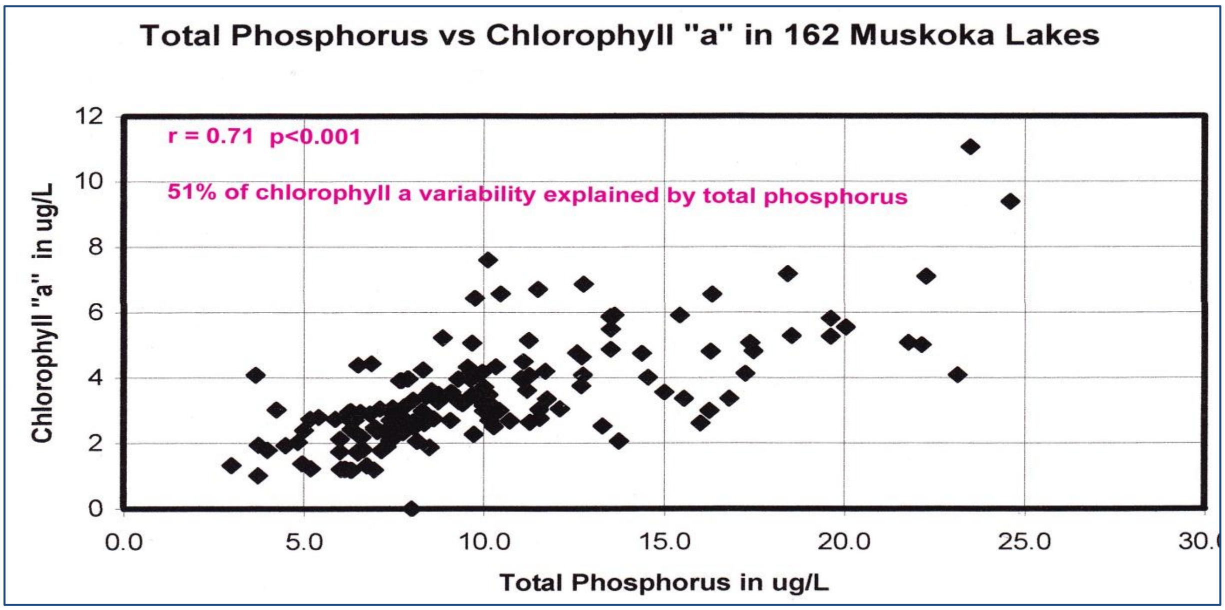
4.3.2 Predictive Relationship Analysis for Total Phosphorus

As was indicated in the earlier findings, the key predictor of the potential for algal blooms and impacts on water clarity is the total phosphorus concentration as measured in the spring after turnover in the fall and before temperature-based stratification takes place.

If this hypothesis is true, then there should be a relationship between total phosphorus and chlorophyll "a", the main pigment associated with algal growth.

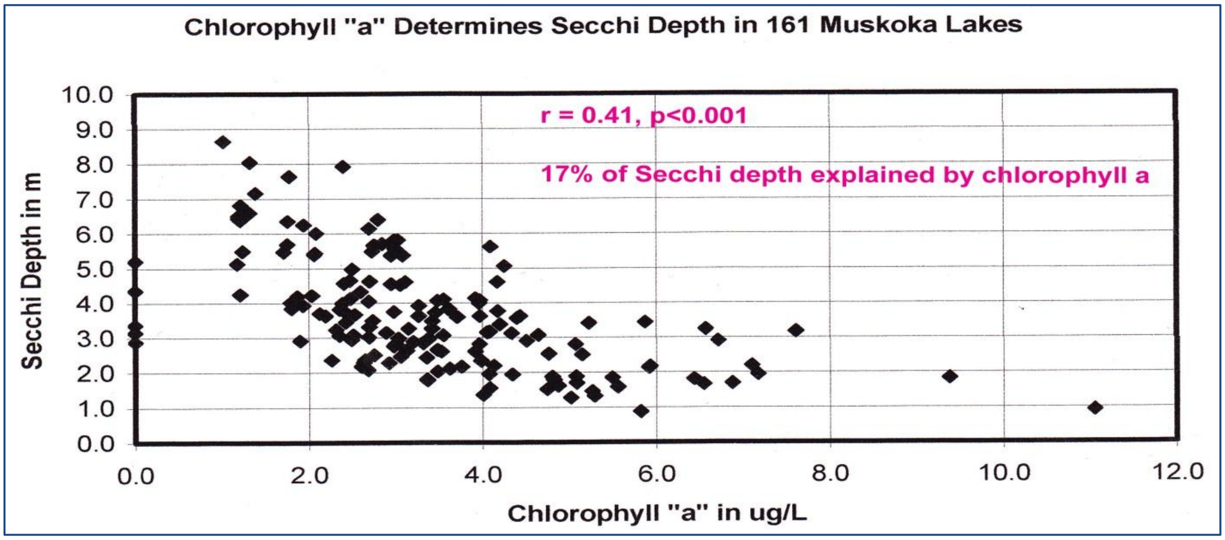
If both of these hypotheses are true, then water clarity as measured via the Secchi depth readings also should be correlated with both total phosphorus and chlorophyll "a" measurements. In other words, as total phosphorus concentrations increase, there should be an increase in chlorophyll "a" (green pigmentation) and a decrease in Secchi depth reflecting a reduction in water clarity.

These relationships were explored by the DMM (GLL, 2005) during the most recent evaluation of the water quality model parameters and indeed, using the DMM data up to 2005 the authors did find statistically significant relationships between all of these parameters when the data were expressed as long term means for all lakes. Based on these relationships, the regression charts developed via use of the entire Muskoka lakes database as published in GLL, 2005, are shown below.



What does this tell us?

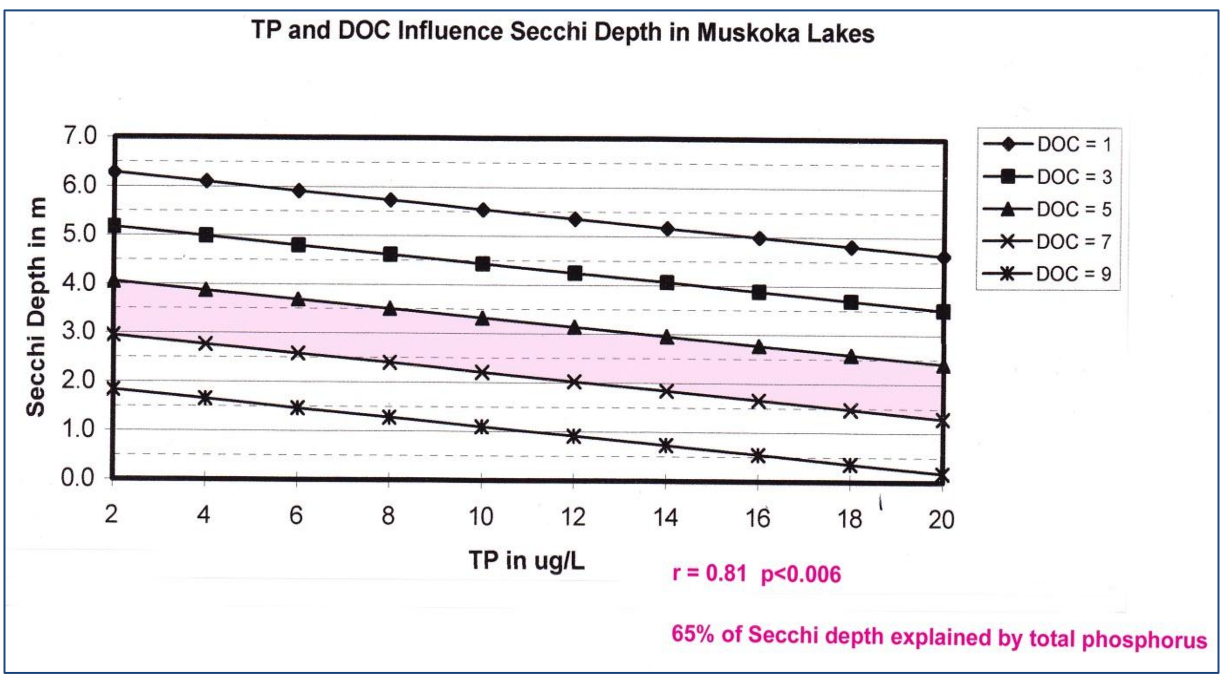
- In the case of total phosphorus and chlorophyll "a", the relationship was positive (higher concentrations of total phosphorus resulted in higher concentrations of chlorophyll "a" which were statistically significant;
- However, the explanatory power of this relationship was not strong, with only 51% of the variability in chlorophyll "a" being explained by concentrations of total phosphorus in the water.



What does this tell us?

- In the second chart, again the relationship between chlorophyll "a" and Secchi depth was statistically significant (and negative) as would be expected: however, the explanatory power was very weak, with only 17% of the variability in Secchi depth being explained by chlorophyll "a" concentrations.

The third chart is the most interesting from a predictive aspect, as it evaluates the direct relationship between total phosphorus and Secchi depth.



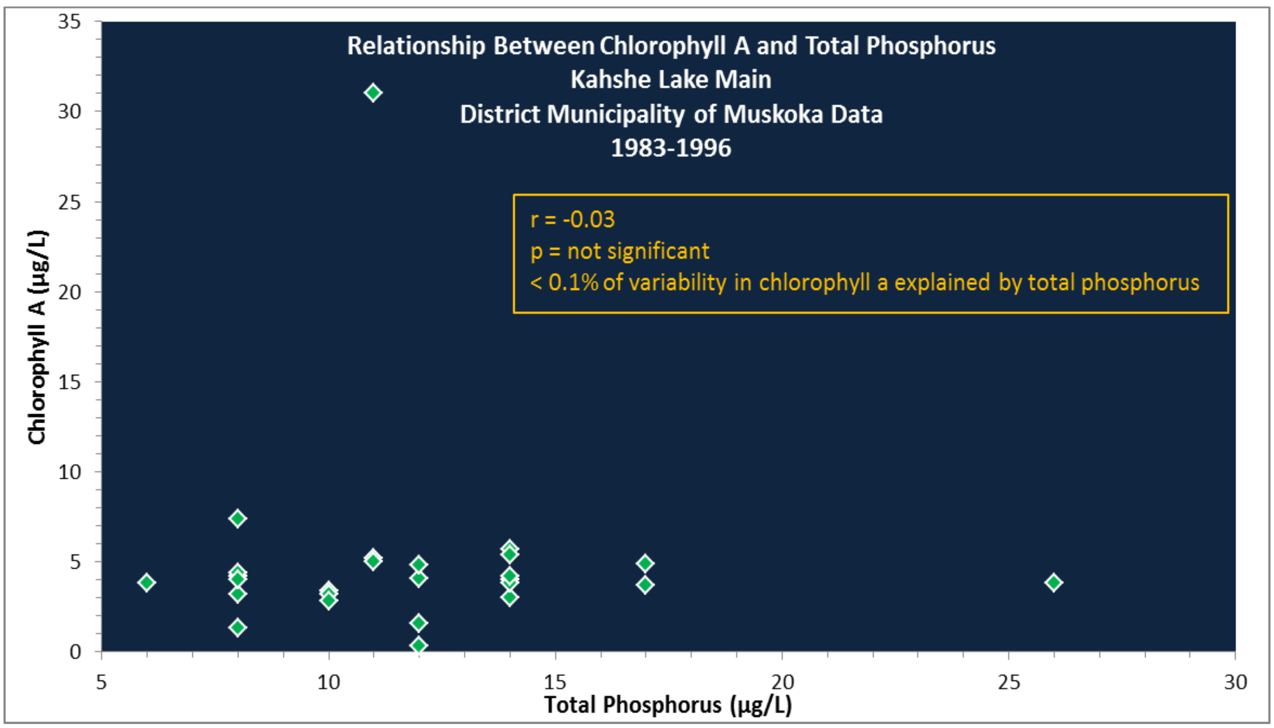
What does this tell us?

- To evaluate this most important relationship, a multiple linear regression was used with dissolved organic carbon (DOC) being added as a contributing factor along with total phosphorus.
- This resulted in an "r" value of 0.81, with a much improved 65% of the variability in Secchi depth being explained by total phosphorus when DOC was factored in.
- The chart highlights the trend-lines for DOC values between 5 and 7 mg/L, as that's the range of DOC concentrations in Kahshe Lake.

Based on these findings, the Kahshe Lake data that was available from DMM was selected to run similar correlation and regression analyses to see if any of these statistical relationships using data from all Muskoka lakes were being seen in Kahshe Lake data.

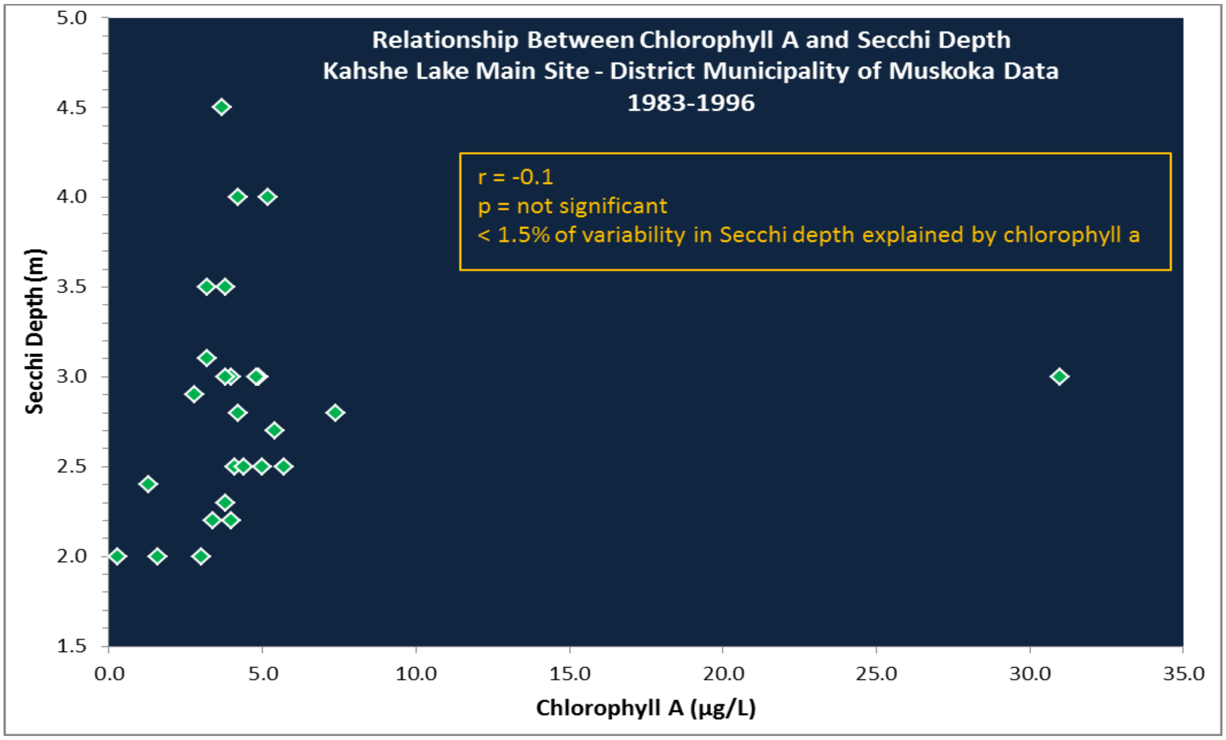
The results are presented in the charts that follow in the same order as those presented above for the overall DMM data set for all Muskoka lakes.

The data used in running these comparisons as well as the correlation and regression statistics are shown in Appendix Tables H, I and J.



What does this tell us?

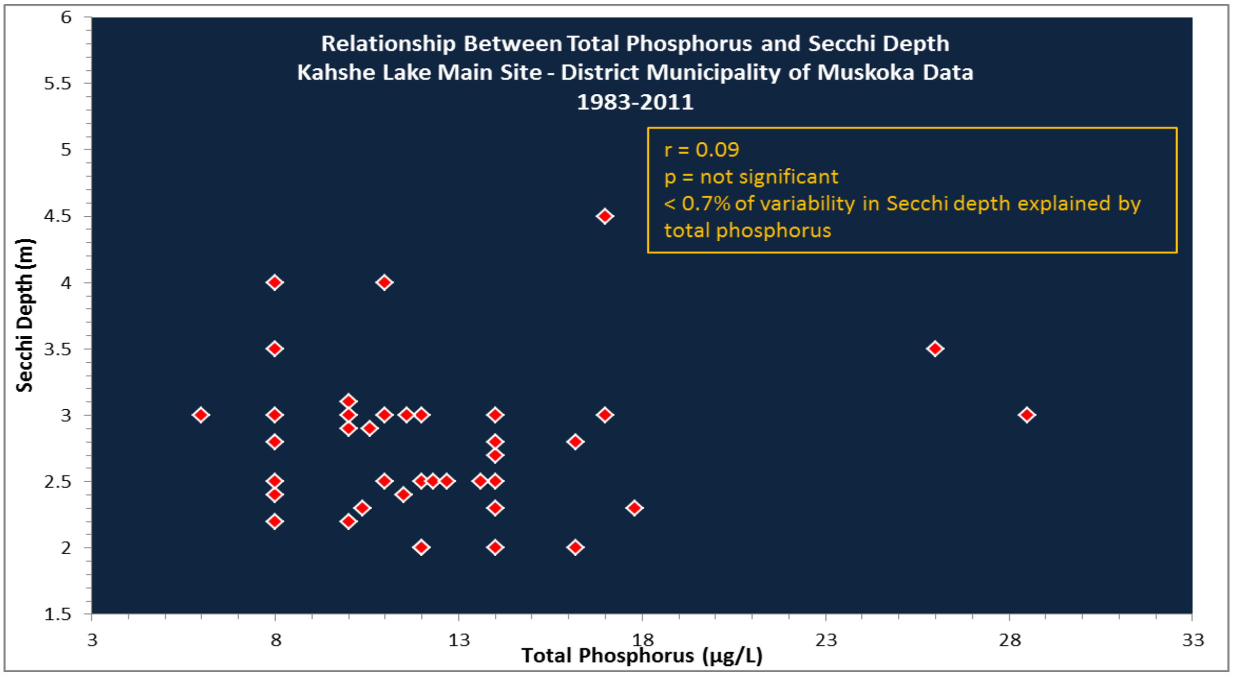
- Using paired total phosphorus and chlorophyll “a” data for the period from 1983 to 1996, when the DMM stopped measuring for chlorophyll “a”, there was no significant relationship between these two parameters.
- In other words, total phosphorus concentrations were not a predictor of green pigmentation of Kahshe Lake water.



What does this tell us?

- Using paired chlorophyll “a” and Secchi depth data for the period from 1983 to 1996, when the DMM stopped measuring for chlorophyll “a”, there was no significant relationship between these two parameters.
- In other words, the degree of green pigmentation of the water had no impact on water clarity as determined by Secchi depth measurements.

And finally:



What does this tell us?

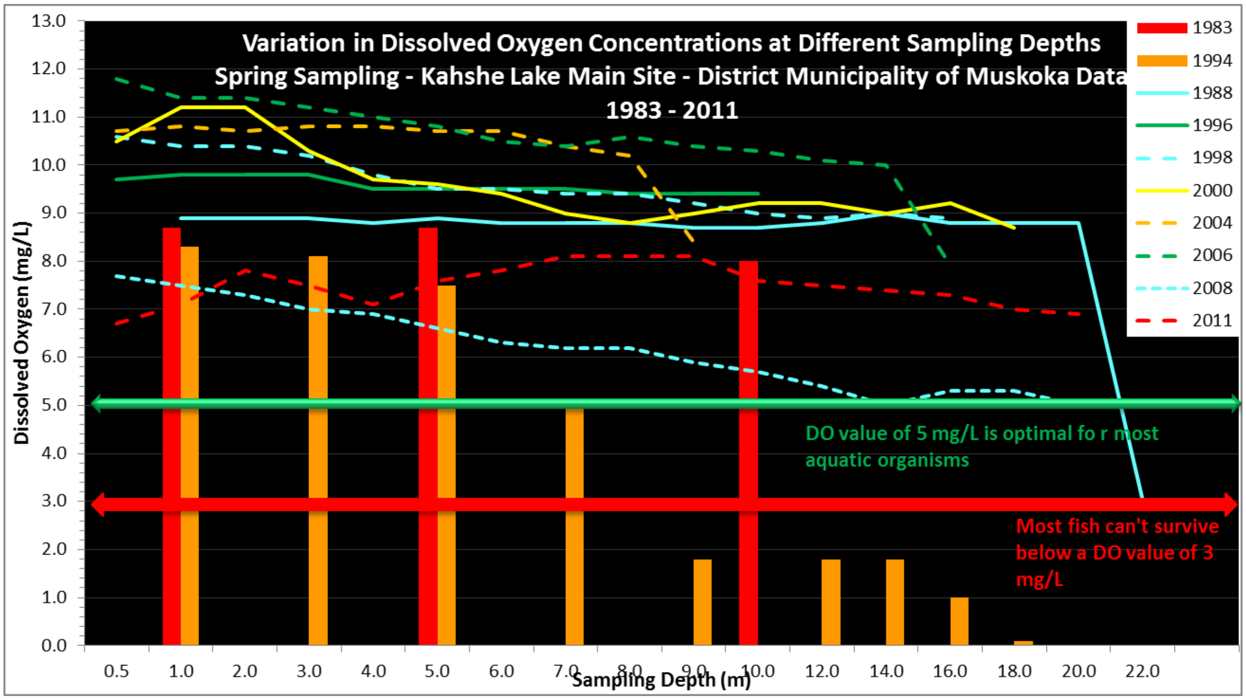
- Using paired total phosphorus and Secchi depth data for the 29 year period from 1983 to 2011, there was no significant relationship between these two parameters.
- In other words, total phosphorus concentrations have had no detectable negative impact on Kahshe Lake water clarity.

4.3.3 Dissolved Oxygen and Water Temperature Relationships

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

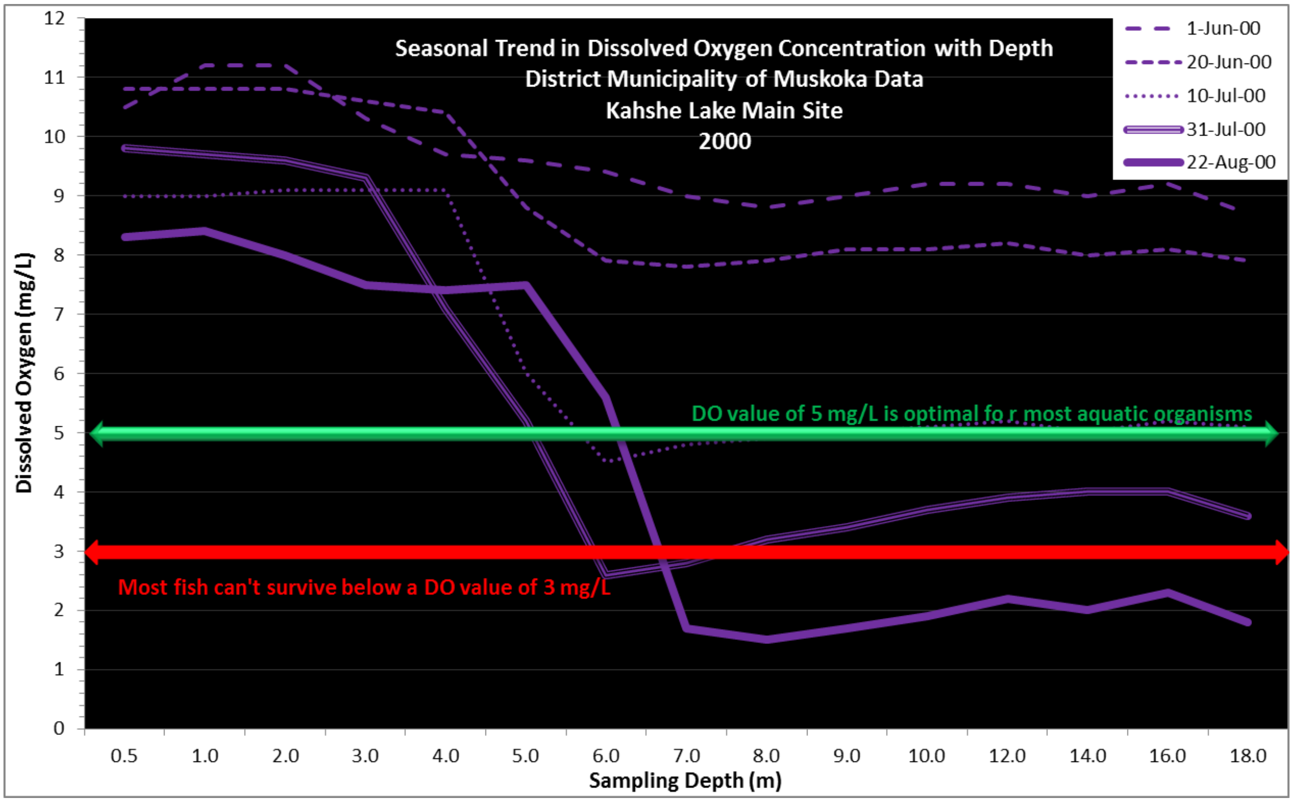
To give some additional perspective on this parameter beyond the information that was presented earlier as part of the 2011 data sheet material from the DMM, an analysis was undertaken by examining the data over the period from 1983 through 2011 to see if there has been any noticeable change in DO concentrations, especially in the deeper horizons, where oxygen is critical to the survival of bottom dwelling organisms. The data for this chart are presented in Appendix Table K.



What does this tell us?

- Although two types of plots (columns and lines) had to be used in order to display this amount of information on one chart, keep in mind that this has only been done to make it easier to see the trends.
- It is apparent from the above chart that in almost all years for which DO has been analyzed, the spring turnover concentrations have been well above the optimal level for aquatic organisms.
- The only exceptions have occurred in 1994, when optimal levels were not met at depths below 7 m.
- DO also fell below the level of 3 mg/L at depths below 9 m in 1994.

Within-year variation in DO concentrations also was evaluated at increasing lake depths, to determine how low DO levels fall as the year progresses, and the lake starts to thermally stratify. The most recent year with sampling data was 2000, when sampling from depths of 0.5 down to 18 m was carried out from early June through August. These results are shown in the chart below and the data are presented in Appendix Table K (continued).

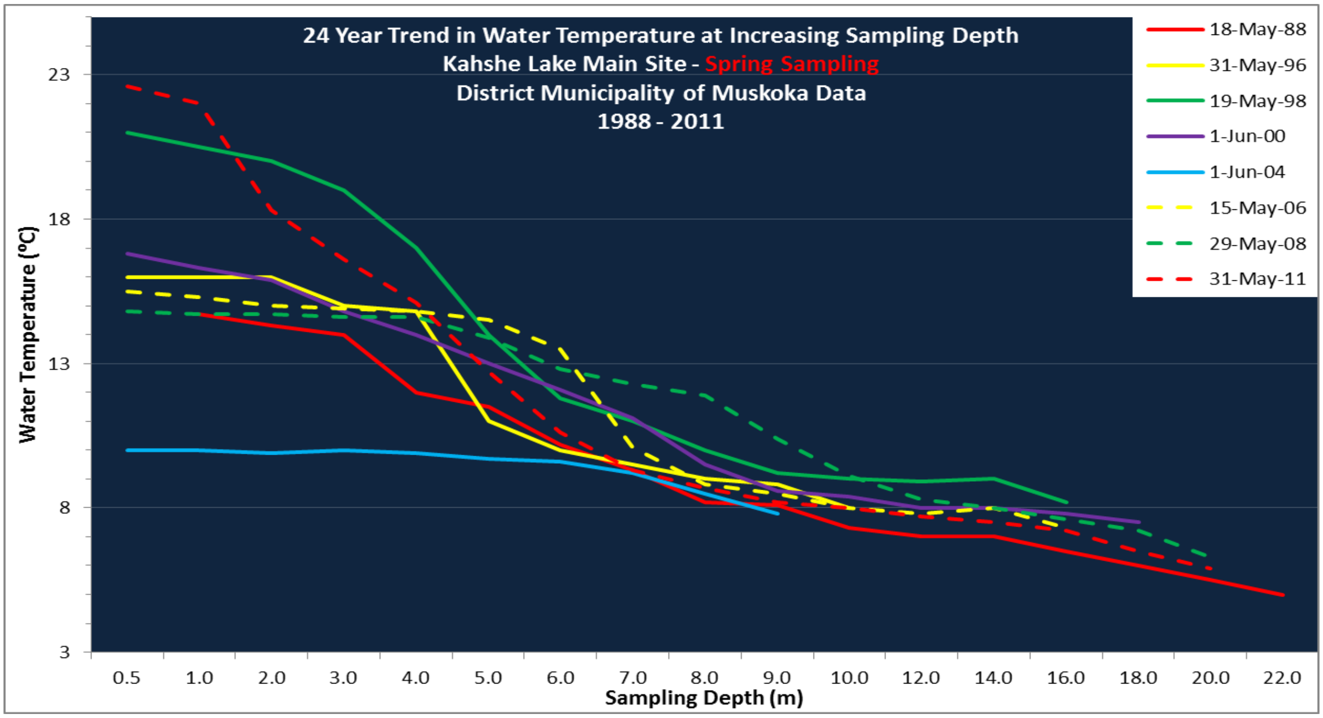


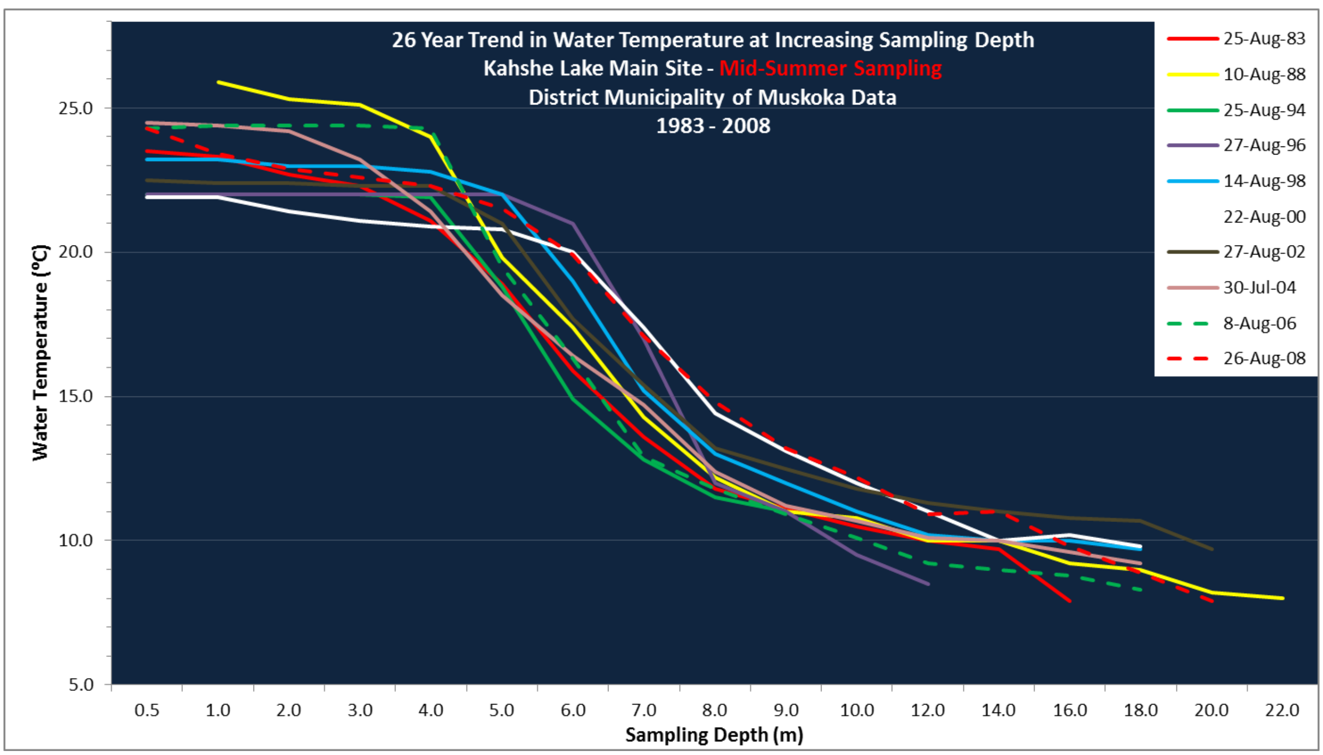
What does this tell us?

- Based on the results for sampling throughout the season in 2000, it is apparent that as the lake stratifies into different temperature layers, the dissolved oxygen in lower depths decreases quite dramatically, especially as depths drop below 4-5 m.
- However, with the exception of the sampling carried out after the end of July, the DO concentrations in the lower depths remains above the level that is optimal for most aquatic organisms.

As for DO, water temperature at increasing depths has been monitored on Kahshe Lake by DMM since the 1980s. Up until 2008, these measurements were taken at least twice during the spring and summer season and in several cases, at monthly intervals. However, in 2011, the water temperature readings were taken only in May.

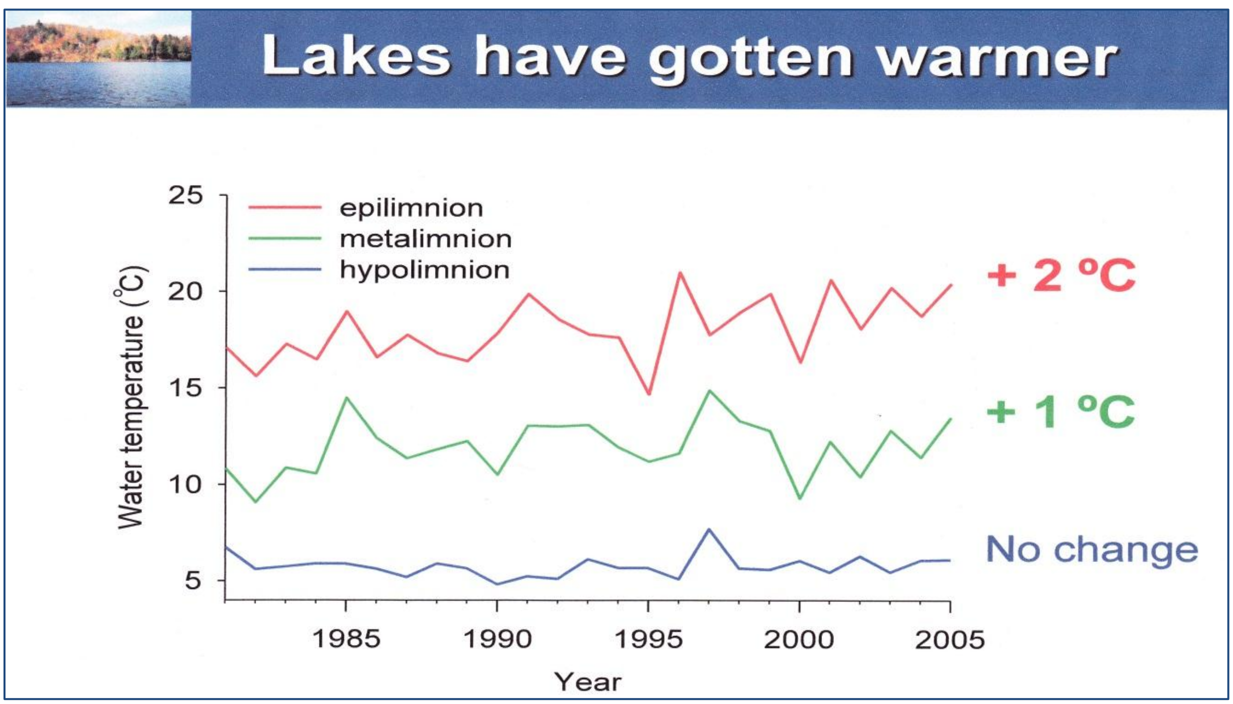
The two charts below show how water temperatures have varied over the 24-26 year period for the spring sampling event as well as the mid-summer sampling in August where data was available. The data for the spring and mid-summer readings are presented in Appendix Tables L and M, respectively.


24 Year Trend in Water Temperature at Increasing Sampling Depth
Kahshe Lake Main Site - Spring Sampling
District Municipality of Muskoka Data
1988 - 2011
Water Temperature (ºC)
Sampling Depth (m)
18-May-88
31-May-96
19-May-98
1-Jun-00
1-Jun-04
15-May-06
29-May-08
31-May-11


26 Year Trend in Water Temperature at Increasing Sampling Depth
Kahshe Lake Main Site - Mid-Summer Sampling
District Municipality of Muskoka Data
1983 - 2008
Water Temperature (ºC)
Sampling Depth (m)
25-Aug-83
10-Aug-88
25-Aug-94
27-Aug-96
14-Aug-98
22-Aug-00
27-Aug-02
30-Jul-04
8-Aug-06
26-Aug-08

What does this tell us?

- In each chart, the coloured lines have been displayed in a manner that depicts the earliest sampling as a solid red line and the most recent data as a dashed red line.
- What this appears to indicate is a possible warming trend in the upper 4 m of the water column during the spring turnover sampling event.
- By mid-summer, this trend was not apparent, as the variability in the data appears fairly consistent from the surface down to the lower, cooler water levels.
- To further explore this apparent warming effect, the findings presented in two water quality lectures given by Dr. M. Palmer (Palmer, 2012) and by Somers et al. (2009) were evaluated.
- In both presentations, based on statistical analysis of larger sets of Muskoka lake data and on a more intensively monitored group of nine lakes evaluated continuously by the MOE since the mid-1970s, a warming effect has been confirmed in the epilimnion (upper 5 m of the water column), and to a lesser degree in the metalimnion.
- In the Palmer study, about 57% of the variance in water temperature was explained by air temperatures. The chart below has been taken directly from the 2012 Palmer presentation.



Source: M. Palmer, 2012

4.4 Can any conclusions be drawn based on the results of a large suite of chemical parameters that have been analyzed by DMM over the past 6-8 years but not included in the Year-End report?

The DMM has analyzed water samples for a much larger suite of chemical and physical parameters than those that are routinely reported in their year-end and data sheet summaries each year.

In a few cases, the substances analyzed in lake water samples from Kahshe and other Muskoka lakes were included in the long term analysis presentations by Palmer (2012) and Somers et al. (2009), so in those cases, the findings from this suite of non-nutrient analyses have been assessed for the combined Muskoka lakes dataset. However, this still left a large number of chemical and physical substances/parameters that have been analyzed but which have not been evaluated for long term trends nor for their potential to impact lake quality. The data for Kahshe Lake and the three other lakes within the Kahshe Lake sub-watershed are presented in Appendix Table A.

As this information has not been interpreted by the DMM, this report attempts to do this by comparing the results for all years for which data exist to surface water benchmarks that are available from the MOE or other regulatory agencies. A brief description of the benchmarks which have been used and what they're designed to protect follows:

- For the anions and cations and other parameters included in the DMM dataset, the findings have been compared to currently available aquatic protection values (APVs) used by the Ontario MOE (MOE, 2011). These values represent the highest concentration of a contaminant in surface water to which an aquatic community can be exposed indefinitely without resulting in an adverse impact.

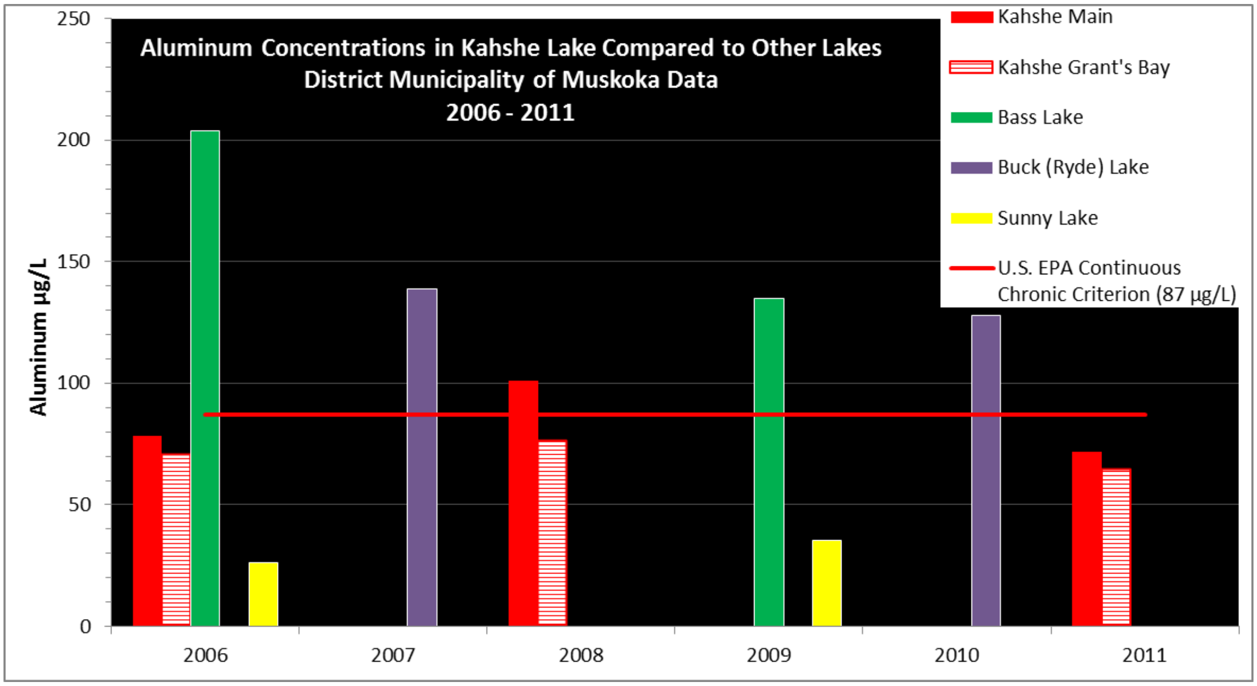
- In cases where an MOE APV was not available, a similar format to the one used by the MOE in protecting surface water from ground water discharges associated with contaminated sites (*O. Reg. 153/04* as amended) has been followed. This involved first checking for a U.S. EPA chronic ambient water quality criterion (based on a continuous chronic criterion, (U.S. EPA, 2012; U.S. EPA, 1986));

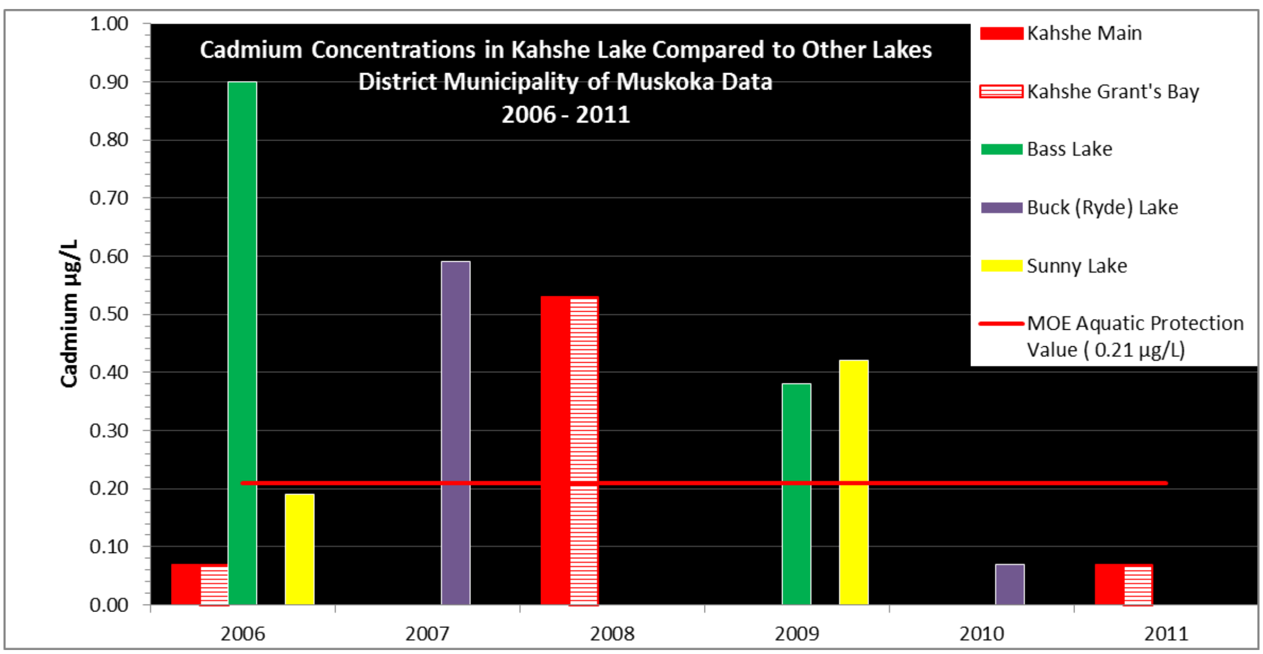
- If neither of these sources had a value, a Canadian Water Quality Guideline (CCME, 2012), a B.C. Ambient Water Quality Criterion (B.C. 2000; B.C. 2001) or a U.S. EPA Tier-II Secondary Chronic Value (Suter II and Tsao, 1996) has been used.

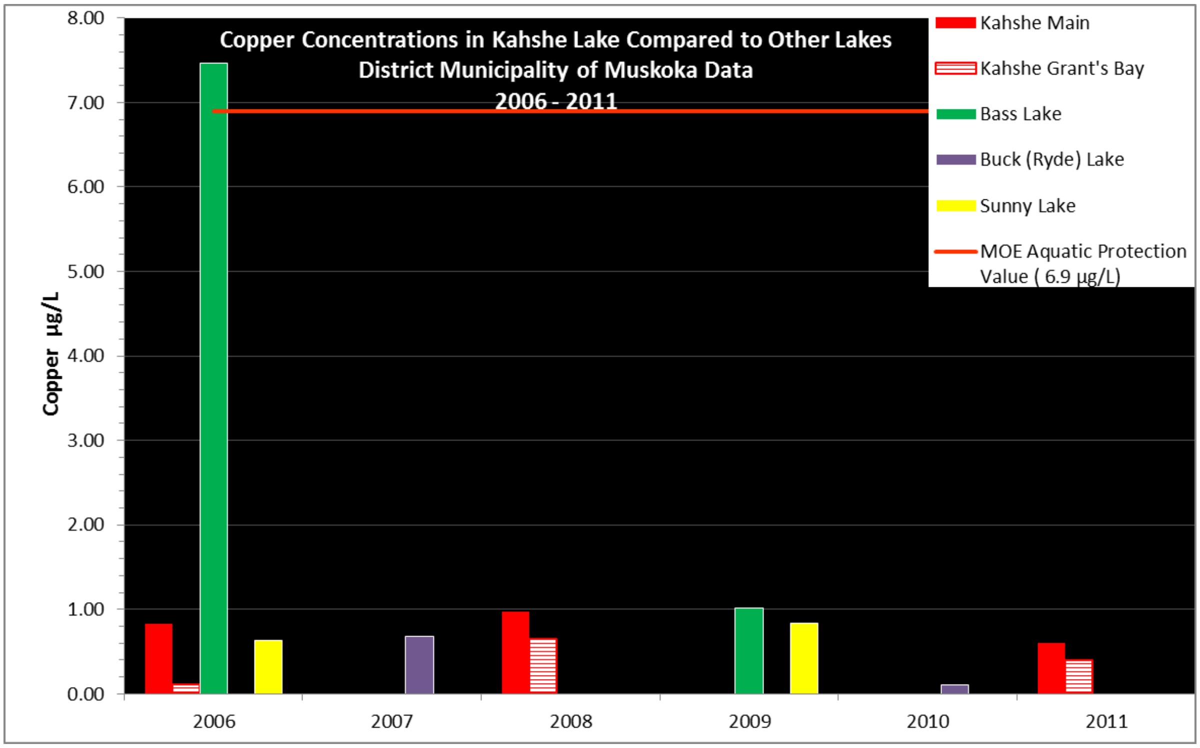
- In all cases, the surface water protection provided via these benchmarks is for <u>long term exposure to concentrations that are considered chronic</u>, as opposed to short-term protection against acute effects.

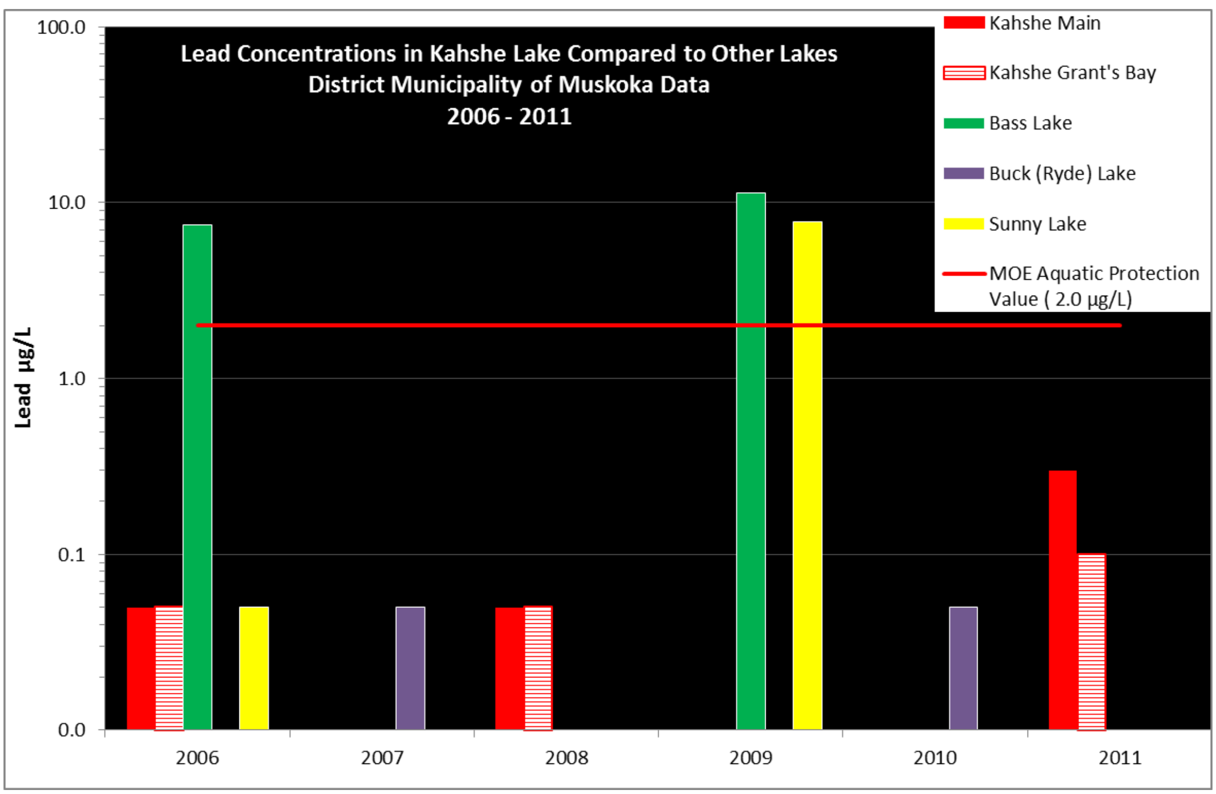
The charts for four of the full suite of chemical parameters in which the relevant surface water protection benchmark was exceeded in water collected from one or more of the four lakes examined are presented as Group 1 below.

Separate data tables for these and all other parameters that have been charted for comparison purposes can be found in Appendix Table N.


Aluminum Concentrations in Kahshe Lake Compared to Other Lakes
District Municipality of Muskoka Data
2006 - 2011
Aluminum µg/L
250
200
150
100
50
0
2006
2007
2008
2009
2010
2011
Kahshe Main
Kahshe Grant's Bay
Bass Lake
Buck (Ryde) Lake
Sunny Lake
U.S. EPA Continuous Chronic Criterion (87 µg/L)


Cadmium Concentrations in Kahshe Lake Compared to Other Lakes
District Municipality of Muskoka Data
2006 - 2011
Cadmium µg/L
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
2006
2007
2008
2009
2010
2011
Kahshe Main
Kahshe Grant's Bay
Bass Lake
Buck (Ryde) Lake
Sunny Lake
MOE Aquatic Protection Value (0.21 µg/L)


Copper Concentrations in Kahshe Lake Compared to Other Lakes
District Municipality of Muskoka Data
2006 - 2011
Copper µg/L
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
2006
2007
2008
2009
2010
2011
Kahshe Main
Kahshe Grant's Bay
Bass Lake
Buck (Ryde) Lake
Sunny Lake
MOE Aquatic Protection Value (6.9 µg/L)


Lead Concentrations in Kahshe Lake Compared to Other Lakes
District Municipality of Muskoka Data
2006 - 2011
Lead µg/L
100.0
10.0
1.0
0.1
0.0
2006
2007
2008
2009
2010
2011
Kahshe Main
Kahshe Grant's Bay
Bass Lake
Buck (Ryde) Lake
Sunny Lake
MOE Aquatic Protection Value (2.0 µg/L)

What does this tell us?

Based on these comparisons using data from Kahshe, Bass, Buck (Ryde) and Sunny Lakes, a few potential issues are apparent with the water quality data that has been generated by the DMM for aluminum, cadmium, copper and lead.

- As shown in the charts above, the quality of the water in one or more of the four lakes in these figures exceeds the relevant surface water aquatic protection value.

- In the case of aluminum, there is unlikely to be an adverse effect, as aluminum toxicity to aquatic organisms is very complex and the benchmark from the U.S. EPA is somewhat dated and has not been updated due to the complexity of aluminum toxicity in water and its relationship with several other substances.

- In the case of cadmium, most of the measured concentrations exceed the MOE's APV of 0.21 µg/L. Based on these findings, the DMM asked the water quality scientists at the MOE’s Dorset facility to examine the results, and it was their opinion that this is a sample contamination problem. As a result, the DMM are now looking into methods to improve the sampling procedure. It is also noted here that the current Canadian Water Quality Guideline (CWQG) for cadmium is 0.017 µg/L, but is in the process of being revised. The proposed new CWQG also is linked to water hardness, and based on Kahshe Lake’s very low hardness values of 4-5 mg/L calcium carbonate equivalents, the CWQG would be set at a lower limit of 0.04 µg/L, a value that is even lower than the MOE’s APV of 0.21 µg/L .

- If we look only at the Kahshe Lake cadmium data, it is apparent that only one year (2008) was elevated above the MOE’s APV and normal values were encountered before and after 2008. This pattern also is indicative of a laboratory or sampling artifact. In follow-up correspondence with the staff at DMM and the MOE, caution has been stressed in placing too much confidence in the data for cadmium and other parameters in this dataset due to the likelihood that the concentrations are simply artifacts of some form of contamination of the samples during the sampling or laboratory analysis. The MOE recommends that it is best to rely only on the findings for aluminum, manganese, iron and zinc.

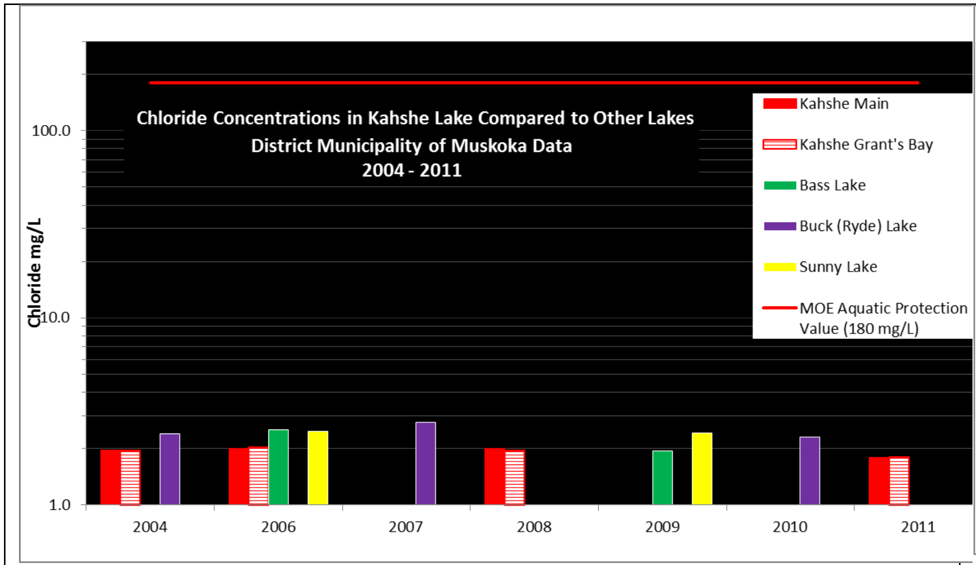
- In the case of copper, the one exceedance of the MOE’s APV in Bass Lake appears to be a laboratory or sampling anomaly, as all other sampling results are well below the APV value.

- The results for lead appear similar to those for copper, and also are likely to have been caused by sampling or analytical error.

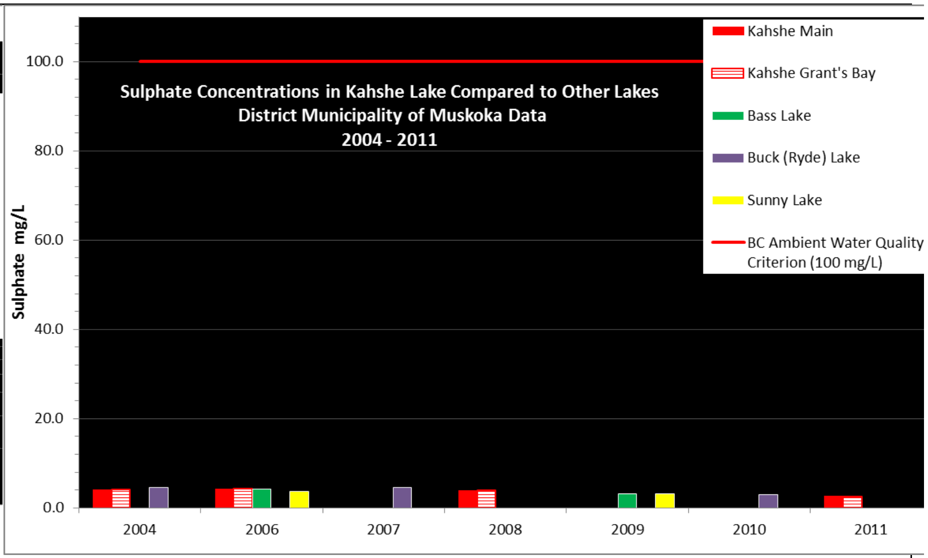
The second group of substances which have been charted include those that appeared in either the Palmer (2012) or Somers et al. (2009) presentations as chemicals that have been evaluated via analysis of the entire Muskoka lakes dataset to examine the possibility that changes are occurring over time.

They include chloride, calcium, sulphate and pH.

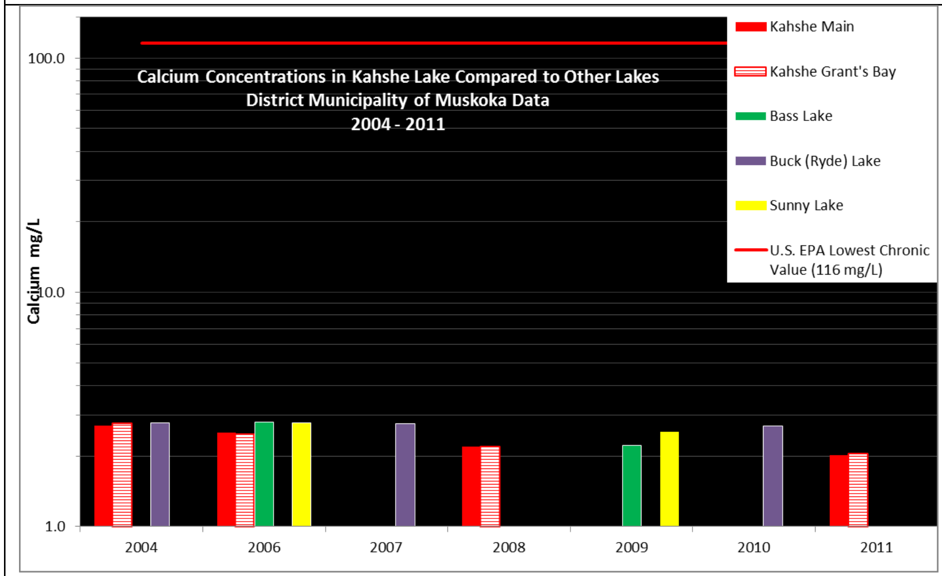
Group 2



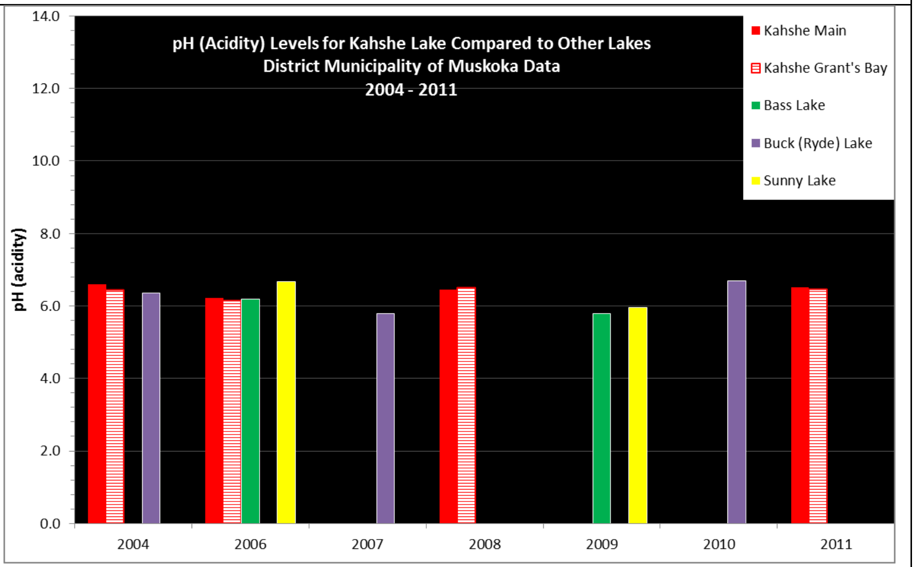
Chloride Concentrations in Kahshe Lake Compared to Other Lakes
District Municipality of Muskoka Data
2004 - 2011
Chloride mg/L
100.0
10.0
1.0
2004
2006
2007
2008
2009
2010
2011
Kahshe Main
Kahshe Grant's Bay
Bass Lake
Buck (Ryde) Lake
Sunny Lake
MOE Aquatic Protection Value (180 mg/L)



Sulphate Concentrations in Kahshe Lake Compared to Other Lakes
District Municipality of Muskoka Data
2004 - 2011
Sulphate mg/L
100.0
80.0
60.0
40.0
20.0
0.0
2004
2006
2007
2008
2009
2010
2011
Kahshe Main
Kahshe Grant's Bay
Bass Lake
Buck (Ryde) Lake
Sunny Lake
BC Ambient Water Quality Criterion (100 mg/L)



Calcium Concentrations in Kahshe Lake Compared to Other Lakes
District Municipality of Muskoka Data
2004 - 2011
Calcium mg/L
100.0
10.0
1.0
2004
2006
2007
2008
2009
2010
2011
Kahshe Main
Kahshe Grant's Bay
Bass Lake
Buck (Ryde) Lake
Sunny Lake
U.S. EPA Lowest Chronic Value (116 mg/L)



pH (Acidity) Levels for Kahshe Lake Compared to Other Lakes
District Municipality of Muskoka Data
2004 - 2011
pH (acidity)
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
2004
2006
2007
2008
2009
2010
2011
Kahshe Main
Kahshe Grant's Bay
Bass Lake
Buck (Ryde) Lake
Sunny Lake

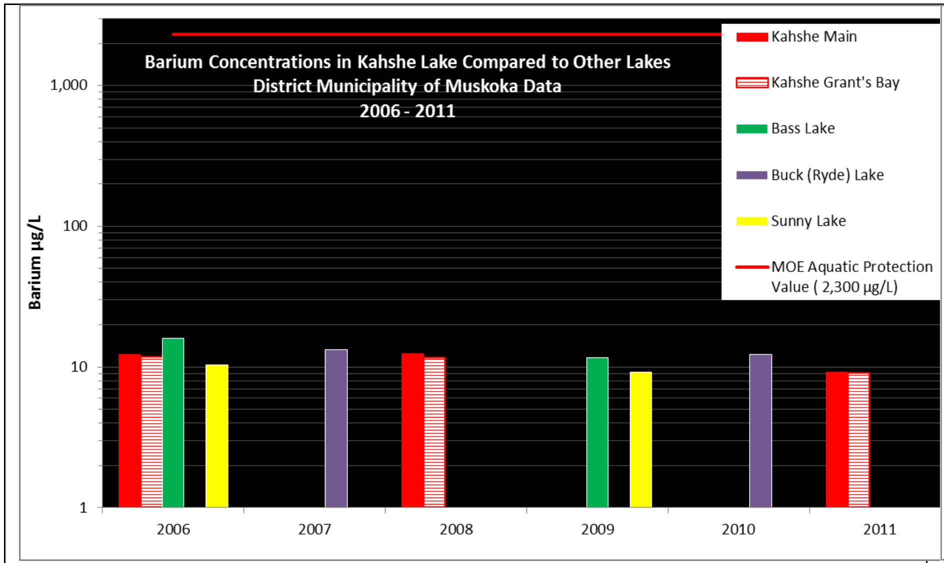
What does this tell us?

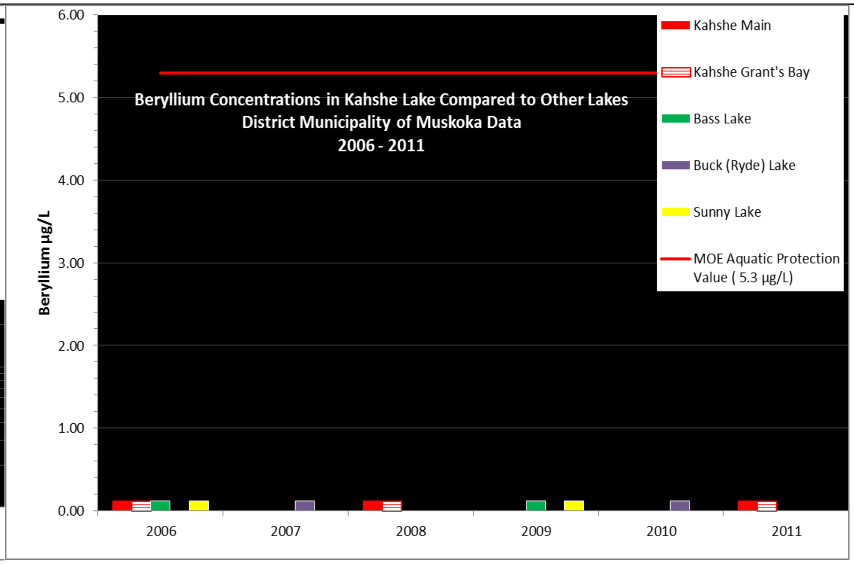
- Although Palmer and Somers et al. have been able to detect changes in water chemistry associated with these substances (chloride increasing; calcium and sulphate decreasing; lake acidity decreasing), none of the charts of water quality for Kahshe, Bass, Buck (Ryde) or Sunny Lakes are showing these trends.
- One of the main reasons why Kahshe Lake data would not be reflective of the long terms trends that are being seen in Muskoka is because for these substances, the monitoring has not been conducted for a long enough period (back to 2004).
- Note also, that in all cases where a surface water protection value was available for the above four substances, all water quality data were well below these values and do not represent a threat to aquatic receptors.

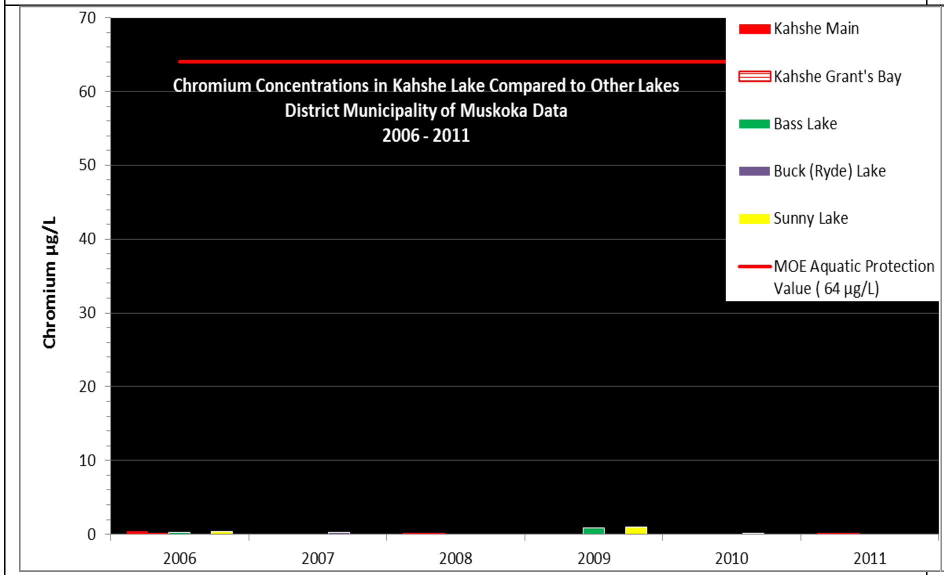
The third group of substances includes those where a surface water benchmark was available, and in all cases, the water from all four lakes was well within the relevant benchmark. These include:

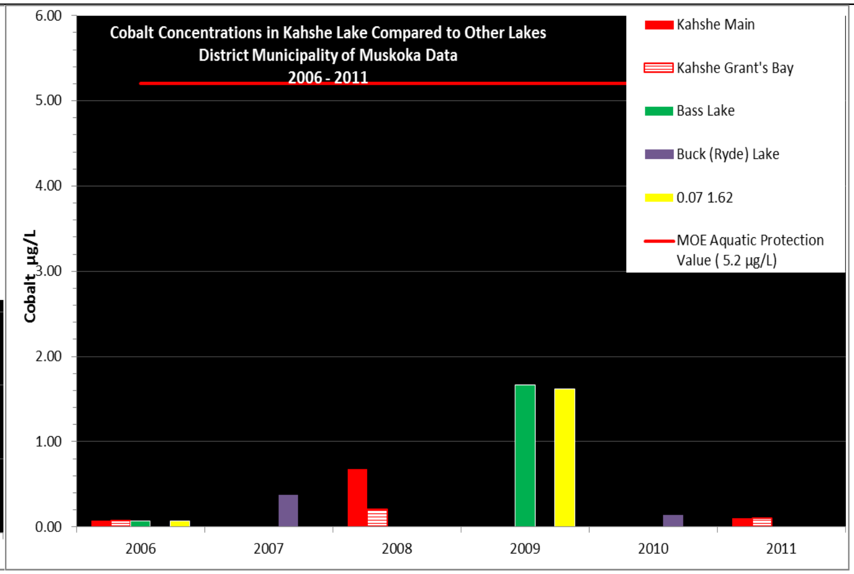
- Barium, beryllium, chromium, cobalt, iron, magnesium, manganese, molybdenum, nickel, nitrate, potassium, sodium, strontium, vanadium and zinc.

Group 3

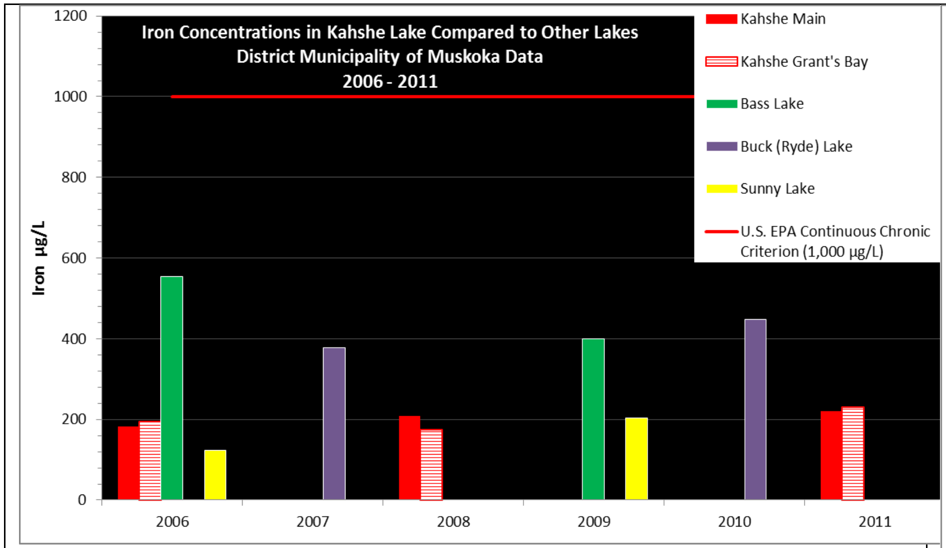

Barium Concentrations in Kahshe Lake Compared to Other Lakes
District Municipality of Muskoka Data
2006 - 2011
Barium µg/L
1,000
100
10
1
2006
2007
2008
2009
2010
2011
Kahshe Main
Kahshe Grant's Bay
Bass Lake
Buck (Ryde) Lake
Sunny Lake
MOE Aquatic Protection Value (2,300 µg/L)

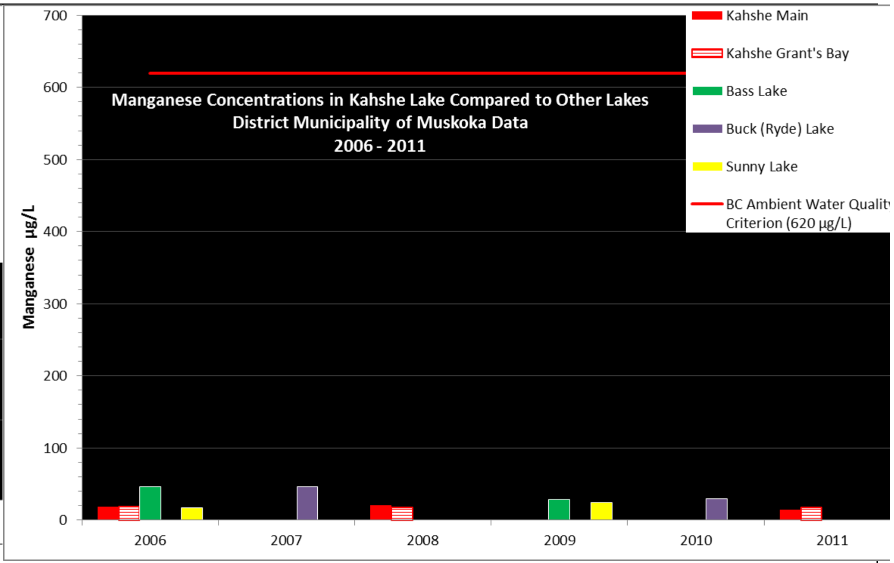

Beryllium Concentrations in Kahshe Lake Compared to Other Lakes
District Municipality of Muskoka Data
2006 - 2011
Beryllium µg/L
6.00
5.00
4.00
3.00
2.00
1.00
0.00
2006
2007
2008
2009
2010
2011
Kahshe Main
Kahshe Grant's Bay
Bass Lake
Buck (Ryde) Lake
Sunny Lake
MOE Aquatic Protection Value (5.3 µg/L)

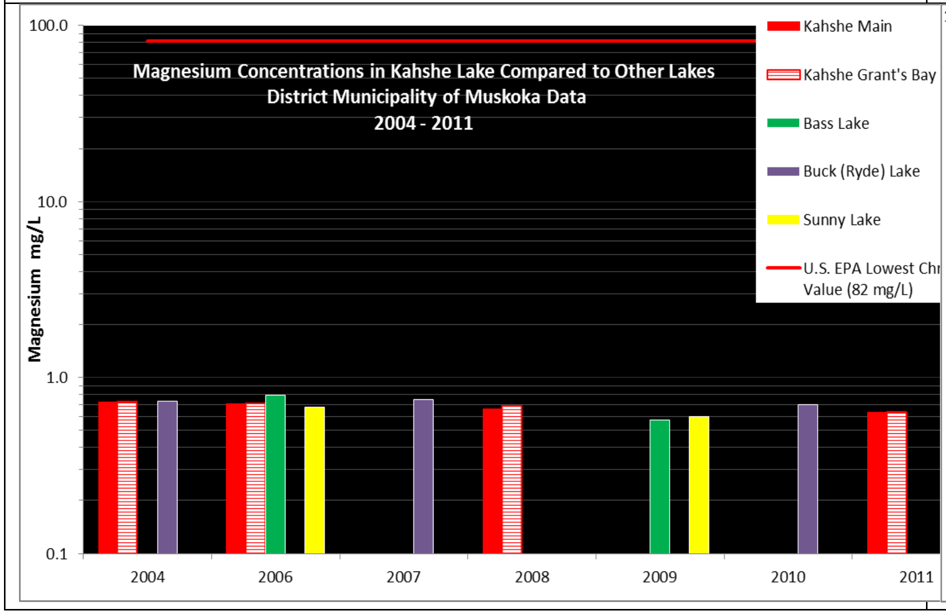

Chromium Concentrations in Kahshe Lake Compared to Other Lakes
District Municipality of Muskoka Data
2006 - 2011
Chromium µg/L
70
60
50
40
30
20
10
0
2006
2007
2008
2009
2010
2011
Kahshe Main
Kahshe Grant's Bay
Bass Lake
Buck (Ryde) Lake
Sunny Lake
MOE Aquatic Protection Value (64 µg/L)

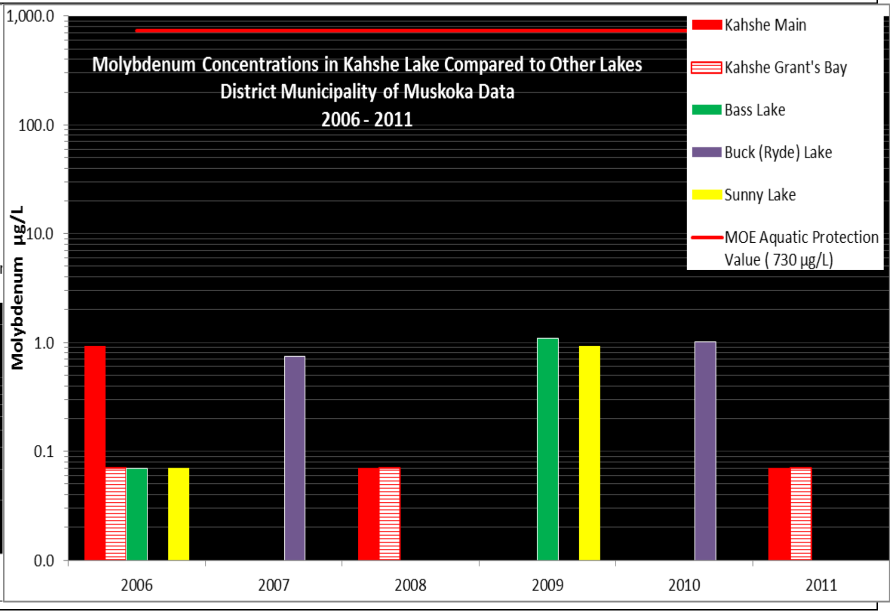

Cobalt Concentrations in Kahshe Lake Compared to Other Lakes
District Municipality of Muskoka Data
2006 - 2011
Cobalt µg/L
6.00
5.00
4.00
3.00
2.00
1.00
0.00
2006
2007
2008
2009
2010
2011
Kahshe Main
Kahshe Grant's Bay
Bass Lake
Buck (Ryde) Lake
0.07 1.62
MOE Aquatic Protection Value (5.2 µg/L)

Third Group (continued)…

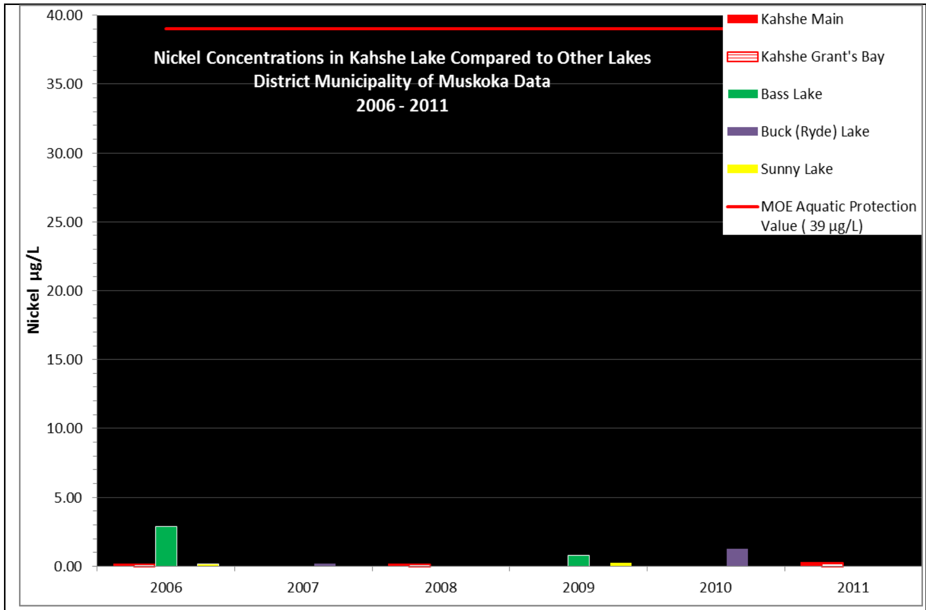


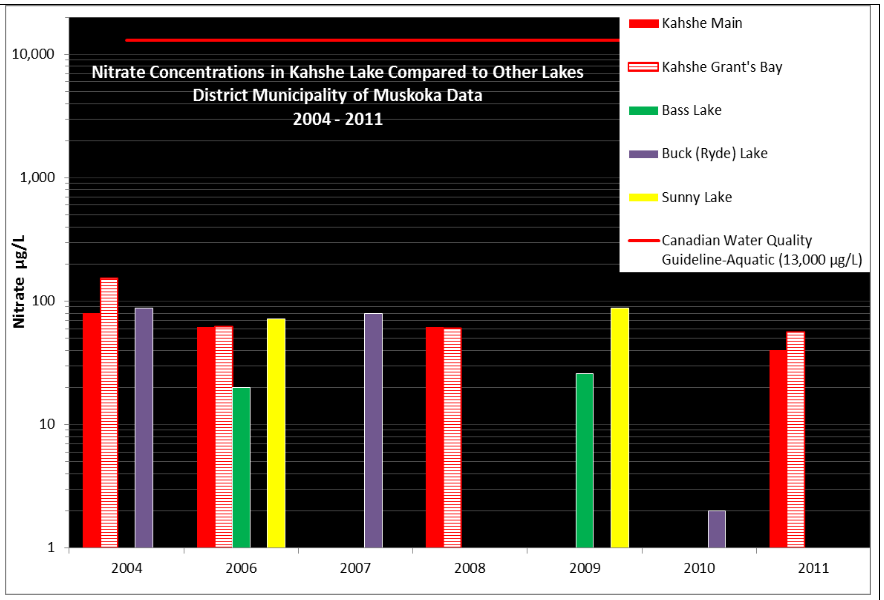


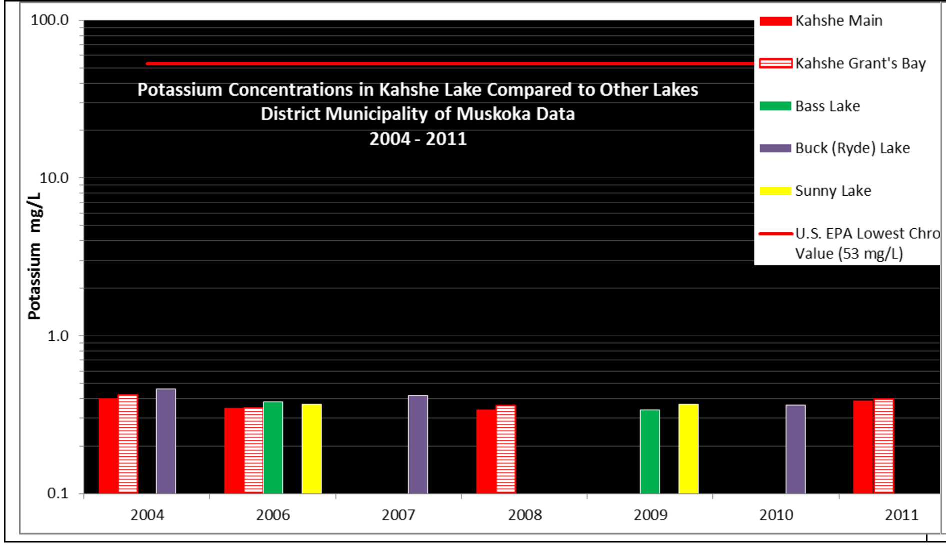


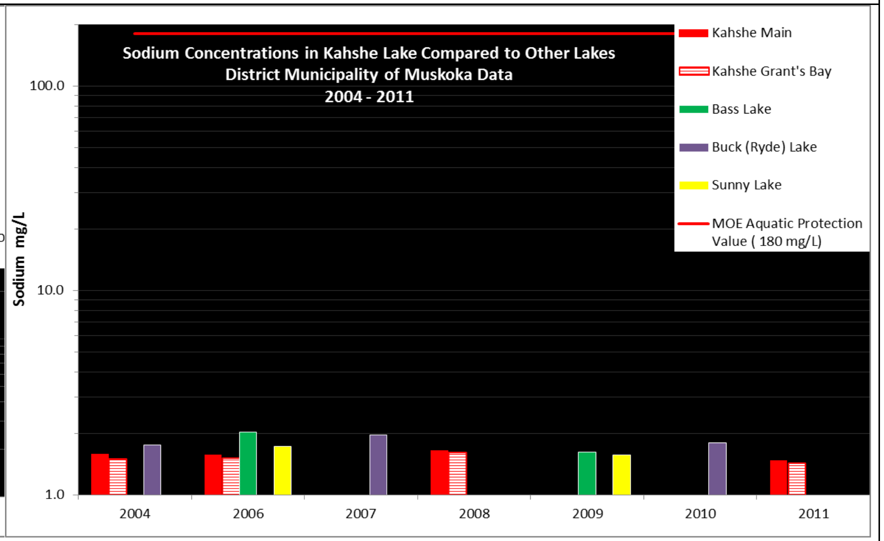


Third Group (continued)…

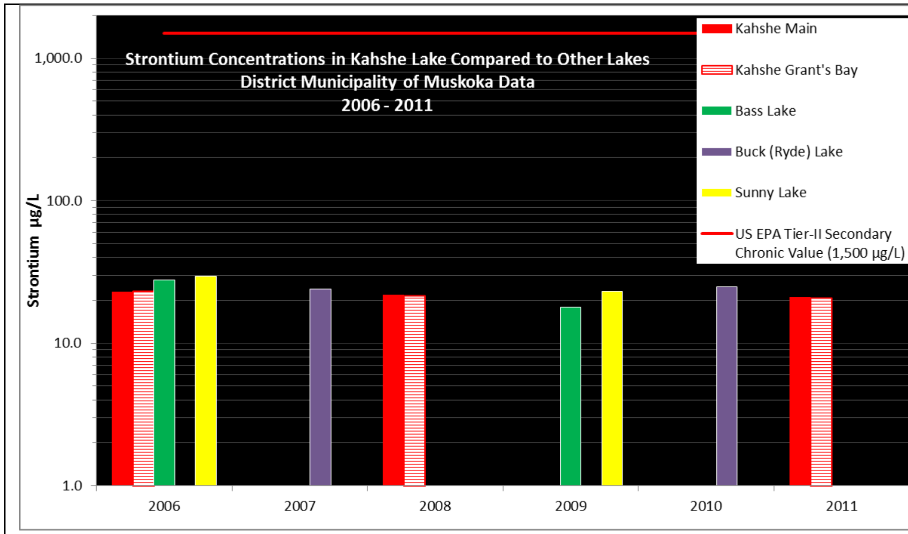


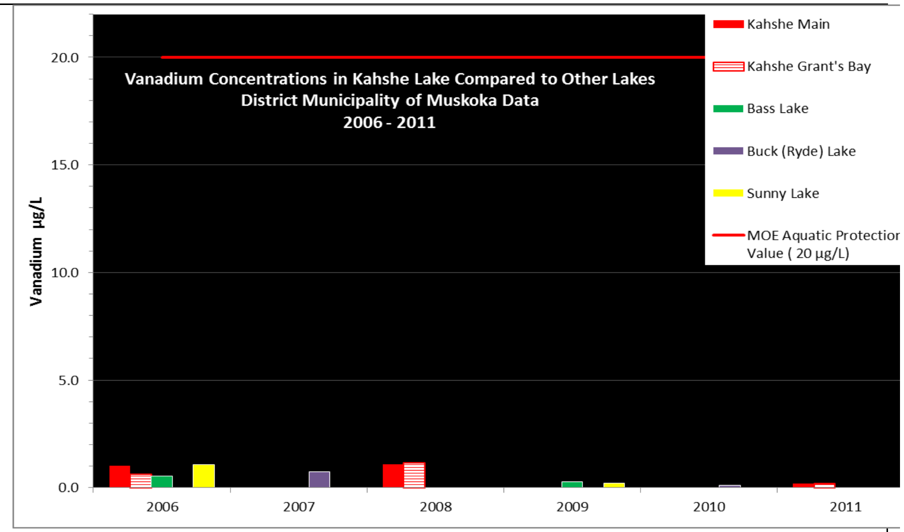


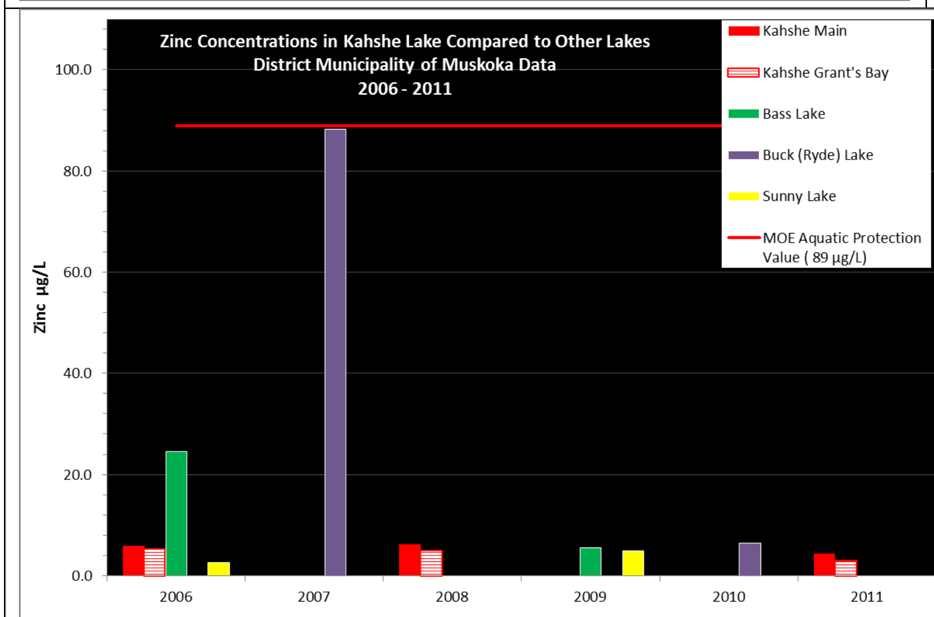




Third Group (continued)…







What does this tell us?

- In all cases the data for parameters falling into Group 3 were all well below the respective APV or other water quality benchmark that was selected.

The fourth group of substances follows, and for these chemicals, no toxicity information was located. As such, the data have been presented without an aquatic protection value for comparative purposes.

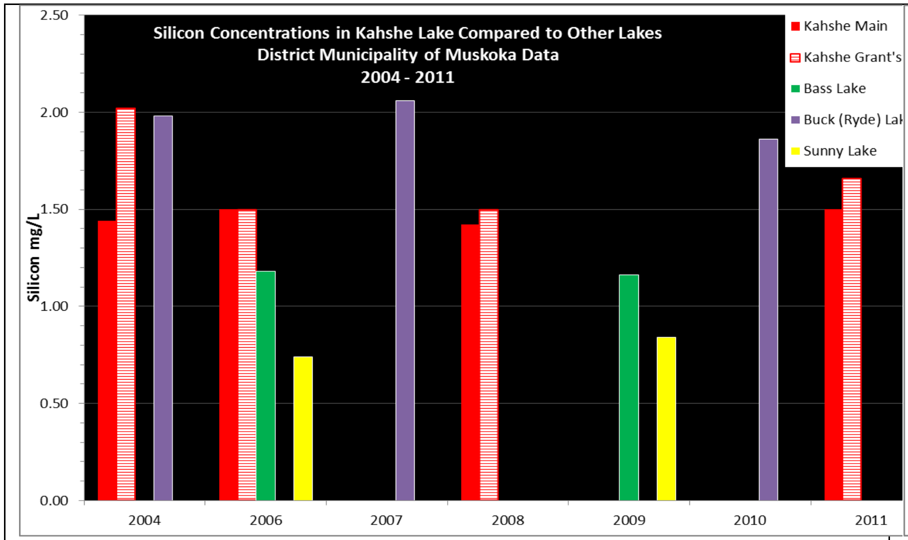
Alphabetically, this group includes

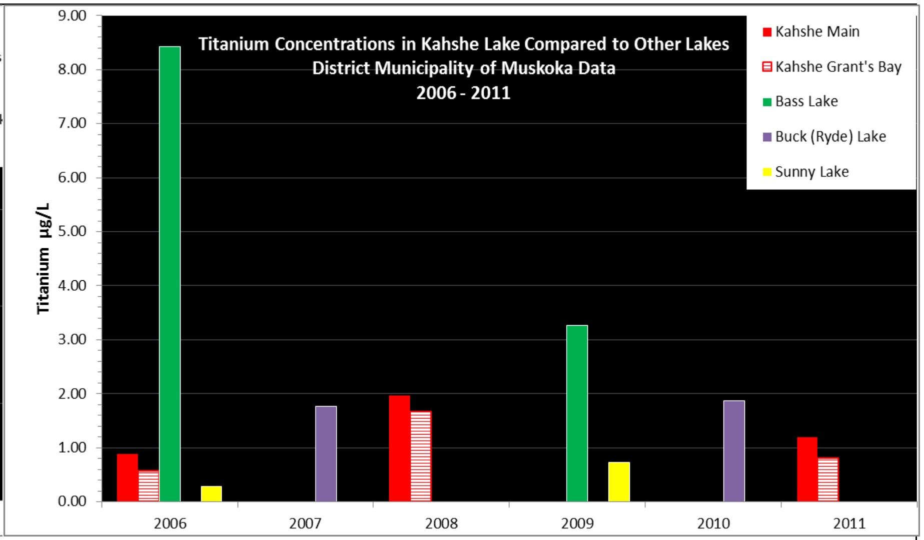
- silicon, titanium and total Kjeldhal nitrogen

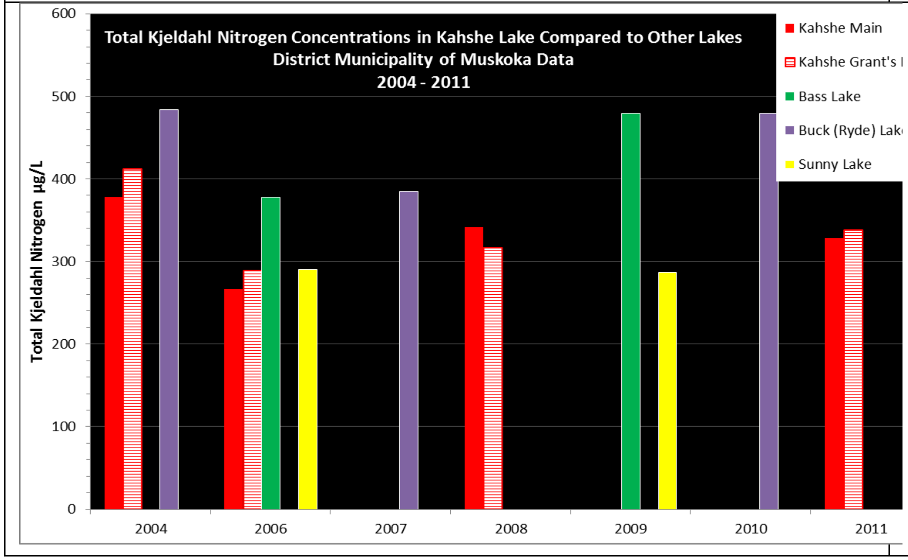
What does this tell us?

- The charts for the chemicals in Group 4 have been provided for information purposes only, as there are no toxicity benchmarks against which these data can be compared.

Fourth Group







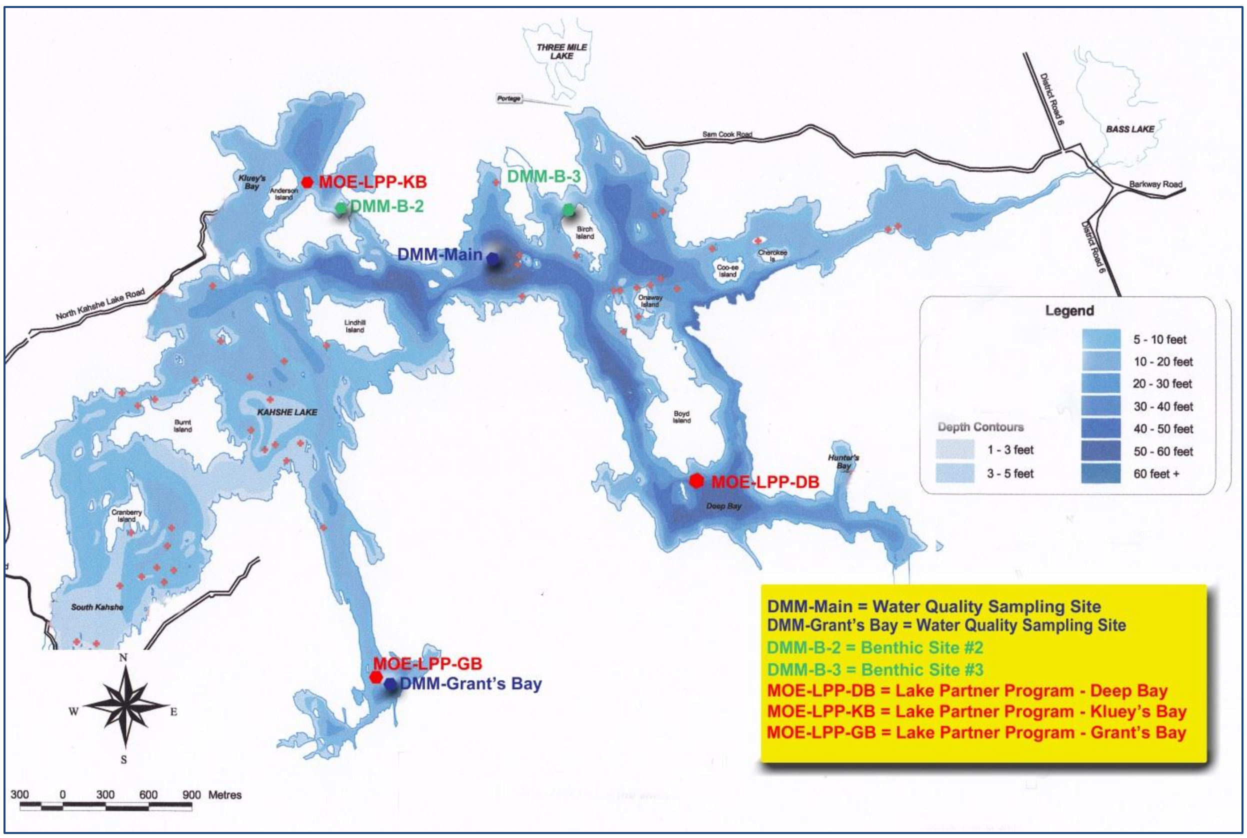
5.0 Evaluation of the DMM Benthic Monitoring Results for Kahshe Lake

Monitoring bottom-dwelling aquatic invertebrate communities has been carried out by the DMM since 2003. This type of monitoring provides an indirect measure of water quality and habitat disturbance, as the composition of the aquatic-invertebrate community and the relative abundances of different species can be used to evaluate the health of the ecosystem.

Aquatic invertebrates include worms, mollusks, insects, crustaceans, and mites. These animals are sensitive indicators of the health, or condition of lakes and streams, as different species have different sensitivities to environmental changes such as pollution or habitat alteration.

Aquatic invertebrates live from one to three years and are in constant contact with lake sediments.

Monitoring on Kahshe Lake is carried out at two locations as shown in green on the map below:



In 2012, the sampling was carried out on August 17 at Site 3, on the north side of Birch Island. Once three replicates of sediment from the shoreline area were collected, DMM staff and volunteers from Kahshe Lake carried out the counting and identification of the benthic organisms. A couple of pictures of the sampling and counting activities have been shown below.

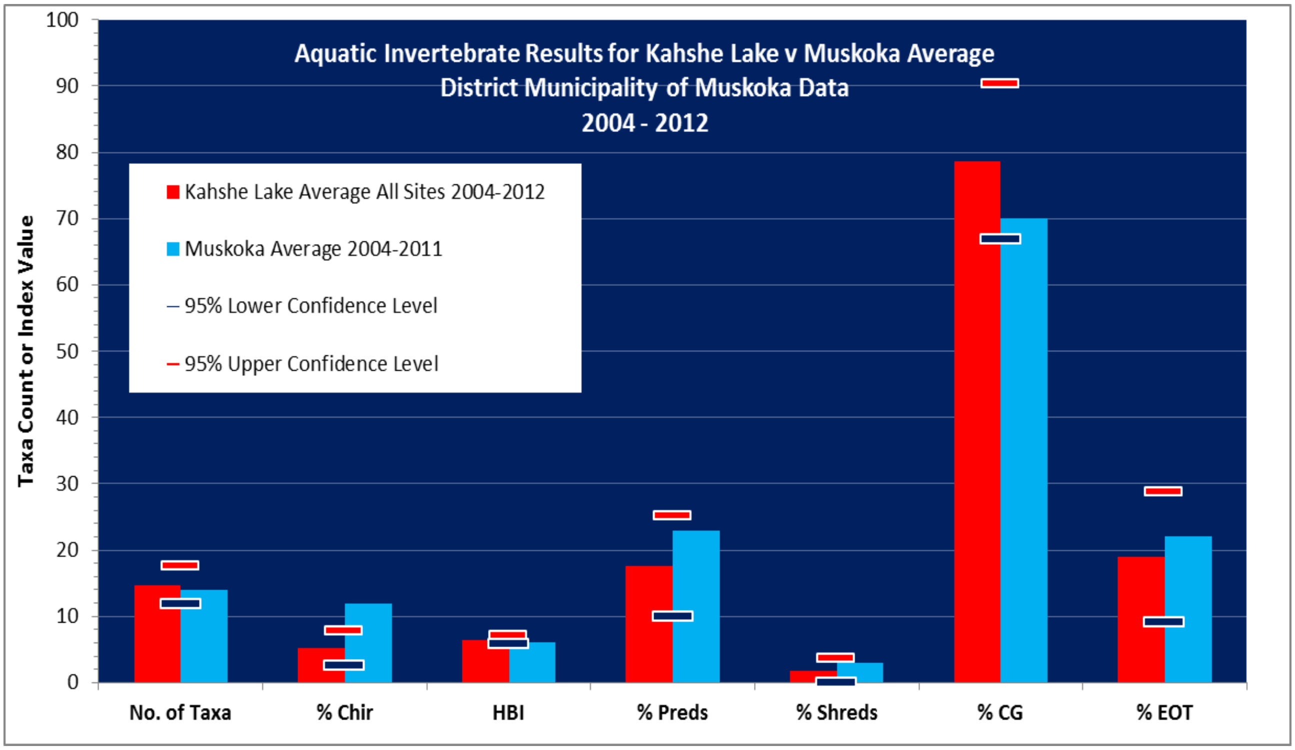
The results of the sampling from both Site 2 and 3 have been combined and compared to the Muskoka average, which is based on 147 samples from 76 reference lakes between 2004 and 2011. A summary of this information is presented in Appendix Table O, with the actual DMM Aquatic Invertebrate Data Sheets for Sites 2 and 3 being presented in Appendices R and S, respectively.

To understand how the sample findings are compared in the chart below, you first have to read through the explanatory material on how the indices are developed. This is shown in the table below.

Table 1: Indices Used to Summarize Aquatic Invertebrate Composition in Muskoka

Name	Description	Explanation of the Index
No. of Taxa	Number of taxa collected (Richness)	The number of taxa is a measure of biological diversity. Richness increases with increasing habitat diversity, suitability, and water quality; therefore, the healthier a site's community, the greater it's number of taxa.
% Chir	Percent of collection made-up of midges (% Chironomidae)	Midges (true flies in the family Chironomidae) are tolerant of pollution and habitat changes so their dominance indicates water quality problems.
HBI	Organic pollution score (Hilsenhoff index value)	The Hilsenhoff index combines information about the abundances of different types of animals collected at a site with information about those animals' sensitivities to sewage pollution, farm wastes, and other sources of nutrients like phosphorus, nitrogen, and carbon. High values of this index indicate pollution; low values indicate good water quality.
% Preds	Percent of collected animals that are predators (% predators)*	In a healthy ecosystem, the numbers of predators and prey are maintained within a narrow range. Extreme fluctuations in this balance signify that the ecosystem is sick.
% Shreds	Percent of collected animals that are adapted to feeding on coarse plant matter (% shredders)*	Shredders are a group of plant eaters adapted to breaking down leaves, wood, and other plant matter that originates on land but gets transported into water bodies. Such animals should be abundant if there is a good connection between a lake and its watershed. In addition to recycling nutrients, shredders are food for other animals.
% GC	Percent of collected animals that are adapted to feeding by collecting small pieces of organic matter (% collector/gatherers)*	Collector-gatherers feed on small pieces of organic matter that arise from the processing activities of shredders (described above). Their presence indicates a good population of shredders, which provide them with food. Like shredders, these animals perform a vital role in energy cycling, and are prey for other animals.
Legend: ∗ In healthy ecosystems, the proportion of the aquatic-invertebrate community that is made-up of predators, shredders, collector/gatherers, and other animals is maintained within a narrow range. Marked divergences in abundances of any type of animal signify a stressed ecosystem. Source: This table provided by DMM		

Using these benthic indices, the results for Kahshe Lake have been plotted against the Muskoka average values in the chart below.



What does this tell us?

- As shown above, the benthic data from both sites on Kahshe Lake are, in all but one case, similar to those of Muskoka lakes chosen by the DMM as reference values.
- When the variability in the Kahshe Lake data are considered by showing the upper and lower confidence levels (to represent the expected range in mean concentrations at the 95% level of confidence), all the indices except one are further shown to be well within the expected range based on the Muskoka reference site comparisons.
- The exception to these findings is for the % Chironomidae, where the average Muskoka value is higher than the corresponding value for Kahshe Lake.
- However, as shown in Table 1 above, Chironomidae are tolerant of pollution and habitat changes, so their dominance indicates water quality problems. As such, the lower value for the Kahshe Lake data is actually desirable.
- Based on these findings, the benthic monitoring results from sampling on Kahshe Lake over the period from 2004 to 2012 have not identified any problems in the growth and survival of aquatic invertebrate which can be related to contamination or habitat disturbance. For all growth and survival metrics, the Kahshe Lake invertebrate populations were similar to or better than the corresponding indices of selected reference lakes in Muskoka.

6.0 Summary and Conclusions

In accordance with the goals and objectives of the Lake Stewardship Committee, which was established by the Kahshe Lake Ratepayers Association (KLRA), a comprehensive review and analysis of all historical environmental monitoring on Kahshe Lake has now been completed and presented in this 2012 Kahshe Lake Steward Report.

6.1 Summary of Findings

The sampling and analysis of Kahshe Lake water and aquatic invertebrate organisms has been ongoing for up to 28 years under two main programs operated by the Ontario Ministry of the Environment (MOE) and the District Municipality of Muskoka (DMM).

These two programs are briefly summarized below:

Lake Partner Program	operated by MOE with sampling and measurement being undertaken by Muskoka Lake Stewards **every year**

- The MOE LPP program consists of the sampling and analysis of lake water for total phosphorus at two locations during the spring turnover period and the measurement of water clarity at three locations via use of a Secchi disc at two week intervals during the ice-free period.
- The program is carried out by the Lake Steward and the results of the analysis and water clarity measurements are published by the MOE on the LPP web-site.

Lake System Health Program	operated by DMM with input and assistance by the MOE and the Muskoka Watershed Council (MWC) – carried out **every two years**

The DMM program consists of sampling at two locations for water chemistry every two years and two additional sites for aquatic invertebrate (benthic) monitoring. The components of the DMM program include:

- Spring phosphorus sampling conducted in May;
- Water sample collection for base chemical parameters (anions, cations) in May;
- Secchi depth measurements collected in May and August;
- Temperature and dissolved oxygen readings collected in May and August;
- Benthic macro-invertebrate sampling in August.

In addition to a year-end report and data summaries for total phosphorus, water clarity, dissolved oxygen and water temperature which are published by the DMM and available on their web-site, the information from the DMM program is consolidated into a Watershed Report Card every four years by the MWC.

Although the MWC Report Card is not specific to Kahshe Lake, the findings from the most recent report in 2010 have been examined and the Kahshe Lake Sub-Watershed received a Grade of A for water quality and B for land.

As the MOE program does not include an annual interpretative report, this analysis of Kahshe Lake water quality has focused on the findings from the DMM program.

The review and analysis was sub-divided into the following components:

- Evaluation of 2011 DMM Year-End Findings - Kahshe Lake Water Quality

- Additional Analysis of Kahshe Lake Water Quality Data, including:
  - a comparison of water quality in Kahshe Lake to results for three up-gradient lakes;
  - a comparison of the DMM findings for total phosphorus and Secchi depth to the MOE's LPP program findings;
  - an analysis of trends over time and predictive relationships among sampling parameters

- Evaluation of the DMM Benthic Monitoring Results for Kahshe Lake

Briefly, the findings from these components of the analysis are summarized below:

EVALUATION OF 2011 DMM YEAR-END FINDINGS - KAHSHE LAKE WATER QUALITY

As indicated, the four main parameters that are summarized in the DMM Year-End report include:

- Total phosphorus, Secchi depth, dissolved oxygen and water temperature

Total Phosphorus

- Phosphorus is a natural substance required by all living organisms. It enters a lake naturally through:
  - release from bottom sediments and wetland areas,
  - via precipitation and soil erosion, and
- Phosphorus is also released from human activities such as:
  - leaching from septic systems,
  - use of phosphorus-based cleaning supplies, and,
  - from use of lawn fertilizers which eventually leach to the lake or are carried via soil erosion.
- Phosphorus samples are collected in the spring during a period called "spring turnover", as studies have shown that this is the best time due to thermal mixing of the lake during spring turnover.
- The reason for focusing on total phosphorus is that it is typically the best chemical indicator of lake eutrophication or enrichment and has been found to be the best chemical signal as a warning sign for potential algal blooms.

- As shown in the chart of 2011 DMM results, there are three types of lakes in terms of total phosphorus concentrations:
  - **Oligotrophic** lakes have a total phosphorus concentration of < 10 µg/L.
  - **Mesotrophic** lakes have a total phosphorus concentration in the range of 11 - 20 µg/L
  - **Eutrophic** lakes have a total phosphorus concentration > 20 µg/L.

- Kahshe Lake falls into the Mesotrophic category, and in 2011, the concentrations at the two sites (17.8 and 10.4 µg/L at Grant's Bay and Kahshe Main, respectively) were in the mesotrophic range.

What does this mean in terms of the potential for algal blooms and the need for concern regarding more intensified development?

- Based on a review of the science, the DMM has opted to conservatively preserve the levels of total phosphorus equated with eutrophication and algal bloom problems based on their predicted background or undeveloped concentrations.

- In the case of Kahshe Lake, the background was set at 9.5 µg/L, resulting in a total phosphorus threshold of 14.2 µg/L

- 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:

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

  - The long-term (10 years) measured total phosphorus concentration, as determined by the DMM Program, also exceeds the "Background + 50%" threshold value.

- A lake that is Over Threshold will be de-listed only after the 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.

- Based on a 2005 analysis of its water quality model, the DMM has rated the lakes in Muskoka in terms of their sensitivity to phosphorus enrichment and the need for action related to development.

- The good news is that Kahshe Lake is listed as being at a level of background + 23% - well below the threshold of background + 50% - and is shown as being low in terms of total phosphorus responsiveness. However, because of limited soil attenuation potential, the phosphorus mobility rating is high. The combination of these two factors results in a moderate sensitivity classification for Kahshe Lake. Bass Lake also is rated as moderate in sensitivity.

Secchi Depth

- Water clarity in the lakes in Muskoka is determined by two main factors:

- The first is dissolved organic carbon (DOC) which colours the water orange-brown. DOC compounds are formed by the decomposition of organic plant matter in wetland areas and concentrations in lake waters are determined by the amount of wetland in the catchment of a lake. The influence of DOC on transparency is entirely natural and cannot be managed to improve water clarity.

- The second determinant of transparency is the level of the plant pigment chlorophyll *"a"* in the water. This pigment is contained in algae which grow in the water and so the amount of chlorophyll reflects the amount of algae in the water.

- 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.

- 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.

- As is apparent from the DMM data presented above, Kahshe Lake is rated as a moderate in terms of its DOC; however, based on the DMM sampling results for 2011, the Secchi depth clarity measurement is less than the 3-5 m typical depth for a Mesotrophic lake, and more representative of an Eutrophic lake.

What does this mean in terms of the potential for algal blooms and the need for concern regarding more intensified development?

- Based on these findings alone, it would appear that water clarity on Kahshe Lake is slightly lower than the typical readings for a lake with our degree of tea colour.

- However, the levels of total phosphorus are well below threshold values, so other factors appear to be involved.

Dissolved Oxygen and Water Temperature

- As adequate concentrations of dissolved oxygen (DO) are necessary for the survival of fish and other aquatic organisms, DO 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 and most fish cannot survive if levels fall below 3 mg/L.

- It is apparent from the DMM chart for Kahshe Lake that:
  - water temperature predictably decreases with depth at this stage of the spring turnover; and.
  - dissolved oxygen concentrations are fairly constant with depth and well within the levels that would support aquatic life at all depths.

- The data for Grant's Bay are similar, although because of a more shallow depth profile, the temperature decrease with increasing lake depth is not as noticeable as it is in the main sampling location where the water depth is about 20 m.

ADDITIONAL ANALYSIS OF KAHSHE LAKE WATER QUALITY DATA

Given the amount of data available from sampling programs conducted on Kahshe Lake and other lakes in Muskoka that have not been included in the 2011 DMM Year End report or not discussed by DMM on a lake-specific basis, this report further explores and compares the findings for Kahshe Lake in four different ways:

i. How do DMM results for Kahshe Lake compare to results from nearby up-gradient lakes?
ii. How do DMM results for Kahshe Lake compare to results from MOE sampling programs?
iii. How do DMM results for Kahshe Lake compare to time-trend and predictive analysis on the full set of Muskoka data? and,
iv. Can any conclusions be drawn based on the results of a large suite of chemical parameters that have been analyzed by the DMM over the past 6-8 years but not included in the Year-End report?

The findings from this additional analysis are summarized below:

i. How do DMM results for Kahshe Lake compare to results from nearby up-gradient lakes?

Before making any comparisons among different lakes, the first analysis was to examine the variability in the total phosphorus data collected on Kahshe Lake.

- Based on the monthly data in the early years, the upper and lower confidence levels were calculated based on a statistical analysis at the 95% probability level and this revealed a significant amount of variability within the early years, when sampling was conducted throughout the season.

- These findings are consistent with those reached by the DMM using total phosphorus sampling data from all Muskoka lakes (GLL, 2005a), where it was concluded that there is an average of 40% variability in concentrations. This is significant, as it means that in order to generate a meaningful determination of total phosphorus concentrations, a lake must be sampled for three consecutive years.

- The next step was to compare total phosphorus and Secchi depth results for Kahshe Lake to three up-gradient lakes, including Bass Lake, Buck (Ryde) Lake and Sunny Lake, all located within the Kahshe Lake Sub-Watershed.

- In spite of some major differences in natural total phosphorus levels, like Kahshe Lake, all three lakes are rated as being Moderate in terms of sensitivity to phosphorus input above natural background levels, and in all cases this is due to their fairly high sensitivity to mobility of the phosphorus associated with septic seepage through soils and overland flow/erosion which can result from shoreline disturbance.

- The comparison of water clarity (Secchi depth) among the lakes examined shows water clarity to be best (deepest Secchi disc value) in Sunny Lake and lowest in Bass and Buck (Ryde) Lakes, with Kahshe Lake coming in second in terms of clarity.

- These findings are in general agreement with the total phosphorus results, in that Sunny Lake had the lowest total phosphorus and highest clarity while Bass Lake had the highest total phosphorus and lowest water clarity.

ii. How do DMM results for Kahshe Lake compare to results from MOE sampling programs?

The next comparison was an evaluation of how the DMM generated results for total phosphorus and Secchi depth compared to those generated via the MOE's LPP program based on sampling by the Kahshe Lake Steward.

- Keeping in mind the different averaging periods that had to be utilized in making this comparison and the variability that exists within the total phosphorus database, it is apparent that when analysis results for similar sampling dates over the period from 1983 to 2011 are plotted, both programs have generated similar results.

- In the case of Secchi depth, the results of the two sampling programs also show a considerable degree of variability over the period from 1983 to 2011, but also are in general agreement in most years, and on average, are in the range of 2.0 to 3.0 m in depth.

iii. How do DMM results for Kahshe Lake compare to time-trend and predictive analysis carried out on the full set of Muskoka data?

- Both of the presentations (Palmer, 2012 and Somers et al., 2009), which looked at long term trends in total phosphorus concluded that Muskoka lakes are experiencing a gradual decrease in total phosphorus concentrations. This trend was also substantiated in a more intensive study carried out by the MOE on nine lakes in Muskoka, where sampling was carried out annually over an almost 30 year period, commencing in the mid-1970s.

- Although the results from Kahshe Lake don't show this type of reduction in total phosphorus, this is not unexpected, as the larger data sets available to evaluate long term changes would have a much higher power of analysis.

- However, based on the results for Kahshe Lake, it is encouraging to note that total phosphorus concentrations are definitely not increasing, and with continued analysis, we may be able to document a decrease in total phosphorus concentrations.

The next comparison involved looking at relationships between some chemical and physical parameters which form the foundation for the water quality model which attempts to relate water quality deterioration to land development activities. The general assumption is that if there is a relationship between total phosphorus and the potential for algal problems and water clarity decreases due to nutrient enrichment, then it should follow that higher levels of total phosphorus should be positively correlated with green pigmentation (chlorophyll “a”) and negatively correlated with water clarity – i.e. higher total phosphorus concentrations should result in higher chlorophyll “a” readings and lower water clarity (Secchi depth) readings.

From the studies by Palmer (2012) and Somers et al. (2009), which used the entire Muskoka lakes dataset, the following relationships were apparent:

- In the case of total phosphorus and chlorophyll “a”, the relationship was positive and statistically significant (higher concentrations of total phosphorus resulted in higher concentrations of chlorophyll “a”).

- However, the explanatory power of this relationship was not strong, with only 51% of the variability in chlorophyll “a” being explained by concentrations of total phosphorus in the water.

- In the case of chlorophyll “a” and Secchi depth, again the relationship was statistically significant, but the explanatory power was very weak, with only 17% of the variability in Secchi depth being explained by chlorophyll “a” concentrations.

- The third comparison was the most interesting, as in this case, a multiple linear regression was used with DOC being added as a contributing factor along with total phosphorus.

- This resulted in a correlation coefficient value of 0.81, with 65% of the variability in Secchi depth being explained by total phosphorus when DOC was factored in.

Based on these findings, correlation and regression analyses were run on the Kahshe Lake data and the results are summarized below:

- Using paired total phosphorus and chlorophyll “a” data for the period from 1983 to 1996, when the DMM stopped measuring for chlorophyll “a”, there was no significant relationship between these two parameters.

- In other words, total phosphorus concentrations were not a predictor of green pigmentation of Kahshe Lake water.

- Using paired chlorophyll “a” and Secchi depth data for the period from 1983 to 1996, when the DMM stopped measuring for chlorophyll “a”, there was no significant relationship between these two parameters.

- In other words, the degree of green pigmentation of the water had no impact on water clarity.

- Using paired total phosphorus and Secchi depth data for the 29 year period from 1983 to 2011, there was no significant relationship between these two parameters.

- In other words, total phosphorus concentrations have had no statistically significant negative impact on Kahshe Lake water clarity as determined by Secchi depth measurements.

The report also examines the DO and water temperature results for Kahshe Lake for trends as summarized below:

- In almost all years for which DO has been monitored, the concentrations have been well above the optimal level for aquatic organisms.

- An examination of within-year trends also was undertaken using data from the year 2000 and this revealed that as the lake stratifies into different temperature zones, the dissolved oxygen in lower depths decreases quite dramatically, especially as depths drop below 4-5 m.

- However, with the exception of the sampling carried out after the end of July, the DO concentrations in the lower depths remains above the level that is optimal for most aquatic organisms.

- In the case of water temperature, the results for the 28 year period from 1983 to 2011 appear to indicate a possible warming trend in the upper 4 m of the water column during the spring turnover sampling event.

- By mid-summer, this trend was not apparent, as the variability in the data appears fairly consistent from the surface down to the lower, cooler water levels.

- These findings appear to be consistent with the findings by Palmer and Somers et al. who carried out statistical analysis of larger sets of Muskoka lake data and on a more intensively monitored group of nine lakes evaluated continuously by the MOE since the mid-1970s. Based on their analysis, a warming effect has been confirmed in the epilimnion (upper 5 m of the water column), and to a lesser degree in the metalimnion (mid-depth zone).

iv. Can any conclusions be drawn based on the results of a large suite of chemical parameters that have been analyzed by the DMM over the past 6-8 years but not included in the Year-End report?

The next comparison involved an analysis of a large suite of chemical parameters that have been analyzed on Kahshe Lake and others in Muskoka since 2004. As these chemical parameters have not been included in the DMM Year-End report, they were analyzed in this report.

In order to evaluate the potential impact of the chemicals that have been analyzed, they were compared to the MOE's Aquatic Protection Values (APVs) that are used in the protection of surface water quality in Ontario against ground water discharge associated with migration from contaminated sites. In several cases, where an MOE APV was not available, an equivalent benchmark was selected from one of a number of regulatory agencies that have set criteria for the protection of aquatic receptors in surface water.

These included:

- U.S. EPA chronic ambient water quality criterion (based on a continuous chronic criterion);
- Canadian Water Quality Guideline,
- B.C. Ambient Water Quality Criterion
- U.S. EPA Tier-II Secondary Chronic Value.

In all cases, the protection provided via these benchmarks is for long term exposure to concentrations that are considered chronic, as opposed to short-term protection against acute effects.

In running these comparisons using data from Kahshe, Bass, Buck (Ryde) and Sunny Lakes, a few potential issues were identified with the water quality data that has been generated by the DMM for aluminum, cadmium, copper and lead, which each showed one or more exceedances of the surface water aquatic protection benchmarks.

- In the case of aluminum, the exceedances are concluded to be minor in nature, as aluminum toxicity to aquatic organisms is very complex and the benchmark that was selected from the US EPA is somewhat dated and has not been updated due to the complexity of aluminum toxicity in water and its relationship with several other substances.

- In the case of cadmium, some of the measured concentrations exceed the MOE's APV of 0.21 µg/L. Based on these findings, staff at the DMM asked the scientists at the MOE’s Dorset facility to further evaluate the possibility that these results signal a need for concern regarding the potential impact on aquatic receptors. The MOE cautioned that the data are likely due to sampling or analysis contamination and that until these issues are resolved, the users of the data should limit their evaluation to aluminum, manganese, iron and zinc.

- Based on the Kahshe Lake cadmium data, only one year (2008) was elevated above the APV and normal values were encountered before and after 2008. This would be typical of a laboratory or sampling artifact.

- In the case of copper, the one exceedance of the MOE’s APV in Bass Lake would appear to be another anomaly, as all sampling results are well within the APV value.

- The results for lead appear similar to those for copper, and also are likely to have been caused by sampling or analytical error.

- Although Palmer and Somers et al. have been able to detect changes in water chemistry associated with chloride (increasing), calcium and sulphate (decreasing), lake acidity (decreasing), none of the charts of water quality for Kahshe, Bass, Buck (Ryde) or Sunny Lakes are showing these trends.

- One of the main reasons why our data would not be reflective of the long terms trends that are being seen in Muskoka is because for these substances, the data go back only to 2004.

Evaluation of the DMM Benthic Monitoring Results for Kahshe Lake

- As shown above, the benthic data from both sites on Kahshe Lake are in all but one case similar to those of Muskoka lakes chosen by the DMM as reference values.

- When the variability in the Kahshe Lake data are considered by showing the upper and lower confidence limits for the entire Kahshe Lake benthic monitoring results, all the benthic health indices except one are further shown to be well within the expected range based on the Muskoka reference site comparisons.

- The exception to these findings is for the % Chironomidae, where the average Muskoka value is higher than the corresponding value for Kahshe Lake.

- However, as Chironomidae are tolerant of pollution and habitat changes, their dominance indicates water quality problems. As such, the lower value for the Kahshe Lake data is actually desirable.

6.2 Conclusions

Based on the findings from over 25 years of water quality sampling and analysis carried out every other year by The District Municipality of Muskoka (DMM) and, every year for a more limited set of parameters by the Ontario Ministry of the Environment (MOE) with the assistance of the Kahshe Lake Steward, the following conclusions regarding the water quality and biological health of Kahshe Lake have been drawn:

Total Phosphorus Concentrations

- In terms of total phosphorus concentrations, Kahshe Lake is currently at a level of background + 23%, which is well below the background-based threshold of 14.2 µg/L which is based on protecting water quality by not allowing concentrations to exceed a threshold level of Background + 50%.

- Kahshe Lake also has been determined by DMM to be low in terms of responsiveness to phosphorus input. However, because of limited soil attenuation potential, the phosphorus mobility rating is high. The combination of these two factors results in a moderate sensitivity classification for Kahshe Lake.

- Based on these and other findings which examined the variability in total phosphorus concentrations, it can be concluded that total phosphorus levels in Kahshe Lake have not decreased over the 28 year sampling period; however, it is also apparent that they are not increasing.

- Based on these and other findings, it is important to continue monitoring for total phosphorus, as other factors may interact with total phosphorus, resulting in an increased potential for nutrient-related algal blooms.

- One of the most important factors which could influence the relationship between total phosphorus and algal blooms is lake temperature. Our results appear to confirm the findings of others that have shown gradual warming of the upper layers of Muskoka lakes, and this has the potential to accelerate algal growth in combination with total phosphorus.

Secchi Depth (Water Clarity)

- The clarity of water is affected by the amount of dissolved organic carbon (tea colouring) and also by increasing levels of nutrients such as phosphorus, which are known to stimulate algal growth.

- Kahshe Lake is rated as a moderate in terms of its dissolved organic carbon concentrations; however, based on the DMM and MOE measurements over the years, the clarity level (visibility depth) is in the range of 2-3 m, slightly below the 3-5 m typical depth for a Mesotrophic lake and more representative of clarity in a mildly Eutrophic lake.

- Based on these findings, it is important to remain vigilant about our monitoring of water clarity and total phosphorus on the lake, especially in view of the influence increased lake temperatures can have on algal growth.

Dissolved Oxygen and Water Temperature

- DMM's evaluation of these two parameters has been ongoing for several years, and is important as both can have impacts on the health of aquatic receptors and, in the case of water temperature, on the potential for algal blooms.

- Based on the findings to date, the dissolved oxygen levels appear to be well within the normal and healthy range for most aquatic organisms and do not appear to have changed over the sampling period.

- However, water temperature in the upper layers of the lake do appear to be getting warmer in recent years, and this is in agreement with the findings of MOE research scientists who have been examining the entire Muskoka lakes database.

Other Chemicals

- To evaluate the significance of the analytical results for a large suite of chemical parameters which have been analyzed for but not reported on by DMM, the data were assessed against surface water quality benchmarks set by the MOE and other agencies to protect aquatic receptors against impacts over long-term exposure periods.

- This has revealed that for aluminum, cadmium, copper and lead, the water quality data for one or more of the four lakes have exceeded these aquatic effects-based benchmarks.

- Given the absence of any known sources of cadmium or lead, it is possible that these exceedances are related to laboratory analysis problems.

- In the case of copper, the single exceedance in Bass Lake also is likely due to a laboratory analysis problem; however, because copper is one component of pressure treated lumber which is used in dock construction, there is some uncertainty as to the cause of this exceedance.

- In the case of aluminum, one possible source would be from oxidation of aluminum boats. However, as the exceedance was very marginal and as the benchmark was outdated due to the complexity of aluminum toxicity within surface waters, there does not appear to be any cause for concern.

- The DMM consulted the MOE regarding the above exceedances, and the MOE recommended that until these sampling and analysis issues have been resolved, the users of the data should limit their evaluation to aluminum, manganese, iron and zinc.

Aquatic Invertebrate (Benthic) Monitoring

- Based on the findings from the aquatic invertebrate sampling and identification program which has been operated by the DMM with assistance from the Kahshe Lake Steward and many KL volunteers over the period from 2004 to the present, the abundance and composition of benthic life on Kahshe Lake is similar to or better than the average results for reference sites from a selected database of Muskoka lakes.

In conclusion, based on the analysis of a large number of chemical and physical parameters by both the DMM and the MOE, it is apparent the waters and biota of Kahshe Lake are in good condition and compare favourably with the results for other Muskoka lakes. However, given the initial signs of increasing water temperatures which are consistent with the findings from other lakes in Muskoka, we need to remain vigilant in our sampling efforts and overall lake stewardship, as warmer waters are more prone to algal growth and may negate potential improvements in nutrient enrichment and other chemical indicators of lake health. As such, each of us needs to do our part to maintain the quality of the water by:

- managing our septic systems properly,
- avoiding the use of products containing phosphorus (detergents and cleaners),
- minimizing near-shore removal or management of vegetation and soil disturbance,
- avoiding the use of any chemical fertilizers and pesticides in areas close to the shore, and,
- taking precautions to minimize the potential for introducing invasive species into the lake.

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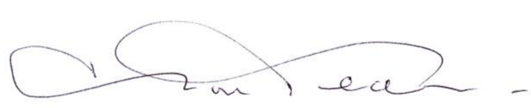
Respectfully submitted,



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2012 Kahshe Lake Steward