2015 Kahshe and Bass Lake Steward Report

Kahshe Lake Ratepayers' Association

June 2016

2015 KAHSHE AND BASS LAKE STEWARD REPORT

TABLE OF CONTENTS

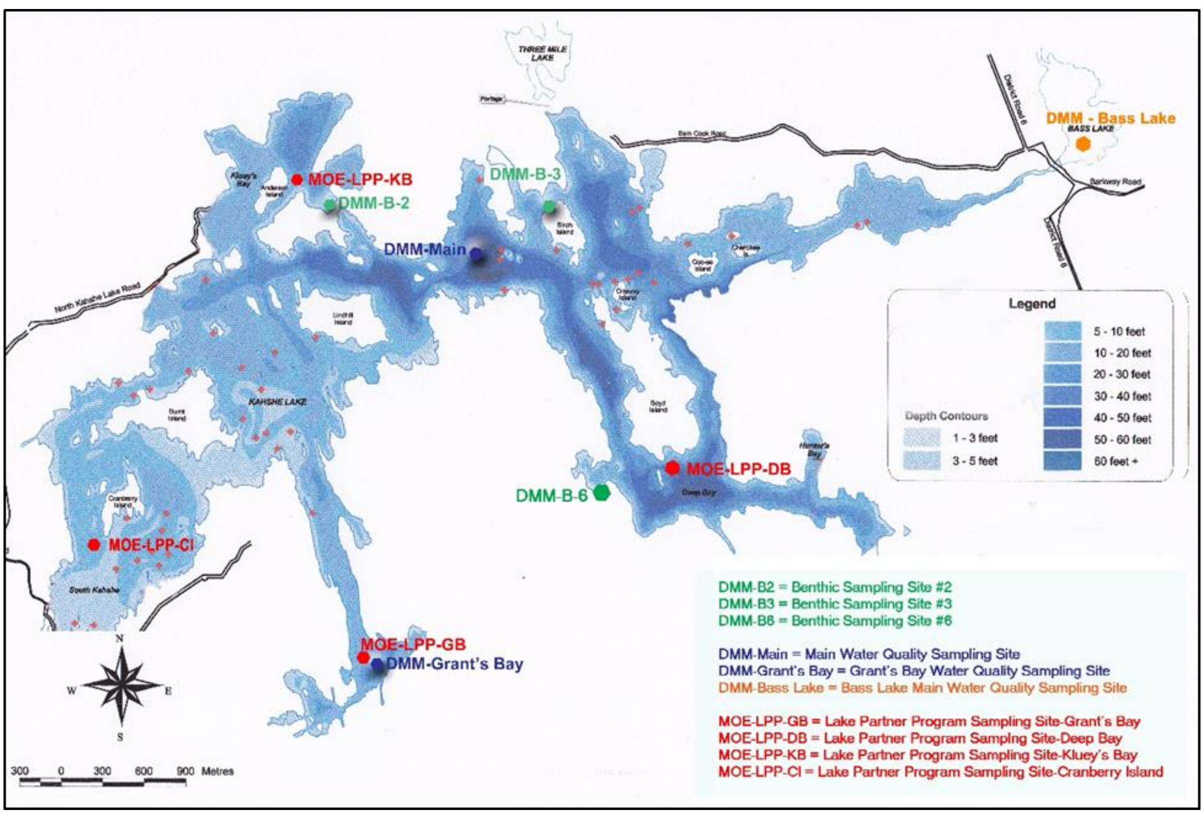
2015 Executive Summary

In accordance with the goals and objectives for the Kahshe Lake Steward, a comprehensive review and analysis of all historical environmental monitoring on Kahshe and Bass Lakes has now been completed and presented within Lake Steward Reports for 2012, 2013 and 2014. These documents are posted on the KLRA web-site (http://www.kahshelake.ca/ne/ls). This report captures the findings from sampling and analysis of both Kahshe and Bass Lakes in 2015. The sampling programs include those of two agencies: The District Municipality of Muskoka (DMM) and the Ontario Ministry of Environment and Climate Change (MOECC). In the latter, the Lake Stewards of Ontario carry out the sampling and measurement and the MOECC analyzes the samples and coordinates the data reporting.

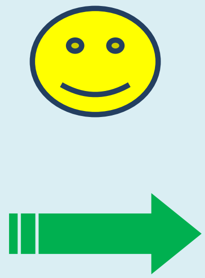
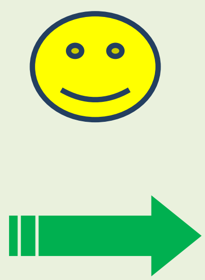
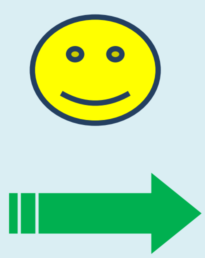
In an effort to simplify the findings for Kahshe and Bass Lakes, this report has been structured to address the following issues/areas of potential concern for both lakes:

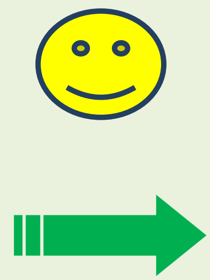
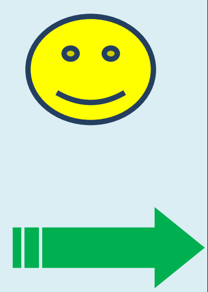
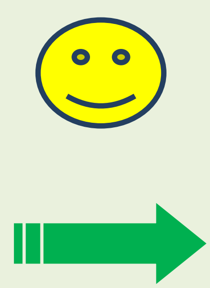
- Total Phosphorus and Water Clarity
- Calcium Depletion
- Lake Acidification
- Dissolved Oxygen and Water Temperature
- Metals and Other Chemicals
- Benthic Health

The map below shows the locations of all sampling site for both DMM and MOECC sampling programs, while the summary table that follows provides brief information on each of the six issues.



Summary of 2015 Findings for Kahshe and Bass Lakes

Measure	Why It's Important	Versus Benchmark*	Comments
Total Phosphorus (P) and Water Clarity	❑ An indicator of water quality degradation and potential for algal blooms. ❑ Linked to planning & development restrictions. ❑ Total P benchmark set to preserve water quality via a background approach. ❑ Natural tea colour of water complicates clarity findings.		❑ Background-based model review now completed and P benchmarks to be revised. ❑ New DMM approach does not change good water quality status for Kahshe L. ❑ However, Bass Lake now flagged for further study because of elevated phosphorus.
Calcium Depletion	❑ Calcium is naturally occurring in soils and rocks and is essential component of aquatic food chain. ❑ There was enhanced leaching from soil to lakes due to acid rain impacts in 1970s & 80s. ❑ Many Muskoka lakes now at lower end of aquatic threshold.		❑ Not a shoreline development issue. ❑ Calcium in Kahshe and Bass L. is currently above benchmark (good), but need to keep monitoring and watch for signs of decline.
Lake Acidity (pH)	❑ In mid to late 1900s, sulphur and other acid gasses from the Sudbury basin plus transboundary air flows from the U.S. acidified many lakes. ❑ Most lakes in Muskoka have recovered following emission controls.		❑ The Ontario objective is to keep pH between 6.5 and 8.5. ❑ Kahshe and Bass Lakes are 10-20 times above the lower pH limit, so there is no concern for impacts on aquatic species. ❑ However, both lakes have a low buffering capacity, so we need to keep monitoring.

Measure	Why It's Important	Versus Benchmark*	Comments
Dissolved Oxygen (DO) And Water Temperature	❑ Oxygen is essential for all aquatic organisms. ❑ It enters surface water from the air and is transferred down to lower depth waters via spring and fall water turnover. ❑ Levels in the bottom waters deplete during the summer and can become anoxic and impact aquatic survival and also release P from sediments.		❑ The PWQO for DO in warm water lakes is 5 mg/L. ❑ The DO levels in mid and lower layers of water in both lakes often drops below the desirable benchmark. ❑ However, neither Kahshe nor Bass L. is considered anoxic and the lower DO levels are tolerated or avoided by aquatic organisms. ❑ The report also charts the 30 year trends in water temperature which show no obvious up or down trend.
All Other Chemicals	❑ DMM samples and analyzes Kahshe and Bass L. for over 30 different metals, nutrients and other chemicals. ❑ They briefly discuss about a dozen of them. ❑ This report analyzes them relative to chronic toxicity benchmarks and charts them all since monitoring began in early 2000s.		❑ All 30 have been compared to chronic toxicity benchmarks from Ontario, Canada and the U.S. EPA. ❑ Most are well below aquatic benchmarks in both Kahshe and Bass L. ❑ A few benchmark exceedances are likely due to analytical problems or benchmarks that are not well supported.
Benthic Health	❑ Counting of aquatic invertebrates (worms, mollusks, insects, crustaceans and mites) has been carried out by the DMM and KLRA on Kahshe L. since 2003. ❑ This gives us an early warning of possible environmental impacts.		❑ Benthic index values from all 3 sampling locations on Kahshe L. are similar to the Muskoka reference (natural) levels. ❑ No problems in the population, growth or survival of aquatic invertebrate which can be related to contamination or habitat disturbance.

Measure	Why It's Important	Versus Benchmark*	Comments

DMM means District Municipality of Muskoka

*

❑ Levels are within accepted benchmarks for water quality

❑ No obvious upward or downward trend has been detected since monitoring began

In conclusion, based on the foregoing summary of the environmental monitoring of Kahshe and Bass Lakes no major issues in terms of environmental quality have been detected. The possible exception is total phosphorus in Bass Lake, which has been flagged by DMM for more intensive study as a result of the review of their background-based water quality model. The additional study will be designed to determine the cause of the elevated total phosphorus in Bass Lake and to determine if any further development restrictions are warranted.

Although there are no major environmental issues, we need to continue with our sampling efforts and practice overall lake stewardship to delay the onset of nutrient enrichment and its impact on lake health. How can we make a difference?

Each of us can do our part to maintain the quality of the water by:

- managing our septic systems properly and having tanks pumped out regularly;
- avoiding the use of products containing phosphorus (detergents and cleaners);
- disposing of toxic wastes (batteries, paint, oil, old gas, pressure-treated lumber and other construction waste) at approved land fill sites;
- minimizing near-shore removal or management of vegetation and ensuring that any shoreline disturbance is conducted in compliance with permitted uses;
- avoiding the use of any chemical fertilizers or pesticides in areas close to the shore; and,
- taking precautions to minimize the potential for introducing both terrestrial and aquatic invasive species.

1.0 Kahshe Lake Stewardship Mandate

In 2013, the Kahshe Lake Steward Committee was dissolved, with the role of the Lake Steward being assigned to a newly created Conservation Committee which reports directly to the Kahshe Lake Ratepayers' Association (KLRA). The Lake Steward has been made a permanent sitting member of this new committee. This change in reporting structure has not altered the roles and responsibilities of the Lake Steward, and these remain as:

- 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.

Another important water quality parameter that is not being routinely monitored in either lake or at the public beaches by any organization is coliform contamination. If you are drinking water from the lake – **<u>which is strongly not recommended</u>** - and want to ensure that your filtering system is functioning properly, you can submit a sample of water to the Simcoe Muskoka Health Unit for coliform analysis. The contact info is:

- 2-5 Pineridge Gate, Gravenhurst, ON, P1P 1Z3. PHONE: 705-684-9090, FAX: 705-684-9887.

Anyone who suspects that a neighbouring septic system is in need of pumping or improved management can also take a sample from the lake and submit it to the Simcoe Muskoka Health Unit.

Given the importance of maintaining fully functional septic systems, the following information has been extracted from a Good Neighbour Resource Hand book article by Rob Abbott which was updated for 2014 by the Conservation Committee.

> Your septic system is a sewage treatment facility that requires careful attention to design, construction, operation and maintenance. **As a property owner, this is your responsibility.** In Ontario, the specifications for construction and maintenance of sewage systems with a flow of less than 10,000 litres per day are regulated under the *Ontario Building Code*, and municipalities are responsible for the inspection and approval of all septic installations. In the case of Kahshe and Bass Lakes, the Building Department of the Town of Gravenhurst is the department with this responsibility. In addition to permitting the installation of septic systems, the Town of Gravenhurst also operates a septic re-inspection program which is briefly summarized below:

- the re-inspection on Kahshe Lake is carried out every 5 years (2008… 2013….);
- it consists of a trained student visiting most (but not always all) properties and carrying out a visual inspection of the tank and bed;
- if the visual inspection finds the tank and bed in good condition, they leave a note to inform the property owner and send a follow-up letter;
- if there are visual signs of failure of the leaching bed, they leave a notice and the Building Department follows up with a letter requiring a pump-out and system inspection with a receipt from a licensed pumper to confirm that it has been carried out;
- if the visual signs point to a serious failure, the Building Department issues a stop order until

evidence is provided that the problem has been corrected.

Unfortunately, there is no systematic process for re-inspections based on permits or on re-inspection findings. However, cottage owners are encouraged to report any suspected problems to the Building Department so they can follow up with an inspection of the system. As noted earlier, another way neighbouring property owners can support a concern regarding possible septic system failure is to submit a sample of lake water from a location close to the suspect property. The sample should go to the Simcoe Muskoka Health Unit for coliform analysis at the address noted on the previous page.

2.0 Overview of Environmental Monitoring

Kahshe amd Bass Lakes are being monitored for water quality and biological functioning parameters under two main initiatives as outlined below:

Lake Partner Program (LPP) – MOECC – Kahshe Lake Only

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

The program has consisted of the following activities:

- **Water clarity measurements**
  - Clarity of the water is measured every two weeks during the ice-free period at four locations using a Secchi disc, and these findings are forwarded to the MOECC for compilation and comparison with other lakes in Ontario.
- **Water quality testing**
  - Water is sampled from the same four locations in May each year and sent to the MOECC where it is analyzed for total phosphorous and calcium.

Given the location of the original three sampling sites, which provide coverage of the eastern and northern areas of the lake, a request was made to the MOECC in the fall of 2013 to add an additional sampling location in the southwest part of Kahshe Lake, where water is generally more shallow and potentially more susceptible to phosphorus-induced algal blooms given the likelihood of warmer water temperatures during the summer months. The MOECC approved this request and a new sampling location was added to the south of Cranberry Is. in 2014.

Lake System Health Program (DMM) – Both Kahshe and Bass Lakes

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 MOECC and several other participating agencies.

The monitoring program consists of 193 sampling sites on 164 lakes on a rotational basis. 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.

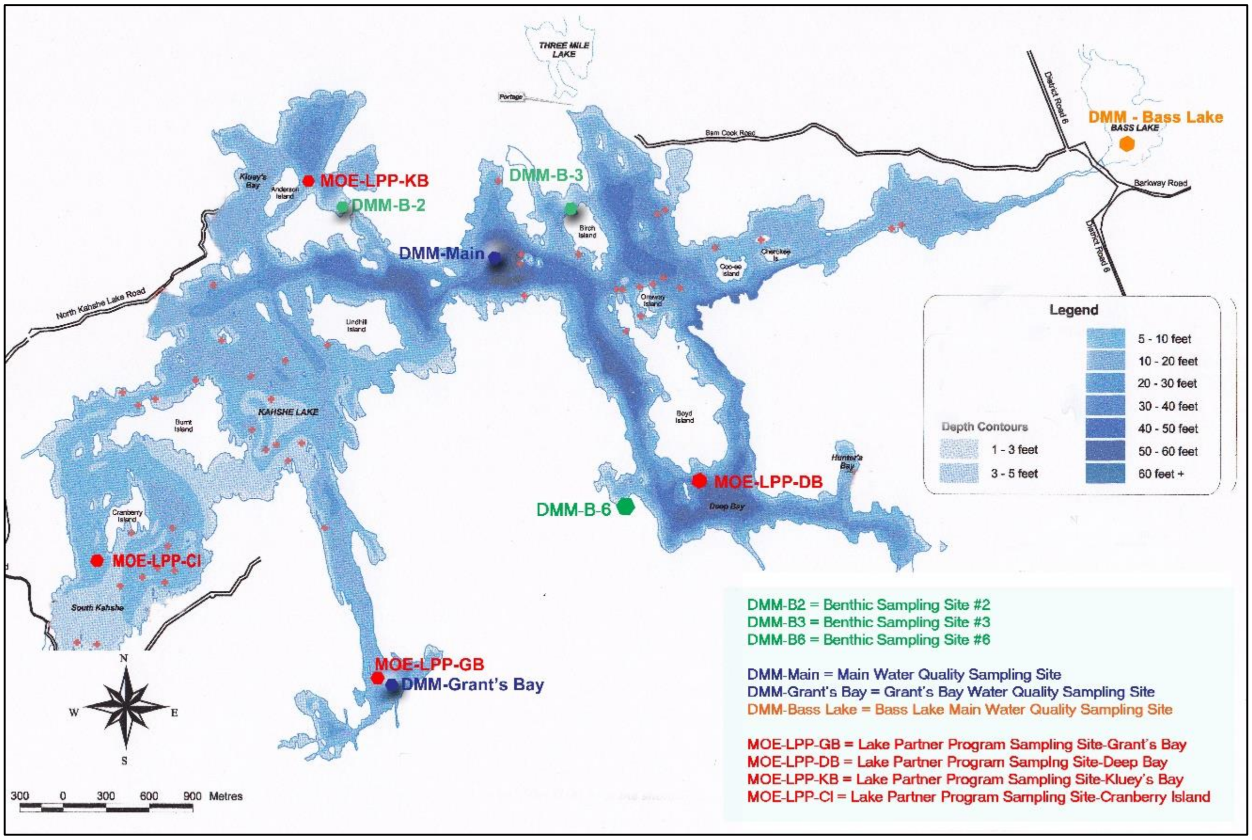
For Kahshe and Bass Lakes, the DMM program consists of the following activities which have been conducted every second year for Kahshe L and every third year for Bass L:

- Spring phosphorus sampling conducted in May (2 sites in Kahshe L and 1 site in Bass L);
- Water sample collection for total phosphorus and a suite of other physical and chemical parameters in May (2 sites in Kahshe L and 1 site in Bass L);
- Secchi depth measurements collected in May and August (2 sites in Kahshe L and one site in Bass L);
- Temperature and dissolved oxygen at increasing water depths taken in May and August (2 sites in Kahshe L and 1 site in Bass L);
- Benthic invertebrate sampling at one of three potential sites in Kahshe L in August each year.

Based on their program timing, the DMM carried out the above sampling program in at both sampling locations in Kahshe Lake and at the one sampling location in Bass Lake in 2015.

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 and Bass Lakes, the locations of water sampling and measurement have been shown on Figure 1 below.

Figure 1: Map Showing 2015 MOECC and DMM Sampling Locations on Kahshe and Bass Lakes



3.0 Results of Monitoring on Kahshe and Bass Lakes

In this report, the results will be presented in several sections which will focus on the main parameters of concern to the health of our lakes. Because both the DMM and the MOECC include sampling of some of the same parameters, this report will make comparisons between the findings of each agency. The main components of this report will address the following main areas of interest in terms of water quality:

- Total Phosphorus and Water Clarity
- Calcium Depletion
- Lake Acidification
- Dissolved Oxygen and Water Temperature
- Metals and Other Chemicals
- Benthic Health

3.1 Total Phosphorus and Water Clarity (Secchi Depth)

The DMM year-end summary report and data sheets provide 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 2015 year-end data sheets for Kahshe Main and Grant's Bay sampling sites show current (2015) and historical sampling results for total phosphorus and Secchi depth as well as current water temperature and dissolved oxygen concentrations with increasing sampling depth. The charts on the above water quality parameters as presented in the 2015 DMM year-end report are attached and include both the Kahshe Lake Main and Grant's Bay locations.

The data sheets for Kahshe Lake show how both total phosphorus and Secchi depth measurements have varied over the 32 year period for which DMM data are available for the Kahshe Lake Main site and the Grant's Bay site which has been monitored over a 17 year period. In both cases, the data confirm a fairly normal amount of variability from year to year, with no apparent upward or downward trend. In terms of threshold values, the 10-year averages for total phosphorus of 11.3 and 12.5 µg/L for the Main and Grant's Bay locations, respectively, are both well below the Kahshe Lake threshold value of 14.2 µg/L.

The DMM data sheet for Bass Lake also is attached, and as for Kahshe Lake, the 10-year average total phosphorus concentration (23.1 µg/L) is well below the Bass Lake threshold value of 30.9 µg/L. Again, these and the Secchi depth findings will be discussed in greater detail later in this report.

To give some perspective on how the findings from Kahshe and Bass Lakes compare with other Muskoka lakes, the 2015 DMM findings for both total phosphorus and Secchi depth at all sampled lakes in Muskoka are presented below.

In the case of total phosphorus, lakes are generally placed in one of three categories as follows:

- Oligotrophic or unenriched lakes are those with total phosphorus below 10 µg/L
- Mesotrophic or moderately enriched lakes are those with total phosphorus between 11 and 20 µg/L
- Eutrophic or enriched lakes are those with total phosphorus greater than 20 µg/L.

Based on these classifications, Kahshe Lake, with 2015 total phosphorous concentrations in the range of 11.4-11.5 µg/L is considered a Mesotrophic lake while Bass Lake at 23.1 µg/L is considered Eutrophic.

In the case of Secchi depth, Kahshe Lake is in the mid-point range for a lake with a moderate level of dissolved organic carbon (DOC). DOC is the chemical parameter that gives the lake water the tea colour, which limits light penetration. Bass Lake also is considered to have a moderate level of DOC, but the Secchi depth is somewhat lower than the mid-point range for lakes considered moderate in DOC and more in line with the clarity of lakes with high levels of DOC.

Figure 2: 2015 Spring Phosphorus Sampling Results

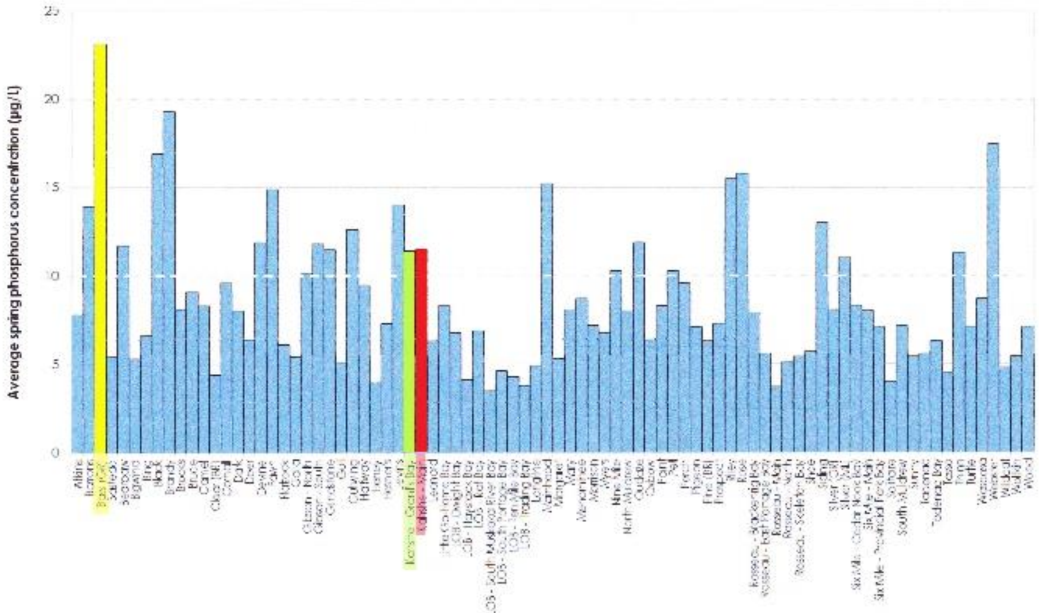
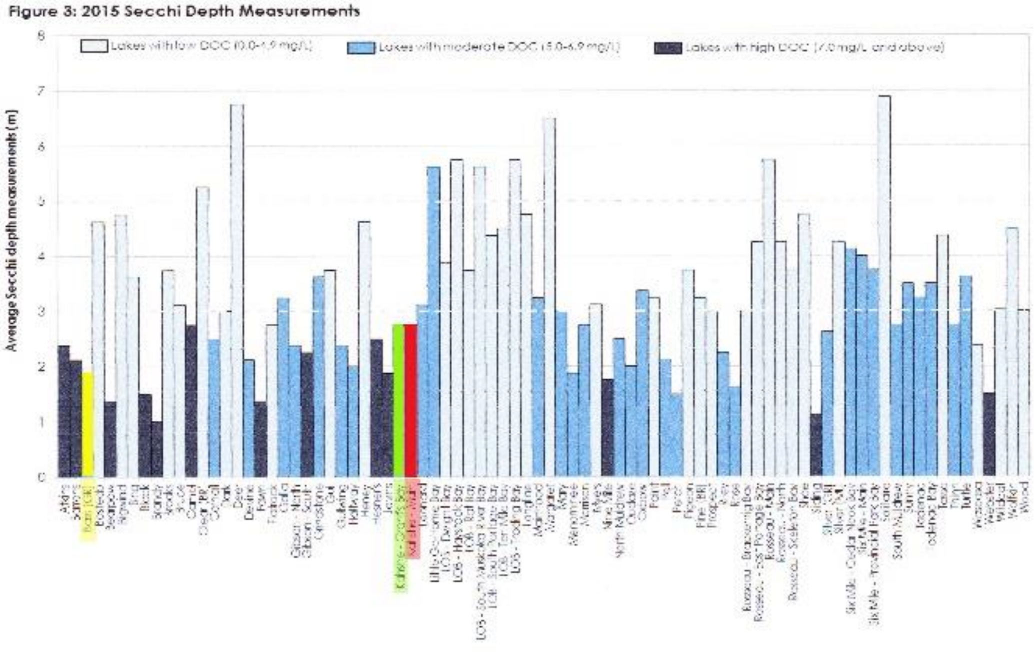


Figure 3: 2015 Secchi Depth Measurements



Before moving on to other chemical and physical parameters, it's important to understand why the DMM places so much focus on phosphorus and Secchi depth, and more importantly, what this means for the future of our two lakes. Phosphorus has been clearly shown to be the main nutrient that controls the growth of algae in Ontario lakes, with higher phosphorus generally resulting in an increase in algal growth, and therefore, decreased water clarity. The DMM also evaluates the responsiveness of lakes in Muskoka to input and mobility of phosphorus as it enters the lake from human and natural sources. As shown on the attached data sheets from DMM, both Kahshe and Bass Lakes are considered moderate in terms of their sensitivity to phosphorus.

This sensitivity rating also factors into the setting of a total phosphorus threshold for lakes in Muskoka. This threshold value is set equal to the background concentration plus an additional 50%. If the lake's measured and modelled phosphorus concentrations over a 10-year period are greater than its threshold value, then the lake is considered "over threshold" and actions will be initiated to reduce the amount of phosphorus entering the lake from its watershed. As noted above, neither Kahshe nor Bass Lakes have 10-year averages greater than threshold. However, the DMM has now completed their review of the water quality model that has been used to set threshold levels. In a letter to property owners of lakes affected by this review, the DMM state:

"The results of the review suggest the need for an updated approach governing development or redevelopment on lakes which reflects scientific advances in the last decade, in recognition that the existing model was too narrowly focused and had some limitations when used to evaluate an individual lake. While any change to planning policy would require an official plan amendment and significant public consultation, the policy direction suggested by the results of the Water Quality Model review recognizes that all lakes should be afforded a high degree of protection through implementation of a set of "Standard" Best Management Practices (BMPs) for all new development or redevelopment of shoreline lots. In addition, the science tells us that certain lakes have been flagged as requiring additional study and potentially a higher level of protection. These "transitional" lakes are identified on the basis of one or more of three "management flags":

- *Total Phosphorus concentrations greater than 20 micrograms/litre,*
- *A rising trend in Total Phosphorus; and/ or*
- *Documented occurrence of a blue-green algal bloom.*

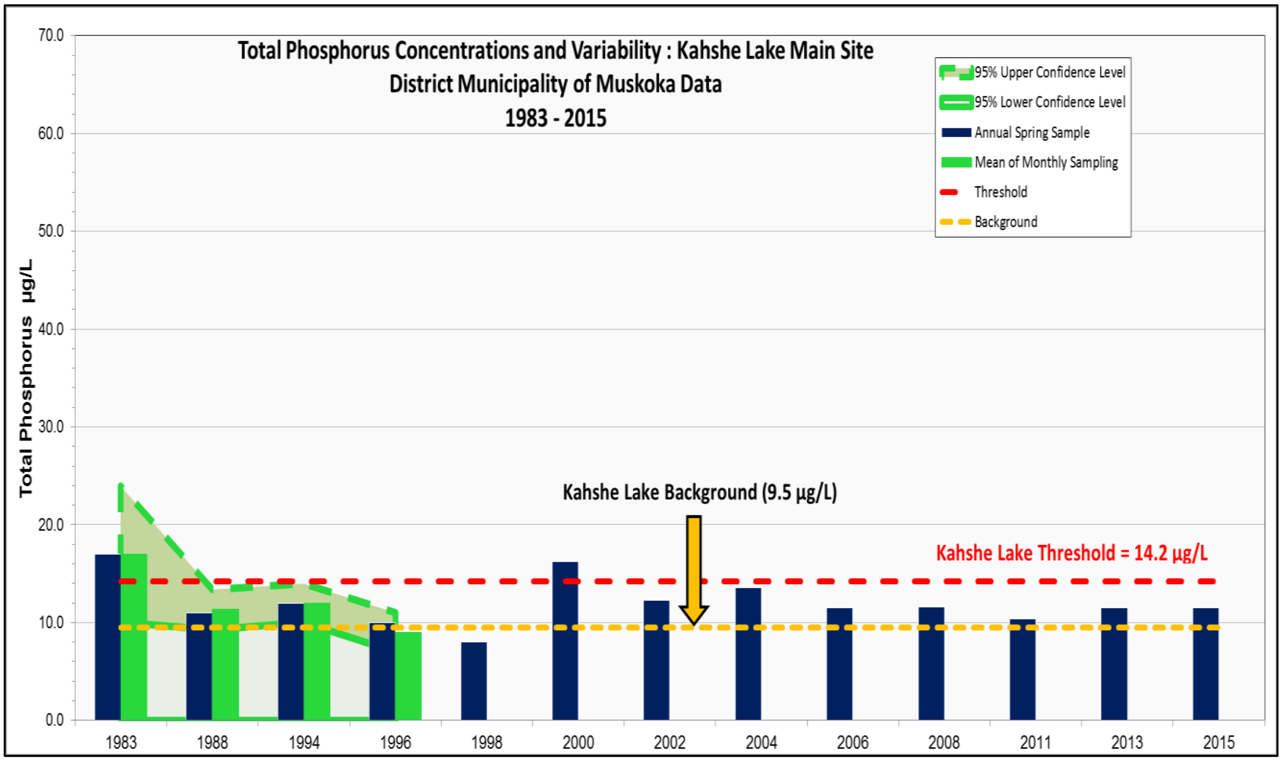
Bass Lake and six other lakes across the District (including Ada (ML), Barron's (GB), Brandy (ML), Bruce (ML), Stewart (ML/GB) and Three Mile (ML) Lakes) are currently affected by these management flags."

Bass Lake was flagged only because it met one of the three conditions, that being a total phosphorus concentration greater than 20 micrograms/L.

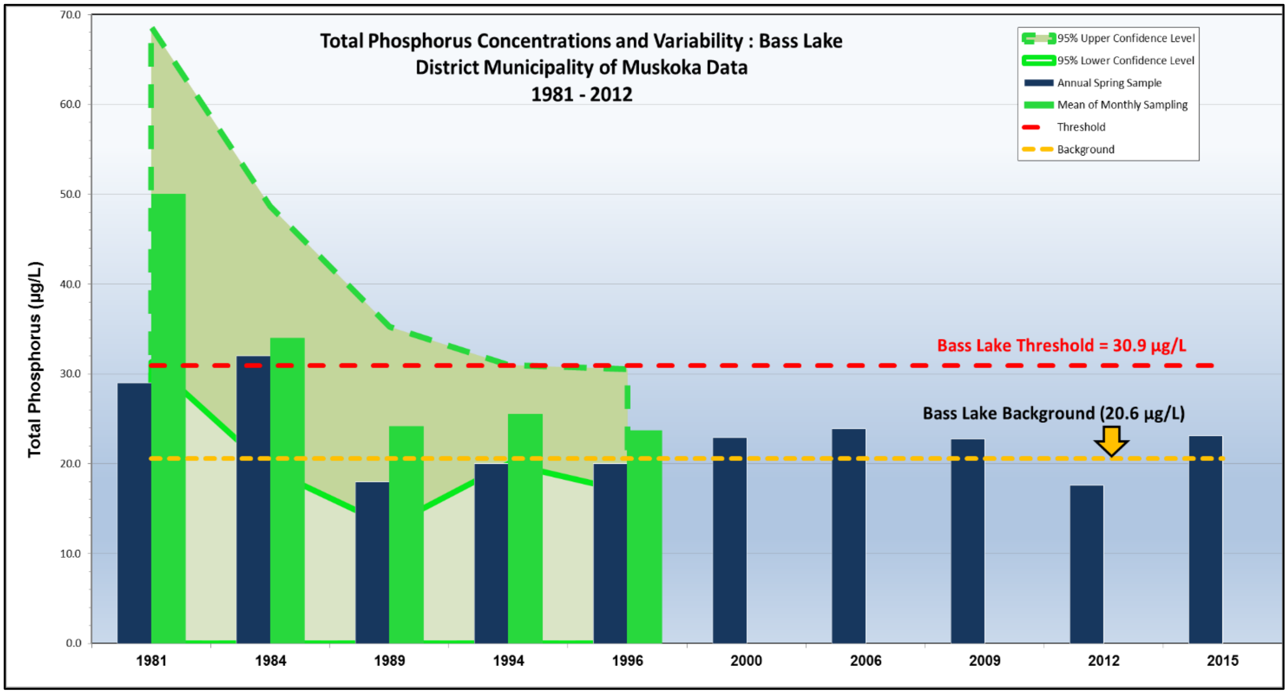
Another group of chemicals that can contribute to eutrophication and plant/algal growth are nitrogen-based compounds. These include nitrate and nitrites as well as ammonia and ammonium. These have also been analyzed by the DMM and the results are discussed in Section 3.5. The findings from the analysis of these compounds indicates that the waters of both Kahshe and Bass Lakes are well within natural surface water levels, and as such, there does not appear to be any detectable impact from

sources that are typically associated with their presence – i.e. discharge from septic systems and the use of nitrogen-based fertilizers on lawns located close to the shoreline.
To more clearly show the historical trends in total phosphorous concentrations over the past 30+ years, separate charts showing the concentrations for both lakes (Main site only for Kahshe L) are presented below. To highlight the difference in total phosphorous concentrations in both lakes, the same scale (0-70 µg/L) has been used.

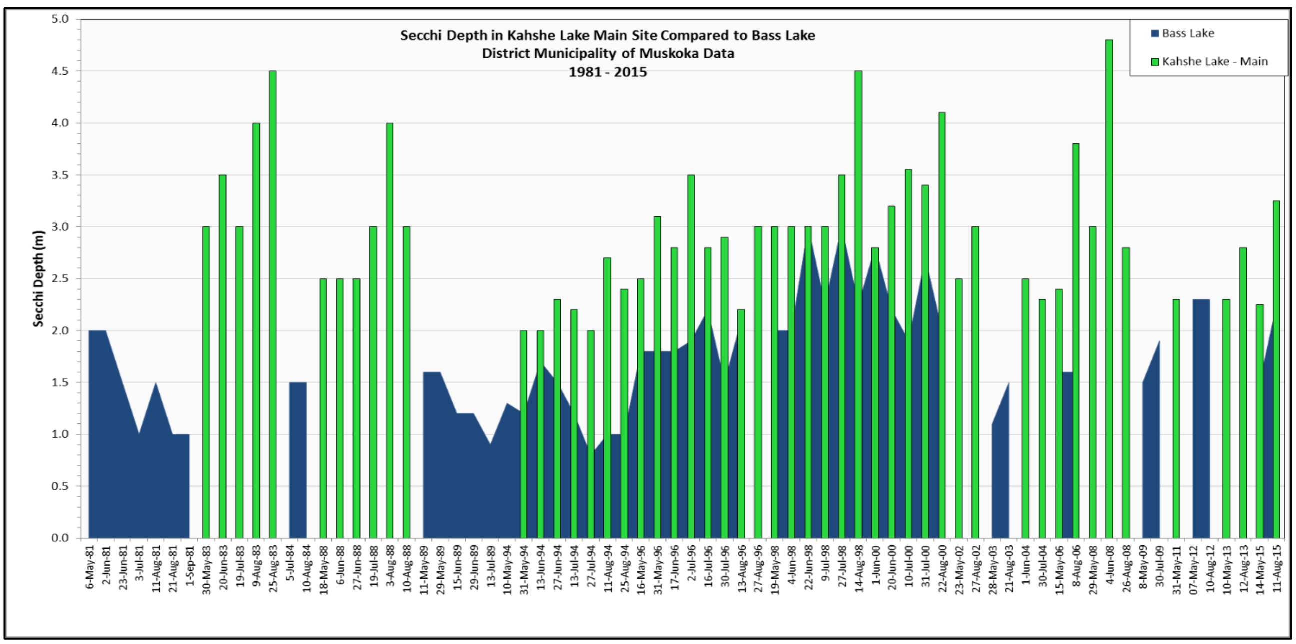
Also shown are the natural background and threshold concentrations as well as the variability (upper and lower confidence intervals for the mean of monthly sampling at a 95th level of probability) that was determined (from 1983 up to 1996) when the sampling was conducted over several dates during the ice-free period.



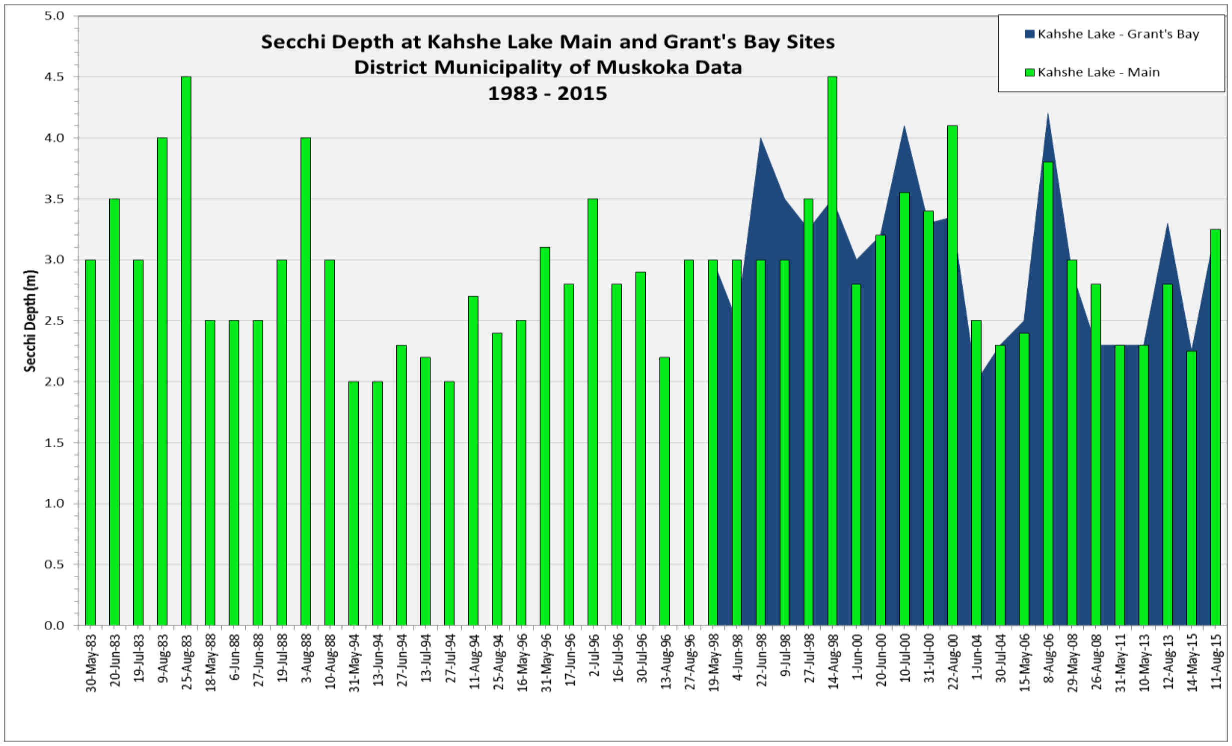
As noted earlier, the concentrations of total phosphorus have remained fairly stable and are only marginally above the natural background concentration in most years. While the total phosphorus concentrations in Bass Lake are considerably higher than in Kahshe Lake, the concentrations also are only marginally above the natural background concentrations and well below the threshold concentration of 30.9 µg/L in most years.



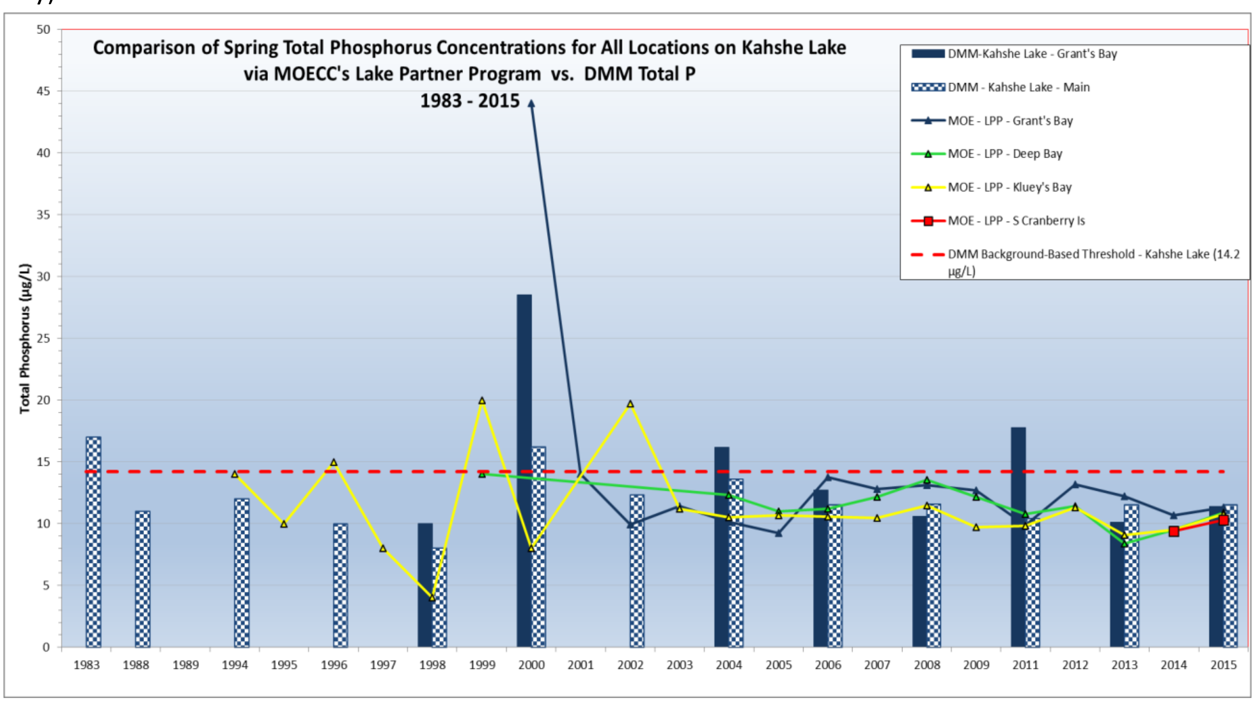
Secchi depth measurements by the DMM over the same period are shown below, and as noted in the individual DMM data sheets discussed earlier, the results clearly show a greater degree of water clarity in Kahshe compared to Bass Lake.



The Secchi depth data for the two sites (Main and Grant's Bay) in Kahshe Lake also appear very similar, as would be expected for sampling sites on the same body of water. These are presented below:

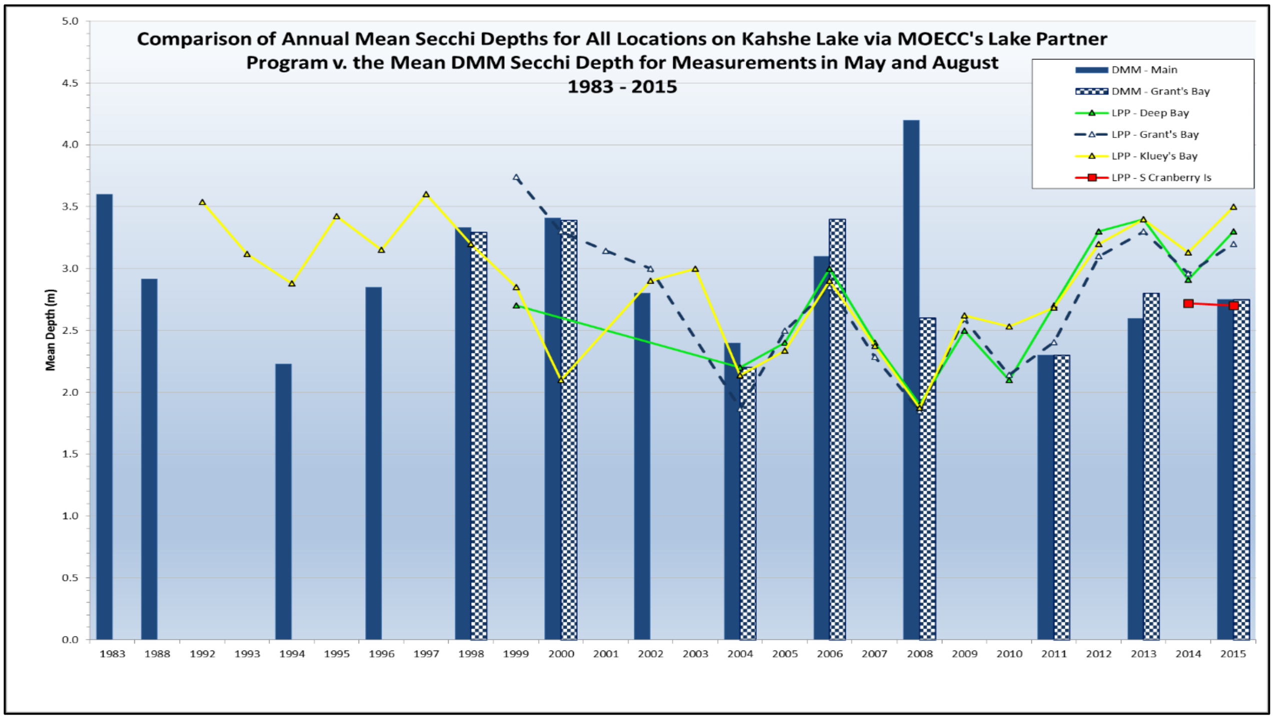


As the MOECC's Lake Partner Program also includes total phosphorus measurements in the spring each year, the next comparison shows the total phosphorus concentrations at all locations on Kahshe Lake via the MOECC's LPP vs. the measurements by the DMM at their two sampling locations (Main and Grant's Bay).



This comparison demonstrates that the two programs are generating similar findings and that there is only a normal amount of variability in total phosphorus concentrations across the five sites that are sampled. Of particular note here are the total phosphorus concentrations at the new location to the south of Cranberry Is. This site was established in 2014 in an effort to include a sampling site in the more shallow water depth portion of the lake, as this is the area which would be most sensitive to increased algal growth due to its potentially higher water temperatures resulting from the shallow depth. As can be seen in the above chart (red line), the total phosphorus concentrations in this area are in the low range of all sites on Kahshe Lake.

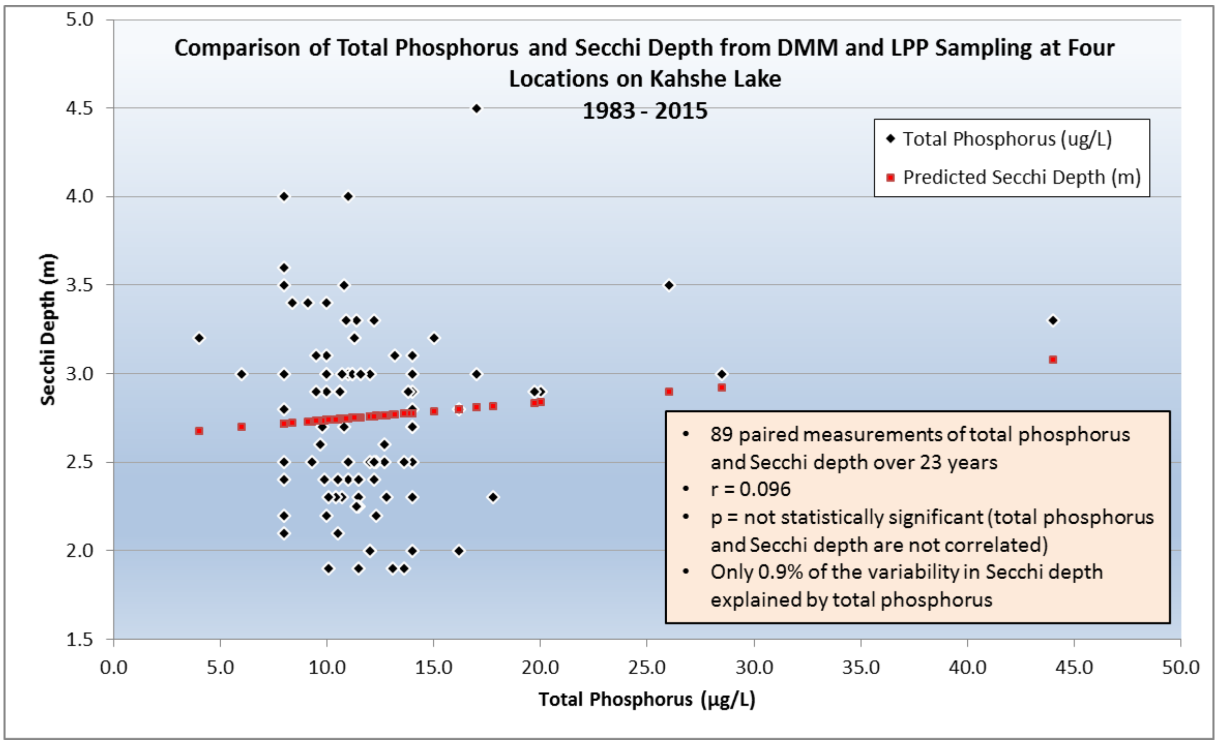
As both the DMM and MOECC (via the Lake Steward) also measure water clarity with the Secchi disk, a similar DMM vs. MOECC comparison has been made as shown below. Note that this comparison is somewhat limited by the fact that the MOECC data represent the average Secchi depths over the 10 bi-weekly measurements from April through September (ice-free period), while the DMM data are the average from only two measurements (May and August).



Based on the above chart, it is apparent that the Secchi depth (water clarity) measurements by both agencies have generated similar findings at the Grant's Bay location where both MOECC and DMM have measured from the same location. Also, it is apparent that water clarity is fairly similar across all Kahshe Lake sampling locations, with only normal variability. However, a couple of things should be noted.

First, the clarity measurements via the MOECC's Lake Partner Program for the new site to the south of Cranberry Is. (shown as a red line) should be ignored, as in almost all cases, the Secchi disk depth was limited by the shallow water condition (i.e. the disk was still visible when it hit bottom and could not be lowered further). The other interesting finding is that since the author took over as the Lake Steward in 2011, the variability in the water clarity measurements has decreased and in all cases, the water clarity depths are consistently greater than those reported by the DMM measurements. I'm not sure why the variability has decreased, but I suspect that the generally greater water clarity measurements that the author has generated are likely due to the fact that unlike the DMM, my measurements are taken on days when the sun is either shining or there is minimal cloud, resulting in greater light penetration into the lake. In contrast, the DMM measurements are made whenever Kahshe Lake is scheduled for measurement, and this could mean that measurements are taken during cloudy and rainy days when ambient light levels are lower.

The last comparison of total phosphorus and water clarity measurements is focused on the relationship between these two variables. As it is well established that total phosphorus is a promoter of algal growth, it follows that increasing levels of phosphorus would be negatively correlated with decreased water clarity. In fact, the DMM (GLL, 2005) have clearly demonstrated that this is the case using all of the Muskoka lake measurement data. To determine if this is the case on Kahshe Lake, I went back through the data from 1983 through 2015 and evaluated the relationship between these two parameters using 89 paired measurements over 23 years. These data are plotted on the chart that follows.



As is apparent from this comparison, there is no statistically significant relationship between total phosphorus and Secchi depth. In fact, the predicted Secchi depth based on these data are slightly positive (as shown with the red squares). Why are these results different than those expected based on the larger Muskoka dataset? I suspect that this lack of a relationship between total phosphorus and water clarity is likely due to a couple of factors:

- As total phosphorus levels are only marginally above background concentrations, the data do not provide a meaningful cause-effect range which would include levels required to stimulate algal growth.
- As Kahshe Lake is considered a tea coloured lake, this may be negating any cause-effect relationship, as the water clarity also is limited by this factor.

While neither of these potential reasons for the absence of a relationship can be proven, the main takeaway here is that the waters of Kahshe Lake fall within the normal range for a lake that is classed as Mesotrophic based on total phosphorus concentrations.

Total Phosphorus and Water Clarity Summary

Phosphorus has been clearly shown to be the main nutrient that controls the growth of algae in Ontario lakes, with higher phosphorus generally resulting in an increase in algal growth, and therefore, decreased water clarity. The DMM also evaluates the responsiveness of lakes in Muskoka to input and mobility of phosphorus as it enters the lake from human and natural sources and both Kahshe and Bass Lakes are considered moderate in terms of their sensitivity to phosphorus.

This sensitivity rating also factors into the setting of a total phosphorus threshold for lakes in Muskoka. This threshold value is set equal to the background concentration plus an additional 50%. If the lake's measured and modelled phosphorus concentrations over a 10-year period are greater than its threshold value, then the lake is considered "over threshold" and actions will be initiated to reduce the amount of phosphorus entering the lake from its watershed. **Neither Kahshe nor Bass Lake is considered over-threshold. However, as a result of a review by the DMM of their water quality model, Bass Lake has now been flagged for further study due to its elevated total phosphorus concentration and may require development restrictions pending the outcome of the study.**

Based on the sampling by both the DMM and MOECC (Lake Steward), the following findings have been discussed in greater detail.

- The total phosphorus data for Kahshe Lake over a 30+ year period demonstrate a fairly normal amount of variability from year to year, with no apparent upward or downward trend.
- In terms of threshold values, the 10-year averages for total phosphorus of 11.3 and 12.5 µg/L for the Main and Grant's Bay locations, respectively, are both well below the Kahshe Lake threshold value of 14.2 µg/L.
- The DMM data for Bass Lake also demonstrate that the 10-year average total phosphorus concentration (23.1 µg/L) is well below the Bass Lake threshold value of 30.9 µg/L.
- Kahshe Lake, with 2015 total phosphorous concentrations in the range of 11.4-11.5 µg/L is considered a Mesotrophic lake while Bass Lake at 23.1 µg/L has the highest total phosphorus concentration of all sampled Muskoka lakes and is in the range referred to as Eutrophic.
- In spite of these higher total phosphorus concentrations, Bass Lake is only marginally above its natural background level – i.e. the phosphorus is mostly natural in origin. However, this is being re-examined as a result of a water quality model review.
- In the case of Secchi depth, Kahshe Lake is in the mid-point range for a lake with a moderate level of dissolved organic carbon (DOC). DOC is the chemical parameter that gives the lake water the tea colour, which limits light penetration.
- Bass Lake also is considered to have a moderate level of DOC, but the Secchi depth is somewhat lower than the mid-point range for lakes considered moderate in DOC and more in line with the clarity of lakes with high levels of DOC.
- A comparison of the total phosphorus concentrations generated by both the DMM and MOECC demonstrates that the two programs are generating similar findings and that there is only a normal

amount of variability in total phosphorus concentrations across the five Kahshe Lake sampling sites. The findings also demonstrate that the total phosphorus concentrations at the new location to the south of Cranberry Is. are at the low end of the range.

- As for total phosphorus, the water clarity measurements by the two agencies at the five sampling locations in Kahshe Lake have demonstrated fairly similar findings and a normal level of variability.
- Finally, an evaluation of the Kahshe Lake total phosphorus and water clarity measurements over the past 23 years has failed to find any statistically significant relationship (correlation) between these two parameters. This is likely due to two factors: 1) total phosphorus concentrations are well below levels which would induce a cause-effect response and 2) the tea colour of the water has negated any cause-effect relationship.

3.2 Calcium Depletion

Another chemical of potential concern to the health of our lake is calcium. In this case, the concern is not related to shoreline development, but arises from a Muskoka trend towards decreasing levels of calcium which has been documented in a recent Canada Water Network Research Program in the Muskoka watershed. Why is calcium so important?

Calcium is a nutrient that is required by all living organisms, including very small organisms called zooplankton (e.g. *Daphnia*) that live in the waters of Muskoka lakes and are a key component of the food chain for other aquatic organisms higher on the food chain. The reproduction of these organisms as well as others like mollusks, clams, amphipods and crayfish have been shown to be adversely affected by low levels of calcium in lake waters.

Based on data from over 700 lakes in Ontario, about 35% currently have calcium levels below 1.5 mg/L, which is considered a limiting threshold for the survival of species like *Daphnia*. One of the implications of reduced calcium is a lowering of biodiversity. Dr. N. Yan explained how this can happen using calcium as an example in response to a Toronto Star article in 2014. He elaborated on a study designed to highlight a fairly fundamental shift from crusty to jelly-clad species as dominants in the plankton, as we move from a higher calcium, phosphorus world in our lakes to a lower calcium, lower phosphorus world.

This has resulted in *Holopedium* taking dominance over *Daphnia*, as it needs 20 times less calcium, and 2 times less phosphorus than *Daphnia*. It also survives attacks from invertebrate predators better and was already widespread in our lakes. Arguably it is a dominant zooplankton species on the Shield. The point of the paper was that it has become more dominant over the last 20-30 years at the expense of its more calcium-needy competitors.

There are indeed a few possible ecological concerns of the change. Yan explained:

1) We are losing biodiversity here, as several species of *Daphnia* are losing out to only one *Holopedium* species;

2) The nutritional value of the large animal plankton is reduced, as *Holopedium* has a much lower mineral content than *Daphnia*. The implications of this should be explored, but are not yet known; and,

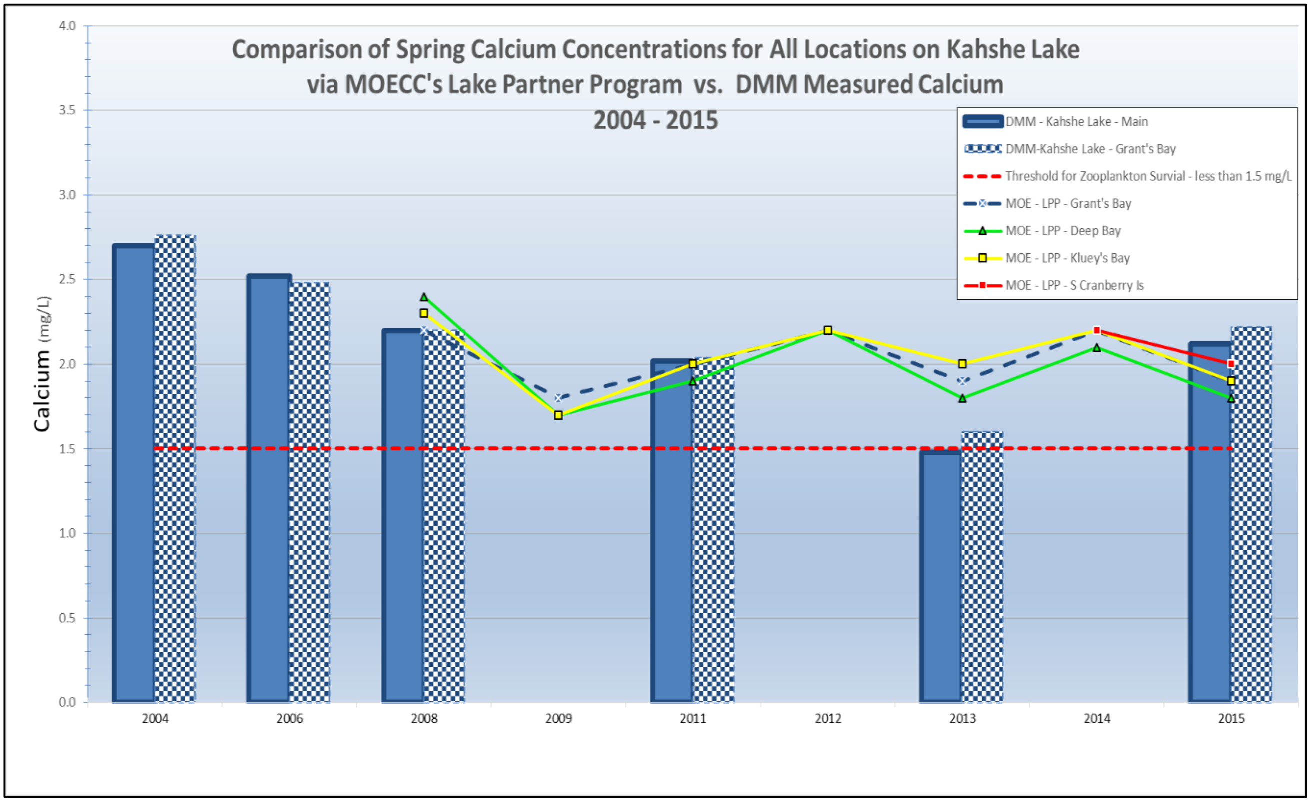
3) There may well be less food passed up the food chain to fish in our small lakes where invertebrate predators are actually key steps between plankton and fish, because *Holopedium* is pretty well protected from most invertebrate predators by its jelly coat. When it is eaten, it has lower mineral content.

In our Muskoka lakes, the absolute abundance of *Holopedium* has increased by an average of about two fold over the last 20 years, and the relative abundance has increased more, said Yan, while the abundance of five species of *Daphnia* has declined. There are two other, smaller species of *Daphnia* that need less calcium than their congeners, and they are still doing well, but this won't last if calcium continues to fall, he said.

Still, jellification doesn't mean the end to fish in our lakes. The thing to understand, said Yan, is that "the sky is not falling, but it's not quite the same sky as it once was." No doubt ongoing research and monitoring is critical to the health of our lakes. The upside to the attention raised by The Toronto Star's article this week, said Yan is that it highlights how "research in Muskoka is alerting the world to intriguing and fundamental changes that accompany human interventions in the natural world."

Studies have shown that the gradual reduction in calcium levels in watershed soils and the water of lakes and rivers is associated with acidic rainfall, forest harvesting and climate change. In the early days, very acidic rain leached the calcium from soils faster than it could be regenerated via natural weathering of underlying rocks and this resulted in increased levels in the water of some lakes. However, as acid deposition rates were reduced, less calcium is now being leached from watershed soils into lakes, resulting in lower calcium concentrations that are threatening the health of aquatic species. Forest harvesting also has played a role, as the removal of timber and subsequent re-growth of forests following timber harvesting has further diminished the supply of calcium in soils that is available for leaching to lakes. Finally, climate change is also playing a role, as it has in some areas, resulted in in decreased water flow within the watershed, resulting in less calcium being exported from watersheds to lakes.

Fortunately, the DMM water sampling program has included calcium since 2004, while the MOECC have been analyzing Kahshe Lake water for calcium since 2008. The chart that follows plots the data over this time period and also shows the 1.5 mg/L threshold for the survival of *Daphnia*.



It is apparent from this analysis that with the possible exception of 2013, Kahshe Lake has maintained an adequate concentration of calcium to support the sensitive zooplankton that are required for the survival of other aquatic organisms that feed upon these creatures. Given that the MOECC data from Grant's Bay and the other two sampling sites in 2013 were all well above the calcium threshold of 1.5 mg/L, the DMM findings for the Main and Grant's Bay sampling sites in 2013 appear to have been influenced by either a sampling or laboratory factor.

Finally, although the sampling period is limited to just over 10 years, there does not appear to be a noticeable downward trend in the calcium data. However, as this is a very short time period to judge a trend, this will need to be followed closely in future sampling, as it has the potential to impact on the quality of aquatic life on our lake.

While the Bass Lake calcium data have not been included in the above chart, the calcium concentrations have ranged from 2.2 to 2.8 mg/L over the period from 2006 through 2015, and as such, are also well above the limiting threshold concentration of 1.5 mg/L. Also, as for Kahshe Lake, there has been no apparent downward trend in the calcium concentrations in Bass Lake over this 9 year period.

Calcium Depletion Summary

While decreasing lake water calcium concentration is an emerging concern for lakes on the Precambrian Shield in Ontario due to its impact on the reproduction and survival of zooplankton and other aquatic species that are important components of the aquatic food chain, levels of calcium below the growth limiting threshold range of 1.5 mg/L have not been identified in the sampling of Kahshe or Bass Lakes.

Nor is there any conclusive evidence from the Kahshe and Bass Lake sampling program by DMM or MOECC to demonstrate a similar downward trend over time like that seen in the Muskoka area.

However, continued monitoring is warranted, as the historical data for Kahshe and Bass Lakes is limited, dating back only to 2004.

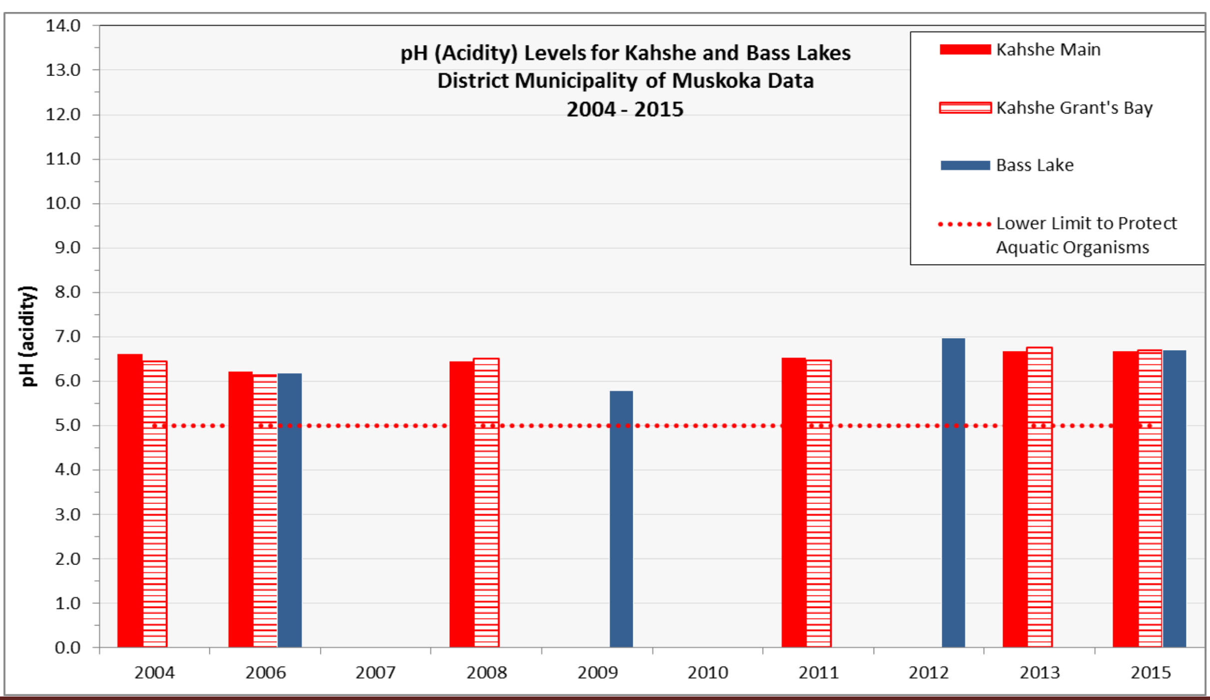
3.3 Lake Acidification

I recently overheard a conversation by a couple of cottagers about how acidic our lake is, so I thought it was time to address this issue. Acidity is measured on a unitless scale referred to as pH. The pH of water is a measure of the hydrogen ion concentration expressed on a scale of 0 to 14, with a pH of 7 being neutral, values below 7 being acidic and above 7 being alkaline. As the hydrogen ion concentration is measured on a logarithmic scale, the change in pH of 1 unit (i.e. from6.0 to 7.0) represents a 10-fold decrease in acidity. Distilled water is considered to be neither acidic nor alkaline, and has a pH of 7.0. However, even in the absence of any man-made acid gases, the natural levels of carbon dioxide in the atmosphere will react with water to generate carbonic acid, and this will cause rain to have a pH of about 5.6.

Although source-oriented acid gasses and particulates have contributed significantly to the acidification of lakes in Ontario, particularly around major sulphur sources in the Sudbury basin, there has been noticeable recovery over the last two decades as emission controls were implemented. The ingress of acidic gasses and particulates of nitrogen and sulphur from transboundary air flows into southern Ontario also have been reduced.

The Provincial water quality objective is to keep pH between 6.5 and 8.5, as values above or below those levels can be harmful to some aquatic organisms. According to the DMM, lakes in Muskoka tend to be slightly acidic, although many lakes have experienced acid stress as a result of acid precipitation mentioned above.

The chart below shows the pH values for Kahshe and Bass Lakes from 2004 through 2015.



It is apparent from this chart that the acidity of both Kahshe and Bass Lakes is well within the normal range and well above the level where impacts to some aquatic species would be encountered. Keep in mind that the scale is logarithmic, and as such, every unit on the Y axis represents a 10-fold higher or lower level of acidity than the one above or below it.

While the pH findings represents good news, it should also be recognized that the waters of Kahshe and Bass Lakes have low levels of alkalinity, and as such, are more susceptible to acidification, as the ability of the water to buffer the acid input is low. The alkalinity results are presented and discussed in Section 3.5.

Lake Acidity Summary

The waters of Kahshe and Bass Lake have acidity (pH) levels that are well within a normal range and more than 10-fold above the pH level of 5.0, where potential aquatic impacts could be observed.

While the pH findings represents good news, it should also be recognized that the waters of Kahshe and Bass Lakes have low levels of alkalinity, and as such, are more susceptible to acidification, as the ability of the water to buffer the acid input is low. As such, continued monitoring of the acidity is warranted.

3.4 Dissolved Oxygen and Water Temperature

Dissolved oxygen (DO) in lake water is important for two main reasons: 1) it is essential for the survival of all aquatic organisms, and 2) a lack of oxygen in the lower layers of the lake (referred to as being anoxic) can cause mobilization of phosphorus from sediments. This is referred to as internal phosphorus loading.

In addition to the consumption of oxygen by fish and other aquatic organisms, the decomposition of organic matter in all layers of the lake consumes oxygen. However, because of the minimal mixing of upper and lower layers of lake water during the ice-free period (referred to as thermal stratification), only the upper layers of water are replenished with oxygen as a result of photosynthesis by aquatic plants, in-bound water from streams and atmospheric oxygen as a result of mixing caused by wind and waves. As such, the gradual depletion of oxygen in the lower layers (hypolimnion) of the lake progresses following spring turnover (after the ice has melted) and does not get re-oxygenated until the late fall turnover again takes place. Water temperature also plays a role in the dissolved oxygen cycling process, as warm water becomes saturated at lower concentrations than required for cold water. However, the bottom line is that the colder waters near the bottom of the lake become gradually depleted of oxygen and can reach levels that will not support aquatic species.

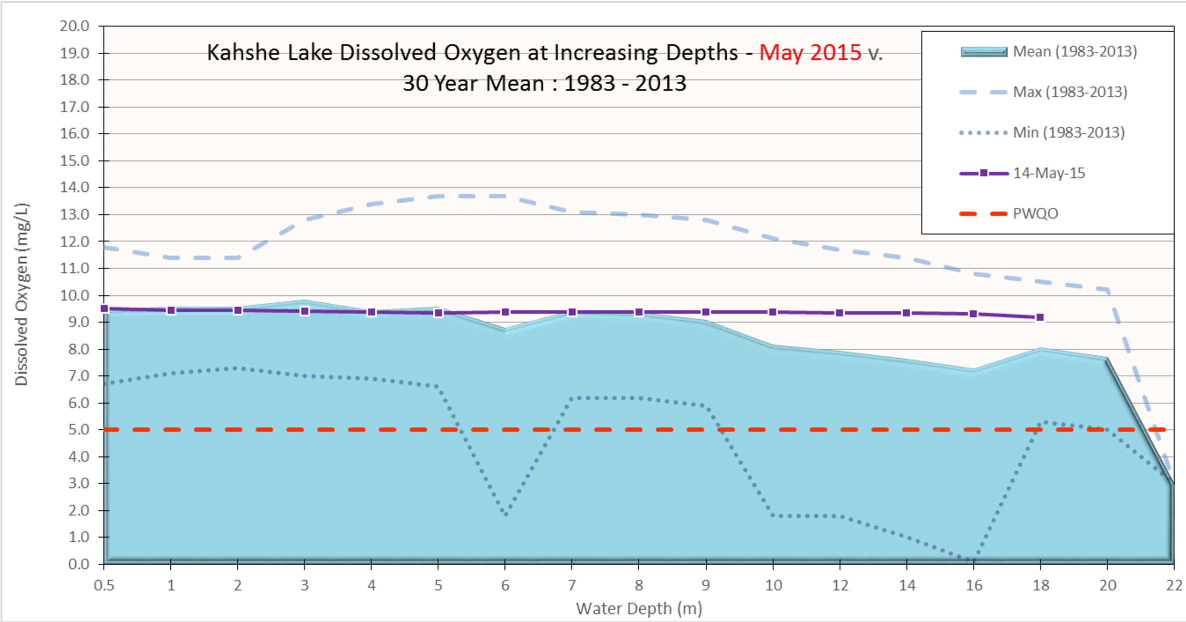
The setting of an aquatic benchmark for DO is typically conducted under both an acute (short term, high concentration) and a chronic (long term, lower concentrations) basis. For chronic exposure, aquatic organism effects include the traditional growth and reproduction impairment, swimming impairment and long term impacts on survival. The low oxygen threshold at which some reaction first becomes apparent is usually referred to as the incipient or critical level. At this level, the organism must extend or adjust its available energies to counteract the influence of hypoxia (oxygen starvation) and/or to move to waters with higher DO levels. Unfortunately, the variability in toxicity symptoms and exposure times challenges the derivation of water quality guidelines for DO, and as a result, the guideline derivation does not follow the standard process.

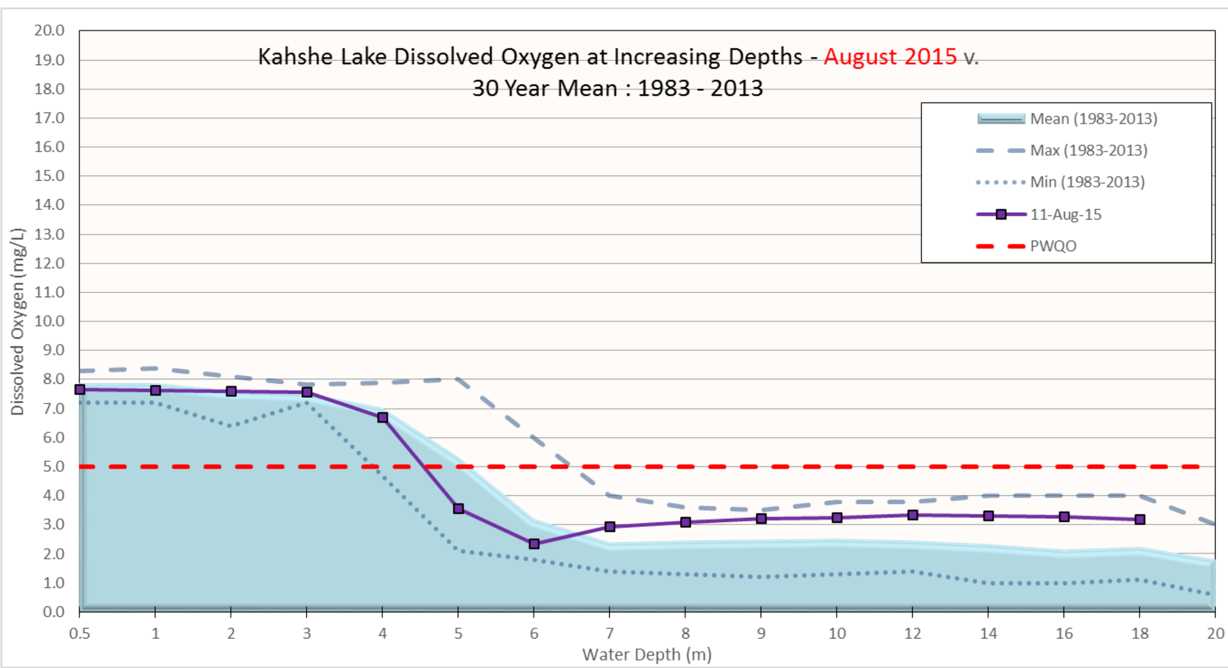
For warm water lakes like Kahshe and Bass, the Provincial Water Quality Objective (PWQO) and the Canadian Water Quality Guideline (CWQG) are set at 5 and 5.5 mg DO/L. This report will use the lower of the two, as other agencies have set DO benchmarks in the 3-4 mg/L range.

The attached DMM data sheets for Kahshe (Main and Grant's Bay) as well as Bass Lake show fairly typical thermal stratification effects which are more pronounced in August compared to the sampling in May after the spring turnover. To give some additional perspective on this parameter (DO), an analysis was undertaken by examining the data over the period from 1983 through 2015 to see if there has been any noticeable change in DO concentrations, especially in the deeper horizons, where oxygen is typically more limited and critical to the survival of bottom dwelling organisms. These data are charted below and include the mean, maximum and minimum for all sampling to 2013, the results for 2015 and the desirable aquatic objective of 5 mg/L, below which some fish and other aquatic organisms would experience some chronic effects. For both Kahshe and Bass Lakes, the results are shown first for the May sampling and then the August sampling, to more clearly show how the lake stratification process works.

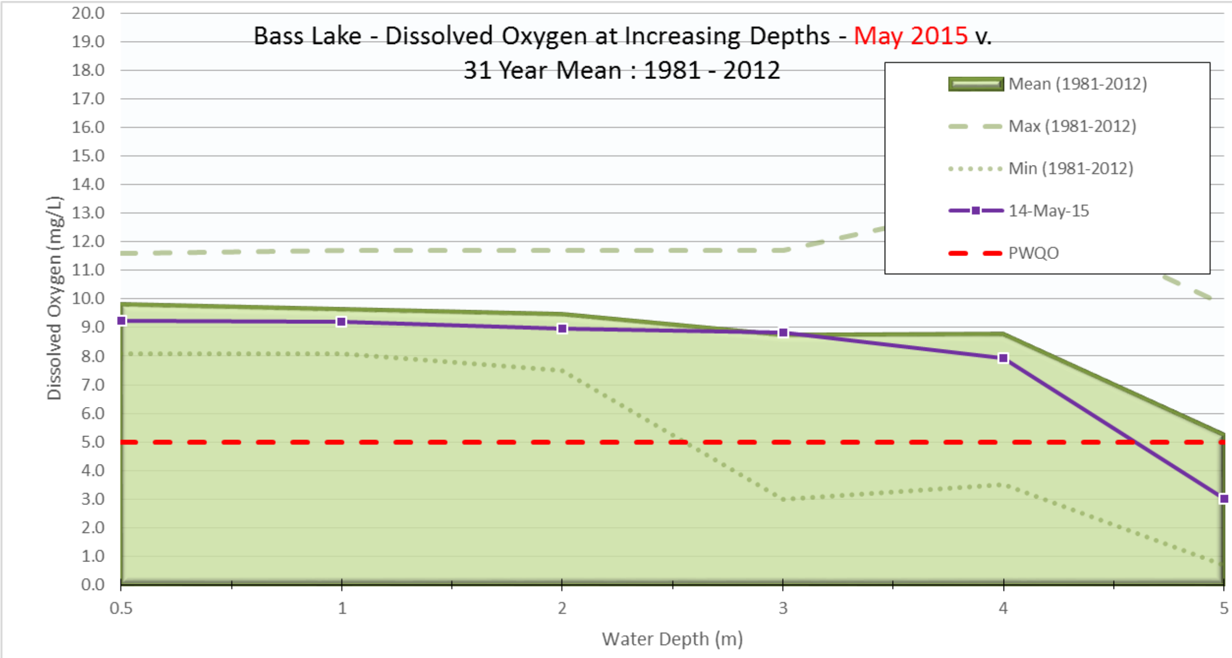
In the case of Kahshe Lake, the two charts below show a typical spring turnover average level of DO from the surface down to the lowest depths. However, by August, the thermal stratification has resulted in a typical reduction in DO at increasing depths. The data also show that the sampling results for 2015 are well within the range of DO experienced over the years since sampling was initiated.

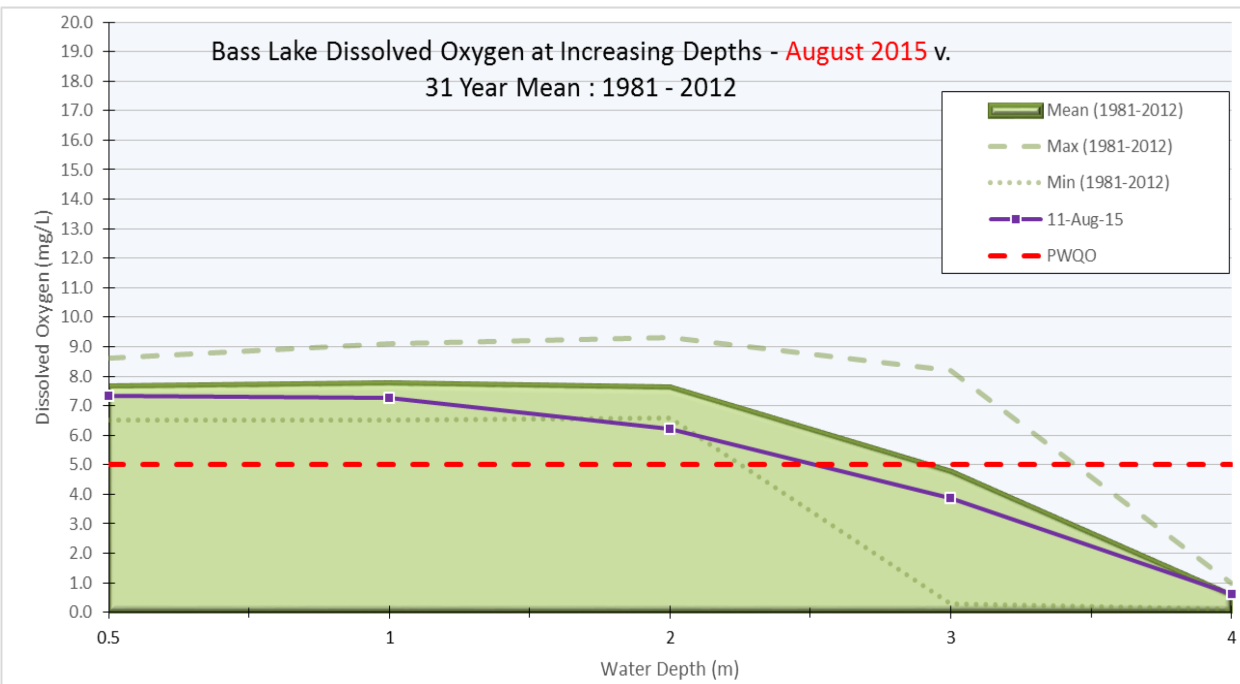
With respect to aquatic species survival, the average DO levels in August tend to fall below the aquatic threshold at depths of about 5 m. This could be problematic for some species; however, it is well documented that fish and other mobile aquatic species possess the ability to avoid reduced DO levels, and this is likely happening towards the end of the year as oxygen is slowly depleted from the lower depths.





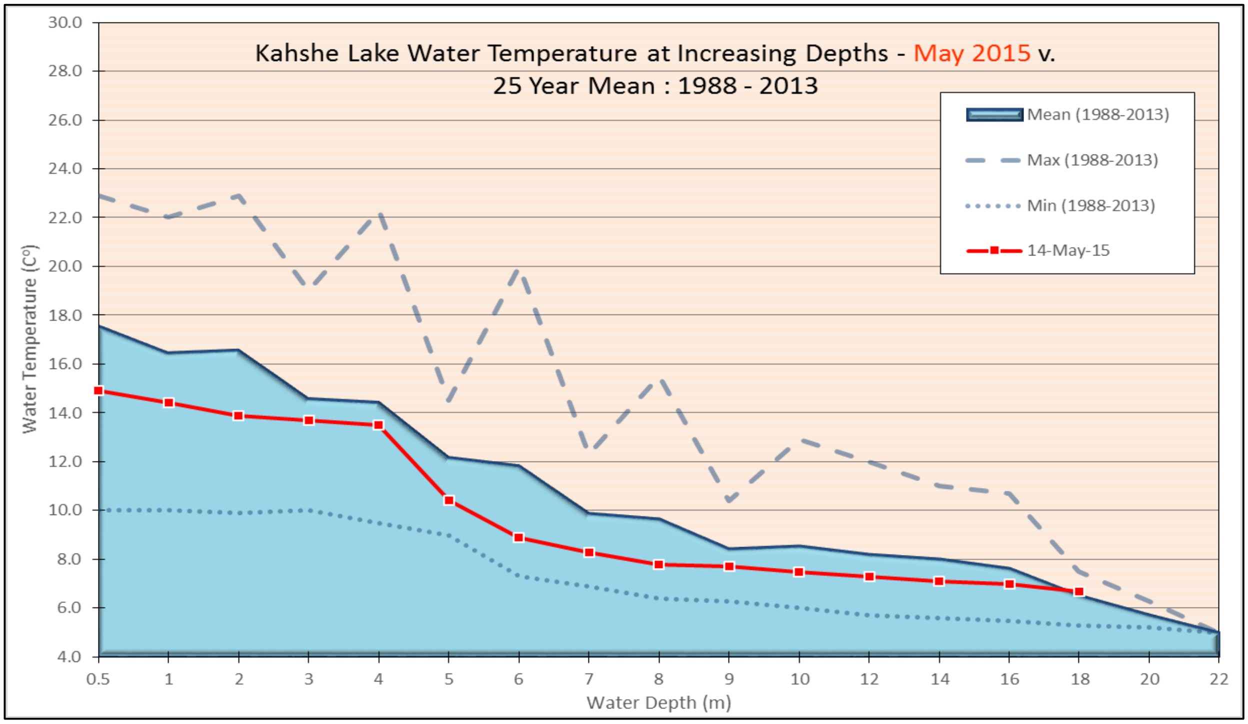
The DO data for Bass Lake also have been charted to show the average, maximum, minimum and 2015 sampling results at increasing water depth in both May and August. They too have been compared to the aquatic threshold value of 5 mg/L.

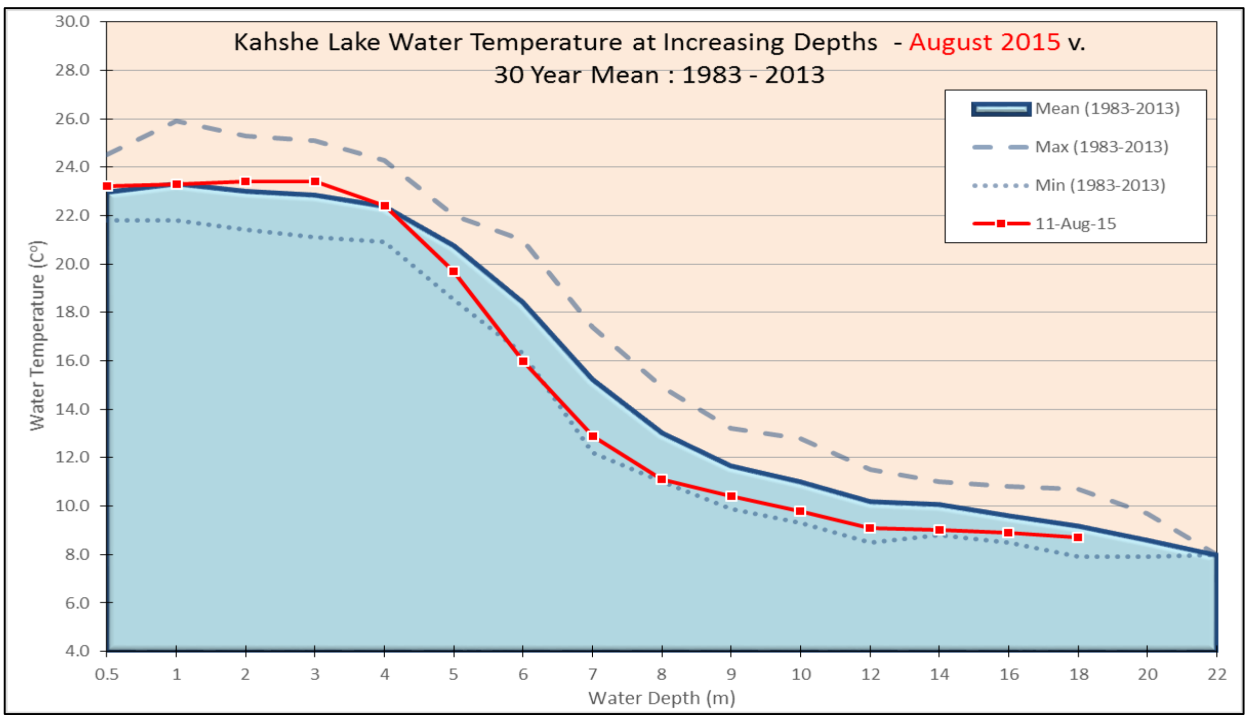




The results for Bass Lake are similar to those of Kahshe Lake, with the exception of a less noticeable decrease in DO levels from May through to August, resulting in DO levels that are generally well above the DO threshold of 5 mg/L at all but the deepest sampling depth. This is likely due to the fact that Bass Lake is much more shallow (4-5 m), and as such, would not experience the same degree of stratification as is the case in the much deeper (22 m) sampling site in Kahshe Lake.

The other parameter that is evaluated at increasing depths is water temperature. As for DO, the data dating back to 1983 have been presented as an average with maximum and minimum values up to 2013, followed by the sampling measurements in 2015.





Water temperature is important for several reasons:

- It affects the solubility of oxygen in water.
- It controls the rate of photosynthesis by algae and higher plants (i.e. warm water promotes algal growth).

- It affects the metabolic rates, life cycles and the sensitivity of all aquatic organisms to parasites and disease.

- It factors into the classification of a lake as a cold or warm water body (both Kahshe and Bass are considered warm water lakes – i.e. not a Lake Trout Lake).

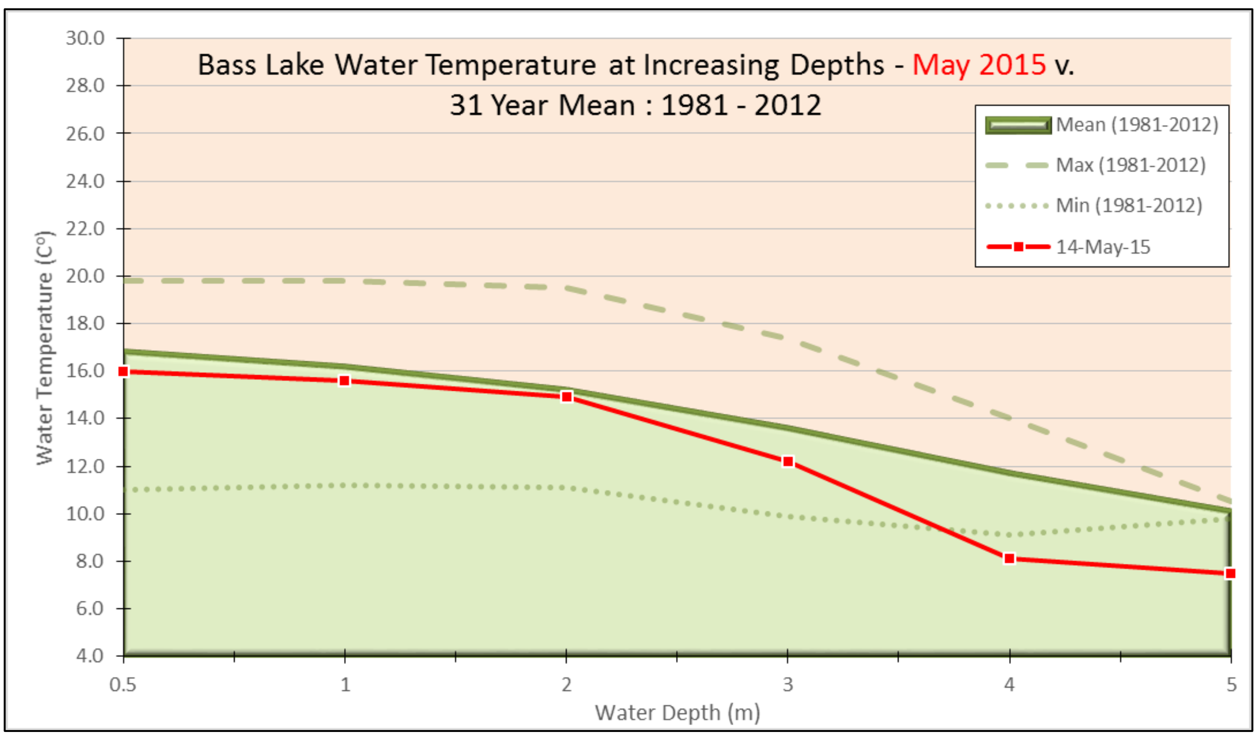
Based on the foregoing charts, the Kahshe Lake findings can be summarized as follows:

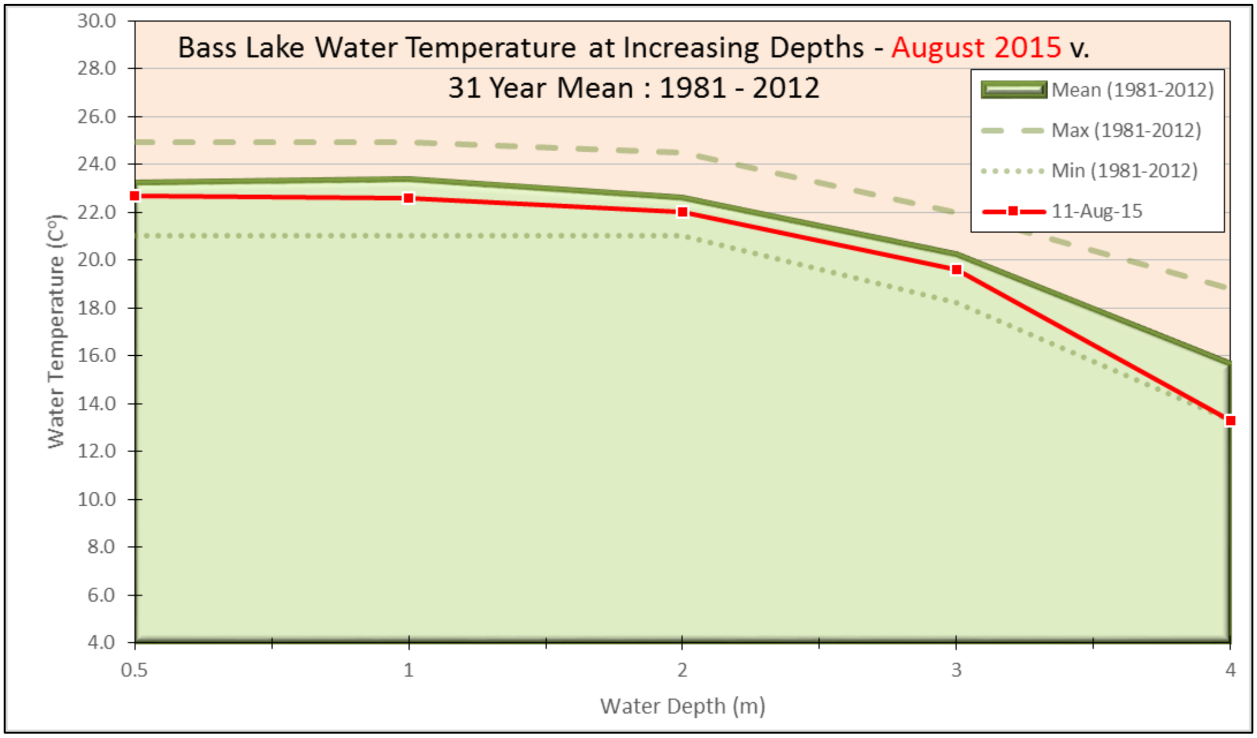
- There is greater year to year variability (as shown by the maximum and minimum values) in water temperature in May than later in the summer (August). This is likely due to differences in the timing of the spring sampling relative to the date the ice melts and to weather conditions during this early stage of the annual lake stratification process.

- Water temperature in May of 2015 was marginally lower than the long term average at all sampling depths.

- Water temperature in August 2015 was similar to the long term average values from the surface down to a depth of 4 m, but well below the long term average at depths greater than 4 m.

As for Kahshe, the water temperature data for Bass Lake are presented for May and August in the charts that follow.





Based on the foregoing charts, the Bass Lake findings can be summarized as follows:

- There is greater year to year variability (as shown by the maximum and minimum values) in water temperature in May than later in the summer (August).
- Water temperature in May and August of 2015 was marginally lower than the long term average at all sampling depths.

In summary, although an analysis of the long term trend in water temperature using all Muskoka lakes has shown a statistically significant increase in water temperature over time for all but the lowest depths (Palmer, 2005), the results for Kahshe and Bass Lakes have not displayed any obvious trend in surface water warming. This is not unexpected, as the temperature data for a single lake would not have the power to detect changes as small (approximately 1-2°C) as those reported using the larger database of all Muskoka lakes.

Dissolved Oxygen and Water Temperature Summary

Dissolved oxygen and water temperature are two parameters that are influenced by lake stratification, the process whereby lake water is turned over in the fall and again following the winter ice melt and then begins to stratify through the spring, summer and fall as water temperature increases at the surface and DO levels decrease with increasing depth.

Dissolved oxygen (DO) in lake water is important for two main reasons: 1) it is essential for the survival of all aquatic organisms, and 2) a lack of oxygen in the lower layers of the lake (referred to as being anoxic) can cause mobilization of phosphorus from sediments. This is referred to as internal phosphorus loading.

Although both parameters have the potential to negatively impact the growth and survival of different aquatic organisms, the levels of DO are more directly involved in aquatic health. While water temperature is important and more directly associated with climate change, it is likely to result in more subtle alterations in water chemistry, biodiversity and population dynamics that are difficult to measure. However, temperature needs to be closely monitored, as increasing temperature can also have indirect impacts by promoting the growth of algal and aquatic plants.

The results of DO measurements at increasing depths in 2015 and over the past 30 years have shown that In the case of Kahshe Lake, the DO sampling results for 2015 are well within the range of average DO experienced over the years since sampling was initiated. While the average DO levels near the end of summer tend to fall below the PWQO aquatic objective of 5 mg/L at depths below 5 m, it is well documented that fish and other mobile species possess the ability to avoid reduced DO levels, and this is likely happening towards the end of the year as oxygen is slowly depleted from the lower depths.

The DO results for Bass Lake are similar to those of Kahshe Lake, with the exception of a less noticeable decrease in DO levels from May through to August, resulting in DO levels that are generally well above the DO objective of 5 mg/L at all but the deepest sampling depth. This is likely due to the fact that Bass Lake is much more shallow (4-5 m), and as such, would not experience the same degree of thermal stratification as is the case in the much deeper (22 m) sampling site in Kahshe Lake.

The water temperature findings for Kahshe Lake have demonstrated greater year to year variability (as shown by the maximum and minimum values) in water temperature in May than later in the summer (August). Water temperature in May of 2015 was marginally lower than the long term average at all sampling depths while water temperature in August 2015 was similar to the long term average values from the surface down to a depth of 4 m, but well below the long term average at depths greater than 4 m. The results for Bass Lake were similar, except water temperature in May and August of 2015 was marginally lower than the long term average at all sampling depths.

Although an analysis of the long term trend in water temperature using all Muskoka lakes has shown a marginal increase in water temperature (Palmer, 2005) over time, the results for Kahshe and Bass Lakes have not shown any obvious warming. This is not unexpected, as the temperature data for a single lake would not have the power of detection that would be possible using a larger database of all Muskoka lakes.

3.5 Anions, Cations and Other Chemicals

The DMM has analyzed water samples for a much larger suite of chemical parameters than those that are routinely reported in their year-end report and data sheet summaries. This leaves a large number of chemicals that have been analyzed but which have not been specifically evaluated for each monitored lake. As in previous years, the 2015 DMM year-end report does include a summary table for several parameters that were analyzed. These include: alkalinity, calcium, chloride, colour, conductivity, dissolved organic carbon, sodium, nitrate, total Kjeldahl nitrogen, pH and sulphate.

The full suite of chemicals analyzed via the DMM sampling program in 2015 included: chloride, nitrogen (ammonia + ammonium), nitrogen (nitrite+nitrate), total Kjeldahl nitrogen, sulphate, aluminum, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, nickel, potassium, silicon, sodium, strontium, titanium, vanadium, zinc. In addition, the following new chemicals were added to the suite of chemicals in 2012 and repeated in 2015: antimony, arsenic, boron, selenium, silver, thallium and uranium.

As most of these chemicals have not been included in the DMM summary table of additional chemical parameters, 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 MOECC 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 MOECC (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 MOECC APV was not available, a similar format to the one used by the MOECC 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. 2001a and b) 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 long term exposure to concentrations that are considered chronic, as opposed to short-term protection against acute effects.

The charts for all chemicals along with their respective water quality benchmarks have been attached and a summary of the findings has been presented in the table that follows.

Category	Analyzed Parameter	Evaluation Benchmark[1]	Comments
Anions	Chloride	MOECC APV	All reported values well below aquatic benchmark
	Nitrogen (ammonia + ammonium)	BC AWQC	All reported values well below the 30 day average for a pH of 6.5 and temperature of 15°C which is set to protect against adverse effects to aquatic species. They are also well below the natural background concentration of around 100 µg/L, indicating a minimal contribution to eutrophication and the potential for algal problems.
	Nitrogen (nitrite +	EC CWQG	All reported values well below the nitrate benchmark

Category	Analyzed Parameter	Evaluation Benchmark[1]	Comments
	nitrate)		which is set to protect against adverse effects to aquatic species. They are also below the natural background nitrate concentration of around 1,000 µg/L, indicating a minimal contribution to eutrophication and the potential for algal problems.
	Nitrogen (total Kjeldahl)	None Found	No benchmark
	Sulphate	BC AWQC	All reported values well below benchmark
Cations	Aluminum	U.S. EPA CCC	Findings in recent years at or marginally higher than the benchmark; however, there is a low level of scientific confidence in the benchmark as both it and similar benchmarks developed by the CCME are considered overly conservative and do not reflect the complex chemical behavior of aluminum under natural conditions.
	Barium	MOECC APV	All reported values well below benchmark
	Beryllium	MOECC APV	All reported values well below benchmark
	Cadmium	MOECC APV	Some exceedances of the benchmark in early years, but none since 2009; likely a sampling or laboratory quality control issue
	Chromium	MOECC APV	All reported values well below benchmark
	Cobalt	MOECC APV	All reported values well below benchmark
	Copper	MOECC APV	One exceedance of the benchmark in 2006, with none since; likely a sampling or laboratory quality control issue
	Iron	U.S. EPA CCC	All reported values well below benchmark
	Lead	MOECC APV	Two exceedances of the benchmark in Bass Lake in early years, but none since 2009; likely a sampling or laboratory quality control issue
	Magnesium	U.S. EPA LCV	All reported values well below benchmark
	Manganese	BC AWQC	All reported values well below benchmark
	Molybdenum	MOECC APV	All reported values well below benchmark
	Nickel	MOECC APV	All reported values well below benchmark
	Potassium	U.S. EPA LCV	All reported values well below benchmark
	Silicon	None Found	No benchmark
	Sodium	MOECC APV	All reported values well below benchmark
	Strontium	U.S. EPA T-II SCV	All reported values well below benchmark
	Titanium	None Found	No benchmark
	Vanadium	MOECC APV	All reported values well below benchmark
	Zinc	MOECC APV	All reported values well below benchmark
Other Chemicals	Dissolved Organic Carbon	DMM Notes	Although there is no aquatic benchmark, the findings for Bass Lake are slightly higher than 7 mg//L, which is the aesthetic objective for recreational use
	Electrical Conductivity	None Found	No benchmark

Category	Analyzed Parameter	Evaluation Benchmark[1]	Comments
	Alkalinity	DMM Notes	Although there is no benchmark, the alkalinity of both Kahshe and Bass Lakes is below 10 mg/L, indicating that both lakes have low buffering capacity and therefore, are potentially susceptible to acidification.
Not Charted	Antimony	MOECC APV	All reported values well below benchmark
	Arsenic	MOECC APV	All reported values well below benchmark
	Boron	MOECC APV	All reported values well below benchmark
	Selenium	MOECC APV	All reported values well below benchmark
	Silver	MOECC APV	All reported values well below benchmark
	Thallium	MOECC APV	All reported values well below benchmark
	Uranium	MOECC APV	All reported values well below benchmark

Legend:

[1] Evaluation Benchmarks

- MOECC APV means Ontario Ministry of Environment and Climate Change – Aquatic Protection Value
- EC CWQG means Environment Canada – Canadian Water Quality Guideline
- BC AWQC means British Columbia Ambient Water Quality Criterion
- U.S. EPA CCCC means United States Environmental Protection Agency Continuous Chronic Criterion
- U.S. EPA LCV means United States Environmental Protection Agency Lowest Chronic Value
- U.S. EPA Tier II SCV means United States Environmental Protection Agency Secondary Chronic Value

Anions, Cations and Other Chemical Summary

The analysis of several additional anions, cations and other chemicals by the DMM has identified no pressing issues from an aquatic health aspect. While there were some exceedances of chronic (long term) benchmarks established by the MOECC and other agencies to protect aquatic receptors, most of these exceedances were detected in the early years of the sampling program and appear to be related to sampling or laboratory artifacts, as more recent sampling has shown concentrations that are in the expected range for non-impacted surface water bodies in Ontario. The only possible exception is for aluminum; however, the benchmark is believed to be overly conservative and based on studies that failed to recognize the complex chemistry of aluminum ion toxicity.

The findings for a couple of other parameters arising from this large suite of chemical parameters have been incorporated into the discussion of other issues where relevant. This includes the results for alkalinity and its relationship with acidification and the various compounds of nitrogen, which are discussed in the section dealing with phosphorus and water clarity, as both nutrients are known to play a role in lake water eutrophication.

3.6 Evaluation of Benthic Monitoring – Kahshe Lake

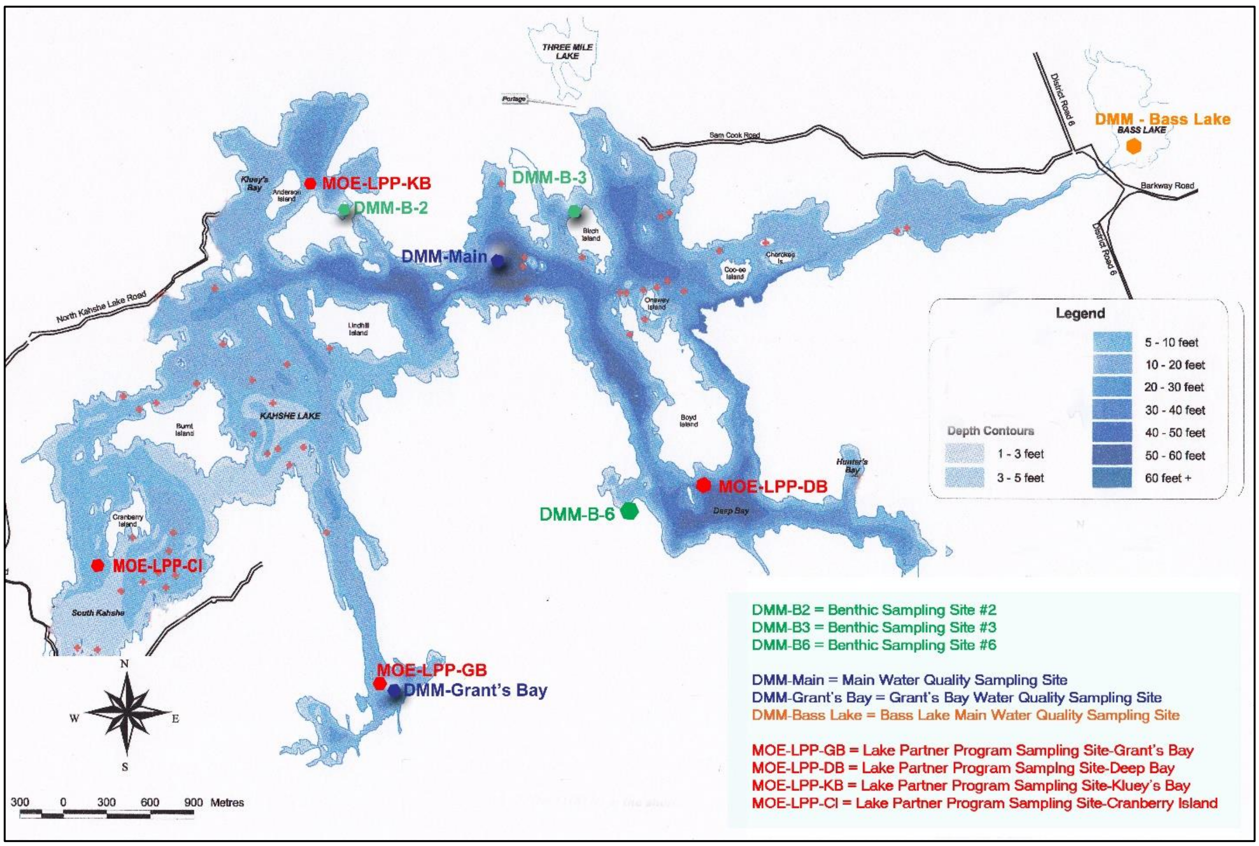
Monitoring bottom-dwelling aquatic invertebrate communities has been carried out by the DMM since 2003. This type of monitoring provides an indirect measure of water quality and habitat disturbance, as the composition of the aquatic-invertebrate community and the relative abundances of different species 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 has been carried out at two locations as shown on Figure 2 below. However, in 2015 a new site was established to provide greater geographical coverage of the lake. This site is referred to as Site 6 on the figure below, and is located in Beaver Bay, just west of the southern tip of Boyd Is. It was referred to as Site 6 based on the fact that it was one of several proposed sites established by the DMM in earlier years.

Figure 2: Map Showing Location of Benthic Monitoring Sites on Kahshe Lake



In 2015, the sampling was carried out on a wet and windy August 20 at Site 6 (shown in Figure 2 above). Once three replicates of sediment from the shoreline area were collected by DMM staff member Dylan Moesker, volunteers from Kahshe Lake (Clare Henderson, Greig Holder, Rob and Allyn Abbot, Dan McCormick, Phil Bruckler, Kathy and Jessica Coats and Ruth Miller - got to work in counting the little critters. My wife Gail, kept the coffee flowing and made sure that lunch was ready when the counting was finished. We were all pretty much soaked from head to toe by the time we finished, but we got it done nevertheless!

I've included a couple of shots of the group during the counting process and one of the DMM biotechnician collecting the samples at Site 6.

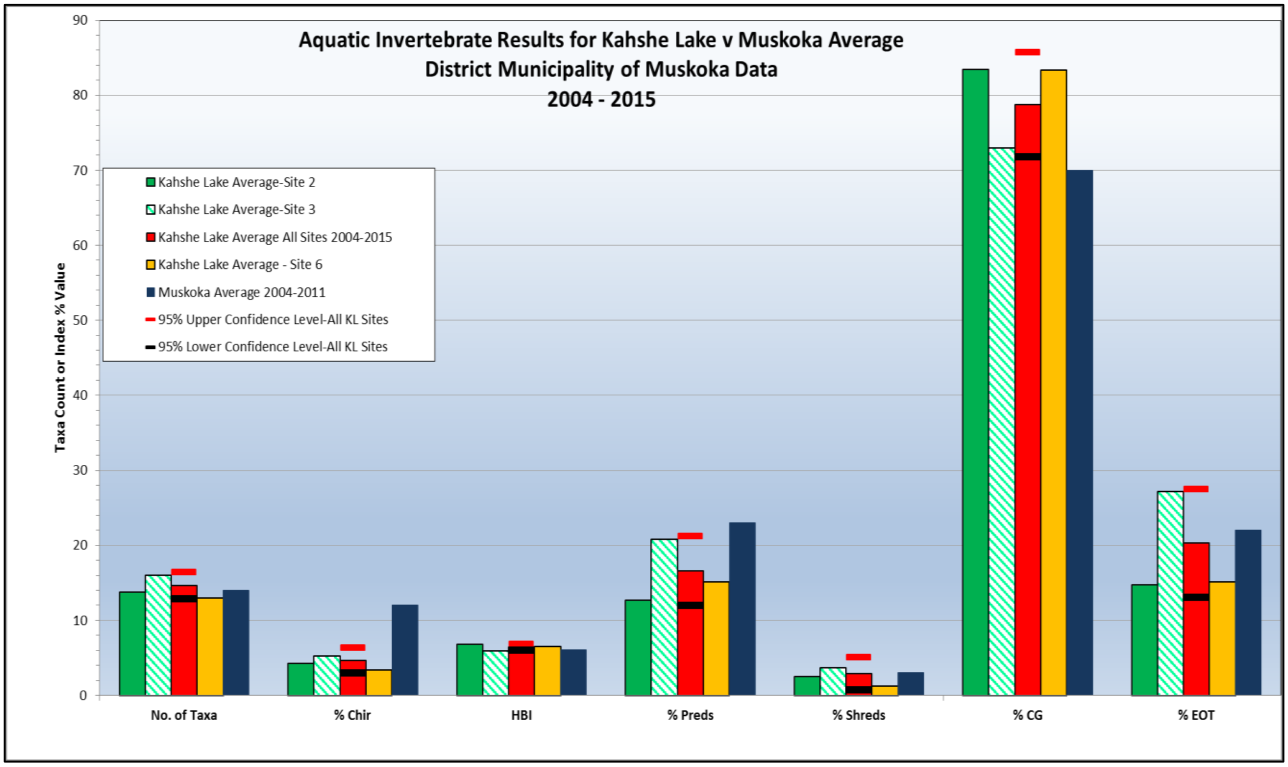
Kahshe Lake Volunteers on Benthic Counting Day – August 20, 2015

DMM Biotechnician Dylan Moesker Collecting Benthic Invertebrates from Site 6 – August 20, 2015

The results of the sampling compared to the Muskoka average, which is based on 147 samples from 76 reference lakes between 2004 and 2011. This included sites from 9 mesotrophic and 26 oligotrophic lakes. The Muskoka average as well as the Kahshe Lake findings have been presented in Table 1 below. To understand how the sample findings are compared, it is necessary to understand the scoring system which uses indices of organism groupings as shown below.

Table 1: Indices used to summarize aquatic invertebrate composition in Muskoka. Indicator	**What it tells us**
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 its number of taxa.
Percent of collection made-up of mayflies, dragonflies, damselflies, and caddisflies (% EOT)	Ephemeroptera (mayflies), Odonata (dragonflies and damselflies), and Trichoptera (caddisflies) are very sensitive to pollution and habitat alteration. They should be prominent in healthy ecosystems, but their numbers will decline in response to stress imposed by human activities.
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.
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.
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 waterbodies. 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.
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.
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.
∗ 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 signifies a stressed ecosystem.	

Using these benthic indices, the 2015 results for Site 6 on Kahshe Lake (shown in orange) have been plotted against the Muskoka average values (dark blue) below. The chart also includes the results from earlier sampling at Sites 2 and 3 as well as an average of all Kahshe Lake sites (shown in red). To recognize the variability that is present, upper and lower confidence intervals (at the 95th percentile above and below the mean) for the average results have been shown with a red dash (upper) and black dash (lower).



As shown in the comparison chart above, the average benthic index values from all sites on Kahshe Lake (solid red bars) are, in all but three cases, similar (i.e. the upper and lower confidence interval of the mean of all Kahshe Lake sites includes the Muskoka average value) to those of Muskoka lakes chosen by the DMM as reference values (solid blue bars).

The three exceptions to these findings are discussed below:

- the % Chironomidae (% Chir), index is lower than the average Muskoka value; however, as shown in Table 1 above, Chironomidae are considered tolerant of pollution and habitat changes, so the marginally lower value for the Kahshe Lake is actually desirable, and indicative of low pollution and a healthy aquatic ecosystem.
- The % Predators (% Preds) index is slightly lower than the average Muskoka value, but is not problematic, as in a healthy ecosystem the numbers of predators and prey should be present within a narrow range. As there are no extreme fluctuations, these results are not problematic.
- % Collectors/Gatherers (%CG) are marginally higher in Kahshe Lake vs. the Muskoka average. This is not problematic, as these types of benthic organisms are indicative of a healthy population of shredders who provide the food required for collectors/gatherers. Like shredders, these animals perform a vital role in energy cycling, and are prey to other animals.

Other features of the benthic monitoring which appear similar to the average results for Muskoka include a high degree of Richness (No. of Taxa) and a virtually similar and low Hilsenhoff Index (HBI), both of which are indicative of good water quality.

Evaluation of Benthic Monitoring Summary

The 2015 and earlier benthic invertebrate monitoring results for three sites on Kahshe Lake have not identified any problems in the population, growth or survival of aquatic invertebrate which can be related to contamination or habitat disturbance.

4.0 Summary and Conclusions

In accordance with the goals and objectives which have been set for the Kahshe Lake Steward by the KLRA, a comprehensive review and analysis of all historical environmental monitoring on Kahshe and Bass Lakes has now been completed and presented within Lake Steward Reports for 2012, 2013 and 2014. These documents are posted on the KLRA web-site (http://www.kahshelake.ca/ne/ls). This report captures the findings from sampling and analysis of both Kahshe and Bass Lakes in 2015.

In an effort to simplify the reporting of a large amount of measurement and analysis data, the report has been structured to address the following issues/areas of potential concern for both Kahshe and Bass Lakes:

- Total Phosphorus and Water Clarity
- Calcium Depletion
- Lake Acidification
- Dissolved Oxygen and Water Temperature
- Metals and Other Chemicals
- Benthic Health

Total Phosphorus and Water Clarity Summary

Phosphorus has been clearly shown to be the main nutrient that controls the growth of algae in Ontario lakes, with higher phosphorus generally resulting in an increase in algal growth, and therefore, decreased water clarity. The DMM also evaluates the responsiveness of lakes in Muskoka to input and mobility of phosphorus as it enters the lake from human and natural sources and both Kahshe and Bass Lakes are considered moderate in terms of their sensitivity to phosphorus.

This sensitivity rating also factors into the setting of a total phosphorus threshold for lakes in Muskoka. This threshold value is set equal to the background concentration plus an additional 50%. If the lake's measured and modelled phosphorus concentrations over a 10-year period are greater than its threshold value, then the lake is considered "over threshold" and actions will be initiated to reduce the amount of phosphorus entering the lake from its watershed. **Neither Kahshe nor Bass Lake is considered over-threshold. However, as a result of a review by the DMM of their water quality model, Bass Lake has now been flagged for further study due to its elevated total phosphorus concentration and may require development restrictions pending the outcome of the study.**

Based on the sampling by both the DMM and MOECC (Lake Steward), the following findings have been discussed in greater detail.

- The total phosphorus data for Kahshe Lake over a 30+ year period demonstrate a fairly normal amount of variability from year to year, with no apparent upward or downward trend.
- In terms of threshold values, the 10-year averages for total phosphorus of 11.3 and 12.5 µg/L for the Main and Grant's Bay locations, respectively, are both well below the Kahshe Lake threshold value of 14.2 µg/L.
- The DMM data for Bass Lake also demonstrate that the 10-year average total phosphorus concentration (23.1 µg/L) is well below the Bass Lake threshold value of 30.9 µg/L.
- Kahshe Lake, with 2015 total phosphorous concentrations in the range of 11.4-11.5 µg/L is considered a Mesotrophic lake while Bass Lake at 23.1 µg/L has the highest total phosphorus concentration of all sampled Muskoka lakes and is in the range referred to as Eutrophic.
- In spite of these higher total phosphorus concentrations, Bass Lake is only marginally above its natural background level – i.e. the phosphorus is mostly natural in origin. However, this is being re-examined as a result of a water quality model review.
- In the case of Secchi depth, Kahshe Lake is in the mid-point range for a lake with a moderate level of dissolved organic carbon (DOC). DOC is the chemical parameter that gives the lake water the tea colour, which limits light penetration.
- Bass Lake also is considered to have a moderate level of DOC, but the Secchi depth is somewhat lower than the mid-point range for lakes considered moderate in DOC and more in line with the clarity of lakes with high levels of DOC.
- A comparison of the total phosphorus concentrations generated by both the DMM and MOECC demonstrates that the two programs are generating similar findings and that there is only a normal amount of variability in total phosphorus concentrations across the five Kahshe Lake sampling sites. The findings also demonstrate that the total phosphorus concentrations at the new location to the south of Cranberry Is. are at the low end of the range.
- As for total phosphorus, the water clarity measurements by the two agencies at the five sampling locations in Kahshe Lake have demonstrated fairly similar findings and a normal level of variability.
- Finally, an evaluation of the Kahshe Lake total phosphorus and water clarity measurements over the past 23 years has failed to find any statistically significant relationship (correlation) between these two parameters. This is likely due to two factors: 1) total phosphorus concentrations are well below levels which would induce a cause-effect response and 2) the tea colour of the water has negated any cause-effect relationship.

Calcium Depletion Summary

While decreasing lake water calcium concentration is an emerging concern for lakes on the Precambrian Shield in Ontario due to its impact on the reproduction and survival of zooplankton and other aquatic species that are important components of the aquatic food chain, levels of calcium below the growth limiting threshold range of 1.5 mg/L have not been identified in the sampling of Kahshe or Bass Lakes.

Nor is there any conclusive evidence from the Kahshe and Bass Lake sampling program by DMM or MOECC to demonstrate a similar downward trend over time like that seen in the Muskoka area.

However, continued monitoring is warranted, as the historical data for Kahshe and Bass Lakes is limited, dating back only to 2004.

Lake Acidity Summary

The waters of Kahshe and Bass Lake have acidity (pH) levels that are well within a normal range and more than 10-fold above the pH level of 5.0, where potential aquatic impacts could be observed.

While the acidity findings represent good news, it should also be recognized that the waters of Kahshe and Bass Lakes have low levels of alkalinity, and as such, are more susceptible to acidification, as the ability of the water to buffer the acid input is low. As such, continued monitoring of the acidity is warranted.

Dissolved Oxygen and Water Temperature Summary

Dissolved oxygen and water temperature are two parameters that are influenced by lake stratification, the process whereby lake water is turned over in the fall and again following the winter ice melt and then begins to stratify through the spring, summer and fall as water temperature increases at the surface and DO levels decrease with increasing depth.

Dissolved oxygen (DO) in lake water is important for two main reasons: 1) it is essential for the survival of all aquatic organisms, and 2) a lack of oxygen in the lower layers of the lake (referred to as being anoxic) can cause mobilization of phosphorus from sediments. This is referred to as internal phosphorus loading.

Although both parameters have the potential to negatively impact the growth and survival of different aquatic organisms, the levels of DO are more directly involved in aquatic health. While water temperature is important and more directly associated with climate change, it is likely to result in more subtle alterations in water chemistry, biodiversity and population dynamics that are difficult to measure. However, temperature needs to be closely monitored, as increasing temperature can also have indirect impacts by promoting the growth of algal and aquatic plants.

The results of DO measurements at increasing depths in 2015 and over the past 30 years have shown that In the case of Kahshe Lake, the DO sampling results for 2015 are well within the range of average DO experienced over the years since sampling was initiated. While the average DO levels near the end of summer tend to fall below the PWQO aquatic objective of 5 mg/L at depths below 5 m, it is well documented that fish and other mobile species possess the ability to avoid reduced DO levels, and this is likely happening towards the end of the year as oxygen is slowly depleted from the lower depths.

The DO results for Bass Lake are similar to those of Kahshe Lake, with the exception of a less noticeable decrease in DO levels from May through to August, resulting in DO levels that are generally well above the DO objective of 5 mg/L at all but the deepest sampling depth. This is likely due to the fact that Bass

Lake is much more shallow (4-5 m), and as such, would not experience the same degree of thermal stratification as is the case in the much deeper (22 m) sampling site in Kahshe Lake.

The water temperature findings for Kahshe Lake have demonstrated greater year to year variability (as shown by the maximum and minimum values) in water temperature in May than later in the summer (August). Water temperature in May of 2015 was marginally lower than the long term average at all sampling depths while water temperature in August 2015 was similar to the long term average values from the surface down to a depth of 4 m, but well below the long term average at depths greater than 4 m. The results for Bass Lake were similar, except water temperature in May and August of 2015 was marginally lower than the long term average at all sampling depths.

Although an analysis of the long term trend in water temperature using all Muskoka lakes has shown a marginal increase in water temperature (Palmer, 2005) over time, the results for Kahshe and Bass Lakes have not shown any obvious warming. This is not unexpected, as the temperature data for a single lake would not have the power of detection that would be possible using a larger database of all Muskoka lakes.

Anions, Cations and Other Chemical Summary

The analysis of several additional anions, cations and other chemicals by the DMM has identified no pressing issues from an aquatic health aspect. While there were some exceedances of chronic (long term) benchmarks established by the MOECC and other agencies to protect aquatic receptors, most of these exceedances were detected in the early years of the sampling program and appear to be related to sampling or laboratory artifacts, as more recent sampling has shown concentrations that are in the expected range for non-impacted surface water bodies in Ontario. The only possible exception is for aluminum; however, the benchmark is believed to be overly conservative and based on studies that failed to recognize the complex chemistry of aluminum ion toxicity.

The findings for a couple of other parameters arising from this large suite of chemical parameters have been incorporated into the discussion of other issues where relevant. This includes the results for alkalinity and its relationship with acidification and the various compounds of nitrogen, which are discussed in the section dealing with phosphorus and water clarity, as both nutrients are known to play a role in lake water eutrophication.

Evaluation of Benthic Monitoring Summary

The 2015 and earlier benthic invertebrate monitoring results for three sites on Kahshe Lake have not identified any problems in the population, growth or survival of aquatic invertebrate which can be related to contamination or habitat disturbance.

Based on the foregoing summary of the environmental monitoring of Kahshe and Bass Lakes, we need to continue with our sampling efforts and practice overall lake stewardship to delay the onset of nutrient enrichment and its impact on lake health. How can we make a difference? Each of us can do our part to maintain the quality of the water by:

- managing our septic systems properly and having tanks pumped out regularly;

- avoiding the use of products containing phosphorus (detergents and cleaners);
- disposing of toxic wastes (batteries, paint, oil, old gas, pressure-treated lumber and other construction waste) at approved land fill sites;
- minimizing near-shore removal or management of vegetation and ensuring that any shoreline disturbance is conducted in compliance with permitted uses;
- avoiding the use of any chemical fertilizers or pesticides in areas close to the shore; and,
- taking precautions to minimize the potential for introducing both terrestrial and aquatic invasive species.

5.0 References Cited

B.C. 2000. Ambient Water Quality Guidelines for Sulphate. Ministry of Environment, Lands and Parks, Province of British Columbia. Technical Appendix, November 2000.

B.C. 2001a. Ambient Water Quality Guidelines for Manganese – Overview Report. Ministry of Environment, Lands and Parks, Province of British Columbia. ISBN 0-7726-4444-6. January 2001

B.C. 2001b. Water Quality Criteria for Nitrogen (Nitrate, Nitrite and Ammonia) – Overview Report. Ministry of Environment, Lands and Parks, Province of British Columbia. August 7, 2001.

CCME, 2012. *Canadian water quality guidelines for the protection of aquatic life: Nitrate Ion*. Canadian Council of Ministers of Environment. Winnipeg, Manitoba.

CCME. 2012. *Draft Scientific Criteria Document for the Development of the Canadian Water Quality Guidelines for the Protection of Aquatic Life: Cadmium*. October 2012.

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

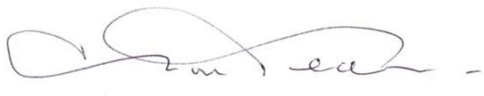
MOE. 2011. *Rationale for the Development of Soil and Ground Water Standards for Use at Contaminated Sites in Ontario*. April 15, 2011, Standards Development Branch, Ontario Ministry of the Environment. PIBS 7386e01.

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.

Suter II, G.W. and Tsao, C. L. 1996. *Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota: 1996 Revision*. U.S. Risk Assessment Program, Oak Ridge, Tennessee. ES/ER/TM-96/R2.

U.S. EPA. 1986. *Quality Criteria for Water 1986*. United States Environmental Protection Agency. Office of Water, Regulations and Standards, Washington, DC. EPA 440/5-86-001

U.S. EPA. 2012. National Recommended Water Quality Criteria. http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm#altable



Ron Pearson

Kahshe Lake Steward

Attachments

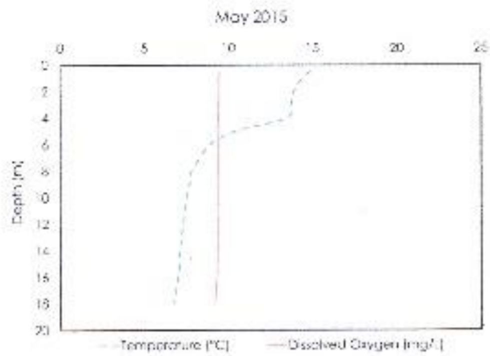
2015 DMM Data Sheets for the Kahshe Lake Main and Grant's Bay Sampling Locations

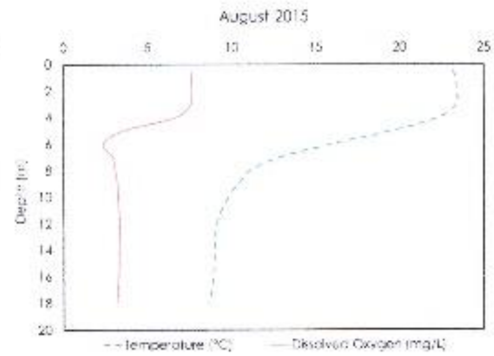
THE DISTRICT OF MUSKOKA

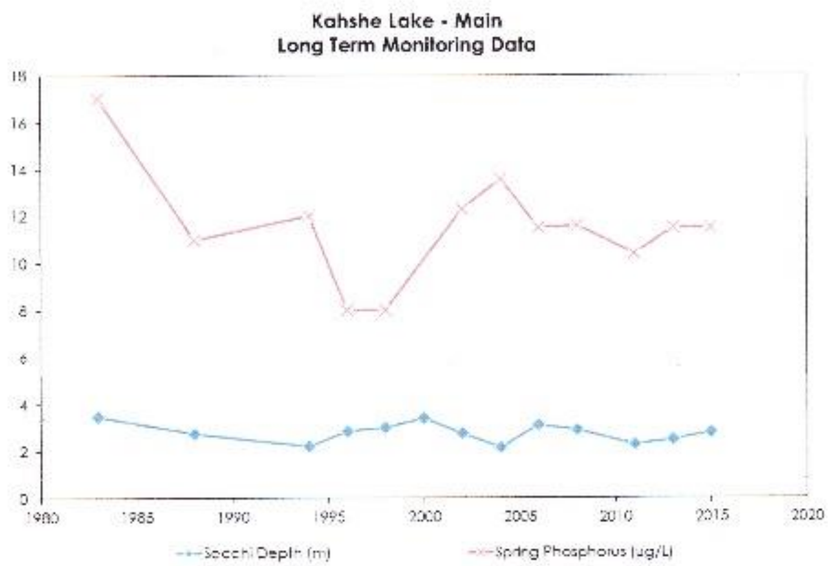
Lake Data Sheet
2015

Kahshe Lake – Main

Municipality:	**Gravenhurst**	Quaternary Watershed:	**Kahshe River**
Surface Area:	**8.21 km²**	Watershed Area (excluding lake):	**32.53 km²**
Maximum Depth:	**20 m**	Lake Trout Lake?	**No**
Wetland Area:	**14 %**	Secchi Depth (10-year average):	**2.7 m**
Phosphorus (10-year average):	**11.3 µg/L**	Sensitivity:	**Moderate**







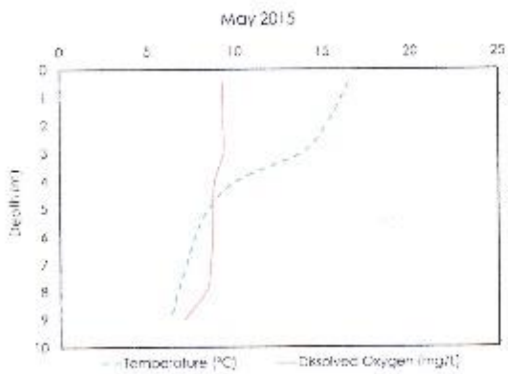
This information is supplied without expressed or implied warranty of any kind, including warranty of fitness for a particular purpose. In no event will The District Municipality of Muskoka be liable for any damages, whether incidental, consequential or direct in conjunction with, or arising from the furnishing or use of this information.

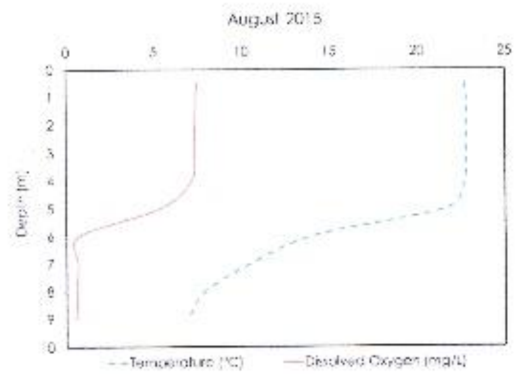
THE DISTRICT MUNICIPALITY OF MUSKOKA

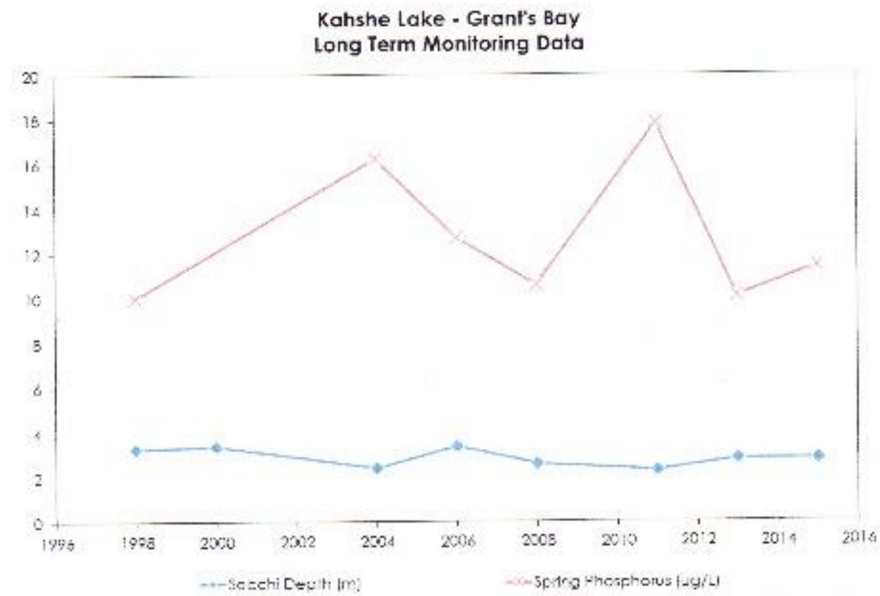
Lake Data Sheet
2015

Kahshe Lake – Grant's Bay

Municipality:	**Gravenhurst**	Quaternary Watershed:	**Kahshe River**
Surface Area:	**8.21 km²**	Watershed Area (excluding lake):	**32.53 km²**
Maximum Depth:	**20 m**	Lake Trout Lake?	**No**
Wetland Area:	**14 %**	Secchi Depth (10-year average):	**2.8 m**
Phosphorus (10-year average):	**12.5 µg/L**	Sensitivity:	**Moderate**







This information is supplied without expressed or implied warranty of any kind, including warranty of fitness for a particular purpose. In no event will The District Municipality of Muskoka be liable for any damages, whether incidental, consequential or direct in conjunction with, or arising from the furnishing or use of this information.

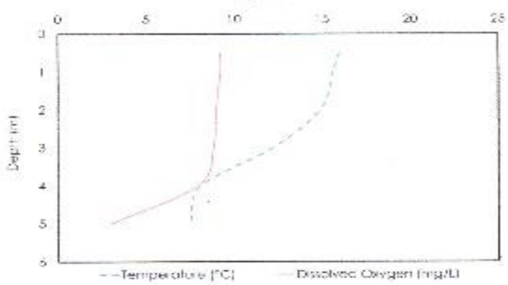
THE DISTRICT OF MUSKOKA

Lake Data Sheet
2015

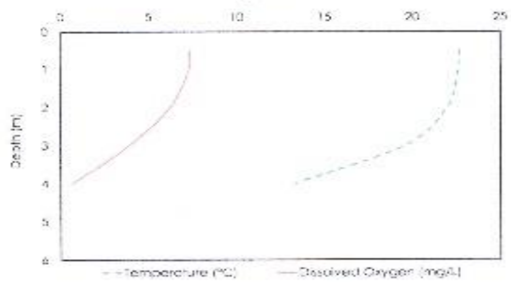
Bass Lake

Municipality:	Gravenhurst	Quaternary Watershed:	Kahshe River
Surface Area:	0.40 km²	Watershed Area (excluding lake):	17.00 km²
Maximum Depth:	8 m	Lake Trout Lake?	No
Wetland Area:	10 %	Secchi Depth (10-year average):	1.9 m
Phosphorus (10 year average):	23.1 µg/L	Sensitivity:	Moderate

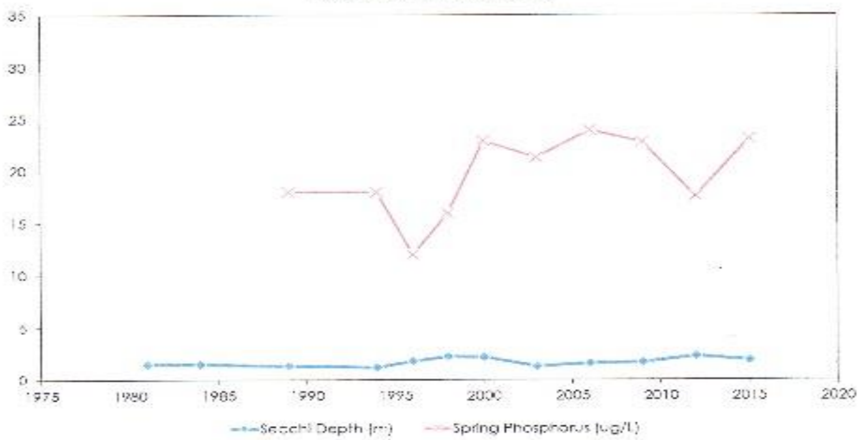
May 2015



August 2015

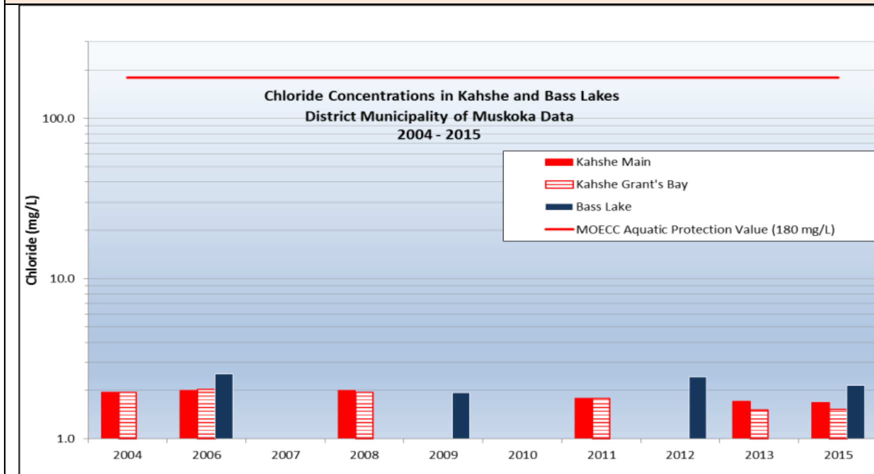


Bass Lake
Long Term Monitoring Data

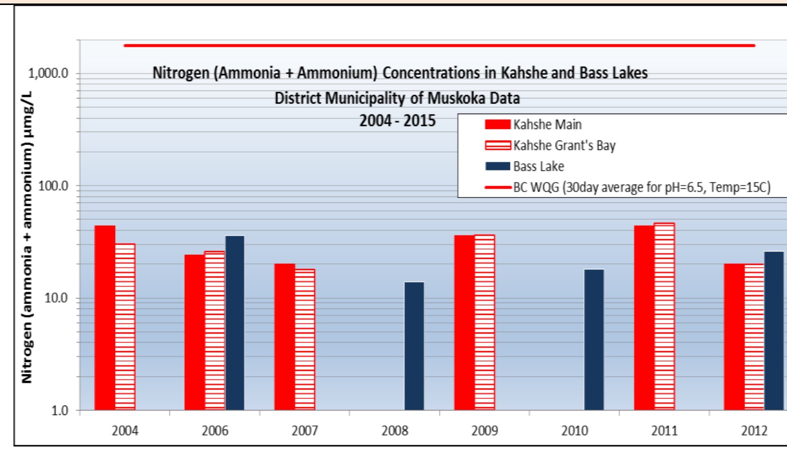


Charts of Water Chemistry Results from DMM Sampling of Kahshe and Bass Lakes

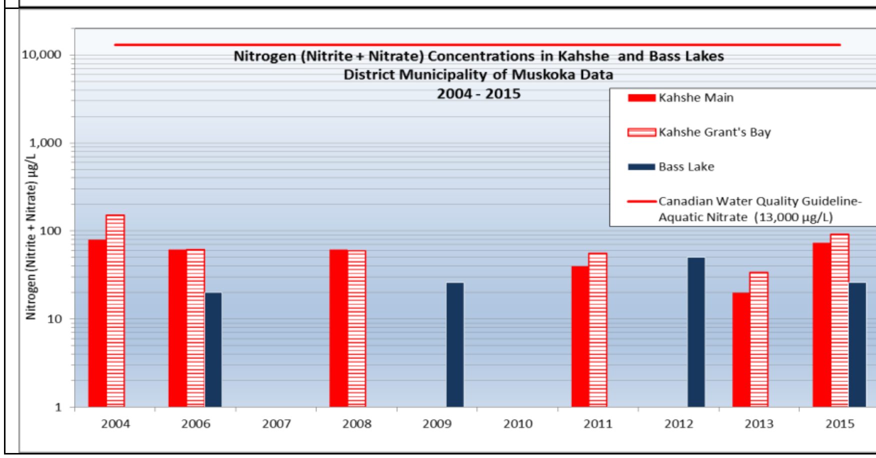
Anions



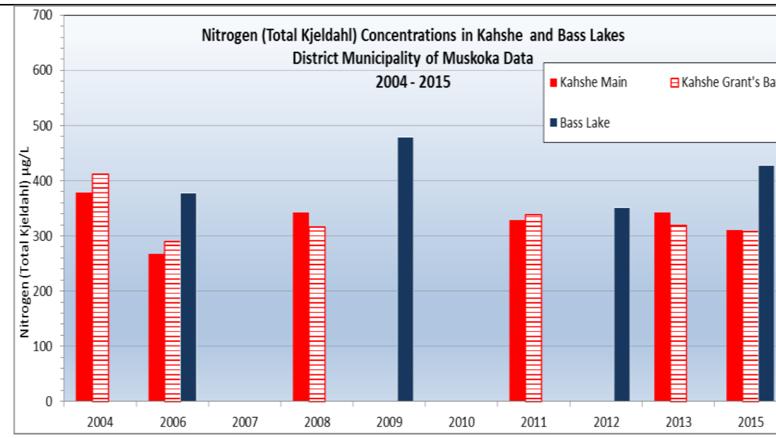
Chloride Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2004 - 2015
Kahshe Main
Kahshe Grant's Bay
Bass Lake
MOECC Aquatic Protection Value (180 mg/L)
Chloride (mg/L)
100.0
10.0
1.0
2004
2006
2007
2008
2009
2010
2011
2012
2013
2015



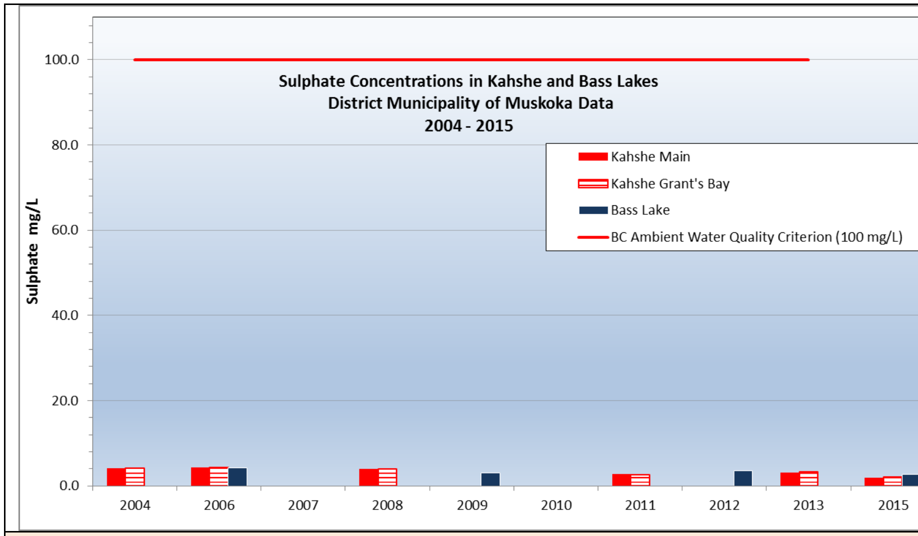
Nitrogen (Ammonia + Ammonium) Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2004 - 2015
Kahshe Main
Kahshe Grant's Bay
Bass Lake
BC WQG (30day average for pH=6.5, Temp=15C)
Nitrogen (ammonia + ammonium) µmg/L
1,000.0
100.0
10.0
1.0
2004
2006
2007
2008
2009
2010
2011
2012



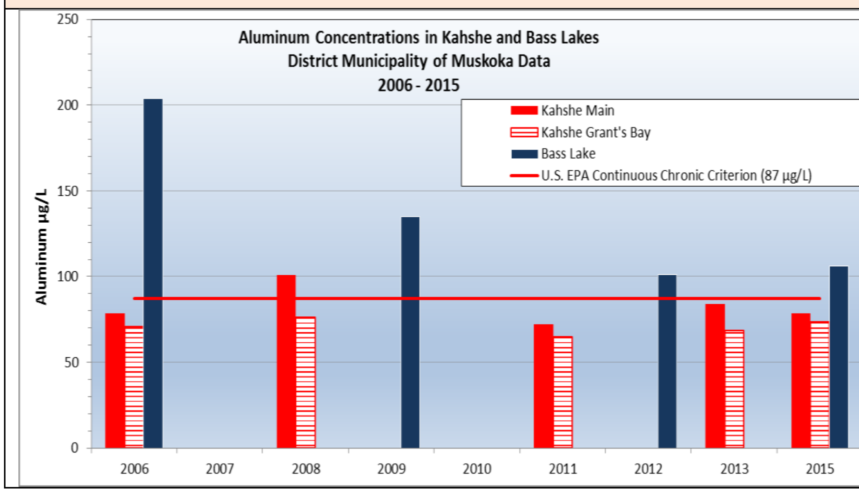
Nitrogen (Nitrite + Nitrate) Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2004 - 2015
Kahshe Main
Kahshe Grant's Bay
Bass Lake
Canadian Water Quality Guideline-
Aquatic Nitrate (13,000 µg/L)
Nitrogen (Nitrite + Nitrate) µg/L
10,000
1,000
100
10
1
2004
2006
2007
2008
2009
2010
2011
2012
2013
2015

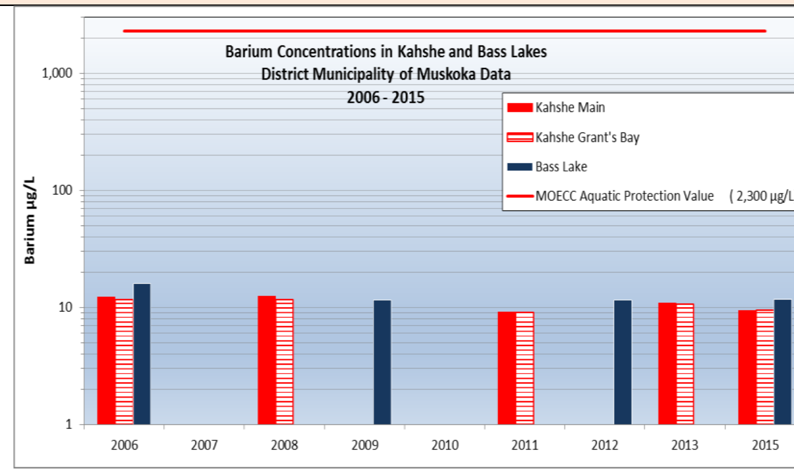


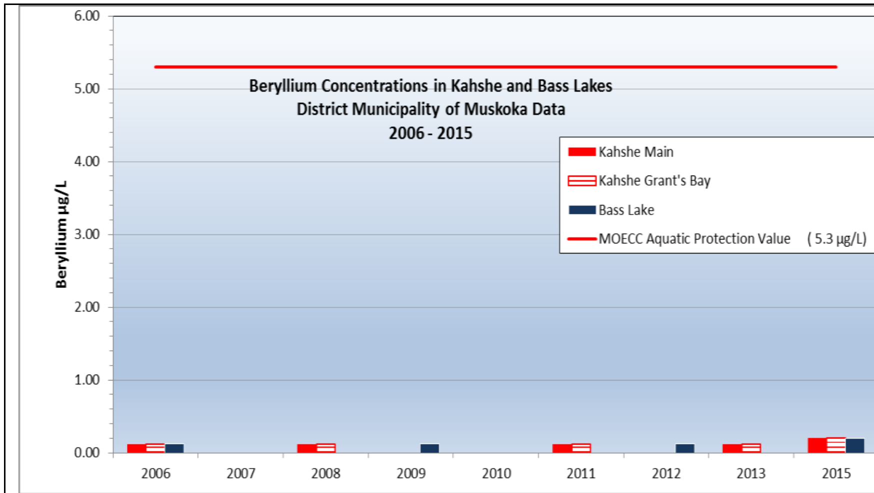
Nitrogen (Total Kjeldahl) Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2004 - 2015
Kahshe Main
Kahshe Grant's Bay
Bass Lake
Nitrogen (Total Kjeldahl) µg/L
700
600
500
400
300
200
100
0
2004
2006
2007
2008
2009
2010
2011
2012
2013
2015

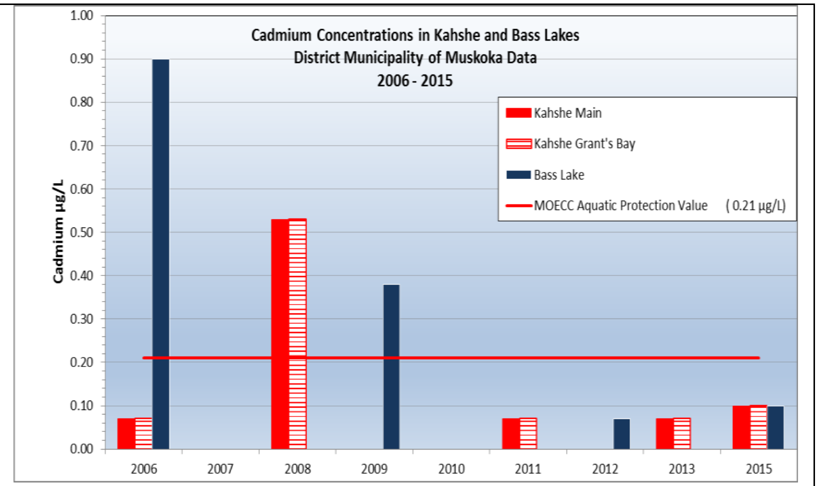

Sulphate Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2004 - 2015
Kahshe Main
Kahshe Grant's Bay
Bass Lake
BC Ambient Water Quality Criterion (100 mg/L)
Sulphate mg/L
100.0
80.0
60.0
40.0
20.0
0.0
2004
2006
2007
2008
2009
2010
2011
2012
2013
2015

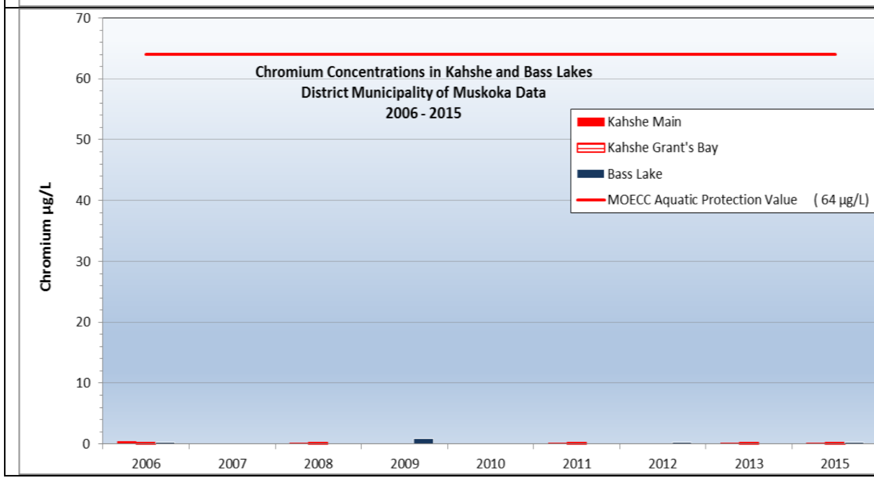
Cations

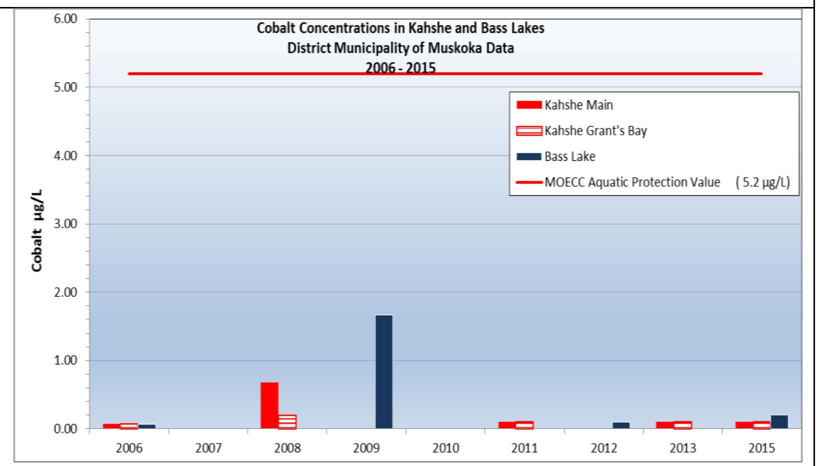

Aluminum Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2006 - 2015
Kahshe Main
Kahshe Grant's Bay
Bass Lake
U.S. EPA Continuous Chronic Criterion (87 µg/L)
Aluminum µg/L
250
200
150
100
50
0
2006
2007
2008
2009
2010
2011
2012
2013
2015

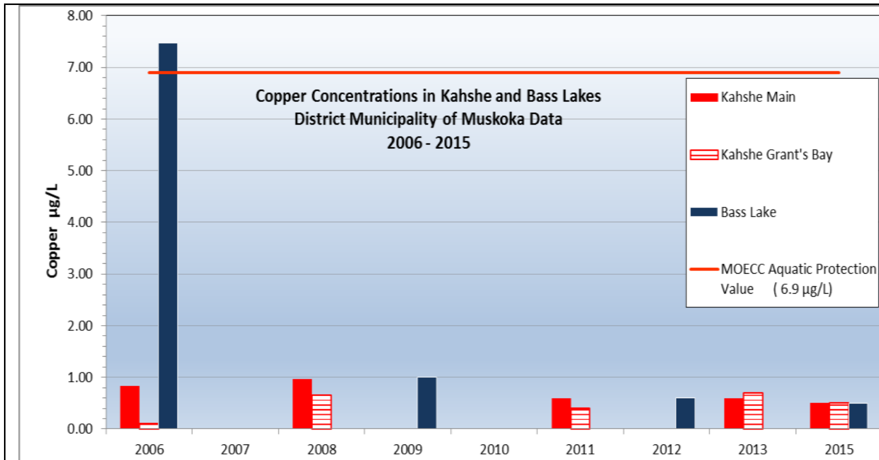

Barium Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2006 - 2015
Kahshe Main
Kahshe Grant's Bay
Bass Lake
MOECC Aquatic Protection Value (2,300 µg/L)
Barium µg/L
1,000
100
10
1
2006
2007
2008
2009
2010
2011
2012
2013
2015

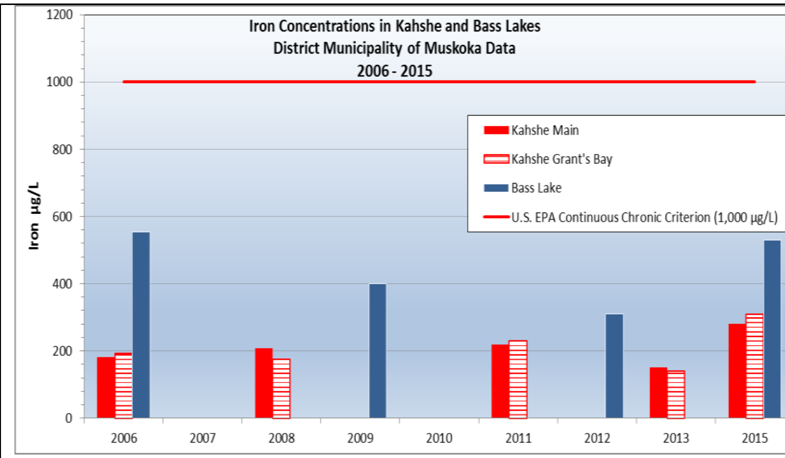

Beryllium Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2006 - 2015
Kahshe Main
Kahshe Grant's Bay
Bass Lake
MOECC Aquatic Protection Value (5.3 µg/L)
Beryllium µg/L
6.00
5.00
4.00
3.00
2.00
1.00
0.00
2006
2007
2008
2009
2010
2011
2012
2013
2015

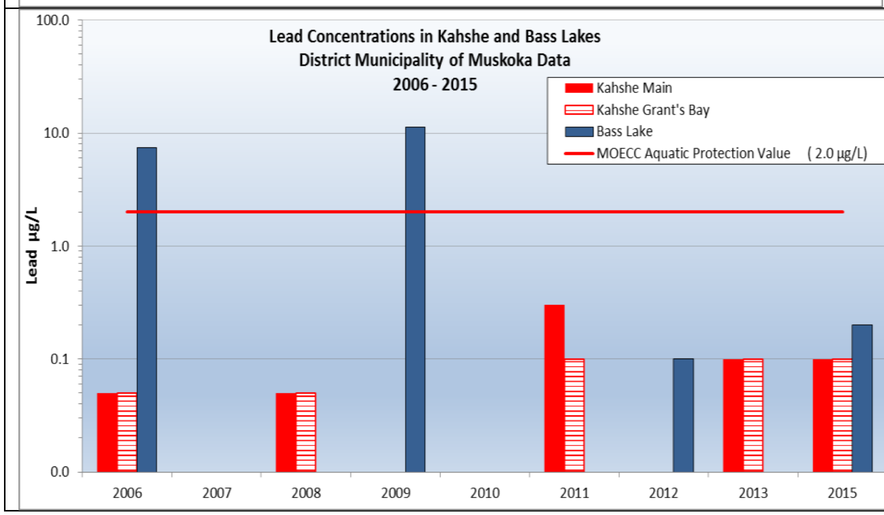

Cadmium Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2006 - 2015
Kahshe Main
Kahshe Grant's Bay
Bass Lake
MOECC Aquatic Protection Value (0.21 µg/L)
Cadmium µg/L
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
2006
2007
2008
2009
2010
2011
2012
2013
2015

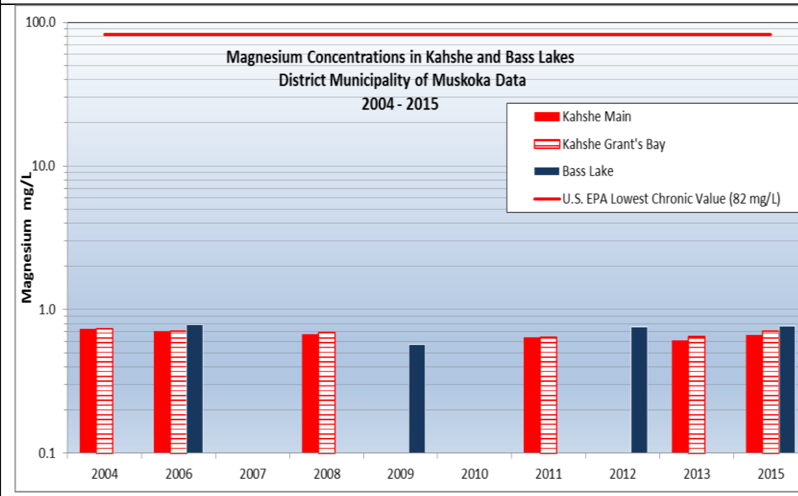

Chromium Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2006 - 2015
Kahshe Main
Kahshe Grant's Bay
Bass Lake
MOECC Aquatic Protection Value (64 µg/L)
Chromium µg/L
70
60
50
40
30
20
10
0
2006
2007
2008
2009
2010
2011
2012
2013
2015

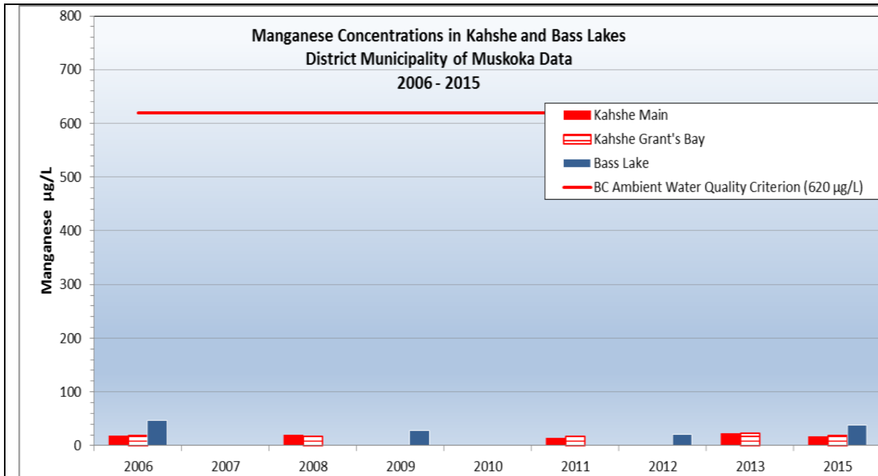

Cobalt Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2006 - 2015
Kahshe Main
Kahshe Grant's Bay
Bass Lake
MOECC Aquatic Protection Value (5.2 µg/L)
Cobalt µg/L
6.00
5.00
4.00
3.00
2.00
1.00
0.00
2006
2007
2008
2009
2010
2011
2012
2013
2015

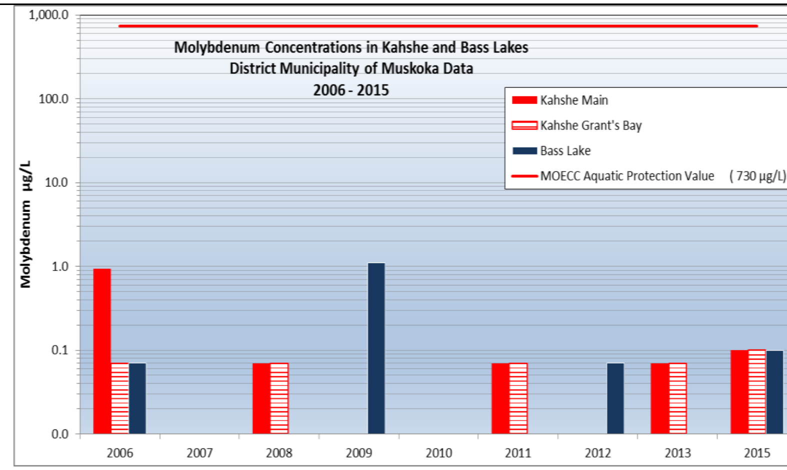

Copper Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2006 - 2015
Copper µg/L
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
2006
2007
2008
2009
2010
2011
2012
2013
2015
Kahshe Main
Kahshe Grant's Bay
Bass Lake
MOECC Aquatic Protection Value (6.9 µg/L)

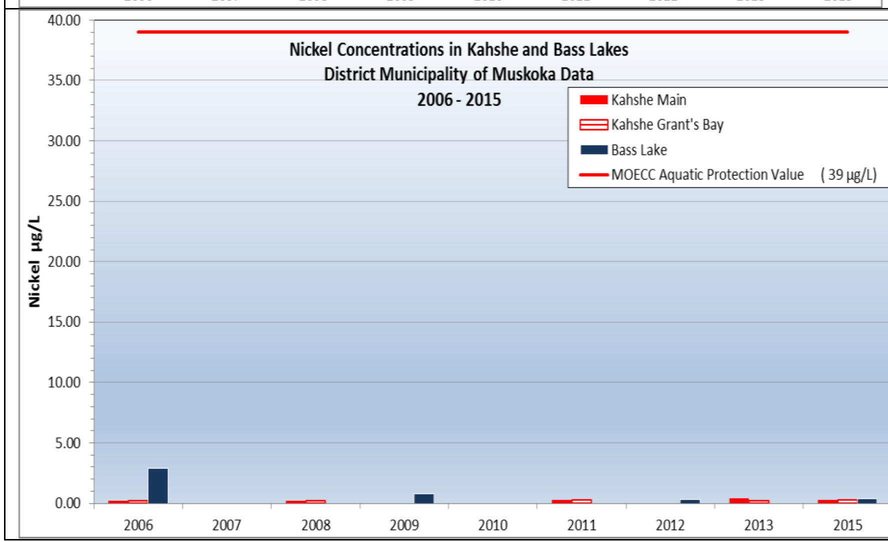

Iron Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2006 - 2015
Iron µg/L
1200
1000
800
600
400
200
0
2006
2007
2008
2009
2010
2011
2012
2013
2015
Kahshe Main
Kahshe Grant's Bay
Bass Lake
U.S. EPA Continuous Chronic Criterion (1,000 µg/L)

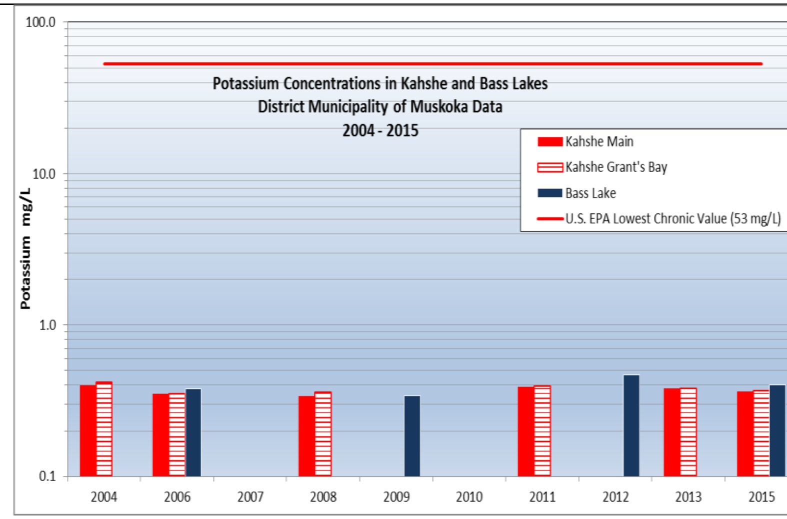

Lead Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2006 - 2015
Lead µg/L
100.0
10.0
1.0
0.1
0.0
2006
2007
2008
2009
2010
2011
2012
2013
2015
Kahshe Main
Kahshe Grant's Bay
Bass Lake
MOECC Aquatic Protection Value (2.0 µg/L)

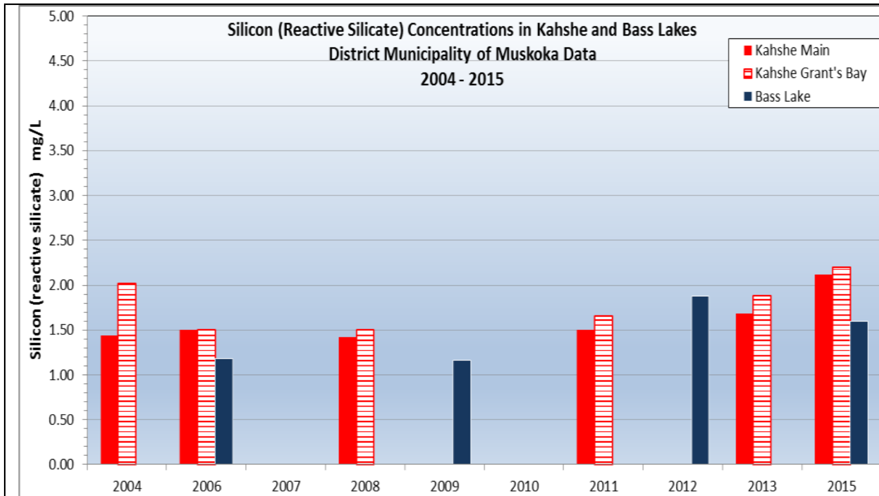

Magnesium Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2004 - 2015
Magnesium mg/L
100.0
10.0
1.0
0.1
2004
2006
2007
2008
2009
2010
2011
2012
2013
2015
Kahshe Main
Kahshe Grant's Bay
Bass Lake
U.S. EPA Lowest Chronic Value (82 mg/L)

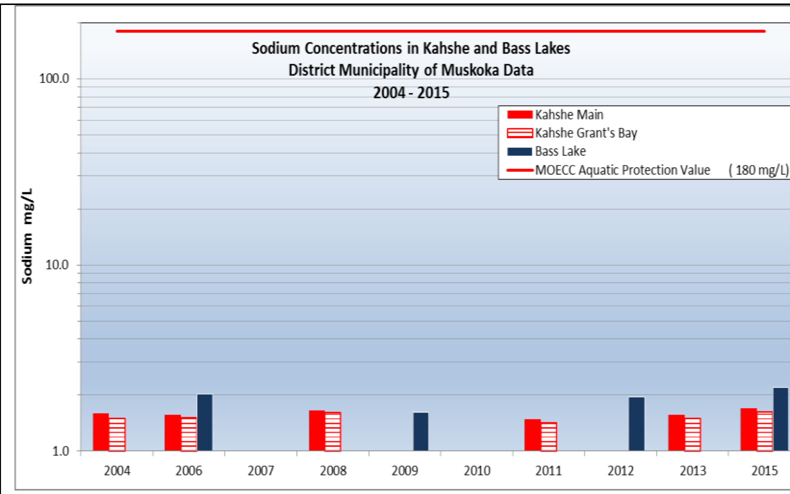

Manganese Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2006 - 2015
Kahshe Main
Kahshe Grant's Bay
Bass Lake
BC Ambient Water Quality Criterion (620 µg/L)
Manganese µg/L
800
700
600
500
400
300
200
100
0
2006
2007
2008
2009
2010
2011
2012
2013
2015

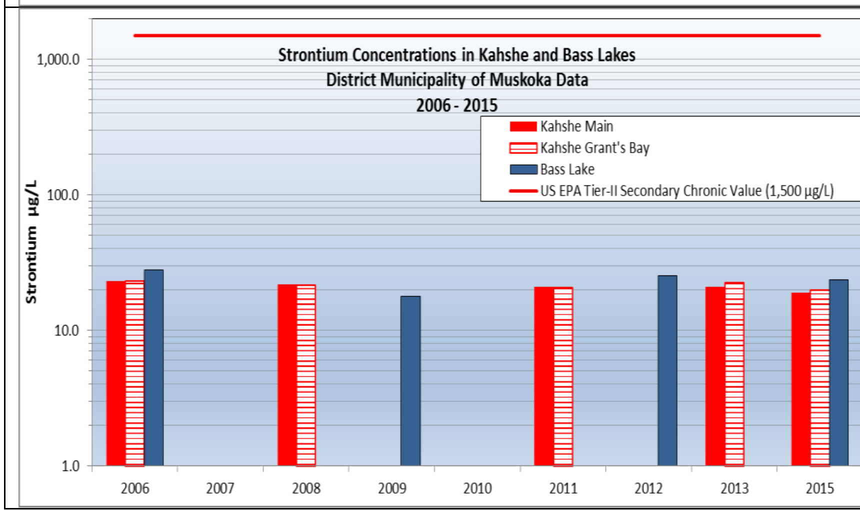

Molybdenum Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2006 - 2015
Kahshe Main
Kahshe Grant's Bay
Bass Lake
MOECC Aquatic Protection Value (730 µg/L)
Molybdenum µg/L
1,000.0
100.0
10.0
1.0
0.1
0.0
2006
2007
2008
2009
2010
2011
2012
2013
2015

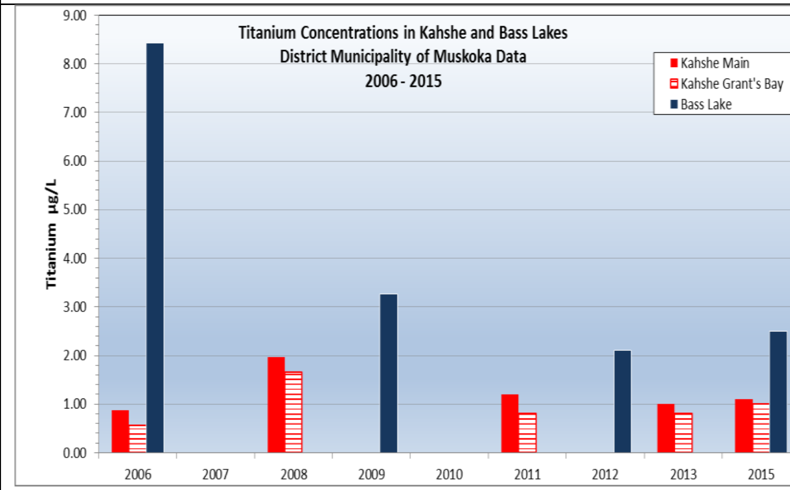

Nickel Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2006 - 2015
Kahshe Main
Kahshe Grant's Bay
Bass Lake
MOECC Aquatic Protection Value (39 µg/L)
Nickel µg/L
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
2006
2007
2008
2009
2010
2011
2012
2013
2015

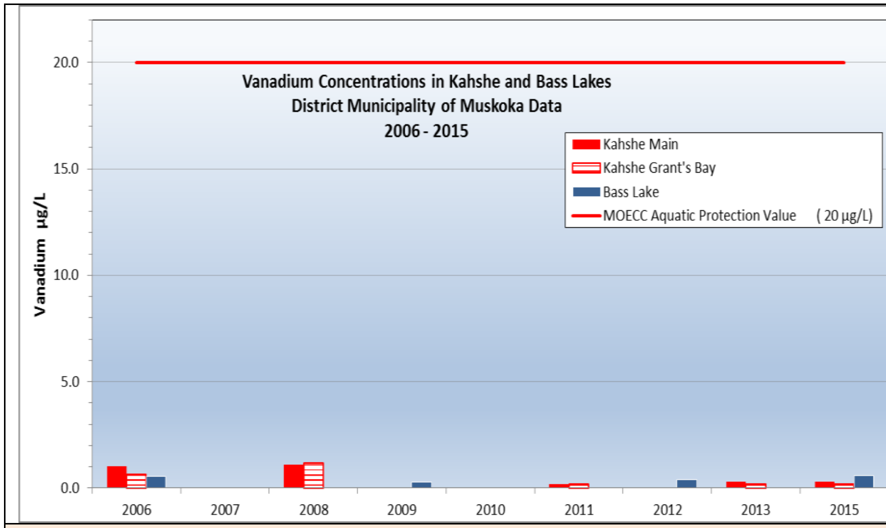

Potassium Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2004 - 2015
Kahshe Main
Kahshe Grant's Bay
Bass Lake
U.S. EPA Lowest Chronic Value (53 mg/L)
Potassium mg/L
100.0
10.0
1.0
0.1
2004
2006
2007
2008
2009
2010
2011
2012
2013
2015

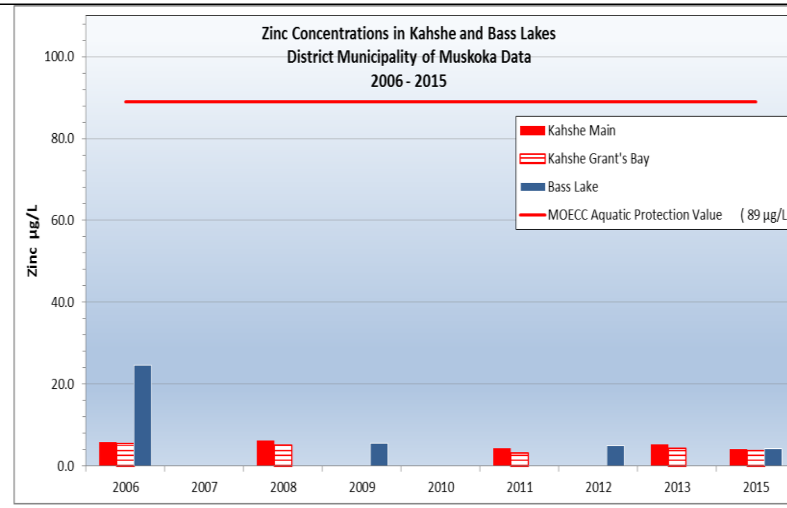

Silicon (Reactive Silicate) Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2004 - 2015
Kahshe Main
Kahshe Grant's Bay
Bass Lake
Silicon (reactive silicate) mg/L
5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
2004
2006
2007
2008
2009
2010
2011
2012
2013
2015


Sodium Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2004 - 2015
Kahshe Main
Kahshe Grant's Bay
Bass Lake
MOECC Aquatic Protection Value (180 mg/L)
Sodium mg/L
100.0
10.0
1.0
2004
2006
2007
2008
2009
2010
2011
2012
2013
2015

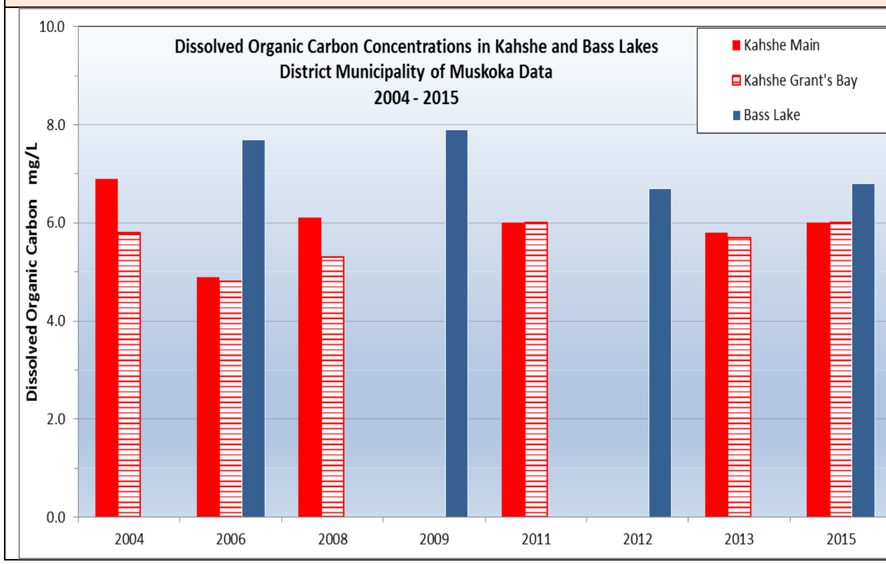

Strontium Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2006 - 2015
Kahshe Main
Kahshe Grant's Bay
Bass Lake
US EPA Tier-II Secondary Chronic Value (1,500 µg/L)
Strontium µg/L
1,000.0
100.0
10.0
1.0
2006
2007
2008
2009
2010
2011
2012
2013
2015

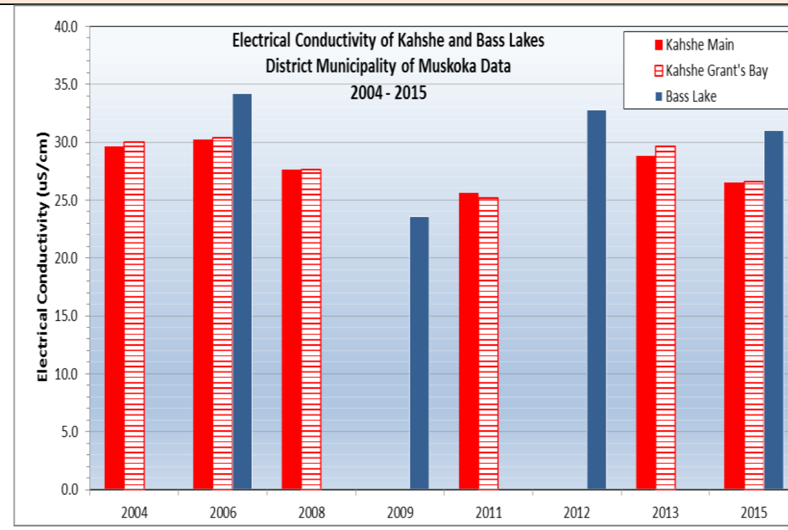

Titanium Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2006 - 2015
Kahshe Main
Kahshe Grant's Bay
Bass Lake
Titanium µg/L
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
2006
2007
2008
2009
2010
2011
2012
2013
2015

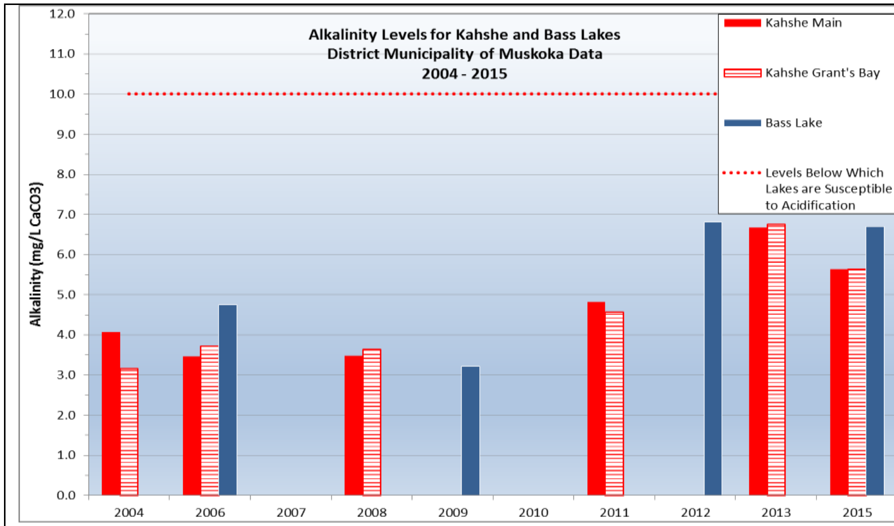




Other Chemicals







Not Charted Chemicals

New Substances Analyzed in 2012, 2013 & 2015

Substance	Units	Kahshe Main	Kahshe Grant's Bay	Bass Lake	Kahshe Main	Kahshe Grant's Bay	Bass Lake	MOECC Aquatic Protection Value
		2013		2012	2015			
Antimony	µg/L	0.07	0.07	0.07	0.2	0.2	0.2	1,600
Arsenic	µg/L	0.1	0.2	0.2	0.2	0.2	0.2	150
Boron	µg/L	4	4	0.48	3	3	4	3,550
Selenium	µg/L	0.1	0.2	0.1	0.1	0.1	0.1	5
Silver	µg/L	0.08	0.08	0.08	0.1	0.1	0.1	0.12
Thallium	µg/L	0.08	0.08	0.08	0.1	0.1	0.1	40
Uranium	µg/L	0.08	0.08	0.08	0.2	0.2	0.2	33

Legend:

Concentrations shown in coloured text are Method Detection Levels, as a quantifiable concentration was not found