2017 Kahshe and Bass Lake Steward Report

Kahshe Lake Ratepayers' Association

April 2018

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2017 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 in annual Lake Steward Reports from 2012 through 2016. These documents as well as Executive Summaries are posted on the KLRA web-site (http://www.kahshelake.ca). This report captures the findings from sampling and analysis of both Kahshe and Bass Lakes in 2017. 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.

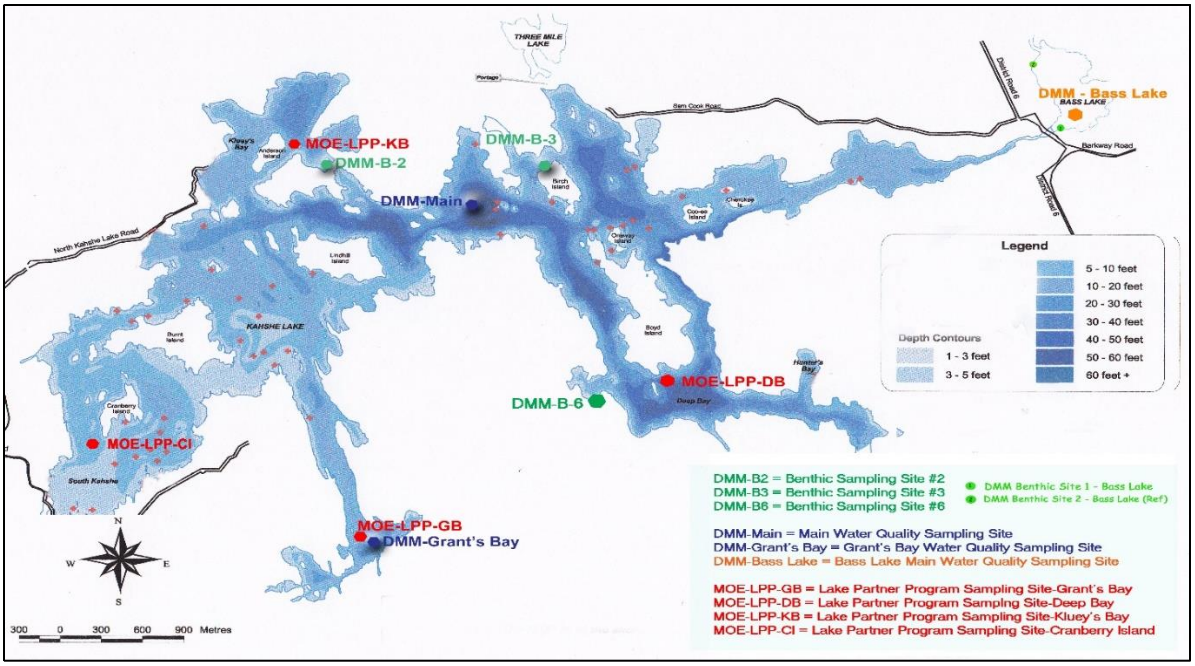
As in 2016, this report has been structured to address the following issues/areas of potential concern for both lakes:

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

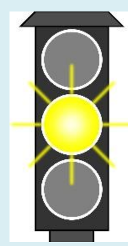
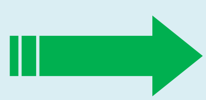
Weather and Water/Ice Conditions in 2017

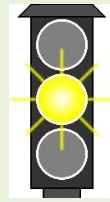
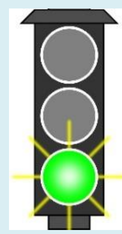
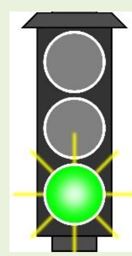
The information on weather and water/ice conditions confirmed that 2017 was fairly normal in terms of temperature but well above normal for rainfall during the spring and summer months. And consistent with the 125 year trend of earlier ice-out dates for Muskoka Lakes that was discussed in the 2016 report, the April 12 ice-out date for Kahshe Lake was earlier than normal in 2017.

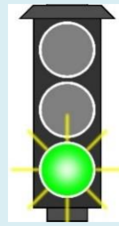
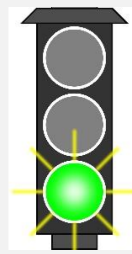
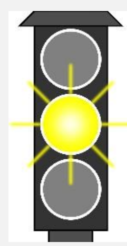
The map below shows the locations of all sampling sites for both DMM and MOECC sampling programs, while the summary table that follows provides brief information on each of the six issues.

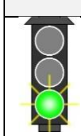


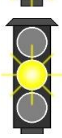
Summary of 2017 Findings for Kahshe and Bass Lakes

Measure	Why It's Important	Level of Concern*	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 the relationship between water clarity and water quality findings.	 Kahshe & Bass 	❑ Background-based model review now completed and phosphorus benchmarks may need to be revised. ❑ New DMM approach does not change good water quality status for Kahshe Lake, where total P levels continue to be low and below background. ❑ However, because of a late season algal bloom that was reported, continued caution is required. ❑ Bass Lake was flagged by DMM for further study in 2016 and 2017 because of elevated phosphorus above 20 µg/L. ❑ No change in total phosphorus in Bass Lake in 2017 and slightly improved water clarity. ❑ Special DMM studies will continue for Bass Lake in 2018.

Measure	Why It's Important	Level of Concern*	Comments
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 show a decline in calcium and are now at lower end of the growth limiting threshold for some aquatic species.	 Kahshe & Bass 	❑ Not a shoreline development issue. ❑ Calcium in Kahshe and Bass Lake is currently above the growth limiting threshold (good), but margin of safety is small, so need to keep monitoring and watch for signs of decline due to possible impacts on some sensitive zooplankton species.
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.	 Kahshe & Bass 	❑ 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.
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.	 Kahshe & Bass 	❑ 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 drop below the desirable benchmark. ❑ However, neither Kahshe nor Bass Lake is considered anoxic and the lower DO levels are limited to late summer and fall and are unlikely to impact aquatic organisms. ❑ The 35 year trends in water temperature show no obvious up or down trend.

Measure	Why It's Important	Level of Concern*	Comments
All Other Chemicals	❑ DMM samples and analyzes Kahshe and Bass Lake for over 30 different metals, nutrients and other chemicals. ❑ This report analyzes them relative to chronic toxicity benchmarks and charts them all since monitoring began in early 2000s.	 Kahshe & Bass 	❑ All 30 have been compared to chronic toxicity benchmarks from Ontario, Canada and the U.S. EPA. ❑ Sampling of Bass Lake in 2017 confirmed that most are well below aquatic benchmarks. ❑ A few historical exceedances are likely due to analytical problems early in the program and/or to benchmarks that are outdated or poorly supported.
Benthic Monitoring	❑ The study of benthic organisms living in the bottom sediment is undertaken as an early warning activity for water quality impairment. ❑ The population of benthic organisms can detect very subtle changes due to alteration in species richness and in the survival or decline of groups of species that respond differently to impaired water quality.	 Kahshe  Bass	❑ There are 3 locations on Kahshe Lake, but they have not been monitored since 2015. ❑ The DMM considers all 3 to be Reference Locations, and adds the findings to a database of Reference Levels across Muskoka. ❑ DMM has conducted benthic assessment at one Reference Site and one Potentially Impacted site on Bass L as part of the Transitional Lake study in both 2016 and 2017. ❑ While there is some indication of potential impacts at one of the sampling locations compared to Muskoka Reference levels, there is insufficient data and significant variability to determine if any negative trend is taking place. ❑ DMM plans to continue the benthic program in 2018.

 Green = Normal and Not a Concern

 Amber = Flagged for continued monitoring and caution as margin of safety is low

 Direction of arrow indicates upward or downward trend 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. However, continued sampling and overall lake stewardship is imperative to delay the onset of nutrient enrichment and algal growth, the depletion of calcium and the introduction of invasive species.

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 (lawns) 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

As a standing member of the Kahshe Lake Conservation Committee, the roles and responsibilities of the Lake Steward include:

- Educating the residents and other users of Kahshe and Bass Lakes on how to **preserve** and **improve** the quality of the lakes and their shorelines.

- Monitoring the environmental quality of both lakes and keeping the association members up to date on the results of the analytical and biological monitoring 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 in 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. For Kahshe and Bass Lakes, the Building Department of the Town of Gravenhurst is the agency with this responsibility. In addition to permitting the installation of septic systems, the Town operates a septic re-inspection program as follows:

- the re-inspection on Kahshe Lake is carried out every 5 years;
- 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.

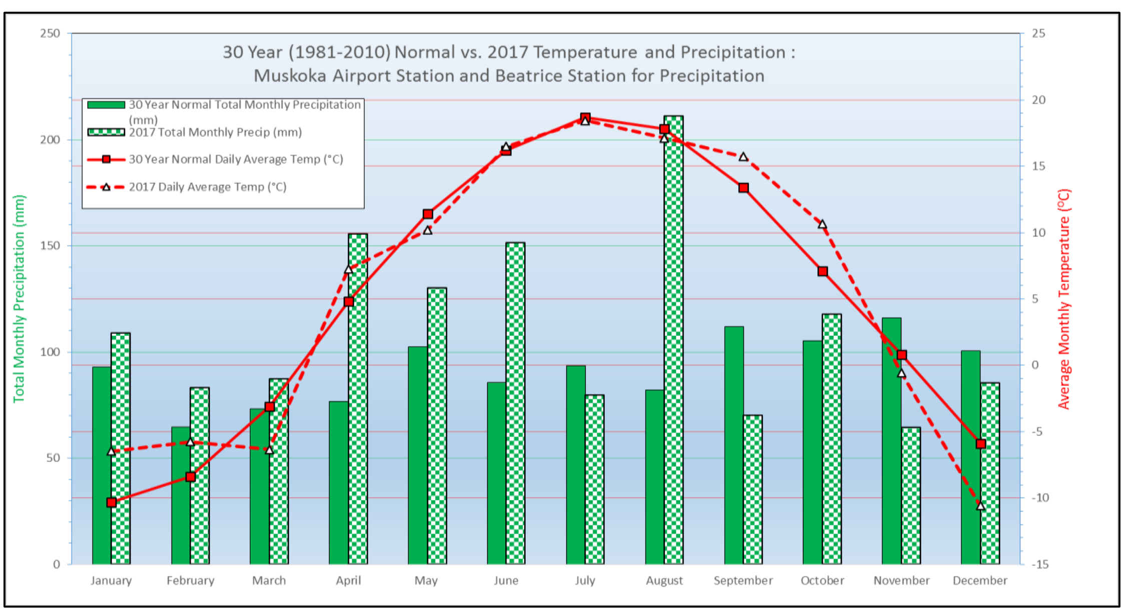
1.0 Overview of Climatic Factors and Water/Ice Conditions

In order to better understand the chemical and physical data that have been collected, this year's report includes an overview of the climatological factors that have the potential to influence the lake monitoring findings. This attempts to answer the question: How normal were temperature, rainfall, water levels and ice-out conditions compared to past years?

Air Temperature and Precipitation

Air temperature and rainfall records from the Muskoka Airport and Beatrice weather monitoring stations in 2017 and earlier years were evaluated. The chart below shows the average monthly air temperature and total monthly precipitation (rain + snow) for the entire 2017 year. These results are then compared to the 30 year (1981-2010) normal monthly temperature and precipitation.

This comparison demonstrates that air temperatures in 2017 were close to normal through most of the year, with a slightly higher than normal temperature in January, February, April, September and October. It comes as no surprise that with the exception of July, total precipitation during the period from April through August was much higher than normal. In August alone, precipitation was 2.5 times higher than normal. Note also that for precipitation data, the results were from the Beatrice Station (north of Bracebridge), as the Muskoka Airport station failed to record precipitation on a regular basis.



Water Levels

Data from the Ontario Ministry of Natural Resources (MNR) as collected at the dam near the south end of Kahshe Lake were provided by the MNR and summarized in the 2016 report. However, to date, the Ministry has not provided this information for 2017. From memory, water levels were elevated beyond normal in the early spring after ice melt. In spite of the above normal rainfall throughout most of the summer, the water levels dropped and were on the low side towards the end of the recreational season.

Ice-Out Times

While there is no official record for ice-out times on Kahshe Lake, the 2016 Lake Steward report did present the findings of a publicly generated data base of ice-out times for Muskoka Lakes (Rosseau and Joseph) dating back 125 years. It is recognized that there would be some differences between these dates (shown in the table below) and the actual dates on Kahshe Lake, the differences are expected to be minimal given the similarity in their locations.

Ice-Out dates for each year: 1886 - 2016

Year	Date	Year	Date	Year	Date	Year	Date	Year	Date	Year	Date	Year	Date	Year	Date	Year	Date	Year	Date
1886	23-Apr	1899	26-Apr	1912	27-Apr	1925	14-Apr	1938	17-Apr	1951	12-Apr	1964	17-Apr	1977	16-Apr	1990	26-Apr	2004	16-Apr
1887	n/a	1900	24-Apr	1913	20-Apr	1926	07-May	1939	01-May	1952	20-Apr	1965	03-May	1978	29-Apr	1991	16-Apr	2005	17-Apr
1888	n/a	1901	20-Apr	1914	21-Apr	1927	18-Apr	1940	29-Apr	1953	06-Apr	1966	20-Apr	1979	21-Apr	1992	01-May	2006	14-Apr
1889	18-Apr	1902	09-Apr	1915	19-Apr	1928	29-Apr	1941	15-Apr	1954	21-Apr	1967	18-Apr	1980	15-Apr	1993	21-Apr	2007	18-Apr
1890	26-Apr	1903	07-Apr	1916	20-Apr	1929	09-Apr	1942	15-Apr	1955	13-Apr	1968	09-Apr	1981	04-Apr	1994	23-Apr	2008	21-Apr
1891	27-Apr	1904	29-Apr	1917	23-Apr	1930	24-Apr	1943	29-Apr	1956	04-May	1969	22-Apr	1982	27-Apr	1995	19-Apr	2009	18-Apr
1892	21-Apr	1905	24-Apr	1918	23-Apr	1931	30-Apr	1944	28-Apr	1957	20-Apr	1970	30-Apr	1983	16-Apr	1996 1997	n/a n/a	2010	02-Apr
1893	26-Apr	1906	20-Apr	1919	16-Apr	1932	06-Apr	1945	29-Mar	1958	26-Apr	1971	02-May	1984	17-Apr	1998	19-Apr	2011	17-Apr
1894	n/a	1907	24-Apr	1920	19-Apr	1933	10-Apr	1946	27-Mar	1959	28-Apr	1972	03-May	1985	23-Apr	1999	09-Apr	2012	23-Mar
1895	22-Apr	1908	27-Apr	1921	08-Apr	1934	21-Apr	1947	27-Apr	1960	22-Apr	1973	17-Apr	1986	10-Apr	2000	28-Mar	2013	13-Apr
1896	17-Apr	1909	29-Apr	1922	17-Apr	1935	16-Apr	1948	10-Apr	1961	22-Apr	1974	28-Apr	1987	13-Apr	2001	28-Apr	2014	29-Apr
1897	27-Apr	1910	01-Apr	1923	28-Apr	1936	23-Apr	1949	12-Apr	1962	21-Apr	1975	01-May	1988	14-Apr	2002	15-Apr	2015	21-Apr
1898	n/a	1911	01-May	1924	17-Apr	1937	24-Apr	1950	01-May	1963	16-Apr	1976	16-Apr	1989	28-Apr	2003	21-Apr	2016	08-Apr

No recorded Ice-Out date — Earliest recorded Ice-Out date: 3-23-2012 — Latest recorded Ice-Out date: 5-07-1926

Ice-Out Data Source and Qualifiers

* To the best of our knowledge, the following individuals were responsible for recording the Ice-Out dates referenced here:

1886-1899: The Henry Family of Minett

1900-1919: Captain John Rogers of Port Sandfield

1920-1930: Victor Croucher, Lake Joseph

1931-1945: Keith Croucher, Lake Rosseau

1946-2006: Cecil Frazer, Port Carling

2007-2016: Robert Goltz, Windermere Area Archive, Lake Rosseau

Not all Ice-Out dates were recorded in the same location or used the same methodology. Over the 130 year period referenced, there were 6 years for which we could find no recorded Ice-Out date. Those years were not included in the calculation of the average Ice-Out dates.

While ice-out data for 2017 from this source have not been found, it has been reported that ice-out for Lake Muskoka in 2017 was April 9. This is similar to the ice-out date of April 12 for Kahshe Lake (as reported by the Rings at Rockhaven). Based on the 2017 information, the long-term trend of earlier ice-out conditions which was apparent from the long-term data up to 2016 appears to be continuing.

Climatic Factors and Water/Ice Condition Summary

The information on weather and water/ice conditions in 2017 confirm the trend towards early ice-out to start the year. This is supported by slightly higher than normal temperatures through January, February and April. In terms of temperature, the remainder of the spring and summer was very similar to the 30 year average, while September was warmer. Precipitation was the major event in 2017, with the amounts recorded in April, May and August being well above average. In August, the rainfall amounted to two and a half times the normal amount of rain.

2.0 Overview of Environmental Monitoring

Kahshe and 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 on Kahshe Lake is conducted by the Lake Steward <u>every year</u>.

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 three 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 three locations plus an additional location to the south of Cranberry Is. in May each year and sent to the MOECC where it is analyzed for total phosphorous and calcium.

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.

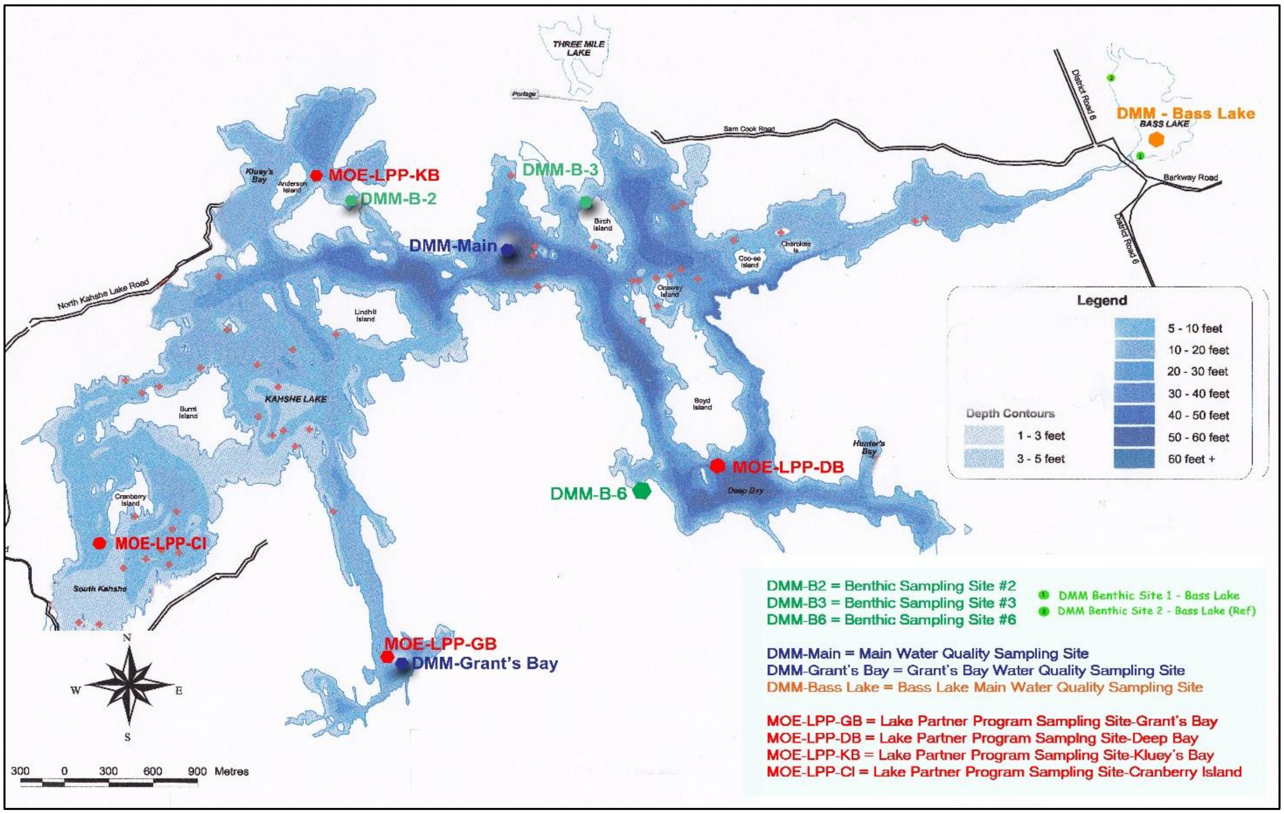
For Kahshe and Bass Lakes, the DMM program consists of the following activities which have been conducted every second year for Kahshe Lake and every third year for Bass Lake:

- Spring phosphorus sampling conducted in May or early June (2 sites in Kahshe Lake and 1 site in Bass L);
- Water sample collection for total phosphorus and a suite of other physical and chemical parameters in May/June (2 sites in Kahshe Lake and 1 site in Bass Lake);
- Secchi disc depth measurements collected in May and August (2 sites in Kahshe Lake and one site in Bass Lake);
- Temperature and dissolved oxygen at increasing water depths taken in May and August (2 sites in Kahshe Lake and 1 site in Bass Lake);
- Benthic invertebrate sampling at one of three sites in Kahshe Lake in August each year and since 2016, at one or two sites in Bass Lake.

Since the DMM program had been carried out on Kahshe Lake in 2015, sampling was carried out again in 2017. Although sampling in 2017 in Bass Lake would not normally have been carried out, it was conducted to further assess water quality, as Bass Lake had been identified as a transitional lake as part of the DMM's review of its water quality model in late 2016. Benthic assessment also was carried out on Bass Lake at one of two sampling locations in 2017 as part of the transitional lake sampling methodology.

To give a better perspective on where the sampling for both the MOECC 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 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 have been presented in several sections to 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 also compares 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 sampling and analysis of phosphorus is important, as it has been clearly shown to be the main nutrient that controls the growth of algae in Ontario lakes, with higher phosphorus generally associated with 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 demonstrated in previous reports, 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 pre-determined 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 may be initiated to reduce the amount of phosphorus entering the lake from its watershed. As noted in last year's report, 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:

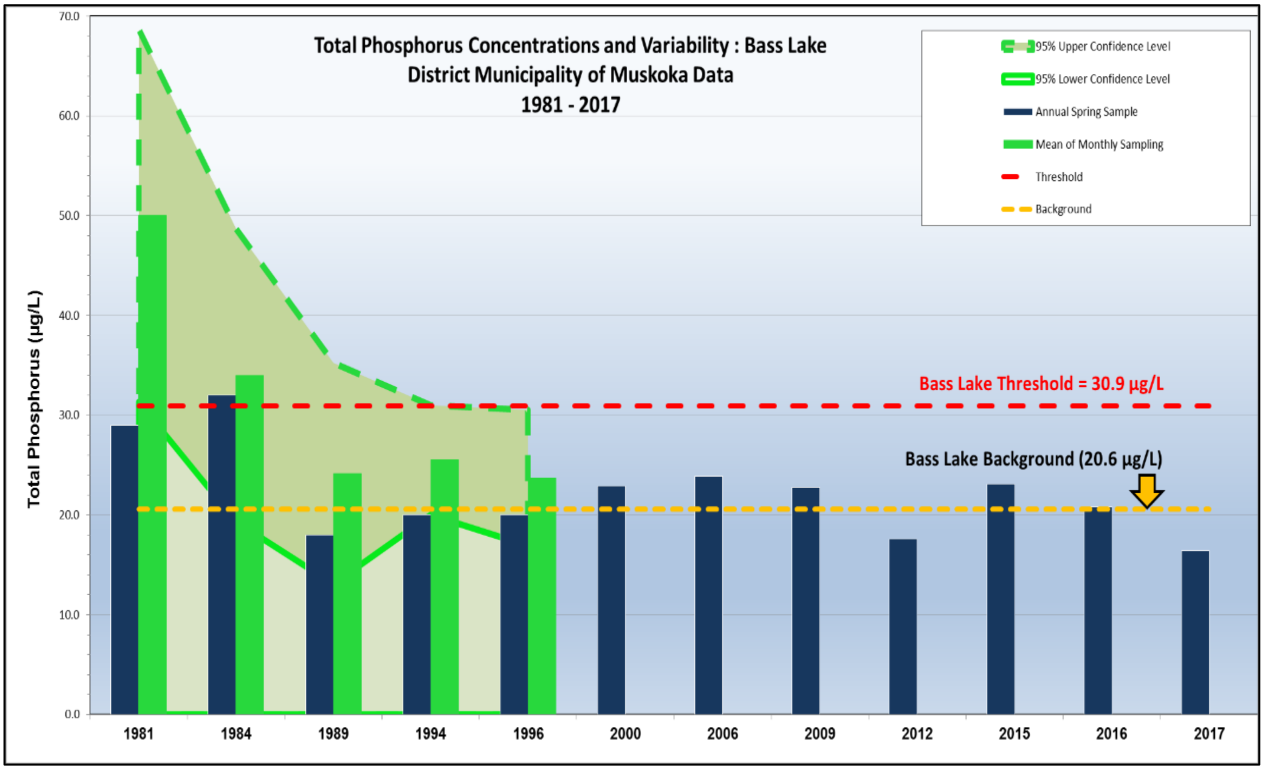
"The results of the review suggest the need for an updated approach governing development or redevelopment on lakes which reflects scientific advances in the last decade, in recognition that the existing model was too narrowly focused and had some limitations when used to evaluate an individual lake. 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. Because of that, the DMM undertook additional sampling of Bass Lake in 2016 even though sampling wasn't due to be carried out until 2018. The special sampling of Bass Lake continued in 2017.

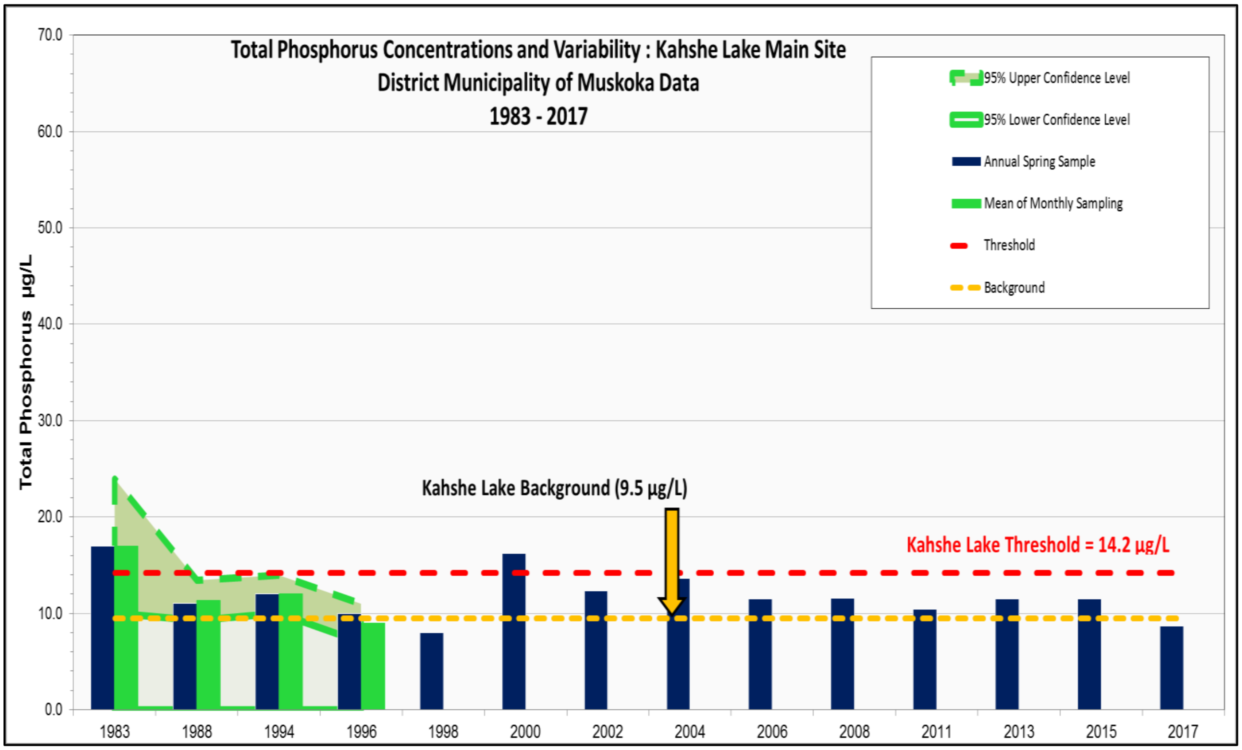
The Bass Lake results for 2017 as well as those of the past 30+ years are shown below:



These findings can summarized as follows:

1. There has been no change in total phosphorus concentrations over the past 35 years
2. Total phosphorus in 2017 was higher than in Kahshe Lake, but well below the DMM's existing Threshold Level and below both the Background Level and the concentration of 20 µg/L that triggered the special Transitional Lake status by DMM.

So how do these findings compare with total phosphorus in Kahshe Lake? The chart below shows the total phosphorus levels at the Main sampling site in Kahshe Lake for 2017 using the same total phosphorus concentration scale.

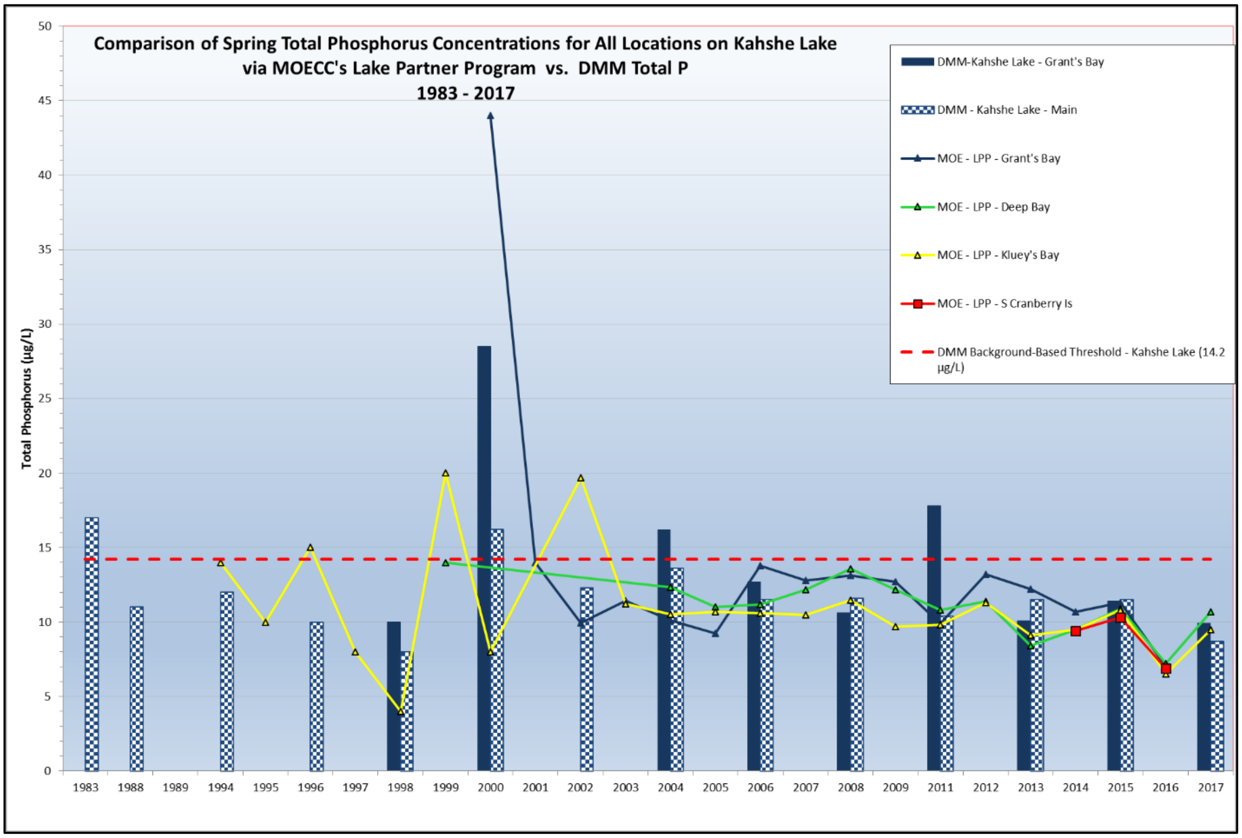


The findings from this comparison are summarized below:

1. The total phosphorus concentration at the Kahshe Lake Main site in 2017 is consistent with the trend of unchanged levels with time over this 35 year period.
2. As for Bass Lake, the 2017 total phosphorus levels are well below the existing Threshold and Background Levels for Kahshe Lake.
3. The total phosphorus concentrations in the water of Kahshe Lake are almost half of what they are in Bass Lake.

Another comparison involving the total phosphorus concentrations has been made to evaluate the Kahshe Lake analysis results generated via the DMM program versus those from the sampling carried out by the Lake Steward for the MOECC's Lake Partner Program (LPP).

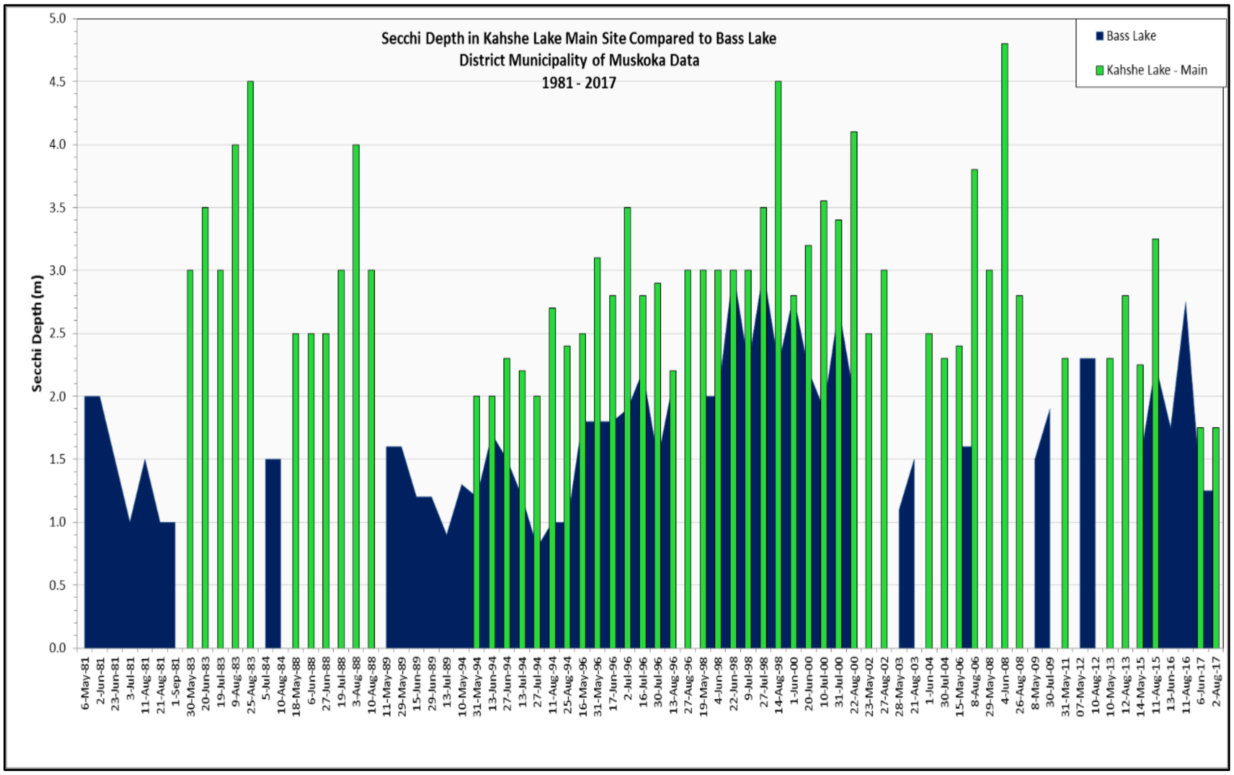
A chart of the results of this comparison follows:



This comparison confirms that the sampling of the three different areas of Kahshe Lake under the LPP has yielded similar results to those from the DMM sampling program at two locations. Note also that in 2017, the sampling and analysis of water from the site just south of Cranberry Island was discontinued, as it had served its purpose through sampling in 2014 through 2016, as the phosphorus concentrations water in this shallow part of the lake (shown in red) were found not to be notably different than the results from other sampling locations on Kahshe Lake.

While the linkage between total phosphorus concentrations and water clarity are typically weak in tea coloured waters where clarity also is impacted by dissolved organic carbon (DOC), we have, nevertheless, monitored clarity via the Secchi disc method for as long as we have data on total phosphorus.

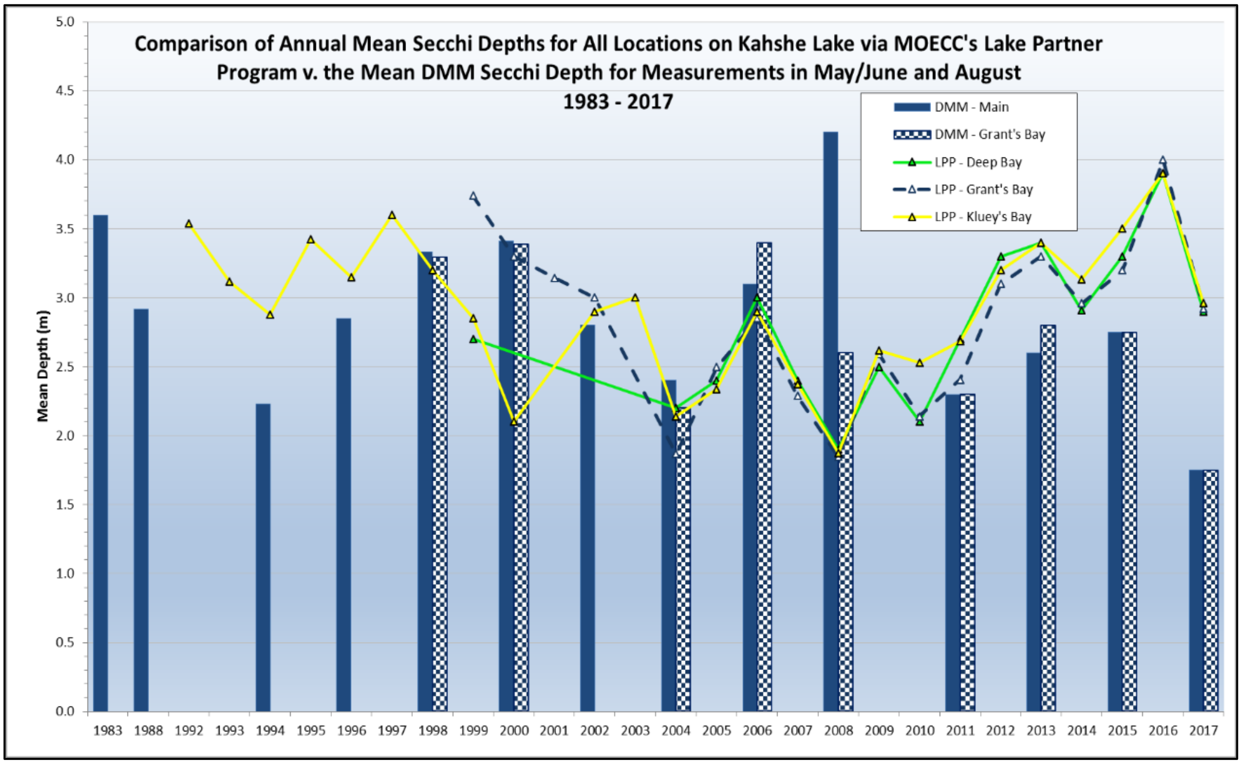
The DMM's water clarity levels for both Bass and Kahshe Lake in 2017 have been compared with the historical results dating back to 1980s in the chart that follows.



In this comparison, Bass Lake is represented by the solid blue area while the Secchi disc data from the Main Site on Kahshe Lake are shown via the green bars. The findings from this comparison are summarized below:

1. Water clarity in Bass and Kahshe Lakes in 2017 was noticeably lower than in almost all previous years.
2. Water clarity is generally better in Kahshe Lake than in Bass Lake, most likely due to the more tea coloured nature of Bass Lake - as confirmed by slightly higher Dissolved Organic Carbon [DOC] levels in Bass Lake vs. Kahshe Lake. This reduced water clarity also could be linked to the smaller size and more shallow nature of Bass Lake, as any shoreline soil runoff into the lake would have a greater impact on the sampling location, as it is closer to the shore of Bass Lake than is the Main Site on Kahshe Lake.

To further explore the trend towards reduced clarity in Kahshe Lake as measured by DMM during 2017, the Lake Partner data for water clarity at the three sampling sites in Kahshe Lake also were evaluated. The findings are shown below.



As noted above, water clarity in both Bass and Kahshe Lake was noticeably lower in 2017 based on the DMM measurements. By comparison, water clarity in Kahshe Lake as measured under the Lake Partner Program also was lower at all three measurement sites compared to 2016. However, the water clarity as measured by the Lake Steward in 2017 as part of the LPP was recorded to be better than the results from DMM. The most likely reason for the discrepancy in actual recorded depths is that the DMM sampling is carried out on pre-planned dates irrespective of weather conditions, while the LPP clarity measurements are made only during days when it is sunny. This could account for the difference, as available sunlight can influence the depth to which the disc can be seen. However, the main finding is that under both programs, water clarity in both lakes was much less in 2017 than in most previous years. While there is no hard evidence to demonstrate a causal factor, the frequent and heavy rainfall during the spring and summer months in 2017 is most likely the main factor, as the runoff of soil and debris into the lakes would have been much greater than during years with more normal rainfall.

It should also be noted that an algal bloom was recorded at the east end of Kahshe Lake in November 2017 and the MOECC's Environmental Monitoring and Reporting Branch was notified. However, the bloom disappeared very quickly and by the time the Ministry had been notified and an investigation organized, the bloom was no longer present. As such, it was not possible to determine if it was a blue-green algal bloom.

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. Based on the 2017 sampling data, neither Kahshe nor Bass Lake is considered over-threshold or even over background. However, as a result of a review by the DMM of their water quality model, Bass Lake has been flagged as a 'Transitional Lake' for further study due to its elevated total phosphorus concentrations and may require shoreline development restrictions pending the outcome of the study.

Based on the sampling by both the DMM and MOECC (Lake Steward), the following conclusions can be drawn:

- In both lakes, there has been no detectable upward or downward trend in total phosphorus concentrations over the past 35 years.
- The total phosphorus data from both the DMM and LPP show some variability, but in general, the findings are similar across the years that samples have been taken.
- Total phosphorus concentrations are almost two times higher in Bass Lake than in Kahshe Lake, but well below the DMM's existing Threshold Level and below the expected Background concentration.
- As for Bass Lake, the total phosphorus levels in Kahshe Lake are well below the DMM's existing Threshold and Background Levels and are essentially unchanged over the past 35 years.
- Water clarity in both Kahshe and Bass Lake in 2017 was noticeably reduced (less clear) compared to historical levels.
- The water clarity findings confirm that water clarity is generally better in Kahshe than in Bass Lake. However, notwithstanding these findings, an algal bloom was reported at the east end of Kahshe Lake late in 2017. As it was late in the season and lasted only a couple of days, it was not determined if it was of the toxic blue-green type, as it disappeared before the MOECC could organize an investigation.
- Finally, based on feedback from the DMM, the 'Transitional' lake status assigned to Bass Lake in 2016, which resulted in additional DMM sampling in 2016 and 2017 is expected to continue in 2018.

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 up 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*. Other species require more than 1.5 mg/L while others can tolerate levels as low as 0.5 mg/L. 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 two 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 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.

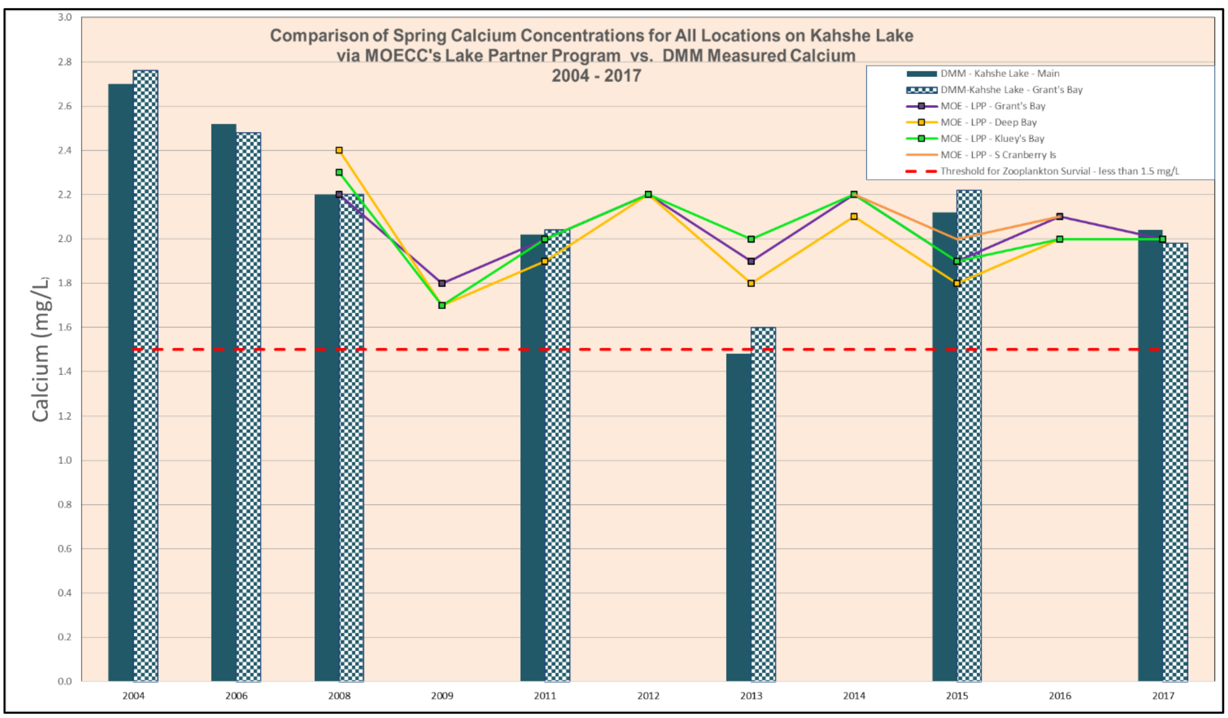
In our Muskoka lakes, the absolute abundance of *Holopedium* has increased by an average of about two fold over the last 20 years, and the relative abundance has increased more, said Yan, while the abundance of five species of *Daphnia* has declined. There are two other, smaller species of *Daphnia* 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 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 calcium data for Kahshe Lake by the two sampling programs (DMM and LPP) over this time period. It also shows the 1.5 mg/L threshold for the survival of sensitive species such as *Daphnia*.

As the findings for Bass Lake (2.12 mg/L in 2017) also were above the lower limit of 1.5 mg/L, they have not been separately charted.



Based on this information, it can be concluded that:

1. Calcium concentrations in both Kahshe and Bass Lakes are above the lower limit that has been set to protect some sensitive zooplankton species, but not all.
2. While we don't have an extensive history of calcium monitoring results, the data we do have

show no obvious signs of increasing or decreasing concentraitons.

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.

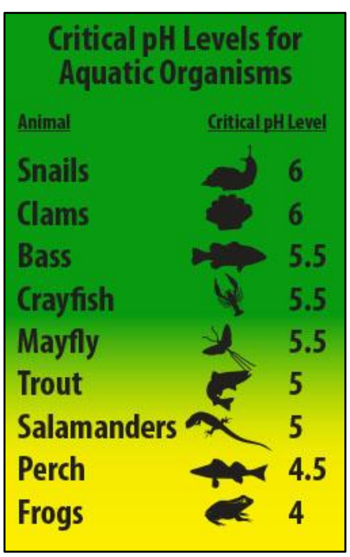
However, as the calcium concentrations in both lakes are only marginally above the limiting value and as this threshold would not be protective of all aquatic organisms, continued vigilance is necessary.

3.3 Lake Acidification

Water 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. from 6.0 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 acidic 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.

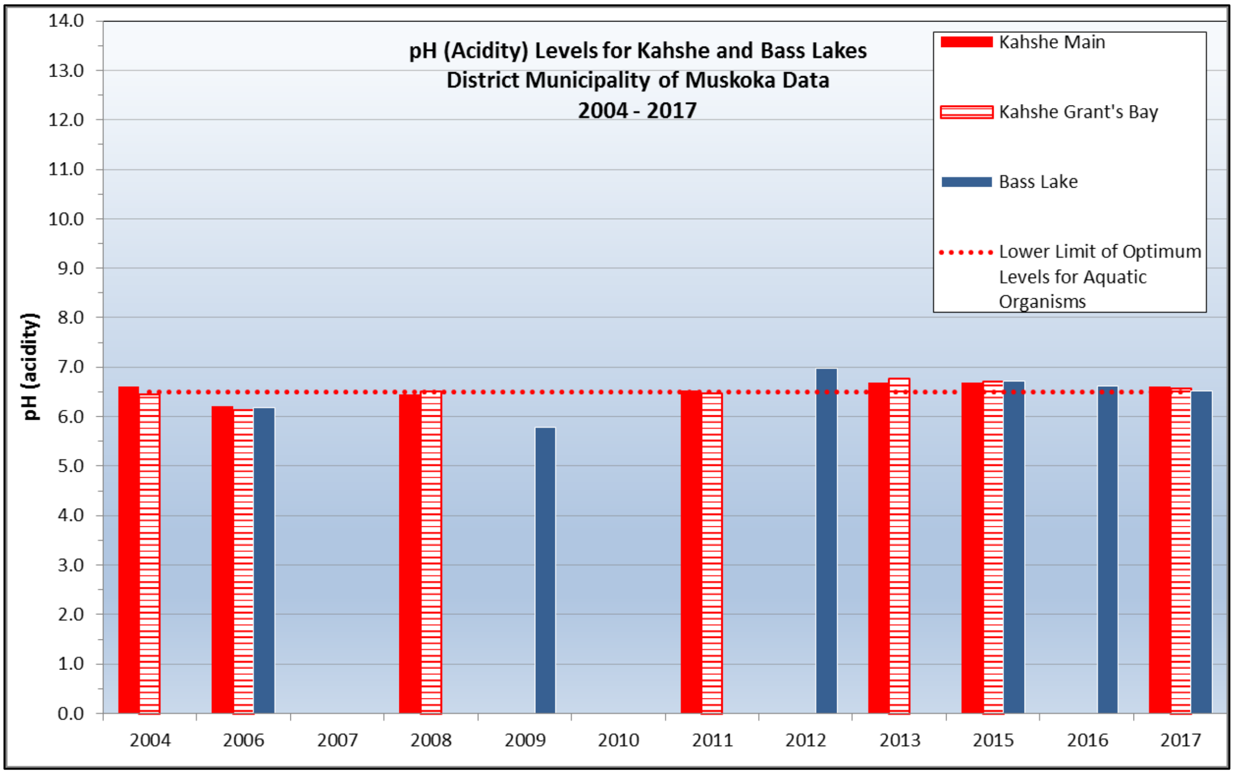
The Provincial water quality objective is to keep pH between 6.5 and 8.5, as values above or below those levels can be harmful to some aquatic organisms.



In the green-shaded figure to the left, the pH level at which key organisms may be lost as their environment becomes more acidic has been shown (EPA. 2017; Effects of Acidification on Ecosystems). Some types of plants and animals are able to tolerate acidic waters and moderate amounts of aluminum. Others, however, are acid-sensitive and will be lost as the pH declines. Generally, the young of most species are more sensitive to environmental conditions than adults. At pH 5, most fish eggs cannot hatch. At lower pH levels, some adult fish die. Some acidic lakes have no fish. Even if a species of fish or animal can tolerate moderately acidic water, the animals or plants it eats might not. For example, frogs have a critical pH around 4, but the mayflies they eat are more sensitive and may not survive pH below 5.5.

The chart below shows the pH values for Kahshe and Bass Lakes from

2004 through 2017.



It is apparent from this chart that the acidity of both Kahshe and Bass Lakes is generally within the lower end of the optimum pH range of 6.5-8.5 and generally above the level of 6.0 where impacts to some sensitive aquatic species might be encountered (see EPA chart above). There is also no evidence of either an increase or decrease in acidity over the 13 year period of monitoring.

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 (neutralize) incoming acid via precipitation is low.

Lake Acidity Summary

The waters of Kahshe and Bass Lake have acidity (pH) levels that are within a normal range and above the lower limit of the optimum level where aquatic impacts may begin to be shown. There is also no evidence of an increase or decrease in acidity over the 13 year monitoring period.

While the pH 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, while there is currently no concern, continued monitoring of the acidity is recommended.

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 over the ice-free period and can reach levels that will not support aquatic species.

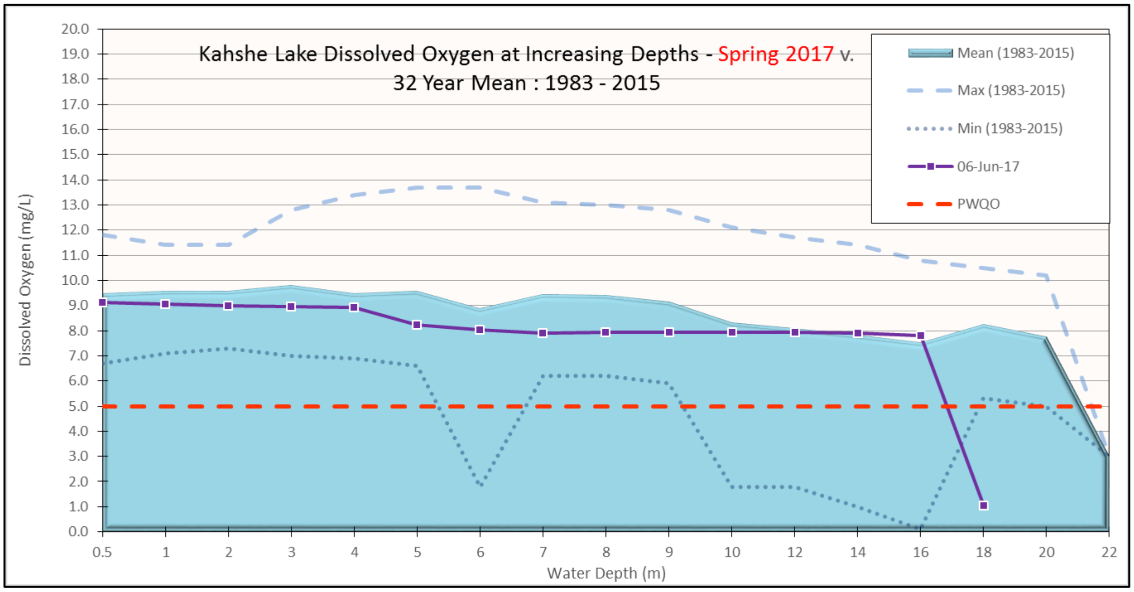
The setting of an aquatic benchmark for DO is typically conducted under both an acute (short term, high concentration) and a chronic (long term, lower concentrations) basis. For chronic exposure, aquatic organism effects include the traditional growth and reproduction impairment, swimming impairment 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.

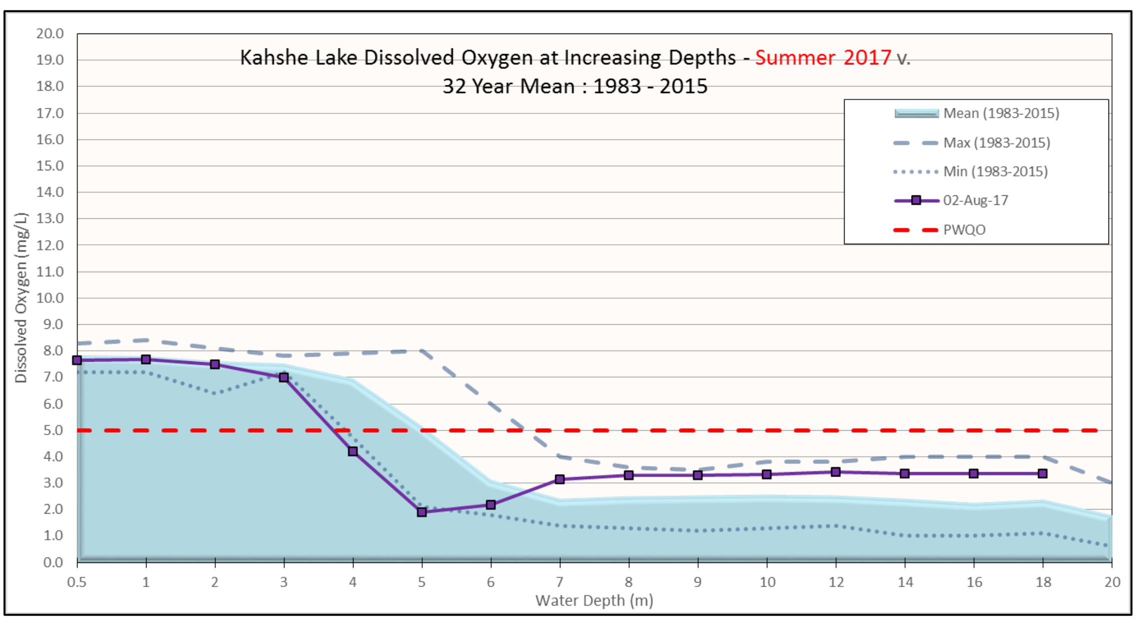
For warm water lakes like Kahshe and Bass, the Provincial Water Quality Objective (PWQO) and the Canadian Water Quality Guideline (CWQG) are set at 5 and 5.5 mg DO/L, respectively. This report will use the lower of the two, as other agencies have set DO benchmarks in the 3-4 mg/L range.

To examine the DMM findings for DO, the mean, maximum and minimum for all sampling to 2016 are plotted against the results for 2017 and the desirable aquatic objective of 5 mg/L. As there was sampling of both Kahshe and Bass Lakes in both the spring and late summer of 2017, the charts for both lakes are presented below.

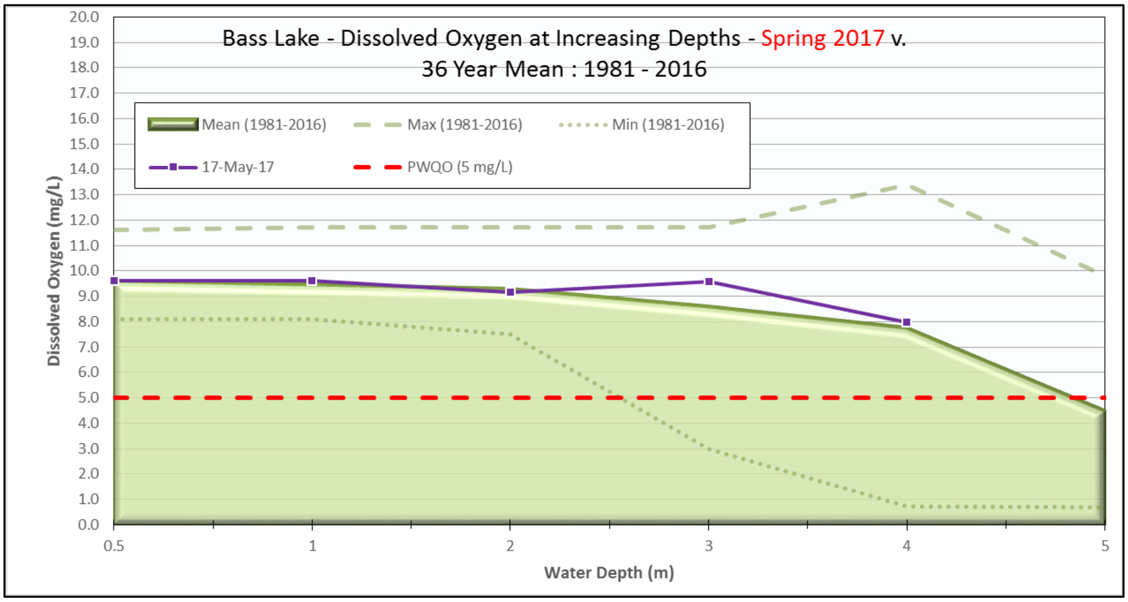
In the case of Kahshe Lake, the results for 2017 are generally similar to the historical mean and within the maximum and minimum levels recorded during the 32 year monitoring period. DO is higher in the spring and more evenly distributed with depth. By late summer, the 2017 DO levels start to decrease at a more shallow depth than has been the case over the 30+ year monitoring period; however, they remain within the historical maximum and minimum levels.

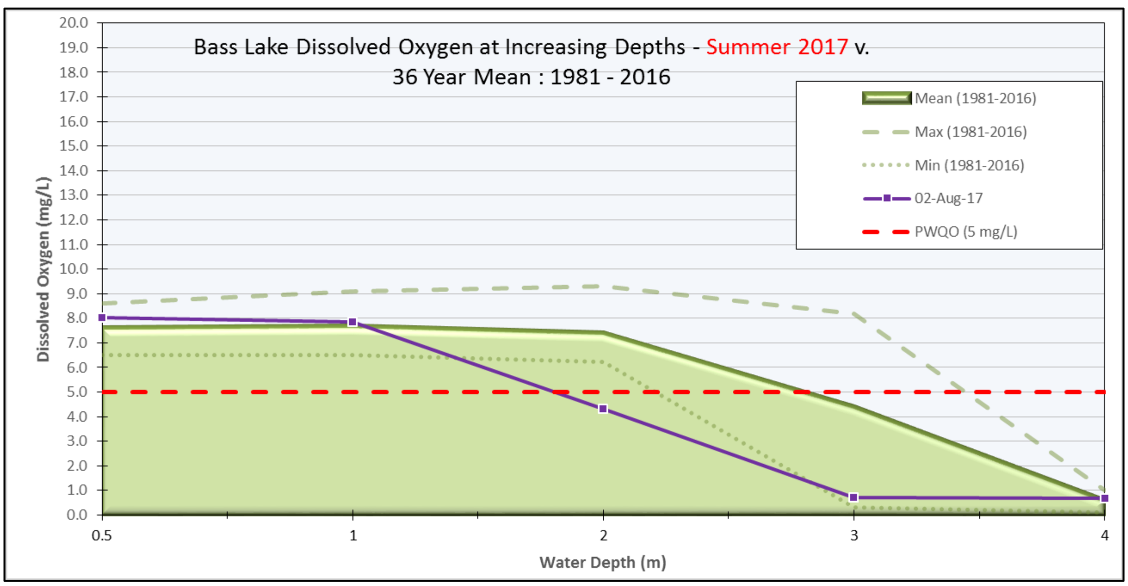
From an aquatic health perspective, the only area of potential concern is the drop in DO concentrations below the PWQO objective at depths greater than 4 m in the late summer. While this pattern is consistent with the historical average, the difference in 2017 is that the decrease below the PWQO was observed about a metre above (4m) where this took place historically (5m). While this is something that should be watched, it should be noted that the 2017 DO levels in the 3.0-6.0 depth range in late summer are still in the same range as the minimum values recorded over the historical sampling period. And from a biological basis, it should also be noted that the DO levels at depths below 6m were actually above average and closer to the maximum DO levels recorded during the period from 1983-2016. As such, there is little likelihood of any aquatic impacts associated with the 2017 findings.





In the case of Bass Lake, the spring sampling results in 2017 are virtually identical to the historical average. However, as in Kahshe Lake, the DO levels in late summer drop below the PWQO at a more shallow depth than has the case historically. As DO levels are strongly linked to the lake stratification process (vertical circulation of water) there are many factors that could be responsible for this late summer decrease in DO to levels below those recorded historically.



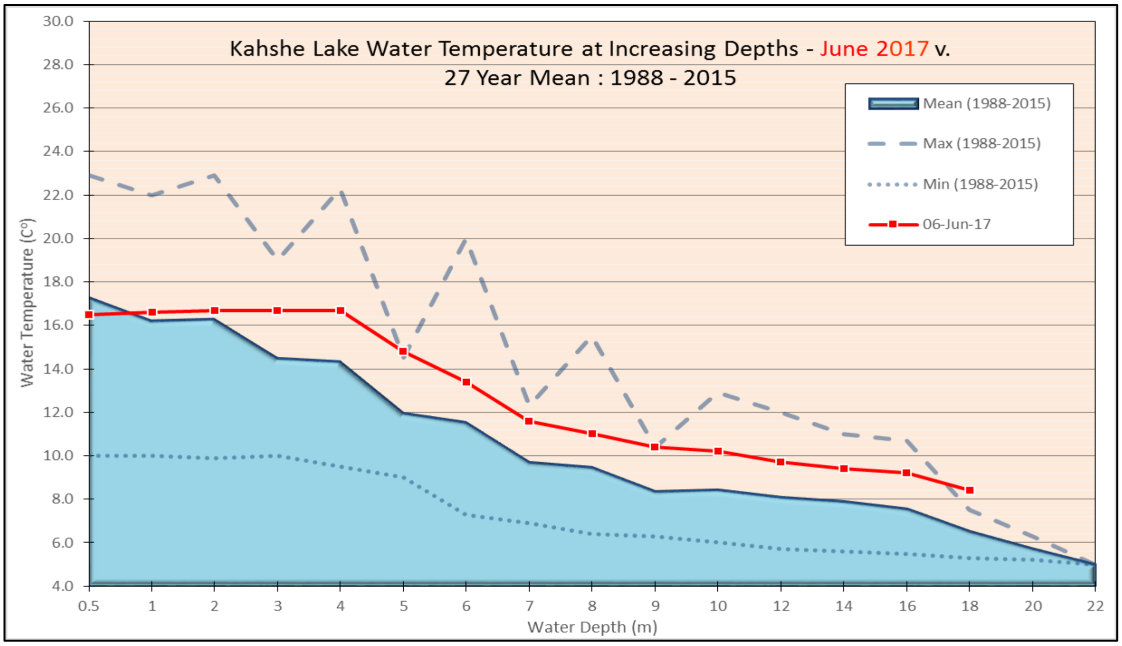


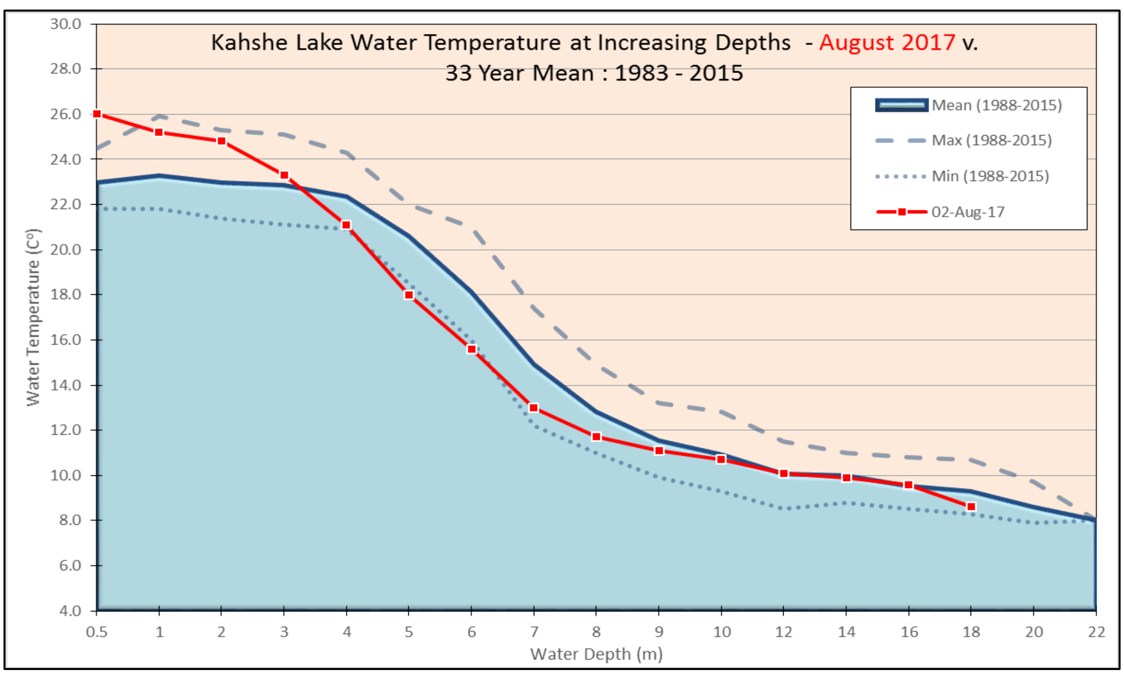
The other parameter that is evaluated at increasing depths is water temperature. Water temperature is important for several reasons:

- 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).

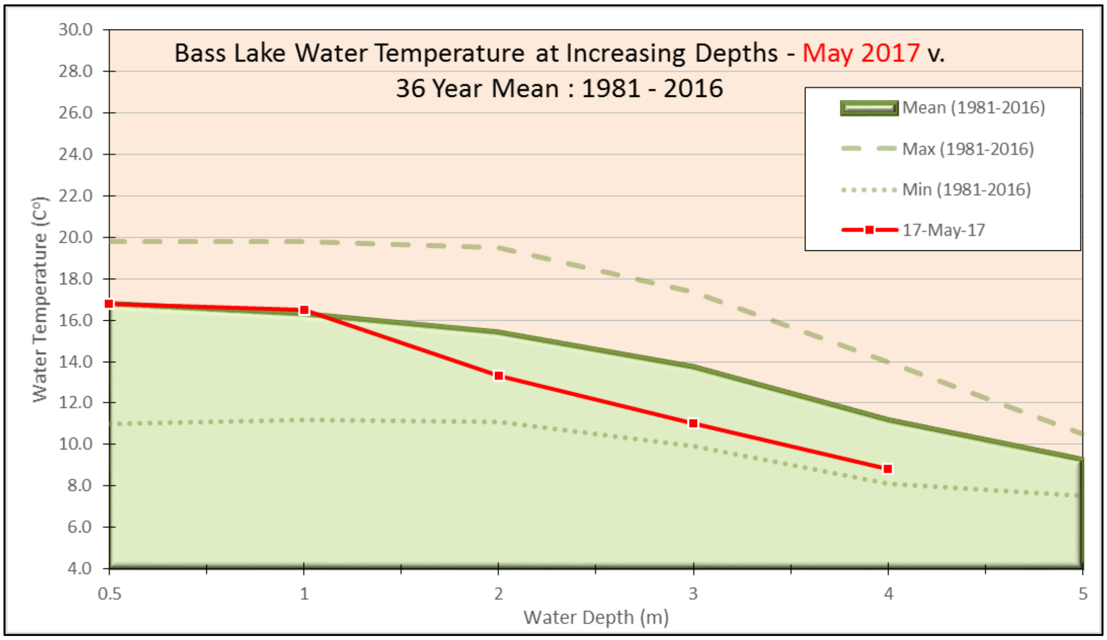
As for DO, the Kahshe Lake data dating back to 1988 have been presented as an average with maximum and minimum values up to 2015, followed by the sampling measurements in June and August 2017.

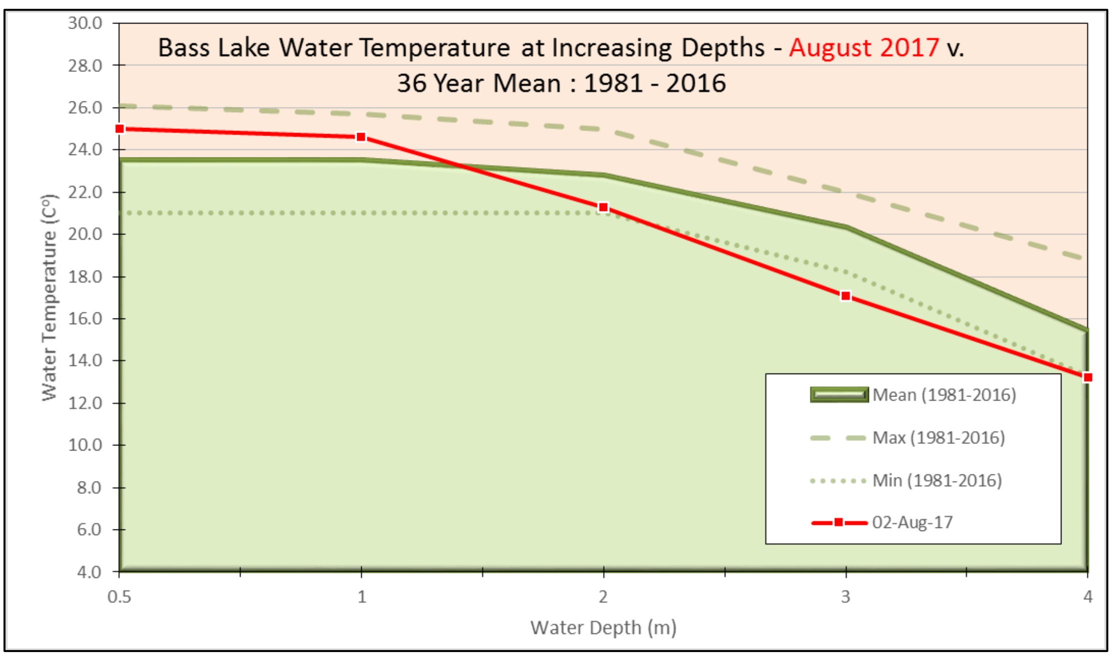




It is apparent from the above two charts that water temperature in the spring of 2017 was slightly warmer than the historical average, but in all cases the temperatures at increasing depths were well within the maximum and minimum values recorded over the 30 year monitoring period. By August 2017, the temperature in the top 3 m was slightly above average while at depths down to 9 m it fell slightly below average. However, as for June, the 2017 results in August were within the historical maximum and minimum range.

The results for Bass Lake follow:





Water temperatures in May and August in Bass Lake were marginally lower than the historical average, but as for Kahshe Lake, they were mostly within the range of maximum and minimum values over this 36 year period.

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^{o}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 climatic changes that factor into 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 (release) of phosphorus from sediments.

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. Water temperature also needs to be closely monitored, as increasing temperature can also have indirect impacts by promoting the growth of algal and aquatic plants.

The DO findings for 2017 are summarized below:

- In the case of both Kahshe and Bass Lakes, the DO results for 2017 are generally similar to the historical mean and within the maximum and minimum levels recorded during the 30+ year monitoring period.
- DO is higher in the spring and more evenly distributed with depth.
- By late summer, the 2017 DO levels in both lakes start to decrease at a more shallow depth than has been the case over the 30+ year monitoring period; however, they remain within the historical maximum and minimum levels.

From an aquatic health perspective, the only area of potential concern is the drop in DO concentrations below the PWQO objective at depths greater than 4 m in the late summer. While this pattern is consistent with the historical average, the difference in 2017 is that the decrease below the PWQO was observed about a metre above (4m) where this took place historically (5m).

While this is a finding that should be monitored, it is unlikely to have any biological impact, as aquatic species are mobile and unlikely to remain at depths where DO was limiting their survival.

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 2017 DMM year-end report for Bass Lake 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 2017 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 2017: 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 Table 1 below.

Table 1: Summary of Chemical Analysis Results – Bass Lake – June 2016

Category	Analyzed Parameter	Evaluation Benchmark[1]	Comments
Anions	Chloride	MOECC APV	All reported values well below aquatic benchmark. Note that the chart uses a logarithmic scale.
	Nitrogen (total Kjeldahl)	None Found	No benchmark
	Sulphate	BC AWQC	All reported values well below benchmark
Cations	Aluminum	U.S. EPA CCC	Findings in most years for Bass Lake are marginally above the benchmark while those in Kahshe Lake are marginally below; 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. Note that the chart uses a logarithmic scale.
	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, although results for Bass Lake appear to be generally higher than those of Kahshe Lake.
	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. Note that the chart uses a logarithmic scale.
	Magnesium	U.S. EPA LCV	All reported values well below benchmark. Note that the chart uses a logarithmic scale.
	Manganese	BC AWQC	All reported values well below benchmark
	Molybdenum	MOECC APV	All reported values well below benchmark. Note that the chart uses a logarithmic scale.
	Nickel	MOECC APV	All reported values well below benchmark
	Potassium	U.S. EPA LCV	All reported values well below benchmark. Note that the chart uses a logarithmic scale.
	Silicon	None Found	No benchmark

Category	Analyzed Parameter	Evaluation Benchmark[1]	Comments
	Sodium	MOECC APV	All reported values well below benchmark. Note that the chart uses a logarithmic scale.
	Strontium	U.S. EPA T-II SCV	All reported values well below benchmark. Note that the chart uses a logarithmic scale.
	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 Ontario aesthetic objective for recreational use.
	Electrical Conductivity	None Found	No benchmark
	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.
Recently Added Cations	Antimony	MOECC APV	All reported values well below benchmark. Note that the chart uses a logarithmic scale.
	Arsenic	MOECC APV	All reported values well below benchmark. Note that the chart uses a logarithmic scale.
	Boron	MOECC APV	All reported values well below benchmark. Note that the chart uses a logarithmic scale.
	Selenium	MOECC APV	All reported values well below benchmark. Note that the chart uses a logarithmic scale.
	Silver	MOECC APV	All reported values well below benchmark. Note that the chart uses a logarithmic scale.
	Thallium	MOECC APV	All reported values well below benchmark. Note that the chart uses a logarithmic scale.
	Uranium	MOECC APV	All reported values well below benchmark. Note that the chart uses a logarithmic scale.

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.

3.6 Evaluation of Benthic Monitoring – Bass Lake

Monitoring of bottom-dwelling aquatic invertebrate communities has been carried out at three locations on Kahshe Lake by the DMM since 2003. However, benthic monitoring on Kahshe Lake was suspended in 2016 in order to focus more on Bass Lake due to its classification as a 'Transitional' lake requiring additional assessment due to its elevated total phosphorus levels.

Benthic 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.

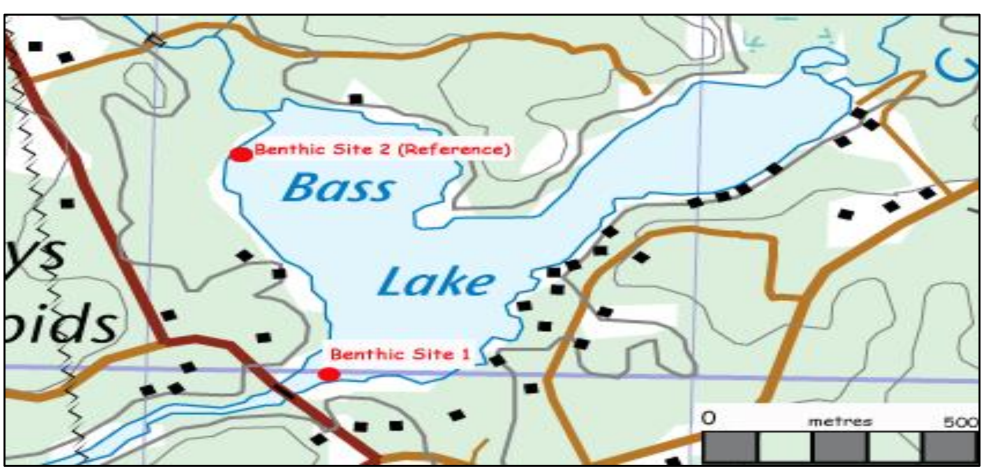
Aquatic invertebrates that are present in bottom sediments include worms, mollusks, insects, crustaceans, and mites. These animals are sensitive indicators of the health, or condition of lakes and streams, as different species have different sensitivities to environmental changes such as pollution or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

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

The DMM carried out benthic sampling at two locations on Bass Lake which were set up in 2016 as part of the Transitional Lake study. The two Bass Lake locations are shown on Figure 2 below. Note that one of the locations (Site 2) is considered a **Reference Site** and is located in an area that will help define the normal range of biological conditions for a given habitat type in Muskoka. Reference sites are not expected to represent 'pristine' conditions; rather, they reflect biological conditions in areas where impacts from several types of human disturbance are likely to be minimal.

It should be noted that all three benthic monitoring sites (Sites 2, 3 and 6) on Kahshe Lake as well as Site 2 on Bass Lake are considered Reference Sites, and as such, the data from these sites has been incorporated into the Muskoka Reference site database which is used for comparison with individual lake sampling results.

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



The results of the benthic sampling and analysis have been compared to the 10 year (2007-2016) Muskoka Reference average, which is based on 90 sampling sites on 41 lakes between 2007 and 2016. In order to better understand the variability that is associated with the average from the Muskoka Reference sites, the DMM was contacted and provided the results from each lake. From this data, the averages for each of the various indices (except HBI) were statistically evaluated to generate a 95% Upper and Lower Confidence Level as well as maximum and minimum values. The Bass Lake findings have been presented in chart form below.

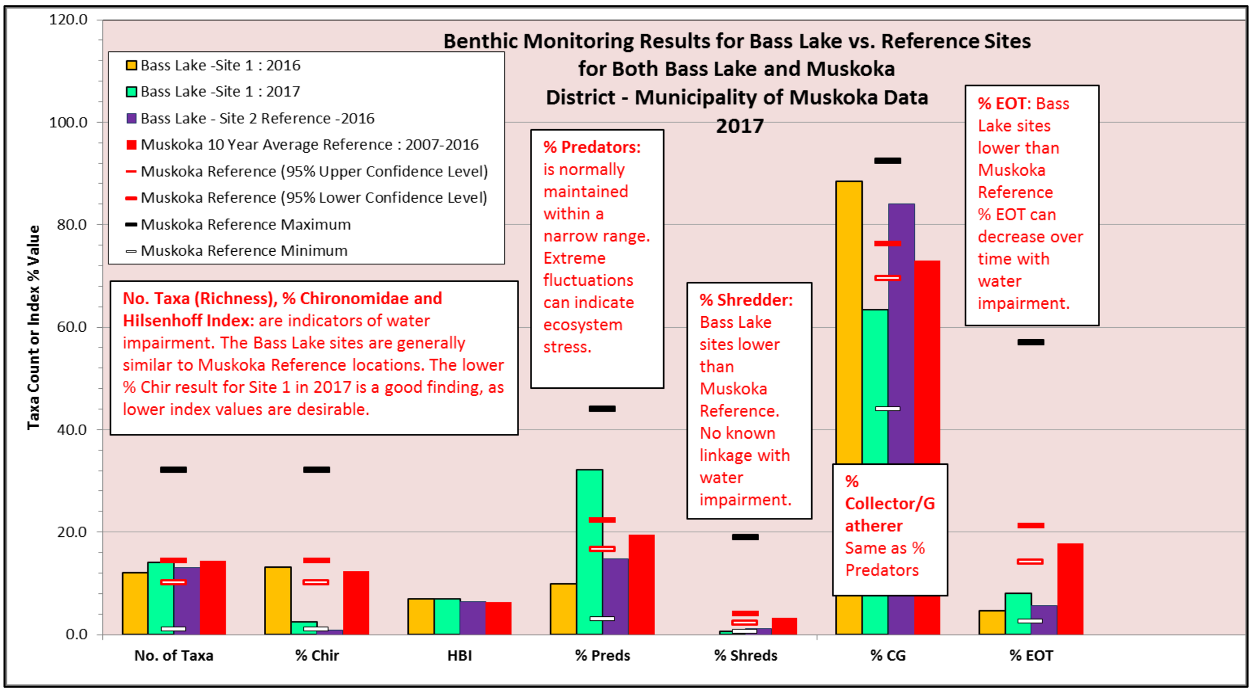
To understand how the sample findings are compared, it is necessary to understand the scoring system which uses indices of organism groupings as shown in Table 2 below.

Table 2: Benthic Indices used to summarize aquatic invertebrate composition in Muskoka.

Indicator	What it tells us
Number of taxa collected (Species Richness)	The number of taxa is a measure of biological diversity. Richness increases with increasing habitat diversity, suitability, and water quality; therefore, the healthier a site's community, the greater it's number of taxa.
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 under stress.
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.

Indicator	What it tells us
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.	

The results for all benthic sampling on Bass Lake are shown below and discussed following the chart. Note that in the case of the Muskoka Reference sites, the chart shows the average (dark blue bar) as well as the maximum and minimum value (black and white tick marks) and an Upper and Lower Confidence Interval (red and white tick marks) based on a 95% level of probability.



The results from the second year of benthic sampling on Bass Lake are summarized as follows:

1. As noted in the above chart, the first three indicators of water impairment (No. Taxa, % Chir and HBI) at Site 1 in 2016 and 2017 are, with one exception, all within the Upper and Lower Confidence Limits for the Muskoka Reference data. The exception is the result for % Chir at Site 1 in 2017 which is marginally lower than the Lower CI, but still above the minimum value recorded for the Muskoka Reference sites. Note also that the lower result for this index in 2017 is actually a good signal, as higher percentages of Chironomidae are a sign of possible water quality impairment, as these organisms are tolerant of water impairment.

2. One indicator of impaired aquatic health (% EOT) shows some potential stress effects, as the Bass Lake results for Site 1 in both 2016 and 2017 are lower than the mean and its lower confidence level for the Muskoka Reference sites. While this finding warrants continued evaluation of this sampling site, it should be noted that the Bass Lake % EOT results are within the maximum and minimum range of the Muskoka Reference site data.
3. The other indicators with results that lie outside the average and upper and lower confidence levels of the Muskoka Reference sites were % Predators, % Shredders and % Collectors/Gatherers. However, in most cases, the sampling results were within the maximum and minimum values for the Muskoka Reference sites. There is no known linkage of these indices with environmental stress.

Based on the above findings for 2017, there is some evidence of benthic population characteristics that are indicative of impaired benthic health at Site 1. However, given the variability of the data and the limited time period over which data have been collected, any definitive conclusion regarding benthic health would require a much more extensive period of monitoring and more sites to enable the data to be scientifically evaluated and significant differences statistically isolated from the variability that is typical of this type of monitoring.

Evaluation of Benthic Monitoring Summary

The 2017 benthic invertebrate monitoring results for Site 1 on Bass Lake have identified one possible indicator of environmental stress (%EOT). However, given the limited time frame over which sampling has been conducted as well as the variability with the Bass Lake and Muskoka Reference values, it would be premature to conclude that any meaningful impacts have been observed. EOT refers to the % of the population of benthic organisms made-up of mayflies, dragonflies, damselflies and caddisflies. These organisms are sensitive to pollution and habitat alteration. Accordingly, they should be prominent in healthy ecosystems, but their numbers will decline in response to stress imposed by human activities

It should also be noted that the Bass Lake Reference site also was lower in %EOT, indicating that this may be a normal benthic population characteristic for this lake.

4.0 Summary and Conclusions

A comprehensive review and analysis of all historical environmental monitoring on Kahshe and Bass Lakes has now been completed and presented within annual Lake Steward Reports from 2012 through 2016. These documents as well as Executive Summaries each year have been posted on the KLRA web-site (http://www.kahshelake.ca).

This report captures the findings from sampling and analysis of both Kahshe and Bass Lakes in 2017.

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

To better understand the chemical and physical data that have been collected, this year's report includes an overview of the climatological factors that have the potential to influence the analytical findings. This attempted to answer the question: How normal were temperature, rainfall, water levels and ice-out conditions compared to past years?

The information on weather and water/ice conditions confirmed that 2017 was slightly warmer and wetter during the summer months, with high water levels in the early spring and lower levels towards the end of summer. And consistent with the 125 year trend of earlier ice-out dates for Muskoka Lakes, ice-out on Kahshe Lake was earlier than normal in 2017.

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 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. Based on the 2017 sampling data, neither Kahshe nor Bass Lake is considered over-threshold or even over background. However, as a result of a review by the DMM of their water quality model, Bass Lake has been flagged as a 'Transitional Lake' for further study due to its elevated total phosphorus concentrations and may require shoreline development restrictions pending the outcome of the study.

Based on the sampling by both the DMM and MOECC (Lake Steward), the following conclusions can be drawn:

- In both lakes, there has been no detectable upward or downward trend in total phosphorus concentrations over the past 35 years.
- The total phosphorus data from both the DMM and LPP show some variability, but in general,

the findings are similar across the years that samples have been taken.

- Total phosphorus concentrations are almost two times higher in Bass Lake than in Kahshe Lake, but well below the DMM's existing Threshold Level and below the expected Background concentration.
- As for Bass Lake, the total phosphorus levels in Kahshe Lake are well below the DMM's existing Threshold and Background Levels and are essentially unchanged over the past 35 years.
- Water clarity in both Kahshe and Bass Lake in 2017 was noticeably reduced (less clear) compared to historical levels.
- The water clarity findings confirm that water clarity is generally better in Kahshe than in Bass Lake. However, notwithstanding these findings, an algal bloom was reported at the east end of Kahshe Lake late in 2017. As it was late in the season and lasted only a couple of days, it was not determined if it was of the toxic blue-green type, as it disappeared before the MOECC could organize an investigation.
- Finally, based on feedback from the DMM, the 'Transitional' lake status assigned to Bass Lake in 2016, which resulted in additional DMM sampling in 2016 and 2017 is expected to continue in 2018.

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.

However, as the calcium concentrations in both lakes are only marginally above the limiting value and as this threshold would not be protective of all aquatic organisms, continued vigilance is necessary.

Lake Acidity Summary

The waters of Kahshe and Bass Lake have acidity (pH) levels that are within a normal range and above the lower limit of the optimum level where aquatic impacts may begin to be shown. There is also no evidence of an increase or decrease in acidity over the 13 year monitoring period.

While the pH 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, while there is currently no concern, continued monitoring of the acidity is recommended.

Dissolved Oxygen and Water Temperature Summary

Dissolved oxygen and water temperature are two parameters that are influenced by climatic changes that factor into 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:

3. It is essential for the survival of all aquatic organisms, and
4. A lack of oxygen in the lower layers of the lake (referred to as being anoxic) can cause mobilization (release) of phosphorus from sediments.

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. Water temperature also needs to be closely monitored, as increasing temperature can also have indirect impacts by promoting the growth of algal and aquatic plants.

The DO findings for 2017 are summarized below:

- In the case of both Kahshe and Bass Lakes, the DO results for 2017 are generally similar to the historical mean and within the maximum and minimum levels recorded during the 30+ year monitoring period.
- DO is higher in the spring and more evenly distributed with depth.
- By late summer, the 2017 DO levels in both lakes start to decrease at a more shallow depth than has been the case over the 30+ year monitoring period; however, they remain within the historical maximum and minimum levels.

From an aquatic health perspective, the only area of potential concern is the drop in DO concentrations below the PWQO objective at depths greater than 4 m in the late summer. While this pattern is consistent with the historical average, the difference in 2017 is that the decrease below the PWQO was observed about a metre above (4m) where this took place historically (5m).

While this is a finding that should be monitored, it is unlikely to have any biological impact, as aquatic species are mobile and unlikely to remain at depths where DO was limiting their survival.

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.

Evaluation of Benthic Monitoring Summary

The 2017 benthic invertebrate monitoring results for Site 1 on Bass Lake have identified one possible indicator of environmental stress (%EOT). However, given the limited time frame over which sampling has been conducted as well as the variability with the Bass Lake and Muskoka Reference values, it would be premature to conclude that any meaningful impacts have been observed. EOT refers to the % of the population of benthic organisms made-up of mayflies, dragonflies, damselflies and caddisflies. These organisms are sensitive to pollution and habitat alteration. Accordingly, they should be prominent in healthy ecosystems, but their numbers will decline in response to stress imposed by human activities

It should also be noted that the Bass Lake Reference site also was lower in %EOT, indicating that this may be a normal benthic population characteristic for this lake.

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. However, continued sampling and overall lake stewardship is imperative to delay the onset of nutrient enrichment and algal growth, the depletion of calcium and the introduction of invasive species.

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 (lawns) 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.

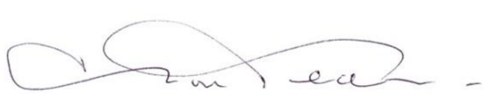
MOE. 2011. *Rationale for the Development of Soil and Ground Water Standards for Use at Contaminated Sites in Ontario*. April 15, 2011, Standards Development Branch, Ontario Ministry of the Environment. PIBS 7386e01.

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



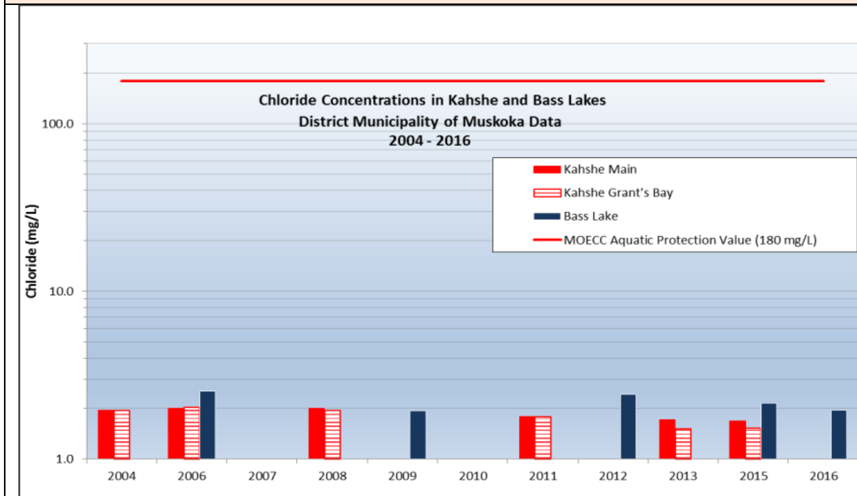
Ron Pearson

Kahshe Lake Steward

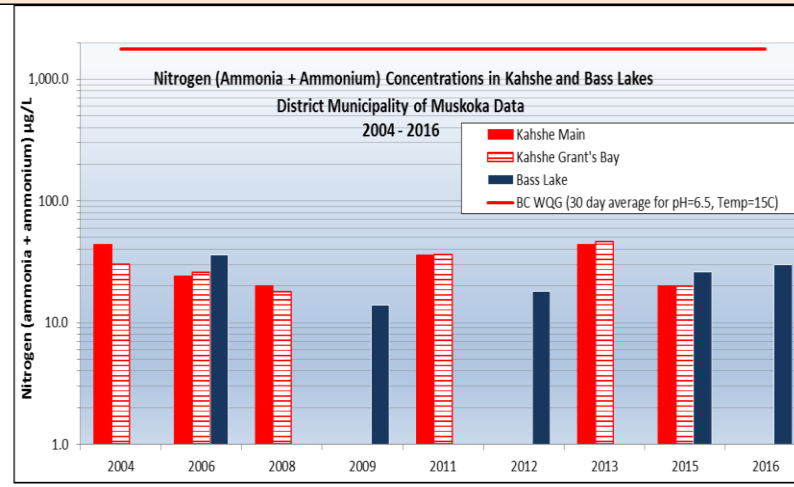
Attachments

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

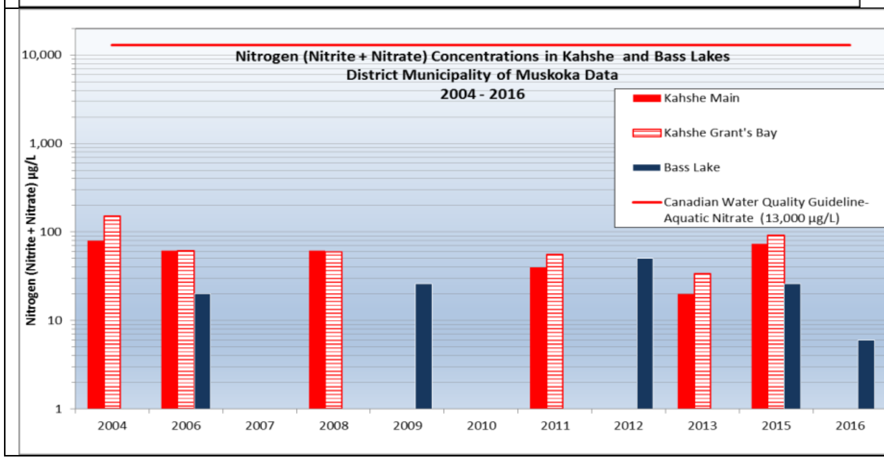
Anions



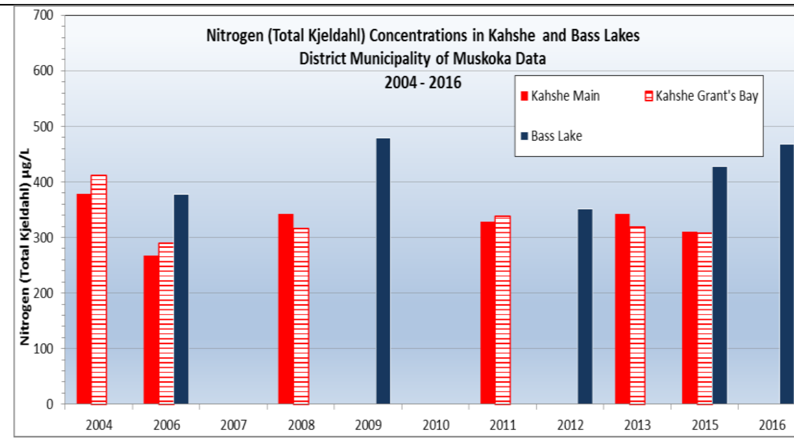
Chloride Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2004 - 2016
Kahshe Main
Kahshe Grant's Bay
Bass Lake
MOECC Aquatic Protection Value (180 mg/L)
Chloride (mg/L)
100.0
10.0
1.0
2004
2006
2007
2008
2009
2010
2011
2012
2013
2015
2016



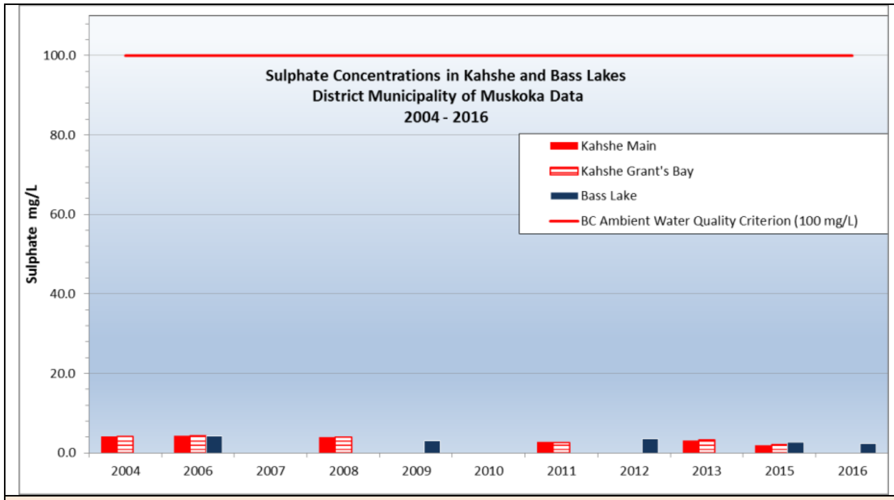
Nitrogen (Ammonia + Ammonium) Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2004 - 2016
Kahshe Main
Kahshe Grant's Bay
Bass Lake
BC WQG (30 day average for pH=6.5, Temp=15C)
Nitrogen (ammonia + ammonium) µg/L
1,000.0
100.0
10.0
1.0
2004
2006
2008
2009
2011
2012
2013
2015
2016



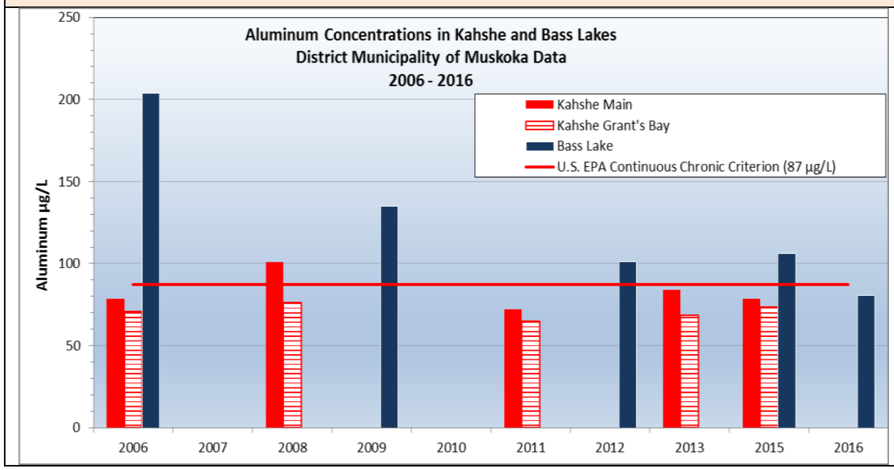
Nitrogen (Nitrite + Nitrate) Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2004 - 2016
Kahshe Main
Kahshe Grant's Bay
Bass Lake
Canadian Water Quality Guideline-Aquatic Nitrate (13,000 µg/L)
Nitrogen (Nitrite + Nitrate) µg/L
10,000
1,000
100
10
1
2004
2006
2007
2008
2009
2010
2011
2012
2013
2015
2016

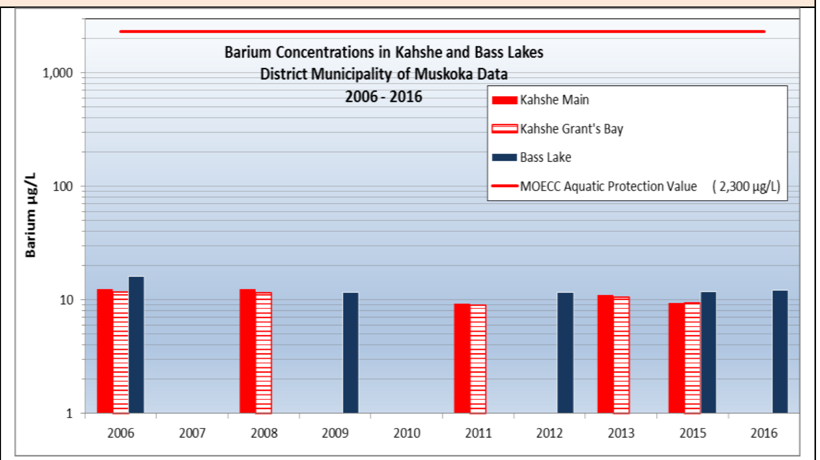


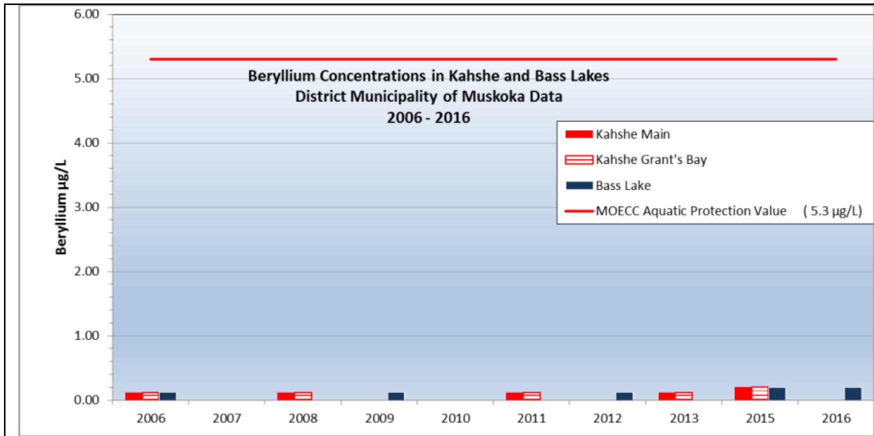
Nitrogen (Total Kjeldahl) Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2004 - 2016
Kahshe Main
Kahshe Grant's Bay
Bass Lake
Nitrogen (Total Kjeldahl) µg/L
700
600
500
400
300
200
100
0
2004
2006
2007
2008
2009
2010
2011
2012
2013
2015
2016

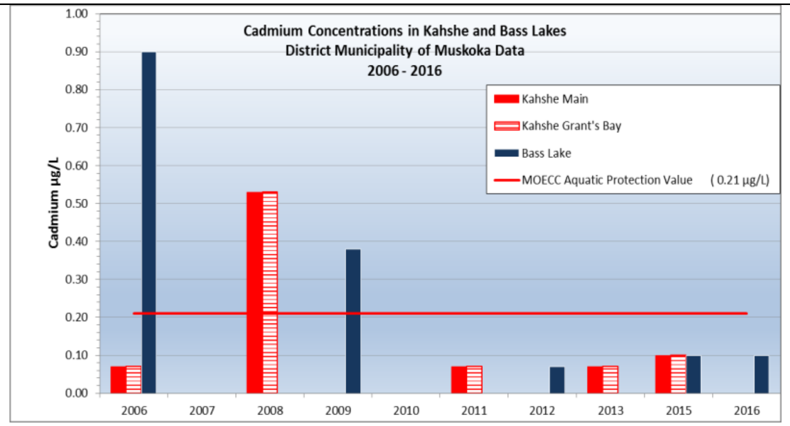

Sulphate Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2004 - 2016
Kahshe Main
Kahshe Grant's Bay
Bass Lake
BC Ambient Water Quality Criterion (100 mg/L)
Sulphate mg/L
100.0
80.0
60.0
40.0
20.0
0.0
2004
2006
2007
2008
2009
2010
2011
2012
2013
2015
2016

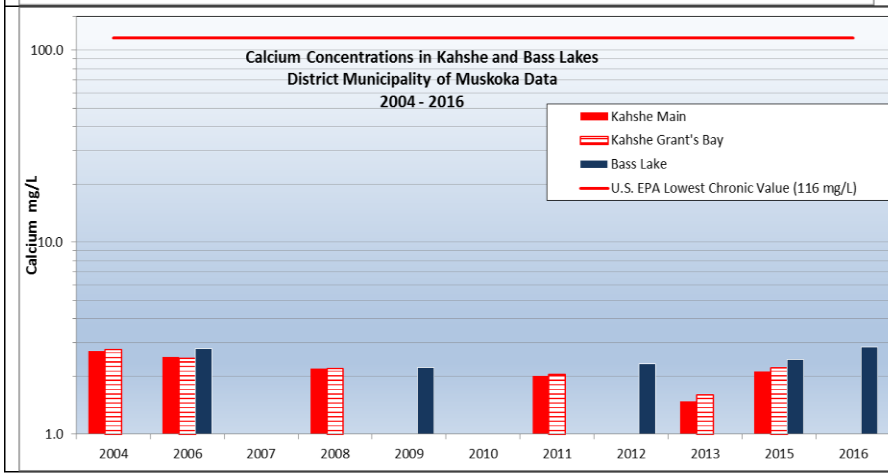
Cations

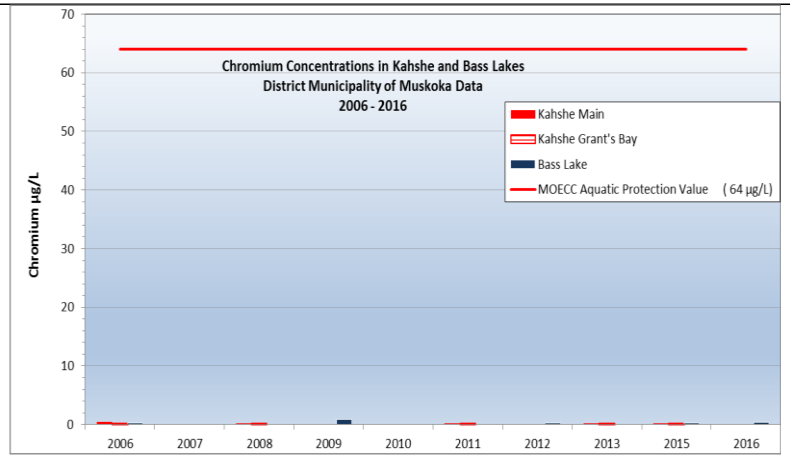

Aluminum Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2006 - 2016
Kahshe Main
Kahshe Grant's Bay
Bass Lake
U.S. EPA Continuous Chronic Criterion (87 µg/L)
Aluminum µg/L
250
200
150
100
50
0
2006
2007
2008
2009
2010
2011
2012
2013
2015
2016

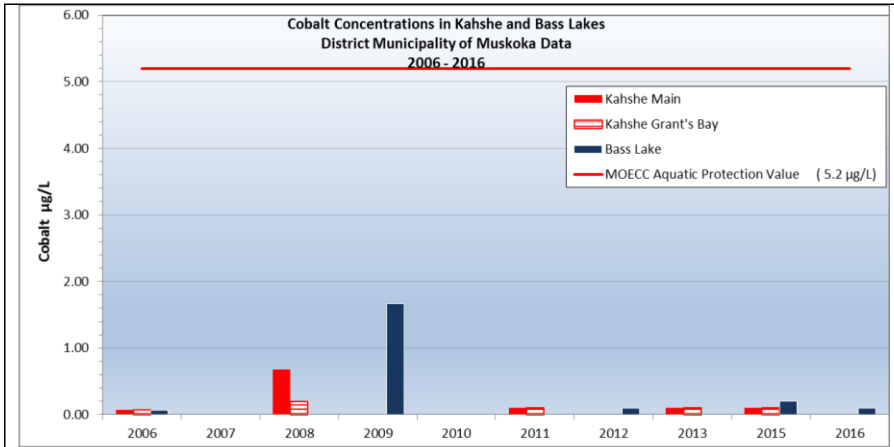

Barium Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2006 - 2016
Kahshe Main
Kahshe Grant's Bay
Bass Lake
MOECC Aquatic Protection Value (2,300 µg/L)
Barium µg/L
1,000
100
10
1
2006
2007
2008
2009
2010
2011
2012
2013
2015
2016

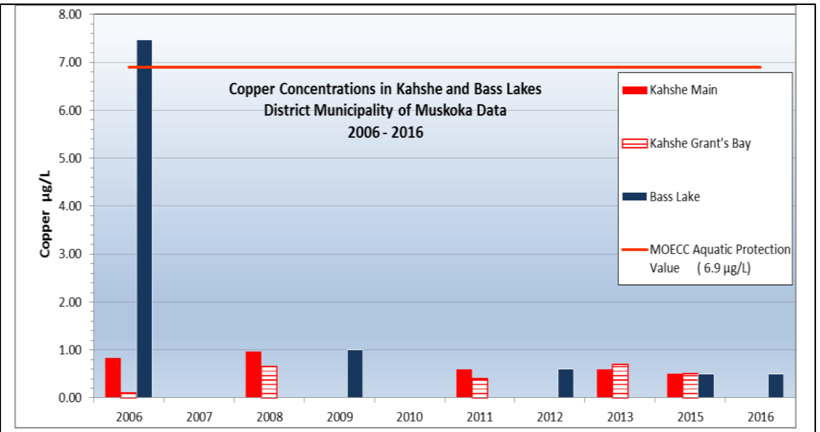

Beryllium Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2006 - 2016
Kahshe Main
Kahshe Grant's Bay
Bass Lake
MOECC Aquatic Protection Value (5.3 µg/L)
Beryllium µg/L

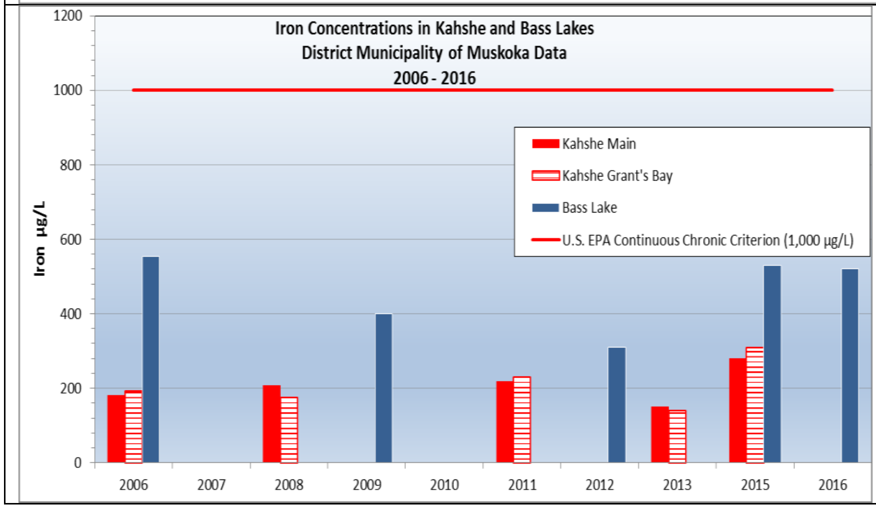

Cadmium Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2006 - 2016
Kahshe Main
Kahshe Grant's Bay
Bass Lake
MOECC Aquatic Protection Value (0.21 µg/L)
Cadmium µg/L

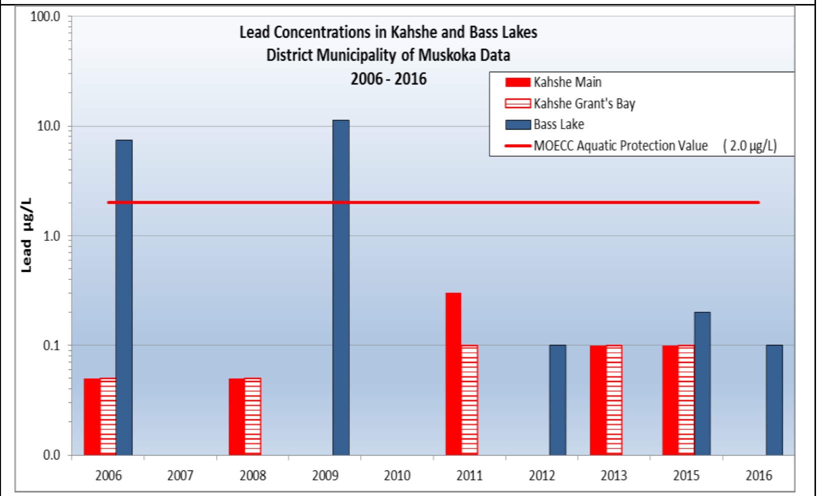

Calcium Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2004 - 2016
Kahshe Main
Kahshe Grant's Bay
Bass Lake
U.S. EPA Lowest Chronic Value (116 mg/L)
Calcium mg/L

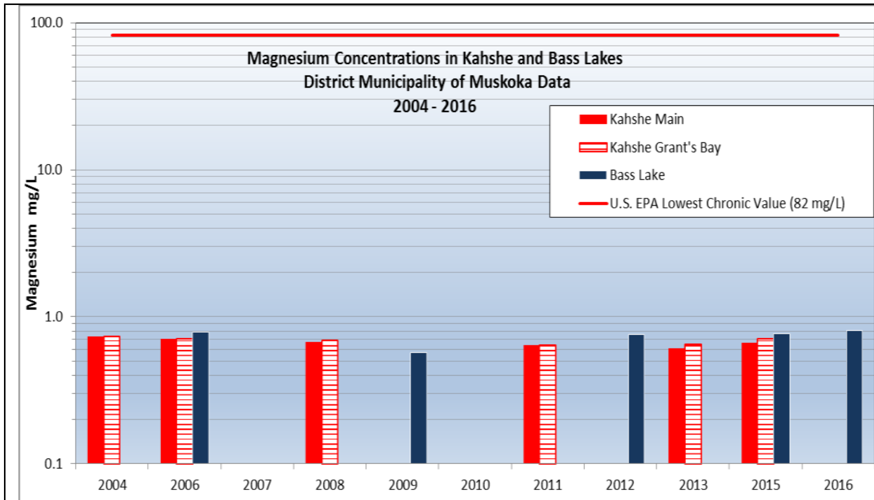

Chromium Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2006 - 2016
Kahshe Main
Kahshe Grant's Bay
Bass Lake
MOECC Aquatic Protection Value (64 µg/L)
Chromium µg/L

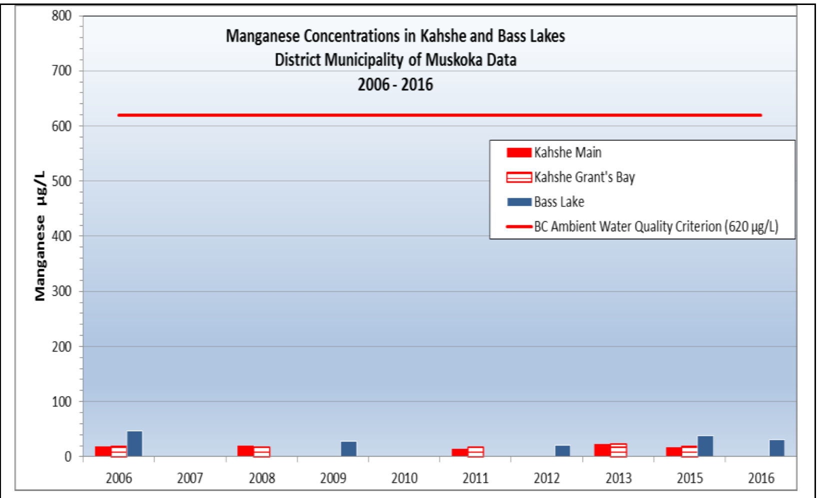

Cobalt Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2006 - 2016
Kahshe Main
Kahshe Grant's Bay
Bass Lake
MOECC Aquatic Protection Value (5.2 µg/L)
Cobalt µg/L
6.00
5.00
4.00
3.00
2.00
1.00
0.00
2006
2007
2008
2009
2010
2011
2012
2013
2015
2016

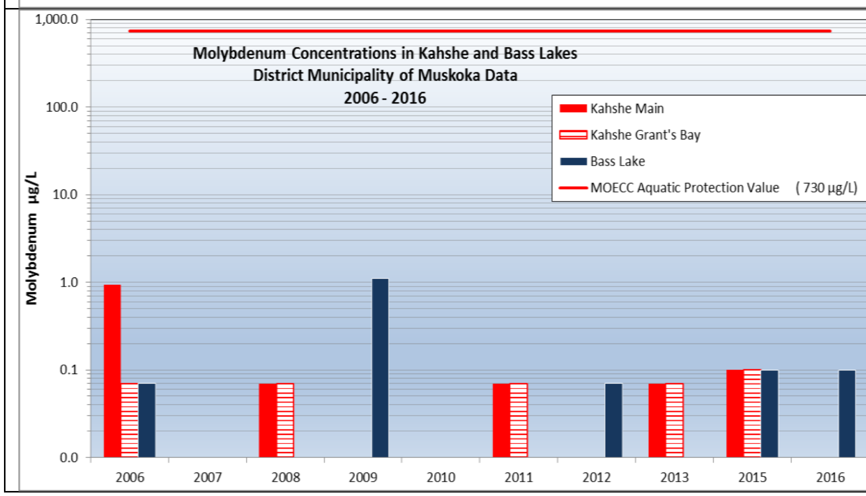

Copper Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2006 - 2016
Kahshe Main
Kahshe Grant's Bay
Bass Lake
MOECC Aquatic Protection Value (6.9 µg/L)
Copper µg/L
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
2006
2007
2008
2009
2010
2011
2012
2013
2015
2016

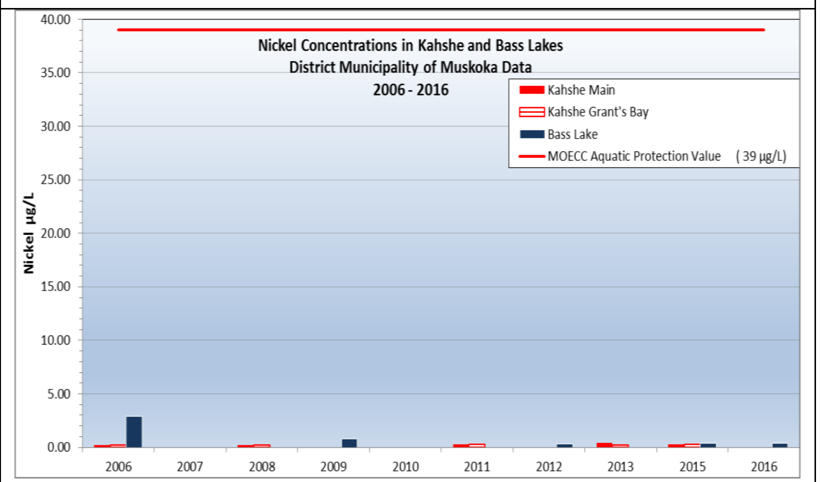

Iron Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2006 - 2016
Kahshe Main
Kahshe Grant's Bay
Bass Lake
U.S. EPA Continuous Chronic Criterion (1,000 µg/L)
Iron µg/L
1200
1000
800
600
400
200
0
2006
2007
2008
2009
2010
2011
2012
2013
2015
2016

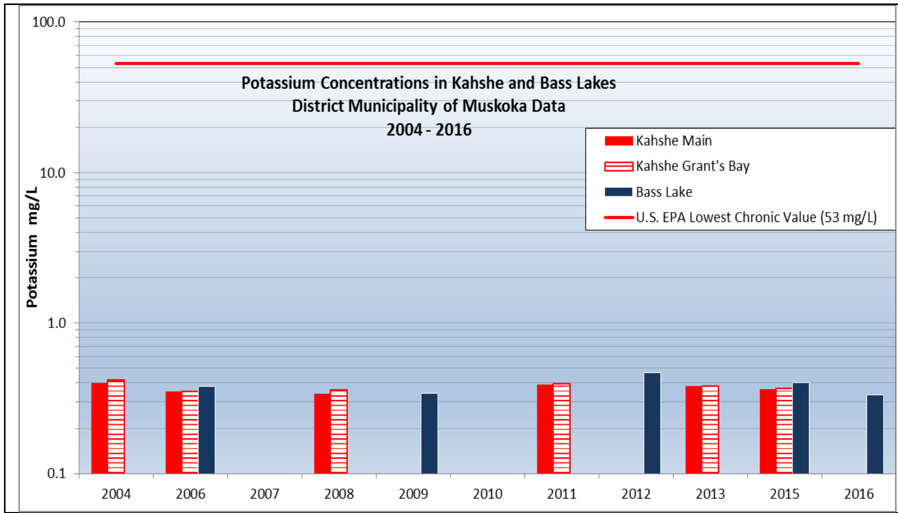

Lead Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2006 - 2016
Kahshe Main
Kahshe Grant's Bay
Bass Lake
MOECC Aquatic Protection Value (2.0 µg/L)
Lead µg/L
100.0
10.0
1.0
0.1
0.0
2006
2007
2008
2009
2010
2011
2012
2013
2015
2016

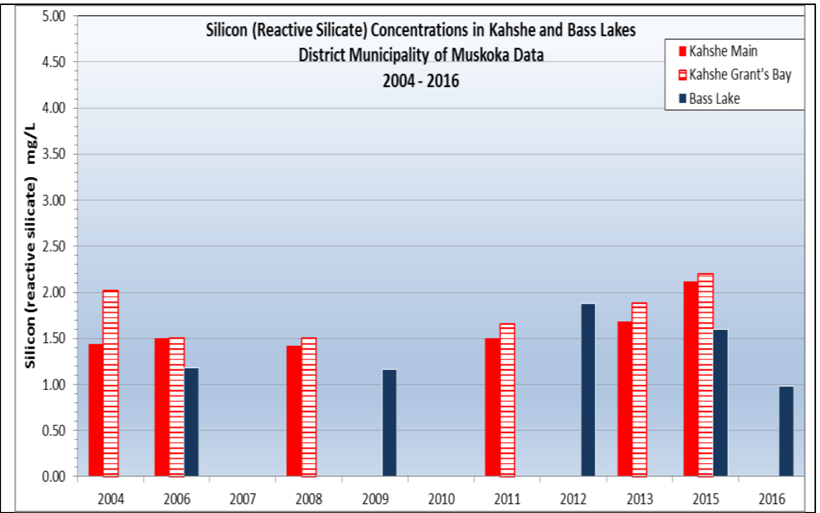

Magnesium Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2004 - 2016
Kahshe Main
Kahshe Grant's Bay
Bass Lake
U.S. EPA Lowest Chronic Value (82 mg/L)
Magnesium mg/L
100.0
10.0
1.0
0.1
2004
2006
2007
2008
2009
2010
2011
2012
2013
2015
2016

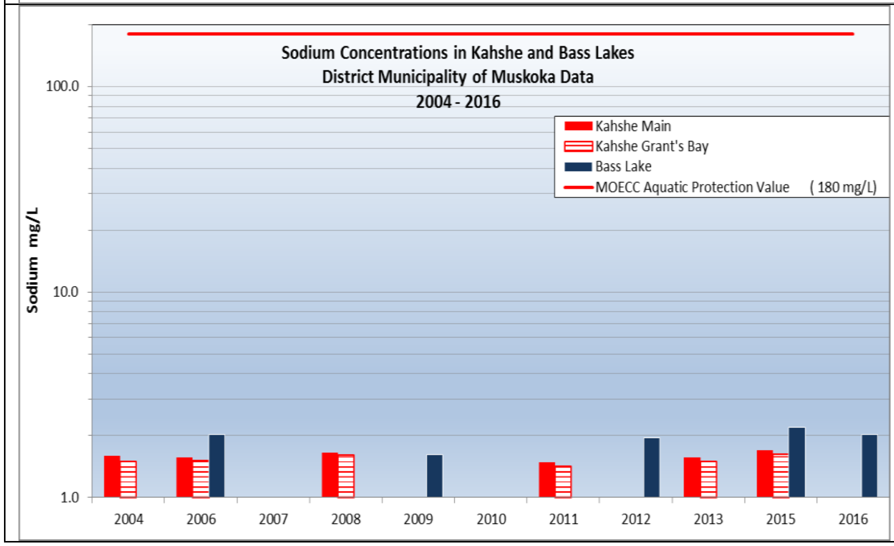

Manganese Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2006 - 2016
Kahshe Main
Kahshe Grant's Bay
Bass Lake
BC Ambient Water Quality Criterion (620 µg/L)
Manganese µg/L
800
700
600
500
400
300
200
100
0
2006
2007
2008
2009
2010
2011
2012
2013
2015
2016

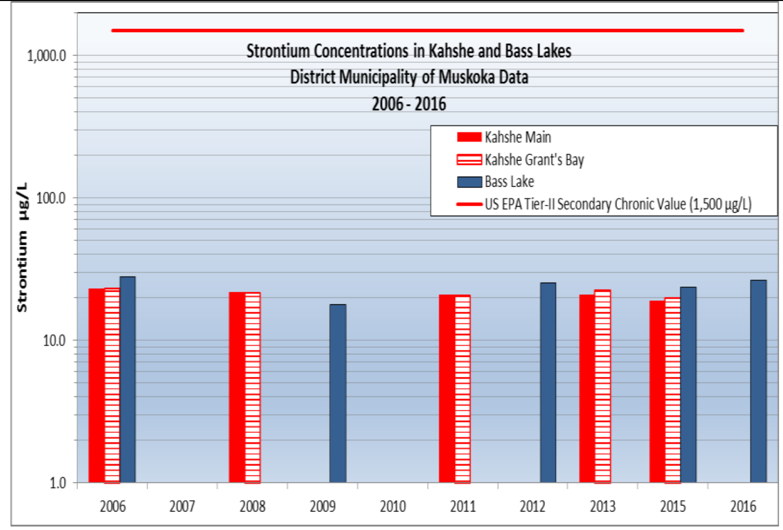

Molybdenum Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2006 - 2016
Kahshe Main
Kahshe Grant's Bay
Bass Lake
MOECC Aquatic Protection Value (730 µg/L)
Molybdenum µg/L
1,000.0
100.0
10.0
1.0
0.1
0.0
2006
2007
2008
2009
2010
2011
2012
2013
2015
2016

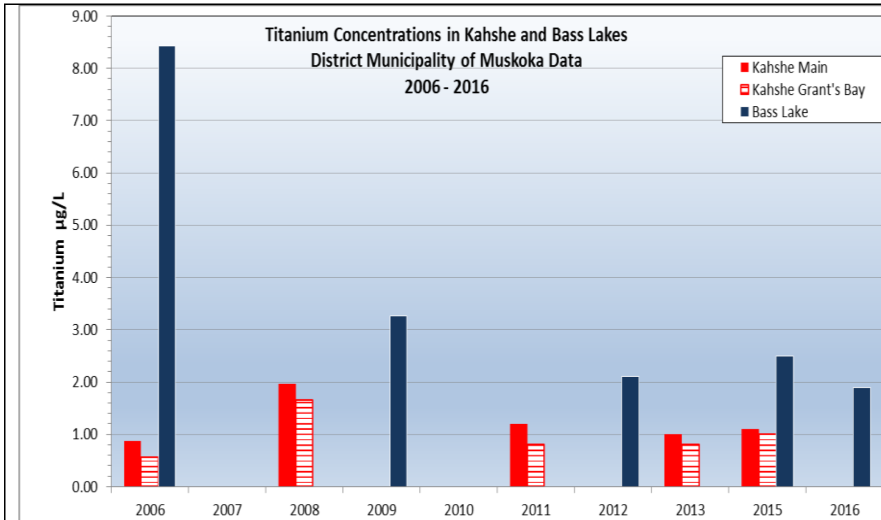

Nickel Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2006 - 2016
Kahshe Main
Kahshe Grant's Bay
Bass Lake
MOECC Aquatic Protection Value (39 µg/L)
Nickel µg/L
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
2006
2007
2008
2009
2010
2011
2012
2013
2015
2016

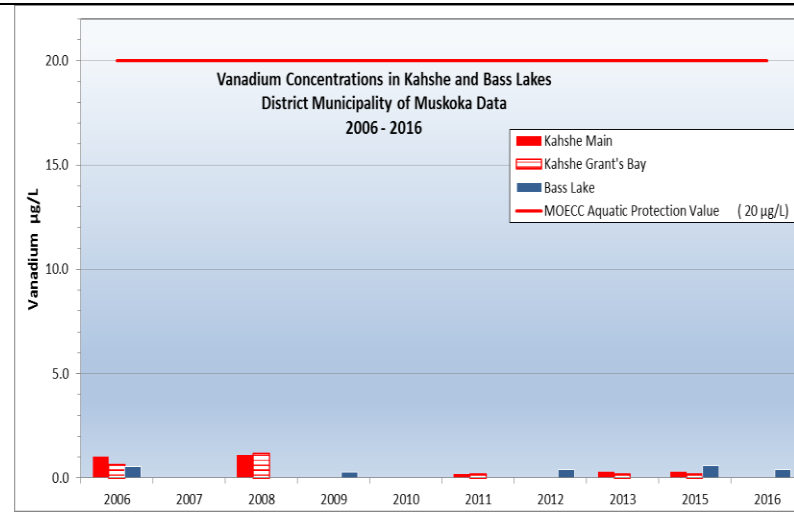

Potassium Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2004 - 2016
Potassium mg/L
100.0
10.0
1.0
0.1
Kahshe Main
Kahshe Grant's Bay
Bass Lake
U.S. EPA Lowest Chronic Value (53 mg/L)
2004
2006
2007
2008
2009
2010
2011
2012
2013
2015
2016

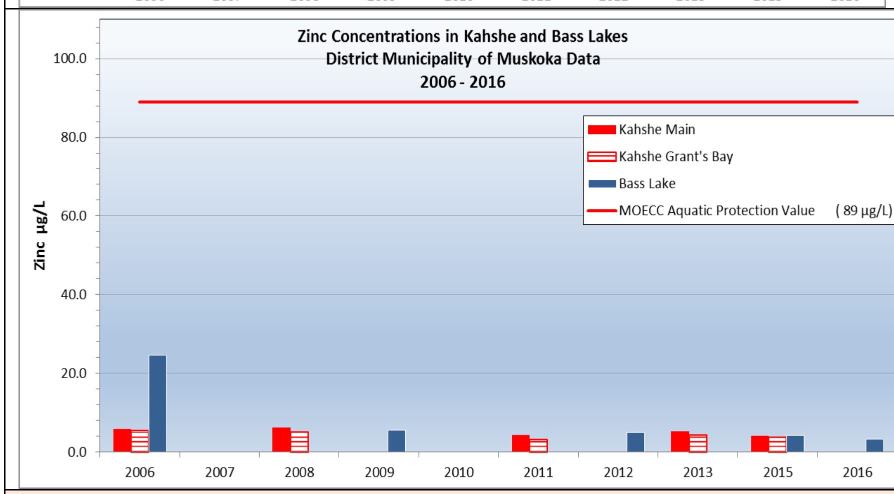

Silicon (Reactive Silicate) Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2004 - 2016
Silicon (reactive silicate) mg/L
5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Kahshe Main
Kahshe Grant's Bay
Bass Lake
2004
2006
2007
2008
2009
2010
2011
2012
2013
2015
2016


Sodium Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2004 - 2016
Sodium mg/L
100.0
10.0
1.0
Kahshe Main
Kahshe Grant's Bay
Bass Lake
MOECC Aquatic Protection Value (180 mg/L)
2004
2006
2007
2008
2009
2010
2011
2012
2013
2015
2016

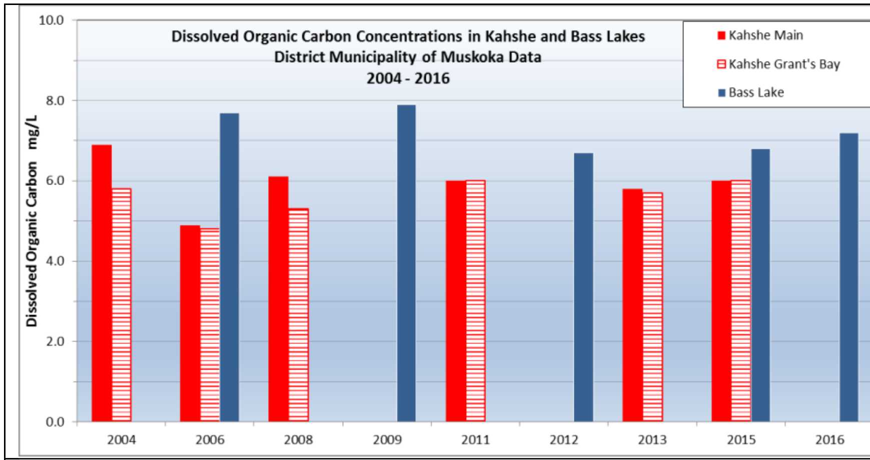

Strontium Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2006 - 2016
Strontium µg/L
1,000.0
100.0
10.0
1.0
Kahshe Main
Kahshe Grant's Bay
Bass Lake
US EPA Tier-II Secondary Chronic Value (1,500 µg/L)
2006
2007
2008
2009
2010
2011
2012
2013
2015
2016

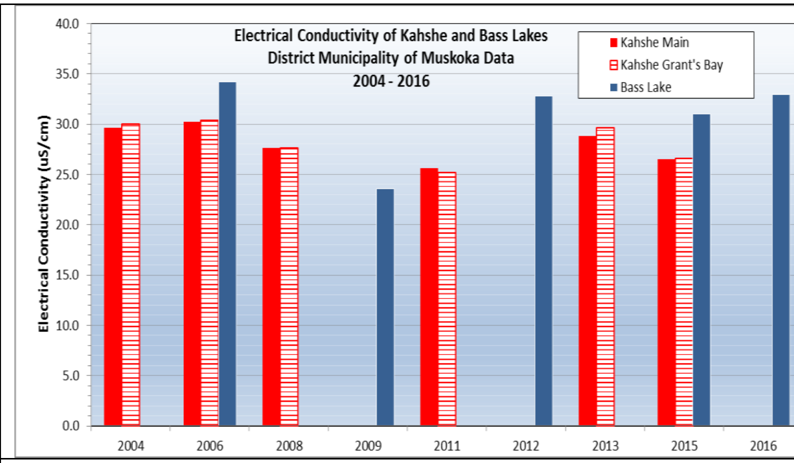


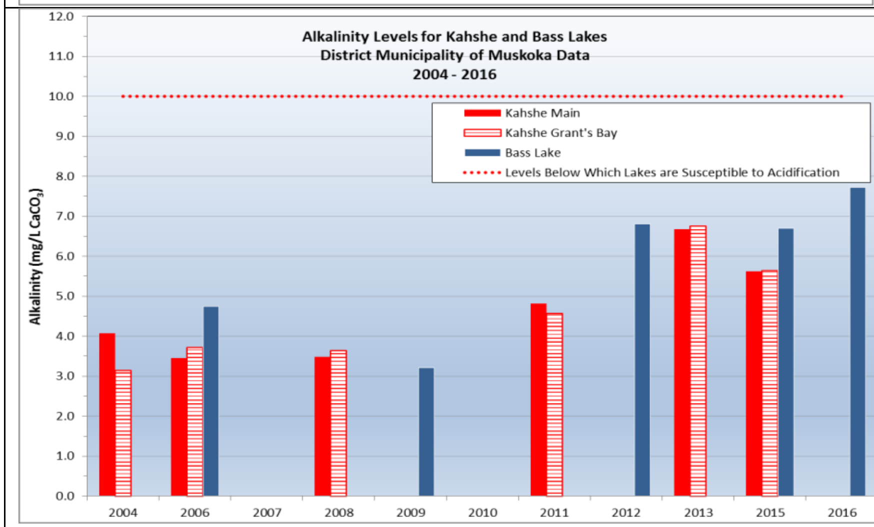




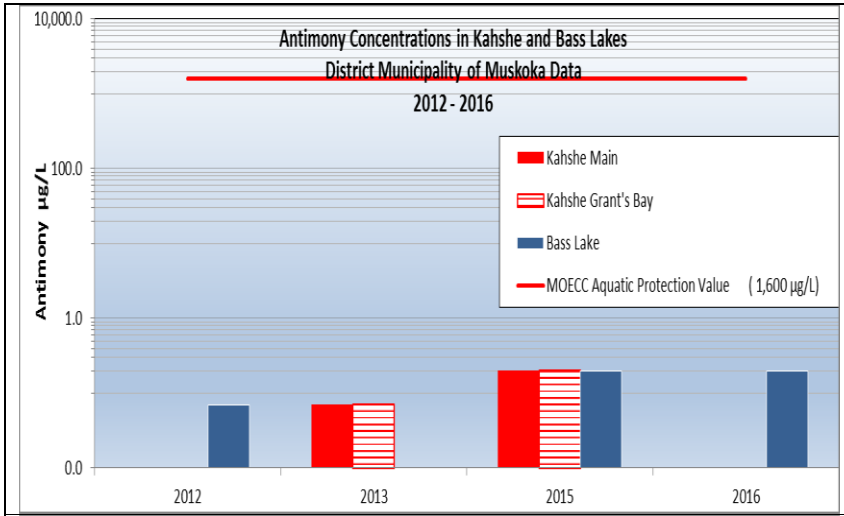
Other Chemicals

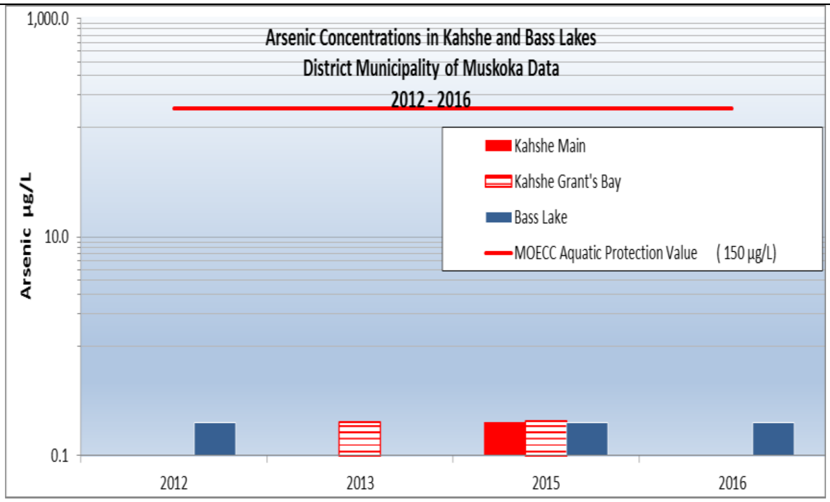


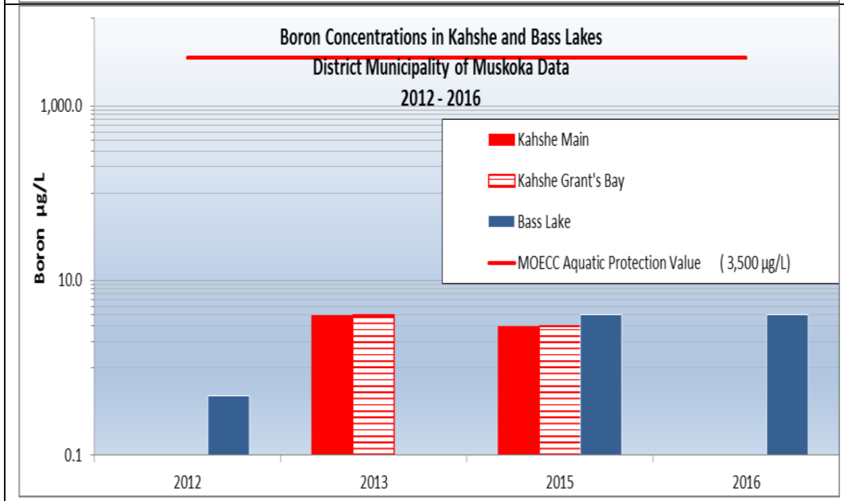


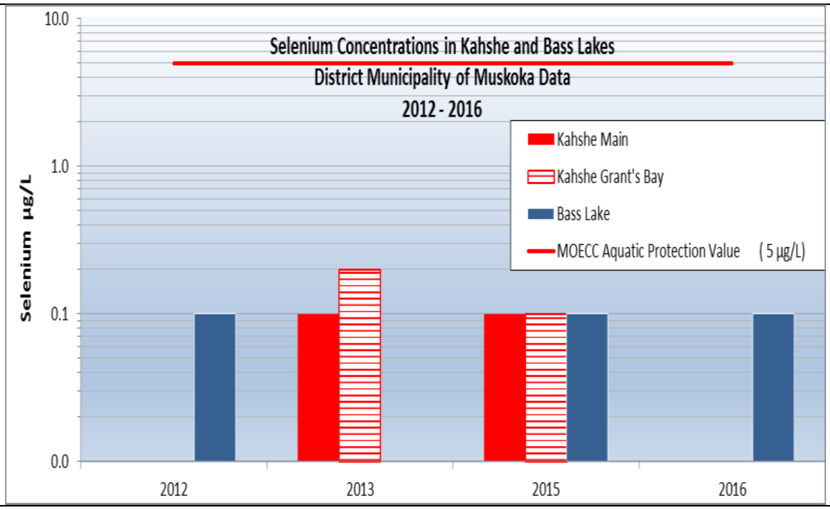


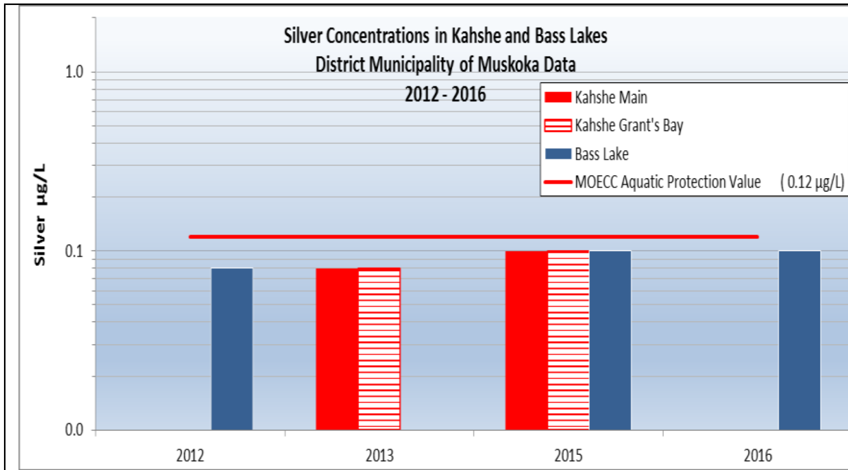
Recently Added Cations

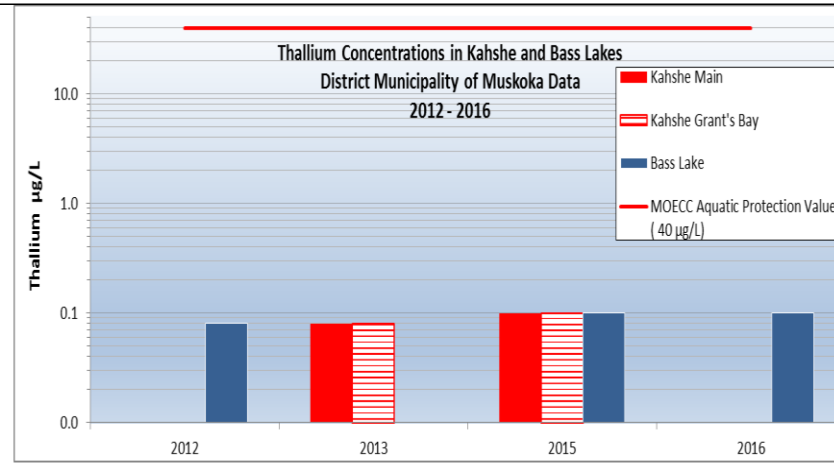

Antimony Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2012 - 2016
Antimony µg/L
10,000.0
100.0
1.0
0.0
2012
2013
2015
2016
Kahshe Main
Kahshe Grant's Bay
Bass Lake
MOECC Aquatic Protection Value (1,600 µg/L)

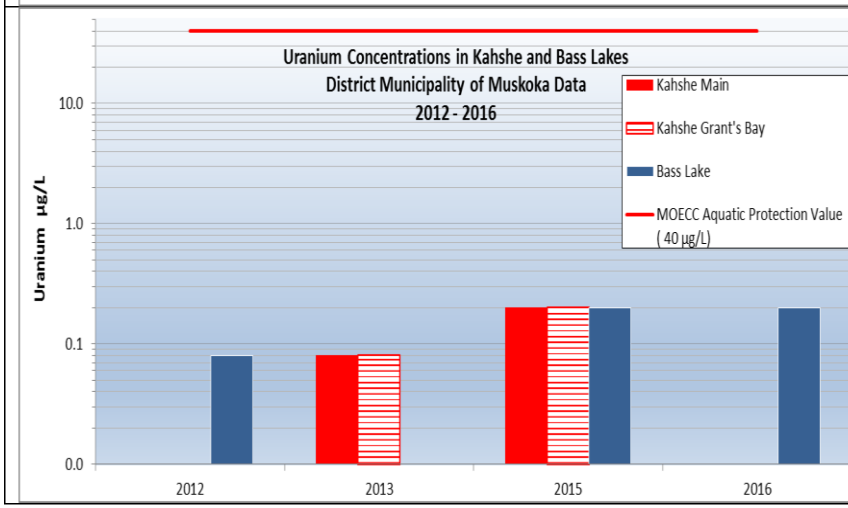

Arsenic Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2012 - 2016
Arsenic µg/L
1,000.0
10.0
0.1
2012
2013
2015
2016
Kahshe Main
Kahshe Grant's Bay
Bass Lake
MOECC Aquatic Protection Value (150 µg/L)


Boron Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2012 - 2016
Boron µg/L
1,000.0
10.0
0.1
2012
2013
2015
2016
Kahshe Main
Kahshe Grant's Bay
Bass Lake
MOECC Aquatic Protection Value (3,500 µg/L)


Selenium Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2012 - 2016
Selenium µg/L
10.0
1.0
0.1
0.0
2012
2013
2015
2016
Kahshe Main
Kahshe Grant's Bay
Bass Lake
MOECC Aquatic Protection Value (5 µg/L)


Silver Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2012 - 2016
Kahshe Main
Kahshe Grant's Bay
Bass Lake
MOECC Aquatic Protection Value (0.12 µg/L)
Silver µg/L
1.0
0.1
0.0
2012
2013
2015
2016


Thallium Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2012 - 2016
Kahshe Main
Kahshe Grant's Bay
Bass Lake
MOECC Aquatic Protection Value (40 µg/L)
Thallium µg/L
10.0
1.0
0.1
0.0
2012
2013
2015
2016


Uranium Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2012 - 2016
Kahshe Main
Kahshe Grant's Bay
Bass Lake
MOECC Aquatic Protection Value (40 µg/L)
Uranium µg/L
10.0
1.0
0.1
0.0
2012
2013
2015
2016