2012

# Lake Monitoring Final Report

St. Croix International Waterway Commission

**This project was funded through the generous financial support of the New Brunswick Environmental Trust Fund and the International Joint Commission (under contract #104-2200732)**

**Disclaimer: While International Joint Commission supports this work, the views within this report are not the official views of the International Joint Commission**

# Introduction

Since 1992, the St. Croix International Waterways Commission has maintained a six year cycle of baseline water quality testing on the major lakes of the St. Croix watershed. In each cycle lakes are tested using consistent monitoring stations, sampling techniques, and laboratory analysis. During the 2012 field season nineteen lakes were sampled. The full sampling schedule since 1992 is seen in Table 1.

| Name | Jurisdiction | County | Years sampled | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1992 | 1993 | 1995 | 1998 | 1999 | 2004 | 2005 | 2012 |
| **Big Lake** | **ME** | **Washington** | | X | | | X | X | | X |
| **Bolton Lake** | **NB** | **York** | | X | | | X | | X | X |
| **Brackett Lake** | **ME** | **Aroostook** | | X | | | X | | X | X |
| **Canoose Lake** | **NB** | **Charlotte** | X | | | X | | | X | X |
| **Deering Lake** | **ME** | **Aroostook** | | X | | | X | | X | X |
| **East Grand Lake** | **ME/NB** | **Aroostook/York** | X | | | X | | | X | X |
| **Fifth Lake** | **NB** | **York** | | | | | X | | X | X |
| **Grand Falls Flowage** | **ME/NB** | **Washington/ Charlotte** | | X | | | X | X | | X |
| **Long Lake** | **ME** | **Washington** | | X | | | X | X | | X |
| **Lewy Lake** | **ME** | **Washington** | | X | | | X | X | | X |
| **Modsley Lake** | **NB** | **York** | | | | | X | | | X |
| **North Lake** | **ME/NB** | **Aroostook/York** | X | | | X | | X | | X |
| **Sixth Lake** | **NB** | **York** | | X | | | X | | | X |
| **Skiff Lake** | **NB** | **York** | X | | | X | | X | | X |
| **Spednic/Palfrey Lake** | **ME/NB** | **Aroostook/York** | X | | | X | | | X | X |
| **Tomah Str mouth** | **ME** | **Washington** | | X | | | | | | |
| **Wauklehegan Lake** | **NB** | **York** | X | | | X | | | | X |
| **West Grand Lake** | **ME** | **Washington** | | X | | | X | X | | X |
| **Woodland Flowage** | **ME/NB** | **Washington/ Charlotte** | | | X | | X | | X | X |
| **Nash Lake** | **ME** | **Washington** | | | | | | X | | X |

**Table 1:Lakes sampled as part of the ongoing baseline sampling of the St. Croix International Waterway Commission, the table denotes which years each lake has been studied, the entirety of this data can be obtained from the commission**

During the 2012 field season each of the study lakes were sampled twice; once in late July or August, and once in September or early October. Table 2 is a record of which dates each lake was sampled. Originally it had been the hope of the commission to sample in June and July; however, because of staff availability and access to equipment the sampling timeline was moved to August and September.

| Waterbody | # of Sampling Stations | First Sample | Second Sample |
|---|---|---|---|
| **Big Lake** | 2 | Aug. 8 | Sept. 17 |
| **Bolton Lake** | 1 | July 31 | Sept. 3 |
| **Brackett Lake** | 1 | Aug. 19 | Sept.13 |
| **Canoose Lake** | 1 | Aug. 14 | Sept. 25 |
| **Deering Lake** | 1 | Aug. 19 | Sept. 13 |
| **East Grand Lake** | 3 | Aug. 20 | Sept. 24 |
| **Fifth Lake** | 1 | July 31 | Sept. 3 |
| **Grand Falls Flowage** | 2 | Aug. 8 | Sept. 17 |
| **Long Lake** | 1 | Aug. 8 | Sept. 17 |
| **Lewy Lake** | 1 | Aug. 8 | Sept. 17 |
| **Modsley Lake** | 1 | Aug. 13 | Sept. 11 |
| **North Lake** | 2 | Aug. 20 | Sept. 24 |
| **Sixth Lake** | 1 | July 31 | Sept. 3 |
| **Skiff Lake** | 1 | Aug. 19 | Sept. 13 |
| **Spednic/Palfrey Lake** | 4 | July 30 | Sept. 12 |
| **Wauklehegan Lake** | 2 | Aug. 13 | Sept. 11 |
| **West Grand Lake** | 1 | Aug. 15 | Oct. 3 |
| **Woodland Flowage** | 2 | Aug. 14 | Sept. 25 |
| **Nash Lake** | 2 | Aug. 15 | Oct. 3 |

**Table 2: 2012 St. Croix lake baseline sampling program sample dates**

# Methodology

At each site in the study water samples were taken from the sub-surface, secchi depth, mid-depth, and near bottom depth. As there was a lack of access to a reliable dissolved oxygen (DO) meter with sufficient cord length, dissolved oxygen profiles were not consistently conducted. Dissolved oxygen readings were taken at the four sample depths when sufficient equipment was available.

Besides DO, field methods followed New Brunswick Department of Environment and Local Government (DELG) field protocol. Depth and secchi readings were conducted at each site, one slight variation was that a viewing scope was used for secchi readings as per the Maine Volunteer Lake Monitoring Program (VLMP) protocol, so that data was comparable to VLMP's annual data collection. Based on the results of total depth and secchi, the four sample depths were determined uniquely at each site and at each sampling. Once determined water samples were taken at each of the four depths, and forwarded to the DELG laboratory in Fredericton, New Brunswick for analysis. Sub surface samples were tested for chlorophyll A concentration and the surface water for aquatic protection analytical package. At secchi depth only chlorophyll A concentration was analyzed, and at mid and near bottom depths only the parameters included in the surface water for aquatic protection package were analyzed. The parameters included in the aquatic protection package are alkalinity, aluminum, antimony, arsenic, cadmium, calcium, chloride, chromium, colour, conductivity, copper, fluoride, iron, lead, magnesium, manganese, nickel, nitrate-nitrogen, nitrate/nitrite, nitrite, pH, potassium, sodium, sulfate, total organic carbon, total phosphorus, total ammonia, total hardness, total nitrogen, turbidity and zinc. All laboratory data was entered into the DELG database for provincial use. All field and laboratory data has been inputted into the Commission's data base and is available to the State of Maine and any other interested stakeholders.

# Results

The entirety of data collected as per the study's methodology is available via the St. Croix International Waterway Commission upon request. What follows is a determination of trophic status and an analysis of more detailed water quality parameters in relation to established water quality guidelines.

The biological productivity, or trophic state, of a lake is described as being oligotrophic, mesotrophic, or eutrophic. A eutrophic lake has relatively high primary production and high nutrient levels, in contrast to mesotrophic, which is moderate, and oligotrophic, which is on the low end of the trophic spectrum. Tropic states are traditionally assessed with an examination of primary water quality parameters, including transparency (Secchi depth), chlorophyll a, and nutrient concentration. The Organization for Economic Co-operation and Development (OECD, 1992) guidelines, which are based on ice-free growing season averages, are used to determine trophic state (Table 3).

| Parameter | Oligotrophic | Mesotrophic | Eutrophic |
|---|---|---|---|
| Secchi depth (m) | ≥ 5 | ≥ 3, < 5 | < 3 |
| Chlorophyll a (ug/L) | < 3.5 | ≥ 3.5, < 5.0 | ≥ 5.0 |
| Total Phosphorus (mg/L) | < 0.010 | ≥ 0.010, ≤ 0.020 | ≥ 0.020 |

**Table 3: Trophic state indicator parameters and associated values (Source: Brylinsky, 2009)**

The trophic status of all nineteen lakes was determined using the primary water quality parameters of transparency (as determined by secchi depth), Chlorophyll A concentration, and Total Phosphorus Concentration. For evaluation the average of each of these parameters across study sites, and at various depths was used. Table 4 summarizes this data and inferred trophic status. The majority of lakes studied over the 2012 field season were of high quality with fifteen being classified as oligotrophic given the most recent data. Modsley and North Lake were classified as mesotrophic and the Canoose Lake, and Waklehegan Lake are classed as eutrophic.

| Lake | Average Secchi Depth (m) | Average Chlorophyll A Concentration (µg/L) | Average Total Phosphorus Concentration (mg/L) | Trophic Status |
|---|---|---|---|---|
| **Big** | 5.74 | 2.40 | 0.0108 | Oligotrophic |
| **Bolton** | 6.20 | 1.20 | 0.0053 | Oligotrophic |
| **Brackett** | 7.19 | 1.93 | 0.0056 | Oligotrophic |
| **Canoose** | 1.54 | 7.60 | 0.0088 | Eutrophic |
| **Deerling** | 8.68 | 1.43 | 0.0060 | Oligotrophic |
| **East Grand** | 8.43 | 1.98 | 0.0028 | Oligotrophic |
| **Fifth** | 6.31 | 1.60 | 0.0063 | Oligotrophic |
| **Grand Falls Flowage** | 4.40 | 2.70 | 0.0071 | Oligotrophic |
| **Lewy** | 4.55 | 2.83 | 0.0070 | Oligotrophic |
| **Long** | 5.13 | 2.85 | 0.0137 | Oligotrophic |
| **Modsley** | 2.95 | 3.28 | 0.0107 | Mesotrophic |
| **Nash** | 7.32 | 1.87 | 0.0059 | Oligotrophic |
| **North** | 3.75 | 3.50 | 0.0057 | Mesotrophic |
| **Sixth** | 5.69 | 2.15 | 0.0058 | Oligotrophic |
| **Skiff** | 7.36 | 2.35 | 0.0065 | Oligotrophic |
| **Spednic** | 6.12 | 2.76 | 0.0065 | Oligotrophic |
| **Waklehegan** | 2.75 | 6.36 | 0.0105 | Eutrophic |
| **Woodland Flowage** | 4.48 | 1.68 | 0.0056 | Oligotrophic |
| **West Grand** | 10.10 | 1.26 | 0.0053 | Oligotrophic |

**Table 4: Trophic Status of Study Lakes, red fill denotes eutrophic ranges, yellow mesotrophic, and no fill oligotrophic. Where there was a conflict in parameter ranges status was determined by the trophic level of the majority of indicators.**

The Council of Canadian Ministers on the Environment (CCME) has a minimum guideline of 5.5 mg/L of dissolved oxygen in freshwater systems (1999). The majority of samples taken during the 2012 field season met or exceeded these levels. Exceptions to this were deep water samples in August at Big Lake (at station BIG 1 at 8.8 m, 5.20 mg/L, and at 16.0 m 0.30 mg/L, and Big 2- 5.00 mg/L at a depth of 8.2 m), and at East Grand Lake (at stations EGR1 at 32.7m 3.68 mg/L, at EGR4 at 18.3 m 4.32 mg/L, and at EGR6 2.98 mg/L at a depth of 13.4 m). These oxygen levels in deep water are by themselves not concerning. Oxygen use is greatest at lake bottom where the processes of decomposition uses available oxygen, and thermal stratification is greatest in the summer months, leading to little mixing of surface oxygen with greater depths. Shallower depths in these lakes show sufficient amounts of oxygen to sustain fish life.

Two August samples exceeded the cadmium non-hardness dependant guideline of 0.17 µg/L (CCME, 1999) with readings of 0.2 µg/L , on Spednic Lake at a depth of 11.6 m, and on Lewy Lake at a depth of 3.0 m. The same sample sites did not show elevated levels of Cadmium in September, leading one to hypothesize that sediment in the samples may have caused the elevated August levels. Similarly copper levels in some August samples were above the 0.002mg/L guideline (CCME, 2012) with readings of

0.0029 mg/L at 4.6 m in Big Lake, 0.0037 mg/L at 3.2 m in Bolton Lake, and 0.003 mg/L at a 7.7 m in Spednic Lake. September results from the same sites did not show elevated levels.

Elevated levels of Aluminum were found in Big Lake (0.110 and 6.080 mg/L), Brackett Lake (9.780mg/L), Canoose Lake (0.110 and 0.110 mg/L), East Grand Lake (12.00 mg/L) , Fifth Lake (0.110 mg/L), Long Lake (5.970 mg/L), Modsley Lake (0.120, 0.120, 0.170, 0.120, 0.120, and 0.130 mg/L), North Lake (15.2 mg/L), Sixth Lake( 0.120,0.110), and Wauklehegan Lake (4.780,0.140). The CCME aluminum guideline for the protection of aquatic life is 0.1 mg/L (CCME, 2012). One sample of highly elevated levels such as those in Brackett or East Grand may be caused by sediment contamination of individual samples. Slightly elevated levels in all samples taken in Modsley Lake suggests a more persistent issue, of which the exact cause is currently unknown.

Maganese Levels in deep samples in nine of the lakes exceeded the aesthetic guideline of 0.2 mg/L (CCME 2012). Samples taken in Spednic Lake(0.86 mg/L) , Skiff Lake (0.92 mg/L), Sixth Lake (0.62 and 0.39 mg/L), North Lake (0.43 mg/L), Nash Lake(0.66 mg/L), Long Lake (0.88 mg/L), Fifth (0.6 mg/L and 0.65 mg/L), East Grand Lake (0.25 mg/L) and Big Lake (0.44 mg/L and 1.1 mg/L). It is important to note that the Maganese guideline is an aesthetic objective and so these elevated levels pose no threat to aquatic life.

In freshwater, environmental total organic carbon (TOC) levels are usually greater than 2 mg/L and less than 10 mg/L (British Columbia Department of Environment, 2011). Four lakes within the study level had ranges of organic carbon that exceeded 10 mg/L. Levels in Wauklehegan Lake range from 8.40-10.50 mg/L, in North Lake 9.70-13.30 mg/L, in Modsley Lake 9.70-10.60 mg/L and in the Canoose Lake 14.70-18.50 mg/L. These ranges suggest increased levels of organic decomposition in these waterways. These results also substantiate the mesotrophic and eutrophic classifications of these four lakes.

Concentrations of Ammonia above 0.2 mg/L are often early indicators of contamination (Spooner, 2007). While the majority of results were well below this level September deep water samples from Big Lake and Spednic and October Sampling at Nash Lake showed levels slightly above this at 0.233, 0.222, and 0.27 mg/L respectively. Given these elevated levels were only seen at one site at each lake, and not supported by results at shallower points it is most likely that these elevated levels are caused by decomposition of bottom organics rather than an anthropogenic source.

# Conclusion

Overall the major lakes of the St. Croix system are of high quality with the majority being classed as oligotrophic lakes. The majority of metals samples that were above guideline values could be explained by sampling occurring too close to bottom sediment, as such special care should be taken in future years to ensure near bottom sampling locations are done slightly higher in the water column, to avoid misleading results. Aluminum results in Modsley Lake suggest a source of aluminum, the cause of which should be investigated as part of further study. The 2012 results can be used for comparison in subsequent years as changes in trophic status would indicate pollution sources. It is the hope of the commission to continue the baseline lake sampling program to ensure the continued high quality of lakes within the St. Croix watershed.

# References

British Columbia Deparment of Environment. 2011. *Water Quality*. Retrieved February 28, 2012, from Environmental Protection Division: http://www.env.gov.bc.ca/wat/wq/BCguidelines/orgcarbon/definitions.html

Brylinksy M. 2009. Lake Utopia Water Quality Assessment. Commissioned by the New Brunswick Department of the Environment.

Canadian Council of Ministers of the Environment (CCME). 1999. Canadian Water Quality Guidelines for the Protection of Aquatic Life. Available online http://ceqg-rcqe.ccme.ca/

CCME. (2012). *Canadian Environmental Quality Guidelines Summary Table.* Retrieved July 4, 2012, from CCME Canadian Environmental Quality Guidelines Online: http://st-ts.ccme.ca/

Organization for Economic Cooperation and Development (OECD) 1982. Eutrophication of Waters. Monitoring Assessment and Control, Final Report. OECD Cooperative Programme on Monitoring of Inland Waters (Eutrophication Control). OECD, Paris.

Spooner, I. (2007). Recognizing Water Problems and Their Solutions. In V. Authors, *Custom Course Materials GEOL 3723.* Wolfville, NS: Acadia University.