New Nouveau Brunswick CANADA

Southwest Miramichi River at Deersdale, NB

The State of Water Quality in New Brunswick's Lakes and Rivers:

Water Quality Monitoring Results 2003-2016

New Brunswick Department of Environment and Local Government

November 2019

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This Report contains internet links that are functional in the web-based version, which can be accessed by visiting www.gnb.ca and following the links to “Departments” > “Environment and Local Government” > “The State of Water Quality in New Brunswick’s Lakes and Rivers: Water Quality Monitoring Results 2003-2016”

Water Quality Monitoring in New Brunswick

This report provides an overview of the current state of New Brunswick's water quality based on analysis of surface water samples collected from 2003 to 2016. This is the first province-wide annual report on the state of New Brunswick's surface water quality and provides general information about water quality science and an overview of the province's monitoring networks.

New Brunswick contains approximately 2500 lakes and 60 000 kilometers of streams and rivers. Surface water quality monitoring is conducted by the Department of Environment and Local Government (DELG), in partnership with Environment and Climate Change Canada, First Nations and non-governmental organizations including provincial Watershed Associations and Lake Associations.

Surface water quality monitoring is conducted for various purposes. Rivers and lakes within the province are monitored to assess ambient conditions (natural background conditions in the surrounding environment), to inform specific Departmental programs and to contribute to the understanding of cumulative effects of various activities within watersheds. Monitoring is also used to assess the effectiveness of conditions that are required as part of the various types of permits and approvals delivered through DELG's Authorizations Branch.

This report provides a brief overview of the ambient conditions for rivers and lakes across the province as well as summarize various monitoring programs and partnerships. This report does not include results of site specific industrial and municipal monitoring but does contribute an overview of this type of monitoring.

Overview of Environmental Science and Protection

The Department of Environment and Local Government's environmental management model is shown in Figure 1. The components include environmental monitoring and assessment, planning for development and growth, protecting the environment through permits, authorizations, program delivery and other regulatory tools. Water quality monitoring contributes important information to each of these functions.

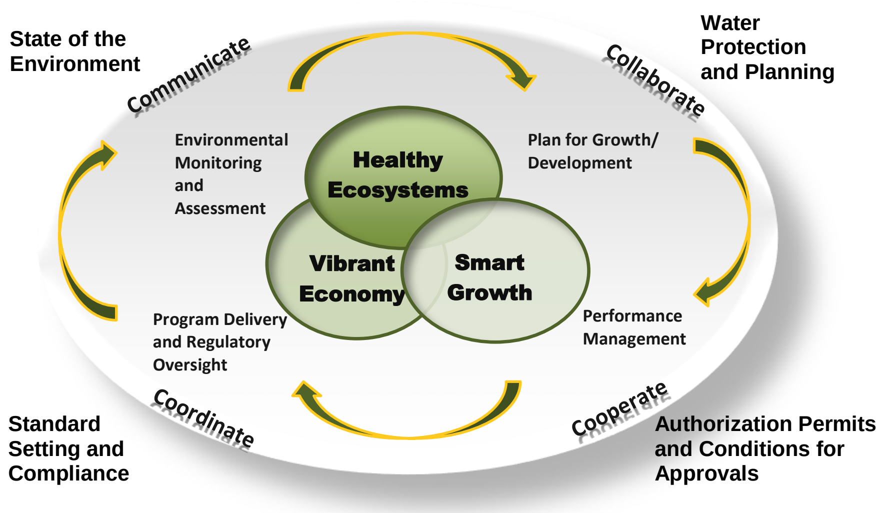


Figure 1. Environmental Science and Protection Model

Surface Water Quality Monitoring

Ambient River Water Quality Monitoring

The Department of Environment and Local Government's primary method of collecting ambient water quality information in rivers is via the Surface Water Monitoring Network (SWMN). This network was fully established in 2003 and is currently composed of 55 monitoring stations that are sampled several times throughout the year. Station locations were selected to provide proper geographical coverage of the province's major river systems (Figure 2). Prior to 2003, monitoring focused on a small group of core river stations and additional monitoring locations were sampled on an annual basis.

Nigadoo River - 2016

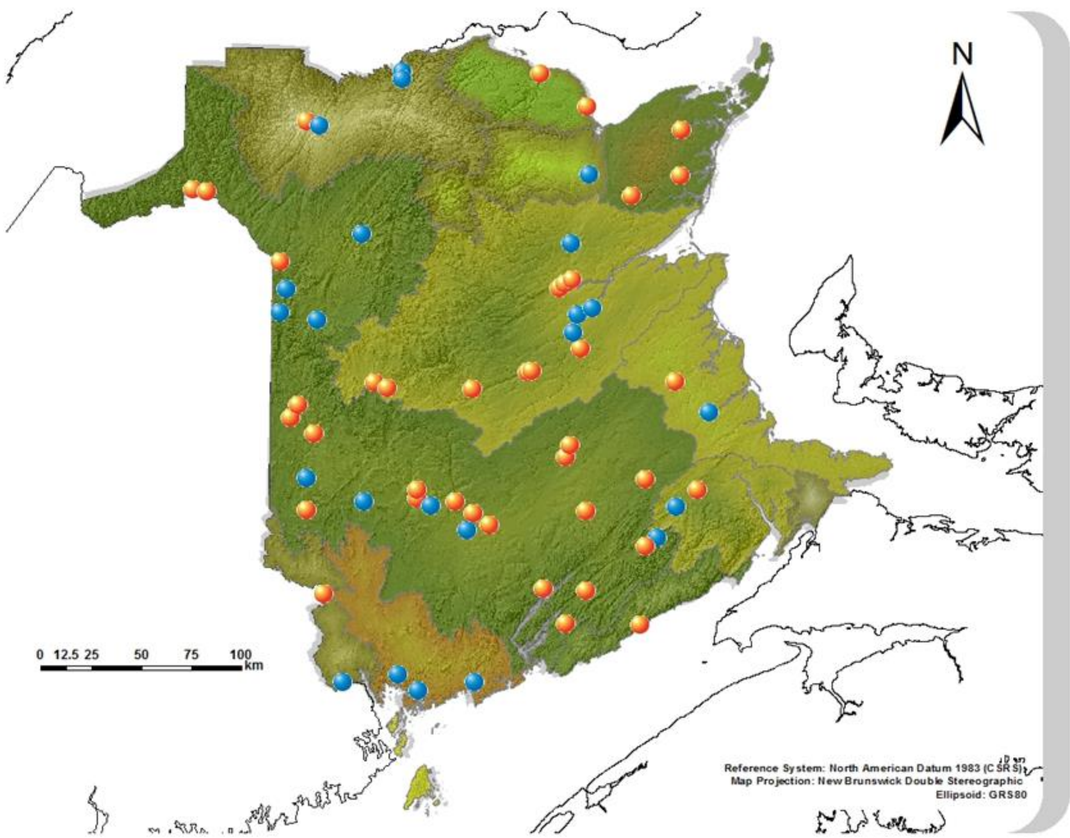


Figure 2. Surface Water Monitoring Network sites sampled between 2003 and 2016. Note that the blue sampling locations correspond with the 23 core stations shown in Figure 4b and were sampled at least 4 times per year between 2003 and 2016. The orange sampling locations were sampled between 2 and 4 times per year between 2003 and 2016 (both data sets from the orange and blue sampling locations were included in Figure 4a).

Why do we monitor?

The goals of the ambient river water quality monitoring program are:

- To monitor, assess and report on the ambient water quality of major rivers and tributaries in the Province of New Brunswick.
- To ensure that high quality data is available to: a) support DELG's programs for planning and approvals; b) contribute to cumulative effects assessments; c) aid in public reporting and d) meet requirements of our partners.
- To contribute water quality data to the annual Canadian Environmental Sustainability Indictor reporting process through the use of the Canadian Council of Minister's of the Environment Water Quality Index.
- To conduct assessments and reporting on our surface waters and to raise awareness of the state of the environment in New Brunswick.

Surface Water Quality Data Portal

The Department of Environment and Local Government has made surface water quality data publicly available online. The data available is from the provincial surface water monitoring network that was collected from 2003 to present. Data is uploaded in near real time after the laboratory analysis is complete.

The data can be found at: Surface Water Quality **Data Portal**

What do we monitor?

The parameters analyzed as part of the Surface Water Monitoring Network are listed in Table 2. These same parameters are also commonly sampled in other surface water monitoring programs and projects in New Brunswick such as lake monitoring and monitoring activities conducted by watershed associations. The parameters are similar to what is monitored by other Canadian jurisdictions.

Table 2: List of parameters assessed in rivers and lakes

Metals/Metaloids		Nutrients	Major Ions	Bacteria	Additional Parameters
Aluminum	Manganese	Nitrate	Sodium	E.coli	pH
Antimony	Molybdenum	Nitrite	Potassium		Conductivity
Arsenic	Nickel	Total Nitrogen	Calcium		Temperature
Barium	Rubidium	Total Kjeldahl Nitrogen	Magnesium		Turbidity
Beryllium	Selenium	Ammonia	Chloride		Alkalinity
Bismuth	Silver	Total Phosphorus	Sulfate		Colour
Boron	Strontium	Dissolved Organic Carbon			Dissolved Oxygen
Cadmium	Tellurium				Hardness
Chromium	Thallium				Fluoride
Cobalt	Tin				Bromine
Copper	Uranium				
Iron	Vanadium				
Lead	Zinc				
Lithium					

Data and Assessment

The Canadian Council of Ministers of the Environment Water Quality Index (CCME, 2017) is one tool that the Department of Environment and Local Government uses to assess and interpret water quality data. The Water Quality Index (WQI) combines a range of water chemistry results and computes an overall score from 0 to 100. There are 5 WQI categories which range from poor (scores below 44) to excellent (scores above 95) (Table 3). To calculate an index value, monitoring results for various parameters are compared with a set of guidelines. DELG includes 11 parameters (arsenic, total ammonia, chloride, copper, dissolved oxygen, iron, nitrate, pH, total phosphorus, turbidity, and zinc) in the WQI calculation and compares the results with the Canadian Council of Ministers of the Environment Water Quality Guidelines for the Protection of Aquatic Life (CCME, 2014) with the exception of turbidity and total phosphorus. For turbidity, DELG uses a provincial/site specific guideline which reflects concentrations typically found in New Brunswick waters. For total phosphorus, DELG uses Ontario's total phosphorus guideline of 0.03 mg/L (OMOE, 1994).

Canadian Environmental Sustainability Indicators (CESI)

CESI is an annual report published by Environment and Climate Change Canada. It describes state of the environment as well as Canada's progress on key environmental sustainability issues. The CESI report is one way the Government of Canada measures the progress of the Federal Sustainable Development Strategy. This Strategy describes the Government of Canada's sustainable development priorities, establishes goals and targets, and highlights government actions. New Brunswick contributes to a number of the CESI indicators, including the Freshwater Quality in Canadian Rivers indicator, which uses the WQI and gives a measure of the ability of rivers to support aquatic life. More information about CESI can be found at: CESI

The parameters used in the WQI were selected to reflect the full range of potential activities that might impact water quality including both point and non-point sources of pollution. Parameters were also chosen to ensure that various parameter groups were represented such as nutrients (represented by phosphorus, ammonia and nitrates), metals/metalloids (represented by arsenic, iron, zinc and copper) and major ions (represented by chloride). The WQI functions optimally when only 10-12 parameters are included in the WQI calculator and so not all parameters included in Table 2 can be included in this type of assessment.

Table 3. CCME Water Quality Index categories and descriptions

Ranking	Interpretation
Excellent (95.0 to 100.0)	Water quality measurements never or very rarely exceed water quality guidelines.
Good (80.0 to 94.9)	Water quality measurements rarely exceed water quality guidelines and, if they do, it is usually by a narrow margin.
Fair (65.0 to 79.9)	Water quality measurements sometimes exceed water quality guidelines and may do so by a wide margin.
Marginal (45.0 to 64.9)	Water quality measurements often exceed water quality guidelines and/or exceed the guidelines by a considerable margin.
Poor (0 to 44.9)	Water quality measurements usually exceed water quality guidelines and/or exceed the guidelines by a considerable margin.

The WQI scores of 53 surface water monitoring network sites based on aggregated data collected from 2014-2016 are summarized in Figure 3. Two sites were not included in the WQI analysis as they did not meet the minimum yearly sampling requirements (each site must be sampled at least 4 times per year). The results show that the water quality at 85% of New Brunswick's monitoring stations fall within either the good or excellent categories, with quality at the remaining stations rated as "fair". Out of the 11 parameters assessed with the WQI, there were 3 that frequently did not meet their respective guidelines; iron was above its guideline 15% of the time, total phosphorus 6% of the time, and dissolved oxygen 3% of the time while the remaining parameters exceeded less than 2% of the time (based on data from all stations).

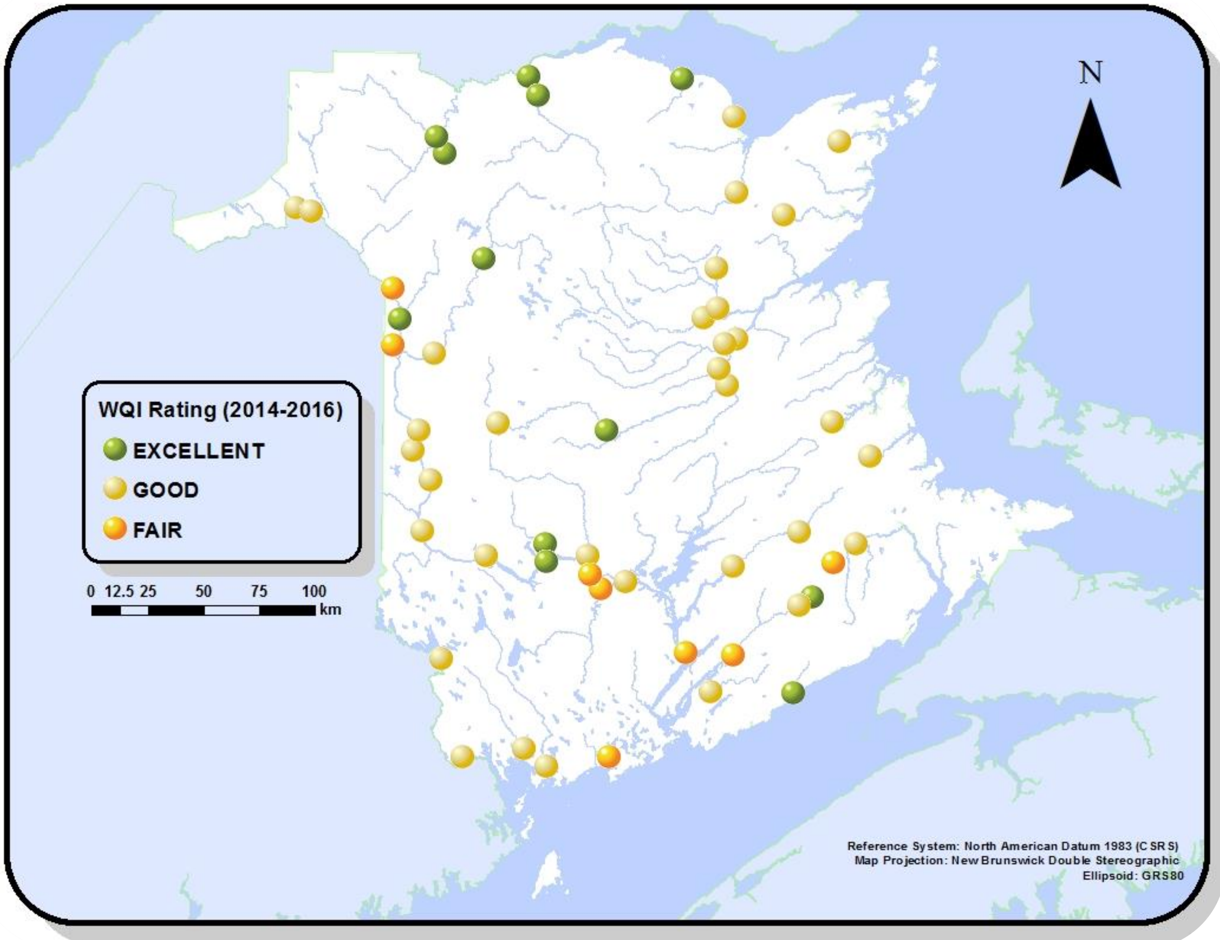


Figure 3. River monitoring stations and their corresponding WQI scores based on data collected from 2014-2016.

The eight sites that were rated as fair include: the Aroostook River at Route 2 Bridge, the Kennebecasis River at Bloomfield Bridge, the Lepreau River above Route 780 Bridge, the Petitcodiac River below Petitcodiac, the Oromocto River at the Route 102 Bridge, the Saint John River at Evandale, Saint John River at Lower Lincoln, and Saint John River above Grand Falls. An overview of potential influences on water quality for each of these sites is listed in Table 4. In general, potential influences that contribute to lower WQI scores include point source effluents (e.g. industrial, municipal), non-point source runoff from forestry, agriculture and residential lands as well as general land use disturbances within riparian zones (e.g. removal of vegetation). It is also possible that natural factors such as geology are influencing the WQI score and these sites may benefit from site-specific guidelines. In order to accurately determine what may be influencing the water quality of these sites further and in-depth assessment would be needed.

Table 4. A summary of the "Fair" stations based on water quality data collected between 2014 and 2016.

Station Name	Location	WQI Score	Parameters not meeting CCME guidelines	Potential Water Quality Influences
Saint John River at Lower Lincoln	South Central NB	65.4	Copper (2), Dissolved Oxygen (1), Iron (4), Total Phosphorus (3), Turbidity (2), Zinc (1)	Municipal and residential development
Saint John River above Grand Falls	Western NB	67.8	Copper (1), Dissolved Oxygen (1), Iron (1), Total Phosphorus (3), Turbidity (1), Zinc (1)	Agriculture, forestry, residential development, and Grand Falls dam
Aroostook River at Route 2 Bridge	Northwestern NB	68.4	Copper (1), Total Ammonia (1), Nitrate (1), Total Phosphorus (1), Zinc (1), Iron (2)	Agriculture, former US military base, municipal effluent and forestry
Oromocto River at Route 102	South Central NB	77.4	Dissolved Oxygen (1), Iron (10), pH (1), Total Phosphorus (1)	Municipal development, residential development, geology (iron)
Petitcodiac River below Petitcodiac	Southeastern NB	78	Chloride (2), Iron (6), Total phosphorus (2), Turbidity (1)	Agriculture, forestry and municipal development
Lepreau River above Route 780 Bridge	Southwestern NB	78.7	Copper (1) Iron (3) , pH (10), Zinc (1)	Small amount of agriculture, residential development, geology (pH)
Kennebecasis River at Bloomfield bridge	Southeastern NB	79.0	Iron (1), Turbidity (1),Total Phosphorus (1), Zinc (1)	Agriculture, forestry, and residential development
Saint John River at Evandale	Southern NB	79	Chloride (1), Iron (2), Total Phosphorus (1)	Agriculture, forestry, and residential development

DELG is involved in mitigating impacts on water quality through numerous programs and regulations that are intended to reduce the impact the various types of development can have on the environment (Table 5). Additionally, the Environmental Trust Fund provides funding to local community groups to help protect the waters of the province. Typically, projects such as water quality monitoring, improvements to riparian zones, and environmental education and awareness initiatives are priority efforts for DELG.

Table 5. Programs and regulations that manage impacts to water quality.

Potential Water Quality Influences	Programs and Regulations that address potential influences on water quality
Municipal Development	Watercourse and Wetland Alteration Regulation, CCME Canada-wide Strategy for the Management of Municipal Wastewater Effluent, Environmental Impact Assessment Regulation
Residential Development	Watercourse and Wetland Alteration Regulation
Agriculture	Environmental Farm Plans, Nutrient management plans,
Forestry	Watercourse and Wetland Alteration Regulation, Crown Land Watercourse and wetland buffer zones

Trends in Water Quality Index Results (2003-2016)

The Water Quality Index has been calculated annually for the Surface Water Monitoring Network data since 2003 using a rolling set of data (results from the latest year are added and results from the oldest year are dropped). Since 2003, the number of stations that fall within each category has fluctuated with a slight upward increase in the number of sites in the excellent and good categories between 2003 and 2007. From 2007 to present, the number of sites in each category has remained relatively constant (Figure 4a). Various factors have influenced these results such as the weather conditions (e.g. a dry year versus a wet year) or improvements made upstream of the sampling sites (e.g. upgrades to municipal wastewater systems, improvements to industrial effluents or restoration of riparian zones), as well as the number of sites sampled in a given year.

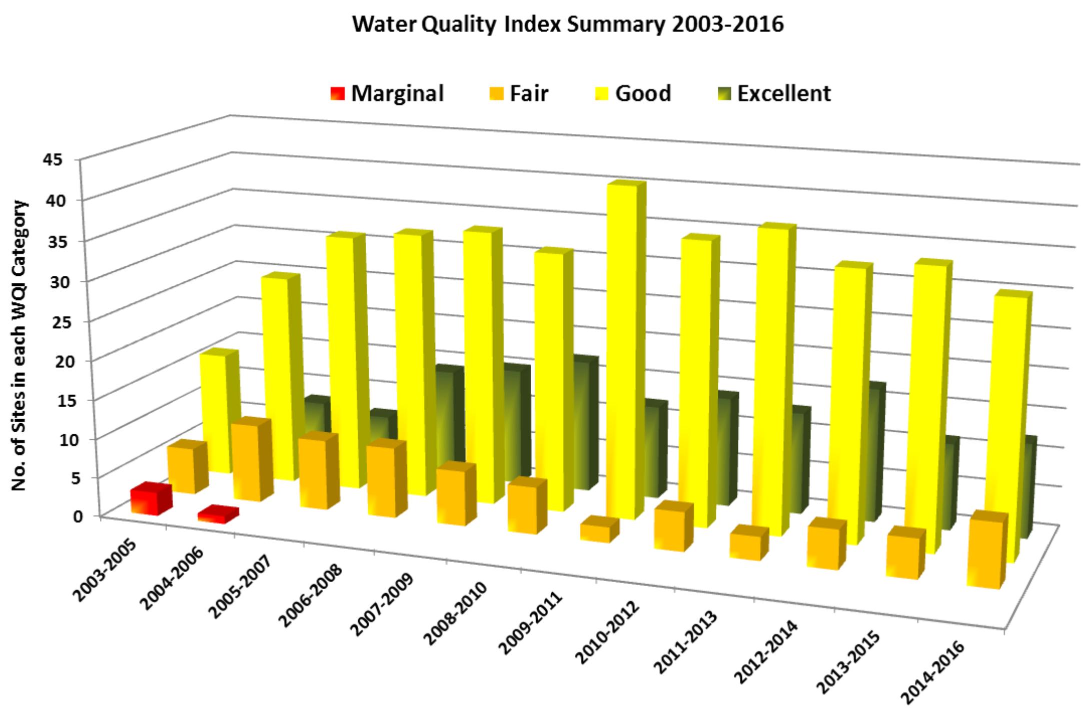


Figure 4a. Water Quality Index scores from 2003-2016 based on data collected through the Surface Water Monitoring Network.

The number of sampling sites has fluctuated due to the addition of new sites early in the monitoring program, the removal of sites due to access issues and interruptions to planned sampling due to weather that may have resulted in a site being sampled less than four times per year and thus could not be included in the WQI calculations

Figure 4b shows the results of the WQI calculated using data obtained from the 23 stations that were consistently monitored since 2003. Between 2003 and 2008, the number of sites within fair category remained relatively consistent over time. In 2009 there was a slight decrease in the number of sites in the excellent category while the number of sites in the good category increased.

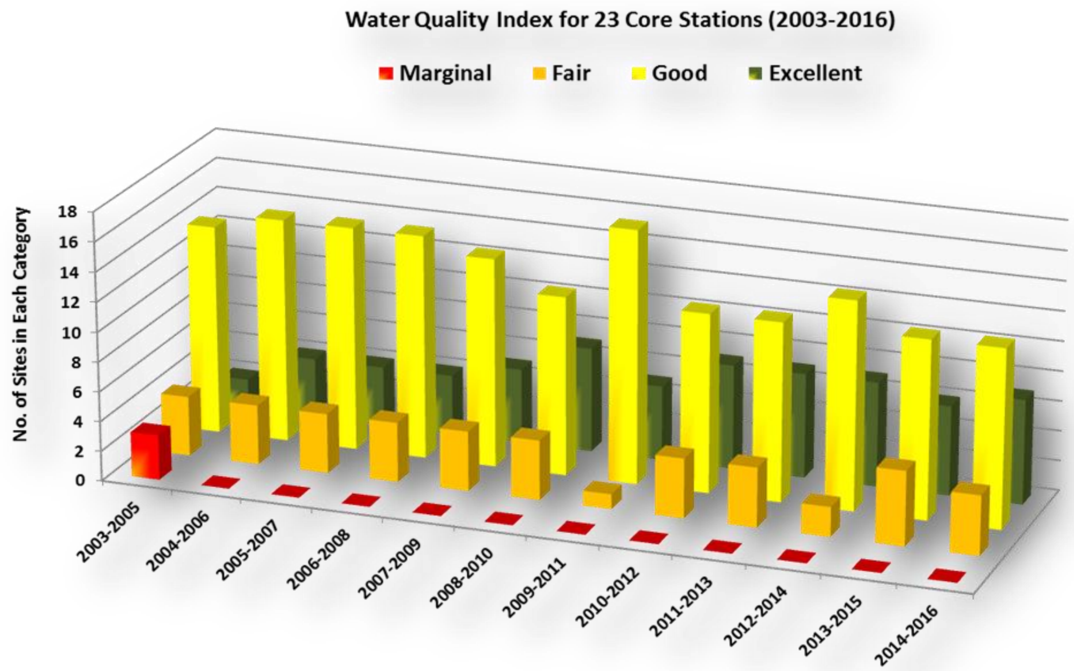


Figure 4b. Water Quality Index scores from 2003-2016 based on data collected through the Surface Water Monitoring Network at 23 sites that were consistently monitored since 2003.

Water Quality Mapping

The following maps illustrate the locations of the monitoring stations along with the concentrations of the key indicators that were chosen for mapping. They include *E. coli*, total phosphorus, dissolved oxygen and pH. The data for the maps was obtained from the 2014 to 2016 SWMN river dataset (55 stations) and the median values of each parameter have been mapped.

Boiestown River - 2016

E. coli

E. coli bacteria are commonly used in water quality testing as an indicator of fecal pollution. These organisms are present in high numbers in the gastrointestinal tract of warm-blooded animals. Wildlife, agricultural runoff, urban storm water and sewage discharges are all potential sources of *E. coli* in surface water. The median concentrations of *E. coli* ranged from 10 MPN/100ml to 180 MPN/100ml, with the highest median concentrations observed in the Saint John River, Kennebecasis River and in the Petitcodiac River. All stations had median concentrations that were below Health Canada's Guidelines for Canadian Recreational Water Quality (Health Canada, 2012) of 400 MPN/100 ml (Figure 5). Note that CCME does not have a guideline for *E. coli* for the protection of aquatic life.

What is the median?

The median can be considered the middle value of a data set, with half the data being less than that value and the other half of the data being greater than that value. The benefit of using median values is that it provides an indication of what a typical or normal value would be for the dataset. For this report, the median was calculated for each sampling location based on data collected between 2014 and 2016 for the parameters presented in Figures 5 through 8.

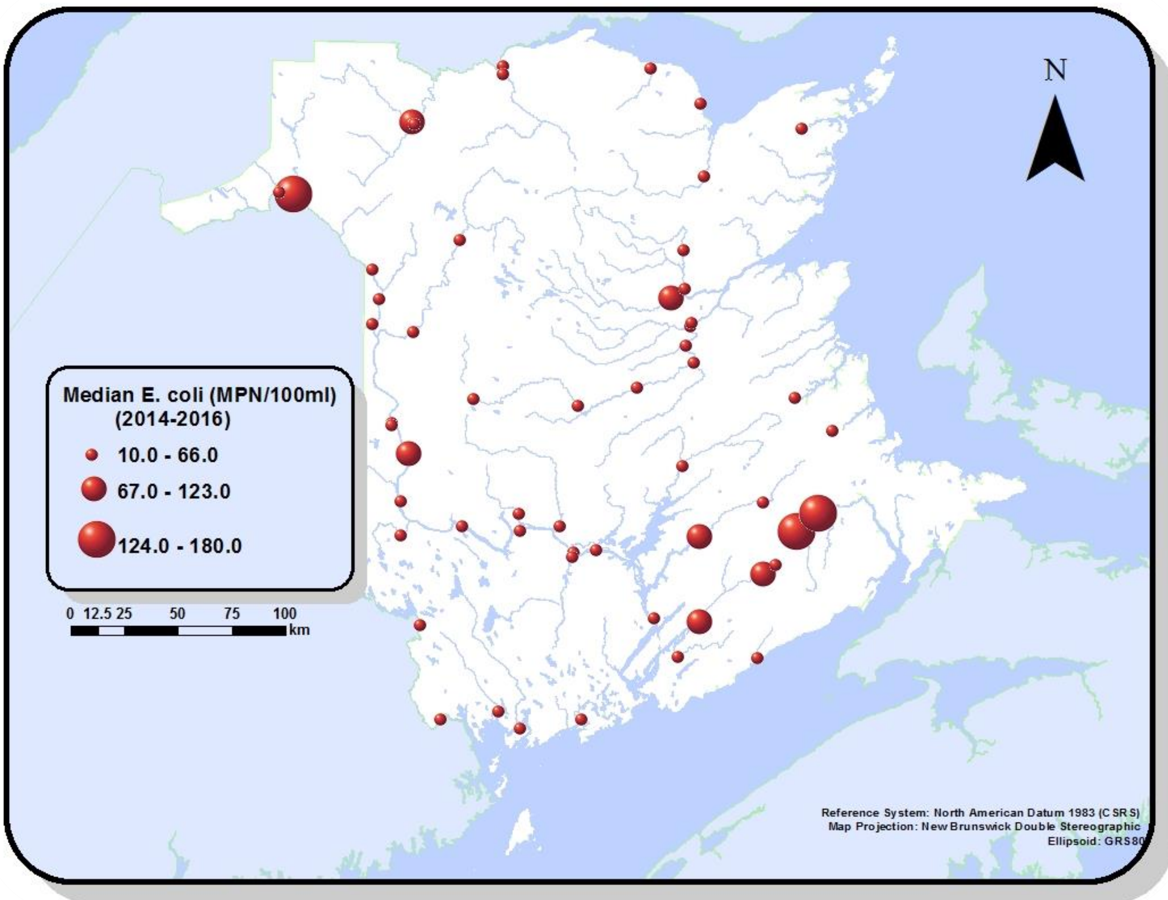


Figure 5. Median *E. coli* concentrations at river monitoring stations between 2014 and 2016.

Total phosphorus

Nutrients such as nitrogen and phosphorus are essential elements for all organisms. However, at elevated concentrations they can lead to nuisance growth of algae in surface waters. In terms of guideline values, DELG uses the Ontario Ministry of Environment's total phosphorus guideline of 0.03 mg/L to reduce the likelihood that algae growth will become excessive (OMOE, 1994). Elevated phosphorus concentrations may be due to point source discharges such as municipal and industrial effluent as well as from non-point sources (e.g. nutrients such as lawn fertilizer carried by runoff from adjacent land and from improperly functioning or undersized on-site sewage disposal systems). The median values ranged from 0.003 mg/L to 0.034 mg/L with most stations having a median total phosphorus concentration below the 0.03 mg/L guideline. Elevated median values of total phosphorus occurred primarily along the Saint John River (Figure 6). The areas with higher concentrations of total phosphorus could experience excessive algae growth.

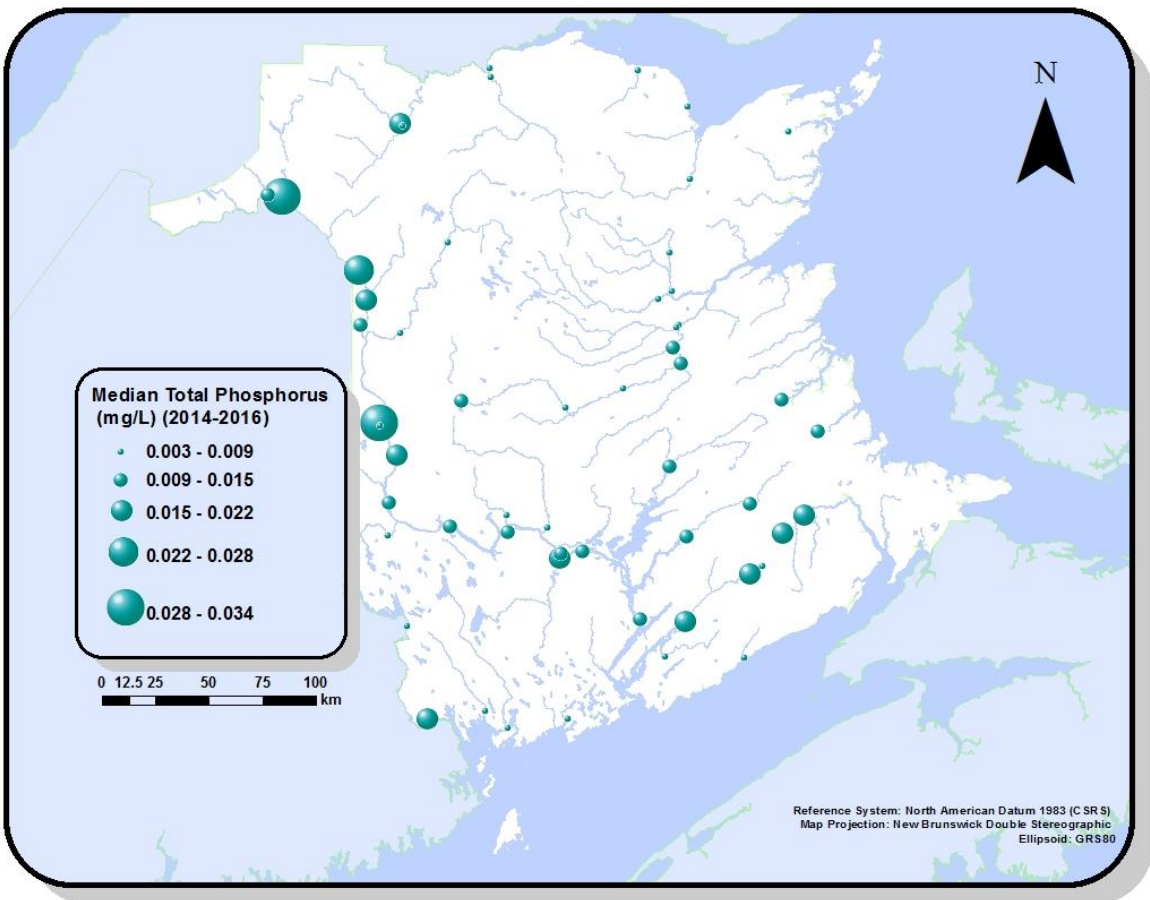


Figure 6. Median total phosphorus concentrations at river monitoring stations between 2014 and 2016.

pH

pH is a measure of the amount of hydrogen ions (H+) in water and is an indication of how acidic or basic water is. Neutral pH is 7, acidic waters have a pH of less than 7 and basic waters have a pH of more than 7. Natural factors such as geology, photosynthesis by aquatic plants, precipitation and inputs from wetlands can influence the pH of rivers. Industrial and municipal wastewater inputs, along with acid rain are other factors that can also affect pH. The CCME guideline for the protection of aquatic life is between 6.5 and 9.0, impacts on aquatic life may occur at pH values outside this range. The median pH values ranged from 6.55 to 8.50 with lower median pH values observed in the Lepreau River, Magaguadavic River, Big Salmon River, Oromocto River and Southwest Miramichi River (Figure 7). Higher pH values are typically found in Northern/Northwestern NB mainly due the underlying geology of the area.

> **Influence of Geology on Water Quality**
>
> Since a watershed is influenced by the underlying geology (rocks and sediments) it is important to factor geology into any water quality assessment. Generally, carbonate-rich and sedimentary bedrock (sandstones, siltstones, shales) are associated with less acidic surface waters (higher pH level), whereas watersheds that contain igneous bedrock (granite, volcanic rock) may have more acidic (lower pH level) surface waters.

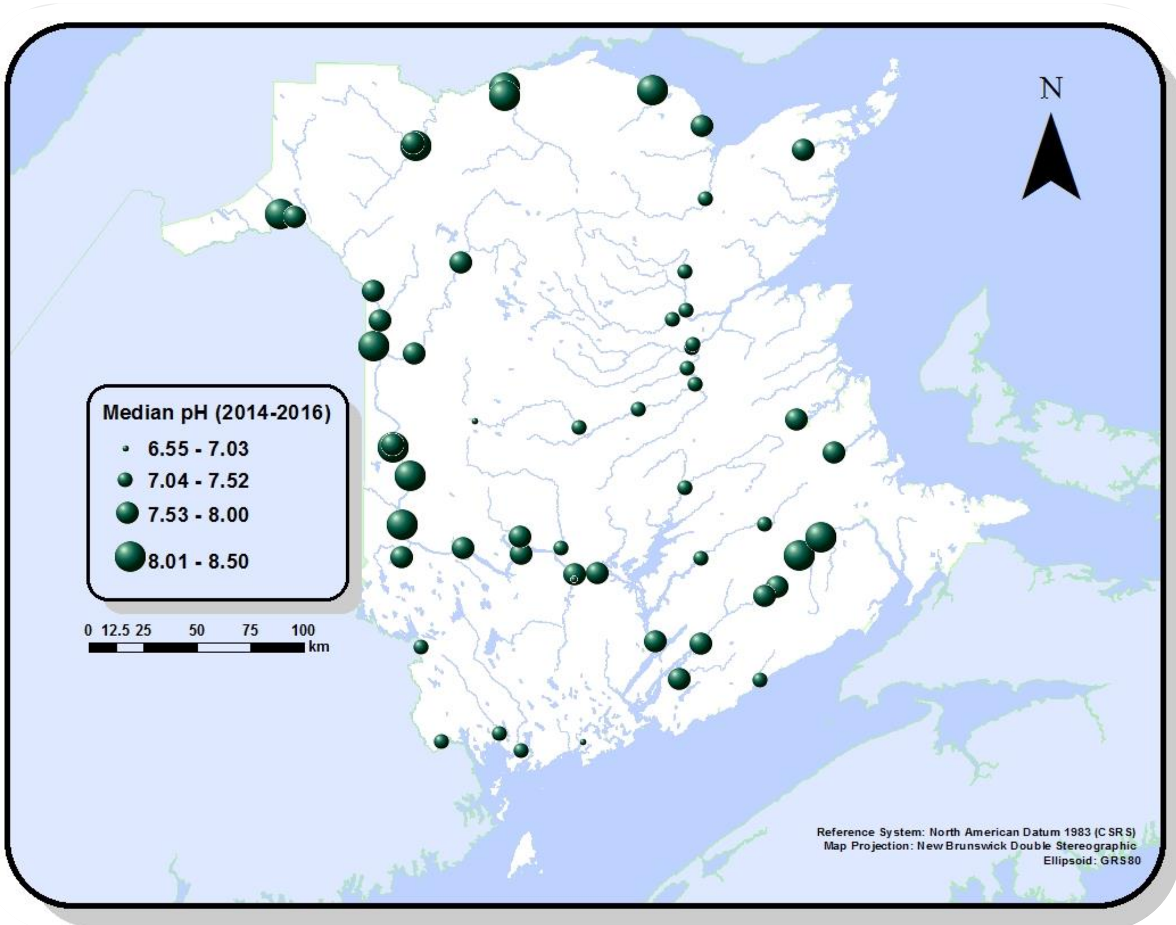


Figure 7. Median pH values at river monitoring stations between 2014 and 2016.

Dissolved Oxygen

Dissolved oxygen is crucial for the survival of aquatic life. Sources of dissolved oxygen in water include atmospheric exchange as well photosynthesis from aquatic plants. Temperature, winds, currents, groundwater input and inflowing water all influence oxygen concentrations. Inputs from point and non-point sources can reduce the amount of available oxygen. The CCME guideline for the protection of aquatic life is 6.5 mg/L and impacts on aquatic life may occur at any concentrations below this value. Between 2014 and 2016, median dissolved oxygen concentrations ranged from 8.55 mg/L to 12 mg/ (Figure 8) and did not exceed the CCME guideline.

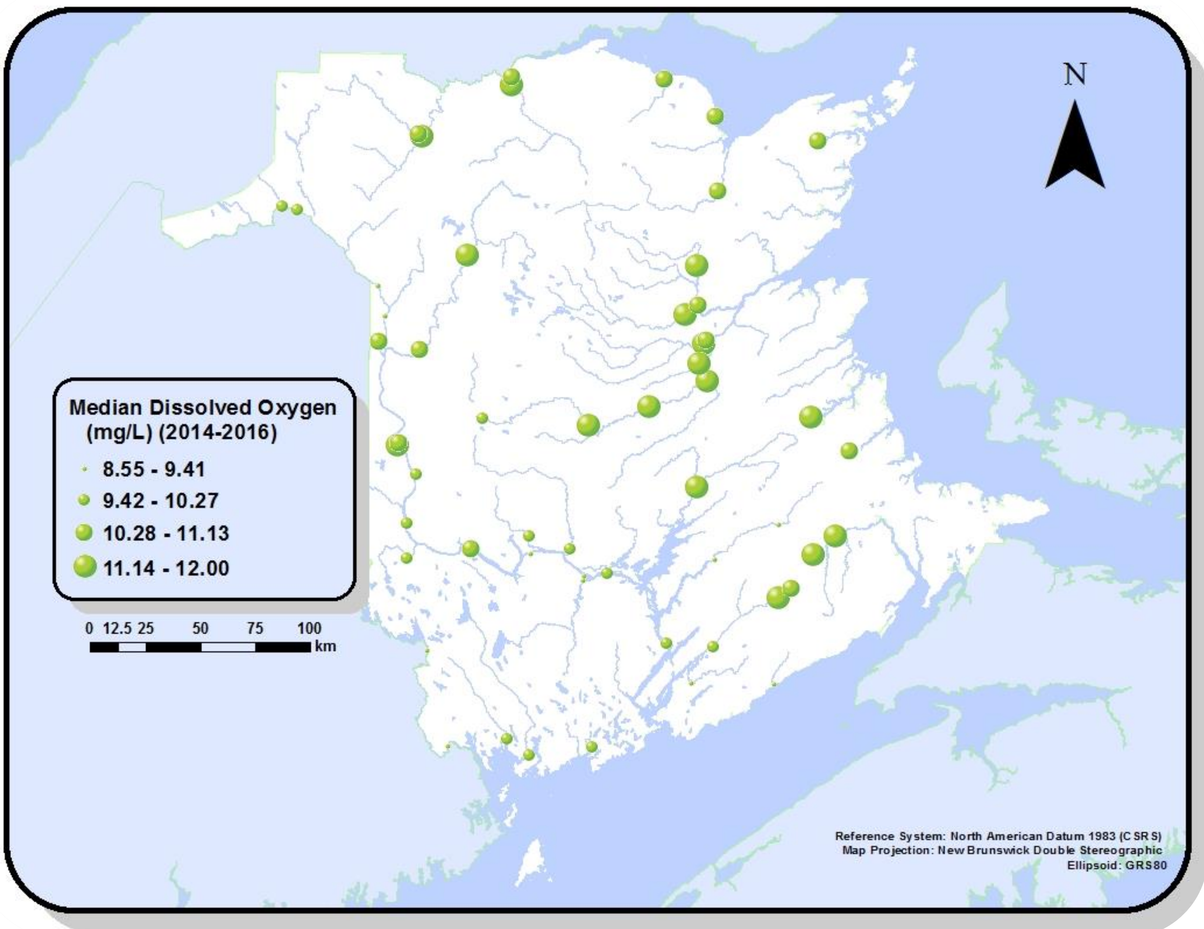


Figure 8. Median dissolved oxygen concentrations at river monitoring stations between 2014 and 2016.

Lake water quality monitoring

DELG has monitored lake water quality for the past 40 years and this has included monitoring for ambient conditions and monitoring as part of the Acid Rain Lakes Program. This section will describe results from the 40 lakes that have been monitored for ambient water quality between 2005 and 2016 (Figure 9). Each year a subset of approximately 10 to 12 of the 40 lakes are sampled twice per year, once in the summer and once in the fall, at multiple stations on each lake. Water samples are collected at various depths through the water column depending of the objectives of the assessment. The water samples are analyzed for the parameters listed in Table 2 with the addition of chlorophyll *a* and Secchi depth.

Lake Partnerships

DELG collaborates with various research entities to increase the knowledge on New Brunswick's lakes. Past work with the Canadian Rivers Institute has included research to understand the triggers of cyanobacteria blooms and assessing the state of New Brunswick's lakes via the collection of fish, benthic macroinvertebrate, and water quality data.

The Department has also partnered with the Natural Sciences and Engineering Research Council of Canada's (NSERC) Canadian Lake Pulse Network whose research will determine what the state of Canada's lakes are, how have they changed and how will they change in the future.

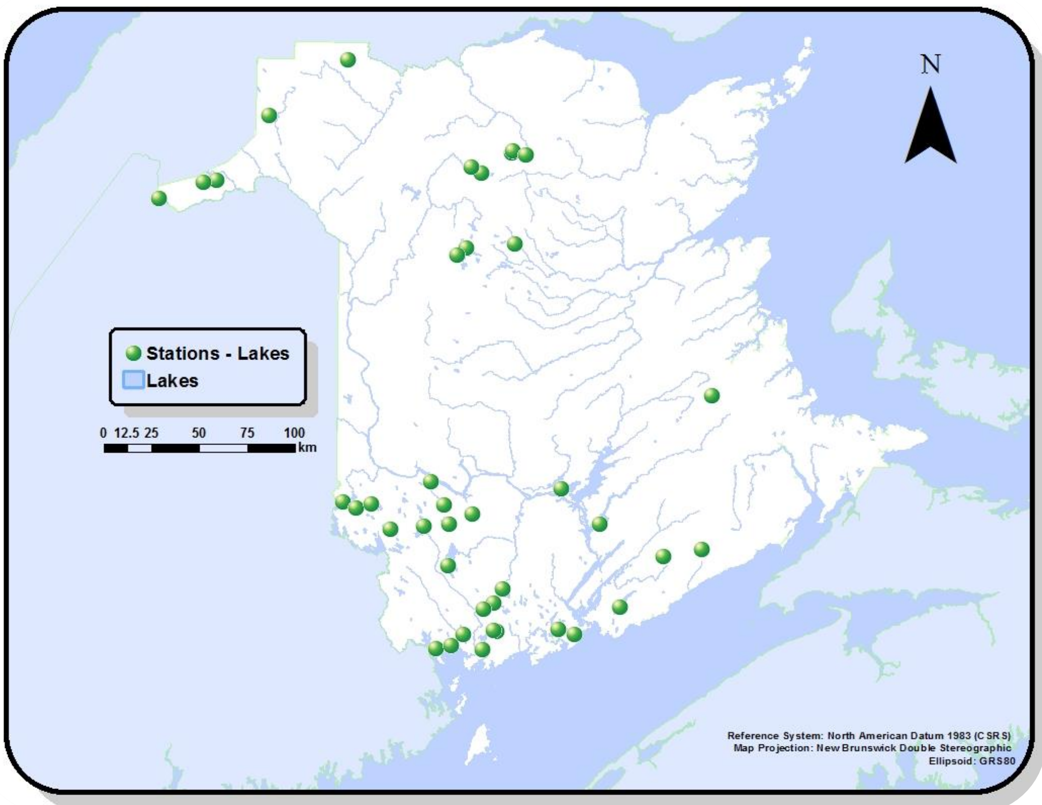


Figure 9. Lakes that were monitored for ambient water quality between 2005 and 2016.

Along with water samples, dissolved oxygen and temperature are measured at the deepest part of each lake at one meter vertical intervals to provide a depth profile. In the Chamcook Lake profile example (Figure 10), the dissolved oxygen and temperature both decrease as depth increases. It is common to find low oxygen concentrations to occur near the bottom of lakes in the late summer. This can be due to a number of factors such as the lake not being easily mixed by wind and the decomposition of organic material which reduces available oxygen in the water. Very low dissolved oxygen (less than 4mg/L) for extended periods of time can lead to impacts on aquatic life (fish kills). However, based on the data DELG has collected from

New Brunswick's lakes, dissolved oxygen concentrations are typically very good, and fish kills due to low oxygen concentrations have not been observed.

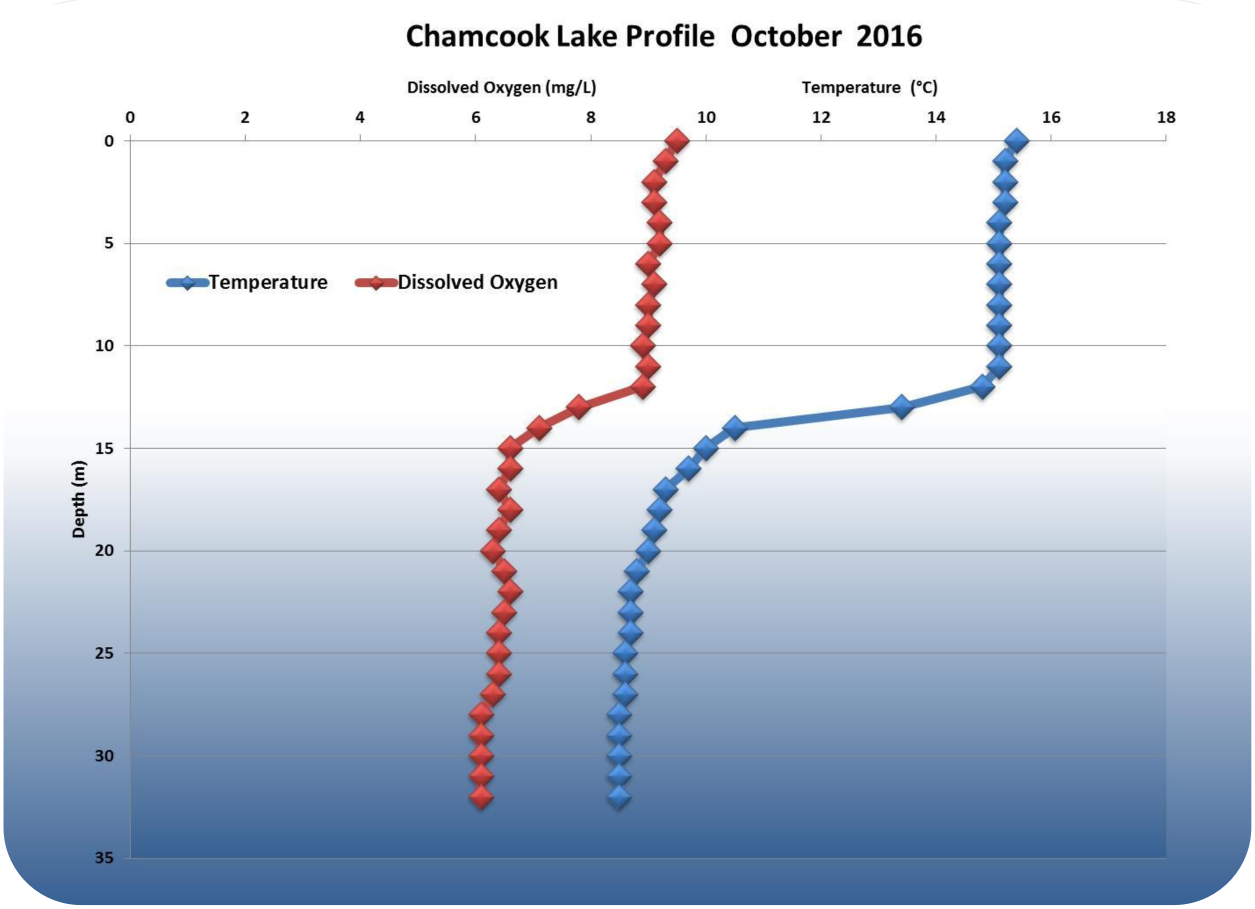


Figure 10. Dissolved oxygen and temperature profile at Chamcook Lake October 2016.

Acid Rain Lakes Monitoring Program

Acid precipitation, or acid rain, is caused when atmospheric pollution (sulfur dioxide and nitrogen oxide causes precipitation to become sufficiently acidic to have adverse impacts on water quality and aquatic life. Due to the low buffering capacity of regional bedrock and an abundance of wetlands that produce organic acids, Atlantic Canada has some of the most acidic waters in Canada. Furthermore, the provinces that are part of the Canadian Precambrian Shield, like Ontario, Quebec, New Brunswick and Nova Scotia, are hardest hit because their water and soil systems do not have the capacity to neutralize the acid precipitation and are therefore more vulnerable to acid deposition (Government of Canada, 2018).8). The extent of chemical alteration resulting from acidic deposition depends largely on the type and quantity of the soils and the nature of the bedrock material in the watershed, as well as on the amount and duration of the precipitation (Environment and Climate Change Canada, 2013).

Watersheds with soils and bedrock containing substantial quantities of carbonate-containing materials, such as limestone and calcite, are less affected by acidic deposition because of the high acid-neutralizing capacity derived from the dissolution of this carbonate material (Environment and Climate Change Canada, 2013). The impacts from these acidic compounds in the atmosphere can occur directly, by deposition on the water surface, or indirectly, by contact with one or more components of the terrestrial ecosystem before reaching any aquatic system. The interactions of acid deposition with the terrestrial ecosystem, including vegetation, soil, and bedrock, result in chemical alterations of the waters draining these watersheds, eventually altering conditions in the lakes downstream (Environment and Climate Change Canada, 2013).

In New Brunswick, the Acid Rain Lakes Monitoring Program, is a collaboration between the Department of Environment and Local Government and Environment and Climate Change Canada and began in 1984 with a set of lakes in the province that were identified as sensitive to acidic precipitation inputs. These were sampled periodically via helicopter between 1984 and 2006 with the total number lakes sampled in each survey ranging between 23 and 98 lakes. The lakes were monitored for general chemistry, metals and on occasion total and methyl mercury.

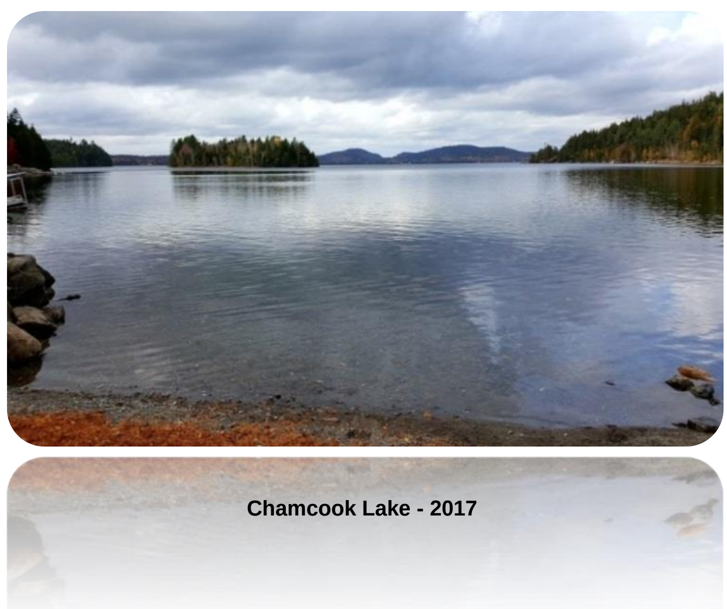
Based on an assessment of data collected from the southern lakes between 1986 and 2001, there was a decline in acid deposition and lakes were exhibiting signs of improvement in terms of decreased sulphate concentrations and increased calcium concentrations, pH levels and the capacity to neutralize acids (Pilgrim et. al, 2003). Additionally, the 2016 Air Quality Monitoring Results report shows a 77% reduction since 1989 in the concentration of key acid precipitation indicators (nitrate and sulphate) (GNB, 2019).

Trophic Status and Nutrients in New Brunswick's Lakes

Lakes are typically classified according to their trophic state, which reflects the physical and biological processes that take place within the waterbody; the word "trophic" refers to nutrition and growth. The water of a eutrophic ("well-nourished") lake contains a great deal of nutrients, supports abundant aquatic life and its productivity (rate of generation of biomass by photosynthesis) is high. An oligotrophic lake has low nutrient concentrations, low productivity and few plants. The characteristics of mesotrophic lakes are somewhere in between the eutrophic and oligotrophic categories. Each lake has a unique set of attributes that contribute to its trophic status. These include:

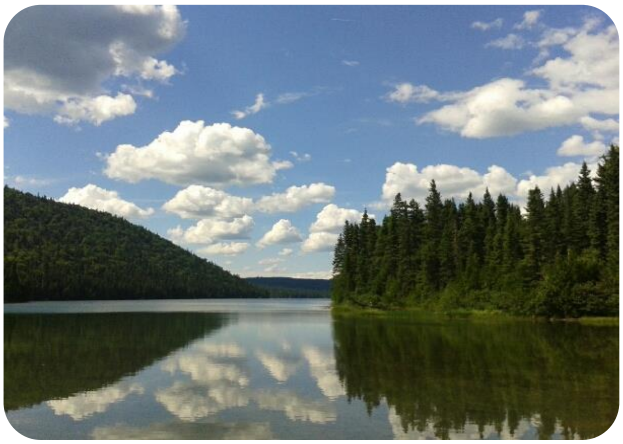
- The rate of nutrient supply (affected by bedrock, soils, surrounding vegetation, human influences);
- The climate (amount of sunlight, temperature, precipitation); and
- The shape (morphology) of the lake basin (water depth, volume, surface area).

Lake succession is a term used to describe the process by which a lake moves from one trophic state to another. It has been compared to an "aging process" in which the "young" oligotrophic lakes that existed following the most recent period of glaciation become mesotrophic over geologic time and eventually become "old" eutrophic lakes. The end point of this succession is a wetland, or bog, and eventually the lake is filled with sediment and becomes dry land. In nature, this succession is not necessarily linear or inevitable.



Chamcook Lake - 2017

Oligotrophic lakes have persisted for thousands of years. That said, lakes can “age” prematurely due to human influences. Eutrophication caused by human influences typically occurs relatively rapidly and results in the excess growth of algae and plants, diminished lake clarity, and lower dissolved oxygen concentrations which can have impacts on aquatic life and the use and enjoyment of a lake. In order to determine the trophic status of a lake it is important to monitor its nutrient concentrations. Nutrients, such as nitrogen and phosphorus, are essential elements for all organisms but at elevated concentrations they can lead to nuisance growth of algae in surface waters.



State Lake - 2013

Bathurst Lake - 2013

Figure 11 illustrates the trophic state of lakes based on the median concentration of total phosphorus measured between 2005 and 2016. For the most part, the lakes sampled are oligotrophic and have low productivity. Washademoak and French Lake both have the highest median total phosphorus concentrations putting them both in the mesotrophic category. A more detailed assessment is needed in order to determine what is causing the difference in total phosphorus concentrations in these two lakes compared to the others.

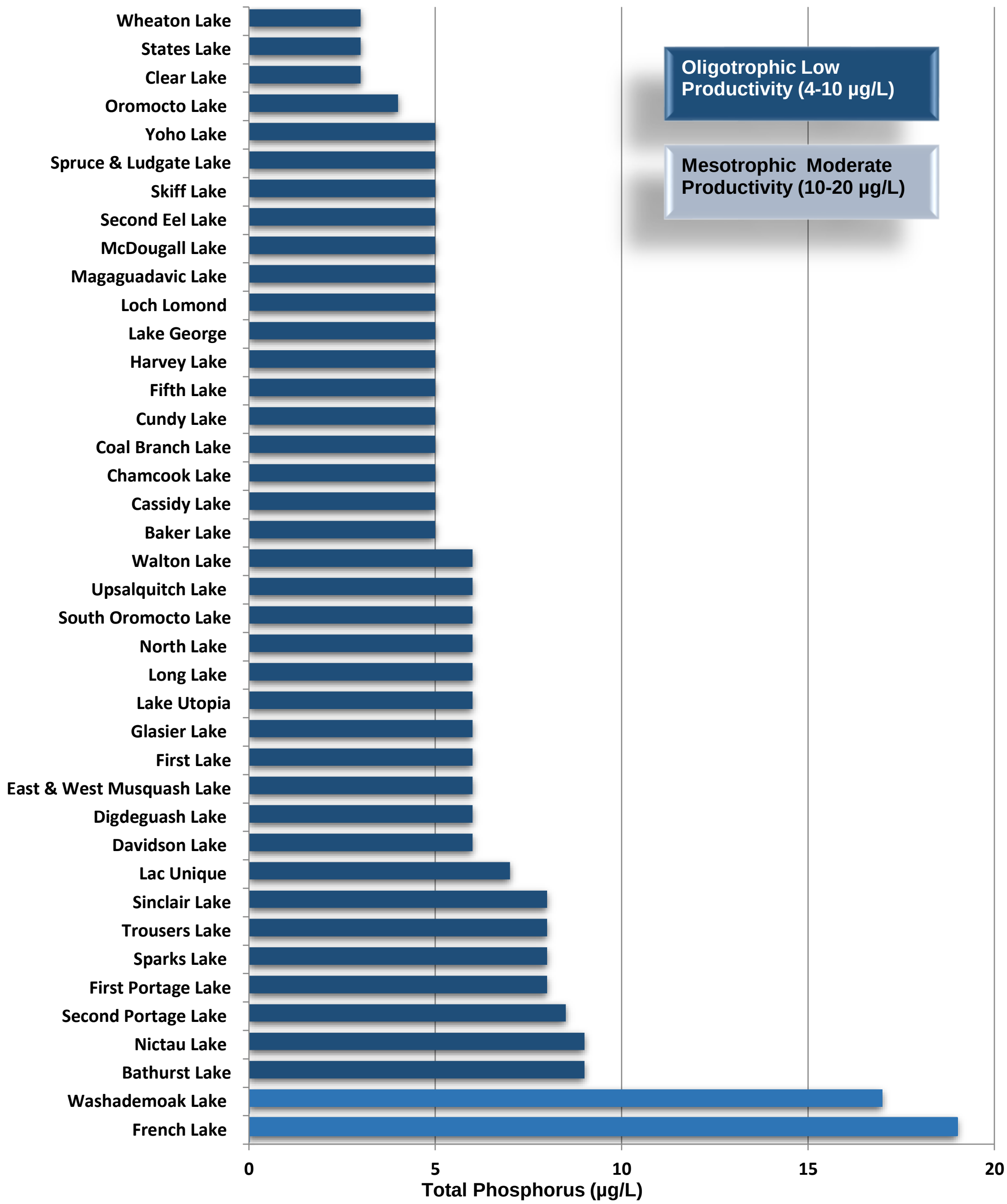


Figure 11. Trophic state of lakes based on median total phosphorus concentrations between 2005 and 2016 in New Brunswick.

Biomonitoring

Aquatic biomonitoring examines organisms that live in water. This helps to interpret the health of the ecosystem. Algae, fish, aquatic plants, zooplankton, and benthic macroinvertebrates can be used in biomonitoring as they are sensitive to changes within aquatic ecosystems. DELG uses benthic macroinvertebrates (BMI) in conjunction with water chemistry sampling to provide a more thorough assessment of water quality. BMI include the insects that live within streams (Figure 12) and can be influenced by a wide range of environmental impacts such as point and non-point sources of pollution, changes in water quantity, habitat alterations, and climate change. The BMI community found in a waterbody can reflect the influences that are impacting a sampling location. For example, if a sampling site is impacted by pollution then the most sensitive invertebrates will be not be present and this provides an indication that further assessment may be needed to understand the source of impacts to the ecosystem.

DELG participates in the Canadian Aquatic Biomonitoring Network (CABIN) in partnership with Environment and Climate Change Canada and utilizes the associated CABIN method to conduct aquatic biomonitoring. CABIN is a nationally recognized standardized method and allows DELG to contribute to a national database along with other organizations. In return DELG can access data that other organizations have collected and makes DELG's participation in CABIN very beneficial as it allows sharing of data between CABIN partners. Older data that was collected before the CABIN method was adopted has been used in the development of an Atlantic Reference Model for CABIN. Various watershed groups and other non-governmental organizations in New Brunswick have been using CABIN as part of monitoring projects that have been funded through the New Brunswick Environmental Trust Fund.

Figure 12. These examples of benthic macroinvertebrates are found in New Brunswick's rivers and streams and are sensitive to pollution. Their presence at a sample location reflects good water quality. Caddisfly larva (top) and stonefly larva (bottom left and right).

Overview of the Canadian Aquatic Biomonitoring Network (CABIN)

The following information was provided by Environment and Climate Change Canada.

The Canadian Aquatic Biomonitoring Network (CABIN) provides nationally consistent methods for the collection of benthic invertebrate communities to assess the biological condition of aquatic habitats. Standard protocols, online tools and formal training have made the program accessible to interested watershed stakeholders and enable collected data to be shared, resulting in more reliable assessments.

The bulk of CABIN participants in New Brunswick have been actively collecting samples since 2007 through various partner organisations. The earliest study conducted was in Fundy National Park in 2002 and 2003.

As of 2016, over 530 samples in 285 locations have been collected throughout the province by the federal and provincial governments, watershed stewardship groups, First Nations, and academic researchers (Figure 13). As a result, partners have been able to establish baselines and develop reference condition models to assess biological condition, assess the effectiveness of remedial projects, and conduct aquatic ecological research. CABIN data can be accessed [here]

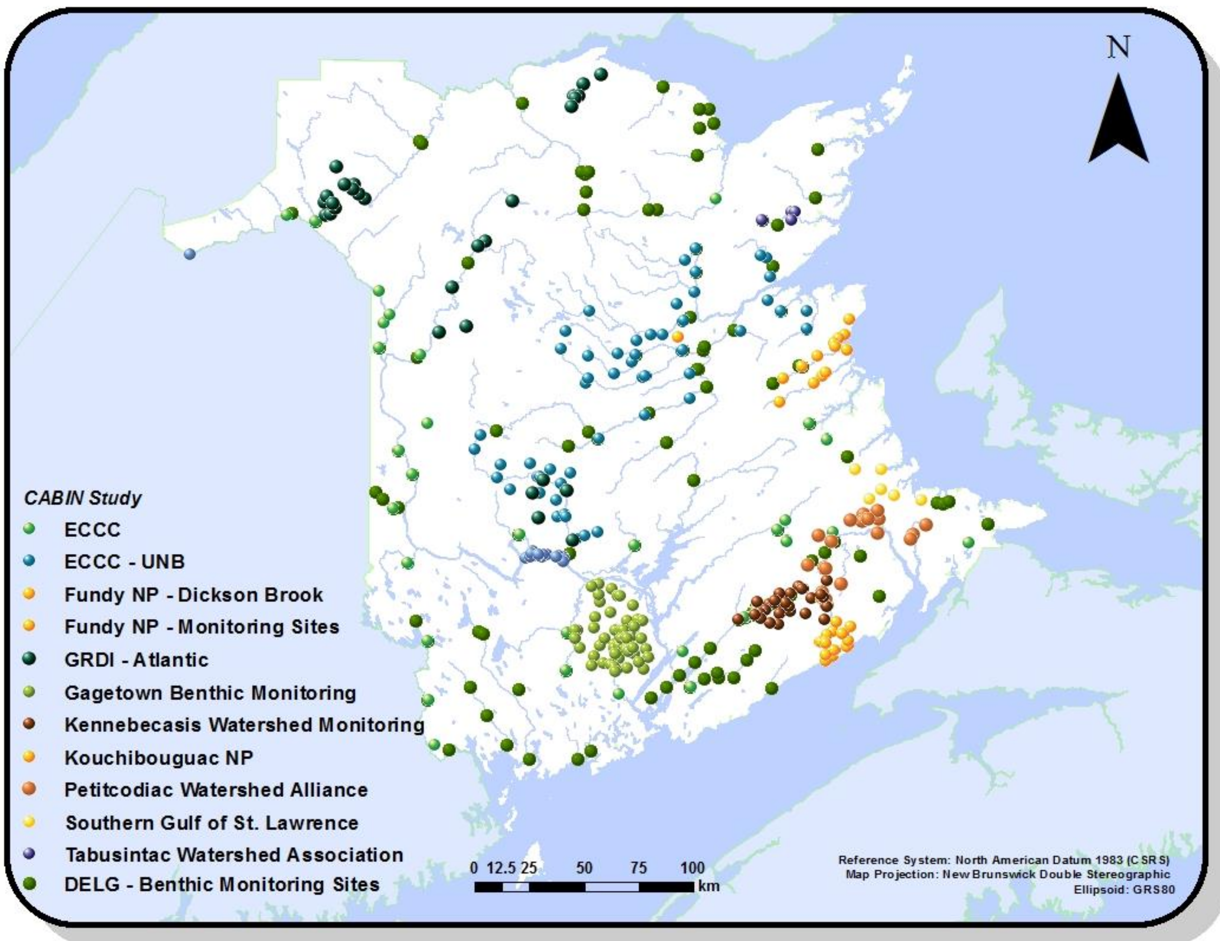


Figure 13. Locations of samples collected by CABIN partners between 2002 and 2016.

Monitoring Partnerships

Canada-New Brunswick Water Quality Agreement

The Canada-New Brunswick Water Quality Agreement is a federal-provincial partnership that is intended to provide support and build capacity for water quality and aquatic ecosystem monitoring as well as reporting requirements for the Canadian Environmental Sustainability Indicators (CESI) annual report. The agreement began in 1988 with various subsequent updates and involves Environment Canada (now Environment and Climate Change Canada - ECCC) and the New Brunswick Department of Environment and Local Government. Each year shared activities within the agreement are determined based on discussions between ECCC and DELG.

Monitoring Partnerships

For more information on various Government of Canada programs and initiatives that are related to surface water please visit the following websites:

- Canadian Aquatic Biomonitoring Network (**CABIN**)
- Canadian Environmental Sustainability Indicators (**CESI**)

Real Time Water Quality:

- Annual Automated Water Quality Monitoring Report. **Big Presque Isle Stream**
- Annual Automated Water Quality Monitoring Report. **St. Croix River at Forest City Dam**

Past and current projects have included:

- Benthic Macroinvertebrate monitoring in New Brunswick rivers
- Increased frequency of river water quality monitoring within transboundary/international waters
- Development of site-specific guidelines for aluminum in NB surface waters
- Public reporting on “near” real time water quality data

Monitoring by Watershed Associations

The Department of Environment and Local Government partnered with watershed organizations in 1998 to help the department implement water quality monitoring. Between 1998 and 2012, nineteen watershed organizations participated in a number of two-year baseline water monitoring partnerships with DELG. This included monitoring *E. coli*, benthic macroinvertebrate populations, and the inorganic chemistry parameters that are listed in Table 2. DELG provided training for the staff and volunteers of each watershed organization to ensure that sampling was properly performed and offered guidance in choosing the number and locations of sampling sites within the watersheds. Monitoring was funded through the Environmental Trust Fund (ETF).

Many of these organizations continued to monitor water quality beyond the initial two-year framework and continue to receive support from the ETF. In some cases, these watershed organizations have chosen to monitor areas of interest within a watershed rather than to continue to sample all the original monitoring sites. This site-specific sampling has proven useful for monitoring the impacts of point or non-point source pollution, impacts of development on water quality, and assessing the effects of restoration work. Data resulting from the samples submitted by watershed

Watershed Factsheets

An example of how DELG has used the water quality data that was collected as part of the partnership with watershed groups is a series of watershed factsheets that were published on DELG’s website. The factsheets contain information on climate, geology, land use and a summary of water quality results. For more information please visit the following website: **Watershed Factsheets** organizations are stored within DELG's database and are used by the department in assessing the water quality throughout the province. DELG is looking at ways to make this information public with the goal of sharing knowledge about water

Volunteer Lakes Monitoring Program

In 2012, five lake associations worked collaboratively with the Department of Environment and Local Government to coordinate a Volunteer Lakes Monitoring Program (VLMP). The five lakes were: Yoho Lake, Lake George, Davidson Lake, Harvey Lake and Magaguadavic Lake. In 2013, the monitoring program was expanded by adding Oromocto Lake. In 2012 and 2013, this collaborative group received Environmental Trust Fund support to purchase water quality monitoring equipment and training was provided by DELG staff to the lake association volunteers. Annual monitoring continues and in 2016, associations representing Chamcook Lake, Lac Unique and Baker Lake joined the VLMP.

When the program began in 2012, the water quality parameters that were being monitored as part of the partnership included: temperature, dissolved oxygen, and Secchi depth. This was expanded to include conductivity and pH in 2013. Monitoring primarily occurs between the months of June and September at multiple sites within each lake.

New Brunswick Alliance of Lake Associations (NBALA)

The NBLA formed in 2013 to support citizen-based lake stewardship in New Brunswick. The Alliance currently consists of 11 lake associations of which many conduct annual water quality assessments through the Volunteer Lake Monitoring Program as well as promote lake stewardship activities and educate lake residents on how to protect and improve their lakes. For more information please visit the following website: **NBALA**

Example of Volunteer Lake Monitoring Program Data

Since 2012, a large amount of lake water quality data has been collected at the nine lakes that are part of VLMP. Yoho Lake was chosen as an example for the current report to illustrate the types of data the VLMP volunteers collect. The assessment of this data set will be included in future versions of the "The State of Water Quality in New Brunswick's Lakes and Rivers" report.

The Yoho Lake Association has monitored four stations within their lake since 2012 on a biweekly basis from May until September (Figure 14). Dissolved oxygen (DO) and temperature data from the Yoho Lake north end station are shown in Figures 15a and 15b, respectively. Water temperature ranges from 10 ºC in May to a high of 22.4 ºC in July at the north end of Yoho Lake (Figure 15a). Water temperature remains uniform throughout the water column at the north end of Yoho Lake which is expected as the lake is quite shallow at this station. The lowest DO level measured was 7.3 mg/L on August 15, 2016 while the highest DO level was 11.9 mg/L on May 13, 2016.

CCME has established Guidelines for the Protection of Freshwater Aquatic Life, and the guideline for DO is 6.5 mg/L. All DO levels met the CCME guideline at this station during the 2016 field season. In general, lower water temperatures coincide with higher levels of dissolved oxygen and these results conform to this expectation.

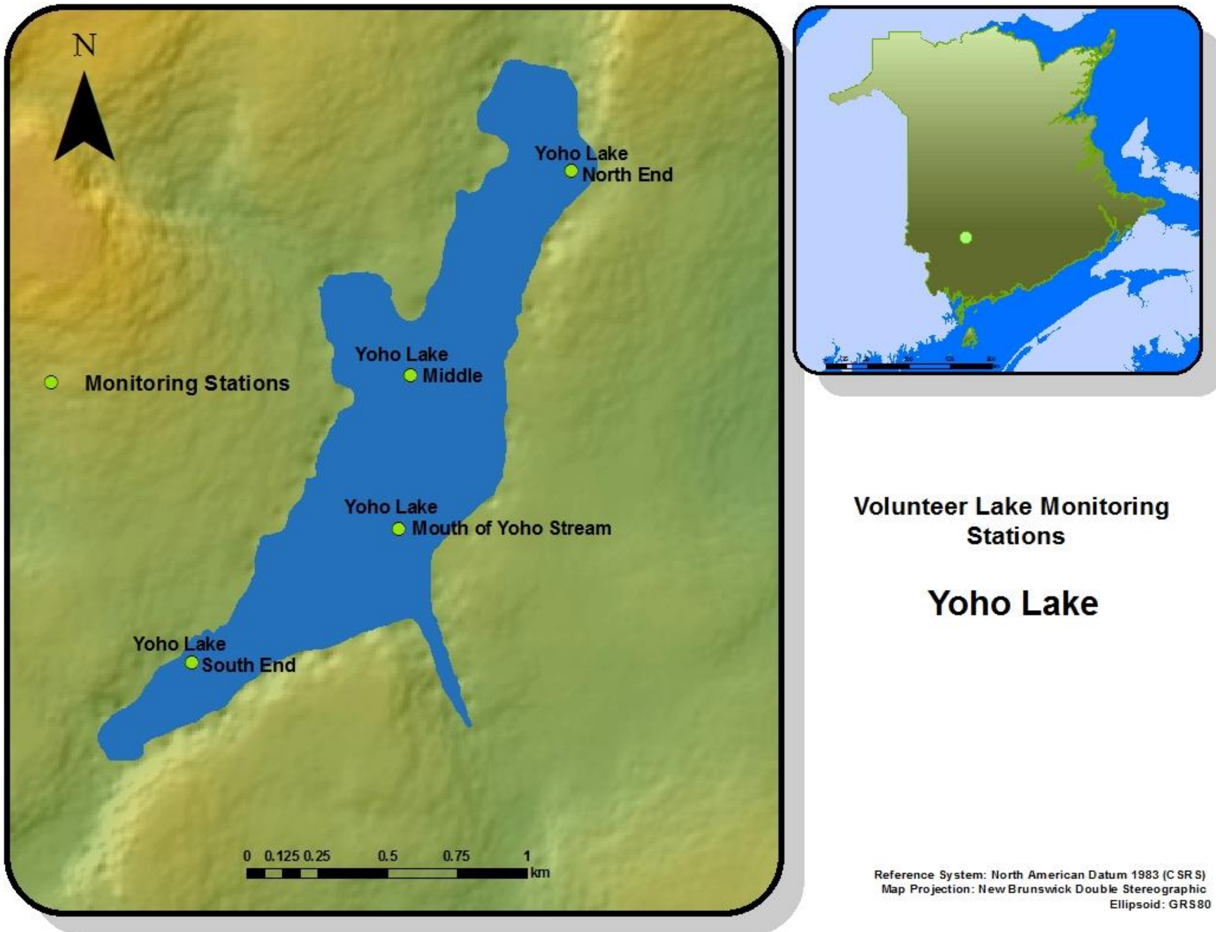


Figure 14. Yoho Lake Monitoring Locations in Southwestern New Brunswick.

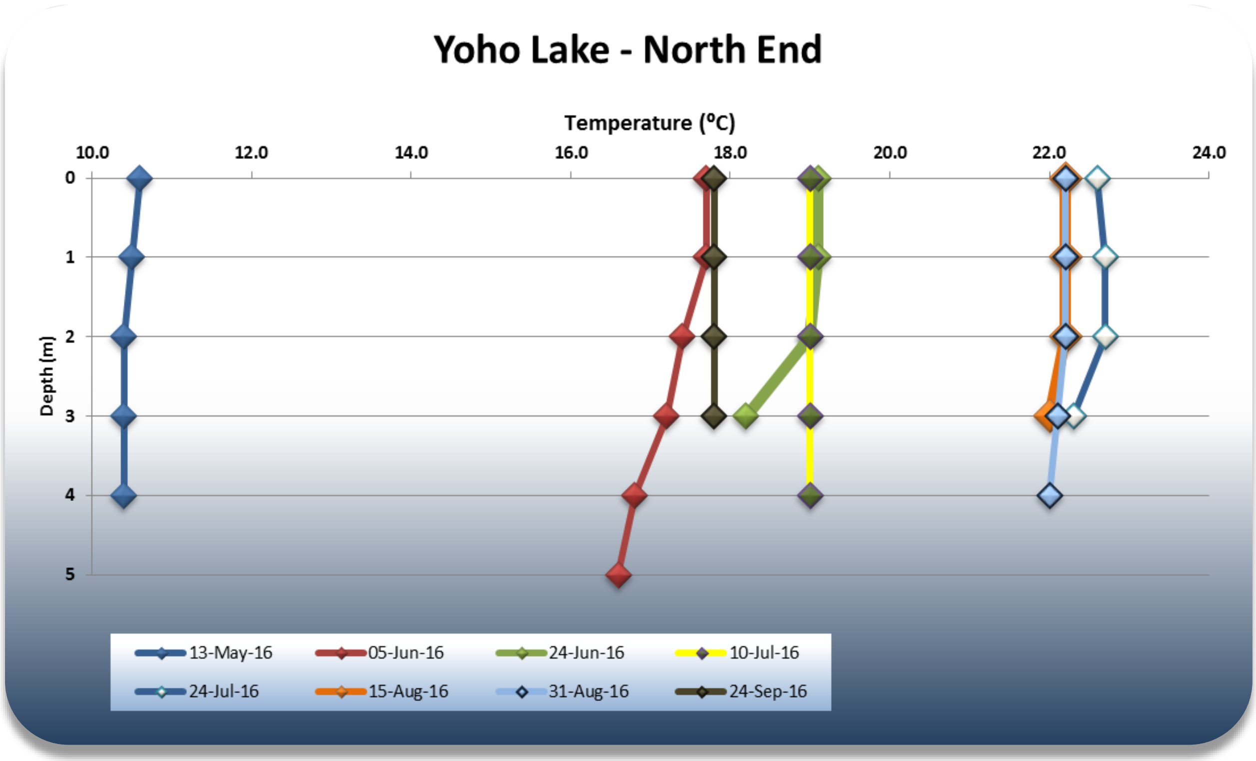


Figure 15a. Water temperature at Yoho Lake North End station in 2016.

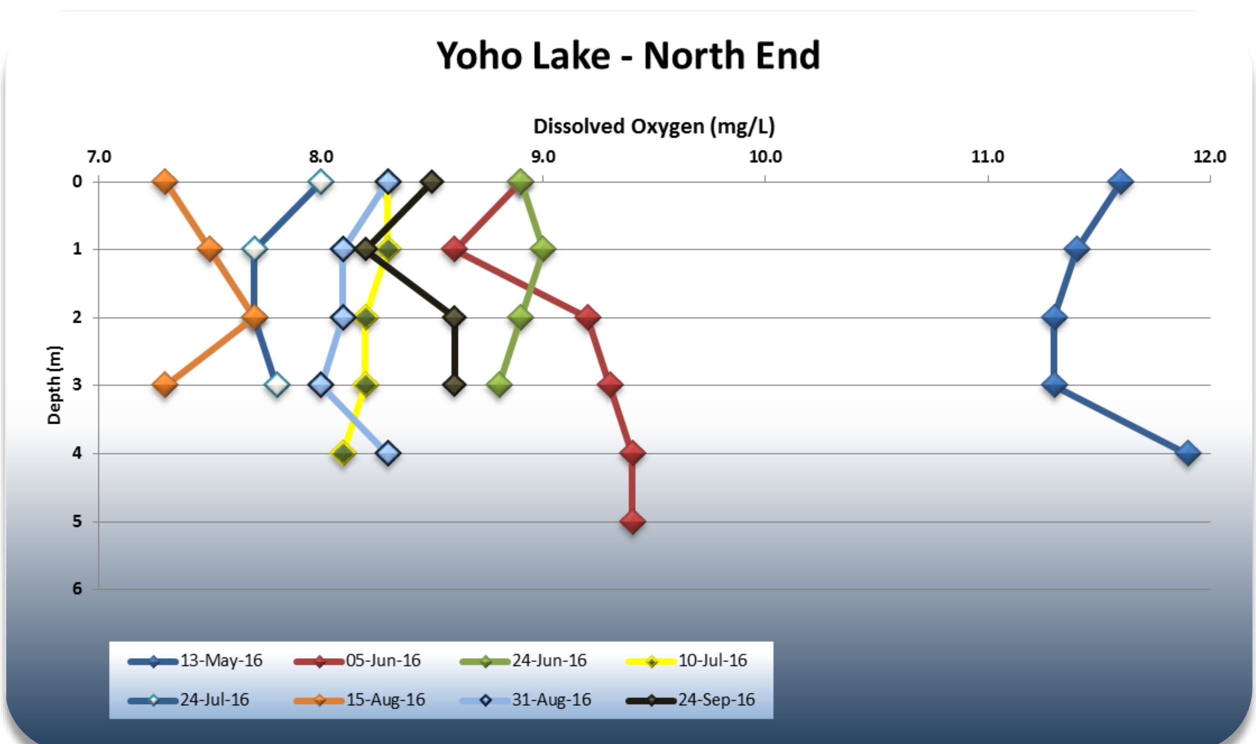


Figure 15b. Dissolved Oxygen at Yoho Lake North End station in 2016.

Additional Water Quality Monitoring Programs

Industrial and Municipal Monitoring Overview

Water quality monitoring at specific sector point-source discharges, is regularly undertaken by facility operators prior to entering the aquatic environment as required under the terms and conditions set in their Approvals to Operate. DELG's Authorizations Branch is responsible for regulating sources of contaminants from sectors which include industrial, institutional, municipal and commercial operations to ensure they are managed in accordance with provincial environmental legislation. This is accomplished by using various regulatory tools (such as standards, approvals, and permits) and through auditing to measure compliance.

Madawaska River - 2016

The *Water Quality Regulation* and *Used Oil Regulation* under the *Clean Environment Act* require that the owners and/or operators of a source of any contaminant that is released to the environment must apply for and obtain an Approval for the construction, operation and modification of the source. The Department issues Approvals to Operate which specify the standard terms and conditions that individual operations must meet in order to be in compliance with the department's environmental legislation and regulations. Effluent discharge limits can be imposed which limit the nature and number of contaminants that can be released from such sources in order to prevent environmental degradation.

All water quality monitoring information collected by facility operators is submitted to the department on an annual basis. This information is then evaluated by the department to assess compliance with effluent discharge limits established in the respective Approvals to Operate.

Monitoring results from the municipal drinking water sector are submitted to the department directly by the laboratory conducting the analysis into an internal electronic data management system. The department is currently investigating the expansion of the electronic data management system to other sectors to ensure a consistent approach to data management and reporting.

CCME Municipal Wastewater Strategy

In 2009 the Canadian Council of Ministers of the Environment (CCME) developed a *Canada-wide Strategy for the Management of Municipal Wastewater Effluent*. The Strategy ensures that wastewater facility owners will have regulatory clarity in managing municipal wastewater effluent under a harmonized framework that is protective of human health and the environment. The Strategy requires that all facilities achieve minimum national standards and develop site-specific discharge objectives.

These objectives will provide additional human health and environmental protection where needed and include pollutants such as pathogens, nutrients and metals.

Since the Strategy was released, municipalities have been funded through New Brunswick's Environmental Trust Fund (ETF) to complete Environmental Risk Assessments (ERA) as part of the Strategy. An ERA consists of initial characterization of the effluent and considers the characteristics of the receiving environment and mixing that occurs in an allocated mixing zone as well as establishing site specific objectives.

For more information on the Strategy, visit: **Municipal Wastewater Effluent**

In addition, DELG staff collects point-source effluent samples from a variety of facilities on a routine basis to compare with the sector-specific data and to verify compliance with effluent discharge limits established in the facility's Approval to Operate. Table 1 provides details on sectors that are required to conduct point-source effluent monitoring, the associated parameters that are typically measured along with the frequency of monitoring to assess overall compliance.

Table 1. Information on industrial and municipal monitoring conducted by various sectors.

Sector	Typical Parameters Monitored at Point-Source	Typical Monitoring Frequency by Operators
Base Metal Smelting	Cadmium, Copper, Zinc, Lead, Arsenic, pH	Daily
	Fish Toxicity	Quarterly
Bioremediation	Benzene, Toluene, Ethylbenzene, and Xylene (BTEX), Modified Total Petroleum Hydrocarbons (TPH)	Monthly
Chemical Manufacturing	Metals, Oil and Grease	Weekly
	Fish Toxicity	Annually
Food Processing	Biological Oxygen Demand (BOD), Total Suspended Solids (TSS), Nutrients, pH	Twice per week
	Fish Toxicity	Quarterly
Inland Fish Hatcheries	Total Phosphorus, Nitrogen	Monthly (June – November)
Lumber and Allied Wood	BOD, TSS	Quarterly
	Fish Toxicity	Biannual
Mining and Mineral Milling	Metals, TSS, pH	Monthly
	Fish Toxicity	Annually
Municipal Wastewater Treatment Facilities	Carbonaceous Biochemical Oxygen Demand (CBOD), TSS, Total Chlorine Residual, Un-ionized Ammonia, Fish Toxicity	Frequency determined based on treatment type and average daily flowrate at each facility.
Non-Municipal Wastewater Treatment Facilities	CBOD, TSS, Total Chlorine Residual	Frequency determined based on treatment type and average daily flowrate at each facility.
Oil Refining	Oil and Grease, Phenols, Sulphide, Ammonia, Total Suspended Matter	Three times per week
	Fish Toxicity	Monthly
Pulp and Paper Mills	BOD, TSS, pH	Daily
	Fish Toxicity	Monthly
Specialty Products	BOD, TSS	Monthly
Utilities	TSS, pH,	Daily
	Metals, modified Total Petroleum Hydrocarbons	Monthly
	Fish Toxicity	Twice per year

New Brunswick's Watershed Protection Program

In New Brunswick, 20 communities receive their drinking water supply from surface water (lakes and rivers). These watersheds are managed by the Watershed Protection Program which is administered by the Source and Surface Water Management Branch of the Department of Environment and Local Government. In 2001, the *Watershed Protected Area Designation Order* under the *Clean Water Act* was implemented to protect and manage the surface water sources of drinking water supplies in New Brunswick.

In 2003, a monitoring program was developed to better understand ambient water quality conditions of the raw source water, to ensure water quality remains unchanged or improved, and to alert the department if there is degradation in water quality within the designated watersheds. Surface water quality samples are collected at various locations within the designated watersheds on a three-year rotation. Since 2006, a total of 22 watersheds were monitored on a three-year rotation. More information on this program and list of the designated watersheds can be found **here.**

Water Quality Issues and Concerns

Algal Blooms

Algae are photosynthetic organisms that occur in water as single cells, filaments or visible colonies and can be either suspended or attached to solid surfaces of material such as rocks and logs. They also occur naturally in nearly all parts of the environment (aquatic and terrestrial). Blue green algae, also known as cyanobacteria, are photosynthetic bacteria which under certain conditions, in aquatic environments, can increase to form a large mass called a "bloom". Algal blooms can form a scum on the surface of the water, produce a foul smell and cause a change in water color (green, blue, or red). Cyanobacteria can also form mats that are attached to rocks in rivers and lakes. Certain types of cyanobacteria have the potential to produce toxins that are potentially harmful to humans and animals and as the bloom decomposes, it uses up oxygen which can adversely affect aquatic life.

Algae Bloom at Wheaton Lake - 2015

Reports of algal blooms have become increasingly common throughout Canada and New Brunswick in the last number of years. New Brunswick has approximately 2500 lakes and since 2008 DELG is aware of 15 lakes and one river that have experienced algal blooms. Most of these are recreational lakes with significant human influences but some are quite remote and have minimal adjacent development. Two of the lakes that have experienced algal blooms are the drinking water supplies for the Town of St. Andrews (Chamcook Lake) and most recently the City of Moncton's upper reservoir (Tower Road Reservoir) which experienced an algal bloom in 2016.

Factors that can contribute to an algal bloom include:

- Increased levels of nutrients such as phosphorus and nitrogen within the water column from point and non-point sources;
- Shallow, slow moving water and a low flushing rate; and
- Climate change impacts which include:
  - Increased frequency of intense rain events which may lead to an increase in nutrient laden run-off;
  - Increased air temperature resulting in increasing water temperatures with many cyanobacteria species preferring warmer water; and
  - Earlier spring melt resulting in a longer growing season for algae.

Algae Bloom Response Protocol

DELG, in partnership with the Department of Health, developed an Algae Bloom Response Protocol which outlines the roles and responsibilities of each department so that there is a coordinated response to reported algae blooms. For more information on the protocol please visit: **Protocol Overview**

Numerous projects over the last 10 years have been funded through the NB Environmental Trust Fund that have focused on reducing nutrient input to lakes such as riparian zone improvements, alternative on-site sewage disposal system designs, and promoting the reduction of use of phosphorus containing products. DELG also provides educational material to lakeside residents highlighting actions to reduce nutrient inputs and encouraging the use of best management practices for forestry and agricultural industries.

Invasive Aquatic Species

An invasive species is defined as an organism (plant, animal, bacteria or fungus) that is not native to region, displaces native plants and animals and represents a threat to biodiversity. Invasive aquatic species can negatively impact aquatic habitat, reduce water quality, impact fishing and affect water- related recreational activities. Invasive aquatic species (IAS) can be introduced to New Brunswick's rivers and lakes through boating, fishing (either by using non-native bait or through their presence on fishing gear), and illegal stocking. It is important to prevent the introduction of invasive aquatic species through education, inspection, and proper cleaning of fishing gear. Preventative measures include:

Eurasian Watermilfoil has been detected in the Saint John River

- Remove any visible mud, plants, fish or animals before transporting equipment.
- Eliminate water from equipment before transporting.
- Clean and dry anything that comes into contact with water (boats, trailers, equipment, clothing, dogs, etc.).
- Never release plants, fish or animals into a body of water unless they came out of that body of water.

More information about Aquatic Invasive Species that are currently a threat to New Brunswick's waterways please visit: **Protect Our Waters**

Additional Issues

- Sedimentation and erosion;
- Bacteria contamination of surface waters;
- Changing water levels and temperatures due to climate change; and
- Pesticides and herbicides

Saint John River, Saint Basile - 2016

Emerging Concerns

Over the course of the last few decades new chemical substances are being detected in waterbodies across Canada. These substances, which are used in industrial processes and in consumer and pharmaceutical products, pose a risk to the environment but their impacts to aquatic life may not be fully understood.

- Pharmaceuticals and personal care products - many of these can now be found in waterbodies across Canada and many are endocrine disruptors, meaning they can alter the functions of hormones in aquatic organisms leading to reproductive effects.
- Nano particles - these are small microscopic particles (100,000 times smaller than the diameter of a human hair) that are in personal care products, paints and other consumer products.
- Flame retardants – found in many common household items including appliances, furniture and clothes.

Conclusions

This report has illustrated that the majority of New Brunswick's rivers and lakes have good water quality. Over the last 30 years there have been significant improvements in surface water management programs, regulations and increased stewardship activities which have contributed to the improved state of the province's surface water quality. In addition, these initiatives and efforts continue to provide the foundation and tools to ensure that water quality continues to make strides in a positive direction for long term sustainability of New Brunswick's waters.

The New Brunswick Department of Environment and Local Government is committed to water quality monitoring throughout the province, continuing to partner with the federal and local governments, watershed groups, First Nations and lake associations as well as continuing to report annually on water quality information to New Brunswickers.

Learn More about Water Quality

Further information about surface water can be found online at: **www.gnb.ca/environment.**

If you have concerns regarding water quality, please contact the appropriate DELG regional office:

Regional Office Contacts:

- ✓ Bathurst (506) 547-2092
- ✓ Fredericton (506) 444-5149
- ✓ Grand Falls (506) 473-7744
- ✓ Miramichi (506) 778-6032
- ✓ Moncton (506) 856-2374
- ✓ Saint John (506) 658-2558

Feedback

We are interested in your feedback on this report. All suggestions will be considered for in future reports. Please forward comments to:
Air and Water Sciences,
Department of Environment and Local Government (DELG)
Phone : (506) 457-4844
Fax:(506) 453-2265
Email : **elg/egl-info@gnb.ca**

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Glossary

Algal bloom: a rapid increase in the population of algae (including blue-green algae, also known as cyanobacteria) in an aquatic system. It is often the result of excess nutrients; specifically, phosphorus and nitrogen. (*prolifération d'alques*)

Ambient: natural background conditions in the surrounding environment outside the zone in which water quality may be influenced by a discharge or source of contamination (*conditions ambiantes*)

Blue-green algae: cyanobacteria also known as blue-green algae or more commonly as "pond scum" are bacteria that occur naturally in surface waters and have photosynthetic capability, meaning they utilize the sun's energy to produce sugar which they use for growth. Cyanobacteria can contain poisons called cyanobacterial toxins which can impact human health. These toxins can also be toxic to pets and livestock if ingested. (*algues bleues*)

Benthic macroinvertebrates: macroinvertebrates are organisms without backbones, which are visible to the eye without the aid of a microscope. Benthic aquatic macroinvertebrates live on, under, and around rocks and sediment on the bottoms of lakes, rivers, and streams. (*macro-invertébrés benthiques*)

CCME: (Canadian Council of Ministers of the Environment) - an intergovernmental forum for collective action on environmental issues of national and international concern, led by Canadian ministers of the environment (federal, provincial and territorial). (*CCME*)

Chlorophyll *a*: a pigment that is found in plants and algae and gives these organisms their green colour. Lake water samples are collected and analyzed for chlorophyll a which provides an indication of how much algae are present in a lake. High values indicate high productivity which can indicate that the lake is receiving excessive nutrients. (*chlorophylle a*)

Contaminant: refers to any solid, liquid, gas, microorganism, odour, heat, sound, vibration, radiation or combination of any of them, present in the environment (a) that is foreign to or in excess of the natural constituents of the environment, (b) that affects the natural, physical, chemical or biological quality or constitution of the environment, (c) that endangers the health, safety or comfort of a person or the health of animal life, that causes damage to property or to plant life or that interferes with visibility, the normal conduct of transport or business or the normal enjoyment of life or use or enjoyment of property. (*polluant*)

Effluent: liquid discharge to a watercourse (e.g. from a sewage or wastewater pipe). (*effluent*)

Environmental Trust Fund (ETF): a dedicated funding source provided by the government of New Brunswick for community-based, action-oriented activities aimed at protecting, preserving and enhancing New Brunswick's natural environment. (*Fonds en fiducie pour l'environnement (FFE)*)

Eutrophic state: a trophic state of a lake characterized by waters extremely rich in nutrients, with high biological productivity. These lakes have higher concentrations of phosphorus and chlorophyll and poorer clarity than mesotrophic lakes. Typically, they are shallow, often muddy and contain an abundance of aquatic plants. (*état eutrophe*)

Median: the middle value of a set of numbers or data points; half the numbers will fall below the median and half above. (*médiane*)

Mesotrophic state: a trophic state of a lake characterized by waters with more nutrients and therefore more biological productivity than in oligotrophic lakes. These lakes are in an intermediate state with respect to depth, chlorophyll concentration, water clarity, and aquatic plants. (*état mésotrophe*)

Non-Point Source: a diffuse or widely distributed source of discharge to water that cannot be attributed to a single, specific location. Discharges from non-point sources typically reach a water body indirectly via wind, overland flow (during precipitation or snow melt) or infiltration to groundwater. (*source non ponctuelle*)

Nutrients: various chemical compounds and elements essential to the growth and survival of living organisms. In aquatic ecosystems, nitrogen and phosphorus are the most important, as they are most often in short supply relative to the needs of aquatic plants, algae, and micro-organisms. (*éléments nutritifs*)

Oligotrophic state: a trophic state of a lake characterized by clear waters with little organic matter or sediment and a relatively low level of productivity. These lakes are usually deep and the shoreline is sparsely populated with aquatic plants. (*état oligotrophe*)

Point Source: a source of discharge to water that can be attributed to a specific location such as a building or facility, or the end of a pipe, channel, or ditch. (*source ponctuelle*)

Productivity (Biological Productivity): the generation of biomass. Primary productivity, which is important in lakes, occurs when inorganic molecules are converted into biomass by algae and plants through photosynthesis. Sunlight penetration, water temperature and available nutrients are key factors affecting primary productivity. (*productivité (productivité biologique*)

Secchi depth: a measure of the transparency of the water and is determined by lowering a black and white disc through the lake water column. Once it is at a depth where it is no longer visible this is called the "Secchi depth". (*profondeur d'après le disque de Secchi*)

Trophic Status (Trophic State): a measure of a lake's productivity. (*état trophique*)

Zooplankton: microscopic animals (crustaceans, larvae, etc.) that float near the surface of water. (*zooplankton*)