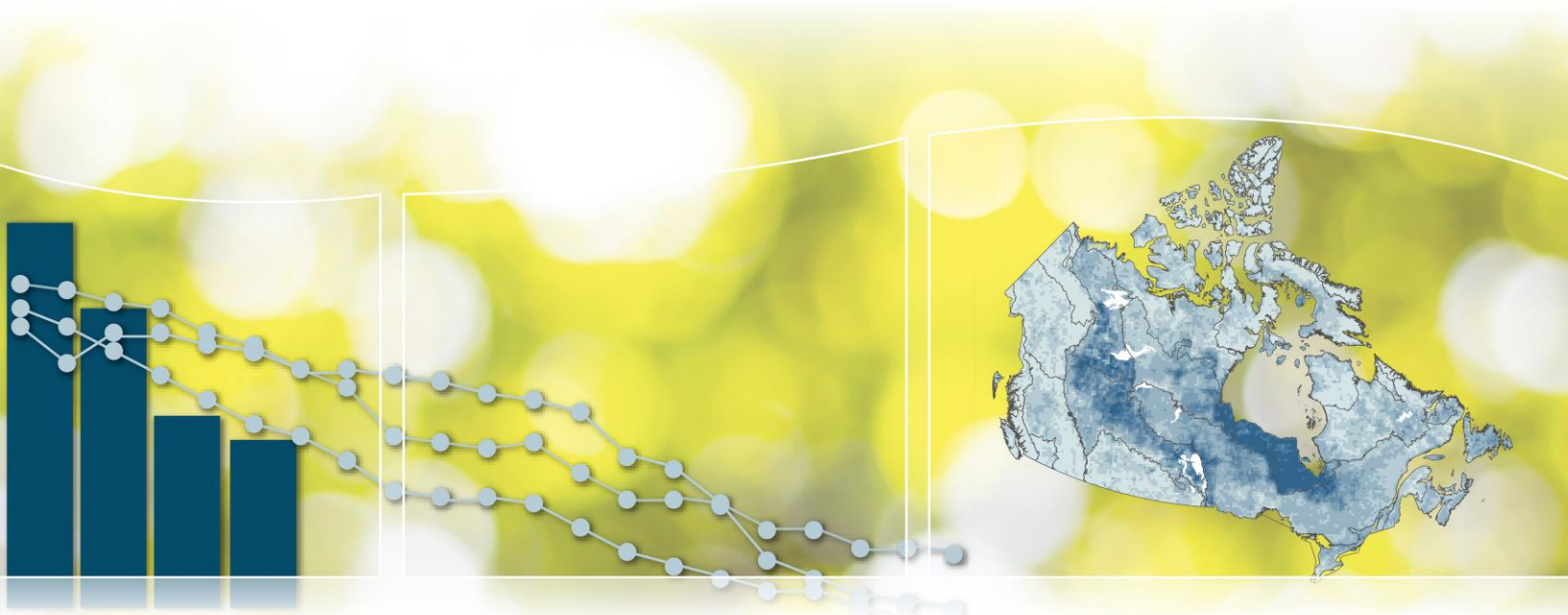
Environment and Climate Change Canada
Environnement et Changement climatique Canada

Canadian Environmental Sustainability Indicators

Nutrients in Lake Winnipeg



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Canadian Environmental Sustainability Indicators

Nutrients in Lake Winnipeg

February 2016

Table of Contents

List of Figures

List of Tables

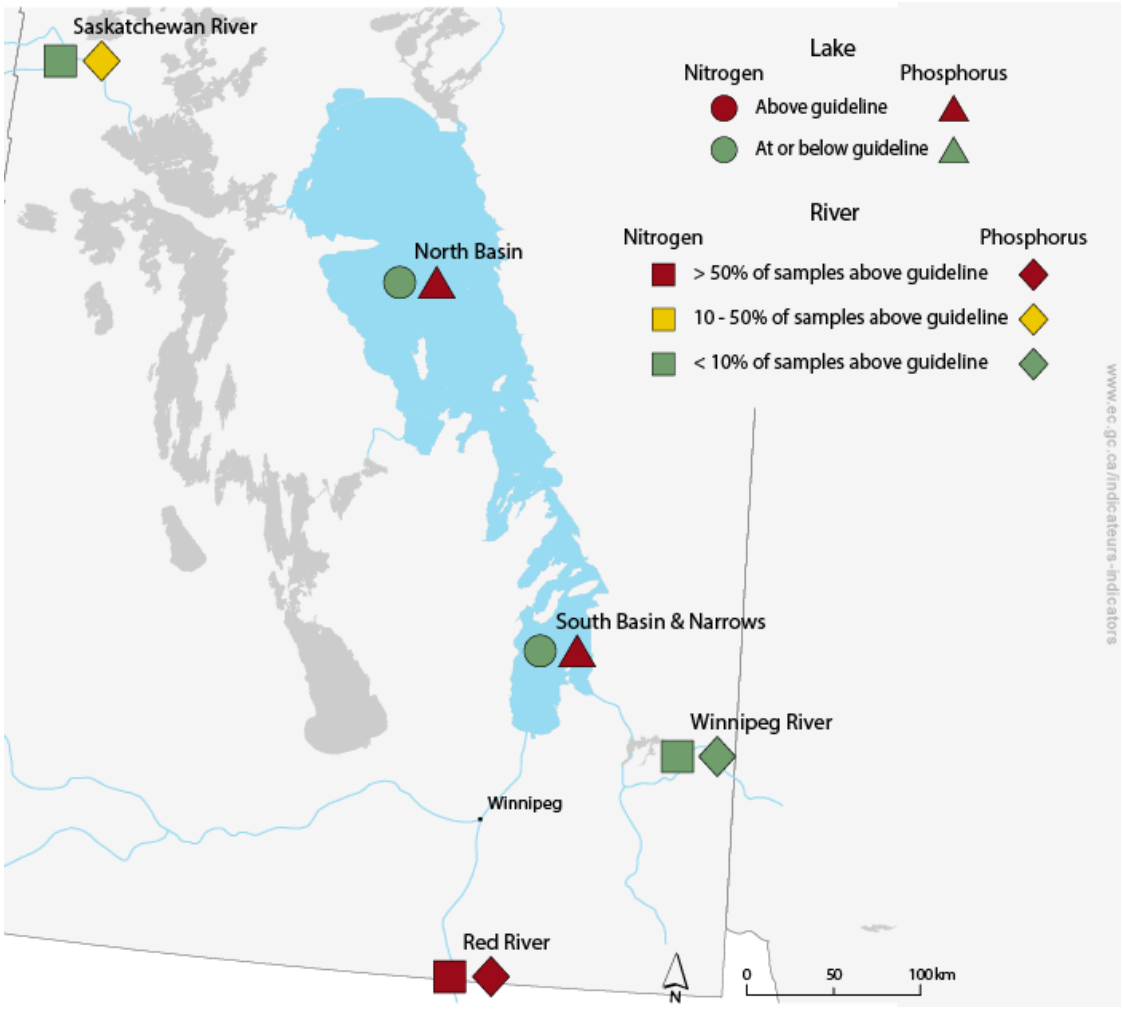
Part 1. Nutrients in Lake Winnipeg Indicators

Phosphorus and Nitrogen Levels in Lake Winnipeg

High phosphorus and nitrogen levels can result in harmful algal blooms in Lake Winnipeg. In 2013, phosphorus levels in its North and South basins and the Narrows were above the water quality guidelines for the protection of freshwater plants and animals most of the time. Nitrogen levels in each basin were generally below water quality guidelines.

Both phosphorus and nitrogen levels were consistently above water quality guidelines for the protection of freshwater plants and animals in the Red River, and always below the guidelines in the Winnipeg River. Just over 44% of phosphorus samples in the Saskatchewan River were above the guidelines for the 2011 to 2013 period while nitrogen samples were always below the guideline values.

Figure 1. Status of phosphorus and nitrogen levels in Lake Winnipeg, Canada, 2013; and in three tributary rivers, Canada, 2011 to 2013



Data for Figure 1

Note: Status colours for the North Basin and the South Basin and the Narrows of Lake Winnipeg were determined by comparing seasonally weighted average total phosphorus and total nitrogen levels in lake water collected from across the basins to the appropriate water quality guidelines for the protection of aquatic life.

For the Red, Winnipeg and Saskatchewan rivers, the total phosphorus and total nitrogen water quality status was determined based on the frequency with which water quality monitoring data were above the guideline values.[1,2]
Source: Manitoba Conservation and Water Stewardship and Environment and Climate Change Canada.

Lake Winnipeg is Canada's sixth-largest freshwater lake and the world's third-largest reservoir, generating hydro-electric power for all of Manitoba.[3] The lake is home to over 30 communities and supports a large commercial fishery, as well as recreation. Lake Winnipeg is composed of a large, deeper North Basin and a smaller, shallower South Basin. The two basins are separated by the Narrows, through which water from the South Basin flows northward. With an average depth of 13 metres in the North Basin and nine metres in the South Basin, the lake is shallow compared to the Laurentian Great Lakes. At 953 240 square kilometres, the lake's drainage basin is the largest drainage basin of all lakes in Canada, covering four provinces and four U.S. states. The shallow waters and large volume of water flowing in from the rivers draining into the lake are major influences on water quality in the lake.

Water quality in Lake Winnipeg has been deteriorating for many years, putting the health of the lake at serious risk. Before European settlement in the region, the lake had moderate levels of phosphorus and nitrogen. Since then, the levels of these nutrients have been affected by a range of human activities. With the opening up of the West, livestock and crop production began contributing phosphorus and nitrogen from manure and fertilizer to the drainage basin. The westward expansion also resulted in the draining of thousands of wetlands that dotted the Prairies, which received and processed nutrients running off the land. Growing cities have also generated more nutrients and changed how water flows across the land.

The excess amount of phosphorus and nitrogen flowing into Lake Winnipeg contributes to increasingly large, frequent, and potentially toxic, algal blooms. The highest levels of phosphorus and nitrogen are typically found in the South Basin near the inflow from the Red River, with levels declining as the water flows north. Without a reduction in nutrients, water quality in the lake will continue to deteriorate.

Phosphorus and nitrogen are key nutrients for plant growth in lakes and rivers. Rock weathering and the natural decomposition of plants and animals are natural sources of phosphorus. Nitrogen is naturally added to the environment by bacteria that convert nitrogen gas in the air into forms plants can use for their growth. Too much or too little in the environment, however, is harmful. Phosphorus and nitrogen from human activity enters Lake Winnipeg through municipal and industrial wastewaters, agricultural runoff, and air pollution. When phosphorus and nitrogen levels in water become too high, aquatic plant growth can become excessive and harmful. The decay of excess plant material can reduce the amount of oxygen available for fish and other aquatic animals. High nutrient levels can also lead to harmful algal blooms, which can kill animals that use the water and affect human health.

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[1] Manitoba Water Stewardship (2011) Manitoba Water Quality Standards, Objectives and Guidelines. Retrieved on 3 March, 2015.

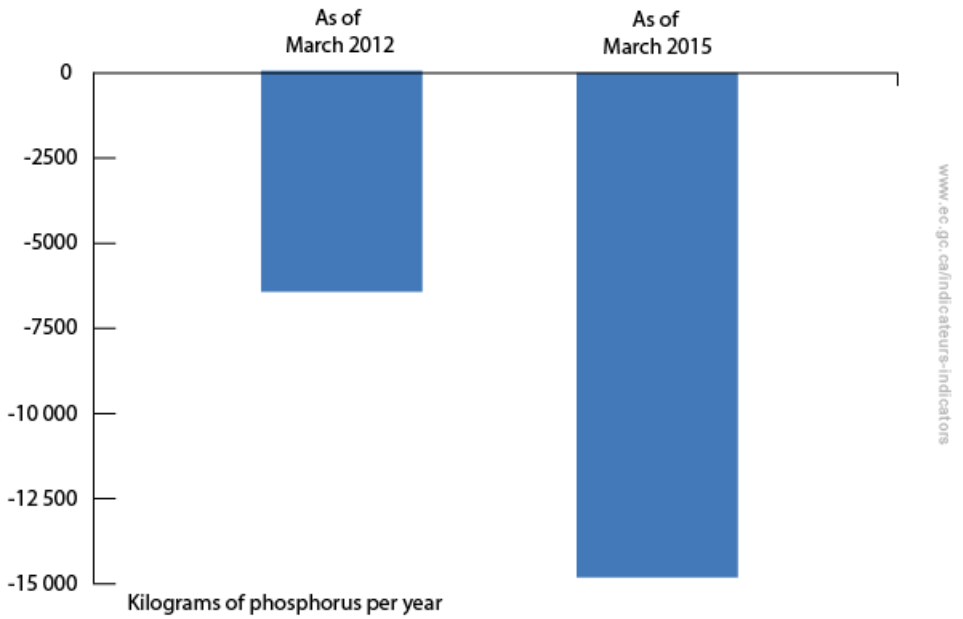
[2] Alberta Environment (2014) Surface Water Quality Guidelines and Objectives. Retrieved on 3 March, 2015.

[3] Environment Canada and Manitoba Conservation and Water Stewardship (2010) State of Lake Winnipeg: 1999 to 2007. Retrieved on 6 February, 2015.

Phosphorus Loads to Lake Winnipeg

As of March 2015, stewardship projects supported by the Lake Winnipeg Basin Stewardship Fund were preventing an estimated 14 800 kilograms of phosphorus per year from entering Lake Winnipeg and its tributary rivers. The drop in the amount of phosphorus reaching Lake Winnipeg reflects reductions of almost 6500 kilograms of phosphorus per year from projects undertaken between April 2008 and March 2012 and just over 8300 kilograms of phosphorus per year for projects completed between April 2012 and March 2015.

Figure 2. Cumulative, estimated reduction in the amount of phosphorus reaching Lake Winnipeg, April 2008 to March 2015



Data for Figure 2

Note: The estimate of reduced phosphorus load represents projects with final reports submitted by March 2015. Figures for each project type are rounded and then summed to give the total.
Source: Environment and Climate Change Canada (2015) Lake Winnipeg Basin Initiative.

Environment and Climate Change Canada, Manitoba Conservation and Water Stewardship and other partners are working closely together to more fully understand the relationships between phosphorus and nitrogen levels and nuisance algal growth in Lake Winnipeg, as well as the impacts of the recent arrival of zebra mussels (*Dreissena polymorpha*). While this work continues, they are also engaging citizens, scientists, and domestic and international partners to reduce phosphorus pollution by supporting stewardship projects, such as erecting fencing to prevent livestock from entering lakes and rivers, stabilizing river banks and lake shorelines, restoring wetlands and planting native shrubs, plants and trees. This work will help Manitoba achieve its long-term goal of reducing phosphorus concentrations in the lake to pre-1990 levels of approximately 0.05 micrograms of phosphorus per litre.

These indicators are used to measure progress toward Target 3.7: Lake Winnipeg Basin – By 2017, reduce phosphorus inputs to water bodies in the Lake Winnipeg Basin, in support of the Province of Manitoba's overall plan to reduce phosphorus in Lake Winnipeg by 50% to pre-1990 levels of the Federal Sustainable Development Strategy 2013–2016.

Part 2. Data Sources and Methods for the Nutrients in Lake Winnipeg Indicators

Introduction

The Nutrients in Lake Winnipeg indicators are part of the Canadian Environmental Sustainability Indicators (CESI) program, which provides data and information to track Canada's performance on key environmental sustainability issues. These indicators are also used to measure progress towards the goals and targets of the Federal Sustainable Development Strategy.

Description and rationale of the Nutrients in Lake Winnipeg indicators

Description

The *Phosphorus and Nitrogen Levels in Lake Winnipeg* indicator reports on the status of total phosphorus and total nitrogen concentrations in the North and South basins and the Narrows of Lake Winnipeg and in its major tributaries. It rates nitrogen and phosphorus status based on whether phosphorus and nitrogen concentrations within Lake Winnipeg and in the Red, Saskatchewan and Winnipeg rivers exceed Manitoba's total phosphorus guideline and Alberta's total nitrogen guideline for the protection of aquatic life. Exceeding a water quality guideline suggests a greater risk to the health of the Lake Winnipeg ecosystem posed by phosphorus and/or nitrogen.

Water quality in Lake Winnipeg is considered to be minimally impacted by nutrients from human activity when ambient water quality samples contain concentrations that meet or are below water quality guideline values as shown by a green symbol on the indicator map. Where phosphorus and nitrogen levels exceed water quality guidelines, water quality is being impaired by nutrients from human activity and a red symbol is used on the indicator map to denote the phosphorus and nitrogen status of the lake.

For the Red, Saskatchewan and Winnipeg rivers, water quality at a given monitoring station is considered to be minimally impacted by nutrients from human activities, as indicated by a green symbol, when fewer than 10% of water quality samples exceed the phosphorus or nitrogen water quality guideline. When 10% to 50% of the samples exceed the phosphorus or nitrogen water quality guideline, the total phosphorus and total nitrogen concentrations are increasing and the tributaries are becoming more impaired with nutrients from human activity. This situation is denoted by a yellow symbol on the indicator map. If more than 50% of the samples exceed the water quality guidelines, total phosphorus and total nitrogen concentrations are likely well above the water quality guidelines and water quality is represented by a red symbol.

The *Reducing Phosphorus Loads to Lake Winnipeg* indicator provides a summary of estimates of the amount of phosphorus per year that is no longer reaching Lake Winnipeg as a result of completed stewardship projects funded by Environment and Climate Change Canada's Lake Winnipeg Basin Stewardship Fund. The contribution of each project to phosphorus reduction in the lake is estimated using equations drawn from the scientific literature specific to the project type.

Rationale

Phosphorus and nitrogen are essential plant nutrients; however, when concentrations of these nutrients in the environment are too high, or too low, they can have harmful impacts on aquatic ecosystems. Lake Winnipeg's waters are naturally mesotrophic with moderate phosphorus and nitrogen concentrations and moderate plant growth compared to other lakes, such as the Great Lakes. A century of agricultural development on the Prairies has increased nitrogen and phosphorus concentrations in the lake to the point where algal growth is approximately 500% greater than it was prior to European settlement.[4]

The *Phosphorus and Nitrogen Levels in Lake Winnipeg* indicator assumes that the water in Lake Winnipeg and its tributaries would rarely have phosphorus and nitrogen levels exceeding water quality guidelines in the absence of human development. Thus, the indicator shows how human activity contributes to phosphorus and nitrogen levels in the Lake Winnipeg basin. The more often the water quality guidelines are exceeded, the greater the risk phosphorus and nitrogen pose to the health of Lake Winnipeg. Continuing to track phosphorus and nitrogen concentrations allows governments and citizens to remain aware of an important aspect of the environmental condition of the lake.

The *Reducing Phosphorus Loads to Lake Winnipeg* indicator measures the contribution that Lake Winnipeg Basin Stewardship Fund projects are making toward reducing the amount of phosphorus reaching Lake Winnipeg from its watershed. Increasing the adoption of beneficial management practices in the Lake Winnipeg watershed will help reduce phosphorus loads from rural sources allowing for the restoration of the lake's ecological integrity.

Recent changes to the indicator

The indicator has been extended to include the new *Reducing Phosphorus Loads to Lake Winnipeg* indicator.

Data

Data source

Total phosphorus and total nitrogen data for Lake Winnipeg are collected by the Water Quality Management Section of Manitoba Conservation and Water Stewardship. Data for the Red, Winnipeg and Saskatchewan rivers are collected by the Water Quality Monitoring and Surveillance Division of Environment and Climate Change Canada.

Phosphorus-loading reduction estimates were provided to the Lake Winnipeg Basin Stewardship Fund in the final reports of all funded projects.

Spatial coverage

Phosphorus and nitrogen concentration data cover the North and South basins of Lake Winnipeg along with the Narrows connecting the two basins. Also included are data from three of Environment and Climate Change Canada's water quality monitoring stations on the Red, Winnipeg and Saskatchewan rivers.

[4] Bunting L., et al. (2011) Sudden ecosystem state change in Lake Winnipeg, Canada, caused by eutrophication arising from crop and livestock production during the 20th century. (PDF, 753 KB) Retrieved on 23 March, 2015.

Table 1. Tributary water quality monitoring stations used in the Phosphorus and Nitrogen Levels in Lake Winnipeg indicator

Station code	Station name	Longitude	Latitude
MA05OC0001	Red River at Emerson, Manitoba	-97.21083	49.00806
MA05PF0022	Winnipeg River at Pointe du Bois	-95.5566116	50.30083
MA05KH0001	Saskatchewan River above Carrot River	-101.34194	53.84167

The *Reducing Phosphorus Loads to Lake Winnipeg* indicator focuses on estimates of phosphorus reductions resulting from beneficial management projects completed in the Lake Winnipeg watershed.

Temporal coverage

The phosphorus and nitrogen status of Lake Winnipeg in 2013 is reported. The status assessment of the tributaries covers 2011 to 2013 period.

The estimated phosphorus load reductions are based on the cumulative results of Lake Winnipeg Basin Stewardship projects undertaken from December 2008 to March 2015 in two phases: Phase 1 ranged from 2008 to 2012; and Phase 2 from April 2012 to March 2015.

Data completeness

Phosphorus and nitrogen concentrations were collected from May to October 2013 on Lake Winnipeg and year-round from 2011 to 2013 for the tributary stations. Data for the lake and tributaries for 1999 to 2013 are graphed in the Methods section to supplement the indicators.

From 2008 to 2015, the Lake Winnipeg Basin Stewardship Fund supported 41 projects in Phase 1 and 33 in Phase 2. Of the projects funded, 61% had a direct impact on phosphorus loading and 39% had an indirect impact. The Reducing Phosphorus Loads to Lake Winnipeg Indicator reports on those projects resulting in reductions of direct phosphorus loadings to Lake Winnipeg and includes data provided by project partners for all projects with final reports submitted by March 31, 2015. The year associated with a project is the year the final report was submitted to the program, not the year the work was done.

Data timeliness

Both indicators were calculated using the most recent data available.

Methods

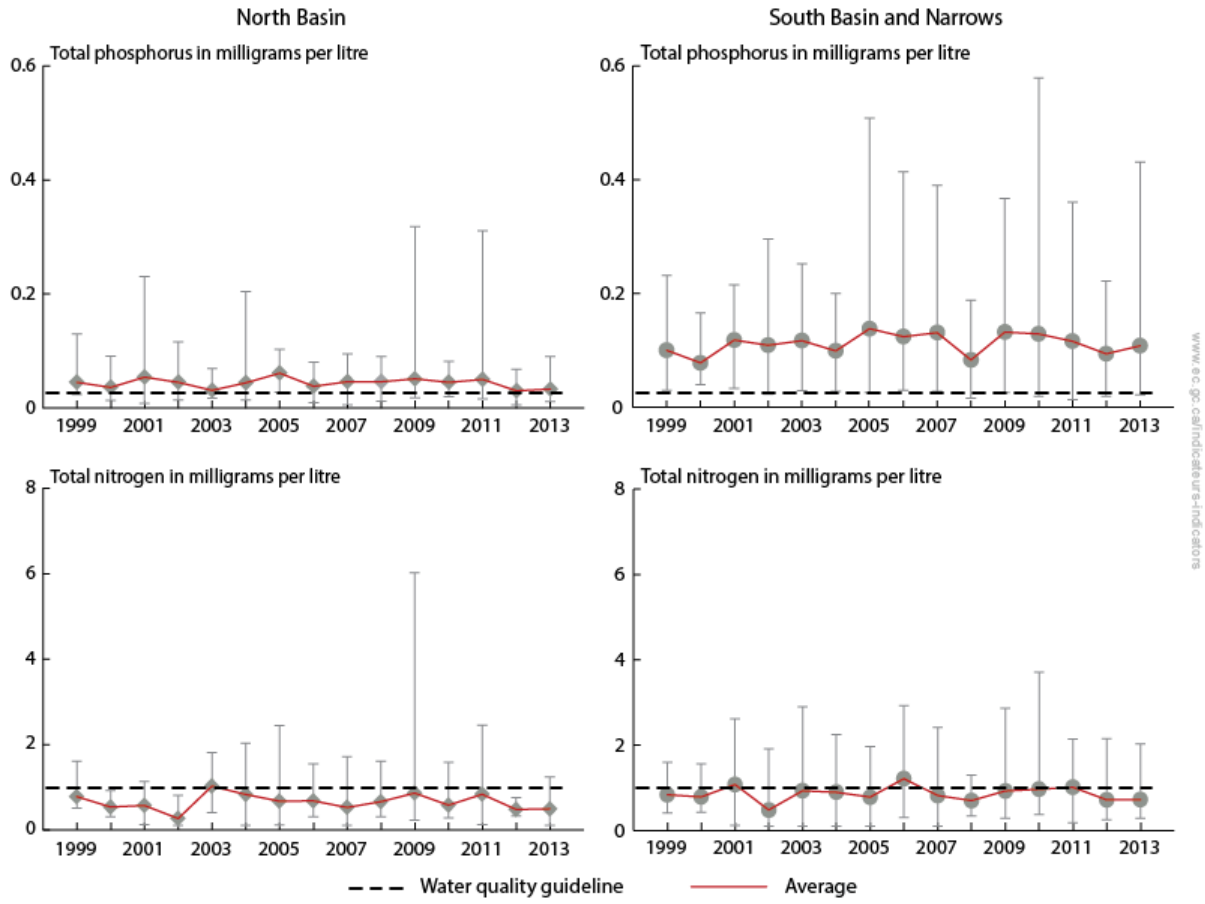
To report on phosphorus (P) and nitrogen (N) levels in Lake Winnipeg, seasonally weighted average total phosphorus and total nitrogen concentrations from May to October in each basin were compared to Manitoba's phosphorus guideline for the protection of aquatic life for lakes (0.025 milligram of phosphorus per litre [mg P/L])[5] and to Alberta's former surface water quality guideline for total nitrogen (1 milligram of nitrogen per litre [mg N/L]).[6]

[5] Manitoba Water Stewardship (2011) Manitoba Water Quality Standards, Objectives and Guidelines. Retrieved on 23 March, 2015.

[6] Alberta Environment (1999) Surface Water Quality Guidelines for Use in Alberta. (PDF; 134 KB) Retrieved on 23 March, 2015.

Seasonally weighted, average phosphorus and nitrogen concentrations are used to account for year-to-year variability in sample collection. The status of the phosphorus and nitrogen levels was classified as either green or red by comparing the 2013 annual seasonally weighted average total nitrogen and total phosphorus concentrations (Figure 3) to the corresponding guidelines. Note that, even where the average values are generally below the guideline, the maximum recorded values may still be above.

Figure 3. Annual seasonally weighted averages for total phosphorus and total nitrogen concentrations in Lake Winnipeg, Canada, 1999 to 2013



Data for Figure 3

Note: Bars show annual minimum and maximum concentrations.

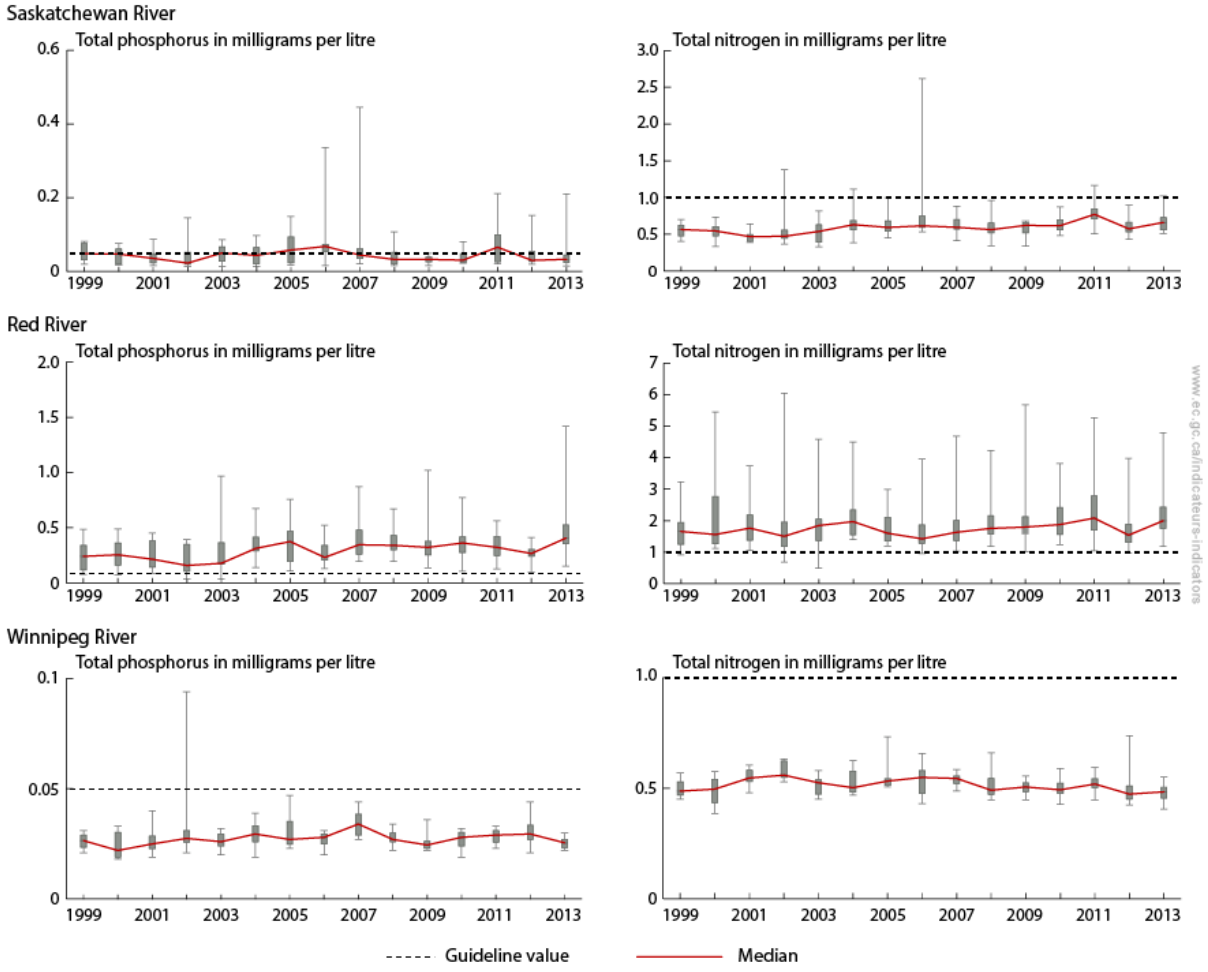
For the Red, Saskatchewan and Winnipeg rivers, the phosphorus and nitrogen status of the water quality monitoring stations was determined by comparing total phosphorus and total nitrogen concentrations to Manitoba's river total phosphorus guideline (0.05 mg P/L)[7] and Alberta's former total nitrogen guideline (1 mg N/L).[8] For the rivers, the number of times the phosphorus and nitrogen concentrations exceeded the guidelines between 2011 and 2013 were summed and divided by the total number of samples collected over the same period (Figure 4). The nutrient status of each station was determined based on the percentage of

[7] Manitoba Water Stewardship (2011) Manitoba Water Quality Standards, Objectives and Guidelines. Retrieved on 3 March, 2015.

[8] Alberta Environment (1999) Surface Water Quality Guidelines for Use in Alberta. (PDF; 134 KB) Retrieved on 23 March, 2015.

samples exceeding the guidelines. Stations with fewer than 10% of samples exceeding the guideline have water quality based on phosphorus or nitrogen represented by a green symbol; and stations with greater than 50% of samples exceeding the guideline are represented by a red symbol. Stations with 10% to 50% of samples exceeding the guideline have a yellow symbol because phosphorus or nitrogen may be a problem. In rivers, total phosphorus or nitrogen concentrations often exceed the guidelines during high flows, most commonly when snow melts in the spring. The 10% cut-off allows for one sample per year to exceed the guideline. A green designation means total phosphorus or nitrogen concentrations are having a minimal effect on the river ecosystem. If greater than 50% of the samples exceed the water quality guideline, median total phosphorus or total nitrogen concentrations are likely well above the water quality guideline and water quality is impaired.

Figure 4. Annual total phosphorus and total nitrogen concentration box plots for the Red, Winnipeg and Saskatchewan rivers, Canada, 1999 to 2013



Data for Figure 4

Note: Bars show annual minimum and maximum concentrations.

Estimates of reductions in phosphorus loading to Lake Winnipeg resulting from the implementation of beneficial management practices were calculated by the Lake Winnipeg Basin Stewardship Fund project partners using the calculations presented in the Lake Simcoe

Clean-Up Fund: Phosphorous Reduction Calculation Report.[9] This document, developed for the Lake Simcoe Clean-Up Fund, is applicable to projects in the Lake Winnipeg basin because it uses generic land use models from the scientific literature.

In general, the amount of phosphorus reaching a watercourse is determined by the form and chemical nature of the phosphorus compounds and the degree of contact with the soil, soil pH, soil texture, soil type and aerobic conditions. Beneficial management practices to reduce phosphorus inputs from agriculture include projects acting directly on a farming practice, such as limiting livestock access to streams through fencing and installing alternate watering sources. Rural projects include those with the potential to reduce phosphorus loading by protecting or stabilizing shoreline habitat, and stream banks or lake shores. Examples of these projects include installation of erosion-control structures and planting trees.

Caveats and limitations

The Phosphorus and Nitrogen Levels in Lake Winnipeg indicator reflects the state of water quality in the Lake Winnipeg basin based on phosphorus and nitrogen concentrations; however, it does not show the effect of spills or other transient events unless these are frequent or long-lasting.

The calculation used for the Phosphorus and Nitrogen Levels in Lake Winnipeg indicator for the major tributaries and the lake is slightly different. This discrepancy exists because total phosphorus concentrations in rivers are influenced by suspended particles in the water, which may increase during high-flow events. Allowing for some natural exceedances associated with high-flow events is important. The size of Lake Winnipeg buffers it from the immediate impacts. The ratings for Lake Winnipeg and its tributaries are nonetheless comparable, with red symbols on the indicator map showing the highest level of impairment by phosphorus or nitrogen in both cases.

The Lake Winnipeg Basin Stewardship Fund uses the most appropriate, current and accepted equations to predict phosphorus loading reductions resulting from the implementation of beneficial management practices because the results of these projects were not directly monitored for phosphorus loadings and concentrations. Despite the rigour behind them, uncertainty exists when using these formulae.

The Reducing Phosphorus Loads to Lake Winnipeg indicator does not compare results to data measuring annual releases of phosphorus or overall land use and activity changes in the basin that would affect phosphorus loading.

The estimates of phosphorus reduction assume that each management project completed through the Lake Winnipeg Basin Stewardship Fund results in a permanent reduction in phosphorus flows to surface waters.

[9] Sealock, L. (2011) Lake Simcoe Clean-Up Fund: Phosphorous Reduction Calculation Report. Great Lakes Management and Reporting Section, Environment Canada.

Part 3. Annexes

Annex A. Data tables for the figures presented in this document

Table A.1. Data for Figure 1. Status of phosphorus and nitrogen levels in Lake Winnipeg, Canada, 2013; and in three tributary rivers, Canada, 2011 to 2013

Lake Winnipeg	Phosphorus water quality guideline (milligram of phosphorus per litre)	Phosphorus level (milligram of phosphorus per litre)	Phosphorus level status	Nitrogen water quality guideline (milligram of nitrogen per litre)	Nitrogen level (milligram of nitrogen per litre)	Nitrogen level status
North Basin	0.025	0.033	Red	1.0	0.49	Green
South Basin and Narrows	0.025	0.108	Red	1.0	0.72	Green

Note: Status colours for the North Basin and the South Basin and the Narrows of Lake Winnipeg were determined by comparing seasonally weighted average total phosphorus and total nitrogen levels in lake water collected from across the basins to the appropriate water quality guidelines for the protection of aquatic life.
Source: Manitoba Conservation and Water Stewardship and Environment and Climate Change Canada.

Table A.2. Data for Figure 1. Status of phosphorus and nitrogen levels in Lake Winnipeg, Canada, 2013; and in three tributary rivers, Canada, 2011 to 2013

River	Phosphorus water quality guideline (milligram of phosphorus per litre)	Proportion of phosphorus levels above the guideline (percentage)	Phosphorus level status	Nitrogen water quality guideline (milligram of nitrogen per litre)	Proportion of nitrogen levels above the guideline (percentage)	Nitrogen level status
Saskatchewan River	0.050	39	Yellow	1.0	5	Green
Red River	0.050	100	Red	1.0	99	Red
Winnipeg River	0.050	0	Green	1.0	0	Green

Note: For the Red, Winnipeg and Saskatchewan rivers, the total phosphorus and total nitrogen water quality status was determined based on the frequency with which water quality monitoring data were above the guideline values.
Source: Manitoba Conservation and Water Stewardship and Environment and Climate Change Canada.

Table A.3. Data for Figure 2. Cumulative, estimated reduction in the amount of phosphorus reaching Lake Winnipeg, April 2008 to March 2015

Year	Estimated cumulative total (kilograms of phosphorus per year)
2008–2012	-6492
2012–2015	-14 808

Note: The estimate of reduced phosphorus load represents projects with final reports submitted by March 2015. Figures for each project type are rounded and then summed to give the total.
Source: Environment and Climate Change Canada (2015) Lake Winnipeg Basin Initiative.

Table A.4. Data for Figure 3. Total phosphorus levels in the North Basin, Lake Winnipeg, Canada, 1999 to 2013

Year	Seasonally-weighted average (milligram per litre)	Minimum (milligram per litre)	Maximum (milligram per litre)	Number of samples
1999	0.045	0.024	0.130	21
2000	0.036	0.013	0.091	29
2001	0.054	0.008	0.231	23
2002	0.045	0.014	0.116	85
2003	0.031	0.017	0.069	13
2004	0.044	0.014	0.204	30
2005	0.061	0.028	0.103	35
2006	0.038	0.009	0.080	60
2007	0.046	0.005	0.095	59
2008	0.046	0.012	0.090	63
2009	0.051	0.018	0.318	53
2010	0.045	0.020	0.082	62
2011	0.05	0.016	0.311	76
2012	0.03	0.005	0.068	78
2013	0.033	0.011	0.09	77

Table A.5. Data for Figure 3. Total nitrogen levels in the North Basin, Lake Winnipeg, Canada, 1999 to 2013

Year	Seasonally-weighted average (milligram per litre)	Minimum (milligram per litre)	Maximum (milligram per litre)	Number of samples
1999	0.778	0.505	1.61	21
2000	0.535	0.305	0.920	29
2001	0.571	0.120	1.130	22
2002	0.267	0.105	0.810	85
2003	1.023	0.405	1.810	13
2004	0.830	0.105	2.030	30
2005	0.673	0.11	2.440	35
2006	0.677	0.305	1.550	59
2007	0.525	0.105	1.710	59
2008	0.662	0.305	1.605	62
2009	0.860	0.228	6.025	53
2010	0.577	0.283	1.583	62
2011	0.116	0.013	0.36	108
2012	0.094	0.019	0.222	113
2013	0.491	0.105	1.24	77

Table A.6. Data for Figure 3. Total phosphorus levels in the South Basin and Narrows, Lake Winnipeg, Canada, 1999 to 2013

Year	Seasonally-weighted average (milligram per litre)	Minimum (milligram per litre)	Maximum (milligram per litre)	Number of samples
1999	0.100	0.030	0.232	32
2000	0.078	0.040	0.166	24
2001	0.118	0.033	0.215	15
2002	0.109	0.023	0.296	87
2003	0.117	0.029	0.252	14
2004	0.099	0.028	0.200	14

Year	Seasonally-weighted average (milligram per litre)	Minimum (milligram per litre)	Maximum (milligram per litre)	Number of samples
2005	0.138	0.026	0.508	51
2006	0.124	0.030	0.414	82
2007	0.131	0.028	0.390	98
2008	0.083	0.016	0.188	103
2009	0.132	0.026	0.367	119
2010	0.129	0.019	0.579	105
2011	0.116	0.013	0.36	108
2012	0.094	0.019	0.222	113
2013	0.108	0.022	0.431	109

Table A.7. Data for Figure 3. Total nitrogen levels in the South Basin and Narrows, Lake Winnipeg, Canada, 1999 to 2013

Year	Seasonally-weighted average (milligram per litre)	Minimum (milligram per litre)	Maximum (milligram per litre)	Number of samples
1999	0.838	0.405	1.600	32
2000	0.788	0.430	1.560	24
2001	1.077	0.12	2.620	15
2002	0.480	0.105	1.910	87
2003	0.929	0.105	2.900	14
2004	0.896	0.105	2.250	14
2005	0.782	0.105	1.970	51
2006	1.214	0.305	2.930	82
2007	0.819	0.105	2.420	98
2008	0.700	0.34	1.300	100
2009	0.927	0.283	2.860	119
2010	0.967	0.372	3.710	104
2011	1.013	0.185	2.140	106

Year	Seasonally-weighted average (milligram per litre)	Minimum (milligram per litre)	Maximum (milligram per litre)	Number of samples
2012	0.717	0.255	2.154	113
2013	0.723	0.285	2.03	109

Table A.8. Data for Figure 4. Annual total phosphorus concentration data for the Saskatchewan River, Canada, 1999 to 2013

Year	Maximum (milligram per litre)	3rd Quartile (milligram per litre)	Median (milligram per litre)	1st Quartile (milligram per litre)	Minimum (milligram per litre)
1999	0.082	0.076	0.048	0.032	0.019
2000	0.076	0.061	0.047	0.020	0.018
2001	0.087	0.049	0.036	0.023	0.016
2002	0.146	0.052	0.023	0.020	0.014
2003	0.086	0.067	0.050	0.028	0.014
2004	0.097	0.065	0.044	0.020	0.013
2005	0.149	0.094	0.058	0.023	0.018
2006	0.336	0.073	0.068	0.054	0.016
2007	0.446	0.061	0.045	0.035	0.020
2008	0.107	0.052	0.033	0.020	0.016
2009	0.049	0.039	0.033	0.026	0.016
2010	0.081	0.049	0.031	0.025	0.022
2011	0.212	0.099	0.066	0.026	0.021
2012	0.152	0.054	0.030	0.027	0.019
2013	0.210	0.044	0.033	0.024	0.015

Note: Data are for Environment and Climate Change Canada's monitoring site: Saskatchewan River above Carrot River (MA05KH0001).

Table A.9. Data for Figure 4. Annual total nitrogen concentration data for the Saskatchewan River, Canada, 1999 to 2013

Year	Maximum (milligram per litre)	3rd Quartile (milligram per litre)	Median (milligram per litre)	1st Quartile (milligram per litre)	Minimum (milligram per litre)
1999	0.699	0.621	0.563	0.474	0.403
2000	0.733	0.603	0.544	0.479	0.332
2001	0.641	0.498	0.466	0.402	0.390
2002	1.378	0.553	0.471	0.442	0.365
2003	0.814	0.628	0.537	0.393	0.328
2004	1.112	0.688	0.630	0.561	0.384
2005	0.997	0.681	0.593	0.540	0.447
2006	2.617	0.745	0.613	0.590	0.531
2007	0.882	0.702	0.594	0.572	0.411
2008	0.957	0.652	0.561	0.519	0.341
2009	0.680	0.658	0.619	0.516	0.339
2010	0.870	0.693	0.616	0.559	0.480
2011	1.163	0.845	0.770	0.710	0.505
2012	0.897	0.662	0.573	0.533	0.432
2013	1.022	0.726	0.660	0.560	0.508

Note: Data are for Environment and Climate Change Canada's monitoring site: Saskatchewan River above Carrot River (MA05KH0001).

Table A.10. Data for Figure 4. Annual total phosphorus concentration data for the Red River, Canada, 1999 to 2013

Year	Maximum (milligram per litre)	3rd Quartile (milligram per litre)	Median (milligram per litre)	1st Quartile (milligram per litre)	Minimum (milligram per litre)
1999	0.485	0.339	0.240	0.115	0.075
2000	0.486	0.360	0.254	0.159	0.068
2001	0.452	0.380	0.213	0.141	0.085
2002	0.390	0.348	0.156	0.104	0.032
2003	0.967	0.363	0.176	0.170	0.032

Year	Maximum (milligram per litre)	3rd Quartile (milligram per litre)	Median (milligram per litre)	1st Quartile (milligram per litre)	Minimum (milligram per litre)
2004	0.673	0.414	0.312	0.288	0.137
2005	0.758	0.467	0.373	0.193	0.107
2006	0.520	0.339	0.230	0.206	0.129
2007	0.870	0.478	0.344	0.259	0.193
2008	0.670	0.428	0.339	0.299	0.194
2009	1.020	0.377	0.321	0.251	0.135
2010	0.773	0.418	0.361	0.272	0.104
2011	0.560	0.418	0.321	0.247	0.125
2012	0.409	0.302	0.265	0.241	0.096
2013	1.420	0.524	0.405	0.354	0.149

Note: Data are for Environment and Climate Change Canada's monitoring site: Red River at Emerson, Manitoba (MA05OC0001).

Table A.11. Data for Figure 4. Annual total nitrogen concentration data for the Red River, Canada, 1999 to 2013

Year	Maximum (milligram per litre)	3rd Quartile (milligram per litre)	Median (milligram per litre)	1st Quartile (milligram per litre)	Minimum (milligram per litre)
1999	3.236	1.942	1.657	1.249	0.913
2000	5.455	2.771	1.561	1.266	1.120
2001	3.735	2.183	1.762	1.375	1.055
2002	6.050	1.956	1.503	1.185	0.687
2003	4.590	2.054	1.846	1.372	0.485
2004	4.500	2.338	1.970	1.550	1.401
2005	2.991	2.102	1.600	1.355	1.196
2006	3.962	1.865	1.425	1.281	0.951
2007	4.680	2.009	1.630	1.370	1.036
2008	4.230	2.155	1.754	1.571	1.179
2009	5.680	2.124	1.797	1.579	1.023

Year	Maximum (milligram per litre)	3rd Quartile (milligram per litre)	Median (milligram per litre)	1st Quartile (milligram per litre)	Minimum (milligram per litre)
2010	3.814	2.417	1.878	1.562	1.241
2011	5.268	2.790	2.084	1.700	1.047
2012	3.979	1.883	1.541	1.309	0.977
2013	4.790	2.427	1.997	1.754	1.180

Note: Data are for Environment and Climate Change Canada's monitoring site: Red River at Emerson, Manitoba (MA05OC0001).

Table A.12. Data for Figure 4. Annual total phosphorus concentration data for the Winnipeg River, Canada, 1999 to 2013

Year	Maximum (milligram per litre)	3rd Quartile (milligram per litre)	Median (milligram per litre)	1st Quartile (milligram per litre)	Minimum (milligram per litre)
1999	0.031	0.029	0.027	0.024	0.021
2000	0.033	0.030	0.022	0.019	0.018
2001	0.040	0.029	0.025	0.023	0.019
2002	0.094	0.031	0.028	0.026	0.021
2003	0.032	0.030	0.026	0.024	0.020
2004	0.039	0.033	0.030	0.026	0.019
2005	0.047	0.035	0.027	0.025	0.023
2006	0.031	0.030	0.028	0.025	0.020
2007	0.044	0.039	0.034	0.029	0.027
2008	0.034	0.030	0.027	0.026	0.022
2009	0.036	0.026	0.025	0.023	0.022
2010	0.032	0.030	0.028	0.024	0.019
2011	0.033	0.031	0.029	0.026	0.023
2012	0.044	0.034	0.030	0.027	0.021
2013	0.030	0.027	0.026	0.023	0.022

Note: Data are for Environment and Climate Change Canada's monitoring site: Winnipeg River at Pointe du Bois (MA05PF0022).

Table A.13. Data for Figure 4. Annual total nitrogen concentration data for the Winnipeg River, Canada, 1999 to 2013

Year	Maximum (milligram per litre)	3rd Quartile (milligram per litre)	Median (milligram per litre)	1st Quartile (milligram per litre)	Minimum (milligram per litre)
1999	0.570	0.530	0.487	0.469	0.450
2000	0.575	0.541	0.496	0.435	0.386
2001	0.605	0.582	0.547	0.530	0.479
2002	0.633	0.624	0.559	0.549	0.529
2003	0.580	0.539	0.525	0.473	0.450
2004	0.625	0.577	0.503	0.483	0.469
2005	0.732	0.544	0.533	0.513	0.505
2006	0.657	0.580	0.549	0.477	0.431
2007	0.585	0.556	0.545	0.521	0.488
2008	0.661	0.545	0.491	0.472	0.447
2009	0.556	0.525	0.506	0.484	0.448
2010	0.590	0.523	0.493	0.476	0.427
2011	0.594	0.543	0.519	0.503	0.448
2012	0.737	0.510	0.474	0.451	0.424
2013	0.551	0.505	0.484	0.455	0.406

Note: Data are for Environment and Climate Change Canada's monitoring site: Winnipeg River at Pointe du Bois (MA05PF0022).

Annex B. References and additional information

References and further reading

Alberta Environment (1999) Surface Water Quality Guidelines for Use in Alberta. (PDF; 134 KB) Retrieved on 23 March, 2015.

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Sealock L (2011) Lake Simcoe Clean-Up Fund: Phosphorous Reduction Calculation Report. Great Lakes Management and Reporting Section, Environment Canada.

Related information

Cleaning Up Lake Winnipeg

Lake Winnipeg

Lake Winnipeg Basin Initiative

State of Lake Winnipeg Report

www.ec.gc.ca

Additional information can be obtained at:

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