Environment Canada Environnement Canada

Summary Report

Lake Winnipeg Basin Initiative

2008/09 – 2011/12

Part of the Government of Canada's Action Plan for Clean Water

Canada

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Cover photos:
MV *Namao*, the Lake Winnipeg Research Consortium research vessel.
Environment Canada water quality monitoring researchers on shore of Lake Winnipeg.
The Hon. Vic Toews (Provencher MP and Minister of Public Safety) and the Hon. Christine Stewart (Minister of Manitoba Water Stewardship) sign the Canada–Manitoba Memorandum of Understanding on Lake Winnipeg.
Photos: Cynthia Thoroski © Environment Canada, 2010

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Acknowledgements

Environment Canada's work under the Lake Winnipeg Basin Initiative was conducted in cooperation and partnership with a number of federal agencies, the Manitoba government, other non-government and academic partners across the watershed, and the scientific community throughout Canada.

In particular, we would like to acknowledge the following agencies: Agriculture and Agri-Food Canada; Fisheries and Oceans Canada; Natural Resources Canada; Canadian Coast Guard; Manitoba Water Stewardship; Manitoba Agriculture, Food and Rural Initiatives; Manitoba Conservation; Ontario Ministry of the Environment; Ontario Ministry of Natural Resources; Alberta Environment; Saskatchewan Ministry of Environment; Minnesota Pollution Control Agency; Manitoba Hydro; the universities of Manitoba, Saskatchewan, McMaster, Guelph and Quebec; Ducks Unlimited Canada; and the Lake Winnipeg Research Consortium.

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- Marlene Cook, former Deputy Mayor for the City of Selkirk;
- David Crate, Chief of Fisher River First Nation and a former commercial fisher;
- Robert T. Kristjanson, a fifth-generation commercial fisher;
- Allan Kristofferson, Managing Director of the Lake Winnipeg Research Consortium;
- David Tomasson, a Manitoba Interlake fisher with past involvement in the Hecla Village Harbour Authority and the Freshwater Authorities Advisory Council; and
- Garry Wasylowski, a cattle producer and Reeve of Armstrong, Manitoba.

Finally, we would also like to acknowledge the work of all the organizations that have participated in or provided funding and in-kind support for Lake Winnipeg Basin Stewardship Fund projects. A full list of stewardship projects can be found on Environment Canada's website at www.ec.gc.ca.

Overview of the Lake Winnipeg Basin Initiative

Lake Winnipeg is the 10th largest freshwater lake in the world and the 6th largest in Canada. The Lake Winnipeg watershed spans almost 1 million km^2, extending over four provinces and into four U.S. states. Water quality has deteriorated in Lake Winnipeg due to excessive amounts of nutrients, primarily phosphorus and nitrogen, from many point and non-point sources such as surface runoff and municipal wastewater effluent. Approximately half of this nutrient load originates from outside Manitoba's borders. The excessive nutrients contribute to the growth of huge tracts of blue-green algae, which rob the lake of oxygen, clog fishing nets, foul beaches and, under certain conditions, produce harmful toxins.

Map of Lake Winnipeg watershed. © Environment Canada, 2010

In 2007, as part of Canada's Action Plan for Clean Water, the Government of Canada announced an investment of $17.7 million over four years, from 2008/09 to 2011/12, to help clean up Lake Winnipeg. The Lake Winnipeg Basin Initiative (LWBI) was developed in response

to the Manitoba government's request for federal support in addressing priority scientific needs within Lake Winnipeg and the broader basin, and to facilitate the coordination of government and stakeholder efforts in this transboundary watershed.

In order to improve the health of Lake Winnipeg, a sound scientific base of knowledge was first required, to determine what, and how much, action is needed. As a result, the major focus of the LWBI was to bring the Government of Canada's freshwater science and monitoring expertise to bear on the nutrient issues facing the lake and the watershed. This work was necessary in order to determine the appropriate measures needed to reduce nutrient loading into the lake, and to identify priority performance indicators to determine if such measures will be effective in improving the health of Lake Winnipeg.

The LWBI's $17.7 million resources were allocated as follows:

- scientific research, monitoring and information/data support ($12.1 million)
- community stewardship programs ($3.7 million)
- facilitating watershed governance ($1.9 million)

Activities in support of the LWBI were launched in 2008/09 on Lake Winnipeg and its major sub-basins, including the Red–Assiniboine and Winnipeg rivers, and Lake of the Woods.

Executive Summary

Activities throughout the four-year, $17.7 million Lake Winnipeg Basin Initiative (LWBI) focused on supporting stewardship activities amongst external and community groups; facilitation and coordination amongst federal and provincial agencies; and filling priority research, monitoring and information needs in Lake Winnipeg and its watershed.

Near-term results of the LWBI were generally achieved, including development of an improved science-based understanding of the dynamics of Lake Winnipeg and its Basin to support and inform policy and decision making, support for community stewardship activities, and development and implementation of a Canada–Manitoba agreement on Lake Winnipeg.

Facilitating Governance

In scope, the Lake Winnipeg Basin is both inter-provincial and international, and involves a myriad of stakeholders, jurisdictions and activities. Long-term collaboration and coordination between relevant stakeholders is fundamental to the health of the Basin. Through the LWBI, Environment Canada established a Lake Winnipeg Basin office in Winnipeg in 2009/10 to coordinate the three focus areas of the LWBI and enhance communications and coordination with existing water management bodies and other agencies.

Canada–Manitoba coordination on Lake Winnipeg water quality issues has greatly enhanced information sharing and cooperation amongst federal and provincial agencies and partners. A Canada–Manitoba Memorandum of Understanding Respecting Lake Winnipeg and the Lake Winnipeg Basin (MOU) was signed in September of 2010, to provide for a long-term collaborative approach to addressing the sustainability and health of the Lake Winnipeg Basin. An MOU Implementation Steering Committee comprised of federal and provincial agencies, and co-chaired by Environment Canada and Manitoba, was established to oversee the implementation of the MOU and development of subsidiary arrangements.

In addition to the MOU steering committee, Environment Canada continued to lead or participate on a number of domestic and transboundary boards, commissions, agencies and stakeholder groups within Manitoba and other provinces, as well as with U.S. agencies. Given the transboundary nature of nutrient sources into Lake Winnipeg, inclusion of the nutrient issue in such collaborations helped to support the development of nutrient management strategies and solutions throughout the vast Lake Winnipeg watershed.

Moving forward, Environment Canada will continue to deliver on its transboundary water mandate in the Lake Winnipeg Basin and will continue its role of ensuring effective communication and complementary approaches within branches of Environment Canada and among federal departments by increasing horizontal coordination of activities.

Stewardship

The Lake Winnipeg Basin Stewardship Fund was launched in 2008/09 to support high-impact, solution-oriented projects aimed at reducing nutrient loads in Lake Winnipeg and its Basin. The Fund supported a variety of "tried and proven" activities to reduce nutrients, studies and projects to aid decision making, as well as practical applications of innovative technologies within the Basin.

Fund priorities included: reducing nutrient inputs from rural and urban sources, controlling point and non-point sources of nutrients, rehabilitating priority aquatic ecosystems that support nutrient reduction and sequestration, and enhancing research and monitoring capacity to assist in decision making.

Over the course of five funding rounds, the Fund received 123 applications for funding. From among those, a total of $2.4 million was committed towards 41 community stewardship projects. The Fund leveraged $5.4 million in monetary and in-kind contributions from more than 250 project partners, multiplying the beneficial impact of the Fund. Project recipients included regional conservation authorities (20), non-profit organizations (9), post-secondary institutions (9), First Nations organizations (2) and municipal governments (1).

Projects were diverse in regards to location, design and approach, reflecting the myriad of contributing sources of nutrient loading into Lake Winnipeg. Thirty-three of the funded projects were in Manitoba, followed by five in Saskatchewan and three in Ontario. This diversity enabled broad-based stakeholder involvement across the watershed, but presented a challenge in focusing Fund resources in strategic areas and activities to maximize the positive benefits to Lake Winnipeg.

Lake Friendly project presentation to Gimli area students. Photo: Loren Remillard © Environment Canada, 2010

Projects addressing non-point sources of nutrients were the predominant activity funded. For example, 31 km of livestock exclusion fencing and 34 alternative watering systems were installed to restrict approximately 7000 livestock from accessing waterways draining into Lake Winnipeg. Riparian restoration efforts included protection or stabilization of 38 km of stream/lake bank. Approximately 17 000 native plants, trees and shrubs were also planted over 74 hectares. Wetland restoration and protection initiatives reclaimed 549 hectares of land, of which 126 are permanently protected by conservation agreements. Research studies of historical water quality

changes in Lake Winnipeg were conducted, complementing work being done in the lake by Environment Canada and provincial scientists. The effective use of riparian zones to filter nutrients was studied. Innovative waste water treatment systems and processes were supported to expand real-life application of available technologies and techniques. Wetland and sensitive habitat mapping was undertaken to advance current and future decision-making regarding Lake Winnipeg.

Research and stewardship efforts were complemented with capacity-building projects such as the Lake Friendly Campaign, designed to raise public awareness of the issues affecting Lake Winnipeg and actions individuals can take to reduce and mitigate nutrient loading across the Basin.

While it is too early to assess the impact of individual projects on nutrient loading to the lake, the Fund served to establish vital new partnerships and provided a foundation for organizations to move forward to deliver long-term benefits for Lake Winnipeg.

Research, Monitoring and Information Management

In response to requests from Manitoba and other stakeholders for federal freshwater expertise and support in fulfilling priority science needs within Lake Winnipeg and the broader watershed, a comprehensive science plan was developed to address research, information and monitoring gaps related to lake ecology, nutrient cycling, and the sources and transport mechanisms for nutrients. The science undertaken by Environment Canada through the LWBI was done in partnership with other agencies, including Fisheries and Oceans Canada, Agriculture and Agri-Food Canada, Manitoba Water Stewardship, the University of Manitoba, and other supporting agencies.

Research

The goal of the research undertaken through the LWBI was to characterize the physical, chemical and biological nature of Lake Winnipeg to better understand the balance of nutrient enrichment and productivity of fisheries in relation to algal blooms, assess non-point contributions of nutrients in the watershed and the lake and the effectiveness of agricultural beneficial management practices (BMPs), and investigate the economic value of clean water and the effectiveness of regulations and social policy on nutrient management in the watershed.

Research included characterizing the status and long-term trends in the biological community in Lake Winnipeg, Lake of the Woods and tributaries, the ecological impacts of blooms,[1] and the potential impacts of nutrient enrichment and invasive species on the food web. In-lake processes that promote algal and cyanobacteria blooms and their potential toxicity were explored. Results indicated that the cyanobacteria species dominating the summer blooms in Lake Winnipeg are not highly toxic, but the risk of toxins can increase dramatically in dense surface or shoreline scums, which commonly occur as a result of wind and currents. Invasive species such as dreissenid mussels could significantly impact light and nutrient regimes in the lake, potentially contributing towards more frequent blooms in the turbid south basin and a shift to more toxic cyanobacteria species in the future.

LWBI scientists used stable isotope “fingerprinting” of nutrients to obtain new information regarding nutrient sources in the Red River basin, analyze the cycling of organic matter and impacts on the food web, the processes that lead to algal bloom development and the factors that affect dissolved oxygen levels in Lake Winnipeg. Dissolved oxygen is crucial to the survival of aquatic ecosystems. Excessive algal growth and associated demands in oxygen consumption can depress oxygen levels in the water column. Despite high nutrient loadings and ongoing algal blooms in Lake Winnipeg, bottom-water oxygen depletion occurred only at a transient level in deeper parts of the north basin. The remainder of the lake is shallow and well-mixed.

[1] Broadly termed “algal” blooms, these occur throughout the year; those of most concern occur in the summer–fall period and are mainly dominated by cyanobacteria (also called “blue-green algae”).

Stable isotope analyses indicated that the Red, Winnipeg and Saskatchewan rivers have distinctive nitrate sources, providing an isotopic signature that enabled tracking of nitrates into Lake Winnipeg. Differences in nitrate sources in the north basin (decay of nitrogen-fixing cyanobacterial blooms) and south basin (primarily animal waste) were pronounced and indicate that each basin requires separate nutrient process models. Stable isotope measurements were also able to trace fish movements. This work provided a multi-year snapshot of the dissolved oxygen and metabolic status of Lake Winnipeg, and a productivity benchmark by which to compare outcomes of future nutrient management development in the lake and its watershed.

Environmental conditions in the Lake Winnipeg Basin are extremely variable, and nutrient loading is influenced by both natural conditions and human activities. As a result, field work was undertaken to examine the transport of nutrients in agricultural watersheds, the impact of snowmelt on nutrient transfer, and the impact of hydrology, climate change and variability on nutrient transfer.

Researchers on deck of vessel, deploying sequential sediment trap into Lake Winnipeg. Photo: Todd Breedon © Environment Canada. 2009

Agricultural activities, particularly synthetic fertilizer application, were found to be the largest potential source of nutrients from human activities into aquatic ecosystems in most areas of the Lake Winnipeg Basin. Agriculture in areas within approximately 100 m of stream channels appeared to be the most critical driver of in-stream nutrient conditions during most seasons and under most flow conditions.

Nutrient loading is also strongly influenced by seasonal hydrology, with snowmelt being a critical period. Concentrations of nutrients varied seasonally, but showed more variability and larger values during winter and snowmelt. Vegetation (particularly winter cereals, riparian vegetation and forage crops) was found to be a significant source of nutrients in snowmelt runoff. Most BMPs have been designed to remove sediments from runoff and often use vegetation to prevent soil erosion and trap dislodged particles. However, the soil may actually buffer dissolved nutrients that are released from residues. This has implications for the development of BMPs, and for land-use management practices, which need to consider the snowmelt period in order to control nutrient loads to Lake Winnipeg and to other water bodies in the watershed.

Climate models and projections show future increases in annual precipitation and temperature, and changes to the hydrologic and nutrient transport regimes, resulting in higher total runoff and earlier snowmelt and discharge peaks. Overall, the effects of climatic changes on the nutrient transport regime need to be considered along with possible future changes in land use, crop type, fertilizer application and transformation processes in the receiving water bodies. Such

changes would have significant implications for water availability and nutrient transport regimes, and for the design and implementation of practices to control nutrient loads to Lake Winnipeg and in the watershed.

Hydrologic models for Lake Winnipeg and Lake of the Woods were developed, which succeeded in reproducing thermal structure and circulation, and examining relationships between a variety of physical, chemical and biological processes. A predictive ecosystem model was developed to simulate the major nutrient and algal dynamics in Lake Winnipeg. Wind-driven circulation plays a crucial role in how materials are mixed, retained and/or flushed from each basin in Lake Winnipeg.

Similarly, watershed models were applied to aid in the understanding and management of surface runoff, nutrients and sediment transport processes, and evaluate the impact of land-use changes and practices. Stakeholder and landowner engagement played an important role in developing the watershed modelling scenarios and decision-support tools. The models indicated that conversion of cropland to hayland had a significant impact on reducing nutrient and sediment loading, followed by wetland restoration. Results of the modelling will be useful for planners and decision makers in identifying changes that may occur based on nutrient management policies.

Researcher standing at edge of field with monitoring equipment for nutrient runoff. Photo: Julie Corriveau © Environment Canada, 2009

A framework for using ecological goods and services (EG&S) was also developed and applied to two case studies in the Lake Winnipeg Basin. Several agricultural BMPs and wastewater treatment strategies were examined to estimate their costs, benefits in terms of phosphorus reduction, and EG&S co-benefits, such as greenhouse gas emission reduction, erosion control and pollination services. Results indicated that wastewater treatment strategies were generally less cost-effective than agricultural BMP strategies when the annualized net cost per tonne of phosphorus removed was considered. Some options for nutrient reduction, such as crop selection and vegetative filter strips, were associated with substantial EG&S co-benefits, although both had limited overall potential to reduce phosphorus loading, compared to other scenarios that were examined.

The value of improvements in EG&S provided by nutrient reduction strategies points to an increased need for including them in policy analysis, and for municipal, provincial, and conservation and watershed authorities to identify, measure and monitor EG&S.

Monitoring

An enhanced water-quality and biological monitoring program was implemented on Lake Winnipeg, Lake of the Woods and within the Lake Winnipeg watershed, to expand existing databases and to support modelling and research projects. Activities included deep-water bottom trawling, monitoring at east-side Lake Winnipeg river outflows, nearshore and marsh locations in the south basin and Red River delta areas, and at the outlet of Lake Winnipeg. Enhanced tributary monitoring was conducted in cooperation with the Manitoba government, to improve estimates of nutrient flux into the Red River between Emerson and Lake Winnipeg. Monitoring data was uploaded to the Lake Winnipeg Web portal.

Aquatic colour methods were developed for use with satellite observations, to support remote sensing imagery for Lake of the Woods and Lake Winnipeg. Remote sensing is a useful tool for tracking of surface algal blooms, and offers a cost-effective approach for monitoring, particularly when ground-based monitoring may not be logistically obtainable on a frequent basis and over large areas. There is evidence of intense bloom activity during dry, warm years, with a suggestion of blooms occurring later each year. Near-real-time images for Lake Winnipeg and Lake of the Woods are being posted to the Lake Winnipeg Web portal.

Two researchers drag net across shoreline of Lake Winnipeg. Environment Canada researchers Elise Watchorn and Lindsay Wazny collect small fish and invertebrate samples (Gimli, Manitoba). Photo: Cynthia Thoroski © Environment Canada, 2010

Using national Canadian Aquatic Biomonitoring Network (CABIN) protocols, a boreal reference condition model and a Prairie wetland biomonitoring protocol were developed. Collaboration was undertaken with other agencies to establish a Prairie biomonitoring network, which would greatly enhance the availability of biomonitoring data in the future. Work was also undertaken to develop a prototype indicator of local nutrient enrichment, based on biomonitoring data.

Monitoring was undertaken at 30 larger lakes and reservoirs in the Lake Winnipeg Basin, to evaluate the role of natural lakes and human-made reservoirs in reducing nutrient transfer from the watershed to Lake Winnipeg. Preliminary results indicate that large lakes and reservoirs in the Basin, particularly those with long water-retention times, sequester a variable but often high proportion of inflowing nutrients—up to 80% in some cases—playing an important role in reducing nutrient loading to Lake Winnipeg.

Funding support was provided to the Lake Winnipeg Research Consortium on an annual basis through the LWBI, to support the Consortium's activities. The Consortium includes a large group of government and non-government agencies dedicated to coordination of research and monitoring, as well as public education and outreach about the state of Lake Winnipeg. The Consortium

also operates the MV *Namao* vessel, the only research and monitoring platform operating on Lake Winnipeg. Environment Canada also designed and supplied a new combined control room and lab addition to the *Namao*'s upper deck, to enhance research capabilities.

Information

LWBI information management activities included creating a single-window, online information portal for sharing data amongst key scientific partners and networks, and providing a basis, based on the results of research and monitoring activities, to inform the development of nutrient objectives and performance indicators for Lake Winnipeg.

The Lake Winnipeg Web information portal was developed, in conjunction with stakeholders, to gather, store and share data concerning the watershed, and to provide users with the tools and information they need to make effective water management decisions. The portal enables users to freely upload their data and information and model results for sharing with others. The portal currently contains about 137 datasets, and was transferred to the University of Manitoba in March 2012, where it will continue to grow and evolve as a comprehensive source of information and a resource for students, scientists and the public.

Image of the Lake Winnipeg Web information portal home page.

Environment Canada also partnered with Manitoba and other agencies to produce the *CA/MB State of Lake Winnipeg 1999-2007* report. This comprehensive report compiled historic data, highlighted recent research, and explored current and emerging issues of concern to the health and integrity of Lake Winnipeg—providing a baseline against which the results of current research and monitoring activities can be compared. Environment Canada also provided support to the Partners for the Saskatchewan River Basin for production of the 2009 *State of the Saskatchewan River Basin* report.

The Lake Winnipeg special edition of the *Journal of Great Lakes Research* was coordinated by Environment Canada, for publication in 2012. Eighteen papers from various government and non-government authors were submitted to the special edition, including many reports stemming from the research undertaken through the LWBI.

Finally, work was undertaken through the LWBI to support Manitoba in developing a science framework for establishing and evaluating nutrient objectives for Lake Winnipeg and tributaries. Environment Canada also worked with Manitoba to identify, finalize and evaluate 18 priority performance indicators to assess the health and detect changes in the lake and watershed.

A report was drafted and is pending peer review, prior to being finalized. The indicators are anticipated to be used to direct future monitoring and research activities, and complement the development of ecologically relevant nutrient objectives.

Further details about the progress and achievements of the LWBI are available on Environment Canada's website at www.ec.gc.ca. More detailed LWBI project reports and technical information about the LWBI science activities, methodologies and research results can be obtained on the Lake Winnipeg Web information portal at http://lwbi.cc.umanitoba.ca.

Conclusion

The LWBI accomplished its near-term deliverables and commitments; however, challenges remain.

The water quality and biological monitoring conducted throughout the four years of the LWBI provided a relatively short "snapshot" of environmental conditions in Lake Winnipeg and its watershed. Spatial and temporal gaps in monitoring data imposed limitations on some of the research and modelling results. For example, reasonable calibration of hydrodynamic and eutrophication models was achieved during the LWBI, but additional observations, including winter measurements, would provide more robust validation of the models. Longer-term water quality and biological monitoring is also necessary to reflect the annual and seasonal variability that exists in the watershed and affects nutrient transport and delivery, and for measuring the effectiveness of current and future nutrient reduction measures on the health of Lake Winnipeg.

Additional areas for potential further exploration were identified throughout the course of the LWBI, including the role of flooding on nutrient loading into Lake Winnipeg, the role of internal recycling of nutrients within the lake, impacts of environmental factors (light conditions, wind speeds, etc.), climate change and variability, and the potential impact of invasive species. Nutrient-related issues in Lake Winnipeg also show parallels with those within the Lake Erie West Basin. Comparison and analyses of these two systems may allow further insight into the factors modifying Lake Winnipeg's response to current and future basin-wide actions.

Environment Canada researcher Gordon Chamberlain collects water sample from shoreline of Lake Winnipeg (Gimli, Manitoba). Photo: Cynthia Thoroski

Work undertaken through the LWBI also points to the need for a standard approach across Canada to measure and value ecological goods and services (EG&S). Applying this concept holds the potential to reveal otherwise-hidden benefits associated with water quality improvement projects.

In order to facilitate transboundary nutrient management, the federal focus going forward should be on the inclusion of the nutrient issue in collaborations with domestic and international mechanisms and partners, in a manner that supports the implementation of a broad bi-national nutrient management strategy across the Red River basin. Opportunities also exist to increase engagement of other provincial and U.S. entities to address nutrient issues in Lake of the Woods and the Winnipeg River system.

Focusing future stewardship efforts and support on sub-watersheds shown to be the significant sources of nutrient loading, along with implementation of long-term water quality monitoring and other evaluation tools, would also enable a more demonstrable assessment of stewardship project impacts on nutrient loading. Targeted initiatives to engage watershed residents in individual and collective behavioural changes would be beneficial in realizing short-term outcomes and garnering support for longer-term systemic solutions. Increased engagement of watershed residents in supporting and participating in potential remedies to address the issues affecting Lake Winnipeg will be important for community-driven stewardship to take hold and grow.

Finally, the role and contributions of partner agencies and stakeholders in contributing to the LWBI cannot be overstated. The expertise, data and advice provided by the Manitoba government, Agriculture and Agri-Food Canada, Fisheries and Oceans Canada, municipal agencies and conservation districts, non-government agencies, landowners and other stakeholders was vital for implementation of all facets of the LWBI. The vast size of the watershed, and the myriad of non-point sources of nutrient loading, makes engagement across a broad spectrum of government and non-government agencies and stakeholders essential for improving the health and sustainability of Lake Winnipeg.

Lake Winnipeg Basin Initiative partners gather for signing of Canada–Manitoba Memorandum of Understanding in Winnipeg.

For More Information

For more information about the Lake Winnipeg Basin Initiative (2008/09 – 2011/2012), please contact:

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