Lake Winnipeg Basin Program Symposium

Summary Report, 2022

Environment and Climate Change Canada
Environnement et Changement climatique Canada

Canada

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Photos throughout this report have been provided courtesy of many individuals who have worked on Lake Winnipeg and throughout its watershed over the past several years.

PREAMBLE AND ACKNOWLEDGEMENTS

Environment and Climate Change Canada (ECCC) hosted the Lake Winnipeg Basin Program (LWBP) Virtual Symposium on January 18, 19, and 20, 2022. This symposium forms part of the LWBP's efforts to share recent scientific advancements and nutrient reduction actions in the Basin and followed a previous in-person symposium held in Winnipeg on March 20 and 21, 2019. The first two days of the symposium focused on ECCC led research, with Day 3 focused on projects funded through the LWBP's grants and contributions funding.

The symposium was opened and closed each day in a good way, with comments and prayers. Indigenous Elders Mary Maytwayashing, Florence Paynter, and Linda St. Cyr-Saric shared their knowledge, perspectives, and their wishes for a good future for the health of Lake Winnipeg and Taylor Fleming from the Manitoba Métis Federation shared her fiddle playing passion.

Many staff from ECCC were instrumental in the organization of the event, including Arthur Friesen, Sharon Reedyk, Michelle Duval, Ute Holweger, Iris Griffin, Jessica Thomson and Dana Hay.

Stratos Inc. facilitated the logistical support for hosting the virtual symposium platform.

Sharon Gurney, Gurney& Associates, provided technical writing support in the preparation of this report.

INTRODUCTION

Lake Winnipeg and its Watershed

Lake Winnipeg is Canada's sixth-largest lake and the eleventh largest freshwater lake in the world. The lake's enormous watershed spans almost a million km^2, covering portions of four provinces (Manitoba, Saskatchewan, Alberta, Ontario) and four states (North Dakota, Minnesota, South Dakota, Montana). The lake's drainage area is approximately 40 times larger than the surface area, covering seven ecological regions within three ecozones, with diverse land-use activities. Approximately half of the basin is under agricultural production and close to seven million people live in the watershed. Water from Lake Winnipeg flows north into the Nelson River system, and then into Hudson Bay.

Lake Winnipeg supports a diverse range of economic, social, and environmental benefits. The lake is a valuable freshwater resource known for its commercial and recreational fisheries and its importance to the traditional livelihood of many Indigenous and Métis communities. The beaches are an important social and economic driver for local communities attracting visitors, cottagers, permanent residents, and associated businesses. The lake supports many lakeside communities along its shoreline and is the homeland of several First Nation and Métis people who value the lake for economic, environmental, and spiritual reasons.

Lake Winnipeg Watershed. Source ECCC (https://www.ec.gc.ca/doc/publications/eau-water/COM1167/image1_e.htm)

There has been increased concern about the health of Lake Winnipeg due to large algal blooms that have increased in size, duration, and frequency since the1990s. Although algae are an important natural component of the freshwater ecosystem, excess algae, and in particular large amounts of cyanobacteria (blue-green algae), are a concern for their potential impacts on recreation, fisheries, animal health, and drinking water.

Protecting water quality in Lake Winnipeg and its watershed is a complex and challenging task. Nitrogen and phosphorus point source discharges originate from many large and small wastewater treatment systems across the watershed, and from the many small and diffuse non-point sources of nutrients arising from both urban and rural landscapes. Both atmospheric loading and internal loading of nutrients from within the lake are additional sources of nutrients that support the growth of nuisance and harmful algal blooms. Efforts to improve the health of Lake Winnipeg will come from efforts throughout the watershed, including wastewater treatment facility upgrades, implementing beneficial management practices to retain runoff and reduce nutrient loading from rural landscapes, and actions to limit the introductions of new aquatic invasive species. The integration of Traditional Knowledge and western science is critical to both understanding and managing the health of Lake Winnipeg.

SYMPOSIUM OBJECTIVES

Share findings

- from ECCC-led research related to nutrients and water quality in Lake Winnipeg and its basin

Feature program accomplishments

- including highlights of funded projects that support the following program priorities:
  - reduced nutrient loading
  - enhanced collaboration throughout the basin
  - engaging Indigenous peoples on water quality issues

Gathering feedback

- on research and on future program priorities for the Lake Winnipeg Basin Program

Algal bloom at Hecla Island Fish Station

DAY 1 SYMPOSIUM PRESENTATIONS

Welcome & Opening

Ute Holweger (ECCC) opened the symposium and welcomed all participants. Ute acknowledged that she was presenting from Treaty One Territory, the traditional lands of the Anishinaabe (Ojibway), Ininew (Cree), Oji-Cree, Dene, Dakota, and is the birthplace of the Métis Nation and heart of the Métis Nation Homeland.

Elder Mary Maytwayashing, Lake Manitoba First Nations, delivered an opening prayer giving thanks to the Creator and provided reflections on the need to nurture Mother Earth and remember that our rivers are the lifeblood of the earth. She asked for strength and protection for all, including future generations, and gave thanks for the ability for us all to gather remotely. Her prayer acknowledged all nature on earth, giving thanks and expressing gratitude for this. Mary then shared a song, in her traditional language, about water and the thunderbirds who work to protect water in her culture. Mary ended her remarks with thanks/ Miigwech.

MP Terry Duguid, Parliamentary Secretary to the Minister of Environment and Climate Change Canada, provided greetings from the federal government. On behalf of the Honourable Minister Guilbeault, he acknowledged that he was speaking from Treaty One Territory, the traditional lands of the Anishinaabe (Ojibway), Ininew (Cree), Oji-Cree, Dene, Dakota, and is the birthplace of the Métis Nation and heart of the Métis Nation homeland.

Parliamentary Secretary Duguid highlighted the importance of Lake Winnipeg, recognizing its economic importance in generating hydroelectricity, and to the recreation and fishing industries, as well as its value to migratory birds, and its value to the cultural and economic needs of communities to those along the shores, in particular to the First Nations and Métis communities.

The Parliamentary Secretary noted that protection and restoration of freshwater resources, including Lake Winnipeg, is a priority for the federal government, as outlined in Minister Guilbeault's mandate letter from the Prime Minister. It is well established that the health of the lake is impacted by nutrient sources, as evidenced by toxic algal blooms. As climate change may further deteriorate conditions, collaboration and partnerships will be key to addressing these challenges in order to achieve greater results. While government action is critical, everyone has a part to play to restore the health of Lake Winnipeg and its watershed.

The challenges facing the Lake Winnipeg watershed are shared across the country, and therefore the federal government is pleased to be moving forward with the creation of the Canada Water Agency, to work with all partners to strengthen collaboration and keep Canada's waters clean.

Through the government's 2021 platform commitments, and Minister Guilbeault's mandate letter from the Prime Minister, he affirmed his commitment to support the action needed to restore the health of Lake Winnipeg.

Lake Winnipeg Basin Program Overview

Scope

Through Budget 2017, Canada invested $25.7 M in the Lake Winnipeg Basin Program to support nutrient reduction, collaboration, and Indigenous engagement activities. This included funding to advance in-lake and watershed-based science, and cost shared projects undertaken by external partners and stakeholders, including Indigenous partners. The LWBP also enabled collaboration arrangements with other government agencies which have advanced data needs for both science and decision making and has provided support for knowledge transfer to connect research with on-the-ground action.

The LWBP is part of a bigger suite of ECCC activities and services in the Lake Winnipeg basin including: The Canada-Manitoba MOU Respecting Lake Winnipeg and the Lake Winnipeg Basin; water quality and quantity monitoring at provincial and international boundaries, and; technical and professional support to inter-jurisdictional organizations such as the Prairie Provinces Water Board, as well as relevant boards of the International Joint Commission.

LWBP Science Plan

The Lake Winnipeg Science Plan embodies five key elements: monitoring to track change and assess the health status of the lake and its watershed; research on nutrient sources and transport pathways to tributaries of Lake Winnipeg; assessing the response of Lake Winnipeg to nutrient reduction, including the BMPs that are needed to reduce nutrient loss from the landscape; evaluating the impact of climate variability on nutrient loading, and; reporting on progress towards restoring a healthy Lake Winnipeg.

LWPB Grants and Contribution Funding Projects:

The LWBP grants and contribution funding supported 74 stakeholder led projects. These projects advanced the three program priorities of nutrient reduction, Indigenous engagement, and collaborative governance.

Funding was provided to support two directed projects over the five years of the program. This included support for the Lake Winnipeg Research Consortium and its operation of the in-lake science platform the MV Namao, and the Canadian Watershed Information Network (CanWIN) online portal, hosted by the University of Manitoba.

The LWPB was able to support 72 application based priority projects related to nutrient reduction, Indigenous engagement, and collaborative governance. These funded projects leveraged significant partner funding from Indigenous partners, NGOs, watershed and transboundary agencies, and scientific associates. A description of these LWBP funded projects is outlined on the LWBP website.

Although project funding for this phase of the LWBP ends on March 31, 2022, work continues on several fronts. A final report on the LWBP will be prepared, summarizing the accomplishments of the program. Collaborative efforts with the Province of Manitoba will continue, including the development of a shared workplan under the Lake Winnipeg MOU. New subsidiary arrangements are being developed under the MOU to specify both collaborative science efforts as well as reconciliation through Indigenous engagement and participation, ensuring that Indigenous knowledge is incorporated into ecosystem health reporting. ECCC will be advancing a Lake Winnipeg Adaptive Management Framework that will consider climate change scenarios and how a changing climate may impact nutrient loading and the health of Lake Winnipeg.

Nutrient Transport and Fate Session[1]

Groundwater-Surface Interactions in the Assiniboine Delta Aquifer Area ~ Serban Danielescu, Agriculture and Agri-Food Canada & ECCC

The Assiniboine Delta Aquifer (ADA) is the largest unconfined aquifer in the Lake Winnipeg basin at 3800 km^2. As approximately 2/3 of the ADA drains into the Assiniboine River, it is important to understand the groundwater-surface water interactions, in particular how this relates to determining the water budget and the transport of nutrients and other contaminants from ADA groundwater to surface water from the ADA to the Lake Winnipeg watershed.

In June (high flow and warm weather) and October (low flow and cold weather) of 2018, groundwater and surface water sampling was conducted across the ADA for a variety of water chemistry constituents, including nutrients, dissolved oxygen, redox conditions, geochemical isotopes, sweeteners, and the herbicide glyphosate. In addition, the age (residence time) of groundwater in the ADA was investigated. Relatively low levels of nitrate, ammonia, and phosphorus were found in the surface and groundwater samples collected during these two sampling periods.

The research found a strong connection between groundwater and small tributaries as reflected in both the chemical composition and the isotopic signatures, in contrast to that found in the main stem of the Assiniboine River. The research found strong reducing conditions in the groundwater showing anoxic conditions, whereas the tributaries should have a mix of oxic and anoxic conditions, with the Assiniboine River showing to be fully oxic in nature. The main stem

[1] Appendix 2 provides a list of relevant published Lake Winnipeg basin research papers related to Day 1 symposium presentation.

showed supersaturated oxygen conditions, with the tributaries showing lower oxygen saturation levels.

Shallow groundwater was found to be both a receptor of nutrients as well as a source of nutrients to surface water within the basin. Groundwater was found to play a significant role in regulating both the flow and the chemical composition of the tributaries of the Assiniboine River within the ADA. The artificial food sweetener acesulfame used in food for humans and animals was detected in the Assiniboine River, but not detected in the smaller tributaries or groundwater samples. Similarly, glyphosate was found in relatively high concentrations in the river, but low or absent from samples collected from tributary and groundwater sampling sites. Isotopic research found a range of groundwater ages, from modern to old (2400 yr.). The movement of water in the subsurface is slow, and shallow groundwater is susceptible to contamination.

The study concluded that the groundwater inflows to the Assiniboine River are significant, as evidenced by the strong connection between the chemical composition of groundwater and the small tributaries. Both flow and chemical composition of groundwater were found to be significant to the Assiniboine River. It was further reported that shallow groundwater could be both a receptor and a source of nutrients.

Future research will focus on an increase in sampling frequency, including event-based monitoring. More work is needed to determine nutrient loads originating from shallow vs deep groundwater samples. In addition, work will continue to further describe water quality depth profiles in groundwater and processes that occur at the groundwater-surface water interface.

Applying a Bayesian Framework to Track Binational Loads and Sources Across the Red-Assiniboine River Basin
~ Agnes Richards, ECCC

The objectives of this work were to develop a binational Bayesian SPARROW model for total phosphorus (TP), which would account for the main sources of uncertainty including loadings estimates, parametric uncertainty, and model structural error. Efforts included testing the model sensitivity with different data sets to use the model to predict TP fluxes and the associated sources to provide a framework for risk-based watershed management.

The SPARROW watershed model was used to relate stream water quality to nutrient sources, landscape delivery factors, as well as nutrient losses to streams, reservoirs, and lakes. The calibrations for this model were deterministic, and the final models were used to predict nutrient fluxes in the Red-Assiniboine River basin. Components from previous versions of the SPARROW model were ported using SAS code to apply it to a Bayesian framework. Open-source languages were used in this work.

Existing data that had been harmonized across the Canada-USA border was used along with new layers of data. This included 101 water quality stations and 350 wastewater treatment systems. For each water quality station, catchments were delineated for individual reaches. Non-contributing areas (e.g., prairie pothole region) were taken into account as they were not contributing to the TP fluxes. A description of model inputs including point and non-point load sources, runoff, and losses was provided. The model was calibrated using different sources of variability to the coefficients. This Bayesian modelling framework was able to successfully calibrate scenarios. The lessons and information from other SPARROW modelling work were used to help develop this framework. The final calibrated Bayesian SPARROW model was used to predict loads and yields across multiple spatial scales from individual reaches to the entire Red-Assiniboine River basin. The model provided estimates of aggregated yields to Lake Winnipeg from 54 natural sub-sub-watersheds. Maps were generated to illustrate fluxes across the basin. The model showed that the majority (57%) of the TP load to Lake Winnipeg originates in the US, with the vast majority of the load (88%) being generated from the Red River basin. Based on aggregated yields, the model identified two major nutrient loading hotspots, one in Canada and one in the USA.

The Canadian hotspot showed that at the catchment scale, 65% of the sources were from wastewater treatment plants, followed by agricultural sources. The reaches with the top three TP fluxes had 90% of their sources from wastewater treatment plants, indicating that management actions to improve wastewater treatment could potentially reduce TP loadings to Lake Winnipeg. The USA hotspot was located in the Fargo area. It was found to deliver 2.6% of the TP load to Lake Winnipeg, with wastewater and agricultural loads being contributors to varying degrees, within differently defined reaches.

Nutrient reduction efforts in the Seine-Rat River watershed

Other significant hotspots for total nitrogen (TN) and TP loading have been identified in tributaries in the USA and Canada. In Canada, these tributary hotspots deliver about 9.1% of the total delivered TP load to Lake Winnipeg, with these loads originating from both wastewater and agricultural sources. In the USA, the other hotspots contribute about 7% of the total delivered TP load to Lake Winnipeg. They were primarily found to be agricultural and stream channel sources.

This modelling helps target nutrient management needs across the watershed. Several next steps were identified to improve the model. This includes the need to consider climate change as it relates to the increased frequency and intensity of storm events, which impact nutrient transport. Bayesian calibrations for a TN model will follow this work. Both TP and TN models are expected to be used as baseline comparisons to consider various climate change scenarios, and also to help evaluate t nutrient targets at different scales. Future work will look at remote sensing data that track algal blooms in Lake Winnipeg and consider how non-contributing areas (prairie potholes) influence the formation of these blooms in wet years when there is spillover into the main river network. This research will support the watershed modelling activities related to binational TP and TN tributary target setting

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Fate of Bioavailable Nutrients from Episodic Wastewater Lagoon Releases ~ Kristin Painter, University of Saskatchewan

There are over 200 lagoons in the Red River valley, many serving populations greater than 2000 individuals. Theses smaller and older lagoons are required to meet the 1.0 mg/L Total Phosphorus (TP) provincial discharge limit; with one-third of the lagoons discharging directly to waterways. This research investigated the fate of nutrients from wastewater lagoon releases on a reach, rather than basin scale. These lagoons deliver nutrients in pulsed releases, generally between May and October, that can vary in ways such as the quantity of effluent released, the timing of the release, as well as the number of releases. It is easy to miss the impact of these discharges if sampling occurs when these systems are not discharging; and these discharges can have a significant impact on water quality during the discharge periods.

Segments of Deadhorse Creek were sampled immediately upstream, at the lagoon discharge point, and at five locations downstream of the Morden lagoon, during three lagoon effluent releases, covering varying environmental conditions. Environmental tracers were utilized, and samples were analyzed for ammonium, nitrate, and soluble reactive phosphorus (SRP) to investigate ways that streams can transform or retain nutrients. The ratio of the tracer ^{14}N to ^{15}N was used to evaluate nitrification of NH_4^+ to NO_3^-, as well as denitrification of NO_3^- to N gases (N_2O and N_2). Nitrogen assimilation by primary producers (e.g. algae) was also investigated using nitrogen tracers.

The fate of phosphorus was investigated by tracking SRP to determine if the stream was a sink, through processes of assimilation, sorption/desorption. The net nutrient uptake length, referred to as $S_{w\text{-}net}$, was calculated for three periods during the summer of 2018, the summer of 2019, and the autumn of 2019. In the summer of 2018, NH4+, NO3- and SRP were all assimilated as shown by a positive $S_{w\text{-}net}$ value. In the summer of 2019, SRP showed a negative $S_{w\text{-}net}$ value, and then during the autumn of 2019 both NO3- and SRP had negative $S_{w\text{-}net}$ values, indicating the export of these key nutrients.

The nitrogen stable isotopes results for primary producers in these same samples did not show clear patterns of nitrification or denitrification over the study area reach, although more activity appeared to be occurring between the 0-2 km reach. No correlation was found between waste nitrogen and primary producers, but the proportion of wastewater nitrogen did increase in the primary producers over the river reach, suggesting that assimilation by primary producers is occurring but is not likely the dominant process. The influence of the season was evident in this study, showing various export of NO3- and SRP varied during the three sampling periods, with higher transport occurring during wetter, higher flow conditions. Also, previous lagoon discharges may have saturated uptake capacity prior to the 2019 sampling period.

The research shows concentrations can overwhelm uptake capacity under current lagoon management approaches. Therefore, instead of pulsed effluent releases, slow continuous discharges may help with nutrient assimilation in the stream. Further study is needed to better understand the processes in sediments and how they may play a role in nutrient transport. At the same time, climate change impacts are increasing hydraulic loads which may impact the number of emergency lagoon discharges that occur now and may increase in the future. Facilities are not required to meet nutrient limits during these emergency discharges. In addition, many communities are outgrowing their infrastructure, and some industrial expansions such as potato washing facilities may put additional stress on these wastewater systems.

Questions and Answers – Nutrient Transport and Fate

Question 1. Agnes Richards: If potholes don't contribute nitrogen and phosphorus to Lake Winnipeg, should we restore potholes if they don't contribute to loading?
Answer: Yes, we should protect these potholes, Devils Lake, and other non-contributing areas. It is critical to reconnect these areas, especially during high flooding years. There is a need to understand which way the water is flowing in these areas. Based on observations and recent studies, having those areas connected during high flooding events is critical.

Question 2. Kristin Painter: What nutrient transit time did you see from the discharge site to the downstream sampling location?
Answer: Can't speak to transit times. The traced sweetener, corrected for dilution, saw a bump in soluble reactive phosphorus near the end, so other nutrient sources may be coming in. Movement was very slow in the summer compared to the fall.

Question 3. Agnes Richards: What were the effects of channel distance on loads to Lake Winnipeg? Are closer sources more important?

Answer: A nutrient source closer to Lake Winnipeg would not necessarily result in a higher load. For example, the city of Fargo contributes a lot even though it is located farther away. It would be helpful to have a map to show the influence of the distances to loading to Lake Winnipeg. This has not been calculated but it can be calculated. We do know how much is produced, and how much is delivered to the lake.

Question 4. Kristin Painter: You mentioned that some small wastewater treatment systems don't have to meet nutrient discharge limits. How much nitrogen and phosphorus are these facilities contributing?

Answer: That is a good question, and more data would be helpful to answer that question. New lagoons are required to meet nutrient discharge limits, however, other lagoons may not need to meet limits.

Water quality sampling

Climate Change Implications on Hydrology Session

Snowpack Responses in the Assiniboine-Red River Basin Under Global Warming Scenarios
~ Rajesh Shrestha, ECCC

Watershed models are being used to improve understanding and prediction of nutrient dynamics at multiple scales in the Lake Winnipeg basin under climate variability and beneficial management practice (BMP) scenarios. This includes hydro-climatic drivers such as precipitation, temperature, and snow, as they impact water availability and nutrient fluxes over the Assiniboine-Red River basin, which contributes over 80% of the nutrient load to Lake Winnipeg. This study assesses snowpack response in the Assiniboine-Red River basin under climate warming scenarios and helps evaluate future changes in hydro-climatic drivers.

Snowmelt-driven runoff was previously determined to be the key driver of nutrient transport from the land to waterways in the basin. Hydro-climatic stressors include multi-year droughts, and frequent flood events in the Red and Assiniboine Rivers, both of which are important to understand how such events influence nutrient fluxes. The researchers used a process-based distributed snow model driven by an ensemble of eight statistically downscaled global climate models (GCMs) to project future changes under policy-relevant global mean temperature projections. Historical trends show an increase in minimum temperatures in both the Red and Assiniboine Rivers basins and only an increase in precipitation in the Red River basin. Based on data from 1976 to 2005, the Red River basin was found to be warmer and wetter, than the Assiniboine River basin. The research evaluated both historic and future changes in mean temperature, mean precipitation, mean rainfall, and mean snowfall under climate scenarios. Under the global mean temperature (GMT) increase from 1.0^{0}C to 3.0^{0}C, the research points to warmer and wetter winter and spring conditions. Summers are expected to be warmer and drier, and the fall season will be warmer. Also, shorter snow cover durations, slower snowmelt, and smaller monthly snow water equivalents (SWE) are predicted, with an expectation that parts of the basin will transition from snow-dominated to a rain-snow hybrid hydrologic regime.

Shores of Lake Winnipeg, Spring 2021

The changes in temperature, precipitation, and the snow-hydrologic regime are expected to have an impact on the basin hydrologic responses, including floods and drought events. Changes to future mid-winter snowmelt, rain-on-snow events, and heavy rainfall events during and after snowmelt could impact flooding. These changes in the snowmelt and runoff are expected to have implications on nutrient fluxes which will affect the water quality of Lake

Winnipeg. Future work includes evaluating controls of temperature, precipitation, and SWE on nutrient fluxes, and also work to contribute to other hydrologic nutrient transport modelling efforts underway in both the Red and Assiniboine basins.

Assiniboine Watershed Modelling to Predict Nutrient Loading Under BMPs and Climate Change Scenarios
~ Yonas Dibike, ECCC

The Assiniboine River contributes about 10% of the TP loading to Lake Winnipeg. This project used modelling methods to predict nutrient loading to the Assiniboine River watershed under various BMP and climate scenarios. Project objectives were to develop a watershed model to improve both the understanding and the predictability of nutrient dynamics and transport.

The SWAT model input variables included land use, soil type, and topography. The driving forces for the modelling framework are meteorological inputs, as they relate to vegetation growth and nutrient leaching and transport. The model outputs were measured as runoff and nutrient load. The data for this hydrological modelling was acquired from several sources, including USGS and the Water Survey of Canada. The watershed was delineated using eight hydrometric stations and 12 large reservoirs, resulting in 74 sub-basins. One of the challenges of the original SWAT modelling effort was accounting for non-contributing areas. A modified version of SWAT was developed to accommodate the fill and spill process of prairie potholes that occur in the watershed. Lakes and wetlands were found to comprise 6.8% of the total Assiniboine watershed area. The model uses additional attributes, and shapefiles of lakes and wetlands to generate the hydrologic response unit. Overall, the modified SWAT model was found to better depict isolated wetlands and hydrologic relationships and to better depict the fill and

Red River water monitoring station at Emerson, MB spill processes more realistically in these isolated wetland areas.

The mean monthly flows between 1980 - 2009 were modelled using the Standard SWAT and the Modified SWAT models, as compared to the observed flow rates at three locations (Kamsack, Brandon, and Headingley). The Modified SWAT model was more effective at reproducing the snowmelt-generated high flows during the spring periods at all three locations, and better able to simulate low-flow winter conditions at the Brandon and Headingley locations.

Using climate change scenarios RCP4.5 and RCP8.5, the Modified SWAT model was found to be accurate in reproducing the snowmelt-generated high flows during the spring periods, and the climate-driven shift to earlier spring peak flows. This is an important improvement as the snowmelt-dominated peak flows are the main driver of sediment and nutrient loading to the Assiniboine River watershed. End of century modelling indicates increases in annual precipitation and temperature across the Assiniboine River watershed, with decreasing summer precipitation compared to the 1976-2005 baseline period. The modified model was found to be more responsive to climatic change with larger projected increases in seasonal and annual flows at most stations. The improvements offered by this dynamic contributing areas model will facilitate longer-term large basin-scale simulations that are more representative of the complex fill-and-spill prairie region of the Lake Winnipeg watershed.

Preliminary results from the nutrient transport modelling were also presented. Nutrient inputs included chemical fertilizer, manure, wastewater effluent, and atmospheric deposition. Nutrient load data for nitrogen and phosphorus were obtained from both Manitoba and Canada databases. The SWAT calibration for total phosphorus (TP) results showed a good correlation between observed and simulated results, however, the model was unable to calibrate total nitrogen (TN). Preliminary results found that the change in TP and TN loading closely follows the corresponding change in streamflow in the river system, with the highest increase in late winter and early spring, and relatively smaller or no changes for the other months. End of this century modelling results (RCP 8.5) indicate that the mean projected increase in nutrient export from the basin (at the most downstream station of Headingley) is in the order of 16% and 76% for TN and TP respectively.

These large-scale watershed models are more appropriate to identify nutrient hotspots and large-scale responses to climatic changes, rather than modelling field-scale BMP scenarios. Work continues to improve the modelling work in the Assiniboine River, and work is underway on the development of a similar model in the Red River watershed. Also, the application of BMPs modelling scenarios is being developed for nutrient load reduction in both watersheds.

A Linked Hydrological-Biochemical Modelling System to Assess Stressors on the State of Lake Winnipeg
~ Chris Spence, ECCC

The Province of Manitoba has set nutrient concentration targets of 0.05 mg/l TP and 0.75 mg/l TN for Lake Winnipeg. Nutrient reduction modelling work by others has suggested that to meet these targets, there would need to be a 10% decrease in flow, a 50% decrease in TP concentration, and a 30% decrease in TN concentration. This modelling research effort investigated hydrological-biochemical factors as they related to stressors on the state of Lake Winnipeg and was undertaken to assist in establishing land and water-use policies and best management practices (BMPs) to meet these lake nutrient targets, given both stable and future climate modelling scenarios.

A prairie catchment classification was conducted throughout the Lake Winnipeg watershed. A total of seven classifications were used, considering both land-use practices and non-contributing areas. The modelling allowed the researchers to determine how a warming climate would impact flow and nutrient loading from different catchment types across the Basin.

Using the Cold Regions Hydrological Model, including wetland distribution data (from Global Surface Water), and climate data (Adjusted and Homogenized Canadian Climate Data1965-2006), a variety of climate and drainage scenarios were tested. This included precipitation increases in 10% increments of normal (80-130%), 1^{0}C increments in temperature (to +6^{0}C), wetland area removal in 10% increments, and wetland replacement with crop production. The model was validated and the sensitivity of flood frequency to drainage was investigated. At all locations evaluated in Alberta, Saskatchewan, and Manitoba, there was a demonstrated increase in streamflow as the wetland drainage area was increased. Wetland loss in the Yorkton and Regina areas showed the largest change in streamflow with wetland drainage scenarios. When both predicted climate change and wetland loss were modelled for each site, the Yorkton location showed the greatest streamflow increase. This demonstrated the importance of retaining wetlands to reduce streamflow and associated nutrient load increases.


Prairie pot-hole wetland

Several policy implications were identified by this research. This included that a flow reduction of 10% in the Red River would be required to meet lake nutrient targets. Yet modelling suggests that with the expected climate change of 3^0C warming and a 10% increase in precipitation alone, annual streamflow will increase by an average of 20%. Similarly, every 10% loss of wetland area would result in a 17% higher average annual flow across the Pothole Till class areas, which represents a significant portion of the Lake Winnipeg watershed. This will result in a commensurate increase in nutrient loading. Land and water management policies and practices need to be designed within the context of climate change. This modelling suggests that a reduction of annual streamflow by at least 35% may be needed to meet nutrient targets.

Future work continues to develop a linked hydrological-biogeochemical modelling platform that can be used to help inform future policies and practices, including linking this watershed model with a limnological model of Lake Winnipeg to explicitly test policy scenarios.

Questions and Answers – Climate Change Implications on Hydrology Session

Question 1. Rajesh Shresth: With a switch to a more hybrid regime, do you anticipate greater or lesser connectivity between wetlands and the tributaries under the future scenarios?
Answer: A decrease in the rate of spring snowmelt may affect the conductivity of the stream but difficult to say for sure.

Question 2. Chris Spence: If we need to hold back more water to reach a 35% decrease in flow, how much land would need to be taken out of production?
Answer: There is not yet a good answer to that question. We have tools to figure that out, but those calculations have not yet been done. Also, there is a need to determine not just how much to decrease, but where it would most effectively be done. This is a key gap to address.

Question 3. Yonas Dibike: Were allowances for the Portage Diversion factored into the modelling?
Answer: Yes, both the Portage Diversion and the Shellmouth Reservoir were included in the SWAT modelling.

Question 4. Chris Spence: If you move away from a chemostatic model for your nutrient load simulations, what model would you apply?
Answer: A chemodynamic model would work, one that accounts for concentration in the discharge. This work is underway.

Question 5. Yonas Dibike: How do your results compare to the work presented by Agnes Richards?
Answer: Although we have not formally compared them, they look to be similar, including the hotspot results. The variation is very similar, which is not surprising as similar input data was used in both projects.

Question 6. Rajesh Shrestha: Why is the rate of snowpack melt expected to slow down?
Answer: This is a function of energy, as less solar energy is available during the period of melt. This would therefore slow the rate of melt.

Question 7. Yonas Dibike: How much of the nutrient load discrepancy seen between the actual and SWAT model results is due to flow, and how much is due to concentration?
Answer: It could be a combination of both. Flow is the driver of nutrient transport.

Question 8. Chris Spence: If we need to decrease flow on the Red River, is wetland restoration the tool to achieve that, given that the pothole region tends to flow to the Assiniboine River?
Answer: This would be part of the answer for sure, keeping water on the land is important. Also, we need to determine how much land would need to be taken out of production. More options need to be explored.

Priority Science Gaps Panel

Merrin Macrae (University of Waterloo), **Helen Baulch** (University of Saskatchewan), and **Pascal Badiou** (Ducks Unlimited Canada) participated in a panel discussion on priority science gaps in the Basin. The panellists were each asked to respond to two questions related to existing knowledge gaps, and options for improving knowledge transfer.

Question 1: From your perspective, what are the top 2-3 knowledge gaps that are needed to support more informed decision making to improve the overall health of Lake Winnipeg?

Answer: Merrin Macrae identified the impact of climate change on nutrient loading to Lake Winnipeg as a key gap. In particular, how will climate change affect the loss of nutrients from fields, as this relates to existing management practices and new management practices that might be employed? It is important to continue testing what BMPs are most effective in cold climates, and also understand if these BMPs will be effective under future climate scenarios, and in priority areas. There is a need to layer land management practices, and climate change models, in terms of both outcomes and the practices needed. There is also a need to target decision making and action in particular landscapes, including nutrient hotspots.

Answer: Helen Baulch identified the need to move from research to action to protect lake health, recognizing there will be lags in seeing improvements in Lake Winnipeg as a response to watershed actions. There are still knowledge gaps around BMP applications for the management of phosphorus. There is a need for zone-based management, focusing on the identified nutrient hot spots in the watershed, and a need for cooperative and constructive management to address impacts from wastewater treatment facilities. It is important to better understand the drivers of change, and what the future might hold in terms of changes in crop management, drainage practices, etc. It will be important to ensure that action taken to address greenhouse gas emissions will not inadvertently worsen water quality.

Answer: Pascal Badiou recognized that while the focus of work is on the health of Lake Winnipeg, it is important not to ignore other lakes in the watershed, including Lake Manitoba and Lake Diefenbaker, as they are facing similar challenges. There is a need to identify diffuse nutrient hotspots, such as that observed in the Souris River watershed. It is also important to undertake wall-to-wall mapping of the remaining natural landscapes in the agricultural regions and identify where wetlands could be restored. This information will be powerful to help guide conservation programming efforts. There is also a need to understand the broad economic costs of farming marginal landscapes, employing the philosophy of 'farm the best and keep the rest'. Marginal lands should be looked at for opportunities to help address the problems seen in the watershed.

Question 2: What opportunities and approaches do you see for improving how knowledge is transferred from research findings to end users who are making on-the-ground decisions?

Answer: Merrin Macrae suggested there is a need for co-developing knowledge with producers to help build trust and ensure recommended action is economically feasible. It would be effective to partner with on-the-ground agricultural advisors to help coordinate and communicate science recommendations to producers. There is a need for an increased emphasis on extension services to help build relationships throughout the agricultural sector. Non-traditional communication tools need to be utilized, such as podcasts and social media.

Answer: Helen Baulch relayed that there is a need for a coordinated message between agencies and partners/producers. This coordinated approach will have a larger impact than multiple differing messages. Also, on-the-ground capacity needs to be strengthened so that local concerns and challenges can be identified and resolved.

Answer: Pascal Badiou recommended that innovative programming, such as the Ducks University Program, is needed to improve knowledge transfer from research to end users. This program relates on-the-ground training to landscape enhancement activities such as wetland restoration. Such programs are expensive and time-consuming, but very effective in knowledge transfer. Also, there is a need to put resources into a centralized research management portal that would facilitate data sharing and communicate the type of research occurring in the basin.

Other Questions and Answers for the Priority Science Gaps panellists

Question 1. Helen Baulch: What are your thoughts on how to bridge the gap with Indigenous communities concerning sharing science and Indigenous knowledge?
Answer: In Saskatchewan, there is a lot of capacity to communicate, but there is a need to support Indigenous land managers in these efforts.

Question 2. Pascal Badiou and Helen Baulch: How do you weed through the details to turn data into information?
Answer: It is important to have people who are willing and skilled at communicating science to policy makers. There is a need to link science to policy, and it is essential there is clear communication of the science to everyone, but in particular to policy makers. Ducks Unlimited has policy and land managers who work together to facilitate the transfer of science to decision-makers at all levels of governments and partner organizations. The science needs to be accessible to facilitate this communication process, including a website that lists what is actionable now.

Question 3. Pascal Badiou: What do we mean by policy?
Answer: Decisions that are made by various levels of government and organizations.
Question 4. Pascal Badiou and Merrin Macrae: In addition to the work being done with high school teachers through Project Wet, how do we better inform future generations?

Answer: Ducks Unlimited has a national education program. This Wetland Centres of Excellence is a national network of schools and community partners that engages students in wetland conservation, including live streaming to schools. There is a need to identify key messages such as preventing the degradation of natural landscapes. This is a challenge, but we know that restoration is not as effective as conservation of wetlands and other natural landscapes. It is important to get feedback from youth and use appropriate media to reach youth (e.g., TikTok). It would be helpful to have materials that could be distributed to educators and facilitate opportunities for experiential field trips.

Closing Day 1

Elder Florence Paynter from Sandy Bay First Nation closed Day One, thanking the organizers for the invitation. She acknowledged the importance of having good baseline data and also understanding what knowledge has been gained. She reminded the audience that Indigenous people should be more fully engaged in this work, recognizing they are land managers, and are directly impacted by the health of land and water. She recognized that scientists are still struggling to answer some questions, which indicates that there are still gaps in knowledge. There is a need to connect science to management and action. There is a need for this data, especially considering climate change predictions. She noted that not all policy/decision-makers are scientists, so there is a need to effectively communicate to all. She commended Ducks Unlimited and the work they do in providing education to Indigenous People. She thanked symposium participants for their important work. After acknowledging Elder Mary's Opening Prayer on water, Elder Florence ended her remarks with an invocation in her Indigenous language, thanking the Creator for life and for allowing participants to share time at the symposium.

DAY 2 SYMPOSIUM PRESENTATIONS

Welcome & Opening

Elder Linda St. Cyr-Saric, from the Red River Métis and Manitoba Métis Federation, welcomed delegates and provided opening prayers on Day Two of the symposium. As part of these prayers, she thanked the Creator for life and for providing guidance. She asked the Creator for help to ensure there was love, respect and understanding amongst us all. She acknowledged gratitude and asked for wisdom and guidance as challenges are confronted. She reminded the delegates that water is life, clean water is essential, and everyone should do all they can to keep water healthy for future generations. The delegates were asked to conduct their work in the spirit of joy, optimism and enthusiasm, wishing participants strength, wisdom and courage.

Lake Ecology Session

Wetland Vegetation Change in Netley-Libau Marsh 1990-2013
~ Gordon Goldsborough, University of Manitoba

Dr. Goldsborough acknowledged his colleagues who have collaborated on this research investigating wetland vegetation change in the Netley-Libau Marsh since 1990. The Netley-Libau Marsh is a large coastal wetland covering 26,000 hectares at the south end of Lake Winnipeg. Given that the Red River is such a significant source of nutrients to Lake Winnipeg, the marsh may be able to play an important role in helping to buffer the impacts of that loading. It has been estimated, that if the marsh was fully remediated, it could store about 6% of the nutrient load coming from the Red River.

Vegetation maps from 1979, represent a year when vegetation abundance was high, as compared to vegetation density in 2001 when very little emergent vegetation was present in the marsh. Potential causes of this vegetation loss include infrequent low-water periods which promote vegetation reestablishment. These stable water level conditions may relate to Lake Winnipeg water management as a hydroelectric storage reservoir, increased drainage within the Red River, and the wet climatic cycle during this period. Other possible contributing factors for vegetation loss could be increased contaminant load and erosion from the Red River, and/or invasive species impacts. High-resolution satellite imagery from the period 1990 to 2013 was evaluated to distinguish specific vegetation zones, and then assessed for correlations between vegetation area, Red River discharge, and the level of Lake Winnipeg. In the period of study, two years were unusual, with 2003 being a year of very low water, and 2011 being a year of very high water. The difference was about 1.5 m, which under normal circumstances should be sufficient to protect high biodiversity. As anticipated, analyses demonstrated a good correlation between the areas of emergent vegetation and the extent of open water over this period of record. Therefore, the extent of open water was used as a proxy for the amount of vegetation for the period 1992-2013. Three vegetation phases were identified between 1990 and 2013; a period of consistent vegetation loss between 1990 and 2002; a second period of massive regeneration of vegetation in 2003; and lastly, a resumption of vegetation loss between 2005 and 2013.

The 2003 drought year resulted in a remarkable reduction in the amount of open water due to vegetation regrowth, which continued even after lake levels returned to higher levels post 2003. Researchers concluded that a single year of low water may be sufficient to allow partial recovery of the vegetation for some time following the low water level year. Mapping the vegetation zones from 1990 to 2013 showed a gradual decrease in upland vegetation and a corresponding increase in wet meadow vegetation.

The study also found a positive correlation between the Red River discharge and Lake Winnipeg levels. Negative correlations of vegetation area with both Lake Winnipeg levels and Red River discharge were found. The vegetation in any given year was not correlated with the water level or the discharge, however, the best correlation was found when a lag period was inserted into the analysis, which would correspond to the vegetation taking some time to respond to these changes.

Between 1990 and 2013, one of the areas of the marsh with significant vegetation loss was the Netley Lake area, in part due to large wind fetch areas and its sensitivity to erosion. The Netley Cut, which was created in 1913 to connect the Red River to Netley, may contribute to erosion of the Netley Lake area. Photographic evidence from 1923 and 2003 show dramatic changes in the size of the Netley Cut connecting these two bodies of water, and a corresponding loss of vegetation in Netley Lake by 2003. Recent images show the continued erosion of the Netley Cut and the deposition of sediments into Netley Lake.

Netley-Libau Marsh, South Basin Lake Winnipeg

A current area of research includes a three-year pilot project coordinated by the Red River Basin Commission, along with numerous partners, looking at techniques for establishing marsh vegetation in Netley Lake using sediment dredged from the main channel of the Red River. This collaborative project involves pumping sediment slurry across a land bridge between the Red River and Netley Lake. Sediment containment options including geotubes, erosion control blankets, and an aquadam were evaluated, with the geotubes being much superior to the other two options. The next phase will include monitoring vegetation growth on these newly developed areas. If this technique is successful, it potentially could be used to re-establish vegetation in larger areas of the marsh in the coming years.

Early Invasion Dynamics of the ZM (Dreissena polymorpha) in Lake Winnipeg: Much ado about nothing?
~ David Depew, ECCC

Dreissenid mussels, historically confined to the Black and Caspian Seas, spread through Western Europe and Western Russia through the canal system. The zebra mussel was brought to Lake St. Clair, Ontario in ship ballast water in the mid-1980s. By the mid-2000s, they had spread across the continental divide. These aggressive invaders have a negative annual economic impact in North America of approximately $300 million, impacting utilities and other operations in and around water. Although both the zebra and quagga mussel are found across North America, only the zebra mussel has been found in Lake Winnipeg. However, the spread of quagga mussels typically lags behind zebra mussel colonization. Changes in water clarity have been observed in lakes that are colonized by invasive mussels. These filter feeders consume phytoplankton, small zooplankton, and detritus from the water column, changing the aquatic food chain and the lake ecosystem. Some fish species, such as the round goby will eat zebra mussels, but not in the abundance necessary to control populations. The anticipated ecosystem consequences of zebra mussels on Lake Winnipeg are many, including impacts on the walleye fishery due to changes in water transparency, the potential collapse of the smelt population, and altered movement of nutrients through the lake ecosystem.

Between 2017-2019, samples were collected from several stations throughout the north and south basins of Lake Winnipeg to understand the dynamics of the muscle population in the lake. A variety of approaches were utilized to sample shallow and deep-water sites to determine mussel density over the three-year period. Higher densities were found in the south basin, with a progressive geographical spread into the north basin by 2019. Detection frequency went from 8% to 32% over the three years, with colonization density in the south basin considered moderate. This research found that zebra mussels had colonized almost all the desirable hard substrates, from gravel to boulders. Zebra mussels do much poorer on soft substrates such as sand and clay. The colonization of mussels in the north basin is showing a lag phase of about ix years. Variation in the size of the mussels also varied, with a very large number of very small mussels on the west side of the south basin, in contrast to lower density large mussels on the east side of the south basin. Recruitment of new mussels was highly variable, with new recruits noticeably absent from the sites along the east side of the south basin. Reasons for this occurrence are unclear, however, the influence of low calcium waters of the Winnipeg River may be limiting shell growth in the larval stage of the mussel population. Lower densities in Traverse Bay, which is heavily influenced by Winnipeg River flows, support this hypothesis. The lower density found in the north basin is unclear but may relate to physical and morphometric characteristics that may constrain the spawning window in the north basin. Other potential influences include a longer water retention time, cooler water temperatures reducing population growth rates, and toxins from cyanobacteria blooms. The quagga mussel, which has not yet been found in the watershed, is better adapted to cooler water and soft sediment conditions presented in Lake Winnipeg, therefore vigilance is necessary to try to minimize this invasion risk.

In summary, this research found that zebra mussels have colonized the most suitable sites in the south basin and the narrows. Mussel longevity was found to be short, with the majority of mussels less than three years of age. The low recruitment found in some regions was likely related to several environmental factors.

Integrated Modelling Framework of Lake Winnipeg Hydrodynamics and Water Quality ~ Jun Zhao, ECCC

The objectives of this modelling study were to develop an integrated modelling framework for Lake Winnipeg to predict water circulation, temperature, and water quality, in both horizontal and vertical profiles; to identify sources of nutrients triggering algal growth, and propose management objectives to seasonally mitigate that growth at both local and lake-wide scales; to integrate zebra mussel effects on phosphorus recycling into models to assess the relative importance of their direct and indirect effects on algal growth; and to predict the lake's response to potential nutrient loading reduction actions to improve water quality by connecting a watershed model to a lake model.

The setup of this resolution Aquatic Ecosystem Model (AEM3D) used several input variables, including the use of bathymetry, inflows from four rivers, two lake outflows, and nutrient load estimates. Riverine flows and wind rose plots were developed. Surface elevations and observed inter-basin exchanges were plotted for 2016. Water temperatures were modelled in the narrows, south, and north basins from June 2016 to May 2017. In addition, hydrodynamic circulation models were developed using depth-averaged water circulation and temperature during this same time period.

Samples were collected between 2016-2019 from eight locations, including current profilers, temperature, and dissolved oxygen. The data were analyzed to identify observed predominant processes, and also to calibrate and validate the lake-wide numerical model, with a focus on year-round inter-basin exchanges. The integrated modelling framework for Lake Winnipeg was described. Hydrodynamic components, biogeochemical driver transformations, and sediment processes were all incorporated into the model. This included internal loading from resuspension, deposition, and diffusive fluxes were calculated within the model.

Several observations were made. The year-round flow exchange between the south and north basins is critical for nutrient management in the lake. During the ice-free periods, the daily oscillations of flow exchanges are directly related to directional wind patterns. The daily inter-basin exchange during the ice-free period can range up to $3.5x10^4$ m^3/s, and under-ice daily exchanges are always northwards, with riverine discharge rates up to $0.5x10^4$ m^3/s.
For the lake water quality modelling, field measurements from 2007 to 2019 were used. The hydrodynamic models have been developed, calibrated and validated for the 2016-2017 period. Additional validation is ongoing. The water quality model is pending validation, and the integration of water quality with zebra mussels is ongoing.

In summary, the AEM3D has been used to simulate water levels, temperature, currents, and ice coverage in Lake Winnipeg. The results on retention time can clarify the inter-basin nutrient exchanges between the south and north basins, as well as the potential migration of zebra mussel larva from the south to the north basin. Work is underway to develop a process-based water quality model which will include algal functional groups, internal loading, and zebra mussels. Upon completion of the process-based water quality model, it will be possible to predict the lake's response to potential nutrient reduction actions, by connecting the watershed model to this lake model.

Questions and Answers – Lake Ecology Session

Question 1. Gordon Goldsborough: Can agricultural herbicides be ruled out as a factor in the observed vegetation decline?
Answer: Yes, this can be ruled out, as herbicide levels are low. We don't see a decline in algae, and if herbicides were a factor, we would see an effect on the marsh vegetation as well as on algae.

Question 2. David Depew: Can you elaborate on how transit time may affect the colonization of zebra mussels in the north basin?

Answer: The larval stage is short-lived (2-4 weeks), therefore they will settle out of the water column as they develop shells and get heavier. Mussels could hopscotch down the lake from new colonization sites.

Question 3. Jun Zhao: Are there zooplankton modules in the model reflecting the interactions of algal growth, zooplankton, and fish?
Answer: This has not been included in the model yet.

Question 4. David Depew: Can you further explain how calcium deficiency for mussels on the east shore may be limiting growth, given that there are large mussels present?
Answer: Predators may be eating small mussels, but there is no direct evidence of this in Lake Winnipeg. The east side of the south basin is quite windy and rough, therefore smaller mussels may get dislodged from their substrate. Low calcium levels found in the Winnipeg River water are likely contributing to fewer mussels due to calcium deficiency. Large mussels can remobilize calcium from their own shells.

Question 5. Jun Zhao: Has any work been done to compare the hydrodynamic model water mass mixing results with the oxygen isotope mapping being done by Geoff Koehler (ECCC)?
Answer: Other colleagues would be in a better position to respond to this question.

Question 6. Gordon Goldsborough: Do you see the potential for wild rice planting in the marsh for food security and to regenerate the marsh ecology?
Answer: Indigenous partners have expressed interest, however, the substrate may not be ideal for wild rice. Other species used for traditional purposes have been discussed and may be possible to cultivate.

Question 7. David Depew: Zebra Mussels ‘much to do about nothing’. Is this true?
Answer: It is hard to say with any degree of certainty. The lack of hard surfaces may limit zebra mussel distribution. Other lakes did not see the maximum impact until the quagga mussel also arrived. There is no comparable water body to Lake Winnipeg to draw on as the lake is unique.

Question 8. Gordon Goldsborough: Yesterday we heard about increasing hydrologic variability expected under climate change. Have you considered what those impacts mean for the vegetation in the marsh?
Answer: No, we have not. Water level fluctuations are important for marsh vegetation, but we have not yet identified this as part of our study.

Question 9. Gordon Goldsborough: What does the increased vegetation mean for Lake Winnipeg, and will we see a regeneration of the vegetation following the 2021 drought?
Answer: The vegetation should be able to remediate nutrients. There is a potential for marsh vegetation to reduce the nutrient load by up to 6%. The drought of this past year may have had a positive impact on the recolonization of vegetation. This was observed over the past three years. Low water levels are important to support vegetation recolonization.

Nutrient Sources in the Watershed Session

Using Load Apportionment Model to Differentiate Diffuse and Point Source Phosphorus Inputs to Streams
~ Kim Rattan, ECCC

Through the use of a load apportionment model, the goals of this research were three-fold: to quantify sources, transport, and timing of nutrients from agriculturally-dominated sub-watersheds to tributaries of the Red River; to provide a broader understanding of the risks related to water quality and quantity management for agricultural watersheds in southern Manitoba; and to improve the understanding of agricultural impacts on nutrient transport through tributaries to Lake Winnipeg. The decline in water quality in Lake Winnipeg, including toxic algal blooms, has the potential to impact both pets and livestock. In addition, declining water quality is expected to impact other important lake resources including the recreation and fishery industries.
Determining the timing of phosphorus release, and the mode of delivery from rural landscapes can be challenging. Releases of nutrients can be episodic, from both non-point and point sources, and streambed interactions are variable. Key knowledge gaps also include understanding within river transformations of phosphorus forms. A land apportionment model

was used to look at the mode of phosphorus delivery, providing a simple and rapid method of modelling flow and nutrient concentrations within the watershed.

The specific objectives of this research were to determine the contribution of continuous (point) versus flow-dependent (diffuse) sources of phosphorus to eight sub-watersheds. Secondly, to identify phosphorus sources and the most effective mitigation strategies to reduce phosphorus concentrations.

Grab samples were collected daily during the rise and peak of snowmelt, weekly during the declining snowmelt period, and biweekly until ice cover at these eight locations. Samples were analyzed for total phosphorus, total dissolved phosphorus, soluble reactive phosphorus, and particulate phosphorus. Discharge was estimated using the relationship between water levels (measured with pressure transducers) and the discharge measured at long-term discharge stations. Total Nutrient loads were calculated using nutrient concentrations (measured and interpolated), and then multiplied by daily discharge and summed by season or year. The Red River watershed study area was divided into eight sub-watersheds ranging in size from 65-626 km^2. For each sub-watershed, crop, livestock and wastewater inputs and removal amounts for total phosphorus were determined.

Outputs of the model estimated that the diffuse non-point source inputs represented 70–100% of the annual phosphorus load across the study sites. Diffuse source inputs comprised a broader range nutrient load, 0–100% during snowmelt, and 53–100% during summer. Point source inputs contributed 0–30% annually, compared to 0–100% during snowmelt and 0–47% during summer. The broader range in seasonal periods compared to annual contributions was indicative of changes in phosphorus sources among seasons.

Seasonal variability in nutrient source apportionment was observed for Deadhorse Creek, the sub-watershed with the greatest wastewater input. Model outputs for the west branch of the La Salle sub-watershed, which had the smallest wastewater input, also indicated sizable point-source contributions. This fugitive phosphorus may have resulted from release, seepage, or leakage from a wastewater lagoon or a livestock waste slurry pond, or runoff from farmyards or manure piles.

In conclusion, the load apportionment model can provide a basis for the identification of major contributing sources, detection of unknown sources, and, in turn, the development of effective mitigation strategies to reduce phosphorus loading, concentrations and eutrophication risk. The model applied in this study can provide a cost-effective option for quantifying diffuse versus point sources of phosphorus in terms of timing, duration, and magnitude. By applying the model separately for each hydrologic period, the researchers were able to produce reliable outputs that identified the relative contribution of diffuse versus point sources for both the snowmelt and summer periods. This type of modelling is expected to assist land managers to focus phosphorus management efforts on the right sources at the right time – key elements of the 4Rs of nutrient management (i.e., applying the right nutrient source at the right rate, at the right time, and in the right place).

Sources of Nitrogen to Stream Food Webs in Tributaries of the Red River Valley ~ Bob Brua, ECCC

To effectively implement management strategies to protect or restore ecological conditions in mixed land-use environments, it is critical to first identify key nutrient sources. The relative contribution of the different nutrient sources and their subsequent assimilation into food webs is not well understood.

The isotopic composition of nitrogen, calculated as the ratio of heavy to light nitrogen isotopes ($^{15}N/^{14}N$, expressed as $\delta^{15}N$), is an important tool for identifying anthropogenic nitrogen sources. In particular, synthetic fertilizer has a distinctive $\delta^{15}N$ value as compared to human and animal waste, therefore making it possible to differentiate between aquatic food webs that utilize nitrogen originating from these different sources.

Heavy isotope increases in the environment in a predictable way, with various sources having specific $\delta^{15}N$ values that are analogous to fingerprints. This serves as a way to identify the importance of anthropogenic sources of $\delta^{15}N$ to food webs. The specific study objectives were two-fold: identify the primary sources o f nitrogen to aquatic food webs in rural streams of the Red River Valley and determine how these sources varied seasonally.

Human sources of nitrogen were identified by associating $\delta^{15}N$ of particulate organic matter and invertebrates with the amount of nutrient-producing activities in the watershed, including the per cent of crop cultivation, livestock density, and wastewater treatment facilities. These sources of nitrogen were also identified by estimating the relative contribution of these nitrogen sources to particulate organic matter and macroinvertebrates. This approach avoids potential confounding effects that could be introduced by assessing higher trophic levels that can incorporate material from multiple trophic levels.


Field scale monitoring

Twenty delineated study catchment areas were characterized based on watershed area, per cent cropland, livestock density, and population wastewater treatment density. Field method techniques used included kick and sweep methods to collect benthic invertebrates and particulate organic matter. Both mayflies and amphipods were used for stable isotope analysis. Spring sampling occurred prior to any sewage discharges, whereas summer sampling would potentially capture sewage discharges.

The results demonstrated that $\delta\ ^{15}N$ values of particulate organic matter and collector-gatherer invertebrates were best predicted by the presence of wastewater treatment lagoons, with $\delta^{15}N$ values increasing with the number of people served by lagoons in spring and summer. When lagoons were present, wastewater contributed a greater proportion of nitrogen to stream food webs than agricultural sources. Waste sources also made a greater relative contribution to food webs in the summer period as compared to the spring. Despite wastewater lagoons releasing effluent in short-term pulsed discharges, the influence of wastewater on food web nitrogen was observed from the summer release into the following spring.

The study drew several conclusions: wastewater rather than agricultural source appears more important than expected as a source of nitrogen to stream food webs; wastewater nitrogen appears to be retained in stream food webs through the fall and winter periods; $\delta^{15}N$ values from both invertebrates and particulate organic matter were best associated with wastewater; there is a greater contribution of wastewater nitrogen sources to the aquatic food webs in the summer following lagoon discharges; the contribution of nitrogen to the aquatic food webs from agricultural sources was consistent among streams and between sampling season; and streams without wastewater lagoons tended to show more balanced contributions from manure and fertilizer sources, particularly in the spring season.

Several management implications were drawn from this work including: waste sources contribute a disproportionate amount of nitrogen in food webs; management practices need to address nitrogen losses from agricultural activities, but also need to consider nitrogen loadings from wastewater treatment facilities; management agencies should implement additional actions to reduce nutrient losses from agricultural lands and wastewater treatment facilities to more effectively protect aquatic ecosystems; and the adoption of nitrogen isotope methods help target & prioritize mitigation efforts.

Contribution of Nitrogen Sources to Streams in the Red River Valley
~ Kristin Painter, University of Saskatchewan

Widespread anthropogenic nutrient-producing activities are occurring within the Red River basin. The contribution and seasonality of nitrogen delivery to streams from human activities, and the knowledge of the role of stream communities, in the assimilation of anthropogenic nitrogen are both not well understood. Layered on top, is the unknown impact of climate variability and its influences on these processes.

The objective of this research was to identify important sources of nitrogen from human activities and assess how sources vary seasonally. The study area included 14 streams in the Red River Valley, varying in size and human activities. Environmental tracers were used to identify the nitrogen sources and estimate the proportional contribution, under varying seasonal conditions. Nitrogen and oxygen stable isotope ratios and concentrations of artificial sweeteners were used to identify the relative contribution of key sources of anthropogenic nitrogen. The vast majority of nitrogen and oxygen exist as ^{14}N and ^{16}O but a very small fraction of the nitrogen or oxygen atoms have extra neutrons which make them slightly heavier. The ratios of the heavy to light isotopes are commonly used as tracers because they behave predictably in the environment, therefore allowing the tracing of nitrogen through the environment. The artificial sweeteners acesulfame, sucralose, and saccharin were used as tracers due to specificity in human waste; with saccharin also used as a feed additive for piglets. The sweeteners monitored in this study help reduce the uncertainty of overlapping sources of nitrogen.

The research found that nitrogen from human or livestock waste accounts for greater than 70% of the nitrogen in streams during snowmelt. Wastewater was prevalent in streams during the spring and summer sampling period. Acesulfame was found to be present widely, whereas saccharin, which degrades quickly, was found in the highest concentrations during snowmelt signalling a manure source. This study also reported that algae readily incorporates bioavailable nitrogen from waste sources, perhaps due to ammonium preference. Therefore, prairie streams have the potential to function as nutrient assimilators rather than simply as conduits for downstream drainage of farmland runoff.

This work demonstrates that stable isotope analysis may be an accessible, cost-effective means of tracking nitrogen sources in the environment. However, the combined use of stable isotopes and artificial sweeteners can help to more clearly interpret the contribution of nitrogen sources in mixed-use watersheds. Management of nitrogen input sources and the preservation of stream function is expected to help mitigate the amount of bioavailable nitrogen from reaching downstream waterbodies including Lake Winnipeg.

Questions and Answers – Nutrient Sources in the Watershed Session

Question 1. Kim Rattan: In reference to the graph of total phosphorus release with flow, the low flow period seems like mostly dissolved form, while the high flow period can be dominated by particulate phosphorus. If true, will this help improve the model?
Answer: That is a good research question, but something we have not yet investigated.

Question 2. Kim Rattan: How does the LAM portion of that model compare with other regression models such as LOADEST and Weighted Regression on time, discharge, and season?
Answer: We did not compare with LOADEST, however, we did use another model that was developed in 2009 and found no statistical differences between the models.

Question 3. Kristen Painter and Bob Brua: Most regulations stipulate ammonia limits. Do they need to consider nitrate, as well?
Answer: That depends on what the regulations are trying to protect, human health vs ecological protection. Nitrate in high concentrations can be toxic. We should be considering ways to reduce ammonia. Nitrates are seen primarily during snowmelt, and they can be quickly taken up within the aquatic ecosystem. Since nitrate is very bioavailable, and an important nutrient for organisms, it would be helpful to investigate this question further.

Question 4. Kristin Painter: Are you able to differentiate between wildlife and livestock contributions?
Answer: No, this is something we can not do with our study. We do know that saccharin is the only manure-related signal, and that signal is primarily associated with hog production, however, this is still an evolving area of research.

Water quality monitoring (ECCC)

Question 5. Kim Rattan: You referenced outdated regulations, as one of the culprits related to nutrient loading. Can you elaborate on what you meant by this?

Answer: This is one of the management strategies to look at, to help control human-related nutrient activities.

Question 6. Bob Brua and Kristin Painter: How does your research influence the development or reassessment of provincial guidelines for lagoon discharge?

Answer: Nutrient discharge limits on larger facilities are very high, and facilities may not be discharging nitrogen at the licence limits. The nitrogen we see in organisms may be more indicative of the source, rather than the concentration.

Priority Science Gaps Panel 2

Nora Casson (University of Winnipeg), **David Lobb** (University of Manitoba), and **Greg McCullough** (University of Manitoba) participated in the second panel discussion on day two of the symposium. The panellists were each asked to respond to two questions:

Question 1: From your perspective, what are the top two to three knowledge gaps that are needed to support more informed decision-making to improve the overall health of Lake Winnipeg?

Answer: Nora Casson

It is important to remember as we discuss gaps, that an enormous amount of progress has been made. The first gap relates to scaling up the biology, chemistry, and hydrology research work that has been done on a plot, edge of field, or tributary scale. Building on the plot scale interventions and the modelling that has been done on smaller scales, it is important to understand how this will impact and scale-up to the entire basin, given the landscape heterogeneity that exists. A second gap relates to the impact of climate change, specifically what are the climate-driven changes that will influence nutrient processes in the Lake Winnipeg basin. Another gap relates to how future climatic extremes in a given year, or over multiple years, will impact both nutrient export and greenhouse gas emissions. Interventions related to nutrient management may have carbon sequestrations benefits as well. It will be important to identify actions that have co-benefits, and there is a need to understand where on the landscape interventions will provide the most bang for the buck.

Answer: David Lobb

The first gap is understanding the physical processes associated with sediments and the associated nutrients passing through the lake, and recirculating within the lake. Lake Winnipeg is a complex system that is also impacted by wind and ice cover, making it difficult to undertake internal loading modelling. Ice cover has declined, and this will change how the lake behaves. The second gap relates to understanding the source of nutrients entering the lake. Atmospheric deposition estimates for both nitrogen and phosphorus are crude and not verified. Atmospheric deposition of nitrogen is considered the third highest source but the specific source is unclear. There is an assumption it comes from soil erosion, but the research from the University of Manitoba suggests otherwise. It is more likely coming from organic sources such as soot, smoke, and pollen rather than mineralogical sources, and the deposition amounts may be much lower than estimated. Fingerprinting the sources would be helpful.

A major gap in our watershed science knowledge is understanding the nature of agricultural land, and where nutrients are originating. Agricultural land is very complex, a mosaic of activities and landscape types. Therefore, management practices need to be specific to the agricultural land targeted.

Answer: Greg McCullough

There is concurrence on the points raised by the other two panellists. Scaling is a challenge as you move from the watershed to the lake. More work is needed on flooding and how that impacts the transport of nutrients, including the leaching of nutrients during these events. The current models are very empirical, and it is difficult to know how well they capture these processes. Model calibration will help evaluate this.

There is a gap in our knowledge of lake food web dynamics. Much of the research stops at the phytoplankton level, but it is important to understand the impacts on the food web including species like sturgeon, smelt, and walleye. Adaptive management of the fishery needs a good understanding of the food web.

There are also gaps in our understanding of watershed processes. Over 80% of the phosphorus loading to Lake Winnipeg is coming from the Red River. This is the most expensive cropland in the province, and there is a high intensity of animal agriculture as well. It is important to stop the loss of wetlands, but these problems are coming from areas where wetlands were lost in the first half of the 20th century, and it is unlikely they will be coming back. We need more research to better understand where these nutrients are coming from within the Red River, and what BMPs might work best to reduce loading here, with a strong focus on hotspot areas in the watershed.

Question 2: What opportunities and approaches do you see for improving how knowledge is transferred from research findings to end users who are making on-the-ground decisions?

Answer: Nora Casson It is critical to ensure science gets to policy makers in a meaningful way. It will be important to engage social scientists who are experts in how you move research to policy. Researchers need to engage with people to get the questions right, and then translate this into policy. More needs to be done to facilitate engagement of the Indigenous voices and communities on the issue of nutrient reduction in the Lake Winnipeg basin. There is a real need for flexibility and creativity in this process. Working at a university there is an opportunity to engage with Indigenous students and help train them to be the next generation of researchers. This might be accomplished through internship programs. Finally, we need to step outside our regular systems of knowledge transfer and talk with Indigenous people and others, in their communities.

Answer: David Lobb

To facilitate knowledge transfer, there is a need to improve coordination, collaboration, and communication amongst researchers. One barrier is the physical location of ECCC scientists in Ontario and Saskatchewan rather than in Manitoba. The distance between researchers even within a city can be an obstacle. The pandemic has made face-to-face contact more challenging. It is important to have direct meaningful interactions of scientists and to end users of that information, including policy makers, social scientists, resource managers, and the public. The work that is done in this area could be improved but funding sources do not often cover post-research communication expenses. It would therefore be helpful if funding sources could accommodate communication work beyond the life of the research work. It is also important to engage non-traditional research partners, such as the public.

Answer: Greg McCullough

To facilitate knowledge transfer, we need to speak to as many people as possible. Lake Winnipeg satellite image communication work has been done in the past and present, and is an effective tool to reach a broad audience from the public to policy makers. Organizations like the Red River Basin Commission are an effective knowledge transfer mechanism as they bring together broad audiences with international representation, developing strategies and policies. Meetings like the Lake Winnipeg Consortium annual science meetings are important as well, so science knowledge can be collated, shared, and gaps can be discussed. Outcomes such as the two State of the Lake reports on Lake Winnipeg science are important. These reports can be used to help guide future funding needs. It is important to participate on boards such as the Lake Winnipeg Foundation, to help facilitate knowledge transfer and broader communication of scientists to non-scientists. These organizations can be important advocates for change. Education efforts for students, such as those conducted on the research vessel the Namao, can also play an important role in communicating science.

Other Questions for Panelists:

Question 1: Can you provide examples of good knowledge transfer from science to policymakers?

Answer: David Lobb

From my perspective, policy makers in Manitoba are not always open to receiving research information, such as riparian health efforts, while US policy makers are more open to dialoguing with researchers to inform policy decisions. There are good efforts underway around the issue of soil health and there is much interest from agricultural policy makers in this area. Scientists are working to bridge gaps by reframing their research in the context of soil health to facilitate this connection.

Answer: Greg McCullough

There has been a change in the way we talk about how to improve the health of Lake Winnipeg. It has evolved from just talking about controlling source inputs, to now having an understanding of the importance of flow and flooding on nutrient transport to the lake, and the need to better manage water to better manage nutrient loading. We need to communicate how to control water, not just nutrient source management. There is significant interest in this issue at senior levels of government.

Question 2: Should LWBP programming have a budget line for Communications?

Answer: David Lobb

There is a need to include communications beyond the duration of the research component of the projects when the funding typically runs out. There is a need to extend the life of the project to facilitate this communication piece, without shortening the research. Communicating research findings should be a requirement of federal research grants. Have funding for 4-5 years to conduct the research, and then an additional 1-2 years to conduct the communication and outreach work would be an important consideration for all research funding sources, not just the LWBP funding.

Answer: Nora Casson

There is a need for communications in funding programs, but also data sharing should be a requirement as well. In terms of communication, a project-by-project communication effort may not be helpful, but rather the communication of a synthesis of the collective research information. Organizations like the Lake Winnipeg Research Consortium and the Lake Winnipeg Foundation could play important roles in helping communicate scientific research results. Extension programs are important and effective. These programs are more prevalent in the US than in Canada. A requirement to have a communication component in a funding program makes sense. Applicants would have to plan how they are going to communicate, and with who, to ensure more impactful research results.

Regarding the issue of communication to policymakers, there is a real issue with the time lag between actions that are taken in the watershed and the impacts that we see in the lake. This will be a continuous challenge, analogous to the challenge of climate change communication.

This is challenging for politicians and funding agencies if you're working on a five-year timescale. It is important to be realistic and optimistic about how actions taken today, will influence the lake not necessarily tomorrow, but in decades to come.

Question 3: There is a tendency to keep gathering information, and it may be impeding us from implementing solutions. How do we balance this? There will always be a need to always learn more, but when do we say we know enough and shift to prioritizing and implementing the solutions we understand?

Answer: Greg McCullough

We know the hot spots, we know the sources, but not enough about how to fix the problem. We may have enough information about agricultural and wastewater sources, so we need to move on to implementing actions to address these sources. There is a need to engage others, including policy makers, producers, agronomists, local governments etc., and perhaps establish pilot projects. Evaluation of whether BMPs that work elsewhere will also work here is critical, as is understanding BMP effectiveness from landscape to landscape. There is a need to consider what subsidies might be needed to implement these actions.

Closing Day 2

Elder Linda St. Cry-Saric expressed her thanks to the Creator, and gratitude for a successful meeting where participants could meet and discuss important issues that affect everyone. Blessings were given to the leaders, facilitators, and participants. She asked the Creator to walk with everyone and their loved ones, and protect all from illness and other dangers. She asked for help to ensure the continuation of the important work underway. Thanks were given to the Creator and the support provided to all. Thank you, Merci, Meegwetch. Amen.

DAY 3 SYMPOSIUM PRESENTATIONS

Welcome & Opening

Taylor Fleming, Manitoba Métis Federation opened the last day of the symposium in a good way by playing three traditional fiddle compositions.

Nadine Stiller, Associate Regional Director General, ECCC, provided a territorial acknowledgement, and a thank you to Taylor Fleming for her music and opening Day Three of the symposium in an energizing way. Symposium participants were thanked for participating, as well as for the work they have done under the challenging conditions that Covid had presented to all.

Canada recognizes the importance of our fresh water resources. The Prime Minister's current mandate letter to ECCC, includes the commitment towards a strengthened freshwater action plan that will provide funding to protect and restore large lakes and rivers including Lake Winnipeg. Work in Lake Winnipeg comes with complexities including its transboundary watershed, and the multiple water uses and impacts throughout the basin. There is an important role for transboundary boards that work in the basin, and a shared interest and commitment to work collaboratively with partners and stakeholders to jointly address these challenges.

In August 2021 Canada and Manitoba signed a new Memorandum of Understanding (MOU), respecting Lake Winnipeg and the Lake Winnipeg basin, confirming a shared dedication to continue to work together to strengthen collaborative efforts to address water quality issues and focus on the ecosystem health. One of the key priorities of this MOU is to collectively advance reconciliation through increased Indigenous engagement and participation, and actions to improve ecological health. ECCC is hosting this symposium to share research findings from ECCC and others, and profile the projects undertaken by funding recipients to reduce nutrient loading, enhance collaboration, and engage Indigenous peoples on water quality issues related to Lake Winnipeg.

Work is underway to implement a strengthened freshwater action plan to address issues in Lake Winnipeg and other freshwater lakes and watershed. This includes the efforts of advancing the new Canada Water Agency, and continued collaboration with provinces and territories, Indigenous peoples, and other freshwater partners and stakeholders.

Partners and stakeholders were thanked for their efforts in implementing actions, and for their dedication to freshwater stewardship in the basin. ECCC will continue to foster partnerships and work collaboratively to improve water quality and restore the ecological health of Lake Winnipeg.

Indigenous Engagement Session

Indigenous Engagement on Lake Winnipeg Basin Nutrient Issues in Treaty 4, 5, and 6, Saskatchewan
~ Lori Bradford, University of Saskatchewan

This project was undertaken in partnership between Treaty, 4, 5 and 6 communities in Saskatchewan. Three community-based research coordinators guided the research, engaging:

- Treaty 4, including Yellow Quill First Nation, within the Lake Winnipegosis sub-drainage basin through Little Red Deer River;
- Treaty 5, including Cumberland House Cree Nation, Métis Local 42, and Northern Village of Cumberland House, within the Saskatchewan River sub-drainage basin and;
- Treaty 6, including the James Smith Cree Nation, within the Saskatchewan River sub-drainage basin upstream of Cumberland House.

The components of this research included; water sampling for nitrate, phosphate, and ammonia content to access the accuracy of citizen science tools and identify hot spots in these watersheds; a document review of Treaty 4, 5, and 6 rights, and review water governance documents as policy leavers; interviews with watershed organizations; and lake value-added activities related to mapping of riparian zones and algal identification.

Water sampling efforts looking at the accuracy of citizen science tools versus laboratory analyses were undertaken and correlations between the field photometers versus the laboratory analyses were conducted. Better correlations were found for ammonia, but less so for phosphate and nitrate, recognizing there may be some errors involved with in-field citizen monitoring tools. Several nutrient hotspots were identified in Treaty 4 and 6 territories.

The interview data were analyzed through the lens of power imbalances, several of which were identified over the decades relating to a lack of Indigenous engagement. Interviews were revealing in terms of how current watershed managers are engaging with Indigenous communities versus the way these communities would like to be engaged. Historically, there has been little Indigenous engagement related to work by local watershed organizations and boards.

In the document review component of this research, Canadian policy specific to prairie water management was compared to that contained within Treaties and Treaty interpretation documents. Stem and leaf diagrams were used to look for relationships between relevant terms.

The value-added activities of this research were considered a very valuable component of the project. A nutrient accumulation risk database was compiled. Working with a GIS specialist, information on land use and water flow were communicated, and a nutrient weighted flow accumulations database was developed for reserves in Saskatchewan. The student employee gained skills in algal and microbe identification, and knowledge on how algal composition and the presence of harmful toxic algal species changed seasonally.

The project resulted in many additional benefits including: relationship and capacity building; new accessible databases; constructive information on the effectiveness of citizen science tools; a better understanding of water governance strategies and how they related to Treaty content; advancement of interdisciplinary approaches and blended knowledge systems; and an opportunity to connect with other projects and agencies.

Several challenges and important lessons were learned including: fieldwork skill building; effective methods to conduct remote interviews; strategies for overcoming barriers of exclusion from watershed projects and meetings; knowledge related to the costs of field equipment; and enhanced knowledge to facilitate participation in watershed discussions.

The next steps involve completion of the data analyses, producing manuscripts, and school curriculum development related to water monitoring and the nutrient app. The knowledge gained in the study will be further disseminated, and grants for future work are being explored.

Reserves by Treaty	
Treaty #1	8
Treaty #2	20
Treaty #3	30
Treaty #4	28
Treaty #5	13
Treaty #6	35
Treaty #7	8
Treaty #8	0
Treaty #10	1
Total	142

Treaties and First Nations in the Lake Winnipeg Basin

Swan Lake First Nation Watersheds Stewardship Project
~ David Scott, Swan Lake First Nation and David Kornelsen, Rootstalk Resources

The Manitoba Watersheds Stewardship District Act, 2020, enables Watershed Districts to develop partnerships with First Nations. The project facilitated the building of these relationships, including the signing of a Memorandum of Understanding (MOU) between the Swan Lake First Nations and its partners (Central Assiniboine, Pembina Valley and Redboine Watershed Districts). The key features and outcomes of the MOU include: a Swan Lake First Nations Watersheds Stewardship Forum; participation in Watershed Districts Program activities; development of strong, respectful partnerships; sharing of Indigenous knowledge to help shape watershed planning; a clearer understanding of Indigenous rights and responsibilities; and harmonization of laws, policies, and practices between the partner agencies.

Meetings held with watershed districts led to the implementation of the Indian Springs Dam project. This separate project was undertaken in a collaborative partnership to address failing infrastructure. A compromise was reached concerning the new dam construction, and it was agreed that the surrounding land was to be managed in traditional ways, recognizing that climate change circumstances need to be considered. Work is being undertaken to protect Swan Lake and the surrounding area to ensure the lake stays healthy for community members but also for the health of Lake Winnipeg downstream.

The DeBlonde Water Retention project was the supported through LWBP funding. The project involves collaboration with the community, watershed districts, local, provincial, and federal agencies. Water will be held back so it can be released gradually. This project is part of a broader water retention plan for Swan Lake First Nations and is a Section 35 consultation project, with critical ongoing dialogue between partners. Indigenous knowledge is being integrated with western science in the management of this water management project.

Culverts ready for installation at DeBlonde Water Retention Project

Lake Winnipeg Basin Program funding has facilitated the development of partnerships and collaboration between agencies, blending western science and traditional knowledge to protect and manage water, and supported capacity building within the Swan Lake First Nation. Challenges such as program funding stackability requirements, and the need for a federal impact assessment when projects are implemented on First Nations land, have resulted in project implementation delays. Efforts to address these barriers and challenges are welcome. Work will continue through these partnerships to adapt to climate change and plan on a watershed basis.

Building Watershed Resilience with Manitoba's First Nations and Watershed Districts ~ Lynda Nicol, Manitoba Association of Watersheds

The role of the Manitoba Association of Watersheds (MAW) is to support 14 watershed districts in their efforts to protect Manitoba's soil, water, habitat, and climate.

Through LWBP funding, MAW supported efforts to facilitate deeper connections between watershed districts and their First Nations partners. MAW's role in this project was to manage the administration and provide opportunities for connection, with the real work of the program being conducted at the district and partner levels.

The specific goals of this project were to: build watershed resilience; strengthen relationships between Watershed Districts and First Nations partners; support activities that reduce nutrients and contaminants in the Lake Winnipeg watershed; advance collaborative governance; work with Indigenous communities on sustainable watershed management; and increase the capacity of watershed stakeholders.

The project included several distinct activities. The first activity focused on the education of watershed districts and involved the districts and their partner First Nations providing an opportunity for an Indigenous speaker to share water-related Indigenous knowledge and perspective. This activity was designed to help watershed districts and partner municipalities in their future interactions with First Nations on water related issues. Representatives from the Swan Lake First Nation and the Centre for Indigenous Environmental Resources also both presented at the 43rd Conservation Districts Conference on how watershed districts can build relationships with First Nations.

The Meeting Place activity fit well within the local governance model, as it involved several watershed districts and their partner First Nations meeting to share knowledge and learn from one another. Specifically, watershed districts had the opportunity to provide an update on the area's local Integrated Watershed Management Plan, and First Nations partners had an opportunity to share their practices, cultivating respect for Indigenous knowledge and expertise. This activity helped build collective decision-making through increased capacity and understanding and also provided an opportunity to help identify watershed priorities and potential projects. Several deliverables were achieved including:

- capacity building to identify risks to water supplies;
- a GPS survey for source water protection assessment;
- flood assessment;
- the installation of eight groundwater monitoring wells; and
- the completion of an Environmental Farm Plan through Manitoba Agriculture in 2020 by the Canupawakpa Dakota Nation, the first Indigenous community to achieve this. In addition, they were awarded the Watershed District Award by Souris River Watershed District and Manitoba Association of Watersheds.

An activity supporting Indigenous cultural education for watershed districts involved sharing Indigenous practices with watershed district managers. Watershed district managers met with Aboriginal, Métis and Inuit Elders/teachers who discussed and demonstrated traditional land and water use practices, ceremonies and history. This activity had the goal of creating long-lasting partnerships between watershed districts and Indigenous communities built on common goals, mutual understanding and environmental priorities, including nutrient management.

The Assiniboine West Watershed District also met with Elders from the Rolling River First Nations, sharing a breakfast to begin building relationships to jointly work on nutrient management activities through a collaborative watershed management framework.

On the topic of watershed planning with First Nations, staff from the Centre for Indigenous Environmental Resources (CIER) facilitated presentations and discussions. Manitoba's watershed districts were introduced to tools to facilitate better engagement with their Indigenous neighbours at all stages of the working relationship.

The final activity focussed on the communication of project components, through activities such as a workshop hosted at the 2021 Manitoba Watersheds Conference. One of the key takeaways from the workshop was the need for ongoing resources to support these relationships, and to champion the need for continued collaboration.

Next steps include: ongoing engagement with First Nations partners in the spirit of collaborative governance; continued recognition of evolving needs for increased capacity to support new partnerships; pursuing new funding opportunities to support new programs and projects to increase capacity at both the watershed district and First Nations partner levels; and taking action to maintain the existing and build new relationships.

Questions and Answers – Indigenous Engagement Session

Question 1. Lori Bradford: Will the data from the citizen science-monitoring program be shared publicly?
Answer: Yes, once our student has finished her thesis the data will be published on the Global Water Futures data network platform. However, we need to determine how some of the data collected by our Indigenous community members within the reserve boundaries, and in compliance with our research agreements, will be shared. There is recognition of the value of this data to others, so this is currently under discussion with the community.

Question 2. Derek Kornelsen and David Scott: What advice do you have for other watershed districts who may want to engage with First Nation communities in their area?
Answer: Don't be afraid to go and knock on their doors, keep everyone informed of any plans that you may have within your districts. Make sure that you have someone from each of those communities to be the spokesperson on behalf of leadership. The First Nations leadership may not necessarily always have the time to engage with each district. It involves an important learning curve, and it is important to keep plugging away at building relationships. Be proactive, respectful, and consistent in terms of engagement on planned projects and potential projects. It is important to have those discussions ahead of time, and not wait for a Section 35 consultation process.

Question 3. Lynda Nicol: Now that the funding for your project has come to a close, how do you think you're going to be able to keep the momentum going?
Answer: This can be done by encouraging continued collaboration and building on David's comments, not be afraid to reach out to your local communities, whether you are a watershed organization or a First Nation Community. At our conference, we heard that there is a need for

champions to go out and share the available information, and work to build these relationships because there's so much long-term benefit to that continued collaboration. Also, focus on communication and provide continued opportunities to collaborate.

Nutrient Reduction Session

Improving Riparian Health and Grazing to Benefit Water Quality ~ Norine Ambrose, Alberta Riparian Habitat Management Society

Riparian areas are extremely diverse and can improve water quality by trapping, storing and chemically changing the nutrients that come into these zones. There are challenges across Canada in terms of land use activities that affect riparian function, including grazing practices, channelization, and shoreline development. Since riparian areas are wetter and support plant growth, these areas are also productive areas for grazing. It is important to manage these areas carefully to keep them healthy and productive for both agriculture, water quality, and other benefits. This project focused on efforts to improve riparian health and grazing management to benefit water quality. In addition to the financial support from the LWBP, there were several partners involved in this initiative, including municipal, provincial, producer groups, and watershed organizations.

The overall goal was to work with landowners to help promote healthy riparian areas through voluntary stewardship action. The LWBP funding resulted in several deliverables, including participation at conferences and the delivery of a webinar and a workshop. Due to Covid, many extension activities were moved online. In addition to providing information and expertise on grazing management and regulatory requirements, materials related to riparian functions were provided. Health inventories were completed to assess the current health of riparian sites. Several projects were undertaken with livestock producers to construct fencing and off-site watering systems.

Efforts are underway to share these results in riparian health reports, on a new Cows and Fish website, and on social media platforms. The success of this work is credited to the funders, partner agencies, and the participating landowners. A key principle of this work is that landowners and their actions are important in determining riparian health and the provision of ecological services.

Wetland and Riparian Area Restoration/Enhancement Protection Program ~ Armand Belanger, East Interlake Watershed District

Various stewardship activities are supported under the program including regenerative agriculture, shelterbelts, livestock fencing and alternative water systems, wetland projects, grassland management, shoreline enhancement, conservation agreements and waterway protection works. The utilization of LIDAR data has helped pinpoint where projects should be located, including wetland restoration sites. Due to Covid, education and outreach activities were scaled back, however, partnerships with agencies such as Ducks Unlimited ensured the completion of several projects. The recent hot dry conditions encouraged many producers to explore alternative watering systems, equating to the protection of approximately 100 acres of riparian area.


Algal blooms Lake Winnipeg

The project undertaken with the support of several partners, including the LWBP, was the Edpond Lake wetland enhancement project. Historical knowledge regarding beaver dam activity was helpful in siting this 8-acre project. The wetland is functioning to regulate spring runoff and recharge the aquifer.

Integrated Watershed Management Plans (IWMPs) facilitate the siting of BMPs in the district and are updated every ten years for areas. A decision was made to merge these two existing plans – Willow Creek and Netley-Grassmere watersheds into a single watershed plan. LIDAR work, including merging of the data in this region, is facilitating stewardship activities on the ground, as flow patterns are better understood. Upcoming work in the region will be focusing on three areas: enhancing climate resilience in the planning process; climate change impact analysis in the planning area; and retention storage network siting and investment planning. These tools are providing opportunities to store more water and reduce nutrient loading to Lake Winnipeg.

Application of Floating Treatment Wetland: Duckweed Phosphorus Treatment Systems in Manitoba's Lake Winnipeg Watershed
~ Richard Grosshans, International Institute for Sustainable Development

There are over 200 wastewater lagoon systems in the Red River valley and over 400 across Manitoba. The smaller facilities are not required to meet nutrient discharge limits, and their impact on loading to the watershed is not well documented. Lagoons are generally constructed as large open systems that do not support rooted plant growth. This research explored the application of floating treatment wetlands and duckweed for reducing nutrient loading in the Lake Winnipeg watershed.

Floating treatment wetlands and duckweed treatment cells at Dunnottar, MB wastewater lagoon

Adding a tertiary wetland component to lagoon treatment can polish the effluent and reduce nutrient discharge downstream. However, this option may not be feasible due to cost, or infrastructure space. Other solutions for these circumstances are the application of floating treatment wetlands. Wetlands are effective at removing nutrients and other contaminants. Since existing lagoons are deep and will not support wetland plant growth, floating platforms can be employed as a substrate for plant growth. The roots that grow beneath the platforms provide habitat for biofilm where treatment (nutrient uptake) occurs. With this technology, there is no need to harvest the vegetation, as the treatment is occurring in the root zone.

The floating treatment wetlands in Dunnottar, located near the shores of Lake Winnipeg, were the first of their kind to be operated in Manitoba. In addition to floating treatment platforms, this treatment system also had a duckweed harvest component. As these floating treatment wetlands have been effective around the world; the expectation was they would also be effective under Manitoba conditions. This research is documenting this biological green technology for use in cold climates. The benefits of these systems are being investigated, with the expectation that they could be scaled and expanded across Manitoba. In addition to nutrient removal, the floating treatment wetland and duckweed systems are being evaluated for their ability to remove other contaminants.

Floating treatment wetlands in stormwater retention pond in East St. Paul, MB.

Both floating treatment wetlands and the duckweed system showed rapid growth. This project grew duckweed on a small scale, so further work is needed to evaluate its growth in larger open lagoon systems. The Dunnottar floating treatment wetlands remain in place, and additional monitoring and research are ongoing. Graduate student work is evaluating the effect of these treatment systems on the treatment of antibiotics and antibiotic-resistant genes in sewage.

The project also evaluated the effectiveness of the floating wetland treatment technology in two stormwater retention ponds in East St. Paul, Manitoba. The treatment system performed well. Conventional stormwater retention ponds are open and do not support natural vegetation growth. These floating treatment systems can act to 'naturalize' these basins to improve water quality, aesthetics, and property value. Floating treatment wetlands can remove between 50 to 80% of phosphorus, nitrogen and suspended solids. Research into the treatment effectiveness of these systems in Manitoba is ongoing.

Questions and Answers - Nutrient Reduction Session

Question 1. Norine Ambrose: Do you think you will ever run out of landowners who are interested in doing this work?
Answer: No, there are about 50,000 agricultural producers in Alberta, including turnover of those properties. Technologies are evolving and more options are available to producers such as portable electric fencing and new watering systems. There is also significant interest in regenerative agriculture.

Question 2. Armand Belanger: Was the regeneration agriculture project successful, and will it continue this coming year?
Answer: There were several bids for regenerative agriculture projects. A decision was made to fund a landowner who had experience with regenerative agriculture and was undertaking a short-term intensive grazing project, as well as work on a multi-species cover crop project. This was in part impacted by drought conditions, but some success was realized.

Question 3. Richard Grosshans: What is done with the harvested duckweed?
Answer: The harvested duckweed was left onsite in Dunnottar after harvesting. Duckweed from the East St. Paul project was hauled to a compost facility at the Brady Landfill. The duckweed can be used for livestock feed as it is very rich in protein and other nutrients.

Question 4. Richard Grosshans: What were the concentrations of total phosphorus in the Dunnottar lagoon before and after installation of the floating treatment wetland platforms? Also, what is the lifespan of this treatment system?
Answer: This was a pilot project so there were insufficient treatment wetlands installed to expect a measurable removal amount from the lagoon. More floating wetlands would need to be installed in a full-scale project. The platforms are constructed using recycled plastic, making them very durable and long-lasting, and requiring only minor maintenance and management.

Question 5. Richard Grosshans: What costs would municipalities incur if they were to use this technology?
Answer: The cost would vary with the size of the facility. For the Dunnottar lagoon, the cost is estimated at $18,000 - $20,000, which is likely much less than an infrastructure upgrade, and

less expensive than dredging regularly. There are both US and Canadian suppliers for the floating wetland platforms, and price and quality comparisons are ongoing.

Innovation & Collaboration Session

Enhancing Capacity for Collaborative Governance in the Lake of the Woods Basin ~ Todd Sellers, Lake of the Woods Water Sustainability Foundation

The focus of this work is on creating mechanisms and relationships in the watershed for collective action. The Lake of the Woods watershed is the eastern transboundary portion of the Lake Winnipeg Basin. Lake of the Woods is the fifth-largest transboundary lake in North America. It suffers from similar problems to Lake Winnipeg, including nutrient-rich waters, toxic blue-green algal blooms, and the introduction of invasive species. Covering 70,000 km^2, water flows through the Lake of the Woods into the Winnipeg River and then to Lake Winnipeg, providing a significant source of nutrients to Lake Winnipeg.

Lake management is complex and water governance is complicated because of its multi-jurisdictional nature spanning Ontario, Manitoba, and Minnesota. Over 20 agencies have some responsibility for the management of the lake. This project supported building and enhancing collaborative governance. The specific objectives included developing a sustainability plan; ensuring there is enough scientific expertise and policy will for action to support that plan; and uniting and coordinating the actions internationally by linking communities, researchers and policymakers. The project has facilitated the development of a multi-jurisdictional water governance framework, coordinated through the International Joint Commission (IJC) Rainy-Lake of the Woods Watershed Board. The framework included input from over 20 agencies and organizations, including public, Indigenous and government members. Three committees have been established for water levels, aquatic ecosystem health, and adaptive management. Several agencies provide input to these committees. In addition, there is a community advisory group, as well as an industry advisory group.

The aquatic ecosystem health committee has a key role to develop recommendations for water quality objectives and developing a collaborative monitoring program. The Committee serves as science and technical support to the IJC board. The core of the project is the international watershed coordination program, which is led by the Lake of the Woods Water Sustainability

Rainy-Lake of the Woods watershed covering portions of Manitoba, Ontario, and Minnesota

Foundation, which works to keep everyone working together at all levels. These efforts include educational initiatives that connect the public with researchers and policy makers.

At the multinational level, the watershed coordination program supports special projects such as developing recommendations for international water quality objectives. Over the past seven years, this work has resulted in significant progress on knowledge within the basin, including over 100 studies that included both western science and Indigenous knowledge. An important part of the overall project has been the development of relationships with Indigenous nations in a good way. A State of the Basin report is being developed with partners including Grand Council Treaty 3, the IJC, agencies and universities and is being released in March 2022 at the Lake of the Woods Watershed Forum. The report includes chapters on Indigenous knowledge, and a synthesis of traditional western science related to priority issues in the basin, including nutrients and algae.

The Lake of the Woods Watershed Forum brings together researchers and policy makers on an annual basis. The 2022 Forum will have a significant focus on nutrients, including a discussion on the nutrient plan for Lake of the Woods. The key elements of this nutrient management plan include research on harmful algal blooms including the discussion of US and Canadian phosphorus targets. Other elements of the plan include coordination mechanisms, relationship building with Indigenous nations, policy needs, and capacity and coordination building.

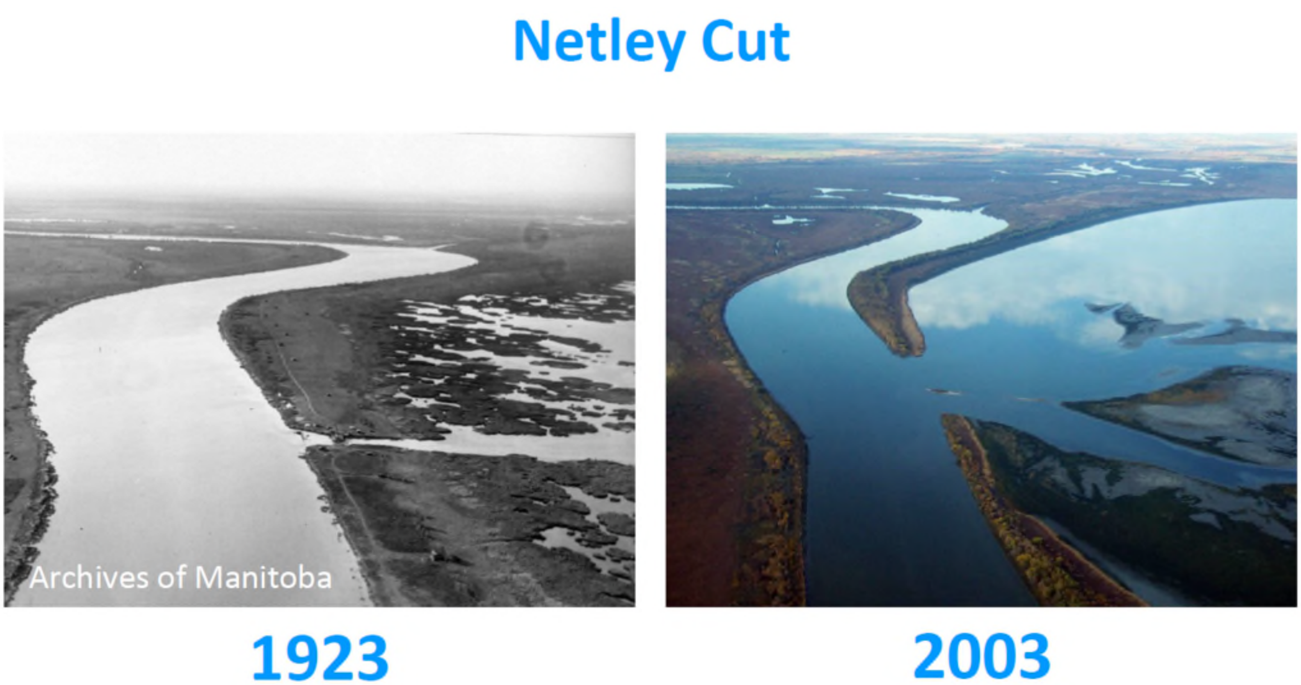
In summary, there is now a coordination mechanism amongst all the jurisdictions and nations, relationships and partnerships are developing with Indigenous nations, and the public is embedded and influential on policy directions and actions to protect the watershed. The Watershed Coordination program has played a key role in coordinating efforts and building relationships through this collaborative governance effort. The LWBP funding has played an important role in supporting this collaborative governance across the Lake of the Woods watershed, which will help to protect downstream Lake Winnipeg.

Netley-Libau Marsh Renewal
~ Steve Strang, Red River Basin Commission

The Netley-Libau Marsh Renewal Pilot Project was a joint initiative of the Red River Basin Commission and several other project partners.

The Netley-Libau marsh is the largest coastal wetland in North America at about 250 sq km. Images of the marsh from 1923 illustrated the beginnings of the Netley cut where water flows from the Red River into the west side of the marsh. The cut is now dramatically larger as illustrated in the photograph below.

Significant losses in vegetation have occurred in this portion of the marsh due to: infrequent low-water periods to permit vegetation re-establishment; Lake Winnipeg water level management; I-increased peak Red River flows; loss of upstream wetlands retaining water; the wet climatic cycle; and ice-breaking activity. This loss of marsh vegetation has diminished the ability of Netley-Libau Marsh to retain nutrients before they enter Lake Winnipeg. It has been estimated that the marsh could have the potential to take up at least 6% of the nutrients flowing through the Red River into Lake Winnipeg if it were a healthy functioning system. This is equivalent to the nutrients discharged by the City of Winnipeg, City of Brandon and Selkirk combined. Although several factors have likely contributed to the loss of vegetation in the marsh, stable lake levels and few low water periods have been identified as significant factors.



“Netley Cut” along the Red River near its mouth to Lake Winnipeg

The goal of this project was to recreate above-water portions of land in the Netley Lake area by pumping sediment from a donor area in the Red River channel and depositing it in the Netley Lake portion of the marsh to provide structure for vegetative regrowth. By raising the bottom of the marsh, the natural seed bank could be activated allowing vegetation to germinate. The governance structure for this project included a project steering committee, as well as a scientific advisory subcommittee that oversaw the day-to-day operations.

Four Amphibex dredgers transferred approximately 15,000 m^3 of silt, sand and clay. This solid material was pumped 1500 – 2000 m across a land bridge and deposited in the Netley Lake area. Vegetative wetland terraces were created with the dredged and pumped materials. Siltation curtains were used to protect the fishery during the construction. To prevent wind and wave action from deteriorating the terraces, three types of containment systems were tested. Erosion control blankets, geotubes, and aquadams were employed and tested for effectiveness, with the geotubes performing well. After two years there was evidence of wetland plant re-establishment in areas that had been elevated.

Phase one of the project is now complete. The low water levels in Lake Winnipeg over the last two years have facilitated the re-establishment of vegetation on these new exposed substrates. There is evidence of wildlife moving back into the area. The next steps include monitoring and reporting on progress in both 2022 and 2023. Additional geotubes will be installed in 2022, and a 5-year funding plan will begin in 2023. Once the vegetated areas are fully established, the geotubes will be removed to reduce any impacts. The collaborative efforts of this project have been beneficial, and these efforts are important to protect the health of Lake Winnipeg.

Win With Water: Collaborative Governance in Action in the Winnipeg Metropolitan Region and the South Basin of Lake Winnipeg
~ Richard Farthing-Nichol, Centre for Indigenous Environmental Resources

The Collaborative Leadership Initiative (CLI) is a partnership between the Centre for Indigenous Environment Research (CIER), the Winnipeg Metropolitan Region, and the Southern Chiefs' Organization. The CLI was established in 2017 as an innovative governance table to take a regional and coordinated approach to large problems that are beyond the scope of any one community to address on their own. This group of elected leaders includes 16 municipalities, 11 First Nations, as well as Grand Chief Jerry Daniels from the Southern Chiefs' Organization. An intergovernmental MOU between 28 First Nations and municipal elected leaders was developed in 2019. The three shared priorities recognized in this MOU are: protection of freshwater resources; waste management; and, economic development and good jobs for all. Program funding supported a range of CLI activities, including leadership meetings and communication efforts.

The first priority related to the protection of freshwater resources has focused on building natural infrastructure projects. There have been three community-led projects undertaken, with these small-scale innovative pilot projects designed to demonstrate how natural infrastructure can improve water quality and provide co-benefits.

Cattail biomass harvesting in the RM of Rosser, MB.

The first pilot project, a partnership with the RM of Rosser, explored harvesting biomass for both nutrient reduction as well as potential energy production. Cattails were harvested and baled, and the 30 bales were estimated to have sequestered about 1.0 kg of phosphorus and 13 kg of nitrogen. The RM of Rosser is now looking at how they to harvest biomass from ditches on an annual basis, and how this biomass could be used as an alternative fuel source for heating RM buildings.

The second project, undertaken with Sagkeeng First Nation, undertook an erosion control pilot project on the shoreline where the Winnipeg River meets Lake Winnipeg. Both rock armour and tree planting were undertaken to stabilize the shoreline and to provide co-benefits for carbon sequestration and habitat provision. It was estimated that the 550 willows and poplar trees planted will sequester 17-35 tonnes of CO^2 once fully grown. Future work will involve collaborating with the community to integrate a naturalized tree planting method into their future shoreline stabilization works.

The third project was a partnership with the Village of Dunnottar to pilot duckweed growth and harvesting in their wastewater lagoon. Duckweed can assimilate significant amounts of nutrients, and the project investigated ways to efficiently harvest the duckweed. An oil skimmer with a suction unit removed the duckweed out of the lagoon, harvesting 254 kilograms of duckweed. This method could be scaled up to remove a significant amount of both nitrogen and phosphorus from wastewater systems, facilitating compliance with the provincially regulated phosphorus limit of 1.0 mg/L of wastewater release. The harvested duckweed can be composted, and potentially used as a soil amendment, or as an additive for ethanol fuel.

The next steps for these natural capital projects are to: finalize the outcomes and lessons learned from pilot projects; continue work on these projects and their potential scaling up and costing; expand the scale and scope to identify future projects as part of a regional network of projects with the CLI partners; and continue knowledge transfer efforts on the feasibility of natural infrastructure projects.

Questions and Answers – Innovation & Collaboration Session

Question 1. Todd Sellers: Do you think that through this collaborative effort, you will be able to achieve common objectives or targets that everyone can agree to?
Answer: The short answer is yes. Both Minnesota and Canada have very similar recommendations on what targets should be established, and there is a general agreement between the two scientific approaches. Minnesota has identified a 17.3% total phosphorus reduction to achieve 30 µg/L in the south portion of the lake. The north portion of the lake is currently about 22 µg/L, and the Ontario interim water quality objective is 20 µg/L. If this objective can be achieved, that would result in about an 8% reduction in nutrient load to the Winnipeg River, which is close to the proposed reduction targets established by Manitoba for the Winnipeg River.

Question 2. Steve Strang: What will you do to ensure that carp will not damage the work you are doing in Netley-Libau Marsh?
Answer: The management plans we have put in place should help mitigate their impact. It is not possible to keep them out, especially when water levels rise. The geotubes should help to reduce potential damage by carp.

Question 3. Richard Farthing: What does the Collaborative Leadership Initiative need to scale up these pilot projects? Are there additional steps being taken to advance this work?

Answer: Financial support is needed, as funding has been identified as a barrier. There may be opportunities through climate resiliency funding for infrastructure. We are working to create a natural asset inventory for the region, along with mapping, to understand where we can have the largest impacts, and then secure funding to undertake more projects.

Advancing Knowledge Session

Community Based Monitoring Program ~ Chelsea Lobson, Lake Winnipeg Foundation

The Lake Winnipeg Community-Based Monitoring Program consists of a network of citizen scientists and watershed partners collecting water samples for phosphorus testing. Addressing phosphorus loading from every portion of the watershed would be overwhelming, therefore it is important to understand which portions of the watershed are contributing the highest phosphorus loads. This project focuses on monitoring phosphorus hotspots so that resources and remedial action can be targeted to benefit Lake Winnipeg. Previous research has reported that the Red River contributes about 68% of the total phosphorus load to Lake Winnipeg, however there is significant land-use variability in this watershed so it was important to sample throughout the Lake Winnipeg watershed. Both the location and timing of sampling are critical to identify accurate loading. The citizen volunteers live in their watersheds and are able to collect samples frequently during snowmelt and large rain events to capture nutrient loading events. This results in a more accurate estimate of phosphorus loading from these locations. To calculate nutrient loads, concentrations and flow rates are needed. Therefore, whenever possible, water quality sampling sites were located close to the Water Survey of Canada flow monitoring stations.

The data was collated to produce phosphorus export maps (kg/ha/y). The 2019 field season results identified several phosphorus hotspots, concentrated in the south portion of the Red River watershed. Results from 2016 to 2019 are available on the Lake Winnipeg Foundation website. Work is underway to generate phosphorus loading maps for the 2020 and 2021 monitoring periods, which will also show the expansion of the monitoring program.

A goal of this program was to ensure that the data can be useful in answering management and policy questions, including providing information to assist agencies to target future efforts and resources in these nutrient hotspot regions. The data is shared in reports and communicated back to the communities through presentations and meetings. Academic partners and agencies, such as the International Institute of Sustainable Development (IISD), have used this date to target their research in nutrient hotspot areas. There is ongoing work to evaluate the collective impact of actions across the larger watershed and the data collected through the Lake Winnipeg Community-Based Monitoring Program will be available to help answer those questions. This work was made possible through the assistance of partners from 10 watershed districts, the Manitoba Métis Federation and 70 citizen scientists.

Manitoba Métis Lake Winnipeg Basin Community-Based Monitoring Program ~ Marci Riel, Manitoba Métis Federation

The Manitoba Métis Lake Winnipeg Basin Community-Based Monitoring Program was initiated in 2018. It is a partnership between the Lake Winnipeg Foundation and the Manitoba Métis Federation (MMF) that supports collaboration between governments and organizations. This MMF Community-Based Water Monitoring program facilitates education and engagement with the Métis Nation through the efforts of the Métis citizen scientists. Priorities of this work include gathering Traditional Knowledge and undertaking water monitoring for phosphorus and salinity to better inform policy. The potential impact of algal blooms on Métis interests such as resource harvesting is also of interest and concern.

Manitoba Metis Federation citizen scientists conducting water quality monitoring.

The Lake Winnipeg Foundation provided training to Métis citizen scientists on water sampling methods. Samples were collected biweekly throughout the open water season, as well as during large rain events. Approximately 100 samples were collected in 2021. The results will be shared through various MMF programs and projects, helping to inform and prioritize opportunities and actions in the basin. There are efforts underway to seek additional opportunities to build capacity within the citizen scientist program.

The MMF also participates in the Weather Keeper Program in partnership with the Centre for Earth Observation Science at the University of Manitoba. The data from these weather stations allow better modelling of nutrient loading and also help predict further impacts of climate change on Lake Winnipeg. Several Métis citizen scientists have been trained to maintain and monitor these weather stations. Communities have benefited in many ways from participating in this program.

Indigenous engagement and education are the highest priority for this program, while working collaboratively with local First Nations and others to address issues such as impacts on the commercial fishing industry. Water quality and climate change are of primary concern to the Métis Nation. This project has helped raise awareness of the issue of eutrophication and toxic algal blooms, including the importance of minimizing nutrient loading to Lake Winnipeg. The monitoring efforts help better inform policymakers, including opportunities to engage with the International Joint Commission and the Red River Basin Commission, and providing opportunities for partnerships for the benefit of all.

Demonstration of the Importance of Targeting Soil Phosphorus Management in Watersheds. Phosphorus Load Reduction using the Phosphorus Reduction Tool ~ Dr. Jian Liu, University of Waterloo

Land management activities will affect the frequency and volume of phosphorus runoff. In this study, four research activities evaluated how crop, soil, and nutrient management practices influence runoff potential and phosphorus loss.

The first research activity involved an information synthesis effort. This work concluded that crop type and yield were positively correlated with water use. Also, crop residue management was found to influence snow trapping, sublimation, and melt. Increases in crop residue resulted in the retention of more snow, a decrease in snow sublimation, and an increase in snow accumulation, as compared to conventional tillage or fallow. Future research needs to quantify the agronomic and environmental trade-offs of crop residue management (soil moisture conservation and soil health vs snowmelt runoff and phosphorus loss); the linkage between crop water use and runoff; and crop and residue management impacts on runoff across various scales.

For example, conservation tillage and zero tillage can help conserve soil moisture for growing crops and improve soil health over the long term, but this also increases snowmelt runoff and phosphorus losses as compared to conventional tillage practices. It will be important to determine how to balance these trade-offs. Crop yields have almost doubled in the past 15 years, and it is unclear how this has influenced both hydrology and nutrient loading to Lake Winnipeg.

The second research activity focused on soil sampling to determine phosphorus levels. This work was conducted in the South Tobacco Creek watershed with nearly 300 soil samples collected from both field and ditch sites. The fields sampled included those under production for canola, corn, wheat, and natural pasture. This work was undertaken to better understand the spatial variability of phosphorus across and within fields, and how management, landscape and soil affect soil test phosphorus results; and determine through modelling how place-based phosphorus management can reduce phosphorus loss. This work helps identify hotspots in the watershed so these areas can be targeted and managed to reduce nutrient losses cost-effectively.

The third research activity focused on improving model performance. The model, developed by Dr. Lobb, was designed for watershed managers to use to determine phosphorus loss based on soil phosphorus levels, crop type, residue management, and runoff volume, all at the field scale. Data from activities one and two were used to improve the model.

The fourth and final research activity focused on scenario analyses. Work is underway to better understand the impacts of future climate change, including evaluating the impact of increasing and decreasing annual rainfall. Changes in soil phosphorus management activities, crop rotation practices, and soil phosphorus draw-down methods will also be evaluated using the model. It is anticipated that this product will help to identify beneficial management practices that producers can adopt to improve water quality without negatively impacting crop production.

Questions and Answers – Advancing Knowledge Session

Question 1. Chelsea Lobson: How do you become a community volunteer, and how much of a commitment is involved?
Answer: The best way to become a volunteer is to reach out to us via email on the Lake Winnipeg Foundation website. The commitment is most intense during the spring, as sampling may be required 2-3 times per week through the snowmelt period, however, it only takes about five minutes to collect the sample. Following the spring, sampling is also undertaken when there is a large rain event.

Question 2. Marci Riel: Is Indigenous knowledge being gathered and is it used to guide where samples are being collected? If it is being gathered, how is it being used to inform decision making and facilitate collaborative action?
Answer: The answer to the first question is yes. We work very closely with the Lake Winnipeg Foundation to select sampling locations, and we try to prioritize areas of concern where our citizens live. Many of our citizen scientists have chosen to sample in areas where they harvest. The MMF is working to ensure the information collected is benefiting their citizen, using the information to help prioritize areas of concern for the Nation. We are also able to focus on relationships with Canada, other governments, and other partners to ensure that programs and projects are being undertaken that relate to these priorities and will inform decision-making and collective action.

Question 3. Jian Liu: Do we know what the best practices are to draw down soil phosphorus?
Answer: Based on research by ECCC on South Tobacco Creek, it was found that when soil phosphorus input was reduced for 3-5 years, phosphorus concentration was reduced in runoff, and crop yield was not impacted. Variable-rate application of phosphorus is an important management tool, and research work is underway to demonstrate the agronomy,

environmental, and economic benefits of variable rate phosphorus application in Saskatchewan and Manitoba.

Closing Day 3

Ute Holweger (ECCC) closed the symposium and provide a summary wrap up of what was discussed. There were many key takeaway messages provided during the symposium. Important advancements have been made in both watershed and lake research, including modelling work to help identify nutrient hotspots. This information is critical to help target action to where it will be most effective in reducing nutrient loading. Monitoring work conducted by researchers and citizen scientists doing community-based monitoring has been essential to accurately assess the effectiveness of both on-the-ground action and in determining long-term trends in water quality conditions.

Other key messages include the need to consider potential surface and groundwater interactions, as well as the impact and the role that nitrogen plays in aquatic ecosystems and landscape processes. It is important to recognize that the uncertainties and predicted changes associated with climate change should not be underestimated. There is an immediate need to do some foresight analysis of what impacts those changes may have on policy decisions, and on-the-ground action. The panellists highlighted that doing research without end-user guidance and involvement will have significant limitations, and science should be effectively communicated to those who need it to bridge the gaps between research and those that are making the decisions on how to best manage our landscapes and water. This includes engaging Indigenous communities and agricultural producers and policymakers. There is a clear need to ensure that scientific research and knowledge are both co-developed and shared more readily between scientists and end users to ensure the information is available in a form that can be both understood and applied. This is especially important when it comes to Indigenous knowledge as it is needed to inform decision making and action in the watershed.

The accomplishments made on the landscape over the past five years to reduce nutrient loading throughout the basin have been both impressive and inspiring. Many co-benefits have been achieved including enhancing both biodiversity and climate resiliency. Perhaps the most important key takeaway is that all of this important work could not be done without collaboration and partnerships. This includes the collaboration and partnering with Indigenous communities, watershed planners, researchers, and citizen scientists to undertake these projects together. It has been clearly articulated that there are many benefits to proactively reaching out to Indigenous partners to build trust and relationships which leads to important partnerships and opportunities to advance common interests.

The information shared throughout the symposium will be captured and used to inform future programming and initiatives.

The next steps for the Lake Winnipeg Basin Program include working on a renewal that aligns with the federal governments commitments related to freshwater protection. ECCC will continue with its important partnership with the Province of Manitoba, through the Lake Winnipeg MOU, including implementing a shared work plan and developing science subsidiary agreements. A key priority of this work will be advancing reconciliation through Indigenous engagement and participation. ECCC will also continue joint efforts with other partners and stakeholders in advancing a Lake Winnipeg Adaptive Management Framework.

Elder Mary Maytwayashing closed the symposium in a good way. Shecommented that although at times she had a hard time understanding the material presented at the symposium, delegates should remember that for thousands of years, ancestors have been scientists in their own way, understanding that both water and weather were sacred. Although water is one of the most critical elements in our lives to survive, we are reminded that we live in a world where our waters are threatened by contaminants, and that with collaboration, passion, and interest we can achieve clean water. Water is sacred and should be respected. Climate change is contributing to problems like flooding, so there is a need to take care of the earth for us to survive. The symposium presentations provided important teachings about the landscape, and she feels fortunate to live by a lake where she can eat the fish from that lake and drink water from an artesian well. Teachings from Elders share that if we don’t take care of each other and take care of the earth, land and the water, the force of nature will bring everything into submission. Water has a spirit, and we are all interconnected. The sun, the grandmother moon and the animals all have spirits. Through this interconnection, we know that what we do on earth today we do to ourselves, and actions can harm our grandchildren, and ones yet to be born. She felt that the work discussed at the symposium is important and that we all learned from these meetings.

In closing, Elder Mary thanked the Creator for bringing delegates together, and gave thanks for a beautiful way of life and all that has been provided to everyone. She reminded the delegates that the winds will bring warm weather, and the Thunderbirds will bring water to help cleanse the earth and make things grow. Thanks was given for the food that comes from the earth, and thanks for the honour of providing the closing prayer. She asked for blessings for the delegates and their families and future generations, and that all will be taken care of, in a good way. Elder Mary gave thanks for the sun, the beautiful day, the snow and the new life it will support as the rivers flow. She asked that these flow in a pure way without chemicals that will harm us and the animals. Blessings were given to all. Meegwetch.

APPENDICES

Appendix 1. Lake Winnipeg Basin Program Virtual Symposium Agenda




Scientific Advancements related to Nutrients and Climate Change

Environment and Climate Change Canada
Lake Winnipeg Basin Program Virtual Symposium

Jan 18
2022

Time	Presentation	Speaker
10:00	**Welcome & Opening**	
10:15	**Program Overview**	
10:30	**Nutrient Transport and Fate**	
	Groundwater-Surface Water Interactions in the Assiniboine Delta Aquifer Area	Serban Danielescu, Agriculture and Agri-Food Canada & ECCC
	Binational Nutrient Loads Across the Red-Assiniboine River Basin	Agnes Richards, Environment and Climate Change Canada
	Fate of Bioavailable Nutrients from Episodic Wastewater Lagoon Releases	Kristin Painter, University of Saskatchewan
	Questions and Answers	
11:45	**Lunch**	
	Break	
12:30	**Climate Change Implications on Hydrology**	
	Snowpack Response in the Assiniboine-Red River Basin under Global Warming Scenarios	Rajesh Shrestha, Environment and Climate Change Canada
	Assiniboine Watershed Modelling to Predict Nutrient Loading Under BMPs and Climate Change Scenarios	Yonas Dibike, Environment and Climate Change Canada
	A Linked Hydrological-Biogeochemical Modelling System to Assess Stressors on the State of Lake Winnipeg	Chris Spence, Environment and Climate Change Canada
	Questions and Answers	
13:45	**Priority Science Gaps Panel**	
	Merrin Macrae, University of Waterloo Helen Baulch, University of Saskatchewan Pascal Badiou, Ducks Unlimited Canada	
	Responding to the following questions: #1 From your perspective, what are the top 2-3 knowledge gaps that are needed to support more informed decision making to improve the overall health of Lake Winnipeg? #2 What opportunities and approaches do you see for improving how knowledge is transferred from research findings to end-users who are making on-the ground decisions?	
	Questions and Answer	
14:20	**Closing**	

Advancing the Knowledge of In-lake and Watershed Science

Environment and Climate Change Canada Lake Winnipeg Basin Program Virtual Symposium

Jan 19
2022

Time	Presentation	Speaker
10:00	**Welcome & Opening**	
10:15	**Program Overview**	
10:30	**Lake Ecology**	
	Wetland Vegetation Change in Netley Libau Marsh	Gordon Goldsborough, University of Manitoba
	Distribution, Density and Biomass of Zebra mussels in Lake Winnipeg	David Depew, Environment and Climate Change Canada
	Numerical study on Circulation and Inter-Basin Exchanges in Lake Winnipeg	Jun Zhao, Environment and Climate Change Canada
	Questions and Answers	
11:45	**Lunch**	
	Break	
12:30	**Nutrient Sources in the Watershed**	
	Using Load Apportionment Model to differentiate Diffuse and Point Source Phosphorus Inputs to Streams	Kim Rattan, Environment and Climate Change Canada
	Sources of Nitrogen to Stream Food Webs in Red River Valley Tributaries	Bob Brua, Environment and Climate Change Canada
	Contribution of Nitrogen Sources to Streams in the Red River Valley	Kristin Painter, University of Saskatchewan
	Questions and Answers	
13:45	**Priority Science Gaps Panel**	
	Nora Casson, University of Winnipeg David Lobb, University of Manitoba Greg McCullough, University of Manitoba	
	Responding to the following questions: #1 From your perspective, what are the top 2-3 knowledge gaps that are needed to support more informed decision making to improve the overall health of Lake Winnipeg? #2 What opportunities and approaches do you see for improving how knowledge is transferred from research findings to end-users who are making on-the ground decisions? Questions and Answer	
14:20	**Closing**	



Actions Throughout the Basin

Jan 20 2022

Environment and Climate Change Canada
Lake Winnipeg Basin Program Virtual Symposium

Time	Presentation	Organization
10:00	**Welcome & Opening**	
10:15	**Program Overview**	
10:30	**Indigenous Engagement**	
	Indigenous Engagement on Lake Winnipeg Basin Nutrient Issues in Treaty 4, 5,and 6, Saskatchewan	Lori Bradford, University of Saskatchewan
	Swan Lake First Nation Watersheds Stewardship Project	Derek Kornelsen, Swan Lake First Nation
	Building Watershed Resilience with Manitoba's First Nations and Watershed Districts	Lynda Nicol,Manitoba Association of Watersheds
	Questions and Answers	
11:15	**Nutrient Reduction**	
	Improving Riparian Health and Grazing to Benefit Water Quality	Norine Ambrose, Cows and Fish (Alberta Riparian Habitat Management Society)
	Wetland and Riparian Area Restoration/Enhancement Protection Program	Armand Belanger, East Interlake Watershed District
	Application of Floating Treatment Wetland (FTW): Duckweed Phosphorus Treatment Systems in Manitoba's Lake Winnipeg Watershed	Richard Grosshans, International Institute for Sustainable Development
	Questions and Answers	
12:00	**Lunch**	
	Break	
12:45	**Innovation & Collaboration**	
	Enhancing Capacity for Collaborative Governance in the Lake of the Woods Basin	Todd Sellers, Lake of the Woods Water Sustainability Foundation
	Netley Libau Marsh Renewal	Steve Strang, Red River Basin Commission
	Building Community-led Natural Infrastructure through the Collaborative Leadership Initiative	Richard Farthing-Nichol, Centre for Indigenous Environmental Resources
	Questions and Answers	
13:30	**Advancing Knowledge**	
	Community Based Monitoring Program	Chelsea Lobson, Lake Winnipeg Foundation
	Manitoba Métis Lake Winnipeg Basin Community Based Monitoring Program	Marci Riel, Manitoba Métis Federation
	Land Management for Reducing Phosphorus Losses	Jian Liu, University of Manitoba
	Questions and Answers	
14:15	**Closing**	

Appendix 2. Lake Winnipeg Basin Research References

The following provides a list of relevant Lake Winnipeg basin research papers from the second Lake Winnipeg special issue of the Journal of Great Lake Research (papers 1 through 12) and two additional papers by ECCC scientists related to Lake Winnipeg and its basin (papers 14 and 15).

1. Psychrotrophic violacein-producing bacteria isolated from Lake Winnipeg, Canada, Journal of Great Lakes Research. Steven B. Kuzyka, Alexander O. Pritchard, Jocelyn Plouffea, John L. Sorensen, and Vladimir Yurkova.

2. Snowpack response in the Assiniboine-Red River basin associated with projected global warming of 1.0°C to 3.0°C, Journal of Great Lakes Research. Rajesh R. Shrestha, Barrie R. Bonsal, Ashish Kayastha, Yonas B. Dibike, and Christopher Spence.

3. Evaluating diffuse and point source phosphorus inputs to streams in a cold climate region using a load apportionment model, Journal of Great Lakes Research. K.J. Rattan, M.J. Bowes, A.G. Yates, J.M. Culp, and P.A. Chambers.

4. An ecological causal assessment of tributaries draining the Red River Valley, Manitoba, Journal of Great Lakes Research. Kristin J. Painter, Robert B. Brua, Patricia A. Chambers, Joseph M. Culp, Chris T. Chesworth, Sophie N. Cormier, Christopher D. Tyrrell, and Adam G. Yates.

5. Morphology and blood metabolites reflect recent spatial and temporal differences among Lake Winnipeg walleye, Sander vitreus, Journal of Great Lakes Research. Matt J. Thorstensen, Lilian M. Wiens, Jennifer D. Jeffrey, Geoffrey M. Klein, Ken M. Jeffries, and Jason R. Treberg.

6. Sources of nitrogen to stream food webs in tributaries of the Red River Valley, Manitoba, Journal of Great Lakes Research. Sophie N. Cormier, Jordan L. Musetta-Lambert, Kristin J. Painter, Adam G. Yates, Robert B. Brua, and Joseph M. Culp.

7. Association of aerobic anoxygenic phototrophs and zebra mussels, Dreissena polymorpha, within the littoral zone of Lake Winnipeg, Journal of Great Lakes Research. Steven Brady Kuzyk, Kaitlyn Wiens, Xiao Ma, and Vladimir Yurkov.

8. Emergent vegetation in Netley-Libau Marsh: Temporal changes (1990–2013) in cover in relation to Lake Winnipeg level and Red River flow, Journal of Great Lakes Research. K. Elise Watchorn, Gordon Goldsborough, Christiane Hudon, and Zofia E. Taranu.

9. Limited evidence of zebra mussel (Dreissena polyorpha) consumption by freshwater drum (Aplodinotus grunniens) in Lake Winnipeg, Journal of Great Lakes Research. Caleb H.S. Wong, Eva C. Enders, and Caleb T. Hasler.

10. Application of dynamic contributing area for modelling the hydrologic response of the Assiniboine River Basin to a changing climate, Journal of Great Lakes Research. Yonas Dibike, Ameer Muhammad, Rajesh R Shrestha, Christopher Spence, Barrie Bonsal, Laurent de Rham, Jaden Rowley, Grey Evenson, and Tricia Stadnyk.

11. Groundwater contributions to surface water in the Assiniboine Delta Aquifer (ADA): A water quantity and quality perspective, Journal of Great Lakes Research. Serban Danielescu, Florent Barbecot, and Victor. Morand.

12. High-resolution hydrodynamic modelling to study year-round circulations and inter-basin exchanges in Lake Winnipeg, Journal of Great Lakes Research. Jun Zhao, Reza Valipour, Luis F. León, and Yerubandi R. Rao.

13. The distribution, density, and biomass of the zebra mussel (Dreissenapolymorpha) on natural substrates in Lake Winnipeg 2017–2019, Journal of Great Lakes Research. David C. Depew, Emily Krutzelmann, K. Elise Watchorn, Amanda Caskenette, and Eva C. Enders.

14. Fate of bioavailable nutrients released to a stream during episodic effluent releases from a municipal wastewater treatment lagoon, Environmental Science Process & Impacts, November 2020. Kristin J. Painter, Robert B. Brua, John Spoelstra, Geoff Koehler, and Adam G. Yates.

15. Contribution of nitrogen sources to streams in mixed-use catchments varies seasonally in a cold temperate region, Science of the Total Environment. Kristin J. Painter, Robert B. Brua, Geoff Koehler, John Spoelstra, and Adam G. Yates.

Appendix 3. Lake Winnipeg Basin Information and Resources

- Lake Winnipeg Basin Program:
- https://www.canada.ca/en/environment-climate-change/services/water-overview/comprehensive-approach-clean/lake-winnipeg.html

- Canadian Environmental Sustainability indications – reductions in Phosphorus loads to Lake Winnipeg (November 2020):
- https://publications.gc.ca/collections/collection_2021/eccc/en4-144/En4-144-89-2020-eng-1.pdf

- Agricultural Practice Effectiveness for Reducing Nutrients in the Red River Basin:
- https://www.redriverbasincommission.org/_files/ugd/4a0263_66436b6661f746c0a8ed15577f950086.pdf

- Lake Winnipeg DataStream:
- https://lakewinnipegdatastream.ca/

- CanWIN Data Hub:
- http://lwbin-datahub.ad.umanitoba.ca/dataset/lwbp

- EOLakeWatch Portal:
- https://www.canada.ca/en/environment-climate-change/services/water-overview/satellite-earth-observations-lake-monitoring.html

- Journal of Great Lakes Research Special Edition – Lake Winnipeg (April 2021):
- https://www.sciencedirect.com/journal/journal-of-great-lakes-research/special-issue/1051ZGPPB5R