December 19, 2008

Dear Members of the Manitoba Clean Environment Commission,

We are concerned about the health of Lake Winnipeg and the plan the Government of Manitoba has embarked on to address the lake's water quality issues. Specifically, we disagree with the Government's plans to improve the health of Lake Winnipeg by making minor reductions in inputs of both phosphorus and nitrogen, rather than making much larger reductions in phosphorus alone. In this letter, we outline the reasons for our concerns and make recommendations for how the government can improve water quality in Lake Winnipeg.

Importance of Lake Winnipeg

Covering an area of 24,400 square kilometres, Lake Winnipeg is the tenth largest freshwater lake in the world. More than 23,000 permanent residents live along the shores of Lake Winnipeg, including eleven First Nation communities. Nine provincial parks, five park reserves, and two ecological reserves immediately surround Lake Winnipeg. Efforts are underway to establish a 42,000 square kilometre region on the east side of Lake Winnipeg as a UNESCO World Heritage Site. Lake Winnipeg serves as a source of drinking water, commercial and subsistence fisheries, tourism and recreation, transportation, and hydroelectric power. Tourism and recreation generate an estimated $100 million per year, the value of commercial fish production is over $20 million per year, and hydropower generation adds as much as $588 million per year to the provincial economy. As Manitobans, we not only have the privilege, but also the responsibility, to be stewards of one of the world's great lakes.

Eutrophication of Lake Winnipeg

Lake Winnipeg is suffering from an environmental problem called "eutrophication", which means that an over-enrichment of nutrients has increased the biological productivity of the ecosystem. Nutrients enter the lake from both point sources (e.g., effluent from wastewater treatment plants) and non-point sources (e.g., runoff of fertilizer from agricultural areas). The most obvious symptom of this problem is the large blooms of cyanobacteria (popularly referred to as "blue-green algae") that cover thousands, and sometimes even tens of thousands, of square kilometres of the lake each summer. Blooms of cyanobacteria are aesthetically displeasing and impair the taste and odour of water. Some cyanobacteria produce potent brain and liver toxins that can harm humans, pets, livestock, and wildlife. Furthermore, when blooms of cyanobacteria die and sink to the bottom of the lake, oxygen is depleted as their bodies are decomposed by bacteria. Low levels of oxygen can stress, or even kill, fish and invertebrates inhabiting the lake. Eutrophication clearly diminishes the quality of water for drinking and recreational activities, poses health risks to humans and wildlife, and changes the structure and function of aquatic food webs. Eutrophication of Lake Winnipeg began several decades ago, but has recently accelerated. Notably, Lake Winnipeg has experienced more frequent and larger blooms of cyanobacteria since the mid-1990s.

The Government of Manitoba's Action on Lake Winnipeg

In 2000, the Manitoba Government announced plans to develop a *Nutrient Management Strategy* for surface waters in Southern Manitoba. The information bulletin released by Manitoba Conservation on April 20, 2000 stated that phosphorus and nitrogen were "the two nutrients most commonly associated with eutrophication", but that "phosphorus…may not be the factor that limits algal growth in many prairie water bodies". The government's lack of recognition of the importance of phosphorus as a key limiting nutrient in freshwaters set the course for nutrient management in Manitoba along a path that was not supported by many aquatic scientists.

Three years later (February 18, 2003), the Manitoba Government announced the *Lake Winnipeg Action Plan*, which included establishing a Lake Winnipeg Stewardship Board to identify "further actions necessary to reduce nitrogen and phosphorus to pre-1970 levels in the lake by 13 per cent or more". Most aquatic scientists were surprised by the government's proposal to reduce nitrogen loading to Lake Winnipeg, as they believed controlling phosphorus alone was all that was required to reverse eutrophication in the lake. Subsequent iterations of the *Lake Winnipeg Action Plan* refer to "further actions necessary to reduce nitrogen and phosphorus to pre-1970 levels in the lake by 13 per cent reduction in nitrogen and 10 per cent reduction in phosphorus", which effectively downgraded the interim target for phosphorus reductions.

The Lake Winnipeg Implementation Committee released a report in 2005 entitled *Restoring the Health of Lake Winnipeg*. This report stated that "efforts to control eutrophication should focus first on reducing phosphorus loading" and that "the oversupply of the plant nutrient nitrogen to aquatic ecosystems is not the cause of eutrophication". Similarly, the Lake Winnipeg Stewardship Board, in a report to the Minister of Water Stewardship in December 2006, acknowledged that "there is some controversy surrounding the roles of nitrogen and phosphorus in stimulating algal productivity and influencing algal community structure in Lake Winnipeg", and thus the Board felt that "priority should be placed on achieving reductions of phosphorus since the benefits to Lake Winnipeg are more clear and unequivocal". Thus both the Lake Winnipeg Implementation Committee and the Lake Winnipeg Stewardship Board recommended that the Government of Manitoba focus on phosphorus reductions to control eutrophication in Lake Winnipeg.

In both of its 2005 and 2006 reports, the Lake Winnipeg Stewardship Board recommended that the Province of Manitoba complete its *Nutrient Management Strategy* and develop water quality objectives for nutrients in Lake Winnipeg that would replace the interim targets set by the *Lake Winnipeg Action Plan*. We are now approaching the end of 2008 and the Government of Manitoba has still not finalized its *Nutrient Management Strategy* nor has it revised the nutrient water quality objectives outlined in the *Lake Winnipeg Action Plan*. Therefore, all actions are currently being taken in the absence of a clear goal and in the absence of a strategy to achieve that goal.

The City of Winnipeg's Wastewater Treatment Upgrade

In 2003, Manitoba's Clean Environment Commission recommended to the Minister of Conservation that the "City of Winnipeg should be directed to plan for the removal of nitrogen and phosphorus from its municipal wastewaters, and to take immediate steps in support of the nutrient reductions targets established for Lake Winnipeg". In response, Manitoba Conservation issued *Environmental Act* licences to the City of Winnipeg which stipulated that the City's three water pollution control centers shall not discharge effluent with concentrations of total phosphorus in excess of 1 mg/L and of total nitrogen in excess of 15 mg/L. By 2014, the City of Winnipeg expects to reduce its phosphorus load to Lake Winnipeg by 65% and its nitrogen load by 47%. As the City of Winnipeg contributes approximately 5% and 4% of the phosphorus and nitrogen loads to Lake Winnipeg, respectively, this sewage treatment upgrade will reduce phosphorus loading to Lake Winnipeg by 3% and nitrogen loading by 2%. The estimated capital cost of the City of Winnipeg's wastewater treatment plant upgrades is $1.2 billion[1].

Management of Eutrophication in Canadian Lakes – A Historical Perspective

During the 1960s, Lakes Erie and Ontario, and Saginaw Bay in Lake Michigan, and many of the largest lakes in Europe were undergoing rapid cultural eutrophication. Cyanobacteria were present in unprecedented numbers and large areas of the lakes were depleted of oxygen. At the time, scientists were arguing over which nutrient was responsible for eutrophication of freshwater lakes. Some argued that it was carbon, others that it was nitrogen, and still others that it was phosphorus.

To help understand the factors contributing to eutrophication in the Laurentian Great Lakes, the federal government established a research station called the "Experimental Lakes Area" (ELA) in north-western Ontario that was staffed by a hand-picked team of prominent aquatic scientists from around the world. A series of whole-lake experiments were conducted at the ELA to study the effects of nutrients on the growth of algae.

In their now classic study, the ELA scientists divided a double-basin lake (Lake 226) in half with a sea curtain and added carbon, nitrogen, and phosphorus to one basin, and only carbon and nitrogen to the other basin. The basin receiving the phosphorus consistently had late summer blooms of nitrogen-fixing cyanobacteria, whereas the other basin did not. Later work confirmed that a low nitrogen-to-phosphorus ratio was the factor that triggered the blooms of nuisance cyanobacteria.

Perhaps the most germane ELA experiment, with respect to Lake Winnipeg, is the long-term study in Lake 227. This lake has been fertilized with constant annual inputs of phosphorus for 40 years. Reducing the nitrogen-to-phosphorus ratio in 1975 caused the algae of the lake to become dominated by cyanobacteria. Since 1990, no nitrogen has been added to the lake at all. Algae continue to be dominated by cyanobacteria and there has been no decline in eutrophication, because the necessary nitrogen is fixed from the atmosphere.

---

[1] $1.2 billion is the total cost of Winnipeg's Wastewater Improvement Plan, of which $670 million is the estimated cost to implement nutrient removal down to 1 mg/L total P and 15 mg/L total N at all three wastewater treatment plants.
This clarification was added after the letter was distributed to signatories.

The ELA studies unequivocally demonstrated that phosphorus was the nutrient that needed to be controlled in order to reverse eutrophication in freshwater lakes. This is because natural mechanisms exist that allow algae to obtain carbon and nitrogen from the atmosphere when they are in short supply in lakes.

The eutrophication studies at ELA were instrumental in guiding policy makers on how to control eutrophication in the Laurentian Great Lakes. In 1972, the Canadian and American governments signed the *Great Lakes Water Quality Agreement*, which led to controls on phosphorus inputs to the Great Lakes. These reductions in phosphorus led to substantial improvements in water quality in Lakes Erie and Ontario, and in Saginaw Bay. In the following decades, phosphorus reductions to lakes in Canada, Sweden, Switzerland, Denmark, and other countries, have led to many other success stories.

Given this historical context, it is easy to appreciate why aquatic scientists were puzzled by Government of Manitoba's plans to control both nitrogen and phosphorus to improve water quality in Lake Winnipeg.

Our Concerns about the Government of Manitoba's Action on Lake Winnipeg

We commend the Government of Manitoba for recognizing the deteriorating water quality of Lake Winnipeg and the need for action to reduce nutrient inputs to the lake. However, we disagree with the Government's plans to make minor reductions in nitrogen and phosphorus to improve the health of Lake Winnipeg. These are the reasons why we disagree:

1. **Reductions in phosphorus inputs alone are sufficient to control eutrophication.** Whole-lake experiments and lake remediation projects, in lakes of many types, have established that phosphorus is the key limiting nutrient in freshwater lakes and that reductions in phosphorus alone are usually sufficient for controlling eutrophication. To our knowledge, there is no evidence that reduction of both nitrogen and phosphorus, rather than phosphorus alone, is necessary for controlling eutrophication in freshwater lakes.

2. **Nitrogen limitation of algae is a symptom, not a cause, of cultural eutrophication.** Whole-lake fertilization experiments have demonstrated that phosphorus loading results in short-term nitrogen deficiencies that temporarily limit primary productivity. These nitrogen deficiencies are eventually corrected by nitrogen-fixing cyanobacteria (as explained in point 3 below). Therefore, short-term bottle and mesocosm experiments that indicate algae are nitrogen-limited should not be regarded as evidence that nitrogen should be controlled because nitrogen limitation is simply a symptom of phosphorus over-fertilization. Unfortunately, the belief that nitrogen needs to be controlled is based on these types of experiments, which are obviously inadequate for predicting the response of whole lakes to changes in nutrient regimes. While there may be other reasons to manage nitrogen (i.e., to meet water quality guidelines for nitrate and/or ammonia), reductions in nitrogen are not necessary to control eutrophication in Lake Winnipeg[2].

[2] Concerns about ammonia toxicity do not necessarily mean that all forms of nitrogen should be removed from wastewater. The risks of ammonia toxicity can be addressed by converting ammonia in wastewater to another form through nitrification.
This clarification was added after the letter was distributed to signatories.

3. **Nitrogen reductions are counter-productive because nitrogen deficiencies stimulate blooms of filamentous cyanobacteria.** When nitrogen is in short supply in lakes, some species of cyanobacteria can trap nitrogen gas from the atmosphere to correct this deficiency. When the availability of nitrogen is low in comparison to that of phosphorus (i.e., low nitrogen-to-phosphorus ratio), many filamentous cyanobacteria produce specialized cells called "heterocysts". In these heterocysts, nitrogen gas is converted to ammonia, a form of nitrogen that is useful for algal growth. The ability of cyanobacteria to fix nitrogen from the atmosphere gives them a competitive advantage over other algae when nitrogen is scarce. Consequently, nitrogen-fixing cyanobacteria typically dominate algal communities when nitrogen-to-phosphorus ratios are low. This phenomenon has been demonstrated in whole-lake experiments in both boreal and prairie lakes in Canada. The main filamentous cyanobacteria in Lake Winnipeg (*Anabaena* and *Aphanizomenon* spp.) can produce heterocysts, and therefore, nitrogen removal would most likely favour the dominance of these nuisance algae.

4. **The effects of the proposed nutrient reductions will not be detectable.** The proposed nutrient reductions (10 and 13% for phosphorus and nitrogen, respectively) are so small that their effects on Lake Winnipeg will be within the range of natural spatial and year-to-year variability. Consequently, it will be difficult to detect changes in nutrient concentrations and phytoplankton biomass in response to these proposed reductions. More importantly, these proposed nutrient reductions will likely not lead, particularly in the short-term, to noticeable improvements in water quality in Lake Winnipeg. Undoubtedly, the public will be frustrated by this lack of improvement, considering hundreds of millions in taxpayer dollars will be spent on wastewater treatment upgrades in the City of Winnipeg alone.

What's New Since the CEC Hearings in 2003?

Since the recommendations made in 2003 by Manitoba's Clean Environment Commission to the Minister of Conservation, several key pieces of information have emerged that are relevant to nutrient management in Lake Winnipeg:

1. **Cyanobacterial nitrogen fixation rates for Lake Winnipeg.** The rate at which cyanobacteria fix atmospheric nitrogen was measured extensively in Lake Winnipeg in 2003 and 2004 (Len Hendzel 2006; *Lake Winnipeg Research Consortium 2006 Annual Workshop*). Based on these measurements, the amount of atmospheric nitrogen fixed by cyanobacteria in Lake Winnipeg was estimated to be 9300 tons per year. To put this in perspective, the City of Winnipeg releases an estimated 3600 tons of nitrogen per year to Lake Winnipeg. It only takes 2-3 weeks for cyanobacteria in Lake Winnipeg to fix the same amount of atmospheric nitrogen that the City of Winnipeg adds to the lake in an entire year. If nitrogen were removed from sewage effluent from the City of Winnipeg, nitrogen-fixing cyanobacteria will easily be able to replace this deficit in Lake Winnipeg.

2. **A 37-year whole-ecosystem experiment demonstrated that “eutrophication of lakes cannot be controlled by reducing nitrogen input”.** One of the top scientific journals recently published findings from a long-term, whole-lake fertilization experiment (Schindler et al 2008; *Proceedings of the National Academy of Sciences*). This study tested the effectiveness of nitrogen controls to reduce lake eutrophication. The authors concluded that “reducing nitrogen inputs increasingly favoured nitrogen-fixing cyanobacteria” and that to control eutrophication, “the focus of management must be on decreasing inputs of phosphorus”.

3. **The recent acceleration of eutrophication in Lake Winnipeg was linked to climate change.** The increase in algal blooms observed in Lake Winnipeg since the mid-1990s is likely driven by changes in precipitation in the Red River Basin (Greg McCullough 2008; *Red Zone: Currents, Chemicals, and Change Symposium*). In the last 15 years, the Red River Basin has experienced higher-than-normal rainfall and an increased intensity and frequency of floods. As a result of these wet conditions, more dissolved nutrients are being washed out of the Red River Basin and into Lake Winnipeg. Therefore, McCullough and his colleagues concluded that the most recent surge in eutrophication in Lake Winnipeg was caused by changes in climatic conditions in the Red River Basin, rather than by direct increases in anthropogenic nutrient loadings.

Our Recommendations for Improving the Health of Lake Winnipeg

We recommend that the Government of Manitoba:

1. **Promptly complete Manitoba’s *Nutrient Management Strategy* and revise the interim nutrient targets proposed in the *Lake Winnipeg Action Plan*.** The government announced its intentions to develop a nutrient management strategy over 8 years ago. The *Nutrient Management Strategy* has not been completed, nor have the interim nutrient targets in the *Lake Winnipeg Action Plan* been replaced by “long-term, ecologically-relevant water quality objectives”. We need a clear goal for improving the health of Lake Winnipeg, a strategy for achieving that goal, and an evaluation method for charting our progress towards that goal.

2. **Focus the program for reducing eutrophication in Lake Winnipeg solely on phosphorus.** Peer-reviewed science and world-wide examples overwhelmingly support the need to focus on phosphorus management to control eutrophication. Removing nitrogen will at best do nothing, and at worst, increase the dominance of the filamentous nitrogen-fixing cyanobacteria that are the public face of eutrophication in Lake Winnipeg and in many other lakes.

3. **Broaden the scope of phosphorus management in the Lake Winnipeg watershed.** Resources intended for nitrogen reductions would be better spent on a more comprehensive management strategy for phosphorus in the Lake Winnipeg watershed, especially in the Red River Basin. Efforts to control phosphorus should not be limited to point sources from urban centers, but rather, must include management of non-point sources of phosphorus in the watershed. In particular, urgent

action is needed to increase the retention of phosphorus in the Red River Basin. Better management/storage of water on the landscape, as well as wetland restoration, are key elements in reducing phosphorus loading to Lake Winnipeg.

4. **Make larger reductions in phosphorus loading to Lake Winnipeg.** The proposed 10% reduction in phosphorus will have a negligible effect on eutrophication in Lake Winnipeg. The interannual and spatial heterogeneity of algal blooms in the lake is very high. Much larger reductions in phosphorus loading are required to make visible improvements in water quality in Lake Winnipeg. It is important to understand, however, that phosphorus loading to Lake Winnipeg largely depends on the flow of the Red River. Consequently, nutrient management needs to be adaptable and responsive to climatic conditions in the Red River Basin (e.g., during flood conditions, nutrient management must be stringent to achieve water quality objectives in Lake Winnipeg, whereas during drought conditions, nutrient management could be relaxed to ensure the economic viability of the fishery).

5. **Be prepared to wait for improvements in water quality.** Changes in water quality following reductions in phosphorus loading may take several years to be visible, because of high recycling of phosphorus between lake sediments and overlying water. Many shallow lakes require 10-20 years to approach a new equilibrium following reductions in phosphorus inputs.

6. **Understand that Lake Winnipeg cannot be "restored" to a pristine state.** Lake Winnipeg is no longer a natural lake. Lake Winnipeg is now a hydroelectric reservoir with a commercial fishery surrounded by a large watershed that has been intensively developed for agriculture, livestock production, mining, forestry, and urban centers. In addition, several exotic species have invaded Lake Winnipeg and climate change has altered the lake's chemistry, biology, and hydrology. The notion of managing nutrients with the goal of restoring Lake Winnipeg to a "natural" state is imprudent. This goal is neither possible to achieve, nor even desirable, to support the interests of the lake's multiple users.

Thank you for considering our recommendations for improving the health of Lake Winnipeg.

Sincerely,

Concerned Scientists from Canada, the United States of America, and Israel

1. Dr. Anne Adkins
2. Mr. Cory Anema
3. Dr. Neil Arnason
4. Mr. Nathan Ballard
5. Dr. Paul Blanchfield
6. Dr. Drew Bodaly
7. Dr. Richard Carignan
8. Dr. Stephen Carpenter
9. Ms. Sandra Chalanchuk
10. Dr. Dennis Cooke
11. Dr. Miriam Diamond
12. Dr. Peter Dillon
13. Dr. Margaret Docker
14. Mr. Robert Fudge
15. Dr. Sarah Gewurtz
16. Prof. Moshe Gophen
17. Dr. Lane Graham
18. Dr. Brenda Hann
19. Dr. Robert Hecky
20. Mr. Len Hendzel
21. Ms. Susan Kasian
22. Ms. Hedy Kling
23. Ms. Nancy Loadman
24. Dr. Lyle Lockhart
25. Dr. Jennifer Lukovich
26. Dr. Murray MacKay
27. Mr. Bruce Maclean
28. Dr. Mariah Mailman
29. Dr. Diane Malley
30. Dr. Greg McCullough
31. Dr. Michael Mehta
32. Dr. Kenneth Mills
33. Dr. Lewis Molot
34. Dr. Randall Mooi
35. Ms. Diane Orihel
36. Dr. Vince Palace
37. Dr. Kazimierz Patalas
38. Mr. David Pelster
39. Dr. Heather Proctor
40. Ms. Rebecca Rooney
41. Mr. Alex Salki
42. Dr. Sherry Schiff
43. Dr. David Schindler
44. Dr. Karen Scott
45. Ms. Dalila Seckar
46. Dr. Leif Sigurdson
47. Dr. Val Smith
48. Dr. Vincent St.Louis
49. Mr. Michael Stainton
50. Dr. Bill Tonn
51. Dr. Michael Turner
52. Dr. Jason Venkiteswaran
53. Dr. Rolf Vinebrooke
54. Dr. Feiyue Wang
55. Mr. Douglas Watkinson
56. Mr. Paul Weidman
57. Dr. Harold Welch
58. Dr. Eugene Welch
59. Ms. Laurie Wesson
60. Dr. Alexander Wolfe
61. Dr. Charles Wong
62. Dr. Norman Yan
63. Dr. Tamar Zohary

The signatories of this letter are expressing their personal opinion and are not representing any agency, institution, or organization.