Manitoba Clean Environment Commission

Supplement to An investigation into nutrient reduction and ammonia treatment

January 2011

Manitoba Clean Environment Commission

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Contents

Foreword

In December 2009, the Minister of Conservation wrote to the Clean Environment Commission asking that it review the City of Winnipeg's revised proposed upgrade plans for the North End Water Pollution Control Centre (NEWPCC) and provide him with advice on this.

In the spring of 2010, as we were concluding the investigation part of this review, we learned of plans by the International Institute of Sustainable Development to hold a "summit" on water issues in the Lake Winnipeg watershed. Given that these deliberations would be relevant to our review, we chose to delay the submission of this report until after attending the conference. Key among the issues considered at the conference, as well as by the "Red Zone II" panel, was the recycling of nutrients throughout watersheds – a matter very germane to our review. As a result, the summit has informed the Commission in reaching the conclusions set out in this report.

The specific question the Commission needed to address in the Minister's request was whether or not the City could meet its licence requirements for ammonia by using the centrate treatment process proposed by the City.

The simple answer is that they might be able to do so. But, just….And not always. And, likely not into the future.

This is discussed in detail in the section entitled "Ammonia". That discussion will set out the reasons for our conclusion about ammonia treatment, which in turn leads to the conclusion that **we continue to support the recommendations made in our 2009 Report.**

The real issue before us should not be simply about the conversion of ammonia and nitrogen. What it should be is: what type of wastewater treatment should the City of Winnipeg be implementing in the 21st century?

In our 2009 Report, the Commission recommended that the "City of Winnipeg should use nutrient removal processes, such as biological nutrient removal…"

Based on our further review of this matter, we are even more of the view that this is the direction the City must follow.

There is one other very significant element to this current review. Although the public discussion has been about the savings that would be realized by the City of Winnipeg if it were not required to fully address ammonia and nitrogen removal at the North End Water Pollution Control Centre, the City, in fact, wants to be relieved of the need to remove nitrogen from the effluent at all of its treatment plants.
From the Mayor's October 2009 letter to the Minister, in which he states that "the City of Winnipeg strongly opposes the new Licence requirement to reduce levels of nitrogen in our wastewater", it may be inferred that the City is seeking to be relieved of the requirement to remove **any** nitrogen from any of its wastewater effluent.

In comments to the Commission during the February 2010 presentation, City officials indicated that they were looking to alternative upgrades at the South End plant.

It is likely that these upgrades would be similar to those proposed for the North End. This would mean limited ammonia conversion and very limited nitrogen removal.

This would require major changes to *The Environment Act* licences.

The Clean Environment Commission is alarmed that the City would seek to backtrack on commitments and requirements for nutrient removal. To that end, based on the current proposal the Commission recommends that no changes be granted to the City's *Environment Act* licences.

Above all, effective environmental stewardship requires both a concerted and a consistent approach. An *ad hoc* approach will not yield results which will ensure that we leave a healthy environment as a legacy to future generations. This is particularly true of wastewater management.

In recent years, it has become very clear that only a watershed approach will guarantee long-term health for our waters— both surface and groundwater. The Clean Environment Commission has long been an advocate for working on a watershed basis and has highlighted this in recent reports.

Over the past decade, the Manitoba Government has taken some very positive steps in this direction. The work of the stewardship boards for Lakes Winnipeg and Manitoba has contributed greatly to our understanding of the issues confronting these lakes. The introduction of new legislation and regulations to address nutrient issues from a variety of sources demonstrate the government's serious intent. Most relevant to the issue at hand, the government has adopted a policy of consistency in its licensing of wastewater treatment plants.

The licences issued to the City of Winnipeg for three separate water pollution control centres, as well as to the Brandon industrial plant, all have the same limits for nutrients remaining in the effluent. Similar conditions are under consideration for the City of Portage la Prairie. As well, similar conditions are either in place (Edmonton, Calgary, Saskatoon) or pending (Regina) for cities across Alberta and Saskatchewan. It must be noted that these are cities in the Lake Winnipeg watershed.

One of the conclusions of the Commission's 2009 report stated:

Nutrient reduction in Manitoba waters is in large measure dependent on actions taken by jurisdictions beyond Manitoba's boundaries. Manitoba cannot expect transboundary cooperation in the reduction of nutrient loading unless it is prepared to reduce its point and nonpoint nutrient loads.

This remains extremely relevant—from both an intergovernmental perspective and a scientific one. Lack of consistency in approach will lead to lack of consistency in result. Our waterways, in particular Lake Winnipeg, are now suffering from such inconsistency.

The Commission concludes that the use of centrate treatment will not allow the City to meet its requirements for removal of total nitrogen, will reinforce its regular failure to meet requirements with respect to nitrate, and will provide only occasional and short term capability to remove un-ionized ammonia, with little or no provision for the expected increase in urban economy and population.

The Commission recommends that the Government of Manitoba continue down the road to consistent and effective environmental stewardship.

Terry Sargeant
January 2011

1. Background

In September 2008, the Minister of Conservation made a request of the Clean Environment Commission (Commission) to conduct an investigation into nutrient reduction and ammonia treatment at the City of Winnipeg's wastewater treatment facilities.

In the Commission's report to the Minister, in March 2009, it was recommended that the limits for phosphorus, nitrogen and ammonia in the wastewater effluent, as set out in *The Environment Act* licences issued to the City, were appropriate and should not be changed (Manitoba Clean Environment Commission 2009).

Based on the evidence presented throughout that review, the Commission concluded that there was no economic or environmental advantage to be gained from phasing in nitrogen reduction requirements after meeting the ammonia and phosphorus discharge limits. This would involve installing additional infrastructure to facilitate nitrate conversion after the technologies for ammonia conversion were installed and operational.

And, based on an examination of wastewater treatment systems, it was concluded that a full-biological nutrient removal (BNR) process would be the best—both for environmental and long term economic reasons. This is the same wastewater treatment process currently used in Calgary, Edmonton, Saskatoon, and Winnipeg's West End plant.

In October 2009, the Mayor of Winnipeg wrote to the Minister objecting to the need to remove nitrogen from the effluent from the City of Winnipeg's wastewater. He argued that this was counter to good science, and that it would, needlessly, involve a large cost.

In large part, the City's position is based on its contention that it is able to meet the ammonia limits through a process other than full-BNR, at a much lower cost. However, this process does not allow for the removal of nitrogen to the limits stipulated in the licence.

In December 2009, the Minister of Conservation wrote to the Commission asking that it review the City's revised proposed upgrade plans for the North End plant. The Minister forwarded a copy of the Mayor's correspondence, which included the letter and a poster prepared by a City engineer (Appendix 3 and 4).

In conducting this review, the Commission considered its 2009 report, as well as much of the material that underpinned that investigation (Manitoba Clean Environment Commission 2009). The Commission met with officials of the Manitoba Government and of the City of Winnipeg. The City officials made a presentation describing their proposal. The Commission also engaged in further review of relevant scientific literature, consulted with a highly regarded academic expert in the field and reviewed the Mayor's correspondence.

In addition, Commission members accepted the Mayor's invitation to attend a presentation made at City Hall by Dr. David Schindler.

Commission members also attended the "Lake Winnipeg Summit" hosted by the International Institute for Sustainable Development, as well as the "Red Zone II" panel discussion, in autumn 2010. In the end, the Commission has concluded that the recommendations made in the 2009 report should stand.

The Commission remains convinced that nitrogen is a significant, negative player in our environment that must be addressed in all its forms and from all sources. We do not believe that "science" supports the view that only phosphorus poses a threat to the Manitoba (and global) environment, including Lake Winnipeg.

The Commission is even more convinced that the Manitoba environment would be best served by the installation of a full-BNR process at all three of the City's Water Pollution Control Centres. Adoption of a full-BNR process would put Winnipeg among the country's leaders in the treatment of wastewater.

The Commission notes that, based on the evidence presented by the City of Winnipeg in 2010, it would be possible for the City to add a full-BNR, nitrification/denitrification process at a later date. In its 2010 presentation, the City suggested that the need for this be reviewed in five years. (Interestingly, in 2003, the City made the same suggestion to the Clean Environment Commission, although then the review would come in ten years (Manitoba Clean Environment Commission 2003)).

It is the Commission's view that this would only be delaying the inevitable. As well, it would mean the continued release of ammonia and nitrogen into Manitoba's environment beyond the limits set out in the licence that is to take effect in 2014. It would also be inconsistent with the Province's direction on nutrient management and the treatment of wastewater at other plants in Winnipeg and other centres in Manitoba (Brandon and Portage).

In the following pages, a recent history regarding wastewater treatment in the City of Winnipeg is provided. A number of the individual matters that form the very complex issue that is nutrient management are also addressed. Issues covered in the Commission's 2009 report are further addressed, as are those raised by the Mayor of Winnipeg in the October 2009 correspondence and the City's February 2010 presentation.

Given the nature of this particular review, the Commission is not producing a report in its usual format; this report should be considered supplemental information to *An Investigation into nutrient reduction and ammonia treatment at the City of Winnipeg's wastewater treatment facilities* (Manitoba Clean Environment Commission 2009). Following a brief "Introduction", a number of sections will be presented, each of which addresses one of the many concerns surrounding this matter.

Included, in appendices, are comments on the Mayor's letter and the attached poster, as well as a discussion on the Precautionary Principle.

2. History

Concerns about water quality in Manitoba waterways, as well as the related debate over the appropriate treatment of the City of Winnipeg's wastewater goes back many decades.

A limited study of water quality in the southern portion of the lake was done in 1973. The report on this study, dated June 1974, noted that "the results showed that both nitrogen and phosphate are high in the lake and above the critical level…" (Department of Mines, Resources and Environmental Management 1974).

The report recommended:

A comprehensive water quality study of Lake Winnipeg and of the contributing drainage is required. Since it appears that the main concern in this lake is aquatic blooms, the study should be carried out with major emphasis on the identification of nutrient inputs and the effect of control measures.

While a number of individual studies have been carried out in the ensuing years, it does not appear that the recommended comprehensive study has ever been done.

In January 1977, the Clean Environment Commission (the Commission) was asked by the Minister of the then-Department of Mines, Resources and Environmental Management to investigate a proposal to establish water quality objectives and stream classifications that would serve as targets for a water quality management program. The report, sent to the Minister in May 1978 recommended that the department should go ahead with implementing these objectives and classifications (Manitoba Clean Environment Commission 1979).

Subsequent to that report, the Commission was asked by the Minister to investigate the application of these objectives to a number of different basins and watersheds. In November 1981, the Commission tabled its report regarding the Red River Watershed. This report arrived at a number of conclusions that are still relevant today. Among these:

• That the bacterial contamination of the Red River by the City of Winnipeg is environmentally unacceptable… to achieve the recommended level of quality will involve planning, considerable time and large capital expenditures.

• That disinfection of the sewage plant effluents will result in a substantial improvement in the incidence of high bacteria counts …. That chlorination is, at this time, the most practical and commonly accepted method of disinfection.…

• After weighing the positive and negative effects of chlorination … the three levels of government [should] undertake research, testing, monitoring and reporting of alternative methods of disinfection.….

• That the City of Winnipeg sewage disposal system does not meet microbiological standards applied to the rest of the Province …. the present policy of the City of Winnipeg in this matter will not lead to environmentally acceptable conditions even in the distant future …. Continuing growth of the City will lead to greater pollution load imposed on the river and result in progressive deterioration unless new action is taken …. Innovative ways ...should be examined.

• The Commission recommends that the City of Winnipeg develop a plan for a gradual improvement of the sewage disposal system aimed at fully meeting the quality objectives for the Red River at some time in the future…. The Commission recommends specifically that **a full scale tertiary treatment project be considered as soon as possible** (Manitoba Clean Environment Commission 1981).

In 1989, the Minister requested that the Clean Environment Commission review and report on proposed water quality objectives for the Red and Assiniboine Rivers (and relevant tributaries) within and downstream of the City of Winnipeg.

In its report in June 1992, the Commission noted that, by 1995, the City would have upgraded all three of its wastewater treatment plants at a cost of $200 million, the result being “effective secondary treatment" (Manitoba Clean Environment Commission 1992).

During these hearings in late-1991 and early-1992, the City raised concerns with ammonia regulation. City officials recommended that cool-water aquatic life not be protected to the un-ionized ammonia level proposed by Manitoba Environment. They took issue with Manitoba Environment's interpretation of the Canadian Council of the Ministers of the Environment (CCME) endorsement of United States Environmental Protection Agency (USEPA) recommendations for un-ionized ammonia. They questioned the independent evaluations undertaken for the Manitoba Water Services Board.

The report noted that the normal treatment of ammonia is by nitrification. The estimated cost to introduce this process at all three plants would be $120 to $175 million. The City questioned whether such costs were justifiable.

The 1992 report also noted that several of the recommendations from the 1981 Red River Watershed Classification review had yet to be implemented.

In the 1992 report, the Commission recommended that the specific requirements for un-ionized ammonia be set at those prescribed by the USEPA by 1997, unless site-specific research has determined otherwise. It further recommended that detailed site-specific studies be undertaken to determine both the acute toxic and chronic effects of un-ionized ammonia from wastewater effluent on the coolwater aquatic life of the rivers. This was to be completed by 1997. (In fact, the City's ammonia report was not completed until November 2002. The full version of the report was not made available to the Province and the Commission until 2008.)

In September 2002, due to a major malfunction at the City's North End Water Pollution Control Centre, a significant amount of raw sewage was released into the Red River. Partly in response to this event, the Minister asked the Commission to review the City's wastewater systems, including the proposed upgrades.

The report, tabled in August 2003, noted that the City of Winnipeg proposed a 50-year pollution prevention plan to achieve Manitoba's *Water Quality Standards, Objectives and Guidelines.* The plan components included effluent disinfection, combined sewer overflow control, ammonia treatment, nutrient reduction, and biosolids management (solid by-product of wastewater treatment) (Manitoba Clean Environment Commission 2003).

During these hearings, the City of Winnipeg proposed that a long-term ammonia conversion strategy be implemented including:

1. regulation of discharges from the City's wastewater treatment plants on a site specific basis;

2. control of ammonia to protect the aquatic environment including treatment of centrate (liquid remaining after dewatering biosolids) at the North End Water Pollution Control Centre; and

3. additional studies, monitoring programs and testing of ammonia toxicity to expand the site-specific knowledge of the effects of ammonia.

In considering the ammonia issue, Environment Canada noted that under Section 64 of the *Canadian Environmental Protection Act*, 1999, ammonia is considered “toxic” and that municipal wastewater effluents are the primary source.

Environment Canada further stated that, without nitrification at all three sewage treatment plants, it is likely that effluents would not be in compliance with Subsection 36(3) of the *Fisheries Act* based on the expected high levels of un-ionized ammonia alone.

Environment Canada confirmed that the City would have to consider additional measures, beyond centrate treatment at the North End plant and maintaining the status quo at the other plants, to achieve compliance with the *Fisheries Act* (Manitoba Clean Environment Commission 2003).

The Commission did not accept the City’s proposal for ammonia conversion, concluding that the City of Winnipeg must develop pollution prevention and compliance strategies to adhere to the provisions of the *Canadian Environmental Protection Act* 1999 and the *Fisheries Act* with respect to ammonia.

In the Commission’s most recent review of City sewage treatment processes in 2009, the City presented what was essentially the same scheme for ammonia treatment as it had in 2003, arguing that with some concessions on the method of calculation, they could meet the licensed limits. The evidence before the Commission, at the time, led to the simple conclusion that they could not meet the limits and that the method for calculation should not be changed (Manitoba Clean Environment Commission 2009).

The City now maintains that, with about two year’s experience with the centrate treatment, it has been proven that this method works and they do not need to resort to full nitrification and denitrification.

3. Introduction

A very unfortunate aspect of this debate is that the public has not really been given the whole story; a full and complete accounting of current scientific findings, facts and uncertainties has not been provided.

Media coverage, as well as communications from the City, has led to the widely held impression that the only potential impact of Winnipeg wastewater that we need be concerned with is cyanobacteria or blue-green algae.

Public attention has been focused almost exclusively on one type of blue-green algae—the type that floats on the top of the lake and is quite unsightly; and which can wash up on beaches interfering with recreation.

It has been widely reported that this type of algae has the ability to fix nitrogen from the atmosphere. While strictly true, this does not happen as easily and may not be as significant as has been made out. (Nitrogen-fixing ability is discussed in more detail in Section 7.)

It has also been stated that the nitrogen-fixing cyanobacteria found in Lake Winnipeg can be toxic. While this may be true, it has yet to be confirmed. There are, however, other forms of blue-green algae found in Lake Winnipeg—which do not get their nitrogen from the air but only from the water—and which are regularly more toxic than the nitrogen fixers. *Microcystis* sp. and *Planktothrix* sp. are known to be highly toxic and are present in Lake Winnipeg. Some of these blue-green algae are obvious as they float on the water's surface, while others are found below the surface and, thus, unseen.

The real, largely ignored story is that nitrogen—in both its ammonia and nitrate forms—poses a much more significant threat to our environment than has been made out by many of the players in this debate.

Among these are threats to biodiversity in lakes and rivers, negative impacts on the health of fish and other aquatic life, as well as the ability to foster excessive growth of many aquatic plants and animals.

Clean Environment Commission review 2008-09

As noted above, in September 2008, the Manitoba Minister of Conservation requested that the Clean Environment Commission conduct an investigation into nutrient reduction and ammonia treatment at the City of Winnipeg's wastewater treatment facilities.

The Commission's investigation focused on the environmental effects of three compounds, which are significant components of urban wastewater: phosphorus, ammonia and nitrogen. The Commission examined the potential impacts on all of the receiving waters of the City of Winnipeg's wastewater, which include: the Red River, Lake Winnipeg, the Nelson River, and Hudson Bay.

There was no debate as to the need to remove as much phosphorus as possible. Nor, with the need to treat ammonia, at least to the level set out in *The Environment Act* licences. There was, however, debate as to the best method for achieving these.

Significant debate was centered on nitrogen, with some claiming that removing nitrogen was ineffective at best and counterproductive at worst. In the Commission's 2009 report, the potential impact of the release of nitrogen into the greater environment was considered, with the conclusion that nitrogen must be removed from wastewater as well.

What exactly does the City propose to do?

Without oversimplifying the process of wastewater treatment, there are three significant steps in nutrient removal: treating/removing phosphorus; converting ammonia to nitrate by a process called nitrification; and converting nitrate to nitrogen gas by a process called denitrification.

The Environment Act licences issued to the City of Winnipeg limit the amount of phosphorus to no more than 1.0 milligrams per litre and the total nitrogen to no more than 15 milligrams per litre in the wastewater discharge. Both are based on a 30-day rolling average. To meet these limits, some form of wastewater treatment will be required.

The licences also require that the City limit the amount of ammonia released into the City's main rivers. These limits—which differ by month—are based on kilograms released in any 24-hour period.

Similar terms were included in the licences for all three treatment plants.

Nutrient removal can be achieved in a number of ways, including chemical/physical or biological processes.

In planning to upgrade its three facilities, the City of Winnipeg chose to design full-biological nutrient removal (BNR) processes for each of the three plants. This is the same process as selected by other major cities in the Lake Winnipeg watershed (Edmonton, Calgary, Saskatoon).

During the design phase for the North End Water Pollution Control Centre, the City came to the conclusion that it could achieve the licensed phosphorus and ammonia limits without needing to implement a full-BNR process. However, it would not be able to meet the nitrogen limits.

What the City proposes to do is treat the centrate (liquid separated from the solid part of the waste stream) using biological nitrification (bacteria convert ammonia to nitrate) and methanol-induced denitrification (methanol is added as a food source for the bacteria which convert nitrate to nitrogen gas). By the City's estimates, this process will remove about 30% of the ammonia and 24% of the total nitrogen from the effluent.

The City has estimated that this process will save $350 million.

In their presentation to the Commission in February 2010, City officials asked to be relieved of the need to remove nitrogen from the City of Winnipeg's wastewater

4. Wastewater Treatment

This section begins with a brief overview of the City's current process for wastewater treatment, including the original upgrade plans. It then turns to the revised upgrade plans for the North End plant. The section concludes with a table showing the differences between the proposed North End upgrade and a full-biological nutrient removal process.

What is Wastewater?

Wastewater is a term typically used to describe liquid wastes from two types of sources. The first source, sanitary sewage, is generated from homes, businesses, institutions and industries. The second source, stormwater, is generated from rain or melting snow that drains off rooftops, lawns, parking lots, roads and other urban surfaces.

Wastewater effluents are the largest source of pollution by volume to surface water in Canada. Wastewater effluents may contain many pollutants and substances of concern including grit, debris, suspended solids, disease-causing pathogens, decaying organic wastes, nutrients and hundreds of chemicals.

How is Wastewater Treated?

Wastewater treatment has one basic goal: to produce a stream of clean water that is safe to return to the environment.

What happens in the treatment plant is essentially the same process that occurs naturally in a stream or lake. But, it speeds up the process. In a wastewater treatment plant, bacteria and other organisms are used to consume waste, but in a much more controlled process than in nature.

Once it arrives at the plant, wastewater is typically treated through a series of major steps: preliminary treatment, primary treatment, secondary treatment, tertiary treatment, and disinfection. There are also other processes designed to reuse or to dispose of the remaining products – sludge treatment, centrate treatment.

Keeping all of these steps functioning effectively is an intricate balance of physical, biological, and chemical processes.

Table 1 provides a summary of the process steps. The accompanying text box provides descriptions of the chemical, physical and biological processes.

Nutrient Removal

Given the negative effects certain nutrients – notably phosphorus, nitrogen and ammonia – can have on receiving waters, it has become essential to remove them from wastewater or convert them to a less-harmful form.

Phosphorus and nitrogen, at excessive levels, can stimulate algal growth. Ammonia, at concentrated levels, is toxic to aquatic animals.

Nutrients may be converted or removed from wastewater by chemical or biological processes. Phosphorus may be removed by the chemical-precipitation process. Phosphorus, nitrogen and ammonia can be removed or limited by a biological nutrient removal process.

Chemical-precipitation process

In the chemical-precipitation process, heavy metals – typically iron or aluminum – are added to the mixed liquor as it leaves the aeration tanks on its way to the secondary clarifiers. The metal reacts with soluble phosphorus to form an insoluble phosphate, which then settles by gravity to the bottom of the secondary clarifiers and is pumped with the waste activated sludge to the sludge digesting tanks.

The chemical precipitation process does not remove any ammonia or nitrogen from the waste water.

Biological nutrient removal

Biological nutrient removal is the most modern of the processes, having been developed for cold-climate use in just the past three decades. In this process, bacteria are used to biochemically decompose the organic contents of the wastewater and to stabilize the end-product.

The significant difference between the current process and a BNR process occurs at the Secondary Treatment stage.

In BNR, bioreactors are compartmentalized to provide three environmental zones suitable for the growth of certain species of naturally-occurring micro-organisms. The three zones are:

Table 1: Wastewater Treatment Processes

WASTEWATER TREATMENT - PRIMER

STEP 1 – PRELIMINARY TREATMENT

Input – Raw sewage gathered from throughout the city.

In this first step, screens are used to remove large objects, such as sticks, rags, leaves, toys, etc. from the inflow. Next, the inflow goes into a "grit chamber" where sand, gravel and other grit are allowed to settle to the bottom by gravity or separated by centrifugal force.

Output –

1. Grit that settles to the bottom of the tanks is removed and sent for disposal at a landfill site.
2. Wastewater stream – a mix of liquid and suspended solids. This goes on to Step 2.

STEP 2 – PRIMARY TREATMENT

Input – the wastewater stream from the Preliminary stage.

In this phase, a series of operations removes most of the solids that will float or settle, a process that can remove up to 50% of pollutants. Sedimentation removes the solids that are too light to fall out in the grit chamber. These tanks (aka "Primary Clarifiers") are designed to hold wastewater for several hours. During that time, floating material, such as oil and grease, can be skimmed off the top, and suspended solids can drift to the bottom of the tank, where they are collected by mechanical scrapers and pumped out of the bottom of the tank. The solids removed at this point are called "primary sludge", and are pumped along for further treatment.

Primary treatment is largely physical. In some operations, chemicals are added at this stage in order to precipitate phosphorus.

Output –

1. Primary Sludge – which goes to the Anaerobic Digester for further treatment.

2. Wastewater Stream – liquid and suspended solids – which is still not clean enough to release into a natural body of water such as the Red River. Secondary treatment is needed to reduce the amount of organic matter, disease-causing organisms and pollutants before it can be released to the river.

STEP 3 – SECONDARY TREATMENT

Input – Wastewater stream from Primary treatment.

There are two general steps in secondary treatment: biological treatment in aeration tanks, followed by settling in "Final Clarifiers".

Secondary treatment is a biological process, where microorganisms feed on waste just as they would in nature to convert the dissolved solids in the wastewater into suspended solids, which can then physically settle out.

One of the most common forms of secondary treatment is the **activated sludge** process. In this method, incoming wastewater and microorganisms are mixed in a large tank using constant aeration and agitation.

After completing the run through the aeration tanks, the wastewater stream or biomass is moved into "clarifiers", where the microorganisms and other solids settle to the bottom.

Table 1 cont'd

Some of the liquid is skimmed off of the top, sent for UV disinfection and then released into the receiving waterbody.

At the end of most secondary treatment processes, 85% to 90% of the organic waste has been removed from the flow of liquid.

Output –

1. Liquid, which may go for further – tertiary – treatment; or may go straight to the disinfection stage.

2. Sludge, which receives further treatment, described below.

SIDESTREAM STEP – SLUDGE TREATMENT

Input – the sludge removed from the primary and final clarifying tanks.

Activated sludge is a continuous process, meaning a portion of the settled solids containing active microorganisms is circulated back to the beginning of the process to continue working. This "return activated sludge" or RAS intensifies (or activates) the transformations in the aeration basin, allowing for the maintenance and use of a robust microbial population.

The portion that does not go back into circulation is called "waste activated sludge" (WAS) and is sent for anaerobic digestion, where it joins the sludge removed from the **primary tanks**.

Once this digestion is complete, the biomass is dewatered, the results being **centrate** (liquid) and **biosolids** (solid). At present, in the City of Winnipeg process, the centrate is not treated, but is returned to mix with the initial inflow and goes through the process again. The biosolids are either applied to farm fields or landfilled. Biosolids have value as a soil amendment and fertilizer from the nutrients in it. These include P, N and various metals – some of which are beneficial, some of which are not.

Output –

1. Centrate, the liquid, which may or may not receive further treatment.

2. Biosolids, which may have use as an agricultural fertilizer and soil amendment. Some proportion may be sent to the landfill.

STEP 4 – TERTIARY TREATMENT

Input – the liquid from the final clarifier.

Tertiary treatment is the next step in wastewater treatment, removing stubborn contaminants that secondary treatment cannot clean up. Wastewater effluent becomes even cleaner in this process through the use of stronger and more advanced treatment systems.

Tertiary treatment includes membrane filtration and separation, ultraviolet disinfection, reverse osmosis, ion exchange, activated carbon adsorption, and enhanced biological nutrient treatment, among others.

At this time, the City of Winnipeg engages only in ultraviolet disinfection.

Output – liquid sufficiently treated and disinfected to be released into the receiving waterways.

Basic Wastewater Treatment Processes

Physical	Biological	Chemical
Physical processes were some of the earliest methods to remove solids from wastewater, usually by passing wastewater through screens to remove debris and solids. In addition, solids that are heavier than water will settle out from wastewater by gravity. Particles with entrapped air float to the top of water and can also be removed. These physical processes are employed in many modern wastewater treatment facilities today.	In nature, bacteria and other small organisms in water consume organic matter in sewage, turning it into new bacterial cells, carbon dioxide, and other by-products. The bacteria normally present in water must have oxygen to do their part in breaking down the sewage. In the 1920s, scientists observed that these natural processes could be contained and accelerated in systems to remove organic material from wastewater. With the addition of oxygen to wastewater, masses of microorganisms grew and rapidly metabolized organic pollutants. Any excess microbiological growth could be removed from the wastewater by physical processes.	Chemicals can be used to create changes in pollutants that increase the removal of these new forms by physical processes. Simple chemicals such as alum, lime or iron salts can be added to wastewater to cause certain pollutants, such as phosphorus, to floc or bunch together into large, heavier masses which can be removed faster through physical processes. Over the past 30 years, the chemical industry has developed synthetic inert chemicals know as polymers to further improve the physical separation step in wastewater treatment. Polymers are often used at the later stages of treatment to improve the settling of excess microbiological growth or biosolids. (U.S. EPA, September 2004, Water Environment Federation 2009).

1. the **anaerobic** zone, which has no dissolved oxygen (phosphorus removal occurs here);
2. the **aerobic** zone, which has dissolved oxygen (nitrification occurs here); and
3. the **anoxic** zone, which has no dissolved oxygen (denitrification occurs here).

In the anaerobic zone, a special species of bacteria, which feed on introduced volatile fatty acids – release stored phosphorus from their cells into the mixed liquor and then absorb soluble phosphorus in greater quantities in the aerobic zone. When the bacteria are removed in the waste-activated sludge, the excess phosphorus they have absorbed is removed from the wastewater.

In the aerobic zone, other bacteria (nitrifying bacteria) convert ammonia to nitrite and then to nitrate through the **nitrification** process.

In the anoxic zone, other species of bacteria (denitrifying bacteria) convert nitrate to nitrogen gas, which is released to the atmosphere. Activated sludge, rather than an additive such as methanol, is used during this process as a food source for the bacteria. This step is known as **denitrification**.

Biological nutrient removal requires a large increase in plant capacity in the form of a number of additional tanks in the secondary stage. The current process in Winnipeg uses only aerobic tanks where the wastewater stream is subject to constant aeration and agitation for a few hours. BNR requires a number of alternating tanks to accommodate the three zones described above. This process also requires a much longer retention time in the secondary stage, which adds to the capacity needs.

It is here where almost all of the costs associated with the North End plant upgrade are. (These costs are often referred to as $350 million.)

It has been suggested that the City might treat the ammonia by nitrification, but not do the nitrogen removal (dentrification). What this would mean is not constructing the anoxic tanks, a relatively small part of this process.

There are many advantages to a full-BNR process, compared to standard secondary treatment. These include:

- a significant reduction in the amount of ammonia released to the environment;
- a significant reduction in the amounts of nitrate or total nitrogen being deposited into the aquatic environment;
- removal of phosphorus at a greater rate in a more ecologically sustainable manner;
- significant reduction in the amount of biosolids that need to be disposed of;
- destruction of a greater number of disease causing pathogens; and
- conversion of many contaminants of emerging concern (pharmaceuticals and other chemicals) to a less harmful form before they are released to the environment. (This is discussed in Chapter 9.)

How does the City treat wastewater now?

The City of Winnipeg operates three wastewater treatment facilities, the West End Water Pollution Control Centre (WEWPCC), the South End Water Pollution Control Centre (SEWPCC) and the North End Water Pollution Control Centre (NEWPCC). The oldest and, by far, the largest plant, the NEWPCC was opened in 1937 and has undergone a number of process upgrades to provide better treatment of wastewater.

Until quite recently, all three centres utilized conventional secondary wastewater treatment processes.

Secondary treatment essentially removes some of the organic matter and reduces the number of disease-causing organisms to a regulated level. In a process such as that used currently by Winnipeg, the secondary treatment step is relatively simple and relatively quick. It is a biological process, where microorganisms feed on waste just as they would in nature to convert the dissolved solids in the wastewater into suspended solids, which can then physically settle out. There is little removal or treatment of nutrients or chemical components.

While secondary treatment is a biological process, it is not a full-biological nutrient removal process, as has come into use in many other jurisdictions in the last two or three decades.

At various points in the wastewater treatment process in the City of Winnipeg, a variety of chemical treatments or amendments may be added to address specific issues, such as adding oxygen to enhance decomposition of organic material, adding acid to prevent clogging of the pipes or more recently to remove some of the phosphorus through chemical means.

At the North End plant, the effluent is exposed to ultraviolet (UV) radiation to kill some of the disease causing agents before the effluent goes into the river. This will be added to the South End plant, as well. At the West End plant, the effluent is held in lagoons and subjected to natural ultraviolet treatment.

The solids that settle out during the process are known as sludge. The sludge from the WEWPCC and the SEWPCC is transferred to the NEWPCC where it is added to the sludge produced there and is placed in large tanks where further biological digestion takes place. Liquid is then removed. This liquid, known as "centrate", contains concentrated organic, nutrient and chemical components. During normal flow periods, the centrate represents, on average, about 1% of the wastewater entering the plant each day; and about 2% during low flow periods, when there is little stormsewer input.

The solid portion or biosolid is dried and applied to farmland as fertilizer or landfilled. The centrate or the concentrated liquid is then sent back through the usual wastewater treatment path where it is added to the incoming wastewater stream and undergoes the standard secondary treatment.

In planning to upgrade its three facilities, the City of Winnipeg chose to design full-biological nutrient reduction (BNR) processes for each of the three plants.

West End Water Pollution Control Centre

The WEWPCC upgrade has been completed with the installation and operation of a full-biological nutrient removal process. For the most part, this plant is able to comply with all licence requirements. However, compliance reporting has indicated there are difficulties in maintaining the phosphorus limit in warm weather months. This needs to be carefully monitored and necessary process adjustments made to, among other things, ensure that this is not an ongoing problem.

Ammonia and total nitrogen outputs are now consistently and often well below the licensed limits. Nitrates are not specifically regulated therefore are not required to be reported, but data provided by the operator shows that the total nitrogen outputs have decreased 50 to 60% using this state of the art system (City of Winnipeg 2011).

South End Water Pollution Control Centre

The SEWPCC has been designed to be a full-BNR plant. In early 2009, the City of Winnipeg told the Commission that BNR, including both nitrification and denitrification is still the most cost-effective option for the South End Water Pollution Control Centre (SEWPCC) because of the need to greatly reduce wastewater ammonia levels to meet the licensed limit. The licensing requirement is to have this plant operational by 2012. However, during a meeting in February 2010, the City indicated that they are now considering alternatives to the original plan that do not include full-BNR. To the Commission's knowledge, the City has not yet requested a change in its licence for the SEWPCC.

The Clean Environment Commission is of the view that it would be a mistake to go down this road and that the City must continue to implement a full-BNR process at the South End plant.

North End Water Pollution Control Centre

While the City initially considered converting the North End plant to a full-BNR process, during the design phase the City came to the conclusion that it could achieve the phosphorus and ammonia targets without needing to implement a full-BNR process. However, it would not be able to meet its nitrogen limits.

What the City proposes to do is to remove phosphorus using chemicals. Ammonia would be dealt with by treating the centrate using a sequencing batch reactor (SBR). This employs biological nitrification and methanol-induced denitrification (methanol is used as the food source for the bacteria).

According to the City's website, this centrate treatment was initially intended to be just one step on the way to a full-BNR process. (Under the terms of their *Environment Act* licence, this process was to be operational by December 31, 2006. The City informed us that it was operational in December 2008.) (http://www.winnipeg.ca/waterandwaste/sewage/default.stm, accessed March 12, 2010).

In its presentations to the Commission in March 2009 and February 2010, the City estimated that centrate treatment would remove about 30% of the ammonia (a decrease from 949 tonnes/yr to 657 tonnes/ yr) and a 24% reduction in total nitrogen (a decrease from 1205 tonnes/yr to 922 tonnes/yr). In contrast, using a full-BNR process, where total nitrogen reduction can be 50% or greater, the 1205 tonnes of nitrogen could be further reduced to 602 tonnes annually--an additional 300 tonnes or more per year could be removed.

On its website, the City states that the centrate process will result in "approximately 10% reduction of total annual phosphorus loading from about 290 tonnes per year to approximately 260 tonnes per year and approximately 12% reduction of total annual nitrogen loading from about 2420 tonnes per year to approximately 2130 tonnes per year." These numbers differ markedly from those in the previous paragraph. The difference in information provided by the City makes it difficult to determine just what the City's intent is in regard to nutrient management.

What is the problem?

Most cities in Western Canada began to introduce "tertiary" treatment in the 1980's. This was also true of many U.S. and European cities.

In 1981, the Clean Environment Commission recommended "that a full scale tertiary treatment project be considered as soon as possible" by the City of Winnipeg.

Winnipeg is only now getting around to this—already in place at its smallest plant, perhaps at the mid-sized plant in the near future. At its largest plant, it proposes another process.

How does the City propose to treat the wastewater at the NEWPCC?

The City proposes to implement a process that, in effect, puts a "patch" into its current system that will allow it to achieve some—but not all—of its licence requirements.

As described above, what the City proposes is to treat a limited amount of the wastewater, only treating the "centrate", rather than engaging in biological nutrient removal of the entire wastewater stream.

For the NEWPCC, this will allow the City to meet its phosphorus limits, but in a way that is not environmentally sustainable. Furthermore, the centrate process will not allow the City to meet its total nitrogen limits, and will contribute to, if not intensify, its inability to meet the CCME nitrate guidelines for the protection of aquatic life. Finally, while the proposed centrate process may allow the City to meet the immediate ammonia limits, the process appears to have limited capability in accommodating the expected growth in urban economy and population or any other changes such as climate change.

What are the concerns with this proposal?

According to the City the plant on average receives just over 200 megalitres of wastewater per day, with much higher volumes experienced in the spring with combined sewer flows.

One significant concern is that the centrate process treats only a fraction of the wastewater stream that enters the plant each day. Only 1%-2% of the wastewater, albeit the most concentrated portion, entering this plant would receive this enhanced treatment, with the remainder released after standard secondary treatment.

While centrate has always been a part of the City's wastewater treatment process, enhanced treatment of this centrate has only recently been applied. This treatment process involves limited biological nutrient treatment, done only to address the ammonia limits set by the province.

The ammonia in the centrate is nitrified (converted to nitrate) and then denitrified (nitrate converted to nitrogen gas) to a limited extent. As the ammonia concentrations are reduced, it results in an increase in the nitrate levels if the wastewater stream is not effectively denitrified as well.

Historical ammonia and nitrate levels for the NEWPCC are provided in Figure 1 & 2. Nitrate levels are consistently greater than existing Canadian Council of Ministers of the Environment guidelines for the protection of aquatic life of 2.9 mg/L. The nitrate concentrations are increasing with decreasing ammonia outputs.

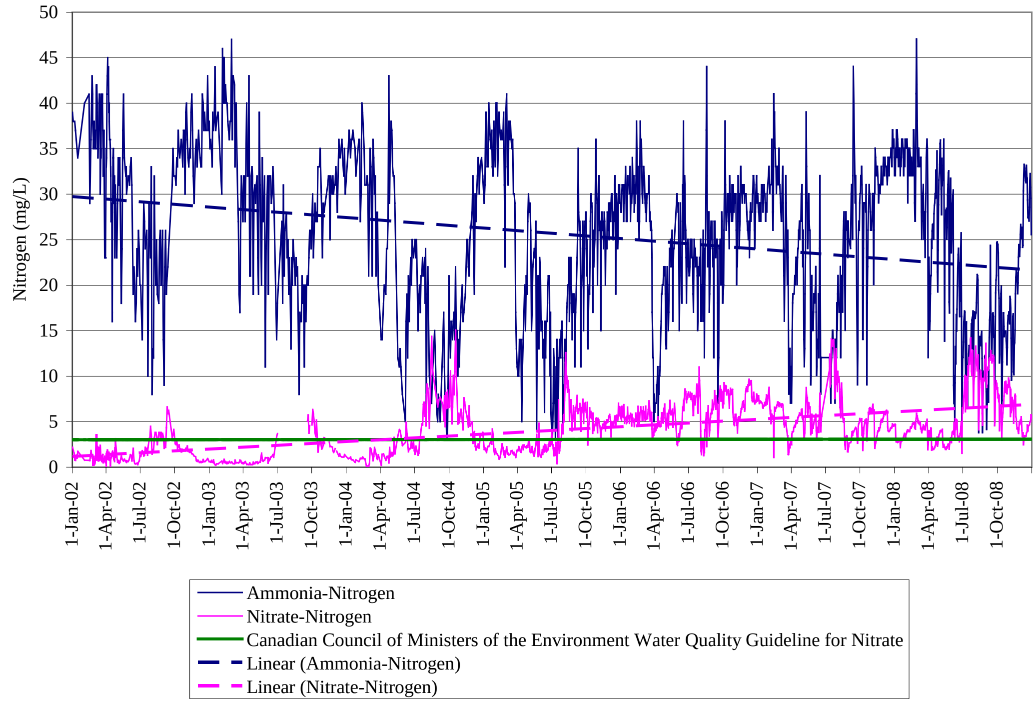

Figure 1: Variation in nitrate and ammonia concentrations in effluent from the City of Winnipeg's North End Water Pollution Control Centre (2002 through 2008). (Source: Water Stewardship)

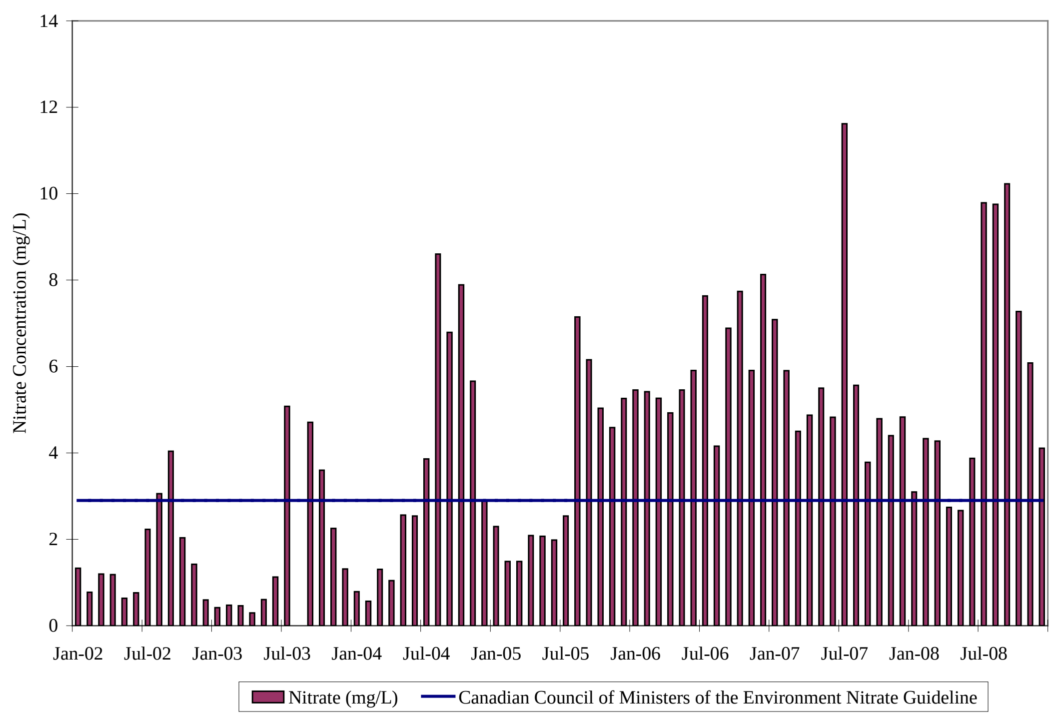

Figure 2: Variation in mean monthly nitrate concentrations in effluent from the City of Winnipeg's North End Water Pollution Control Centre (2002 through 2008). (Source: Water Stewardship).

Using the centrate process, the ability to remove nutrients is greatly reduced. Information provided on the City's website indicates that biological nutrient removal would reduce the total phosphorus load by 62% and total nitrogen by 45% at the West End plant and by 58% and 41%, respectively, at the South End plant. On the other hand, centrate treatment, at the North End, would reduce total phosphorus by only 10% and total nitrogen by 12%. (The original projection, if all three plants were converted to BNR, was a 72% decrease in phosphorus entering the river system from Winnipeg's wastewater.) http://www.winnipeg.ca/waterandwaste/sewage/default.stm, accessed March 17, 2010).

A comparison of the outputs from a centrate treatment process vs. a full-BNR treatment process is presented in Table 2.

Costs

The City has estimated that its centrate treatment process will save $350 million.

In 2008, the Province contracted with Associated Engineering of Vancouver to analyze the projected costs for the design and construction of the NEWPCC.

Based on the reports provided by the City, Associated Engineering determined the total cost for this plant, including contingency, engineering and city administration fees, to be $531 million. Of this, Associated Engineering determined that just under $33 million of this would be required for the denitrification (nitrogen removal) step—representing 6.2% of the total (Associated Engineering 2008).

Recently, the City has been using a figure of $400 million for the total cost of implementing a full-BNR process at the North End plant. Of this, $50 million would go to chemical phosphorus removal, with the remaining $350 million attributed to nitrification and denitrification (ammonia treatment and nitrogen removal).

While it is difficult to compare the two totals, it is safe to conclude that more than 90% of the $350 million price tag would be attributed to conversion of ammonia to nitrate, rather than the deactivation of nitrogen by conversion of nitrate to nitrogen gas.

To put these costs into some perspective, a current federal government document indicates a benefit to cost ratio of 3 to 1 for wastewater treatment. It further goes on to state:

There are numerous benefits to improved wastewater effluent quality. These include healthier fish and aquatic systems, increased recreational use, higher property values, reduced health risks from recreational contact with and consumption of fish, reduced water supply costs for municipalities and industry, increased commercial fisheries use, and increased value placed on ecosystem and water quality by individuals and households for the benefit of both current and future

Table 2: Comparison of centrate treatment to full- biological nutrient removal process.

City of Winnipeg Proposed Centrate Treatment	Full Biological Nutrient Removal
Phosphorus is bound to metals, in an unusable form.	Phosphorus in a readily usable form.
Ammonia reduction ~ 30%	Ammonia reduction >50%
Some samples remain at toxic level.	Few samples remain at the toxic level.
Nitrate release increased and will be consistently greater than the CCME 2.9mg/l for the protection of aquatic life.	Minimal nitrate released to the river, below the CCME 2.9mg/l for the protection of aquatic life.
No effect on contaminants of emerging concern (hormones, drug residues etc.)	Breaks down many contaminants of emerging concern to non-harmful components.
<5% of wastewater stream treated	100% of wastewater stream treated
Products:	**Products:**
Sludge with phosphorus bound in an unusable form.	Sludge with available phosphorus.
40% increase in sludge volume.	Decrease in sludge production.
Metals are added to the sludge.	No metals added to the sludge.
Ecologically unsustainable nitrate concentrations flowing to the river.	Ecologically sustainable nitrate concentrations flowing to the river.
	Harmless nitrogen gas released to the air.
Possibility of greater frequency of toxic ammonia concentrations released to the river, above the licensed values than is ecologically sustainable (once every three years).	Ecologically sustainable low toxicity ammonia concentrations flowing to the river, below licensed levels consistently.
Contaminants remain in viable form.	Some contaminants are broken down to less harmful components.

generations. (Government of Canada 2010).

Operating Costs

The City has also claimed that there would be savings of $9 million to be realized in operating costs. In its 2010 presentation to the Commission, the City addressed this issue. The City stated that the costs for operating a BNR plant and for dealing with the resultant biosolids would be $17.5 million. For the alternative, chemical phosphorus removal, they presented figures for the cost of the chemicals and for the handling of biosolids which included landfilling and tipping fees. These total $8.3 million, giving the supposed savings of $9.2 million.

A detailed account of what was included in the BNR operating costs was provided to the Commission by the City. It included amounts for electricity, natural gas, labour, maintenance and contingency, totalling $10.475 million.

The operating costs for the alternative, provided in the City's February 2010 presentation, did not include such figures.

A fair comparison would be to subtract the $10.475 million from the $17.520, leaving a cost of $7.045 million. This would indicate that BNR has a lower operating cost.

The claim that a BNR plant would be more costly to operate than a physical/chemical one runs counter to almost universal experience. Institutions as diverse as the City of Calgary (Manitoba Clean Environment Commission 2009), the U.S. Environmental Protection Agency (2007) and the U.S. Army Corps of Engineers (2001) maintain that BNR is more cost-effective. Indeed, the City of Winnipeg has claimed the same for its South End plant.

Furthermore, in considering its operating costs, it doesn't appear that the City has taken into consideration soon-to-be implemented, as well as anticipated, regulatory changes, which will require changes to current practices.

It must be noted that, as of January 2011, winter spreading of biosolids is banned, as set out in the Nutrient Management Regulation 106/2008 under *The Water Protection Act*. This will require the City to store approximately six months worth of biosolids before they can be safely applied to agricultural fields. This will include the additional 40% that can result from chemical phosphorus removal.

The Province has also stated that it intends to reduce and eventually eliminate landfilling as a disposal practice for biosolids. It is expected that this will occur gradually over the next several years in consultation with biosolids generators including the City of Winnipeg. This direction is consistent with the biosolids management objectives under development through the Canadian Council of Ministers of the Environment which will promote the beneficial re-use of biosolids nutrients.

Given that landfilling of biosolids will not be an option for the City, these aspects must be factored into cost and benefits of either system.

How does the City justify this proposal?

This process has only one advantage—it is cheap.

In order to justify this proposed system, the City has engaged in a full-frontal attack on the need to remove nitrogen. The City has subscribed to the position that the only issue of real concern is with the growth of blue-green algae in Lake Winnipeg.

In this argument, the City has failed to take into account the effect of wastewater on the watershed and has not considered the full scientific record that is available regarding nutrients and their effect on the environment.

Further, the City has taken the view that the removal of nitrogen will actually foster the growth of these blue-green algae by causing them to fix more nitrogen.

While the Commission agrees that reduced ratios of nitrogen relative to phosphorus can favour nitrogen-fixing by cyanobacteria, it also notes that the addition of both nitrogen and phosphorus can favour growth of both nitrogen-fixing and non-nitrogen fixing, often toxic, cyanobacteria (see below).

Conclusion

The centrate treatment system proposed appears to be designed to address the minimum environmental requirements today, without consideration for changes that are coming in the near future. Environmental standards are constantly being reviewed and updated with new information. The implementation of the CCME wastewater management guidelines will be facilitated by regulations enacted by the federal government in the next few years. These will specifically address toxic substances such as ammonia, which are detrimental to the health of fish and aquatic organisms.

Also many of the aquatic environmental standards are being reassessed by CCME and are likely to be altered and subsequently incorporated into Manitoba's Water Quality Guidelines in the next few years.

Designing a system to address only today's requirements is environmentally and fiscally inadvisable and leaves no flexibility for imminent, expected or unexpected changes in the future, with potentially serious environmental consequences. A full upgrade to the system is required. Every year it is put off, additional nutrients and pollutants are contributing to the load in Lake Winnipeg, when they could be easily reduced
.

5. Phosphorus

What is the story on phosphorus?

As noted in the Commission's 2009 Report, analyses by the Manitoba Government indicate that, since 1970, phosphorus loading to Lake Winnipeg increased by 10 per cent. Studies done in the 1970s showed that 25 per cent of the phosphorus entering the lake was being retained. By 2001, this had increased to 74 per cent.

So, there has never been any debate in respect of phosphorus. It is universally agreed that it must be reduced to the lowest level possible.

Phosphorus may be removed by either physical/chemical or biological processes.

While the physical/chemical method of phosphorus removal can be very effective, there are significant downsides in that there is a significant increase in the amount of sludge that must be disposed, as well as that the phosphorus in the resulting biosolids is more tightly bound making it less available for use as a fertilizer.

Biological phosphorus removal results in a high-quality fertilizer, a lower amount of biosolid production and biosolids that are more amenable to land application.

In the treatment of wastewater, the use of magnesium added to the centrate stream to remove both nutrients can create a product called struvite, a valuable agricultural fertilizer. While this can be done in the physical/chemical process, it is more effective when coupled with an initial biological treatment to create a waste stream with an elevated nutrient level.

Given that phosphorus is not a renewable resource and there is a commercial demand for struvite, recovery of phosphorus in this form would be favourable for the environment and for fiscal management.

What does the City propose for phosphorus removal?

The City has chosen to rely on chemical removal.

The chemical removal process proposed involves the precipitation of phosphorous by a metal salt, usually aluminum or iron.

The use of chemicals to remove phosphorus binds the phosphorus in such a way that virtually eliminates its availability for plant uptake. It also adds metals to the sludge, some of which may be harmful to agricultural land.

Chemical phosphorus removal has the added disadvantage of resulting in an increase in the amount of biosolids of up to 40%. This will add to the costs and difficulties in disposing of the biosolids. This will be further complicated with the prohibition of winter spreading, as well as the phasing out of landfilling of biosolids in coming years.

Phosphorus Recovery

In recent years, there has been much research into processes for the recovery of phosphorus from wastewater. In large part, this has been precipitated by an impending “peak” in the amount of easily-mined rock phosphorus.

A 2009 report from the International Institute for Sustainable Development targets the City of Winnipeg’s wastewater system as an important component in the recovery and re-use of phosphorus in the Lake Winnipeg watershed and, in turn, an important component in the recovery of Lake Winnipeg. The IISD report estimated that roughly 30% of Canada’s fertilizer consumption could be met by converting all of its wastewater treatment plants to biological treatment systems with struvite recovery technology (Ulrich 2009).

However, the use of a chemical process to remove phosphorus negates the possibility of phosphorus recovery.

On the other hand, with a BNR process, phosphorus removal can be very efficient and result in a form of phosphorus that is highly usable to the agriculture community. This ‘recycling’ of urban phosphorus will help reduce the importation of new phosphorus to Manitoba farms from outside the Lake Winnipeg watershed, and should, eventually, reduce the effects of agricultural fertilization on water quality.

The IISD report highlighted a process developed by a B.C.-based company, Ostara, that removes struvite from the wastewater. (There are a number of companies developing processes for phosphorus recovery. Ostara is probably the most-commercially advanced at this time.) Their process has, at least, two significant benefits. One is that it prevents the build-up of struvite in pipes in the treatment plant, reducing the need to clean these pipes. The second is that the struvite can be sold as a highly effective phosphorus fertilizer.

As noted in the Commission's 2009 report, this struvite recovery process can very quickly pay for itself and then return profits to the City.

In its March 2009 presentation to the Commission, the City was clear that it intends to add chemicals in such a way that will permanently bind the phosphorus. This would, almost certainly, eliminate the possibility of any phosphorus-recovery.

WinGro

The City does operate a program to recover and recycle nutrients, known as WinGRO. Dewatered biosolids from the North End Water Pollution Control Centre (NEWPCC) are hauled to and spread on agricultural land. The WinGRO program is operated in compliance with terms and conditions prescribed in a license issued under *The Environment Act* to the City of Winnipeg.

However, based on information provided by the City, phosphorus is not one of the recycled nutrients. According to the City, "WinGRO biosolids are an excellent source of organic nitrogen and micronutrients such as copper. They are also a very good soil conditioner enhancing the water holding capabilities of the soil and making it less susceptible to wind erosion."

Conclusion

The Commission continues to believe that the licensed limit for phosphorus is appropriate and must be maintained at a minimum. Every reasonable effort must be made to remove as much phosphorus as possible from the City's wastewater effluent.

And, the Commission continues to encourage the City to explore possibilities for phosphorus recovery. As noted above, there are considerable environmental and economic benefits to be realized in removing struvite from the centrate stream in wastewater treatment.

During its 2010 presentation, the City informed the Commission that it is currently conducting pilot testing on removing struvite from the centrate. The Commission would encourage the City to continue to pursue its efforts to extract struvite from wastewater at all of its plants.

6. Ammonia

What is the story on Ammonia?

There is also no argument in respect of ammonia. It is agreed that ammonia must be treated—at least to the level set out in the City's environmental licences.

Ammonia, a compound of nitrogen and hydrogen, is a component of wastewater effluent which, if left untreated, is released to the aquatic environment, where it can be toxic for aquatic species.

Ammonia is considered one of the most significant pollutants in the aquatic environment, not only because of its highly toxic nature, but also its general occurrence across surface water systems. Because fish and other aquatic species lack the mechanisms that most mammals have to prevent ammonia from building up in the bloodstream, ammonia can be toxic for aquatic organisms. At acute levels (levels where the adverse effects of a substance result from a single exposure or multiple exposures over a short period of time) it can lead to death. At lower, chronic levels (the ability of a substance or mixture of substances to cause harmful effects over an extended period, usually upon repeated or continuous exposure sometimes lasting for the entire life of the exposed organism), it is associated with organ damage, and reductions in growth and reproduction rates.

Ammonia licence limits

Manitoba has a different way of determining allowable ammonia limits than in provinces to the west of us, which include a number of cities in the Lake Winnipeg watershed. The cities of Calgary and Edmonton have summer (5 mg/L) and winter (10 mg/L) limits for ammonia. In Saskatchewan, Swift Current has a summer limit of 1 mg/L and a winter limit of 3 mg/L, while in Regina, the limit is 10 mg/L in winter and 4 mg/L in summer (Associated Engineering 2008). Ontario has limits between 1 to 20 mg/L depending on the receiving environment according to Water Stewardship. Grand Forks removes ammonia concentrations to below 1.0 mg/L (City of Grand Forks pers. comm.).

Based on the City's own monitoring, it would meet the Alberta limits on only 47 days of the year. On many days, it would exceed by 2–3 times.

In Manitoba, the limit is based on seasonal mass loading and varies by month. In most months, especially in spring, this limit is much higher than in our neighbouring provinces.

Ammonia licence limits are based on the Manitoba Water Quality Standards, Objectives and Guidelines. Calculation of these limits takes into consideration Red River flows and river water quality including pH, temperature, and ammonia concentrations as well as effluent flows and quality leaving the treatment plant. Also considered is mixing in the river and the amount of the river flow that is allocated to address these additions. The licence limits consider flows expected in the Red River based on a complete set of data from 1913 to 2007 and recognizes that it is unreasonable to require wastewater treatment systems to be designed to meet objectives all of the time especially under low flow conditions. It is recognized that healthy aquatic life communities can withstand occasional stress and recover.

Manitoba Water Stewardship believes that this manner of determining ammonia limits is the more appropriate approach for Manitoba waters.

Ammonia Treatment

Ammonia is treated in wastewater by nitrification, a process in which ammonia is converted to nitrate. As a rule, this nitrate is then further converted to nitrogen gas which is released to the air.

The most effective method of nitrifying ammonia in wastewater treatment is by a biological process. The City has incorporated full-biological nutrient removal (BNR) at the West End Water Pollution Control Centre (WEWPCC) which began operation in December 2008. In 2009, the City told the Commission that BNR is still the most cost effective option for the South End Water Pollution Control Centre (SEWPCC) because of the need to reduce wastewater ammonia levels by greater than 67% to meet the licence limit.

During the design phase of the North End plant, the City came to the conclusion that it could achieve the ammonia targets without needing to implement a full-BNR process. What the City proposes to do is treat the centrate by a process that employs limited biological nitrification and methanol-induced denitrification. By their estimates, this process will remove about 30% of the ammonia and 24% of the total nitrogen.

The information presented to Clean Environment Commission in early 2009—by both provincial and city officials—indicated that, while the centrate treatment would go a long way to treating ammonia, significant concerns remained.

In a presentation to the Commission in March 2009, the City stated that it would still exceed the licence limits 14% of the time—or about once every seven days. In order to enable it to meet its ammonia limits, the City requested changes regarding the calculation of ammonia limits. One was that the City be assigned more than 75 per cent of the assimilative capacity of the receiving waters. In the 2009 report, the Commission recommended against this change, in part, on the basis that this was already far more generous than in other Manitoba cities.

The second requested change was that the period of record used in determining the assimilative capacity of the receiving waters be shortened from 1913 to the present to 1962 to the present. Again, the CEC recommended against making this change, stating that while "[t]he post-1962 years have been wetter than the previous decades, … that is certainly no guarantee that precipitation patterns may not change in the future."

Another significant concern, in respect of ammonia, for the Commission was the risk posed to fish in the Red River. The Commission was informed that the City had failed to meet federal standards in 13 of the 15 tests conducted at the North End plant prior to 2009. This meant that the current ammonia discharges were not complying with the federal *Guideline for the Release of Ammonia Dissolved in Water Found in Wastewater Effluents*.

On those bases, the Commission concluded that the City's proposed centrate treatment process was not sufficient to meet its environmental obligations.

Has anything changed?

In its presentation to the Commission in February 2010, the City noted that the centrate treatment process has been in operation at the NEWPCC since December 2008. It provided results from this experience that the City believes indicate that compliance may be achieved with the centrate process. The results showed that the ammonia concentrations and total nitrogen concentrations over the first year had decreased, for the most part, from previous results.

Information posted on the City's website—and provided to the Department of Water Stewardship—show that the City was out of compliance with the Environment Act licence limits for one day in July 2009 and eighteen days in October 2009. The City informed the Commission that the October incident was due to the need to shut the operation down for warranty inspection.

In response to this Manitoba Water Stewardship has provided the following comment:

The information provided by the City of Winnipeg simply demonstrates that it continues to not be able to meet its ammonia limits and warranty inspections of the SBRs [sequencing batch reactors] are not sufficient excuse to be out of compliance for such a long period of time. Wastewater treatment must be designed such that enough capacity is provided to ensure adequate treatment during shut-down, repairs, clean-out, warranty inspections and other events (equipment failure, unusual weather conditions, minor plant upsets, operator variability, etc.) that can reasonably be expected to occur over the lifetime of the facility. Wastewater treatment systems need also to be designed and have capacity for projected future demand rather than current demand including accepting wastewater that is currently discharged through combined sewer overflows, new wet industry and/or residential developments, including accepting wastewater from rural municipalities such as West St. Paul.

The City has no data to support its claim that it can meet its Environment Act licence limits in any sort of consistent manner over the long-term. Indeed, the data demonstrate that it cannot meet the licence limits for ammonia even over the short-term.

It should be noted that implementation of biological nutrient removal will ensure that the City of Winnipeg can meet not only their ammonia license limits but also reduce nitrogen and phosphorus concentrations in an environmentally sustainable manner and provide better treatment of emerging contaminants such as pharmaceuticals.

Compliance reporting for most of an additional year has shown that ammonia levels were consistently below the licensed limit, when the SBR was in operation. There were two days in August 2010 where the ammonia limit was exceeded. Phosphorus and nitrogen outputs remained above the prescribed limits, although they have decreased from previous levels.

In its presentation, the City also provided evidence regarding the failed toxicity tests. It is its view that the toxicity testing protocol is flawed, providing erroneous results. It indicated to us that this has been accepted by Environment Canada, with the result that they no longer have failing results in this regard.

Water Stewardship indicates that, while this is accurate and that the City appears to meet the necessary conditions, it noted that the City has only analyzed four of the 16 failed tests according to the new protocol.

In further support of the Commission’s position that the City must engage in significantly more ammonia treatment, it bears repeating from the 2009 Report:

However, it should be borne in mind that the ammonia limits already have provision for exceedances calculated into them. They are intended to protect up to 95 per cent of all genera from unacceptable impacts, provided they are not exceeded more than once every three years. Exceeding the limits

more than once every three years would mean that the aquatic environment would be in a state of constant recovery. (Manitoba Conservation 2002; ii, 8-9).

What is Environment Canada's view on Ammonia?

In addition to Provincial regulations on ammonia, the Federal government, through Environment Canada, also plays a role in its release, pursuant to the *Canadian Environmental Protection Act*, 1999 and the *Fisheries Act*.

In a presentation to the CEC, during the 2003 hearings on City of Winnipeg wastewater treatment, Environment Canada stated:

… the City's plan to address ammonia toxicity solely through centrate treatment appears to be inadequate…… without nitrification at all three sewage treatment plants, it is likely that effluents would not be in compliance with Subsection 36(3) of the *Fisheries Act* based on the high levels of unionized ammonia alone….. while adoption of centrate treatment is an important first step towards ammonia control, a more rigorous and timely reduction of ammonia is required.

What about the Canadian Council of Ministers of the Environment?

The Canadian Water Quality Guidelines for the Protection of Aquatic Life 2009 (Canadian Council of Ministers of the Environment 2009b) provide a limit of 0.019 mg/L of un-ionized ammonia and limits for total ammonia based on pH and temperature. The Province has incorporated these guidelines into its calculated limits.

However, nitrification of ammonia results in the production of nitrate-nitrogen if it is not also denitrified. This form of nitrogen is most readily available to stimulate plant growth and can be harmful to aquatic organisms that are sensitive to nitrogen.

The current national guideline for nitrate-nitrogen to protect aquatic life is 2.9 mg/L. CCME is currently reviewing the water quality guideline for nitrate but any revisions are not expected to vary greatly from this figure.

Based on the history of nitrate concentrations in City's effluent from 2002—2008, the City will not be able to meet the current CCME guideline for the protection of aquatic life of 2.9 mg/L using centrate treatment.

Demographics

In all of its considerations, and particularly in respect of ammonia, the City seems to have not considered future growth.

The Manitoba Bureau of Statistics has estimated that between 2008 and 2028, Manitoba's population is expected to grow just over 25%. A disproportionate amount of this growth is likely to occur in the City of Winnipeg.

In addition, the City has, from time-to-time, suggested that it might enter into contracts with neighbouring municipalities for treatment of their wastewater. It is unknown, at this time, how this growth might affect the City's ability to meet its future ammonia limits.

However, given that the City is only just able to meet the limits now, this needs to be carefully considered.

Conclusion

At the core of the current review is the City's contention that it can meet its *Environment Act* licence limits for ammonia through its proposed centrate treatment process.

The Commission has come to the conclusion that great concerns remain with respect to the capacity of the centrate process and its ability to consistently achieve compliance with the licence ammonia limits. In addition, as these ammonia concentrations decrease, the nitrate concentrations will increase well above those provided in the national guidelines.

Based on data provided by the City of Winnipeg, the proposed process could decrease the ammonia limits minimally below the current regulated limits, and not infrequently exceed them at critical times of the year. Reliability assurances for this system cannot be provided. No contingency plans were included with this proposal that would address the concerns raised by the Province and should conditions suddenly change.

In the opinion of the Commission, the small buffer between the required limit and the projected effluent load is not adequate to provide appropriate protection to the aquatic environment in anticipation of all conditions. Furthermore, given that both federal and provincial regulations/guidelines on ammonia may change within a few years, to ignore this now would only be delaying the inevitable.

7. Nitrogen in the Environment

Nitrogen has become a major point of debate in this discussion. While this section doesn't pretend to resolve the debate, it does address a number of the points relevant to this issue.

The discussion in this section is intended to make the point that nitrogen is not the environmentally benign element that many would have us believe. To ensure an environmentally sustainable future for Manitoba, including Lake Winnipeg, nitrogen must be addressed.

What is the story on Nitrogen?

Nitrogen is an essential nutrient for all life. However, in excess and in the activated forms, it can be harmful to the environment.

The Commission's 2009 report described in considerable detail the growing concern with nitrogen in the environment. This was well summed up in the 2004 Nanjing Declaration, adopted by the participants at the Third International Nitrogen Conference, which noted that reactive nitrogen lost to the environment "has led to disturbances in the nitrogen cycle, and has increased the probability of nitrogen induced problems such as pollution of freshwaters, terrestrial and coastal ecosystems, decreasing biodiversity and changing climate and pose a threat to human health." With further growth in the global population, they state this "disturbance of the nitrogen cycle will become worse unless adequate measures are taken" (Nanjing Declaration 2004).

It is in this regard that the controversy over the need to remove nitrogen from the City's wastewater has arisen. During the 2009 investigation, the Commission received a letter signed by 63 scientists, some of them renowned in this field, who argued that it would be a waste of money to require the City to remove nitrogen from the wastewater. Their view is that this could be counter-productive, leading to an increase in the amount of blue-green algae. It is their further view that removing nitrogen would be a wasted effort, as the blue-green algae can get it from the atmosphere, if it is not available in the water. These scientists based their position, in large part, on experiments begun in the Experimental Lakes Area in Ontario in 1973.

In its 2009 report, the Commission did not dispute these findings. The Commission did, however, note that there is an equally significant body of scientists who do not completely share this view. These scientists have further investigated the complex relationships between phosphorus, nitrogen and cyanobacteria in lake ecologies and have concluded that it goes much beyond simple cause and effect.

The Commission made the point —very clearly—that the investigation was not focused only on blue-green algae, but at the entire Manitoba ecosystem, including a much more comprehensive view of Lake Winnipeg and the aquatic system as far as Hudson Bay.

The Commission concluded that *The Environment Act* licence limit of 15 mg/L was appropriate.

The Global Nitrogen Cycle

The Earth's atmosphere is, by volume, 78% nitrogen gas and it is estimated that less than 0.02% is actually accessible to living organisms. This type of nitrogen is benign. To be available for most biological growth, nitrogen must be converted to an activated or fixed form by combining with other elements such as hydrogen and oxygen. Only a few species of bacteria and blue-green algae can fix nitrogen gas.

This reactive or fixed nitrogen moves through the biological system by cycling through biological organisms and processes (life and death of plants and animals) and is built into the various biological compounds (proteins and waste products such as ammonia), with a small amount being mineralized or incorporated into soils or sediments.

For the global nitrogen cycle to remain in balance, reactive nitrogen must be returned back to nitrogen gas. This may happen through many steps and transfers through the biological system, changing forms many times before being returned to the atmosphere as nitrogen gas. These steps are called nitrification and denitrification. In nitrification, ammonia is converted to nitrate by certain types of bacteria in oxygen rich environments and, in denitrification, the nitrate is converted back to nitrogen gas by another set of bacteria in low oxygen conditions.

During these conversions nitrous oxide (a greenhouse gas) can be released.

Human Interference with the Global Nitrogen Cycle

Human interference with the global cycle has led to the enhanced availability of reactive nitrogen. Among the consequences of direct significance in this discussion are:

• Accelerated losses of biological diversity, especially losses of plants adapted to efficient use of nitrogen, and losses of animals and microorganisms that depend on them.

• Fish kills due to ammonia toxicity.

• Decline in amphibians in southern Ontario due to long-term exposure to elevated nitrate concentrations.

• Acidification of lakes and streams.

• Increase of transfer of nitrogen through rivers to estuaries and coastal waters.

• Eutrophication of freshwater lakes and systems.

• Elevated risks to humans and animal health through increased frequency and spatial extent of algal blooms.

• Global climate change and stratospheric ozone depletion, both of which have impacts on human health and ecosystem health.

(Chambers et al. 2001, Cowling et al. 1998, Galloway et al. 2003, Vitousek et al. 1997).

If this reactive nitrogen from wastewater treatment is not converted back to nitrogen gas in any appreciable amount, it enters the river system and is transported downstream. These activated forms of nitrogen may be converted to nitrogen gas by biological processes in the aquatic system, may make a short or longer stop in the aquatic system by being incorporated into biological material or into the sediments and then released back to the system sometime in the future or may pass right on through making its way to the ocean.

The Canadian Council of Ministers of the Environment Wastewater Strategy (2009) encourages the address of wastewater issues at a watershed level and not solely on a localized environment level. Several scientific authorities have cautioned that only focusing on phosphorus removal and not considering nitrogen removal will allow more nitrogen to be transported downstream where it can make eutrophication worse and eventually end up in the estuarine and coastal marine environment where it may negatively impact the environment (Barton and Atwater 2002, Conley et al. 2009, Galloway et al. 2003, Paerl 2009).

These same effects are being observed in the Lake Winnipeg watershed currently, produced not by a decrease in the phosphorus load, but by retention of the load within the lake. This circumstance could be further exacerbated if only phosphorus and not nitrogen inputs to the lake are decreased. Activated nitrogen and phosphorus from agricultural and wastewater sources are arriving at Lake Winnipeg at increasing levels each year and are incorporated into biological materials to a certain level. The phosphorus however, is remaining in the lake in greater amounts, 50% more than previously measured;

nitrogen continues to enter the system at an increasing rate and leaves to the Nelson River in the same historical proportions (30%), although the total amounts are increasing (Lake Winnipeg Stewardship Board 2006). As the Nelson is a fast-moving river, little natural denitrification is likely occurring in the river bed and the activated nitrogen is being deposited in the nitrogen limited coastal environment out of balance with historical phosphorus inputs. It is not known however, what effect the hydro-electric dams may have on this nutrient flow. To date, relatively few studies have investigated the effects of excess nutrients on the coastal Hudson Bay environment, although many studies conclude that such environments are sensitive to damage arising from excess nitrogen inputs (Carstensen 2007, Conley et al. 2009, Elser 2007, Erisman et al. 2007, Howarth and Marino 2006, Paerl 2009, Rabalais 2002, Savage et al. 2010, Smith et al. 2006, Vitousek et al. 1997).

In a recent presentation, the effect of nitrogen moving beyond Lake Winnipeg was dismissed. The reasons given were that there was a small and scattered human population that would not be noticeably affected and the amounts of nitrogen would be so small reaching Hudson Bay that their effects are negligible.

Manitoba is charged with the protection of its entire environment regardless of the human population level or any currently identified problems. The only reasonable approach is to work at the watershed level, addressing nutrients and other deleterious inputs from source to sink. Lifecycle analyses of the elements, especially nitrogen and phosphorus, are required to determine their effects on the entire watershed and to be able to take appropriate management actions.

In addition, as outlined in *The Sustainable Development Act* and its Principles, Manitoba has a global responsibility to address environmental degradation issues through prevention or reversal of effects where possible, for the benefit of Manitobans and the global community.

Nitrogen and Lake Winnipeg

Nitrogen in its various forms arrives at Lake Winnipeg from many sources.

A relatively constant supply is provided by the City of Winnipeg wastewater facilities while there are great seasonal fluxes coming off the landscape from agricultural and natural sources. The greatest amount of this nitrogen is arriving in the activated form.

Along with phosphorus, this nitrogen provides a source of nutrients for biological growth. When one or both of these nutrients are plentiful, excess biological growth occurs (eutrophication), the greatest growth is observed when both are at high levels (Bloomqvist et al. 1994, Bunting et al. 2005, Conley et al. 2009, Elser et al. 1990, Finlay et al. 2010, Hyenstrand et al. 1998b, Leavitt et al. 2006, Lewis and Wurtsbaugh 2008, Paerl 2009, Smith et al. 2006, Stark and Richards 2008, Wilhelm et al. 2003).

As phosphorus is plentiful in Lake Winnipeg, the resulting biological community composition may be more influenced by the nitrogen supply within the lake, depending upon the environmental conditions (weather, light etc.) (Camargo and Alonsa 2006, Leavitt 2006, Moss et al. 2005, Paerl 2009).

This nitrogen supply can come from other parts of the watershed through the river system, can be recycled from the decay of biological materials in the lake, at times from the sediments and at other times from nitrogen fixed from the air by cyanobacteria.

The greatest inputs however are from the watershed. The timing, form (activated, organic or particulate) and total loading of both nitrogen and phosphorus have an effect on the resulting biological community (Bloomqvist et al. 1994, Gonzales Sagrario et al. 2005, Gueydan 2005, Hyenstrand et al. 1998b, Moss et al. 2005, Stark and Richards 2008, Wilhelm et al. 2003).

The constant presence of elevated levels of nitrate may have deleterious effects on animal and plant species that are sensitive to nitrogen and are constantly exposed to these levels. Unlike ammonia, nitrate is not considered toxic to aquatic organisms, but there are a number of organisms with sensitivity to nitrate levels. Often these are overlooked because there is no massive die-off that is immediately obvious but over time and constant exposure the fitness of these sensitive species declines and they die out (Camargo et al. 2005, Canadian Council of Ministers of the Environment 2009b, Gonzalez-Sagario et al. 2005, Hecnar 1995, Pip 2006, Rouse et al. 1999).

For these reasons, the CCME is addressing this issue by providing guidelines for nitrate levels that will maintain a healthy aquatic environment. The current limit is 2.9 mg/L, although it is under review.

Nitrogen Fixation

Great emphasis has been put on the fact that the floating mat types of blue-green algae often seen in Lake Winnipeg can fix nitrogen and that, if there is limited nitrogen supplied in the water, they will use this ability to proliferate and contribute nitrogen to the nitrogen pool within the lake.

What has not been emphasized in this debate is that the act of fixing nitrogen from the atmosphere is not nearly as easy a process as some have made out.

Nitrogen fixation by these species is very energy intensive, requires phosphorus-driven chemical reactions and should be considered to be a last resort that is utilized only when aquatic sources of nitrogen are depleted.

Nitrogen fixation does not take place until a population of these blue-green algae has been established, has used up all its available resources, including the stored nitrogen and phosphorus in their cells, and then resorts to the production of nitrogen fixing cells. They use these cells to capture nitrogen from the air and to maintain or expand their immediate dominance in the aquatic system, usually later in the growing season.

Factors other than low nitrogen levels that influence nitrogen capture are light intensity, temperature, pH and water column stability (stratification).

When nitrogen fixation does occur, it does not stay constant throughout the day. The rate of nitrogen fixation can be highly variable within an area, within a day, between days, within a season and between seasons. It is quite dependent upon outside influences. Nitrogen fixation will cease to take place if light intensity is compromised by lake mixing or poor weather conditions or if nutrients become available through lake mixing or external sources.

The City of Winnipeg states that in a few weeks nitrogen fixation by blue-green algae can surpass the amount of nitrogen the City contributes to Lake Winnipeg in one year. Even if this were the case, it is questionable whether it is significant. The city's wastewater is supplying nitrogen in an inorganic form that facilitates blue-green algae growth, whereas the nitrogen taken from the air may be incorporated into organic nitrogen and be recycled at a slower pace, requiring many chemical reactions within the lake's biological systems or more likely, released directly back to the air.

Studies in many areas, including shallow prairie lakes, have concluded that nitrogen fixed by cyanobacteria does not contribute significantly to the long-term in-lake nitrogen pool (Barica 1990, Howarth et al. 1988, Levine and Lewis 1987, Tõnno and Nõges 2003, Vrede et al. 2008).

Updated analysis and interpretations of historical data

In a 2010 paper, Scott and McCarthy reassessed the data which underpinned a number of the prevailing conclusions regarding the contribution of nitrogen fixation and the proliferation of nitrogen fixing blue-green algae at Experimental Lake 227. Their stated purpose was:

…to evaluate if cyanobacterial N fixation could sufficiently balance N and P concentrations in Lake 227 over multiannual timescales.

Their analysis led to two significant conclusions:

1) that nitrogen fixation does not appear to contribute significantly to the long-term nitrogen pool and

2) that with decreasing nitrogen levels, the amount of blue-green algae produced on an annual basis is also decreasing.

Scott and McCarthy also examined whether "controlling nitrogen inputs could actually aggravate the dominance of nitrogen-fixing cyanobacteria." Their conclusion was:

… phytoplankton biomass decreased in response to decreased N availability, suggesting that the degree of eutrophication can be controlled by managing N inputs concurrently with P.

In this regard, they further noted that:

failure to control external N inputs also may exacerbate the proliferation of non-N-fixing cyanobacteria such as *Mycrocystis*. This genus… forms toxic blooms affecting public health and drinking water supplies…

This is in keeping with conclusions made by other researchers who found that addition of nitrogen in high phosphorus conditions can facilitate the production of potentially toxic, non-nitrogen fixing cyanobacteria (Barica et al. 1980, Finlay et al. 2010, Lathrop 1988, Levine and Schindler 1999).

Scott and McCarthy's findings on the control of both nitrogen and phosphorus are consistent with similar conclusions made by other authors who have addressed nutrient management on a watershed-wide basis (Conley 2009, Paerl 2009, Savage 2010).

These and other studies lead the Commission to the conclusion that it cannot be stated with any certainty that nitrogen fixation in Lake Winnipeg makes a significant contribution to the long-term nitrogen pool. It follows that a decrease in nitrogen supply will result in a decrease of the cyanobacterial population over the long-term and that both nitrogen and phosphorus reductions must be addressed at the same time.

Nitrogen and Wastewater

In 2009, the CCME endorsed a Canada-wide strategy for the sustainable management of municipal wastewater effluent (Canadian Council of Ministers of the Environment 2009a). The Strategy requires that all facilities achieve minimum National Performance Standards and develop and manage site-specific Effluent Discharge Objectives. Partial implementation of this strategy will be facilitated through regulations put in place by the federal government, and will specifically address ammonia.

Untreated ammonia that enters the river is quickly converted, by nitrification, to nitrate by the bacteria in the river but little is denitrified or converted to nitrogen gas. The City of Winnipeg has had difficulties in keeping the ammonia concentrations below the required limits on many occasions within a year and over many years (Manitoba Clean Environment Commission 2009).

At the same time, the nitrate concentrations were often much above the current CCME level of 2.9mg/L for the protection of aquatic life (Figures 1 & 2). The conversion of the WEWPCC and the SEWPCC to full-BNR plants will alleviate this problem at these sites. However, controlling the ammonia concentrations and addressing nitrate concentrations at the NEWPCC plant will be problematic without installation of full-BNR.

Limited study has been done on the Red River to determine its biodiversity status and the effect of nutrients and other components in the City's effluent on organisms living in the river. In comparison to other prairie cities this impact will continue until such time as all of Winnipeg's wastewater facilities are upgraded.

Conclusion

The Commission remains of the view that nitrogen continues to be of significant environmental concern. This supplemental review has reinforced the conclusions reached in the 2009 report. More recent literature has provided further evidence that both nitrogen and phosphorus play a significant role in the eutrophication of lakes. In particular:

• There is a body of evidence that links high nitrogen levels with the eutrophication of lakes.

• The issues under consideration go beyond eutrophication in lakes. There are valid and responsible environmental reasons for the Province to also engage in nitrogen control measures, including nitrogen's impacts on marine waters, riverine environments, and biodiversity. Nitrogen discharges in City of Winnipeg wastewater are part of a global nitrogen cascade (the mobilization of reactive nitrogen in the air, water and soil) with negative environmental impacts. It is in keeping with Manitobans' global responsibilities to limit those discharges and, if not prevent, limit their negative impacts

• Phosphorus and nitrogen both play a role in contributing to the eutrophication of Manitoba waters.

• Regulation of phosphorus and nitrogen from point sources such as urban wastewater treatment systems should be a key element of the provincial nutrient management strategy. The sooner the City of Winnipeg develops full nutrient management capability, the more effective role it will be able to play in implementing the provincial strategy. Phasing in nitrogen control is not appropriate

8. Cyanobacteria/Blue-Green Algae

What kinds of cyanobacteria are there in Lake Winnipeg and what makes them grow?

This section addresses some of the most common types of blue-green algae found in Lake Winnipeg. It notes the complex nature of their production. And, it points out that Lake Winnipeg is not a typical large lake and examines how this impacts on algae production.

There are generally two functional types of blue-green algae that grow in Lake Winnipeg, nitrogen fixers and non-nitrogen fixers. Either type can be toxic but in general in Lake Winnipeg, nitrogen fixers are more likely to be non-toxic. The non-nitrogen fixers are more often toxic than the nitrogen fixers, but the frequency of their occurrence in Lake Winnipeg has not been studied.

The nitrogen-fixing species have filamentous cells that form the large green floating mats that are evident in the satellite images and the many photographs of green slime on the beaches. These mats can be unsightly, smelly and a nuisance, but they are not generally harmful to animals and humans. The common nitrogen fixers observed in Lake Winnipeg are *Anabaena spp*. and *Aphanizomenon* spp.

The other common types of blue-green algae found in Lake Winnipeg are non-nitrogen fixers which can only get their nitrogen from the water. They are a diverse group, ranging from floating colonies of microscopic cells (*Microcystis*) to elongated chains of cells (*Planktothrix*). In both cases, many of the most common representatives of these blue-green algae produce a potent toxin. Although *Microcystis* is capable of forming unsightly blooms similar to those of nitrogen fixing cyanobacteria, colonies of *Planktothrix* are adapted to live deep in the water where light is scarce, and only rarely produce obvious surface scum. During such blooms, the surface waters may appear to be less densely crowded with cyanobacteria, but the water may have a higher concentration of toxins. In instances where these blooms also wash ashore, they can represent a substantial exposure hazard to humans and animals.

The production and maintenance of blue-green algae populations in a lake system is a very complex process and not nearly as simple as a straight-line cause and- effect relationship as has been provided in recent presentations. Many current and wide-ranging scientific studies have outlined the complexity of these relationships (Bloomqvist et. al. 1994. Carstensen et al. 2007, Dokulil and Teubner 2000, Downing et al. 2001, Elser et al. 2007, Ferber et al. 2004, Flores and Barone 1998, Gueydan 2005, Hyenstrand et al.1998a, Jacoby et al. 2000, Levine and Schindler 1999, McCarthy et al. 2009, Moss et al. 2005, Paerl 1987, Paerl 2009, Pip and Allegro undated, Pip 2006, Rabalais 2002, Reynolds 1998, Schade et al. 2005, Smith et al. 2006, Tõnno and Nõges 2003, Vrede et al. 2008).

Blue-green algal blooms are dependent upon a web of chemical and biological reactions that are highly affected by weather and atmospheric conditions. The outcome of these processes is also dependent upon the existing hydrology (water supply and movement patterns), geomorphology (the type of rock surrounding and underlying the lake), and the current level of nutrients in the lake. Many diverse scientific studies demonstrate that, in combination with phosphorus, nitrogen in its various forms plays a significant role in the types and amount of cyanobacteria that are produced (Barica et al. 1980, Bloomqvist et al. 1994, Bunting et al. 2007, Camargo and Álonso 2006, Conley et al. 2009, Elser et al. 1990, Finlay et al. 2010, Gonzalez Sagrario et al. 2005, Gueydan 2005, Hyenstrand et al. 1998(b), Jacoby et al. 2000, Leavitt et al. 2006, Lewis and Wurtsbaugh 2008, Moss et al. 2005, Pip 2006, Paerl 2009, Présing et al. 2008, Rabalais 2002, Reynolds 1998, Sanchis et al. 2002, , Savage et al. 2010, Scott and McCarthy 2010, Smith et al. 2006, Stark and Richards 2008, Von Rückert and Giani 2004, Vrede et al. 2008, Wilhelm et al. 2003).

In addition to the effects of phosphorus and nitrogen, micro-nutrients such as iron, are thought to play a role in controlling blue-green-algae blooms (Fay 1992, North et al. 2007, Tõnno et al. 2005). Other factors such as grazing by aquatic animals, temperature, light penetration, nutrient turnover, water currents and stratification (layering) of the lake are also significant factors in the production and maintenance of the different types of cyanobacteria in a lake.

The scientific literature provides descriptions of many studies related to cyanobacterial production observed in many different types of lakes and under a variety of environmental conditions. The resulting planktonic and cyanobacterial populations vary nearly as much as the differing situations under which they are studied. Most descriptions that characterize the growth of cyanobacteria are related to seasonal lake processes. The larger, deeper lakes generally have a predictable seasonal pattern where the lake will stratify (develop temperature controlled layers) seasonally (summer and winter). During the spring and fall, the lake becomes mixed. During stratification, there is little mixing of the water between the layers and nutrients can become trapped in one layer and may not be available to other parts of the lake where nutrients have become depleted. Cyanobacteria are adapted to move up and down in the lake to capture these nutrients, where other plants are not so mobile.

Lake Winnipeg does not typically follow these seasonal patterns. It is considered a shallow polymictic lake (well-mixed lake from top to bottom) where stratification or layering is infrequent. As a consequence, there is regular mixing and generally a more constant supply of nutrients throughout the lake than if the lake were to stratify.

The resulting planktonic and cyanobacterial population composition does not rely solely on any one factor (such as the relative amounts of nitrogen and phosphorus), it is highly dependent upon the interaction and influence of many factors from within and outside the lake, making the identification of a single definitive management solution impossible. However, both nitrogen and phosphorus play a significant role in their growth. A suite of actions that should include the reduction of nutrient inputs from both urban and agricultural sources is required. Reduction of both phosphorus and nitrogen inputs are required for lake restoration and to minimize effects on the eventual receiving water, Hudson Bay (Conley et al. 2009, Paerl 2009, Savage et al. 2010, Schindler 2006, Scott and McCarthy 2010).

Conclusion

Current scientific literature indicates that both phosphorus and nitrogen have an effect on the composition and intensity of biological populations in an aquatic system, freshwater and marine. It can also be concluded that there is no one rule that can be universally applied to all situations to predict the outcome, each situation has its own unique conditions that must be taken into account. In a highly complex biological system, caution is required in focusing on only one type of organism or one parameter to develop management actions.

In Section 7, the Commission noted some of the most current research in this area. The particular papers that are discussed support the recommendations made in this (and the 2009) report calling for the removal of both nitrogen and phosphorus.

To quote the concluding sentence in one of these papers:

Recent experiences increasingly point to the importance and long-term efficacy of dual, as opposed to single, nutrient reduction strategies as a means of controlling eutrophication along the entire continuum. (Paerl 2009).

9. Contaminants of Emerging Concern

Contaminants of emerging concern are pollutants not currently included in routine monitoring programs and may be candidates for future regulation depending on their (eco) toxicity, potential health effects, public perception, and frequency of occurrence in environmental media.

Contaminants of emerging concern include several types of chemicals:

• Persistent organic pollutants (POPs) such as polybrominated diphenyl ethers (PBDEs; used in flame retardants, furniture foam, plastics, etc.);

• Pharmaceuticals and personal care products (PPCPs), including human prescribed drugs (e.g., antidepressants, blood pressure), over-the-counter medications (e.g., ibuprofen), bactericides (e.g., triclosan), sunscreens, synthetic musks;

• Veterinary medicines such as antimicrobials, antibiotics, anti-fungals, growth promoters and hormones;

• Endocrine-disrupting chemicals (EDCs), including synthetic estrogens and androgens, naturally occurring estrogens, as well as many others capable of modulating normal hormonal functions and steroidal synthesis in aquatic organisms.

They are characterized by having:

• a perceived or real threat to human health, public safety or the environment;

• no published health standards or guidelines;

• insufficient or limited available toxicological information or toxicity information that is evolving or being re-evaluated; or

• significant new source, pathway, or detection limit information.

The most direct route of release of contaminants of emerging concern into the environment is through the discharge of wastewater treatment plant effluents into surface waters. Biosolids containing such contaminants may be placed in landfills or spread on agricultural land for soil amendment, where these compounds may be transported by runoff into the surrounding surface water or may leach into underlying groundwater.

They can, in aquatic environments, act as endocrine disruptors, causing fish to develop sexual abnormalities. In experiments in the Experimental Lakes Area, the addition of EDCs was found to cause fat-head minnows to develop both male and female reproductive organs (Kidd, 2007).

Although the current lack of evidence on widespread environmental effects makes it premature to justify increased operating and capital costs, the European Union has invoked the Precautionary Principle, encouraging member countries to begin treatment of wastewater for contaminants of emerging concern.

Traditional sewage treatment does not remove these hormones.

However, full-biological nutrient removal treatment has been found to effectively remove most hormones from municipal wastewater (Andersen et al. 2003). A recent study of the Brandon wastewater treatment plant, which employs a BNR system, found that between 75 and 90 per cent of various endocrine-disrupting compounds were removed (Cicek et al. 2007). This result may not arise from the bacterial activity, but from the process, which has a longer treatment period than more traditional processes and from the presence of both aerobic and anaerobic zones in the treatment process.

The Canadian Council of the Ministers of the Environment is currently investigating contaminants of emerging concern in biosolids. Depending upon their findings, additional guidelines regarding the fate of biosolids from wastewater facilities may be forthcoming.

Conclusion

In implementing municipal wastewater treatment, it is necessary to consider the negative impacts of these contaminants. To construct a system that is not capable of addressing these impacts would be shortsighted.

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Appendix 1: Minister's Letter

FAXED 12/14/09

MINISTER OF CONSERVATION

Legislative Building
Winnipeg, Manitoba, CANADA
R3C 0V8

December 7th, 2009

Mr. Terry Sargeant
Chair, Clean Environment Commission
305-155 Carlton Street
Winnipeg, MB R3C 3H8

Dear Mr. Sargeant:

Further to recent discussions, I am writing to ask that the Clean Environment Commission provide advice on the City of Winnipeg's revised proposed upgrade plans for the North End Wastewater treatment plant.

In March of 2009, you provided me with a report from the Commission titled, *An Investigation into Nutrient Reduction and Ammonia Treatment at the City of Winnipeg's Wastewater Treatment Facilities*. This was the Commission's 3rd review of the City of Winnipeg's required wastewater upgrades following the commission's reports of 1992 and 2003. Your report concluded and recommended that:

- *In order to protect the environment, City of Winnipeg wastewater treatment facilities must be regulated and operated in a manner that ensures the following:*
    - *(a) Phosphorus discharges should be as low as possible. The concentration of total phosphorus in the effluent on any day must not exceed 1.0 milligram per litre, as determined by the 30-day rolling average. The City of Winnipeg should set itself an operating target of 0.5 milligrams per litre.*
    - *(b) Nitrogen discharges must not exceed 15 milligrams per litre, as determined by the 30-day rolling average.*
    - *(c) The mass ratio between nitrogen and phosphorus discharges must be maintained at 15:1.*
    - *(d) Ammonia discharge limits must be based on the longest available period of record for river flow, a portion of no more than 75 per cent of the assimilative capacity for the receiving waters, and on the provisions of the draft Manitoba Water Quality Standards, Objectives, and Guidelines.*

The Commission also recommended that:

- *The City of Winnipeg should use nutrient removal processes, such as biological nutrient removal, that increase resource recovery and reduce the City's environmental footprint to the greatest extent possible.*

I have received correspondence from the City of Winnipeg that I have attached for your review. As you will see the City of Winnipeg has asked that the requirement to remove nitrogen at its North End wastewater treatment plant be reconsidered for two reasons that it identifies in the attachment to its letter. The City has formally appealed its licence limits on ammonia to Manitoba Conservation. Its position is that if further ammonia reductions were not required at the North End plant, or could be achieved in a different manner as outlined in the poster attached to the letter, it would be able to meet all licence requirements, except nitrogen removal, in a long term sustainable manner.

I would note that City officials have advised the Commission and provincial officials that they agree full biological nutrient removal upgrades for the South End plant are needed.

I am requesting that the Commission review the City of Winnipeg's revised proposed upgrade plans for the North End Wastewater treatment plant. I ask for your advice on this matter as soon as possible.

Thank you for undertaking this important task.

Yours sincerely,

The Honourable Bill Blaikie
Minister of Conservation

Appendix 2: Precautionary Principle

Does the precautionary principle ignore science?

In its 2009 report, the Commission relied on the Precautionary Principle in respect of two different issues:

1. Portioning the assimilative capacity of the rivers -

In the report, the Commission wrote:

In its 2003 report, the Commission recommended that the City be assigned 75 per cent of the assimilative capacity of the receiving waters. The 75 per cent figure is much more generous than the percentage portioned to other Manitoba cities. The Commission believes that portioning is an appropriate and precautionary approach to this issue. It does not support expanding the City's portion of the assimilative capacity of the receiving waters beyond 75 per cent.

2. The effect on eutrophication of removing nitrogen -

The Commission wrote:

In short, while there is general agreement on the need to reduce phosphorus loading as much as possible to allow lakes to recover from eutrophication, there is ongoing debate in the scientific community over the benefits and risk of reductions in nitrogen loading to lakes—although there is agreement that nitrogen reductions should not serve to decrease the nitrogen-to-phosphorus ratio. Furthermore, elevated nitrogen levels are associated with loss in biodiversity, and eutrophication and toxicity to amphibians.

While the Commission does not presume to be able to resolve these debates, particularly since, in some instances, the issues are site-specific and results may not be transferable, it will be taking a precautionary approach in making recommendations based on this research. Employing such an approach will require policies that reduce nitrogen loading and increase the nitrogen-to-phosphorus ratio in receiving waters.

The Commission was criticized for this use of the Precautionary Principle, in at least two places:

• An op-ed article in the Winnipeg Free Press; and

• In the poster which accompanied the Mayor's letter. The poster was attributed to City of Winnipeg engineers, engineers and scientists from the University of Manitoba and the University of Alberta; and scientists from the federal Department of Fisheries and Oceans.

The Commission's use of this Principle was dismissed as unscientific.

What is the PrecautionaryPrinciple?

While the concept of such a principle had its origins in the 1930s and received much consideration in the ensuing years, it wasn't until the Rio Conference in 1992 that it became widely known.

Principle #15 of the Rio Declaration notes:

In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation. (United Nations 1992).

Since Rio, it has received much international attention, particularly among some of the world's leading environmental scientists. It has been restated by a number of such gatherings:

Wingspread Statement on the Precautionary Principle—1998:

When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically.

(The Wingspread Conference on the Precautionary Principle was convened by the Science and Environmental Health Network). (Science and Environmental Health Network 1998).

European Commission Communication on the Precautionary Principle—February 2000:

The precautionary principle applies where scientific evidence is insufficient, inconclusive or uncertain and preliminary scientific evaluation indicates that there are reasonable grounds for concern that the potentially dangerous effects on the environment, human, animal or plant health may be inconsistent with the high level of protection chosen by the EU. (Commission of the European Communities 2000).

Cartagena Protocol on Biosafety—January 2000:

Lack of scientific certainty due to insufficient relevant scientific information . . shall not prevent the Party of import, in order to avoid or minimize such potential adverse effects, from taking a decision, as appropriate, with regard to the import of the living modified organism in question. (Convention of Biological Diversity 2000).

Lowell Statement on Science and the Precautionary Principle—September 2001:

Growing awareness of the potentially vast scale of human impacts on planetary health has led to a recognition of the need to change the ways in which environmental protection decisions are made and the ways that scientific knowledge informs those decision. As scientists and other professionals committed to improving global health, we therefore call for the recognition of the precautionary principle as a key component of environmental and health policy decision making, particularly when complex and uncertain threats must be addressed.

(The Lowell Center for Sustainable Production, based at the University of Massachusetts Lowell, develops, studies, and promotes environmentally sound systems of production, healthy work environments, and economically viable work organizations.) (International Summit on Science and the Precautionary Principle 2001).

Does the Precautionary Principle have any status in law?

Some commentators argue that the precautionary principle is already a principle of international law, based in part on existing state practice and its incorporation into the five environmental instruments signed at Rio de Janeiro in 1992. At the very least, the precautionary principle can be viewed as an emerging principle of international environmental law.

It has been incorporated into law in a number of jurisdictions, including the European Union. In Canada, the principles have been incorporated into individual statutes—both federally and provincially.

Examples of application in Canada of precautionary approaches in policy statements, statutory language and judicial interpretation date from at least the late eighties.

In addition, the 2001 Royal Society's Expert Panel Report on the Future of Biotechnology advocated that Canadian regulatory agencies adopt the precautionary principle.

The House of Commons Standing Committee on Environment and Sustainable Development has pressed for strong emphasis on the precautionary principle in at least two reports, and the precautionary principle has been incorporated into the *Canadian Environmental Protection Act* 1999 and the *Oceans Act*.

In a recent Supreme Court of Canada decision, *Hudson*, the majority of the Court cited a number of authorities favouring the proposition that the precautionary principle has become a principle of customary international law. In reviewing the principle, the court considered it to be relevant in interpreting domestic Canadian law, and in particular recognized the value of a precautionary approach to issues and decisions involving potential environmental hazards.

In Manitoba, *The Sustainable Development Act*'s Principles and Guidelines for Sustainable Development includes one entitled "Prevention", which mirrors the Precautionary Principle:

Manitobans should anticipate, and prevent or mitigate, significant adverse economic, environmental, human health and social effects of decisions and actions, having particular careful regard to decisions whose impacts are not entirely certain but which, on reasonable and well-informed grounds, appear to pose serious threats to the economy, the environment, human health and social well-being.

So, to dismiss the Precautionary Principle as unscientific demonstrates a misunderstanding of international scientific consideration and of federal, provincial and international law.

Appendix 3: The Mayor's Letter

There are a number of statements made in the letter from the Mayor of the City of Winnipeg to the Minister of Conservation which require further consideration:

1. *... the City agrees with the goal of these Licence requirements—to reduce algae blooms and to protect the health of the local rivers and Lake Winnipeg. We want to do our share in achieving that goal.*

The goal of the licence requirements is far more than this. It is more correctly stated in *The Environment Act*:

The intent of this Act is to .... ensure that the environment is protected and maintained in such a manner as to sustain a high quality of life, including social and economic development, recreation and leisure for this and future generations...

Or, as stated in the Mission of the Environmental Assessment & Licensing Branch:

...ensure that developments are regulated in a manner that protects the environment and public health, and sustains a high quality of life for present and future Manitobans.

While one of the outcomes of these goals will be to reduce algae blooms and to protect the health of the local rivers and Lake Winnipeg, these are far from the only goals.

In the Commission's 2009 Report, it was made very clear that the review of the potentially-negative impacts of nitrogen went far beyond just blue-green algae.

2. *...the City of Winnipeg strongly opposes the* ***new*** *Licence requirement to reduce levels of nitrogen in our wastewater. There is a considerable body of scientific evidence that demonstrates that reducing phosphorus—not nitrogen—is the key element in reducing algae blooms in freshwater lakes…there is some evidence that it may even have a negative effect on Lake Winnipeg water quality.*

It is incorrect to describe the requirement for nitrogen removal as new. It has been in all three licences since they were issued, as well as in other locations in Manitoba. It was first recommended in the Clean Environment Commission report in 2003. And, it is hardly unknown, as other jurisdictions in Canada have removed nitrogen for at least two decades.

Still, this statement is, in part, correct. There is a significant school of scientists who believe that reducing phosphorus—not nitrogen—is the key element in reducing algae blooms in freshwater lakes. The Commission was clear in its 2009 report that it also accepted this premise. To that end, the Commission recommended that the City ensure that its nitrogen and phosphorus removal adhere to the 15:1 ratio.

However, the jury is still out in respect of the second part of the above statement—"that there is some evidence that nitrogen removal may even have a negative effect." There is an equally significant body of scientists who do not accept this premise. Some of these scientists have conducted studies that have led them to conclude that in lakes with excessive amounts of phosphorus, nitrogen becomes the limiting nutrient and should be removed.

As noted in Section 7, a recent reassessment of Experimental Lake 227 data found that after the addition of nitrogen to the lake was stopped, the amount of phytoplankton biomass decreased (Scott and McCarthy 2010).

3. *Cyanobacteria, the undesirable "bluegreen algae", have the ability to draw the nitrogen they need to thrive from the atmosphere, particularly if it is in short supply in the water.*

This statement is also, in part, true. Some blue-green algae do have the ability to acquire nitrogen from the atmosphere. However, it is a far more complex process than this simple statement would indicate. While it can be done, it is not easily done and this captured nitrogen does not appear to add significantly to the in-lake nitrogen pool.

The nitrogen-fixing blue-green algae are undesirable algae because they are what is seen on the lake surface, becoming even more obvious when they washes up on the shore.

Other blue-green algae, which do not have the ability to take nitrogen from the atmosphere and which live mostly below the surface and, thus, unseen for the most part, feed off the nitrogen that is in the water. Among these species are some that are often known to be toxic.

4. *Scientists have estimated that Cyanobacteria blooms in Lake Winnipeg can in a few weeks draw in as much nitrogen from the atmosphere as that generated by the whole city of Winnipeg in a full year.*

This statement overemphasizes the significance of the nitrogen fixing process. (This is discussed more fully in Section 7.)

5. *The reduction in nitrogen may even foster a preferential growth environment for the undesirable bluegreen algae.*

As noted above, there is open debate among scientists on this. On the other side, high levels of nitrogen may foster the growth of even-more potentially undesirable toxic algae (Levine and Schindler 1999).

One current study noted that "failure to control external N inputs also may exacerbate the proliferation of non-N-fixing cyanobacteria such as *Mycrocystis*. This genus…forms toxic blooms affecting public health and drinking water supplies …" (Scott and McCarthy 2010).

6. *The City informed the Commission that ammonia removal accomplished through centrate treatment in conjunction with appropriate adjustments to the mainstream biological treatment processes has the potential to remove ammonia to the limits stipulated in the NEWPCC Licence.*

Based on the information provided to the Commission in early 2009, the City was not able to meet its licence-required ammonia limits through this centrate treatment process.

However, based on their more recent experience, with the process in operation, it does appear that they may be able to meet the limits during most, albeit not all, of the test period.

This is discussed in detail in Section 6.

7. *City believes that the limits established by Manitoba Conservation are overly stringent.*

This is not so, when compared to other prairie cities in the Lake Winnipeg watershed. Although Manitoba uses a different system to set the limits than the other two Prairie Provinces, the Manitoba limits are no more stringent than elsewhere. It is arguable that—for many months of the year—the Manitoba limits are less stringent.

8. *In my opinion, it is not financially or environmentally prudent to spend the extra $350 million.*

There is no question that it would be environmentally prudent. Implementing a full-biological nutrient removal process would be, by far, the most favourable process for the environment. This has been demonstrated quite clearly in many other jurisdictions in the Lake Winnipeg watershed, notably Calgary, Edmonton and Saskatoon. BNR has the capability to remove far more of the nutrients of concern—phosphorus, nitrogen and ammonia—than the process preferred by the City. The centrate treatment system will do only part of the job. It appears that the centrate process, along with chemical additions, will be successful at removing phosphorus to the licensed limits, may convert enough of the ammonia to just meet the licensed limits, and will not remove total nitrogen to the specified limits. It will have no effect on contaminants of emerging concern.

Whether this is good enough for the environment and society we will discover in time.

As to whether it would be financially prudent is not for the Clean Environment Commission to determine. The Commission would note, however, that on the occasion of the opening of the City's new water treatment plant in late 2009, Councilor Browaty was quoted in the Free Press as conceding that "you can't put a price on clean, safe water."

719

SAM KATZ
MAYOR • MAIRE

October 7, 2009

The Honourable Stan Struthers
Minister of Conservation
Room 330 – 450 Broadway Ave
The Province of Manitoba
Winnipeg MB R3C 0V8

Dear Honourable Struthers:

Further to recent media coverage and discussion in the Manitoba Legislature, I am writing with respect to the Clean Environment Commission recommendation regarding the City of Winnipeg Wastewater Treatment Plants.

Subsequent to the 2009 Clean Environment Commission (CEC) report, Manitoba Conservation re-issued Environment Act Licences to the City of Winnipeg requiring upgrades to our wastewater treatment plants to reduce outputs of phosphorus, ammonia, and nitrogen. The re-issuance followed a CEC review of the appropriate level of nitrogen reduction. I have been authorized by Executive Policy Committee to provide this response to those Licence requirements.

First, it is important to note that the City agrees with the goal of these Licence requirements – to reduce algae blooms and to protect the health of the local rivers and Lake Winnipeg. We want to do our share in achieving that goal.

Accordingly, the City supports and intends fully to comply with the Licence requirements to reduce levels of phosphorus and ammonia in our treated wastewater. We therefore commit (at a cost of about $250 million) to:

- Reducing the output of phosphorus to one milligram per litre or less at all three wastewater treatment plants.
- Reducing ammonia to levels in the treated effluent at the North End and South End plants that would not be harmful to aquatic life.

However, the City of Winnipeg strongly opposes the new Licence requirement to reduce levels of nitrogen in our wastewater. There is a considerable body of scientific evidence that demonstrates that reducing phosphorus – not nitrogen – is the key element in reducing algae blooms in freshwater lakes. Sixty-three prominent international scientists recently provided a letter to the CEC strongly urging that nutrient control focus on phosphorus and not on nitrogen removal. Indeed, the prevailing view in the scientific community is that reducing nitrogen will have no effect in reducing the blooms of undesirable algae, and there is some evidence that it may even have a negative effect on Lake Winnipeg water quality.

Cyanobacteria, the undesirable "blue-green algae", have the ability to draw the nitrogen they need to thrive from the atmosphere, particularly if it is in short supply in the water. Scientists have estimated that Cyanobacteria blooms in Lake Winnipeg can in a few weeks draw in as much nitrogen from the atmosphere as that generated by the whole city of Winnipeg in a full year. Therefore, even if all the nitrogen from the City's wastewater treatment plants were eliminated, the evidence is that this would have no effect on blue-green algae because the algae would simply draw its nitrogen from the atmosphere. The reduction in nitrogen may even foster a preferential growth environment for the undesirable blue-green algae.

The conclusion that nitrogen removal is not beneficial is supported by actual full-scale scientific fieldwork done in the Experimental Lakes area over 37 years by Dr. David Schindler, a highly-regarded expert in this area. Dr. Schindler's research demonstrated that algae blooms are directly related to excess phosphorus loading to a water body, and that nitrogen loading is not a significant factor. He, like many other scientists, agrees that reducing phosphorus loading to Lake Winnipeg alone, without any reduction in nitrogen loading, would in itself be sufficient to minimize the growth of undesirable algae blooms. Significantly, Dr. Schindler has indicated he fully supports the City's position that reducing nitrogen levels are unnecessary in order to achieve a reduction in undesirable algae blooms.

Dr. Schindler's critical scientific work has been published in journals that are highly respected in the scientific community and influential on science policy-making in the world. The two most relevant published papers are:

- Science (Schindler, D.W. 1977. Evolution of phosphorus limitation in lakes, Science 195: 260-262), and
- Proceedings of the US National Academy of Science (Schindler, D.W., et. al, 2008. Eutrophication of lakes cannot be controlled by reducing nitrogen input: Results of a 37-year whole-ecosystem experiment, PNAS vol. 105).

On page 46 and page 47 of the CEC's report "An investigation into nutrient reduction and ammonia treatment at the City of Winnipeg's wastewater treatment facilities" (March 2009), the CEC did not accept "the City's argument that it can meet its ammonia limits without nitrification". The Water and Waste Department informed the CEC that ammonia removal accomplished through Centrate treatment in conjunction with appropriate adjustments to the mainstream biological treatment processes has the potential to remove ammonia to the limits stipulated in the NEWPCC Licence, and that building new and costly facilities for nitrification may not be required. Notwithstanding that the City believes that the limits established by Manitoba Conservation are overly stringent, I am please to advise that the City made the appropriate process adjustments and fully complied with the ammonia limit each and every day for the month of August, 2009. Note that the ammonia limit set for August is the lowest and most stringent of all the calendar months. Based on this successful full-scale ammonia removal demonstration, we are confident that we can maintain compliance with the ammonia limits for the whole year with our existing facility at the NEWPCC. As such, there is no need to build additional and costly facilities to treat ammonia to the limits specified in the Licence for the NEWPCC.

As noted, even without the nitrogen reduction requirements, the estimated cost to the City of Winnipeg to comply with the Environment Act Licences limits for phosphorus and ammonia is about $250 million. Unless the Licence requirements are amended, up to $350 million will have to be spent on meeting the nitrogen reduction requirements. The City cannot ask its water and sewer ratepayers to shoulder the burden of this extraordinarily high cost, especially when there is very convincing scientific evidence that says it will have no positive impact on resolving the problem. In my opinion, it is not financially or environmentally prudent to spend the extra $350 million.

Obviously, this issue is of critical importance to Winnipeg residents and we strongly urge Manitoba Conservation to reconsider the Licence requirement on nitrogen reduction. If the Province does not change their position, we have an obligation to share this issue with our residents.

I respectfully request that you consider the City's position and let me know how you wish to proceed. A response is respectfully requested by October 14, 2009.

Yours sincerely,

Sam Katz

Sam Katz
MAYOR

cc The Honourable Gary Doer, Premier
The Honourable Christine Melnick, Minister of Water Stewardship
All Council Members of The City of Winnipeg
Mr. Glen Laubenstein, Chief Administrative Officer, The City of Winnipeg
Mr. Barry MacBride, Director of Water & Waste, The City of Winnipeg

Appendix 4: Poster

To support the City of Winnipeg appeal, the Mayor's letter included a poster done by a City engineer and others.

The poster stated the following Objectives:

● To show the disconnect between protecting the aquatic environment and the drive to reach increasingly lower effluent nitrate-nitrogen limits.

● Demonstrate that the use of the Precautionary Principle to define treatment plant upgrades:

- Conflicts with sound scientific information;
- Results in huge costs;
- Increases carbon footprint.

● Case study of Lake Winnipeg and Winnipeg's North End plant:

- Removal of NO3 (nitrate) may in fact promote blooms of cyanobacteria in Lake Winnipeg;
- Show the impact of deep nitrate removal on Winnipeg's North End plant upgrade costs.

None of these premises stands up to careful scrutiny.

1) In respect of the "disconnect between protecting the aquatic environment" and reducing nitrogen, the poster offers as support a quotation from a letter to the Clean Environment Commission from 63 scientists, which stated:

Removing nitrogen will at best do nothing, and at worst, increase the dominance of the filamentous nitrogen fixing cyanobacteria.

The Commission notes that there is great deal of current scientific literature available that does not appear to convey the strong consensus view inferred by the City. Furthermore, the Commission considers that this is only one aspect of the aquatic environment the Manitoba Government is charged with protecting. Elsewhere in this report we discuss other environmental concerns posed by nitrogen in our waters.

2. In the 2009 report, the Commission recommended use of the Precautionary Principle in two instances. (This is discussed in detail in Appendix 2.)

In no case does the Commission's recommended use of the Precautionary Principle conflict with "sound science", nor does it involve "huge costs".

The whole premise of the Precautionary Principle is: "When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically." The Commission's 2009 report shows that this is the case in the recommended courses of action.

The Precautionary Principle is accepted universally.

3. As noted elsewhere in this report, there is significant, recent scientific evidence which would, at the very least, minimize, if not negate the claim that the removal of nitrogen

may promote blooms of nitrogen-fixing cyanobacteria in Lake Winnipeg.

Conclusion

The creators of this poster have failed to consider the full scientific record. Recent scientific reviews have come to differing conclusions in respect of the potential, long-term impacts of nitrogen on the environment, as well as the contribution of nitrogen fixation to the long-term nitrogen balance.

Environmentally Sensible Effluent Nitrogen Limits

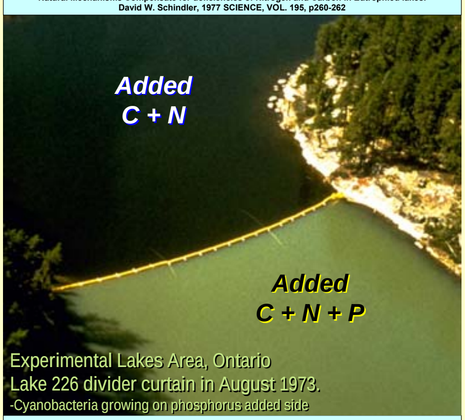
N. Szoke, D. Celmer - City of Winnipeg, Water and Waste Dept., 1199 Pacific Ave., Winnipeg, MB, Canada, R3E 3S8 (nszoke@winnipeg.ca)
J. Oleszkiewicz, Q. Yuan – Department of Civil Engineering; University of Manitoba, 15 Gillson St., EITC Bldg E1-368, Winnipeg, MB, Canada, R3T 5V6
M. Stainton M. Paterson, L. Lockhart (retired) - Fisheries and Oceans Canada, Freshwater Institute, 501 University Cres., Winnipeg, MB, Canada, R3T 2N6
D. Schindler - Killam Memorial Chair and Professor of Ecology at the University of Alberta, Edmonton. Dept. of Biological Sciences, University of Alberta, Edmonton, AB, Canada, T6G 2E9

Objectives

- To show the disconnect between protecting the aquatic environment and the drive to reach increasingly lower effluent Nitrate Nitrogen limits
- Demonstrate that the use of the Precautionary Principle to define treatment plant upgrades:
  - Conflicts with sound scientific information;
  - Results in huge costs;
  - Increases carbon foot print.
- Case study of Lake Winnipeg and Winnipeg's North End plant:
  - Removal of NO_3 may in fact promote blooms of cyanobacteria in Lake Winnipeg
  - Show the impact of deep nitrate removal on Winnipeg's North End plant upgrade costs

Evolution of Phosphorus Limitation in Lakes

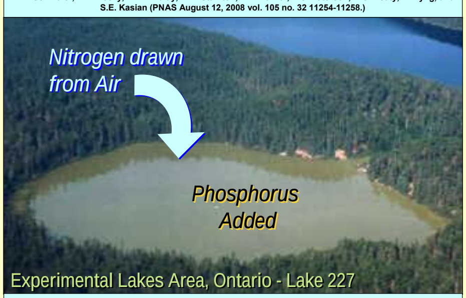
Natural Mechanisms Compensate for deficiencies of Nitrogen and Carbon in Eutrophied lakes.
David W. Schindler, 1977 SCIENCE, VOL. 195, p260-262



- Whole lake experiment undertaken to understand the algal response to Carbon (C), Nitrogen (N) and Phosphorus (P) additions
- Agreement that phytoplankton growth limited by P supply
- Controlling N input to lakes may adversely affect water quality, low N:P ratios favor cyanobacteria

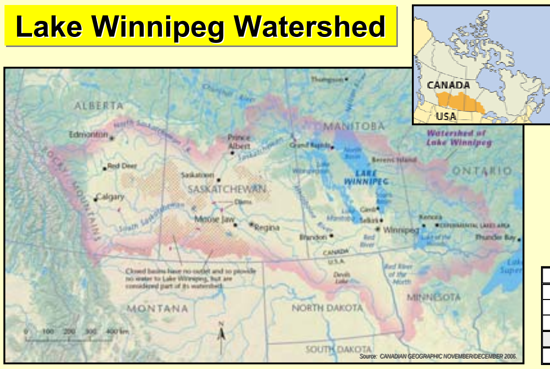
Eutrophication of lakes cannot be controlled by reducing nitrogen input: Results of a 37-year whole-ecosystem experiment

D.W. Schindler, R.E. Hecky, D.L. Findlay, M.P. Stainton, B.R. Parker, M.J. Paterson, K.G. Beaty, M. Lyng, and S.E. Kasian (PNAS August 12, 2008 vol. 105 no. 32 11254-11258.)



- Fertilized for 37 years to test the theory that controlling N inputs can control eutrophication
  - Constant annual inputs of P, and
  - Decreasing inputs of N
- Reducing N favored cyanobacteria growth
- Biomass produced was in proportion to P
  - Cyanobacteria can draw requisite N from air.
- Focus must be on reducing P, not N to reduce eutrophication

Lake Winnipeg Watershed

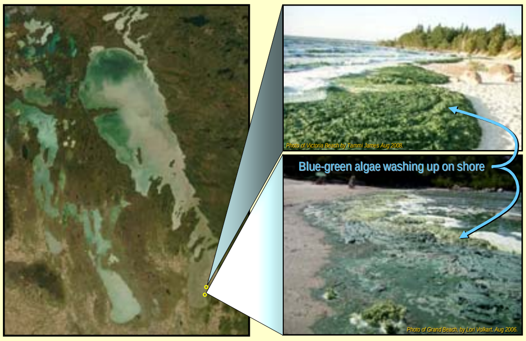


Lake Winnipeg Facts:

- 2nd largest watershed in Canada
  - Land area ~ 1,000,000 km^2
  - Lake area ~ 24,500 km^2
- Within the watershed
  - 6.6 million people
  - 210 million P.E. (livestock)

Inputs to Lake Winnipeg (Tonnes/year)

Sources	Total Nitrogen		Total Phosphorus	
Non-Point	71,100	74.1%	6,500	81.3%
Points	6,000	6.3%	1,000	12.5%
Other	18,800	19.6%	500	6.3%
Total	**95,900**	**100%**	**8,000**	**100%**
North End Plant	***2,300***	***2.4%***	***310***	***3.9%***



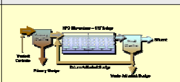
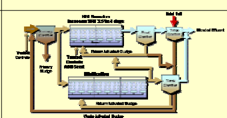
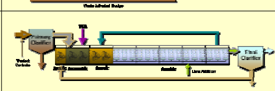
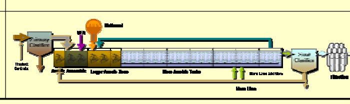
Nitrate Removal Not Beneficial to Lake Winnipeg

- 63 prominent scientists wrote to the Manitoba Clean Environment Commission.
  - *"Removing nitrogen will at best do nothing, and at worst, increase the dominance of the filamentous nitrogen-fixing cyanobacteria."*

Manitoba Clean Environment Commission Chose to Rely on Precautionary Principle

- P discharges from Winnipeg's wastewater plants should be as low as possible:
  - ≤ 1.0 mg/L total P, (30-day rolling average)
  - Operating goal ≤ 0.5 mg/L total P
- N discharges from Winnipeg's wastewater plants should be:
  - ≤ 15 mg/L total N (30-day rolling average)
  - N:P to be maintained at 15:1
- Implication: At 0.5 mg P/L and 1:15 ratio requires 7.5 mg N/L in effluent
- Insufficient carbon in influent to reach an operating N limit of 7.5 mg/L
  - Forces LoT Upgrades
  - Requires external carbon source, e.g., methanol

Cost for North End Plant Upgrades (BioWin, CAD$), Q = 224 ML/d

Option and Description	Process Schematic	Effluent Performance Targets (mg/L)	Capital Cost (Million)	Future Cost 20 yrs @ 6 % (Millions)
Centrate N and P Removal No Change to Main Plant		TP ~ 3.0 NH_3 ~ 17 TN ~ 25	$ 30	$ 85
Bioaugmentation, Increase Main Plant SRT, Split stream Partial Nitrification, Chem. P		TP ≤ 1.0 NH_3 ≤ 3.0 TN ~ 25	$ 130	$ 350
BNR Main Plant		TP ≤ 1.0 NH_3 ≤ 3.0 TN ≤ 15	$ 430	$ 1100
LoT – BNR Main Plant		TP ≤ 0.3 NH_3 ≤ 1.0 TN ≤ 5.0	$ 730	$ 1500

Conclusions

1. Removing nitrates to low levels is not required to protect Lake Winnipeg.
2. Removal of nitrates can encourage the growth of cyanobacteria
3. Use of precautionary principle may negate science, increase costs, and increase carbon footprint.
4. Additional cost (20-years) to reduce North End plant's total N contribution to Lake Winnipeg:
   - 1.3 % reduction to Lake ~ $0.7 billion to achieve TP ≤ 1.0 and TN ≤ 15
   - 2.1 % reduction to Lake ~ $1.2 billion to achieve TP ≤ 0.3 and TN ≤ 5.0