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Development of a Nutrient Management Strategy for Surface Waters in Southern Manitoba

Foreword

One of the greatest challenges facing water quality managers in the prairie and southern portion of the boreal forest regions of Canada and the northern United States is to better understand and to control, where necessary, the introduction of plant nutrients into surface waters. Prairie soils tend to be naturally rich in nitrogen and phosphorus, streams may be turbid thus limiting light penetration, and phosphorus - the nutrient most easily controlled from point-source discharges - may not be the factor that limits algal growth in many prairie water bodies. Eutrophication of surface waters is a scientifically complex process and nutrient management options can be difficult and costly to implement.

The purpose of this draft document is to outline the main tasks and issues that need to be considered and addressed as a nutrient management strategy is developed and implemented. Your comments and suggestions on the attached draft are welcomed as we proceed to develop and to implement a nutrient management strategy.

Please forward comments on the attached draft by June 30, 2000 to the following:

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Introduction

Eutrophication is one of the most important water quality issues in the prairie and boreal plain ecozones in western Canada. Water quality monitoring results indicate that most of the large river systems that flow across the prairie and boreal plain ecozones contain relatively high concentrations of phosphorus and nitrogen, the two nutrients most commonly associated with eutrophication. The main factors that may contribute to the high nutrient content in these systems include erosion of naturally fertile soils, surface run-off of fertilizers from cultivated fields, run-off from livestock pasture and feedlots, urban run-off and storm sewer discharges, and agricultural, industrial, and urban sewage effluent discharges. Some of the larger river systems that are of particular concern to southern Manitoba include the Assiniboine, Souris, and Red River systems, all of which carry significant amounts of nutrients into the province from the west and south.

Concerns have been raised over the potential for eutrophication processes to not only negatively impact rivers and streams that flow through the region, but also adversely affect the water quality of Lake Winnipeg, since the lake is the eventual recipient of the nutrient load transported by many of these rivers and streams.

Nutrient enrichment can directly or indirectly impact the water quality of surface waters. An overabundance of nutrients can lead to excessive growth of algae and macrophytes within an aquatic system, which can greatly alter the overall structure of the ecosystem by favouring the growth of opportunistic species, resulting in an overall decrease in biological diversity across the entire ecosystem. As well, the decay process that follows the decline or die-off of algal and macrophyte populations uses up large amounts of dissolved oxygen. This can have serious consequences on aquatic animals, such as fish and invertebrates, which rely on an adequate supply of dissolved oxygen for survival. Low oxygen concentrations also result in the release of the nutrient phosphorus from the sediment, making it available for algal growth. Eutrophication may also decrease the suitability of a water supply for domestic use (including human drinking), livestock watering, and recreational use. Algal blooms associated with eutrophic waters are often dominated by species of blue-green algae, some of which are known producers of potent nerve and liver toxins. Such a situation can present a health risk for humans, household pets, and livestock that drink the water, and for people who use the water for recreational purposes. There is also some evidence that the toxins produced by blue-greens may be transferred up the food web, and may adversely affect wildlife populations such as fish and water birds. Besides being potentially toxic, the presence of an algal bloom in a drinking water source can clog treatment plant filters, and often imparts an unsightly appearance, and unpleasant taste and odour to the finished water. Algal blooms and extensive macrophyte growth are also considered aesthetically unappealing and can detract from the recreational use of a surface water.

The water quality problems that arise as a result of eutrophication of drinking and recreational waters are difficult and expensive to remedy. For drinking water sources the cost of additional treatment may be prohibitive in many jurisdictions, while for recreational waterbodies, a decline in the aesthetic quality of the water can adversely affect tourism, and lead to decreased land and cottage values.

Nutrient enrichment has long been recognized as a major water quality issue. Many important steps have been implemented in Manitoba and elsewhere to better understand and to implement appropriate and feasible control options. Water quality objectives were first developed for phosphorus in the mid-1970s in many jurisdictions in North America, but were largely focussed on preventing eutrophication of lakes. These approaches have been used in a number of cases in Manitoba, particularly for bodies of water known to be sensitive to nutrient addition. For example, in several cases municipal and agricultural effluents are used for irrigation purposes on either growing crops or parklands as an alternative to direct discharge to streams or rivers, some effluents are discharged to wetlands or constructed wetlands, and phosphorus-removal technologies are used in at least one other case. Adoption of the recent Livestock Manure and Mortality Management Regulation requires the application of manure as a fertilizer at agronomic rates. In addition, many local stewardship groups and Conservation Districts are promoting the restoration of wetlands and protective riparian zones as a means of both preserving habitat and intercepting runoff from agricultural lands.

However, despite these efforts in Manitoba and similar efforts elsewhere, eutrophication remains an important water quality issue. This has prompted many agencies to begin to develop new nutrient management strategies or approaches aimed at controlling excessive inputs of nutrients to surface waters. The Water Quality Management Section of Manitoba Conservation has responded to the nutrient enrichment issue by identifying the need for the development of a long-term nutrient management strategy for the province and to begin work towards this strategy.

The purpose of this document is to identify the main challenges, tasks, and issues that will have to be considered in the development of a nutrient management strategy for waterways in southern Manitoba. The Water Quality Management Section has already begun to address many of the items outlined below, and will continue to build-on and refine these subject areas as more water quality data is collected and as information from similar work being carried out in other jurisdictions becomes available.

Item 1 – Eutrophication in Southern Manitoba

An important first task in the development of a nutrient management strategy for southern Manitoba is to gather background information on the current nutrient status of waterways in the region. This task will require the following activities:

A. Review and compare existing water quality guidelines/objectives/criteria for nutrient related variables (phosphorus, nitrogen, chlorophyll-*a*, and turbidity) in Manitoba and elsewhere.

B. Conduct a search of the Water Quality Management Section database for data on the nutrient related variables phosphorus (including total, dissolved, and ortho-phosphorus), nitrogen (including ammonia, nitrate-nitrite, and total Kjeldahl nitrogen), chlorophyll-*a*, and turbidity in samples collected from water quality monitoring stations in rivers and streams in Manitoba.

C. Extract, summarize and interpret the data to determine levels of exceedence above existing objectives and to identify any spatial and temporal trends in the data. It is important to understand whether key nutrients are changing with time.

D. Identify gaps in the existing database.

   1. Identify any nutrient related variables that may be useful in describing the nutrient status and degree of eutrophication within a river or stream and that are currently lacking or insufficiently represented in the database.

   2. Develop a sampling plan to remedy data gaps. This involves creating a list of core variables for analysis and prioritizing which stations to sample and where to add new stations if required.

Item 2 - Derive Numeric Objectives for Nutrient Variables

Results from preliminary work on some of the issues in Item 1 indicate that the current Manitoba Surface Water Quality Objectives and objectives in place elsewhere in the prairies for nutrients are inadequate. Because of this, the derivation of new numeric objectives for nutrient variables is one of the first challenges in the development of a nutrient management strategy for southern Manitoba. Numeric objectives, as opposed to narrative objectives, are important in controlling eutrophication because they allow water quality managers to make informed, scientifically defensible decisions with regard to regulating nutrient inputs to surface waters.

Two approaches to deriving numeric nutrient objectives will be used simultaneously. These are: (1) Regional Based Objectives and (2) Objectives Based on Receiving Waters.

(1) Regional Based Objectives

The chemical and physical characteristics of a waterway are determined in large part by the features of its drainage basin or watershed. Topography, natural vegetation cover, land-use practices, climate, geology, and soil type can vary considerably between watersheds, and as a result, no two waterways are exactly the same in terms of flow regime, physical characteristics, and water chemistry. The growth of algae and macrophytes is dependent in large part on the availability of phosphorus and nitrogen. However, primary productivity in streams is also influenced by light exposure, temperature, water clarity, flow regime, grazing, the presence of toxic pollutants, and micro-nutrient concentrations, all of which vary between waterways.

Given the considerable variation that exists between aquatic systems, it is unrealistic that a single numeric objective for each nutrient variable could be applicable to all the rivers and streams in southern Manitoba. It is apparent that more site-specific objectives are required. Although the establishment of nutrient objectives for individual waterways is impractical at this time, it is reasonable to consider deriving nutrient objectives at a regional scale.

Regional boundaries for regionally-based nutrient objectives can be based on ecological units such as ecozones or ecoregions, or on drainage units such as drainage basins or watersheds. The scale at which the regional boundaries are set is dependent on the level of environmental variability that is deemed acceptable, and the amount of the resources that can be devoted to the derivation process.

Once regional boundaries are established the process of developing nutrient objectives for the regions can proceed. Major tasks to undertake in the development of regional nutrient objectives include:

A. Identify the major problems associated with eutrophication within each region and prioritize which regions and waterways require the most immediate attention.

B. Identify core variables used to assess eutrophication in southern Manitoba (these are the variables for which objectives will be established).

C. Develop focused monitoring programs or studies, if required, to better define the relationship between nutrients and primary productivity and to identify any temporal or spatial trends in rivers within each region.

D. Identify reference streams or reaches that represent ambient of non-impacted conditions within each region.

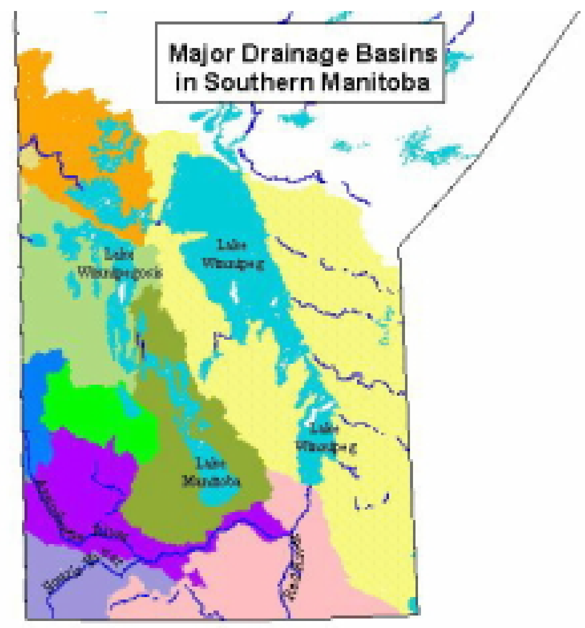
E. Analyze the data using acceptable statistical methods and empirical and simulation models to identify relationships between nutrient concentrations and primary productivity. Nutrient objectives have to be scientifically defensible; otherwise they will be of little value when it comes to managing and regulating nutrient inputs to streams and rivers from point and non-point sources.

F. Derive nutrient objectives based on the results of the statistical analysis and modelling work.

The derivation of the nutrient objective values can take one or more of the following approaches.

- Objectives may be derived on the basis of information obtained from reference stream conditions within each region.
- Objectives can be established at levels based on predictive relationships between nutrient concentrations and acceptable levels of primary productivity. (This approach should consider different water use objectives - acceptable levels of algae may differ depending on water use within the stream/river).
- Establish nutrient objectives based on recommendations in the scientific literature and on existing objectives and guidelines derived for other jurisdictions in Canada, the United States, and elsewhere.

G. Continue to support work being conducted elsewhere in the prairies, and in particular, eutrophication studies being undertaken by the Committee on Water Quality of the Prairie Provinces Water Board.



(2) Objectives Based on Receiving Waters

This approach involves developing objectives for waterways based on the effects that stream nutrient loads have on the lakes and reservoirs into which they enter.

Lake Winnipeg is the recipient of much of the drainage in the southern half of Manitoba. Since most of the waterways that flow into the lake carry significant amounts of nutrient, with eutrophication in the southern basin of the lake perhaps approaching conditions observed in Lake Erie in the past century (Wood 1999). It is possible to reverse or halt this process by developing nutrient objectives for streams which enter the lake that are based on the carrying capacity of the lake itself. In doing so the water quality of the lake and possibly the water quality of waterways upstream of the lake will be protected.

The derivation of nutrient objectives for surface waters in southern Manitoba based on the water quality and carrying capacity of Lake Winnipeg will require extensive studies and data collection, and detailed statistical analysis and modelling. The major steps in the process include:

A. Determine the carrying capacity of Lake Winnipeg.

B. Determine the amount of external nutrient loading that is contributed by rivers and streams that flow into the lake.

C. Determine the maximum acceptable nutrient concentrations for streams entering lake Winnipeg. This will be based both on the carrying capacity of the lake and the relative contribution of each stream to the total nutrient loading to the lake.

D. Develop nutrient objectives for rivers and streams entering the lake, keeping in mind that the objectives have to protect the water quality of the receiving water, as well as the water quality and water uses of the watercourse upstream of the lake.

Item 3: Managing Nutrient Sources

Some jurisdictions have already developed, or are in the process of developing a watershed (or drainage basin) based approach to nutrient management. The watershed approach involves first identifying all of the inputs to the river system within a basin or watershed, followed by the development and implementation of strategies aimed at reducing these inputs. The watershed or basin management approach is often multi-disciplinary and requires the cooperation of all stakeholders within the watershed. The approach is in keeping with the overall movement towards a more holistic, ecosystem-based approach to environmental management.

Nutrient sources that are discrete observable discharges are called point sources, while sources that are more diffuse and more difficult to quantify are called non-point sources.

Control of Nutrient Loading from Point Sources

Point sources of nutrients in southern Manitoba include wastewater treatment lagoon discharges, sewage and wastewater treatment plant discharges, urban storm water drains, and channelled run-off associated with large livestock operations. Issues and actions to consider in the control of nutrient inputs from point sources include:

A. All point sources of nutrients have to be identified and any information/data about nutrient loading from these point sources has to be gathered. This information can then be analyzed/modelled along with existing stream nutrient and flow data to ensure compliance with the nutrient objectives of the stream.

B. In cases where non-compliance occurs, nutrient control measures such as tertiary treatment (e.g. constructed wetlands) or nutrient reduction technology (e.g. alum applications) may have to be considered.

C. In the case of streams that have multiple point sources, the sources will be encouraged to coordinate their discharges in such a way as to ensure that stream nutrient objectives are not exceeded and water use is not compromised during discharge periods.

D. Point source discharges may have to be relocated to minimize negative impacts to the waterway and to water uses along the waterway.

E. Education awareness campaigns may need to be initiated that are aimed at reducing nutrient inputs in domestic and industrial wastewater.

Control of Nutrient Loading from Non-point Sources

Non-point source loading refers to nutrient loading from land surface run-off across a watershed or catchment basin. Non-point sources of nutrients in southern Manitoba include surface water runoff from urban areas, fertilized fields, pastures, and livestock holding areas. Run-off from non-fertilized lands can also be considered a non-point source of nutrients simply because of the naturally high soil fertility in some parts of southern Manitoba. Other non-point sources of nutrients include atmospheric deposition and groundwater seepage.

In general, nutrient inputs to a waterway from non-point sources tend to be extremely variable, intermittent, and difficult to predict and control. This makes assessing their contribution to the eutrophication of a given waterway much more difficult to ascertain. Some management practices that help to control non-point source loading of nutrients to waterways include:

A. Control of runoff waters and soil erosion from agricultural and urban areas through improved methods of landscaping.

B. Use of precision farming practices to limit the amount of excess chemical fertilizers and manure applied to cultivated land.

C. Preservation or re-establishment of riparian vegetation along waterways.

D. Restricted access of cattle and other livestock to waterways.

E. Increased awareness of eutrophication in rural areas with emphasis on the need to change or alter farming practices.

F. Increased cooperation, communication, and education between government (all levels), producers, conservation groups, and other concerned parties.

Item 4 – Develop a Geographic Information System (GIS) for the Nutrient Management Strategy

The development of a GIS is an important component of the nutrient management strategy. A GIS allows one to create customized maps with geo-referenced data. Using the GIS will allow water quality data to be displayed, interpreted, and modeled on a geographic scale (spatial analysis). This will help facilitate better decision making on the part of water managers and better communication of the data and management plans to regulators, elected officials, and the general public.

All point sources that discharge to water (licensed or otherwise), associated data, and ambient water quality data, should be included in the GIS. This information will be gleaned from Environment Act Licences, client files, the Water Quality Management Section database, and historical records, and by conferring directly with Department staff in the Municipal and Industrial Approvals Section and in the regional offices.

Item 5 – Other Issues and Considerations

Other issues and items to consider in the development of a nutrient management strategy include:

A. Public perceptions of water quality can differ significantly from place to place such that the levels of primary productivity that are considered tolerable in one locale may be regarded as overly excessive in another locale.

B. Establishing objectives for nutrients with the goal of keeping algal and macrophyte growth below "nuisance" levels for aesthetic reasons may not adequately protect aquatic life, preserve ecosystem structure, or limit blue-green algae toxin production. Because of this, the development of nutrient objectives will also have to consider the various types of water usage.

C. Chemical and physical features may vary considerably between reaches along the same waterway. This is particularly true for some of the large rivers in the province and may necessitate the division of such waterways into segments with each segment having its own set of nutrient objectives.

D. Many of the rivers and streams in southern Manitoba originate from outside of the province. As such, a nutrient strategy for southern Manitoba will have to seek some level of inter-provincial and international co-operation and input.

Schedule of Activities (tentative)

The steps required to derive nutrient objectives and develop a nutrient management plan are quite complex and will require a significant commitment of time and energy from those involved in the process. The following is a tentative schedule of activities geared towards the development of a nutrient management strategy that will be undertaken over the next three years.

- Finalize outline of Nutrient Management Strategy: July 2000
- Review and report of WQMS database and develop list of core variables for monitoring: September - April 2000
- Begin development of a carrying-capacity model for Lake Winnipeg: January 2000 - June 2000
- Develop monitoring plan for sampling during 2000 growing season (May – October): May 2000
- Develop a GIS for the nutrient strategy: September 1999 – on-going

- Explore nutrient objective derivation options in greater detail and decide on appropriate methods based on data interpretation, GIS and statistical analysis, research in the literature, methods used in other jurisdictions, and in consultation with professional colleagues, conservation groups, stakeholders, and other interested parties: May 2000 – December 2000.

- Explore management options (through research and consultation) that can be used to help reduce inputs of nutrients to surface waters: May 2000 - ongoing

- Continue to establish and run focused monitoring programs to collect data (where lacking) to be used in the development of nutrient objectives: January 2001 - future

- Establish nutrient objectives: 2002 –2003

- Using the objectives as a guide, develop and implement a nutrient management plan. The plan should emphasize the nutrient abatement options that are available to nutrient discharges and run-off to surface waters, but should also include a set of regulations to encourage compliance with the nutrient objectives and the management plan.

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