Lakeshore Capacity Assessment Handbook

Protecting Water Quality in Inland Lakes on Ontario's Precambrian Shield

Consultation Draft
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Ministry of the Environment
Ministry of Natural Resources
Ministry of Municipal Affairs and Housing

Ontario

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Preface

This ***Lakeshore Capacity Assessment Handbook*** has been prepared by the Ministry of the Environment in partnership with the ministries of Natural Resources and Municipal Affairs and Housing. It was developed to provide guidance to municipalities and other stakeholders involved in the development of Ontario's inland lakes. While municipalities aren't required to carry out lakeshore capacity assessment, this planning tool is strongly recommended by the Ontario government as an effective way of complying with the *Planning Act*, the Provincial Policy Statement (2005), the *Ontario Water Resources Act* and the federal *Fisheries Act*.

This document is based on the scientific understanding and the government policies in place at the time of publication. Questions about planning issues should be directed to the Ministry of Municipal Affairs and Housing. Scientific or technical questions dealing with water quality should be directed to the Ministry of the Environment. Questions concerning fisheries should be directed to the Ministry of Natural Resources.

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Executive summary

Purpose

This handbook has been prepared by the Ministry of the Environment in partnership with the Ministries of Natural Resources and Municipal Affairs and Housing to guide municipalities carrying out lakeshore capacity assessment on inland lakes on Ontario's Precambrian Shield.

About lakeshore capacity assessment

Lakeshore capacity assessment is a planning tool that can be used to control the amount of one key pollutant — phosphorus — entering inland lakes on the Precambrian Shield by controlling residential shoreline development. High levels of phosphorus in lake water will promote eutrophication — excessive plant and algae growth, resulting in a loss of water clarity, depletion of dissolved oxygen and a loss of habitat for species of coldwater fish such as lake trout. While shoreline clearing, fertilizer use, erosion and overland runoff can all contribute phosphorus to an inland lake, the primary human sources of phosphorus are septic systems — from cottages, year-round residences, camps and other recreational facilities. Lakeshore capacity assessment can be used to predict how much of this residential shoreline development an inland lake on the Precambrian Shield can sustain without exhibiting any adverse effects related to high phosphorus levels.

It should be emphasized that lakeshore capacity assessment addresses only some aspects of water quality — phosphorus, dissolved oxygen and lake trout habitat. Municipalities and lake planners also need to consider other pollutants (such as mercury, bacteria and petroleum products) and other sources of pollution (including industries, agriculture and boats). It must also be emphasized that water quality isn't the only important factor that should be considered in determining the development capacity of lakes. Factors such as soils, topography, hazard lands, crowding and boating limits may be as or more important than water quality. Finally, it's important to emphasize that, to be effective, the technical process of carrying out lakeshore capacity assessment must be followed by implementation — in other words, the information obtained must be incorporated into municipal official plans and policies.

Benefits of lakeshore capacity assessment

Use of lakeshore capacity assessment by municipalities (along with proactive land-use controls) and enforcement of water-related regulations and bylaws will help to ensure that the quality of water in Ontario's inland lakes is preserved. Protection of water quality will also protect environmental, recreational, economic and property values.

Lakeshore capacity assessment enhances the effectiveness of the land-use development process in many ways:

- It incorporates the concept of ecosystem sustainability in the planning process
- It's consistent with watershed planning
- It promotes land-use decisions that are based on sound planning principles
- It addresses many relevant aspects of the new Provincial Policy Statement, which came into effect on March 1, 2005. The Provincial Policy Statement is issued under section 3 of the *Planning Act*.
- It encourages land-use decisions that maintain or enhance water quality
- It encourages a clear, coordinated and scientifically sound approach that should reduce conflict among stakeholder groups

- It encourages a consistent approach to lakeshore capacity assessment across the province
- It's cost effective

The net effect of lakeshore capacity assessment will likely be to shift development from lakes that are already well developed to those that are less developed.

Carrying out lakeshore capacity assessment

A lake's capacity for development is assessed with the Lakeshore Capacity Model. The model, first developed in 1975, quantifies linkages between natural sources of phosphorus to a lake, human contributions of phosphorus from shoreline development, water balance, the size and shape of a lake and the resultant phosphorus concentrations. The model uses a number of assumptions about phosphorus loading, phosphorus retention and usage figures.

The model allows the user to calculate how the quality of water in a lake will change in response to the addition or removal of shoreline development such as cottages, permanent homes and resorts. It predicts important indicators of water quality: total phosphorus concentration, volume of lake trout habitat and dissolved oxygen concentration in bottom waters at the critical end-of-summer period. The model can be used to calculate predevelopment conditions in a lake, how much development can be added (in terms of the number of lots) without altering water quality beyond a given endpoint, and the difference between current conditions and that endpoint.

Land use planning application and best management practices

Best management practices (BMPs) are planning, design and operational procedures that reduce the migration of phosphorus to water bodies, thereby reducing the effects of development on water quality. These BMPs apply to all lots, vacant or developed.

Increasing the setback of septic systems from shorelines increases the potential for phosphorus attenuation by soils. Maintaining shoreline vegetation, installing vegetative buffers and minimizing the amount of exposed soil also helps to reduce phosphorus loading — that is, the amount of phosphorus entering a body of water. Septic systems should use a tile bed that retains phosphorus well. Use of a siphon or pump to distribute septic tank effluents to the tile bed can also reduce phosphorus loading. Moreover, phosphorus loadings from septic systems can be reduced by avoiding the use of septic starters, ensuring that all sewage waste goes into the septic tank, pumping the tank out every three to five years and reducing water use.

Monitoring water quality

The predictions made by the Lakeshore Capacity Model should be validated by monitoring the quality of water in a lake. Water quality measurements may include total phosphorus, chlorophyll *a*, water clarity and dissolved oxygen. The Ministry of the Environment's Lake Partner Program can help municipalities fulfil their monitoring requirements. Through partnerships with other agencies and a network of volunteers, the program currently collects water quality samples from more than 1,000 locations across the province.

1.0 INTRODUCTION TO LAKESHORE CAPACITY ASSESSMENT

1.1 Purpose of the handbook

For many people, the image of Ontario is synonymous with the image of our northern lakes. When they think of our province, they think of anglers casting for walleye in the early morning mist, children leaping from docks into clear, sparkling waters and the rugged, tree-lined shores made famous by the Group of Seven. There are more than 250,000 inland lakes that dot the granite of Ontario's Precambrian Shield and these are an invaluable legacy for the residents of the province. Some people experience their beauty year round, as residents. Others return every summer — some of them travelling great distances — for canoe tripping, fishing, cottaging, or to experience the solitude and the spiritual renewal that can be realized in these spectacular natural settings.

This handbook has been prepared as a tool to help protect the quality of water in Ontario's Precambrian Shield lakes by preventing excessive development along their shores. It has been developed by the Ministry of the Environment (MOE) in partnership with the Ministry of Natural Resources (MNR) and the Ministry of Municipal Affairs and Housing (MMAH) with input from a diverse group of stakeholders. The advice in this handbook is intended for municipalities on the Precambrian Shield that have inland lakes within their boundaries. As such, it will be most useful to municipal planners, technical staff and consultants working on water quality in inland lakes. Nevertheless, cottagers' associations, residents living on lakes, conservation authorities and proponents of development should also find it informative.

The *Lakeshore Capacity Assessment Handbook* is a guide and resource for municipalities. Lakeshore capacity assessment will help municipalities meet their obligation under the *Planning Act* to be consistent with the water, fish habitat and natural heritage policies of the Provincial Policy Statement (2005).

This handbook also incorporates a revised provincial water quality objective for phosphorus, and references a dissolved oxygen criterion developed by the Ministry of Natural Resources to protect lake trout habitat in inland lakes on the Precambrian Shield.

The handbook will become the basis for training resource managers in municipalities, the private sector and within MOE, MNR and MMAH. This will help to ensure consistent use and interpretation of lakeshore capacity assessment policies, the Lakeshore Capacity Model and its assumptions.

Outline of the handbook

The *Lakeshore Capacity Assessment Handbook* is organized so that more general material is presented at the beginning of the handbook and an increasing level of detail is found as one proceeds through it. The early sections are therefore suitable for general audiences, while the later chapters are targeted at more technical audiences. The greatest level of detail is found in the appendices.

Section 1.0: Provides an introduction to lakeshore capacity assessment and outlines why it's needed, what it will achieve, and what effect it will have on future lake development in the province.

Section 2.0: Examines the relationship between phosphorus, dissolved oxygen and water quality. It outlines the rationale for and approach used in the revised provincial water quality objective for phosphorus and contains a brief description of the dissolved oxygen criterion for the protection of lake trout habitat.

Section 3.0: Presents the basics of lakeshore capacity assessment. This includes a discussion on where it may be applicable, when it should be considered, what it will tell the user and what is needed to carry it out.

Section 4.0: Presents more detail on lakeshore capacity assessment and outlines how to apply the Lakeshore Capacity Model, the recommended provincial assessment tool for lakeshore capacity planning. It also addresses the updated and standardized technical assumptions used in the model, the steps involved in running it and the expected results.

Section 5.0: Provides a brief overview of land use planning application and best management practices, what they can achieve and why they're useful to municipalities (or residents' and cottagers' associations) for protecting lake water quality. It also briefly addresses phosphorus abatement technologies.

Section 6.0: Focuses on monitoring water quality: why it's important, what to monitor and how to do it. It also provides an overview of MOE's Lake Partner Program.

Section 7.0: A brief conclusion.

The appendices to the handbook contain the rationale for a revised provincial water quality objective for phosphorus for Ontario's inland lakes on the Precambrian Shield, a list of resources, and MOE technical bulletins on water quality monitoring.

1.2 What is lakeshore capacity assessment?

At its simplest, lakeshore capacity assessment is a planning tool that is used to predict how much development can take place on inland lakes on the Precambrian Shield (**Figure 1**) without impairing water quality (i.e., by affecting levels of phosphorus and dissolved oxygen). Development is defined as any activity which, through the creation of additional lots or units or through changes in land and water use, has the potential to adversely affect water quality and aquatic habitat. Development includes the addition of permanent residences, cottages, resorts, trailer parks, campgrounds and camps.

Figure 1. Ontario's Precambrian Shield (shaded area)

Lakeshore capacity assessment can be used in two major ways:

1. To determine the maximum allowable development (in terms of number of lots) that can occur on a lake without degrading water quality past a defined point.
2. To predict the expected effect of future development.

The goals of lakeshore capacity assessment are to help maintain the quality of water in recreational inland lakes and to protect coldwater fish habitat by keeping changes in the nutrient status of inland lakes within acceptable limits. Lakeshore capacity assessment can be carried out on any inland lake on the Precambrian Shield, although its accuracy decreases for lakes that don't stratify during the summer months (i.e., shallow lakes).

The goals of lakeshore capacity assessment are to help maintain the quality of water in recreational inland lakes and to protect coldwater fish habitat by keeping changes in the nutrient status of inland lakes within acceptable limits.

Lakeshore capacity assessment is based on controlling the amount of one key pollutant — phosphorus — entering a lake by controlling residential shoreline development. Phosphorus is a nutrient that affects the growth of algae and aquatic plants. Excessive phosphorus can lead to excessive algal and plant growth, which in turn leads to unsightly algal blooms, depletion of dissolved oxygen and loss of habitat for coldwater fish such as lake trout — a process known as eutrophication.

As outlined in Section 2.0, phosphorus comes from both natural and human sources. In the absence of urban drainage or point sources such as sewage treatment plants, the primary human sources of phosphorus to Ontario's Precambrian Shield lakes are septic systems from houses and cottages. Shoreline clearing, fertilizer use, erosion and overland runoff can also be important sources of phosphorus to inland lakes. Lakeshore capacity assessment helps planners understand what level of shoreline development can take place on an inland lake without appreciably altering water quality (i.e., beyond water quality guidelines or objectives for levels of phosphorus and dissolved oxygen).

MOE's mandate to protect water quality allows it to establish maximum phosphorus concentrations for individual lakes and to express these limits in terms of an allowable phosphorus load from shoreline development. Nutrient (phosphorus) enrichment may also reduce the amount of cold, well-oxygenated water needed by fish such as lake trout. Development planning, therefore, must protect fish habitat in accordance with the requirements of the federal *Fisheries Act* and *The Department of Fisheries and Oceans policy for the management of fish habitat*[1].

Lakeshore capacity assessment is a planning tool that will help municipalities achieve a consistent approach to shoreline development on inland lakes across the province. As previously noted, MOE recommends that municipalities use lakeshore capacity assessment to ensure sustainable development of the inland lakes in their area.

Lakeshore capacity assessment alone won't guarantee good water quality and healthy fish populations.

There are many other pollutants — such as mercury, fuel, and wastewater from pleasure boats, which includes dish/shower/laundry water (grey water) and sewage (black water) — and other land uses — such as industrial use, urbanization, timber harvesting and intensive agriculture — that can degrade water quality. To protect water quality, municipalities and lake users need to have regard for federal, provincial and municipal water-related laws, bylaws and policies. Municipalities also need to develop proactive land-use controls.

Handbook users should remember that lakeshore capacity assessment, while effective at protecting some aspects of water quality, is by no means a panacea for all water quality problems in inland lakes.

Water quality is only one of many factors that influence the development capacity of inland lakes.

In some cases, water quality may not be the most critical factor in determining whether a lake has reached its development capacity. The development capacity of a lake is also influenced by fish and wildlife habitat, the presence of hazard lands, vegetation, soils, topography and land capability (the suitability of land for use without permanent damage). Other factors that influence development capacity include existing development and land-use patterns, as well as social factors such as crowding, the number and type of boats in use, compatibility with surrounding land-use patterns, recreational use and aesthetics. Lakeshore capacity assessment doesn't and can't address these other factors.

The technical process of carrying out lakeshore capacity assessment won't, in and of itself, protect water quality — implementation is required.

The information obtained from lakeshore capacity assessment — for example, the maximum number of lots permitted on a lake or the names of lakes that have been determined to be at development capacity — needs to be incorporated into the policies of a municipality's official plan. The implementation of lakeshore capacity assessment is addressed in Section 3.4.

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[1] Department of Fisheries and Oceans. 1986. The Department of Fisheries and Oceans policy for the management of fish habitat. Department of Fisheries and Oceans. Ottawa. 28 p.

Lakeshore Capacity Assessment and Drinking Water

The outcome of the lakeshore capacity assessment will confer benefits on water quality that may, if a lake or watershed provides drinking water, also limit inputs of chemicals and pathogens to this drinking water source. A comprehensive strategy for the protection of drinking water supplies is under development. The *Clean Water Act*, passed into law in October 2006, takes a science and watershed-based approach to drinking water source protection as part of the Ontario government's Source-to-Tap framework.

1.3 Why we need lakeshore capacity assessment

The inland lakes on Ontario's Precambrian Shield are a major environmental, recreational and economic resource for the province. We need lakeshore capacity assessment as a tool for at least three reasons:

1. To help protect environmental resources
2. To help protect recreational and economic resources
3. To meet obligations under the *Planning Act*

Protecting environmental resources

Like other ecosystems, freshwater lakes are dynamic systems with an inherent resilience to stress — that is, they possess the ability to self-regulate and repair themselves. But, again like other ecosystems, inland lakes have a carrying capacity (limit) to the amount of stress they can tolerate. The near collapse of the Lake Erie ecosystem in the 1960s due to excessive phosphorus levels is one such example: a coordinated, basin-wide strategy was needed to reduce phosphorus levels and begin restoring the lake's health.

An important water quality concern related to development on Ontario's Precambrian Shield is eutrophication, which is caused by a high amount of phosphorus entering a lake. Unlike most pollutants, phosphorus isn't toxic to aquatic life. In fact, it's an essential nutrient that is supplied to the aquatic system from natural sources such as rainfall and runoff from the watershed. However, when the amount of phosphorus entering a water body is excessive, it sets off a chain reaction. First, algae proliferate causing a loss in water clarity — the lake user sees this as greener water which is less aesthetically-appealing. In some cases, algal growth is dense and localized — this is called a bloom. Next, the algae die off and settle to the bottom of the lake, where bacteria begin the process of decomposition. This process consumes oxygen which, in turn, reduces the level of dissolved oxygen in the bottom waters and reduces the amount of habitat available for sensitive aquatic life such as lake trout. Lakes undergoing eutrophication may lose populations of lake trout and experience shifts in fish populations to more pollution-tolerant species.

Lakeshore capacity planning has been practiced for about 25 years in Ontario. During this time, MOE regional staff have modeled or accumulated files on more than 1,000 inland lakes. Of these, approximately 30 per cent have been declared to be at development capacity because of high phosphorus levels. About 45 per cent of the lakes that are at capacity are lake trout lakes in which a cold, well-oxygenated fish habitat is threatened by further shoreline development.

Lakeshore capacity assessment will help municipalities to protect lakes that are already at capacity against further deterioration in water quality and to protect the quality of water in lakes with remaining development capacity. It will also help them to sustain healthy fisheries.

Protecting recreational and economic resources

Lakeshore capacity assessment will help to protect the significant economic values that are associated with Ontario's inland lakes:

- Ontario residents own approximately 1.2 million recreational boats.[2]
- Anglers spend approximately $1.7 billion annually in Ontario on a range of goods and

[2] Great Lakes Regional Waterways Management Forum. 1999. The Great Lakes: A waterways management challenge. Harbor House Publishers, Inc. Michigan.

services related to recreational fishing.[3]

- Ontario's Great Lakes and inland lakes support one of the largest commercial fisheries in the world, with a landed value of more than $40 million annually.[4]
- Crown lands and waters encompass approximately 87 per cent of Ontario's land mass. Many visitors engage in resource-based tourism activities on these lands including, for 1999, more than 5.6 million Canadian, American and overseas visitors. These resource-based visitors spent almost $1.1 billion in Ontario.[5]
- Of the 5.6 million resource-based trips in Ontario in 1999, 4.8 million (86 per cent) were overnight trips. Many of these visitors were engaged in water-related activities: 50 per cent participated in water sports (including swimming); 39 per cent went hunting or fishing.[6]

The *Planning Act* and the Provincial Policy Statement

Under the 1996 amendments to the *Planning Act*, municipalities assumed far greater responsibility for their own land-use planning decisions. Protection of matters of provincial interest is now a responsibility that is shared between the Ontario government and municipalities. MOE and other Ontario government agencies no longer assess all development applications. As a result, municipalities need better tools to meet their obligations under the Provincial Policy Statement (PPS) to protect water quality and fish habitat and to evaluate the effect of developments on the local environment. Lakeshore capacity assessment is one such tool that will help municipalities meet these obligations. Under the 2004 amendments to the *Planning Act* all planning approval authority decisions made shall be consistent with the Provincial Policy Statement, which came into effect on March 1, 2005. This replaced the previous wording of the *Planning Act* which stated that approval authorities, when making decisions “shall have regard to” the PPS.

One reason for the preparation of the Lakeshore Capacity Assessment Handbook was to provide a tool to help protect the quality of water in Ontario’s Precambrian Shield lakes by preventing excessive development along their shores. It can also be used as a tool to help support the public and planning authorities with applying the water and natural heritage policies of the PPS. Its use is limited to inland lakes on the Precambrian Shield — especially cold water lakes and particularly lake trout lakes.

Copies of the PPS (2005) are readily available online and directly from the Ministry of Municipal Affairs and Housing. Changes to the PPS were made in 2005 following extensive consultation and review.

It’s always important to remember that the PPS (2005) must be read in its entirety. With that in mind, land-use planners must consider many matters to reach a decision that is consistent with the PPS (2005). For lake trout lakes or any other water bodies, decisions shall be consistent with the PPS (2005) water quality policies and with the fish habitat policies including any definitions where they apply.

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[3] Ontario Ministry of Natural Resources. 2003. 2003 Recreational Fishing Regulations Summary. Queen's Printer for Ontario.

[4] Office of the Provincial Auditor of Ontario. 1999. 1998 Annual Report. Queen's Printer for Ontario.

[5] Ontario Ministry of Tourism and Recreation. 2002. An Economic Profile of Resource-Based Tourism in Ontario, 1999. Queen's Printer for Ontario.

[6] Ontario Ministry of Tourism and Recreation. 2002. An Economic Profile of Resource-Based Tourism in Ontario, 1999. Queen's Printer for Ontario.

1.4 What lakeshore capacity assessment will achieve

Lakeshore capacity assessment is a useful planning tool that will enhance the effectiveness of the land-use planning and development process in a number of ways. It incorporates the concept of ecosystem sustainability into the planning process.

Lakeshore capacity assessment is built upon the knowledge that inland lakes have a finite and measurable capacity for development. Central to the province's ecosystem approach to land-use planning is the concept that "everything is connected to everything else". Degradation of one element of an ecosystem (in this case, degradation of water quality) will ultimately affect other elements of the same ecosystem. Lakeshore capacity assessment will help to protect the quality of water in inland lakes for the future. Protecting the quality of water in a lake will also help to protect its aquatic communities, coldwater fish habitat and the quality of water in downstream systems.

Lakeshore capacity assessment is consistent with watershed planning.

The Ontario government has adopted watershed planning as the preferred approach to water resource planning. Watershed planning takes a broad, holistic view of water resources and considers many factors including water quality, terrestrial and aquatic habitat, groundwater, hydrology and stream morphology (form and structure). Although lakeshore capacity assessment is more narrow in focus (as it considers only water quality), it's consistent with watershed management in that it considers upstream sources and downstream receptors when assessing the development capacity of a lake. It's a tool that will enable municipalities sharing a watershed to work together to protect the resource.

Lakeshore capacity assessment is consistent with the strategic shifts outlined in the report, *Managing the Environment: A Review of Best Practices*[7].

Lakeshore capacity assessment fits well with the strategic shifts outlined in the *Managing the Environment* report, commissioned by the Ontario government and issued in January 2001. Specifically, lakeshore capacity assessment reflects the shift towards:

- Place-based management using boundaries that make ecological sense
- Use of a flexible set of regulatory and non-regulatory tools
- A shared approach to environmental protection that includes the regulated community, non-governmental organizations, the public and the scientific/technical community

Lakeshore capacity assessment promotes land-use decisions that are based on sound planning principles and addresses many relevant aspects of the Provincial Policy Statement (2005).

The implementation of lakeshore capacity assessment will demonstrate sound planning principles at the municipal level by reflecting the land-use policies in a municipality's official plan. As outlined in Section 1.3, lakeshore capacity assessment supports the protection of provincial interests identified in the *Planning Act* and the Provincial Policy Statement (2005). This includes protecting water quality, natural heritage features and communities.

[7] Executive Resource Group. 2001. Managing the Environment: A Review of Best Practices, Volume 1.

Lakeshore capacity assessment encourages land-use decisions that maintain or enhance water quality.

While the Ontario government maintains jurisdiction and legislative authority for water quality and quantity under the *Ontario Water Resources Act* and the *Environmental Protection Act*, municipalities are required to consider more restrictive procedures and practices to safeguard water resources. Lakeshore capacity assessment is a proactive method by which municipalities can determine the sustainability of shoreline development on inland lakes with respect to water quality. It will help protect or enhance water quality so that permanent and seasonal residents can continue to enjoy good water clarity. It will also help to protect fish habitat and fisheries.

Lakeshore capacity assessment encourages a clear, coordinated and scientifically sound approach that should reduce conflict among stakeholder groups and avoid or reduce the need for Ontario Municipal Board hearings.

Lakeshore capacity assessment is grounded in science and has been used for many years. It was developed by the Ontario government to guide municipalities with their planning responsibilities and should reduce conflict and disagreement among participants involved in the land-use planning system. It will help municipalities to determine their lakeshore development capacity as they develop or update their official plans. Municipalities will then be able to set long-term planning policies before development expectations are generated and investments are made in property acquisition and subdivision design.

Lakeshore capacity assessment encourages a consistent approach across the province.

The Ontario government is promoting the use of this handbook and the Lakeshore Capacity Model to encourage a consistent approach across the province.

Lakeshore capacity assessment is cost effective.

When municipalities carry out lakeshore capacity assessment and then develop general policies that are expressed in official plans and zoning bylaws, this process avoids duplication of effort. This is also the case when a development proposal requires a proponent to deal with more than one municipality.

1.5 What the effect will be on future lake development

There are currently more than 220,000 residential and cottage properties on Ontario's inland lakes.[8] Cottage development is sporadic and therefore difficult to predict. Annual demand for new lakeshore properties may increase somewhat in the future, but isn't expected to reach the high levels encountered in the late 1980s because of changes in disposable income and growing interest in recreational and retirement properties in warmer climates[9].

Municipal use of lakeshore capacity assessment — in conjunction with the revised provincial water quality objective for phosphorus for inland lakes on the Precambrian Shield — may allow for fewer new residential and cottage lots on some lakes and more on others, as compared to the existing assessment procedure. The net effect is likely to be a redirection of development from lakes that are already well developed to lakes that are less developed.

[8] Cottage Life Magazine. 2004. Cottage Life Advertising Brochure.

[9] Ontario Ministry of the Environment (Economic Services Branch). 1997. Economic Analysis of the Proposed Lakeshore Development Policy: Socio-economic value of water in Ontario. Queen's Printer for Ontario.

Using the Boshkung Lake Watershed in Haliburton as an example, it's estimated that use of lakeshore capacity assessment on its 35 lakes will allow a sufficient supply of new residential and cottage lots to be able to meet demand for another 25 to 30 years. The Ministry of Natural Resources may, from time to time, add to the supply by releasing either individual cottage lots or blocks of Crown land. Where Crown land is being released, MNR must comply with the class environmental assessment process, which includes discussions with and input from municipalities and area residents.

2.0 PHOSPHORUS, DISSOLVED OXYGEN AND WATER QUALITY

2.1 Link between phosphorus and water quality

As noted in Section 1.3, phosphorus is an essential nutrient that is supplied to aquatic systems from both natural sources, such as rainfall and overland runoff, and human sources. Unlike most aquatic pollutants, phosphorus isn't toxic to aquatic life. High levels of phosphorus, however, can set off a chain of events that can have serious repercussions on the aesthetics of recreational waters and the health of coldwater fisheries.

The phosphorus concentration of a lake is one measure of the desirable attributes we wish to protect as the lake's shoreline is developed. These attributes include clear water for recreation and a well-oxygenated habitat for coldwater fish.

For Ontario's inland lakes on the Precambrian Shield, trophic (nutrient) status is determined by the level of phosphorus in the water (**Table 2**). These lakes are naturally oligotrophic (low in nutrients) or mesotrophic (moderately nutrient-enriched) and most can accommodate small increases in phosphorus levels. However, all lakes have a finite capacity for nutrient assimilation, beyond which water quality is impaired. Excessive phosphorus loadings to a lake promote the growth of algae, sometimes leading to algal blooms on or beneath the lake's surface. The proliferation of algae reduces water clarity, which lessens a lake's aesthetic appeal. More serious effects may occur after the algae die and settle to the bottom. When this takes place, bacteria levels increase to decompose the algae and collectively their respiration consumes more oxygen in the water column. This means a loss of the cold, well-oxygenated habitat that is crucial to the survival of coldwater species such as lake trout. The ultimate outcome can be extirpation (local extinction) of the species.

The main human sources of phosphorus to many of Ontario's recreational inland lakes are septic systems from houses and cottages. Clearing the shoreline of native vegetation, use of fertilizers, stormwater runoff and increased soil erosion also can contribute significant amounts of phosphorus to a lake.

Table 1. Total phosphorus and its relationship to trophic status

Trophic status	Total phosphorus range (µg/L)
Oligotrophic	<10
Mesotrophic	10-20
Eutrophic	>20

MOE's mandate for protection of water quality allows it to establish maximum phosphorus concentrations for individual lakes and express these limits in terms of the allowable phosphorus load from shoreline development. MNR currently reviews projects that may alter fish habitat to make sure they meet the requirements of provincial legislation. Since nutrient enrichment can also reduce the amount of cold, well-oxygenated water used by fish such as lake trout, MNR has developed a new criterion for dissolved oxygen to protect lake trout habitat.

Development planning must protect fish habitat in accordance with the requirements of the federal *Fisheries Act* and Fisheries and Oceans Canada policy for the management of fish habitat[10]. Projects that may alter fish habitat fall under the jurisdiction of Fisheries and Oceans Canada for review under section 35 of the *Fisheries Act*. Fisheries and Oceans Canada has negotiated agreements with some conservation authorities to carry out these reviews at varying levels, depending on the capability of the conservation authority. Fisheries and Oceans Canada has a similar agreement with Parks Canada to carry out section 35 reviews for projects in national parks, marine conservation areas, historic canals and historic sites.

2.2 Provincial water quality objective for phosphorus

This section of the handbook provides an overview of the relationship between phosphorus and water quality and outlines the rationale for and approach used in the revised provincial water quality objective for phosphorus. More detail is found in Appendix A, *Rationale for a revised phosphorus criterion for Precambrian Shield lakes in Ontario*.

Existing approach

The Ontario government's goal for surface water management is "to ensure that the surface waters of the province are of a quality which is satisfactory for aquatic life and recreation".[11] The existing PWQO for total phosphorus was developed by MOE in 1979.[12] It drew on the trophic status classification scheme of Dillon and Rigler[13], and was designed to protect against aesthetic deterioration and nuisance concentrations of algae in lakes and excessive plant growth in rivers and streams.

In 1992, the PWQO for total phosphorus was given interim status. This reflected both the uncertainty about the effects of phosphorus and the fact that phosphorus isn't toxic to aquatic life. The interim PWQO doesn't explicitly distinguish between lakes in different regions of Ontario (*i.e.,* Precambrian Shield versus southern Ontario). Instead, it sets different targets for lakes depending on whether they have naturally low productivity (total phosphorus less than 10

Interim
Provincial Water Quality Objective
for total phosphorus (1979)

Current scientific evidence is insufficient to develop a firm objective at this time [*i.e.,* 1979]. Accordingly, the following phosphorus concentrations should be considered as general guidelines which should be supplemented by site-specific studies:

- To avoid nuisance concentrations of algae in lakes, average total phosphorus concentrations for the ice-free period should not exceed 20 µg/L.
- A high level of protection against aesthetic deterioration will be provided by a total phosphorus concentration for the ice-free period of 10 µg/L or less. This should apply to all lakes naturally below this value.
- Excessive plant growth in rivers and streams should be eliminated at a total phosphorus concentration below 30 µg/L.

[10] Department of Fisheries and Oceans. 1986. The Department of Fisheries and Oceans policy for the management of fish habitat. Department of Fisheries and Oceans. Ottawa.

[11] Ontario Ministry of Environment and Energy. 1994. Water management: Policies, guidelines, Provincial Water Quality Objectives of the Ministry of Environment and Energy. Queen's Printer for Ontario.

[12] Ontario Ministry of Environment and Energy. 1979. Rationale for the establishment of Ontario's Provincial Water Quality Objectives. Queen's Printer for Ontario.

[13] Dillon, P.J. and F.H. Rigler 1975. A simple method for predicting the capacity of a lake for development based on lake trophic status. *J. Fish. Res. Bd. Can.* 32: 1519-1531.

µg/L) or naturally moderate productivity (total phosphorus greater than 10 µg/L) (*see sidebar*).

In summary, the intent of the interim PWQO for total phosphorus in lakes is to:

- Protect the aesthetics of recreational waters by preventing losses in water clarity
- Prevent nuisance blooms of surface-dwelling algae
- Maintain the existing diversity in the clarity of water of Precambrian Shield lakes
- Provide indirect protection against oxygen depletion

Need for a revised approach

The need to revise the approach for managing phosphorus stems from an improved understanding of the relationship between phosphorus concentrations in water and the resulting plant and algal growth in lakes and rivers. It also reflects an improved understanding of watershed processes, biodiversity and the assessment of cumulative effects. A revised approach would ensure adoption of these considerations in the water management process.

Although the existing, two-tiered guideline for total phosphorus in lakes has performed well for more than 20 years, it fails to protect against the effects of cumulative development. Further, it doesn't protect the province's current diversity in lake water quality and its associated biodiversity. As illustrated in **Figure 2**, there is a wide range of nutrient levels in Ontario's inland lakes, with a prevalence of oligotrophic lakes.

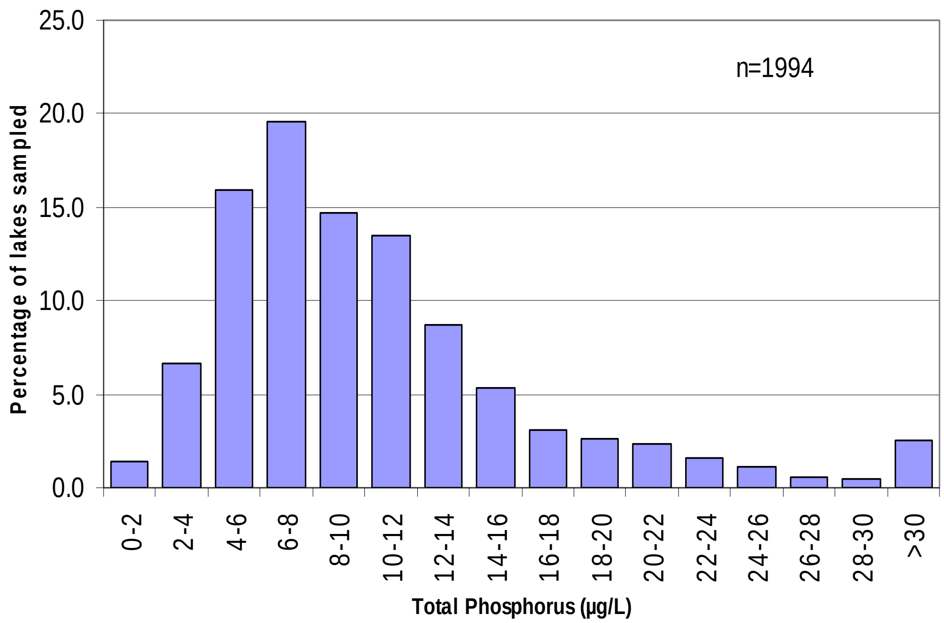

Figure 2. Distribution of total phosphorus concentrations in sampled Ontario lakes (source: MOE Inland Lakes database, March 2004)

The logical outcome of the application of the Ontario government's two-tiered 1979 phosphorus objective is that, over time, the quality of water in recreational lakes will converge on each of the two water quality objectives. This will produce a cluster of lakes slightly below 10 µg/L and another slightly below 20 µg/L. This will reduce the diversity in lake water quality and, with it, the diversity of the associated aquatic communities.

Revised approach

The revised PWQO for lakes on the Precambrian Shield allows a 50 per cent increase in phosphorus concentration from a modeled baseline of water quality in the absence of human influence.

The revised approach has the following advantages:

- Each water body would have its own water quality objective, described with one number (*i.e*., ‘undeveloped’ or ‘background’ plus 50 per cent)
- Development capacity would be proportional to a lake’s original trophic status.
- Each lake would remain closer to its original trophic status classification. A lake with a predevelopment phosphorus level of 10 µg/L could be developed to 15 µg/L, maintain its mesotrophic classification, and development would not be unnecessarily constrained to 10 µg/L.
- The existing diversity of trophic status in Ontario would be maintained forever, instead of having a future set of lakes at 10 µg/L and another at 20 µg/L.

2.3 Phosphorus and dissolved oxygen

The lake trout, *Salvelinus namaycush*, is found in about 2,200 lakes in Ontario, most of which are on or near the Precambrian Shield. These lakes are noted for their relatively pristine water quality: they have high clarity, low levels of dissolved solids, organic carbon and phosphorus, high concentrations of dissolved oxygen, cool temperatures in bottom waters year round and relatively stable water levels. Self-sustaining populations of lake trout are found in these lakes because they provide the specific, narrow environmental conditions required by this species.

Ontario's lakes were re-colonized by lake trout 10,000 years ago after the glaciers of the last Wisconsin Ice Age retreated. Populations have been largely isolated from one another since that time and adaptation to local conditions has led to genetically distinct, locally adapted stocks. The preservation of genetic diversity of the species requires conservation of individual populations through the protection of the habitat and water quality in the lakes in which they occur.

Lake trout are long-lived and late maturing, with females first spawning at six to 10 years of age. This late maturation, combined with modest egg production and low recruitment rates, makes lake trout vulnerable to external factors that increase mortality. These factors include over-fishing and degradation or loss of spawning and summer habitat.

Loss of summer habitat is influenced by phosphorus loading. In the southern part of their range, lake trout live in the hypolimnion during the summer. The hypolimnion is isolated from the atmospheric and photosynthetic supply of oxygen from the time when the lakes become thermally stratified during spring overturn until recirculation or turnover takes place in the fall. To sustain lake trout over the summer, the hypolimnion must contain enough dissolved oxygen. When nutrient enrichment takes place as a result of shoreline development, the algae production-decomposition cycle depletes the oxygen in the deep waters of the hypolimnion.

Low concentrations of dissolved oxygen in bottom waters impair the lake trout’s respiration, and therefore its metabolism, which compromises its ability to swim, feed, grow and avoid predators. Studies have shown that juvenile lake trout need at least seven milligrams (mg) of dissolved oxygen per litre (L) of water. Measured as a mean, volume-weighted, hypolimnetic dissolved oxygen concentration (MVWHDO), this level is also sufficient to make sure that natural recruitment takes place. The provincial water quality objective for dissolved oxygen allows for the establishment of more stringent, site-specific criteria for the protection of sensitive biological communities.[14] The Ministry of Natural Resources has consequently developed a criterion of 7 mg of dissolved oxygen/L (measured as MVWHDO) for the protection of lake trout habitat (see references in Appendix B). Loadings of phosphorus that deplete oxygen to levels below 7 mg/L (MWVHDO) won’t be permitted. Preservation of an average of 7 mg of dissolved oxygen/L in the hypolimnion of Ontario's lake trout lakes will help to sustain the province's lake trout resources.

[14] Ontario Ministry of Environment and Energy. 1994. Water management: Policies, guidelines, Provincial Water Quality Objectives of the Ministry of Environment and Energy. Queen’s Printer for Ontario.

3.0 BASICS OF ASSESSING LAKESHORE CAPACITY

3.1 When lakeshore capacity assessment should be considered

Lakeshore capacity assessment is a scientifically-established and recommended tool for municipalities to use on a routine basis as part of their ongoing land-use planning process. Triggers to carry out lakeshore capacity assessment may include the following conditions:

- When developing or updating official plans
- If significant or unusually large amounts of development are proposed for a lake
- If a development is to take place within 300 metres of a lake or a permanently flowing stream[15]
- If water quality problems (such as elevated levels of phosphorus, loss of water clarity, or algal blooms) are noted
- If populations of coldwater fish species such as lake trout, lake whitefish or brook trout are present
- If changes in fisheries have been noted, especially diminishing populations of coldwater species such as lake trout
- If cottagers or year-round residents raise concerns about the effects of development on water quality

3.2 What lakeshore capacity assessment will tell you

The Lakeshore Capacity Model will estimate a lake's development capacity and compare its current level of development to this estimate. If the lake hasn't attained its development capacity, the model will also estimate the additional amount of development it can tolerate. This will allow a municipality to decide how many residential and cottage lots or other uses should be permitted on the lake. **Municipalities with lake trout lakes should note that dissolved oxygen may be a more stringent criterion than phosphorus for limiting development on these lakes to protect fish habitat.**

[15] The use of the 300-metre distance is described in Section 4.3 of the handbook. The area within 300 metres of a lake or permanently flowing stream is considered to be the area of influence for phosphorus loading, (*i.e.,* the area within which phosphorus from septic systems may move to the lake or stream).

What is needed to carry out a lakeshore capacity assessment

Expertise needed

Resource managers, planners and environmental engineers carrying out lakeshore capacity assessment on inland lakes will require some level of familiarity with environmental resource management, the overall land-use development process and the Lakeshore Capacity Model. Some municipalities may have staff with this expertise; others won't. Local conservation authorities may have experts on staff that could be of assistance.

Most resource managers, planners and environmental engineers with a basic understanding of aquatic science can be trained to use the Lakeshore Capacity Model in less than a week. Alternately, there are consultants familiar with lakeshore capacity assessment and the model that could provide municipalities with their expertise.

Information sources

The Government of Ontario's Lakeshore Capacity Model uses input data from sources such as topographic maps, geological maps, fishing maps (*e.g.,* bathymetric maps, aquatic habitat inventory and lake files available from MNR for all significant cottage lakes in the province), MOE's lake files, and additional information that has been built into the model.

Shoreline development is the critical managed parameter. Information can be obtained from the assessment roles of municipalities, lake residents' associations or direct counts. The Municipal Property Assessment Corporation can provide assessment data that explicitly identify waterfront lots and second-tier development.

In areas of the province where they exist, conservation authorities can also be a source of information on water quality in lakes and tributaries.

Information needed

This section provides an overview of the information needed to run the Lakeshore Capacity Model. The minimum information required to run the LCM is:

- Lake name
- Lake latitude and longitude, defined as the point where the outflow leaves the lake (degrees, minutes, seconds)
- Lake area (hectares)
- Local catchment or watershed area, excluding both the lake area and the area of any upstream lakes and their watershed(s) (hectares)
- Current shoreline development status (*i.e.,* the number of cottages and resort units and the nature of their usage: permanent/seasonal/extended seasonal); this information should also include vacant lots of record
- Land-use data for the watershed (*i.e.,* the percent of the watershed that is composed of wetlands, agricultural or urban land use)
- Categorization of the hypolimnion as anoxic or oxic

- Observed or measured total phosphorus concentrations to evaluate the model's performance

If you wish to model oxygen conditions and/or to evaluate lake trout habitat and the effect of development on lake trout habitat, further information is required:

- Detailed morphometric/bathymetric data (areas within each contour interval in hectares)
- Water temperature profiles from August and September to determine the depth of the hypolimnion at the end of summer stratification (metres)
- Dissolved oxygen profiles to evaluate the model's performance
- Maximum fetch (maximum distance across the lake through the deepest location in kilometres)

Additional information that will improve the accuracy of the model's predictions includes:

- Lake mean depth [volume ÷ area] (metres)
- Detailed site specific information to assess whether there is potential for the long-term attenuation of phosphorus in watershed soils (see Section 5.2 for additional information)

3.4 Implementing lakeshore capacity assessment

The Implementation of effective lakeshore capacity assessment will require a coordinated and cooperative approach by the various agencies involved to develop and implement the planning and regulatory tools that are needed. It's expected that implementation will be phased in place in a manner that reflects differing levels of municipal organization and the ability of municipalities to develop or acquire the expertise needed to do the assessment.

Adoption of appropriate policies in official plans and zoning bylaws

It is recommended that municipalities and planning boards update the policies in their official plans to implement lakeshore capacity assessment. These may include policies and regulations that identify:

- Water quality objectives required to protect water quality and fish habitat
- Where lakeshore capacity assessments need to be done and/or lake capacity limits need to be established prior to additional development approvals
- Where lakeshore capacity assessments have been done and/or lake capacity limits have been established and:
    - Which lakes, if any, have reached their development capacity
    - Which lakes haven't reached their development capacity and what additional application requirements, approval considerations and/or development conditions may be required to protect their water quality and coldwater fish habitats

Where the catchment area of a lake is shared with another municipal planning authority, official plans should establish a mechanism for allocating development capacity in cooperation with the neighbouring jurisdiction(s) to make sure that the water quality objectives of the lake are met.

All undeveloped lands in the catchment area of a lake should be placed in a zone that permits only low intensity uses, such as conservation or rural uses, until the development capacity has been established for the lake. New development should only be permitted after a review of the proposed development against the evaluation criteria provided in the official plan.

Establishment of appropriate review mechanisms for new development

All municipal planning authorities that have been delegated or assigned responsibility for the approval of new development through mechanisms such as official plans, zoning bylaws, severances and subdivision plans should ensure as part of their review that:

- New development will meet all the policies of the official plan, including water quality objectives
- Where no policies on water quality exist in an official plan, the limits specified in this handbook and the provincial water quality objectives can be used as a basis for defining water quality limits
- Where appropriate, a Lakeshore Capacity Model is used and development capacity limits are established
- Development doesn't exceed the capacity of the lake
- Appropriate design and construction conditions are incorporated as conditions of approval to minimize the effect of development on water quality and fish habitat
- All planning decisions shall be consistent with the applicable policies in the Provincial Policy Statement (2005)

Modeling, setting capacity limits and allocating development capacity

In reviewing new developments, municipal planning authorities are encouraged to:

- Use the Lakeshore Capacity Model to establish development capacity limits, where necessary
- Set development capacity limits for lakes within their jurisdiction
- Allocate lakeshore development capacity among landowners and developers within the catchment area of a lake
- Cooperate in the allocation of development capacity where the catchment area of a lake is shared with an adjacent municipal planning authority or authorities

Municipalities and planning boards are viewed as the most appropriate level of government to carry out these responsibilities. They're in the best position to identify and set development limits at the local level in the context of other social, economic and environmental considerations. This will require municipalities to train staff, hire consultants or work with conservation authorities to use the Lakeshore Capacity Model, set development capacities and translate them into development potential. Costs for such activities can often be recouped from the applicants as part of the development review process.

Upper-tier municipalities with planning and engineering staff are viewed as having the responsibility and capacity to carry out this role. The Ontario government encourages these jurisdictions to assume responsibility for the entire process of lakeshore capacity planning with some ongoing technical assistance and training from the province.

Other municipalities will be expected to assume full responsibility for lakeshore capacity assessment over time. In these areas, MOE and MNR currently conduct lakeshore capacity assessment, but will gradually withdraw from site-specific assessment and review as municipalities and planning boards develop this capacity.

Consent-granting authorities are expected to make decisions on the suitability of severance applications based on planning direction received from the municipalities or planning boards in which they're located. A consent-granting authority generally shouldn't approve the creation of new building lots in the catchment area of a lake until development capacity limits have been established.

Provincial role

The Ontario government, through MOE and MNR, will provide technical support to municipal planning authorities by:

a) Providing educational/outreach materials on the application of the Lakeshore Capacity Model

b) Providing municipalities with existing information on lake trout habitat and lakes at or near development capacity

c) Providing technical advice or support to municipalities on lakeshore capacity assessment, when asked

d) Providing technical advice to municipalities on site-specific applications of the Lakeshore Capacity Model on a limited, short-term basis until the municipalities have fully assumed the responsibilities outlined in b) above

In areas with no municipal organization, MNR and MOE will continue to apply the Lakeshore Capacity Model and establish lakeshore capacity limits.

Watershed planning

Ecosystem-based watershed planning is used to assess long-term changes and cumulative effects, and overcomes the limitations of administratively-defined planning boundaries. The Ontario government recognizes watershed planning as the ecologically meaningful scale for planning. This is a policy of the Provincial Policy Statement (2005) and is consistent with the principles of drinking water source protection.

The PPS (2005) also states that a coordinated, integrated and comprehensive approach should be used when dealing with planning matters which cross municipal boundaries. The watershed is the appropriate arena for this inter-municipal coordination — especially as applied to inland lakes and river systems. Conservation authorities are watershed-based and already provide inter-municipal coordination in various parts of the province.

4.0 APPLYING THE LAKESHORE CAPACITY MODEL

4.1 Elements of the model

The Ontario government's Lakeshore Capacity Model quantifies the linkages between the natural contributions of phosphorus to a lake, the contributions of phosphorus to a lake from shoreline development, the water balance of a watershed, the size and shape of a lake and the resultant phosphorus concentration. A schematic of the model is given in **Figure 3.**

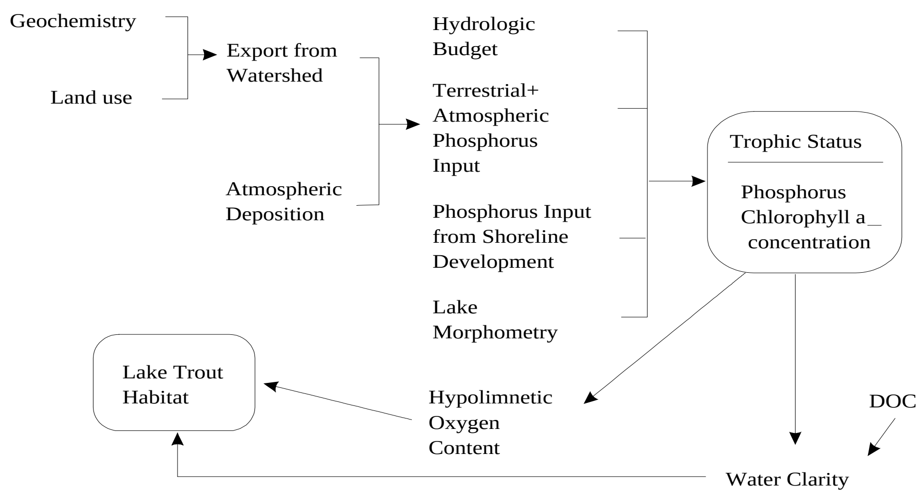

Figure 3. Ontario government's Lakeshore Capacity Model

The model allows the user to calculate how the water quality of a lake will be affected by the addition or removal of shoreline developments (such as permanent homes, seasonal cottages, resorts, campsites) and point source discharges (such as sewage treatment plants). It can calculate the natural, undeveloped condition of a lake, the amount of development (in terms of number of lots) the lake could sustain without changing its total phosphorus concentration past a given point, and the difference between existing conditions and that tolerance point. The model also allows the user to theoretically modify the land-use parameters for upstream lakes to estimate the effect of potential development on downstream lakes in the watershed.

4.2 How the model was developed

The Dillon-Rigler model, published in 1975[16], was the first model to address specifically the relationship between the eutrophication of Ontario's Precambrian Shield lakes and the density of residential development on their shorelines. Its rapid acceptance by the international scientific community led to the development of the Ontario government's Lakeshore Capacity Study (1976-1980) in the belief that substantial predictive relationships might be developed for other responses of lakes to shoreline development. The Lakeshore Capacity Study was coordinated by the Ministry of Municipal Affairs and Housing and published in 1986[17]. It produced predictive models for land-use (MMAH), fisheries exploitation and wildlife (MNR), microbiology and water quality (MOE), as well as a capacity model that integrated all of these components (MMAH). Although several of these models were very useful, MOE's water quality model was the only one that management agencies adopted for routine use.

MOE's Lakeshore Capacity Model is based on the nutrient level or trophic status of a lake. It provides an accurate and quantitative linkage between the level of shoreline development and the level of phosphorus in a lake. This output can subsequently be used to predict the impacts of development on water clarity and deepwater oxygen content. Subsequent work has refined the model and added significant new areas of understanding, most notably a component that links the protection of lake trout habitat to the control of shoreline development.

Over time, resource managers in MOE's regional offices, other government agencies in Canada and the United States, and the scientific and consulting communities have adopted the Lakeshore Capacity Model as an assessment tool. Although the model was accepted as a useful planning approach, the Ontario government never formalized its implementation. As a consequence, resource managers developed their own modifications to the model to address local concerns and interpretations. By the early 1990s, it became apparent that these informal implementation arrangements were no longer suitable; significant variations of the model were in use across the province, leading to a fragmented approach to water quality protection and confusion among stakeholders.

With the MOE's corporate adoption of watershed planning in 1993, a process leading to the formalization of lakeshore capacity assessment in policy was begun. This handbook is a result of this process. It was developed to give clear and consistent guidance to developers and lake residents, provide clear advice and planning tools to municipalities and other agencies, and provide effective succession training to ministry staff. In addition, the old model has been refined and new capabilities (such as a prediction of deepwater oxygen levels) have been added.

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[16] Dillon. P.J. and F.H. Rigler. 1975. A simple method for predicting the capacity of a lake for development based on lake trophic status. *J. Fish. Bd. Can.* 32: 1519-1531.

[17] Ontario Ministry of Municipal Affairs and Housing (Research and Special Projects Branch). 1983-1986. Lakeshore Capacity Study. Queen's Printer for Ontario:

- Committee Report
- Land use (Downing, J.C. 1986. Ministry of Municipal Affairs and Housing)
- Fisheries (McCombie, A.M. 1983. Ministry of Natural Resources)
- Microbiology (Burger, C.A. 1983. Ministry of the Environment)
- Trophic Status (Dillon, P.J., Nicholls, K.H., Scheider, W.A, Yan, N.D. and Jeffries, D.S. 1986. Ministry of the Environment)
- Wildlife (Euler, D.L. 1983. Ministry of Natural Resources)
- Integration (Teleki, G. 1986. Ministry of Municipal Affairs and Housing)

4.3 Assumptions built into the model

The Lakeshore Capacity Model includes several assumptions and coefficients. These numeric data represent the unknown and variable conditions in a lake or watershed. In the past, resource managers often adapted these variables to fit local conditions or to achieve certain management goals.

The mathematical assumptions in the current model have been refined over the past 25 years. They reflect the position of the MOE as of March 2006 and are based on the best and most current scientific evidence. They also reflect MOE's commitment to a precautionary approach, as outlined in the Ministry's *Statement of Environmental Values*. This approach supports the use of conservative assumptions to protect the environment when there is uncertainty in the science. Resource materials related to the assumptions are listed in Appendix B, *Lakeshore capacity assessment resources*.

Users may request permission to use alternate assumptions and coefficients in the model, provided they produce substantiation that is acceptable to the approval authority. MOE will also review any proposed changes.

Definition of shoreline development

The definition of shoreline development in the Lakeshore Capacity Model includes any dwelling (including resorts, campgrounds, etc.) within 300 metres of a lake or a permanently flowing stream that flows into the lake.

Phosphorus loadings to septic systems

Since the Lakeshore Capacity Model was first developed in the 1970s, the water usage rates for recreational lakes have increased due, in part, to the increased use of washing machines and dishwashers. These changes have been partially offset by decreases in the phosphorus content of detergents. The model now assumes that 0.66 kilograms of phosphorus is contributed per capita per year to septic systems. This loading is considered to be the most appropriate coefficient in cases where detailed site-specific measurements haven't been made.

In general, lesser phosphorus loading rates should only be used for calculating lakeshore capacity where:

- The sewage effluent is received and treated in a municipally or provincially operated system designed to produce lower per unit phosphorus loading levels
- The sewage effluent is transported, treated and discharged outside the catchment area of the lake in accordance with regulatory requirements

Other sources of phosphorus from shoreline development

The Lakeshore Capacity Model focuses on phosphorus from septic systems as the major, human contributor to lake loadings. In recent years, as lake developments have become more urban with extensive cleared areas, gardens and turf grass, overland runoff has also been recognized as an additional contributor of phosphorus.

The model assumes an overland run-off loading to lakes of 0.04 kilograms of phosphorus per lot per year. This is calculated by multiplying the export coefficient for phosphorus from pasture land (9.8 mg/m^2/yr; Dillon et al. 1986, Appendix B) by the mean size of lots in the District of Muskoka and the County of Haliburton (3798 m^2, n>1000; Paterson et al. 2006, Appendix B).

Additional sources of phosphorus such as golf courses, agriculture, forestry, or lake sediments may also contribute significant nutrient loads to lakes. In cases where these loads have been quantified, they may also be input into the Lakeshore Capacity Model.

Attenuation of phosphorus from septic systems

The original Lakeshore Capacity Model was based on the assumption that 100 per cent of the phosphorus from septic systems would ultimately move into lakes. This reflected the predominance of thin, organic or sandy soils and tills on the Precambrian Shield, the fractured nature of the bedrock, and the predominance of aging septic systems that were designed for hydraulic purposes (*i.e.,* to ensure fast infiltration) rather than for nutrient retention. Furthermore, at the time of model development, there was no scientific evidence that phosphorus could be attenuated in watershed soils over the long-term. Subsequent studies, however, have shown that the movement of phosphorus from septic tank-tile bed systems may be attenuated to some degree in certain types of soils[18,19]

The balance between recent science and the need for regulatory precaution can be accommodated by the use of a three-step 'graduated' approach that recognizes that phosphorus attenuation may occur in some watersheds, and may increase with distance from the shoreline. Thus, the current Lakeshore Capacity Model includes a provision for attenuation based on the distance of the septic system from the lake. This approach is presented as a guideline for modeling purposes, and is recommend for use at sites where deeper (generally > 3 m), noncalcareous, native soils are present, and where detailed site-specific information are unavailable (**Figure 4**). It assumes that:

- 100 % of the phosphorus (P) from septic systems within 100 metres of the shoreline or a permanently flowing stream enters the lake
- 67 % of the P from septic systems between 100 and 200 metres of the shoreline or a permanently flowing stream enters the lake
- 33 % of the P from septic systems between 200 and 300 metres of the shoreline or a permanently flowing stream enters the lake

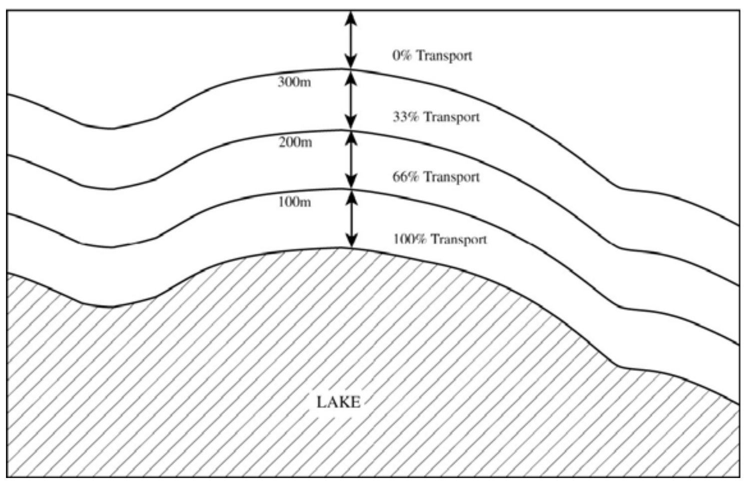


Figure 4. Assumed attenuation of phosphorus

- None of the P from septic systems over 300 metres from the shoreline or a permanently flowing stream enters the lake

[18] Robertson, W.D., S.L. Schiff and C.J. Ptacek, 1998. Review of phosphate mobility and persistence in 10 septic system plumes. Groundwater. 36: 1000-1010.

[19] Robertson, W.D. 2003. Enhances attenuation of septic system phosphate in noncalcareous sediments. Groundwater. 41: 48-56.

The approach to be used reflects the type of information that is available on factors that influence the movement of phosphorus in soils. There are three basic approaches:

Use of phosphorus attenuation factors

1. In certain areas of the province where soils are thin or absent, and bedrock is exposed or fractured, site-specific information may show that very little phosphorus is retained and modelers should use a 100 per cent loading coefficient within 300 m of the shoreline or inflowing tributary.
2. Where deeper native soils are present, and in the absence of site-specific info the modeler should use the attenuation figures in **Figure 4** as a guideline.

Site engineering and vegetated buffers as nutrient sinks

In urban areas, techniques such as stormwater detention ponds, constructed wetlands and infiltration areas can be used to reduce the concentration of nutrients in overland runoff. For lakeshore properties, techniques such as shoreline naturalization and vegetated buffer strips have been accepted in many jurisdictions as sound management practices. However, there is not enough information to reliably predict the level of nutrient control that may be achieved through such techniques, or their long-term effectiveness at reducing phosphorus loading. Accordingly, the Lakeshore Capacity Model makes no allowances for mitigation of overland runoff through site engineering and vegetated buffers. It's recommended, however, that further studies be done to quantify the effectiveness and longevity of such techniques.

Rivers, wetlands and phosphorus transport

The Lakeshore Capacity Model assumes that all the phosphorus leaving one lake will be transported downstream to the next lake. Questions have been raised about the potential for phosphorus retention in wetlands and river channels. Evidence to date doesn't support the idea of phosphorus retention in either wetlands or river channels on a long-term basis. In both rivers and riverine wetlands, phosphorus retention is seasonal, with retention in the summer and export during high flow periods in the spring and fall. Accordingly, the current model doesn't include the possibility of phosphorus retention along river systems between lakes. This assumption may be revisited in the future as more information is gathered.

Usage rate of shoreline properties

One of the critical unknown variables in the Lakeshore Capacity Model is the usage rate of shoreline properties: how many days a year a property is occupied and by how many people. Usage rates vary dramatically with factors such as distance to major population centres and rate of conversion of seasonal residences to permanent use. Some indication of current usage rates may be obtained from surveys, tax records, lake residents' associations, topographic maps or aerial photos, although uncertainties are associated with all these information sources. Estimating future usage rates is more difficult. Estimating usage rates for uses other than year-round residences and seasonal cottages (such as resorts) is also challenging. The current MOE position is that the provincial standard usage rates should remain in effect (**Table 2**).

Table 2. Standard usage rates for lakeshore residences

Type of shoreline residence	Usage rate (capita years per year)
Seasonal	0.69
Extended seasonal	1.27
Permanent	2.56

Usage rates can be modified based on local survey data. MOE also recommends that lake managers develop and update registries of development for each lake. Where usage is unknown, MOE recommends using the seasonal rate of 0.69 capita years per year as a default. The extended seasonal rate of 1.27 capita years per year should be used for non-permanent developments that have reliable year-round access.

MOE also recommends that specific phosphorus loading and/or usage rates be used for youth camps, resorts, permanent trailer parks, and campgrounds/tent trailers/RV parks:

Phosphorus loading / usage rates

Youth camps

Each camper = 125 g per year

Resorts ***(serviced, housekeeping cabins or meal plan)***

Each resort unit = 1.18 capita years per year; **OR**

Each guest = 308 g per year; **OR**

If staff are considered, the resort contribution can be estimated using the extended seasonal usage figure of 1.27 capita years per year per unit

Trailer parks

Each site or hook up = 0.69 capita years per year

Campgrounds / Tent trailers / RV parks

With septic system to service pump outs, comfort and wash stations:
Each campsite = 0.37 capita years per year

With vaulted (*i.e.*, pumped out) outhouses and grey water treatment

To allocate remaining development (existing vacant lots plus new severances) where usage patterns are known, managers should use a hybrid usage factor: the existing ratio of seasonal to permanent residences and their respective standard usage factors.

Watershed-based planning issues

Lakeshore capacity assessment is consistent with watershed planning in that it considers phosphorus loading on a watershed basis. All lakes in a watershed have to be taken into account and modeled to make accurate predictions. Failure to model all lakes in a watershed may result in: 1) an overestimate of the concentration of phosphorus in the target lake because, with no accounting for retention by upstream lakes, the phosphorus export from the entire watershed will be added to the target lake; or 2) an underestimate of the P concentration in the target lake because the phosphorus load from nutrient-rich lakes upstream is not considered. In practice, lakes that are less than 10 hectares in size aren't considered unless they have significant shoreline development. Wetlands aren't modeled as separate water bodies.

Watershed-based planning can be applied in three different ways, depending upon the situation:

Application of watershed-based planning

1. **First time modeling, no lakes known to be at capacity**
   All upstream sources of phosphorus must be accounted for in a lake's budget. Development capacity must allow for human sources of phosphorus from upstream. In this case, the watershed includes all lakes greater than 10 hectares in size, and smaller lakes with significant development, up to the headwaters of that catchment.

2. **Risk assessment**
   When a lake is getting close to capacity, managers should review the implications of further upstream development, taking into consideration the amount of sampling that has been done:
   - How much development capacity is left upstream?
   - What type of development is planned for the future?
   - What lakes are least sensitive to further development?
   - How much will full development upstream drive a target lake past its water quality objective?
   - What resource is at risk if an objective is exceeded (e.g.

Lakeshore capacity assessment should be based on phosphorus loadings for the entire watershed so that phosphorus offset trading, remediation and mitigation can be incorporated if they become established practices.

Comparisons between modeled estimates and measured water quality values

There will always be some discrepancy between modeled estimates and measured water quality values. This can occur because current development may not yet be expressed as changes in trophic status due to the lag time that exists between construction and phosphorus loading. Discrepancies may also result from use of inappropriate coefficients, inaccurate water quality data, or an insufficient sampling period.

MOE recommends that total phosphorus be used as the parameter for comparison of model results with measured values. The sampling period must be long enough to enable the long-term mean to be estimated to within 20 per cent with 95 per cent confidence. In most cases, this means that two years of spring overturn measurements or one year with five measurements of volume-weighted phosphorus concentrations should be used (*see* Section 6.2, Table 4). Measurements should be summarized as a median or arithmetic mean for comparison purposes.

If the modeled estimates and measured values are within 20 per cent of each other, then they aren't considered to be significantly different. If the modeled estimates and measured values differ by more than 20 per cent, then lake managers should inspect the measured record for quality and the data used in the model for accuracy, consider alternative coefficients that may be more accurate, and consult other water quality measurements (*i.e.,* Secchi depth and oxygen-temperature profile records).

Changes to model assumptions

During the past 20 years, some of the original assumptions and coefficients of the Lakeshore Capacity Model have been modified based on new scientific evidence. With the shift to municipalities for many responsibilities in land-use planning and in recognition of the need for a stable planning environment, questions have been raised about how best to continue with the process of updating assumptions. MOE recommends establishing a working group with representation from MOE, MNR, MMAH, municipalities and the private sector to periodically review major scientific advances and to discuss challenges to the model. Based on this information, the workgroup would consider if changes to the model are warranted.

4.4 Overview of the Lakeshore Capacity Model

The Lakeshore Capacity Model will assess the lakeshore capacity of a specific lake. The model was developed and calibrated for Precambrian Shield lakes in south-central Ontario, but has been tested and used in lakes across the entire Precambrian Shield. It predicts several different indicators of water quality: total phosphorus concentration, dissolved oxygen concentration at the critical end-of-summer period and the absolute volume of lake trout habitat. At the end of the assessment process, the user will have had the opportunity to determine the amount of development — whether seasonal, permanent, resort or point source that each lake in a watershed could accommodate while adhering to its water quality targets.

The Lakeshore Capacity Model is an assessment tool that is intended to be used by resource managers to predict the response of water quality to shoreline development. The municipal bodies surrounding the lake or the watershed are responsible for implementing the model predictions and allocating lakeshore capacity after the assessment has been completed.

Using the Lakeshore Capacity Model to assess the development capacity of a lake

1. Modeling begins at the top of the watershed and continues downstream until the target lake is reached. The model is used to track phosphorus sources and the transport of phosphorus from one lake to the next downstream lake.
2. The model calculates the total phosphorus (TP) concentration of a lake by calculating what the TP concentration would have been without shoreline development (the predevelopment concentration) and adding this amount to the current estimated TP contribution from shoreline development.
3. Once the TP concentration of a lake has been calculated, the model can be used to calculate the dissolved oxygen concentration. The modeled estimates can then be compared with measured values.
4. The model can also be used to calculate the response of water quality to increases in shoreline development as well as the

5.0 LAND USE PLANNING APPLICATIONS AND BEST MANAGEMENT PRACTICES

5.1 Why use best management practices?

Best management practices (BMPs) are practices that can help to reduce the migration of phosphorus from septic system effluents to water bodies, thereby reducing the effects of shoreline development on lake water quality. Coupled with lakeshore capacity assessment, BMPs will help municipalities to maintain good lake water quality. On their own, BMPs can help to reduce the adverse effects of shoreline development on inland lakes.

Best management practices can take many forms. One category involves practices that can be implemented during the planning and construction phase of shoreline development and especially during the design and construction of septic systems. Other practices relate to the ongoing maintenance of a septic system and other operating practices of the cottage or homeowner. An overview of BMPs that lessen phosphorus migration is provided below. Sources of more detailed information on BMPs are listed in Appendix B.

As noted in Section 4.3, BMPs such as shoreline naturalization and vegetated buffer strips have been accepted in many jurisdictions as sound management practices for lakeshore properties. However, there is insufficient information on these techniques to reliably predict the level of nutrient control that may be achieved or their long-term effectiveness at reducing phosphorus loading. This is why the Lakeshore Capacity Model makes no allowances for mitigation of overland runoff through site engineering and vegetated buffers.

Involving residents and cottagers' associations in the voluntary adoption and promotion of BMPs is a useful way to introduce the notion of lake stewardship (caring for lakes). Where they exist, conservation authorities often have programs or communications materials that promote the use of BMPs.

5.2 Development and planning considerations

Shoreline setbacks "in general"

The *Ontario Building* Code (OBC) sets a province-wide uniform standard requiring that there be a minimum of 15 metres clearance between a Class 4 or 5 Sewage System and any lakes, pond, spring, river or stream (as well as other water sources such as wells or reservoirs). This requirement is intended to mitigate pathogens that are harmful to humans from entering water bodies. There are no requirements in the building code with respect to phosphorus.

To address possible impacts of development on fish habitat, municipalities may enact zoning bylaws setting out setbacks or other zoning provisions. These could, for example, set out setback greater than 15 metres or zone the shoreline to restrict locating of buildings or structures. Such bylaws would be established through the planning process under the *Planning Act.*

Throughout the area covered by this Handbook, the Precambrian Shield with its typically thin soil cover and fractured bedrock conditions, where lakes are not at capacity then MOE and MNR routinely recommend a minimum of 30 metre setback or a 30 metre non-development zone from any water body. If natural heritage features are identified on or adjacent to a lot then additional appropriate setbacks or restrictive development zones might be required.

Cottagers and lake residents are encouraged to provide as great a setback as possible to minimize the impact of development on lakes. As discussed below, the underlying principle of an extended setback is that the farther the tile field from the lakes, the greater the capacity for intervening soils – presuming that they are of sufficient depth and type – to intercept and attenuate phosphorus.

Vegetation and site preparation

Phosphorus is an essential element required to support plant growth. What is not broadly accepted scientifically, however, is the amount of phosphorus that is removed permanently by a vegetative buffer that may exist at the shoreline of the proposed lot. Because of this uncertainty, further studies should be completed to quantify the effectiveness and longevity of such techniques.

Although this Handbook cannot currently recommend attributing a specific attenuation rate to a vegetative buffer for the purposes of modeling and development, a vegetated buffer is still considered to be a Best Management Practice. Where variables such as slope and soils are unknown, as noted above, MNR and MOE recommend a minimum 30-metre vegetated buffer.

Where natural vegetation – such as cattails and bulrushes – exists at the juncture of land and water, it should be maintained. Where this doesn't occur naturally, or has been removed, a vegetative buffer (riparian zone) of shrubs and ground cover can be planted along a shoreline bank. Preserving aquatic vegetation and retaining shoreline woodlots will also help to reduce phosphorus loadings. To capture and infiltrate runoff, infiltration trenches with filter fabric and crushed stone may be placed along the drip line of the cottage or house instead of traditional gutters and downspouts.

Septic system design

Cottagers and lake residents may take measures they consider will lessen the impact of their on-site sewage treatment on the environment as long as these measures do not impact negatively on any of the approved and OBC-required features of the sewage system. For example, acidic sites on non-calcareous sands (sands with low % calcium carbonate), may provide better phosphorus retention than sites on calcareous sands. Another example is the use of a siphon or pump to reduce phosphorus loading by providing an even distribution of septic tank effluents to the tile bed. Until a technology is proven effective over the long term, however, the phosphorus removal rate cannot be factored into the lakeshore capacity modeling.

What is a lake at capacity?

Lake can be modeled and/or measured to determine what their carrying capacity is with respect to shoreline development. Modeling takes into account vacant lots of record, incorporates assumptions that are inherent in the calculation of 'background' or 'undeveloped' conditions, and can be predictive with respect to any remaining capacity of the lake. When a lake is 'measured' to be at capacity, then any additional lakeshore development is beyond its carrying capacity. See section 2.0 for a discussion on the link between phosphorus, dissolved oxygen, water quality, and lakeshore capacity. (See also Appendix A and references in Appendix B).

As set out in Section 2.2, the revised Provincial Water Quality Objectives (PWQO) for lakes on the Precambrian Shield allows a 50 per cent increase in phosphorus concentration from a modeled baseline of water quality in the absence of human influence. Based on this test, a lake would be 'at capacity' with respect to phosphorus if the modeling process determined that the existing development, including vacant lots of record, exceeded the modeled 'background' or 'undeveloped' concentration of (total) phosphorus, plus 50%.

The PWQO for dissolved oxygen allows for the establishment of more stringent criteria for the protection of specific, biologically-sensitive communities. A small percentage of all lakes provide suitable lake trout habitat. Low concentrations of dissolved oxygen in deeper water impair lake trout respiration, and therefore its metabolism, which compromises its ability to swim, feed, grow, and avoid predators. Studies have shown that juvenile lake trout need at least seven milligrams (mg) of dissolved oxygen per Litre (L) of water to thrive and reproduce. The Ministry of Natural Resources consequently recognizes a criterion of 7 mg/L dissolved oxygen measured a mean volume-weighted hypolimnetic concentration at the end-of-summer, to protect lake trout habitat. For more information on this criterion, and how it is measured, please see references in Appendix B.

To protect natural heritage features, including fish habitat, policy 2.1.6. of the PPS (2005) includes direction that development and site alteration shall not be permitted on adjacent lands to the natural heritage feature unless the ecological function of the adjacent lands has been evaluated and it has been demonstrated that there will be no negative impacts on the natural features or on their ecological function. Further to this, policy 2.1.5. of the PPS (2005) provides that development and site alteration shall not be permitted in fish habitat except in accordance with provincial and federal requirements. Provincial and federal requirements are defined in the PPS (2005) as legislation and policies administered by the federal and provincial governments for the purpose of protection of fish and fish habitat, and related, scientifically-established standards such as water quality criteria for protecting lake trout populations.

The PPS (2005) is intended to be read in its entirety and the relevant policies are to be applied to each situation, including any definitions where they apply.

Requirements and restrictions for development on lakes at capacity

The following applies to lakes that have been modeled to be at-capacity for phosphorus (i.e., phosphorus concentrations exceed 'background' or 'undeveloped' concentrations + 50%), or have measured dissolved oxygen concentrations that are less than MNR's criterion for lake trout lakes (i.e., less than 7 mg/L dissolved oxygen, measured as mean volume-weighted hypolimnetic dissolved oxygen concentration at end-of-summer). Where these circumstances exist, new lot creation should only be allowed:

- to separate existing habitable dwellings, each of which has a separate septic system, provided that the land use would not change;
- where all new tile fields would be located such that they would drain into a drainage basin which it not at capacity; or
- where all new tile fields would be set back at least 300 metres from the shoreline of lakes, or such that drainage from the tile fields would flow at least 300 metres to the

lake; and,

The following additional site-specific criteria can be applied where new development is proposed on at-capacity lakes and where certain municipal planning tools and agreements are in place such as a Development Permit System under the *Planning Act*, and/or site alteration and site planning control and tree-cutting by-laws under the *Municipal Act*:

- where a site-specific soils investigation prepared by a qualified professional has been completed showing the following site conditions:
    - the site where the septic tile-bed is to be located, and the region below and 15 metres down-gradient of this site, toward the lakeshore or a permanently-flowing tributary, across the full width of the tile bed, consists of deep (more than three metres), native and undisturbed, non-calcareous (<1% $CaCO_3$ equivalent by weight) overburden with acid-extractable concentrations of iron and aluminum of >1% equivalent by weight (following Robertson 2005, 2006, Appendix B). Soil depth shall be assessed with test pits and boreholes at several sites. Samples for soils chemistry should be taken at a depth adjacent to, or below, the proposed tile bed; and
    - an unsaturated zone of at least 1 ½ metres depth exists between the tile bed and the shallowest depth (maximum) extent of the water table. The position of the water table shall be assessed with test pits during the periods of maximum soils saturation (e.g., in the spring, following snowmelt, or late fall)

Given that some relevant measures are not applicable law under the Ontario Building Code, agreements pursuant to the *Planning Act* that are registered on title will be needed to ensure the following for each lot created:

- if additional fill material is required when constricting the tile bed for the sewage disposal system, it shall consists of silt-free, fine to medium-grained non-calcareous soils (sediments; <1% $CaCO_3$ equivalent by weight) with acid-extractable concentrations of >1% equivalent by weight (following Robertson 2005,2006, Appendix B);
- design of the septic system shall include pump-dosing or equivalent technology to uniformly distribute septic effluent over the tile bed;
- no add-on system components such as water-softening apparatus, to ensure the proper functioning of the septic tank-tile bed system over the long-term;
- provision of a 30-metres minimum undisturbed shoreline buffer and soils mantle, with the exception of a pervious pathway;
- preparation of a stormwater management report and a construction mitigation plan (including phosphorus attenuation measures such as directing runoff and overland drainage from driveways, parking areas, other hard surfaces to soak away pits, infiltration facilities);
- location of the tile bed, in accordance with the recommendations of the site-specific soils investigation;
- long-term monitoring – for research purposes – of the sewage disposal system and reports to the planning approval authority and the Ministry of Environment. Monitoring would commence from the time of installation of the sewage treatment systems and proceed for at least 10 years. This monitoring will, at a minimum, include:

- sampling locations immediately below the tile bed, down-gradient of the tile bed, and at least one site up-gradient of the tile bed;
- collection of groundwater samples by a certified professional. All samples should be field filtered (0.45 µm) prior to atmospheric exposure. Samples for PO_4^{3-} (or TP) and Fe should be acidified in the field (pH < 2) with HCl or H_2SO_4, and analysed within two weeks of collection; and
- chemical analyses should also include pH, chloride, total or dissolved phosphorus, nitrate, ammonium and iron;
- sampling to occur annually (mid-summer) for the first five years, and once (mid-summer) every five years thereafter.

Lakes modeled to be 'at capacity' – Implementation of the "graduated" approach of phosphorus attenuation (Section 4.3)

This section applies to new lot creation on lakes that have been modeled to be at capacity, and where detailed site-specific information regarding phosphorus attenuation in watershed soils does not exist. Where soil attenuation rates using the 'graduated' approach with respect to distance from the shoreline – as set out in Section 4.3 – have been incorporated into a modelled lakeshore capacity assessment, then new lot creation may take into consideration bands of soil attenuation. Note that this will permit very limited land division of existing vacant lots. For example, no additional land division would be possible between the lakeshore and 100 m, where phosphorus attenuation is assumed to be negligible. Two vacant lots that have sufficient lot depth to locate development between 100 and 200 metres of the lakeshore could be reconfigured into three lots.

5.3 BMPs for maintenance and operation

Inspection and Regulation

Septic systems are regulated by provisions in the Building Code. Systems are required to perform based on the standard or requirements in place when the system was approved for use. If a system is not performing to the standard required of it and an inspector believes the system presents a health hazard, remedial steps may be required of the operator to bring the septic system into compliance.

Septic system operation and maintenance

Septic systems contained on one lot with a designed sewage flow of not more than 10,000 litres per day are regulated through the *Building Code Act* (1992) and the Building Code, which are administered by the Ministry of Municipal Affairs and Housing. The Building Code contains technical requirements that must be met when constructing a new septic system, or when extending, repairing or altering an existing system. The Code also mandates that owners of septic systems operate and maintain their systems in accordance with requirements to which they were designed. Under the Act, enforcement bodies have the authority to determine whether existing systems are unsafe, to issue orders where unsafe conditions are found and, in extreme conditions, to remediate dangerous situations at the owner's expense.

All household sewage waste should be discharged into its septic tank. Wastewater (grey water) from laundry and saunas shouldn't be discharged directly into the drain field as the detergent and soap scum will quickly clog soil pores and cause the septic system to fail.

Starters shouldn't be added to septic systems as enough bacteria are available in the wastes that are flushed into the septic tank. Septic systems should be pumped out every three to five years to remove solids and scum. While the tank is being pumped out, the cover should be removed to make sure that all solids are pumped out. Pumping through the inspection port may clog the outlet baffle with scum and grease.

Water conservation

Excessive water use is the most common cause of septic failure. Residents should be encouraged to reduce as much as possible the amount of water they use for bathing, laundry and flushing the toilet.

Shoreline vegetation

Surface waters can be contaminated by soil particles that have been washed or blown into the water. In addition to reducing water clarity, these particles may also carry phosphorus into the water. Residents can minimize soil erosion by retaining a vigorously growing filter zone (or buffer) of native grasses, trees and shrubs beside the lake and along any streams that empty into the lake. Residents can also reduce erosion by maintaining native vegetation throughout their properties to minimize areas of exposed soil. The use of native vegetation as a ground cover instead of a lawn is especially beneficial as it doesn't require the application of pesticides and phosphorus-rich fertilizers that can add to water quality problems. Minimizing the amount of impermeable surfaces such as concrete or asphalt will reduce stormwater runoff and its erosive effects.

5.4 Phosphorus abatement technologies

In recent years, interest has grown in the potential to reduce phosphorus loadings to inland lakes by using technologies such as different filter media for septic systems. Currently, approval of conventional septic systems is carried out under the Ontario Building Code. This statute sets out septic system requirements including distance from water and size.

The Lakeshore Capacity Model takes into account the phosphorus load from conventional sewage treatment systems. The model allows for the phosphorus load to be varied if phosphorus abatement or phosphorus removal technologies are used. Currently, the Ontario government hasn't acknowledged any technologies as being suitable to be installed with, or instead of, small-scale subsurface sewage treatment systems for individual dwellings, cottages or other small buildings.

6.0 MONITORING LAKE WATER QUALITY

6.1 Why monitoring is important

As noted in Section 3.4, although the Lakeshore Capacity Model makes reliable predictions when properly applied, it should be validated by water quality monitoring. Monitoring water quality in a lake over time will allow municipalities to follow trends, determine whether the lake systems are behaving as predicted and detect any unforeseen problems as they emerge.

The following sections provide an overview of monitoring. More detailed information on what and how to monitor is available from MOE.[20] Historical information on a lake's water quality may also exist at MOE (*e.g.,* through its Lake Partner Program) or at the local conservation authority. For more about acquiring such information, see Appendix B, *Lakeshore capacity assessment resources*.

6.2 What should be monitored?

The most useful estimate of trophic status, considering ease of collection and temporal variability, is total phosphorus (TP). For the purpose of using the Lakeshore Capacity Model, the optimal method of assessing the trophic status of a lake is to collect several years of TP data at spring overturn. Alternately, a lake can be characterized by using whole-lake, volume-weighted, ice-free means of TP (**Table 3**). Epilimnetic TP data (*i.e.,* samples taken from the warm, wind-circulated upper layer of a thermally stratified lake) aren't as suitable for use in the Lakeshore Capacity Model.

In lakes that support populations of lake trout, dissolved oxygen is a critical measure. Levels of dissolved oxygen are usually at their minimum just before fall turnover and monitoring usually focuses on this time period. To better understand seasonal changes, spring profiles can also be taken to determine the degree of mixing. Several years of data, taken at multiple depths, are needed to make sure that atypical profiles aren't being used to represent long-term average conditions.

[20] Ontario Ministry of Environment and Energy. 1992. Measuring the trophic status of lakes: sampling protocols. Queen's Printer for Ontario.

Table 3. Optimal sampling strategies for the most commonly used trophic status indicators[21]

Indicator	Derivation	Sample method	Samples per year		Number of years		Time
			95% confident of being within				
			10% mean	20% mean	10% mean	20% mean	
TP$_{(so)*}$	usually single sample	5m composite	1[‡]	1[‡]	10	2	during spring turnover prior to thermal stratification
TP$_{(if)*}$	average of all samples collected for ice-free period	composites when lake is mixed volume weighted during stratification	9-13 (bi-weekly)	4-5 (monthly)	5	1	between ice out and freeze up
TP$_{(epi)*}$	average of all samples collected during stratification	epilimnetic composite	19	5	7	2	during thermal stratification
Chl $a_{(ss)*}$	average of all samples collected during stratification (*e.g.* through self help programs)	euphotic zone composites	less than for Chl $a_{(if)}$; should use Chl $a_{(if)}$ if spring/fall blooms expected				during thermal stratification
Chl $a_{(if)*}$	average of all samples collected for ice-free period	euphotic zone composites	10	5	>5	2-5	between ice out and freeze up
Oxygen	usually profile data	oxygen meter with some Winkler test samples to confirm	sample frequency based on final use of data				key period just prior to fall de-stratification
Secchi	**i**ndividual observations	Secchi disc	11-17 (weekly)	3-4 (monthly)	2-5	1	ice-free period

* **so** = spring overturn; **if** = ice free; **epi** = epilimnetic; **ss** = summer stratified

‡ usually only enough time for one visit

[21] Ontario Ministry of Environment and Energy. 1992. Measuring the trophic status of lakes: sampling protocols. Queen's Printer for Ontario.

6.3 Lake Partner Program

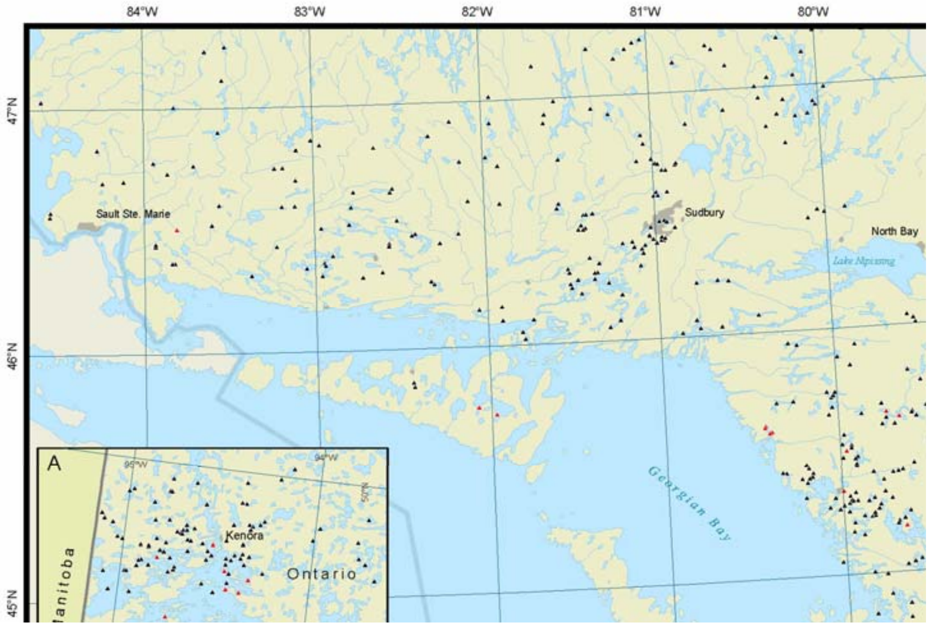
The Ministry of the Environment's Lake Partner Program works in partnership with the Federation of Ontario Cottagers' Associations, the Lake of the Woods District Property Owners Association and many other organizations to foster lake stewardship by increasing the public's awareness of the links between phosphorus and water clarity in Ontario lakes.

The program uses volunteers to collect total phosphorus (TP) and water clarity data for lakes throughout Ontario and cooperates with many science partners (including other MOE departments and municipalities) to provide accurate TP monitoring for specific lake sets of interest. The program has been quite successful: in 2004, water quality information was collected from more than 1,000 locations scattered throughout the major cottage areas of the province (**Figure 5**).

Lakes on the Precambrian Shield are sampled once each spring for TP, while water clarity is measured monthly with a Secchi disc during the ice-free period (May through October). Off-shield lakes are sampled monthly for both TP and water clarity during the ice-free period.

The TP samples are analysed by MOE to an average precision of approximately 0.7 µg/L, which is sensitive enough to detect between-year differences in spring turnover concentrations for individual lakes. The numbers are also precise enough to test the performance of the Lakeshore Capacity Model or for use as input to hypolimnetic oxygen models.

The Lake Partner Program is based out of the Ministry's Dorset Environmental Science Centre. Annual reports for the program are made available to volunteers, science partners and the public in hard copy or electronically via the ministry's website (www.ene.gov.on.ca). Inquiries about the Lake Partner Program can be made by calling 1-800-470-8322 or by emailing lakepartner@ene.gov.on.ca.


84°W
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46°N
45°N
Sault Ste. Marie
Sudbury
North Bay
Lake Nipissing
Georgian Bay
A
Kenora
Ontario
Manitoba

6.5 How chemical analysis should be done

Phosphorus occurs naturally in many forms. Both organic and inorganic phosphorus are present as dissolved, colloidal and particulate fractions in lake water samples. The analysis of total phosphorus (TP) in a lake water sample is the best test to yield precise results for phosphorus.

Total phosphorus can be accurately measured even at low microgram per litre (µg/L) levels if certain precautions are taken. To obtain acceptable phosphorus results, it's best to use the classic colourimetric method: reduced phospho-antimonyl-molybdate (heteropolyblue) complexing reaction with subsequent colourimetric measurement. This reaction is specific to the orthophosphate form and is stable and relatively interference-free (when arsenate and silicate concentrations are both less than 10 µg/L). Phosphorus analysis by inductively-coupled plasma emission isn't recommended because the level of detection is generally 50 µg/L or greater. This isn't sensitive enough for modeling the trophic status of Precambrian Shield lakes.

The colourimetric method is amenable to automation, making large numbers of analyses possible. It's straightforward and quick, giving reliable results if done by a trained analyst. Sample pre-treatment is further simplified through the use of an autoclave and acid digestion with persulfate oxidation. This digestion converts all phosphorus fractions (total phosphorus) to orthophosphate.

The optimal method of TP analysis for the purpose of the Lakeshore Capacity Model also includes the collection of duplicate lake water samples directly into the autoanalyzer tubes to minimize container effects.

The laboratory at MOE's Dorset Environmental Science Centre specializes in low-level phosphorus analysis and can be contacted for information on this procedure. The ministry's Laboratory Services Branch can also be contacted to provide information on methods to determine both total and soluble phosphorus at higher concentrations for a nominal fee (about $35 currently). Contacts for the ministry are listed in Appendix B. There are also several commercial labs in the province that can carry out TP analysis using the colourimetric method.

7.0 CONCLUSION

Lakeshore capacity assessment is a tool to help municipalities and other agencies with responsibility for land-use planning to develop inland lakes in a sustainable manner. Used in concert with other federal, provincial and municipal water-related laws, regulations and bylaws, lakeshore capacity assessment will help to ensure that the province's inland lakes on the Precambrian Shield will continue to have good water quality and healthy fish communities for generations to come.

This *Lakeshore Capacity Assessment Handbook* was developed, along with the Lakeshore Capacity Model, to help municipalities to meet their obligations under the *Planning Act* and the Provincial Policy Statement (2005). Cooperation among agencies, municipal planning authorities, residents' and cottagers' associations, developers and the public will help to achieve sustainable development of Ontario's inland lakes.