1.0 INTRODUCTION

In light of source water protection legislation and development pressures in Simcoe County, Barrie and Orillia, several collaborative studies were undertaken to assess the ability of water bodies in the Lake Simcoe and Nottawasaga River Watersheds to assimilate the effects of both existing land uses and approved committed growth plans. These studies, collectively referred to as the *Assimilative Capacity Studies* (ACS), were conducted by consultants under the direction of the Lake Simcoe Regional Conservation Authority (LSRCA) and Nottawasaga Valley Conservation Authority (NRCA) in participation with provincial government agencies and local municipalities. ACS funding was provided by the Province of Ontario, as part of an *Inter-Governmental Action Plan* (IGAP) initiated by the Ministry of Municipal Affairs and Housing in 2005, which was focused on the Lake Simcoe and Nottawasaga River watersheds.

The ACS forms Phase 1 of IGAP, which is a process initiated by the Province of Ontario in partnership with the municipalities of Simcoe County, and the Cities of Barrie and Orillia, to address concerns about population growth and development pressures and help municipalities plan for the future. The purpose of the ACS Studies for the two watersheds as it relates to the IGAP is to advise governments on the state of the watershed and recommend future actions to ensure their long term health. Technical and public consultation support for the ACS was provided by consultants under the direction of the LSRCA and the NVCA, with frequent feedback on the results and direction of the studies provided by multi-agency/multi-discipline Steering, Technical and Public Relations Committees. The major studies conducted for the ACS component of IGAP, and consultants responsible are listed below:

1. Quantification of current and likely future point and non-point sources of nutrient and sediment contributions from subwatersheds within the Lake Simcoe and Nottawasaga River Basins. (Greenland International, Inc.)

2. Hydrodynamic modeling of dispersion processes, algal growth, settling, and dissolved oxygen cycles in Lake Simcoe (Gartner Lee/Baird) and Nottawasaga Bay (SNC Lavalin) with respect to aquatic community and habitat integrity.

3. Development of Pollutant Load Targets to ensure ecological integrity of the Lake Simcoe and the Nottawasaga River watersheds and serve as a planning tool for future development and conservation strategies (The Louis Berger Group, Inc. in association with Greenland International, Inc.)

1.1 OBJECTIVE OF THIS REPORT

This report documents the process, methodology, analysis, and results of the study conducted to develop pollutant load targets for the Lake Simcoe and Nottawasaga River Watersheds (the last of the studies presented in the list above). The study relies on, and is a natural continuation of, the work conducted in the other assimilative capacity studies, including the *CANWET™ Modeling Project: Lake Simcoe and Nottawasaga River Basins Final Report* (Greenland International, Inc.), the *Hydrodynamic Mixing Zone Modeling of the Confluence of the Nottawasaga River and Nottawasaga Bay* (SNC Lavalin), and the *Three Dimensional (3D) and Hydrodynamic Modeling for Lake Simcoe* (Baird and Associates and Gartner Lee Ltd.).

In general, this study attempts to take the results and conclusions of the other ACS studies and monitoring efforts, and create a framework within which land management and land use decisions can be readily evaluated for their potential to impact water quality conditions, the health of resident aquatic communities, and preserve recreational use of area waterbodies.

To this end, the report:

1. Describes a general framework for setting load based water quality thresholds, or 'load targets', designed to ensure the preservation of aquatic communities and recreational uses in the Lake Simcoe and Nottawasaga River Watersheds.

2. Presents a characterization of the current and potential future physical, biological, and anthropomorphic conditions found in each of the land areas for which a pollutant target will be proposed (the 'subwatersheds').

3. Presents preliminary load targets for a primary pollutant of concern based on current and potential future conditions within each subwatershed.

4. Provides a list of recommendations for further refinement and implementation of water quality targets.

5. Provides base information which will be utilized in subsequent phases of the IGAP related to the analysis of potential growth options.

To summarize, the overall objective of the Pollutant Target Load Study was to **utilize information developed in the other Assimilative Capacity Studies**, **develop a framework for setting phosphorus load targets for the study watersheds**, and apply this framework to **derive preliminary phosphorus load targets**. It should be noted that this is only the first phase of this process, and should not be considered an endpoint with respect to the derivation of phosphorus load targets. This is not a decision document. Further detailed subwatershed level assessment and analysis will be required to refine the information presented in this report in order to set phosphorus load targets within an as yet undeveloped regulatory framework.

In their current state, the preliminary targets developed in this study can be used as a general guide for discussions concerning broad scale land use decision making. This analysis is intended to serve as the foundation upon which more detailed studies will be conducted in order to support the development of targeted subwatershed level plans for rehabilitation and pollutant mitigation that will result in the greatest level of pollutant reduction, and therefore the greatest overall benefits to each of the study watersheds.

1.2 BACKGROUND

The process presented in the following report is based on the development and implementation of the Total Maximum Daily Load (TMDL) process currently being implemented in the United States and regulated by the US Environmental Protection Agency. In the U.S., this process is driven by the requirements outlined in the Federal Clean Water Act of 1972, which requires each state to develop a list of waters that do not meet applicable water quality standards or do not fully support their designated uses, and develop a TMDL for each pollutant causing the impairment of waterbody on that list.

What is a TMDL?

A TMDL is the greatest amount of a given pollutant that a water body can receive without violating water quality standards and/or designated uses.

How is it calculated?

A watershed approach is used to develop the TMDL, requiring the consideration of all potential sources of pollutants, both point and non-point sources in a given drainage. The process begins with the collection of information concerning water quality, point source discharges, precipitation, soils, geology, topography, and land use (construction, agriculture, mining, etc.) within a given watershed. All impaired water-body segments within the watershed are identified, along with the potential pollutants causing the impairments.

Once the impairments and pollutants causing the impairments are identified, a methodology for development of the TMDL is prepared, including a description of the data to be used and an identification of the appropriate models and tools required to calculate the TMDL. In most cases, computer models are used to calculate pollutant loads which are selected based on the type of pollutants to be modeled, the amount of data available, and the type of water body.

Once calculated, portions of the TMDL are allocated to non-point sources and point sources, and a margin of safety is added to reflect the inherent scientific uncertainty in the TMDL calculation, seasonal variation on pollutant sources, and the potential for future development. The following formula is used to prepare this calculation:

$$\mathbf{TMDL = WLA + NPS + MOS}$$

Where:
TMDL= Total Maximum Daily Load
WLA = Wasteload Allocation – the total pollutant load allocated to point sources.
NPS = Non-Point Source load allocation – the total pollutant load allocated to non-point sources.
MOS = Margin of Safety – accounts for uncertainties in TMDL development.

How is it used?

After the TMDL has been determined, and the necessary load reductions by source calculated, an implementation plan is developed for the watershed spelling out the actions necessary to achieve the goals. The plan specifies limits for point source discharges and recommends best management practices (BMPs) for nonpoint sources. It also estimates associated costs and lays out a schedule for implementation.

1.3 IMPLEMENTATION OF THE TMDL PROCESS IN THE CURRENT STUDY

The US EPA has developed specific protocols that outline the process steps for developing a rational, science-based assessment of the impairment and calculation of a TMDL. The following figure (**Figure 1.3-1**) taken directly from the EPA's Protocol for Developing Nutrient TMDLs (EPA, 1999; EPA 841-B-99-007) outlines this protocol. This general protocol was used in the current study to develop a framework for setting pollutant target loads for the Lake Simcoe and Nottawasaga River watersheds.

Note: The following sections describe the steps of the U.S. *TMDL* process, and how these steps were implemented for setting phosphorus *target loads* in the Lake Simcoe and Nottawasaga River Watersheds. The use of these two terms is specific in this document. That is, the term *TMDL* is used in all references to the process as implemented in the U.S., whereas the term *target loads* is applied when describing targets developed for the study watersheds in Ontario, CA. This distinction was applied to avoid confusion when discussing load targets in this study which are reported on a yearly timescale. The term *target load* is also flexible enough to be used in subsequent efforts that may focus on the development of target loads on a monthly timescale.

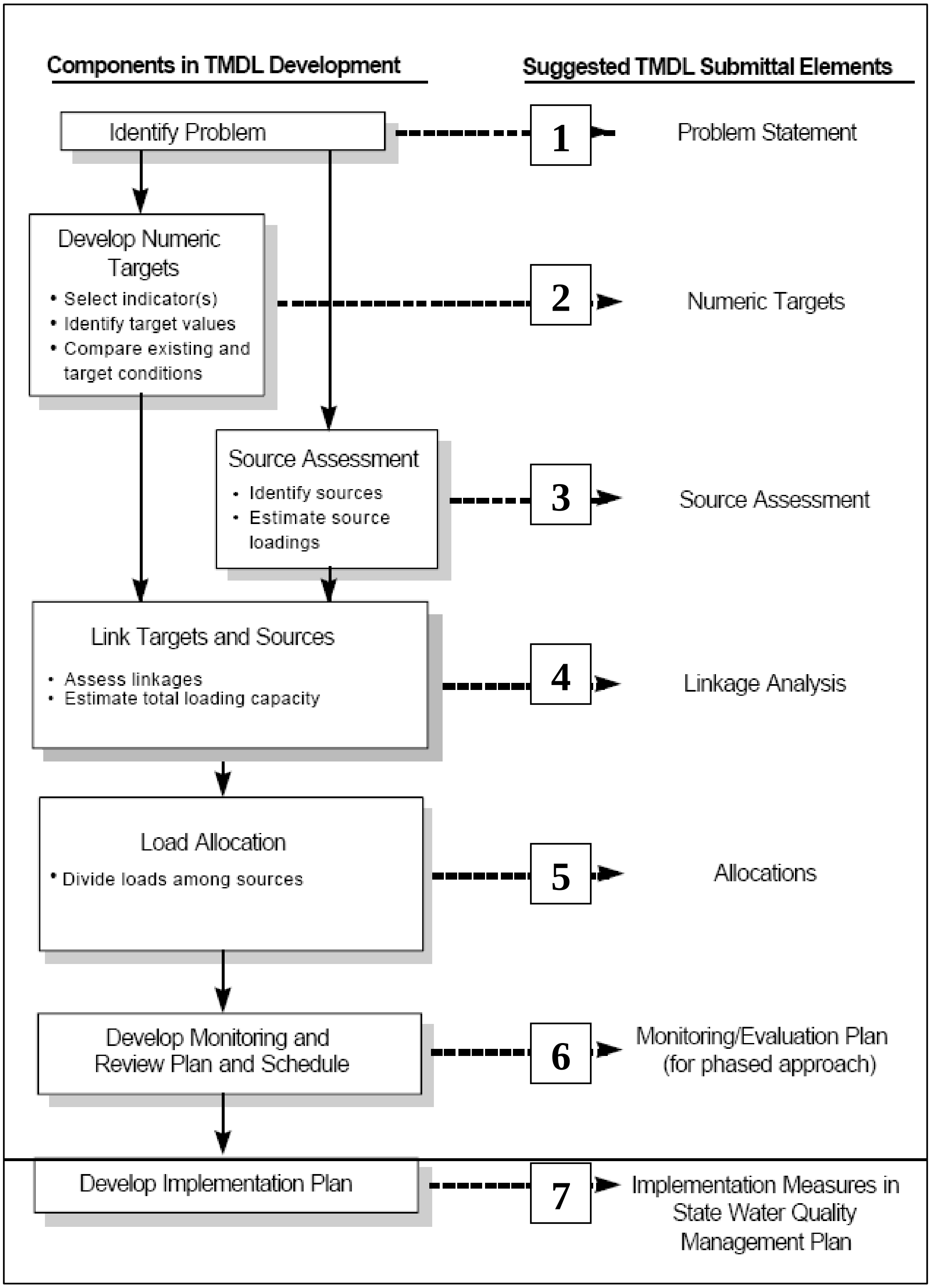


Figure 1.3-1: General Components of TMDL Development (from EPA, 1999)

The scope of this analysis and report includes only the first five steps of the process presented above. These steps, and a general description of their implementation in the current study, are presented below.

Step 1 - Problem Identification

The objective of Step 1, Problem Identification, is to identify and characterize the nature of the water body impairment. In this study, the primary water quality problems for both watersheds were identified at the outset of the study by the Lake Simcoe and Nottawasaga River Conservation Authorities. For Lake Simcoe, impacts on aquatic habitat and recreational uses from eutrophication processes, such as increased growth of nuisance vegetation in Cook's Bay and reduced Dissolved Oxygen (DO) levels in deep water habitats of lake, have long been the primary concern for water resource management and monitoring efforts (LSEMS, 2003). There has been, and continues to be, significant research into these impacts. In the Nottawasaga River watershed, impaired aquatic habitats and poor river aesthetics from turbidity along the middle and lower reaches of the Nottawasaga River during baseflow conditions are the primary concern.

In addition to these primary concerns, additional problems and objectives were identified at the subwatershed level as a result of the analysis conducted to evaluate the concerns described above. Subwatershed level issues are generally described later in this document in Chapters 2 and 3.

Step 2 - Identify Indicators and Developing Targets

The purpose of Step 2 of TMDL development is to 1) identify an indicator pollutant and 2) develop a numeric target value for that indicator to attain water quality standards. For the purposes of this study, phosphorus was identified as the primary pollutant of concern, and therefore, total phosphorus was used as the indicator of phosphorus conditions in the environment.

Primary Indicator - Total Phosphorus

As described above, eutrophication processes are the primary source of impaired conditions in Lake Simcoe, and high levels of nutrients, specifically phosphorus, have long been identified as the primary cause (LSEMS, 2005).

In Lake Simcoe, as in most other freshwater lakes, phosphorus is the 'limiting' nutrient. That is, phosphorus is generally the nutrient of lowest supply though important for the creation of biomass by aquatic macrophytes and algae. As a result of this, changes in ambient phosphorus levels are well correlated to changes in biotic production in lake ecosystems. When phosphorus levels are low, growth of rooted plants and algae are also normally low. When phosphorus levels are high, plant growth is significant and algal blooms may occur. When phosphorus levels are high and an excess of aquatic macrophyte and algal biomass growth is observed, dissolved oxygen (DO) levels decrease. This decrease is caused by an increase in oxygen demand by bacteria decomposing dead plant and algal biomass, leaving less available oxygen for fish and other aquatic biota.

Review of the available monitoring data shows that phosphorus levels in the surface waters draining into Lake Simcoe are routinely above the Provincial Water Quality Objective (PWQO) guideline of 0.03 mg/L. This review also showed that phosphorus exceeded the PWQO guideline far more often than any other pollutant of concern.

Monitoring data in the Nottawasaga River watershed also shows frequently elevated levels of phosphorus (See *Subwatershed Characterizations*, Chapter 2). However, the direct link between phosphorus levels and baseflow turbidity concerns in the lower portion of the Nottawasaga River, has not been as well substantiated as in the Lake Simcoe watershed. Other potential stressors may include excess sediment, elevated nitrogen levels, and suppressed baseflow conditions due to high levels of surface water usage. Nevertheless, elevated phosphorus levels are found in many locations in the watershed, and any load targets designed to reduce phosphorus loads would also result in nitrogen and sediment reductions. Thus, for the purposes of this study, phosphorus was selected as the most likely indicator of impaired conditions in the Nottawasaga River Watershed.

Target Setting

Once an indicator is identified, in this case total phosphorus, a target value for that indicator is determined that will allow for the attainment of water quality objectives. This target condition is established to provide measurable environmental management goals and a clear linkage to attaining water quality objectives. Target values for some indicators can be established directly through numerical criteria in water quality standards. However, in those cases where no numerical standard is available, or where additional water quality objectives must be considered, additional mechanisms can be employed in target development. This latter case, was required to meet management goals in the Nottawasaga River and Lake Simcoe watersheds.

Developing a Target Strategy: Lake Simcoe

In the Lake Simcoe watershed, two water quality objectives served as the foundation for development of a phosphorus target setting strategy.

The first objective considered is an existing interim 75 tonnes/yr total phosphorus load limit proposed for Lake Simcoe. This lake-based target was developed and agreed upon by MOE and local watershed stakeholders to protect deep water lake trout habitat. It was calculated based on modeling studies which correlated the amount of total phosphorus entering the lake to deep water DO levels (Nicholl, 1995, LSEMS ITR Imp.B.17). From these studies it was determined that phosphorus entering the lake could not exceed 75 tonnes/year and still maintain the deep water DO concentrations necessary to maintain lake trout habitat (5 mg/L). It should be noted that, roughly one third of the 75 tonnes/yr load is from direct atmospheric deposition. Thus, this limit effectively correlates to a 50 tonnes/yr limit on land based sources of phosphorus entering Lake Simcoe (Nicholl, 1995, LSEMS ITR Imp.B.17).

Comparison of the 50 tonnes per year lake target with the most recent estimates of phosphorus loads from the CANWET™ Modeling Project shows that current phosphorus loads, approximately 41.5 tonnes per year based on recent weather conditions (Greenland International, 2006), are below the 50 tonnes/yr lake target. Based on this information, deep water DO levels should be above 5 mg/L, and presumably water quality is satisfactory for aquatic life and recreational uses.

However, a review of recent observations and studies suggests that the narrative water quality objective, "to ensure that the surface waters of the province are of a quality which is satisfactory for aquatic life and recreation" is not currently being met for the Lake Simcoe watershed. This fact is evidenced by the proliferation of nuisance aquatic plant growth in the Lake as well as by notable declines in cold water fisheries (LSEMS, 2003). This suggests that although the proposed *numeric* target set to preserve a 5 mg/L deep water DO level appears to be met for the lake, the *narrative* guidelines are clearly not met based on observations of current water quality, biotic communities, and lake aesthetics.

Therefore, a second water quality objective, the PWQO total phosphorus guideline for the streams and rivers flowing into the lake (0.03 mg/L), should also be considered. This guideline was set forth by the Ministry of the Environment (MOE) and issued under the authority of legislation to ensure that water quality conditions are maintained: "at a level which is protective of all forms of aquatic life and all aspects of the aquatic life cycles during indefinite exposure to the water", and, in a manner that meets public health and aesthetic concerns to ensure recreational uses are preserved. As presented in the Water Management Policy and Guidelines (MOE, 1994), these guidelines do not have any formal legal status, but by their successful use over the years, are now seen as standard practice for water resources management.

To compare this guideline with the most recent modeled load estimates, the total annual flow volume entering the lake from each of the 23 subwatersheds (derived from the CANWET™ Modeling Project) was multiplied by the 0.03 mg/L total phosphorus guideline. This yielded 23 subwatershed PWQO based phosphorus loads that, summed together, could be compared to the current phosphorus load estimates. Comparison of the PWQO derived phosphorus load of 23.7 tonnes/yr with the 41.5 tonnes/yr estimate from the CANWET™ model shows that phosphorus loads entering the lake exceed the PWQO guideline.

This latter comparison suggests that phosphorus levels are elevated in at least some of the watersheds that drain into the lake, and provides some rationale for recent proliferation of nuisance aquatic plant growth in the lake, complaints concerning water aesthetics, and the noted declines in cold water fisheries (LSEMS, 2003).

Table 1.3-1 presents these above described comparisons and describes the method of calculation for each.

Table 1.3-1: Total Phosphorus Loads: Potential Targets, Current Conditions, and Committed Growth Scenario for the Lake Simcoe Watershed		
Load Assessment/ Target Type	**Calculated Lake Load from Land Based Sources (tonnes/year)**	**Calculation Method**
Current Phosphorus Load Estimate	**41.5**	The CANWET™ model study provided calibrated estimates of the average monthly phosphorus load entering the lake from each of the lake's subwatersheds under both current land use conditions and a committed growth scenario. Subwatershed loads were then summed to yield a total lake load from all land based sources. Point source estimates for this calculation were based on current average yearly discharge totals for the current land use condition. [For additional information see CANWET™ Modeling Project: Lake Simcoe and Nottawasaga River Basins (Greenland, 2006).]
DO-based Lake Target	**~50**	This total represents the land based load portion of a proposed Lake Target of 75 tonnes/year (Nicholl, 1995, LSEMS ITR Imp.B.17). The value was calculated based on limnological studies of the lake, and was intended to maintain a late summer deep water DO concentration of 5 mg/L to protect lake trout habitat.
PWQO-based Lake Target	**23.7**	The target load based on the PWQOs for phosphorus was calculated by multiplying the PWQO phosphorus guideline of 0.03 mg/L by the average monthly flow volumes derived from CANWET™ for all drainages entering the lake. This calculation essentially yields an estimate of the total average yearly phosphorus load entering the lake assuming all streams/rivers entering the lake have a constant total phosphorus concentration of 0.03 mg/L.

To utilize both the lake based target agreed upon by MOE and local watershed stakeholders *and* a load target based on a PWQO guideline set forth under the authority of legislation, a tiered targeting strategy was proposed by the Berger-Greenland Team and agreed upon by the ACS Technical Advisory Committee. The strategy developed presented the lake target as the ultimate, or 'primary' phosphorus target, and subwatershed level targets as 'secondary' targets designed to improve water quality conditions in identified 'impaired subwatersheds' while maintaining conditions in watersheds that were generally considered unimpaired. Development of a phosphorus target strategy in this manner would allow for focused improvement of water quality conditions where it is most needed, while at the same time ensure that the overall DO-based lake target continued to be met in the future.

Since the primary target has already been determined, i.e. no more than 50 tonnes of phosphorus per year from all land based sources should be delivered to the lake, only the secondary subwatershed level targets required further development in this study. These targets would specifically focus on improving water quality conditions in watersheds that were not meeting the narrative PWQOs (MOE, 1994). To this end, each subwatershed was determined to be either 'impaired' or 'unimpaired' based on a review of the available water quality data, biological monitoring information, and local knowledge provided by Conservation Authority staff. In addition, each subwatershed phosphorus load estimate from the CANWET™ Modeling Project was compared against a phosphorus load target derived by multiplying the yearly flow from the subwatershed by the PWQO guideline of 0.03 mg/L.

Subsequent correlation between the overall condition of each subwatershed, i.e. whether impaired or unimpaired, with whether the CANWET™ modeled phosphorus loads met or exceeded the PWQO derived load target, yielded four different pairing categories. Each of these strategies was treated with one of two methods for setting a phosphorus load target at the subwatershed level. These pairings and their alphabetic designator are listed below:

Target Setting Option	Impaired?	Provincial Water Quality Objective[1] Met?
A	No	Yes
B	Yes	No
C	No	No
D	Yes	Yes

Following agreement on the four general potential target setting categories listed above, the ACS Technical Steering Committee determined that all targets developed would need to take into account anticipated conditions under the approved committed growth scenario. This land use projection was prepared by the ACS project's participating municipalities in consultation with MMAH based on approved municipal Official Plan designations. The land use map was also verified by the IGAP consultants. No analyses were undertaken in terms of ultimate "potential" growth areas, including references to the *"Provincial Places to Grow"* forecasts.

The resultant land use distribution provided by this compilation was then used in the CANWET™ (v2.0) model to provide an estimate of potential future phosphorus loads that were used in this study for pollutant target setting. Preparation of the future scenario models included updating soil phosphorous and groundwater nitrogen grids (which depend on land use), tile drainage mapping, septic system usage mapping and projected future waste water treatment plant effluent volumes with the assumption that concentrations remain unchanged or that mass loadings from the treatment plants remain

[1] This column refers to the subwatershed level PWQO-based phosphorus target load derived by multiplying the total yearly flow volume from the CANWET Modeling Project by the 0.03 mg/L total phosphorus concentration guideline.

unchanged. Assigned waste water treatment plant volumes and septic system usage was dependant on population projections provided by individual municipal units.

Phosphorus loads from the wastewater treatment facilities generated by CANWETTM (v2.0) were analyzed using the following two scenarios: (i) loads remain the same as under existing conditions using reported historical flows and concentrations (ii) loads increase under the assumption that the concentrations remain the same as reported historically, but flow rates increase proportionally to the projected population increase with an assumption of 0.45 m3 per cap per day. Please note that these scenarios were modeled without consideration for the current capacity of the treatment facilities.

Target Setting Strategy

The following table (**Table 1.3-2**) lists the four target setting options with reference to the target methodology proposed for each. A brief description of each category, the method for calculation of a pollutant target for each, the rationale for the approach, and the potential exceptions to the strategy of each category follows.

Table 1.3-2: Target Setting Strategy Developed for the Lake Simcoe Watershed

Target Setting Option	Impaired?	Provincial Water Quality Objective Met?	Target Methodology
A	No	Yes	Set = CANWET™ modeled phosphorus load under the approved growth scenario
B	Yes	No	Set = to PWQO **or** lowest possible load under a comprehensive BMP scenario (based on PRedICT model)
C	No	No	
D	Yes	Yes	Set = CANWET™ modeled phosphorus load under the approved growth scenario & **Identify potential additional stressors**

Option A:

Those watersheds that are considered generally *unimpaired* with respect to biologic community quality, water aesthetics, and recreational uses that have *low* current phosphorus loads are considered to be in the preferred condition. As a result of this, the phosphorus target for these subwatersheds were set equal to the phosphorus load modeled under the committed growth scenario (Greenland, 2006).

Exception: In the event that land use changes under the approved committed growth scenario resulted in elevated modeled phosphorus loads that exceeded the PWQO based target load for the subwatershed, the subwatershed target would be set at the PWQO based target load. In this way, no subwatershed with low phosphorus levels would be permitted to exceed the PWQO based guideline as a result of committed growth land use changes.

Option B:

Those watersheds that are considered *impaired* with respect to biologic community quality, water aesthetics, and/or recreational uses that have *high* modeled phosphorus loads require management action to improved water quality conditions. For these subwatersheds, the phosphorus load target was set equal to a ‘reduced’ version of the phosphorus load modeled under the committed growth scenario to ensure improvement in water quality conditions.

Two methods were proposed for applying a reduction to the modeled phosphorus loads under the committed growth scenario for impaired subwatersheds with high phosphorus loads. The first, was simply to set the phosphorus load targets for the impaired subwatersheds equal to the PWQO-based phosphorus load. However, comparison of the current load estimates and the PWQO-based target loads suggests that in many cases the necessary load reductions would be impractical given current knowledge of BMP effectiveness, the state of currrent water treatment technology, and reasonable monetary expenditure. Thus, a second method was proposed for developing phosphorus load targets for impaired subwatersheds that applied the use of the Pollution Reduction Impact Comparison Tool (PRedICT) developed by Barry Evans at the Penn State Institute of the Environment. The PRedICT model is a post-processing tool designed for use with the CANWET™ model that allows for analysis of the effect of BMP implementation on reducing pollutant loads. It evaluates BMP performance by applying area-weighted loading rate reductions for phosphorous, nitrogen, and sediment on the CANWET™ output data.

Using the PRedICT model, a hypothetical scenario of Best Management Practices (BMPs) to reduce phosphorus loads[1] was evaluated for each subwatershed. This analysis resulted in a revised phosphorus load that both took into account anticipated phosphorus loads under the committed growth scenario under the hypothetical assumption that a host of BMPs would be implemented to reduce phosphorus loads. Once calculated, the revised phosphorus load became the target for watersheds with a high modeled phosphorus load. Derivation of phosphorus load targets in this manner allowed for the calculation of a phosphorus target load that is technically feasible, and in this way, provide a more reasonable assessment of an achievable total phosphorus lake target.

Exception: In the event that the PRedICT modeled phosphorus load fell below the PWQO-based load target, the target was set to equal the PWQO. In this way, no

[1] For a description of the methodology used to develop hypothetical BMP scenarios for each subwatershed, see *Section 1.4 Subwatershed Characterizations and Results Organizatio: PRedICT Modeling Results*

subwatershed with elevated phosphorus loads would be required to reduce phosphorus loads below an approved phosphorus guideline.

Option C:

Those watersheds that are considered generally *unimpaired* with respect to biologic community quality, water aesthetics, and/or recreational uses, but have *high* modeled phosphorus loads may act as a source of phosphorus that causes adverse impacts on water quality conditions in other parts of the watershed. This can be the case where physical conditions of the drainage are such that the expression of impacts associated with high levels of nutrients is less likely. For example, physical characteristics to support vegetation proliferation and algal blooms may not be available in swift running waters in high gradient streams even if high phosphorus loads are present. However, as the high phosphorus content water from these streams reaches larger rivers, with lower flow velocity, and abundant unshaded shallows, the effects of elevated nutrient waters may be expressed resulting in vegetation proliferation, algal blooms, and reduced DO levels. Thus, for these subwatersheds, the phosphorus load target was set equal the phosphorus loads modeled under the committed growth scenario *with* the implementation of BMPs.

Exception: In the event that the PRedICT modeled phosphorus load fell below the PWQO-based load target, the target was set to equal the PWQO. In this way, no subwatershed with elevated phosphorus loads would be required to reduce phosphorus loads below an approved phosphorus guideline.

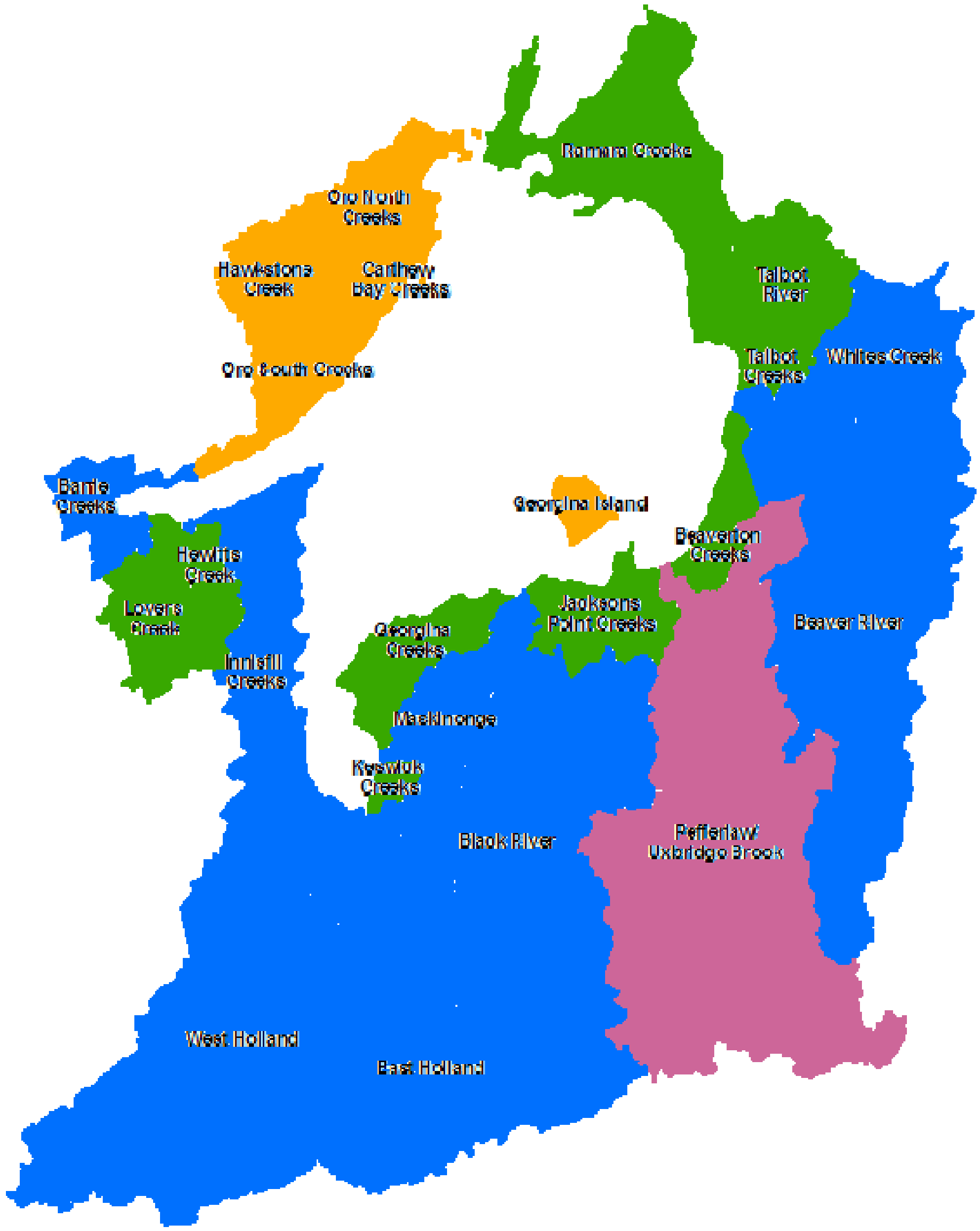
Option D:

Those watersheds that are considered *impaired* with respect to biologic community quality, water aesthetics, and/or recreational uses, but have *low* modeled phosphorus loads are likely impaired for reasons other than phosphorus. For these subwatersheds, phosphorus may not be the problem, and therefore, applying a reduction to current phosphorus load estimates would not be useful. For these subwatersheds, the phosphorus target is set equal to the phosphorus load modeled under the committed growth scenario, and future efforts should focus at identifying other potential stressors of the water's designated uses.

Exception: In the event that land use changes under the approved committed growth scenario resulted in elevated phosphorus loads that exceeded the PWQO based target load for the subwatershed, the subwatershed target would be set at the PWQO based target load. In this way, no subwatershed with low phosphorus levels would be permitted to exceed the PWQO based guideline as a result of committed growth land use changes.

Application of the Lake Simcoe Target Setting Strategy

The following figure (**Figure 1.3-2**) presents a summary of the target options described above as applied to each of the 23 subwatersheds in the Lake Simcoe Watershed.



Target Setting Option	Color	Impaired?	PWQO Met?	Target Methodology
A	Orange	No	Yes	Set = CANWET™ modeled phosphorus load under the approved growth scenario
B	Blue	Yes	No	Set = to PWQO or lowest possible load under a comprehensive BMP scenario (based on PRedICT model)
C	Green	No	No	
D	Purple	Yes	Yes	Set = CANWET™ modeled phosphorus load under the approved growth scenario & Identify potential additional stressors

Figure 1.3-2 Lake Simcoe Summary of Target Setting Options

Developing a Target Strategy: Nottawasaga River Watershed

In contrast to Lake Simcoe, the Nottawasaga River watershed has no previously developed phosphorus load targets. Thus, the target setting strategy developed relied primarily on the comparison of existing and approved growth scenario phosphorus load estimates with load estimates calculated based on the 0.03 mg/L PWQO total phosphorus guideline for streams and rivers. As presented above, targets were set at the subwatershed level to allow for focused water quality improvement at the subwatershed scale where improvements are most needed.

To apply this guideline for setting total phosphorus load targets, it was first necessary to understand the general relationship between the current phosphorus loading condition and the load target based on the PWQO total phosphorus guideline of 0.03 mg/L. **Table 1.3-3** presents this comparison and describes the method of calculation for each.

Table 1.3-3: Total Phosphorus Loads: Potential Targets, Current Conditions, and Committed Growth Scenario for the Nottawasaga River Watershed

Load Assessment/ Target Type	Calculated Load from Land Based Sources (tonnes/year)	Calculation Method
Current Phosphorus Load Estimate	**47.0**	The CANWET™ model study provided calibrated estimates of the average monthly phosphorus load each of the subwatersheds under both current land use conditions and a committed growth scenario. Subwatershed loads were then summed to yield a total load from all land based sources. Point source estimates for this calculation were based on current average yearly discharge totals for the current land use condition. [For additional information see CANWET™ Modeling Project: Lake Simcoe and Nottawasaga River Basins (Greenland, 2006).]
PWQO-based Watershed Target	**28.1**	The target load based on the PWQOs for phosphorus was calculated by multiplying the PWQO phosphorus guideline of 0.03 mg/L by the average monthly flow volumes derived from CANWET™ for all drainages. This calculation essentially yields an estimate of the total average yearly phosphorus load produced by the watershed assuming all streams and rivers have a total phosphorus concentration of 0.03 mg/L.

Based on the information presented in **Table 1.3-3**, the current total phosphorus load is well above the PWQO based target load, and would require a watershed-wide phosphorus load reduction of approximately 43% to meet a PWQO based phosphorus target for the entire watershed. Further analysis of current load estimates at the subwatershed level suggests that 11 of 12 subwatersheds produce phosphorus loads above a PWQO-based subwatershed load target.

However, a review of aquatic sampling data, a recent survey of stream health, and input from knowledgeable NVCA staff suggests that many of the subwatersheds modeled as producing high levels of phosphorus load, also support high quality aquatic communities and instream habitats. In other words, the *numeric* phosphorus load targets are mostly exceeded, but the *narrative* objectives, i.e. to ensure healthy aquatic communities and preserve recreational uses, appear to be met in many subwatersheds. NVCA suggests that these systems exhibit strong, event-based pulses of nutrients that quickly move through the system. Though total system loads may be high, these systems quickly return to low ambient nutrient concentrations as reflected in their aquatic communities and (limited) base flow nutrient data. These loadings may potentially impact the Lower Nottawasaga as spring pulses of nutrients from headwater areas may be retained in the Lower Nottawasaga through sedimentation.

The same targeting strategy proposed for Lake Simcoe was applied to the Nottawasaga River watershed resulting in a range of potential pairings between the status of the modeled loads when compared to the PWQO objectives, and qualitative assessment of stream and overall watershed health. **Figure 1.3-3** on the following page summarizes the overall phosphorus target setting framework developed for the Nottawasaga River watershed.

Steps 3 and 4 - Source Assessment and Linkages

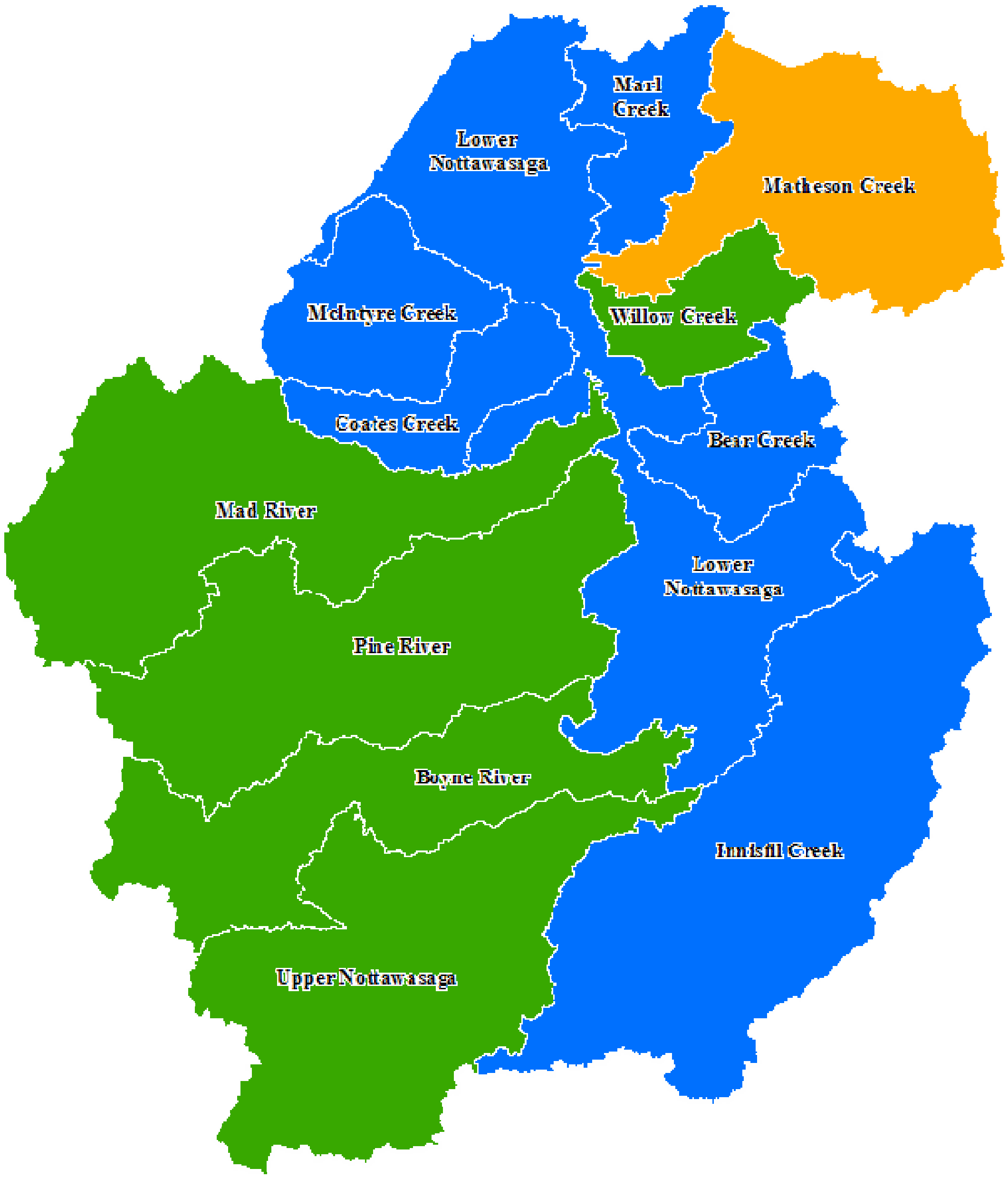
Steps 3 and 4 of the TMDL process involve the identification of the various sources in the watershed of the indicator pollutant and calculation of their contribution to the total pollutant load. Through this process, a linkage between the indicator pollutant and the identified sources is established providing a cause-and-effect relationship between the pollutant of concern and the pollutant sources.

The source assessment for this TMDL development was conducted as part of the *CANWET™ Modeling Project: Lake Simcoe and Nottawasaga River Basins Final Report* (Greenland International, 2006) and is supported by the review of water quality data and subwatershed conditions presented in this report (Chapters 2 and 3). The CANWET™ model provided estimates of pollutant loads from each subwatershed broken down by source areas (i.e. different land use types and point sources). Calibration efforts utilizing available water quality and flow information allowed for the customization of the model to fit the physical and hydrologic conditions of the area. This process allowed for a more direct linkage between modeled loads and measured loads from sources within each watershed.

Step 5 –Allocations

During step 5 of the TMDL process, a loading capacity is determined for each pollutant to attain water quality guidelines. The identified loading capacity is then distributed or “allocated” among the significant sources of the pollutant of concern. Wasteload allocations (WLA) consist of the allowable loadings from existing point sources, in this case, the maximum level listed on the Certificate of Approval for each discharger. Non-point source allocations (NPS) establish the allowable loadings from natural background and from existing and future nonpoint sources.

A margin of safety is usually identified during this step to account for uncertainty in the analysis and future growth, although it may also be identified in other TMDL components. The margin of safety may be applied implicitly by using conservative



Target Setting Option	Color	Impaired?	PWQO Met?	Target Methodology
A	Orange	No	Yes	Set = CANWET™ modeled phosphorus load under the approved growth scenario
B	Blue	Yes	No	Set = to PWQO or lowest possible load under a comprehensive BMP scenario (based on PRedICT model)
C	Green	No	No	
D	Purple	Yes	Yes	Set = CANWET™ modeled phosphorus load under the approved growth scenario & Identify potential additional stressors

Figure 1.3-3 Nottawasaga River Watershed Summary of Target Setting Options

assumptions in the TMDL development process or explicitly by setting aside a portion of the allowable loading. For the purposes of this analysis, the margin of safety (MOS) was set at 10% of the target load.

1.4 SUBWATERSHED CHARACTERIZATIONS AND RESULTS ORGANIZATION

Each subwatershed proposed for target load development in the Lake Simcoe and Nottawasaga River watersheds is characterized in the following two chapters. This characterization is intended to provide the reader with a general idea of the physical, biological, and social features and processes in the subwatershed to provide context for understanding the reported phosphorus load calculations and proposed target loads.

Below is a summary of the type of information as well as the data sources used in the Lake Simcoe and Nottawasaga subwatershed characterizations.

Location

Though many residents of an area know where the streams are, few know the boundaries of the watershed in which they live. The first section in each subwatershed characterization provides a description and map of the subwatershed boundary and its relationship to area roads, political boundaries, and populated places.

Subwatershed delineations were determined by the LSRCA for the Lake Simcoe Watershed and by Greenland International for the Nottawasaga River Watershed. Both delineations were conducted using GIS data and a minimum threshold of 750 ha for drainage area size.

Land use

Phosphorus loading rates, and therefore ultimately phosphorus loads, are heavily dependant on the type of land uses found in a given area. For example, areas of continuous forest produce little phosphorus load per unit area, whereas agricultural land uses produces much larger amounts of phosphorus per unit area due to the use of fertilizers and the production of manure. Thus, understanding the distribution of land uses in each subwatershed is critical for understanding modeled total phosphorus load estimates.

Existing land use distributions in the Lake Simcoe watershed were derived from ecological land use classification (ELC) mapping data by grouping land uses into a few generalized land use categories. The ELC mapping was developed by visually inspecting high resolution ortho-imagery, manually defining land use boundaries, and classifying each region. The classification was followed up by field verification to ensure accuracy. (LSRCA, 2005c)

The existing land use grid used for the Nottawasaga River watershed was generated using a combination of 2002 Landsat satellite imagery and ancillary thematic data. The ancillary data included available base data and high resolution ortho-imagery used for reference in choosing sampling areas. Advanced segmentation and textural analysis techniques were included with traditional nearest neighbor classification methods. The minimum mapping unit is in the order of 1 ha. An accuracy assessment using random samples interpreted from OMNR's 2001 color infrared imagery was conducted. In simpler terms, the spectral characteristics of the satellite image were used to automatically categorize the image into land use categories. This was done by assigning a range of color (spectral) characteristics to each land use category and using computer software to evaluate the properties of each grid cell of the image and determine its most likely land use category. (LSRCA, 2005e)

The land use layer for the committed growth scenario was prepared by the project's participating municipalities, in consultation with MMAH. The Ministry compiled the data layer, which was then reclassified by the LSRCA for use in the CANWET™ model. Please note, that there may be significant inaccuracies in this land use data that may significantly affect CANWET™ model results. The committed growth land use map developed reflects only approved municipal Official Plan designations. The land use map was also verified by the IGAP consultants. No analyses were undertaken in terms of ultimate "potential" growth areas. (LSRCA 2005d & LSRCA 2005b)

It is important to note the limitations associated with the future growth scenario. The future land use layer includes only "approved" development plans that fall under the Official Plans for each municipality. The life span for the various official plans within the study areas are not consistent in time frame and the approved future land use layer will not include any new proposals that are approved after the preparation of this land use layer. The future land use layers are based on the existing conditions land use and modified to incorporate new developments included in approved Official Plans. The final land use mapping was verified and approved for use in the studies by MMAH and municipalities concerned.

Earth Resources

A brief summary of the major earth resources is provided in each subwatershed characterization. Factors such as topography, geology, and soil hydrologic groups are important to understanding the phosphorus transport from land based sources to streams.

Landforms and geologic features such as moraines, plains, and escarpments have different hydrological properties that can affect ground water input, erosion rates, and surface water runoff in a given watershed. Moraine and escarpment features of the Lake Simcoe and Nottawasaga River watershed are especially important serving as a significant source of groundwater for watersheds in which they are found. (OGS, 2003) Soils are classified into hydrologic groups based on the permeability and runoff potential of a given soil type (**Table 1.4-1**). They are commonly used in land use based water quality and quantity models to determine runoff volumes and erosion rates. Soils of hydrologic soil group "A" are well to excessively well drained and have low runoff potential, whereas soils of hydrologic group "D" are poorly drained and have high runoff potential especially when found on slopes. Hydrologic groups B and C have intermediate hydrologic properties. (OMAF, 2004)

Table 1.4-1: Hydrologic Soil Groups

Group	Description
A	High infiltration rates. Soils are deep, well drained to excessively drained sand and gravels.
B	Moderate infiltration rates. Deep and moderately deep, moderately well and well-drained soils with moderately coarse textures.
C	Moderate to slow infiltration rates. Soils with layers impeding downward movement of water or soils with moderately fine or fine textures.
D	Very slow infiltration rates. Soils are clayey, have high water table, or shallow to an impervious cover

Water Resources

Stream, waterbody, and wetland locations provided by the LSCRA and NVCA are presented in the following subwatershed descriptions. Major drainage patterns relative to topographic features and landuses are presented, as well as wetland types and locations within each subwatershed. (LSRCA, 2005a)

Biological Data:

Biological sampling is used by both the LSCRA and NVCA to monitor the health of lakes, streams, and rivers. Since different species show different tolerances to impacts from pollution or disturbance, an understanding of the types of species present in a given stream can serve as a measure of stream health.

Both LSRCA and NVCA conduct benthic macroinvertebrate sampling within the Lake Simcoe and Nottawasaga watersheds. Benthic macroinvertebrates are bottom dwelling aquatic organisms that are useful in evaluating the overall health of a stream because of their particular habitat preference, sensitivity to disturbance, and low mobility within the watershed. (LSRCA, 2006)

Since 2002, LSRCA has been monitoring the instream benthic macroinvertebrate communities at more than 53 stations in the lake watershed. Macroinvertebrates collected in each sample were identified and then the species composition of each sample was analyzed using a variety of metrics that evaluate, for example: community richness, diversity, feeding groups, and the proportion of pollution sensitive species. These metrics are used to determine if the sample is representative of a community sensitive or tolerant to pollution and can be used to track any trends at a site over time.
The Hilsenhoff Biotic Index (HBI) is one metric used by LSRCA to determine the overall stream water quality based on biotic composition. HBI assesses the sensitivity of organisms to organic pollution, water quality, and habitat conditions. **Table 1.4-2** shows the HBI biotic index calculated, the associated water quality, and the degree of organic pollution assumed for each index (LSRCA, 2006). In contrast to many other metrics, a lower HBI indicates better water quality.

LSRCA has also conducted fish sampling within the watershed since 2002 at over 246 stations within the watershed. Fish sampled are identified, tallied, and weighed for analysis using a fish Index of Biotic Integrity (IBI). This index is based on such factors as the overall sample size, species richness, and presence of native species. According to LSRCA, the IBI scores calculated were revised so that samples including cold water species such as brook trout received a slightly higher score (LSRCA, 2006).

Table 1.4-2: Hilsenhoff Biotic Index Metric (HBI)

Biotic Index	Water Quality	Degree of Organic Pollution
0-3.50	Excellent	No apparent organic pollution
3.51-4.50	Very good	Possible slight organic pollution
4.51-5.50	Good	Some organic pollution
5.51-6.50	Fair	Fairly significant organic pollution
6.51-7.50	Fairly poor	Significant organic pollution
7.51-8.50	Poor	Very significant organic pollution
8.51-10.00	Very poor	Severe organic pollution

Fish habitat potential was also determined by LSRCA for each sampling site. Watercourses in the Lake Simcoe Watershed were divided into one of seven habitat categories as follows: small riverine coldwater, small riverine warmwater, intermediate riverine coldwater, intermediate riverine warmwater, large riverine, estuarine and lacustrine (**Table 1.4-3**). Whether a watercourse was considered small, intermediate, or large was based on either the relative stream size or drainage area. Cold or warmwater watercourses were determined based on physical and biological attributes. Coldwater habitats were more specifically determined based on factors such as the ratio of baseflow to average annual flow, the presence of hydrologic soils, the degree of stream slope as well as the historic presence or absence of trout within the watercourse (LSRCA, 2006).

Table 1.4-3: Stream Habitat Potential					
HABITAT CATEGORY	PHYSICAL CHARACTERISTICS				BIOLOGICAL CHARACTERISTICS
	MEAN BASEFLOW (m3/s/km2)	DRAINAGE AREA (km2)	STREAM ORDER	TEMP.	
Small riverine coldwater	high	less than 10	1ST and 2nd order (sometimes 3rd)	Stable	trout historically and currently present
Small riverine warmwater	low	less than 10	1st and 2nd order	Fluctuates	trout not historically or currently present
Intermediate riverine coldwater	moderate - high	10 - 200	3rd and 4th order, (although some 2nd and 5th)	Stable	trout historically and currently present
Intermediate riverine warmwater	low	10 - 200	3rd, 4th and 5th order	Fluctuates	trout not historically or currently present, but important migratory corridor
Large riverine	low - moderate	> 200	6th order and higher	Fluctuates	trout not historically or currently present, but important migratory corridor

The NVCA has conducted benthic macroinvertebrate monitoring (biomonitoring) since 1996. Initial biomonitoring efforts utilized the BioMAP protocol (Griffiths, 1993). Beginning in 1999, monitoring and assessment protocols were modified toward a “reference condition approach” whereby biomonitoring samples were compared to similar, relatively pristine reference sites to assess stream health. This monitoring approach was the progenitor of the Ontario Benthos Biomonitoring Network system (OBBN; 2004) which has been developed by the Ministry of the Environment for use in Ontario. Since 2004, the NVCA has employed the OBBN biomonitoring protocol for most of its benthic monitoring efforts though BioMAP is still used for specific WWTP monitoring projects at the request of the regional MOE office.

The Nottawasaga Valley Conservation Authority collects approximately 80 benthic macroinvertebrate samples annually (40 in April/ May and 40 in October/November) using the Biological Monitoring and Assessment Program (BioMAP) as the core indicator within the Watershed Health Monitoring Program (NVCA, 2005). BioMAP analyzes a macroinvertebrate sample using both a density derived (WQId) and a qualitative/presence absence (WQIq) index, as well as a set of summary metrics to determine whether conditions are considered ‘impaired’, below potential,’ or ‘unimpaired’. These indexes were used to derive the overall impairment rating at sampling sites (Great Lakes 2000 Clean up Fund and NVCA, 1999). In addition, NVCA, Ministry of Natural Resources, and others have also conducted fish sampling within the watershed since 1961 at over 200 stations. Fish collected were identified and recorded as being ‘absent’, ‘rare’, or ‘common’ within the stream. Fish samples were also used as indicators for cold and warmwater fisheries as well as indicators of pollution.

NVCA determined an overall stream health ranking for approximately 30% of all stream miles in the watershed based on instream habitat, water quality, and current biological community composition in comparison to historic or unimpaired conditions. Stream health was considered 'impaired' if the stream quality was significantly different from its potential and considered 'below potential' if the aquatic community was close to pristine conditions but constraints such as pollution were present. According to NVCA, many sites within the Nottawasaga Basin are considered 'unimpaired' or close to meeting potential conditions. Overall, stream health assessments are used to determine areas of the watershed in need of restoration and protection (NVCA, 1998), (NVCA, 2002). .

Ambient Monitoring Data

Available ambient water quality data in the Lake Simcoe watershed was provided by the LSCRA. For each water quality parameter, the count, arithmetic mean, minimum (min), maximum (max), and data range is presented over 10 years from 1995 through 2004. Water quality sampling was not always conducted consistently every year between 1995 and 2004, and for some water quality parameters, sampling was discontinued in the late nineties but resumed in 2004.

Water quality parameters sampled included dissolved oxygen (DO), biochemical oxygen demand (BOD),Temperature (T), specific conductivity (cond.), and pH. Phosphorus was collected as both total phosphorus (TP) and dissolved phosphorus (PO_4-P), and nitrogen was collected in the form of total Kjeldahl nitrogen (TKN), ammonium (NH_4-N), and nitrate (NO_3-N). Total nitrogen was computed as the summation of the average concentration of TKN and NO_3-N. Solids were measured as total residual (Tot. Res.) and Turbidity (Turb).

Available ambient water quality data in the Nottawasaga watershed was provided by the NVCA. For each water quality parameter, the count, arithmetic mean, minimum (min), maximum (max), and data range is presented over 10 years from 1995 through 2004. Water quality sampling was not always conducted consistently every year between 1995 and 2004, and for some water quality parameters, sampling was discontinued in 1996 but resumed in 2004.

Water quality parameters collected included field parameters such as dissolved oxygen (DO), Temperature (T), specific conductivity (μS/cm), and pH. Phosphorus was collected as total phosphorus (TP) and dissolved phosphorus (PO_4-P). Nitrogen was collected in the form of total Kjeldahl nitrogen (TKN), ammonium (NH_4-N), and nitrate (NO_3-N). Total nitrogen was computed as the summation of every measurement taken for TKN and NO_3-N. Solids were measured as total residual solids (Tot. Res.) and Turbidity (Turb.). The biochemical oxygen demand (BOD_5) was also determined.

General summaries of ambient water quality criteria are provided for many of the sample measurements listed for each subwatershed. General thresholds used for assessing whether a measured quantity is generally 'elevated/high' or 'low' are based on MOE provincial water quality objectives as well as literature values as shown in **Table 1-4-4**.

Table 1-4.4 Guidance Values Used in Water Quality Data Assessment

Parameter	Guidance Values			Source
	Min	**Max**	**Reference Condition Values (25th percentile for Ecoregion VII)**	
Dissolved Oxygen (mg/L)	5 (Cold Water)	-	-	MOE, 1994
	4 (Warm Water)	-	-	
pH (SU)	6.5	8.5	-	MOE, 1994
Total Phosphorus (mg/L)	-	0.030	-	MOE, 1994
BOD5 (mg/L)	1-2	-	-	Naiman and Bilby, 1998
Total Nitrogen (mg/L)	0.28	2.15	0.48	US EPA, 2000
Turbidity (NTU)	0.5	102.75	1.5	US EPA, 2000

* Excessive plant growth in river and steams should be eliminated at this total phosphorus concentration.

To date, total nitrogen (TN) and turbidity guidelines have not been specified by the Ministry of the Environment and Energy (MOE). Therefore, guideline levels for TN and turbidity were obtained from the U.S. Environmental Protection Agency (US EPA). US EPA has established numerical ecoregional nutrient criteria based on ecoregions (specific geographic regions) delineated based on variations in geology, climate, and soil type. The reference values generated are inteneded to be used as a starting point to identify more precise numeric levels for nutrient parameters to protect aquatic life, recreational, or other uses (US EPA, December 2000 and December 2001).

Based on the similarities in geography with the Lake Simcoe and Nottawasaga Watersheds, US EPA nutrient ecoregion VII, subecoregion 83 is considered to be representative of this area. The Lake Simcoe watersheds and this subecoregion share the following similar characteristics: a glaciated landscape, agricultural activity, high population density, and a climate strongly influenced by the Great Lakes. For ecoregion VII, TN and turbidity criteria were established based on data observed between 1990 and 1999 obtained from agencies such as USGS (United States Geological Survey). US EPA's guidance criteria are expressed as the upper 25th percentile of a reference population of streams within an ecoregion. This percentile is used since it is likely associated with minimally impacted conditions, will likely be protective of designated uses, and provides management flexibility (EPA, 2000).

Water Permits

Water takings in Ontario are governed by the Ontario Water Resources Act and the Water Taking and Transfer Regulation. Section 34 of the act requires anyone taking more than a total of 50,000 liters in a day, with some exceptions, to obtain a Permit To Take Water. Available information concerning the location and permit limits for Permits to Take water in both the Nottawasaga River and Lake Simcoe Watersheds were provided for this analysis (MOE, 2005).

CANWET™ Modeling Results

The CANWET™ model was used to determine phosphorous loads under existing conditions and under the approved growth scenario as part of the *CANWET™ Modeling Project: Lake Simcoe and Nottawasaga River Basins Study* (Greenland International, Inc.). Results from this study are presented for each subwatershed in a variety of forms, including average and yearly total phosphorus loads, average monthly concentrations, and average yearly loads by source. In this study general comparisons between the current and future growth scenarios and the monthly distribution of phosphorus load delivery are presented.

Please note that the intent of the current study was to utilize information developed in the other Assimilative Capacity Studies to develop a framework for setting phosphorus load targets for the study watersheds, and apply this framework to derive preliminary phosphorus load targets. Since this study was intended only to apply the use of the pollutant load estimates from the CANWET™ Modeling Project Study for target setting purposes, presentation of a detailed description of the CANWET™ model, modeling results, data used for phosphorus load assessment, are not appropriate to address in this context. For detailed information concerning the CANWET™ model and modeling results, please consult the companion CANWET™ Modeling Project Study done in parallel with this analysis.

PRedICT Modeling Results

The PRedICT tool (Evans et. al, 2003) was used in the current study to evaluate potential phosphorus load reductions based on the implementation of a comprehensive set of BMPs developed specifically for each subwatershed by the LSRCA and NVCA. The BMP scenario developed by the LSRCA and NVCA is presented as well as its effect at reducing source specific phosphorus loads calculated under the committed growth scenario. The estimated total cost of each scenario is also presented.

The Pollution Reduction Impact Comparison Tool (PRedICT) software application was developed for use in evaluating the implementation of both rural and urban pollution reduction strategies at the watershed level. The tool allows users to create various scenarios in which current landscape conditions and pollutant loads, including both point and non-point sources, can be compared against 'future' conditions that reflect the use of different pollution reduction strategies such as agricultural and urban best management practices (BMPs), stream protection activities, the conversion of septic systems to centralized wastewater treatment, and upgrading treatment plants from primary to secondary to tertiary treatment. Based on specific inputs, built-in reduction coefficients and unit costs are utilized to calculated resultant nutrient and sediment load reductions and scenario costs. While the input information for PRedICT can be compiled manually, the most efficient way to accomplish this task is to use the CANWET™ modeling system.

Within the tool, BMP systems rather than individual BMPs as described below are more often used as the basis for agricultural load reductions. This is due to the fact that BMPs are typically used in combination rather than individually to mitigate on-farm loss of soil and nutrients. **Table 1.4-5** shows the agricultural and Urban BMP options used in PRedICT as well the model input used in the development of BMP scenarios for each subwatershed

Table 1.4-5: Agricultural and Urban BMP Options Used in PRedICT

Option	Estimated BMP Phosphorus reduction efficiency	Estimated Cost ($ per hectare unless noted)	Model Input*	
Agricultural BMPs				
Cropland Protection	0.06	$65	X %	Represents % of row crop land in future scenario that will be under the application of proposed new BMPs that are not currently implemented in the existing conditions model.
Conservation	0.38	$98	X %	
Strip Cropping/contour farming	0.09	$24	X %	
Ag to forest land conversion	0.09	-	X %	
Ag to wetland conversion	0.77	-	X %	Represents % of pasture and row crop land in future scenario that will be under the application of proposed new BMPs that are not currently implemented in the existing conditions model.
Nutrient Management	0.28	$24	X %	
Grazing Land Management	0.00	$1,174	X %	Represents % of pasture in future scenario that will be under the application of proposed new BMPs that are not currently implemented in the existing conditions model.
Terraces and Diversions	0.34	$555	X %	represents % of pasture and row crop land in future scenario that will be under the application of proposed new BMPs that are not currently implemented in the existing conditions model.
Vegetated Buffer Strips	0.51	$197	X km	-
Streambank Fencing	0.78	$2,051	X km	New fencing etc. along streams passing through agricultural lands
Streambank Stabilization	0.49	$108	X km	-
Urban BMPs				
Constructed Wetlands	0.51	$304,910.05	X%	This will be the product of % change in urban land area within the sub-watershed multiplied by the % of the new urban land area that will be serviced by ponds/wetlands.
Detention Basins	0.83	$26,475.96	X%	
Wastewater BMPs (Costs per capita unless noted)				
Conversion of Septic systems to secondary treatment plant	0.10	$19,800.00	Distribution of future septic systems and efficiencies of future treatment plants should	

Table 1.4-5: Agricultural and Urban BMP Options Used in PRedICT			
Option	**Estimated BMP Phosphorus reduction efficiency**	**Estimated Cost ($ per hectare unless noted)**	**Model Input***
Conversion of septic systems to tertiary treatment plant	0.60	-	be reflected in the committed growth scenario GIS mapping.
Conversion of primary treatment to secondary treatment	0.10	$330.00	
Conversion primary treatment to tertiary treatment	0.60	$396.00	
Conversion of secondary treatment to tertiary treatment	0.50	$198.00	

*The model input values were specified by the LSRCA and NVCA for each subwatershed. Individual values are shown in Chapters 2 and 3

The unit costs associated with implementing the various individual BMPs were estimated by LSRCA and NVCA based on a review of costs associated with BMP implementation efforts conducted in the Lake Simcoe and Nottawasaga River Watersheds. Only the costs associated with initial BMP implementation and construction are considered. Thus, long-term operation and maintenance costs are not included.

Please note that phosphorus reduction calculations through BMP modeling using PRedICT only allow for yearly assessment of load reduction. At this time, PRedICT is not capable of assessing monthly variables in BMP effectiveness and phosphorus reduction.

BMP Scenarios developed by LSRCA

Crop Residue Management & Cover Crops

- Assumed that a maximum of 70% of farms within the watershed would/could undertake these practices
- Used data provided by Statistics Canada Census of Agriculture on the number and area of farms in each subwatershed with crops and the percentage of these farms already utilizing crop residue management and cover crops
- In subwatersheds where there was no census data (either there were no farms reporting, or if the number of farms in a subwatershed was less than 4, Statistics Canada would not release the data due to privacy issues), maximum values were used
- In one watershed with very few farms (only 4), a value of 0 was assigned, as there was little opportunity for improvement
- The mean of Pefferlaw and Uxbridge subwatersheds was used, as the two were combined on the tables supplied

Strip Cropping/Contour Farming

- Assumed that a maximum of 20% of farms would utilize these practices

- Used data provided by Statistics Canada Census of Agriculture on the number and area of farms in each subwatershed with crops, and the percentage already practicing strip cropping/contour farming
- In subwatersheds where there was no data (either there were no farms reporting, or if the number of farms in a subwatershed was less than 4, Statistics Canada would not release the data due to privacy issues), maximum values were used
- In one watershed with very few farms (only 4), value of 0 was assigned, as there was little opportunity for improvement
- The mean of Pefferlaw and Uxbridge subwatersheds was used, as the two were combined on the tables supplied

Crop Rotation/Cover Crops

- Assumed a maximum of 80% of farms could undertake these practices
- Used data provided by Statistics Canada Census of Agriculture on the number of farms in each subwatershed with crops, and the percentage of these farms already utilizing crop rotation and cover crops
- In subwatersheds where there was no data (either there were no farms reporting, or if the number of farms in a subwatershed was less than 4, Statistics Canada would not release the data due to privacy issues), maximum values were used
- In one watershed with very few farms (only 4), a value of 0 was assigned, as there was little opportunity for improvement
- The mean of Pefferlaw and Uxbridge subwatersheds was used, as the two were combined on the tables supplied

Nutrient Management

- The number of farms that currently have nutrient management plans is unknown
- Assumed that a maximum of 75% of farms would undertake nutrient management

Length of Stream with Vegetated Buffer Strips

- Intersected detailed land use and watercourse layers to determine the length of stream flowing through both intensive and non-intensive agricultural areas. The length of stream flowing through agricultural lands represented the potential opportunities for vegetated buffers.

Length of Stream with Fencing

- Intersected detailed land use and watercourse layers to determine the length of stream flowing through hay/pasture and pasture land uses. Estimated that 20% of this stream length could potentially be fenced.

Length of Stream with Bank Stabilization

- This number was assigned a value of zero for all subwatersheds, as there was no method for determining the length of stream that required bank stabilization.

Portion of High Density Urban Land Use Serviced by Ponds

- Determined % of urban area (urban area determined through land use layer) that could be serviced through stormwater retrofits. This potential has been determined through Urban Stormwater Management Strategies developed through the LSRCA

Portion of High Density Urban Serviced by Wetlands
- There is no potential for high density urban areas to be serviced by wetlands

Portion of Low Density Urban Serviced by Ponds
- Determined that there was no potential for servicing of low density urban areas.

Portion of Low Density Urban Serviced by Wetlands
- There is no potential for servicing low density urban areas by wetlands

Length of High Density Urban Streams with Buffers
- Intersected the detailed land use and watercourse layers to determine the length of stream running through high density urban areas. The potential length of stream that could be fenced was determined to be 5% (or 2.5% per side) of the length of stream flowing through high density urban land uses

Length of High Density Urban Streams with Stabilization
- This was assigned a value of zero, as there was no method available to determine the length of stream requiring bank stabilization

Length of Low Density Urban Streams with Buffers
- Intersected the detailed land use and watercourse layers to determine the length of stream running through low density urban areas. The potential length of stream that could be fenced was determined to be 5% (or 2.5% per side) of the length of stream flowing through low density urban

Length of Low Density Urban Streams with Stabilization
- This was assigned a value of zero, as there was no method available to determine the length of stream requiring bank stabilization

BMP Scenarios developed by NVCA

For most categories, estimates are based on internal NVCA discussion/consultation rather than detailed analysis (i.e. analysis of agricultural census information).

Row Crops
- For each subwatershed, assumed 50% total uptake of residue management/cover crop/rotation BMPs and weighted each combination equally
- Contour farming was a rough estimate based on subwatershed slopes - range from 25% on Escarpment tributaries to 10% on flatter landscapes (i.e. Willow Creek)
- Nutrient management uptake was assumed to be 50% for all subwatersheds

Hay/Pasture

- Nutrient management was assumed to be 5% for all subwatersheds
- Grazing land management was assumed to be 20% for all subwatersheds (assumes more hay cover than pasture use)

Rural Stream BMPs

- Estimated from potential project lengths within each subwatershed

Urban Lands

- Assumed that all new development (high and low density) will be serviced by stormwater ponds
- Stream buffer/stabilization was based on estimate of unbuffered/unstabilized stream banks (existing) within new urban lands
- These BMPs do not include allowances for stormwater/riparian retrofits in urban areas.

Phosphorus Targets

The last section in each characterization presents the target load calculation and allocation table based on the strategy developed for each subwatershed.

This calculation presented earlier in this chapter:

Target Load (per yr) = WLA + NPS + MOS

Where:
WLA = Wasteload Allocation – the total pollutant load allocated to point sources.
NPS = Non-Point Source load allocation – the total pollutant load allocated to non-point sources.
MOS = Margin of Safety – accounts for uncertainties in TMDL development.

Given that the target load is determined prior to load allocation, this value serves as the starting point of the calculation. From this number, a 10% margin of safety (MOS) is subtracted followed by subtraction of the maximum permitted amount from any discharger in the subwatershed (WLA). After the MOS and WLA are subtracted from the target load, the remained is the allocation to non-point sources (NPS).

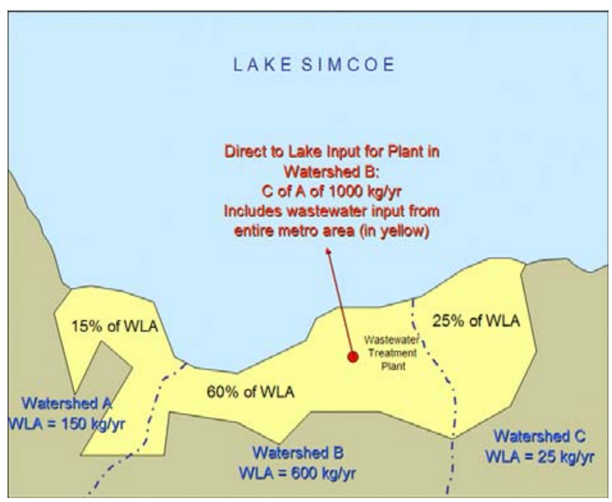
For example, if the identified target load is 1,000 kg/yr, then the MOS is 100 kg/yr. This leaves 900 kg/yr for allocation to any permitted dischargers in the watershed or non-point sources. The **maximum** permitted discharge level under the Certificate of Approval (C of A) for a given facility in the subwatershed is then removed from the 900 kg/yr, for example, this may be 400 kg/yr. This leaves 500 kg/yr of phosphorus that can be allocated to all non-point sources in the watershed. The final allocation for this example would be:

Target Load (per yr)	=	WLA	+	NPS	+	MOS
1000 kg/yr	=	400 kg/yr	+	500kg/yr	+	100 kg/yr

There are two comments to be made concerning this calculation. The first deals with the calculation of WLAs for Lake Simcoe subwatersheds, and the second concerns what should be the course of action when the combination of the WLA and MOS meet or exceed the identified Target Load resulting in a negative NPS allocation. For the purposes of this study, the latter of these questions will remain unresolved, and the reader is directed to the *Chapter 2 Summary of Results* where negative NPS load allocations and the circumstances leading to them are presented for review and consideration.

Several wastewater treatment plants in the Lake Simcoe watershed deliver their discharge directly to the lake. As a result, the phosphorus load derived from these facilities does not enter any stream in the subwatershed, and therefore, this load does not impact the water quality condition of water resources in the subwatershed. It is for this reason, the comparisons made between the current modeled phosphorus loads and the PWQO-based phosphorus loads (an instream guideline) are only done using the non-point source component of the modeled phosphorus load when a direct to lake discharger is in the subwatershed[1].

Although these sources do not directly impact subwatershed streams, they do affect the quality of the lake, and therefore need to be accounted for within the phosphorus load allocation. Though there is more than one way to account for direct to lake sources in the watershed, the authors chose to ensure that the link between those responsible for the wastewater (i.e. the homes and businesses serviced by the wastewater treatment facility) and the associated phosphorus load delivered to the lake remain inherently connected. To do this, phosphorus loads for direct to lake dischargers were allocated to each subwatershed based on the proportion of the total service area falling within each serviced subwatershed. The adjacent graphic depicts this condition for three hypothetical subwatersheds serviced by a treatment facility located in the central subwatershed that delivers its discharge directly to the lake.



This condition is only pertinent for those subwatersheds that deliver directly to the lake. This would not be applicable to treatment plants that receive wastewater from adjacent subwatersheds that discharge to a stream. Under this condition, the wasteload, regardless of its origin, impacts the water quality conditions in the watershed it discharges too, and therefore the WLA can not be distributed to an adjacent subwatershed.

[1] This also assumes that there are no other dischargers in the watershed that don't deliver phosphorus loads direct to the lake.

The following table (**Table 1.4-6**) lists the seven direct to lake discharging treatment facilities relative to the proportion of the subwatersheds they serve, and the resultant WLA that is attributed to each of the subwatershed allocation tables.

Table 1.4-6:Direct to Lake Wasteloads Attributed to the Lake Simcoe Subwatersheds

WCPC Name	**Barrie**	**Innisfil (Lakeshore)**	**Keswick**	**Lagoon City**	**Lake Simcoe Lagoon (Brock)**	**Orillia**	**Sutton**	**Grand Total**
WCPC Plant C of A (kg/year)	5,080	786	1,322	249	190	3,000	224	10,851
Existing + Future Phosphorous Load (kg/year)	2,706	252	382	58	36	867	104	4,405
Subwatershed	**Wasteload Contributions** (Proportion of WLA) WLA Attributed to Subwatershed*							**Wasteload Allocations (kg/year)**
Beaverton Creeks					(0.5) 93.7			94
Black River							(0.7) 154.7	155
East Holland			(0.1) 89.4					89
Georgina Creeks			(0.3) 384.1				(0.3) 64.7	449
Hewitts Creek	(0.1) 269.9							270
Innisfil Creeks	(0) 45.2	(1) 784.7						830
Keswick Creeks			(0.4) 463.1					463
Lovers Creek	(0.2) 1050.9							1,051
Maskinonge			(0.3) 355.9					356
Oro North Creeks						(0.6) 1714.5		1,715
Ramara Creeks				(1) 248.7				249
Whites Creek					(0.2) 36.6			37
Imported	(0.3) 1518	(0) 1.3	(0) 29.6	(0) 0.3	(0) 1.1	(0.4) 1285.5	(0) 4.6	2,840
TOTAL	**5,080**	**786**	**1,322**	**249**	**190**	**3,000**	**224**	**10,851**

* The number in () is the percentage of the WLA attributed to each subwatershed based on the proportion of the facility service area that falls within each subwatershed