Innisfil Creeks Subwatershed Plan

Lake Simcoe Region
conservation authority

2012

The Innisfil Creeks Subwatershed Plan

2012

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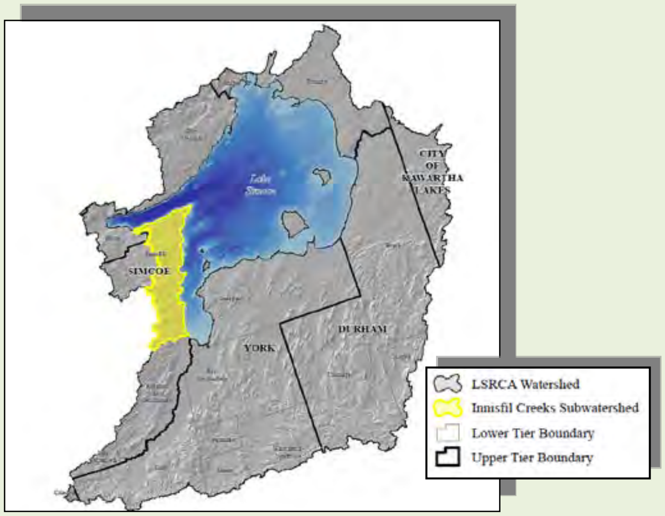
The Innisfil Creeks Subwatershed Plan (2012)

Executive Summary

WHAT IS A SUBWATERSHED PLAN?



Subwatershed planning is a process whereby the components of the environmental system are characterized, the stresses and demands on those systems are identified, and actions are recommended to guide the management of the subwatershed. These demands can be from urban and agricultural land uses and recreation; and also include the ecological needs of the system. Social and economic factors are also considered through the subwatershed planning process.

A subwatershed plan will normally include recommendations around:

- Stormwater management
- Protection of the integrity of both hydrological and hydrogeological functions.
- Improvement of water quality.
- Conservation of wetlands and woodlands.
- Maintenance or enhancement of fish habitat.
- Conservation and restoration of ecologically functional natural features and corridors.
- Land-use planning.

Maintenance of the ecological processes of the subwatershed through the retention of key natural heritage features, sufficient supplies of ground and surface water, and the protection of water quality and aquatic habitat while planning for urbanizing land uses and landscape restoration, are integral to the subwatershed planning process.

Subwatershed plans are often implemented through the incorporation of policies into municipal planning documents, including Official Plans, and Secondary, District or Community Plans and subsequent development applications.

CONTEXT

This subwatershed plan looks at the tributaries that make up the Innisfil Creeks subwatershed. The subwatershed is located on the western side of the Lake Simcoe watershed. It lies almost entirely within the Town of Innisfil, with just over 3% within the City of Barrie and less than 1% in the Town of Bradford West Gwillimbury. The subwatershed is 107 km^2 in size, and accounts for 4% of Lake Simcoe's total watershed area. It consists of 17 named streams: Banks Creek, Belle Aire Creek, Bon Secours Creek, Carson Creek, Cedar Creek, Gilford Creek, Holland River, Innisfil Creeks (small unnamed tributaries), Leonard's Creek, Mooselanka Creek, Moyer Creek, Sandy Cove Creek, Strathallan Creek, Sylvan Creek, Upper Marsh Creek, White Birch Creek, and Wilson Creek. All of the subwatershed's streams have headwaters in agricultural areas, and then flow downstream, some through urban areas, before entering the lake.

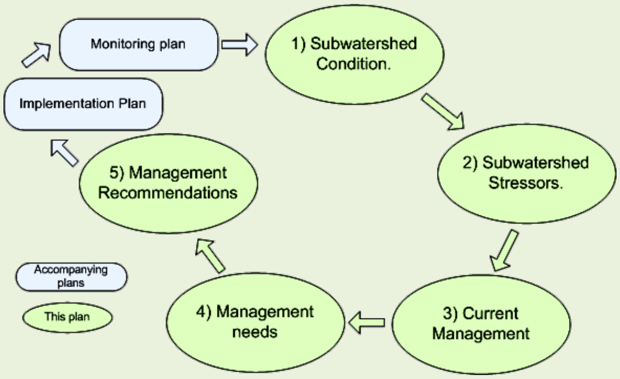
Land use in the subwatershed is currently dominated by agriculture, which occupies 45% of the subwatershed area. Natural heritage cover accounts for 33% of the subwatershed. Developed land accounts for approximately 14 % of the land use; while the remaining area includes rural development, roads and railways, golf courses, and aggregate operations. This area has undergone fairly significant change in recent years, with the urban area expected to continue to expand

This subwatershed plan was prepared under the direction of the Lake Simcoe Protection Plan (LSPP), which was released by the province in 2009. The LSPP identifies the preparation of subwatershed evaluations/plans as a crucial stage in its implementation. The LSPP states that they “will be critical for prioritizing actions, developing focused action plans, monitoring and evaluating results…[and will] provide more detailed guidance for area-specific hydrologic and natural heritage resource planning and management.”

It should be noted that the Lake Simcoe Region Conservation Authority’s (LSRCA’s) Integrated Watershed Management Plan (IWMP) (2008) also influenced the development of this subwatershed plan. The IWMP, released by the LSRCA in 2008, is considered to be a road map that outlines the future direction of the protection and rehabilitation of the entire Lake Simcoe watershed. Its broad-scale recommendations provide the basis for a number of this plan’s recommended actions for the smaller scale Innisfil Creeks subwatersheds; these two reports are meant to complement each other.

APPROACH

The initial focus of this subwatershed planning exercise used an ecosystem approach. This approach takes into consideration all of the components of the environment to assess the overall health of the environment in the subwatershed. This includes considerations of the movement of water through the system, land use, climate, geology, and local species. Everything is intricately related, and changes in any one area can have significant effects on others



State-pressure-response framework

In this subwatershed plan, we include an analysis of water quality, water quantity, aquatic habitat, and terrestrial habitat (e.g. wetlands, forests, and grasslands). Each chapter follows an identical format loosely structured around a *state-pressure-response* framework. Each chapter begins with a description of the current condition (*state*), then describes the stressors likely leading to the current condition (*pressure*), and finally provides recommendations for improvement (*response)*.

Based on this analysis, a separate document, known as an “Implementation Plan” was developed to act upon the recommendations made in the subwatershed plan. The implementation plan was prepared by LSRCA staff, and reviewed by a subwatershed plan working group, comprised of representatives from municipalities, provincial ministries, conservation authorities and community group representatives. The Implementation Plan will become the common work plan used in long term protection and rehabilitation efforts.

STATUS

Water Quality –There is one location on Leonard's Creek that we visit regularly to take samples of the surface water to be tested for a number of substances, including phosphorus and suspended sediments. Sampling began at the Leonards Creek station in 2008; this station is thought to provide a good representation of conditions on other tributaries in the subwatershed. There is a similar station for testing groundwater in the subwatershed.

The majority of the data from the Leonards Creek station indicates that the water quality generally meets relevant guidelines, although there are some concerns regarding concentrations of the nutrient phosphorus. For example, close to half of samples exceed the phosphorus guidelines, with the average concentration being only slightly under the provincial objective.

With respect to other water quality parameters, the vast majority of samples for chloride, nitrate, and total suspended sediment meet their respective guidelines, with only one chloride sample exceeding the Canadian Water Quality Guideline. Mitigation measures will be required in this subwatershed to ensure that water quality is maintained or improved; particularly as the water quality issues shift as a result of land use changes (e.g. there will be more metals and less nitrates as the land use shifts from agricultural to urban).

Water Quantity –

Groundwater (GW) flows generally toward Cook's Bay and the lakeshore just to the north of it, and into Kempenfelt Bay. Research indicates that while there is some groundwater contribution to some of the subwatershed's tributaries, as indicated by the presence of the sensitive fish species brook trout, groundwater discharge does not appear to be a substantial contributor to the flow of the creeks in this subwatershed. There is, however, little monitoring data with respect to flow in the subwatershed, a better understanding of the flow characteristics can be gained through the collection of additional data.

In order to protect groundwater recharge, the process by which rain and melting snow percolates from the surface through the soil to replenish groundwater stores (which also corresponds to ensuring that there is a water source for streams and wetlands), areas referred to as Significant Groundwater Recharge Areas have been identified for the study area; and work is currently underway to identify Ecologically Significant Groundwater Recharge Areas, which are areas thought to contribute to features such as coldwater streams and wetlands.

Fish Habitat –Fish communities in these subwatersheds vary. Coldwater species, including mottled sculpin and brook trout, have been found in Sandy Cove Creek, White Birch Creek, Burts Drain, and Leonard's Creek. Others show signs of stress with either no fish caught, or with fish species found that are less sensitive to environmental stresses. Benthic invertebrate communities (organisms that live at the bottom of rivers and lakes) also vary widely within the subwatershed. The healthiest sites when looking at both fish and benthic invertebrates are White Birch and Strathallan Creek, and Cedar Creek displays the poorest conditions. Impacts to the aquatic communities in these subwatersheds can be attributed to a wide range of factors, including expanding urban areas, uncontrolled stormwater run-off, changes made to streams, invasive species, the removal of streambank vegetation, and agriculture. Conditions can be improved through stream rehabilitation, wetland protection, streambank planting, and treating stormwater run-off from both urban and agricultural areas.

The Terrestrial Natural Environment – These features include woodlands, wetlands, grasslands, and riparian (streambank) habitat, and account for approximately 33% of the land area in the Innisfil Creeks subwatershed. Woodlands cover 26% of the subwatershed. This is slightly below Environment Canada's Areas of Concern guideline of 30% as a minimum threshold for maintaining woodland dependent biodiversity. Wetland cover occupies11% of the subwatershed, a relatively healthy level. Natural riparian cover along the streams and shoreline of the subwatershed is relatively low, at 49.7% and 17.7% respectively. Significant increases in urban area and climate change are of significant concern to the natural environment features in this subwatershed.

RECOMMENDATIONS

Recommendations based on analysis of the current conditions and stressors are provided in each chapter of this subwatershed plan. There are close to 80 recommendations in total, with some pertaining to all of the partners involved in the development of the plan, including the LSRCA, municipalities, and the provincial ministries of Natural Resources; Environment; and Agriculture, Food, and Rural Affairs. Through policies in the Lake Simcoe Protection Plan, it is expected that municipal Official Plans will be consistent with these recommendations

These recommendations include:

- Continued implementation of on-the-ground stewardship projects to improve water quality and aquatic habitat, promote infiltration of precipitation, and broaden the extent of natural features
- Promoting and supporting water conservation and re-use initiatives
- Improved land use planning practices to minimize the impacts of development
- Educating members of the public and targeted industries on topics including the dangers of using invasive species in horticulture, the importance of maintaining groundwater recharge areas, and good practices for the use of road salt to minimize environmental impacts
- Studying the potential impacts of climate change and developing plans to limit its impacts
- Researching and using new and innovative solutions to address uncontrolled stormwater
- Evaluating monitoring activities, and adjusting programs as necessary
- Striving to ensure that natural features lost through development are re-established in other parts of the watershed

NEXT STEPS

These recommendations form the basis of the Implementation Plan, which is the framework and process for acting on the recommendations. The Implementation Plan prioritizes the recommendations; identifying activities to be carried out to achieve each of the priority recommendations. It also identifies the milestones to be met, specific deliverables, and partners' responsibilities. The implementation process will also include regular tracking of activities to ensure that milestones are being met.

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1 Approach and Management Setting

1.1 Introduction

A subwatershed plan is the characterization of the current conditions and stressors of the natural environment. The plan considers the multiple competing demands, provides recommendations to guide management, as well as providing direction on how recommendations may be acted upon.

The Innisfil Creeks subwatershed is located in the western portion of the Lake Simcoe watershed and is 107.2 km^2 in size, which accounts for 4% of Lake Simcoe's total watershed area. The Innisfil Creeks subwatershed lies mostly within the Town of Innisfil (County of Simcoe), but has a small portion (3.3%) lying within the boundaries of the City of Barrie and in the Town of Bradford West Gwillimbury (0.7%). One major road is found within the subwatershed boundaries.

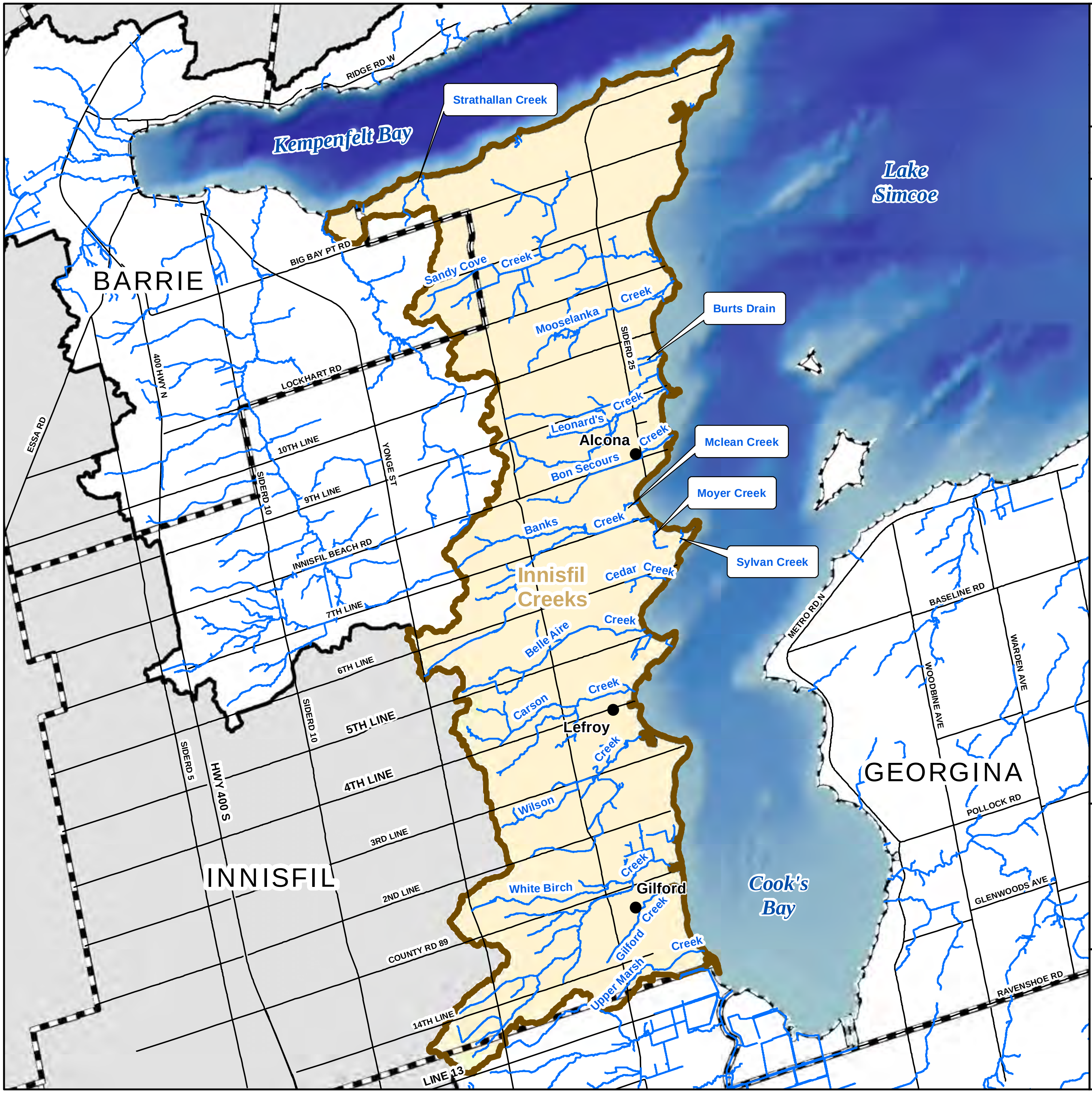
According to available data, there are 17 named streams in the Innisfil Creeks subwatershed: Banks Creek, Belle Aire Creek, Bon Secours Creek, Carson Creek, Cedar Creek, Gilford Creek, Holland River, Innisfil Creeks (small unnamed tributaries), Leonard's Creek, Mooselanka Creek, Moyer Creek, Sandy Cove Creek, Strathallan Creek, Sylvan Creek, Upper Marsh Creek, White Birch Creek and Wilson Creek. All of these streams flow from west to east into Lake Simcoe, with the exception of Strathallan Creek which flows north into Kempenfelt Bay, and all have headwaters in agricultural areas, flowing downstream through urban areas before entering the lake. In total, the Innisfil Creeks subwatershed has a combined watercourse length of 149,086 m, which is about 3.5% of the total combined watercourse length of the entire watershed.

In the Lake Simcoe watershed, the various land uses have had considerable impacts on water quality and quantity, and aquatic and terrestrial habitats. In order to mitigate the impacts of land use changes in each of the subwatersheds, and to prevent future impacts, subwatershed plans are developed. These plans provide a framework for the implementation of remedial activities and a focus for community action. More importantly, they prevent further serious degradation to the existing environment and can reduce the need for expensive rehabilitation efforts. Subwatershed plans provide a framework within which sustainable development can occur.

As part of the requirements through the Lake Simcoe Protection Plan (LSPP), subwatershed evaluations need to be developed and completed for priority subwatersheds within five years of the Plan coming into effect. Subwatersheds plans for York Region (includes the East and West Holland Rivers, Maskinonge River and Black River subwatersheds) were completed in 2010 and Durham Region (includes the Beaver River and Pefferlaw Brook subwatersheds) in 2012. The subwatershed plans prepared for the Town of Innisfil (includes Innisfil Creeks subwatershed) and the City of Barrie (includes Barrie Creeks, Lovers Creek and Hewitt's Creek subwatersheds) is scheduled for completion in 2012. The evaluation of these subwatersheds will reflect the goals, objectives and targets of the Lake Simcoe Protection Plan and will be tailored to the needs and local issues within each.

The Innisfil Creeks subwatershed

Figure 2-1



Legend

—	Road
▬ ▬	Municipal Boundary
〜	Watercourse
▨	Innisfil Creeks Subwatershed

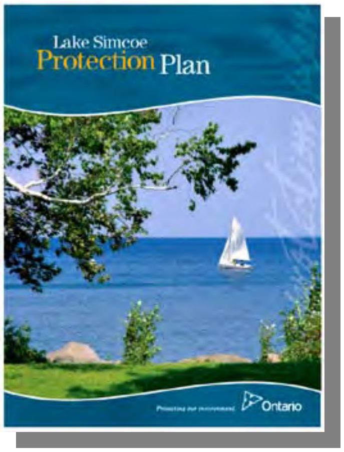
Lake Simcoe Region Conservation Authority

0 0.5 1 2 3 4 5 Kilometres

N

This product was produced by the Lake Simcoe Region Conservation Authority and some information depicted on this map may have been compiled from various sources. While every effort has been made to accurately depict the information, data / mapping errors may exist.
This map has been produced for illustrative purposes only.
LSRCA GIS Services DRAFT created July 2010.

1.2 Subwatershed Evaluation Requirements within the Lake Simcoe Protection Plan



The Lake Simcoe Protection Plan (LSPP), released by the Province in 2009, aims to be a comprehensive plan to protect and restore the ecological health of the lake and its watershed. Its priorities include restoring the health of aquatic life, improving water quality, maintaining water quantity, and improving ecosystem health by protecting and rehabilitating important areas, as well as addressing the impacts of invasive species, climate change, and recreational activities.

Preparation of subwatershed evaluations/plans is identified as a crucial stage in implementation of the LSPP. The LSPP states that subwatershed plans “will be critical in prioritizing actions, developing focused action plans, monitoring and evaluating results…. The plans will provide more detailed guidance for area-specific hydrologic and natural heritage resource planning and management.”

Policies within the LSPP guiding the preparation of this subwatershed plan are:

8.1-SA Within one year of the date the Plan comes into effect, the MOE and LSRCA in collaboration with other ministries, the First Nations and Métis communities, watershed municipalities, the *Lake Simcoe Coordinating Committee* and the *Lake Simcoe Science Committee* will develop guidelines to provide direction on:

a. identifying sub-lake areas and subwatersheds of the *Lake Simcoe watershed* and determining which sub-lake areas and subwatersheds are of priority;
b. preparing subwatershed evaluations including, where appropriate, developing subwatershed-specific targets and recommending actions that need to be taken within subwatersheds in relation to:
    i. the phosphorus reduction strategy (Chapter 4),
    ii. stormwater management master plans, including consideration of the amount of impervious surfaces within subwatersheds (Chapter 4),
    iii. water budgets (Chapter 5),
    iv. instream flow regime targets (Chapter 5),
    v. preventing *invasive species* and mitigating the impacts of existing *invasive species* (Chapter 7),
    vi. natural heritage restoration and enhancement (Chapter 6),
    vii. increasing public access (Chapter 7), and
    viii. climate change impacts and adaptation (Chapter 7);
c. monitoring and reporting in relation to subwatershed targets that may be established; and
d. consultation to be undertaken during the preparation of the subwatershed evaluations.

8.2-SA In developing the guidance outlined in 8.1, the partners identified above will develop approaches to undertake the subwatershed evaluations in a way that builds upon and integrates with source protection plans required under the Clean Water Act, 2006, as well as relevant work of the LSRCA and watershed municipalities.

8.3-SA Within five years of the date the Plan comes into effect, the LSRCA in partnership with municipalities and in collaboration with the MOE, MNR, and MAFRA will develop and complete subwatershed evaluations for priority subwatersheds.

8.4-DP Municipal official plans shall be amended to ensure that they are consistent with the recommendations of the subwatershed evaluations.

This plan is being developed to meet requirements of policy 8.3-SA, while also following requirements of policies 8.1-SA and 8.2-SA. Ensuring municipal Official Plans are updated in accordance with policy 8.4-DP is identified as an activity within the associate implementation plan.

This subwatershed plan aims to be consistent with the themes and policies of the Lake Simcoe Protection Plan to ensure a consistent approach is being taken by all of the partners toward improving watershed health.

The ecosystem approach to environmental management takes into consideration all of the components of the environment. These components include the movement of water through the system, the land use, climate, geology, human communities, and all of the species that comprise the community living in the system. These ecosystem components are all intricately related, and changes in any can have significant effects on the others.

To manage natural resources using an ecosystem approach it is essential to establish biophysical boundaries. In the Lake Simcoe watershed, the subwatersheds or river systems that drain into the lake have been identified as the best “fit” for the implementation of an ecosystem study because they are virtually self-contained water-based ecosystems (OMOE and OMNR, 1993). Watersheds are defined as the area of land drained by a watercourse and, subsequently, the land draining to a tributary of the main watercourse (Lake Simcoe is the “main watercourse” in this case) is called a subwatershed. Watershed processes are controlled by the hydrologic cycle (Figure 1-2). The movement of water influences topography, climate, and life cycles. It is due to this connectivity that any change within the watershed will impact other parts of the subwatershed.

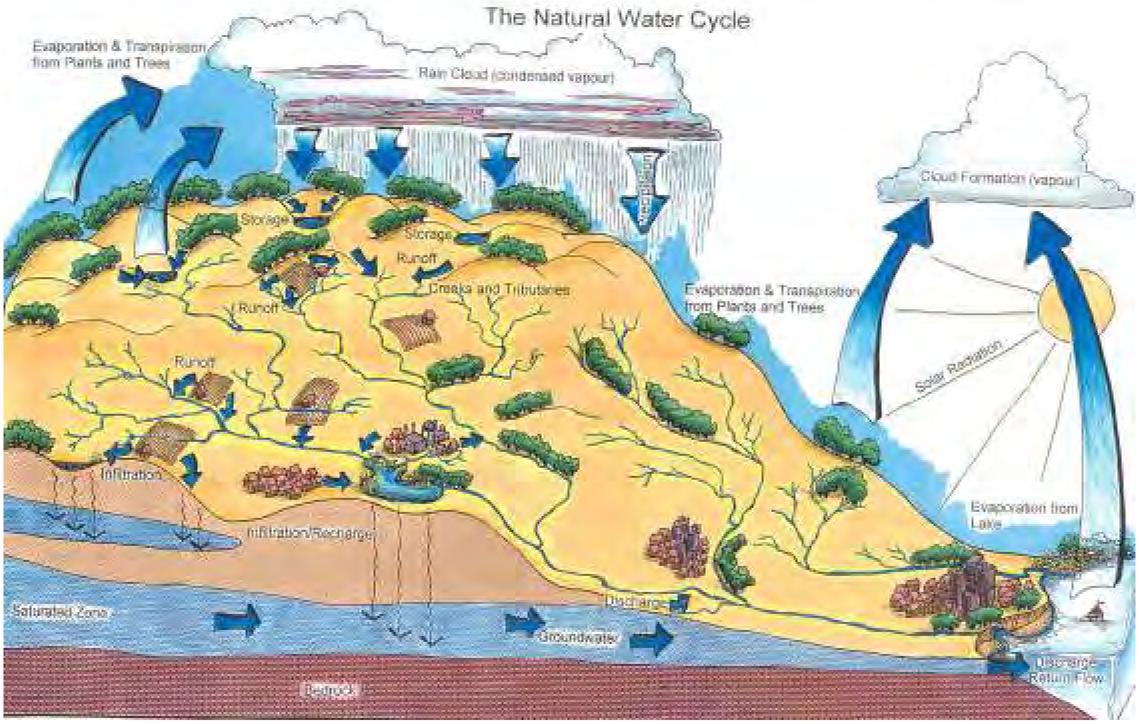


Figure 1-2: The hydrological cycle (image courtesy of Conservation Ontario).

1.3 Subwatershed Planning Context

This subwatershed plan has been written firstly to comply with the requirements under the Province's Lake Simcoe Protection Plan. However there are other documents that have influenced and fed into the development of this plan and its recommendations including the LSRCA's Integrated Watershed Management Plan (2008). The Integrated Watershed Management Plan, released by the Lake Simcoe Region Conservation Authority in 2008, was intended to be a roadmap to provide future direction for the protection and rehabilitation of the Lake Simcoe watershed ecosystem. Its broad-scale recommendations for the Lake Simcoe watershed provided the basis for a number of this plan's recommended actions.

Technical documents that are being developed to meet the 'strategic action' policy requirements of the Lake Simcoe Protection Plan and their expected completion dates are shown in Figure 1-3. As these documents are scheduled to be phased in over a number of years, they will be incorporated in the subwatershed plans as they become available. In cases where the documents are not available when a subwatershed plan is being written, they will be incorporated into the five year review and update of the subwatershed plan, as well as be addressed in the implementation plan where feasible.

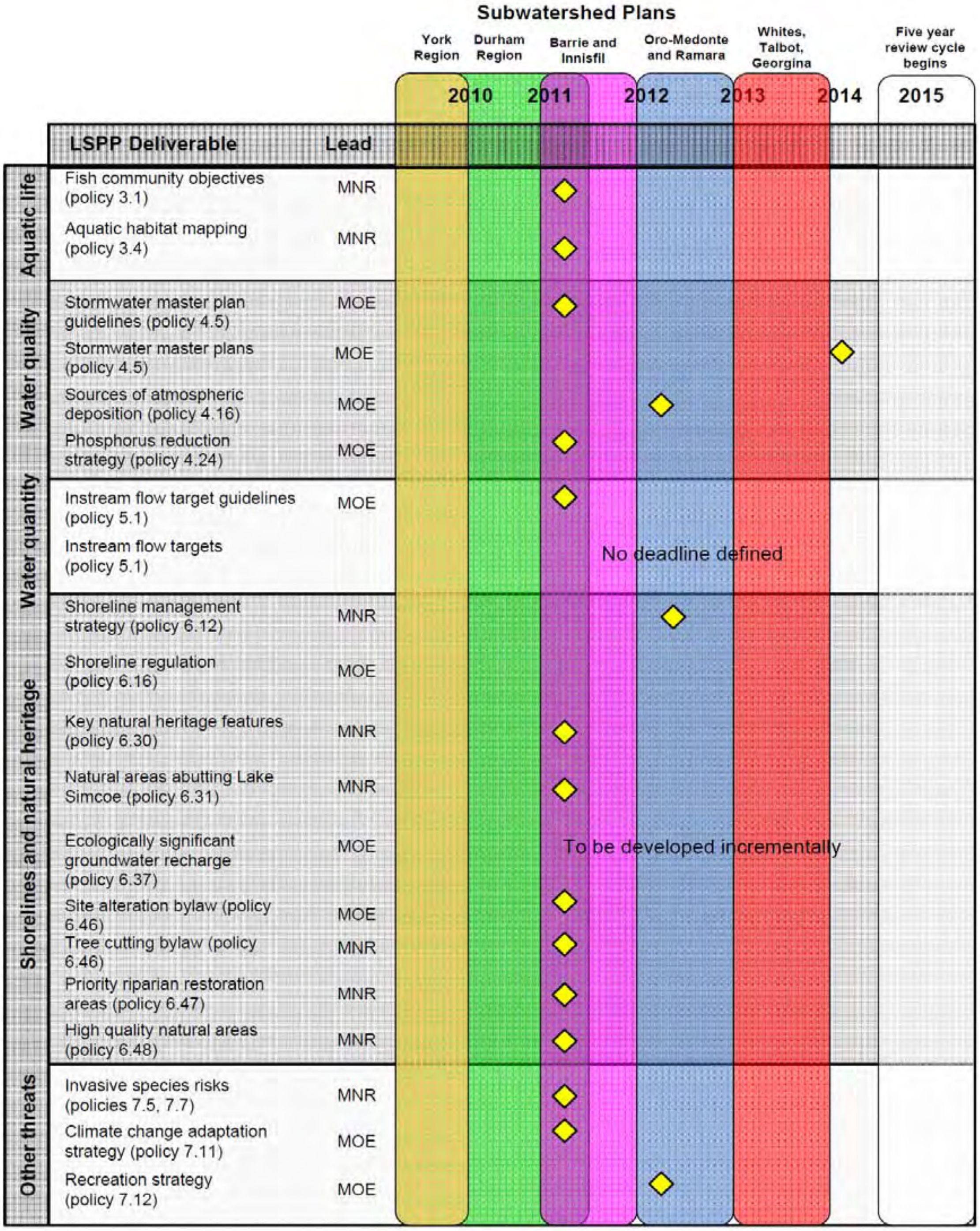


Figure 1-3: Anticipated availability of LSPP 'strategic action' documents.

This subwatershed plan also aims to complement and be supportive of the policies of the applicable upper and lower tier municipal official plans and the related municipal programs that strive to achieve similar outcomes related to subwatershed health. Within the City of Barrie, studies have also been completed that have contributed to this report, including background documents for the Secondary Plan for the annexed lands along the City of Barrie's southern border. This border has been extended to included 2,293 hectares of land from the Town of Innisfil to accommodate the projected growth within the City of Barrie. The background documents for the Secondary Plan provide a platform for identifying development opportunities and limitations within the annexed lands, as well as a scope of the environments (economic, social, cultural, natural) that already exist (Barrie, 2010). The Secondary Plan is also accompanied by an Infrastructure Master Plan which addresses stormwater management needs as projected development occurs. This subwatershed plan is being developed concurrently with the Secondary Plan.

1.4 Subwatershed Planning Process

Preliminary Consultation

Start up meetings were had with the Town of Innisfil, City of Barrie, Ministry of the Environment (MOE) and Ministry of Natural Resources (MNR) to go over the intended direction and scope of the subwatershed plan, the projected timeline and how it would incorporate any new information coming from studies currently underway.

Characterization

The initial focus of the subwatershed planning exercise has involved the completion and summarization of subwatershed characterization work. It also involved the development of water quality, quantity, aquatic, and terrestrial habitat models to assess the environmental impacts associated with potential changes in the landscape. Based on this important information, recommendations are developed to address the stressors as well as the gaps and limitations for each parameter. They are also intended to be consistent with the policies of the LSPP.

Subwatershed Working Group – Review Committee

The Subwatershed Working Group (SWG) consists of representatives from the City of Barrie, Town of Innisfil, Simcoe County, MOE, MNR, MAFRA, and the South Simcoe Streams Network. This is a voluntary committee that is essential for reviewing content of the plan and developing recommendations. The SWG convened at approximately three to four month intervals during 2011 and 2012. Before each meeting, committee members are presented with characterization chapters and their associated recommendations. Comments received on the characterization material were documented and addressed, while comments received on recommendations were discussed, incorporated and re-distributed for further discussion/approval at the next meeting. This was done to ensure that all parties are fully aware of, and agree with, final recommendations that will be the basis of the Subwatershed Implementation Plans.

Public Consultation

Public consultation occurred in the fall of 2012 to educate residents within the subwatersheds about the plans, what the current conditions are of their local natural areas, what the immediate stressors are and what recommendations have been developed to improve the conditions.

1.5 Subwatershed Implementation Process

Implementation Plan

Recommendations were used to form the basis of the development of the Implementation Plan for the subwatersheds. The Implementation Plan is a framework and process for acting on the recommendations put forth in the Subwatershed Plans. It prioritizes the recommendations, identifying activities to be carried out, the milestones to be met, timeframes and, partner's responsibilities. The Implementation Plan was drafted by staff and revised by the SWG during a one day workshop.

Implementation Working Group

Upon approval of this subwatershed plan it is proposed that the subwatershed working group transition into an implementation working group. The primary role of the working group will be to oversee, track and report on progress of the various activities identified in the implementation plan. Project updates, integrating and linking the numerous efforts, and monitoring and reporting on success will be the ongoing business of the IWG.

It is recognized that many of these undertakings will be dependent on funding from all levels of government. Should there be financial constraints, it may affect the ability of the partners to achieve these recommendations. These constraints and other potential challenges will be addressed by the IWG with the ultimate goal of adapting as necessary to achieve the desired outcomes of the recommendations.

Implementation

Implementation of recommendations will be the responsibility of the agencies and organizations identified in the implementation plans. In many cases implementation will require collaboration between different partners to achieve the required outcomes, and will also be funding dependent.

To ensure that this subwatershed plan remains current and relevant, it has been developed using an adaptive management framework. As such, it is proposed that the subwatershed plan be updated every five years to ensure that it contains the best available science and monitoring data reflecting the health of the subwatershed and associated environmental stressors. Between updates to the plan, ongoing monitoring, assessing and evaluation of the subwatersheds as well as the extent and effectiveness of implementation of the recommendations of this subwatershed plan will be occurring, with new reports and studies being produced. Communications will need to be updated to coincide with these studies and implementation approaches will need to adapt to reflect the most current information available

Figure 1-4 depicts the relationship between this subwatershed plan and the materials that have guided and contributed to its development. It also depicts the implementation plan, which will provide details of a plan to undertake the recommended actions.

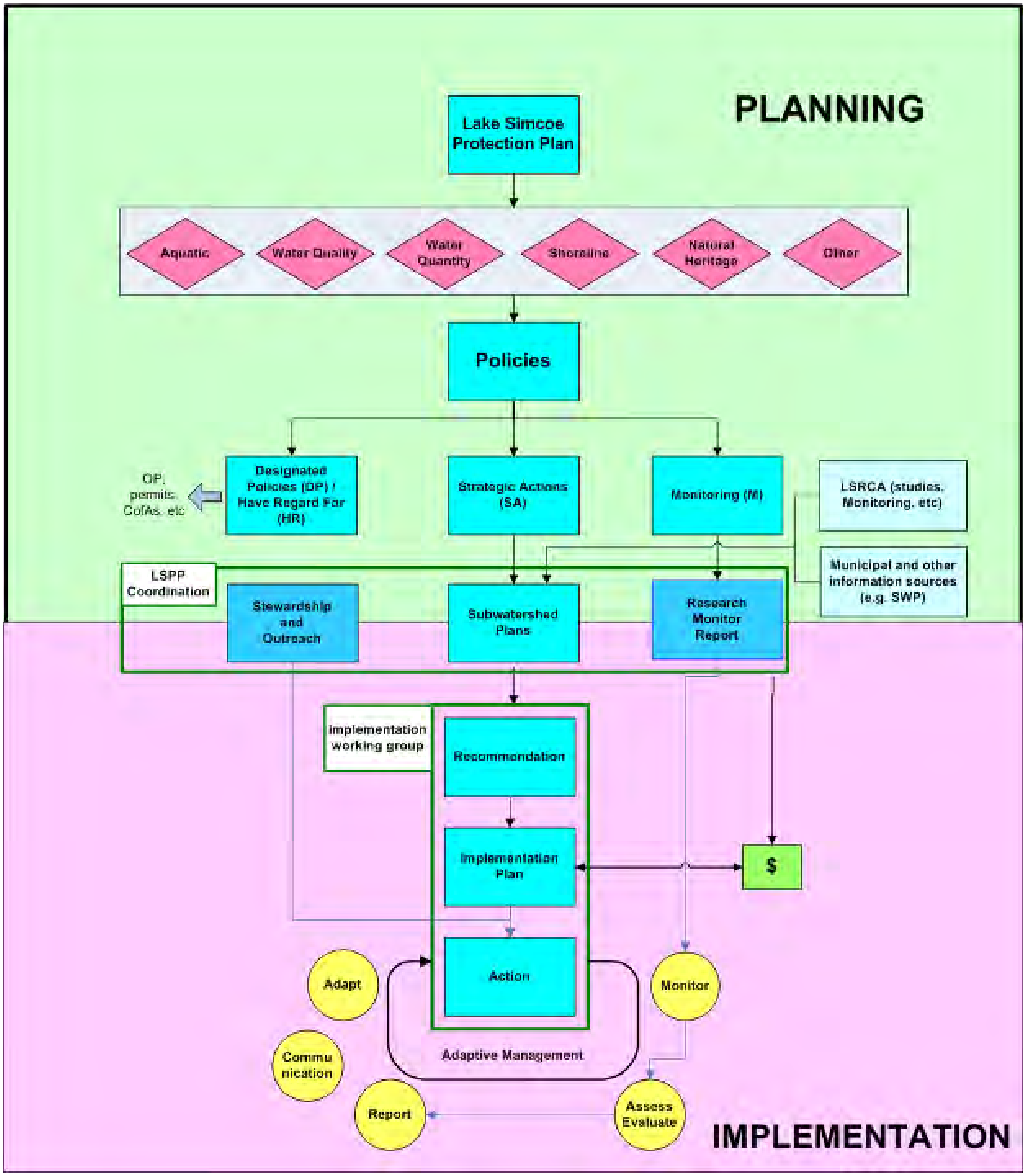


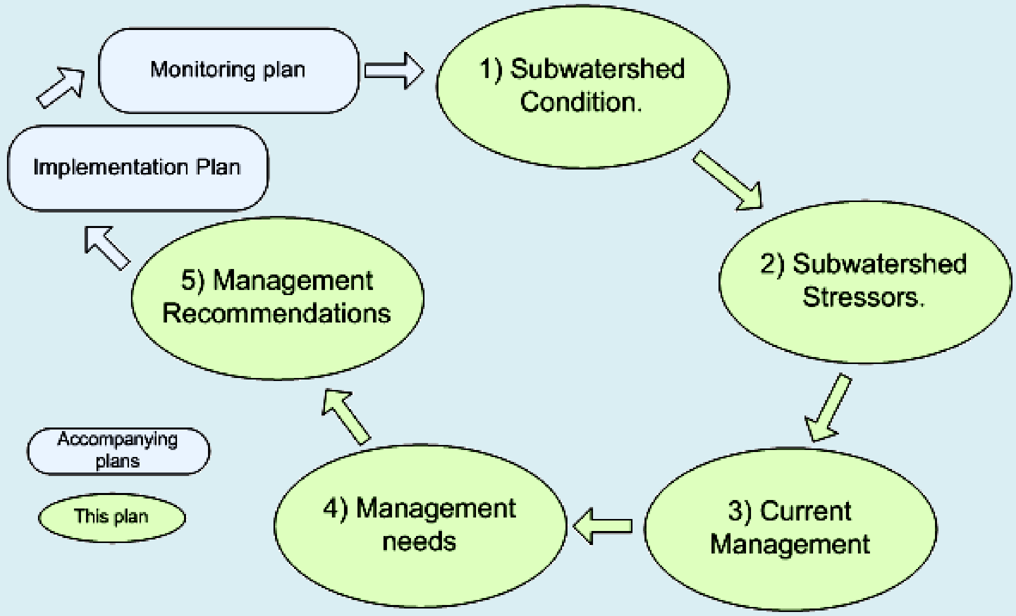
Figure 1-4: Subwatershed planning context

1.6 Current Management Framework

The goals and management recommendations offered in this plan have been developed in context of the Lake Simcoe Protection Plan (LSPP) and other existing legislation and their associated plans and policies. There are many regulations related to the protection and restoration of Lake Simcoe and its subwatersheds, and although each of these acts and associated plans differ, although in some cases policies do overlap. The manner in which regulations differ include: (1) the number and types of watershed activity they have authority over. For example some regulations have a very broad mandate, regulating many activities (e.g. the LSPP) while others are very specific (e.g. The Endangered Species Act); (2) the legal effect of policies they contain; (3) the geographic area they represent; and (4) the degree of implementation–many aspects of more recent legislation, such as the Lake Simcoe Protection Plan, still need to be acted upon. Each chapter of this subwatershed plan provides a more detailed assessment of the legislation and associated polices related to that particular subwatershed element e.g. water quantity or aquatic habitat).

1.7 How this plan is organized

This plan includes a chapter dedicated to each of the five subwatershed features identified above, these being water quality, water quantity, aquatic habitat, and terrestrial natural heritage. Each of these chapters follows an identical format, loosely structured around a pressure-state-response framework, in that each chapter firstly describes the current condition (state), secondly describes the stressors likely leading to the current condition (pressure), and finally recommends management responses in the context of the current management framework (response) (See text box below).



Plan section:

1) ***Subwatershed Condition:*** Describes and analyzes the current state or condition of the subwatershed feature based on the best available data and information. This assessment is based on monitoring data, model output, surveys etc.
2) ***Subwatershed Stressors:*** Uses the best available information to identify and quantify the factors affecting the current condition of the watershed. For example, describing phosphorus loads from different land use activities.
3) ***Current Management:*** Establishes the relationship of the subwatershed plan to other legislation and planning documents;
4) ***Management needs:*** Identifies areas within the current management framework where improvements within this plan may be able to have greatest impact i.e. gaps or opportunities for the subwatershed plan to act upon.
5) ***Management recommendations:*** outlines resource management goals and objectives; as well as options for protection, rehabilitation, and enhancement of conditions in the subwatershed.

The resulting plan will protect the existing natural resources, facilitate informed planning decisions, and improve the efficiency of the development review process. An over-arching concept to keep in mind throughout the subwatershed planning process is that it is far more beneficial, both financially and ecologically, to protect resources from degradation than to rehabilitate them once they have been damaged.

2 Study Area: The Innisfil Creeks subwatershed

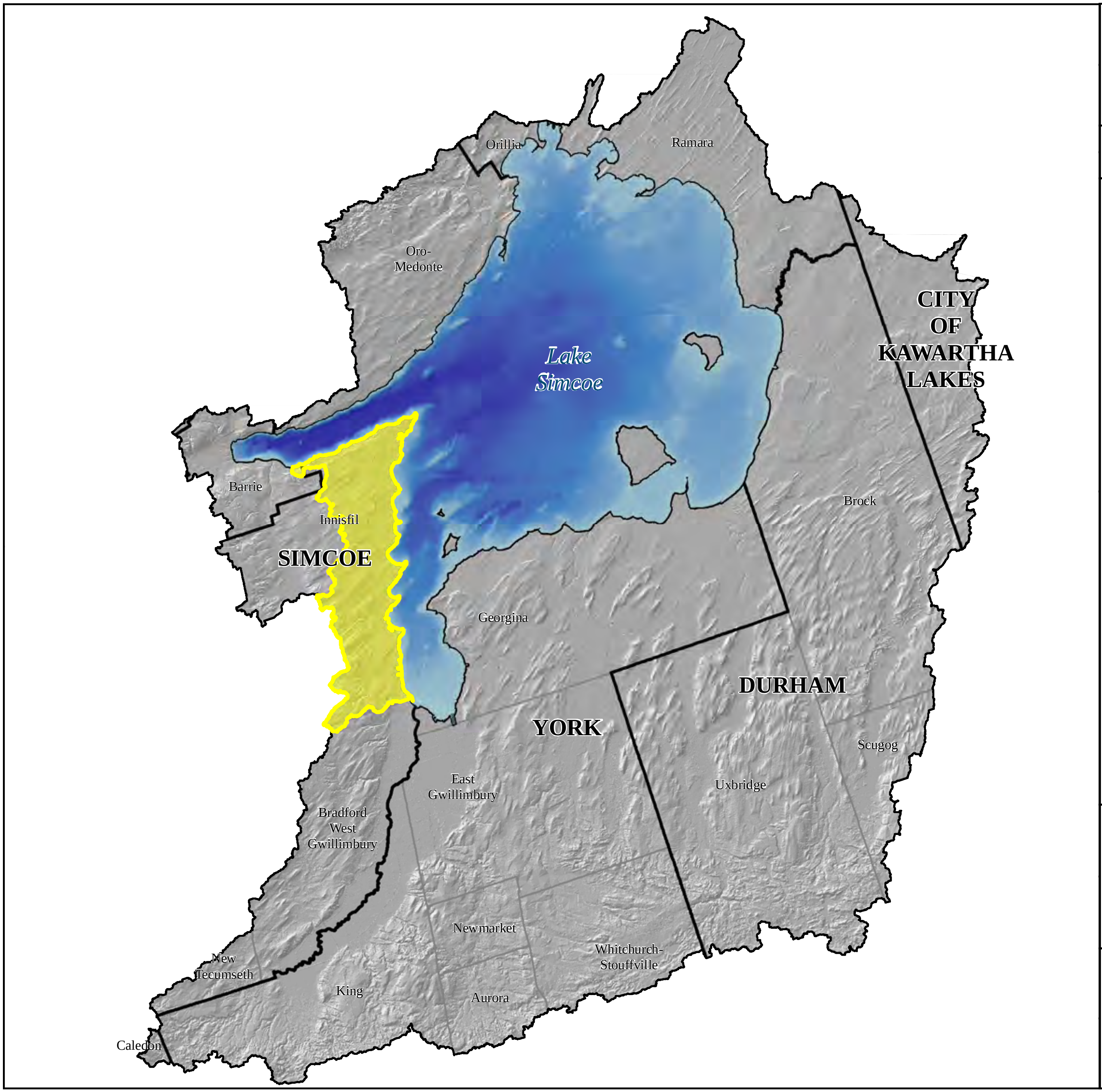
2.1 Location

All of the lands within the Lake Simcoe watershed ultimately drain into Lake Simcoe, via one of the tributary rivers. The Innisfil Creeks subwatershed is one of 18 subwatersheds that drain into Lake Simcoe. The subwatershed's southern streams empty into Cook's Bay, the northern ones empty into the main basin, and one drains into Kempenfelt Bay (Figure 2-1).

The Innisfil Creeks subwatershed is located almost entirely within the Town of Innisfil, with a small portion falling into the City of Barrie (3.3%). Within the subwatershed boundaries there are 15 named streams, as well as a few small creeks, draining separately into Lake Simcoe. As previously mentioned in **Chapter 1 - Introduction**, all of the streams have headwaters in agricultural areas and flow from west to east, through urban areas, before entering Lake Simcoe. The exception is Strathallan Creek, which flows north into Kempenfelt Bay. The Innisfil Creeks subwatershed is not as densely populated as some of its neighbouring subwatersheds, and has a total area of approximately 107.2 km^2 with a total watercourse length of 149 km (including all branches), or about 3.5% of the total combined watercourse length of the entire Lake Simcoe watershed.

Location of the Innisfil Creeks subwatershed

Figure 1-1



Legend

- LSRCA Watershed
- Innisfil Creeks Subwatershed
- Lower Tier Boundary
- Upper Tier Boundary

Lake Simcoe Region conservation authority

0 1 2 4 6 8 10
Kilometres

N

This product was produced by the Lake Simcoe Region Conservation Authority and some information depicted on this map may have been compiled from various sources. While every effort has been made to accurately depict the information, data / mapping errors may exist.
This map has been produced for illustrative purposes only.
LSRCA GIS Services DRAFT created July 2010.

2.2 Human Geography

2.2.1 Population and Municipal Boundaries

Because the subwatershed boundaries and the municipal boundaries are not the same, the subwatersheds contain residents from multiple municipalities. Innisfil Creeks is located mostly within the Town of Innisfil, with a small portion in the City of Barrie and even less the Town of Bradford-West Gwillimbury.

Population within the Town of Innisfil expanded from an estimated 31,175 residents in the 2006 census to 33,061 in the 2011 census, resulting in an increase of 6.1% over the 5 year period. This population is a not a very mobile one, with only 10% having changed their address between the 2001 and 2006 census, suggesting that people may have deeper roots here and a longer term investment in their community. The median age of those living in the Town of Innisfil is 40.3, slightly above the provincial average, and a median income of $29,888, above both the City of Barrie and the provincial average (Stats Canada, 2006). The projected population for the Town of Innisfil is 56,000 by 2031 (Growth Plan for the Greater Golden Horseshoe, 2006, Office Consolidation January 2012). This is a 70% increase over a 20 year period

The population of City of Barrie during the 2006 census was estimated to be 128,430. This rose to 135,711 during the 2011 census, representing a 5.7 % population increase over a five year period. While this is a large population, it is also a very mobile one with an estimated 54% having changed addresses between the 2001 and 2006 census, possibly indicating that residents may have a short term view of their community. The median age of those living in the City of Barrie is 35.4, almost four years younger than the provincial median of 39 years, and the median income for 2005 was $28,785, above the provincial median income of $27,258 (Stats Canada, 2006). The projected population for the City of Barrie is 210,000 by 2031 (Growth Plan for the Greater Golden Horseshoe, 2006, Office Consolidation January 2012). This is a 55% increase from the 2011 population of approximately 135,711 (Stats Canada, 2011).

Municipal population from each municipality and total population density for each of the subwatersheds is presented on the following page in Table 2-1.

Table 2-1: Estimated population and population density within the Innisfil Creeks subwatershed (Data Source: Stats Canada, 2006 Community Profiles)

Subwatershed	Subwatershed Area (km^2)	Municipality	Total Municipal Population (2011)	Estimated Municipal Population (2011) within subwatershed	Estimated Total subwatershed population (2011)	Estimated Population Density (persons/km^2)
Innisfil Creeks	107.15	Town of Innisfil	33,079	25,876	27,049	252
		City of Barrie	135,711	1,144		
		Town of Bradford-West Gwillimbury	28,077	29		

The level of education attained by a person can influence both their career choice and income level. Table 2-2 lists the percentage of the Town of Innisfil and City of Barrie populations, 15 years and over, and their education attainment compared to that of the provincial standings.

Table 2-2: Educational attainment for the Town of Innisfil and City of Barrie (Stats Canada, 2006).

	Town of Innisfil	City of Barrie	Province of Ontario
No certificate; diploma or degree	27%	22%	22%
High school certificate or equivalent	29%	29%	27%
Apprenticeship or trades certificate or diploma	13%	9%	8%
College; CEGEP or other non-university certificate or diploma	20%	24%	18%
University certificate or diploma below the bachelor level	3%	3%	4%
University certificate; diploma or degree	9%	13%	20%

As of January 1, 2010 the City of Barrie's southern border extended to include 2,293 hectares of land from the Town of Innisfil to accommodate the City's projected growth. With the removal of these annexed lands, approximately 500 residents that were in the Town of Innisfil are now located within the City of Barrie.

2.2.2 Land Use

Land use within the Innisfil Creeks subwatershed has been divided up into 12 classes including intensive and non-intensive agriculture, rural development, urban areas, and natural heritage features (Figure 2-2). Land uses with 0% coverage in a subwatershed were not reported.

Land use in the Innisfil Creeks subwatershed is currently dominated by agriculture (45%) and natural heritage cover (33%). Urban areas account for 15% of the subwatershed land use, including commercial, estate residential, institutional, and other various land uses. Other land uses occupying smaller areas include commercial (0.3%), industrial (0.3%), aggregate (0.5%), institutional (0.5%), and manicured open space (0.5%).

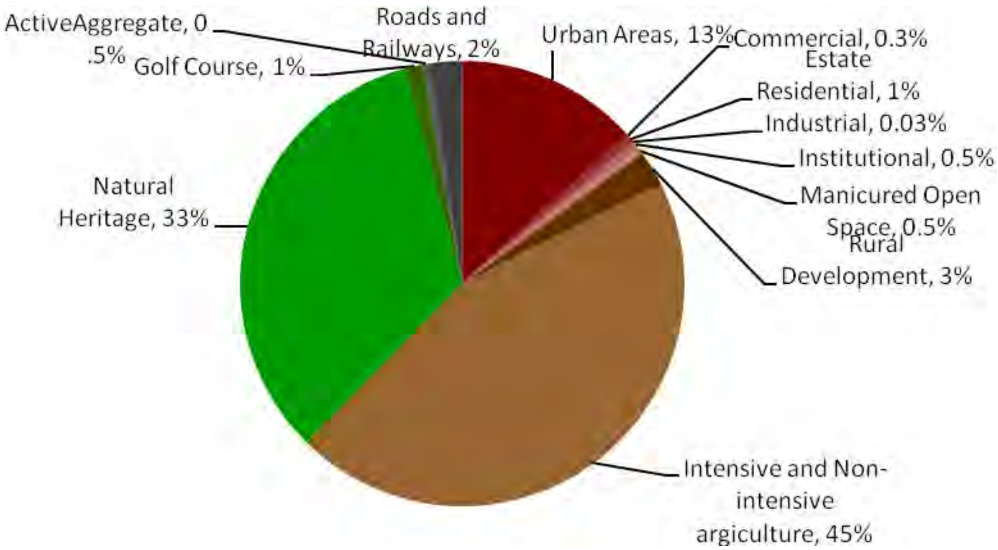
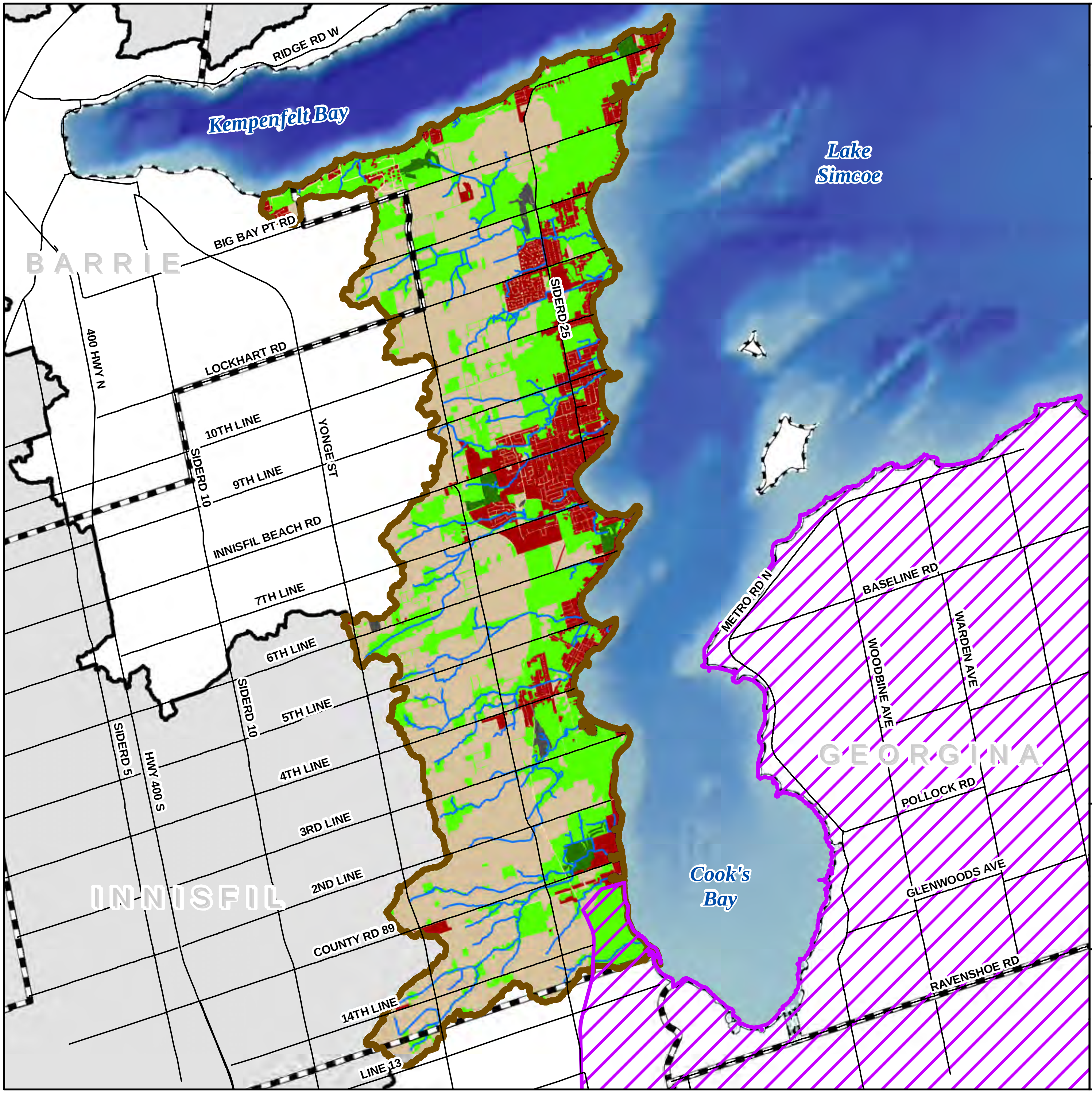


Figure 2-2: Land use distribution within the Innisfil Creeks subwatershed.

The distributions of land uses within the Innisfil Creeks subwatershed can be seen in Figure 2-3.

Land uses in the Innisfil Creeks subwatershed

Figure 2-3



Legend

— Road

▬ Municipal Boundary

〜 Watercourse

▨ Greenbelt (Protected Country Side)

Land Use

🟥 Urban

▨ Rural

🟩 Natural Heritage

🟩 Golf Course

⬛ Aggregate

Lake Simcoe Region conservation authority

0 0.5 1 2 3 4 5 Kilometres

N

To see how the Innisfil Creeks subwatershed compares to the other subwatersheds within the Lake Simcoe watershed, Figure 2-4 to Figure 2-6 illustrate all 18 of the Lake Simcoe subwatersheds from the subwatershed with the highest percentage of urban, natural heritage and rural land uses to the subwatershed with the lowest percentage. The Innisfil Creeks subwatershed is outlined in black.

For urban land use (Figure 2-4), the Innisfil Creeks has the sixth highest percentage (15%). The subwatershed with the highest percentage is the Barrie Creeks subwatershed in the western part of the watershed with 63%, while the Whites Creek subwatershed in the eastern part of the watershed has the lowest (1%).

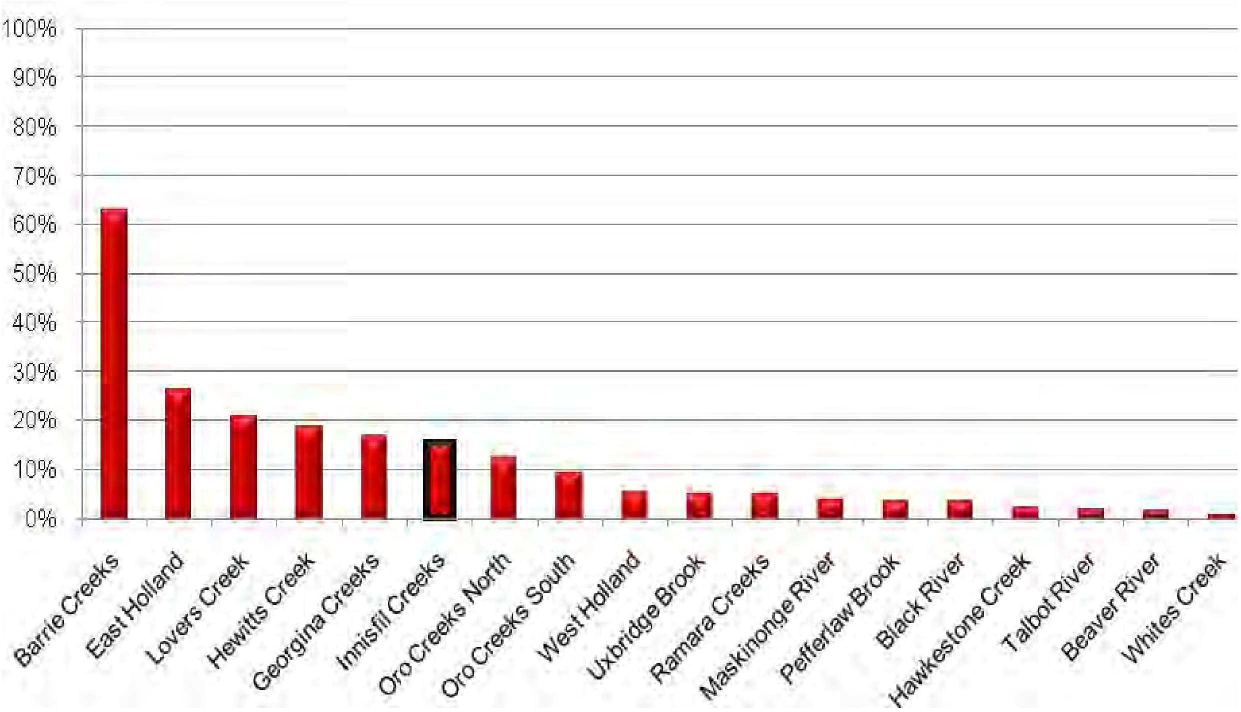


Figure 2-4: Urban land use in the Lake Simcoe subwatersheds.

The subwatershed with the highest percentage of natural heritage land cover is Hawkestone Creek (57%) in the north-west of the watershed, while the Barrie Creeks subwatershed in the west has the lowest percentage (17%). The Innisfil Creeks subwatershed has the seventh lowest percentage with 33% (Figure 2-5).

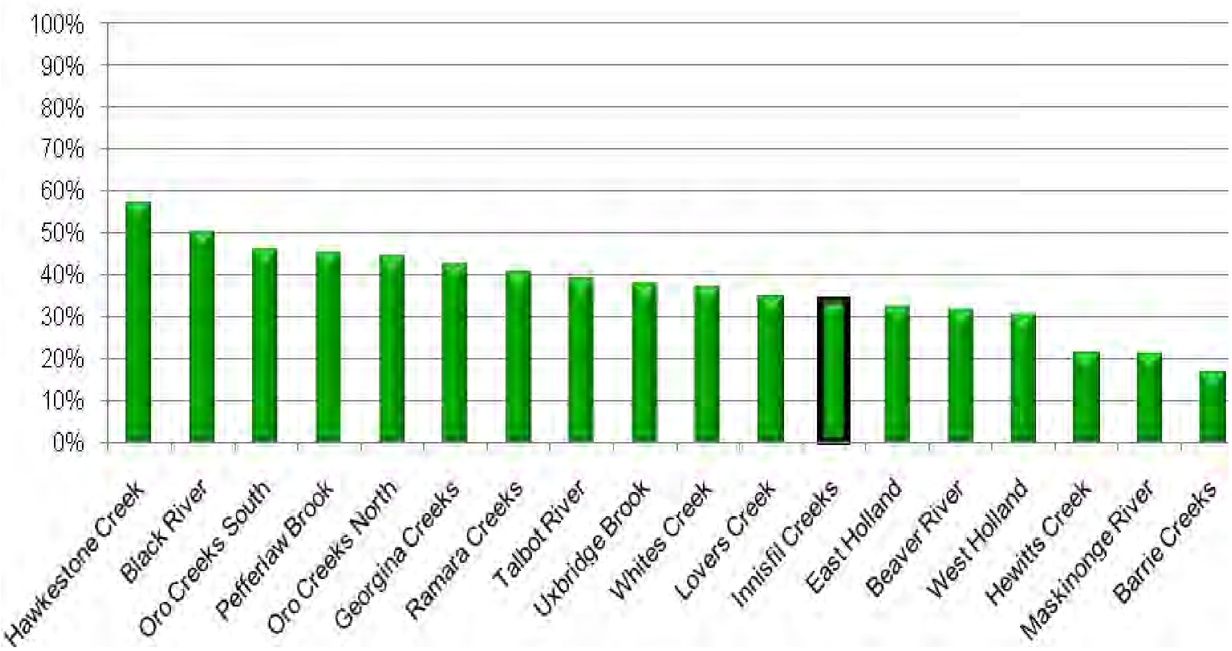


Figure 2-5: Natural heritage land cover in the Lake Simcoe subwatersheds.

Figure 2-6 illustrates the rural land use in the Lake Simcoe subwatersheds. The Maskinonge River subwatershed in the southern part of the watershed has the highest percentage with 73%, while the Barrie Creeks subwatershed in the west has the lowest (4%) percentage of rural landuse, with a large percentage gap between it and of the second lowest subwatershed (East Holland) which has 34%. The Innisfil Creeks subwatershed is in the middle with 48%.

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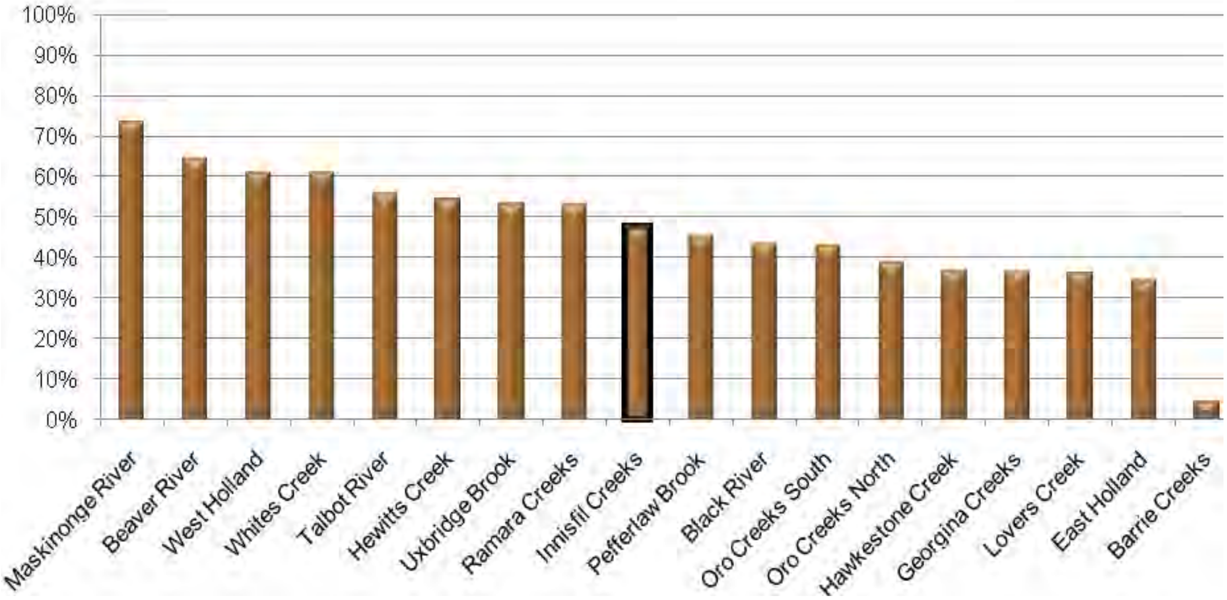

Figure 2-6: Rural land use in the Lake Simcoe subwatersheds.

2.2.2.1. Impervious Surfaces

Impervious surfaces refer to hardened surfaces, such as roads, parking lots, and rooftops, which are made of (or covered in) a material impenetrable by water (i.e. asphalt, concrete, brick, rock, etc)[1]. As this reduces the amount of water infiltrating down into the groundwater supplies and increases surface runoff, the hydrologic properties or drainage characteristics of the area are significantly altered.

An increase in impervious surfaces, generally associated with urban growth, can impact the surrounding environment in a number of ways. These impacts include: decreases in evapotranspiration as there is little vegetation and the permeable soil is paved over; decreases in groundwater recharge; increases in frequency and intensity of surface runoff, leading to an increase in flow velocities and energy (which can alter the morphology of the stream through channel widening, under cutting of banks, sedimentation, and braiding of the stream); thermal degradation of the watercourses; decreases in water quality as pollutants are washed off streets into storm drains or ditches which discharge to watercourses or the lake; and impairment of aquatic communities (which can be negatively affected by all impacts listed above).

Environment Canada's Areas of Concern (AOC) Guidelines (2004) suggest a lower limit of 10% imperviousness, where subwatersheds should still be able to maintain surface water quality and quantity, and preserve aquatic species density and biodiversity. The AOC Guidelines further recommend an upper limit of 30% as a threshold for degraded systems that have already exceeded the 10% impervious guidelines. The Innisfil Creeks subwatershed is above the 10% guideline, but is below the upper limit threshold with approximately 21% impervious surface. As this subwatershed hasn't reached the 30% threshold, there is still room through mitigative action and careful development practices to reduce or at least maintain this number to assist in maintaining water quality. Figure 2-7 illustrates the impervious cover within the subwatershed.

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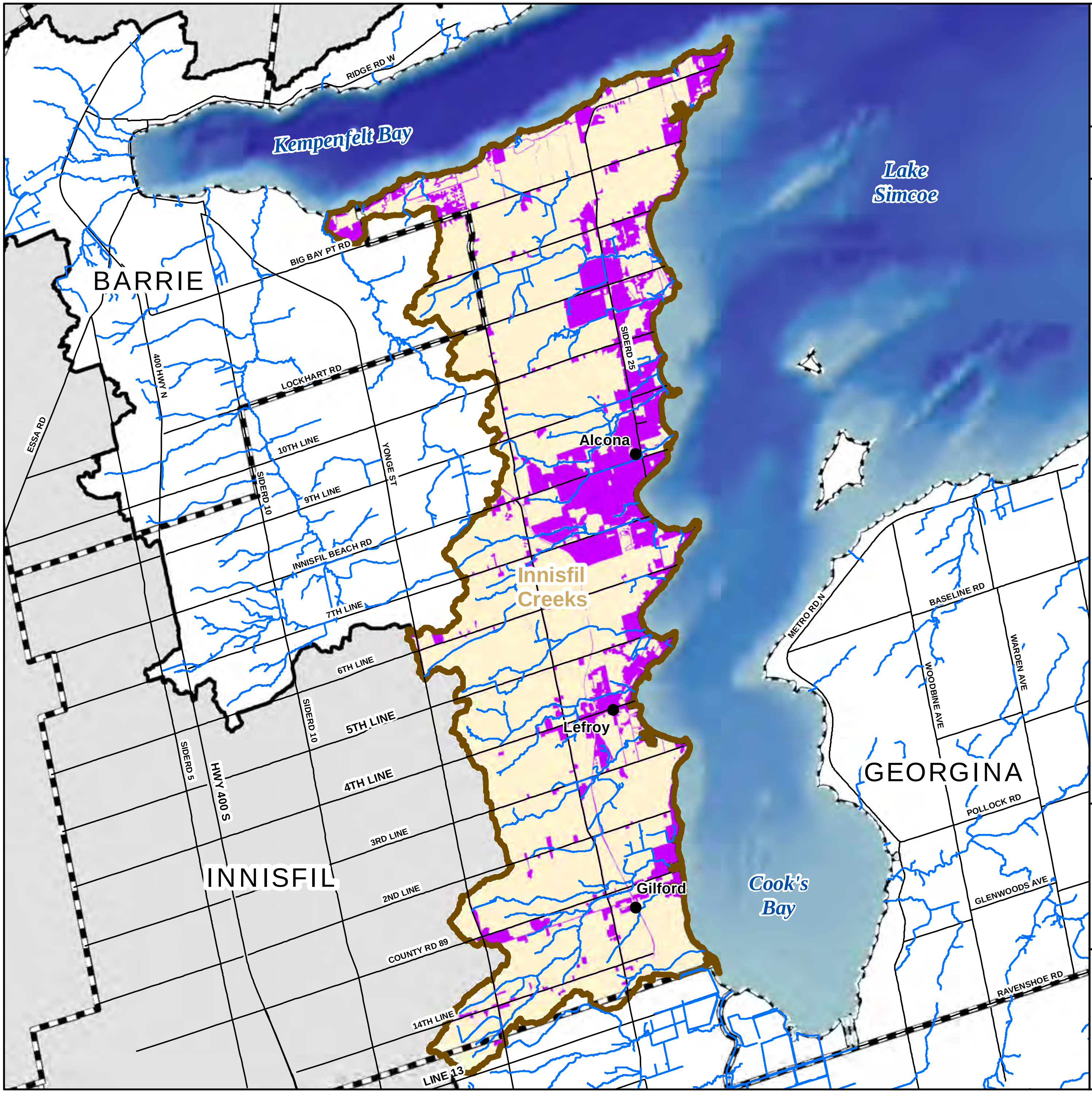
[1] For the majority of this report, impervious surfaces do not include features such as wetlands. These are sometimes considered impervious in hydrogeological models, such as those presented in **Chapter 4 – Water Quantity**.

Impervious cover in the Innisfil Creeks subwatershed

Figure 2-7



Legend

— Road

▬ Municipal Boundary

〰 Watercourse

▢ Subwatershed

■ Impervious Area

(includes Active aggregates,Commercial, Inactive Aggregates, Estate Residential, Road, Rail, Rural Developmetn, and Urban)

0 0.5 1 2 3 4 5 Kilometres

N

This product was produced by the Lake Simcoe Region Conservation Authority and some information depicted on this map may have been compiled from various sources. While every effort has been made to accurately depict the information, data / mapping errors may exist.
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2.2.2.2. Settlement Areas

For the most part, the built up, urban areas in the Town of Innisfil tend to be in communities along the shoreline, while the majority of the town remains rural, unlike the City of Barrie which continues to be one of the major urban areas within the Lake Simcoe watershed. Compared to past population projections, the Lake Simcoe watershed population continues to grow faster than originally anticipated (LSEMS, 1995). Urban development activities have subsequently increased to keep pace with this population growth. Construction of new dwellings was essential to meet the demands of the rising populations within the urban centres, and between the 2001 and 2006 census, there was an increase of approximately 840 private dwellings in the Town of Innisfil. In the City of Barrie there was an increase of approximately 10,000 private dwellings (Statistics Canada, 2006). Settlement areas are shown in Figure 2-8.

Even with a growing population, there are still a large number of residents who work outside their municipality, county, and even province and Canada. Many of the people who work in large cities cannot afford to live within them, so they commute from smaller towns that have a more affordable cost of living. These small towns/communities are known as ‘bedroom communities’. Typically bedroom communities are located in rural or semi-rural areas, surrounded by green space, and are in close proximity to a major highway that leads to the larger cities. The Town of Innisfil is a good example of this, with only 14% of the total employed labour force working in the municipality. The City of Barrie could also be considered a bedroom community for some of the larger cities, such as the City of Toronto, but as its economy grows it is slowly becoming a focal urban centre itself. Within the City of Barrie, approximately half of the population works within the City (49%) and the other half works outside it (51%) (Table 2-3).

Table 2-3: Place of work status in the Town of Innisfil and City of Barrie (Data Source: Statistics Canada, 2006).

Place of Work Status	Town of Innisfil		City of Barrie	
	Population	**Pop. Percentage (%)**	**Population**	**Pop. Percentage (%)**
Worked at home	1,045	6	4,080	6
Worked outside Canada	60	0.4	240	0.4
No fixed workplace address	2,470	15	7,520	11
Worked in census (municipality) of residence	2,195	14	33,315	49
Worked in different census subdivision (municipality) within the census division (county) of residence	4,635	29	9,770	14
Worked in different census division (county)	5,700	35	12,660	19
Worked in different province	40	0.2	120	0.2
Total employed labour force	**16,145**	**100**	**67,705**	**100**

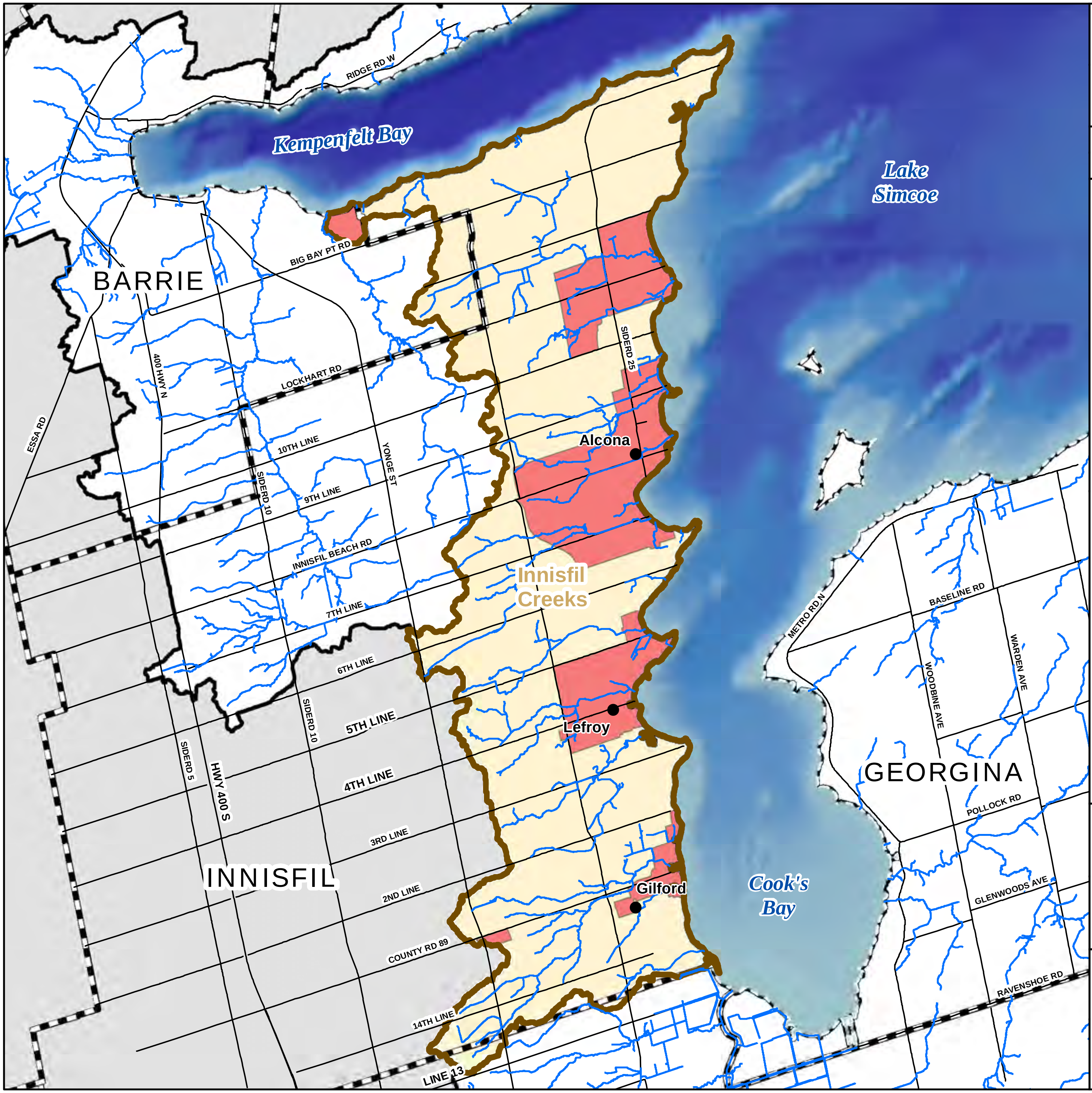
The economy of the bedroom communities tends to focus around real estate, general retail, and services that are oriented to serving residents. Industrial and technological industries are not a main focus and offer fewer employment opportunities. This is evident in the Town of Innisfil where the industries that saw the largest growth between the 2001 and 2006 census were finance and real estate (24.8%), health, social and educational services (28.8%), and agriculture and other resource-based industries (31.2%). The industries with the lowest growth included construction and manufacturing (5.4%), while business services saw a 0.7% decrease (Table 2-4). Even though there is an increase in various industries, a reason that many people choose to live in the Town of Innisfil, whilst working outside it, is the opportunity to enjoy the large amount of waterfront along the eastern and northern borders of the town. There is still a large influx of residents who own or rent cottages during the summer months, but many people who work in the city are moving to more natural areas and converting seasonal properties to permanent residences. This brings business to the area and increases the demands for services.

The City of Barrie, with more residents working within the municipality, saw an increase in all industries with the largest in agriculture and other resource-based industries (82.8%). Most of the other industries saw an increase of at least 25%, with the smallest increase being in construction and manufacturing (18.9%) and wholesale and retail trade (20.4%).

Table 2-4: Changes in industry in the Town of Innisfil and City of Barrie (Data Source: Statistics Canada, 2001 and 2006).

Industry	Town of Innisfil			City of Barrie		
	Innisfil 2001 census	**Innisfil 2006 census**	**% change**	**Barrie 2001 census**	**Barrie 2006 census**	**% change**
Agriculture and other resource-based industries	385	505	31.2	495	905	82.8
Construction	4320	1735	5.4	13,150	5,315	18.9
Manufacturing		2820			10,315	
Wholesale trade	2685	1100	13.4	11,095	3,705	20.4
Retail trade		1945			9,655	
Finance and real estate	630	785	24.8	2,840	3,610	27.1
Health care and social services	1510	1130	28.8	8,125	6,555	38.9
Educational services		815			4,735	
Business services	2880	2860	-0.7	9,610	12,030	25.2
Other services	2575	3180	23.5	10,575	14,320	35.4
Total Experienced work force	**14,980**	**16,880**	**12.7**	**55,885**	**71,140**	**27.3**

* Red font indicates a decrease



Settlement areas in the Innisfil Creeks subwatershed.

Figure 2-8

Legend

— Road

▬ Municipal Boundary

〰 Watercourse

🟥 Settlement

▨ Innisfil Creeks Subwatershed

Lake Simcoe Region conservation authority

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2.3 Human Health and Well-being

One of the major reasons for understanding and managing watersheds and their function is to protect the health and well-being of watershed residents. Figure 2-9 illustrates the watershed governance prism (Parkes *et al.*, 2010) and the four different aspects of watershed governance including “watersheds”, “ecosystems”, “health and well-being” and “social systems”. The combination of all of the aspects of watershed management gives a comprehensive view of the way watershed governance can link the determinants of health and well-being to watershed management.

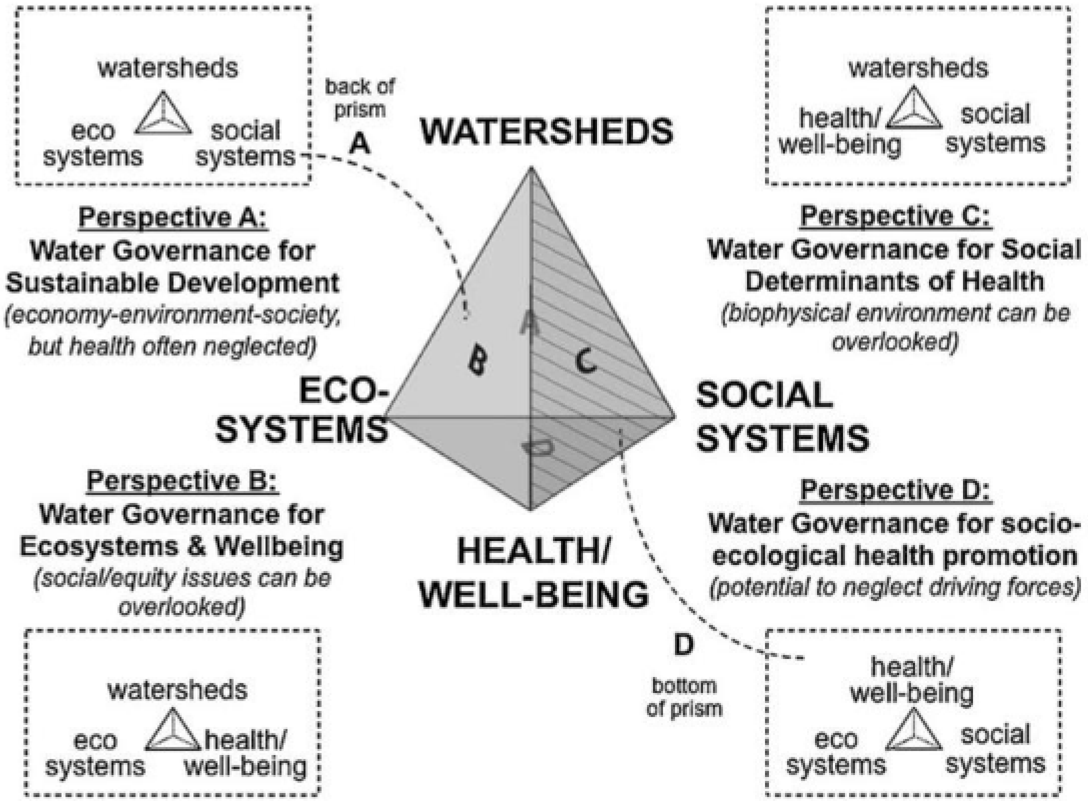

Figure 2-9: Watershed governance prism (Parkes *et al.,* 2010).

The management of the Lake Simcoe watershed includes a number of these perspectives, incorporating issues related to human health and well-being, protection of wildlife habitats, and ensuring the preservation of water quality and water quantity.

The following sections highlight the link the between the Lake Simcoe watershed and the related health benefits for residents of the watershed.

2.3.1 Outdoor Recreation and Human Health

Within an urban setting, green spaces (including parks, conservation areas, forests, wetlands, streams, and lake shore) are at a premium. Even within a more rural setting, these features are sometimes taken for granted when, in fact, they are an essential part of a healthy community.

2.3.1.1. Physical

Whether it's an open soccer field, running/walking trails through forests, or sandy beaches along the lake front, the green spaces within this subwatershed provide a number of outdoor recreational opportunities for residents and visiting tourists. The different types of areas available offer a variety of physical activities that would not be available at a local gym and come at little to no cost. Parks and sports field provide areas for recreational or pick up games of soccer, football, or frisbee. Trails are areas to walk, run, or bike. Parks and conservation areas with forests and wetlands provide a range of recreational and aesthetic opportunities and the nearby lake shore and waterways offer residents a place to swim, canoe, kayak, and fish. It is these types of areas that encourage the physical stimulation of individuals and families as a whole, creating a healthier lifestyle for people of all ages.

By encouraging children to be active outdoors at a young age, a number of health-related issues can be minimized or avoided all together. These include:

- Childhood Obesity: In Canada, approximately 26% of children ages 2-17 are currently overweight or obese (Childhood Obesity Foundation). Obesity can also lead to a number of other diseases including Type-2 diabetes, hypertension, asthma, and cardiovascular disease (NEEF).
- Vitamin D Deficiency: The most common diseases resulting from a lack of Vitamin D include rickets (children) and osteoporosis later in life (NEEF).
- Myopia: One study found that 12 years olds who spent less time doing near-work activities (reading, drawing, etc) and more time doing outdoor activities were two to three times less likely to develop myopia than those who spent the majority of their time doing near-work activities (Rose *et al.,* 2008).

Within the Innisfil Creek subwatershed there are a number of parks and recreational opportunities available including baseball diamonds, soccer pitches, swimming areas, play structures, and walking trails. A full list of parks and trails is available at http://www.town.innisfil.on.ca/Parks-and-Trails.

The Town of Innisfil also has the Luck Conservation Area within its municipal boundaries (and within the Innisfil Creeks subwatershed boundaries). This is a 20 ha natural area with forest, streams and ponds, as well as being home to the Gilford Arboretum, managed by the Gilford and District Horticultural Society. The society provides a network of walking trails, as well as interesting specimen trees and plants.

2.3.1.2. Mental

In addition to physical health benefits, there are a number of mental health benefits associated with natural areas. These areas, free of technology and the "jolts per minute" of contemporary life, allow people to take in their surroundings, and benefit from the serene and calming environment. Those who like to explore natural areas are mentally engaged to interact with the surrounding flora and fauna and associate these visual 'pictures' with other senses, such as touch, smell, and sound. Studies have also shown the effects of nature on the social interactions, emotional status, and cognitive growth of children. Many young children have grown up watching television, playing on computers or with video games with very little 'play-time' (unstructured, spontaneous activity) in their daily routine. Burdette and Whitaker (2005) suggest that through playing outdoors, a child's social interactions, emotional status, and their cognitive growth are improved. In an unstructured, non-monotonous environment they will come across different situations that encourage them to problem solve, interact, and communicate with others and learn from the different experiences they are exposed to. Studies also show interactions with nature have positive impacts on those with attention-deficit/hyperactivity disorder (ADHD). Something as simple as a 20 minute walk through park was found to increase concentration and elicit a positive emotional response (Faber and Kuo, 2008).

It should also be noted that many individuals also have an important spiritual connection to the environment.

2.3.1.3. Community Engagement and Cohesiveness

The more people recognize the benefits that the green spaces in their city or town have on their well-being, the more they will work to maintain and protect these areas. Green spaces can bring a community together to perform maintenance and restoration work, create fun and interactive environments, boost tourism (and in turn the local economy), and are places for community events, camps or public forums. By putting effort into caring for the green spaces and enjoying the benefits they gain from them, people form an attachment to these areas, as well as their community as a whole.

2.3.1.4. Economic Benefits

While the previous section highlighted the social and health benefits of urban natural areas, studies have also shown the monetary benefits of having tree lined streets and urban natural areas.

For example, the presence of mature trees in residential areas can increase the sale prices of neighbouring properties by 2-15% (Wolf, 2007; Donovan and Butry, 2009), and decrease the amount of time such properties are on the market (Donovan and Butry, 2009). The presence of larger natural areas nearby can increase property values by up to 32% (Wolf, 2007). Even during the initial development process, retaining mature trees on residential lots can increase their sale value by up to 7% (Theriault *et al*., 2002).

In addition to increasing property values, natural areas in or near residential neighbourhoods can act as a draw for white-collar workers working in high paying, creative jobs, who prefer to live in an urban setting that encourages their 'creativity', through a stimulating, diverse, cultural setting with easily accessible natural amenities for a healthy lifestyle. As a result, the preservation of urban green space can attract new businesses with highly paid staff, and strengthen the local economy (Florida, 2002).

Commercial sectors can also benefit from an increase in urban tree cover. Studies have shown that shoppers tend to spend more time, and make more purchases, in downtown commercial and retail districts that have more trees, creating income both for the city and for store owners (Wolf, 2005).

2.3.2 Drinking Water Source Protection

A major threat to human health is the degradation and depletion of freshwater resources. Degradation of water quality can either be anthropogenic or natural in nature. Humans can impact their water through:

- Poor sanitation habits (crude solid waste disposal methods, improper filtration methods of waste water and drinking water);
- Removal of riparian buffers, allowing unfiltered run off from streets, lawns, and agricultural fields to go directly into waterways;
- Improper storage of chemicals that can spill in to surface water or leach into the ground to reach the deeper groundwater resources;
- Warming of water temperatures (creates ideal temperatures for bacteria) by connecting runoff systems to watercourses or creation of standing bodies of water that link to the watercourse.

Climate change can also impact water quality through changes in air temperature, precipitation, and extreme events by:

- Releasing contaminants: extreme events and increases in precipitation may damage buildings/containers holding contaminants, cause the overflow of retention areas holding contaminants, and/or wash surface contaminants into watercourses;
- Transporting contaminants: extreme events can transport contaminants greater distances, potentially increasing the exposure to them;
- Creating warmer environments: surface waters become more hospitable to pathogens and other waterborne disease.

Poor water quality, either because of anthropogenic or natural conditions, can lead to an increase in water-borne diseases, loss of fisheries, contaminated food sources, and closures of beaches due to high levels of the bacteria *E. coli*. Residents can be directly impacted through sickness, increases in food costs (uncontaminated), or loss/decrease in income (loss of fisheries, farms with unusable, contaminated produce).

Depletion of available water is another major health concern. Low water quantity can result in water restrictions that lead to lower agricultural produce yields, increasing the cost of food. Less water available to residents also means that there is less water available to natural environments, leading to a loss of habitat.

In 2006, the provincial government made a commitment to the citizens of Ontario by passing the *Clean Water Act* (CWA). The CWA introduced a new level of protection – Source Water Protection - for the Province’s drinking water resources that will help communities across Ontario enjoy a safe and plentiful supply of clean drinking water for generations to come. Drinking Water Source Protection is the first step in a multi-barrier approach to protecting our sources of drinking water. It identifies possible threats to drinking water, assesses the risks of those threats, mitigates them and plans ahead to prevent contamination before it gets into the water supply. It is a responsible and effective way of ensuring safe, clean drinking water and avoiding serious health issues.

2.3.2.1. Drinking Water Systems and their Vulnerable Areas

The South Georgian Bay-Lake Simcoe (SGBLS) Source Protection Region (SPR) is one of 19 in Ontario. It contains three Source Protection Areas (Lakes Simcoe and Couchiching-Black River, Nottawasaga Valley, and Severn Sound) that are composed of four watersheds: Lake Simcoe[2], Black-Severn River, Nottawasaga Valley, and Severn Sound watersheds.

One of the key documents of the Source Protection program that has been completed for each of the Source Protection Areas (and the watersheds within their borders) is the Assessment Report. The SGBLS Source Protection Committee released three Assessment Reports in November 2011 that provides the following information for each area:

- Characterization of the Source Protection Area watershed: this includes descriptions of the natural and human geography;
- A Conceptual water budget for the entire Source Protection Area and a Tier 1 water budget for each subwatershed: those systems identified as having water quantity stress in the Tier 1 water budget progress to a more detailed Tier 2 water budget and Tier 3 if needed;
- Broad scale assessment of Regional Groundwater Vulnerability: this aspect of the Assessment Report requires that both Highly Vulnerable Aquifers (HVA) and Significant Groundwater Recharge Areas (SGRAs) be identified; and
- Drinking water system assessment: for each drinking water system within the Terms of Reference, the Vulnerability of the supply wells or surface water intakes is assessed and any potentially Significant Threats to the water quality are identified.

Within the whole SGBLS SPR there are 108 drinking water systems, with 31 in the Lake Simcoe watershed. There are three systems in the Innisfil Creeks subwatershed. Two of these are groundwater supply systems (the Golf Haven and Goldcrest Well Supplies), while the other is a surface water intake (Alcona Water Treatment Plant). Even though a large portion of the Barrie Water Treatment Plant Intake Protection Zone (IPZ) is located along the northern shore of the subwatershed, the IPZ-2 stretches down within the Lovers Creek subwatershed and has therefore been accounted for in the Barrie Subwatershed Plan.

Each of the drinking water systems in the Innisfil Creeks subwatershed have had their vulnerable areas delineated. These vulnerable areas that are directly associated with drinking water systems are referred to as Wellhead Protection Areas (WHPAs) for groundwater systems and Intake Protection Zones (IPZs) for surface water intakes:

- A WHPA is the area around a wellhead where land use activities have the greatest potential to affect the quality of water that flows into the well. Each WHPA is subdivided into four time-of-travel zones that estimate the amount of time it would take a contaminant to reach the municipal well
    - WHPA-A: 100 m radius.
    - WHPA-B: 2 year time of travel (tot) capture zone
    - WHPA-C: 5 year tot capture zone
    - WHPA-C1: 10 year tot capture zone (for WHPAs delineated before April 2005).

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[2] Information for the Innisfil Creeks subwatershed can be found in the Approved Lakes Simcoe and Couchiching-Black River Source Protection Area Assessment Report, Part 1: Lake Simcoe. Chapter 10 of this Assessment Report is specific to the Town of Innisfil.

  - WHPA-D: 25-year tot capture zone
- Similarly, an IPZ is the area around a surface water intake and includes three time-of-travel zones.
  - IPZ-1: 1000 m radius
  - IPZ-2: 2 hour time of travel
  - IPZ-3: Area within the surface water body through which contaminants released during an extreme event could be transported to the intake. For the intakes associated with these (and Innisfil Creeks) subwatersheds this includes the entire Lake Simcoe watershed.

Two additional vulnerable areas that were also delineated in the Assessment Reports are Significant Groundwater Recharge Areas (SGRAs) and Highly Vulnerable Aquifers (HVAs). These vulnerable areas do not pertain directly to any particular drinking water system, but instead are on a regional (landscape) scale:

- SGRAs are areas where water enters an aquifer (underground reservoirs from which we draw our water) through the ground. Recharge areas are significant when they supply more water to an aquifer than the land around it. Significant Recharge Areas are an important area on the landscape for ensuring a sufficient amount of water enters an aquifer. For example, paving over an SGRA would prevent water from getting into the ground to recharge an aquifer, potentially decreasing the amount of water available.
- HVAs are those areas where an aquifer may be more prone to contamination. These areas have been identified where there is little or no protection from an overlying aquitard (a protective layer of low permeability materials). Generally, the faster water is able to flow through the ground to an aquifer, the more vulnerable the area is to contamination. For example, a fuel spill would get into an aquifer much more quickly where a HVA has been identified than where one has not.

Further information on these two regional scale Vulnerable Areas can be found in the SGBLS SPR Assessment Reports.

Both the Town of Innisfil and City of Barrie have groundwater and surface water being used to supply drinking water to their residents. With over 156,700 people (combined) relying on these water supplies as a source of safe drinking water it stresses the importance of maintaining and/or improving the quality (and quantity) of these supplies. When initiating, contributing, and/or participating in restoration efforts along streams draining into Lake Simcoe, or on the lake itself, it benefits not only the local wildlife and natural habitats, but also all those who depend on the watershed and lake as a source of safe drinking water.

For the Assessment Report, studies were done to assess the vulnerability, issues, and threats for each of the Wellhead Protection Areas and Intake Protection Zones. All three of the systems within the Innisfil Creeks subwatershed are located within the Town of Innisfil and consist of the Alcona Water Treatment Plant, Golf Haven Well Supply, and Goldcrest Well Supply.

The Alcona Water Treatment Plant is a surface water intake located on the eastern shore of the subwatershed at the inlet to Cook’s Bay. This system had a total of five significant drinking water threats identified in association with one land parcel. The significant threats identified are all associated with the municipal sewage treatment plant within the IPZ-1 (SGBLS-SPC, 2011).

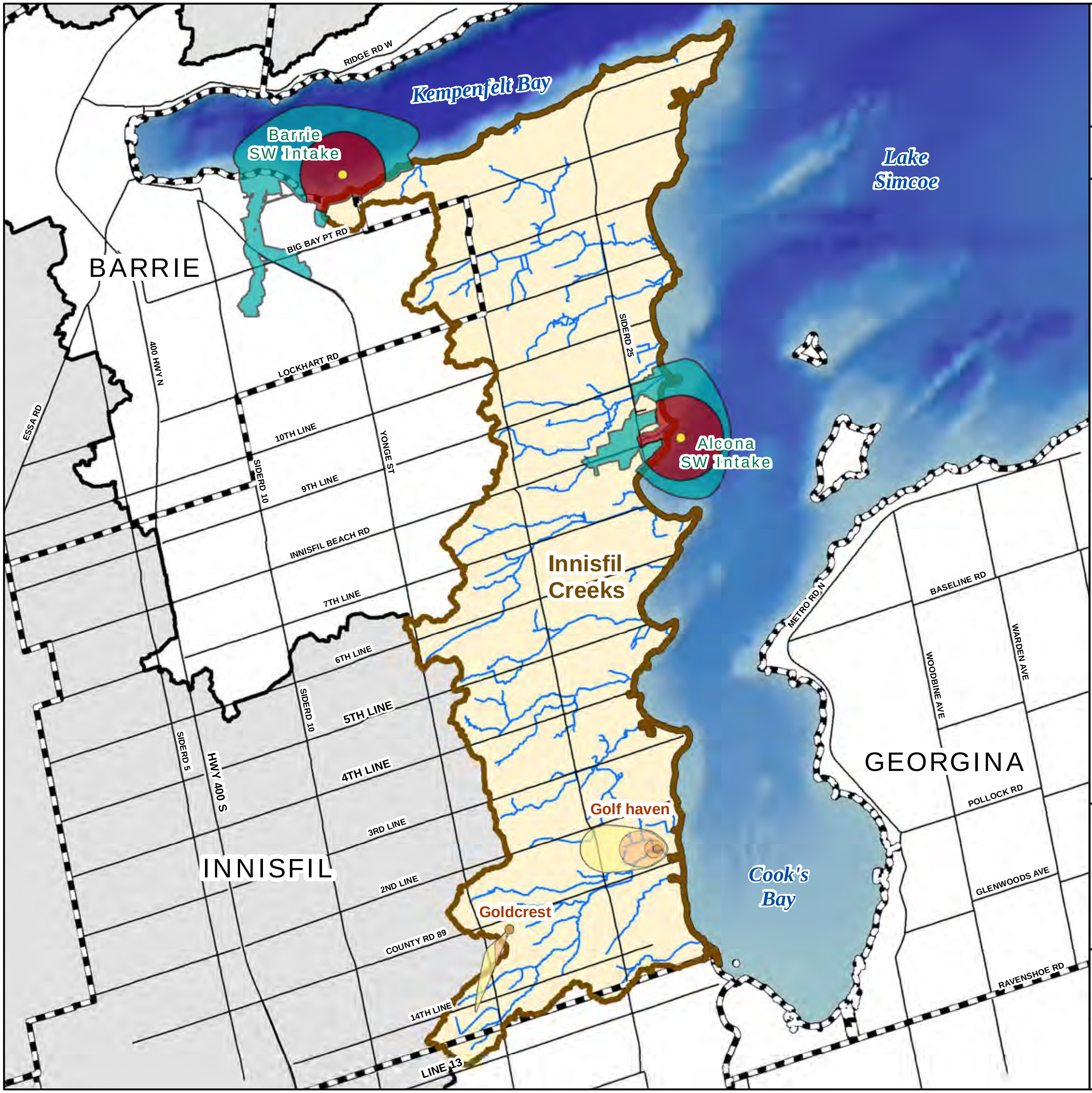
The Golf Haven Well Supply has two wells located in the south east area of the Innisfil Creeks subwatershed. A total of 21 significant drinking water threats were identified in association with

20 land parcels. These significant threats were mainly related to individual sewage systems (SGBLS-SPC, 2011).

Finally, the Goldcrest Well Supply has two wells located in the south western part of the Innisfil Creeks subwatershed and had a total of 19 significant drinking water threats identified in association with 15 land parcels. The significant threats reflect a variety of land uses, from residential to agriculture to commercial (SGBLS-SPC, 2011).

The final document the Source Protection Committee is responsible for is creating a Source Protection Plan that will be effective in mitigating all existing significant threats and preventing new ones from arising on the landscape. The process of creating this plan includes the SPC developing policies to protect drinking water supplies. With input from local municipalities, the SPC has developed an evaluation criteria that ensures all policies will be specific, measureable, achievable, realistic, and time bound, or SMART for short. The Source Protection Plan is expected to be completed in 2012.

Full results of these studies, showing the vulnerability scores and the enumeration of threats to drinking water can be found in the Approved Lakes Simcoe and Couchiching-Black River Assessment Report, Part 1: Lake Simcoe. The local vulnerable areas (Wellhead Protection Areas and Intake Protection Zones) for the drinking water systems located in each of the three subwatersheds within this report are shown in Figure 2-10 (Note: The IPZ-3 is not included for this figure).



Vulnerable areas (WHPA/IPZ) located within the Innisfil Creeks subwatershed.

Figure 2-10

Legend

—	Road
▬	Municipal Boundary
〰	Watercourse
▨	Innisfil Creeks Subwatershed
🟥	IPZ-1 (1000m)
🟩	IPZ-2 (2-hrs time of travel)
🟫	WHPA-A (100m)
🟧	WHPA-B (2-yrs tot)
▨	WHPA-C1 (10-yrs tot)
🟨	WHPA-D (25-yrs tot)

Lake Simcoe Region conservation authority

0 0.5 1 2 3 4 5 Kilometres

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2.3.3 Ecological Goods and Services.

In addition to the direct benefits to human health provided by public natural areas and clean drinking water, the environment also provides a range of other, less tangible, benefits, often termed 'ecological goods and services'. These benefits include the storage of floodwaters by wetlands, water capture and filtration by forests, the absorption of air pollution by trees, and climate regulation.

Forests, wetlands, and rivers that make up watersheds are essentially giant utilities providing ecosystem services for local communities as well as the regional and global processes that we all benefit from. Ecosystems provide many services including carbon storage and sequestration, water storage, rainfall generation, climate buffering, biodiversity, soil stabilization, and more (Global Canopy Programme. http://www.globalcanopy.org/main.php?m=3).

These benefits are dependent on ecosystem functions, which are the processes, or attributes, that maintain the ecosystems and the species that live within them. Humans are reliant on the capacity of natural processes and systems to provide for human and wildlife needs (De Groot, 2002). These include products received from ecosystems (e.g. food, fibre, clean air and water), benefits derived from processes (e.g. nutrient cycling, water purification, climate regulation), and non-material benefits (e.g. recreation and aesthetic benefits) (Millennium Ecosystem Assessment, 2003).

In 2008, the Lake Simcoe Region Conservation Authority partnered with the David Suzuki Foundation and the Greenbelt Foundation to determine the value (natural capital) of the ecosystem goods and services provided by the natural heritage features in the watershed in the report: *Lake Simcoe Basin's Natural Capital: The Value of the Watershed's Ecosystem Services* (Wilson, 2008). By identifying and quantifying ecosystem services within a watershed, environmental resources can be directed towards areas that are currently of high value or areas that have the potential to be of high value.

2.3.3.1. Valuing Ecosystems

There have been several techniques developed to estimate economic values for non-market ecosystem services. The method used for the 2008 study uses avoided cost (i.e. damages avoided) and replacement cost (cost to replace that service) for ecosystem service valuation, as well as contingent valuations or willingness-to-pay studies for cultural values. Some of the values were derived using direct analysis and some values were adapted from other studies. Table 2-6 summarizes the value of the various ecosystem services by land cover type in the Innisfil Creeks subwatershed, as well as for the whole Lake Simcoe watershed. All ecosystem service values have been updated to 2010 Canadian dollars.

The estimated values provided are likely a conservative estimate because our knowledge of all the benefits provided by nature is incomplete, and because these values are likely non-linear in nature (i.e. the value of natural capital and its services will increase over time, as natural areas become more scarce, and demands for services such as clean water or mitigation of climate change become greater). It is also important to note that without the earth's ecosystems and resources, life would not be possible, so essentially the true value of nature is priceless. The valuations of ecosystem services, however, provide an opportunity to quantitatively assess the current benefits and the potential costs of human impact.

Table 2-5: Summary of non-market ecosystem service values by land cover type (2010 values).

Land Cover Type	Total Innisfil Creeks subwatershed value ($million/yr)	Total Lake Simcoe basin value ($million/yr)
Cropland	2.32	54.52
Forest	8.93	207.93
Forest/ Wetlands*	15.95	466.64
Wetlands	3.34	176.12
Grasslands	0.54	22.49
Hedgerows/ Cultural Woodland	0.19	6.31
Pasture	1.24	41.80
Urban Parks	0.17	3.18
Water**	0.01	1.54
Total	**32.70**	**980.53**

* This includes treed swamps.
** This does not include the value of Lake Simcoe

As has been demonstrated, the natural systems of the Innisfil Creeks subwatershed provide a number of goods and services. These so-called “free” ecosystem services have, in fact, significant value. The analysis in the 2008 report provided a first approximation of the value of the non-market services provided – totalling annually (in 2010 values) for the Lake Simcoe watershed $980 million and at least $32.7 million for the Innisfil Creeks subwatershed. The most highly valued natural assets are the forests and treed swamps. For the Lake Simcoe watershed these were calculated to be worth $208 and $467 million per year, respectively. These values for Innisfil Creeks were $8.9 million and $5.9 million.

The high value for forests reflects the many important services they provide, such as water filtration, carbon storage, habitat for pollinators, and recreation. Treed swamps and wetlands provide high value because of their importance for water filtration, flood control, waste treatment, recreation, and wildlife habitat.

It is important to note that while the value of Lake Simcoe is not included in the watershed total, it is of considerable value to all surrounding natural and human communities within the Lake Simcoe watershed. It is the focal point of many waterfront communities (such as the City of Barrie and Town of Innisfil), provides a vast number of recreational opportunities for both locals and tourists alike, is a source of drinking water for seven municipal surface water intakes, supports a substantial fishery, and as well as being a significant natural heritage feature, it provides people with beautiful scenery. As such, the preservation of the lake and the rest of the natural heritage features within the watershed results in a significant cost savings in municipal infrastructure that would otherwise be needed to service watershed residents and users.

2.4 Geology and Physical Geography

The geology, topography and other physical features of a subwatershed provide the foundation for the subwatershed's hydrological and ecological processes, as they have a strong influence on factors such as local climate patterns, types of land cover, land use practices, and surface water and groundwater flow paths.

2.4.1 Geology

There have been a number of studies that have lead to the geologic understanding in the Innisfil area. A generalized description of the bedrock geology, quaternary geology, and conceptual stratigraphic units within the Innisfil Creeks subwatershed is provided. For more detailed information the reader is referred to: Johnson *et al*., 1992; Barnett, 1992; and Armstrong and Carter, 2006.

2.4.1.1. Bedrock Geology

The bedrock can be characterized as being from the Paleozoic Era, consisting primarily of limestone of the Middle Ordovician Simcoe Group. The Simcoe Group overlies the Precambrian 'basement' rock units that comprise the Canadian Shield and outcrop *(present at surface)* north of the Lake Simcoe watershed. The Simcoe Group has been overlain by a sequence of sediments that have been deposited over the last 135,000 years by glacial, fluvial, and lacustrine environments.

The Middle Ordovician-aged carbonates and shales of the Simcoe Group were deposited in a gradually deepening shelf system in a shallow subtropical sea approximately 460 million years ago (Brookfield and Brett, 1988). The Simcoe Group consists of four formations that dip gently toward the southwest: Gull River Formation, Bobcaygeon Formation, Verulam Formation, and the Lindsay Formation from oldest to youngest. However, only the Verulam and Lindsay Formations are found within the subwatershed boundary.

Verulam Formation

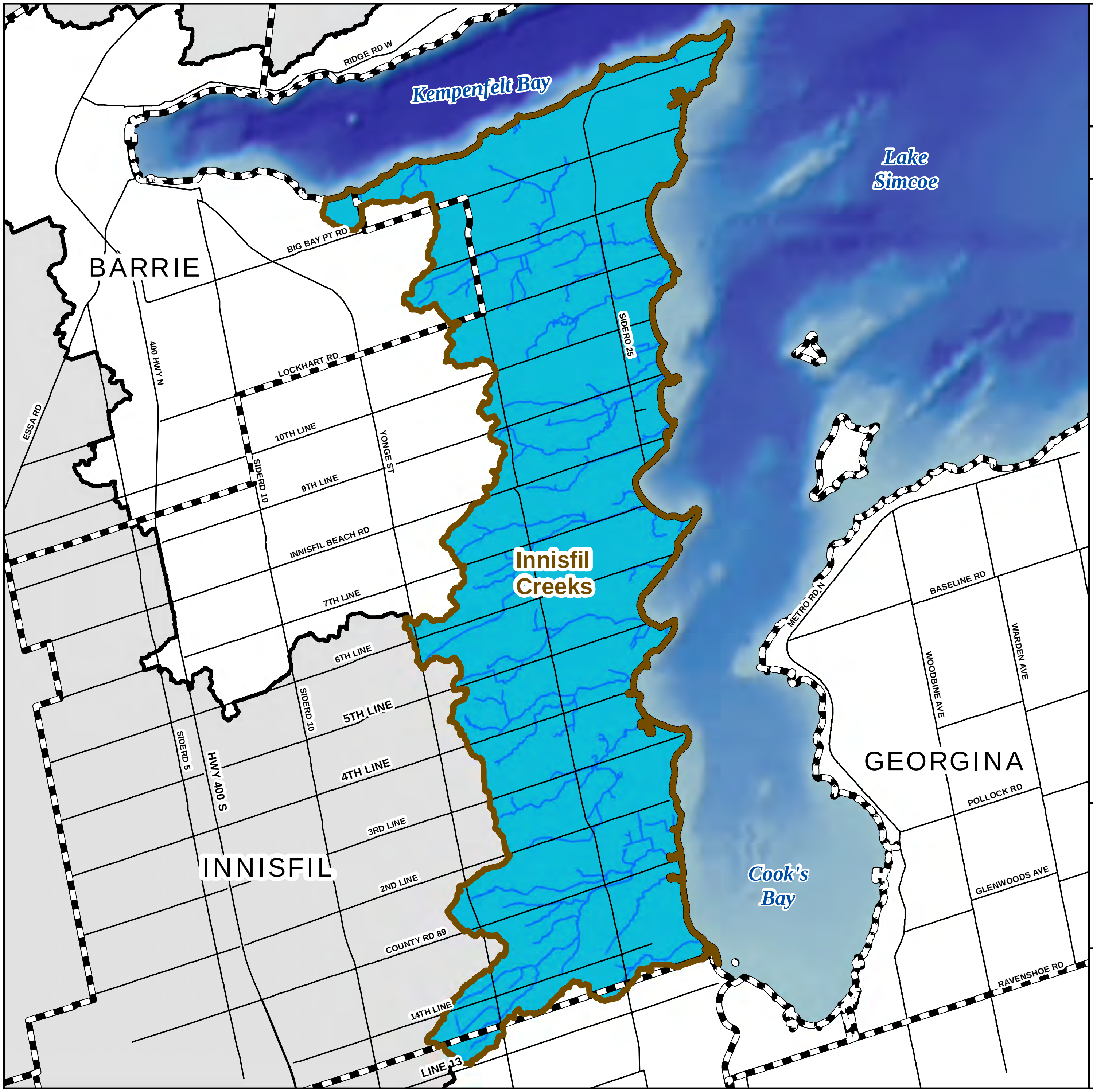
The oldest Paleozoic rocks underlying the subwatershed are those of the Verulam Formation. The formation occurs along the shoreline of Kempenfelt and Cook's Bay. The formation is a member of the Simcoe Group (which is represented as [blue] on Figure 2-11). The formation ranges in thickness from 32 to 65 m and consists of fossiliferous limestone with inter-beds of calcareous shale. The depositional environment of Verulam Formation was open marine shelf (Thurston *et al*., 1992).

Lindsay Formation

The Lindsay Formation overlays the Verulam Formation and extends up from the south toward Kempenfelt Bay, underlying most of the western portions of the subwatershed. The formation is represented as (blue) on Figure 2-11. The Lindsay Formation tends to be less than 67 m thick and is richly fossiliferous, which indicates that the depositional environment was a shallow to deep marine environment (Thurston et al., 1992).

Bedrock geology in the Innisfil Creeks subwatershed.

Figure 2-11



Legend

- Road
- Municipal Boundary
- Watercourse
- 🟦 51a Ottawa Group; Simcoe Group; Shadow Lake Fm.

Lake Simcoe Region conservation authority

0 0.5 1 2 3 4 5 Kilometres

N

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2.4.1.2. Bedrock Topography

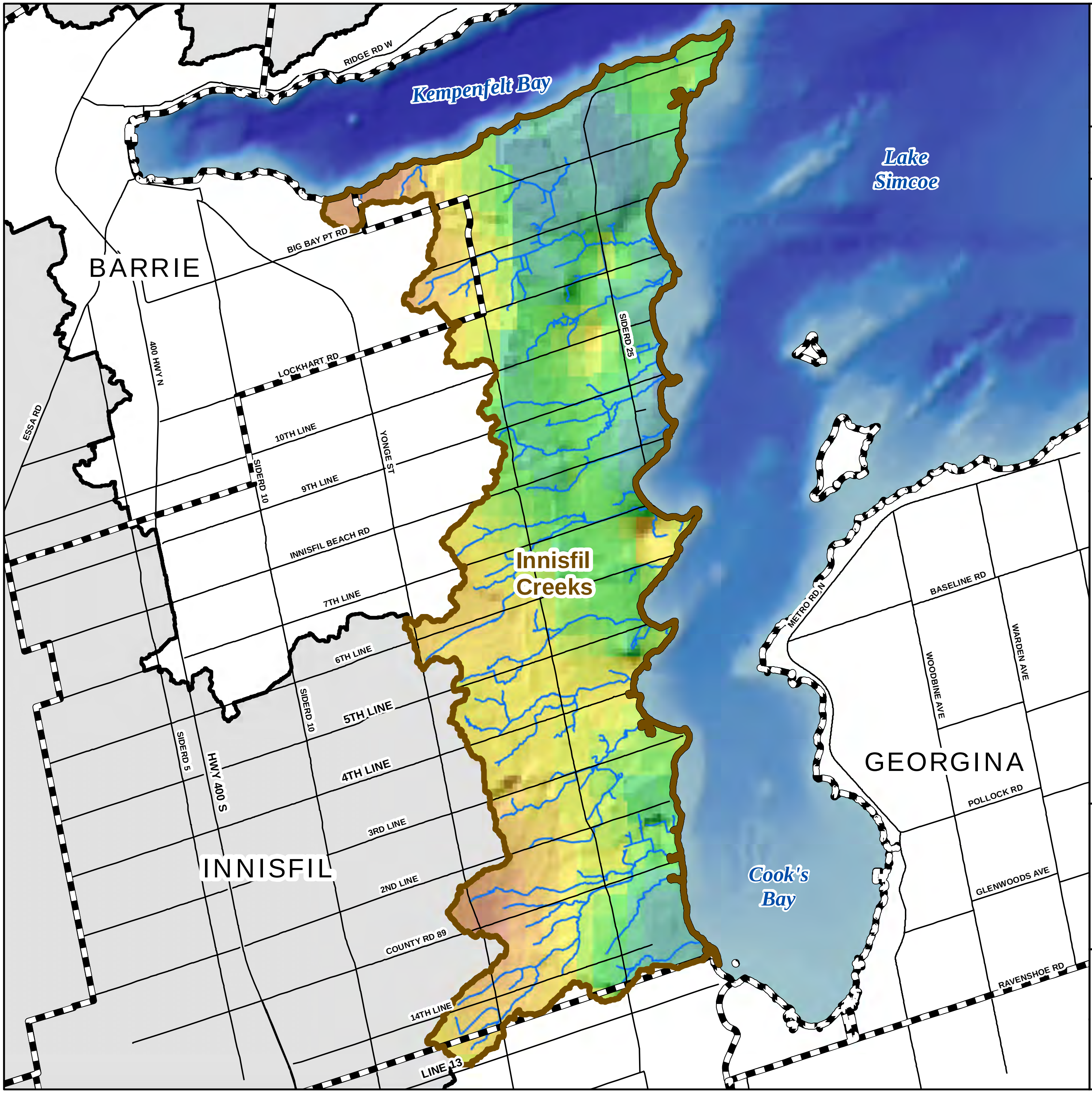
The bedrock surface of the subwatersheds has a general elevation range of 115 to 179 mASL (Figure 2-12). The bedrock surface is thought to have been the result of a long period of non-deposition and/or erosion activity that occurred between the deposition of the sedimentary bedrock and the overlying sediments.

The topographic lows are associated with significant valleys that have been eroded into the bedrock surface. These valleys are believed to be a result of fluvial activity prior to glaciation, approximation 440 to 2 million years ago with additional modification by glacial processes over the last 2 million years (Earthfx and Gerber, 2008).

A major bedrock valley known as the Laurentian bedrock channel traverses through the south-western portion of the Lake Simcoe watershed, in the neighbouring subwatersheds. Recent interest has been generated over the Laurentian Channel (also referred to as the Laurentian Valley), a proposed Tertiary-aged river network that extended from Georgian Bay to Lake Ontario (Brennan *et al*., 1998; Sharpe *et al*., 2004). This interest has been driven primarily by the attempt to locate additional sources of potable water as increasing population continues to place additional stress on existing groundwater supplies. This valley identifies an ancient drainage system that extended from Georgian Bay to Toronto.

Bedrock topography in the Innisfil Creeks subwatershed.

Figure 2-12



Legend

— Road

▬ Municipal Boundary

〰 Watercourse

Bedrock Top Elv (m)

- 🟥 <112
- 🟥 114
- 🟧 116
- 🟧 118
- 🟧 120
- 🟧 122
- 🟧 124
- 🟧 126
- 🟧 128
- 🟨 130
- 🟨 132
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- 🟦 >172

Lake Simcoe Region conservation authority

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2.4.1.3. Quaternary Geology

Glacial History

The bedrock within the Innisfil Creeks subwatershed is overlain by unconsolidated sediments, known as the overburden, which were deposited during the Quaternary Period. The Quaternary Period can be further divided into the Pleistocene (Great Ice Age) and the Holocene (Recent) Epochs. During the Pleistocene, at least four major continental-scale glaciations occurred, which include, from youngest to oldest, the Wisconsinan, Illionian, Kansan, and Nebraskan Stages (Dreimanis and Karrow, 1972). All of the surficial deposits within the subwatershed, and within most of southern Ontario, are interpreted to have been deposited within the subwatershed, and within most of southern Ontario are interpreted to have been deposited by the Laurentide Ice Sheet during the Wisconsinan glaciations. The Laurentide Ice Sheet is the glacier that occupied most of Canada during the Late Wisconsinan period, approximately 20,000 years ago (Barnett, 1992).

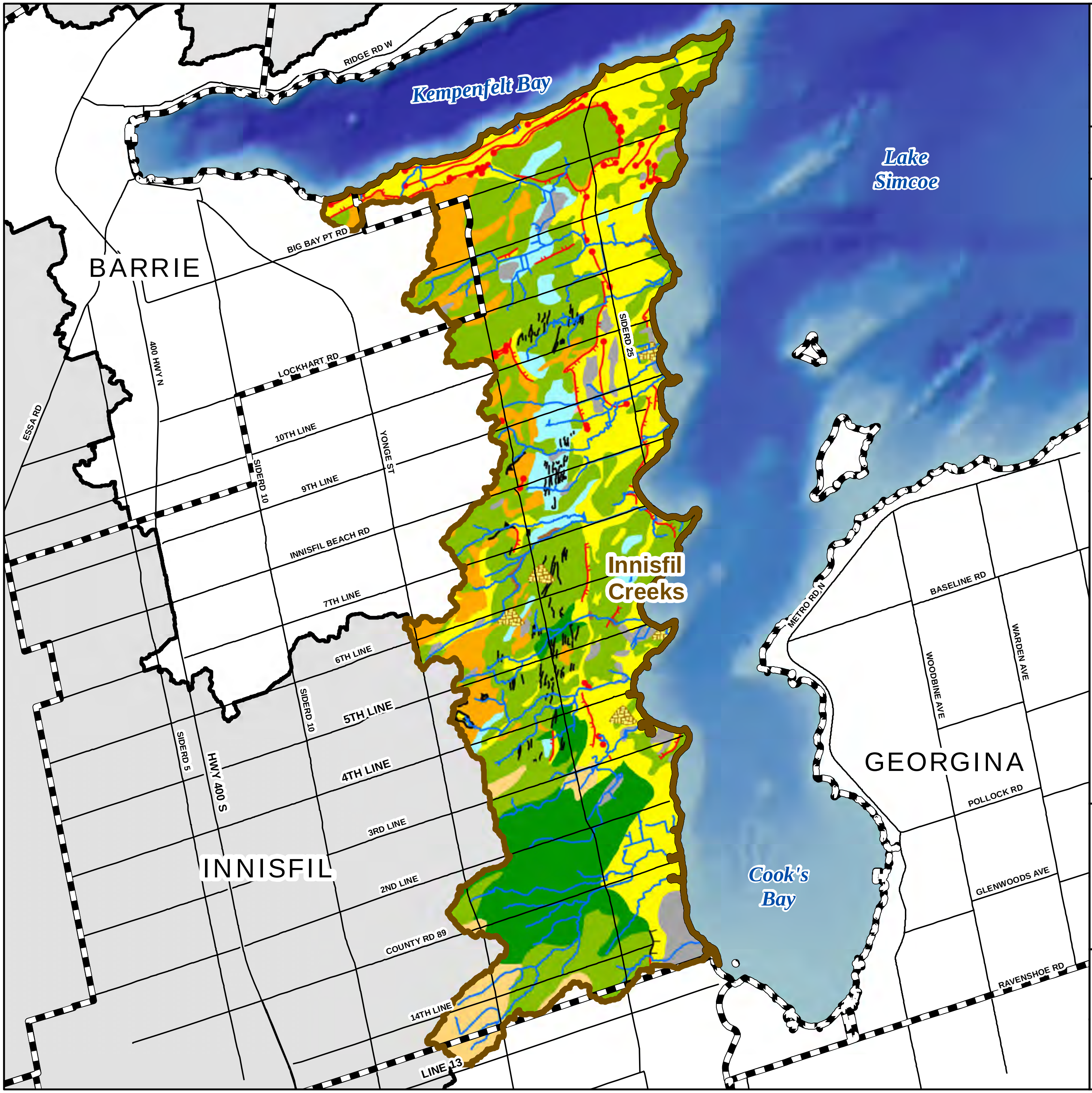
Sediments deposited during the Late Wisconsinan substage are extensive in southern Ontario and are thought to represent all of the surficial deposits in the subwatersheds. All of the deposits which outcrop at surface within the subwatersheds were likely laid down within the last 15,000 years during and after the Port Bruce Stade. Deep boreholes indicated that older Wisconsinan deposits do occur at depth; however, it is not always possible to date them (Dreimanis and Karrow, 1972). These deposits are often quarried by the aggregate industry for use in infrastructure building. The quaternary deposits are depicted on Figure 2-13.

Quaternary Sediment Thickness

Within the subwatershed the Quaternary sediment thickness is the difference between the ground surface and the bedrock surface. The thickness of the Quaternary sediments has been determined from borehole and water well information within the subwatershed. Figure 2-14 shows the thickness ranges from approximately 39 to 186 m. The Paleozoic bedrock topography appears to strongly influence the overlying Quaternary sediment thickness and distribution. The thicker Quaternary sediments occur in bedrock topographical lows (i.e. within bedrock valleys), while the thinnest areas of Quaternary deposits occur at the north end of the subwatershed, south of Cook’s Bay.

Surficial geology in the Innisfil Creeks subwatershed.

Figure 2-13



Legend

— Road

▬ Municipal Boundary

〰 Watercourse

▲ drumlin

● beach

┬ bluff

▼ icslope

— ribl

┬ terrace

🟥 1: Precambrian bedrock

🟩 5b: Stone-poor, carbonate-derived

🟩 silty to sandy till

🟩 5d: Glaciolacustrine-derived

🟩 silty to clayey till

🟧 6: Ice-contact stratified deposits

🟧 7: Glaciofluvial deposits

🟦 8a: Massive-well laminated

🟨 9b: Littoral-foreshore deposits

🟨 9c: Foreshore-basinal deposits

🟫 12: Older alluvial deposits

🟫 19: Modern alluvial deposits

⬜ 20: Organic deposits

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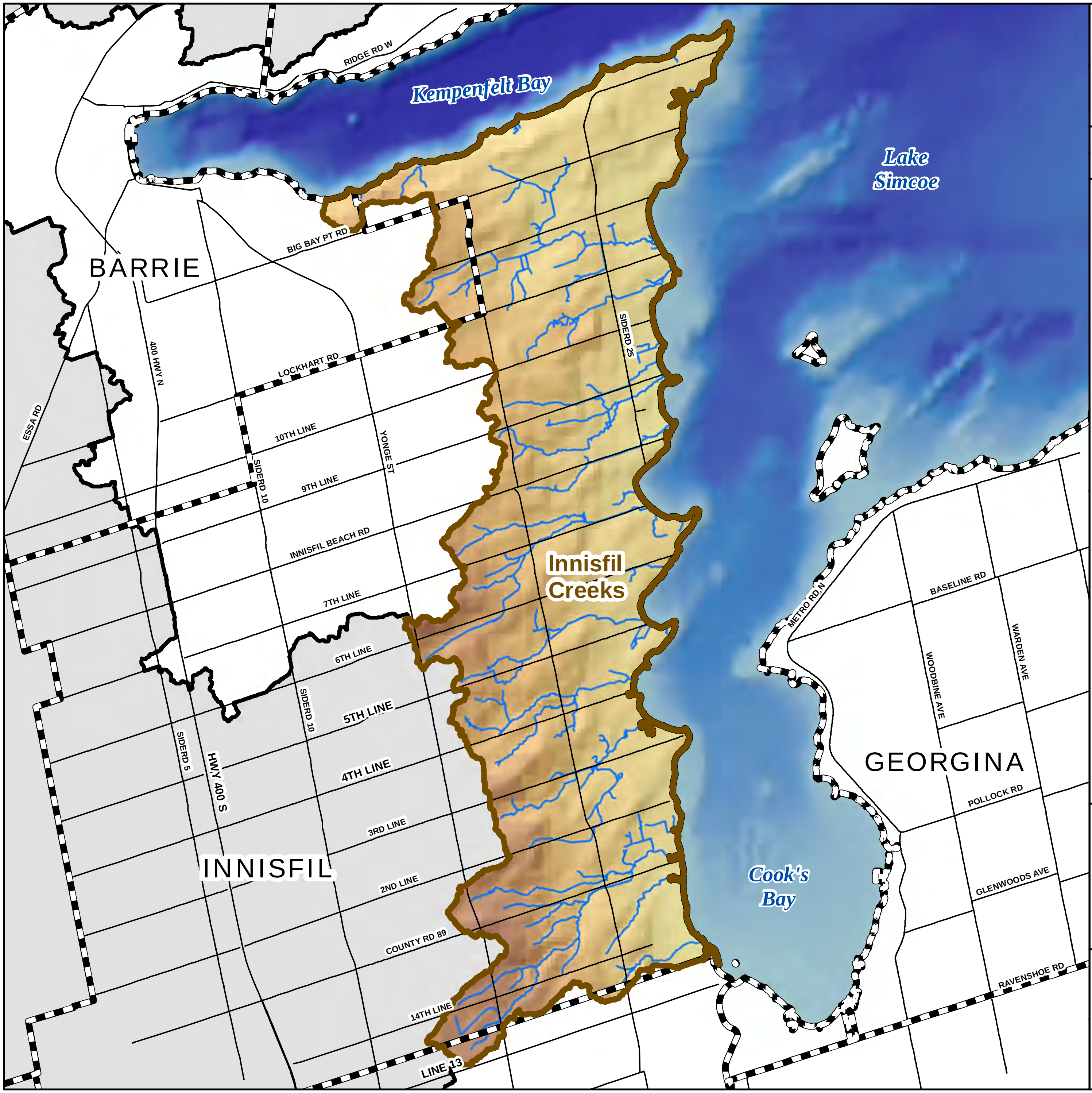

Overburden thickness in the Innisfil Creeks subwatershed.

Figure 2-14

Legend

— Road

▬ Municipal Boundary

~ Watercourse

Overburden Thickness (m)

▨	50	▨	95	▨	155
▨	55	▨	100	▨	160
▨	60	▨	105	▨	165
▨	65	▨	110	▨	170
▨	70	▨	115	▨	175
▨	75	▨	120	▨	180
▨	80	▨	125	▨	185
▨	85	▨	130	▨	190
▨	90	▨	135	▨	200
		▨	140	▨	220
		▨	145	▨	240
		▨	150		

Lake Simcoe Region conservation authority

0 0.5 1 2 3 4 5 Kilometres

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2.4.1.4. Hydrostratigraphy

The geology of the subwatershed significantly influences the local hydrogeology, which is the study of groundwater. Hydrogeologists study the geologic formations to understand how much water infiltrates into the subsurface, where it flows, how quickly it flows, and where it re-enters the surface water system. Changes in groundwater quantity and quality have potential impacts on natural functions that could affect the surface water flow regime, aquatic ecosystems, and use of the resource as a viable water supply.

Hydrostratigraphy is the spatial mapping of geologic formations based on their water bearing properties. The hydrostratigraphy of the surficial deposits within the subwatershed is complex as a result of the glacial history. There are a number of ongoing initiatives to understand the local hydrostratigraphic framework of the Southern Simcoe County and Barrie area. The following subsections provide a brief overview of relevant and previously completed stratigraphic studies.

The stratigraphic framework of Quaternary glacial and non-glacial sediments, as shown in Figure 2-15, was completed by AquaResource *et al*., 2011 for the City of Barrie Tier 3 Water Budget and Risk Assessment, which encompasses a large portion of the Innisfil Creeks subwatershed. The conceptual model builds upon previous models built for the South Simcoe Groundwater Studies (Golder, 2004). Four regional aquifers have been defined throughout study area. An aquifer is an underground saturated permeable geological formation that is capable of transmitting water in sufficient quantities under ordinary hydraulic gradients to serve as a source of groundwater supply. Aquifers are typically composed of coarse grained materials such as sands and gravels. The aquifers are named A1 through A4, from top to bottom. Despite the continuity of the hydrostratigraphic framework, it is important to note that pinchouts, lenses, and windows do occur within any given unit (AquaResource *et al*., 2011). A description of the interpreted regional hydrostratigraphic framework is provided below. The discussion of the layers is focused on the areas where the data exists. Key features for the Innisfil Creeks subwatershed will be pointed out where known.

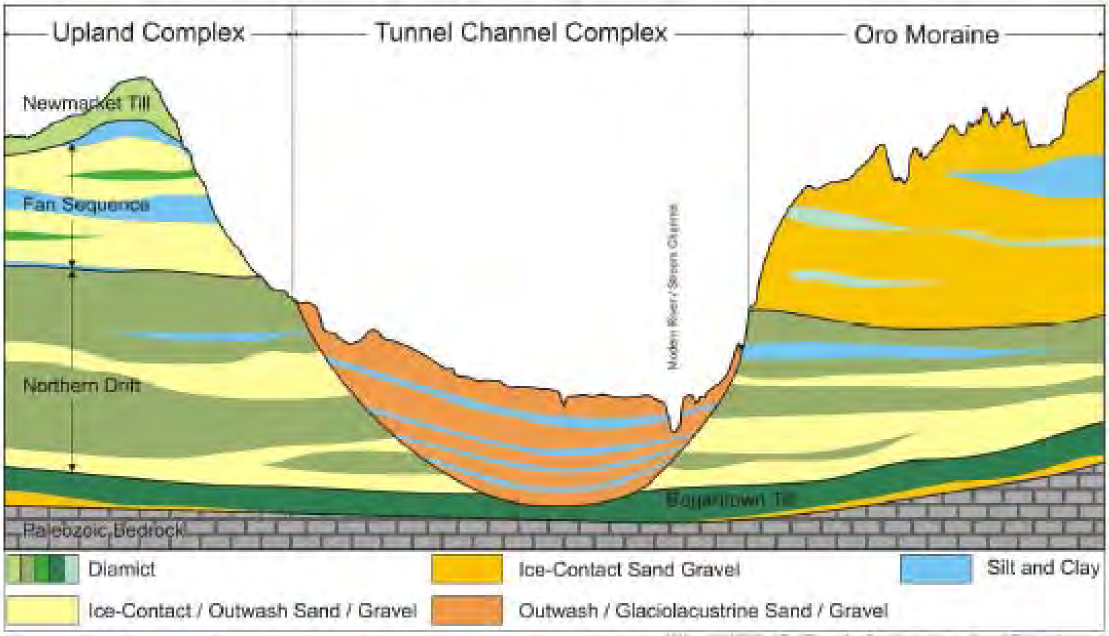


Figure 2-15: Generalized conceptual stratigraphy of upland complexes, lowland tunnel channel complexes and the Oro Moraine (AquaResource *et al*., 2011).

The nine conceptual model layers (from youngest to oldest) are:

1. Upper Confining Layer
2. Aquifer 1 (A1)
3. Confining Layer 1 (C1)
4. Aquifer 2 (A2)
5. Confining Layer 2 (C2)
6. Aquifer 3 (A3)
7. Confining Layer 3 (C3)
8. Aquifer 4 (A4)
9. Top of Bedrock

Upper Confining Layer (UC)

The upper confining layer or aquitard has been mapped as coarse-grained lacustrine deposits which are part of a regionally extensive sand plain extending west from the shoreline of Cook's Bay. An aquitard is a confining bed and/or formation composed of rock or sediment that retards but does not prevent the flow of water to or from an adjacent aquifer. It does not readily yield water to wells or springs, but stores groundwater.

Aquifer 1 (A1)

The A1 aquifer is commonly associated with the upland areas. Overall, the aquifer can be described as being composed of fine to medium grained sand with occasional occurrences of gravel. Detailed logging of this unit in the northwest part of Barrie (Dixon hydrogeology , 2001) indicates that the upper aquifer consists of a number of coarsening upward sequences of lacustrine sand with only minor occurrences of silt (AquaResource et al, 2011).

Confining Layer 1 (C1)

The C1 layer has been cored within the City of Barrie and is described as varved clay and silt. The C1 layer is noted as thin to non-existent in some areas (typically west of Barrie toward Angus) (AquaResource *et al*., 2011).

Aquifer 2 (A2)

The A2 aquifer is found in the elevation range of approximately 175 to 230 mASL within the lowland areas but the stratigraphic equivalent extends up to approximately 250 mASL to the northeast, under the Oro Moraine. The aquifer can generally be described as being composed of sand, with some clast rich portions. The aquifer is interpreted to extend under Kempenfelt Bay and to the north (towards Midhurst). The lower elevation of the aquifer in the vicinity of Kempenfelt Bay corresponds with the deeper channelized aquifer and suggests that it may represent in-filled former river channels in this area. The A2 aquifer ranges in thickness from approximately 10 to 30 m in most areas. It is regionally extensive, but does pinch out in some areas. The eastern part of the A2 aquifer is interpreted to be in direct contact with Kempenfelt

Bay, based on the base elevation of the bay and the interpreted aquifer extents near its shores (AquaResources *et al*., 2011).

Confining Layer 2 (C2)

The C2 layer has been described as a silty sand to sandy silt, stone-rich diamicton (AquaResource & Golder, 2009).

Aquifer 3 (A3)

The A3 aquifer is commonly referred to as the lower aquifer and is the primary groundwater supply source for the Town of Innisfil drinking water. The aquifer is composed of extensive coarse grained sand and gravel, which readily transmits the flow of water. The A2 aquifer is interpreted to be in contact with the A3 aquifer in some locations. The elevation of the A3 aquifer ranges from 150 to 195 mASL, and ranges in thickness from 10 to 40 m. North of Innisfil, the aquifer is interpreted to be in direct contact with the A4 aquifer in the City of Barrie core, at the location of the interpreted tunnel channel (AquaResource *et al*., 2011).

Confining Layer 3 (C3)

Confining Layer 3 is thin to absent in some areas. Where present the layer is composed of fine-grained silts and clays (AquaResource & Golder, 2009).

Aquifer 4 (A4)

The A4 aquifer is typically found at elevations below 150 mASL in areas of depressed bedrock elevation. The aquifer is reported to consist of fine to medium grained sand with minor gravel deposits in some areas. The aquifer is thin to absent in some areas, and is often limited to areas of depressed bedrock elevation. In the Golf Haven area the aquifer is removed from bedrock depressions the aquifer is very thin and composed of fine grained sand and silt, and is underlain by till (AquaResource & Golder, 2009).

Top of Bedrock

The Middle-aged Ordovician aged carbonates of the Simcoe group (discussed above) are in direct contact with the bottom of the A4 aquifer.

2.4.2 Physiography, Topography, and Soils

2.4.2.1. Physiography

Physiography is the study of the physical structure of the surface of the land. A physiographic region is an area with similar geologic structure and climate, and which has a unified geomorphic history (DRAFT GRIPS, 2008). The study of physiography is important from a water resource perspective as the knowledge gained from knowing the land composition aids hydrogeologists and hydrologists in understanding the groundwater and surface water flow systems. The physiography of an area is also important from an agricultural perspective as the sediments and landforms present at the surface influence the types of crops that can easily be grown.

The physiographic regions within the Innisfil Creeks subwatershed are a direct result of the deposition and erosion of the quaternary sediments (overburden) during glacial and post-glacial events, and closely correspond to the topography discussed in the following section. According to Chapman and Putnam (1984), two physiographic regions are found within the subwatersheds: Simcoe Lowlands and the Peterborough Drumlin Field (Figure 2-16).

Simcoe Lowlands

The Simcoe Lowlands is the physiographic region that comprises narrow stretches of land along the shores of Kempenfelt and Cook's Bay within the subwatershed. The region is described as having lower elevations, with flat-floored valley features that generally correspond to current river systems (Sharpe *et al*., 1999). The lowlands were flooded by glacial Lake Algonquin and as a result are floored by sand, silt, and clay (Chapman and Putnam, 1984).

Peterborough Drumlin Field

Drumlin is a Celtic word meaning little hill. Drumlins are typically oval shaped hills with smooth convex contours. In areas where drumlins are pointing in the same direction, the direction of movement of a glacier during the last ice age can be determined (Chapman and Putnam, 1984).

The Peterborough Drumlin Field extends south of Kempenfelt Bay down to the Oak Ridges Moraine, encompassing the majority of the subwatershed. The physiographic region is typically characterized by numerous drumlins that are on average oriented 60° west of south or 240° azimuth and rise up from the surrounding Newmarket Till plain. On average, drumlins are 20-75 m in width and 100-450 m in length. Internally, drumlins are composed of a stone-rich, slightly silty to silty fine to medium grained sand till.

2.4.2.2. Topography

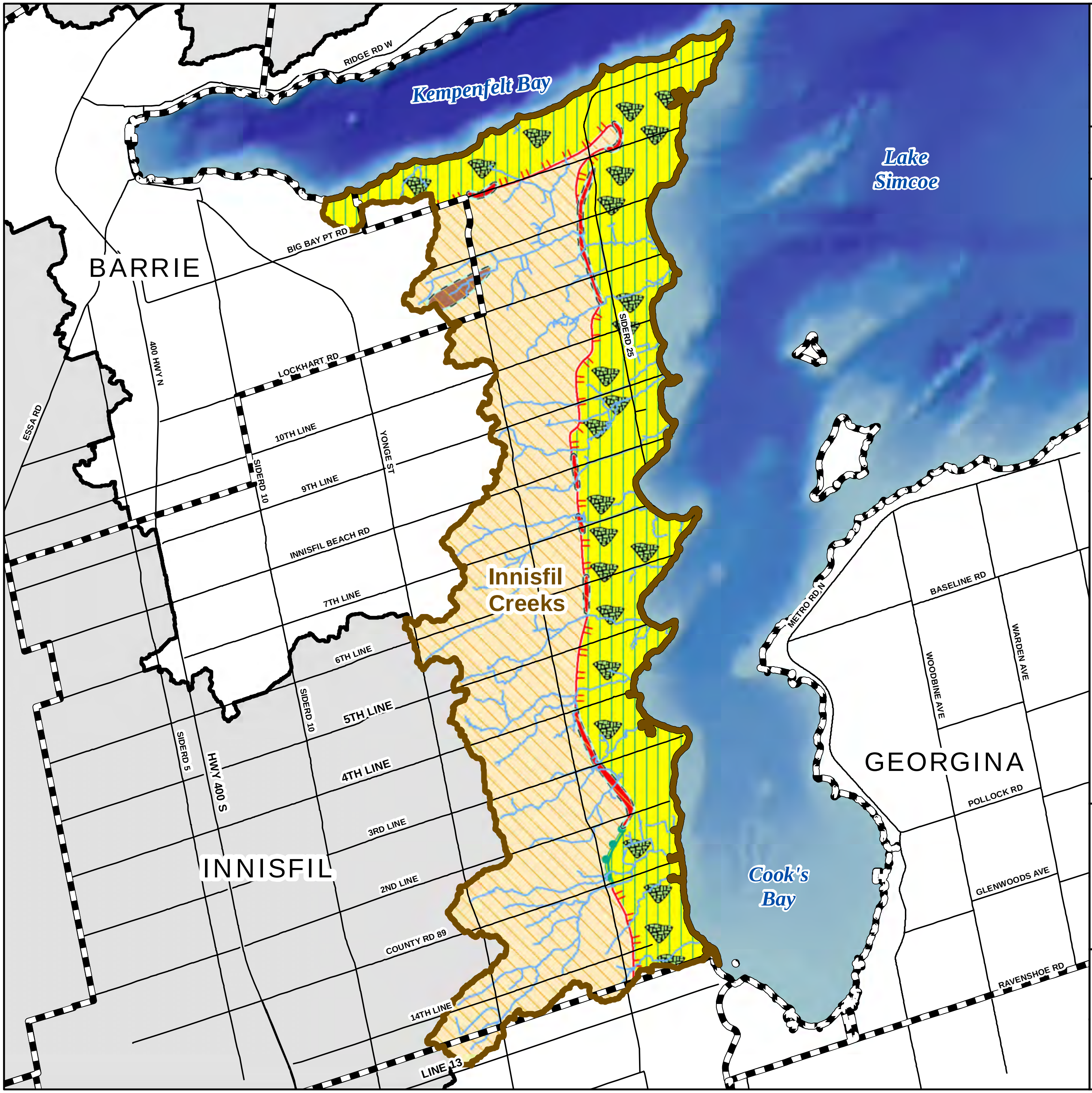
The topography of the subwatershed closely corresponds to the physiographic regions that comprise the subwatersheds. The topographic features of the Innisfil Creeks subwatershed are related to the present-day stream network, as well as their geological history, including significant glacial events. The ground surface topography within the subwatersheds ranges from 306 metres above mean sea level (mASL) in the Innisfil Heights area to 216 mASL along the shores of Kempenfelt and Cook's Bay (Figure 2-17).

2.4.2.3. Soils

The soils present within the subwatershed influence the type and productivity of the vegetation communities commonly found growing within the subwatersheds. Soils also influence the quality and quantity of water entering the ground and running along the surface. Traditionally, soils within the subwatershed have been characterized based on the coarseness of their texture. Coarse textured soils (gravel and sand) allow water to infiltrate better than finer-textured soils (clay, silty loam) do. The texture of the soil is important because it directly influences the landscape's ability to generate runoff. For example, during a heavy thunderstorm, rainfall that cannot infiltrate the ground will pool on the surface. Once enough water has collected it will start flowing overland as a result of gravity and in so doing can erode soil particles, washing them into ditches, streams and lakes. Figure 2-18 depicts the spatial distribution of the soil types present throughout the subwatersheds.

Physiography in the Innisfil Creeks subwatershed.

Figure 2-16



Legend

- —— Road
- ▬ Municipal Boundary
- 〰 Watercourse

Physiography Features

- ▲ Boulder pavement
- - - - Contact
- ┬┬┬ Shorecliff
- ●●● Shorecliff (Weakly developed)
- ▥ Simcoe Lowlands
- ▨ Peterborough Drumlin Field
- 🟥 Beach
- 🟫 Drumlin
- 🟨 Sand Plain
- ▭ Till Plain (Drumlinized)

Lake Simcoe Region conservation authority

0 0.5 1 2 3 4 5 Kilometres

N

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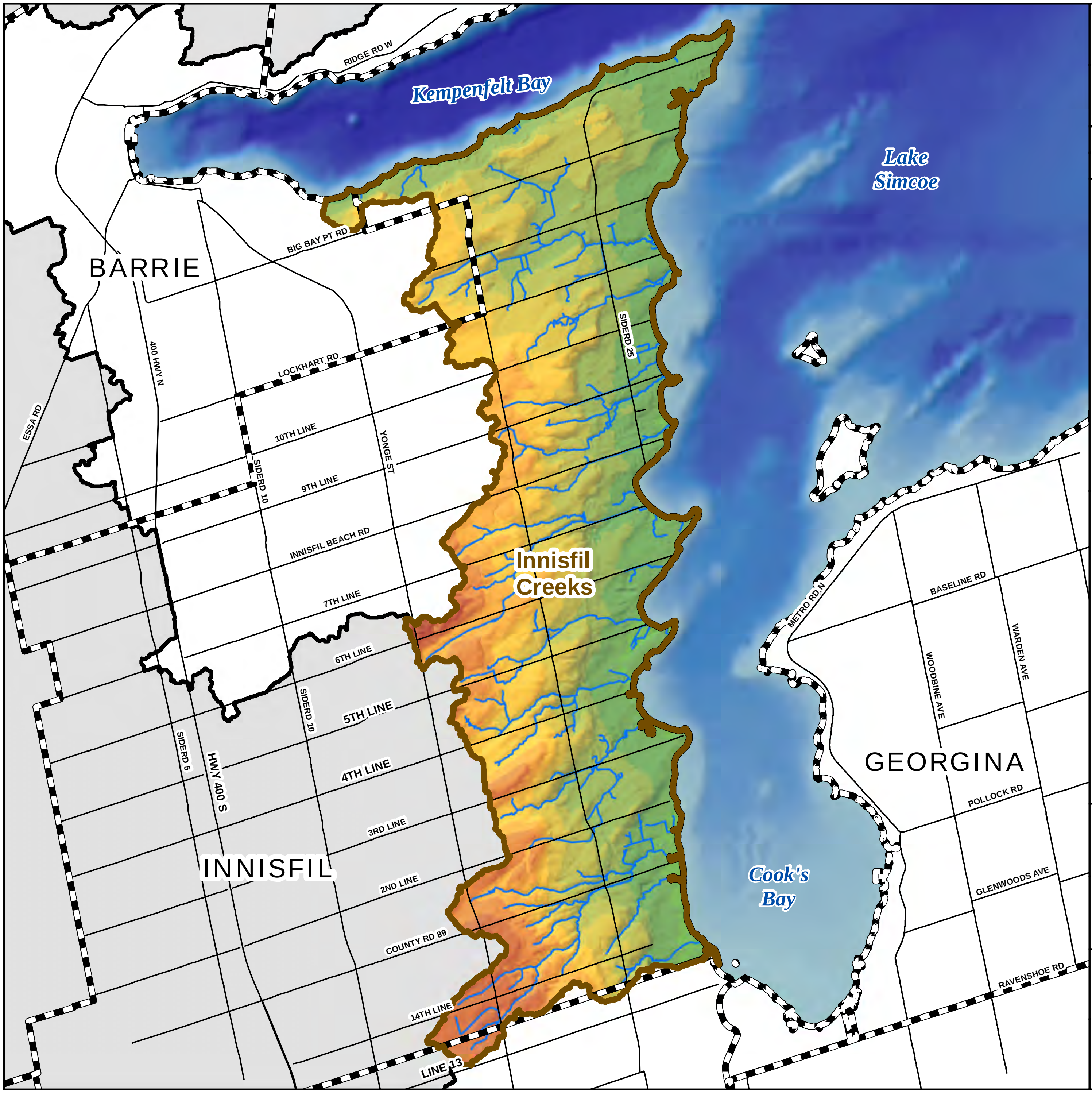
Ground surface topography in the Innisfil Creeks subwatershed.

Figure 2-17



Legend

Road

Municipal Boundary

Watercourse

Ground Surface Elevation (m)

100 - 120	280 - 290
120 - 140	290 - 300
140 - 160	300 - 310
160 - 170	310 - 320
170 - 180	320 - 330
180 - 190	330 - 340
190 - 200	340 - 360
200 - 210	360 - 380
210 - 220	380 - 400
220 - 230	400 - 420
230 - 240	420 - 440
240 - 250	440 - 460
250 - 260	460 - 480
260 - 270	480 - 500
270 - 280	500 - 520
	520 - 540
	540 - 560

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0 0.5 1 2 3 4 5 Kilometres

N

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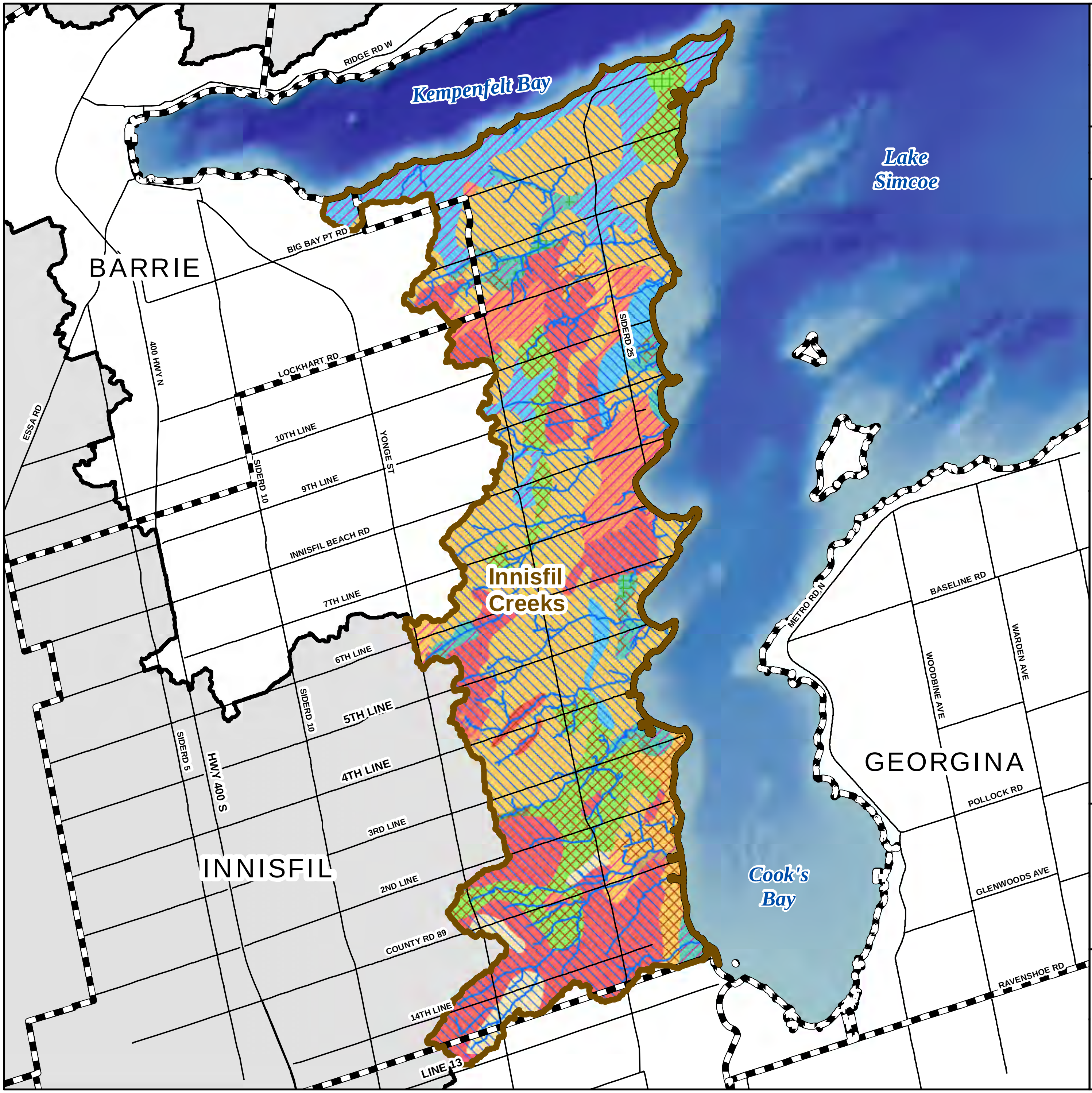
Soils in the Innisfil Creeks subwatershed

Figure 2-18



Legend

— Road

▬ Municipal Boundary

〰 Watercourse

Soil Hydro Class

▨ A - high infiltration rates

▨ B - moderate infiltration rates

▨ C - slow infiltration rates

▦ D - very slow infiltration rates

Soil Texture Class

■ GRAVELLY SANDY LOAM

■ SAND

■ SANDY LOAM

■ FINE SANDY LOAM

■ LOAM

■ LOAMY SAND

■ SILTY LOAM

■ SILTY CLAY LOAM

■ ORGANIC

Lake Simcoe Region conservation authority

0 0.5 1 2 3 4 5 Kilometres

N

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2.5 Fluvial Geomorphology

2.5.1 Introduction and background

Fluvial geomorphology is the study of the processes that influence the shape and form of streams and rivers. It describes the processes whereby sediment and water are transported from the headwaters of a watershed to its mouth. These processes govern and constantly change the form of river and stream channels, and determine how stable the channels are. Fluvial geomorphology provides a means of identifying and studying these processes, which are dependent on climate, land use, topography, geology, vegetation, and other natural and human influenced changes.

An extensive understanding of geomorphic processes and their influences is required in order to protect, enhance, and restore stream form in a watershed. Changes in land use, and urbanization in particular, can significantly impact the movement of both water and sediment, and can thus cause considerable changes to the geomorphic processes in the watershed. Changes to the morphology of stream channels, such as accelerated erosion, can impact the aquatic community, which has adapted to the natural conditions, and can also threaten human lives, property, and infrastructure.

2.5.2 Geomorphic Processes

All streams and river systems are constantly in a state of transition, influenced by the flow of water and the amount of sediment entering into the system, which in turn are influenced by climate and geology. The amount of water delivered to the surface of a watercourse, as well as how and when it arrives is influenced by climate. Typical patterns are high flow events during the spring freshet, and low flow conditions during the winter and summer months.

The surficial geology of an area influences the path of water once it reaches the ground surface. The underlying geology establishes the volume and proportion of groundwater and surface water available to flow through a watershed through its effect on infiltration. Geology also shapes the amount and type of sediment that enters a watercourse, and the strength and erodibility of the surficial material through which the watercourse flows. A complex underlying geology and topography can result in considerable variation in channel character, as well as sensitivity to potential impacts, within the same drainage system.

Natural watercourses respond to continually changing conditions in flow and sediment supply with adjustments in shape and channel position. These changes take place through the processes of erosion and deposition. This ability to continually change is an inherent characteristic of natural systems that allows the morphology of the channels to remain relatively constant. The state in which flow and sediment supply are balanced to achieve this stable channel form is referred to as “dynamic equilibrium.” While in a state of dynamic equilibrium, channel morphology is stable but not static, since it makes gradual changes as sediment is deposited and moved throughout the watercourse. For example, many natural watercourses can be seen to “migrate” within their floodplain over time. This is due to the erosion of the outsides of channel bends, but with corresponding deposition of material on the insides of bends. This process maintains the balance between flow and sediment supply in the system. Riparian and aquatic biota are adapted to and depend on the habitats provided by a system in dynamic equilibrium.

2.5.3 *Current Status*

Specific fluvial geomorphology studies have not been completed for these subwatersheds, but some other information was available through other studies. The information and data provided within this section has been collected by LSRCA staff completing studies on the condition of the fisheries in the subwatersheds. While a fisheries study is specific in nature, it also tends to provide a "snap-shot" of the biological, chemical and physical characteristics of the system. It should also be noted that some sections of the watercourses in the subwatershed have been moved, piped, channelized, eliminated or manipulated in some fashion to varying degrees. While specific data on the exact location and the degree to which a stream has been manipulated is not currently available, it is fair to say that the alteration of the watercourses has changed both the shape and functioning ability of them. Information on the impacts of manipulating watercourses is available in **Chapter 5 - Aquatic Natural Heritage**.

2.5.3.1. Strahler Stream Order

Stream order is a measure of the magnitude of a stream within a watershed and allows for the comparison of rivers of different sizes or importance within or between systems (Dunne and Leopold, 1978). A first-order stream is an unbranched tributary that typically drains the headwater portion of the watershed. When two or more first order streams converge the downstream segment is classified as a second order stream. A third-order stream is the downstream segment of the confluence of two or more second order streams, and so on. As the order of a stream increases, the characteristics of the watercourse typically change. Larger order streams are generally characterized by lesser elevation gradients, slower velocities, and an increased stream area to accommodate the flow from additional tributaries.

Table 2-7 below presents the stream order and the total length of the creek within the Innisfil Creeks subwatershed. To allow more detailed reporting, the Innisfil Creeks subwatershed has been divided up into the individual creeks: Banks, Belle Aire, Bon Secours, Carson, Cedar, Gilford, Leonard's, Mooselanka, Moyer, Sandy Cove, Strathallan, Sylvan Upper Marsh, White Birch, and Wilson, as well as the smaller unnamed creeks (Innisfil Creeks, which include Innisfil Creeks 1 and Innisfil Creeks 2) (see Figure 2-1 for location of the creeks).

Table 2-6: Innisfil Creeks subwatershed stream order and stream length.

Creek	Stream Order	Length of Creek per Order (m)	% of Creek per Order
Banks Creek (#5)	1st	6,701	44
	2nd	4,936	32
	3rd	3,611	24
	TOTALS	***15,248***	***100***
Belle Aire Creek (#7)	1st	4,395	52
	2nd	1,452	17
	3rd	2,634	31
	TOTALS	***8,481***	***100***
Bon Secours Creek (#4)	1st	1,221	26
	2nd	3,480	74
	TOTALS	***4,701***	***100***
Carson Creek (#8)	1st	3,591	28
	2nd	4,147	33
	3rd	3,232	26

Creek	Stream Order	Length of Creek per Order (m)	% of Creek per Order
	4th	1,686	13
	TOTALS	***12,655***	***100***
Cedar Creek (#6)	1st	657	44
	2nd	823	56
	TOTALS	***1,480***	***100***
Gilford Creek	1st	2,752	100
	TOTALS	***2,752***	***100***
Innisfil Creeks	1st	6,465	83
	2nd	1,334	17
	TOTALS	***7,799***	***100***
Leonard's Creek (#3)	1st	7,777	51
	2nd	5,838	39
	3rd	1,546	10
	TOTALS	***15,160***	***100***
Mooselanka Creek (#2)	1st	2,837	44
	2nd	765	12
	3rd	2,880	44
	TOTALS	***6,482***	***100***
Moyer Creek	1st	807	73
	2nd	303	27
	TOTALS	***1,110***	***100***
Sandy Cove Creek (#1)	1st	10,828	47
	2nd	6,891	30
	3rd	1,746	8
	4th	3,526	15
	TOTALS	***22,991***	***100***
Strathallan Creek	1st	2,055	93
	2nd	159	7
	TOTALS	***2,213***	***100***
Sylvan Creek	1st	382	100
	TOTALS	***382***	***100***
Upper Marsh Creek	1st	1,162	35
	2nd	2,145	65
	TOTALS	***3,308***	***100***
White Birch Creek (#10)	1st	14,112	49
	2nd	8,399	29
	3rd	5,720	20
	4th	461	2
	TOTALS	***28,693***	***100***
Wilson Creek (#9)	1st	7,232	54
	2nd	3,784	28
	3rd	2,449	18
	TOTALS	***13,465***	***100***

2.5.3.2. Drainage Density

Drainage density is a measure of how well a watershed is drained by its streams and is calculated as the total length of all streams within a watershed divided by the total area of the watershed. Typically, streams with high drainage densities are characterized by greater peak flows, high suspended and bed loads, and steep slopes (Dunne and Leopold, 1978). The average drainage density of the Innisfil Creek subwatershed is more than 20% greater than the average Lake Simcoe watershed drainage density (Table 2-8). This indicates potentially greater relief and increased erosion compared to other Lake Simcoe subwatersheds. The drainage densities of the Innisfil Creeks are fairly homogenous with the exception of Strathallan Creek and Sylvan Creek. Strathallan Creek has a fairly small subwatershed and high local relief resulting in very straight un-branched drainage. Sylvan Creek is a very small creek with a subwatershed area of only 0.056 km^2, which makes measuring the stream length and delineating the subwatershed boundary difficult using GIS.

Table 2-7: Innisfil Creeks subwatershed stream length, watershed area and drainage density.

Creek	Total Stream Length (km)	Watershed Area (km^2)	Drainage Density (km/km^2)
Banks Creek (#5)	15.248	9.618	1.585
Belle Aire Creek (#7)	8.481	5.076	1.671
Bon Secours Creek (#4)	4.701	2.030	2.316
Carson Creek (#8)	12.655	7.409	1.708
Cedar Creek (#6)	1.480	1.850	0.800
Gilford Creek	2.752	1.995	1.380
Innisfil Creeks	7.799	4.504	1.732
Leonards Creek (#3)	15.160	4.010	3.781
Mooselanka Creek (#2)	6.482	2.404	2.697
Moyer Creek	1.110	1.015	1.093
Sandy Cove Creek (#1)	22.991	18.270	1.258
Strathallan Creek	2.213	0.516	4.287
Sylvan Creek	0.382	0.054	7.127
Upper Marsh Creek	3.308	1.730	1.912
White Birch Creek (#10)	28.693	12.972	2.212
Wilson Creek (#9)	13.465	8.127	1.656
Innisfil Creeks (at subwatershed level)	146.92	81.58	1.801
***Simcoe Watershed Avg	3578.589	2446.274	1.463

****The Lake Simcoe watershed average includes the subwatersheds of: Barrie Creeks, Beaver River, Black River, East Holland River, Georgina Creeks, Georgina Island, Hawkestone Creek, Hewitts Creek, Lovers Creek, Maskinonge River, Oro Creeks North, Oro Creek South, Pefferlaw/Uxbridge Brook, Ramara Creeks, West Holland River, and Whites Creek.*

2.5.3.3. Elevation along watercourse

When there is a change in elevation, such as when water flows down from headwaters to base levels, energy is produced. Where there is greater fall (steeper slope) energy is gained and waters flow faster, picking up more sediment and having more force to erode banks. These can also be areas of unique fishery habitats where water is flowing quickly over shallow bedrock (riffles and rapids) that are used by some fish species such as brook trout (*Salvelinus fontinalis*), walleye (*Sander vitreus*), and longnose dace (*Rhinichthys cataractae),* as spawning grounds. Depending on the fall, it can also create a barrier to some aquatic species that are unable to swim against the force of the flow. Where the elevation levels out, the energy dissipates, releasing sediment and creating a slower flowing stream. These different processes help to alter the stream system over time. Stream profiles are shown below in relation to underlying surficial geology and features (discussed in Section 2.4.2) and only represent the main branch.

Figure 2-19 illustrates the stream profile of ten of the Innisfil Creeks starting from headwater elevation (length = 0) down to Lake Simcoe (elevation = 220). Average gradient ranges from a low gradient (0.50% gradient for Sandy Cove) to a relatively steep medium gradient (1.04% for Upper Marsh and Wilson Creeks). The rest fall somewhere in between those values: Banks (0.72%), Belle Aire (1.01%), Bon Secours (0.96%), Cedar (0.51%), Leonard's (0.89%), Mooselanka (0.82%), and White Birch (0.84%). Overall the streams in the subwatershed have similar gradients, with a few that have steeper sections and others that are levelled out in areas. The stream length does vary across the watershed (see Table 2-8 for lengths of each).

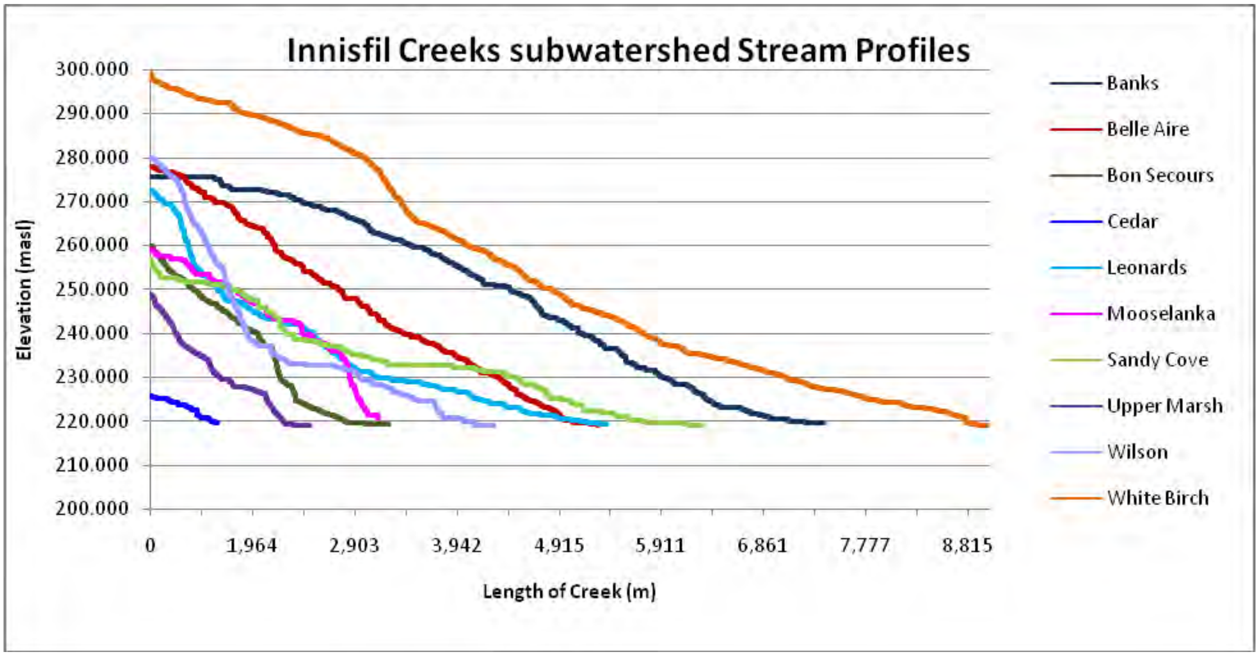


Figure 2-19: Innisfil Creeks subwatershed stream profiles.

2.5.3.4. Bank Stability

The stability of the stream bank depends on the strength of erosive forces against the bank and the stream bank's ability to minimize the impacts. Erosion is a natural process that occurs in all stream systems, but its effects can be exacerbated by changes (both natural and anthropogenic) to the system. Precipitation events can rapidly increase flows and in turn increase the rate of erosion. As the force of the water and the sediments increases, the stream bank's resistance decreases and scouring occurs. Visible signs of this include eroded sections near river bends and undercut banks. If banks are already unstable, excessive undercutting can lead to slumping where large portions of stream bank can collapse.

Unstable sites are those that typically have:

- Removal of riparian vegetation, whose roots create a network of tiny soil anchors and slow overland flow;
- Replacement of large, deep-rooted vegetation with impervious surfaces (i.e. in urban areas), which cause an increase in the volume and velocity of overland water flow; and
- Removal of in-stream debris which can provide a means of slowing water and decreasing the force at which it interacts with the stream bank.

Figure 2-20 illustrates the percentage of stream bank along White Birch, Sandy Cove, Belle Aire, Leonard's, and Wilson Creeks that are unstable, moderate or stable.

White Birch Creek has five sites that range from the headwaters of one of the branches (WBC-E) to the site closest to the mouth at Cook's Bay (WBC-A). Sites WBC-A, -B, and -C are located close together and all have a similar, high amount of stable stream bank and a smaller portion of unstable stream bank. These sites are close to golf courses. Sites WBC-D and WBC-E are further upstream, on different branches, but both surrounded by rural land use and small amounts of natural heritage areas. Both of these sites have a larger percentage of unstable stream banks, with Site WBC-D having almost equal amounts stable and unstable, while the majority of Site WBC-E stream banks are unstable.

Sandy Cove Creek also has five sites that are spread out from the mouth at Lake Simcoe (SANDY-A) to the headwaters of one of the branches (SANDY-E). With the exception of Site SANDY-A, all sites have a high percentage of stable stream bank, located through a variety of land uses.

Belle Aire Creek has four sites, located mostly in the eastern half of the watercourse with Site BELLE-A at the mouth and Site BELLE-D midway along the creek. All four sites have greater than 80% of stable stream bank and run through urban, rural, and natural heritage areas.

Leonard's Creek also has four sites spread along the whole creek. With the exception of Site LEONARD-B, all of the sites have at least 50% unstable stream bank. Both LEONARD-A and LEONARD-C are located within urban areas, with LEONARD-B and LEONARD-D in natural heritage areas that are surrounded by either urban or rural land use.

Lastly, Wilson Creek has three sites located near the mouth, one midway down the main branch and the last (WILSON-C) midway down a tributary. Both Site WILSON-A and WILSON-C have a high percentage of stable stream bank, and are in natural heritage and rural areas. Site WILSON-B has 60% unstable stream bank with smaller percentages of stable and moderate stream bank. This site is located in area with both natural heritage and aggregate land uses.

It should be noted that these sites were randomly chosen, where possible, and provide a general representation of the stream bank conditions.

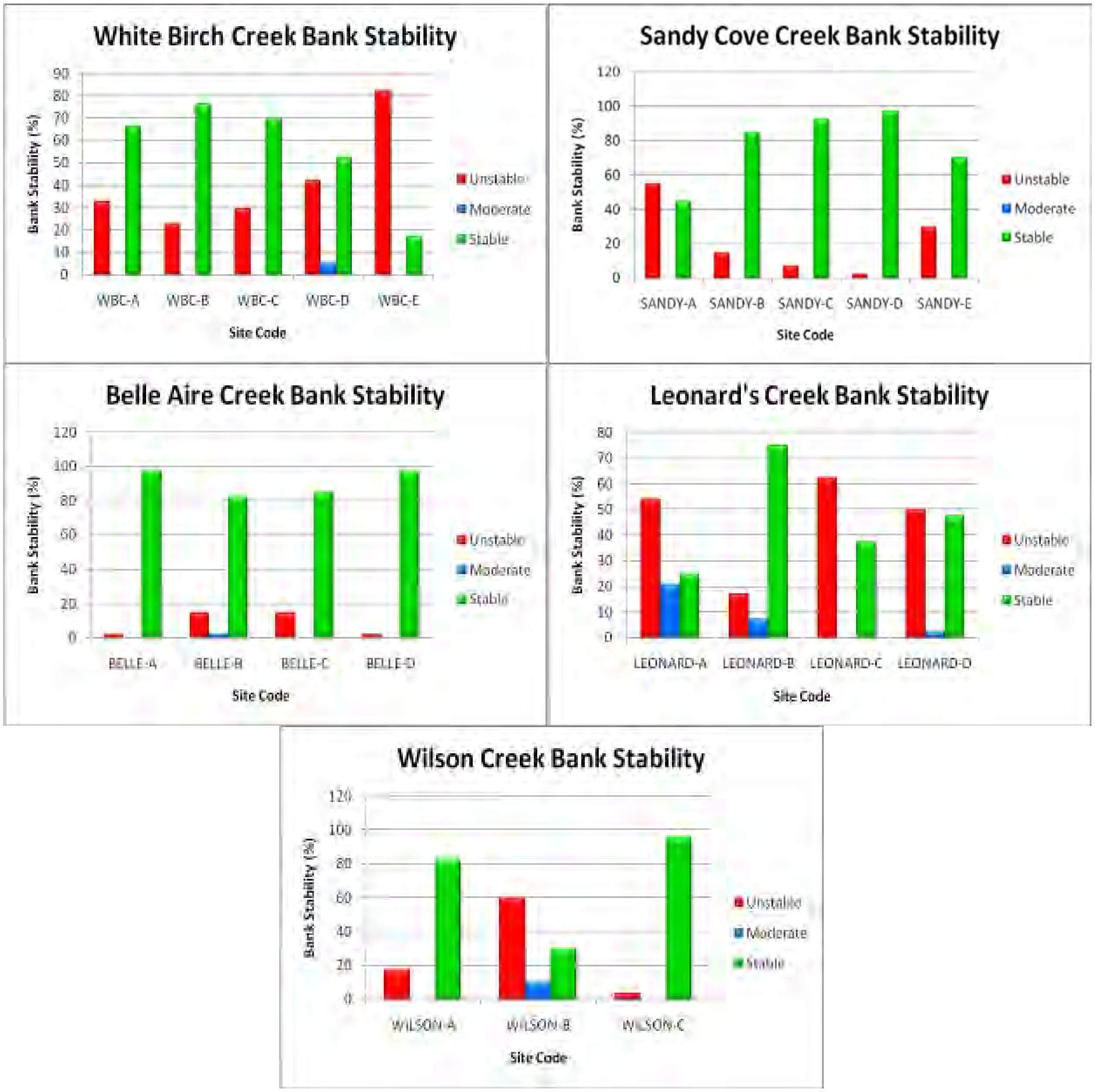


Figure 2-20: Percentage of stream bank that is unstable, moderate, or stable for five creeks within the Innisfil Creeks subwatershed.

2.6 Climate and climate change

2.6.1 Current climate conditions and trends

The Innisfil Creeks subwatershed lies within the Simcoe and Kawartha Lakes climatic region as defined by Brown *et al*. (1980). The climate within the subwatershed and surrounding area is characterized by moderate winters, warm summers, and long growing seasons with usually reliable precipitation patterns. Variations in topography, prevailing winds, and proximity to Georgian Bay and Lake Simcoe lead to local differences in climate across the subwatershed.

Climate data collected from the Barrie WPCC station has been used to characterize the climate for the Innisfil Creeks subwatershed and to support the water budget analysis that is discussed within **Chapter 4 – Water Quantity**.

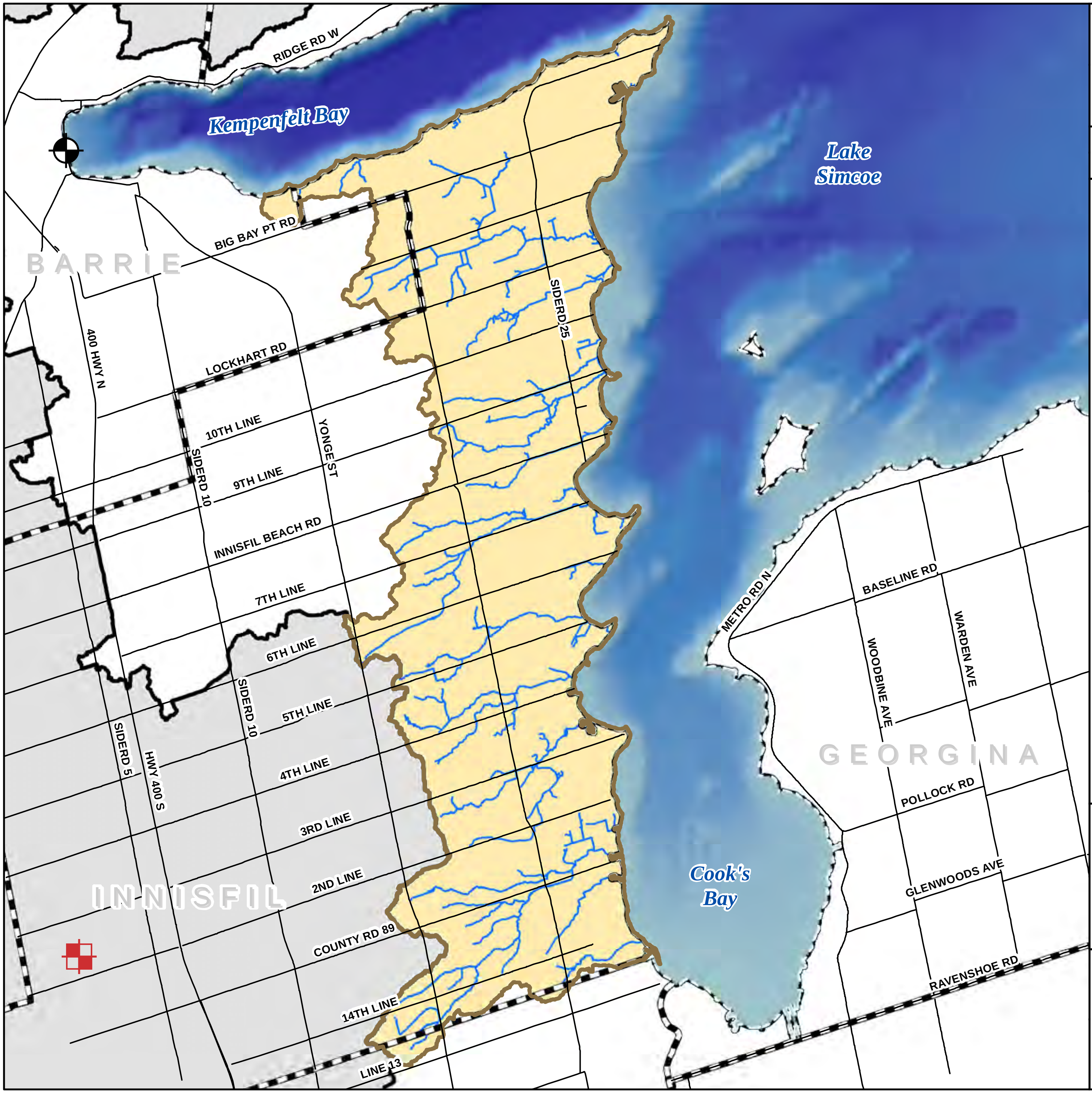
Table 2-8 displays a summary of the climate normals from 1971 to 2001 for the climate stations located within the City of Barrie and the surrounding municipalities (Figure 2-21). Based on the data collected at the Barrie WPCC station, the average mean annual temperature is 6.7 °C, while the total mean annual precipitation is 921 mm/yr. It should be noted that precipitation patterns have become less predictable in recent years, perhaps due to climate change.

Long-term climate data was obtained from Environment Canada stations shown on Figure 2-21 including daily maximum and minimum temperature, daily rainfall and snowfall, and hourly rainfall for the period of 1950-2008. The data gaps were infilled using methods carried out according to the methodology outlined in “Filling gaps in meteorological data sets used for long-term watershed modelling” (H.O Schroeter, D.K. Boyd, and H.R. Whitely) by Schroeter & Associates in 2009. The record period for the Barrie WPCC (6110218) after the data infilling exercise was from 1950-2008.

Table 2-8: Summary of climate normals (1971-2001) for the City of Barrie and surrounding area (modified from AquaResource and Golder, 2010).

Station Name	Elevation (mASL)	Mean Annual Temperature °C			Mean Annual Precipitation		
		Avg.	Min.	Max.	Rainfall (mm)	Snowfall (cm)*	Total (mm)
Angus Camphill	212	6.2	0.4	12.1	636	215	851
Barrie WPCC**	221	6.7	1.7	11.7	683	237	921
Cookstown	244	6.3	1.1	11.4	657	161	818
Essa Ont Hydro	216	6.6	1.5	11.8	670	213	884
Midhurst	226	6.6	1.3	11.9	687	222	908

* The water storage capacity of 1 cm of snow pack is equivalent to 1 mm of rainfall



Location of climate stations in and around the Innisfil Creeks subwatersheds

Figure 2-21

Legend

Climate Station

⊕ LSRCA Station

🟥 NVCA Station

— Road

▬ Municipal Boundary

〰 Watercourse

Lake Simcoe Region conservation authority

0 0.5 1 2 3 4 5 Kilometres

N

2.6.1.1. Temperature

To examine temperature trends for the past 60 years, the daily average air temperature was averaged for each year to produce Figure 2-22 to compare the average annual, average maximum annual, and average minimum annual air temperature. Figure 2-22 gives a general overview of the temperature trends at the Barrie WPCC meteorological monitoring station, illustrating how all appear to fluctuate in relatively the same manner over the years.

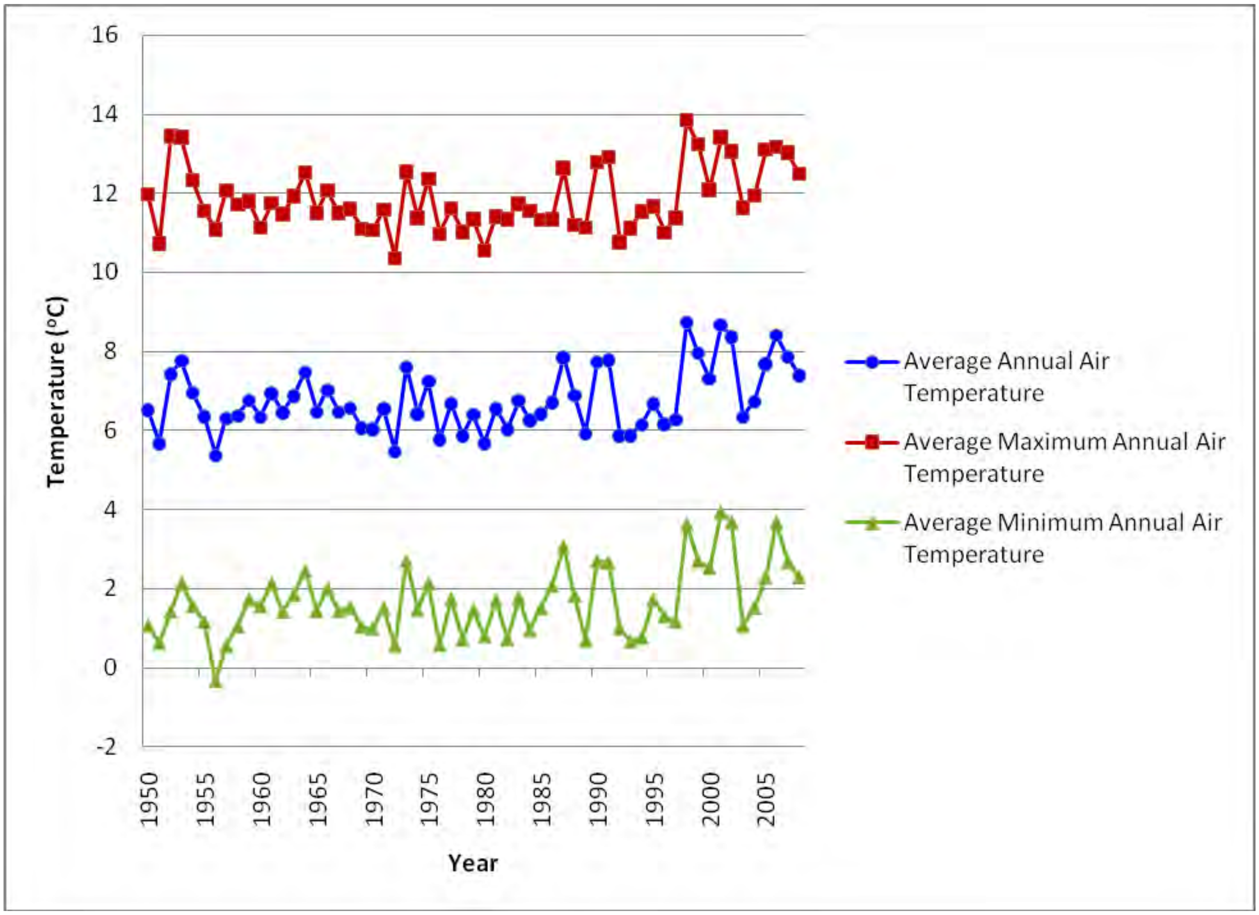


Figure 2-22: Comparison of the average annual, maximum and minimum temperatures at the Barrie WPCC Meteorological Monitoring Station (1950-2008). Source: SGBLS, 2012.

Figure 2-23 displays only the average annual temperature, giving a closer look at the trend for the period of record. From it we can see that there is a gradual increase over the entire period, with this trend becoming more pronounced after 1980. There is a slight decrease at the beginning of the period of record from 1950 through the 1960s, followed by a plateau for the next 20 years or so before starting to increase. Overall, there has been an increase of 0.87°C over the past 60 years.

It should be noted that this is only a broad assessment of temperature trends at the Barrie WPCC meteorological monitoring station.

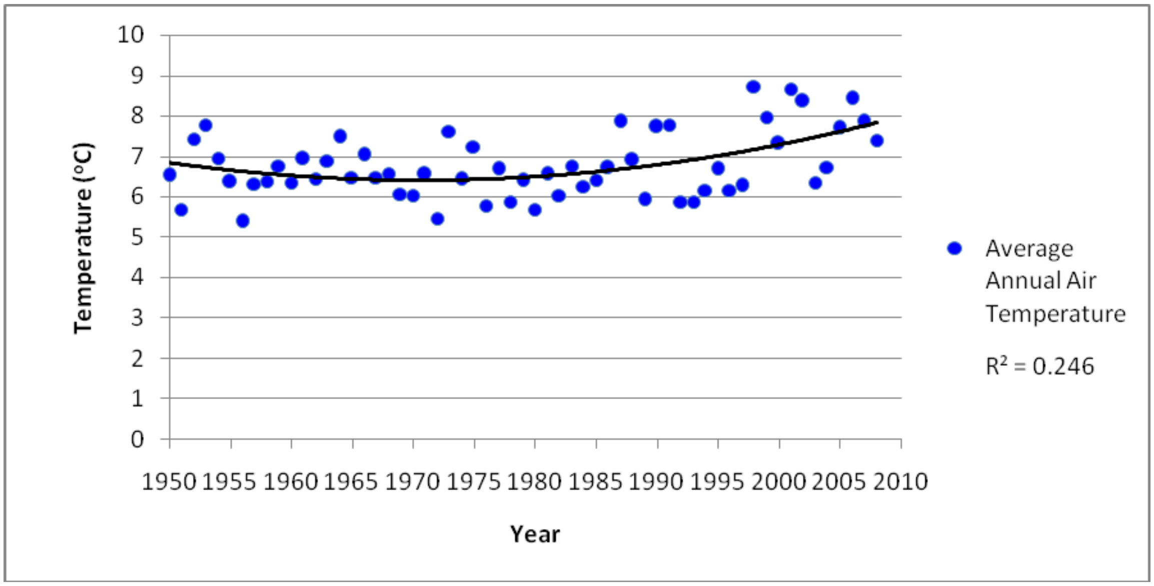


Figure 2-23: Average annual temperature at the Barrie WPCC Meteorological Monitoring Station (1950-2008). Source: SGBLS, 2012.

2.6.1.2. Precipitation

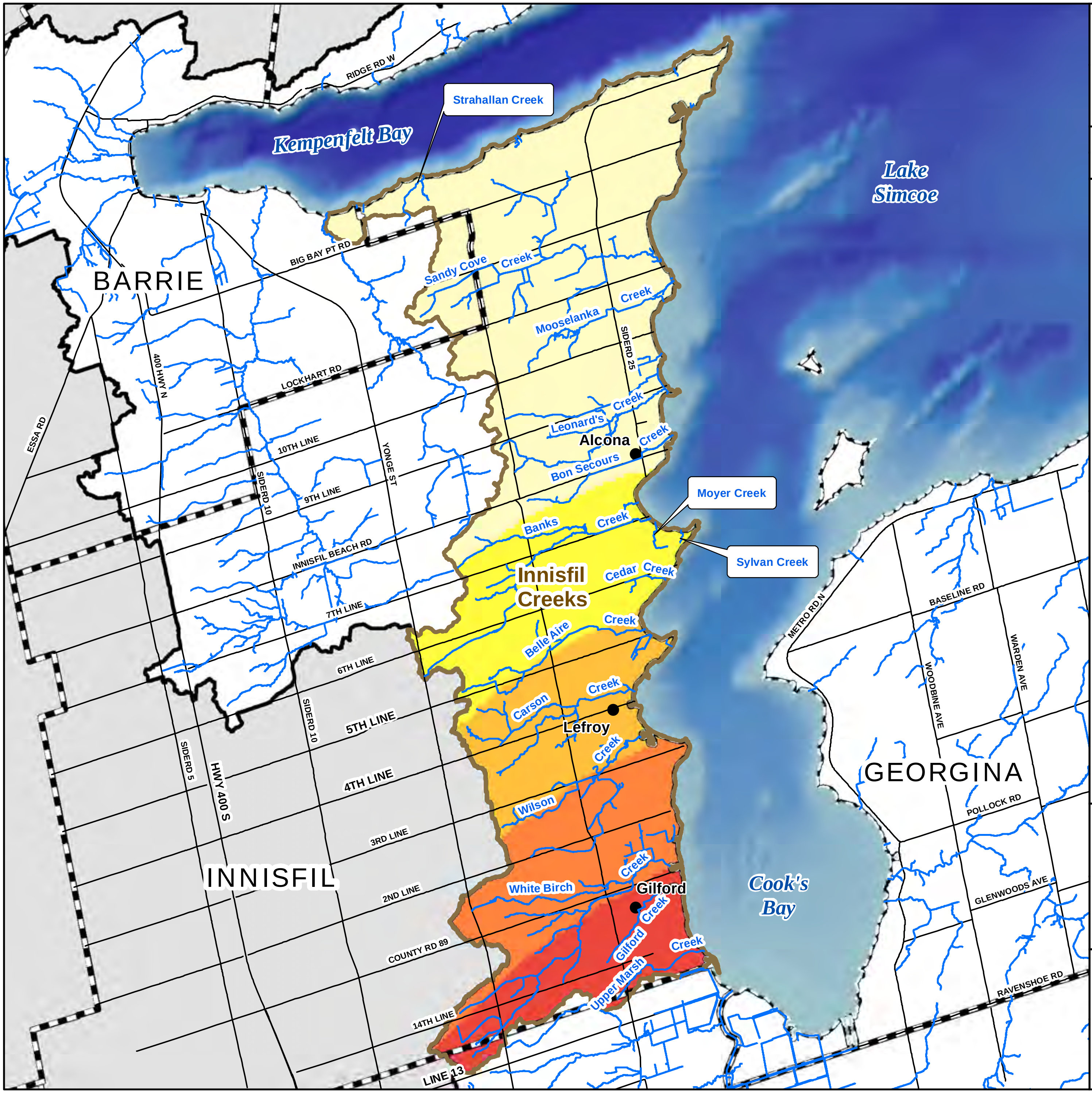
Precipitation is the driving force of the hydrological cycle, influencing aquatic and wetland habitats, as well as urban storm water management needs.

Figure 2-24 illustrates the spatial distribution of annual precipitation over the study area as averaged over the study period and interpolated by the PRMS model (this model is described in **Chapter 4 – Water Quantity**). These data also show that annual average precipitation is fairly uniform across the three subwatersheds.

The mean monthly precipitation measured at Barrie WPCC from 1971-2000 is shown in Figure 2-25 and shows the amount that fell as rain and the amount that fell as snow in each month. Figure 2-26 illustrates the total annual precipitation from 1950 to 2008. Fluctuations in the amount of precipitation, particularly winter precipitation, are somewhat expected at the Barrie WPCC meteorological station due to its close proximity to Lake Simcoe, causing lake effect precipitation events. Overall, there is no significant change in annual precipitation over the past 60 years, but a possible tendency to increasing precipitation since the 1980s.

Annual Precipitation (mm/yr) in the Innisfil Creeks subwatershed as distributed by PRMS

Figure 2-24



Legend

- Road
- Municipal Boundary
- Watercourse
- Innisfil Creeks Subwatershed
- ▲ Stream Gauges

Observed Annual Average Precipitation (mm/yr)

- 🟥 970 - 972
- 🟧 973 - 974
- 🟧 975 - 976
- 🟨 977 - 978
- ▨ 979 - 980

Lake Simcoe Region conservation authority

0 0.5 1 2 3 4 5 Kilometres

N

LSRCA GIS Services DRAFT TF created November 2011.

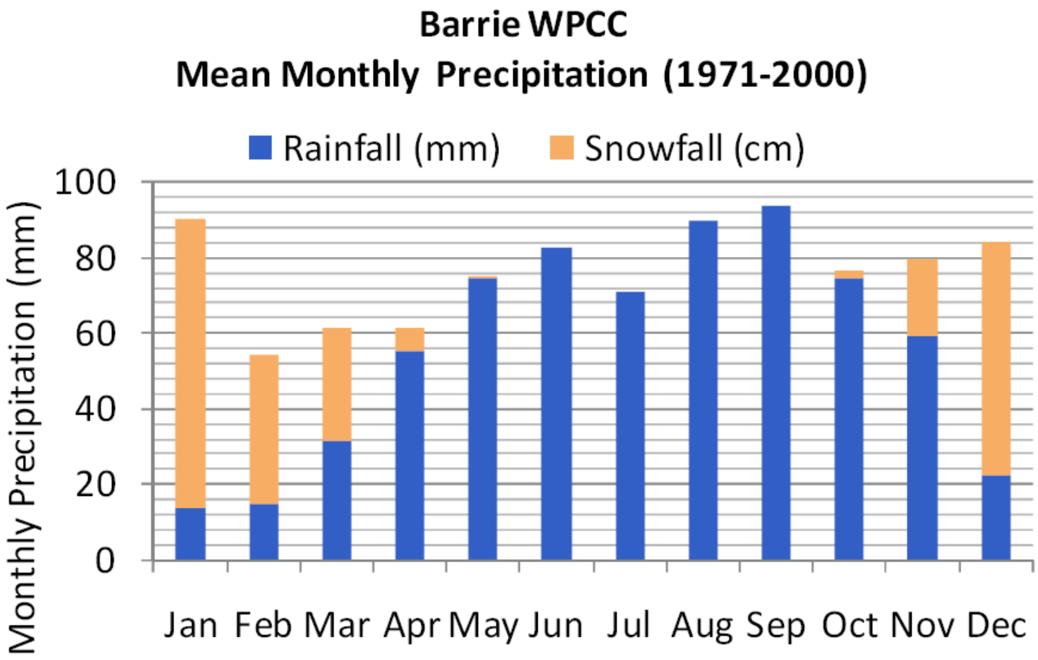


Figure 2-25: Mean monthly precipitation as snowfall and rainfall for Barrie WPCC station (AquaResource *et al*., 2011).

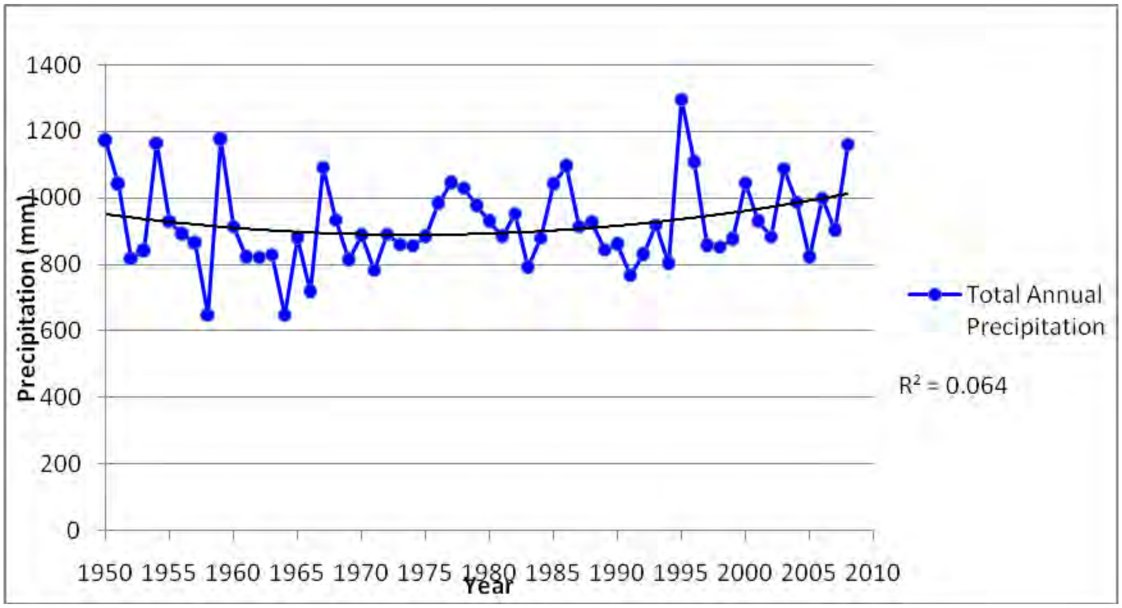


Figure 2-26: Total annual precipitation at the Barrie WPCC Meteorological Monitoring Station (1950 - 2008). Source: SGBLS, 2012.

2.6.1.3. Thermal Stability of Lake Simcoe

The thermal stability of the lake is important as it can have significant impacts on the biological communities within the lake, which in turn can impact the lives of those who rely on the lake as a resource. The thermal stability of the lake refers to the amount of energy needed for a water column to mix completely, overcoming the vertical density differences of thermal stratification. In a system where there is low stability, the lake completely mixes, whereas in a system where there is high stability there is little to no mixing (remains stratified). In Lake Simcoe, which is a dimictic lake, the water column is thermally stratified during the ice-free season, and mixes in the spring and fall. Most winters, it completely freezes over.

To determine if the thermal stability of Lake Simcoe was changing in relation to mean air temperatures (collected at Environment Canada's weather station at Shanty Bay), Stainsby *et al.* (2011) compared the water column stability of the lake at three locations (main basin, Kempenfelt Bay, and Cook's Bay), and the timing of stratification in the spring and turnover in the fall occurred over an approximate 30 year time period (1980-2008). As the Innisfil Creeks subwatershed has section of waterfront along parts of each of these areas, results for all three are included.

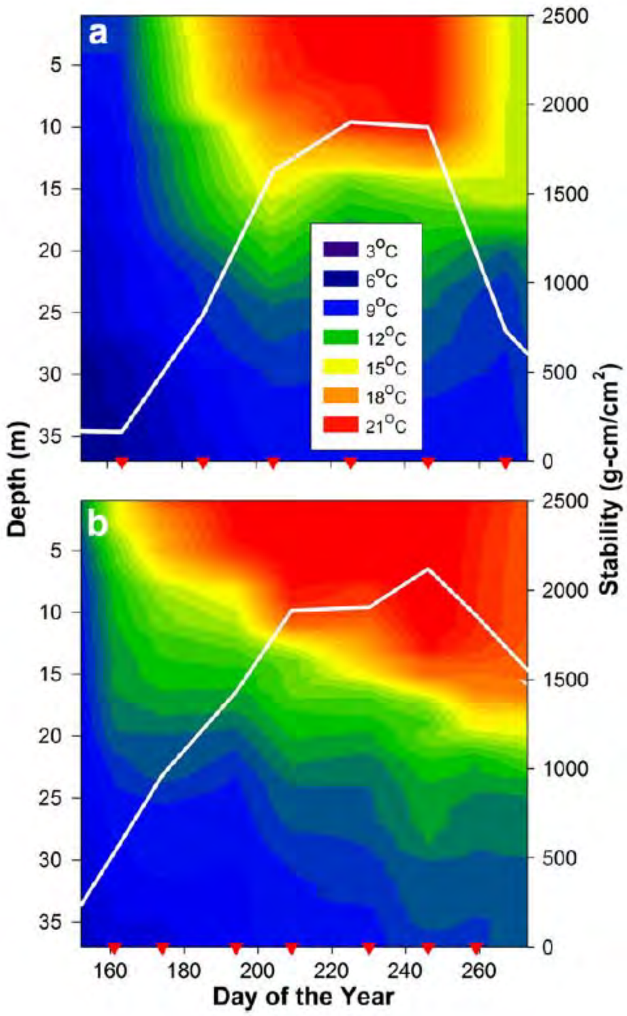


Figure 2-27: Seasonal water column temperature contour in degrees Celsius) and stability (white line) in Kempenfelt Bay in 1980 (a) and 2002 (b). Red triangles show the sampling dates along the x-axis. Source: Stainsby *et al.*, 2011.

Out of the three sampling areas, Kempenfelt Bay generally has higher thermal stability due to its deeper depths (max 42 m; mean 26 m), whereas Cook's Bay tends to have lower thermal stability because of its shallower depths (max 21 m; mean 8 m) and consequently smaller volume of water that needs to mix or stratify (Stainsby *et al.*, 2011).

The first parameter studied was the temperature of Kempenfelt Bay during the ice-free period of the year. Figure 2-27 illustrates the temperature changes in Kempenfelt Bay from 1980 (a) and 2002 (b) as well as the stability of the lake. From it we can see that, in comparison to the 1980 graph, in 2002 there is a high degree of red (warmer temperatures during the ice-free season) and wider contours (the lake begins to stratify earlier in the year and mixes later in the fall, increasing the overall time the lake remains stratified), all of which correspond with the recorded higher lake stability (white line) (Stainsby *et al.*, 2011).

To further support these findings, Figure

2-28 illustrates the timing of the onset of stratification in the Kempenfelt Bay (Figure 2-24a), the main basin (Figure 2-28b), and Cook's Bay (Figure 2-28c). It can be seen from the data that the lake is stratifying earlier in the year. As of 2002, stratification is occurring approximately 20 days earlier in Kempenfelt Bay (Figure 2-28a) than it was in 1980. In the main basin stratification is occurring approximately 13 days earlier (Figure 2-34b), while in Cook's Bay, stratification is occurring approximately 25 days earlier (Figure 2-28c).

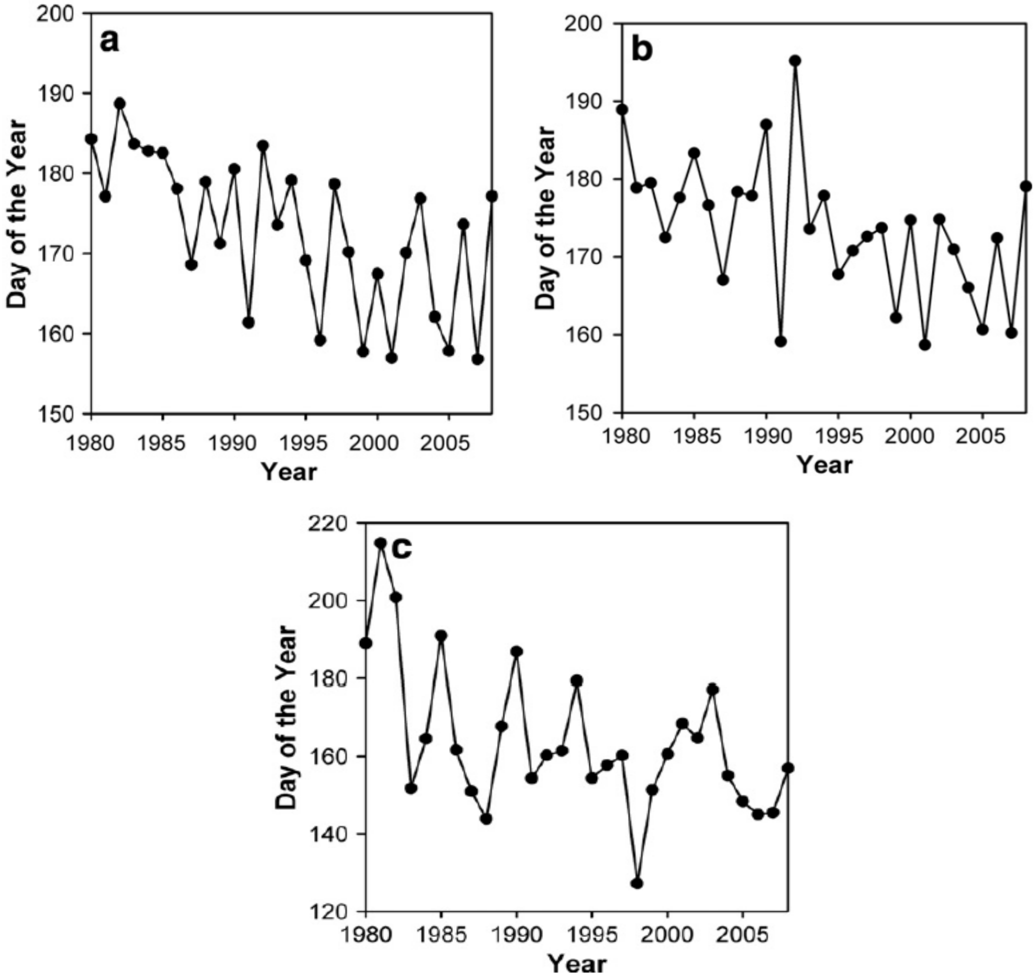


Figure 2-28: The timing of the onset of stratification in (a) Kempenfelt Bay, (b) the main basin, and (c) Cook's Bay. Source: Stainsby *et al.*, 2011.

When looking at the fall turnover, Figure 2-29 shows it to be occurring later and later each year for the different sections of the lake. Between 1980 and 2002, mixing of the water column in the fall is occurring approximately 15 days later in Kempenfelt Bay (Figure 2-29a). In the main basin of Lake Simcoe, fall turnover is occurring 18 days later (Figure 2-29b) and approximately 24 days later in Cook's Bay (Figure 2-29c).

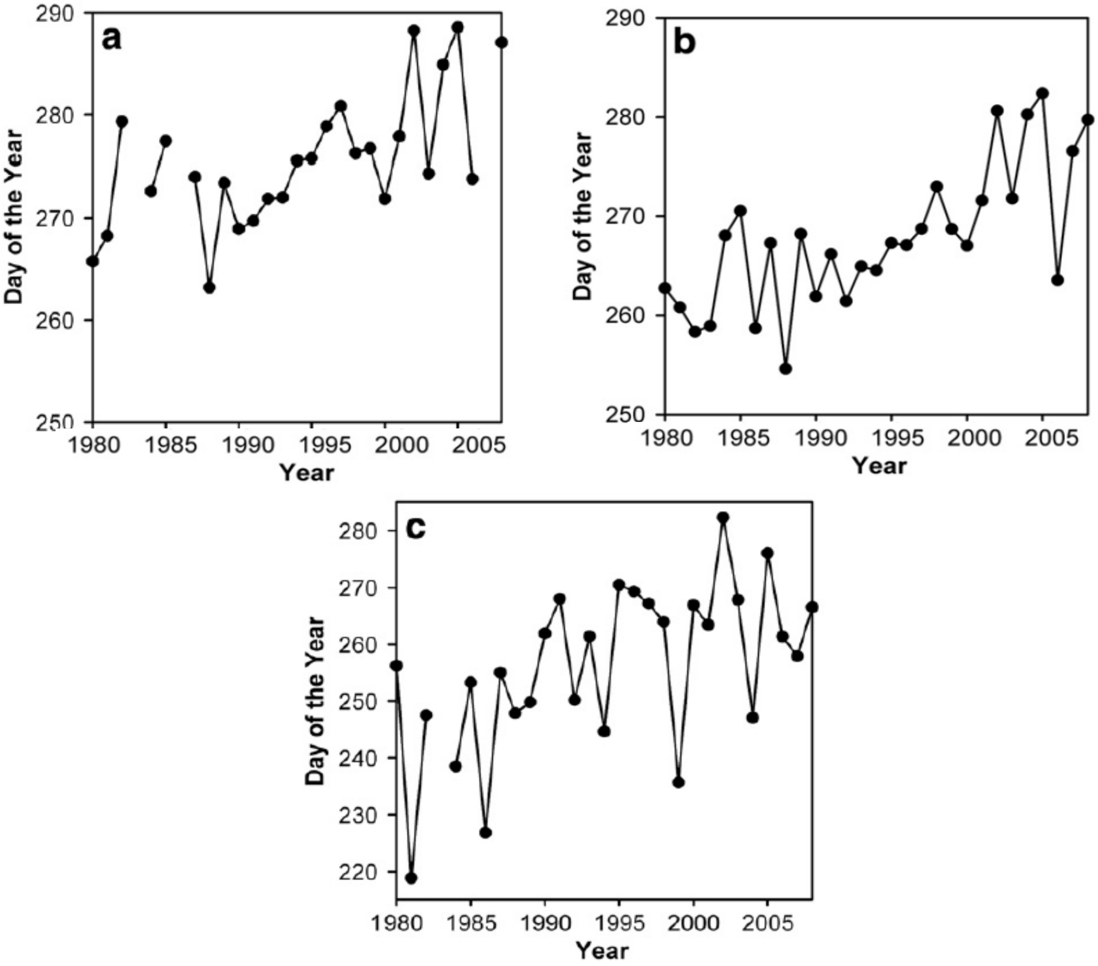


Figure 2-29: The timing of fall turnover in (a) Kempenfelt Bay, (b) the main basin, and (c) Cook's Bay. Source: Stainsby *et al.*, 2011.

Together this means that the lake remains stratified for a longer period of time. A longer stratified period can result in an increase in oxygen depletion in the hypolimnion, which in the deeper zones may create "dead zone" areas where conditions are anoxic. These conditions can also potentially increase the release of nutrients (such as phosphorus) and contaminants from sediments. The impacts of this can include large fish die-offs, decrease in the fisheries, algal blooms (which, when dead and decomposing at the bottom further decrease oxygen levels) and can deteriorate drinking water (Kling, *et al*. 2003).

The length of the stratification period in Kempenfelt Bay and in the main basin has increased approximately 33 days from 1980 to 2008 (Figure 2-30 a and b). In comparison, the changes in the length of time the water column remains stratified were most significant in Cook's Bay where the water column remains stratified 56 days longer (Figure 2-30c).

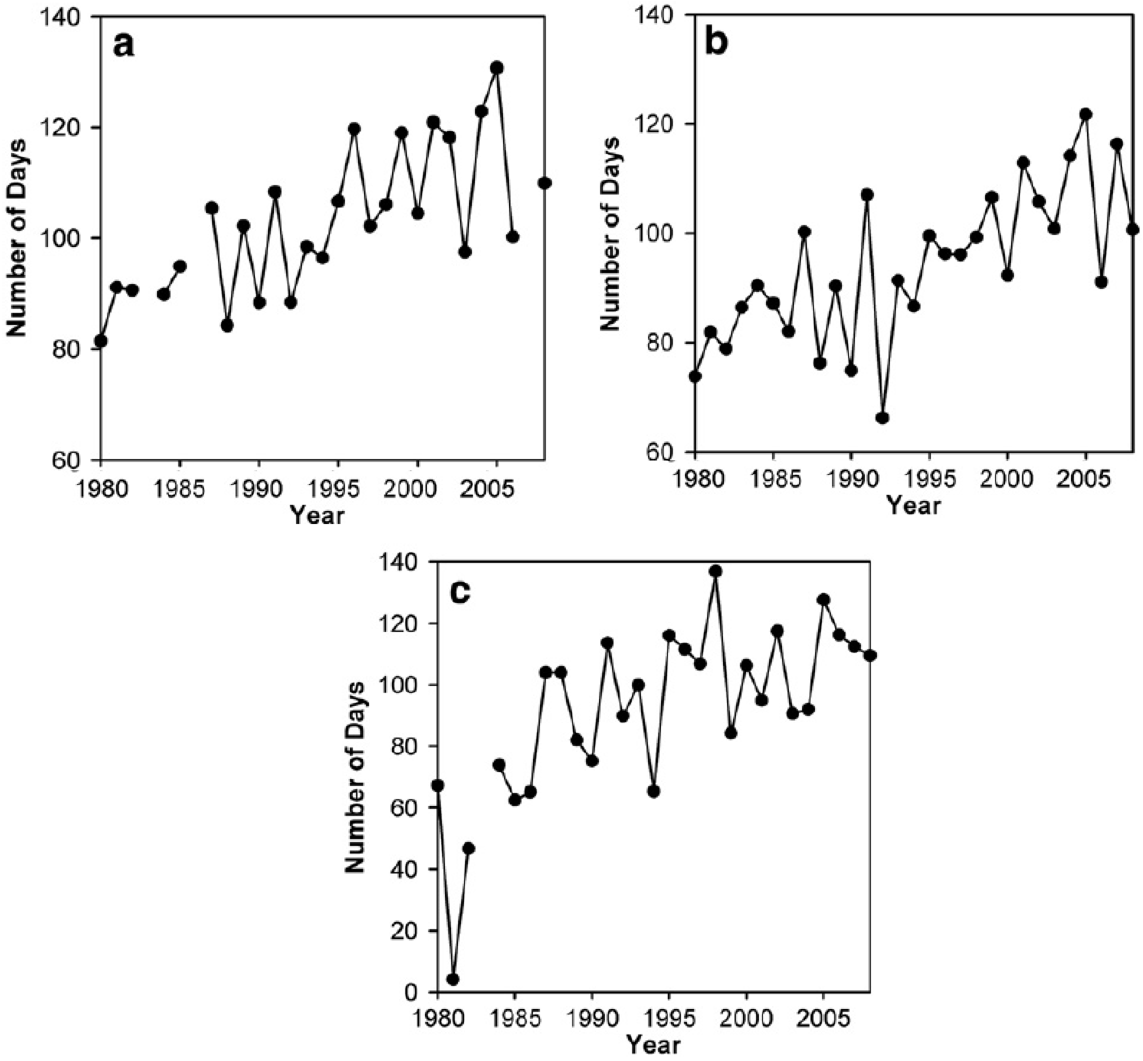


Figure 2-30: The length of the stratified period in (a) Kempenfelt Bay, (b) the main basin, and (c) Cook's Bay. Source: Stainsby *et al.*, 2011.

Many of the impacts already being observed in the Lake Simcoe watershed counteract much of the work the LSRCA and partner municipalities have done to increase dissolved oxygen concentrations and decrease phosphorus levels in Lake Simcoe. To ensure that the efforts taken are successful, despite the impacts of climate change, projects undertaken on tributaries, particularly those that are managed as coldwater need to focus on reducing the temperature and the amount of phosphorus input. This can include an increase in riparian habitat, improved stormwater management, and improvement of construction practices and agricultural practices. Additionally, municipalities are encouraged to include climate change adaptation policies in the Official Plans, to plan for the future and implement pre-emptive measures.

2.6.2 Climate change and predicted scenarios

Climate change can have numerous impacts on ecological systems and those who depend on them. As mentioned in the previous section, an increase in air temperature can increase the thermal stability of the lake, extending the stratified period, as well as changing the composition of biological communities and creating ideal growing conditions for algae and bacteria. An increase in temperature can also cause an increase in evaporation and evapotranspiration, decreasing the amount of water infiltrating into the ground and recharging the groundwater system. Changes in precipitation patterns will also impact the hydrologic cycle, whether these changes show less or more precipitation. Where less precipitation is falling, habitats will experience drought, and be susceptible to fires (terrestrial) and reduction in area (watercourses and wetlands), and less water will be available replenish aquifers. Where more precipitation falls, it is likely that flows will be altered (potentially changing the stream morphology), stormwater retention areas may overflow (releasing contaminants), and there is an increased risk of flooding and property damage. Further impacts of climate change can be found in the following chapters, where applicable, in the stressors section. An important part of addressing these stressors is to gain an understanding of what the changes will be in the future and act accordingly to minimize the impacts. Climate models, used worldwide, give us an estimate of what these possible changes are.

To obtain more accurate projections for parameters such as seasonal and annual temperature and precipitation, an ensemble of climate models are typically run together. The report "Adapting to Climate Change in Ontario: Towards the Design and Implementation of a Strategy and Action Plan" was released by the Expert Panel on Climate Change in November 2009 (EPCCA, 2009). The study included a review of climate change model projections for Ontario, completed by Environment Canada (CCCSN, 2009). The projections were based on a combination of 24 models and divides Ontario into 63 grid cells, one of which covers the Lake Simcoe watershed. Three scenarios were produced based on future amount of greenhouse gas (GHG) emissions (Low, Medium and High).

Table 2-9 lists the projected change in average annual and seasonal temperatures, comparing 1961-1990 to the 2050s. From it we can see under high GHG emissions there is a projected increase in temperature of 3% for the area. All seasons are expected to see at least a 2.2% temperature increase; however the most significant increase is seen during the winter, where there is a projected increase of 2.5 -3.4% based on Low to High GHG emissions.

Table 2-9: Summary of projected change in average annual temperature (°C) in the 2050s compared with 1961-1990 (CCCSN, 2009).

	Projected change in air temperature (°C)		
	GHG emmision scenario		
Season	**Low**	**Medium**	**High**
Annual	2.3	2.7	3.0
Winter	2.5	3.0	3.4
Spring	2.2	2.5	2.8
Summer	2.2	2.6	2.9
Autumn	2.3	2.6	2.8

Table 2-10 lists the projected change in average annual and seasonal temperatures, comparing 1961-1990 to 2050s.Under the high GHG emission scenario, annual precipitation is projected to increase by 5.51%. All seasons are expected to increase by at least 3.06%, with the exception of summer precipitation. As the amount of GHG emissions increase, there is only a slight increase predicted for the Low and Medium emission scenarios, and a decrease in the amount of precipitation of -0.62% under High GHG emission scenario.

Table 2-10: Summary of projected change in precipitation (%) in 2050s compared with 1961-1990 (CCCSN, 2009).

	Projected change in precipitation (%)		
	GHG emmision scenario		
Season	**Low**	**Medium**	**High**
Annual	5.15	5.45	5.51
Winter	9.38	10.19	10.76
Spring	8.58	9.1	9.65
Summer	0.92	0.11	-0.62
Autumn	3.06	3.79	3.82

Despite the use of a combination of multiple models, it is important to note that there is still a very high level of uncertainty associated with the projections. As scientists continue to understand the smaller interactions (i.e. what role clouds play in climate change) and are able to integrate them into the models, this uncertainty will decrease.

2 Study Area: The Innisfil Creeks subwatershed

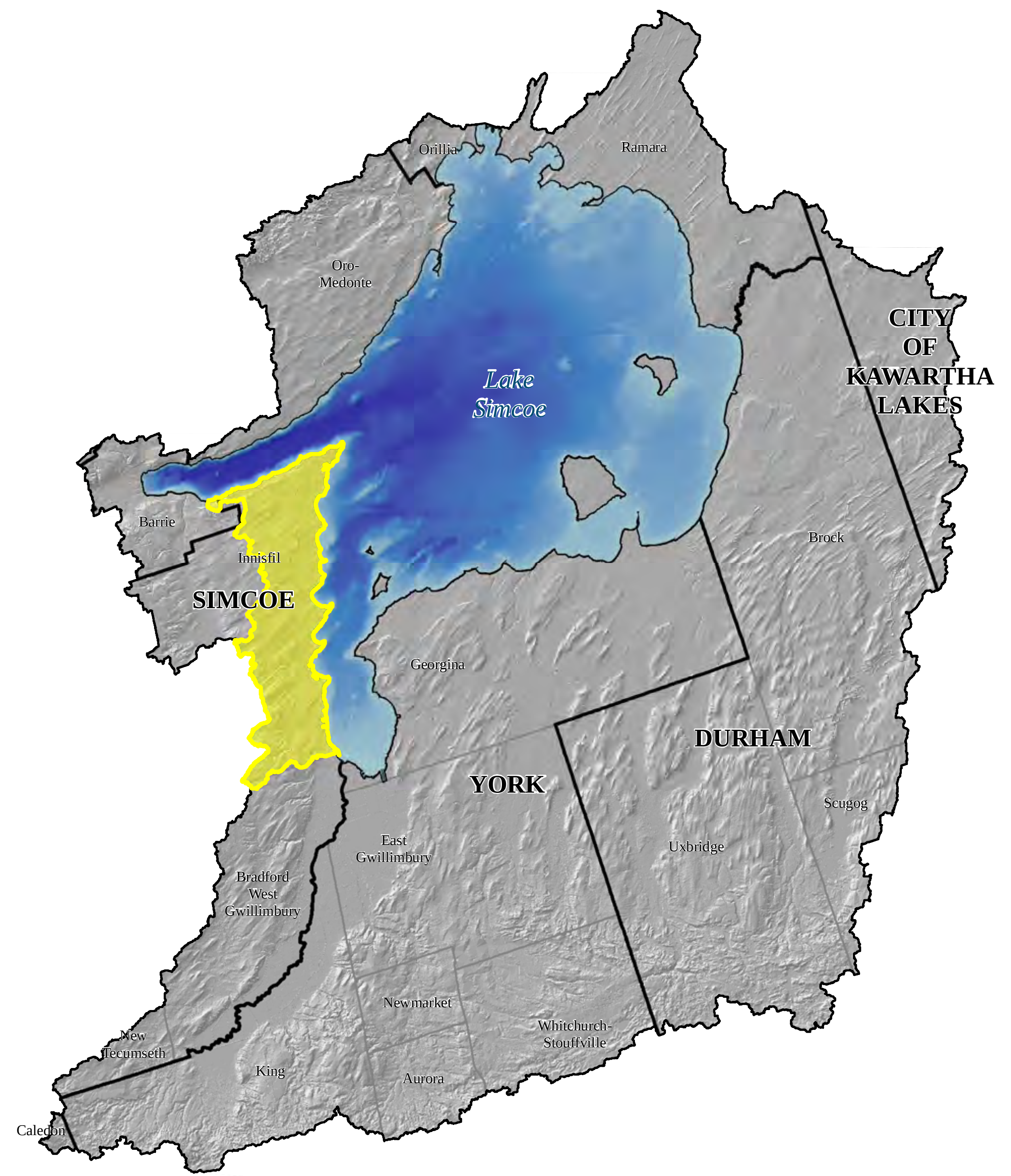
2.1 Location

All of the lands within the Lake Simcoe watershed ultimately drain into Lake Simcoe, via one of the tributary rivers. The Innisfil Creeks subwatershed is one of 18 subwatersheds that drain into Lake Simcoe. The subwatershed's southern streams empty into Cook's Bay, the northern ones empty into the main basin, and one drains into Kempenfelt Bay (Figure 2-1).

The Innisfil Creeks subwatershed is located almost entirely within the Town of Innisfil, with a small portion falling into the City of Barrie (3.3%). Within the subwatershed boundaries there are 15 named streams, as well as a few small creeks, draining separately into Lake Simcoe. As previously mentioned in **Chapter 1 - Introduction**, all of the streams have headwaters in agricultural areas and flow from west to east, through urban areas, before entering Lake Simcoe. The exception is Strathallan Creek, which flows north into Kempenfelt Bay. The Innisfil Creeks subwatershed is not as densely populated as some of its neighbouring subwatersheds, and has a total area of approximately 107.2 km^2 with a total watercourse length of 149 km (including all branches), or about 3.5% of the total combined watercourse length of the entire Lake Simcoe watershed.

Location of the Innisfil Creeks subwatershed

Figure 1-1



Legend

▨ LSRCA Watershed
🟨 Innisfil Creeks Subwatershed
☐ Lower Tier Boundary
☐ Upper Tier Boundary

Lake Simcoe Region conservation authority

0 1 2 4 6 8 10
Kilometres

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2.2 Human Geography

2.2.1 Population and Municipal Boundaries

Because the subwatershed boundaries and the municipal boundaries are not the same, the subwatersheds contain residents from multiple municipalities. Innisfil Creeks is located mostly within the Town of Innisfil, with a small portion in the City of Barrie and even less the Town of Bradford-West Gwillimbury.

Population within the Town of Innisfil expanded from an estimated 31,175 residents in the 2006 census to 33,061 in the 2011 census, resulting in an increase of 6.1% over the 5 year period. This population is a not a very mobile one, with only 10% having changed their address between the 2001 and 2006 census, suggesting that people may have deeper roots here and a longer term investment in their community. The median age of those living in the Town of Innisfil is 40.3, slightly above the provincial average, and a median income of $29,888, above both the City of Barrie and the provincial average (Stats Canada, 2006). The projected population for the Town of Innisfil is 56,000 by 2031 (Growth Plan for the Greater Golden Horseshoe, 2006, Office Consolidation January 2012). This is a 70% increase over a 20 year period

The population of City of Barrie during the 2006 census was estimated to be 128,430. This rose to 135,711 during the 2011 census, representing a 5.7 % population increase over a five year period. While this is a large population, it is also a very mobile one with an estimated 54% having changed addresses between the 2001 and 2006 census, possibly indicating that residents may have a short term view of their community. The median age of those living in the City of Barrie is 35.4, almost four years younger than the provincial median of 39 years, and the median income for 2005 was $28,785, above the provincial median income of $27,258 (Stats Canada, 2006). The projected population for the City of Barrie is 210,000 by 2031 (Growth Plan for the Greater Golden Horseshoe, 2006, Office Consolidation January 2012). This is a 55% increase from the 2011 population of approximately 135,711 (Stats Canada, 2011).

Municipal population from each municipality and total population density for each of the subwatersheds is presented on the following page in Table 2-1.

Table 2-1: Estimated population and population density within the Innisfil Creeks subwatershed (Data Source: Stats Canada, 2006 Community Profiles)

Subwatershed	Subwatershed Area (km^2)	Municipality	Total Municipal Population (2011)	Estimated Municipal Population (2011) within subwatershed	Estimated Total subwatershed population (2011)	Estimated Population Density (persons/km^2)
Innisfil Creeks	107.15	Town of Innisfil	33,079	25,876	27,049	252
		City of Barrie	135,711	1,144		
		Town of Bradford-West Gwillimbury	28,077	29		

The level of education attained by a person can influence both their career choice and income level. Table 2-2 lists the percentage of the Town of Innisfil and City of Barrie populations, 15 years and over, and their education attainment compared to that of the provincial standings.

Table 2-2: Educational attainment for the Town of Innisfil and City of Barrie (Stats Canada, 2006).

	Town of Innisfil	City of Barrie	Province of Ontario
No certificate; diploma or degree	27%	22%	22%
High school certificate or equivalent	29%	29%	27%
Apprenticeship or trades certificate or diploma	13%	9%	8%
College; CEGEP or other non-university certificate or diploma	20%	24%	18%
University certificate or diploma below the bachelor level	3%	3%	4%
University certificate; diploma or degree	9%	13%	20%

As of January 1, 2010 the City of Barrie's southern border extended to include 2,293 hectares of land from the Town of Innisfil to accommodate the City's projected growth. With the removal of these annexed lands, approximately 500 residents that were in the Town of Innisfil are now located within the City of Barrie.

2.2.2 Land Use

Land use within the Innisfil Creeks subwatershed has been divided up into 12 classes including intensive and non-intensive agriculture, rural development, urban areas, and natural heritage features (Figure 2-2). Land uses with 0% coverage in a subwatershed were not reported.

Land use in the Innisfil Creeks subwatershed is currently dominated by agriculture (45%) and natural heritage cover (33%). Urban areas account for 15% of the subwatershed land use, including commercial, estate residential, institutional, and other various land uses. Other land uses occupying smaller areas include commercial (0.3%), industrial (0.3%), aggregate (0.5%), institutional (0.5%), and manicured open space (0.5%).

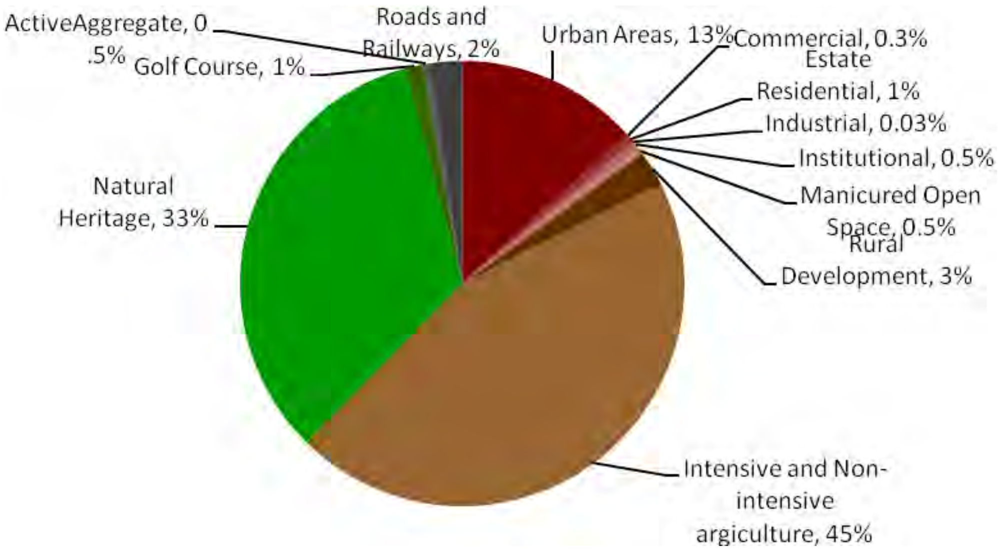
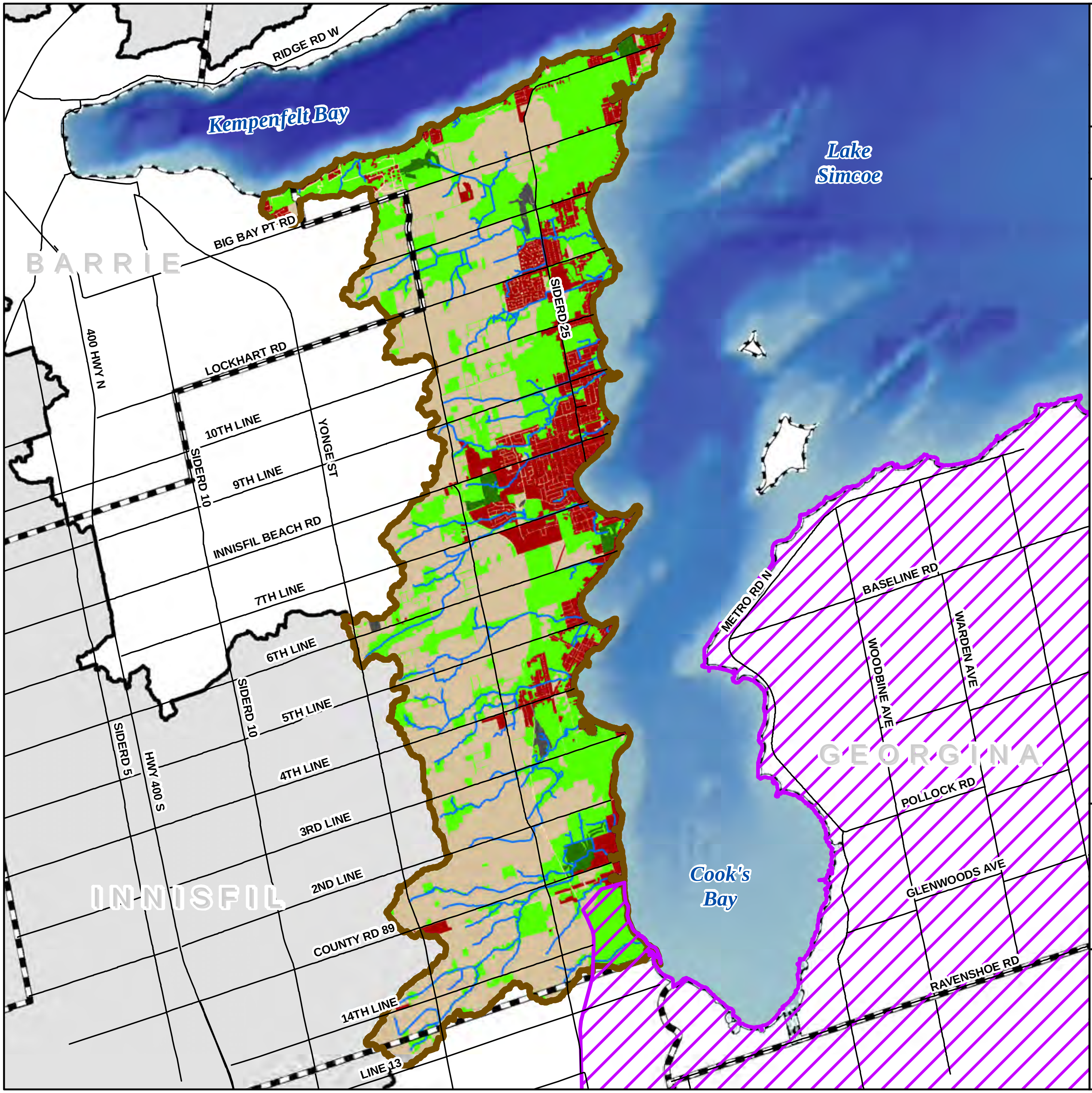


Figure 2-2: Land use distribution within the Innisfil Creeks subwatershed.

The distributions of land uses within the Innisfil Creeks subwatershed can be seen in Figure 2-3.

Land uses in the Innisfil Creeks subwatershed

Figure 2-3



Legend

- Road
- Municipal Boundary
- Watercourse
- Greenbelt (Protected Country Side)

Land Use

- 🟥 Urban
- Rural
- 🟩 Natural Heritage
- Golf Course
- Aggregate

Lake Simcoe Region conservation authority

0 0.5 1 2 3 4 5
Kilometres

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To see how the Innisfil Creeks subwatershed compares to the other subwatersheds within the Lake Simcoe watershed, Figure 2-4 to Figure 2-6 illustrate all 18 of the Lake Simcoe subwatersheds from the subwatershed with the highest percentage of urban, natural heritage and rural land uses to the subwatershed with the lowest percentage. The Innisfil Creeks subwatershed is outlined in black.

For urban land use (Figure 2-4), the Innisfil Creeks has the sixth highest percentage (15%). The subwatershed with the highest percentage is the Barrie Creeks subwatershed in the western part of the watershed with 63%, while the Whites Creek subwatershed in the eastern part of the watershed has the lowest (1%).

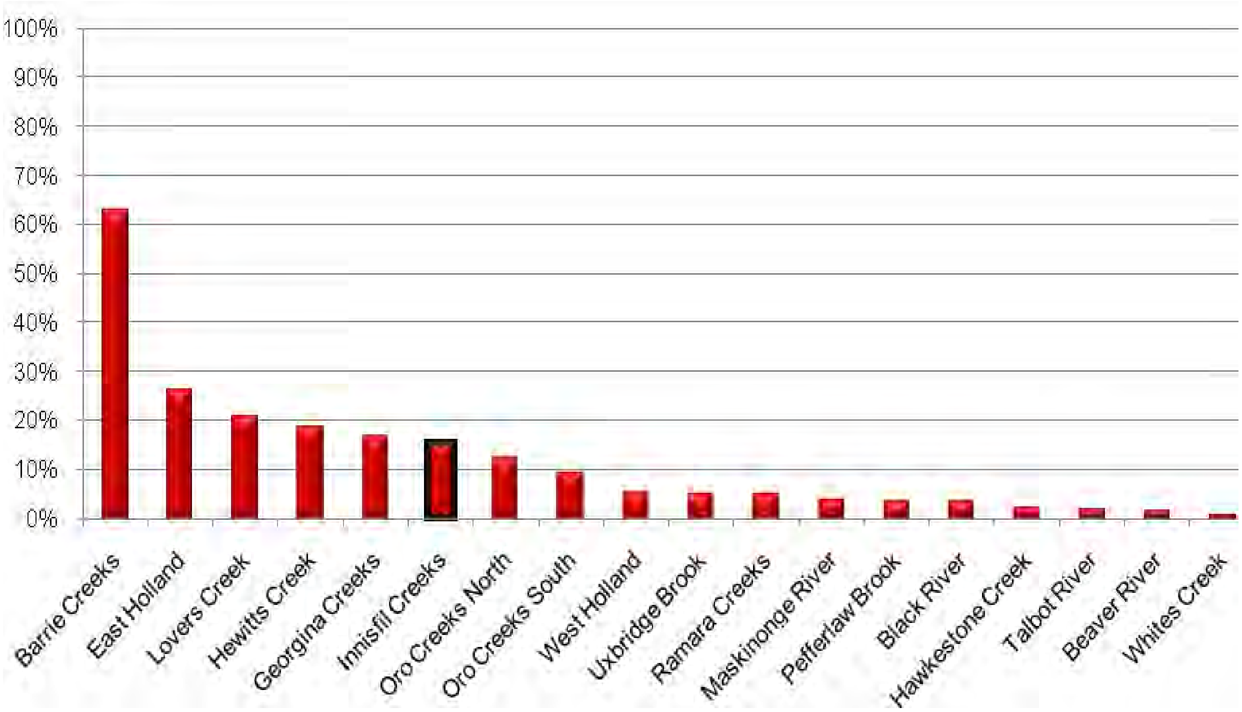

Figure 2-4: Urban land use in the Lake Simcoe subwatersheds.

The subwatershed with the highest percentage of natural heritage land cover is Hawkestone Creek (57%) in the north-west of the watershed, while the Barrie Creeks subwatershed in the west has the lowest percentage (17%). The Innisfil Creeks subwatershed has the seventh lowest percentage with 33% (Figure 2-5).

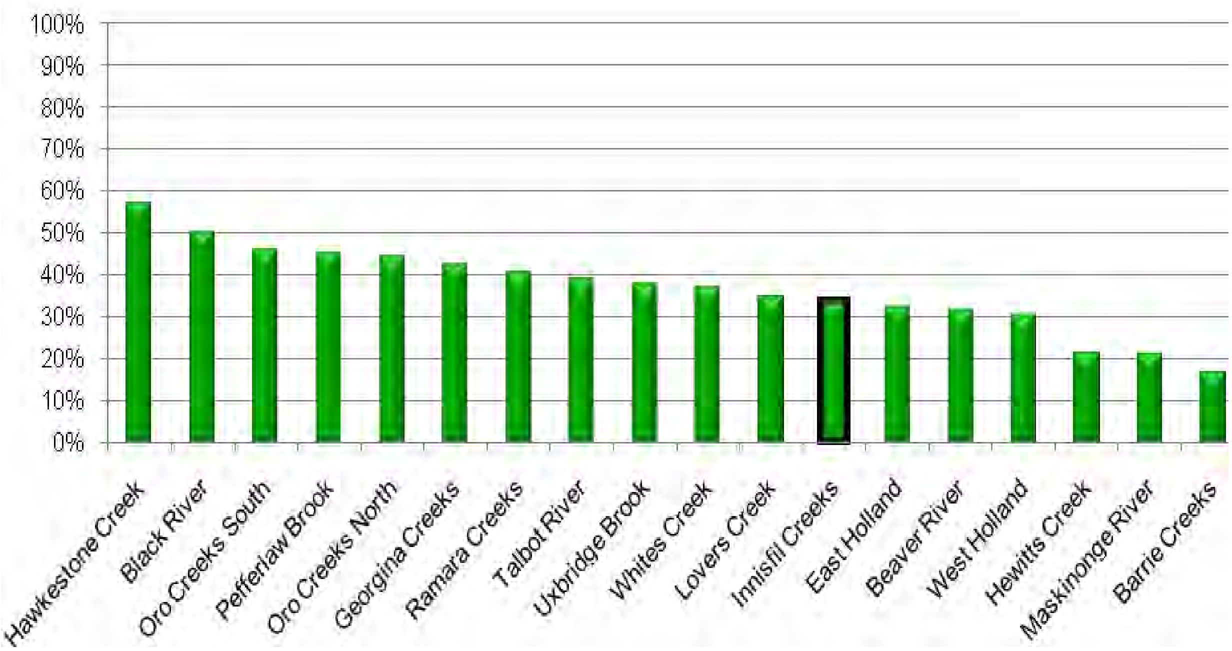

Figure 2-5: Natural heritage land cover in the Lake Simcoe subwatersheds.

Figure 2-6 illustrates the rural land use in the Lake Simcoe subwatersheds. The Maskinonge River subwatershed in the southern part of the watershed has the highest percentage with 73%, while the Barrie Creeks subwatershed in the west has the lowest (4%) percentage of rural landuse, with a large percentage gap between it and of the second lowest subwatershed (East Holland) which has 34%. The Innisfil Creeks subwatershed is in the middle with 48%.

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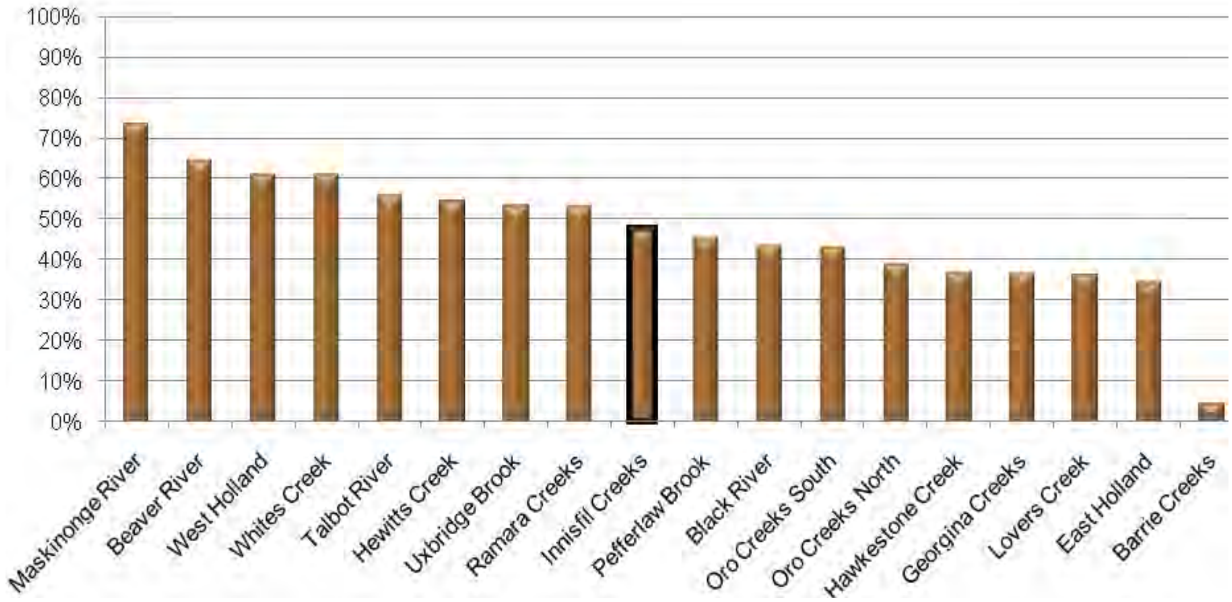

Figure 2-6: Rural land use in the Lake Simcoe subwatersheds.

2.2.2.1. Impervious Surfaces

Impervious surfaces refer to hardened surfaces, such as roads, parking lots, and rooftops, which are made of (or covered in) a material impenetrable by water (i.e. asphalt, concrete, brick, rock, etc)[1]. As this reduces the amount of water infiltrating down into the groundwater supplies and increases surface runoff, the hydrologic properties or drainage characteristics of the area are significantly altered.

An increase in impervious surfaces, generally associated with urban growth, can impact the surrounding environment in a number of ways. These impacts include: decreases in evapotranspiration as there is little vegetation and the permeable soil is paved over; decreases in groundwater recharge; increases in frequency and intensity of surface runoff, leading to an increase in flow velocities and energy (which can alter the morphology of the stream through channel widening, under cutting of banks, sedimentation, and braiding of the stream); thermal degradation of the watercourses; decreases in water quality as pollutants are washed off streets into storm drains or ditches which discharge to watercourses or the lake; and impairment of aquatic communities (which can be negatively affected by all impacts listed above).

Environment Canada's Areas of Concern (AOC) Guidelines (2004) suggest a lower limit of 10% imperviousness, where subwatersheds should still be able to maintain surface water quality and quantity, and preserve aquatic species density and biodiversity. The AOC Guidelines further recommend an upper limit of 30% as a threshold for degraded systems that have already exceeded the 10% impervious guidelines. The Innisfil Creeks subwatershed is above the 10% guideline, but is below the upper limit threshold with approximately 21% impervious surface. As this subwatershed hasn't reached the 30% threshold, there is still room through mitigative action and careful development practices to reduce or at least maintain this number to assist in maintaining water quality. Figure 2-7 illustrates the impervious cover within the subwatershed.

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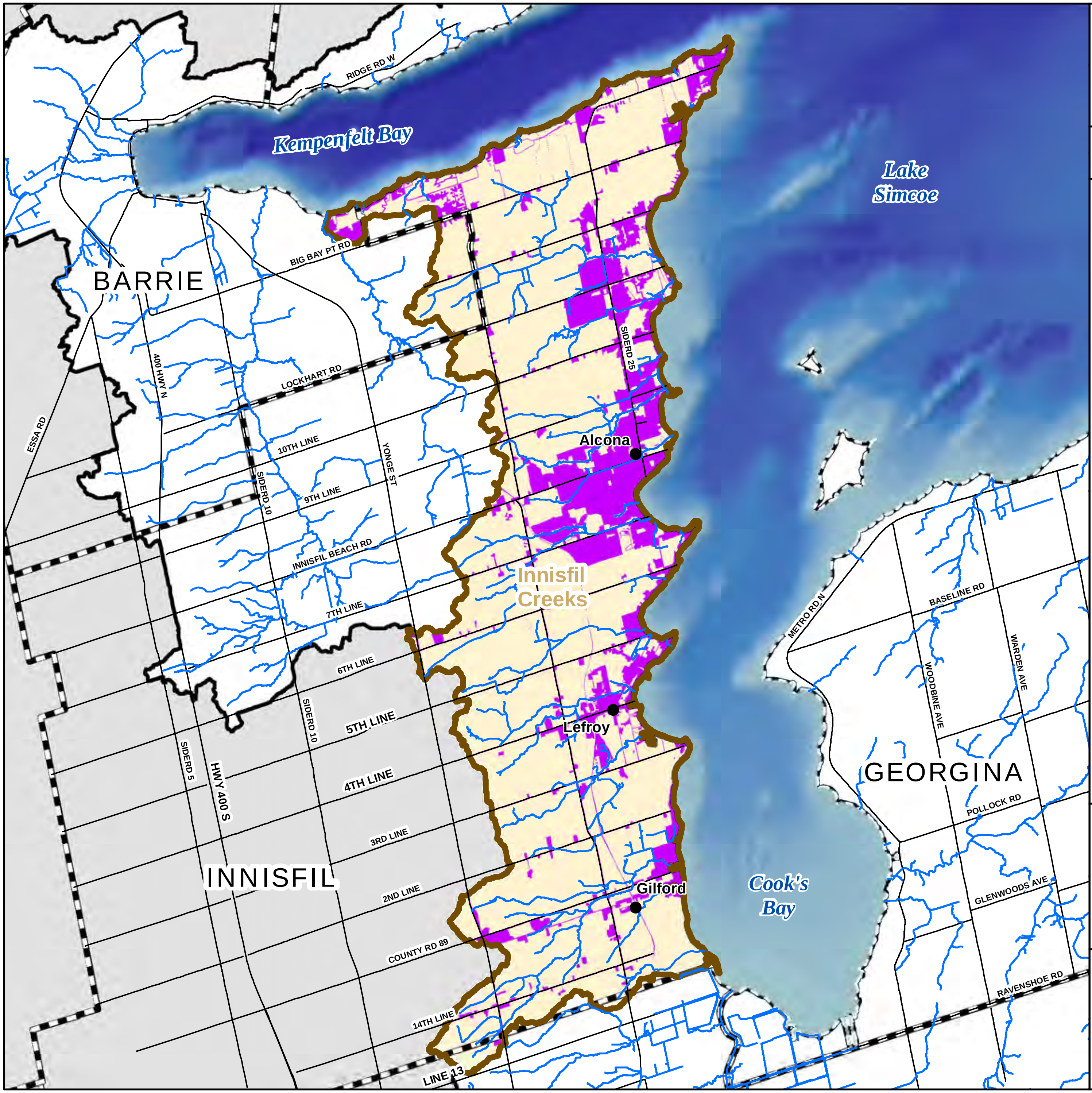
[1] For the majority of this report, impervious surfaces do not include features such as wetlands. These are sometimes considered impervious in hydrogeological models, such as those presented in **Chapter 4 – Water Quantity**.



Impervious cover in the Innisfil Creeks subwatershed

Figure 2-7

Legend

- Road
- Municipal Boundary
- Watercourse
- Subwatershed
- Impervious Area

(includes Active aggregates,Commercial, Inactive Aggregates, Estate Residential, Road, Rail, Rural Developmetn, and Urban)

Lake Simcoe Region conservation authority

0 0.5 1 2 3 4 5 Kilometres

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2.2.2.2. Settlement Areas

For the most part, the built up, urban areas in the Town of Innisfil tend to be in communities along the shoreline, while the majority of the town remains rural, unlike the City of Barrie which continues to be one of the major urban areas within the Lake Simcoe watershed. Compared to past population projections, the Lake Simcoe watershed population continues to grow faster than originally anticipated (LSEMS, 1995). Urban development activities have subsequently increased to keep pace with this population growth. Construction of new dwellings was essential to meet the demands of the rising populations within the urban centres, and between the 2001 and 2006 census, there was an increase of approximately 840 private dwellings in the Town of Innisfil. In the City of Barrie there was an increase of approximately 10,000 private dwellings (Statistics Canada, 2006). Settlement areas are shown in Figure 2-8.

Even with a growing population, there are still a large number of residents who work outside their municipality, county, and even province and Canada. Many of the people who work in large cities cannot afford to live within them, so they commute from smaller towns that have a more affordable cost of living. These small towns/communities are known as ‘bedroom communities’. Typically bedroom communities are located in rural or semi-rural areas, surrounded by green space, and are in close proximity to a major highway that leads to the larger cities. The Town of Innisfil is a good example of this, with only 14% of the total employed labour force working in the municipality. The City of Barrie could also be considered a bedroom community for some of the larger cities, such as the City of Toronto, but as its economy grows it is slowly becoming a focal urban centre itself. Within the City of Barrie, approximately half of the population works within the City (49%) and the other half works outside it (51%) (Table 2-3).

Table 2-3: Place of work status in the Town of Innisfil and City of Barrie (Data Source: Statistics Canada, 2006).

Place of Work Status	Town of Innisfil		City of Barrie	
	Population	**Pop. Percentage (%)**	**Population**	**Pop. Percentage (%)**
Worked at home	1,045	6	4,080	6
Worked outside Canada	60	0.4	240	0.4
No fixed workplace address	2,470	15	7,520	11
Worked in census (municipality) of residence	2,195	14	33,315	49
Worked in different census subdivision (municipality) within the census division (county) of residence	4,635	29	9,770	14
Worked in different census division (county)	5,700	35	12,660	19
Worked in different province	40	0.2	120	0.2
Total employed labour force	**16,145**	**100**	**67,705**	**100**

The economy of the bedroom communities tends to focus around real estate, general retail, and services that are oriented to serving residents. Industrial and technological industries are not a main focus and offer fewer employment opportunities. This is evident in the Town of Innisfil where the industries that saw the largest growth between the 2001 and 2006 census were finance and real estate (24.8%), health, social and educational services (28.8%), and agriculture and other resource-based industries (31.2%). The industries with the lowest growth included construction and manufacturing (5.4%), while business services saw a 0.7% decrease (Table 2-4). Even though there is an increase in various industries, a reason that many people choose to live in the Town of Innisfil, whilst working outside it, is the opportunity to enjoy the large amount of waterfront along the eastern and northern borders of the town. There is still a large influx of residents who own or rent cottages during the summer months, but many people who work in the city are moving to more natural areas and converting seasonal properties to permanent residences. This brings business to the area and increases the demands for services.

The City of Barrie, with more residents working within the municipality, saw an increase in all industries with the largest in agriculture and other resource-based industries (82.8%). Most of the other industries saw an increase of at least 25%, with the smallest increase being in construction and manufacturing (18.9%) and wholesale and retail trade (20.4%).

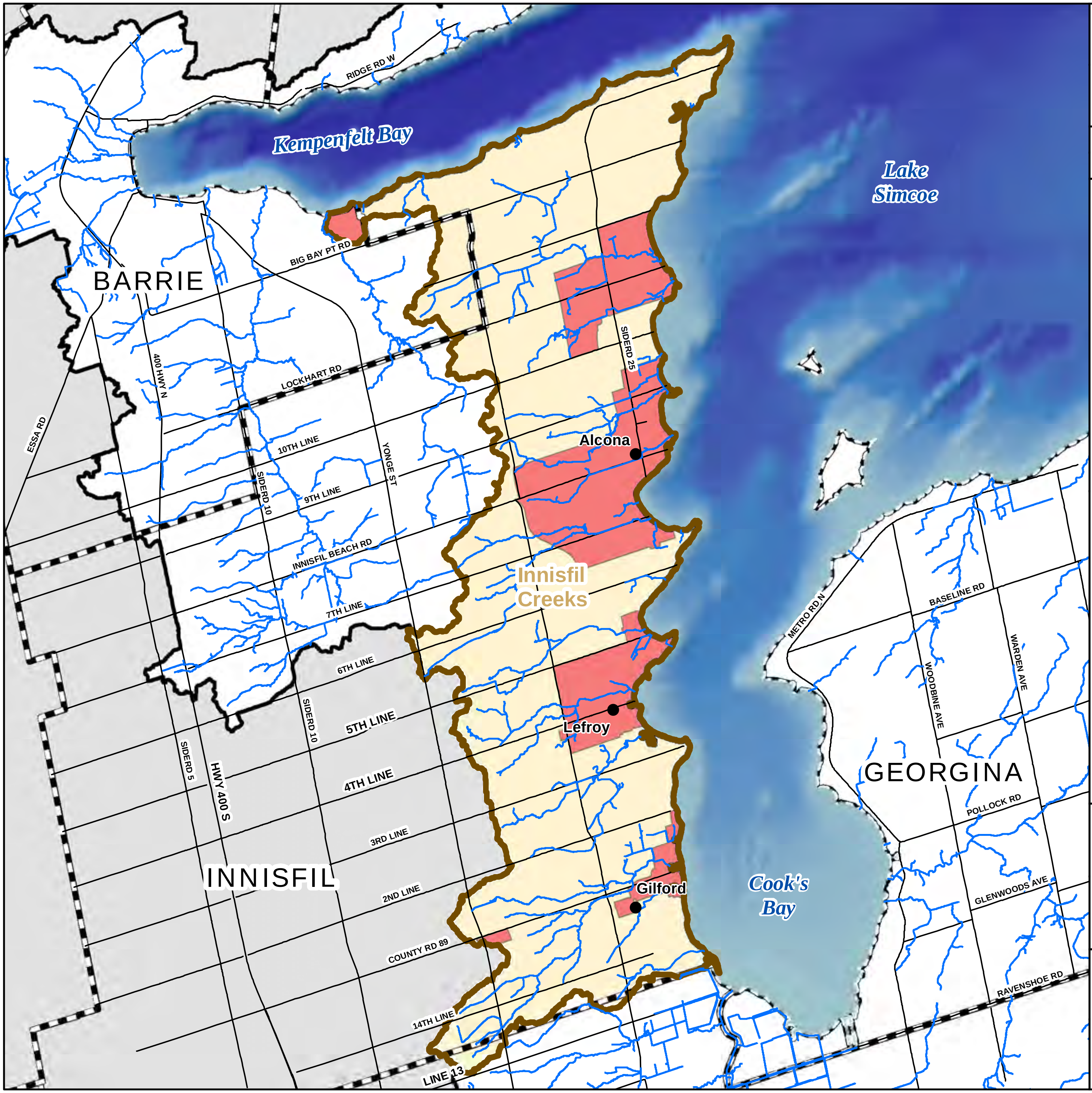
Table 2-4: Changes in industry in the Town of Innisfil and City of Barrie (Data Source: Statistics Canada, 2001 and 2006).

Industry	Town of Innisfil			City of Barrie		
	Innisfil 2001 census	**Innisfil 2006 census**	**% change**	**Barrie 2001 census**	**Barrie 2006 census**	**% change**
Agriculture and other resource-based industries	385	505	31.2	495	905	82.8
Construction	4320	1735	5.4	13,150	5,315	18.9
Manufacturing		2820			10,315	
Wholesale trade	2685	1100	13.4	11,095	3,705	20.4
Retail trade		1945			9,655	
Finance and real estate	630	785	24.8	2,840	3,610	27.1
Health care and social services	1510	1130	28.8	8,125	6,555	38.9
Educational services		815			4,735	
Business services	2880	2860	-0.7	9,610	12,030	25.2
Other services	2575	3180	23.5	10,575	14,320	35.4
Total Experienced work force	**14,980**	**16,880**	**12.7**	**55,885**	**71,140**	**27.3**

* Red font indicates a decrease

Settlement areas in the Innisfil Creeks subwatershed.

Figure 2-8



Legend

Road

Municipal Boundary

Watercourse

Settlement

Innisfil Creeks Subwatershed

Lake Simcoe Region conservation authority

0 0.5 1 2 3 4 5 Kilometres

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2.3 Human Health and Well-being

One of the major reasons for understanding and managing watersheds and their function is to protect the health and well-being of watershed residents. Figure 2-9 illustrates the watershed governance prism (Parkes *et al.*, 2010) and the four different aspects of watershed governance including "watersheds", "ecosystems", "health and well-being" and "social systems". The combination of all of the aspects of watershed management gives a comprehensive view of the way watershed governance can link the determinants of health and well-being to watershed management.

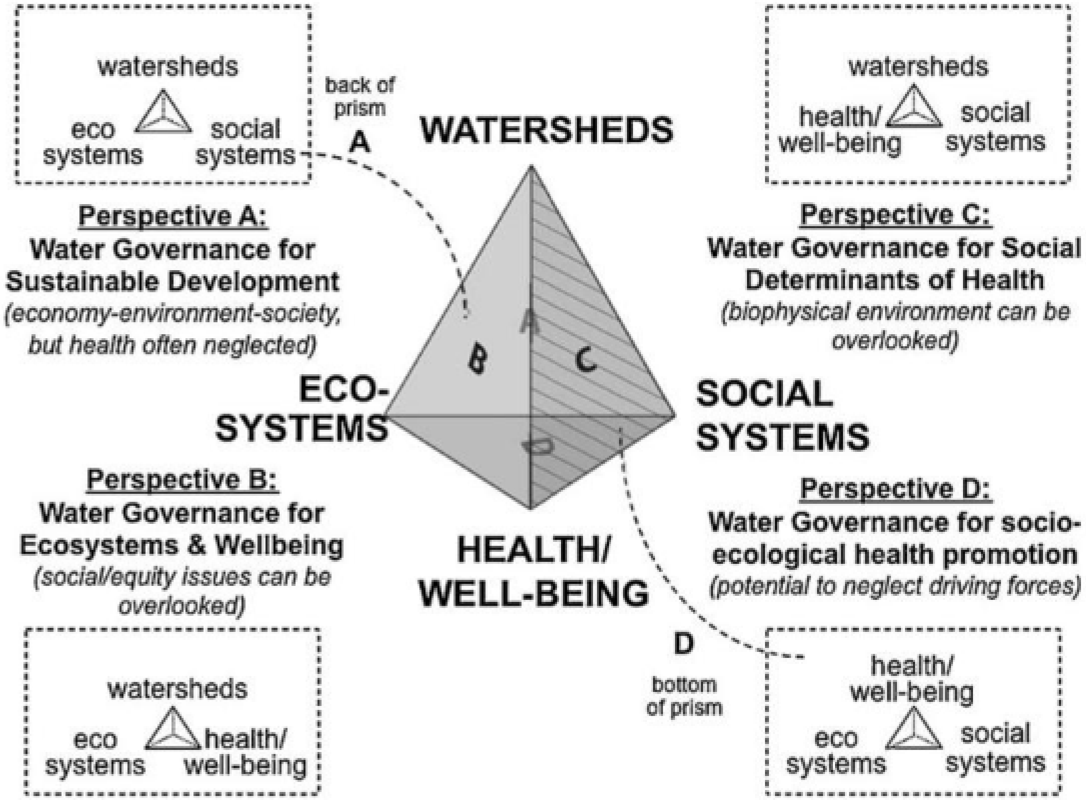

Figure 2-9: Watershed governance prism (Parkes *et al.,* 2010).

The management of the Lake Simcoe watershed includes a number of these perspectives, incorporating issues related to human health and well-being, protection of wildlife habitats, and ensuring the preservation of water quality and water quantity.

The following sections highlight the link the between the Lake Simcoe watershed and the related health benefits for residents of the watershed.

2.3.1 Outdoor Recreation and Human Health

Within an urban setting, green spaces (including parks, conservation areas, forests, wetlands, streams, and lake shore) are at a premium. Even within a more rural setting, these features are sometimes taken for granted when, in fact, they are an essential part of a healthy community.

2.3.1.1. Physical

Whether it's an open soccer field, running/walking trails through forests, or sandy beaches along the lake front, the green spaces within this subwatershed provide a number of outdoor recreational opportunities for residents and visiting tourists. The different types of areas available offer a variety of physical activities that would not be available at a local gym and come at little to no cost. Parks and sports field provide areas for recreational or pick up games of soccer, football, or frisbee. Trails are areas to walk, run, or bike. Parks and conservation areas with forests and wetlands provide a range of recreational and aesthetic opportunities and the nearby lake shore and waterways offer residents a place to swim, canoe, kayak, and fish. It is these types of areas that encourage the physical stimulation of individuals and families as a whole, creating a healthier lifestyle for people of all ages.

By encouraging children to be active outdoors at a young age, a number of health-related issues can be minimized or avoided all together. These include:

- Childhood Obesity: In Canada, approximately 26% of children ages 2-17 are currently overweight or obese (Childhood Obesity Foundation). Obesity can also lead to a number of other diseases including Type-2 diabetes, hypertension, asthma, and cardiovascular disease (NEEF).
- Vitamin D Deficiency: The most common diseases resulting from a lack of Vitamin D include rickets (children) and osteoporosis later in life (NEEF).
- Myopia: One study found that 12 years olds who spent less time doing near-work activities (reading, drawing, etc) and more time doing outdoor activities were two to three times less likely to develop myopia than those who spent the majority of their time doing near-work activities (Rose *et al.,* 2008).

Within the Innisfil Creek subwatershed there are a number of parks and recreational opportunities available including baseball diamonds, soccer pitches, swimming areas, play structures, and walking trails. A full list of parks and trails is available at http://www.town.innisfil.on.ca/Parks-and-Trails.

The Town of Innisfil also has the Luck Conservation Area within its municipal boundaries (and within the Innisfil Creeks subwatershed boundaries). This is a 20 ha natural area with forest, streams and ponds, as well as being home to the Gilford Arboretum, managed by the Gilford and District Horticultural Society. The society provides a network of walking trails, as well as interesting specimen trees and plants.

2.3.1.2. Mental

In addition to physical health benefits, there are a number of mental health benefits associated with natural areas. These areas, free of technology and the "jolts per minute" of contemporary life, allow people to take in their surroundings, and benefit from the serene and calming environment. Those who like to explore natural areas are mentally engaged to interact with the surrounding flora and fauna and associate these visual 'pictures' with other senses, such as touch, smell, and sound. Studies have also shown the effects of nature on the social interactions, emotional status, and cognitive growth of children. Many young children have grown up watching television, playing on computers or with video games with very little 'play-time' (unstructured, spontaneous activity) in their daily routine. Burdette and Whitaker (2005) suggest that through playing outdoors, a child's social interactions, emotional status, and their cognitive growth are improved. In an unstructured, non-monotonous environment they will come across different situations that encourage them to problem solve, interact, and communicate with others and learn from the different experiences they are exposed to. Studies also show interactions with nature have positive impacts on those with attention-deficit/hyperactivity disorder (ADHD). Something as simple as a 20 minute walk through park was found to increase concentration and elicit a positive emotional response (Faber and Kuo, 2008).

It should also be noted that many individuals also have an important spiritual connection to the environment.

2.3.1.3. Community Engagement and Cohesiveness

The more people recognize the benefits that the green spaces in their city or town have on their well-being, the more they will work to maintain and protect these areas. Green spaces can bring a community together to perform maintenance and restoration work, create fun and interactive environments, boost tourism (and in turn the local economy), and are places for community events, camps or public forums. By putting effort into caring for the green spaces and enjoying the benefits they gain from them, people form an attachment to these areas, as well as their community as a whole.

2.3.1.4. Economic Benefits

While the previous section highlighted the social and health benefits of urban natural areas, studies have also shown the monetary benefits of having tree lined streets and urban natural areas.

For example, the presence of mature trees in residential areas can increase the sale prices of neighbouring properties by 2-15% (Wolf, 2007; Donovan and Butry, 2009), and decrease the amount of time such properties are on the market (Donovan and Butry, 2009). The presence of larger natural areas nearby can increase property values by up to 32% (Wolf, 2007). Even during the initial development process, retaining mature trees on residential lots can increase their sale value by up to 7% (Theriault *et al*., 2002).

In addition to increasing property values, natural areas in or near residential neighbourhoods can act as a draw for white-collar workers working in high paying, creative jobs, who prefer to live in an urban setting that encourages their 'creativity', through a stimulating, diverse, cultural setting with easily accessible natural amenities for a healthy lifestyle. As a result, the preservation of urban green space can attract new businesses with highly paid staff, and strengthen the local economy (Florida, 2002).

Commercial sectors can also benefit from an increase in urban tree cover. Studies have shown that shoppers tend to spend more time, and make more purchases, in downtown commercial and retail districts that have more trees, creating income both for the city and for store owners (Wolf, 2005).

2.3.2 Drinking Water Source Protection

A major threat to human health is the degradation and depletion of freshwater resources. Degradation of water quality can either be anthropogenic or natural in nature. Humans can impact their water through:

- Poor sanitation habits (crude solid waste disposal methods, improper filtration methods of waste water and drinking water);
- Removal of riparian buffers, allowing unfiltered run off from streets, lawns, and agricultural fields to go directly into waterways;
- Improper storage of chemicals that can spill in to surface water or leach into the ground to reach the deeper groundwater resources;
- Warming of water temperatures (creates ideal temperatures for bacteria) by connecting runoff systems to watercourses or creation of standing bodies of water that link to the watercourse.

Climate change can also impact water quality through changes in air temperature, precipitation, and extreme events by:

- Releasing contaminants: extreme events and increases in precipitation may damage buildings/containers holding contaminants, cause the overflow of retention areas holding contaminants, and/or wash surface contaminants into watercourses;
- Transporting contaminants: extreme events can transport contaminants greater distances, potentially increasing the exposure to them;
- Creating warmer environments: surface waters become more hospitable to pathogens and other waterborne disease.

Poor water quality, either because of anthropogenic or natural conditions, can lead to an increase in water-borne diseases, loss of fisheries, contaminated food sources, and closures of beaches due to high levels of the bacteria *E. coli*. Residents can be directly impacted through sickness, increases in food costs (uncontaminated), or loss/decrease in income (loss of fisheries, farms with unusable, contaminated produce).

Depletion of available water is another major health concern. Low water quantity can result in water restrictions that lead to lower agricultural produce yields, increasing the cost of food. Less water available to residents also means that there is less water available to natural environments, leading to a loss of habitat.

In 2006, the provincial government made a commitment to the citizens of Ontario by passing the *Clean Water Act* (CWA). The CWA introduced a new level of protection – Source Water Protection - for the Province's drinking water resources that will help communities across Ontario enjoy a safe and plentiful supply of clean drinking water for generations to come. Drinking Water Source Protection is the first step in a multi-barrier approach to protecting our sources of drinking water. It identifies possible threats to drinking water, assesses the risks of those threats, mitigates them and plans ahead to prevent contamination before it gets into the water supply. It is a responsible and effective way of ensuring safe, clean drinking water and avoiding serious health issues.

2.3.2.1. Drinking Water Systems and their Vulnerable Areas

The South Georgian Bay-Lake Simcoe (SGBLS) Source Protection Region (SPR) is one of 19 in Ontario. It contains three Source Protection Areas (Lakes Simcoe and Couchiching-Black River, Nottawasaga Valley, and Severn Sound) that are composed of four watersheds: Lake Simcoe[2], Black-Severn River, Nottawasaga Valley, and Severn Sound watersheds.

One of the key documents of the Source Protection program that has been completed for each of the Source Protection Areas (and the watersheds within their borders) is the Assessment Report. The SGBLS Source Protection Committee released three Assessment Reports in November 2011 that provides the following information for each area:

- Characterization of the Source Protection Area watershed: this includes descriptions of the natural and human geography;
- A Conceptual water budget for the entire Source Protection Area and a Tier 1 water budget for each subwatershed: those systems identified as having water quantity stress in the Tier 1 water budget progress to a more detailed Tier 2 water budget and Tier 3 if needed;
- Broad scale assessment of Regional Groundwater Vulnerability: this aspect of the Assessment Report requires that both Highly Vulnerable Aquifers (HVA) and Significant Groundwater Recharge Areas (SGRAs) be identified; and
- Drinking water system assessment: for each drinking water system within the Terms of Reference, the Vulnerability of the supply wells or surface water intakes is assessed and any potentially Significant Threats to the water quality are identified.

Within the whole SGBLS SPR there are 108 drinking water systems, with 31 in the Lake Simcoe watershed. There are three systems in the Innisfil Creeks subwatershed. Two of these are groundwater supply systems (the Golf Haven and Goldcrest Well Supplies), while the other is a surface water intake (Alcona Water Treatment Plant). Even though a large portion of the Barrie Water Treatment Plant Intake Protection Zone (IPZ) is located along the northern shore of the subwatershed, the IPZ-2 stretches down within the Lovers Creek subwatershed and has therefore been accounted for in the Barrie Subwatershed Plan.

Each of the drinking water systems in the Innisfil Creeks subwatershed have had their vulnerable areas delineated. These vulnerable areas that are directly associated with drinking water systems are referred to as Wellhead Protection Areas (WHPAs) for groundwater systems and Intake Protection Zones (IPZs) for surface water intakes:

- A WHPA is the area around a wellhead where land use activities have the greatest potential to affect the quality of water that flows into the well. Each WHPA is subdivided into four time-of-travel zones that estimate the amount of time it would take a contaminant to reach the municipal well
    - WHPA-A: 100 m radius.
    - WHPA-B: 2 year time of travel (tot) capture zone
    - WHPA-C: 5 year tot capture zone
    - WHPA-C1: 10 year tot capture zone (for WHPAs delineated before April 2005).

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[2] Information for the Innisfil Creeks subwatershed can be found in the Approved Lakes Simcoe and Couchiching-Black River Source Protection Area Assessment Report, Part 1: Lake Simcoe. Chapter 10 of this Assessment Report is specific to the Town of Innisfil.

    - WHPA-D: 25-year tot capture zone
- Similarly, an IPZ is the area around a surface water intake and includes three time-of-travel zones.
    - IPZ-1: 1000 m radius
    - IPZ-2: 2 hour time of travel
    - IPZ-3: Area within the surface water body through which contaminants released during an extreme event could be transported to the intake. For the intakes associated with these (and Innisfil Creeks) subwatersheds this includes the entire Lake Simcoe watershed.

Two additional vulnerable areas that were also delineated in the Assessment Reports are Significant Groundwater Recharge Areas (SGRAs) and Highly Vulnerable Aquifers (HVAs). These vulnerable areas do not pertain directly to any particular drinking water system, but instead are on a regional (landscape) scale:

- SGRAs are areas where water enters an aquifer (underground reservoirs from which we draw our water) through the ground. Recharge areas are significant when they supply more water to an aquifer than the land around it. Significant Recharge Areas are an important area on the landscape for ensuring a sufficient amount of water enters an aquifer. For example, paving over an SGRA would prevent water from getting into the ground to recharge an aquifer, potentially decreasing the amount of water available.
- HVAs are those areas where an aquifer may be more prone to contamination. These areas have been identified where there is little or no protection from an overlying aquitard (a protective layer of low permeability materials). Generally, the faster water is able to flow through the ground to an aquifer, the more vulnerable the area is to contamination. For example, a fuel spill would get into an aquifer much more quickly where a HVA has been identified than where one has not.

Further information on these two regional scale Vulnerable Areas can be found in the SGBLS SPR Assessment Reports.

Both the Town of Innisfil and City of Barrie have groundwater and surface water being used to supply drinking water to their residents. With over 156,700 people (combined) relying on these water supplies as a source of safe drinking water it stresses the importance of maintaining and/or improving the quality (and quantity) of these supplies. When initiating, contributing, and/or participating in restoration efforts along streams draining into Lake Simcoe, or on the lake itself, it benefits not only the local wildlife and natural habitats, but also all those who depend on the watershed and lake as a source of safe drinking water.

For the Assessment Report, studies were done to assess the vulnerability, issues, and threats for each of the Wellhead Protection Areas and Intake Protection Zones. All three of the systems within the Innisfil Creeks subwatershed are located within the Town of Innisfil and consist of the Alcona Water Treatment Plant, Golf Haven Well Supply, and Goldcrest Well Supply.

The Alcona Water Treatment Plant is a surface water intake located on the eastern shore of the subwatershed at the inlet to Cook's Bay. This system had a total of five significant drinking water threats identified in association with one land parcel. The significant threats identified are all associated with the municipal sewage treatment plant within the IPZ-1 (SGBLS-SPC, 2011).

The Golf Haven Well Supply has two wells located in the south east area of the Innisfil Creeks subwatershed. A total of 21 significant drinking water threats were identified in association with

20 land parcels. These significant threats were mainly related to individual sewage systems (SGBLS-SPC, 2011).

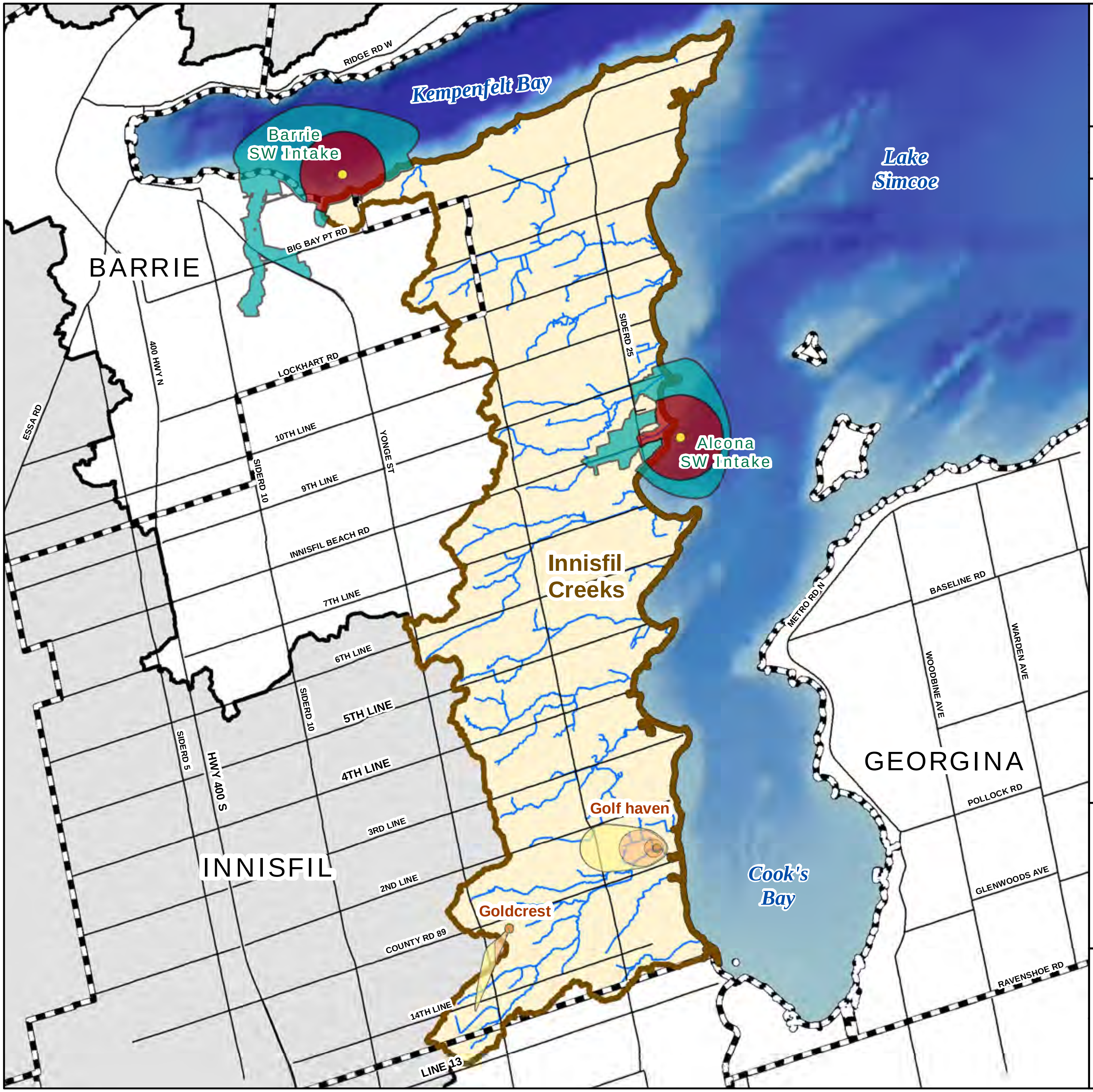
Finally, the Goldcrest Well Supply has two wells located in the south western part of the Innisfil Creeks subwatershed and had a total of 19 significant drinking water threats identified in association with 15 land parcels. The significant threats reflect a variety of land uses, from residential to agriculture to commercial (SGBLS-SPC, 2011).

The final document the Source Protection Committee is responsible for is creating a Source Protection Plan that will be effective in mitigating all existing significant threats and preventing new ones from arising on the landscape. The process of creating this plan includes the SPC developing policies to protect drinking water supplies. With input from local municipalities, the SPC has developed an evaluation criteria that ensures all policies will be specific, measureable, achievable, realistic, and time bound, or SMART for short. The Source Protection Plan is expected to be completed in 2012.

Full results of these studies, showing the vulnerability scores and the enumeration of threats to drinking water can be found in the Approved Lakes Simcoe and Couchiching-Black River Assessment Report, Part 1: Lake Simcoe. The local vulnerable areas (Wellhead Protection Areas and Intake Protection Zones) for the drinking water systems located in each of the three subwatersheds within this report are shown in Figure 2-10 (Note: The IPZ-3 is not included for this figure).

Vulnerable areas (WHPA/IPZ) located within the Innisfil Creeks subwatershed.

Figure 2-10



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2.3.3 Ecological Goods and Services.

In addition to the direct benefits to human health provided by public natural areas and clean drinking water, the environment also provides a range of other, less tangible, benefits, often termed 'ecological goods and services'. These benefits include the storage of floodwaters by wetlands, water capture and filtration by forests, the absorption of air pollution by trees, and climate regulation.

Forests, wetlands, and rivers that make up watersheds are essentially giant utilities providing ecosystem services for local communities as well as the regional and global processes that we all benefit from. Ecosystems provide many services including carbon storage and sequestration, water storage, rainfall generation, climate buffering, biodiversity, soil stabilization, and more (Global Canopy Programme. http://www.globalcanopy.org/main.php?m=3).

These benefits are dependent on ecosystem functions, which are the processes, or attributes, that maintain the ecosystems and the species that live within them. Humans are reliant on the capacity of natural processes and systems to provide for human and wildlife needs (De Groot, 2002). These include products received from ecosystems (e.g. food, fibre, clean air and water), benefits derived from processes (e.g. nutrient cycling, water purification, climate regulation), and non-material benefits (e.g. recreation and aesthetic benefits) (Millennium Ecosystem Assessment, 2003).

In 2008, the Lake Simcoe Region Conservation Authority partnered with the David Suzuki Foundation and the Greenbelt Foundation to determine the value (natural capital) of the ecosystem goods and services provided by the natural heritage features in the watershed in the report: *Lake Simcoe Basin's Natural Capital: The Value of the Watershed's Ecosystem Services* (Wilson, 2008). By identifying and quantifying ecosystem services within a watershed, environmental resources can be directed towards areas that are currently of high value or areas that have the potential to be of high value.

2.3.3.1. Valuing Ecosystems

There have been several techniques developed to estimate economic values for non-market ecosystem services. The method used for the 2008 study uses avoided cost (i.e. damages avoided) and replacement cost (cost to replace that service) for ecosystem service valuation, as well as contingent valuations or willingness-to-pay studies for cultural values. Some of the values were derived using direct analysis and some values were adapted from other studies. Table 2-6 summarizes the value of the various ecosystem services by land cover type in the Innisfil Creeks subwatershed, as well as for the whole Lake Simcoe watershed. All ecosystem service values have been updated to 2010 Canadian dollars.

The estimated values provided are likely a conservative estimate because our knowledge of all the benefits provided by nature is incomplete, and because these values are likely non-linear in nature (i.e. the value of natural capital and its services will increase over time, as natural areas become more scarce, and demands for services such as clean water or mitigation of climate change become greater). It is also important to note that without the earth's ecosystems and resources, life would not be possible, so essentially the true value of nature is priceless. The valuations of ecosystem services, however, provide an opportunity to quantitatively assess the current benefits and the potential costs of human impact.

Table 2-5: Summary of non-market ecosystem service values by land cover type (2010 values).

Land Cover Type	Total Innisfil Creeks subwatershed value ($million/yr)	Total Lake Simcoe basin value ($million/yr)
Cropland	2.32	54.52
Forest	8.93	207.93
Forest/ Wetlands*	15.95	466.64
Wetlands	3.34	176.12
Grasslands	0.54	22.49
Hedgerows/ Cultural Woodland	0.19	6.31
Pasture	1.24	41.80
Urban Parks	0.17	3.18
Water**	0.01	1.54
Total	**32.70**	**980.53**

* This includes treed swamps.
** This does not include the value of Lake Simcoe

As has been demonstrated, the natural systems of the Innisfil Creeks subwatershed provide a number of goods and services. These so-called “free” ecosystem services have, in fact, significant value. The analysis in the 2008 report provided a first approximation of the value of the non-market services provided – totalling annually (in 2010 values) for the Lake Simcoe watershed $980 million and at least $32.7 million for the Innisfil Creeks subwatershed. The most highly valued natural assets are the forests and treed swamps. For the Lake Simcoe watershed these were calculated to be worth $208 and $467 million per year, respectively. These values for Innisfil Creeks were $8.9 million and $5.9 million.

The high value for forests reflects the many important services they provide, such as water filtration, carbon storage, habitat for pollinators, and recreation. Treed swamps and wetlands provide high value because of their importance for water filtration, flood control, waste treatment, recreation, and wildlife habitat.

It is important to note that while the value of Lake Simcoe is not included in the watershed total, it is of considerable value to all surrounding natural and human communities within the Lake Simcoe watershed. It is the focal point of many waterfront communities (such as the City of Barrie and Town of Innisfil), provides a vast number of recreational opportunities for both locals and tourists alike, is a source of drinking water for seven municipal surface water intakes, supports a substantial fishery, and as well as being a significant natural heritage feature, it provides people with beautiful scenery. As such, the preservation of the lake and the rest of the natural heritage features within the watershed results in a significant cost savings in municipal infrastructure that would otherwise be needed to service watershed residents and users.

2.4 Geology and Physical Geography

The geology, topography and other physical features of a subwatershed provide the foundation for the subwatershed's hydrological and ecological processes, as they have a strong influence on factors such as local climate patterns, types of land cover, land use practices, and surface water and groundwater flow paths.

2.4.1 Geology

There have been a number of studies that have lead to the geologic understanding in the Innisfil area. A generalized description of the bedrock geology, quaternary geology, and conceptual stratigraphic units within the Innisfil Creeks subwatershed is provided. For more detailed information the reader is referred to: Johnson *et al*., 1992; Barnett, 1992; and Armstrong and Carter, 2006.

2.4.1.1. Bedrock Geology

The bedrock can be characterized as being from the Paleozoic Era, consisting primarily of limestone of the Middle Ordovician Simcoe Group. The Simcoe Group overlies the Precambrian 'basement' rock units that comprise the Canadian Shield and outcrop *(present at surface)* north of the Lake Simcoe watershed. The Simcoe Group has been overlain by a sequence of sediments that have been deposited over the last 135,000 years by glacial, fluvial, and lacustrine environments.

The Middle Ordovician-aged carbonates and shales of the Simcoe Group were deposited in a gradually deepening shelf system in a shallow subtropical sea approximately 460 million years ago (Brookfield and Brett, 1988). The Simcoe Group consists of four formations that dip gently toward the southwest: Gull River Formation, Bobcaygeon Formation, Verulam Formation, and the Lindsay Formation from oldest to youngest. However, only the Verulam and Lindsay Formations are found within the subwatershed boundary.

Verulam Formation

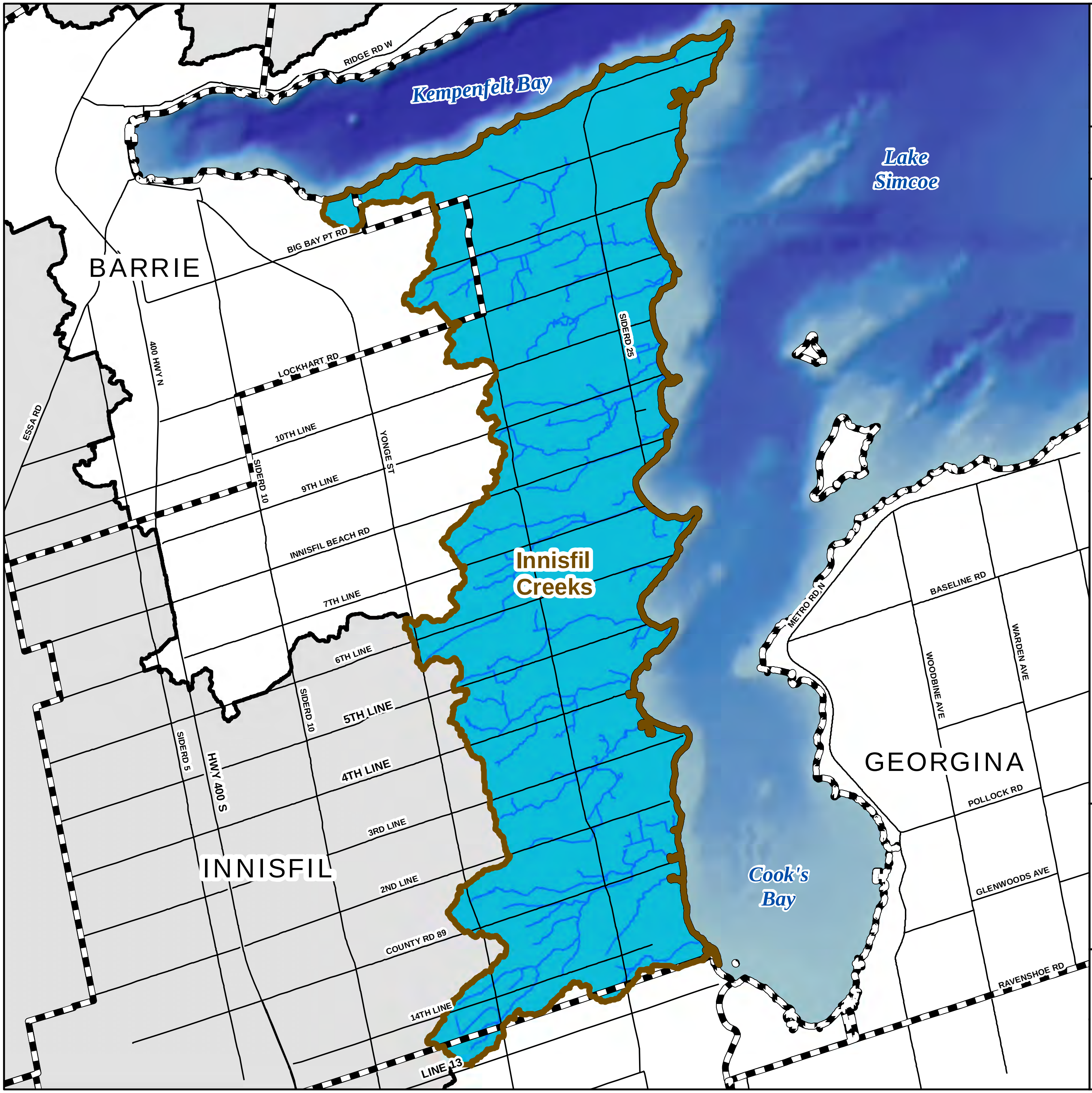
The oldest Paleozoic rocks underlying the subwatershed are those of the Verulam Formation. The formation occurs along the shoreline of Kempenfelt and Cook's Bay. The formation is a member of the Simcoe Group (which is represented as [blue] on Figure 2-11). The formation ranges in thickness from 32 to 65 m and consists of fossiliferous limestone with inter-beds of calcareous shale. The depositional environment of Verulam Formation was open marine shelf (Thurston *et al*., 1992).

Lindsay Formation

The Lindsay Formation overlays the Verulam Formation and extends up from the south toward Kempenfelt Bay, underlying most of the western portions of the subwatershed. The formation is represented as (blue) on Figure 2-11. The Lindsay Formation tends to be less than 67 m thick and is richly fossiliferous, which indicates that the depositional environment was a shallow to deep marine environment (Thurston et al., 1992).

Bedrock geology in the Innisfil Creeks subwatershed.

Figure 2-11



Legend

―	Road
▬	Municipal Boundary
〰	Watercourse
🟦	51a Ottawa Group; Simcoe Group; Shadow Lake Fm.

Lake Simcoe Region conservation authority

0 0.5 1 2 3 4 5 Kilometres

N

2.4.1.2. Bedrock Topography

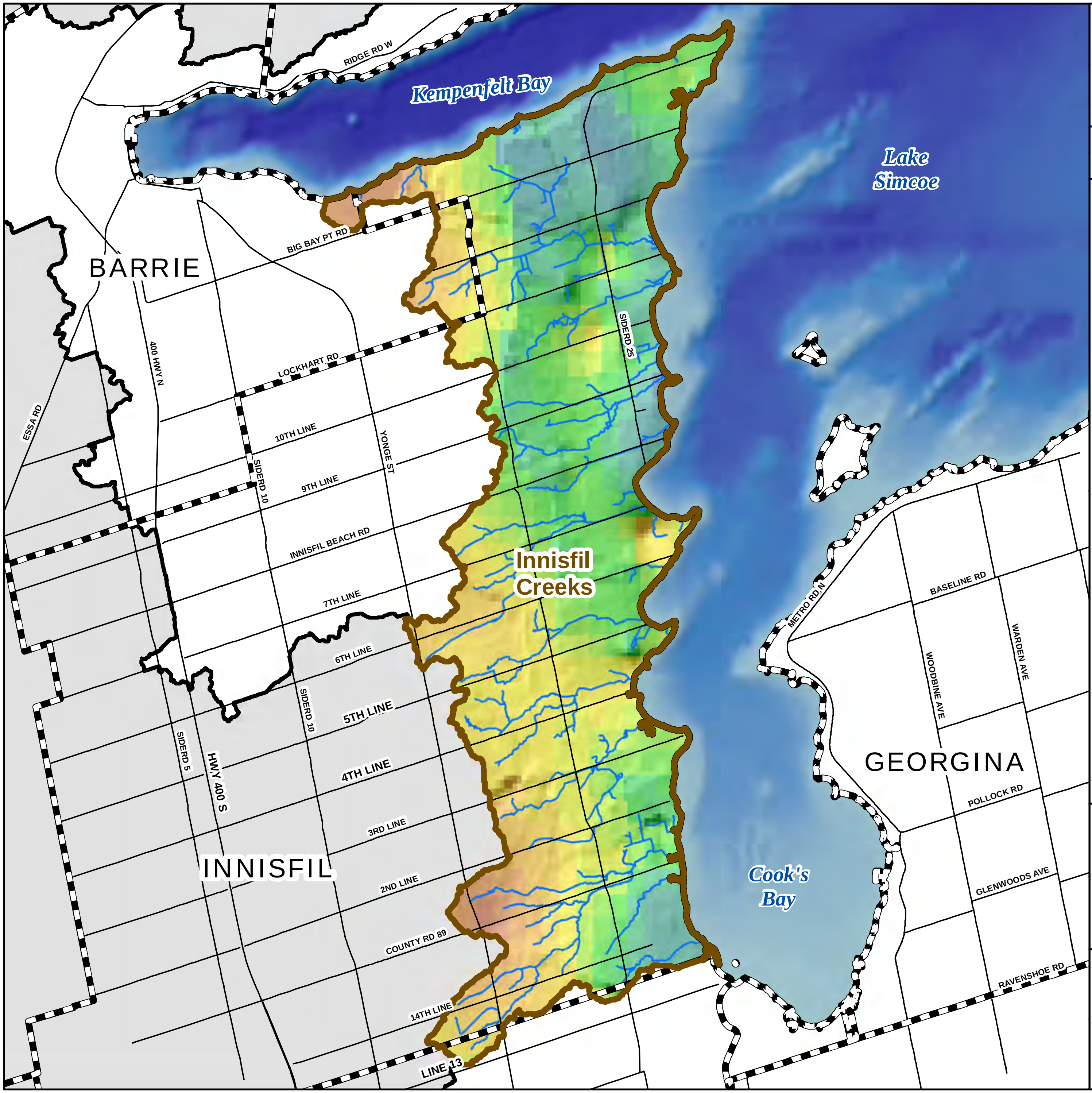
The bedrock surface of the subwatersheds has a general elevation range of 115 to 179 mASL (Figure 2-12). The bedrock surface is thought to have been the result of a long period of non-deposition and/or erosion activity that occurred between the deposition of the sedimentary bedrock and the overlying sediments.

The topographic lows are associated with significant valleys that have been eroded into the bedrock surface. These valleys are believed to be a result of fluvial activity prior to glaciation, approximation 440 to 2 million years ago with additional modification by glacial processes over the last 2 million years (Earthfx and Gerber, 2008).

A major bedrock valley known as the Laurentian bedrock channel traverses through the south-western portion of the Lake Simcoe watershed, in the neighbouring subwatersheds. Recent interest has been generated over the Laurentian Channel (also referred to as the Laurentian Valley), a proposed Tertiary-aged river network that extended from Georgian Bay to Lake Ontario (Brennan *et al*., 1998; Sharpe *et al*., 2004). This interest has been driven primarily by the attempt to locate additional sources of potable water as increasing population continues to place additional stress on existing groundwater supplies. This valley identifies an ancient drainage system that extended from Georgian Bay to Toronto.

Bedrock topography in the Innisfil Creeks subwatershed.

Figure 2-12



Legend

Road

Municipal Boundary

Watercourse

Bedrock Top Elv (m)

<112	130	154
114	132	156
116	134	158
118	136	160
120	138	162
122	140	164
124	142	166
126	144	168
128	146	170
	148	172
	150	>172
	152	

Lake Simcoe Region conservation authority

0 0.5 1 2 3 4 5 Kilometres

N

LSRCA GIS Services DRAFT created July 2010.

2.4.1.3. Quaternary Geology

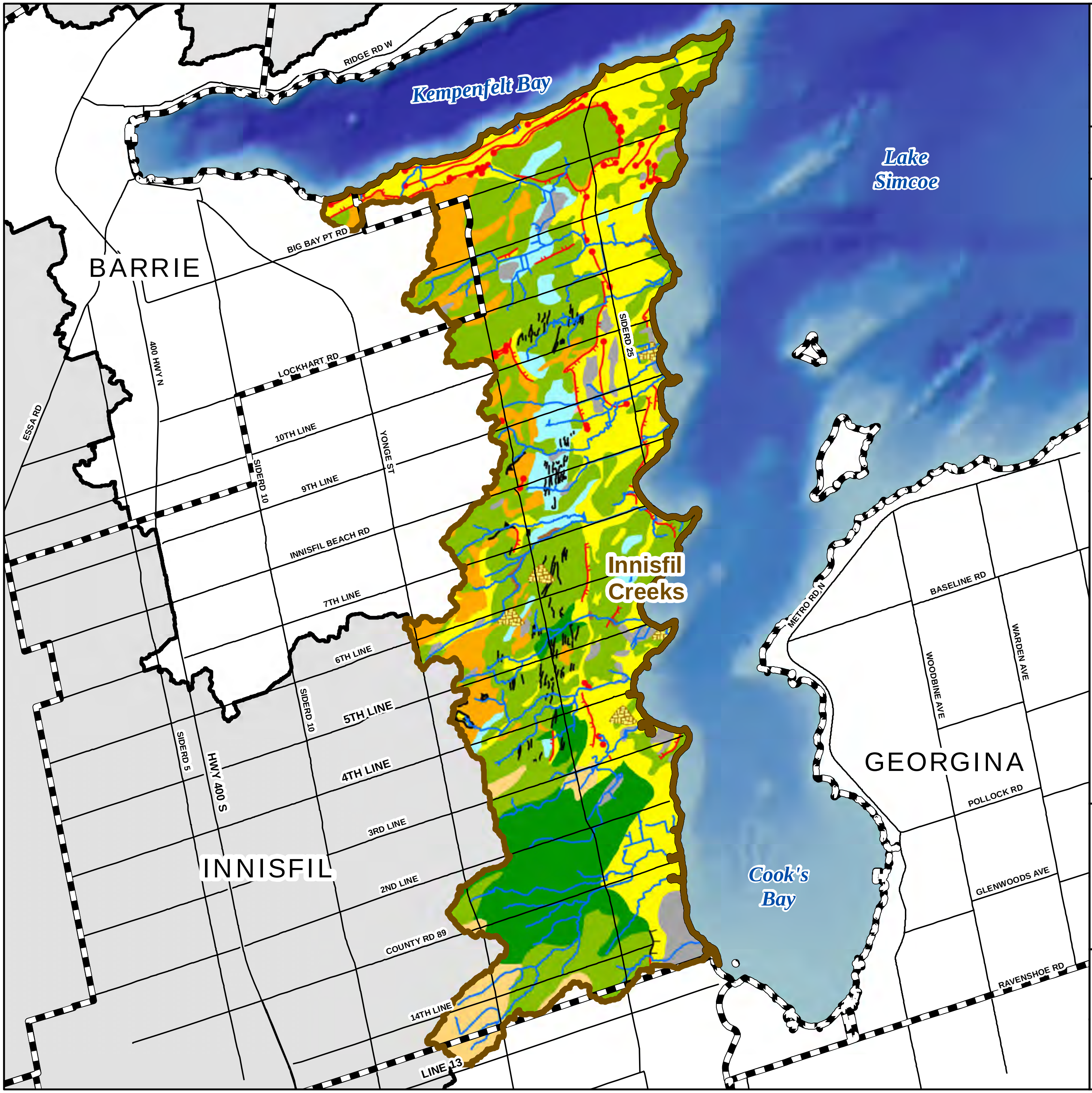
Glacial History

The bedrock within the Innisfil Creeks subwatershed is overlain by unconsolidated sediments, known as the overburden, which were deposited during the Quaternary Period. The Quaternary Period can be further divided into the Pleistocene (Great Ice Age) and the Holocene (Recent) Epochs. During the Pleistocene, at least four major continental-scale glaciations occurred, which include, from youngest to oldest, the Wisconsinan, Illionian, Kansan, and Nebraskan Stages (Dreimanis and Karrow, 1972). All of the surficial deposits within the subwatershed, and within most of southern Ontario, are interpreted to have been deposited within the subwatershed, and within most of southern Ontario are interpreted to have been deposited by the Laurentide Ice Sheet during the Wisconsinan glaciations. The Laurentide Ice Sheet is the glacier that occupied most of Canada during the Late Wisconsinan period, approximately 20,000 years ago (Barnett, 1992).

Sediments deposited during the Late Wisconsinan substage are extensive in southern Ontario and are thought to represent all of the surficial deposits in the subwatersheds. All of the deposits which outcrop at surface within the subwatersheds were likely laid down within the last 15,000 years during and after the Port Bruce Stade. Deep boreholes indicated that older Wisconsinan deposits do occur at depth; however, it is not always possible to date them (Dreimanis and Karrow, 1972). These deposits are often quarried by the aggregate industry for use in infrastructure building. The quaternary deposits are depicted on Figure 2-13.

Quaternary Sediment Thickness

Within the subwatershed the Quaternary sediment thickness is the difference between the ground surface and the bedrock surface. The thickness of the Quaternary sediments has been determined from borehole and water well information within the subwatershed. Figure 2-14 shows the thickness ranges from approximately 39 to 186 m. The Paleozoic bedrock topography appears to strongly influence the overlying Quaternary sediment thickness and distribution. The thicker Quaternary sediments occur in bedrock topographical lows (i.e. within bedrock valleys), while the thinnest areas of Quaternary deposits occur at the north end of the subwatershed, south of Cook’s Bay.



Surficial geology in the Innisfil Creeks subwatershed.

Figure 2-13

Legend

— Road
▬ Municipal Boundary
〰 Watercourse
▲ drumlin
●—● beach
┬┬ bluff
▼—▼ icslope
— ribl
┴┴┴ terrace
🟥 1: Precambrian bedrock
🟩 5b: Stone-poor, carbonate-derived
🟩 silty to sandy till
🟩 5d: Glaciolacustrine-derived
🟩 silty to clayey till
🟧 6: Ice-contact stratified deposits
🟧 7: Glaciofluvial deposits
🟦 8a: Massive-well laminated
🟨 9b: Littoral-foreshore deposits
🟨 9c: Foreshore-basinal deposits
🟫 12: Older alluvial deposits
🟫 19: Modern alluvial deposits
⬜ 20: Organic deposits

Lake Simcoe Region conservation authority

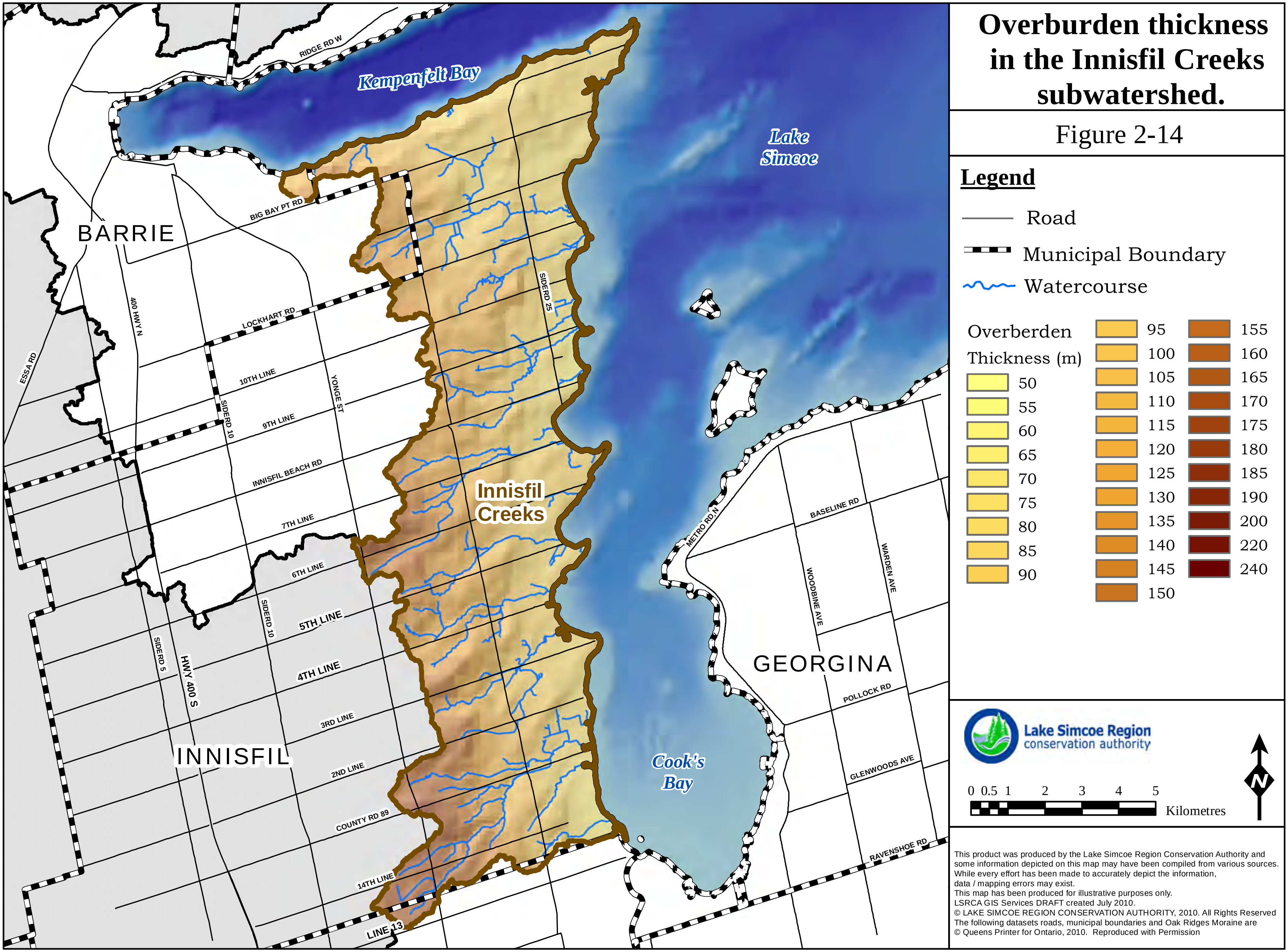
0 0.5 1 2 3 4 5
Kilometres

N

LSRCA GIS Services DRAFT created July 2010.

Overburden thickness in the Innisfil Creeks subwatershed.

Figure 2-14



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2.4.1.4. Hydrostratigraphy

The geology of the subwatershed significantly influences the local hydrogeology, which is the study of groundwater. Hydrogeologists study the geologic formations to understand how much water infiltrates into the subsurface, where it flows, how quickly it flows, and where it re-enters the surface water system. Changes in groundwater quantity and quality have potential impacts on natural functions that could affect the surface water flow regime, aquatic ecosystems, and use of the resource as a viable water supply.

Hydrostratigraphy is the spatial mapping of geologic formations based on their water bearing properties. The hydrostratigraphy of the surficial deposits within the subwatershed is complex as a result of the glacial history. There are a number of ongoing initiatives to understand the local hydrostratigraphic framework of the Southern Simcoe County and Barrie area. The following subsections provide a brief overview of relevant and previously completed stratigraphic studies.

The stratigraphic framework of Quaternary glacial and non-glacial sediments, as shown in Figure 2-15, was completed by AquaResource *et al*., 2011 for the City of Barrie Tier 3 Water Budget and Risk Assessment, which encompasses a large portion of the Innisfil Creeks subwatershed. The conceptual model builds upon previous models built for the South Simcoe Groundwater Studies (Golder, 2004). Four regional aquifers have been defined throughout study area. An aquifer is an underground saturated permeable geological formation that is capable of transmitting water in sufficient quantities under ordinary hydraulic gradients to serve as a source of groundwater supply. Aquifers are typically composed of coarse grained materials such as sands and gravels. The aquifers are named A1 through A4, from top to bottom. Despite the continuity of the hydrostratigraphic framework, it is important to note that pinchouts, lenses, and windows do occur within any given unit (AquaResource *et al*., 2011). A description of the interpreted regional hydrostratigraphic framework is provided below. The discussion of the layers is focused on the areas where the data exists. Key features for the Innisfil Creeks subwatershed will be pointed out where known.

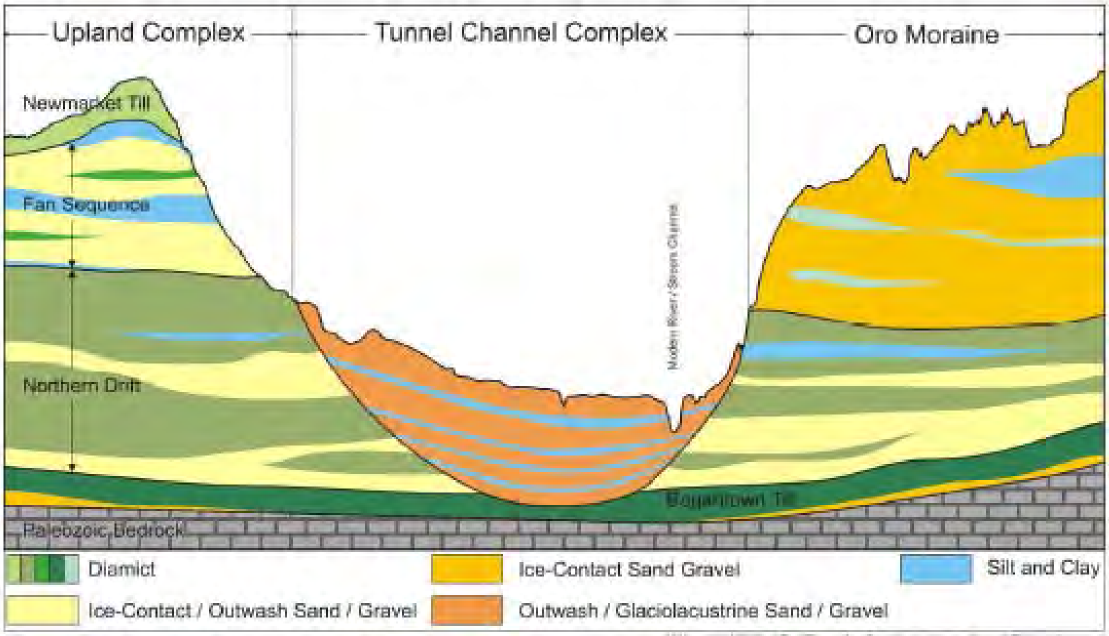


Figure 2-15: Generalized conceptual stratigraphy of upland complexes, lowland tunnel channel complexes and the Oro Moraine (AquaResource *et al*., 2011).

The nine conceptual model layers (from youngest to oldest) are:

1. Upper Confining Layer
2. Aquifer 1 (A1)
3. Confining Layer 1 (C1)
4. Aquifer 2 (A2)
5. Confining Layer 2 (C2)
6. Aquifer 3 (A3)
7. Confining Layer 3 (C3)
8. Aquifer 4 (A4)
9. Top of Bedrock

Upper Confining Layer (UC)

The upper confining layer or aquitard has been mapped as coarse-grained lacustrine deposits which are part of a regionally extensive sand plain extending west from the shoreline of Cook's Bay. An aquitard is a confining bed and/or formation composed of rock or sediment that retards but does not prevent the flow of water to or from an adjacent aquifer. It does not readily yield water to wells or springs, but stores groundwater.

Aquifer 1 (A1)

The A1 aquifer is commonly associated with the upland areas. Overall, the aquifer can be described as being composed of fine to medium grained sand with occasional occurrences of gravel. Detailed logging of this unit in the northwest part of Barrie (Dixon hydrogeology , 2001) indicates that the upper aquifer consists of a number of coarsening upward sequences of lacustrine sand with only minor occurrences of silt (AquaResource et al, 2011).

Confining Layer 1 (C1)

The C1 layer has been cored within the City of Barrie and is described as varved clay and silt. The C1 layer is noted as thin to non-existent in some areas (typically west of Barrie toward Angus) (AquaResource *et al*., 2011).

Aquifer 2 (A2)

The A2 aquifer is found in the elevation range of approximately 175 to 230 mASL within the lowland areas but the stratigraphic equivalent extends up to approximately 250 mASL to the northeast, under the Oro Moraine. The aquifer can generally be described as being composed of sand, with some clast rich portions. The aquifer is interpreted to extend under Kempenfelt Bay and to the north (towards Midhurst). The lower elevation of the aquifer in the vicinity of Kempenfelt Bay corresponds with the deeper channelized aquifer and suggests that it may represent in-filled former river channels in this area. The A2 aquifer ranges in thickness from approximately 10 to 30 m in most areas. It is regionally extensive, but does pinch out in some areas. The eastern part of the A2 aquifer is interpreted to be in direct contact with Kempenfelt

Bay, based on the base elevation of the bay and the interpreted aquifer extents near its shores (AquaResources *et al*., 2011).

Confining Layer 2 (C2)

The C2 layer has been described as a silty sand to sandy silt, stone-rich diamicton (AquaResource & Golder, 2009).

Aquifer 3 (A3)

The A3 aquifer is commonly referred to as the lower aquifer and is the primary groundwater supply source for the Town of Innisfil drinking water. The aquifer is composed of extensive coarse grained sand and gravel, which readily transmits the flow of water. The A2 aquifer is interpreted to be in contact with the A3 aquifer in some locations. The elevation of the A3 aquifer ranges from 150 to 195 mASL, and ranges in thickness from 10 to 40 m. North of Innisfil, the aquifer is interpreted to be in direct contact with the A4 aquifer in the City of Barrie core, at the location of the interpreted tunnel channel (AquaResource *et al*., 2011).

Confining Layer 3 (C3)

Confining Layer 3 is thin to absent in some areas. Where present the layer is composed of fine-grained silts and clays (AquaResource & Golder, 2009).

Aquifer 4 (A4)

The A4 aquifer is typically found at elevations below 150 mASL in areas of depressed bedrock elevation. The aquifer is reported to consist of fine to medium grained sand with minor gravel deposits in some areas. The aquifer is thin to absent in some areas, and is often limited to areas of depressed bedrock elevation. In the Golf Haven area the aquifer is removed from bedrock depressions the aquifer is very thin and composed of fine grained sand and silt, and is underlain by till (AquaResource & Golder, 2009).

Top of Bedrock

The Middle-aged Ordovician aged carbonates of the Simcoe group (discussed above) are in direct contact with the bottom of the A4 aquifer.

2.4.2 Physiography, Topography, and Soils

2.4.2.1. Physiography

Physiography is the study of the physical structure of the surface of the land. A physiographic region is an area with similar geologic structure and climate, and which has a unified geomorphic history (DRAFT GRIPS, 2008). The study of physiography is important from a water resource perspective as the knowledge gained from knowing the land composition aids hydrogeologists and hydrologists in understanding the groundwater and surface water flow systems. The physiography of an area is also important from an agricultural perspective as the sediments and landforms present at the surface influence the types of crops that can easily be grown.

The physiographic regions within the Innisfil Creeks subwatershed are a direct result of the deposition and erosion of the quaternary sediments (overburden) during glacial and post-glacial events, and closely correspond to the topography discussed in the following section. According to Chapman and Putnam (1984), two physiographic regions are found within the subwatersheds: Simcoe Lowlands and the Peterborough Drumlin Field (Figure 2-16).

Simcoe Lowlands

The Simcoe Lowlands is the physiographic region that comprises narrow stretches of land along the shores of Kempenfelt and Cook's Bay within the subwatershed. The region is described as having lower elevations, with flat-floored valley features that generally correspond to current river systems (Sharpe *et al*., 1999). The lowlands were flooded by glacial Lake Algonquin and as a result are floored by sand, silt, and clay (Chapman and Putnam, 1984).

Peterborough Drumlin Field

Drumlin is a Celtic word meaning little hill. Drumlins are typically oval shaped hills with smooth convex contours. In areas where drumlins are pointing in the same direction, the direction of movement of a glacier during the last ice age can be determined (Chapman and Putnam, 1984).

The Peterborough Drumlin Field extends south of Kempenfelt Bay down to the Oak Ridges Moraine, encompassing the majority of the subwatershed. The physiographic region is typically characterized by numerous drumlins that are on average oriented 60° west of south or 240° azimuth and rise up from the surrounding Newmarket Till plain. On average, drumlins are 20-75 m in width and 100-450 m in length. Internally, drumlins are composed of a stone-rich, slightly silty to silty fine to medium grained sand till.

2.4.2.2. Topography

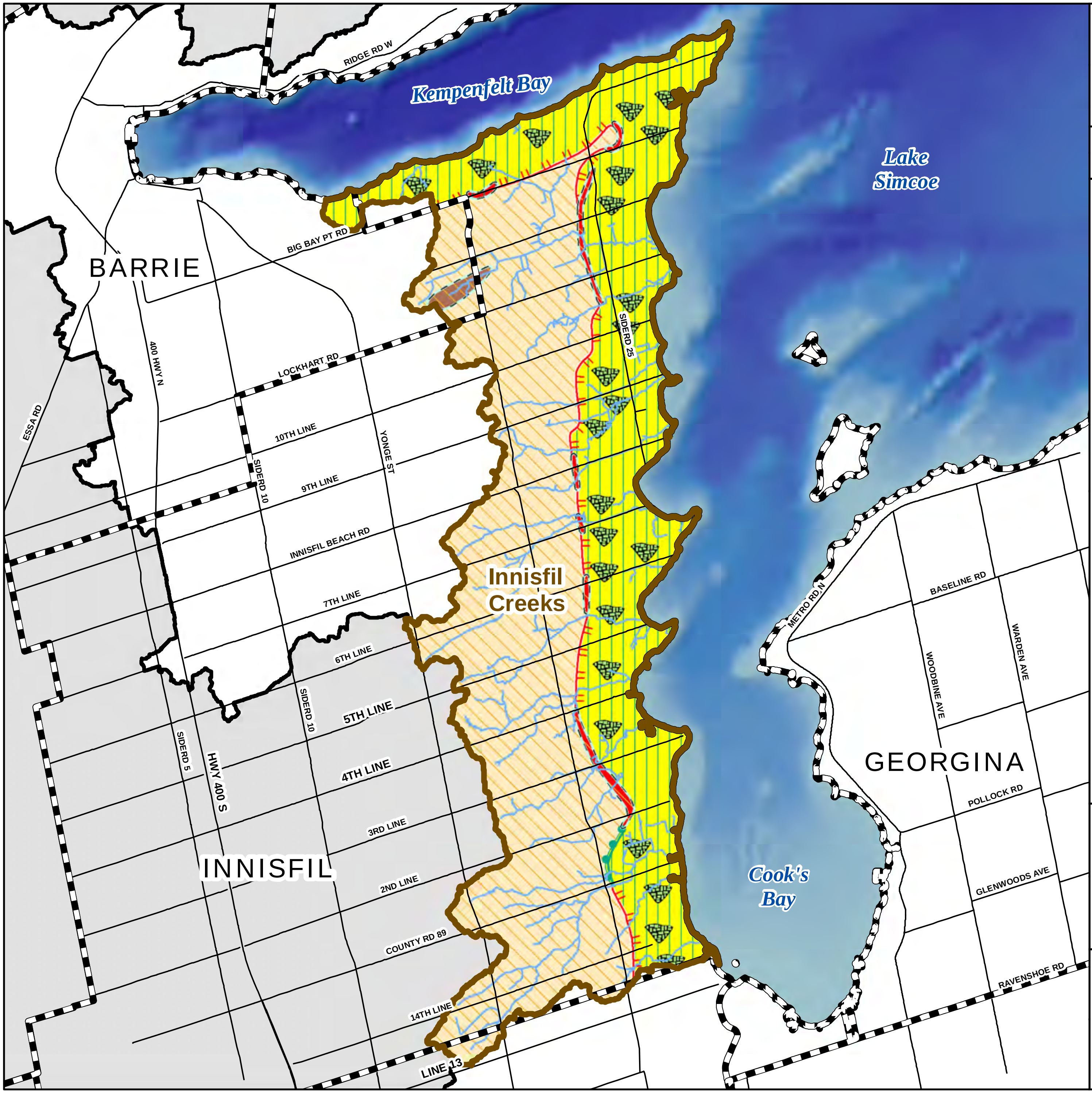
The topography of the subwatershed closely corresponds to the physiographic regions that comprise the subwatersheds. The topographic features of the Innisfil Creeks subwatershed are related to the present-day stream network, as well as their geological history, including significant glacial events. The ground surface topography within the subwatersheds ranges from 306 metres above mean sea level (mASL) in the Innisfil Heights area to 216 mASL along the shores of Kempenfelt and Cook's Bay (Figure 2-17).

2.4.2.3. Soils

The soils present within the subwatershed influence the type and productivity of the vegetation communities commonly found growing within the subwatersheds. Soils also influence the quality and quantity of water entering the ground and running along the surface. Traditionally, soils within the subwatershed have been characterized based on the coarseness of their texture. Coarse textured soils (gravel and sand) allow water to infiltrate better than finer-textured soils (clay, silty loam) do. The texture of the soil is important because it directly influences the landscape's ability to generate runoff. For example, during a heavy thunderstorm, rainfall that cannot infiltrate the ground will pool on the surface. Once enough water has collected it will start flowing overland as a result of gravity and in so doing can erode soil particles, washing them into ditches, streams and lakes. Figure 2-18 depicts the spatial distribution of the soil types present throughout the subwatersheds.

Physiography in the Innisfil Creeks subwatershed.

Figure 2-16



Legend

- Road
- Municipal Boundary
- Watercourse

Physiography Features

- Boulder pavement
- Contact
- Shorecliff
- Shorecliff (Weakly developed)
- ▥ Simcoe Lowlands
- ▨ Peterborough Drumlin Field
- 🟥 Beach
- 🟫 Drumlin
- 🟨 Sand Plain
- Till Plain (Drumlinized)

Lake Simcoe Region conservation authority

0 0.5 1 2 3 4 5 Kilometres

N

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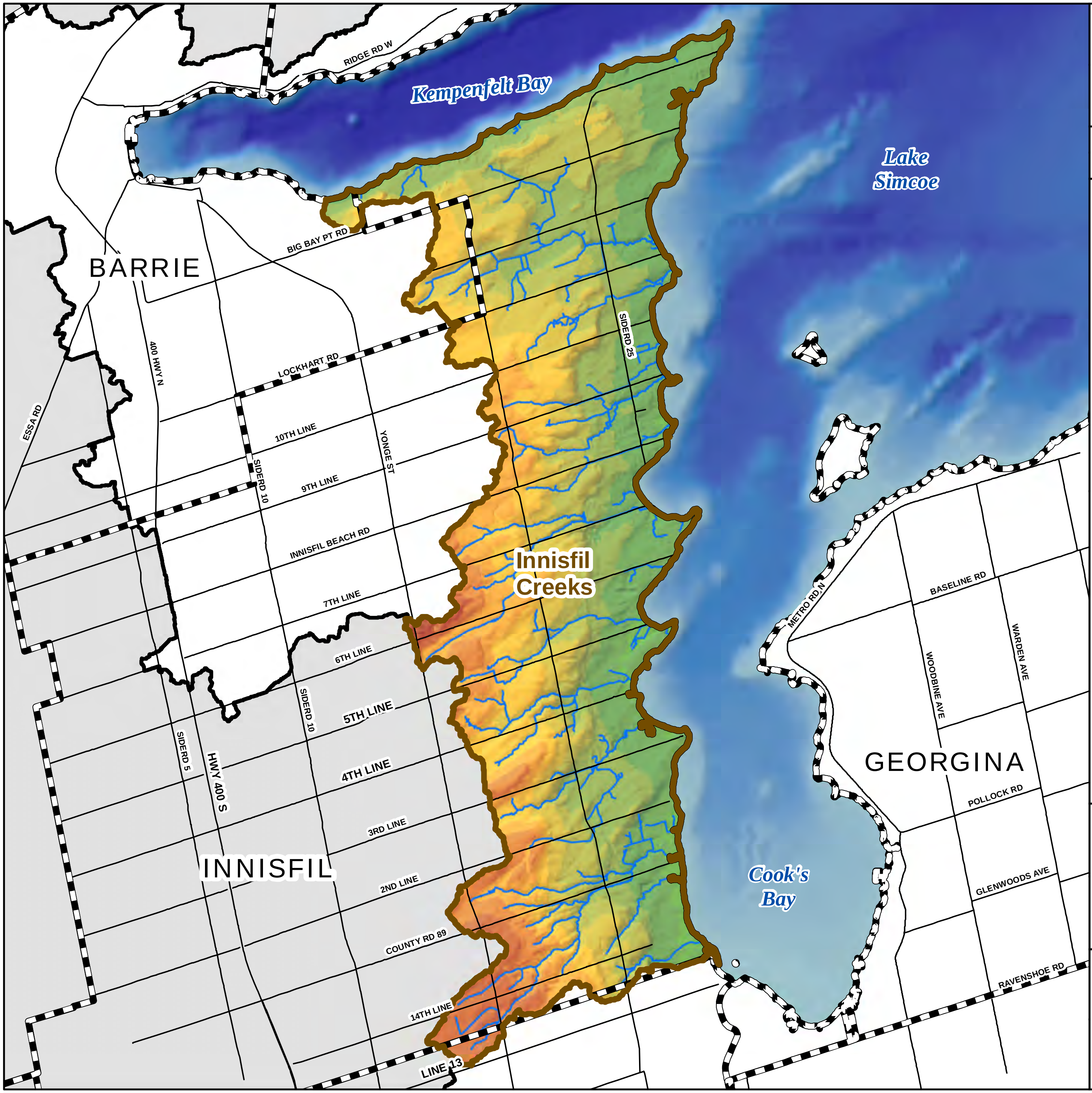
LSRCA GIS Services DRAFT created July 2010.



Ground surface topography in the Innisfil Creeks subwatershed.

Figure 2-17

Legend

Road

Municipal Boundary

Watercourse

Ground Surface Elevation (m)

100 - 120	280 - 290
120 - 140	290 - 300
140 - 160	300 - 310
160 - 170	310 - 320
170 - 180	320 - 330
180 - 190	330 - 340
190 - 200	340 - 360
200 - 210	360 - 380
210 - 220	380 - 400
220 - 230	400 - 420
230 - 240	420 - 440
240 - 250	440 - 460
250 - 260	460 - 480
260 - 270	480 - 500
270 - 280	500 - 520
	520 - 540
	540 - 560

Lake Simcoe Region conservation authority

0 0.5 1 2 3 4 5 Kilometres

N

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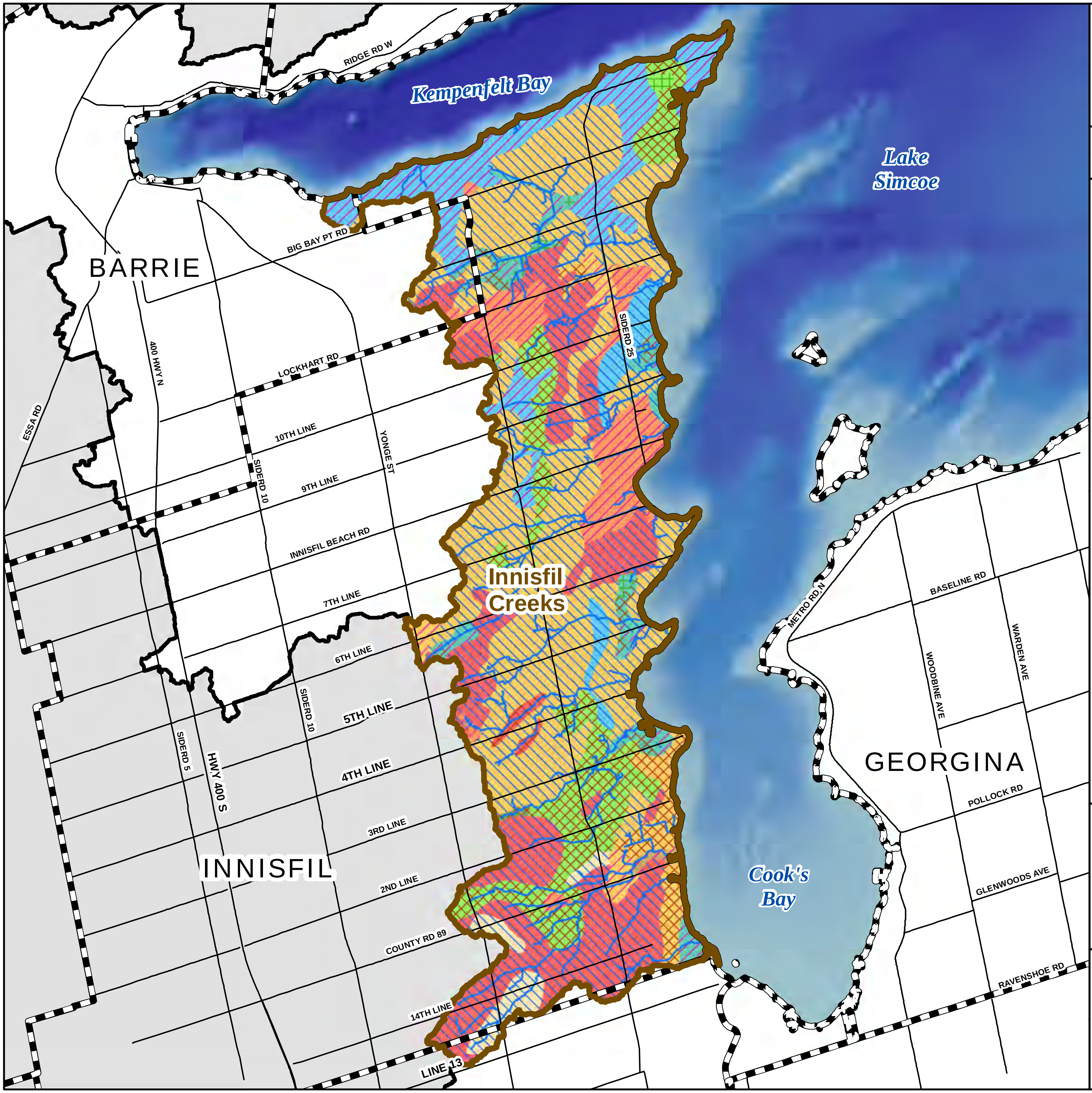


Soils in the Innisfil Creeks subwatershed

Figure 2-18

Legend

Road

Municipal Boundary

Watercourse

Soil Hydro Class

▨ A - high infiltration rates

▨ B - moderate infiltration rates

▨ C - slow infiltration rates

▦ D - very slow infiltration rates

Soil Texture Class

🟦 GRAVELLY SANDY LOAM

🟫 SAND

🟧 SANDY LOAM

🟨 FINE SANDY LOAM

🟥 LOAM

🟧 LOAMY SAND

🟩 SILTY LOAM

🟩 SILTY CLAY LOAM

🟩 ORGANIC

Lake Simcoe Region
conservation authority

0 0.5 1 2 3 4 5
Kilometres

N

LSRCA GIS Services DRAFT created July 2010.

2.5 Fluvial Geomorphology

2.5.1 Introduction and background

Fluvial geomorphology is the study of the processes that influence the shape and form of streams and rivers. It describes the processes whereby sediment and water are transported from the headwaters of a watershed to its mouth. These processes govern and constantly change the form of river and stream channels, and determine how stable the channels are. Fluvial geomorphology provides a means of identifying and studying these processes, which are dependent on climate, land use, topography, geology, vegetation, and other natural and human influenced changes.

An extensive understanding of geomorphic processes and their influences is required in order to protect, enhance, and restore stream form in a watershed. Changes in land use, and urbanization in particular, can significantly impact the movement of both water and sediment, and can thus cause considerable changes to the geomorphic processes in the watershed. Changes to the morphology of stream channels, such as accelerated erosion, can impact the aquatic community, which has adapted to the natural conditions, and can also threaten human lives, property, and infrastructure.

2.5.2 Geomorphic Processes

All streams and river systems are constantly in a state of transition, influenced by the flow of water and the amount of sediment entering into the system, which in turn are influenced by climate and geology. The amount of water delivered to the surface of a watercourse, as well as how and when it arrives is influenced by climate. Typical patterns are high flow events during the spring freshet, and low flow conditions during the winter and summer months.

The surficial geology of an area influences the path of water once it reaches the ground surface. The underlying geology establishes the volume and proportion of groundwater and surface water available to flow through a watershed through its effect on infiltration. Geology also shapes the amount and type of sediment that enters a watercourse, and the strength and erodibility of the surficial material through which the watercourse flows. A complex underlying geology and topography can result in considerable variation in channel character, as well as sensitivity to potential impacts, within the same drainage system.

Natural watercourses respond to continually changing conditions in flow and sediment supply with adjustments in shape and channel position. These changes take place through the processes of erosion and deposition. This ability to continually change is an inherent characteristic of natural systems that allows the morphology of the channels to remain relatively constant. The state in which flow and sediment supply are balanced to achieve this stable channel form is referred to as “dynamic equilibrium.” While in a state of dynamic equilibrium, channel morphology is stable but not static, since it makes gradual changes as sediment is deposited and moved throughout the watercourse. For example, many natural watercourses can be seen to “migrate” within their floodplain over time. This is due to the erosion of the outsides of channel bends, but with corresponding deposition of material on the insides of bends. This process maintains the balance between flow and sediment supply in the system. Riparian and aquatic biota are adapted to and depend on the habitats provided by a system in dynamic equilibrium.

2.5.3 Current Status

Specific fluvial geomorphology studies have not been completed for these subwatersheds, but some other information was available through other studies. The information and data provided within this section has been collected by LSRCA staff completing studies on the condition of the fisheries in the subwatersheds. While a fisheries study is specific in nature, it also tends to provide a "snap-shot" of the biological, chemical and physical characteristics of the system. It should also be noted that some sections of the watercourses in the subwatershed have been moved, piped, channelized, eliminated or manipulated in some fashion to varying degrees. While specific data on the exact location and the degree to which a stream has been manipulated is not currently available, it is fair to say that the alteration of the watercourses has changed both the shape and functioning ability of them. Information on the impacts of manipulating watercourses is available in **Chapter 5 - Aquatic Natural Heritage**.

2.5.3.1. Strahler Stream Order

Stream order is a measure of the magnitude of a stream within a watershed and allows for the comparison of rivers of different sizes or importance within or between systems (Dunne and Leopold, 1978). A first-order stream is an unbranched tributary that typically drains the headwater portion of the watershed. When two or more first order streams converge the downstream segment is classified as a second order stream. A third-order stream is the downstream segment of the confluence of two or more second order streams, and so on. As the order of a stream increases, the characteristics of the watercourse typically change. Larger order streams are generally characterized by lesser elevation gradients, slower velocities, and an increased stream area to accommodate the flow from additional tributaries.

Table 2-7 below presents the stream order and the total length of the creek within the Innisfil Creeks subwatershed. To allow more detailed reporting, the Innisfil Creeks subwatershed has been divided up into the individual creeks: Banks, Belle Aire, Bon Secours, Carson, Cedar, Gilford, Leonard's, Mooselanka, Moyer, Sandy Cove, Strathallan, Sylvan Upper Marsh, White Birch, and Wilson, as well as the smaller unnamed creeks (Innisfil Creeks, which include Innisfil Creeks 1 and Innisfil Creeks 2) (see Figure 2-1 for location of the creeks).

Table 2-6: Innisfil Creeks subwatershed stream order and stream length.

Creek	Stream Order	Length of Creek per Order (m)	% of Creek per Order
Banks Creek (#5)	1st	6,701	44
	2nd	4,936	32
	3rd	3,611	24
	TOTALS	***15,248***	***100***
Belle Aire Creek (#7)	1st	4,395	52
	2nd	1,452	17
	3rd	2,634	31
	TOTALS	***8,481***	***100***
Bon Secours Creek (#4)	1st	1,221	26
	2nd	3,480	74
	TOTALS	***4,701***	***100***
Carson Creek (#8)	1st	3,591	28
	2nd	4,147	33
	3rd	3,232	26

Creek	Stream Order	Length of Creek per Order (m)	% of Creek per Order
	4th	1,686	13
	TOTALS	***12,655***	***100***
Cedar Creek (#6)	1st	657	44
	2nd	823	56
	TOTALS	***1,480***	***100***
Gilford Creek	1st	2,752	100
	TOTALS	***2,752***	***100***
Innisfil Creeks	1st	6,465	83
	2nd	1,334	17
	TOTALS	***7,799***	***100***
Leonard's Creek (#3)	1st	7,777	51
	2nd	5,838	39
	3rd	1,546	10
	TOTALS	***15,160***	***100***
Mooselanka Creek (#2)	1st	2,837	44
	2nd	765	12
	3rd	2,880	44
	TOTALS	***6,482***	***100***
Moyer Creek	1st	807	73
	2nd	303	27
	TOTALS	***1,110***	***100***
Sandy Cove Creek (#1)	1st	10,828	47
	2nd	6,891	30
	3rd	1,746	8
	4th	3,526	15
	TOTALS	***22,991***	***100***
Strathallan Creek	1st	2,055	93
	2nd	159	7
	TOTALS	***2,213***	***100***
Sylvan Creek	1st	382	100
	TOTALS	***382***	***100***
Upper Marsh Creek	1st	1,162	35
	2nd	2,145	65
	TOTALS	***3,308***	***100***
White Birch Creek (#10)	1st	14,112	49
	2nd	8,399	29
	3rd	5,720	20
	4th	461	2
	TOTALS	***28,693***	***100***
Wilson Creek (#9)	1st	7,232	54
	2nd	3,784	28
	3rd	2,449	18
	TOTALS	***13,465***	***100***

2.5.3.2. Drainage Density

Drainage density is a measure of how well a watershed is drained by its streams and is calculated as the total length of all streams within a watershed divided by the total area of the watershed. Typically, streams with high drainage densities are characterized by greater peak flows, high suspended and bed loads, and steep slopes (Dunne and Leopold, 1978). The average drainage density of the Innisfil Creek subwatershed is more than 20% greater than the average Lake Simcoe watershed drainage density (Table 2-8). This indicates potentially greater relief and increased erosion compared to other Lake Simcoe subwatersheds. The drainage densities of the Innisfil Creeks are fairly homogenous with the exception of Strathallan Creek and Sylvan Creek. Strathallan Creek has a fairly small subwatershed and high local relief resulting in very straight un-branched drainage. Sylvan Creek is a very small creek with a subwatershed area of only 0.056 km^2, which makes measuring the stream length and delineating the subwatershed boundary difficult using GIS.

Table 2-7: Innisfil Creeks subwatershed stream length, watershed area and drainage density.

Creek	Total Stream Length (km)	Watershed Area (km^2)	Drainage Density (km/km^2)
Banks Creek (#5)	15.248	9.618	1.585
Belle Aire Creek (#7)	8.481	5.076	1.671
Bon Secours Creek (#4)	4.701	2.030	2.316
Carson Creek (#8)	12.655	7.409	1.708
Cedar Creek (#6)	1.480	1.850	0.800
Gilford Creek	2.752	1.995	1.380
Innisfil Creeks	7.799	4.504	1.732
Leonards Creek (#3)	15.160	4.010	3.781
Mooselanka Creek (#2)	6.482	2.404	2.697
Moyer Creek	1.110	1.015	1.093
Sandy Cove Creek (#1)	22.991	18.270	1.258
Strathallan Creek	2.213	0.516	4.287
Sylvan Creek	0.382	0.054	7.127
Upper Marsh Creek	3.308	1.730	1.912
White Birch Creek (#10)	28.693	12.972	2.212
Wilson Creek (#9)	13.465	8.127	1.656
Innisfil Creeks (at subwatershed level)	146.92	81.58	1.801
***Simcoe Watershed Avg	3578.589	2446.274	1.463

****The Lake Simcoe watershed average includes the subwatersheds of: Barrie Creeks, Beaver River, Black River, East Holland River, Georgina Creeks, Georgina Island, Hawkestone Creek, Hewitts Creek, Lovers Creek, Maskinonge River, Oro Creeks North, Oro Creek South, Pefferlaw/Uxbridge Brook, Ramara Creeks, West Holland River, and Whites Creek.*

2.5.3.3. Elevation along watercourse

When there is a change in elevation, such as when water flows down from headwaters to base levels, energy is produced. Where there is greater fall (steeper slope) energy is gained and waters flow faster, picking up more sediment and having more force to erode banks. These can also be areas of unique fishery habitats where water is flowing quickly over shallow bedrock (riffles and rapids) that are used by some fish species such as brook trout (*Salvelinus fontinalis*), walleye (*Sander vitreus*), and longnose dace (*Rhinichthys cataractae),* as spawning grounds. Depending on the fall, it can also create a barrier to some aquatic species that are unable to swim against the force of the flow. Where the elevation levels out, the energy dissipates, releasing sediment and creating a slower flowing stream. These different processes help to alter the stream system over time. Stream profiles are shown below in relation to underlying surficial geology and features (discussed in Section 2.4.2) and only represent the main branch.

Figure 2-19 illustrates the stream profile of ten of the Innisfil Creeks starting from headwater elevation (length = 0) down to Lake Simcoe (elevation = 220). Average gradient ranges from a low gradient (0.50% gradient for Sandy Cove) to a relatively steep medium gradient (1.04% for Upper Marsh and Wilson Creeks). The rest fall somewhere in between those values: Banks (0.72%), Belle Aire (1.01%), Bon Secours (0.96%), Cedar (0.51%), Leonard's (0.89%), Mooselanka (0.82%), and White Birch (0.84%). Overall the streams in the subwatershed have similar gradients, with a few that have steeper sections and others that are levelled out in areas. The stream length does vary across the watershed (see Table 2-8 for lengths of each).

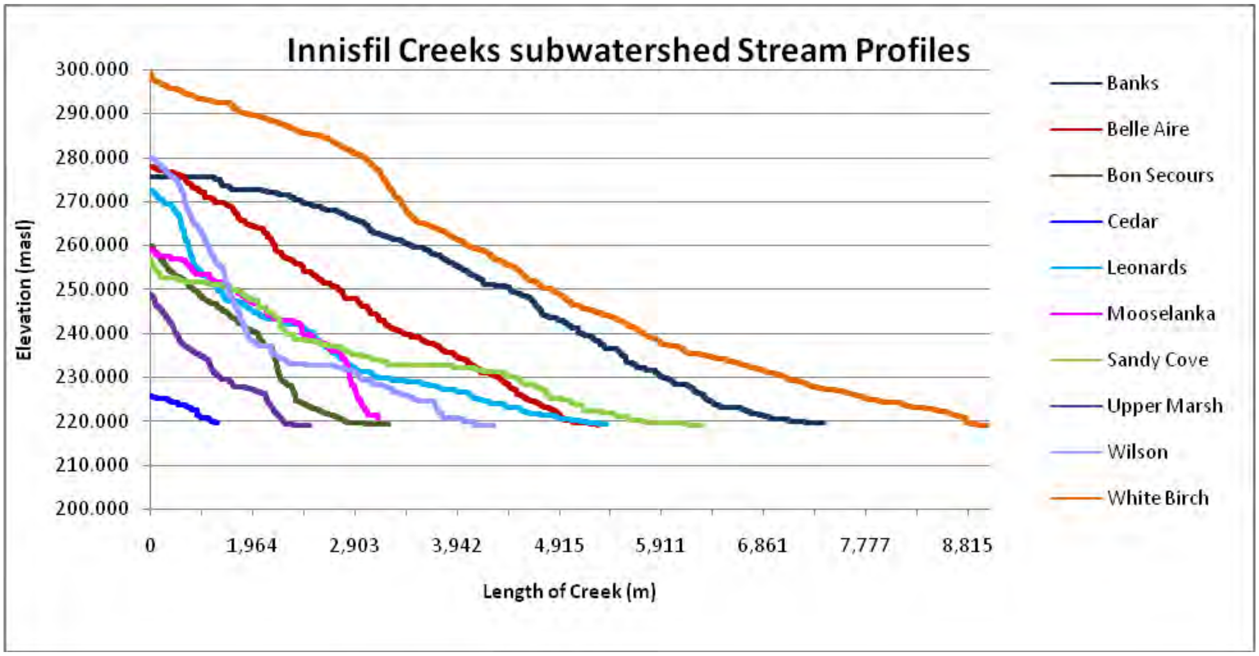


Figure 2-19: Innisfil Creeks subwatershed stream profiles.

2.5.3.4. Bank Stability

The stability of the stream bank depends on the strength of erosive forces against the bank and the stream bank's ability to minimize the impacts. Erosion is a natural process that occurs in all stream systems, but its effects can be exacerbated by changes (both natural and anthropogenic) to the system. Precipitation events can rapidly increase flows and in turn increase the rate of erosion. As the force of the water and the sediments increases, the stream bank's resistance decreases and scouring occurs. Visible signs of this include eroded sections near river bends and undercut banks. If banks are already unstable, excessive undercutting can lead to slumping where large portions of stream bank can collapse.

Unstable sites are those that typically have:

- Removal of riparian vegetation, whose roots create a network of tiny soil anchors and slow overland flow;
- Replacement of large, deep-rooted vegetation with impervious surfaces (i.e. in urban areas), which cause an increase in the volume and velocity of overland water flow; and
- Removal of in-stream debris which can provide a means of slowing water and decreasing the force at which it interacts with the stream bank.

Figure 2-20 illustrates the percentage of stream bank along White Birch, Sandy Cove, Belle Aire, Leonard's, and Wilson Creeks that are unstable, moderate or stable.

White Birch Creek has five sites that range from the headwaters of one of the branches (WBC-E) to the site closest to the mouth at Cook's Bay (WBC-A). Sites WBC-A, -B, and -C are located close together and all have a similar, high amount of stable stream bank and a smaller portion of unstable stream bank. These sites are close to golf courses. Sites WBC-D and WBC-E are further upstream, on different branches, but both surrounded by rural land use and small amounts of natural heritage areas. Both of these sites have a larger percentage of unstable stream banks, with Site WBC-D having almost equal amounts stable and unstable, while the majority of Site WBC-E stream banks are unstable.

Sandy Cove Creek also has five sites that are spread out from the mouth at Lake Simcoe (SANDY-A) to the headwaters of one of the branches (SANDY-E). With the exception of Site SANDY-A, all sites have a high percentage of stable stream bank, located through a variety of land uses.

Belle Aire Creek has four sites, located mostly in the eastern half of the watercourse with Site BELLE-A at the mouth and Site BELLE-D midway along the creek. All four sites have greater than 80% of stable stream bank and run through urban, rural, and natural heritage areas.

Leonard's Creek also has four sites spread along the whole creek. With the exception of Site LEONARD-B, all of the sites have at least 50% unstable stream bank. Both LEONARD-A and LEONARD-C are located within urban areas, with LEONARD-B and LEONARD-D in natural heritage areas that are surrounded by either urban or rural land use.

Lastly, Wilson Creek has three sites located near the mouth, one midway down the main branch and the last (WILSON-C) midway down a tributary. Both Site WILSON-A and WILSON-C have a high percentage of stable stream bank, and are in natural heritage and rural areas. Site WILSON-B has 60% unstable stream bank with smaller percentages of stable and moderate stream bank. This site is located in area with both natural heritage and aggregate land uses.

It should be noted that these sites were randomly chosen, where possible, and provide a general representation of the stream bank conditions.

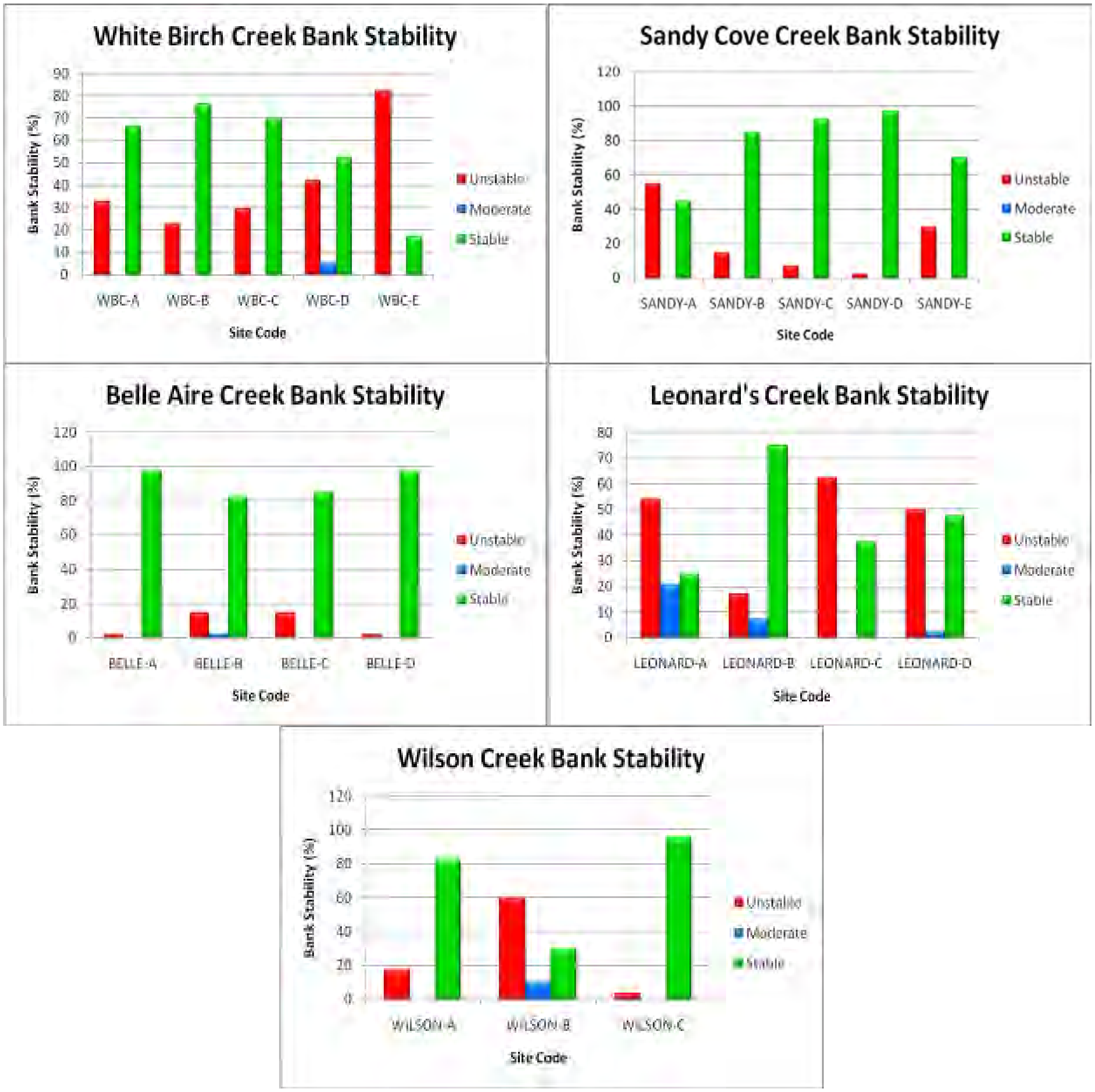


Figure 2-20: Percentage of stream bank that is unstable, moderate, or stable for five creeks within the Innisfil Creeks subwatershed.

2.6 Climate and climate change

2.6.1 Current climate conditions and trends

The Innisfil Creeks subwatershed lies within the Simcoe and Kawartha Lakes climatic region as defined by Brown *et al*. (1980). The climate within the subwatershed and surrounding area is characterized by moderate winters, warm summers, and long growing seasons with usually reliable precipitation patterns. Variations in topography, prevailing winds, and proximity to Georgian Bay and Lake Simcoe lead to local differences in climate across the subwatershed.

Climate data collected from the Barrie WPCC station has been used to characterize the climate for the Innisfil Creeks subwatershed and to support the water budget analysis that is discussed within **Chapter 4 – Water Quantity**.

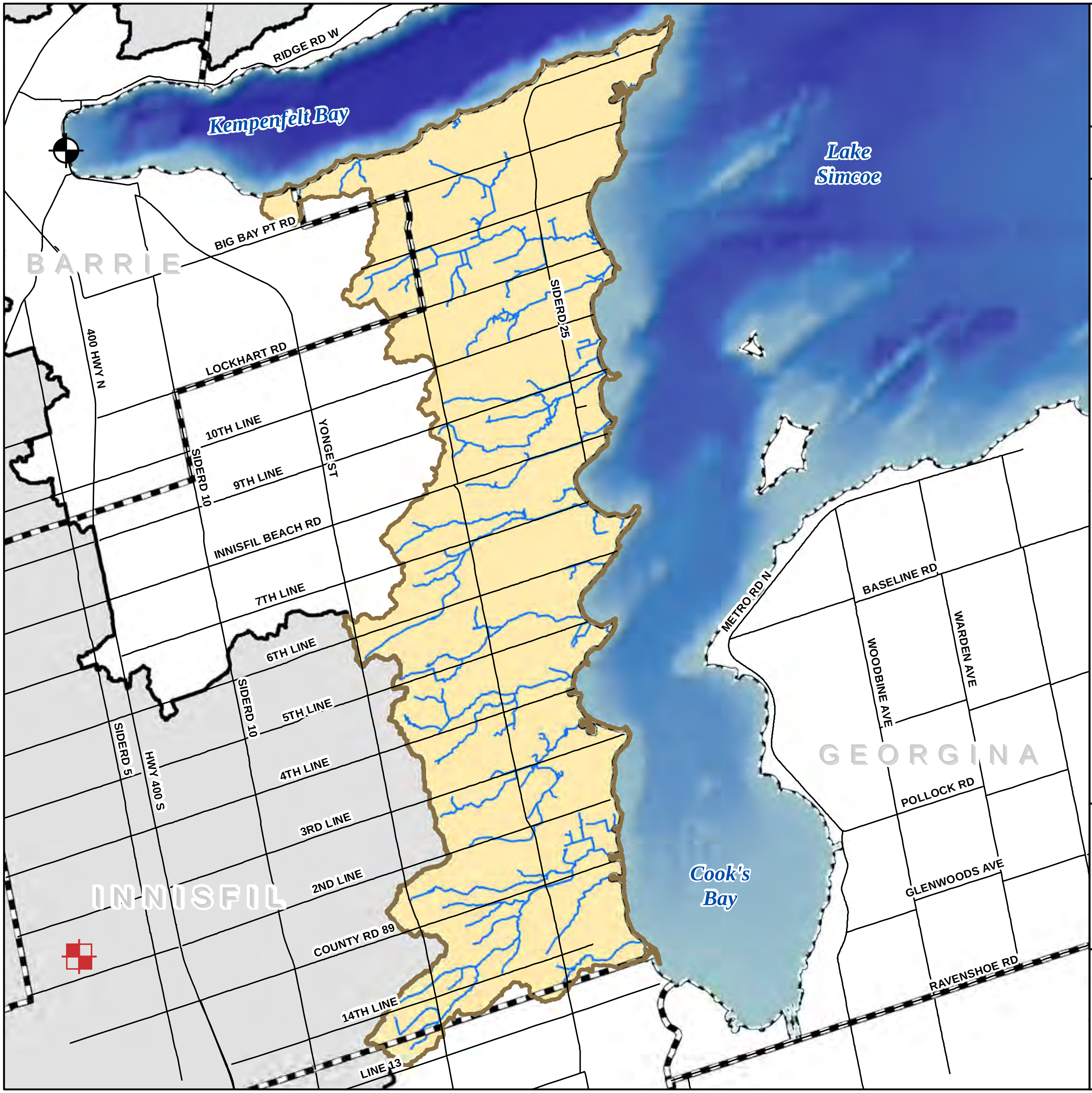
Table 2-8 displays a summary of the climate normals from 1971 to 2001 for the climate stations located within the City of Barrie and the surrounding municipalities (Figure 2-21). Based on the data collected at the Barrie WPCC station, the average mean annual temperature is 6.7 °C, while the total mean annual precipitation is 921 mm/yr. It should be noted that precipitation patterns have become less predictable in recent years, perhaps due to climate change.

Long-term climate data was obtained from Environment Canada stations shown on Figure 2-21 including daily maximum and minimum temperature, daily rainfall and snowfall, and hourly rainfall for the period of 1950-2008. The data gaps were infilled using methods carried out according to the methodology outlined in “Filling gaps in meteorological data sets used for long-term watershed modelling” (H.O Schroeter, D.K. Boyd, and H.R. Whitely) by Schroeter & Associates in 2009. The record period for the Barrie WPCC (6110218) after the data infilling exercise was from 1950-2008.

Table 2-8: Summary of climate normals (1971-2001) for the City of Barrie and surrounding area (modified from AquaResource and Golder, 2010).

Station Name	Elevation (mASL)	Mean Annual Temperature °C			Mean Annual Precipitation		
		Avg.	Min.	Max.	Rainfall (mm)	Snowfall (cm)*	Total (mm)
Angus Camphill	212	6.2	0.4	12.1	636	215	851
Barrie WPCC**	221	6.7	1.7	11.7	683	237	921
Cookstown	244	6.3	1.1	11.4	657	161	818
Essa Ont Hydro	216	6.6	1.5	11.8	670	213	884
Midhurst	226	6.6	1.3	11.9	687	222	908

* The water storage capacity of 1 cm of snow pack is equivalent to 1 mm of rainfall



Location of climate stations in and around the Innisfil Creeks subwatersheds

Figure 2-21

Legend

Climate Station

⊕ LSRCA Station

🟥 NVCA Station

— Road

▬ Municipal Boundary

~ Watercourse

Lake Simcoe Region conservation authority

0 0.5 1 2 3 4 5 Kilometres

N

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LSRCA GIS Services DRAFT created June2011.

2.6.1.1. Temperature

To examine temperature trends for the past 60 years, the daily average air temperature was averaged for each year to produce Figure 2-22 to compare the average annual, average maximum annual, and average minimum annual air temperature. Figure 2-22 gives a general overview of the temperature trends at the Barrie WPCC meteorological monitoring station, illustrating how all appear to fluctuate in relatively the same manner over the years.

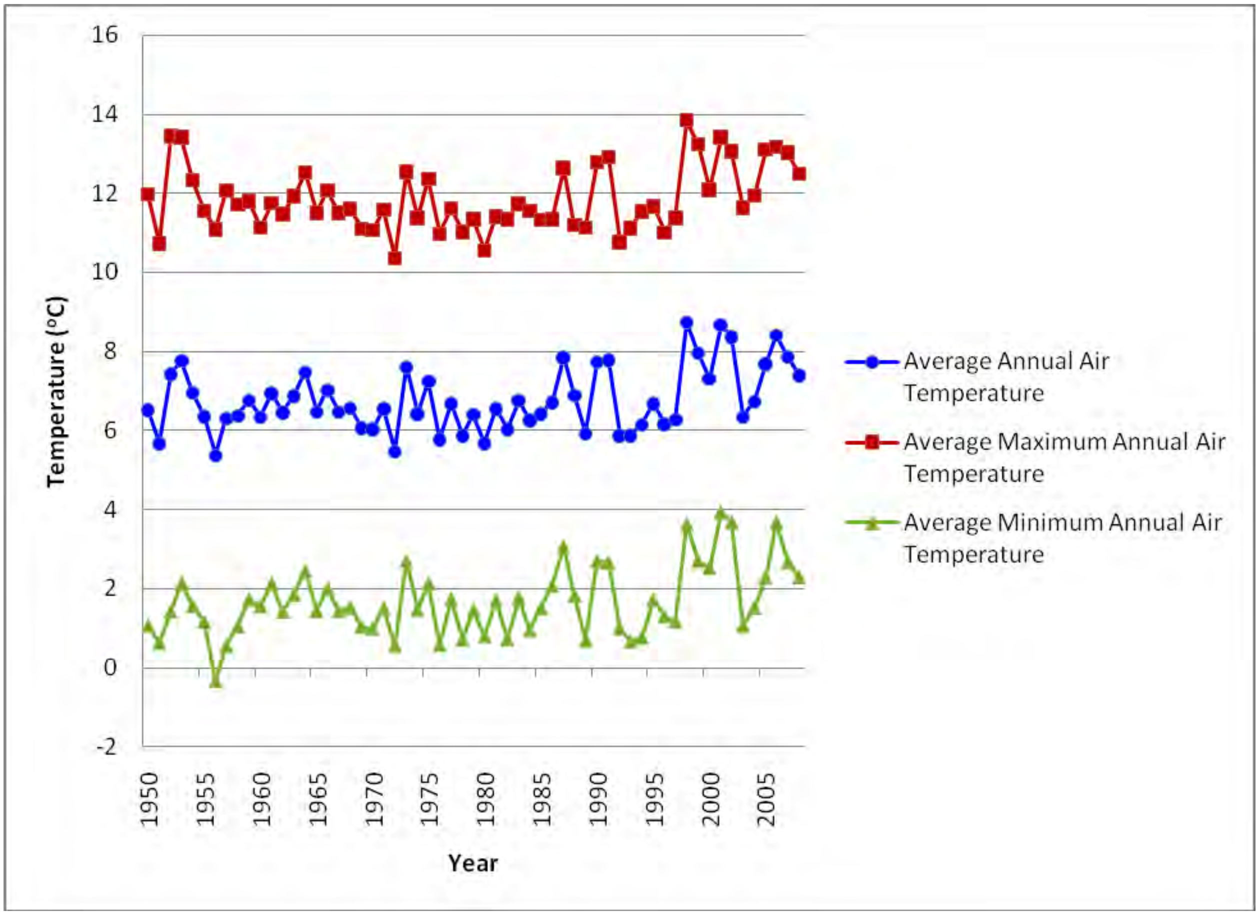


Figure 2-22: Comparison of the average annual, maximum and minimum temperatures at the Barrie WPCC Meteorological Monitoring Station (1950-2008). Source: SGBLS, 2012.

Figure 2-23 displays only the average annual temperature, giving a closer look at the trend for the period of record. From it we can see that there is a gradual increase over the entire period, with this trend becoming more pronounced after 1980. There is a slight decrease at the beginning of the period of record from 1950 through the 1960s, followed by a plateau for the next 20 years or so before starting to increase. Overall, there has been an increase of 0.87°C over the past 60 years.

It should be noted that this is only a broad assessment of temperature trends at the Barrie WPCC meteorological monitoring station.

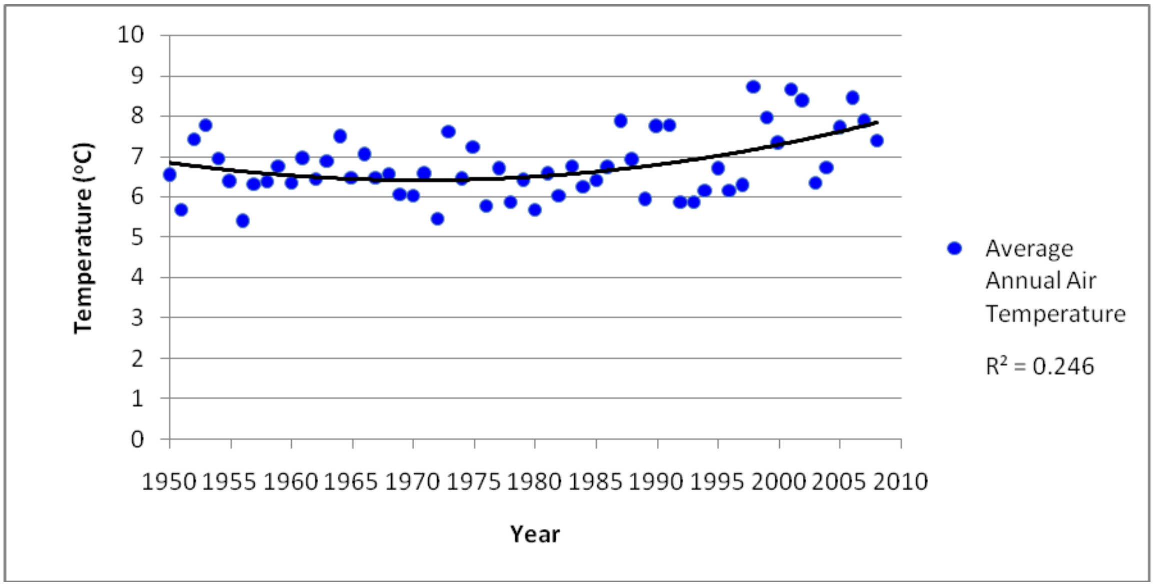


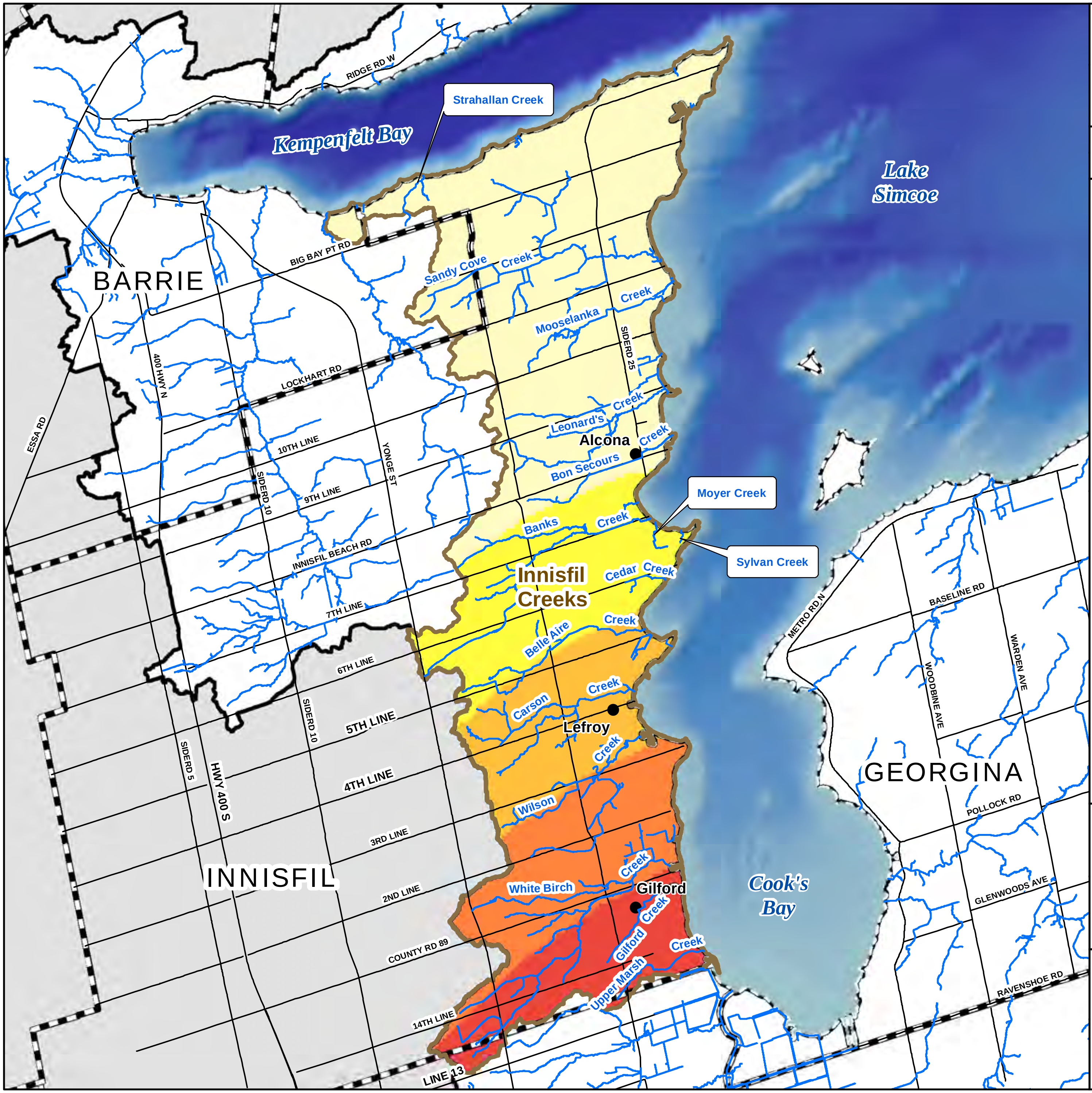
Figure 2-23: Average annual temperature at the Barrie WPCC Meteorological Monitoring Station (1950-2008). Source: SGBLS, 2012.

2.6.1.2. Precipitation

Precipitation is the driving force of the hydrological cycle, influencing aquatic and wetland habitats, as well as urban storm water management needs.

Figure 2-24 illustrates the spatial distribution of annual precipitation over the study area as averaged over the study period and interpolated by the PRMS model (this model is described in **Chapter 4 – Water Quantity**). These data also show that annual average precipitation is fairly uniform across the three subwatersheds.

The mean monthly precipitation measured at Barrie WPCC from 1971-2000 is shown in Figure 2-25 and shows the amount that fell as rain and the amount that fell as snow in each month. Figure 2-26 illustrates the total annual precipitation from 1950 to 2008. Fluctuations in the amount of precipitation, particularly winter precipitation, are somewhat expected at the Barrie WPCC meteorological station due to its close proximity to Lake Simcoe, causing lake effect precipitation events. Overall, there is no significant change in annual precipitation over the past 60 years, but a possible tendency to increasing precipitation since the 1980s.



Annual Precipitation (mm/yr) in the Innisfil Creeks subwatershed as distributed by PRMS

Figure 2-24

Legend

- Road
- Municipal Boundary
- Watercourse
- Innisfil Creeks Subwatershed
- ▲ Stream Gauges

Observed Annual Average Precipitation (mm/yr)

- 🟥 970 - 972
- 🟧 973 - 974
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Lake Simcoe Region conservation authority

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This product was produced by the Lake Simcoe Region Conservation Authority and some information depicted on this map may have been compiled from various sources. While every effort has been made to accurately depict the information, data / mapping errors may exist.
This map has been produced for illustrative purposes only.
LSRCA GIS Services DRAFT TF created November 2011.

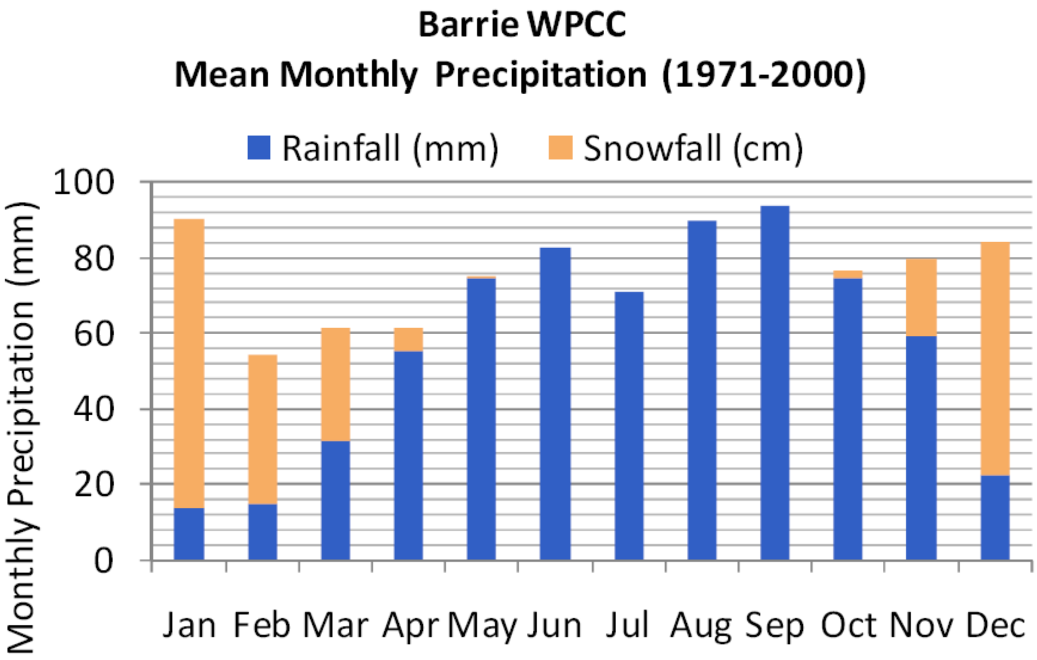

Figure 2-25: Mean monthly precipitation as snowfall and rainfall for Barrie WPCC station (AquaResource *et al*., 2011).

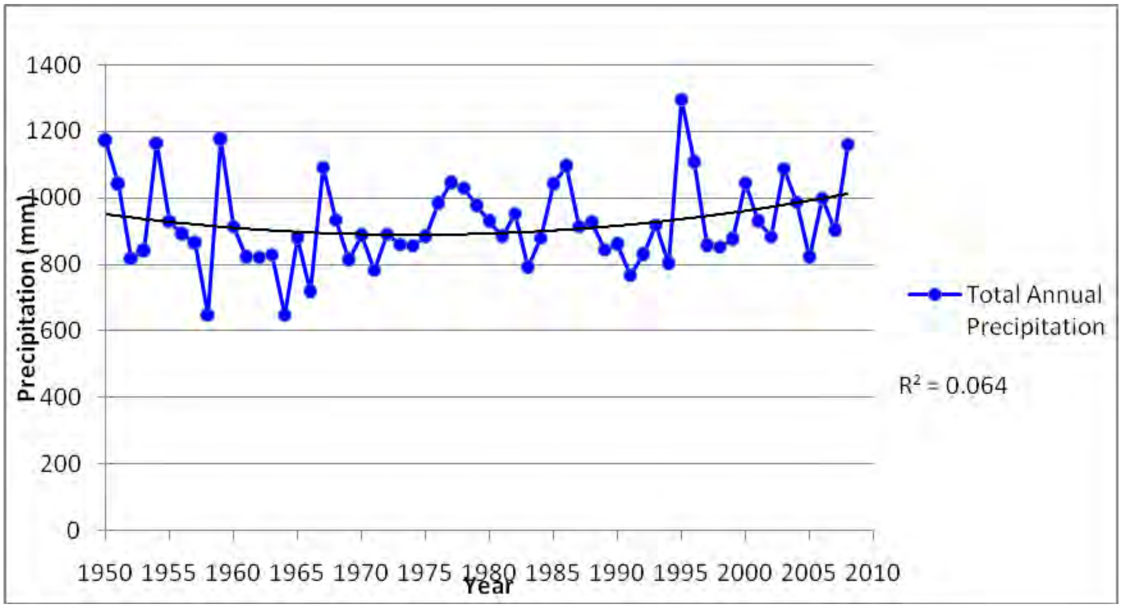

Figure 2-26: Total annual precipitation at the Barrie WPCC Meteorological Monitoring Station (1950 - 2008). Source: SGBLS, 2012.

2.6.1.3. Thermal Stability of Lake Simcoe

The thermal stability of the lake is important as it can have significant impacts on the biological communities within the lake, which in turn can impact the lives of those who rely on the lake as a resource. The thermal stability of the lake refers to the amount of energy needed for a water column to mix completely, overcoming the vertical density differences of thermal stratification. In a system where there is low stability, the lake completely mixes, whereas in a system where there is high stability there is little to no mixing (remains stratified). In Lake Simcoe, which is a dimictic lake, the water column is thermally stratified during the ice-free season, and mixes in the spring and fall. Most winters, it completely freezes over.

To determine if the thermal stability of Lake Simcoe was changing in relation to mean air temperatures (collected at Environment Canada's weather station at Shanty Bay), Stainsby *et al.* (2011) compared the water column stability of the lake at three locations (main basin, Kempenfelt Bay, and Cook's Bay), and the timing of stratification in the spring and turnover in the fall occurred over an approximate 30 year time period (1980-2008). As the Innisfil Creeks subwatershed has section of waterfront along parts of each of these areas, results for all three are included.

Out of the three sampling areas, Kempenfelt Bay generally has higher thermal stability due to its deeper depths (max 42 m; mean 26 m), whereas Cook's Bay tends to have lower thermal stability because of its shallower depths (max 21 m; mean 8 m) and consequently smaller volume of water that needs to mix or stratify (Stainsby *et al.*, 2011).

The first parameter studied was the temperature of Kempenfelt Bay during the ice-free period of the year. Figure 2-27 illustrates the temperature changes in Kempenfelt Bay from 1980 (a) and 2002 (b) as well as the stability of the lake. From it we can see that, in comparison to the 1980 graph, in 2002 there is a high degree of red (warmer temperatures during the ice-free season) and wider contours (the lake begins to stratify earlier in the year and mixes later in the fall, increasing the overall time the lake remains stratified), all of which correspond with the recorded higher lake stability (white line) (Stainsby *et al.*, 2011).

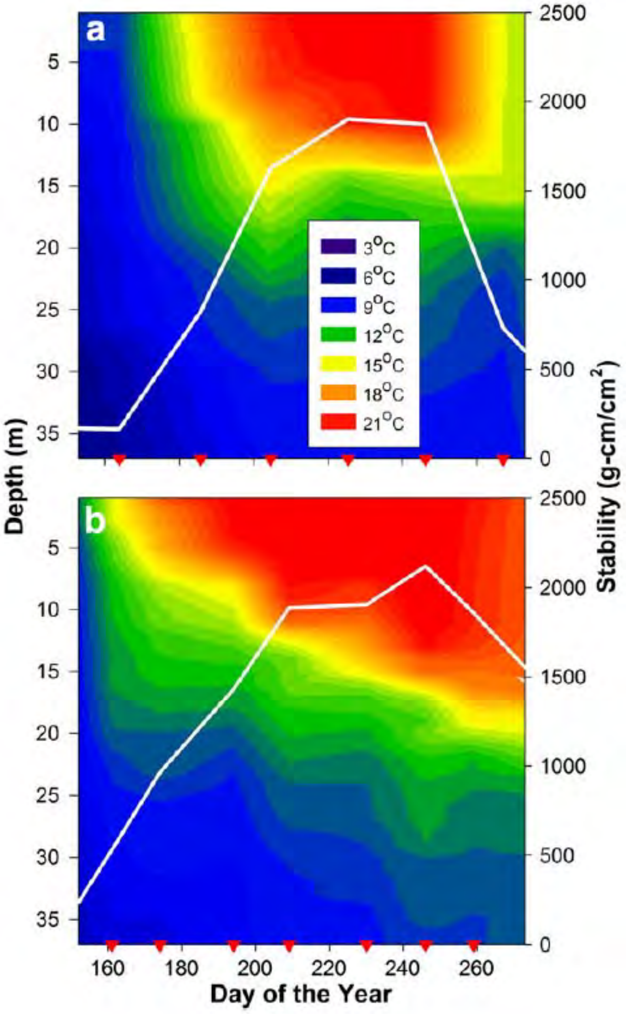

Figure 2-27: Seasonal water column temperature contour in degrees Celsius) and stability (white line) in Kempenfelt Bay in 1980 (a) and 2002 (b). Red triangles show the sampling dates along the x-axis. Source: Stainsby *et al.*, 2011.

To further support these findings, Figure

2-28 illustrates the timing of the onset of stratification in the Kempenfelt Bay (Figure 2-24a), the main basin (Figure 2-28b), and Cook's Bay (Figure 2-28c). It can be seen from the data that the lake is stratifying earlier in the year. As of 2002, stratification is occurring approximately 20 days earlier in Kempenfelt Bay (Figure 2-28a) than it was in 1980. In the main basin stratification is occurring approximately 13 days earlier (Figure 2-34b), while in Cook's Bay, stratification is occurring approximately 25 days earlier (Figure 2-28c).

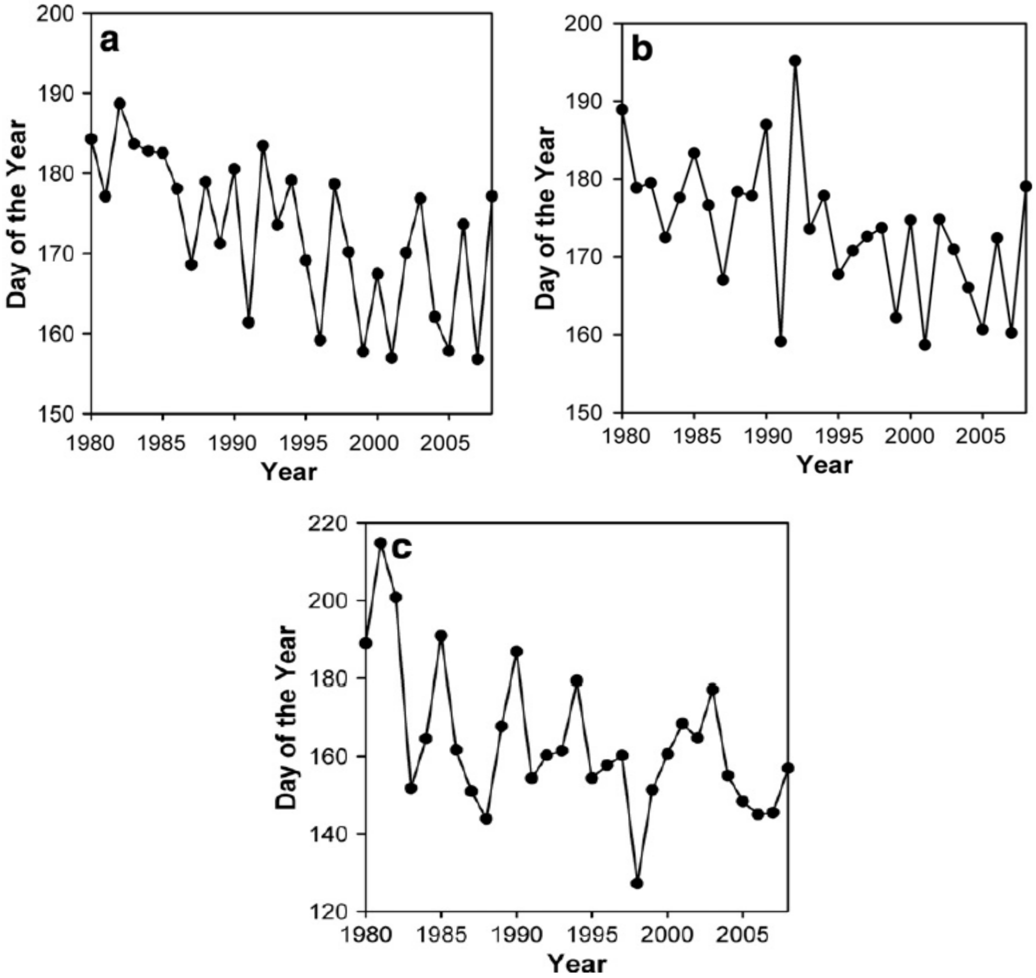

Figure 2-28: The timing of the onset of stratification in (a) Kempenfelt Bay, (b) the main basin, and (c) Cook's Bay. Source: Stainsby *et al.*, 2011.

When looking at the fall turnover, Figure 2-29 shows it to be occurring later and later each year for the different sections of the lake. Between 1980 and 2002, mixing of the water column in the fall is occurring approximately 15 days later in Kempenfelt Bay (Figure 2-29a). In the main basin of Lake Simcoe, fall turnover is occurring 18 days later (Figure 2-29b) and approximately 24 days later in Cook's Bay (Figure 2-29c).

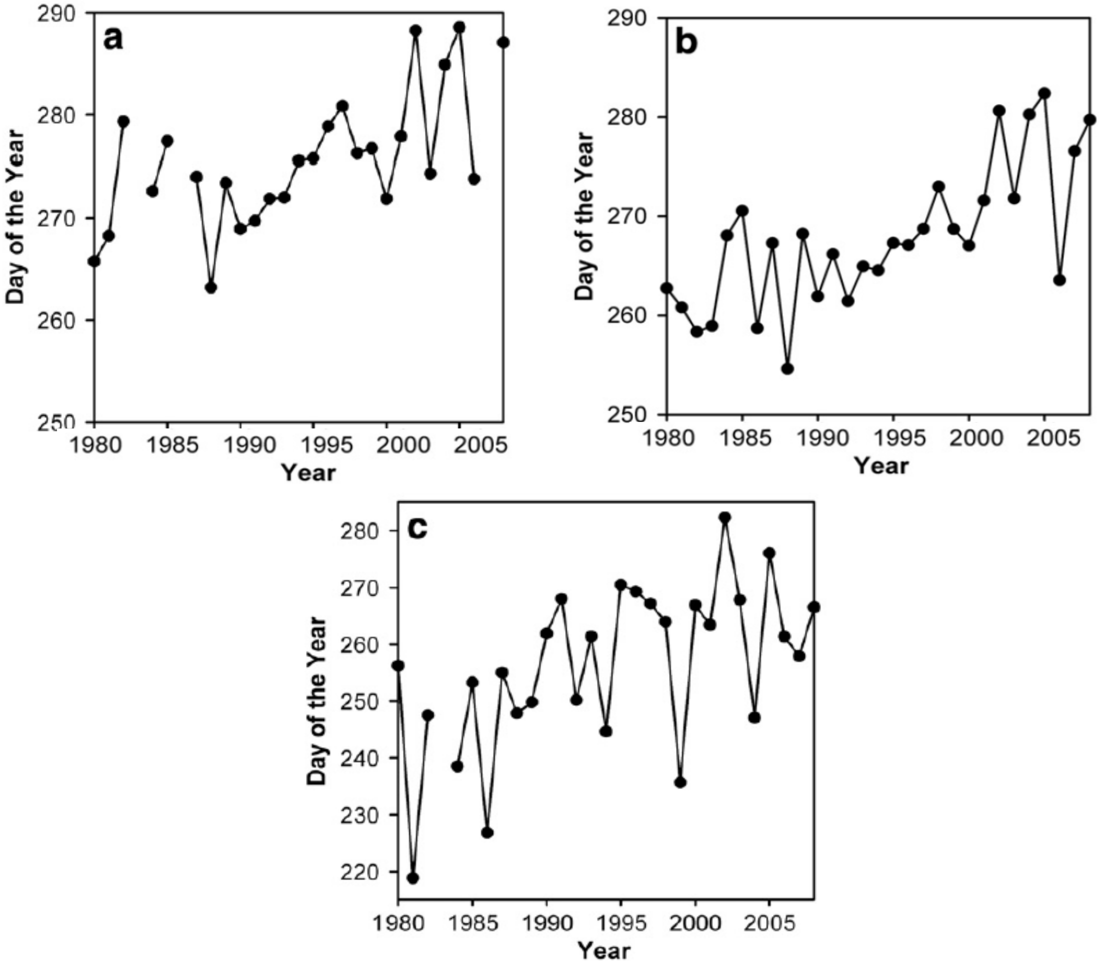

Figure 2-29: The timing of fall turnover in (a) Kempenfelt Bay, (b) the main basin, and (c) Cook's Bay. Source: Stainsby *et al.*, 2011.

Together this means that the lake remains stratified for a longer period of time. A longer stratified period can result in an increase in oxygen depletion in the hypolimnion, which in the deeper zones may create "dead zone" areas where conditions are anoxic. These conditions can also potentially increase the release of nutrients (such as phosphorus) and contaminants from sediments. The impacts of this can include large fish die-offs, decrease in the fisheries, algal blooms (which, when dead and decomposing at the bottom further decrease oxygen levels) and can deteriorate drinking water (Kling, *et al*. 2003).

The length of the stratification period in Kempenfelt Bay and in the main basin has increased approximately 33 days from 1980 to 2008 (Figure 2-30 a and b). In comparison, the changes in the length of time the water column remains stratified were most significant in Cook's Bay where the water column remains stratified 56 days longer (Figure 2-30c).

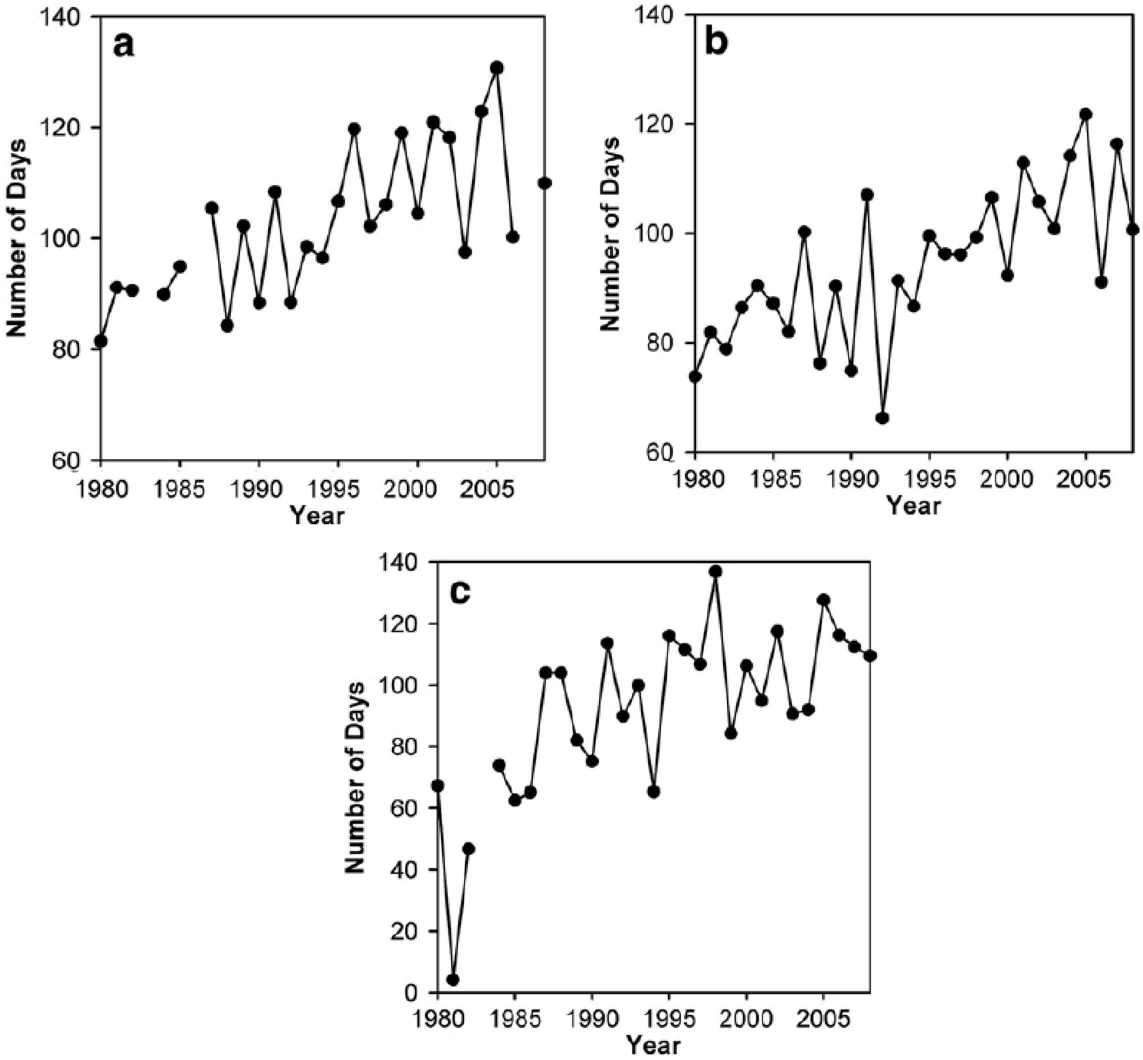

Figure 2-30: The length of the stratified period in (a) Kempenfelt Bay, (b) the main basin, and (c) Cook's Bay. Source: Stainsby *et al.*, 2011.

Many of the impacts already being observed in the Lake Simcoe watershed counteract much of the work the LSRCA and partner municipalities have done to increase dissolved oxygen concentrations and decrease phosphorus levels in Lake Simcoe. To ensure that the efforts taken are successful, despite the impacts of climate change, projects undertaken on tributaries, particularly those that are managed as coldwater need to focus on reducing the temperature and the amount of phosphorus input. This can include an increase in riparian habitat, improved stormwater management, and improvement of construction practices and agricultural practices. Additionally, municipalities are encouraged to include climate change adaptation policies in the Official Plans, to plan for the future and implement pre-emptive measures.

2.6.2 Climate change and predicted scenarios

Climate change can have numerous impacts on ecological systems and those who depend on them. As mentioned in the previous section, an increase in air temperature can increase the thermal stability of the lake, extending the stratified period, as well as changing the composition of biological communities and creating ideal growing conditions for algae and bacteria. An increase in temperature can also cause an increase in evaporation and evapotranspiration, decreasing the amount of water infiltrating into the ground and recharging the groundwater system. Changes in precipitation patterns will also impact the hydrologic cycle, whether these changes show less or more precipitation. Where less precipitation is falling, habitats will experience drought, and be susceptible to fires (terrestrial) and reduction in area (watercourses and wetlands), and less water will be available replenish aquifers. Where more precipitation falls, it is likely that flows will be altered (potentially changing the stream morphology), stormwater retention areas may overflow (releasing contaminants), and there is an increased risk of flooding and property damage. Further impacts of climate change can be found in the following chapters, where applicable, in the stressors section. An important part of addressing these stressors is to gain an understanding of what the changes will be in the future and act accordingly to minimize the impacts. Climate models, used worldwide, give us an estimate of what these possible changes are.

To obtain more accurate projections for parameters such as seasonal and annual temperature and precipitation, an ensemble of climate models are typically run together. The report "Adapting to Climate Change in Ontario: Towards the Design and Implementation of a Strategy and Action Plan" was released by the Expert Panel on Climate Change in November 2009 (EPCCA, 2009). The study included a review of climate change model projections for Ontario, completed by Environment Canada (CCCSN, 2009). The projections were based on a combination of 24 models and divides Ontario into 63 grid cells, one of which covers the Lake Simcoe watershed. Three scenarios were produced based on future amount of greenhouse gas (GHG) emissions (Low, Medium and High).

Table 2-9 lists the projected change in average annual and seasonal temperatures, comparing 1961-1990 to the 2050s. From it we can see under high GHG emissions there is a projected increase in temperature of 3% for the area. All seasons are expected to see at least a 2.2% temperature increase; however the most significant increase is seen during the winter, where there is a projected increase of 2.5 -3.4% based on Low to High GHG emissions.

Table 2-9: Summary of projected change in average annual temperature (°C) in the 2050s compared with 1961-1990 (CCCSN, 2009).

	Projected change in air temperature (°C)		
	GHG emmision scenario		
Season	**Low**	**Medium**	**High**
Annual	2.3	2.7	3.0
Winter	2.5	3.0	3.4
Spring	2.2	2.5	2.8
Summer	2.2	2.6	2.9
Autumn	2.3	2.6	2.8

Table 2-10 lists the projected change in average annual and seasonal temperatures, comparing 1961-1990 to 2050s.Under the high GHG emission scenario, annual precipitation is projected to increase by 5.51%. All seasons are expected to increase by at least 3.06%, with the exception of summer precipitation. As the amount of GHG emissions increase, there is only a slight increase predicted for the Low and Medium emission scenarios, and a decrease in the amount of precipitation of -0.62% under High GHG emission scenario.

Table 2-10: Summary of projected change in precipitation (%) in 2050s compared with 1961-1990 (CCCSN, 2009).

	Projected change in precipitation (%)		
	GHG emmision scenario		
Season	**Low**	**Medium**	**High**
Annual	5.15	5.45	5.51
Winter	9.38	10.19	10.76
Spring	8.58	9.1	9.65
Summer	0.92	0.11	-0.62
Autumn	3.06	3.79	3.82

Despite the use of a combination of multiple models, it is important to note that there is still a very high level of uncertainty associated with the projections. As scientists continue to understand the smaller interactions (i.e. what role clouds play in climate change) and are able to integrate them into the models, this uncertainty will decrease.

3 Water Quality– Surface and Groundwater

3.1 Introduction and background

The chemical, physical and microbiological characteristics of natural water make up an integrated index we define as “water quality”. Water quality is a function of both natural processes and anthropogenic impacts. For example, natural processes such as weathering of minerals and various kinds of erosion are two actions that can affect the quality of groundwater and surface water. There are also several types of anthropogenic influences, including point source and non-point sources of pollution. Point sources of pollution are direct inputs of contaminants to the surface water or groundwater system and include municipal and industrial wastewater discharges, ruptured underground storage tanks, and landfills. Non-point sources include, but are not exclusive to, agricultural drainage, urban runoff, land clearing, construction activity and land application of waste that typically travel to waterways through surface runoff and infiltration. Contaminants delivered by point and non-point sources can travel in suspension and/or solution and are characterized by routine sampling of surface waters in the Lake Simcoe watershed.

The Lake Simcoe Protection Plan (LSPP) identifies a number of targets and indicators related to water quality in Lake Simcoe and its tributaries, which include:

- Reducing phosphorus loadings to achieve a target for *dissolved oxygen* of 7 mg/L in the lake (long-term goal currently estimated at 44 tonnes per year)
- Reducing pathogen loading to eliminate beach closures
- Reducing contaminants to levels that achieve Provincial Water Quality Objectives or better

For the most part, these targets are established to preserve the health of the Lake, rather than its tributaries. As such, the LSPP has also provided indicators to evaluate progress in achieving the water quality targets that can be evaluated in a subwatershed basis. These include:

- Total phosphorus
  - Concentration
  - Loading
- Pathogens
  - Beach closures
- Other water quality parameters, including:
  - Chlorides
  - Other nutrients (e.g. nitrogen)
  - Total suspended solids
  - Heavy metals
  - Organic chemicals

Where information is available, current conditions and trends are provided for the main water quality indicators, as identified by the LSPP.

3.2 Current Status

3.2.1 Measuring Groundwater Quality

Groundwater quality sampling is typically conducted twice annually at all Provincial Groundwater Monitoring Network (PGMN) wells located throughout the Lake Simcoe watershed. Each sample was routinely analyzed for 41 chemical parameters including metals, nutrients and general chemistry. One PGMN well located within the Innisfil Creeks, subwatershed was monitored from 2001 to 2010 (Figure 3-1).

In addition, much work has been done through the *Clean Water Act, 2006* Source Protection Program. As a requirement of the *Clean Water Act, 2006*, Source Water Protection Authorities are required to determine the vulnerability of aquifers to water quality stressors and identifying potential threats to drinking water supply. Results of this vulnerability and threats assessment are presented in the Approved Lake Simcoe and Couchiching-Black River Source Protection Area, Part 1: Lake Simcoe Assessment Report (SGBLS, 2011). This report discusses the three types of vulnerable areas associated with aquifers, these being: (1) Well Head Protection Areas (WHPA); (2) Significant Ground Water Recharge Areas (SGRA); and (3) Highly Vulnerable Aquifers (HVA).

A WHPA is the area around a wellhead where land use activities have the greatest potential to affect the quality of water that flows into the municipal supply well. Location of the WHPAs within the Innisfil Creeks subwatershed can be found in **Chapter 2 - Study Area**.

3.2.2 Measuring Surface Water Quality and Water Quality Standards

Water quality is currently sampled at one station on Leonards Creek under the LSPP (Figure 3-1). Samples collected under the LSPP are collected year round, every three weeks in the winter months (December to March) and every two weeks from April to November. Samples are analyzed for 12 parameters by the Laboratory Services Branch of the Ministry of Environment, and are assessed using the Provincial Water Quality Objectives (PWQO) (Ministry of Environment, 1994). As stated by the Ministry of Environment, the goal of the PWQO is to protect and preserve aquatic life and to protect the recreational potential of surface waters within the province of Ontario. Meeting the PWQO is generally a minimum requirement, as one has to take into account the effects of multiple guideline exceedances, overall ecosystem health, and the protection of site-specific uses. In instances where a chemical parameter is not included in the PWQO, the Canadian Water Quality Guidelines for the Protection of Aquatic Life (CWQG) are applied (Environment Canada, 2003). The CWQG were developed by the Environmental Quality Branch of Environment Canada to protect aquatic species by establishing acceptable levels for substances that affect water quality and are based on toxicity data for the most sensitive species found in streams and lakes of Canada. Some of the water quality variables of greatest concern for the Innisfil Creeks subwatershed are summarized in Table 3-1.

Table 3-1: A summary of surface water quality variables and their potential effects and sources

Variable	Effects	Sources	Objective/Guideline
Chloride	Control of excess chloride levels is important to protect the aesthetics and taste of drinking water. High levels may also have an impact on aquatic life. Background concentrations in natural surface waters are typically below 10 mg/L.	The largest source of chloride is from road salt applications during the winter months. Other sources include waste water treatment, industry, potash used for fertilizers	CCME (draft June 2010): CWQG for protection of freshwater aquatic life is 128 mg/L for chronic (long-term) exposure and the benchmark concentration is 586 mg/L for acute (short-term) exposure.
Total Phosphorus	Phosphorus promotes eutrophication of surface waters by stimulating nuisance algal and aquatic plant growth, which deplete oxygen levels as they decompose resulting in adverse impacts to aquatic fauna and restrictions on recreational use of waterways.	Sources include lawn and garden fertilizers, animal wastes, eroded soil particles and sanitary sewage.	Interim PWQO: 0.03 mg/L to prevent excessive plant growth in rivers and streams.
Total Suspended Solids (TSS)	Elevated concentrations reduce water clarity which can inhibit the ability of aquatic organisms to find food. Suspended particles may cause abrasion on fish gills and influence the frequency and method of dredging activities in harbours and reservoirs. As solids settle, coarse rock and gravel spawning and nursery areas become coated with fine particles, limiting the ecological function of these important areas. Many pollutants are readily adsorbed and transported by suspended solids, and may become available to benthic fauna.	TSS originates from areas of soil disturbance, including construction sites and farm fields, lawns, gardens, eroding stream channels, and grit accumulated on roads	CWQG: 25 mg/L + background (approx 5 mg/L) for short term (<25 hr) exposures. EPA (1973(and European Inland Fisheries Advisory Commission (1965): no harmful effects on fisheries below 25 mg/L
Metals	Heavy metals generally have a strong affinity to sediments and can accumulate in benthic organisms, phytoplankton, and fish. Several heavy metals are toxic to human health, fish and other aquatic organisms at low concentrations.	Most metals in surface runoff are associated with automobile use, wind-blown dusts, roof runoff and road surface materials	PWQOs: Copper: 5 μg/L Zinc: 20 μg/L Lead: 5 μg/L Iron: 300 μg/L

Water quality monitoring sites in the Innisfil Creeks subwatershed

Figure 3-1

Legend

―	Road
▬ ▬	Municipal Boundary
~	Watercourse
▨	Historic Water Quality Station
⊕	Water Quality Stations (LSPP)

Lake Simcoe Region conservation authority

0 0.5 1 2 3 4 Kilometres

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LSRCA GIS Services DRAFT created July 2010.

3.2.2.1. Temperature Collection

The MNR/DFO protocol ("*A Simple Method to Determine the Thermal Stability of Southern Ontario Trout Streams*" (Stoneman, C.L. and M.L. Jones 1996), Figure 5-1 in **Chapter 5 - Aquatic Natural Heritage**) suggests that trout streams are considered to be coldwater if they have an average maximum summer temperature of approximately 14°C. Cool water sites are considered to have average maximum summer temperatures of 18°C. Warm water sites have an average maximum daily water temperature of 23°C.

To monitor these temperatures, electronic data loggers are installed throughout the Lake Simcoe watershed during the hot summer months. They are installed in late May/early June and then retrieved in late September/early October each year. The loggers are used to monitor the daily fluctuations in water temperature of the watercourse over the summer. They are set to take a temperature reading every hour for the entire study period. Periodic checking of the loggers throughout the summer is necessary for quality control purposes. Once the loggers are retrieved in early Fall from the various stream locations, the data is downloaded and then compared to the air temperature data over the same period of time. Using an Excel spreadsheet, the maximum, minimum and mean temperatures for each day are graphed. There is some emphasis placed on the daily high temperatures and average maximum temperatures specifically in cold water stream conditions. The various streams can then be classified as cold, cool or warm (see **Chapter 5 - Aquatic Natural Heritage**, for figure displaying temperature of creeks). Daily minimum stream temperatures are used to observe stream recovery from periods of extended warming and the influence of groundwater/baseflow in the individual system.

The LSRCA has been collecting temperature data for approximately six years in the Innisfil Creeks subwatershed (Note: data has been collected to characterize the watercourses, so for some sites this means data has only been collected once, while others that are being monitored for long term trends are collected every year). While this has been sufficient for increasing our understanding of where coldwater systems are found in the subwatershed, it is difficult at this point to see any trends or patterns in the data for most sites. There are factors influencing water temperature in addition to upstream and surrounding land use, including air temperature and the amount of precipitation, which make it difficult to analyze trends in water temperature.

3.2.2.2. Beach Monitoring

Public beaches in the Town of Innisfil are monitored every year, from June to the end of August, to ensure that the quality water (in terms of bacteria) is safe for swimmers. Typically, a there is a minimum of five sampling sites at each beach that are spread out to be representative of the whole beach area. Samples are normally taken once a week, but additional samples will be taken under certain conditions. Samples are sent to the Provincial Laboratory and analyzed for *E.coli* bacteria (key indicator of fecal pollution). Other parameters are not tested for unless deemed necessary. Additional data that is recorded at the time of sampling include weather conditions, whether there was rain in the previous two days, wind direction, degree of wave action, number of bathers, number of water fowl and/or animals in the area and clarity of the water (Simcoe Muskoka Health Unit, 2011).

Innisfil Beach Park

3.2.3 Groundwater Quality Status

Within the Innisfil Creeks subwatershed, WHPAs have been delineated for the Golf Haven and Goldcrest Well Supplies. An assessment of potential Significant Threats was undertaken within each WHPA, with potential threats associated with individual septic systems being the most common threat identified for the Golf Haven Well Supply and a variety of land uses (residential, commercial, agricultural) for the Goldcrest Well Supply (SGBLS, 2011).

For more in-depth information on the drinking water systems in this subwatershed, see the Approved Lakes Simcoe and Couchiching – Black River Source Protection Area, Part 1: Lake Simcoe Watershed Assessment Report (SGBLS, 2011). Individual studies completed by consultants on the water quality of the drinking water sources are available in the Assessment Reports Appendix I for the Town of Innisfil.

3.2.4 Surface Water Quality Status

Water quality sampling at Leonard's Creek has been ongoing since 2008 which unfortunately is not long enough to examine the data for trends. While metals are not collected under LSPP sampling, an examination of chloride, phosphorus and TSS in Table 3-2 shows phosphorus to be the main parameter of concern for Leonard's Creek. The proportion of phosphorus samples meeting the PWQO is only slightly greater than 50%. The median concentration of the data set is 0.029 mg/L only slightly below the PWQO of 0.03 mg/L. A scatter plot of phosphorus data is displayed in Figure 3-2. Further sampling is necessary to better characterize the phosphorus concentrations in the system due to the short period of record and also to capture the full range of flow conditions and seasonality. Table 3-2 also shows the vast majority chloride and TSS concentrations and all nitrate concentrations are meeting the relevant guideline. As there is relatively little urbanization in the catchment it is expected that chloride concentrations would be lower, compared to other subwatersheds, and only one sample from the 2008-2010 period of record has exceeded the CWQG of 128 mg/L. None of the samples exceeded the CWQG acute toxicity guideline[1] of 586 mg/L.

Table 3-2: Current surface water quality conditions for Leonard's Creek (2008-2010).

Monitoring Station	Current Conditions (2008 – 2010) Percentage of samples that meet objectives Orange = median Concentration >objective Green = median Concentration < objective			
	Chloride	Phosphorus	Nitrate	TSS
Leonards Creek	99	55	100	94
Objective	**128 mg/L**	**0.03mg/L**	**2.9 mg/L**	**30 mg/L**

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[1] An estimate of the point at which severe effects to the aquatic ecosystem are likely to occur over a 24 to 96 hour exposure period.

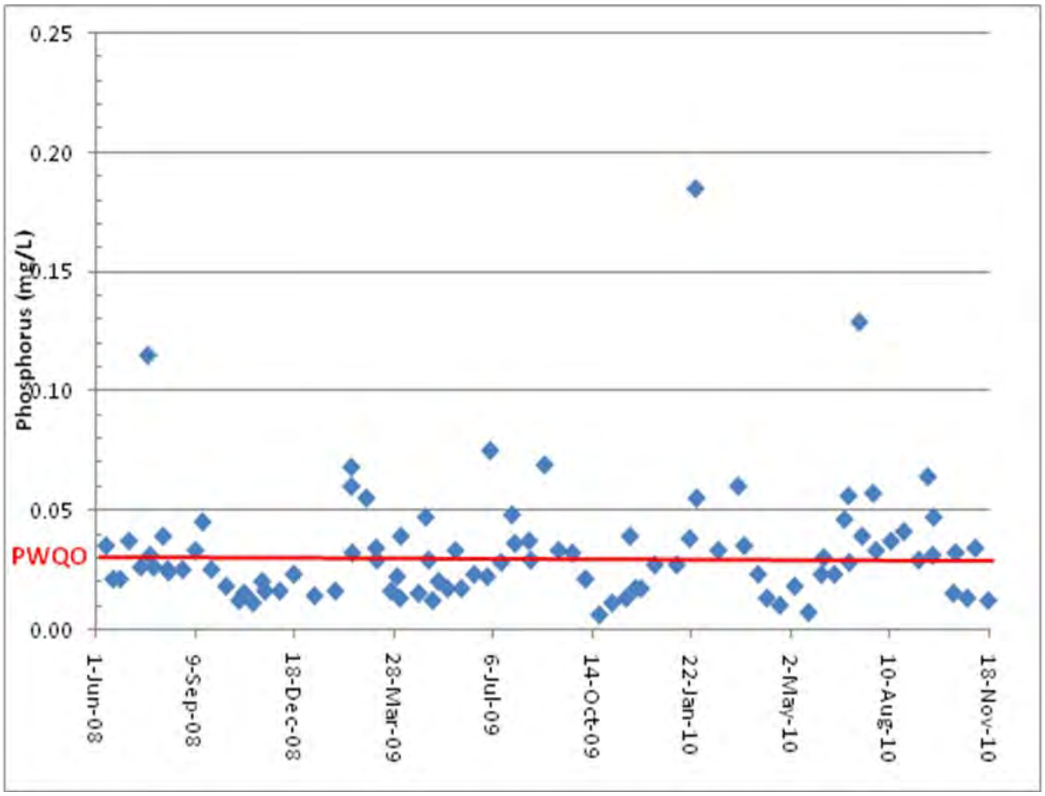


Figure 3-2: Leonard's Creek phosphorus concentrations (mg/L), 2008-2010.

With much of the Innisfil Creeks catchments supporting similar land use characteristics to the Leonard's Creek catchment it is likely that the water quality issues are similar across much of the subwatershed. Indeed as the biologic data shows (**Chapter 5 - Aquatic Natural Heritage**) the majority of creeks received benthic invertebrate scores in the 'good' to 'fairly poor' range which is primarily based on the degree of organic pollution. The Leonard's Creek benthic invertebrate score at the water quality station is 'fair', indicating fairly significant organic pollution, which is likely a reflection of the phosphorus concentrations recorded in the water quality samples. As such it is reasonable to assume that the benthic scores in the other creeks are being driven by phosphorus concentrations and would be seeing concentrations and guideline exceedances in the range of those at Leonard's Creek. Unless mitigation measures are put in place, it is also likely that water quality issues within the systems will shift as a result of the land use changes (i.e. as development replaces agriculture, metals may continue to rise and become a greater issue, while nitrate may see a decreasing trend and become less of an issue). Recommendations at the end of this chapter provide direction to avoid further decline in water quality. For comparison, Table 3-3 displays current water quality trends for key parameters at long term stations throughout the Lake Simcoe watershed.

Table 3-3: Current water quality onditions in the Lake Simcoe watershed

Monitoring Station	Current Conditions (2006 – 2010) Percentage of samples that meet objectives Orange = median Concentration >objective Green = median Concentration < objective							Current Condition Trend Analysis (2002-2010)$^{+}$ Orange = Increasing Grey = no significant trend Green = Decreasing						
	Chloride	Phosphorus	Nitrate	TSS	Iron	Zinc	Copper	Chloride	Phosphorus	Nitrate	TSS	Iron	Zinc	Copper
West Holland River *	95	8	97	89	76	100	91	🟩	▨	▨	🟩	▨	▨	🟧
Tannery Creek	60	9	100	66	34	94	89	🟩	🟧	🟩	🟧	🟧	▨	🟧
Mt. Albert Creek	100	14	100	74	56	100	94	🟧	🟧	▨	🟧	🟧	▨	🟧
Beaver River*	100	74	98	95	83	97	100	▨	▨	▨	▨	🟧	▨	🟧
Pefferlaw River*	100	53	100	97	89	97	97	🟧	▨	▨	▨	▨	▨	🟧
Lovers Creek*	67	65	100	87	65	100	97	🟧	🟧	🟩	▨	▨	🟧	🟧
Schomberg River	100	19	99	79	33	100	94	🟧	▨	🟩	▨	▨	▨	🟧
Maskinonge River**	92	6	100	93	17	97	83	▨	▨	▨	▨	n/d	n/d	n/d
East Holland River*	33	3	100	44	3	89	71	▨	▨	🟩	▨	▨	▨	🟧
Black River*	98	36	100	99	80	100	100	🟧	▨	▨	🟧	▨	▨	🟧
Hawkestone Creek*	99	83	100	97	89	100	97	▨	🟧	🟩	▨	🟧	▨	🟧
Uxbridge Brook	100	31	100	89	74	97	97	🟧	▨	▨	▨	🟧	▨	▨
Objective	128 mg/L	0.03 mg/L	2.9 mg/L	30 mg/L	300 µg/L	20 µg/L	5 µg/L							

* Chloride, Phosphorus and Nitrate Trends for this station = 2000 to 2010.
** All trends for this station are 2003-2010

3.2.2.3. Beach Postings

The Simcoe Muskoka Health Unit (SMU) collects samples at each of the beaches in the City of Barrie and Town of Innisfil, to test for *E.Coli* levels. Table 3-4 and Table 3-5 list each of the beaches in the municipalities and indicate which years had an advisory or closure posted, and for how many days.

An advisory indicates that bacteria levels in the water are at a concentration that could potentially cause minor skin, eye, ear, nose, and throat infections and stomach disorders. Warning signs are posted at the beach and those who still choose to swim are advised to not put their head under water or swallow the water.

A closure, which rarely occurs, happens when there is a catastrophic event or an immediate risk to health present. Examples that could cause a beach closure include sewage spills or toxic chemical release, etc.

In the Town of Innisfil, there were no beach closures in the 2006-2011 period of record. Only Killarney Beach has had no advisory postings, while each of the other seven beaches had had at least one advisory posting, with Alcona North Beach having one (sometimes multiple) advisories every year except in 2007 and 2011. Leonard's Beach has also had at least one advisory posting every year, except for 2009 and 2010 (Table 3-4).

Table 3-4: List of beach postings in the Town of Innisfil, 2006-2011 (SMU, 2011).

Beach	Year	Posting	# of days
9Th Line Beach	2006	Advisory	9
		Advisory	2
		Advisory	n/a
	2007/2008/2009/2010/2011	-	
Alcona North Beach	2006	Advisory	9
		Advisory	6
		Advisory	n/a
	2007	-	
	2008	Advisory	3
	2009	Advisory	3
		Advisory	3
	2010	Advisory	2
		Advisory	1
		Advisory	14
	2011	-	
Alcona South Beach	2006	Advisory	2
		Advisory	n/a
	2007	Advisory	2
	2008	Advisory	3
	2009	-	
	2010	Advisory	n/a
	2011	-	

Beach	Year	Posting	# of days
Crescent Harbour Beach	2006	-	
	2007	Advisory	8
	2008/2009/2010/2011	-	
Gilford Beach	2006/2007/2008/2009/2010/2011	-	
Innisfil Centennial Park	2006	Advisory	n/a
	2007/2008/2009/2010/2011	-	
Killarney Beach	2006/2007/2008/2009/2010/2011	-	
Leonard's Beach	2006	Advisory	1
		Advisory	1
		Advisory	7
	2007	Advisory	8
	2008	Advisory	1
	2009/2010	-	
	2011	Advisory	15
		Advisory	8

Since 2006, beaches in the City of Barrie have only been closed once. In August 2006 there was major sewage spill, creating a large brown stain in the water. Beaches were immediately closed as a precaution, but when the brown, murky water was tested, bacteria levels were not higher than normal. Minets Point and Tyndale Beaches also experienced one advisory in that year. Since then, Minets Point Beach has had an advisory posting in 2009, 2010 and two in 2011. Wilkins Beach had one advisory posting in 2011 (Table 3-5).

Table 3-5: List of beach postings in the City of Barrie 2006-2011 (SMU, 2011).

Beach	Year	Posting	# of days posted
Barrie Centennial Park	2006	Closure	1
	2007/2008/2009/2010/2011	-	
*Gables Beach	2006	Closure	1
Johnsons Beach	2006	Closure	1
	2007/2008/2009/2010/2011	-	
Minets Point Beach	2006	Advisory	2
		Closure	1
	2007/2008	-	
	2009	Advisory	2
	2010	Advisory	8
	2011	Advisory	7
		Advisory	2
Tyndale Beach	2006	Advisory	3
		Closure	1
	2007/2008/2009/2010/2011	-	

Beach	Year	Posting	# of days posted
Wilkins Beach	2006	Closure	1
	2007/2008/2009/2010	-	
	2011	Advisory	2

** In 2007, the Simcoe Muskoka Health Unit (SMU) removed Gables Beach from the beach water monitoring program.*

Johnsons Beach – City of Barrie

Key points – Current Water Quality Status:

- Groundwater sampling at the one PGMN well from 2001 to 2010 showed no exceedances of guidelines for the 184 parameters analyzed.
- Through the Source Protection Program, potential Significant Drinking Water Threats were identified in association with individual septic systems for the Golf Haven Well Supply, and a variety of land uses (residential, commercial, agricultural) for the Goldcrest Well Supply.
- Surface water is sampled at only one creek, Leonard's, in the Innisfil Creeks subwatershed and only has data from 2008-2010, too short to establish trends.
- While the majority of samples for all parameters (chloride, phosphorus, nitrate and TSS) where below the PWQO objectives, the proportion of phosphorus samples meeting this guideline were only slightly greater than 50%. As such, phosphorus appears to be the main parameter of concern for Leonard's Creek, which is the only watercourse from which water quality samples are taken.
- In 2011, there were two advisory postings at Leonard's Beach, one at Wilkins and two at Minets Point Beach. Beaches have not been closed in the Town of Innisfil during the 2006-2011 period of record, and have only been closed once (2006) in the City of Barrie, after a major sewage spill.

3.3 Factors impacting status - stressors

There are numerous factors that can have an effect on the water quality of the ground and surface water within these subwatersheds. These include:

- Phosphorus,
- Chloride,
- Sediment,
- Thermal degradation,
- Pesticides,
- Metals,
- Bacteria
- Emerging contaminants,
- Uncontrolled stormwater and impervious surfaces,
- Recreation, and
- Climate change.

These factors are discussed further in the following sections.

3.3.1 Groundwater

Because groundwater moves more slowly and is subject to natural filtering as it moves through the soil, the quality of groundwater is most often better than that of surface water. As the water moves through the soil, contaminants are subject to the processes of adsorption, where they are bound to soil particles; precipitation; and degradation over time. These processes serve to improve the quality of the water.

There are some substances that can easily move through the groundwater system without attenuation by any of the aforementioned processes. The most notable of these is chloride from road salt. Further, if a contaminant source is located near a discharge area, there may not be sufficient time and distance for natural filtering to occur. There are also some parameters, including iron and chloride, which are naturally found within some groundwater aquifers.

Groundwater quality can also be impacted by anthropogenic factors. In rural areas, levels of contaminants including bacteria, phosphorus, nitrates, and road salt can become elevated where the groundwater is beyond the capacity of the natural filtration capability of the soils. Sources of contaminants in these areas are fertilizers, improperly functioning septic systems, manure storage facilities, and road salt application. In urban areas, groundwater can be subject to contamination by road salt, hydrocarbons, metals, solvents, bacteria, phosphorus, and other nutrients. Groundwater contamination becomes an issue where it is discharged to the surface and is used by animals or humans. As mentioned in Section 3.2.3, the Golf Haven and Goldcrest Well Supplies had no contaminants identified as Drinking Water Issues or Conditions, however possible Significant Threats were identified related to individual septic systems (Golf Haven) and a variety of land uses (Goldcrest).

3.3.2 Surface Water

3.3.2.1. Phosphorus

One of the most significant causes of water quality degradation in Lake Simcoe and its tributaries is an excess of phosphorus. Phosphorus promotes the eutrophication of surface waters by stimulating excessive growth of plants and algae. This impairs both the aquatic communities (the decomposition of this extra plant material depletes dissolved oxygen levels, particularly in the deeper parts of the lake where there is critical coldwater species habitat) and recreational opportunities (restricts recreational use of waterways, washes up on beaches, creates a negative aesthetic view along the shoreline, etc).

Phosphorus occurs naturally in the environment and is a vital nutrient needed by both plants and animals. However, current land uses have increased the phosphorus loading to Lake Simcoe from an estimated 32 T/yr (prior to settlement and land clearing in the 1800s) to a current estimated 72 T/yr (MOE, 2010). Rural and agricultural land uses make up the majority of the Innisfil Creeks subwatershed land area (48%). Both runoff from pastures and crop land, as well as wind which erodes topsoil, contribute to the phosphorus loading in this subwatershed. Urban land use makes up only 15% of this subwatershed, but still contributes a considerable amount to the phosphorus loading through stormwater runoff (discussed further in Section 3.3.2.9).

Phosphorus load estimates were originally calculated in the *Assimilative Capacity Studies, 2006*, but have since been updated by the original authors, the Louis Berger Group, in a report completed in September, 2010, entitled '*Estimation of the Phosphorus Loadings to Lake Simcoe*'. A watershed model (CANWET) that estimates nutrient loads based on inputs such as land use, precipitation and soil type was used for both the ACS and the updated study. The following table (Table 3-6) presents the average yearly phosphorus loads derived from each source in the subwatersheds under current conditions, the approved growth scenario, and the approved growth scenario with implementation of agricultural BMPs. Urban BMPs are not considered in this particular study as the model used did not consider them, but the model is currently being updated and future versions of this Plan will include the amount of phosphorus that can be reduced through urban BMPs. However, in Section 3.3.2.9 (Uncontrolled stormwater and impervious surfaces), BMPs related to retrofit opportunities for stormwater ponds and the resulting phosphorus reduction are presented for the subwatershed.

The primary sources of phosphorus in the Innisfil Creeks subwatershed, under existing conditions, are derived from septic systems (23%), crop land (22.8%) and high intensity development (21%). Under the approved growth scenario, there is a projected increase in total phosphorus loads of 29% without the implementation of agricultural BMPs (does not consider urban BMPs). The projected phosphorus load under the approved growth scenario can be reduced by approximately 5.6% through the implementation of BMPs (Table 3-6). Taken together, this suggests that with agricultural BMP implementation under the committed growth scenario, phosphorus loading will still increase by 21.8% compared to the current estimated load if all committed growth plans are implemented. When compared to all the subwatersheds in the Lake Simcoe watershed, Innisfil Creeks is the 6th highest contributor of total phosphorus to the lake, based on current conditions. Under the committed growth scenario, it will still be the 6th highest contributor (Berger, 2010a).

Table 3-6: Phosphorus loads by source for the Innisfil Creeks subwatershed associated with agriculture BMP scenarios (Berger, 2010a).

Source	**Existing (kg/year)**	**Committed Growth Scenario (kg/year)**	**Change (Existing Condition to Committed Growth)**	**Committed Growth (with BMPs) (kg/year)**	**Change (Committed Growth scenario with BMP implementation)**	**% Change (with BMP implementation)**
Hay/Pasture	67	63	-4	62	-1	-2%
Crop Land	796	748	-48	519	-229	-31%
Turf-Sod	10	8	-2	8	0	0
Tile drainage	170	158	-12	158	0	0
Low intensity development	21	21	0	21	0	0
High intensity development	729	1,466	737	1,466	0	0
Septics	816	816	0	816	0	0
Polder	0	0	0	0	0	0
Quarry	29	28	-1	28	0	0
Unpaved road	20	20	0	20	0	0
Transition	8	6	-2	6	0	0
Forest	8	7	-1	7	0	0
Wetland	0	0	0	0	0	0
Stream bank	114	120	6	96	-24	-20%
Groundwater (shallow subsurface flow)	444	416	-28	416	0	0
Point sources	258	629	371	629	0	0
TOTAL	**3,490**	**4,504**	**1,014**	**4,250**	**-254**	**-6%**

▨ *- Based on Strategic Direction #3 in the Phosphorus Reduction Strategy, future development should be moving to no net increase in phosphorus. Currently our understanding is that the province is working on a phosphorus reduction tool to ensure this.*

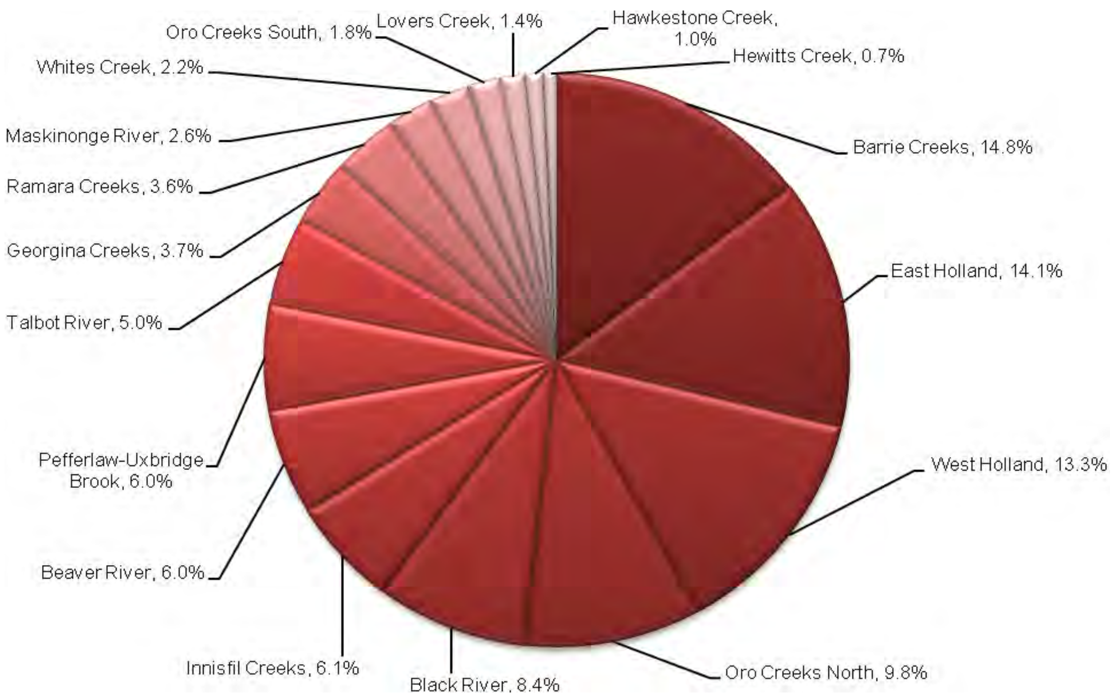


Figure 3-3: Percent phosphorus loads to Lake Simcoe per subwatershed under current conditions (data: Berger, 2010).

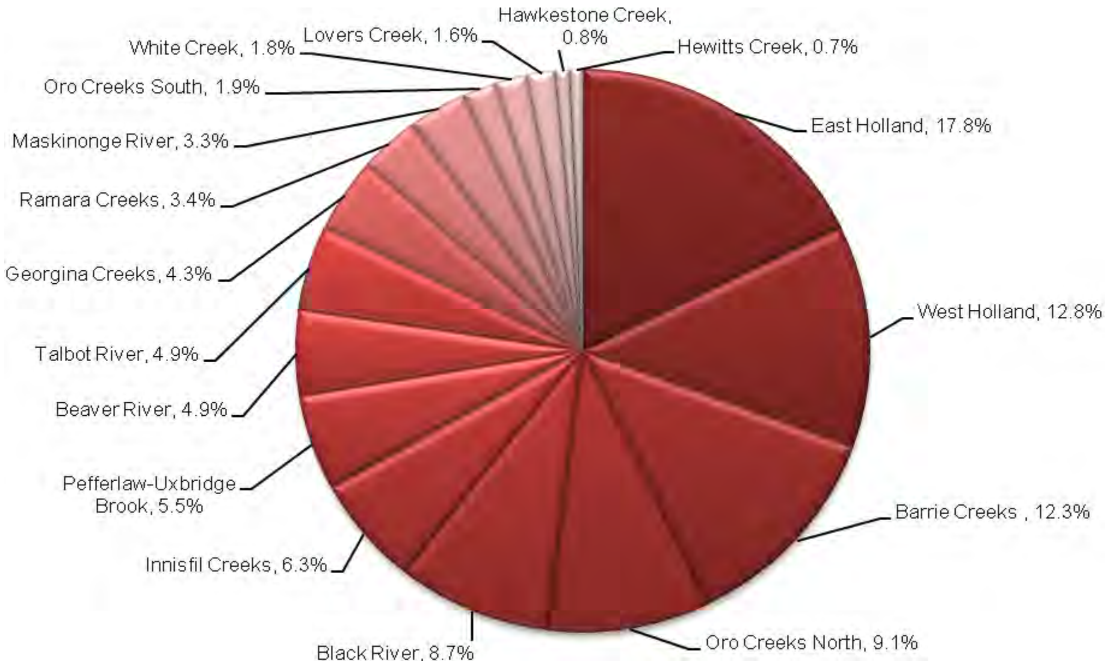


Figure 3-4: Percent phosphorus loads to Lake Simcoe per subwatershed under committed growth scenario (data: Berger, 2010).

Another way to look at the phosphorus loading of each subwatershed is the amount per year per hectare. Figure 3-5 illustrates this, showing that Innisfil Creeks is the 6th largest contributor per hectare to Lake Simcoe. While Innisfil Creeks has the same ranking as in Figure 3-3, the large difference is seen in the Barrie Creeks subwatershed, which becomes the highest contributor per hectare, with almost three times Oro Creeks North which is the second highest contributor per hectare in the Lake Simcoe watershed.

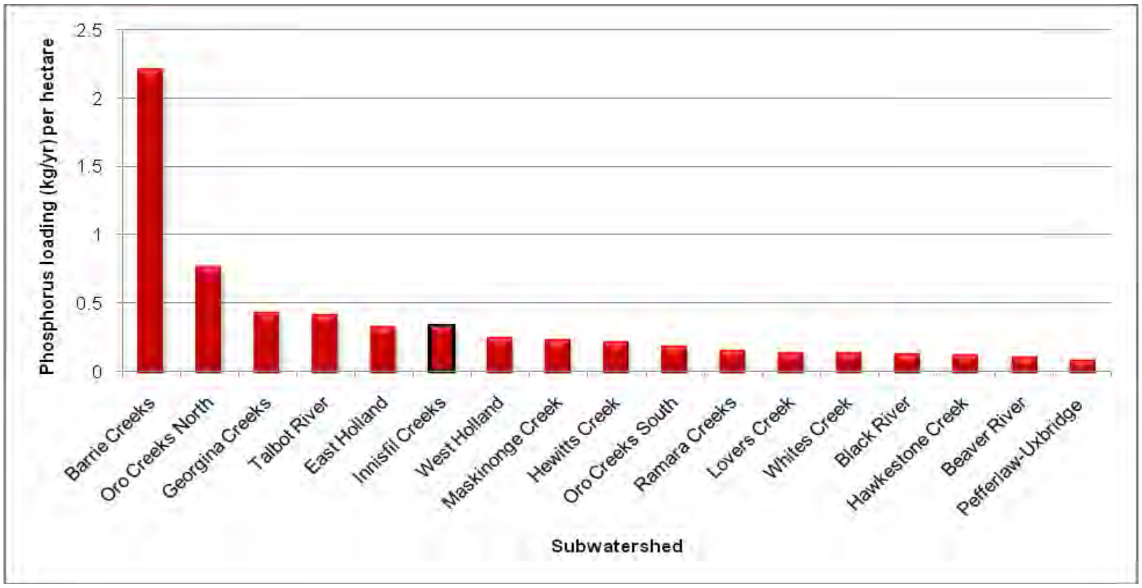


Figure 3-5: Phosphorus loading (kg/yr) per hectare for each Lake Simcoe subwatershed (data: Berger, 2010).

Additionally, the Innisfil Creeks subwatershed can be split up into 11 catchments, each named by the tributaries they contain. The areas of the catchments range from 287.3 ha (Innisfil Creeks 3) to 1,911.7 ha (Belle Aire/Carson Creek). As already mentioned, an overall potential reduction of 5.6% can be achieved through the implementation of agricultural BMPs. However, to achieve the basin wide total phosphorus target of 44 T/year, the CANWET watershed model also produced targets for individual subwatersheds. These were further narrowed down to catchment level targets to give a better idea of the priority areas for phosphorus reduction. Figure 3-6 illustrates the total phosphorus loads per catchment, based on the agricultural BMP scenario, while Figure 3-7 illustrates the target total phosphorus loads for each catchment. The difference between the two is a further 71.1% reduction from the agricultural BMP scenario to the required (modelled) target loads.

To prioritize areas for phosphorus reduction, each catchment area was assessed based on the amount of phosphorus that needs to be reduced to reach the target, and the associated unit cost ($/kg). For instance, a catchment which contributes relatively high phosphorus loads, but can be reduced at a lower cost, is a higher priority than a catchment that contributes lower phosphorus loads or has a higher unit cost. Berger (2010) prioritized all the catchments in the Lake Simcoe watershed, splitting them into four Tiers (Tier 1 being the highest priority, Tier 4 the lowest) for each subwatershed. Table 3-7 lists each of the 11 catchments based on this ranking system.

Table 3-7: Classification of catchments in prioritization tiers (Berger, 2010).

Subwatersheds	**Catchments***			
	Tier 1 (highest priority)	**Tier 2**	**Tier 3**	**Tier 4 (lowest priority)**
Innisfil Creeks Subwatershed		Banks Creek	Innisfil Creeks 1	Innisfil Creeks 2
		Belle Aire/Carson Creek	Innisfil Creeks 3	
		Mooselanka/ Leonards/ Bon Secours Creek	Strathallan Creek	
		Sandy Cove Creek	Upper Marsh Creek	
		White Birch Creek		
		Wilson Creek		

** Catchments are illustrated in following figure*

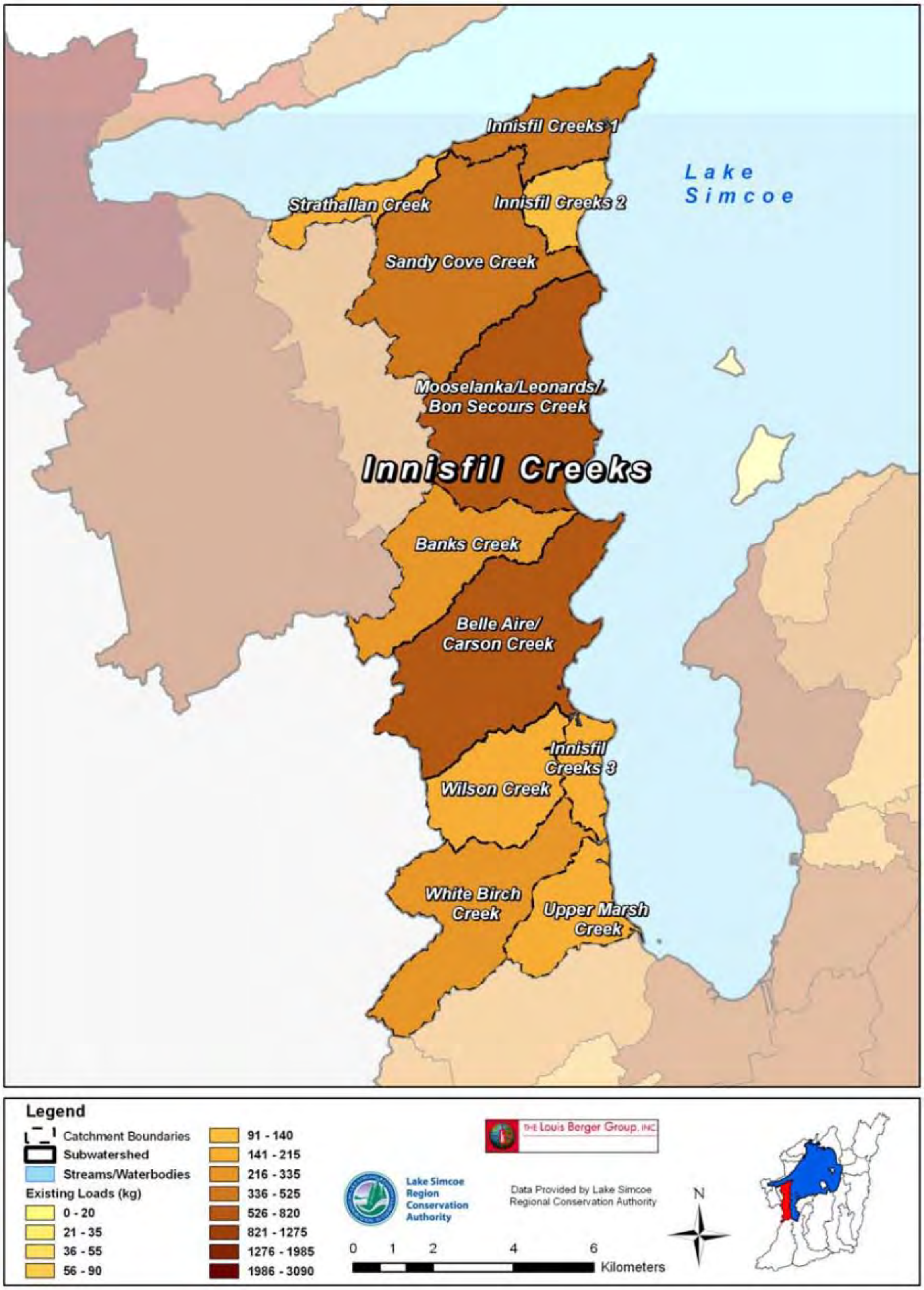


Figure 3-6: Innisfil Creeks subwatershed agricultural BMP scenario total phosphorus loads (Berger, 2010).

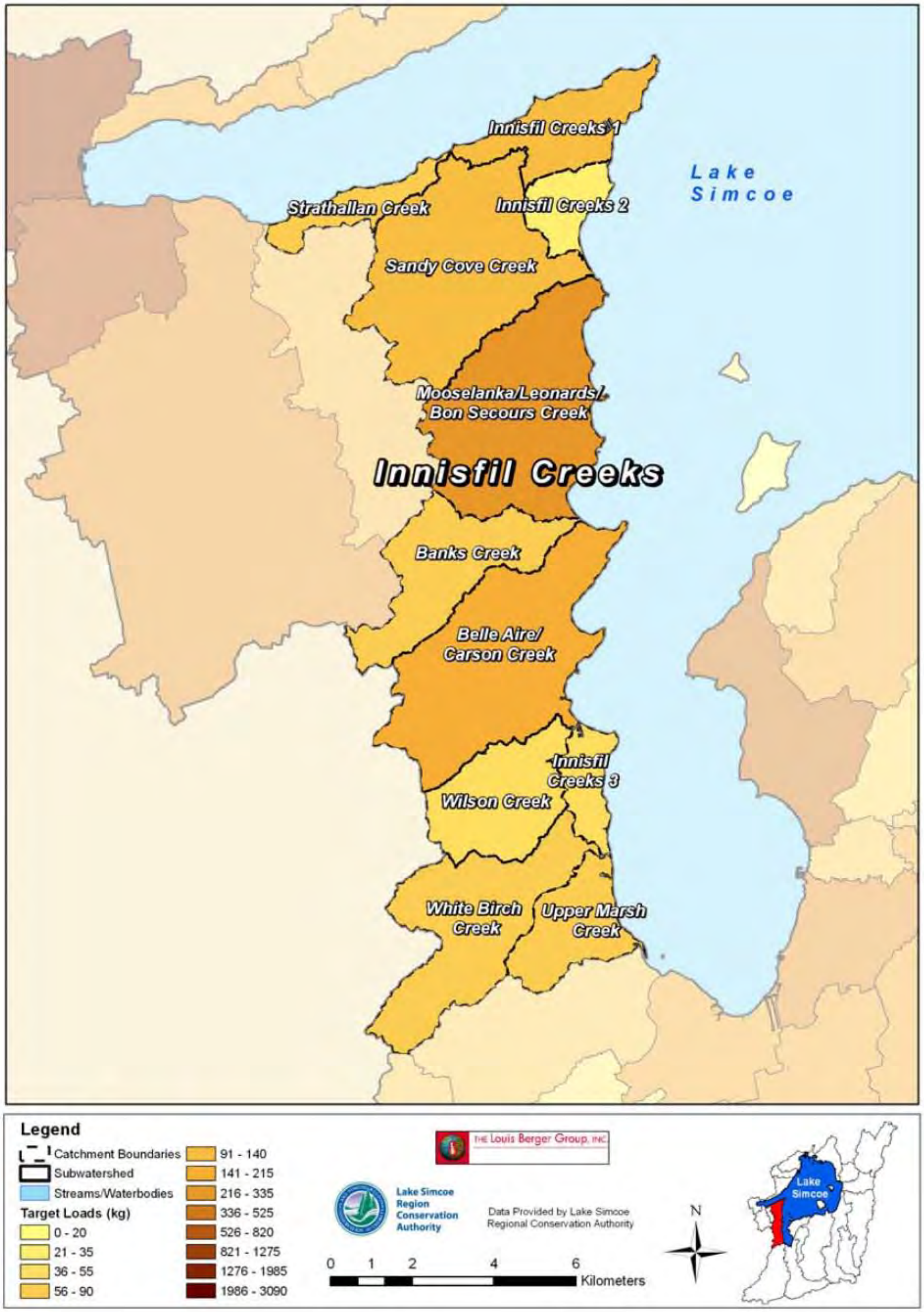


Figure 3-7: Innisfil Creeks subwatershed target total phosphorus loads (Berger, 2010)

3.3.2.2. Chloride

The main source of chloride, in its various compounds, in the environment is from road salt (Environment Canada, 2001). It enters the environment through runoff from roadways as well as through losses from salt storage and snow disposal sites. Due to its high solubility, chloride very easily contaminates both surface and groundwater.

High levels of chloride, such as those found in runoff water draining from roads and salt storage yards, can damage the roots and leaves of aquatic and terrestrial plants, and can also have behavioural and toxicological impacts to animals. Continued exposure to high chloride levels can cause a shift from sensitive communities to those more tolerant of degraded conditions (including a number of invasive species that are able to thrive).

3.3.2.3. Sediment

While a certain amount of sediment input is normal in a natural system, in larger amounts it begins to cause a number of problems. Many contaminants, including phosphorus, bind themselves to soil particles, and eroding soil acts as a vector for introducing these particulates to an aquatic system. There are also impacts to aquatic biota, which are discussed in greater detail in **Chapter 5 - Aquatic Natural Heritage**.

There are a number of sources of sediment in the Innisfil Creeks subwatershed:

Development sites: these sites are often stripped of vegetation well in advance of development in an effort to reduce costs as the development is built in phases. These bare soils are then subject to erosion by both wind and water. The proper installation of erosion controls can prevent some of the soil from reaching watercourses, but need to be inspected and maintained regularly.

Agricultural areas: fields are particularly vulnerable to erosion whenever they are bare (e.g. after tilling and in the spring prior to the establishment of crops). The flow of melt waters and precipitation over the fields during these periods can result in a huge influx of sediment. In addition, some farmers may also remove treed windbreaks and riparian vegetation along watercourses flowing through their properties in order to maximize the cultivable land, both of which help to prevent soil erosion. Practices such as conservation tillage and the use of cover crops, as well as the implementation of appropriate BMPs, will help to reduce soil loss and its associated impacts on watercourses. For more information on the extent of agriculture and riparian buffers in this subwatershed, see **Chapter 2 - Study Area** and **Chapter 6 - Terrestrial Natural Heritage**, respectively.

Urban areas: The use of sand, as well as salt, for maintaining safe road conditions during the winter is commonplace. However, large quantities of sand remain on the roadsides after all of the snow has melted in the spring, and if it is not removed (e.g. by street sweeping) in a timely manner, much of it will be washed away by surface runoff during rain events. This is of particular concern in areas without stormwater controls, as the sand will be transported directly to local watercourses. For more information on the extent of urban area within this subwatershed, see **Chapter 2 - Study Area**.

3.3.2.4. Thermal degradation

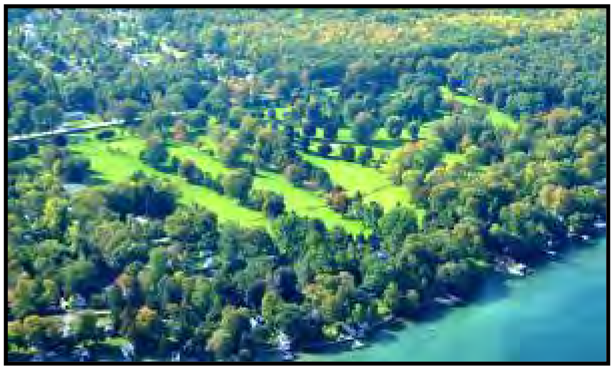
The warming of surface water can generally be attributed to one of two factors: flow over impervious surfaces, and/or the detention of water in a pond. During the summer, impervious surfaces such as parking lots and rooftops can become extremely warm. As water flows over these surfaces before discharging to a watercourse, its temperature increases as well. The detention of water in a pond increases the surface area of the water that is exposed to sunlight, and keeps it there for a prolonged period of time, leading to warming. Although online ponds are the greatest concern due to their direct impact on the watercourse, offline ponds (including stormwater ponds and detention ponds for irrigation) that discharge to watercourses are also a concern. While the planting of vegetation around a pond and along its outflow, and the installation of structures such as bottom-draws to ensure that the coolest water is being discharged can help to reduce the heating effect, ponds will still have an impact on the thermal regime of a watercourse. This issue will likely worsen as the amount of impervious area in the subwatershed increases in the coming years. **Chapter 5 - Aquatic Natural Heritage** discusses the impact of thermal degradation on survival of cool water fish such as brook trout and which watercourses are experiencing a degree of thermal degradation.

3.3.2.5. Pesticides

Given the large proportion of agricultural and urban land uses, pesticide use is a concern in these subwatersheds. While pesticide use for cosmetic purposes has been banned by the Province of Ontario, which is a very positive step, there are a number of exceptions to this law that allows for the use of pesticides for public health or safety (including the protection of public works structures), golf courses, specialty turf, specified sports fields, arboriculture and to protect natural resources, if certain conditions are met. There are also exceptions for agriculture, forestry, research and scientific purposes, and uses of pesticides for structural exterminations (e.g., in and around homes to control insects) and uses of pesticides required by other legislation. Due to the number of uses still allowed for pesticides, there is still the potential for these substances to end up in the surface waters of the subwatersheds. There can be a number of impacts to both terrestrial and aquatic systems due to pesticide contamination, including:

- Cancers, tumours and/or lesions on fish and animals;
- Reproductive inhibition/failure – reduced egg suppression and hatching, sterility;
- Nest and brood abandonment;
- Immune system suppression;
- Endocrine disruption;
- Weight loss;
- Loss of attention; and
- Loss of predator avoidance (Ongley, E., 1996, Helfrich *et al*., 2009).

The use of best management practices for the storage and use of pesticides can limit the amount of pesticide required in a given area, and will also reduce the movement of the pesticides from target areas. These practices should be promoted throughout the



Golf course within the Innisfil Creeks subwatershed.

subwatershed.

In 2004 the LSRCA conducted a Toxic Pollutant Screening Program (LSRCA, 2004) collecting stream water and sediment samples throughout the watershed to analyze for a number of pollutants including current and past use pesticides. This included a water sample from Leonards Creek which did not detect any of the parameters for which the screening was intended.

3.3.2.6. Metals

Metals are found almost everywhere and are persistent within the environment. While some naturally occur in nature, elevated amounts in settled areas are typically associated with agricultural waste, industrial wastes (e.g. metal finishing, tanneries, plastic fabrication, etc) , residential sewage and urban runoff (Adriano, 2001). These elevated levels of metals in the environment can have significant impacts on wildlife communities, as metals can bioaccumulate within organisms, cause chronic toxicity, and adversely affect organisms' behaviour, growth, metabolism and reproduction (Wright and Welbourne, 2002).

In 2008, Landre, *et al.* took sediment samples from Lake Simcoe, at the same 22 locations of an earlier study (Johnson and Nicolls, 1988). Sampling sites were located in the main basin, at the outlet from Lake Couchiching, and in Kempenfelt Bay and Cooks Bay. Each of the samples was tested for 17 metals: aluminum, arsenic, barium, cadmium, cobalt, chromium, copper, iron, mercury, manganese, nickel, lead, rubidium, antimony, strontium, vanadium, and zinc. This study found high concentrations of cadmium, chromium, copper, mercury, nickel, lead and zinc near the shore in Kempenfelt, with concentrations decreasing farther away from shore and into the main basin. A similar pattern was seen in Cook's Bay, with sites closest to the shore having the highest metal concentrations (Landre *et al.,* 2011).

Higher concentrations close to shorelines are not unexpected as these are the areas of the subwatersheds experiencing urban growth, both in the residential and commercial sectors, and is where streams running through agricultural and urban lands dump loads into the lake. In addition, metal pollution historically was not regulated from metal finishing facilities and tanneries that were operating in and around Kempenfelt Bay in the past.

When comparing current results to the results of the earlier study (Johnson and Nicolls, 1988), metal concentrations had remained the same or decreased, with the exception of copper and zinc in Kempenfelt Bay. The concentrations of these two metals were on par with the peak levels seen in the 1950s, 60s and 70s (both decreased slightly in 1980s). Additionally, cadmium, mercury, lead and antimony were found at concentrations that were three to seven times higher than pre-1900s conditions (Landre *et al.,* 2011). Of all the metals studied, chromium was the greatest concern, as it exceeded the Ontario Sediment Quality Guidelines severe effect level at three sample sites. This makes it one of the metals of most concern to ecological systems. Depending on the chemical form of chromium, the type of organism and the life stage of the organism, contamination over the guideline can impact the growth, activities, reproduction and survival, as well as causing changes to chromosomes and physical formation, due to its carcinogenic, mutagenic and teratogenic properties (U.S Environmental Protection Agency, 2011).

Overall though, because of a decrease in industrial activity, better wastewater treatment and an increase in urban area, there has been a shift in the source of metals from industrial discharge to urban runoff (Landre *et al.,* 2011). Hence, to manage the concentration of metal contaminants in Lake Simcoe, it is important to install and maintain sufficient stormwater treatment facilities and to decrease metal inputs into stormwater.

3.3.2.7. Bacteria

The presence of bacteria in surface waters has become a significant concern in recent years. Municipal health units monitor the health of local beaches at regular intervals throughout the summer to ensure that they are safe for human contact. The Provincial Water Quality Objective (PWQO) for body-contact recreation has been defined by the Ministry of the Environment by using the relative numbers of *Escherichia coli* (*E. coli*) bacteria as an indicator to assess the risk to human health. When the *E. coli* population exceeds the PWQO, the beach is designated unsafe for bathing activities. *E. coli* is a fecal bacteria found in the intestines of mammals that can cause serious illness and even death.

The presence of high levels of *E. coli* in the lake's waters is an indication of contamination by human sewage or animal wastes. While there are other reasons for beach postings, including water turbidity, the presence of blue-green algae, or poor aesthetics, closures in Lake Simcoe are generally due to high levels of *E. coli*. The number of beach closures due to high concentrations of *E. coli* varies from year to year, as they are heavily influenced by precipitation levels. Stormwater carries with it animal waste (e.g. from farms with livestock, as well as from pet and waterfowl waste), which can contaminate beaches when it reaches them either through direct runoff from adjacent areas, or being carried to tributaries and discharged when it reaches the lake).

From 2006 to 2011, no beaches were closed in the Town of Innisfil and beaches in the City of Barrie have only been closed once, in 2006, in response to a major sewage spill. In 2011 there were three advisories at two City of Barrie beaches (Minets Point Beach (2) and Wilkins Beach (1)), and 2 at Leonard's Beach (Town of Innisfil) (SMU, 2011).

3.3.2.8. Emerging contaminants

As anthropogenic activities increasingly impact our natural areas, the potential for introduction of harmful substances becomes more of a concern. It is for this reason that a Toxic Pollutant Screening Program was initiated by the Lake Simcoe Region Conservation Authority in 2004. The goal of this project was to develop a better understanding of the location and prevalence of certain elements, chemicals, and chemical compounds that have the potential to negatively impact either human or aquatic life in the watershed. Sampling through this program revealed that there are currently some substances whose levels exceed regulatory guidelines in some Lake Simcoe tributaries (e.g. Polycyclic Aromatic Hydrocarbons in East Holland River sediments). In addition, there were some substances, such as pharmaceutical products, that were not included in this monitoring work. Many of these substances have the potential to impact humans and affect aquatic life.

Endocrine Disrupting Chemicals

Endocrine disrupting chemicals (EDCs) are chemicals which adversely affect the endocrine system, which is a set of glands and the hormones which guide development, growth, reproduction, and behaviour. Harmful effects have been observed on wildlife and humans including reproductive disorders, impacts on growth and development, as well as the incidence of some cancers. EDCs can come from both natural and man-made sources including pesticides; hormones, including both natural and synthetic which are used in oral contraceptives and in livestock farming; and can be the product of industrial processes such as incineration. In nature, EDCs including PCBs and other man-made chemicals have caused, among other issues, severe reproductive problems in fish and birds, swelling of the thyroid glands in numerous animal species, reduction in frog populations, and, in birds, the thinning of eggshells.

Pharmaceuticals and Personal Care Products

The presence of pharmaceuticals and personal care products (PPCPs) in the natural environment has been a growing concern over the past two decades, and will become more prevalent with the growing population and increasing use of these products. While the effects of pharmaceuticals on humans during the course of treatment are very well studied; the impacts of their by-products after use is not. Although some of the products and their by-products can be broken down incidentally at Waste Pollution Control Plants, the plants are generally not equipped to remove PPCPs from waste water. Studies have shown hormones, antibiotics, anti-inflammatory drugs, fragrances, antiseptics, sunscreen agents and a host of other PPCPs in varying amounts in the environment, though they are mostly seen within 100 metres of a waste water treatment plant discharge. In general, the levels in the environment are quite low; however, the effects of prolonged exposure to low levels are not well known. Some studies have shown that PPCPs have the potential to alter physiology, behaviour, and reproductive capacity. Concerns in the environment related to PPCPs include endocrine disruption in aquatic life and antibiotic resistance. Further understanding of these and other concerns is required in order to determine potential steps.

Polybrominated Diphenyl Ethers

Polybrominated Diphenyl Ethers (PBDEs) are emerging as a chemical of concern to both human and environmental health due to their persistence and ability to bioaccumulate in the environment. PBDEs are a group of chemicals used as flame retardants in a number of manufactured products, particularly in plastics. They are found in most homes and businesses in products such as electronics, TVs, textiles, cars, aircrafts, construction products, adhesives, sealants, and rubber products. They have become an increasingly common pollutant and have been found in samples taken in air, water, and land. PBDEs have been also been detected in a number of species (including humans) worldwide and studies are finding that levels of PBDEs have been increasing steadily and substantially over time. In the Canadian environment the greatest potential risk from PBDEs is secondary contamination in wildlife from the consumption of prey with elevated PBDE levels as well as effects on benthic organisms through exposure to PBDEs in sediments.

Due to the environmental persistence and bioaccumulation of PBDEs they are defined as toxic to the environment as defined under the Canadian Environmental Protection Act (CEPA). Currently, Canada is proposing a ban on the import and manufacture of a number of forms of PBDEs. This ban however does not include the decaBDE form, the most commonly used form. Efforts to control the release of decaBDE would involve working with industry and stakeholders to minimize the impact of PBDEs in the environment. Through the federal government, environmental objectives are also being proposed for virtual elimination of a number of forms of PBDEs detectable in the environment.

3.3.2.9. Uncontrolled stormwater and impervious surfaces

In the Innisfil Creeks subwatershed, urban land use makes up 15% of total land use. Runoff in urban areas, particularly those built prior to the requirement for stormwater management, can carry a host of pollutants to local watercourses. These pollutants build up on roads, driveways and parking lots, and even lawns, and are washed to watercourses during precipitation events. The pollutants that can be carried by urban stormwater runoff include nutrients and pesticides from lawns, parks and golf courses; road salts; tire residue; oil and gas; sediment; and nutrients and bacteria from pet and wild animal faeces. Generally, concentrations of pollutants such as bacteria (e.g. *Escherichia coli*, fecal coliform, *Pseudomonas aeruginosa* and fecal streptococci), nutrients (e.g. phosphorus, nitrogen), phenolics, metals and organic compounds are higher in urban stormwater runoff than the acceptable limits established in the PWQO (MOE, 1994).

In the past it was common practice to route stormwater directly to streams, rivers or lakes in the most efficient manner possible. This practice typically has negative impacts on the receiving watercourse. Over the last two decades this has changed and efforts are made to intercept and treat stormwater prior to its entering watercourses or waterbodies. However, in many older urban areas stormwater typically still reaches watercourses untreated.

Paved surfaces increase the volume and velocity of surface runoff, which leads to streambank erosion, contributing more sediment to watercourses. Subwatersheds with less than 10% imperviousness[2] (hardened surfaces) should be able to maintain surface water quality and quantity and preserve aquatic species density and biodiversity, as recommended in Environment Canada’s Areas of Concern (AOC) Guidelines (2004). The AOC Guidelines further recommend an upper limit of 30% as a threshold for degraded systems that have already exceeded the 10% impervious guidelines. The Innisfil Creeks subwatershed is above the 10% guideline, but is below the upper limit threshold with approximately 21% impervious surface. As this subwatershed hasn’t reached the 30% threshold, there is still room through mitigative action and careful development to reduce or at least maintain this number to assist in maintaining the water quality.

The increase in impervious surface area associated with urban growth and the resultant increases in stormwater runoff can have significant effects on water quality and quantity and aquatic habitat in a subwatershed. While it will obviously not be possible to eliminate impervious surfaces and their impacts, there are activities that can be undertaken to reduce these impacts.

The requirement for stormwater management facilities in all new developments will help to mitigate these issues in urban areas, however, the ongoing maintenance of these facilities is crucial to ensuring that they continue to reduce sediment and nutrient loads as designed. Additional best management practices should also be implemented in conjunction with stormwater management wherever possible to reduce the amount of these pollutants, as even a stormwater facility with the highest level of control does not achieve 100 % removal. A further input of sediment and nutrients from urban areas is the wind erosion of soils stripped bare for development. These areas can be without vegetation for prolonged periods of time, and can be a significant source of windborne pollution.

Based on the Stormwater Practices Manual (MOE, 1994, 2003), there are various levels of stormwater control established to ensure the protection of receiving waters (i.e. watercourse, ditch, lake). Four levels of protection were established focusing on the ability of stormwater management ponds to control and remove suspended solids. The four levels are:

> **Level 1** is the most stringent level of protection designed to protect habitat which is essential to the fisheries productivity (such as spawning, rearing and feeding areas) and requires 80% removal of suspended solids.

---

[2] Impervious surfaces refer to any hardened surface, but do not include features such as wetlands that are sometimes considered impervious in hydrogeological models

> **Level 2** protection calls for a 70% removal of suspended solids. In this instance the receiving water can sustain the increased loading without a decrease in fisheries productivity.
>
> **Level 3** controls are relaxed further, requiring a 60% sediment removal rate again reflecting the lower quality of the receiving water for fish production.
>
> **Level 4** controls exclusively address retrofit situations where, due to site constraints the other levels of control cannot be achieved. Level 4 protection is not considered for any new development, only for instances where uncontrolled urban areas can implement some stormwater management facilities to improve the environmental health.

Urban areas in the Innisfil Creeks subwatershed include the communities of Alcona, Stroud, Gilford and Lefroy in the Town of Innisfil and the City of Barrie. In the urban areas in the Town of Innisfil, 67% of the stormwater is uncontrolled, while 14% has quantity control only. The remaining 19% is controlled by Level 1, 2, 3 or 4 stormwater facilities. Of the stormwater control in the urban areas in the City of Barrie approximately 62% is uncontrolled, 22% has quantity control only, and the remaining 16% is controlled by Level 1, 2, 3 or 4 stormwater facilities (Table 3-9, Figure 3-9).

The *Lake Simcoe Basin Stormwater Management and Retrofit Opportunities* report (LSRCA, 2007) identified and evaluated opportunities to control phosphorus from existing urban areas. In the urban areas, stormwater runoff should be addressed through stormwater pond retrofits. These include creating facilities in uncontrolled catchments or upgrading existing facilities or quantity only facilities to higher level of control (i.e. Level 1). The report identified a total of 46 and 56 retrofit opportunities in the Town of Innisfil and the City of Barrie, respectively (this number may differ slightly from the report as these totals include different scenarios). The number of retrofit opportunities in the Innisfil Creeks subwatershed and the percentage of phosphorus that will be prevented from entering the watercourses, and ultimately the lake, are presented in Table 3-8 and illustrated in Figure 3-10.

Table 3-8: Retrofit opportunities in the Innisfil Creeks subwatershed.

Subwatershed	City of Barrie	Town of Innisfil*	Percent (%) difference in phosphorus loading (kg/yr)
Innisfil Creeks	0	31	13%

**The remaining 15 retrofit opportunities in the Town of Innisfil are located in the Lovers Creek (13) and Hewitt's Creek (2) subwatersheds.*

By design, stormwater ponds trap sediment, a feature which results in a reduction in pond volume and thus reduced efficiency by which particulates (and phosphorus) are removed. Critical to maintaining this efficiency is the regular removal of the sediment accumulated in the pond. As part of a 2010 study the current volume of stormwater ponds in Barrie and Innisfil were investigated and compared with design volumes. Without any stormwater controls, the 32 stormwater catchments would contribute a total phosphorus load of 1,381 kg/yr. With the existing stormwater controls all operating at designed efficiency, the total phosphorus load is reduced to 294 kg/yr (which is a reduction of 1,087 kg/yr). However, the study found many ponds were not operating at designed efficiency, due to a lack of maintenance, and the annual phosphorus load from these catchments is 552 kg/yr, a loss in efficiency of 258 kg/yr.

Of the 13 ponds surveyed in the Innisfil Creeks subwatershed, 12 were originally designed to meet Level 1 criteria and one to meet Level 2 criteria. When the ponds were surveyed in 2010, only three were still operating at Level 1, while four were operating at Level 2, three at Level 3 and three had filled with sediment to the point where they no longer had a permanent pool volume or a volume lower than Level 4 efficiency (Figure 3-8).

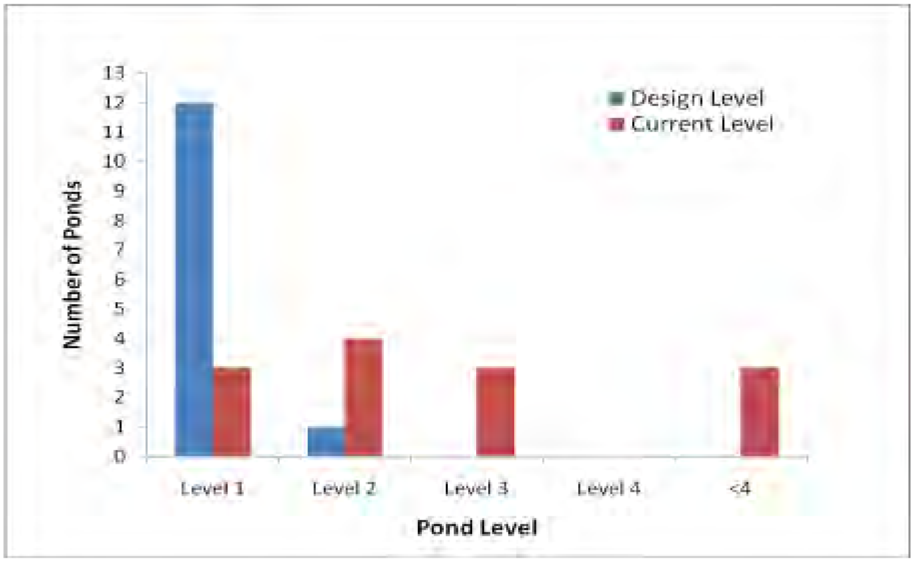


Figure 3-8: Innisfil Creeks – pond design efficiency level vs. 2010 surveyed efficiency level,

Full details of the study can be found in the report "2010 Stormwater Pond Maintenance and Anoxic Conditions Investigation" (LSRCA, 2011).

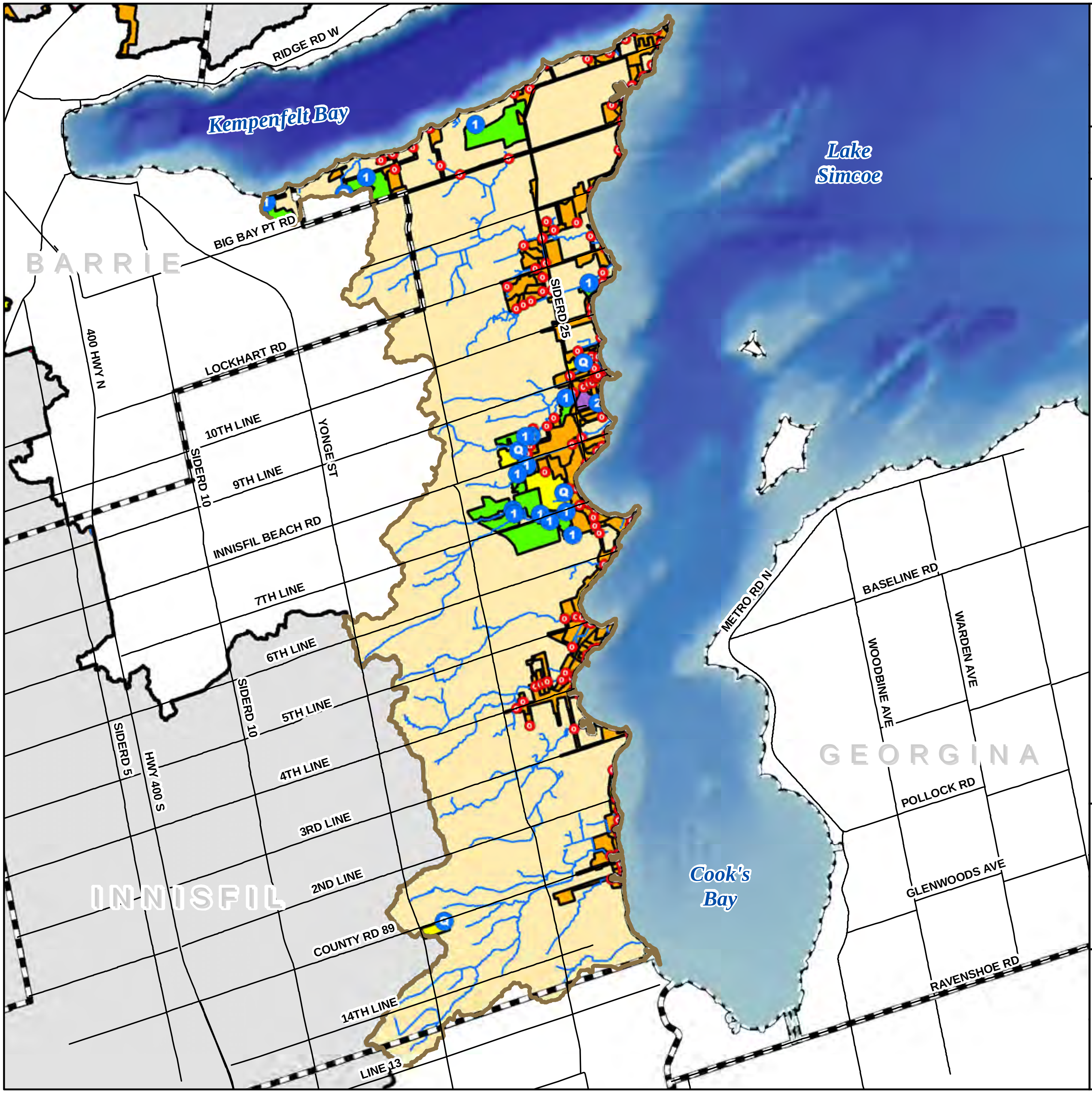
Stormwater Pond – I-N74

Table 3-9: Controlled vs. uncontrolled stormwater catchments in the Town of Innisfil and the City of Barrie.

Location	Total Number of Catchments	Total Urban Area (ha) Used	Uncontrolled			Quantity			Level 1			Level 2			Level 3			Level 4			Controlled (Total of Levels 1 to 4)		
			#	**Area (ha)**	**% (area)**	**#**	**Area (ha)**	**% (area)**	**#**	**Area (ha)**	**% (area)**	**#**	**Area (ha)**	**% (area)**	**#**	**Area (ha)**	**% (area)**	**#**	**Area (ha)**	**% (area)**	**#**	**Area (ha)**	**% (area)**
Town of Innisfil	181	2116.87	150	1417.9	67	12	289.1	14	15	371.5	18	2	38.4	2	0	0	0	0	0	0	17	409.87	19
City of Barrie	198	3957.42	136	2446.6	62	43	878.5	22	16	546.9	14	3	85.4	2	0	0	0	0	0	0	19	632.28	16
Totals	**379**	**6074.29**	**286**	**384.56**	**129**	**55**	**1168**	**36**	**31**	**918.4**	**32**	**5**	**124**	**4**	**0**	**0**	**0**	**0**	**0**	**0**	**36**	**1042.2**	**35**

Stormwater control in the Innisfil Creeks subwatershed.

Figure 3-9



Legend

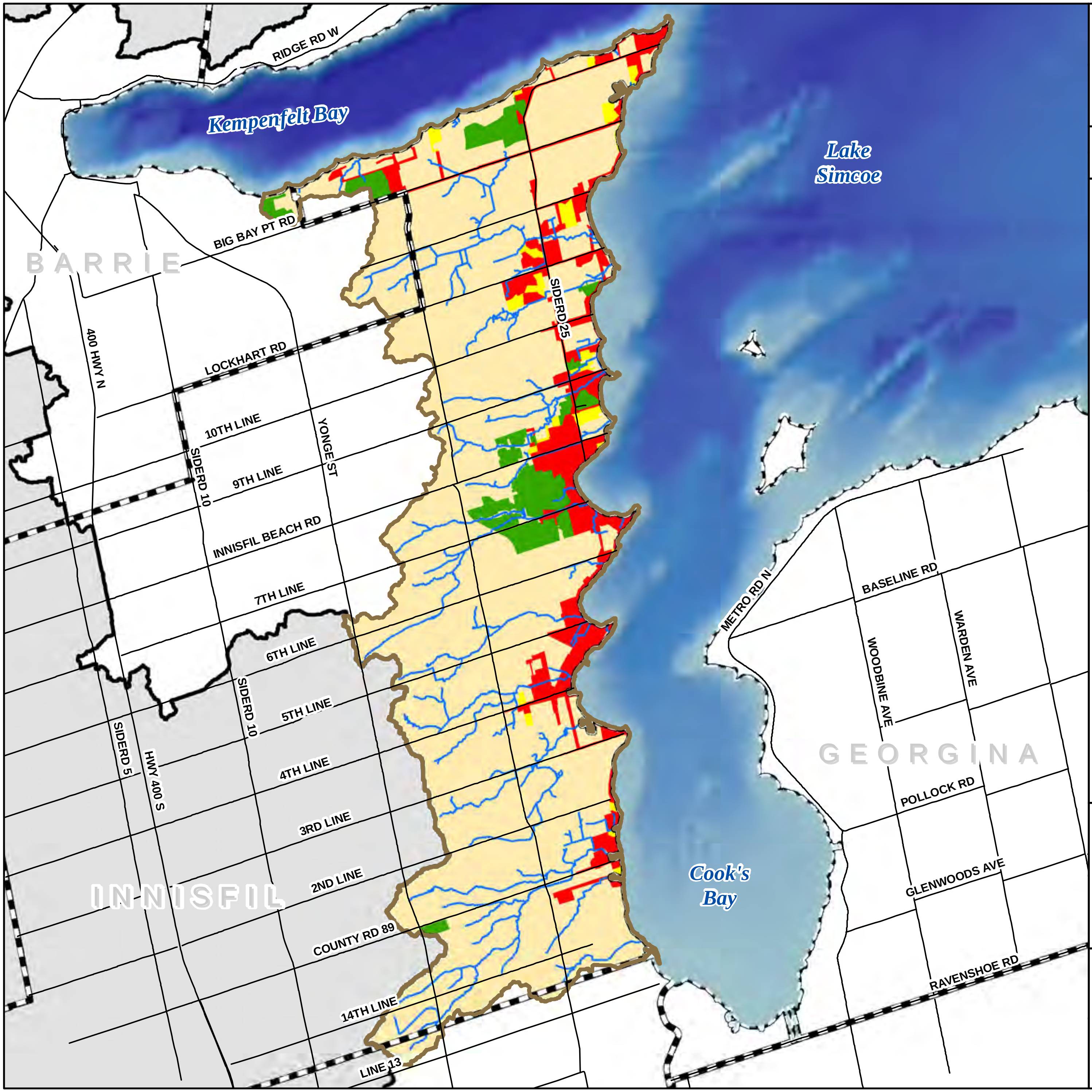
- Road
- Municipal Boundary
- ① Level 1 Pond
- ② Level 2 Pond
- ③ Level 3 Pond
- ④ Level 4 Pond
- Q Quantity Pond
- U Uncontrolled Pond
- O Stormwater Outlet
- 🟩 Level 1 Control
- 🟪 Level 2 Control
- ▨ Level 3 Control
- 🟥 Level 4 Control
- 🟨 Quantity Control
- 🟧 Uncontrolled

Lake Simcoe Region conservation authority

0 0.5 1 2 3 4 5 Kilometres

N

This product was produced by the Lake Simcoe Region Conservation Authority and some information depicted on this map may have been compiled from various sources. While every effort has been made to accurately depict the information, data / mapping errors may exist.
This map has been produced for illustrative purposes only.
LSRCA GIS Services DRAFT created July 2010.



Uncontrolled stormwater and retrofit opportunities in the Innisfil Creeks subwatershed.

Figure 3-10

Legend

— Road

▬ Municipal Boundary

〰 Watercourse

Storm Watersheds

🟩 Controlled

🟨 Uncontrolled, Retrofit Opportunity

🟥 Uncontrolled, No Retrofit Opportunity

Lake Simcoe Region conservation authority

0 0.5 1 2 3 4 5 Kilometres

N

3.3.2.10. Recreation

Natural areas such as streams and rivers are a popular location for recreational activities such as hiking, boating and snowmobiling. These activities, if not managed correctly and undertaken in a responsible manner, can negatively impact the surface water quality in the area. Impacts from recreational activities can include increased bank erosion and instability, loss of riparian area resulting in an increase in input of total suspended solids (TSS) and pollution. Stresses on these sensitive areas may be increasing as a result of increasing population and diminishing natural heritage lands.

3.3.2.11. Climate Change

While difficult to predict direct results of climate change to water quality within the Lake Simcoe watershed, it is likely that it will exacerbate the previously mentioned water quality stressors, creating cumulative, long-term impacts.

Warmer temperatures will lead to further thermal degradation of watercourses and create ideal habitat for bacteria and pathogens. An increase in the frequency and intensity of weather events can also have an impact on contaminants, including:

- Causing the release of contaminants through damage to storage facilities, overflow of retention areas and mobilization of surface contaminants that are normally immobile;
- Transporting contaminants greater distances; and
- Increasing the quantity of contaminants (such as road salt) that are required to deal with weather events (such as snowfall)

Figure 3-11 illustrates two different climate scenarios (based on different models) and how they will impact the total phosphorus loads in the coming years for Innisfil Creeks. The climate change scenario outputs were initially reporting the base case phosphorus load (2004-2007). However, it was felt using the 2004-2007 loads in light of the other longer term scenarios does not provide a meaningful comparison and could be misleading given the small snap-shot of time. The rationale behind this reasoning is that the climate change scenarios use a much greater modelling period of 30 years (1961-1990) to develop the climate change precipitation and temperature projections. Thus, to have a meaningful comparison, model runs were performed using the original precipitation and temperature data spanning the period 1961-1990, comparing existing loads and future climate change loads using the same modelling period of 30 years. Both scenarios show decreases in phosphorus loads to 2070, with the CGM scenario showing a slight increase that is still below baseline, while the GISS scenario also increases but past the baseline load.

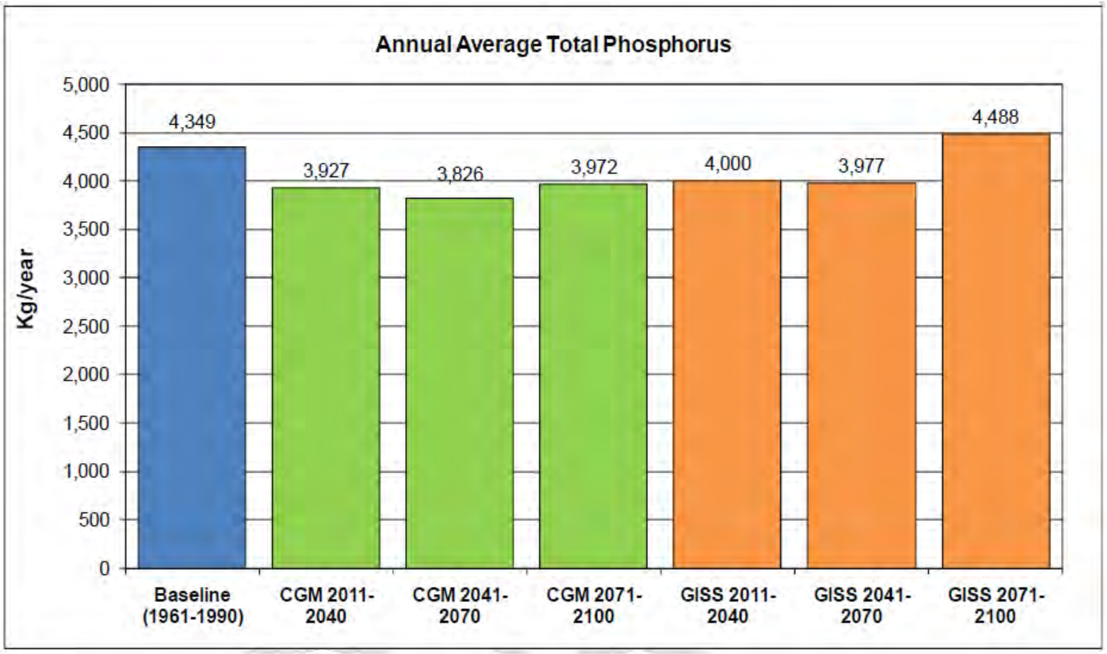


Figure 3-11: Base case land use applied to climate change scenarios for total phosphorus loads in the Innisfil Creeks subwatershed

Further information on how climate change will affect aquatic and terrestrial natural heritage can be found in **Chapter 5 – Aquatic Natural Heritage** and **Chapter 6 – Terrestrial Natural Heritage**.

Key points – Factors Impacting Water Quality - Stressors:

- No contaminants were identified as Drinking Water Issues or Conditions in the Innisfil Heights and Stroud Well Supplies.
- The primary sources of total phosphorus in the Innisfil Creeks subwatershed are septic systems (23%), crop land (22.8%) and high intensity development (21%). Under the approved growth scenario in the ACS modelling, there is a projected increase in total phosphorus loads of 29% if agricultural BMPs were not implemented.
- When comparing the phosphorus loads (kg/yr) per hectare of the subwatersheds in the Lake Simcoe watershed, Innisfil Creeks is the 6th largest contributor.
- Most of the chloride in the subwatersheds comes from the use of road salt. Currently there is not enough data to accurately describe chloride load trends within the subwatersheds. It is expected that loads will increase into the future as the urban areas continue to expand.
- Sediment sources include sites stripped for development, agricultural areas, and sand used on roads in the winter. Sediment itself is a pollutant, and also acts as a vector for other pollutants, such as phosphorus.
- Increasing surface water temperatures can be attributed to overland flow across impervious surfaces and discharge from ponds. Stream temperature issues can be expected to increase in the coming years as the amount of impervious area increases.
- The emerging threat of climate change will interact with all of these threats, creating additive long-term impacts. In the Innisfil Creeks, based on climate change scenarios, phosphorus is expected to decrease up to 2070, at which point it will start to increase.

3.4 Current Management Framework

Various programs exist to protect and restore the water quality in the Lake Simcoe watershed, ranging from regulatory mechanisms, to funding and technical support provided to private landowners, to ongoing research and monitoring.

Many of these programs already address some of the stresses to water quality in the Innisfil Creeks subwatershed, as outlined below.

3.4.1 Protection and Policy

There are numerous acts, regulations, policies and plans aimed at maintaining or improving water quality. These include the Lake Simcoe Protection Plan, the Provincial Policy Statement, the *Clean Water Act* and municipal official plans. This management framework addresses many of the stresses identified in these subwatersheds. In Table 3-10 we categorize nine such stressors, recognizing that many of these overlap and that the list is by no mean complete. The legal effects of the various Acts, policies, and plans on the stressors are categorized as ‘existing policies in place’ (shown in green), or ‘no applicable policies’ (shown in red). The policies included in the table include those which have legal standing and must be conformed to, or policies (such as some of those under the Lake Simcoe Protection Plan) which call for the development of further management tools, research or education programs.

The intent of these regulations, policies and plans are summarized in **Section 1.3 – Current Management Framework**. Readers interested in the details of these regulations, policies and plans are directed to read the original documents.

Table 3-10: Summary of the current management framework as it relates to the protection and restoration of water quality.

Stressor affecting water quality	Lake Simcoe Protection Plan (2009)	Growth Plan for the Greater Golden Horseshoe (2006)	Provincial Policy Statement (2005)	Nutrient management Act (2002)	Ontario Water Resources Act (1990)	Environmental Protection Act (1990)	Clean Water Act (2006) – Source Water Protection^	LSRCA Watershed Development Policies (2008)	Comprehensive Stormwater Management Master Plan Guidelines (2011)	Simcoe County Official Plan (2007)	Town of Innisfil Official Plan (2006)	City of Barrie Official Plan (2009)
Development and site alteration	🟩	🟩	🟩	🟥	🟥	🟥	🟥	🟩	🟩	🟩	🟩	🟩
Application of road salt	🟥	🟩	🟥	🟥	🟩 3	🟥	🟥	🟥	🟥	🟥	🟥 8	🟥
Loss of natural heritage features	🟩	🟩	🟩	🟥	🟥	🟥	🟥	🟩	🟩	🟩	🟩	🟩
Uncontrolled Stormwater	🟩	🟩	🟩	🟥	🟩	🟥	🟥	🟩	🟩	🟩	🟩	🟩
Impervious surface	🟩	🟥	🟩	🟥	🟥	🟥	🟥	🟩	🟩	🟥 7	🟩	🟩
Discharge of material	🟥	🟥	🟥	🟩	🟩	🟩	🟩	🟥	🟩	🟥	🟩	🟩
Agricultural runoff	🟩	🟥	🟥	🟩	🟥	🟥	🟥	🟥	🟥	🟩	🟩	🟥 9
Septic systems	🟩	🟥	🟩 2	🟥	🟩 4	🟥	🟥	🟩 5	🟥	🟥	🟩	🟩
Climate change	🟩	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟩 6	🟥	🟥	🟥

🟩 **Existing Policies** 🟥 **No applicable policies**

[1] Gives specifics of what stormwater management plans are to include, but these are very general (e.g. ‘protect water quality’)

[2] PPS specifies where private septic systems would be allowed, does not give details around inspections/restrictions

[3] General policy regarding the discharge of any material that may impair the quality of water (not specific to road salt)

[4] Septic systems >10,000 L/day are regulated under OWRA (smaller systems under building code)

[5] One policy regarding replacement of septic systems that are in wetlands

[6] Refers to the Climate Change Adaptation Strategy in the LSPP – Policy 7.11

[7] Targets for impervious cover provided for the Oak Ridges Moraine Conservation Plan areas, but not subject area

[8] Policies refer only to the storage of road salt, not application

[9] Only mention is land use policy where non-intensive agriculture is permitted within Future Urban designation provided it does not jeopardize plans for urban development

Legislation and policy restrictions are the primary source of protection for water quality in the Lake Simcoe watershed, guided by the fundamental Provincial planning policies as articulated in the Provincial Policy Statement (PPS) and Lake Simcoe Protection Plan (LSPP). However, some stressors are better suited to policy and regulation than others. For example, a water quality stressor such as climate change is hard to regulate; however, stressors associated with site alterations and stormwater are much easier to control and regulate.

Policy tools to deal with these stressors can be found in Provincial Policy (such as PPS or LSPP), municipal official plans and zoning bylaws, and Conservation Authority Regulations. Together these documents are intended to provide protection to features that are significant both locally and provincially, while providing clarity to private landowners, and accountability to the electorate.

Further to the guidelines provided by the PPS, the LSPP identifies additional targets to improve existing water quality in the Lake Simcoe watershed. These targets call for the reduction of phosphorus, pathogens (such as *E. coli*) and contaminants (i.e. heavy metals, organic chemicals, sediments and chlorides). To assist in achieving these targets, policies established under the Lake Simcoe Protection Plan place firmer controls on sewage treatment plants (Policies 4.1-4.4), stormwater management (Policies 4.-5-4.12) , septic systems (Policies 4.13-4.15) and construction activities (Policies 4.16-4.21), as well as promoting better management practices throughout the various communities in the watershed (LSPP, 2009).

Within the Lake Simcoe watershed and its tributaries, excessive phosphorus is considered the most significant cause of water quality impairment. Because of this, Policy 4.24-SA of the LSPP committed the Province, LSRCA, local stakeholders, municipalities and other partners to develop a comprehensive Phosphorus Reduction Strategy within the first year of the Plan. In June 2010, the Lake Simcoe Phosphorus Reduction Strategy (PRS) was completed. The PRS is an adaptive management tool that takes a watershed based approach to manage the phosphorus levels in Lake Simcoe. By looking at the problems and researching solutions for the lake and its tributaries, the PRS provides direction to achieve proportional reductions from each major contributing source of phosphorus to reduce the current total load of 72 T/yr down to 44 T/yr in the future. The goal of 44 T/yr is the annual phosphorus load required to achieve the LSPP deep water dissolved oxygen target of 7 mg/L, that research proposes is needed to support a naturally reproducing and self-sustaining cold water fishery in Lake Simcoe.

The PRS is broken down into six key concepts, derived from the LSPP, to address the major sources or sectors contributing phosphorus to the Lake Simcoe watershed. These include:

- Adaptive Management;
- Watershed Approach;
- Stewardship and Community Action;
- Source-specific Actions;
- Monitoring and Compliance; and
- Research, Modelling and Innovation.

Each of these sections includes the ways in which that concept can address the stressors and how they contribute the overall function of the PRS tool. Additionally, “strategic directions” have been incorporated into the PRS to set out actions to be taken to reach the goal of 44 T/yr. Many of the gaps, related mostly to insufficient information available, are addressed in the “strategic directions” to continue research efforts and link to the appropriate actions (such as stewardship efforts, work with aggregate and development industries, etc). Related policies from the LSPP have also been included in the source-specific actions to further the connection between the PRS and LSPP documents.

The watershed based approach for protecting drinking water was first adopted in Ontario in 2006, with the *Clean Water Act* to protect drinking water at its source, as part of the Province's overall commitment to safeguard human health and the environment by using a multi-barrier approach. The protection of sources of drinking water in the lakes, rivers, and underground aquifers of Ontario comprises the first barrier. Source Protection complements the other components, which include effective water treatment, secure distribution systems, monitoring programs, and responses to adverse test results, by reducing the risk that water is contaminated in the first place. Participants in the Source Protection program include the Ministry of the Environment, Source Protection Authorities, Source Protection committees, municipalities, First Nations, consultants, and the public. The Proposed Source Protection Plan was submitted to the Ministry October 22, 2012 and is currently (2012) waiting for approval. The Source Protection Plan is a document that focuses on preventing the overuse and contamination of drinking water supplies across the SGBLS SPR. The plan includes policies and strategies to protect drinking water by allowing municipalities to take a proactive approach in preventing, reducing, or eliminating significant threats to water resources (for example: chloride from road salt).

In addition to the PPS, the LSPP, the *Clean Water Act* and the other acts and policies in Table 3-10, the municipalities, in this case the City of Barrie and Town of Innisfil, municipal Official Plans are key to preserving and improving water quality within the subwatersheds.

The City of Barrie Official Plan has both goals and policies set around the preservation and improvement of water quality for Kempenfelt Bay and the watercourses within the city. It touches on most of the stressors listed in Table 3-10, with the exception of application of salt, agricultural runoff, and climate change. Management of water resources, with respect to natural heritage and resources (under General Policies), is to be looked at with an integrated watershed approach when reviewing development proposals. The City is responsible for promoting water conservation and maintaining the quality and sustainability of surface and groundwater resources, protecting, improving and restoring them where possible (Policy 3.5.2.3). In terms of water and wastewater, there are policies to ensure the City make an effort "to use modern and cost effective water pollution abatement measures in order to provide safe, sanitary and efficient methods of water treatment and waste water disposal" (Policy 5.2.2.1).

Under the Barrie OP Policy 5.3.2.2 (policies for stormwater management) all major developments are required to prepare stormwater management studies and plans; channelization is restricted (unless necessary for flood relief, erosion control, fisheries protection or to environmentally enhance the site); development proposals are restricted from locating stormwater management facilities on lands designated as Environmental Protection or Open Space (unless in accordance with provincial policy); and where necessary existing stormwater ponds should be retrofitted to the standards of the City and senior government legislation. Policy 5.3.2.3 looks at the design criteria for development, directing new development away from flood prone areas; encouraging the creation of green roofs and ponding on flat roofs in areas of high density; and promoting best management practices for development occurring on aquifers or areas that may have groundwater recharge. There is also reference to policies set out for water quality in the LSPP.

Similarly, the Town of Innisfil Official Plan also addresses almost all the stressors listed in Table 3-10, again with the exception of application of salt and climate change, with goals, objectives and policies focused on protecting, improving and restoring water quality of the watercourses and the groundwater found within the municipality. Natural heritage policies (2.4.1-2.4.7) focus on strengthening linkages to protect and enhance surface and groundwater quality. A naturalized riparian buffer adjacent to watercourses and the shoreline is encouraged in existing development and required in future development to improve water quality and fish habitat (Policy 2.7.10). Further, in terms of development, Policy 4.7.1 states “applications for development and large scale site alteration, including golf courses, within the Town must be supported by a Surface Water Quality Analysis demonstrating, to the satisfaction of the Town in consultation with the applicable conservation authority and the Ministry of the Environment, that there will be no negative impacts on the water quality of Lake Simcoe, its tributaries…”.

There are also a number of policies around maintaining and preventing degradation of the water quality in Lake Simcoe, as a large portion of the Lake Simcoe shoreline is within the municipality. These include providing full municipal sewer sources to portions of the shoreline that are currently on individual septic systems (Policy 2.7.7).

Lastly, on a smaller scale than the LSPP, the Subwatershed Plans themselves are also an important vehicle for highlighting the current conditions of the water quality, what the stressors are, where the gaps are in current acts, regulations, policies and plans, and to provide recommendations that count on the involvement of various partners, as well as encouraging their incorporation into municipalities Official Plans.

3.4.2 Restoration and Remediation

There are a range of programs operating in these subwatersheds to assist private landowners improve the environmental health of their land.

The Landowner Environmental Assistance Program (LEAP) is a partnership between the Lake Simcoe Region Conservation Authority, its member municipalities, and the York, Durham, and Simcoe chapters of the Ontario Federation of Agriculture. This program provides technical and financial support to landowners in the Lake Simcoe watershed wanting to undertake stewardship projects on their land. Project types which have traditionally been funded by the LEAP program include managing manure and other agricultural wastes, decommissioning wells and septic systems, fencing and planting riparian areas, and increasing the amount of wildlife habitat in the watershed, among others. Since 1989, LEAP has supported a number of projects specifically aimed at improving water quality in this subwatershed, including 54 septic system upgrades, two stormwater pond retrofits, 10 well decommissionings and three wellhead protection projects in the Innisfil Creeks subwatershed. The Ministry of Natural Resources has also completed two septic system upgrades.

The Ontario Ministry of Agriculture, Food and Rural Affairs has also partnered with Agriculture and Agri-Food Canada and the Ontario Soil and Crop Improvement Association to provide the Environmental Farm Program to registered farm landowners throughout the province. This farmer-focused program provides funding to landowners who have successfully completed an Environmental Farm Plan for projects including management of riparian areas, wetlands, and woodlands. Through this program approximately 35 projects that would improve water quality have been implemented in the Town of Innisfil, while in the City of Barrie less than five have been completed.

In 2008 and 2009, LSRCA field staff surveyed the majority of the watercourses in this subwatershed, documenting the range of potential stewardship projects that could be implemented to help improve water quality and fish habitat. This survey found 40 sites in this subwatershed where runoff was entering creeks, potentially impacting water quality.

3.4.3 Science and Research

An ongoing commitment to applied science and research is necessary to improve our understanding of the water quality within the Lake Simcoe watershed. Ongoing monitoring programs led by the MOE and the LSRCA, and periodic research studies conducted by academics, are contributing to our understanding of these values.

Since the 1980s, efforts have been made through the Lake Simcoe Environmental Management Strategy (LSEMS) to identify and measure sources of phosphorus in the watershed and recommend remedial measures. As set out in the Lake Simcoe Protection Act (passed December 2008), objectives of the LSPP include reduction of phosphorus loads. Estimates of total phosphorus (TP) loads to the tributaries and lake are used to evaluate the progress towards achieving the water quality-related objectives of LSEMS and the LSPP. Research projects aimed at understanding the links between phosphorus loading and biotic impairment also require estimates of phosphorus loading to the lake. Since the 1990s, annual TP loads have been estimated from atmospheric deposition, tributary discharge, urban runoff, water pollution control plants (WPCPs), septic systems, and vegetable polders. Total phosphorus loss from the lake through the outflow is also quantified. Quantitative hydrological data and lake water balances are evaluated and used for the calculation and validation of the loads.

The Ontario Ministry of the Environment, Environment Canada, Parks Canada, and LSRCA operate monitoring sites throughout the watershed and information from these programs is used for load estimations. Ongoing research and monitoring will aid in detecting changes in watershed conditions that affect phosphorus loads. The effectiveness of management efforts and understanding of issues, such as climate change and atmospheric deposition, will improve through research and monitoring and we will be better prepared to deal with future impacts.

There is also a current monitoring project within the City of Barrie which includes the newly (2010) retrofitted Bryne Drive stormwater pond (located just north of Mapleview Dr) that is treating a relatively new industrial/commercial catchment. Prior to the retrofit, the pond was undersized and not providing adequate treatment of stormwater runoff. As part of the retrofit project, performance monitoring by the LSRCA of the facility pre- and post- construction was recommended examine water quality improvements of the receiving stream and see what the overall benefits are. The post construction monitoring data will also be used to examine the performance of the new pond by comparing flow and concentrations (for parameters such as phosphorus, chloride and suspended solids) at both the inlet and outlet of the pond. The ponds' ability to retain these parameters under a variety of storm intensities and durations will yield valuable information for not only this project but will also be useful in furthering the knowledge base on urban stormwater management.

In addition to these ongoing monitoring programs, numerous scientific and technical reports have been published based on research conducted in the Lake Simcoe watershed. As a result of this combined focus, Lake Simcoe is one of the most intensively studied bodies of water in Ontario. The results of this research have been summarized, in part, in LSEMS (2008) and Philpot et al (2010), and have informed the development of this subwatershed plan.

The Lake Simcoe Protection Plan also commits the MOE, MNR, MAFRA, and LSRCA to research and monitoring related to water quality in Lake Simcoe and its tributaries. An enhanced scientific water quality monitoring program is proposed to continue and build upon routine monitoring of key parameters and of biological indicators linked to water quality, as well as monitoring and reporting upon the effectiveness of measures put forth to improve water quality (Policy 4.22). Additionally, scientific research projects that build on existing research and monitoring programs for identifying emerging issues are to be promoted (Policy 4.23).

3.5 Management Gaps and Recommendations

As described in the previous sections, many regulations and municipal requirements aimed at protecting water quality of the Innisfil Creeks subwatersheds already exist. Similarly these subwatersheds have been the focus of numerous restoration and remediation efforts, such as those coordinated through the Landowners Environmental Assistance Program (LEAP) and the Environmental Farm Plan. Despite this strong foundation, there are a number of gaps in the management framework that need to be considered. This section identifies some of the gaps in existing protection and restoration of the water quality in the Innisfil Creeks subwatershed, and outlines recommendations to help fill these gaps.

It is recognized that many of the undertakings in the following set of recommendations are dependent on funding from all levels of government. Should there be financial constraints, it may affect the ability of the partners to achieve these recommendations. These constraints will be addressed in the implementation phase.

3.5.1 Groundwater (Hydrogeologic and Hydrologic)

There is a need to maintain, and in some locations, enhance groundwater flow patterns in terms of volume and temperature in the tributaries that are dependant on baseflow contributions for the ecological requirements of those systems, within the Innisfil Creeks subwatershed.

> **Recommendation 3-1**- That the LSRCA, with the support of the MOE, provide a white paper to subwatershed municipalities describing the range of LID technologies that could potentially be used to mitigate the impacts of development on surface and groundwater quality and quantity. Further, that the LSRCA and subwatershed municipalities identify the barriers associated with the uptake of LID technology and, with the support of MOE, develop recommendations for overcoming these barriers.
>
> **Recommendation 3-2** - That the federal and provincial governments provide sufficient financial incentives, or otherwise address barriers identified in Recommendation #3-1, to ensure subwatershed municipalities use Low impact Development (LID) practices and promote the adoption of Smart Growth Urban Design Guidelines.

3.5.2 Surface Water

3.5.2.1. <u>Urban - improving stormwater</u>

Within the Town of Innisfil (including the recently annexed lands) it has been calculated that 67% of the urban area does not have any stormwater control, 14% has quantity control only, and the remaining 19% is controlled by Level 1, 2, 3 or 4 stormwater facilities. The general lack of stormwater control within the subwatershed provides many opportunities for retrofits and/or more innovative Low Impact Design (LID) solutions. Significant reductions in phosphorus loads to Lake Simcoe, in addition to improvements to the tributaries, would result from improved stormwater control. While Secondary Plans are in development for the annexed lands, this clean slate could also be considered a unique opportunity to implement innovative solutions to stormwater control. Maintenance of existing stormwater facilities has also been identified as an issue within the watershed, with many facilities operating at one or more level below their design.

The LSPP already includes a number of polices related stormwater management, leading off with the requirement for municipalities to prepare and implement comprehensive stormwater management master plans. The following recommendations build on the LSPP stormwater management policies.

Recommendation 3-3 - That the subwatershed municipalities, with the assistance of the LSRCA, promote the increased use of innovative solutions to address stormwater management and retrofits such as:

- enhanced street sweeping and catch basin maintenance, particularly in those areas currently lacking stormwater controls;
- improving or restoring vegetation in riparian areas;
- installation of rainwater harvesting; construction of rooftop storage and/or green roofs; the use of bioretention areas and vegetated ditches along roadways;
- the use of soakaway pits, infiltration galleries, permeable pavement and other LID solutions, where conditions permit; and
- the on-going inventory, installation, and proper maintenance of oil grit/hydrodynamic separators combined with the use of technologies to enhance their effectiveness where appropriate.

Recommendation 3-4 - That the Province of Ontario, through the implementation of the Lake Simcoe Phosphorus Reduction Strategy, provide significant incentive funding to the relevant municipalities and/or the LSRCA to maintain, construct, and /or retrofit stormwater facilities as identified by the LSRCA Stormwater Rehabilitation program.

Recommendation 3-5 - That the subwatershed municipalities routinely monitor and maintain the design level of existing stormwater facilities. In addition to maintaining design level, criteria for maintenance should also include frequency and exposure to spills and other contaminant sources. Further, that the federal and provincial governments be requested to share in the cost of maintenance.

Recommendation 3-6 - That the subwatershed municipalities complete the Stormwater Management Master Plans as outlined in the LSPP 2011 Comprehensive Stormwater Management Master Plans Guidelines document with particular emphasis on maintenance of facilities, and the need for retrofits where appropriate.

Recommendation 3-7 - That the LSRCA and its partners recognize that while the construction and/or retrofit of quality control facilities is extremely important, quantity control is also an important consideration in some areas of the Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds; therefore, quantity control facilities should be constructed in those areas where geographical space is limited or other LID options are not feasible. In these situations, federal and provincial governments should provide financial incentives to allow municipalities to complement quantity control stormwater ponds with an enhanced street sweeping program.

Recommendation 3-8 - That Official Plans be amended to contain policies that would help minimize impervious surface cover in the Innisfil Creeks subwatershed through requirements such as using low impact development solutions, limiting impervious surface areas on new development, and/or providing stormwater rates rebates and incentives to residential and non-residential property owners demonstrating best practices for managing stormwater.

3.5.2.2. Urban – construction practices

Projected growth within this subwatershed dictates that rate of construction is going to increase. Significant deterioration to tributary water quality can occur during construction phase as exposed soils are very susceptible to run-off and wind erosion if codes of practices are not followed. While site alteration by-laws, and policies in the LSPP (e.g. 4.20-DP) aim to minimize construction phase impacts, further improvements could be made through use of current BMP and improved enforcement.

> **Recommendation 3-9** - That the LSRCA and watershed municipalities promote and encourage the adoption of best management practices to address sedimentation and erosion controls during construction and road development.
>
> **Recommendation 3-10** - That subwatershed municipalities and LSRCA improve current monitoring and enforcement of site alteration by-laws by undertaking a review of the current program and ensuring that adequate resources are available for the improvements.

3.5.2.3. Urban – reducing salt (chloride)

Currently there is insufficient long-term trend data for almost all of the creeks within the Innisfil Creeks subwatershed. Only Leonard's Creek is monitored, of which a large portion is located in mainly in rural and natural heritage cover, and therefore is currently not experiencing elevated chloride levels. Continued monitoring is required to determine if there is an increasing trend, as is being found in the neighbouring subwatersheds (Lovers and Hewitt's Creeks subwatersheds). As it is likely that the systems within the more urban areas of the Town of Innisfil are experiencing increasing trends, that could be impacting the health of the aquatic communities, steps to reduce chloride are needed.

> **Recommendation 3-11 -** That the LSRCA, with the support of subwatershed municipalities, develop a program to determine relative contribution of chloride from road salt application, establish baseline indicators, and examine the effectiveness of current protocols on salt storage, application, and disposal, as outlined in their respective Salt Management Plans, adapting them as necessary.
>
> **Recommendation 3-12** – That the LSRCA, with the support of subwatershed municipalities, identify areas within the Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds which are vulnerable to road salt (as outlined by Environment Canada). This assessment may be refined through further examination of relative salt tolerance of local biota. As outlined in Environment Canada's Code of Practice for the Environmental Management of Road Salt, municipalities should examine alternate methods of protecting public safety while reducing environmental impacts in these areas, once identified.
>
> **Recommendation 3-13 -** That subwatershed municipalities, with the assistance of the LSRCA, develop or adopt a program such as the Region of Waterloo's "Smart about Salt" program, to educate snow removal contractors and property managers about best practices for reducing salt use while ensuring that public safety is not compromised. Further, that subwatershed municipalities examine the feasibility of adopting a certification program, wherein private contractors could become certified as "smart" salt applicators, reflecting their understanding of the need to balance environmental protection and public safety in snow and ice management, and the feasibility of requiring all contractors working on municipal property to have such certification.

> **Recommendation 3-14** - Recognizing that increasing concentrations of chloride in watercourses is an emerging issue shared by all municipalities in the Lake Simcoe watershed, that the watershed municipalities, LSRCA, MOE, and MNR form a Salt Working Group as a mechanism to share information on best practices for salt application, methods of increasing public awareness of the environmental impacts of road salt, and the effectiveness of municipal Salt Management Plans.

3.5.3 Agriculture

Subwatershed modelling (that excludes atmospheric) indicates that 30% of phosphorus loads can be attributed to agriculture in the Innisfil Creeks subwatershed. Recent water quality monitoring (2008 to 2010) within Leonard's Creek has shown that 45% of the samples for phosphorus concentration exceed the provincial standards. Considering the current concentrations of phosphorus in Leonard's Creek, and the large proportion that can be attributed to agricultural sources, actions leading to reduction in agricultural phosphorus loads to this creek, as well as all the others within the Innisfil Creek subwatershed, are a priority.

Within the current management framework, the Nutrient Management Act contains the most stringent policies related to agriculture, as it requires plans for the management of nutrients created and/or stored on farms. Other policies relate to the protection of agricultural resources, but few relate to the management of nutrients from agricultural areas, with only 'have regard to' statements encouraging the use of agricultural BMPs.

Although there are currently no requirements for farmers to undertake BMPs such as cover crops, conservation tillage, the planting of windrows, and leaving riparian buffers intact, there are a number of available programs to assist farmers to implement these programs. In particular, the Environmental Farm Plan program and LSRCA's Landowner Environmental Assistance Program (LEAP) provides guidance and funding for a number of types of projects. Other gaps in current management include policies requiring livestock to be fenced and kept out of watercourses, an activity that causes numerous water quality issues as well as causing bank instability.

> **Recommendation 3-15** - That the subwatershed municipalities, through the LSRCA, create a roundtable made up of municipalities, LSRCA, MOE, MNR, OFA, NGOs, and related landowner representatives, or through existing frameworks such as the Lake Simcoe Stewardship Network, to determine co-operative ways of implementing phosphorus reduction and improved water quality measures in Hewitt's, Lovers, and Innisfil Creeks, and to develop an 'action plan' for their implementation within the agricultural and rural communities.
>
> **Recommendation 3-16 -** That the spatially-explicit tool to be developed under Recommendations 5-7 and 5-8 (**Chapter 5 – Aquatic Habitat**) be used to prioritize allocation of stewardship resources, so that funds are provided in locations where maximum phosphorus reduction can be achieved.

Note that unrestricted livestock access and its related impacts were reported on and remedial actions are recommended as part of the implementation of agricultural BMPs in **Chapter 5 - Aquatic Habitat**. Recommendations 5-7 and 5-8 are most relevant to the concern.

3.5.4 Water Temperature – thermal degradation

Increases in stream temperature in the subwatersheds, whether they are due to impervious surfaces, lack of riparian vegetation, reduction of groundwater contributions, or climate change negatively affect the distribution and existence of coldwater resources like brook trout and mottled sculpin due to their restrictive thermal requirements.

> **Recommendation 3-17**– That, as new or retrofit stormwater facilities are constructed, LSRCA work with subwatershed municipalities to reduce potential thermal impacts of those stormwater ponds and to recognize the importance of LID uptake in relation to maintaining stream temperature.
>
> **Recommendation 3-18**- That the LSRCA work with its federal, provincial, and municipal partners to refine the anticipated impacts of climate change in the Lake Simcoe watershed. This information can then be used to develop management strategies to address these impacts. Emphasis at this time should be placed on building ecological resilience in vulnerable subwatersheds through stream rehabilitation, streambank planting, barrier removal, and other BMP implementation in conjunction with the protection of current hydrologic functions.

Note that thermal issues associated with dams were also reported on and remedial actions are recommended as part of the implementation of BMPs in **Chapter 5 - Aquatic Habitat**. Recommendation 5-7 and 5-9 assist in dealing with this specific concern.

3.5.5 Monitoring and Assessment

Currently there is only one surface water station within Leonard's Creek representing the many smaller creeks within the Innisfil Creeks subwatershed. Obviously there is a significant need to provide improved and expanded information on temporal and spatial change in water quality within the subwatersheds. The existing monitoring networks are not comprehensive enough and a review of the expectations of the program is required. More extensive and frequent sampling will be required to meet future needs. In addition, potential issues related to new water quality contaminants such as pharmaceuticals will require further investigation.

> **Recommendation 3-19**- That the LSRCA enhance the existing monitoring network, through the comprehensive monitoring strategy, to address identified limitations and gaps of the current monitoring program. Review of potential enhancements should consider:
>
> - Undertaking periodic monitoring of toxicants such as pesticides and pharmaceuticals
> - Spatial coverage of monitoring stations relative to addressing key monitoring questions such as the relationship between changes in land use cover and changes in water quality and quantity
> - Establishing water quality monitoring stations in the headwaters, in addition to the mouths, of the tributaries
> - Monitoring additional parameters that are are key indicators of ecosystem health and restoration progress such as brook trout spawning.
>
> **Recommendation 3-20** – That the MNR, LSRCA, and MOE develop a framework to allow effective and efficient management and sharing of data before implementing the

comprehensive monitoring program. This framework may include the designation of one agency as the curator of all monitoring data collected in the Lake Simcoe watershed.

Recommendation 3-21 - That the LSRCA, MNR and MOE analyse and report the results of the existing and proposed water quality, water quantity, and aquatic and terrestrial natural heritage monitoring programs annually, and that the information be used to update the LSRCA Watershed Report Card. Further, stakeholders should be made aware when updates are available, and be provided access to the monitoring data collected via a web portal, to increase distribution and communication of this data.

Recommendation 3-22 – That the LSRCA, in collaboration with MNR, MOE, and MAFRA, develop a program for assessing efficacy of new stormwater facilities, stewardship best management practices, and restoration projects, to improve understanding of the effectiveness of stewardship efforts.

4 Water Quantity – Surface and Groundwater

4.1 Introduction and Background

The effective management of water resources requires the accounting of the total quantity of water and its distribution within a watershed, known as a water budget. The input into the budget is the total amount of precipitation within a watershed and the outputs include evaporation, transpiration, infiltration (movement of water into the subsurface), and runoff (or overland flow) into rivers and streams, which all make up components of the hydrologic cycle.

Surface water quantity deals with components of the hydrologic cycle that move overland and are within lakes, streams and wetlands. Surface flow is comprised of groundwater discharge into rivers and streams, overland flow from rain, snow melt, and precipitation that falls directly into lakes, rivers, streams and wetlands.

Groundwater quantity deals with components of the hydrologic cycle that are present below the earth's surface, in the spaces between rocks and soil particles. The discharge of groundwater to lakes and streams remains relatively constant from season to season; it therefore forms an important part of the surface water flow system, and is particularly important when surface runoff is at its lowest levels, when it can be the only source of water to streams.

Many natural systems rely on a consistent supply of groundwater. Fish species that depend on coldwater conditions for their survival require a very high ratio of cold, clean groundwater to total stream flow. Many ponds and wetlands are maintained by groundwater flow during the dry summer months. In many areas throughout the subwatershed, humans are extremely dependent on a reliable supply of groundwater for many purposes including irrigation of fields, potable water, industry, and recreation.

Targets set for water quantity under the Lake Simcoe Protection Plan include:

- Maintenance of instream flow regimes that are protective of aquatic ecosystem needs, and;
- Effective water conservation and efficiency plans

The physical properties of a watershed, such as drainage area, slope, geology, and land use can influence the distribution of the water and the processes that function within it. This chapter quantifies the surface and groundwater components within the hydrologic cycle for the watershed and also identifies how the rural and urban land uses in the Innisfil Creeks subwatershed have altered the hydrologic cycle (Figure 4-1), including changes to the surface flow volumes, annual flow patterns, and the risk of flooding.

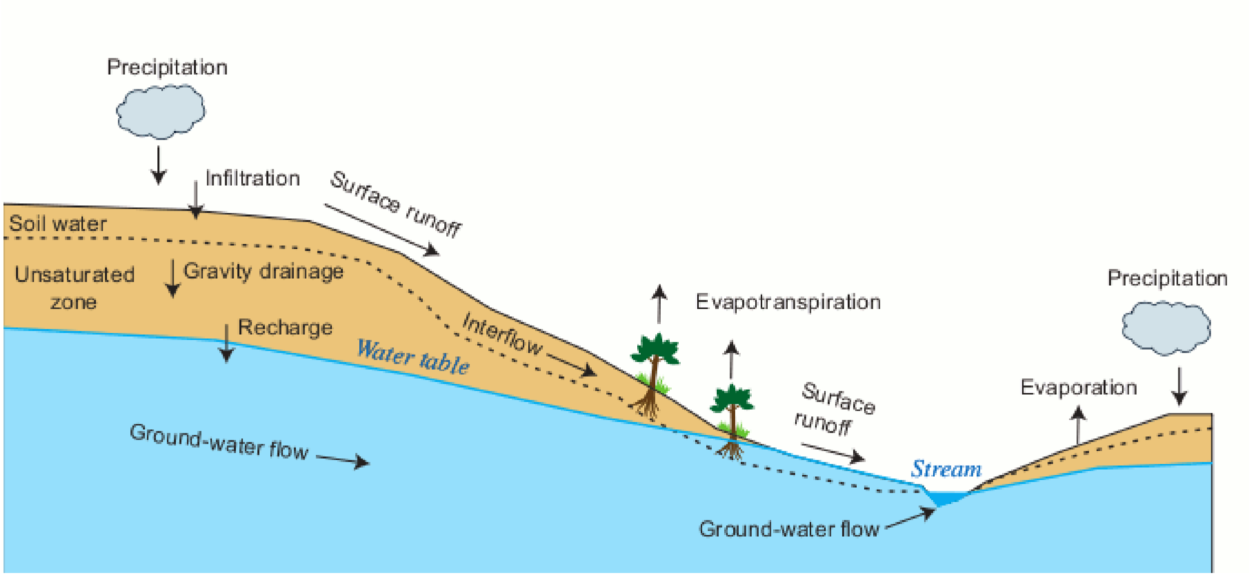


Figure 4-1: Hydrologic cycle (USGS, 2008).

4.1.1 Understanding the factors that affect water quantity

There are several factors that influence the quantity of surface and groundwater available within a subwatershed. They are climate, geology, land use, and water use.

Climate

Both surface and groundwater quantity can be influenced by a number of climatic factors including precipitation, evaporation, and evapotranspiration. Precipitation is the main climate variable that has a direct influence on the quantity of water available, since it is the main input into the system. The amount of precipitation that falls, particularly in one event, will have a significant influence on how much infiltrates into the soil, and how much will run off. In southern Ontario, relatively little precipitation runs over the land to watercourses, as a high percentage of the precipitation is either cycled back into the atmosphere through evapotranspiration or infiltrates into the soil; although, in the case of an intense storm event where a large quantity of precipitation falls over a short period of time, most of the precipitation will be directed overland. This will also occur with a significant snowmelt event. These types of events are generally observed in March or April snowmelts or the onset of spring rains in April or May. Table 2-9, **Chapter 2- Study Area and Physical Setting**, shows the total mean annual precipitation at the Barrie WPCC climate station is 921mm.

There are other variables associated with climate that will influence water quantity. In particular, evapotranspiration is strongly influenced by climate and, unlike precipitation, it is considered an output or loss to the system. Evapotranspiration is the water lost to the atmosphere by two processes, evaporation and transpiration. Evaporation is the loss from open bodies of water, such as lakes and reservoirs, wetlands, bare soil, and snow cover; transpiration is the loss from living plant surfaces. Other factors that affect the evapotranspiration process include net solar radiation, surface area of open bodies of water, wind speed, density and type of vegetative cover, availability of snow moisture, root depth, reflective land surface characteristics, and season.

Geology and physiography

The geology and physiography also has a significant influence on water movement within the subwatershed. The underlying geology and the type of soil present at the surface (surficial geology) will determine how much water will be infiltrated during a precipitation event and how much water will flow overland to a watercourse. In addition, knowledge of the local geology and physiography is needed to understand how water moves both on and beneath the ground in saturated and unsaturated zones. For example, coarse-grained and loosely packed soils, such as sands and gravels, will promote groundwater recharge, whereas fine-grained or hard packed soils, such as clay, will allow less water to infiltrate to recharge the groundwater system. **Chapter 2 – Study Area and Physical Setting** provides more information and figures related to the geology and physiography of the study area.

Land use and land cover

Land use and cover are important factors that can strongly influence both surface and groundwater quantity because they will affect several aspects of the water budget including surface water runoff, evaporation, and infiltration. Developed land will often have a higher proportion of impervious surface, such as roadways, parking lots, and buildings roofs. Increased runoff rates result in erosion and reduced infiltration to recharge groundwater reserves. In addition, groundwater pathways may also be affected by development, which can result in decreased discharge to wetlands and streams.

The main land use classifications present in the Innisfil Creeks subwatershed include urban, rural, natural cover (e.g. wetlands, woodlands, and grasslands), golf courses, and aggregate extraction (Figure 2-2 in **Chapter 2 – Study Area**). Wetlands are found in areas of topographic lows and the groundwater often intersects the surface in these areas. The intersection of the surface with the groundwater table allows for a constant flow of surface water in these areas.

As the population continues to grow, urban areas are expanding, resulting in widespread areas of impervious surfaces. These impervious surfaces lead to a decrease in the time it takes a watercourse to reach to peak flow following a rain event, as the ability to store and slowly release water has been eliminated. Watercourses in the undeveloped areas of the subwatershed exist under natural conditions making them less vulnerable to extreme changes in climatic events; for example the time it takes to reach peak flow is not as rapid as in urban areas. As impervious surfaces increase in area, volume of peak flow can also increase as water cannot infiltrate into the ground, and therefore runs off into surface water bodies, which can increase the risk of flooding, particularly during the spring freshet.

Water use

In the Innisfil Creeks subwatershed both surface and groundwater are used for a variety of purposes, including municipal water supply, agriculture, commercial use, golf course irrigation, private water supplies, and by the native plants and animals. Many of these users withdraw large amounts of water and could potentially be putting stress on the system. Therefore, it is important to be able to identify the large water users by location, source of water (surface or groundwater), type of water use, and volume of water taken to ensure the available water supply within the subwatershed is managed in a sustainable manner. An effort to quantify these water withdrawals has been undertaken within studies required under the Clean Water Act and the Lake Simcoe Protection Plan (discussed in Section 4.3).

4.1.2 Previous Studies

Information from several groundwater and water budget studies was used to assess the hydrogeology of the Innisfil Creeks subwatershed. The following is a list of key studies and reports that have influenced the information provided in this chapter:

South Simcoe Groundwater Management Study

The MOE funded a series of groundwater studies across the province in the early 2000s to help municipalities measure the quantity, quality, and location of groundwater in aquifers. A number of these studies were completed within or overlapping the Lake Simcoe watershed, as outlined below.

The South Simcoe Groundwater Partnership, consisting of the Nottawasaga Valley Conservation Authority (NVCA), LSRCA, Canadian Forces Bases (CFB) Borden, the Simcoe County District Health Unit, the MOE, and the local municipalities within the study area, was established in October 2001 to examine local groundwater resources across an area that included the western portion of the Lake Simcoe watershed, adjacent to Lake Simcoe, and stretching west across much of the Nottawasaga River watershed. The work was completed by Golder Associates Ltd. (GAL) and Dixon Hydrogeology on behalf of the South Simcoe Groundwater Partnership (Golder Associates and Waterloo Hydrogeologic, 2004).

The study delineated local aquifers, identified risks to groundwater quality and quantity, defined the Wellhead Protection Areas (WHPAs) for all municipal water supplies and provided planning tools for protecting and managing groundwater.

Source Water Protection water budget studies and modelling initiatives

Much of the information presented throughout this chapter has been extracted from and is consistent with the information, data, and modelling results developed and reported through several Source Water Protection (SWP) water budget studies. These studies were developed according to provincial direction provided by the Ministry of the Environment (MOE) in the Technical Rules (MOE, 2008) prepared for the provincial Source Water Protection program under the *Clean Water Act* (2006).

A number of modelling initiatives have been undertaken in the Innisfil Area. These include groundwater and surface water models developed for the SGBWLS Tier 2 Water Budget and Water Quantity Stress Assessment and the Barrie Tier 3 Water Budget and Water Quantity Risk Assessment that formed the basis for the Innisfil Creeks subwatershed Tier 2 Assessment completed for the Lake Simcoe Protection Plan modelling work.

- South Georgian Bay-Lake Simcoe Watershed Preliminary Conceptual Water Budget Report (2007);
- Lake Simcoe Watershed Tier One Water Budget and Water Quantity Stress Assessment Report (LSRCA, 2009);
- South Georgina Bay West Lake Simcoe Hydrostratigraphic Conceptual Model Report (AquaResource and Golder, 2010);
- Tier 2 Water Budget and Water Quantity Stress Assessment Report (AquaResource and Golder, 2010);
- South Georgina Bay West Lake Simcoe Tier 2 Water Budget and Water Quantity Stress Assessment Report (AquaResource and Golder, 2010)
- Water Balance Analysis of the Lake Simcoe Basin using the Precipitation-Runoff Modelling System (PRMS) (Earthfx, 2010).
- City of Barrie Tier Three Water Budget and Local Area Risk Assessment Conceptual Understanding Memorandum (AquaResource, Golder and IWC, 2010) – DRAFT

- City of Barrie Tier Three Water Budget and Local Area Risk Assessment Groundwater Flow Model (AquaResource, Golder and IWC, 2011) – DRAFT

Lake Simcoe Protection Plan Water Budget and Ecologically Significant Groundwater Recharge Area Assessment
As a requirement under the Lake Simcoe Protection Plan, a Tier 2 water budget was completed for the Innisfil Creeks subwatershed. This study included revising models previously completed under source water protection initiatives as mentioned above. The water budget and stress assessment results presented in this chapter are findings from this study.

Lake Simcoe Region Conservation Authority surface water monitoring program
Information about water quantity is required by a wide audience, including research scientists, policy-makers, design engineers, and the general public. Water level and flow data are used by decision makers to resolve issues related to sustainable use, infrastructure planning, and water apportionment. Hydrological models use the data to improve the forecasting of floods and water supplies, and to predict the impacts of changes in flow regimes to human and aquatic health and economic activity.

The Lake Simcoe Region Conservation Authority, in co-operation with Environment Canada and the MOE, operates and maintains 16 hydrometric stations on the major tributaries of Lake Simcoe. Data is collected, catalogued, and interpreted by the Lake Simcoe Region Conservation Authority using Kisters WISKI hydrologic software. This data is essential for flood-forecasting, planning, nutrient budget estimation for Lake Simcoe, and to support the water quantity information needs of our municipal partners.

4.2 Current status

4.2.1 Hydrogeologic setting

The hydrogeology of the Innisfil Creeks subwatershed is shaped by the stratigraphic framework discussed in **Chapter 2 – Study Area and Physical Setting** (Section 2.4). For numerical modelling purposes, a hydrostratigraphic conceptual model and layer structure was developed in preparation for three-dimensional groundwater flow modelling. This work was completed by AquaResource and Golder (2010) and AquaResource *et al*., (2011) for the Tier 2 Water Budget and Water Quantity Stress Assessment and further refined for the City of Barrie Tier 3 Water Budget and Water Quantity Risk Assessment, both of which build upon previous models developed for the South Simcoe Groundwater Studies (Golder, 2004). In addition, the Innisfil Creeks Tier 2 study included a number of modelling refinements using the Tier 3 model and extending it to the entire Innisfil Creeks subwatershed.

The hydrostratigraphic units refer to groups of geologic layers that possess similar hydrologic characteristics and that are considered to act together as an aquitard or aquifer unit at the scale of the investigation. The subwatershed contains both overburden and bedrock aquifers that can be utilized for water supply; however, the majority of the municipal supplies and all of the large capacity wells are constructed in overburden. Within the subwatershed, the most transmissive units are the coarse-grained overburden deposits typically found at depth. Groundwater flows rapidly through these deposits, and they act as excellent local and regional aquifers.

The aquifer system contains four major sand and gravel aquifer units (from shallowest to deepest: A1, A2, A3, and A4). The shallowest units (A1 and A2) are generally unconfined in the subwatershed, with A1 mainly constrained to upland areas. The aquifer system and hydrostratigraphy within the subwatershed were divided into the following 10 hydrostratigraphic units and 14 layers model layers as outlined in Table 4-1 (AquaResource *et al*., 2010).

Table 4-1: Hydrostratigraphic units within the subwatershed (Table has been modified from AquaResources *et al.*, 2011).

Model Layer	Unit Name	Description
Layer 1	SrfG	Represents conductance in stream beds, mapped surficial geology. 0.10-3 m in thickness.
Layer 2, 3	UC	Represents confining layer over A1, mostly present in upland areas such as the Oro Moraine.
Layer 4	A1	Upper most aquifer, present in upland areas. Frequently exists as surficial and unconfined, stratigraphically equivalent to the Oak Ridges Moraine, generally is associated with coarse and interglacial sediments mapped as ice-contact stratified drift.
Layer 5	C1	Upper Aquitard
Layer 6	A2	Intermediate Aquifer, stratigraphically equivalent to interstadial units within the Northern Till. Within the lowland areas it is often the uppermost coarse-grained unit, commonly used for private water supplies, as well as some of the smaller municipal water supply wells (i.e. Innisfil)
Layer 7	C2	Intermediate Aquitard, providing protection to the municipal aquifer
Layer 8, 9, 10, 11	A3	Main municipal production aquifer, stratigraphically equivalent to the Thorncliffe deposits in the Upland regions. Represents the bulk of the Barrie-Borden channel aquifer.
Layer 12	C3	Lower Aquitard
Layer 13	A4	Lower Aquifer, thin and sometimes combined with A3 in the Barrie City Core, where C3 is thin or absent.
Layer 14	C4	Lower Aquitard, also represents weathered bedrock.

4.2.2 Hydraulic Properties

Hydraulic properties such as hydraulic conductivity, specific storage (S_s), specific yield (S_y) hydraulic gradients, and porosity characterize the amount, rate, and direction of groundwater flow through soil and rock. Hydraulic conductivity is the primary variable that controls the calculated hydraulic head distribution throughout a groundwater flow model. Coarse grained materials (sands and gravels) are assigned a higher hydraulic conductivity than finer grained materials (silts and clay). Specific storage and porosity are closely related hydraulic properties. Porosity refers to the volume of void space per unit volume of geologic materials, where specific storage refers to volume of water stored within the geologic materials.

Table 4-2 provides a summary of the average initial estimated aquifer parameters derived mainly from pumping tests at the municipal wells. Further refinement of these estimates was completed during the calibration stage of model development, this is shown in (AquaResource *et al.*, 2011).

Table 4-2: Average initial hydraulic conductivity estimates (AquaResource *et al.*, 2011).

Unit	Mean Hydraulic Conductivity (m/s)
UC	1.66E-06
A1	1.12E-04
C1	2.43E-07
A2	1.44E-04

Unit	Mean Hydraulic Conductivity (m/s)
C2	3.4E-07
A3	5.4E-03
C3	3.68E-07
A4	8.49E-05
C4	1.75E-07

4.2.3 Groundwater flow

Groundwater flow is controlled by the variation in aquifer transmissivity (i.e. hydraulic conductivity multiplied by aquifer thickness) taking into consideration hydraulic gradients. Groundwater moves continuously but at different rates based on the hydraulic properties of the hydrostratigraphy mentioned in Section 4.2.1. Groundwater will flow down a hydraulic gradient from points of higher to lower hydraulic heads. The direction of movement at any point within the system is dependent on the distribution of hydraulic potential (Funk, 1997). Within each formation, groundwater can move in both the horizontal and vertical directions. Since the shallow water table commonly follows the ground surface topography, horizontal flow can be topographically mapped using water table data obtained from shallow wells. Figure 4-2 and Figure 4-3 illustrate the predicted shallow (A1 aquifer) and deep (A3 aquifer) water level contours produced in the steady state groundwater flow model. They can be used to approximate groundwater flow directions. These figures were derived from the Draft Innisfil Tier 2 Study and are based on observed water levels in observation and pumping wells (AquaResource, 2012).

As illustrated in Figure 4-2 shallow water levels throughout the subwatershed are shown to mimic the ground surface topography, and the flow converges towards the higher order streams and Lake Simcoe. The groundwater elevation contours compare well with the observed water level contours illustrated within the Barrie Tier 3 report (AquaResource *et al.*, 2011), in that flow gradients are similar, both in terms of direction and magnitude, especially considering flow driven toward Cooks Bay.

As illustrated in Figure 4-3, the deep aquifer water level contours within the study area are similar to the shallow water levels, however they exhibit a more subdued expression. Although the simulated equipotentials reflect the same flow gradients as the observed equipotentials, some local features within the simulated results are absent. The upgradient area between the Lovers Creek and Innisfil Creeks subwatersheds is smaller in extent than that in the shallow, indicating that downward gradients are the strongest in this area.

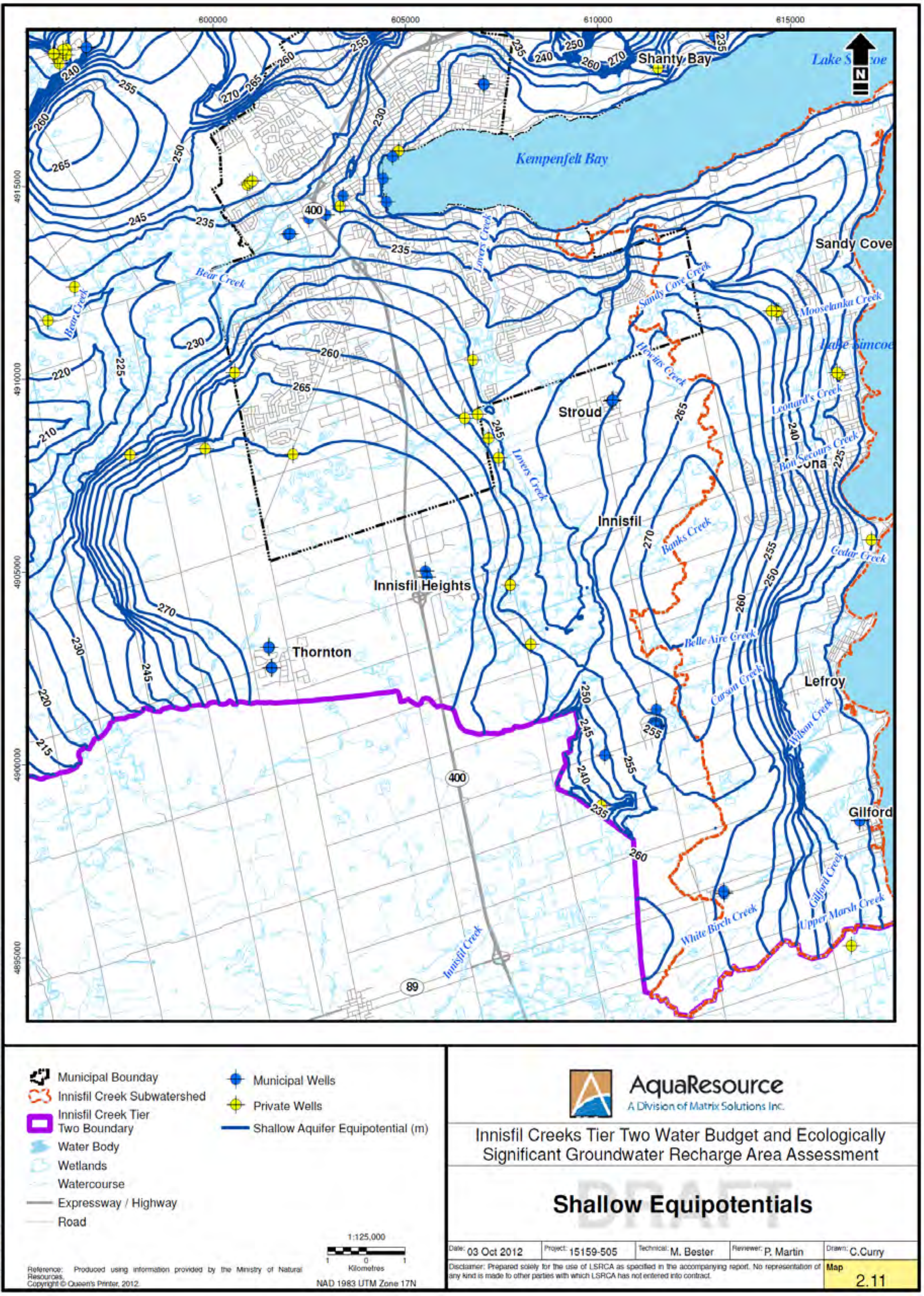


Figure 4-2: Shallow water levels (AquaResource, 2012).

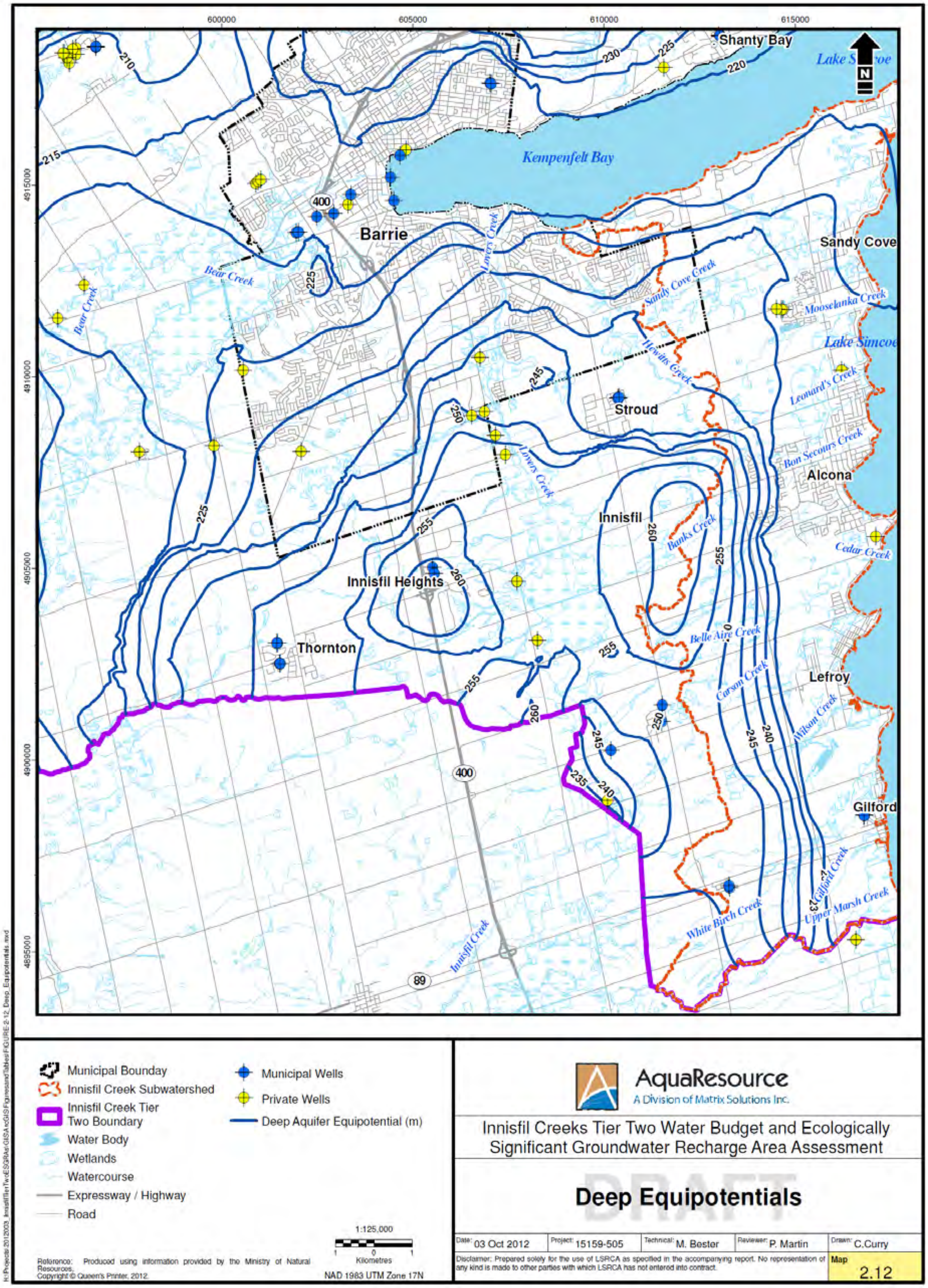


Figure 4-3: Deep water levels (AquaResource *et al*., 2010).

4.2.4 Streamflow

At this point, there are no streamflow monitoring stations in this subwatershed and we are therefore not able to characterize flow characteristics.

Runoff/impervious surface

Streamflow characteristics at a particular point in a river system reveal much of what is occurring in the landscape upstream of that point. Streamflow integrates all aspects of the hydrologic cycle but is also influenced by the topography and size of the watershed; vegetative cover and associated transpiration rates; infiltration capacity of the soil; and anthropogenic activities such as water withdrawals, dams and impoundments, discharge of wastewater, and land use changes such as increasing impervious surfaces. Much of the influence of these factors can be gleaned through an examination of a river hydrograph, which would show how the river responds to precipitation events of various sizes and intensities. Systems with high gradients, high levels of impervious surfaces or low infiltration capacity soils, and a low percent cover of natural vegetation are characterized by a quick and short response to precipitation events, and are considered ‘flashy’ systems. This can exacerbate erosion and water quality issues through increased water volume and velocity, greater transport of contaminants, and geomorphic changes to natural river form. These impacts will be greater where these factors are actively changing (i.e. an increasing amount of impervious surface) and the river system is changing in response.

Conversely, systems with low gradients, large catchment areas, low impervious surface cover, highly permeable soils, and high coverage of natural vegetation typically respond to a precipitation event more slowly, for a longer duration, and with lower peak water levels. Artificial dams or impoundments can achieve the same result. Typically this type of system will be less prone to flooding, will have lower levels of contaminants in transport due to slower velocity or channel scour, and have a greater flow stability (i.e. will better maintain baseflow between precipitation events). This type of system is commonly referred to as having greater storage. Still this storage in a system can be overwhelmed by a large spring freshet and/or high intensity, long duration, or frequent precipitation events, which cause the system to respond quickly and dramatically.

As there are currently no flow monitoring stations in the Innisfil Creeks subwatershed, it is not possible at this point to characterize the response of its watercourses to precipitation and snowmelt events.

Baseflow

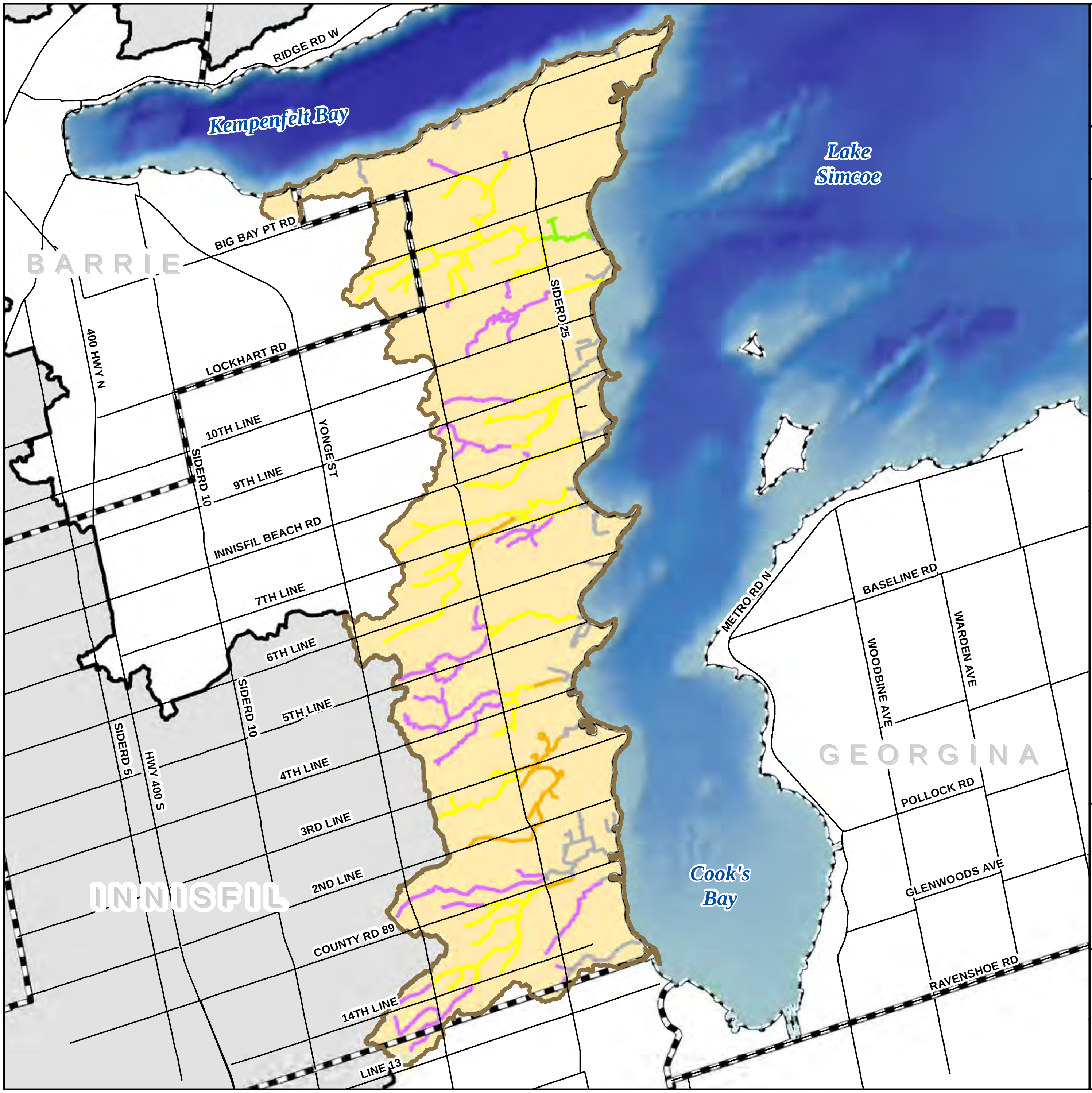
Baseflow is considered the portion of stream flow that is derived from groundwater discharge, from sources such as springs and seepages that release the cool groundwater. The baseflow component within streams is vital for fish populations that require coldwater habitat. This habitat can be affected by localized pumping as the aquifers are drawn down and less baseflow is released.

While flow gauges are a very effective tool for examining baseflow, none are present in the Innisfil Creeks subwatershed to accurately describe baseflow across the subwatershed. For this reason discrete baseflow measurements were conducted on the Innisfil Creeks in June 2005. The results for the 2005 survey conducted by the LSRCA are illustrated in the following Figure 4-4.

Figure 4-4 indicates that very little to no stream flow was observed 72 hours after precipitation events, indicating that groundwater discharge is not a substantial contributor of flow to the tributaries of the Innisfil Creeks subwatershed. The small, relatively steep-sloped geographic form of the Innisfil Creeks subwatersheds, coupled with the ephemeral nature of the streams, indicates a flashy, high energy system that is prone to considerable erosion and increased flooding potential.

Baseflow in the Innisfil Creeks subwatershed.

Figure 4-4



Legend

— Road

▬ Municipal Boundary

▨ Innisfil Creeks Subwatershed

Base Flow (L/s/km)

— <-20

— -10 to -20

— -5 to -10

— -0.01 to -5

— 0.01 to 5

— 5 to 10

— 10 to 20

— 20 to 30

— >30

— Dry, Standing or Too Low

— No Data

Lake Simcoe Region conservation authority

0 0.5 1 2 3 4 5 Kilometres

N

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LSRCA GIS Services DRAFT created July 2010.

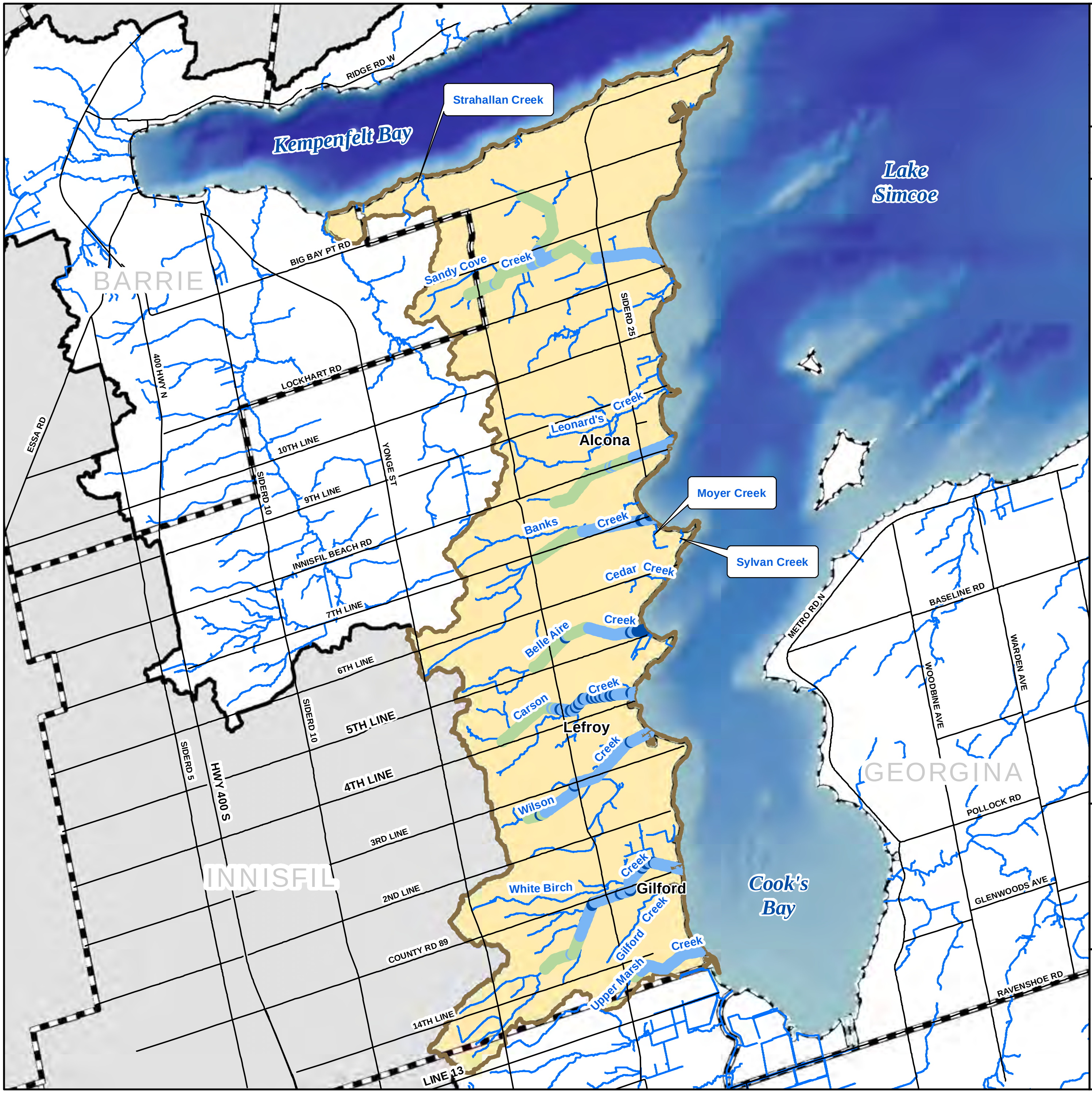
4.2.5 Groundwater discharge

In areas where the static water table intersects the ground surface there is potential for discharge to occur. Groundwater discharge areas are often in low topographic areas and can be observed in and around watercourses in the form of springs and seeps, or as baseflow to streams. These areas are characterized by upward vertical hydraulic gradients. The portion of water that is contributed from groundwater is referred to as baseflow and provides clean, cool water to streams and wetlands.

Groundwater discharge rates vary throughout the year due to seasonal and longer-term changes in recharge and groundwater potentials. Hydrograph separation techniques (as discussed in the previous section) applied to long term surface water flow records are the best methods for quantifying the portion of streamflow derived from groundwater discharge to streams. However, as discussed in Section 4.2.4 there are no gauges within the study area, and other than spot flow measurements stream tributaries are not monitored.

The groundwater discharge areas produced from the Tier 2 model (AquaResource, 2012) are shown on Figure 4-5. A comparison of the discharge mapping from the model with maps produced by LSRCA (2010) shows that most coldwater and coolwater fishery stream reaches, both of which are known to be groundwater discharge areas, are well represented within the model. An exception would be in the extreme upper reaches of the streams, particularly those close to or above the simulated water table, which are not as well represented due to a lack of local refinement (AquaResource *et al*., 2011).

In addition, a potential discharge map was created (Figure 4-6) using the potentiometric surface produced from shallow wells in the MOE water well database in conjunction with topographic mapping. Potential discharge zones are where the water levels are within two metres of the ground surface. As seen from the figure, many of these potential discharge locations coincide with know wetlands and coldwater streams.



Groundwater discharge to surface water simulated from the SGBWLS Tier 2 FEFLOW model

Figure 4-5

Legend

—	Road
▬ ▬	Municipal Boundary
~	Watercourse
▨	Innisfil Creeks Subwatershed

River Discharge (m^3/day)

●	> 300
●	300 to 100
●	100 to 0
●	< 0

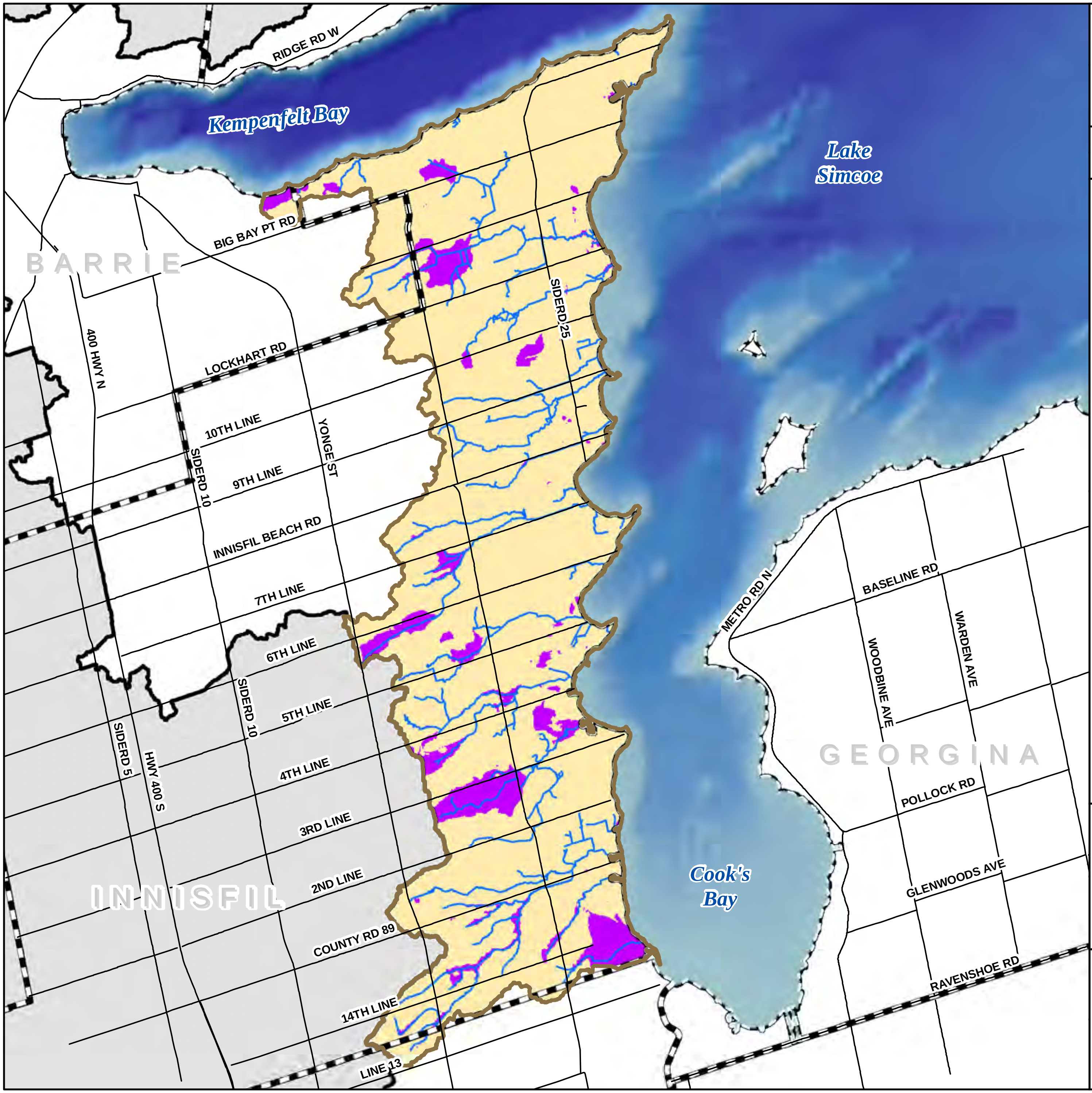
Lake Simcoe Region conservation authority

0 0.5 1 2 3 4 5 Kilometres

N

Potential discharge in the Innisfil Creeks subwatershed.

Figure 4-6



Legend

- — Road
- ▬ Municipal Boundary
- 🟨 Innisfil Creeks Subwatershed
- 🟪 Discharge

Lake Simcoe Region conservation authority

Groundwater Monitoring

- The static water levels measured in monitoring wells characterize the amount of water stored in an aquifer, aquifer complex, or saturated portion of the subsurface system. Groundwater levels can fluctuate due to precipitation, barometric pressure, temperature, and water withdrawal.
- Monitoring these ambient groundwater levels can enhance understanding of baseline conditions and assess how groundwater is affected by climate change, seasonal fluctuation, and land and water use. Monitoring helps to identify trends and emerging issues, and provides a basis for making informed resource management decisions. The data can also be used to measure the effectiveness of the programs and policies that are designed to manage and protect groundwater resources.
- From 2004 to 2010, groundwater levels and quality were monitored from the well location within the Town of Innisfil as part of the Provincial Groundwater Monitoring Network. This well has since been abandoned and replaced in 2012 by the by another well located within the Town.

4.2.6 Groundwater recharge

Groundwater is replenished as precipitation or snowmelt infiltrates into the ground surface. Precipitation is the primary source of groundwater recharge (i.e., the amount of water that infiltrates through the unsaturated zone and ultimately reaches the water table). However, the rate and direction of groundwater movement is influenced by the distribution and thickness of surficial geology and associated soil properties, topography, vegetation, land cover and land use. For example, water will move more readily through coarse loose material and bedrock fractures than through material such as clay or unfractured rock. In areas where there are impervious surfaces, such as within urban areas, the amount of infiltration is reduced, while in areas of sands and sandy loam, particularly within the upland areas to the north of the subwatershed, infiltration rates are increased. In addition, recharge is enhanced in areas where the ground surface is hummocky and water cannot move as easily to contribute as runoff to nearby creeks and rivers.

The mapping of the recharge zones and the policies that protect them are necessary to ensure the sustainability of groundwater supplies and a healthy subwatershed. The rate of groundwater recharge varies over the study area and is controlled by the factors listed above. Rates of recharge within the subwatershed were based on annual average recharge as predicted by the PRMS model completed by Earthfx (2010b) within the subwatershed contributing to the Lake Simcoe basin. Recharge rates were also adjusted slightly to account for consumptive losses due to private water takings for agriculture and domestic supply. Simulated baseflows using initial estimates of recharge were analyzed and the recharge rates were adjusted until a good match was achieved with values determined by baseflow separation. A map showing the final, calibrated recharge distribution for the study area is shown in Figure 4-7. The figure illustrates rates of recharge within the Innisfil Creeks subwatershed range from no recharge to greater than 350 mm/yr.

As expected, groundwater recharge is higher in areas with highly permeable soils (i.e. sands and gravels), and lower in compacted soils (i.e. silts/tills, and clays). Typically, urbanized areas tend to show lower recharge rates due to the impervious area, which limits the volume of water that can infiltrate. However, little of the subwatershed is occupied by urban areas and therefore where there is little to no recharge it is generally due to soil conditions. In groundwater discharge areas (i.e. wetlands), recharge is zero or very low as the water table is at or near the ground surface. The integrated model also provides insight regarding areas with very high recharge rates (e.g. > 350 mm/yr). These areas are along boundaries between soils of high permeability (gravels and sands) and low permeability (silts/tills and clays). In these areas, the low permeability soils generate overland runoff that flows onto high permeability soils, where it infiltrates and recharges the groundwater system (AquaResource *et al*., 2011).

Significant Groundwater Recharge Areas

Significant Groundwater Recharge Areas (SGRAs) can be described as areas that can effectively move water from the surface through the unsaturated soil zone to replenish available groundwater resources. The mapping of these recharge zones is necessary to ensure the sustainability of groundwater supplies. In turn, land development plans should consider the protection of these areas in order to maintain the quantity and quality of groundwater required by a healthy subwatershed.

SGRAs were developed for the entire Lake Simcoe watershed to meet the technical requirements under the Clean Water Act, 2006. In 2008, the Lake Simcoe Region Conservation Authority commissioned the development of a surface water model of the Lake Simcoe basin by Earthfx (2010b). This model, which covers the Innisfil Creeks subwatershed, was developed using the PRMS, an open source model developed by the US Geological Survey (Leavesley *et al*., 1983). The model used precipitation, temperature, and other climate data from 28 long-term Environment Canada climate stations across the basin, along with land use, soil type, topography, and vegetation data to predict groundwater recharge, runoff, and evapotranspiration. The model was developed in a “fully-distributed” manner in which model inputs and outputs were uniquely defined on a 100 by 100 m cell grid to fully represent spatial variability in the study area. The model was calibrated to 28 years of streamflow data from 13 Environment Canada HYDAT stream gauges.

SGRAs within the Lake Simcoe watershed represent areas where the recharge rate is 15% greater than the average recharge (164 mm/yr) across the watershed. The shaded areas within Figure 4-8 represent a recharge rate of 189 mm/yr. A comparison of Figure 2-13 indicates that the most significant areas for groundwater recharge within the Innisfil Creeks subwatershed are associated with surficial sand and gravel deposits and range between 300-500 mm/yr.

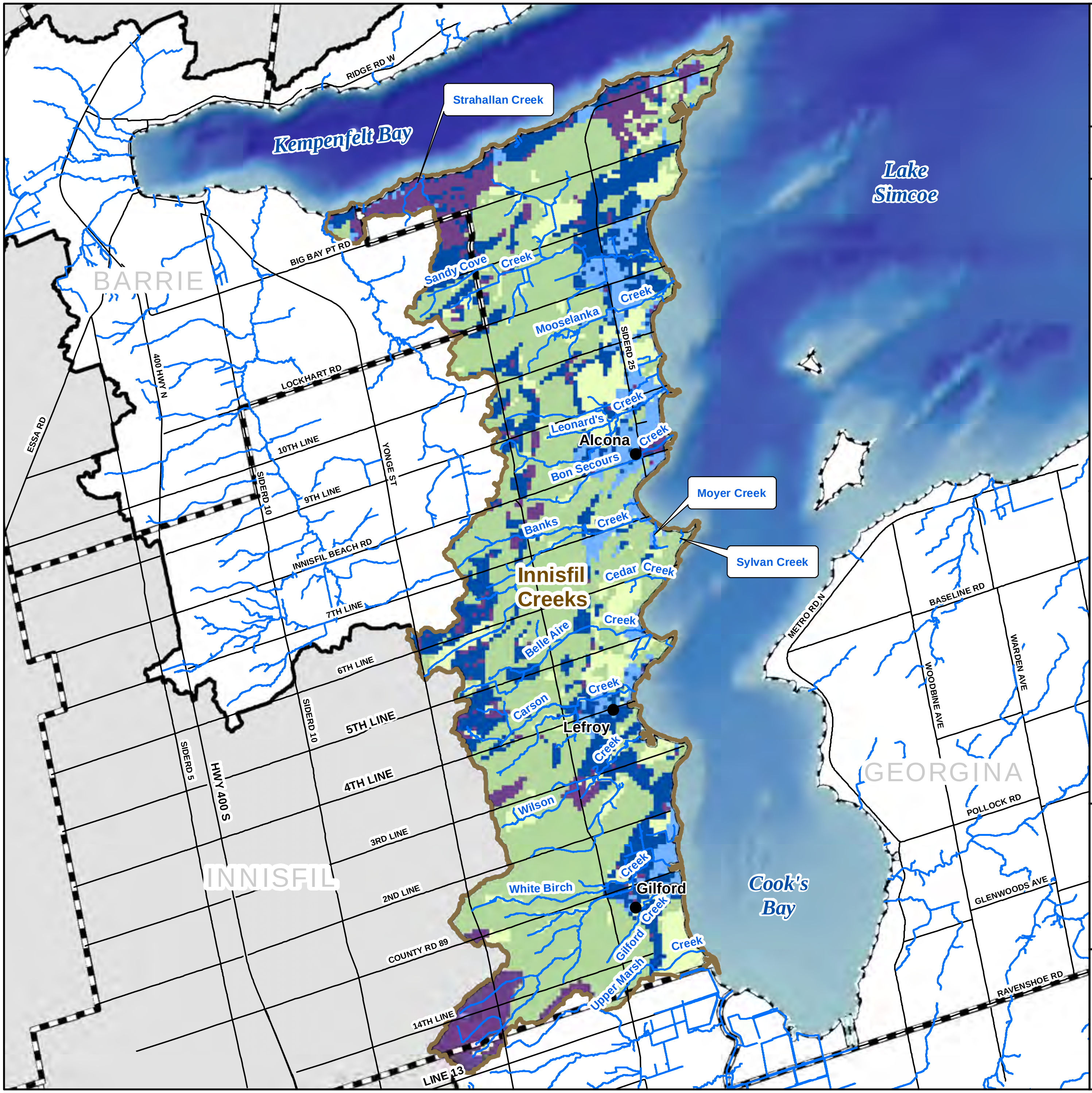
Ecologically Significant Groundwater Recharge Areas

Ecologically Significant Groundwater Recharge Areas (ESGRAs) are identified as areas of land that are responsible for supporting groundwater systems that sustain sensitive features like coldwater streams and wetlands. To establish the ecological significance of the recharge area, a linkage must be present between the recharge area and the ecologically significant feature (e.g., a reach of a coldwater stream, a wetland, or an area of natural or scientific interest (ANSI)). The identification of an ESGRA is not related to the volume of recharge that may be occurring, rather they represent pathways in which recharge, if it occurred, would reach that feature. While delineating ESGRAs is an important task in establishing the linkage between a recharge area and an ecologically sensitive feature it is not a certainty that ESGRAs will coincide with SGRAs, as they may not support high volumes of recharge. While ESGRAs and SGRAs are not mutually exclusive, the areas where they do coincide support high volumes of recharge and support ecologically sensitive features.

ESGRAs are currently being delineated for the Innisfil Creeks subwatershed by AquaResource Inc. using the FEFLOW model developed by AquaResource *et al*. (2011) for the Innisfil Tier 2 Water Budget. LSRCA identified a range of features deemed to be ecologically significant within the Innisfil Creeks subwatershed. These include headwater streams, coldwater fisheries, wetlands, and other locations where sensitive species are found. From these features, reverse particle tracking will be conducted by releasing virtual particles at a specified starting point within the subwatershed (wetlands and coldwater stream reaches). The groundwater model then tracks the particles backward through the aquifer until the point of entry is reached at the surface. The point of entry is an area that will be delineated as a recharge area for those sensitive features for the purpose of identifying ESGRA.

Simulated average annual groundwater recharge (mm/yr) from the PRMS model

Figure 4-7



Legend

Road

Municipal Boundary

Watercourse

Innisfil Creeks Subwatershed

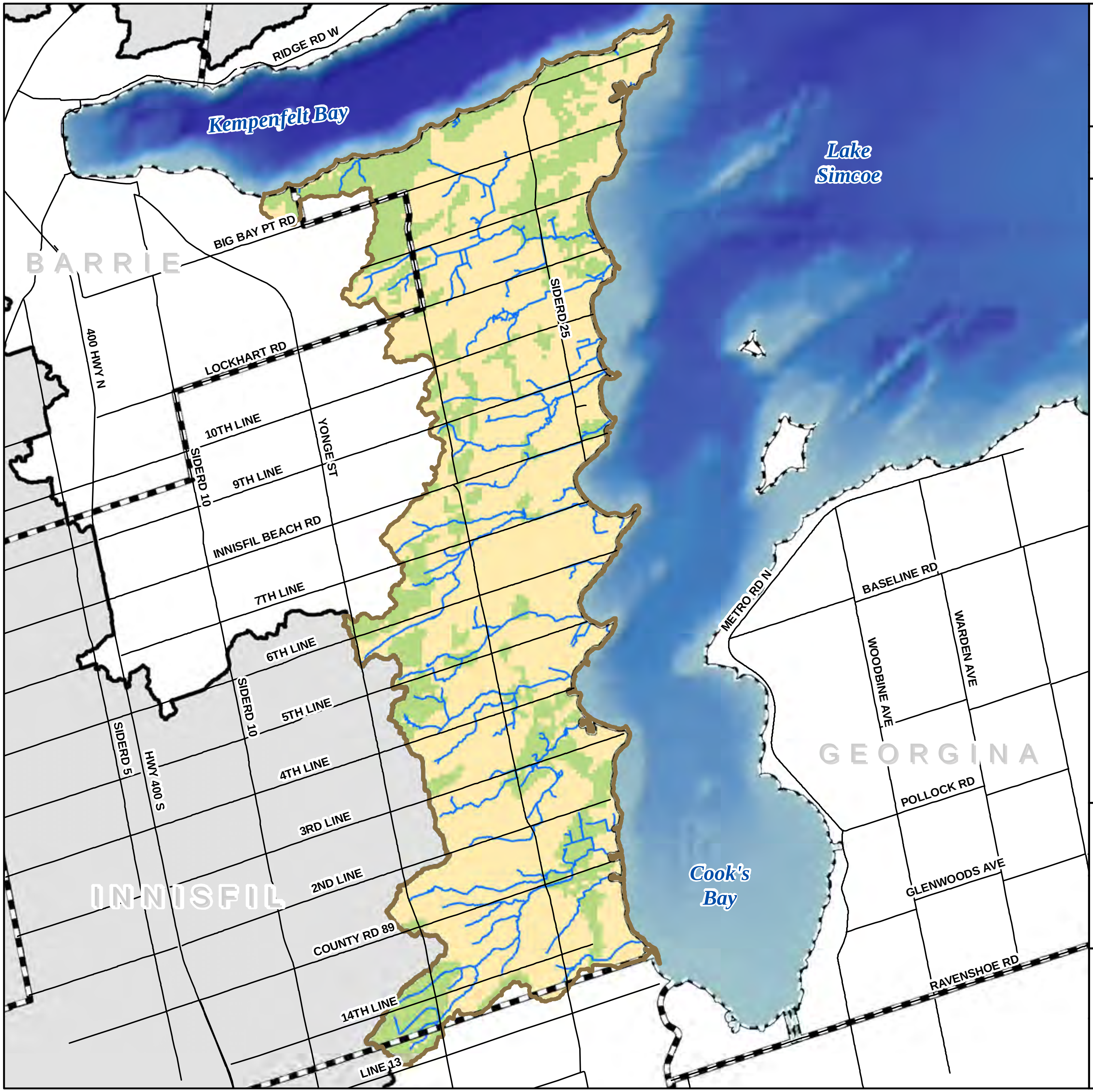
Recharge (mm/yr)

- -1 - 30
- 30 - 125
- 125 - 250
- 250 - 350
- 350 - 675

Lake Simcoe Region conservation authority

0 0.5 1 2 3 4 5 Kilometres

N



Significant Groundwater Recharge Areas in the Innisfil Creeks subwatershed

Figure 4-8

Legend

—	Road
▬ ▬	Municipal Boundary
🟨	Innisfil Creeks Subwatershed
🟩	Recharge

Lake Simcoe Region conservation authority

0 0.5 1 2 3 4 5 Kilometres

N

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4.2.7 Current Climatic Conditions

Precipitation and temperature

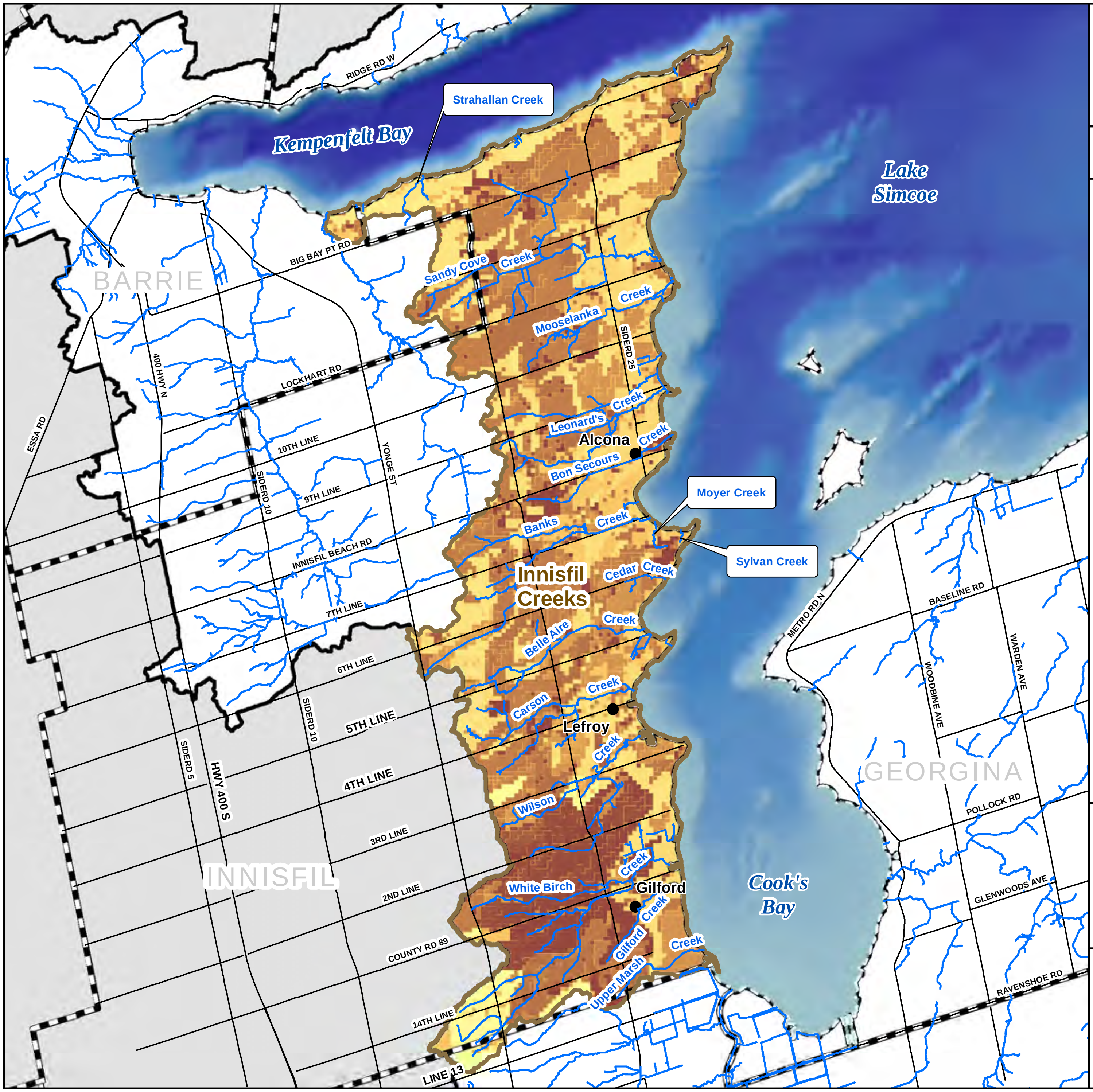
Precipitation in the form of rain or snow replenishes both the surface water and groundwater systems within a subwatershed. Typically, precipitation will vary seasonally and from year to year due to climatic factors. Precipitation is often measured at one or more meteorological stations within a subwatershed using precipitation gauges. Precipitation is an input value in the water balance calculation accounting for a portion of the available water supply.

Long-term climate data was obtained from Environment Canada stations shown on Figure 2-21, **Chapter 2 – Study Area and Physical Setting**, including daily maximum and minimum temperature, daily rainfall and snowfall and hourly rainfall for the period of 1950-2005.

Evapotranspiration

As previously mentioned, evapotranspiration (ET) is the water lost to the atmosphere by two processes, evaporation and transpiration. Evaporation is the loss from open bodies of water, such as lakes and reservoirs, wetlands, bare soil, and snow cover; transpiration is the loss from living-plant surfaces. Several factors other than the physical characteristics of the water, soil, snow, and plant surfaces also affect the evapotranspiration process. Areas covered by plants will have more evapotranspiration occurring than developed areas with impervious surfaces. Unlike precipitation, ET is accounted for as a loss to the system in the water budget calculation.

Potential evapotranspiration (PET) was calculated using the simpler Hargreaves model (Hargreaves and Allen, 2003 and Wu, 1997) which requires only two climate parameters; temperature and incident radiation. The incident solar radiation is adjusted based on slope and slope aspect, vegetation type, winter/summer cover density, and winter transmission factor (i.e., percentage of short-wave radiation passing through the winter vegetation canopy). PET was adjusted to account for Actual Evapotranspiration (AET), which depends on the soil type and the amount of water in interception storage and in the recharge zone (upper part of the active soil zone) (Earthfx, 2010a). The average net annual ET occurring over the subwatershed is displayed on Figure 4-9.



Average net annual evapotranspiration (mm/yr) in the Innisfil Creeks subwatershed

Figure 4-10

Legend

— Road

▬ Municipal Boundary

〰 Watercourse

Innisfil Creeks Subwatershed

▲ Stream Gauges

Observed Annual Average Evapotranspiration (mm/yr)

High : 747

Low : 190

Lake Simcoe Region conservation authority

0 0.5 1 2 3 4 5 Kilometres

N

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LSRCA GIS Services DRAFT TF created November 2011.

4.3 Water budget estimates

A water budget characterizes the hydrologic conditions within a subwatershed by quantifying the various elements of the hydrologic cycle, including precipitation, interception, and evapotranspiration, as shown in Figure 4-10. It can therefore be used to identify areas where a water supply could be under stress, now or in the future. This will help protect the ecological and hydrological integrity of an area by establishing water supply sustainability targets and strategies.

Tier Two Water Budgets and Water Quantity Stress Assessments have been undertaken in support of the Source Water Protection Program in those subwatersheds that were determined to have a moderate or significant potential for stress in the Tier One Water Budget and Water Quantity Stress Assessment. The goal of the Tier Two Water Budget and Water Quantity Stress Assessment is to confirm or negate the stress assignment completed in the Tier One using a more detailed approach that includes detailed and complex modelling tools to estimate water flow volumes to compare to the consumptive demand estimates (MOE, 2008a). The role of the Tier Two is to refine the estimation of water budget components to facilitate a more reliable stress assessment and allow subwatersheds with marginal stress levels to avoid the detailed local assessments required in the Tier Three. Should the elevated stress levels be confirmed in the Tier Two assessment, an even more detailed Tier Three Water Budget and Water Quantity Risk Assessment is required.

Although the Tier One Water Budget was completed for Innisfil Creeks subwatershed through the source water protection initiatives, it did not have a stress assessment high enough to trigger a Tier Two assessment. Therefore, the Tier Two study completed by AquaResources (2012) was undertaken through the Lake Simcoe Protection Plan initiatives and the results are presented in the following sections.

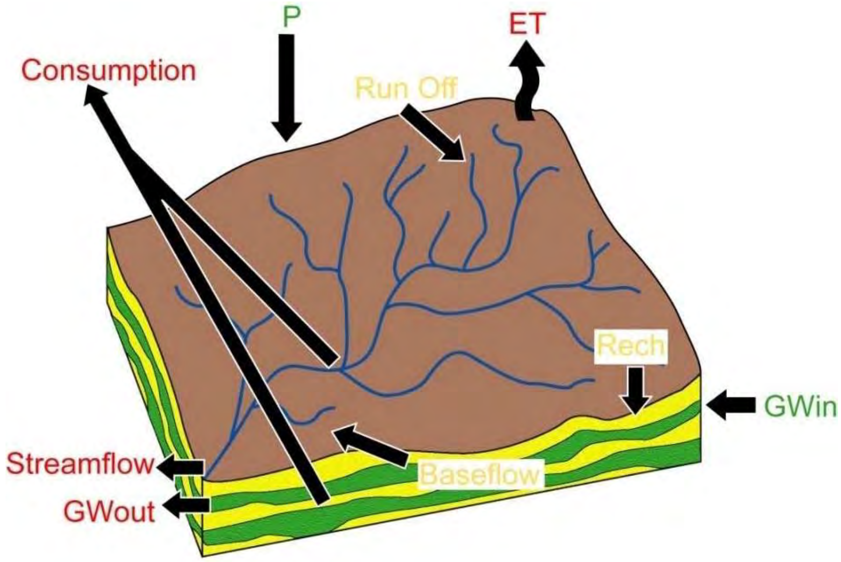


Figure 4-10: Water budget components

The general water budget may be expressed as an equation with water Inputs = Outputs + Change in Storage; or

$$P + SW_{in} + GW_{in} + ANTH_{in} = ET + SW_{out} + GWout + ANTH_{out} + \Delta S$$

Where:

P = Precipitation

SWin = surface water flow into the watershed

GWin = groundwater flow into the watershed

ANTHin = anthropogenic or human inputs such as waste discharges

ET = evapotranspiration

SWout = surface water flow out (includes runoff)

GWout = groundwater flow out

ANTHout = discharge to wells (i.e. drinking water supplies)

ΔS = change in storage (surface water, soil moist)

Source: (OMOE, 2005b)

The following section describes how the input and output values of the water budget equation were determined for the Innisfil Creeks subwatershed. The findings of the water budget study are discussed below.

4.3.1 Water supply estimation

Water supply is the amount of water available at any given instant for use as a drinking water source, for recreational activities, or to support ecological functions. In surface water resources, available supply is considered to be a proportion of streamflow, which is monitored at a number of stations across the Lake Simcoe basin. Determination of surface water supply thus involves the interpolation of gauge data to the outlets of subwatersheds in gauged systems, and interpolation from similar subwatersheds for ungauged systems. Typically, surface water supply has been based on expected monthly flows (as determined through statistical analysis of observed flows or through surface water modelling). For groundwater, the available supply for a subwatershed is considered to be the sum of the recharge and subsurface inflows (lateral inflow or underflow in).

The water supply component of the stress assessment was estimated using a numerical groundwater flow model, which was originally developed for the Barrie Tier 3 study. This groundwater model incorporated the enhanced knowledge of the geologic surface and sub-surface gained from the conceptual model discussed in the previous section.

As part of the water budget process, estimates of the water budget component fluxes were examined across the study area. Table 4-3 summarizes the estimated overall groundwater fluxes for the subwatershed. The table summarizes watershed inflows including recharge and groundwater interbasin flow. Outflows include stream discharge, groundwater pumping, and groundwater interbasin flow. The water budget parameters are calculated based on information derived from both the surface water and groundwater flow models and are presented in units of m^3/d and mm/year. In addition to the potentiometric surface for the productions aquifer, Figure 4-11 illustrates the estimated cross-boundary groundwater flow between the Innisfil Creeks subwatershed and adjacent subwatersheds (AquaResource, 2012).

Average annual recharge in this area is approximately 216 mm/year. Average annual base flow is 63 mm/year from all streams and wetlands across the subwatershed. Approximately 155 mm/yr of groundwater flows out of the subwatershed to the subsurface under Lake Simcoe. This flow to Cook's Bay is driven by the hydraulic gradient in the shallow layers of the model.

As stated above, the Innisfil Creeks subwatershed was not incorporated within the SGBWLS Tier Two study (AquaResource, 2010). However, a comparison of water budget terms to the Lake Simcoe Tier One water budget show consistency between the two studies, with slightly lower pumping quantities within the present study, due to the shutdown of the Alcona Well field as well as using updated Water Taking reporting estimates, as opposed to applying assumptions based on the Permitted Rates of privately permitted wells. It should also be noted that groundwater cross boundary flows between subwatersheds were not explicitly considered within the Tier One Water Budget calculations.

Table 4-3: Water budget summary by subwatershed (AquaResource, 2012).

	Flows		
Inflow Components	(m^3/d)	(L/s)	(mm/yr)
Groundwater Recharge	63,500	735	216
Flow from Innisfil Creek Subwatershed	1,570	18	5.3
Flow from Hewitts Creek Subwatershed	80	1	0.3
Total Groundwater Inflow	65,150	754	221
Outflow Components	(m^3/d)	(L/s)	(mm/yr)
Surface Water Discharge	43,900	508	149
Streams	9,150	106	31
Wetlands	9,350	108	32
Lake Simcoe (Top Slice)	25,400	294	86
Permitted Wells	700	8	2
Flow to Lovers Creek Subwatershed	40	0	0.1
Flow to Cook's Bay (Subsurface flow)	13,510	156	46
Flow to Kempenfelt Bay (Subsurface flow)	7,000	81	24
Total Groundwater Outflow	65,150	754	221

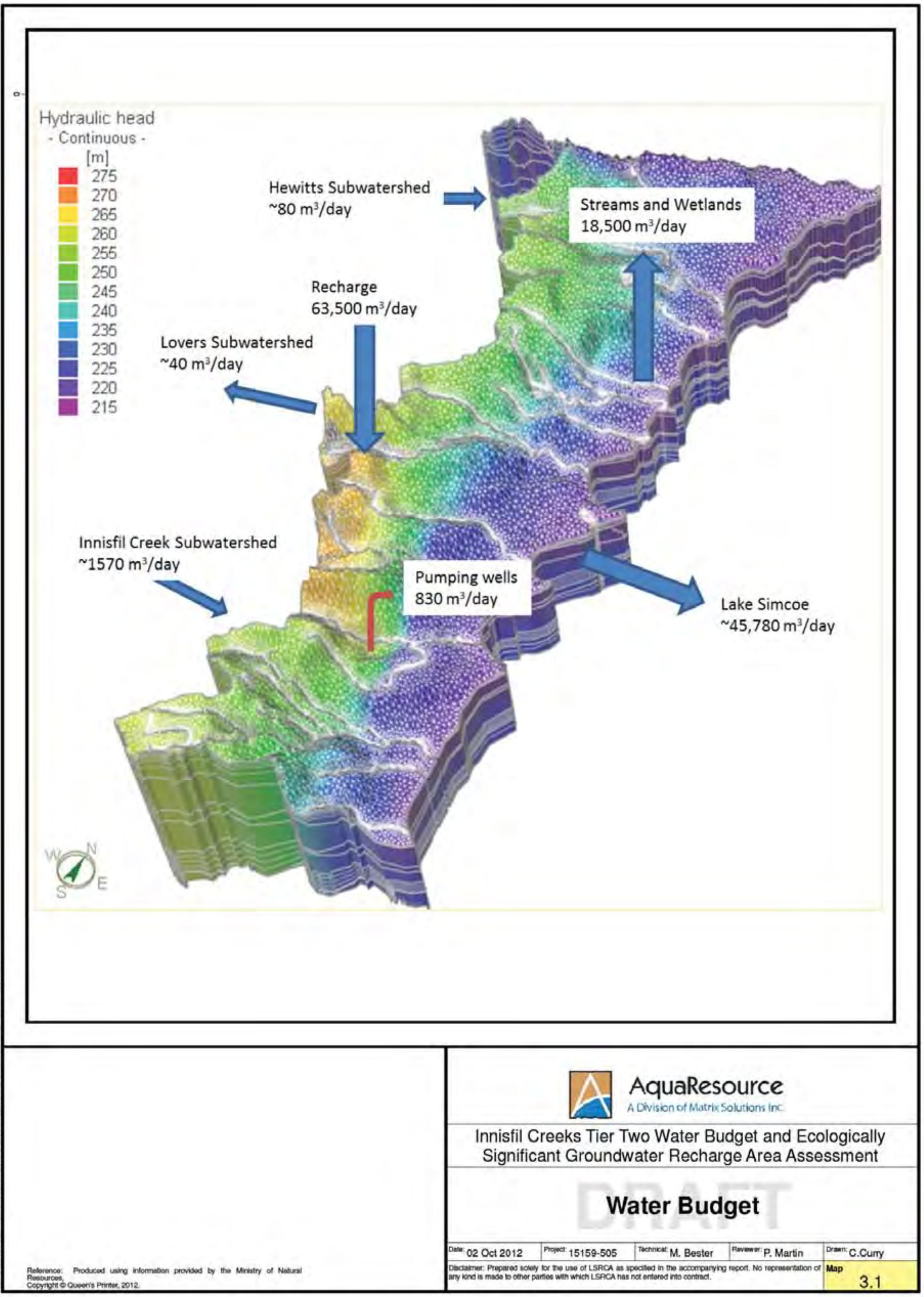


Figure 4-11: Water budget results from the Tier Two Assessment (AquaResource, 2012).

4.3.2 Water demand estimation

The water demand has been estimated from a number of information sources, including the Permit to Take Water (PTTW) database, population estimates, and water well records. This section provides a summary of the consumptive groundwater demands for Innisfil Creeks subwatershed assessed as part of the Tier Two Stress Assessment (AquaResource, 2012).

Consumptive groundwater demand refers to water that is taken and not returned to its original source (i.e. aquifer) within a reasonable amount of time. Understanding this type of water demand is critical to the development of a water budget framework. An estimate of the extent and variability of water use throughout the study area is required to identify the subwatersheds that may be under the highest degree of potential hydrologic stress, and to guide future efforts to refine water budget tools in those areas (AquaResource, 2012).

The total consumptive water demand is estimated based on the following components (AquaResource, 2012):

- Municipal water demand: municipal water demand estimates were generated based on pumping rates reported by municipalities, where available;
- Permitted water demand: the Province of Ontario issues Permits to Take Water (PTTW) for water takings greater than 50,000 litres per day (L/d). Permitted water demand was estimated using reported pumping rates from the 2009 Water Taking Reporting System (WTRS) or by combining the permitted rate with the months of expected active pumping. Consumptive factors were then applied to determine the amount of pumped water that is not returned to the original source in a reasonable amount of time; and,
- Non-permitted water demand: pumping rates for non-permitted takings were pro-rated by area based on the Tier One Stress Assessments (LSRCA, 2009a, 2009b, 2009c).

Table 4-5 shows the number of water takings within the Innisfil Creeks subwatershed. These estimates are used to compute the stress assessment in the following section.

Future consumptive demand was also estimated for the subwatersheds not identified as potentially stressed under existing conditions. After the consumptive demand was estimated a consumptive factor was applied to determine the proportion of groundwater not returned to the original source within a reasonable amount of time.

<u>Permitted water demand</u>

Section 34 of the Ontario Water Resources Act (OWRA) states that any person or business taking more than 50,000 litres of surface or groundwater per day are required by law to obtain a PTTW from the Ministry of the Environment, excluding water used for domestic, livestock watering, or firefighting purposes.

The most important source of consumptive demand information is the Ministry of Environment's Permit to Take Water database and actual municipal water use data. Information from the Ministry's 2009 Water Taking and Reporting System (WTRS) was used to estimate actual water demands for this assessment.

Only permits representing sustained water takings were used in the assessment; temporary permits such as pumping tests were not included. The PTTW program is now requiring users to report actual pumping rates; however, this updated information was not available for this study.

Since the actual pumping rates were unavailable some considerations were taken into account when using the database:

1) Permit holders often request a volume that exceeds their requirements to be listed on the permit. This is often done to ensure compliance in dry years, or to secure sufficient water for possible future expansion.
2) The permitted volume is often derived from the capacity of the pumping equipment rather than the requirements of the user, which can drastically overestimate the user's demand.
3) The database does not maintain a record of whether the permit is just for seasonal use.
4) Multiple sources may be included on a particular permit, and the total refers to all sources associated with the permit. To estimate the total demand, the total permitted rate should be logically divided amongst the active source locations.
5) The spatial location of the water taking sources is not always accurate.
6) The PTTW database is not current with respect to the MOE's actual permitting activities.
7) Historic water takings may be "grandfathered" and do not require a permit. As a result, there may be some significant water takers not accounted for.

Municipal Water Use

Municipal water supplies shown in Figure 4-12 represent the majority of the permitted use within the Innisfil Creeks subwatershed. As such, accurate estimates of municipal water use are a critical component of the consumptive water demand estimate. For this Tier Two Stress Assessment, 2011 reported municipal pumping rates were obtained from the municipalities and in some cases the 2009 Water Taking Reporting System was used to obtain rates.

Table 4-4 summarizes the municipal systems within the Tier Two Stress Assessment, as well as the source and year of the reported pumping rates. The most recent reported rates were utilized where multiple reported rates were available.

Table 4-4: Summary of municipal systems (AquaResource, 2012).

Community	Well Name	Source of Data	Average Annual Pumping Rate		
			(m^3/day)	(L/s)	(mm/yr)
Goldcrest	77-2	Reported 2011	28	0.3	0.10
	88-1	Reported 2011	24	0.3	0.08
Sandy Cove Acres*	Well 1	WTRS 2009	185	2.1	0.63
	Well 2	WTRS 2009	183	2.1	0.62
	Well 3	WTRS 2009	190	2.2	0.65
Total			698	8	2.38

*communal system

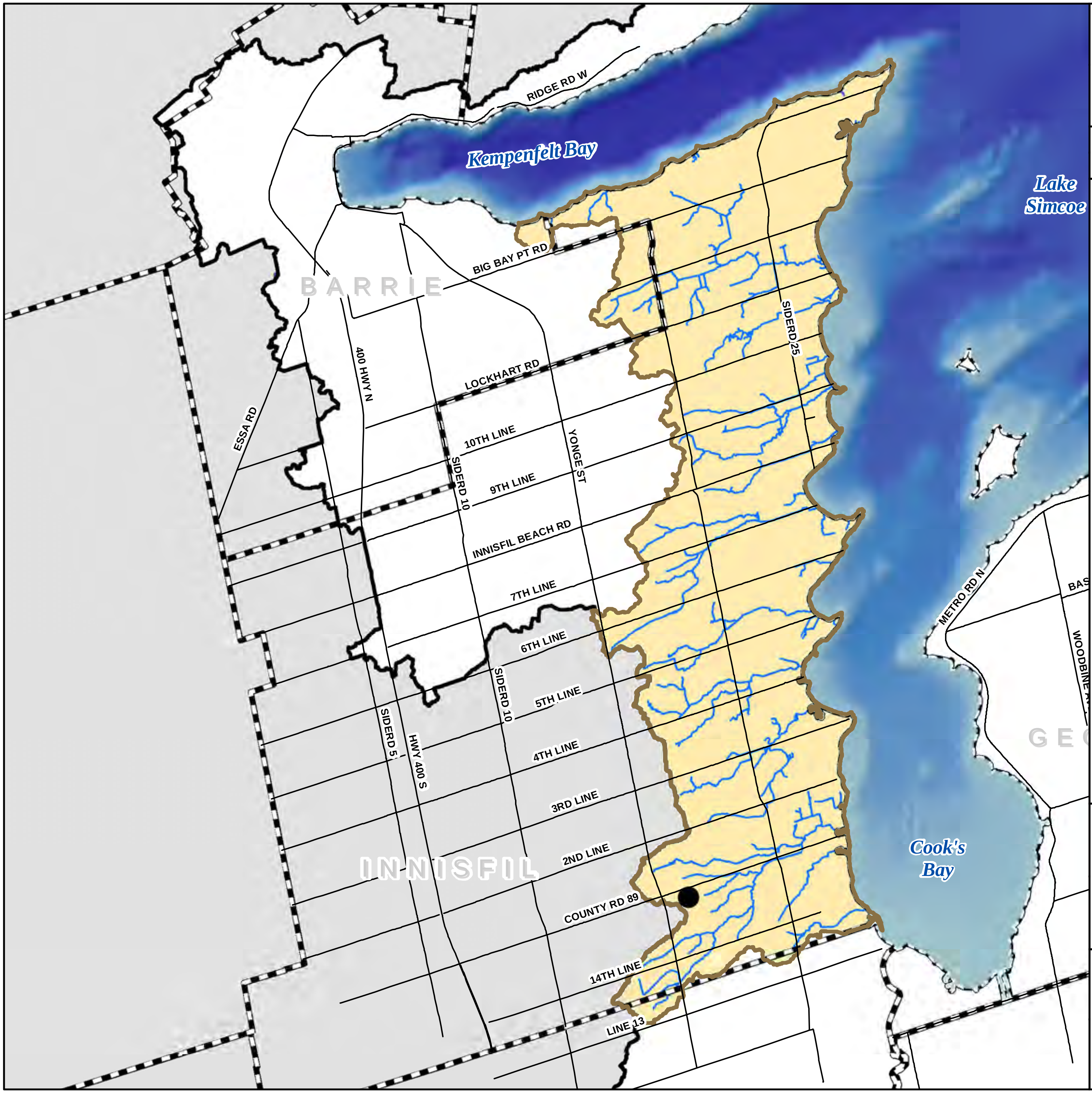
Table 4-5: Monthly consumptive demand (AquaResource, 2012).

Permit Number	Well	Consumptive Demand (m^3/day)													
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg	Max
00-P-1381	Goldcrest Well 1	22	11	27	28	23	41	56	38	28	18	15	22	27	56
00-P-1381	Goldcrest Well 2	21	30	15	20	27	30	37	22	21	26	30	24	25	37
0206-7HFH8Q	Golf Course Well	0	0	0	9	9	9	9	9	9	0	0	0	5	9
87-P-3008	Sandy Cove Well 1	185	185	185	185	185	185	185	185	185	185	185	185	185	185
87-P-3008	Sandy Cove Well 2	182	182	182	182	182	182	182	182	182	182	182	182	182	182
87-P-3008	Sandy Cove Well 3	190	190	190	190	190	190	190	190	190	190	190	190	190	190
Unserviced Domestic		553	553	500	553	536	553	536	553	553	536	553	536	543	553
Nonpermitted Agricultural		0	0	0	0	0	137	137	137	137	0	0	0	46	137
Total		1263	1263	1210	1274	1266	1493	1510	1602	1493	1327	1276	1238	1342	1602

Table 4-6: Percentage of consumptive water demand by sector (AquaResource, 2012).

Agricultural		Commercial		Industrial		Miscellaneous	Recreation	Remediation	Private Water Supply		Municipal Water Supply	Livestock and Rural Domestic	Total Estimated	Total Reported
Est.	Rep.	Est.	Rep.	Est.	Rep.	Est.	Rep.	Rep.	Est.	Rep.	Rep.	Est.	Est.	Rep.
-	-	0.3%	-	-	-	-	-	-	43%	-	54%	4%	54%	46%

Notes: Est. = Estimated; Rep. = Reported; Totals may differ slightly due to rounding.



Municipal groundwater supply system within the Innisfil Creeks subwatershed.

Figure 4-12

Legend

Road

Municipal Boundary

Watercourse

● Municipal Well

Innisfil Creeks Subwatershed

Lake Simcoe Region conservation authority

0 0.5 1 2 3 4 5 Kilometres

N

This product was produced by the Lake Simcoe Region Conservation Authority and some information depicted on this map may have been compiled from various sources. While every effort has been made to accurately depict the information, data / mapping errors may exist.
This map has been produced for illustrative purposes only.
LSRCA GIS Services DRAFT created July 2010.

Other Permitted Water Demand

Non-municipal permitted water taking types included in the assessment are: agriculture, commercial, dewatering, industrial, miscellaneous, recreational, and remediation activities.

Non-permitted water demand

In addition to permitted water use, there are various types of non-permitted water uses, such as livestock watering and un-serviced domestic use (typically rural residents). Non-permitted agricultural and un-serviced domestic water were estimated as part of the Tier One Water Budget and Stress Assessment (LSRCA, 2009). These estimates were utilized to quantify non-permitted water use for the existing Tier Two Stress Assessment and are shown in Table 4-7.

Legal non-permitted estimated agriculture water demand includes water used for livestock watering, equipment washing, and any other agricultural water use excluding water used for irrigation. Non-permitted agriculture water demand was estimated as part of the Tier One Water Budgets and Stress Assessments (LSRCA, 2009).

It should also be noted that since the non-permitted agriculture demand was based on a census-based estimation technique it is not possible to accurately determine the source of water used. For the Tier Two assessment it was assumed that half of the water would be supplied from a surface source and half would be supplied from a groundwater source. The consumptive nature of non-permitted agriculture water use is also hard to determine, as the water can be used for so many different things. To be on the conservative side all non-permitted agriculture water takings were assumed to be 100% consumptive.

The unserviced domestic water use includes any household water use that is not supplied by a municipal water source. An estimate of the unserviced domestic water use was calculated as part of the Tier One Water Budgets and Stress Assessments. The estimates from the Tier One were also area pro-rated to the boundaries of the subwatershed. The unserviced domestic water use was assumed to be 20% consumptive in the Tier Two assessment. This assumption was made because the majority of unserviced domestic water use comes from rural areas, supplied by private wells. Since these takers are generally in rural areas the water taken would be returned to the groundwater system through the septic system.

Table 4-7: Non-permitted agriculture and unserviced domestic water use (AquaResource, 2012).

Water Use	Demand		
	(m^3/day)	(L/s)	(mm/yr)
Non-Permitted Agricultural	46	0.5	0.2
Un-serviced Domestic	543	6.4	1.9
Total	589	6.9	2.0

Monthly correction factor and consumption correction factor

Monthly Usage Factors

Monthly estimates of water use are required to represent the seasonal changes in total water use across a subwatershed. All water demand reported in the Tier 2 Stress Assessments have been adjusted per Table 4-8, where 1 designates the permit is active, and 0 designates it is inactive. This facilitates the estimate of actual water used in a subwatershed, as it recognizes that many types of water taking operations only take water during a specific time period each year (e.g., snow making generally is active December, January, and February).

Consumptive Use Factors

Water consumption refers to the amount of water removed from a hydrological system and not returned back to the same system in a reasonable time period. To assess the portion of pumped water that is being removed from the hydrologic system, estimates of water demand must consider consumptive use, as opposed to the total amount of water that may be pumped from a system (AquaResource and Golder, 2010).

Estimating consumptive water demand requires a proper consideration of scale, as well as the physical water taking operation. Some water takers may have large extraction volumes associated with their permits while actually consuming very little of that water. As an example, aggregate washing operations are permitted to pump large volumes of water between washing and settling ponds, and a relatively small percentage is lost to evaporation, or is removed offsite within the washed material. Another example is a dewatering activity where groundwater that is pumped to lower the water table is discharged to a nearby creek. At the scale of a subwatershed very little of this water is actually consumed; however, this water taking would be fully consumptive with respect to the pumped aquifer (AquaResource and Golder, 2010).

The percent water demand calculation requires the estimate of water which is consumed and not returned to the original source within a reasonable amount of time. Therefore, for a groundwater assessment, if water is removed from the groundwater system and not returned to the groundwater system, the taking is assumed to be 100% consumptive. Groundwater takings are typically 100% consumptive, since wastewater is seldom returned to the groundwater system, but rather discharged to surface water systems. Exceptions would include irrigation, where a portion of the applied irrigation water would saturate surficial soils and percolate beneath the evaporative root zone, returning to the groundwater system.

Table 4-9 provides a list of consumptive use factors (MOE, 2007) that are used for water takings where water is returned to the same source from which it is taken. These values correspond to the ‘Specific Purpose’ assigned by the MOE to each permit. Where water was not returned to the same source, a consumptive factor of 1 is used. While these factors are generalized, they provide a consistent approach for the initial estimation of consumptive water use. It is recognized that within a specific water use sector the proportion of pumped water consumed may significantly vary between individual operations; the generalized factors, presented in Table 4-9, represent a significant source of uncertainty. As such, they were modified as part of a sensitivity analysis to ensure the uncertainty does not affect the stress level assignment.

Table 4-8: Monthly demand adjustments based on active months of taking (MOE, 2007).

General Purpose	Specific Purpose	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Agricultural	Field and Pasture Crops	0	0	0	0	0	1	1	1	1	0	0	0
Agricultural	Fruit Orchards	0	0	0	0	0	1	1	1	1	0	0	0
Agricultural	Market Gardens/Flowers	0	0	0	0	0	1	1	1	1	0	0	0
Agricultural	Nursery	0	0	0	0	0	1	1	1	1	0	0	0
Agricultural	Other - Agricultural	0	0	0	0	0	1	1	1	1	0	0	0
Agricultural	Sod Farm	0	0	0	0	0	1	1	1	1	0	0	0
Agricultural	Tender Fruit	0	0	0	0	0	1	1	1	1	0	0	0
Agricultural	Tobacco	0	0	0	0	0	1	1	1	1	0	0	0

General Purpose	Specific Purpose	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Commercial	Aquaculture	1	1	1	1	1	1	1	1	1	1	1	1
Commercial	Bottled Water	1	1	1	1	1	1	1	1	1	1	1	1
Commercial	Golf Course Irrigation	0	0	0	0	0	1	1	1	1	0	0	0
Commercial	Mall / Business	1	1	1	1	1	1	1	1	1	1	1	1
Commercial	Other - Commercial	1	1	1	1	1	1	1	1	1	1	1	1
Commercial	Snowmaking	1	1	0	0	0	0	0	0	0	0	0	1
Construction	Other - Construction	1	1	1	1	1	1	1	1	1	1	1	1
Construction	Road Building	1	1	1	1	1	1	1	1	1	1	1	1
Dewatering	Construction	1	1	1	1	1	1	1	1	1	1	1	1
Dewatering	Other - Dewatering	1	1	1	1	1	1	1	1	1	1	1	1
Dewatering	Pits and Quarries	1	1	1	1	1	1	1	1	1	1	1	1
Industrial	Aggregate Washing	0	0	0	0	1	1	1	1	1	1	1	0
Industrial	Cooling Water	1	1	1	1	1	1	1	1	1	1	1	1
Industrial	Food Processing	1	1	1	1	1	1	1	1	1	1	1	1
Industrial	Manufacturing	1	1	1	1	1	1	1	1	1	1	1	1
Industrial	Other - Dewatering	1	1	1	1	1	1	1	1	1	1	1	1
Industrial	Other - Industrial	1	1	1	1	1	1	1	1	1	1	1	1
Industrial	Pipeline Testing	1	1	1	1	1	1	1	1	1	1	1	1
Institutional	Other - Institutional	1	1	1	1	1	1	1	1	1	1	1	1
Institutional	Schools	1	1	1	1	1	1	0	0	1	1	1	1
Miscellaneous	Dams and Reservoirs	1	1	1	1	1	1	1	1	1	1	1	1
Miscellaneous	Heat Pumps	1	1	1	1	1	1	1	1	1	1	1	1
Miscellaneous	Other - Miscellaneous	1	1	1	1	1	1	1	1	1	1	1	1
Miscellaneous	Pumping Test	1	1	1	1	1	1	1	1	1	1	1	1
Miscellaneous	Wildlife Conservation	1	1	1	1	1	1	1	1	1	1	1	1
Missing	Missing	1	1	1	1	1	1	1	1	1	1	1	1
Recreational	Other - Recreational	1	1	1	1	1	1	1	1	1	1	1	1
Recreational	Wetlands	1	1	1	1	1	1	1	1	1	1	1	1
Remediation	Groundwater	1	1	1	1	1	1	1	1	1	1	1	1
Remediation	Other - Remediation	1	1	1	1	1	1	1	1	1	1	1	1
Water Supply	Campgrounds	0	0	0	0	1	1	1	1	1	0	0	0
Water Supply	Communal	1	1	1	1	1	1	1	1	1	1	1	1
Water Supply	Municipal	1	1	1	1	1	1	1	1	1	1	1	1
Water Supply	Other - Water Supply	1	1	1	1	1	1	1	1	1	1	1	1

Table 4-9: Consumptive use factors (MOE, 2007).

Category	Specific Purpose	Consumptive Factor	Category	Specific Purpose	Consumptive Factor
Agricultural	Field and Pasture Crops	0.80	Institutional	Hospitals	0.25
Agricultural	Fruit Orchards	0.80	Institutional	Other - Institutional	0.25
Agricultural	Market Gardens / Flowers	0.90	Institutional	Schools	0.25
Agricultural	Nursery	0.90	Miscellaneous	Dams and Reservoirs	0.10
Agricultural	Other - Agricultural	0.80	Miscellaneous	Heat Pumps	0.10
Agricultural	Sod Farm	0.90	Miscellaneous	Other - Miscellaneous	1.00
Agricultural	Tender Fruit	0.80	Miscellaneous	Pumping Test	0.10
Agricultural	Tobacco	0.90	Miscellaneous	Wildlife Conservation	0.25
Commercial	Aquaculture	0.10	Recreational	Aesthetics	0.25
Commercial	Bottled Water	1.00	Industrial	Manufacturing	0.25
Commercial	Golf Course Irrigation	0.70	Industrial	Other - Industrial	0.25
Commercial	Mall / Business	0.25	Industrial	Pipeline Testing	0.25
Commercial	Other - Commercial	1.00	Industrial	Power Production	0.10
Commercial	Snowmaking	0.50	Recreational	Fish Ponds	0.25
Construction	Other - Construction	0.75	Recreational	Other - Recreational	0.10
Construction	Road Building	0.75	Recreational	Wetlands	0.10
Dewatering	Construction	0.25	Remediation	Groundwater	0.50
Dewatering	Other - Dewatering	0.25	Remediation	Other – Remediation	0.25
Dewatering	Pits and Quarries	0.25	Water Supply	Campgrounds	0.20
Industrial	Aggregate Washing	0.10	Water Supply	Communal	0.20
Industrial	Brewing and Soft Drinks	1.00	Water Supply	Municipal	0.20
Industrial	Cooling Water	0.25	Water Supply	Other - Water Supply	0.20
Industrial	Food Processing	1.00			

4.3.3 Water reserve estimation

Within the Technical Rules (MOE, 2008a) water reserve is defined as the water that is required to be “protected” to support other uses within the watershed including ecosystem needs and other human uses such as sewage assimilation, hydroelectric power production, and navigation. This reserve value is calculated as 10% of groundwater discharge. Ecological needs include sustaining groundwater discharge to sensitive coldwater fish habitat. The reserve quantity is subtracted from the total water source supply prior to evaluating the percent water demand. For surface water, within subwatershed that have gauged flow stations, the 10th percentile of stream flow (Q90) was used as the reserve value. For surface water within ungauged subwatershed the Tessmann (1980) method was used to estimate instream flow, which is documented in the Guidance Module 7 (MOE, 2007).

Surface water reserve estimation

The methods recommended to estimate the water reserve include 10th percentile streamflow (Q90), which has been used within gauged subwatershed. This flow value is most representative for reserve, as it is the flow value that is exceeded 90 percent of the time.

Within ungauged subwatershed, the Tessmann method has been applied to estimate streamflow values. Tessmann (1980) adapted Tennant's (1976) seasonal flow recommendations to calibrate the percentage of monthly available flow to local hydrologic and biologic conditions including monthly variability.

As noted within the MOE Guidance Module 7 (MOE, 2007), when using the Tessmann method the estimated reserve value may be larger than the water supply calculated for summer low flows. To mitigate this, a reserve value of 30% of the monthly streamflow would be applied in place of the Tessmann equation. This has been done based on the MOE Guidance Module 7 (MOE, 2007), which indicates that this reserve value is designed to add a buffer to already conservative percent demand thresholds.

Groundwater reserve estimation

The Guidance Module recognized that groundwater discharge to streams must be maintained to sustain baseflow throughout a watershed. Instream flow requirements are used to estimate the ecological component of the surface water reserve term for the Tier 2 stress assessment. As it is difficult to separate out the groundwater and surface water components of the instream requirements, Technical Rule 3 (MOE, 2008a), indicates that 10% of the existing groundwater discharge should be considered as the groundwater reserve component for each subwatershed. Groundwater discharge has been calculated using a baseflow separation technique, for gauged and simulated stream hydrographs. It is recognized that preserving 10% of baseflow is a simplified approach to preserving ecological requirements. Future work on determining instream flow needs will have to focus on identifying a flow regime that captures the range of seasonal high and seasonal low flows.

Key points – Current Hydrogeologic and Water Quantity Status:

- The physical properties of a watershed, such as drainage area, slope, geology, and land use can influence the distribution of the water and the processes that function within a watershed.
- Monitoring groundwater levels can characterize baseline conditions, and assess how groundwater is affected by climate change, seasonal fluctuation, and land and water use. Monitoring groundwater levels can help to identify trends and emerging issues, and can provide a basis for making informed resource management decisions, measure the effectiveness of the programs and policies that are designed to protect these groundwater resources.
- A refined understanding of the aquifer systems and groundwater flow as part of the subwatershed components and processes is vital in maintaining the ecological balance and sustainability of resources within a watershed.
- The water level maps for the subwatershed show that there are cross boundary groundwater flows within the Innisfil Creeks subwatershed that support the aquifer system.
- Groundwater discharge is the main component of streamflow during dry periods and as such maintains an environment that allows cold water fish to survive even during the dry summer months.
- Groundwater recharge can be described as areas that can effectively move water from the surface through the unsaturated soil zone to replenish available groundwater resources. The mapping of these recharge zones show that the most significant recharge within the subwatershed occur within the western portion of the subwatershed and is associated with high permeability (sand & gravel) materials.

4.4 Factors impacting status - stressors

Land use change, increased water use, short-term summer droughts and long-term climate change can all result in stress on the quantity of water within a watershed. Potential impacts of these stressors include reduced groundwater recharge or discharge, increased surface water runoff, well interferences and changes to groundwater flow patterns and groundwater-surface water interaction.

The purpose of completing a water budget and water quantity stress assessment is to determine if the watershed can support current or future water takings without exhibiting a continued long-term decline in groundwater levels or surface water flow. The most basic definition of stress is whether a watershed can support the current levels of pumping without exhibiting a continued long term decline in water levels.

4.4.1 Water demand

Several water budget initiatives have been undertaken to identify potential water quantity stress within the subwatershed. The indicators of stress presented in this report are based on these studies and more information can be obtained from AquaResource (2012).

Considerable effort was made in the Tier 1 (LSRCA, 2009), Tier 2 (AquaResource, 2012), and ongoing Tier 3 (AquaResources *et al*., 2010) water budgets discussed in previous sections to document the various sources of water demand. Table 4-5 and Table 4-6 summarize the monthly consumptive demand by subwatershed and the percentage of Consumptive Water Demand by Sector per subwatershed. The values contained within Table 4-5 are the sum of the consumptive demand associated with PTTWs (municipal and non-municipal) as well as non-permitted agricultural demand and un-serviced domestic demand.

The subwatershed consumptive water demand is examined in more detail in Table 4-6, which presents the percent of average consumptive water demand used by water use sectors, broken down by subwatershed. Also included in Table 4-6 is the proportion of consumptive demand that is derived from reported values, as well as the portion that is estimated by information contained within the PTTW database.

Municipal water supply is the water use sector with the largest consumptive water demand. The only other water use sectors are agricultural and a golf course.

Water demand estimates generated through use of reported (actual) pumping rates from the WTRS provide more-reliable estimates of the consumptive demand. As shown in Table 4-6, nearly half of the consumptive water demand for the subwatershed is based on reported rates.

Municipal Water Supplies

Table 4-4 discusses the municipal water supply systems found within the study area. There are two municipal and one communal groundwater supply systems within the study area that service the Goldcrest and Sandy Cove Acres communities. The municipal water takings account for approximately 54% of the estimated total groundwater taking within the Innisfil Creeks subwatershed. Municipal well locations are shown on Figure 4-12.

Future municipal water demand was estimated from a variety of sources. In municipalities with long term Water Supply Plans, future average daily water demand was obtained directly from municipalities. For the Innisfil municipal water supply systems, projected average daily pumping rates were not available, but projected maximum daily pumping rates were presented. The maximum daily rates, however, do not represent typical long-term pumping conditions and therefore are not appropriate for use in the stress assessment. For these systems, the maximum daily rate was scaled down by a peaking factor of 2.5 to obtain estimates of average future demand. A peaking factor of 2.5 is the average peaking factor (i.e., ratio of maximum to average demand) for all municipal systems in the Tier Two Stress Assessment where both average and maximum daily pumping rates were available.

Where future water demand was not directly available, it was estimated by applying either future population growth estimates, or by applying residential development plans to existing average daily per capita water use for each municipal water system. Future population estimates were available for the Town of Innisfil. It was assumed that each residential unit houses 2.6 persons as per Statistics Canada 2006 Census for Ontario, and that each person uses 348 L/day as per the combined residential and commercial water use rate for the City of Barrie in the Environment Canada 2004 Municipal Water Use Database.

Other Permitted Uses

Table 4-6 outlines the permitted groundwater takings by subwatershed and by water use sector. For Innisfil Creeks subwatershed there are five non-municipal permits in the subwatershed.

4.4.2 Land Use

It is important to consider land cover within a water budget study because it affects several aspects of the water budget including surface water runoff, evaporation, and infiltration. Developed land generally has a higher proportion of impervious surface, such as roadways, parking lots, and building roofs. Increased runoff rates result in erosion and reduced infiltration to recharge groundwater reserves. The potential for the introduction of contaminants to both groundwater and surface water must be a consideration when a new land use is being proposed. Each type of land use can affect the quantity of both ground and surface water in the subwatershed.

Natural land cover and land use was simulated in the water budget using Ecological Land Classification (ELC) data provided by the LSRCA. The land use data is used within the water budget analysis to provide a more accurate estimate of groundwater recharge within the study area. Land use has been discussed in more detail within Section 2.2.2

The land use within the Innisfil Creeks subwatershed has been divided up into 12 classes including intensive and non-intensive agriculture, rural development, industrial, and natural heritage features (Figures 2-2 and 2-3 in **Chapter 2 – Study Area and Physical Setting**). Land uses with less than 0% coverage of a subwatershed were not reported.

Land use in the Innisfil Creeks subwatershed is currently dominated by agriculture (45%) and natural heritage cover (33%). Urban areas account for 15% of the subwatershed land use, including commercial, estate residential, institutional, and other various land uses. Other land uses occupying smaller areas include commercial (0.3%), industrial (0.3%), aggregate (0.5%), institutional (0.5%), and manicured open space (0.5%).

Land use and Significant Groundwater Recharge Areas

Significant Groundwater Recharge Areas (SGRAs) can be described as areas that can effectively move water from the surface through the unsaturated soil zone to replenish available groundwater resources. These areas should be protected to maintain the quantity and quality of groundwater required by a healthy subwatershed. The mapping of these recharge zones can aid policy development required for land development applications. Future land development plans should focus on promoting land use activities that maintain and protect the recharge occurring within the SGRAs.

Figure 4-13 shows the land use distribution within the SGRA portion of the Innisfil Creeks subwatershed. As shown on the figure the subwatershed contains very low levels of impervious (hardened) surfaces due the urban areas. Urban land uses (urban, institutional, industrial, and commercial) comprise approximately 7% of the landuses within the SGRAs, most of which are within the Alcona area.

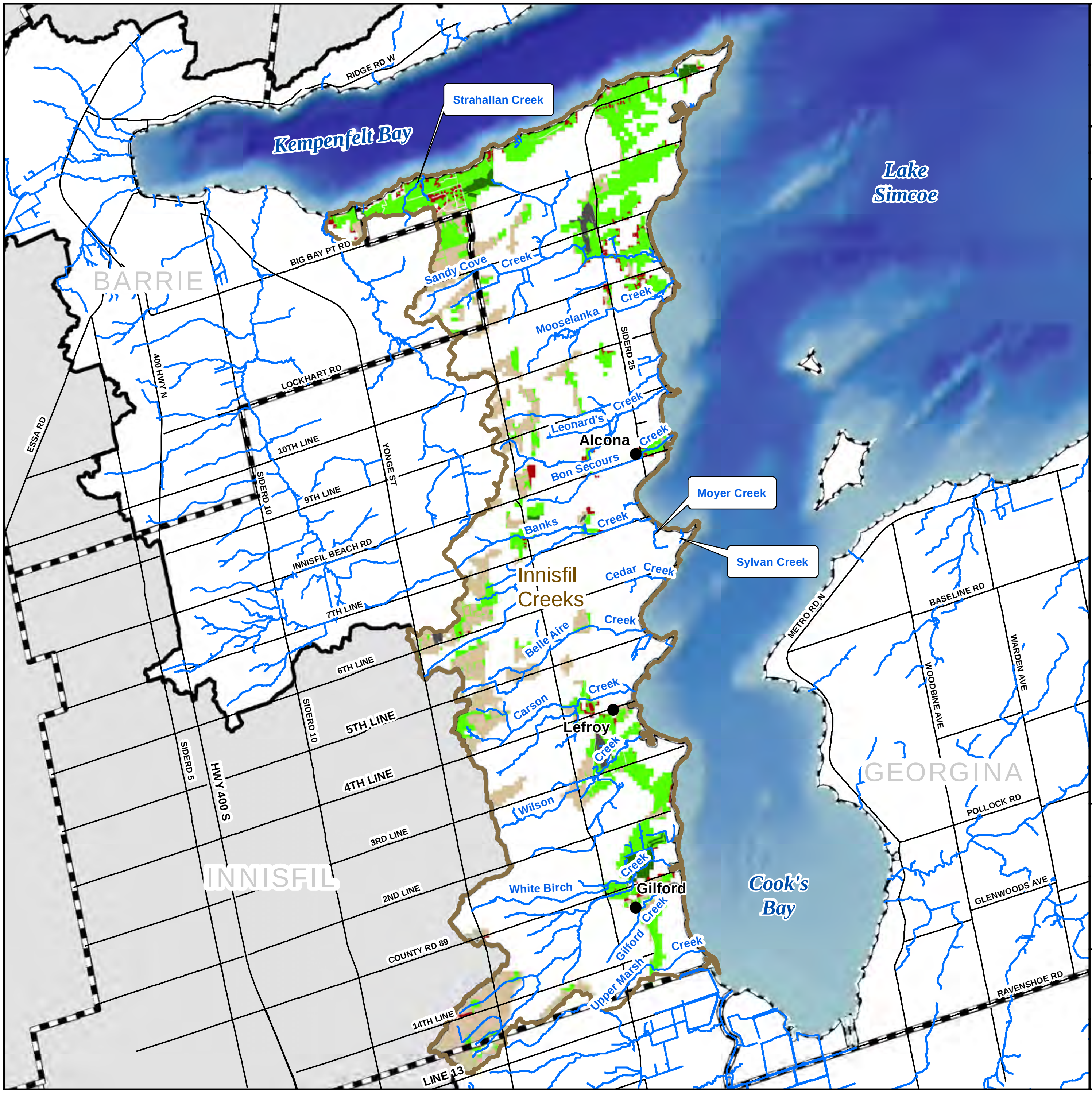
Natural heritage features also comprise approximately 46% of the landuse within the SGRAs. The natural heritage features leave the landscape in a natural state promoting infiltration. Intensive and non-intensive agriculture account for approximately 38% of landuse within the subwatershed.

Future land use projections

In addition to future water demand estimates, future water supply was also estimated for water budget purposes. This was accomplished by modifying the recharge rates according to projected changes in urban land use. Recharge modification for future conditions was assumed to be based on the change in urban area alone. For the subwatershed, the total recharge volume was decreased, assuming that any additional urbanized area would have 50% impervious cover.

Spatial distribution of land use within Significant Groundwater Recharge Areas

Figure 4-13



Legend

- Road
- Municipal Boundary
- Watercourse
- Innisfil Creeks Subwatershed

Land Use

- 🟥 Urban
- Rural
- 🟩 Natural Cover
- Golf Course
- Aggregate

Lake Simcoe Region conservation authority

0 0.5 1 2 3 4 5 Kilometres

N

This product was produced by the Lake Simcoe Region Conservation Authority and some information depicted on this map may have been compiled from various sources. While every effort has been made to accurately depict the information, data / mapping errors may exist.
This map has been produced for illustrative purposes only.
LSRCA GIS Services DRAFT TF created November 2011.

4.4.3 Climate

The climate of the Innisfil Creeks subwatershed directly determines the quantity of surface and groundwater present in the system. When the spring melt occurs, a large volume of water is released. This water will first infiltrate the ground. When the soil becomes supersaturated the remaining water will flow overland until it reaches the tributaries and main branch of the river.

The temperature in the subwatershed can directly affect the quantity of water present in the system. In the cold winter months the water is frozen at the surface so the quantity of available water is reduced. In the hot summer months the water is flowing but an overall loss is occurring due to the high rates of evaporation.

4.4.4 Water Budget Stress Assessments

Potential water quantity stress is being estimated on a subwatershed scale through the Source Protection Planning process. Several water budget initiatives have been undertaken to identify potential water quantity stress within the subwatershed. The indicators of stress presented in this report are based on the Innisfil Tier 2 study by AquaResources (2012).

The approach for conducting a Tier Two Stress Assessment is outlined in the Province's Guidance Module for Water Budget and Water Quantity Risk Assessment (MOE, 2011). This Guidance Document prescribes an approach for estimating subwatershed stress based on estimates of water supply, water reserve, and water demand in each subwatershed. While the Technical Rules (MOE, 2009) and the Guidance Module (MOE, 2011) provide a standard approach for carrying out the Tier Two Stress Assessment, this approach was tailored for the Innisfil Tier 2 study within the context of the Lake Simcoe Protection Plan, in which the interconnection of groundwater to surface water features are a priority (AquaResource, 2012).

The stress assessment evaluates the ratio of the consumptive demand for permitted and non-permitted users to water supplies, minus water reserves, within each subwatershed and calculated using the equation shown in following blue text box. The major components of the water budget have been estimated and tabulated as described in the preceding sections, including water supply, water demand, and water reserve.

The percentage of quantity demand can be expressed as in the following equation:

$$\%WaterDemand = \frac{Q_{DEMAND}}{Q_{SUPPLY} - Q_{RESERVE}}$$

where:

Q_{Demand} = amount of water consumed (pumped);

Q_{Supply} = recharge plus lateral groundwater inflow into the subwatershed (Qr + Qin); and

$Q_{Reserve}$ = the portion of available surface water or groundwater reserved for other needs such as navigation, assimilative capacity, and ecosystem health. This is estimated as 10% of the model

For groundwater systems, the stress assessment calculation is carried out for the average annual demand conditions and for the monthly maximum demand conditions; groundwater supply is considered constant under both these conditions. The stress level for groundwater systems is also categorized into three levels (significant, moderate, or low) according to the thresholds listed in Table 4-10.

Table 4-10: Groundwater potential stress thresholds

Groundwater Potential Stress Level Assignment	Average Annual Percent Water Demand	Monthly Maximum Percent Water Demand
Significant	> 25%	> 50%
Moderate	> 10%	> 25%
Low	0 – 10%	0 – 25%

The Tier 2 Water Budget for the Innisfil Creeks subwatershed (AquaResource, 2012) conducted Percent Water Demand calculation for three different demand scenarios: 1) existing water demand; 2) planned water demand; and 3) future water demand estimates. Under each scenario, the potential for stress is evaluated by comparing the amount of water consumed (consumptive water demand) with the amount of water available (water supply). Only those subwatersheds identified as having a low potential for stress under the existing demand require assessment for the planned and future demand scenarios (i.e., once a subwatershed stress assessment is determined to be moderate or significant, further scenarios are not warranted).

Once the existing, planned, and future demand scenarios have been completed, the subwatersheds still classified as having a low potential for stress are subject to the drought assessment scenario. Typically, the drought scenario involves evaluating the ability of the existing or planned wells to maintain the ability to meet demand throughout potential drought conditions (a two-year and ten-year period of drought). However, for the purposes of the LSPP, the Drought Assessment Scenario involves selecting short (two-year) periods of low precipitation, and assessing the impacts on discharge to surface water features.

The two-year drought is a form of initial screening scenario to evaluate a short term drought condition. For simplicity, this drought period is simulated by removing all groundwater recharge over a two-year period. If the screening scenario shows possible impacts on groundwater levels over the two-year period, a drought scenario should be completed using a longer term (i.e., ten years) climate period that represents historical drought conditions.

The Percent Water Demand scenarios were based on subwatershed-wide demand and supply; whereas the drought assessment scenario is based on the available water supply to surface water features.

Existing Conditions

The percent water demand was calculated for the Innisfil Creeks subwatershed using estimates of groundwater supply, reserve, and consumptive demand as discussed in previous sections. Table 4-11 shows these values and the results of the stress assessment calculation.

As seen in Table 4.4, potential for stress levels using the Percent Water Demand under existing conditions is low. Therefore, further analysis under future conditions is warranted. A comparison to the Tier One stress assessment shows that the level of risk is comparable. The groundwater consumption in 2011 compared to that in 2008 is slightly lower, due to the switch to a surface water drinking water supply within the town of Alcona.

Table 4-11: Stress assessment components and percent water demand – existing conditions (AquaResource, 2012).

Component		Flow (m^3/day)
Groundwater Supply	Recharge	63,500
	Flow In	1,650
	Total	65,150
Groundwater Reserve		4,390
Consumptive Demand	Annual Average	1,291
	Monthly Max	1,602
Water Demand %	Annual Average	2%
	Monthly Max	3%

Future Conditions

The future water demand scenario evaluates future consumptive water demand estimates for a future population throughout each municipality's planning horizon. The projected municipal demand was obtained from the local municipalities. In areas where projections were unavailable future pumping rates were estimated from official growth plans and population estimates. Future demand estimates were estimated within the subwatershed using a peaking factor of 2.5. The water supply component was computed using future land use projections to estimate changes in groundwater recharge. Water reserve and groundwater inflows were assumed to remain unchanged from existing conditions.

As the non-municipal demand remained unchanged from existing conditions, the future consumptive demand was estimated by combining the future municipal demand estimates with the existing non- municipal demand estimates, under both average and monthly maximum conditions. The future maximum monthly municipal demand was estimated by applying a maximum-monthly factor of 1.5 to the average annual municipal demand. The maximum-monthly factor of 1.5 is the average maximum- monthly factor for all municipal systems in this subwatershed where actual (reported) monthly takings were available under existing conditions. In other words, on average under existing conditions, the monthly maximum pumping rate was 1.5 times the average annual pumping rate within the Study Area. This factor is assumed to be the same under future conditions. The future municipal and non-municipal demand were added together to obtain overall future consumptive water demand estimates (AquaResource, 2012).

In addition to future water demand estimates, future water supply was also estimated. This was accomplished by modifying the recharge rates according to projected changes in urban land use. Recharge modification for future conditions was assumed to be based on the change in urban area alone. For this subwatershed, the total recharge volume was decreased by 4%, based on estimates supplied in the SGBWLS project and assuming that any additional urbanized area would have a 50% impervious cover. The projected groundwater recharge rates were used with the groundwater flow in under existing conditions as the water supply term for the Percent Water Demand under future conditions (AquaResource, 2012).

The results of the Percent Water Demand (

Table 4-12) under future conditions indicate that the potential for stress is low.

Table 4-12: Stress assessment components and percent water demand – future conditions (AquaResource, 2012).

Component		Flow (m^3/day)
Groundwater Supply	Recharge	60,960
	Flow In	1,650
	Total	62,610
Groundwater Reserve		4,390
Consumptive Demand	Future	1,642
	Monthly Max	2,540
Water Demand %	Annual Average	3%
	Monthly Max	4%

Drought Scenario

According to the Technical Rules (MOE, 2009), subwatersheds can also be identified as having a potential for moderate stress if water levels at pumping wells (Rule 35.2.e) are not sufficient for either normal operation or requires shutdown. The Technical Rules identify a two-year and a ten-year drought scenario (Rule 35.2.f/g) to identify these risks. These scenarios are designed to capture probable periods of drought conditions; both short- and long- duration droughts. For the purpose of this study, the same scenarios were designed, but as a tool to analyze the effect of drought on the health of local streams and wetlands, rather than at pumping wells (AquaResource, 2012).

The two-year drought scenario represents a situation where groundwater recharge is eliminated for a period of two years, while pumping is maintained at average conditions. Similarly, the ten-year drought scenario involves transient groundwater flow modelling using estimated monthly recharge rates over a prolonged drought period. For both, initial conditions for the transient groundwater flow model should be equal to the current steady-state calibrated conditions. At the end of the drought scenario period, baseflows are compared to current steady state conditions to quantify a relative decrease in discharge to the streams from the groundwater system.

Two Year Drought Analysis

The two-year drought was performed by removing all recharge to the Innisfil Subwatershed (and surrounding area) and running the model transiently for two years. Table 4-13 indicates the current discharge conditions, the discharge condition after two years of decreased recharge and the percent difference in each surface water feature within the Study Area. Figure 4.2 shows a map of where these impacts occur.

As seen in the above results, all of the creeks and wetlands experienced drastic decreases in discharge throughout the two year drought scenario. However, a scenario in which recharge is eliminated entirely for two years is unlikely, therefore, the ten-year drought scenario is warranted to further quantify the impacts on surface water features.

Table 4-13: Two year drought results (AquaResource, 2012).

Water Body	SteadyStateFlux	Drought Flux	Percent Reduction
Banks Creek (#5)	-200.30	-0.04	100%
Belle Aire Creek (#7)	-56.37	-0.17	100%
Big Bay Point Wetland	-9.31	0.00	100%
Bon Secours Creek (#4)	-957.88	-17.11	98%
Carson Creek (#8)	-76.09	-0.29	100%
Gilford Creek	-18.08	0.00	100%
Holland Marsh Wetland	-6,236.83	0.00	100%
Leonard's Beach Swamp	-1,747.29	0.00	100%
Leonard's Creek (#3)	-605.93	-16.99	97%
Little Cedar Point Wetland	-5,878.21	-356.19	94%
Mooselanka Creek (#2)	-18.10	-0.02	100%
Sandy Cove Creek (#1)	-6,738.34	-26.90	100%
Unnamed Innisfil Wetland	-477.27	0.00	100%
Upper Marsh Creek	-1.37	0.00	100%
White Birch Creek (#10)	-250.31	-0.20	100%
Wilson Creek (#9)	-223.34	-0.01	100%
Wilson Creek Marsh	-1,228.97	0.00	100%

Ten Year Drought Analysis

This section will be updated pending the completion of a revised report from the consultants who are undertaking this analysis.

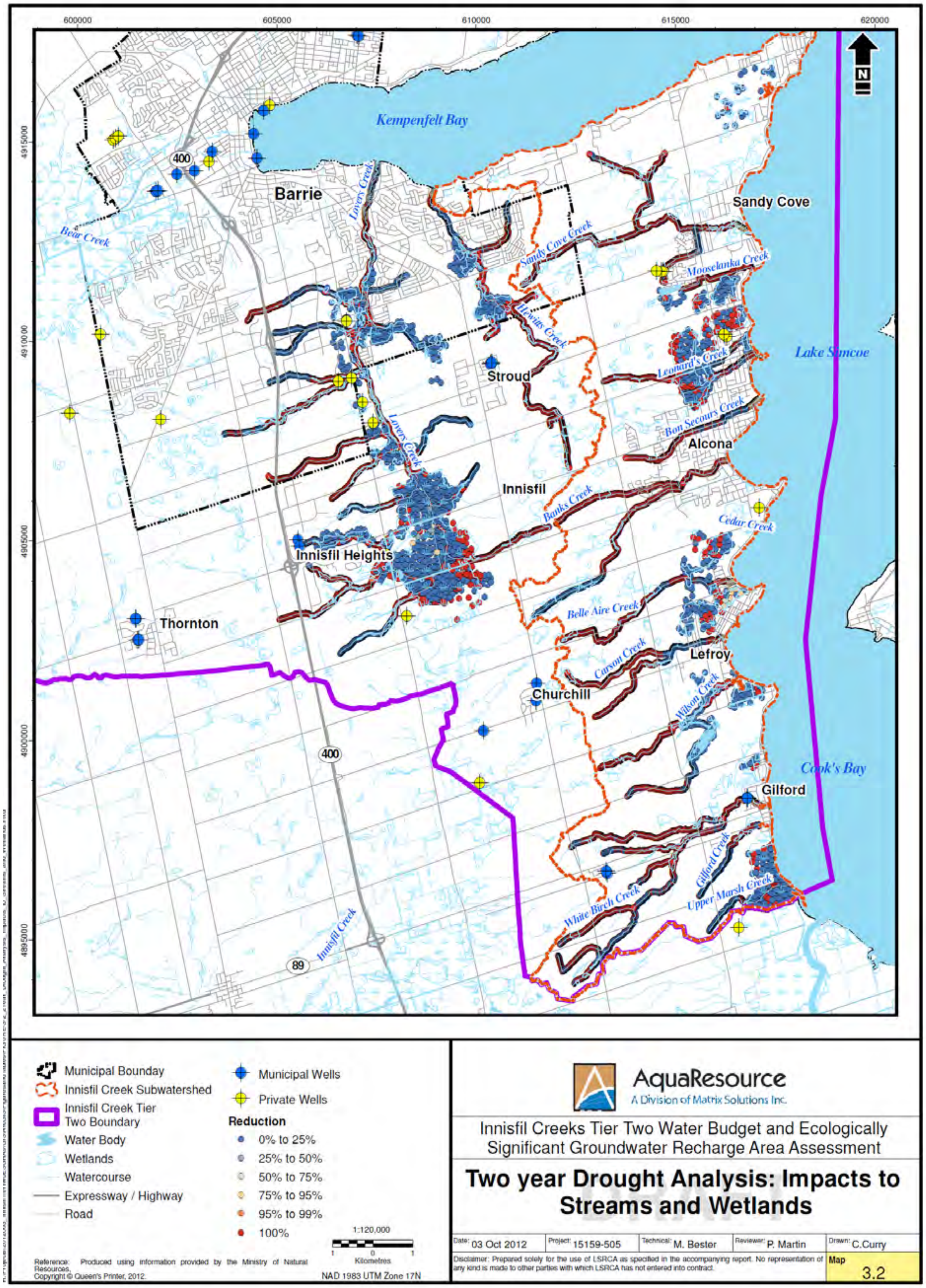


Figure 4-14: Two year drought analysis: impacts to streams and wetlands (AquaResource, 2012).

Key points – Factors impacting Water Quantity status - stressors:

- The water demand estimates for the Innisfil Creeks subwatershed suggest that water demand is relatively uniform over the year, within minor increases during the summer months, due to the majority of water supply being used for municipal and commercial purposes.
- The average annual groundwater demand from all sources in the Innisfil Creeks subwatershed is 471,215 m^3/yr.
- Municipal water supply accounts for 54% of the consumption within the Innisfil Creeks subwatershed, while livestock and rural domestic use accounts for 4% and 43% respectively.
- Within the significant groundwater recharge areas, the Innisfil Creeks subwatershed is dominated by agricultural activities and natural cover with a limited amount of urban areas.
- The Tier 2 water budget estimated the current groundwater use for the Barrie Creeks subwatershed is 471,215 m^3/yr, which represents 3% of the available annual groundwater supply.
- The Tier 2 water budget confirmed the stress assessment completed for the Tier 1 and indicated that the Innisfil Creeks subwatershed is not stressed from a groundwater perspective.
- Initial work on setting targets for maintaining flow regimes that are sufficient to meet ecological needs has been completed for the neighbouring Lovers Creek; however more work needs to be done to in Lovers Creek to fully understand the flow regimes and finalize the methodology before the process is initiated and targets can be set in the Innisfil Creeks subwatershed.

4.5 Current Management Framework

4.5.1 Protection and policy

There are numerous acts, regulations, policies and plans aimed at maintaining or improving water quantity. These include the Provincial Policy Statement, the Ontario Water Resources Act, the Growth Plan for the Greater Golden Horseshoe, the Lake Simcoe Protection Plan, and the Clean Water Act.

This management framework relates to many different stressors that can potentially affect water quantity, ranging from the urban development to the demand for water resources. Table 4-15 categorizes four such stressors, recognizing that many of these activities overlap and that the list is by no means inclusive of all activities. The legal effects of the various Acts, policies, and plans on the stressors is categorized as 'existing policies in place', or 'no applicable policies'. The policies included in the table include those which have legal standing and must be conformed to, or policies (such as some of those under the Lake Simcoe Protection Plan) which call for the development of further management tools, research or education programs.

Readers interested in the details of these regulations, policies, and plans are directed to read the original documents.

Table 4-14: Summary of current regulatory framework as it relates to the protection and restoration of water quantity

Stressor affecting water quantity	Lake Simcoe Protection Plan (2009)	Growth Plan for the Greater Golden Horseshoe (2006)	Provincial Policy Statement (2005)	Ontario Water Resources Act (1990)	Water Opportunities Act (2010)	Clean Water Act (2006)	DRAFT South Georgian Bay Lake Simcoe Source Protection Plan (2011)	LSRCA Watershed Development Policies (2008)	City of Barrie Official Plan (2009)	Simcoe County Official Plan (2007)	Town of Innisfil Official Plan (2006)
Impervious surfaces	🟩	🟩	🟩	🟥	🟥	🟩	🟩	🟩	🟩	🟩	🟩
Agricultural water demand	🟩	🟩	🟩	🟩	🟥	🟩	🟥	🟥	🟩	🟥	🟥
Commercial and residential water demand	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟥	🟩	🟥	🟩
Climate change	🟩	🟥	🟥	🟥	🟥	🟥	🟩 *	🟥	🟥	🟥	🟥

🟩 Restrictive policies in place

🟥 No applicable policies

* No policies to prevent climate change, but policies include an assessment of possible impacts

As can be seen in Table 4-15, a number of Acts, plans, and policies already exist to protect the quantity of surface and groundwater in the Innisfil Creeks subwatershed. Most of these policy tools are directed towards protecting and enhancing groundwater recharge and discharge, or promoting water conservation.

Under the Provincial Policy Statement, municipalities are required to restrict development and site alteration in or near vulnerable headwaters, seepage areas, recharge/discharge areas, springs, and wetlands in order to protect, improve or restore their hydrologic function. Under the LSPP, the Conservation Authority is to identify areas of ecologically significant groundwater recharge (i.e. areas where groundwater which eventually supports sensitive features such as wetlands or cold water streams, initially enters the system), and municipalities are to incorporate policies in their respective Official Plans to protect, improve, and restore the function of these, as well as significant groundwater recharge areas previously identified under the South Georgian Bay – Lake Simcoe Source Protection Plan.

Under the 2009 Barrie Official Plan, the City has committed to identifying surface and ground water features which are necessary for the hydrological integrity of the watershed, and incorporating them in the Official Plan, along with policies to protect, improve, or restore the hydrological functions of these features, including their contribution to aquatic habitat and base flow.

The Town of Innisfil Official Plan has identified significant groundwater recharge areas to be protected from incompatible development and site alteration. Smaller areas, such as seepage areas and springs are protected indirectly, by their use in identifying significant woodland areas (which are then provided some protection from development).

The flow of water outside these critical hydrologic areas is protected, in part, by requirements for storm water development. In the City of Barrie, all major developments require the preparation of stormwater management studies and plans, which must be consistent with the City's Master Drainage Studies and requirements of LSRCA.

In new or expanded settlement areas in the Town of Innisfil, a Master Drainage Plan is to be undertaken, which will establish preliminary targets for storm water quantity, including ensuring no increase in flows from predevelopment levels, as well as developing a stormwater management plan to manage urbanization impacts on surface and ground water quantity. In areas where such a master drainage plan has been created, any proposed developments must comply with its targets and guidelines. In areas where a master drainage plan doesn’t exist, any proposed development larger than five units is required to develop a stormwater management plan that includes an assessment of pre and post development discharge, impacts on surface and ground water quantity, and how development will maintain or enhance baseflow.

Under the Lake Simcoe Protection Plan, this threshold is to be reduced to four units (or individual units larger than $500m^2$). The LSPP also requires that stormwater management plans be consistent with the Tier 2 water budgets developed under the South Georgian Bay-Lake Simcoe Source Protection Plan, as well as minimizing anticipated changes in water flow between the pre-development and post-development period.

Furthermore, the draft South Georgian Bay – Lake Simcoe Source Protection Plan prohibits an increase in impervious cover in vulnerable areas around municipal wells, unless it can be demonstrated pre-development recharge can be maintained, and also prohibits designating new land uses that result in recharge reduction that would create a ‘significant threat’, unless the proponent can demonstrate that post-development recharge will match pre-development recharge.

Water conservation is promoted through regulatory restrictions, education programs, and municipal water use efficiency plans.

For example, under the Ontario *Water Resources Act*, any use of water which exceeds 50,000 litres per day requires a Permit to Take Water from the Ministry of the Environment. Under the LSPP, results of Tier 2 water budgets may provide background information for decisions made by the MOE related to these Permits. The LSPP also directs the MOE and MNR to develop in-stream flow targets for water quantity stressed subwatershed, which include the Innisfil Creeks subwatershed. When completed, these targets are to be used to inform future strategies related to water taking, which may include policies that identify how much water can be allocated among users in a subwatershed, including setting aside an allocation to support the natural functions of the ecosystem.

Results of these Tier 2 water budgets and instream flow targets are also intended to inform municipal water conservation plans, which the LSPP requires the City of Barrie and Town of Innisfil to prepare and implement. These plans are intended to establish targets for water conservation and efficiency, identify water conservation measures such as the use of flow-restricting devices and other hardware, and practices and technologies associated with water reuse and recycling, as well as methods for promoting water conservation including full-cost pricing for residents on municipal water supplies, and public education and awareness programs for rural residents not on municipal water systems.

Water conservation and stewardship is also to be promoted in the agricultural, recreational, commercial, and industrial sectors, through partnerships between government agencies and key private stakeholders.

4.5.2 Restoration and remediation

Although neither the Provincial government (through the Lake Simcoe Community Stewardship Program) nor the LSRCA (through the Landowner Environmental Assistance Program) have funding for stewardship projects specific to issues related to water quantity, projects such as retrofitting on-line ponds and planting trees and shrubs which are supported by those programs will have benefits related to reducing evaporation, and increasing groundwater recharge. These projects are described in more detail in chapters 3, 5 and 6.

The Environmental Farm Plan program, which is a partnership between the Ontario Ministry of Agriculture, Food and Rural Affairs, Agriculture and Agri-Food Canada, and the Ontario Soil and Crop Improvement Association does support projects specifically directed to managing water use on farms. Projects supported through the Environmental Farm Plan include infrastructure to support water use efficiency, including both in-barn and irrigation equipment, and support for establishing off-line irrigation ponds to reduce water taking demands on surface water features. Several dozen such projects have been implemented on farmland in the Barrie and Innisfil area.

4.5.3 Science and research

As a result of the tragedy in Walkerton in 2000, and the subsequent *Clean Water Act* and Source Protection Planning process, the amount of research conducted on water quantity and groundwater movement in the Lake Simcoe watershed increased exponentially.

The development of the South Georgian Bay – Lake Simcoe Source Protection Plan was supported by the establishment of a subwatershed-scale water budget, which described the movement of water among hydrologic elements in the watershed (e.g. wetlands, soils, aquifers), and the extractions of this water for human use. These budgets, and associated stress assessments also formed a significant part of the data used in drafting this subwatershed plan.

Another important component of the Source Protection Plan was the identification of ‘Significant Groundwater Recharge Areas’. These areas are locations where surficial geology and hydraulic gradient tend to support a relatively high volume of water recharging into aquifers. More recently, the LSPP has directed LSRCA to identify ‘Ecologically Significant Groundwater

Recharge Areas.' This new class of recharge area is identified based on ecological interactions, rather than volume of water. To identify these areas, reverse particle tracking models have been developed based on groundwater models created as part of the Source Protection Planning process, to identify areas which contribute groundwater to sensitive surface features such as wetlands and coldwater streams. ESGRAs are currently being delineated for the Innisfil Creeks subwatershed by AquaResource Inc. using the FEFLOW model developed by AquaResource *et al*. (2011) for the Innisfil Tier 2 Water Budget.

In order to support water budgeting and other watershed-scale modeling, LSRCA manages a network of 12 climate stations (including precipitation gauges), and 15 surface water flow stations (in partnership with the Water Survey of Canada). These stations provide monthly stream flow data, which can be used to monitor mean, median and baseflow conditions for many of Lake Simcoe's subwatershed. For further information on research and monitoring related to water budgeting, see the Source Water Protection *Assessment Report: Lakes Simcoe and Couchiching- Black River Source Protection Area* (South Georgian Bay-Lake Simcoe Source Protection Committee, 2011).

4.6 Management gaps and recommendations

As described in the previous sections, a number of regulations and municipal requirements aimed at protecting water quantity in the Innisfil Creeks subwatershed already exist. Despite this strong foundation, there are gaps in the management framework that need to be considered. This section identifies some of the gaps in the existing protection of the water quantity in the Innisfil Creeks subwatershed, and outlines recommendations to help fill these gaps.

It is recognized that many of the undertakings in the following set of recommendations are dependent on funding from all levels of government. Should there be financial constraints, it may affect the ability of the partners to achieve these recommendations. These constraints will be addressed in the implementation phase

4.6.1 Water Demand

Recommendation 4-1 - That the LSRCA and subwatershed municipalities promote and support low impact design (LID) solutions such as rainwater harvesting, rain gardens, and grey water reuse to manage stormwater and supplement residential water use.

Recommendation 4-2 - That the MOE be encouraged to continue to improve the Water Taking Reporting System by integrating the Permit To Take Water (PTTW) database with the Water Well Information System (WWIS) database, and connecting those takings to wells / aquifers to facilitate impact assessment (i.e. the PTTW database needs to be connected to the WWIS database).

4.6.2 Ecological Flows

Recommendation 4-3 - That the MNR and MOE, in partnership with LSRCA, develop a more detailed surface water budget for the Innisfil Creeks subwatershed that will provide basis of actions needed to determine ecological (instream) flow targets.

Recommendation 4-4 – That the MOE, with assistance from LSRCA, MNR and the University of Guelph, determine in-stream flow regime targets for Barrie, Lovers, Hewitt's, and Innisfil Creeks. These targets should be based on the Guidance Document framework (LSRCA 2010) which is being used for the Maskinonge River subwatershed.

Recommendation 4-5 – That the MOE and MNR, with assistance from LSRCA, develop a strategy to achieve the instream flow regime targets. This strategy should address both high and low flow requirements and provide a plan for implementing strategy recommendations.

4.6.3 Reducing impacts of land use – groundwater recharge and discharge

Recommendation 4-6 - Municipalities shall only permit new development or redevelopment in significant recharge areas, where it can be demonstrated through the submission of a hydrogeological study and water balance, that the existing groundwater recharge will be maintained (i.e. there will be no net reduction in recharge).

Recommendation 4-7 - Municipalities should amend their planning documents to require that runoff in significant recharge areas meet the enhanced water quality criteria outlined in the MOE Stormwater Management Guidance Document, 2003, as amended from time to time, prior to it being infiltrated.

Recommendation 4-8 - That municipalities incorporate the requirement for the re-use or diversion of roof top runoff (clean water diversion) from all new development in significant recharge areas away from storm sewers and infiltrated to maintain the pre-development water balance (except in locations where a hydrogeological assessment indicates that local water table is too high to support such infiltration) in their municipal engineering standards.

Recommendation 4-9 - The MOE should only issue Environmental Compliance Approvals for new storm water management facilities within significant recharge areas that maintain the pre-development groundwater recharge rates and meet the enhanced water quality criteria outlined in the MOE Stormwater Management Guidance Document, 2003, as amended from time to time.

Recommendation 4-10 - The MOE shall only issue Environmental Compliance Approvals for Stormwater Management Facility retrofits within significant recharge areas, that attempt to improve, maintain or restore the pre-development water balance, and meet the enhanced water quality criteria outlined in the MOE Stormwater Management Guidance Document, 2003, as amended from time to time.

Recommendation 4-11 – Municipalities, in collaboration with the Lake Simcoe Region Conservation Authority, shall undertake an education and outreach program focusing on the importance of significant recharge areas, and the actions residents and businesses can take to maximize infiltration from impervious surfaces while minimizing contamination such as salt.

Recommendation 4-12 - The Lake Simcoe Region Conservation Authority should create eligibility for stormwater management retrofits and infiltration projects under the LEAP program within significant recharge areas.

Recommendation 4-13 - Municipalities shall collaborate with the Lake Simcoe Region Conservation Authority to promote infiltration of clean water in significant recharge areas, and prioritize stormwater retrofits utilizing water quality controls, and ultimately infiltration devices for treated stormwater runoff.

Recommendation 4-14 - The MOE should consider providing financial assistance to implement stormwater management facility retrofits and infiltration projects within significant recharge areas.

Recommendation 4-15 - Municipalities should include significant recharge areas in their assessment of areas vulnerable to road salt, and modify their municipal Salt Management Plans and snow disposal plans as necessary.

4.6.4 Climate Change

Recommendation 4-16 –That the LSRCA, with the assistance of MOE and MNR, develop a fully integrated groundwater and surface water model, that is able to take advantage of real-time or near real-time flow data, to predict how stream flow volumes will respond to the seasonal and ecological impacts of climate change, in terms of increased peak flows, reduced baseflows, and increased water demand.

Recommendation 4-17- That the LSRCA work with its federal, provincial, and municipal partners to refine the anticipated impacts of climate change in the Lake Simcoe watershed. This information can then be used to develop management strategies to address these impacts. Emphasis at this time should be placed on building ecological resilience in vulnerable subwatershed through stream rehabilitation, streambank planting, barrier removal, and other BMP implementation in conjunction with the protection of current hydrologic functions.

5 Aquatic Natural Heritage

5.1 Introduction

Habitat can be described as a place where an animal or plant normally lives, often characterized by a dominant plant form or physical characteristic. All living things have a number of basic requirements in their habitats including space, shelter, food, and reproduction. In an aquatic system, good water quality is an additional requirement. In a river system, water affects all of these habitat factors; its movement and quantity affects the usability of the space in the channels, it can provide shelter and refuge by creating an area of calm in a deep pool, it carries small organisms, organic debris, and sediments downstream which can provide food for many organisms and its currents incorporate air into the water column which provides oxygen for both living creatures and chemical processes in the water and sediments. Habitat features also frequently affect and are affected by other features and functions in a system. For instance, the materials comprising a channel bed can affect the amount of erosion that will take place over time; this in turn affects the channel shape and the flow dynamics of the water. The coarseness of the channel's bed can also affect the suitability for fish habitat – some species require coarse, gravelly deposits for spawning substrates, while finer sediments in the shallow fringes of slow moving watercourses often support wetland plants that are required by other species.

All habitat features are impacted by changes in the system, both natural and anthropogenic in nature. There are numerous causes of stress in an aquatic environment. Any type of land use change from the natural condition will place a strain on the system, and can cause significant changes to the aquatic community. The conversion of natural lands such as woodland and wetland to agriculture or urban uses eliminates the functions that these features perform, such as improvement of water quality, water storage, and increasing the amount of infiltration to groundwater. This can result in impacts to water quality and a reduction in baseflow, resulting in watercourses that are unable to support healthy communities of native biota.

The following sections in this chapter highlight the current status (Section 5.2) of each of the main watercourses in the Innisfil Creeks subwatershed, as well as the stressors impacting them (Section 5.3), and the current management framework in place to protect and restore them (Section 5.4).

5.2 Current Status

To assess the environmental quality and the overall health of the aquatic system, the Lake Simcoe Protection Plan has provided indicators to determine how well the aquatic ecosystem is functioning. The indicators which are relevant for the subwatersheds and their tributaries are:

- Natural reproduction and survival of native aquatic communities;
- Presence and abundance of key sensitive species, and;
- Shifts in fish community composition.

To address these indicators, a number of analyses have been done on the stream systems. The following sections summarize these results.

LSRCA field crew - Electrofishing

5.2.1 Overview of aquatic communities – Tributaries

5.2.1.1 Fish community

Studying the health of the fish community of the Innisfil Creeks subwatershed provides an important window into the health of the aquatic system as a whole. Fish are sensitive to a great number of stresses including water quality, temperature, flow regimes, and the removal of in-stream habitat. While they are able to move quickly in response to a sudden change in conditions (e.g. a release of a chemical into the system) and are therefore not a good indicator of these types of issues, prolonged stresses will eventually cause a shift in the fish community from one that is sensitive and requires clean, cool water to survive to one that is more tolerant of lower quality conditions. Long term monitoring will identify changes and trends occurring in the fish community the subwatershed, and will help to identify and guide restoration works.

A total of 32 species have been captured from the Innisfil Creeks subwatershed since 1975 (Table 5-1). Some of these species have only historic records (before 1990), some only current (after 1990) and others have both (1975-present). The fish communities in the subwatersheds range from cold headwater communities featuring such species as brook trout (*Salvelinus fontinalis*) and mottled sculpin (*Cottus bairdii*) to diverse warm water systems containing such species as creek chub (*Semotilus atromaculatus*) and brown bullhead (*Ameiurus nebulosus).*

The water temperature of a system can dictate the composition of the fish community, as well as determine the way systems are managed. Figure 5-1 illustrates the combination of maximum air temperatures versus water temperature at 4 pm (when water temperatures tend to reach their maximum) that makes a cold, cool or warm water stream. Typically, the average maximum summer water temperatures for a cold water system is 14°C. Cool water is approximately 18°C and warm water systems have an average summer maximum daily water temperature of approximately 23°C (Stoneman and Jones, 1996). This temperature rating system has been used to classify the tributaries in the Lake Simcoe watershed.

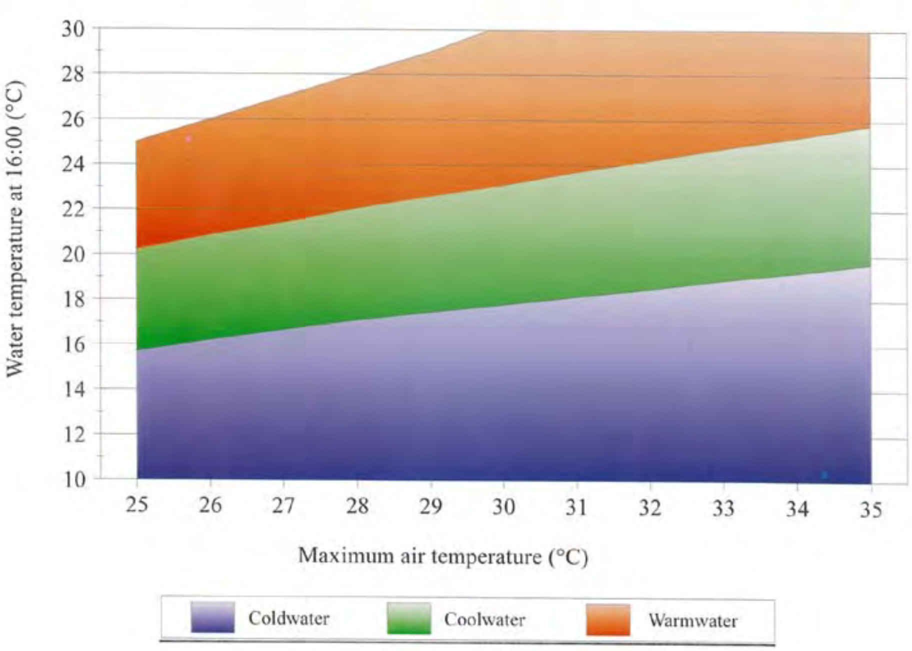


Figure 5-1: Cold, cool and warm water trout stream temperature ranges (Stoneman and Jones, 1996).

Table 5-1: Fish species captured in the Innisfil Creeks subwatershed from 1975-2011.

Common Name	Innisfil Creeks subwatershed										
	Strathallan	Sandy Cove	Burt's Drain	Leonard's	McLean	Cedar	Belle Aire	Carson	Wilson	White Birch	Upper Marsh
Brook Trout *(Salvelinus fontinalis)*		▓									
Rainbow Smelt ^ *(Osmerus mordax)*								■			
Northern Pike *(Esox lucius)*								■	■		
White Sucker *(Catostomus commersoni)*		▓		▓			▓	▓	▓	▓	
Central Mudminnow *(Umbra limi)*		▓	▓	▓			▓		▓	░	▓
Northern Redbelly Dace *(Phoxinus eos)*		░		▓			▓	▓	░	▓	▓
Finescale Dace *(Phoxinus neogaeus)*				▓							
Emerald Shiner *(Notropis atherinoides)*		■	▓	▓			▓	▓	░		
Common Shiner *(Luxilus cornutus)*				▓				▓	░	▓	
Blackchin Shiner *(Notropis heterodon)*			▓					▓			
Blacknose Shiner *(Notropis heterolepis)*			▓	▓				▓			
Spotfin Shiner *(Cyprinella spiloptera)*			▓								
Sand Shiner *(Notropis stramineus)*		■			▓		▓				
Bluntnose Minnow *(Pimephales notatus)*		░	▓	▓	▓	▓	▓	▓	░	■	
Fathead Minnow *(Pimephales promelas)*		▓		▓			▓	▓	░	▓	▓
Blacknose Dace *(Rhinichthys atratulus)*		▓	▓	▓	▓	▓	▓	▓	▓	▓	
Longnose Dace *(Rhinichthys cataractae)*	▓	■	▓							▓	
Creek Chub *(Semotilus atromaculatus)*	▓	▓		▓			▓	▓	▓	▓	
Pearl Dace *(Margariseus margarita)*		■									

Common Name	Innisfil Creeks subwatershed										
	Strathallan	Sandy Cove	Burt's Drain	Leonard's	McLean	Cedar	Belle Aire	Carson	Wilson	White Birch	Upper Marsh
Brown Bullhead (*Ameriurus nebulosus)*									░		
Banded Killifish (*Fundulus diaphanous)*							▓	▓	░		
Brook Stickleback (*Culaea inconstans)*		▓	▓	▓	▓	▓	▓	▓	▓	▓	▓
Rock Bass (*Ambloplites rupestris)*		▓		▓			▓		░		
Pumpkinseed (*Lepomis gibbosus)*				▓			▓	▓	░	░	
Smallmouth Bass (*Micropterus dolomieu)*									▓		
Yellow Perch (*Perca flavescens)*		░					▓	■	░	░	
Iowa Darter (*Etheostoma exile)*		░									
Johnny Darter (*Etheostoma nigrum)*		░								▓	
Mottled Sculpin (*Cottus bairdi)*		░	░	░						▓	
Slimy Sculpin (*Cootus cognatus)*	▓										

■	**Captured historically (before 1990)**
▓	**Captured historically and present day (before and after 1990)**
░	**Captured present day (after 1990)**

Note: Not all of the main tributaries in the Innisfil Creeks subwatershed are shown here. Mooselanka, Bon Secours, Banks, Moyer, Sylvan and Gilford Creeks do not have any LSRCA monitoring sites and as such have not been included in this table.

^ = Not native to Lake Simcoe Watershed

A general overview of the current fish communities is looked at first to see what type of fish are at a site (cold water species[1], warm water species[2], or no fish) and what the temperature of the creek is at the site (cold, cool or warm water), as well as the location of dams that block passage for some fish species (Figure 5-2). This broad overview can show the general shifts in the fish communities as coldwater fish communities either change into warm water fish communities or habitat absent of fish, as water temperatures rise or where dams are present.

Figure 5-2 shows that temperature varies along the most of the watercourses where data is available. While the majority of these creeks are cold water systems, cold water species are present only in Strathallan, Sandy Cove, Burts Drain, Leonard's, and White Birch Creeks. There are also a number of sites that either have only warm water species or no fish species at all. The dams depicted on Figure 5-2 show where the major barriers to fish are located.

There are a few anomalies where cold water species are found within warm water habitat or warm water species in cold water habitat. The most likely reason that cold water species are found in warm water habitat is that there are small nearby temperature micro habitats, such as undercut banks and heavily shaded areas with cold water upwellings, springs, or seeps. It is also possible that a species was passing through or leaving the warm water habitat at the time of sampling, but this would be more unusual. Warm water species are habitat generalists and can exist in warm, cool, or coldwater conditions.

An Index of Biotic Integrity (IBI) was used to assess the ecological integrity of the creeks through an analysis of the composition of fish communities within the system (Figure 5-3). Fish population and community composition surveys are valuable tools in examining the health and stability of streams and rivers. Over time, shifts in composition along with the presence or absence of key species not only provides an indication of system health but can be used to help identify what ecosystem stressors, such as climate change and urbanization, are influencing aquatic habitats.

With this method there are five rankings that can be assigned to a site:

- Very good: Excellent diversity, top predators, trout present and high fish abundance
- Good: Average diversity, top predators present, trout present, average abundance
- Fair: Low/average diversity, some top predators, no trout, low/average abundance of fish
- Poor: Low diversity, no top predators, no trout, low abundance of fish
- No Fish: No fish were captured at these sites

While the IBI is generally applicable to the Lake Simcoe watershed, there is potential for improvement by including a greater range of top predators into the IBI calculations. Currently only brook trout are weighed and measured individually. This may skew the results as warm water predators are not included in the IBI calculations.

Overall, Figure 5-3 shows that the ecological integrity of the systems vary spatially across the subwatersheds, with many of the sites showing fair conditions. There are also several 'good' ratings in the subwatershed, as well as a number of sites that were rated as having poor ecological integrity. It must also be noted that 5 of the 29 sites recorded no fish captured.

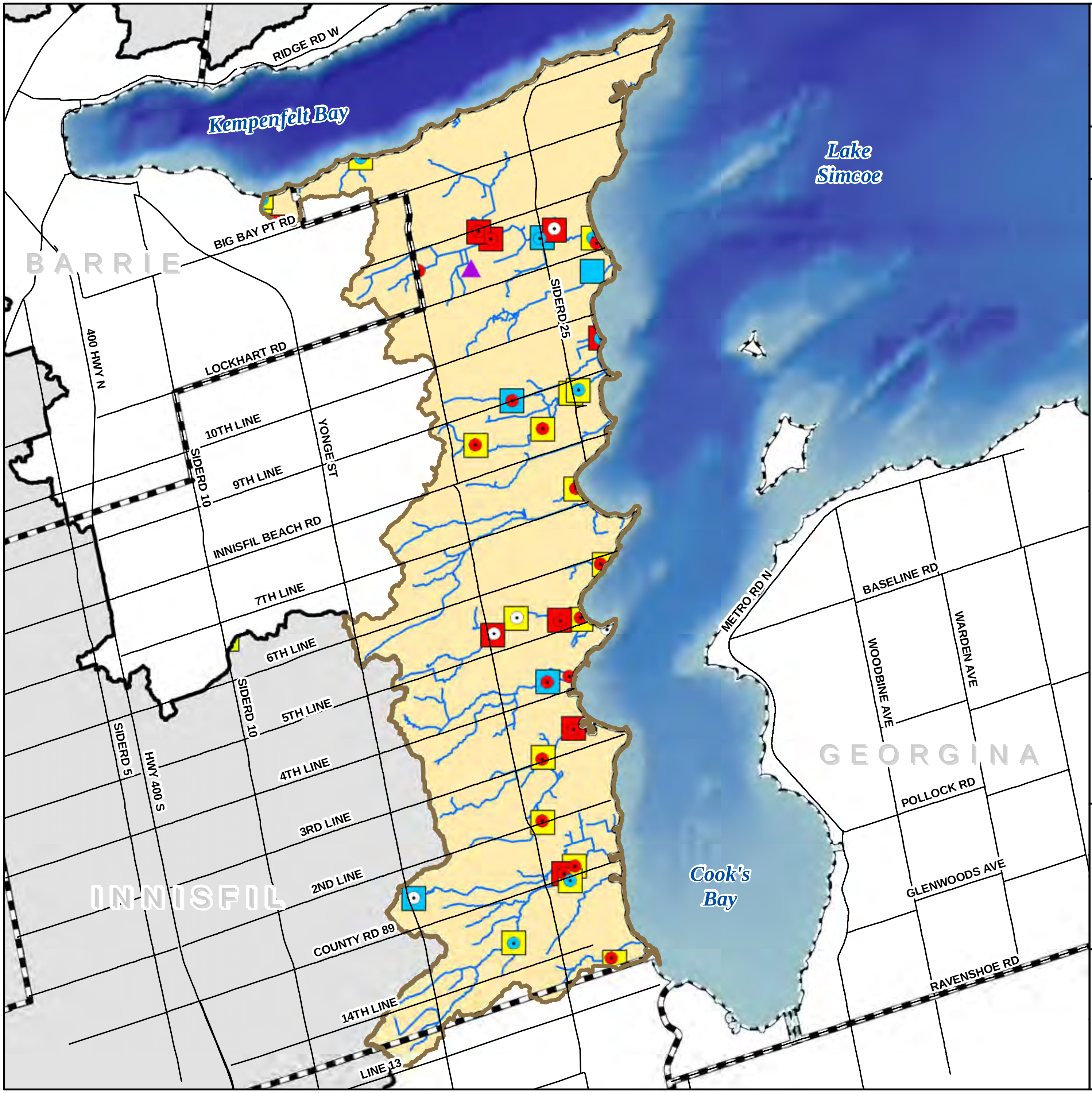
---

[1] Cold water species are indicators of cold water habitat. Coldwater species found in these subwatersheds include: rainbow trout*, brook trout, rainbow smelt *, mottled sculpin and slimy sculpin (*not native to Lake Simcoe watershed). All others listed in Table 5-2 are either cool or warm water species.

[2] Warm water species are considered to be generalist species that are not coldwater indicators and can exist in warm, cool and coldwater sections of a stream.

Occurence of fish communities in relation to measured in-stream water temperature in the Innisfil Creeks subwatershed.

Figure 5-2



Legend

▲ Dam

Fish
- ● Cold
- ○ No Fish
- ● Warm

Temperature
- 🟦 Cold
- 🟨 Cool
- 🟥 Warm

— Road

▬ Municipal Boundary

〰 Watercourse

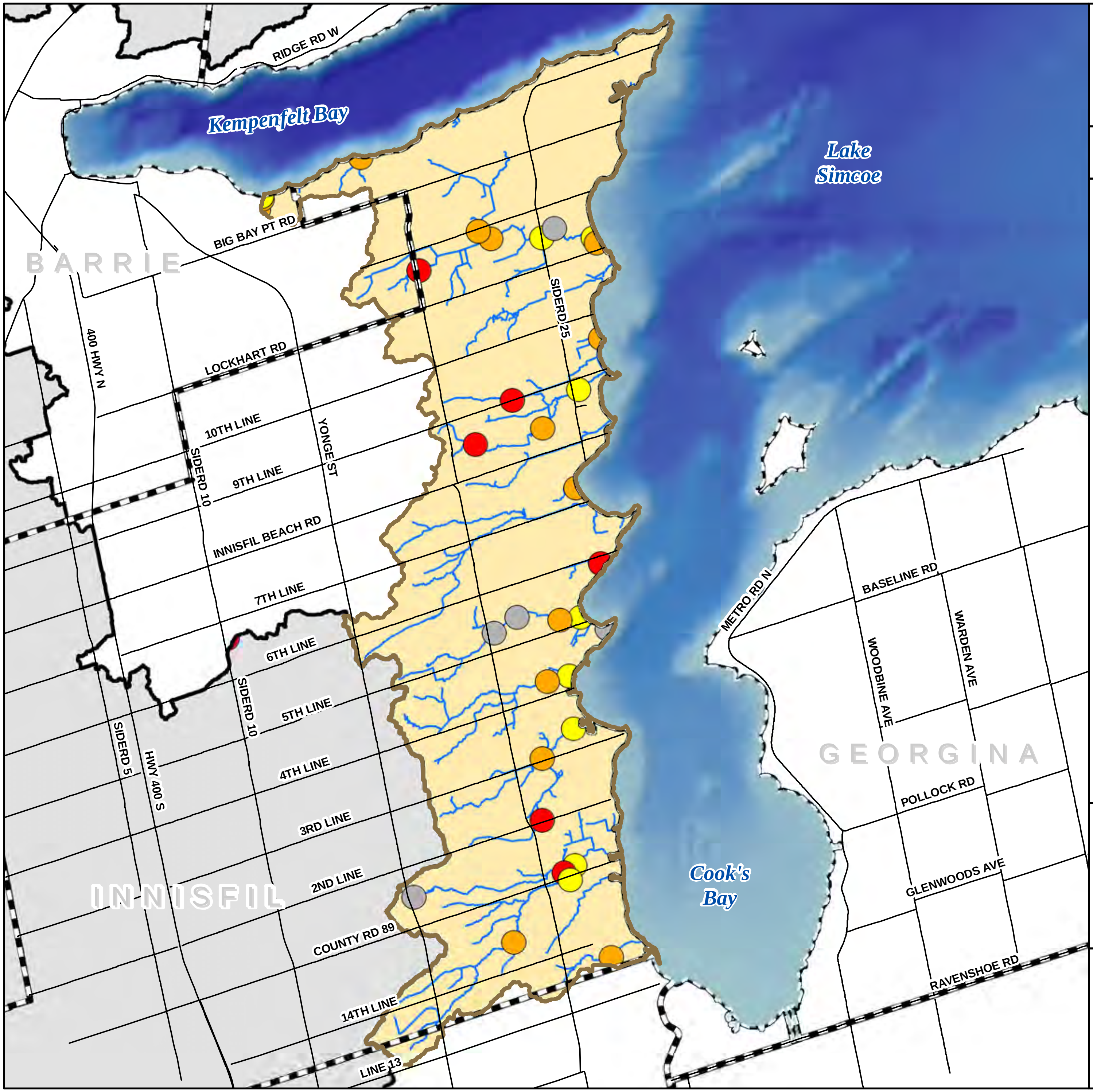
Lake Simcoe Region conservation authority

0 0.5 1 2 3 4 5 Kilometres

N

Ecological integrity of stream sites based on fish community conditions assessed using an Index of Biotic Intergrity (IBI)

Figure 5-3



Legend

Index of Biotic Integrity

- 🟢 Very Good
- 🟡 Good
- 🟠 Fair
- 🔴 Poor
- ● No Fish
- — Road
- — Municipal Boundary
- ~ Watercourse

Lake Simcoe Region Conservation Authority

0 0.5 1 2 3 4 5 Kilometres

N

The historic and current presence of brook trout and mottled sculpin (both key indicator species for cold water habitat) was mapped in Figure 5-4 and Figure 5-5. A comparison of past and current habitat ranges can further show shifting of the cold water fish communities in the system and where areas that used to be cold water habitat are possibly transitioning to cool or warm water systems. Additionally, current data is available to compare the number of adults to young of the year for brook trout populations, possibly indicating areas of successful natural reproduction and survival of the species.

Figure 5-4 shows the historic and current presence of brook trout in the Innisfil Creeks subwatershed, while Figure 5-5 shows the historic and current presence of mottled sculpin. These figures also point out that all streams with historic brook trout and mottled sculpin populations have maintained their cold water attributes, and have supported brook trout and/or mottled sculpin communities over the last 10-35 years (depending on the system). Mottled sculpin populations have seen an increase in their range in the subwatershed, expanding from historically being found in one creek to being currently being found in four. Of the two creeks with historic brook trout, Banks Creek no longer has its population. It is also thought that in the past, most of the creeks within this subwatershed had the necessary attributes to sustain brook trout populations. But, by the time they were sampled, changes in surrounding land uses and stream alterations had impacted the creeks to a degree where they no longer provided suitable brook trout habitat.

The reasoning for selecting brook trout as a key indicator species is provided in the following case study.

Significance of brook trout in the tributaries of Lake Simcoe

The brook trout (*Salvelinus fontinalis)* is a native fish species that inhabits the Lake Simcoe watershed in cold, clear gravel-based tributaries. They are a member of the Char family, which also includes arctic char, bull trout and lake trout. Brook trout characteristically have fairly specific coldwater life history requirements. As they are considered the proverbial “canary in the coal mine” indicator for local rivers and streams, the presence of brook trout in a local stream is an indicator of high quality water and habitat features. As a result, only the healthiest tributaries in the Lake Simcoe watershed can support brook trout.

Because of their need for the cold water habitat, typically created by spring stream bank seepage entering streams at the surface or groundwater upwelling through the streambed substrate, brook trout populations are closely linked to the geology of the watershed. They are commonly found in aquatic habitats with porous substrates, in the form of sands and gravels, and with the presence of groundwater that reaches the surficial soil layers.

Brook Trout (*Salvelinus fontinalis*)

Groundwater-based streams tend to be less variable both in flow and temperature. Because groundwater originates below ground surface, it is not subject to the extremes in heat and cold that a watercourse would be. Typically the temperature of groundwater is cooler in the summer and warmer in the winter than ambient surface stream temperatures. Groundwater adds to the volume of flow of the stream as baseflow, and contributes to a significant moderating thermal influence on the system.

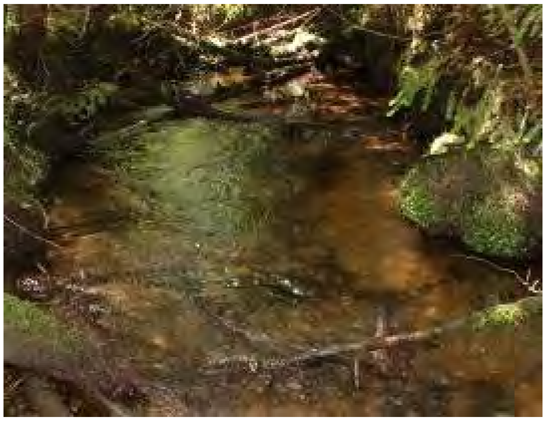
Brook trout grow and survive best in stream temperatures between 13°C and 18°C, although they are known to tolerate temperatures up to 23°C for short durations. This species is sensitive to small increases in stream temperature and the resulting lower dissolved oxygen levels,

Brook trout spawning over groundwater upwelling site

changes in pH, and decreases in water quality. These changes are most often related to changes in land use through land development or intensive agricultural practices, which can include: cutting of stream bank vegetation, excess sedimentation, and the interception of close-to-surface groundwater, all of which contribute to cumulative change in tributaries. On-stream dams or barriers are another significant factor impacting brook trout, as they warm downstream temperatures, act as a silt trap for sediment moving downstream, and prevent movement of fish to colder upstream reaches. The decrease in water quality also tends to create a more suitable habitat for non-native fish species (such as brown trout and rainbow trout) that may out-compete the native brook trout for resources.

Successful brook trout reproduction has specific physical requirements. Between October and December, mature brook trout seek out areas of upwelling groundwater in the streambed to spawn. These sites may be distributed evenly throughout a tributary or there may be very limited locations where upwelling can be detected. While they prefer to spawn over a gravel/sand substrate, the size of the substrate is of less importance than the presence of upwelling activity. Eggs deposited in a ‘nest’ (commonly known as a redd) are flushed by constantly moving interstitial groundwater which is stable in temperature and normally slightly warmer than ambient stream temperature during the winter months. This condition allows the eggs to develop more quickly, resulting in the emergence of larval brook trout in late March. Compared to other resident fish species and to the non-resident trout species, this is very early in the season and provides the young brook trout with a competitive advantage in terms of food availability and time to grow and mature.

Despite their sensitivity to change, brook trout and their habitat respond well to stream rehabilitation. Efforts are focused primarily on reducing thermal and sediment impacts and improving in-water habitat. Typical techniques like adding instream structures, such as bank stabilizers, deflectors, cedar sweepers, overhead cover, half logs, and strategic rock and gravel placement, are used. In addition, planting stream banks with appropriate native vegetation, restricting livestock access with fencing, and protecting spring seeps adjacent to the channel are often undertaken as part of a stream rehabilitation plan. These methods are particularly effective where groundwater continues to provide baseflow and where other local biophysical features have not been impacted.

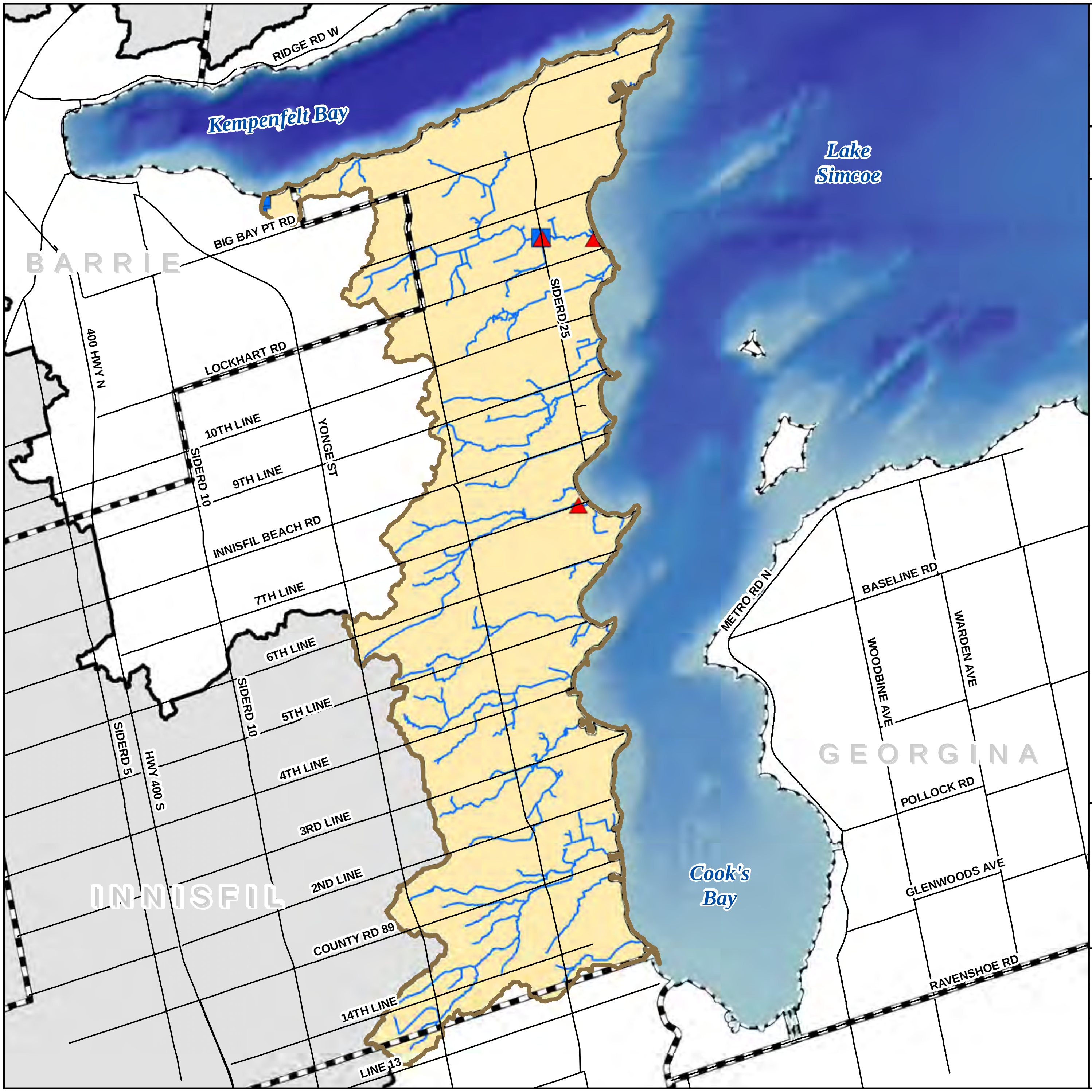


Typical tributary that supports brook trout

Today, it is important that we protect, restore and maintain current and historic brook trout habitat, as these are areas that are, or have the potential to be, high quality aquatic habitats, in terms of both water quality and habitat features. As such, additional efforts need to be undertaken to protect the tributaries of the Lake Simcoe watershed that support these native fish.

Historic and current presence of brook trout in the Innisfil Creeks subwatershed.

Figure 5-4



Legend

- Road
- Municipal Boundary
- Watercourse
- 🟦 Current Brook Trout
- ▲ Historic Brook Trout

Lake Simcoe Region conservation authority

0 0.5 1 2 3 4 5 Kilometres

N

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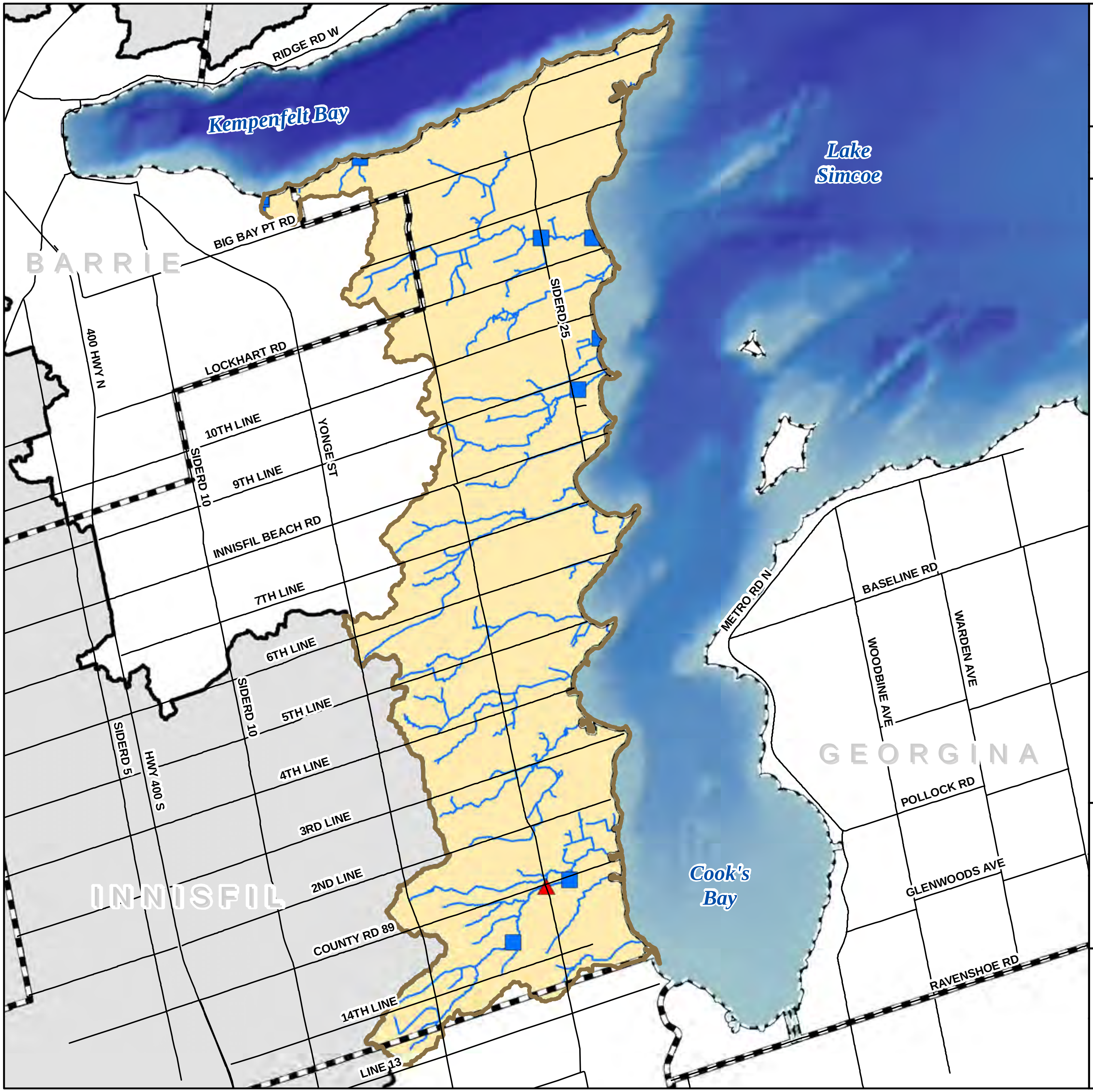

Historic and current presence of mottled sculpin in the Innisfil Creeks subwatershed

Figure 5-5

Legend

—	Road
▬ ▬	Municipal Boundary
～	Watercourse
🟦	Current Mottled Sculpin
▲	Historic Mottled Sculpin

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5.2.1.2 Benthic community

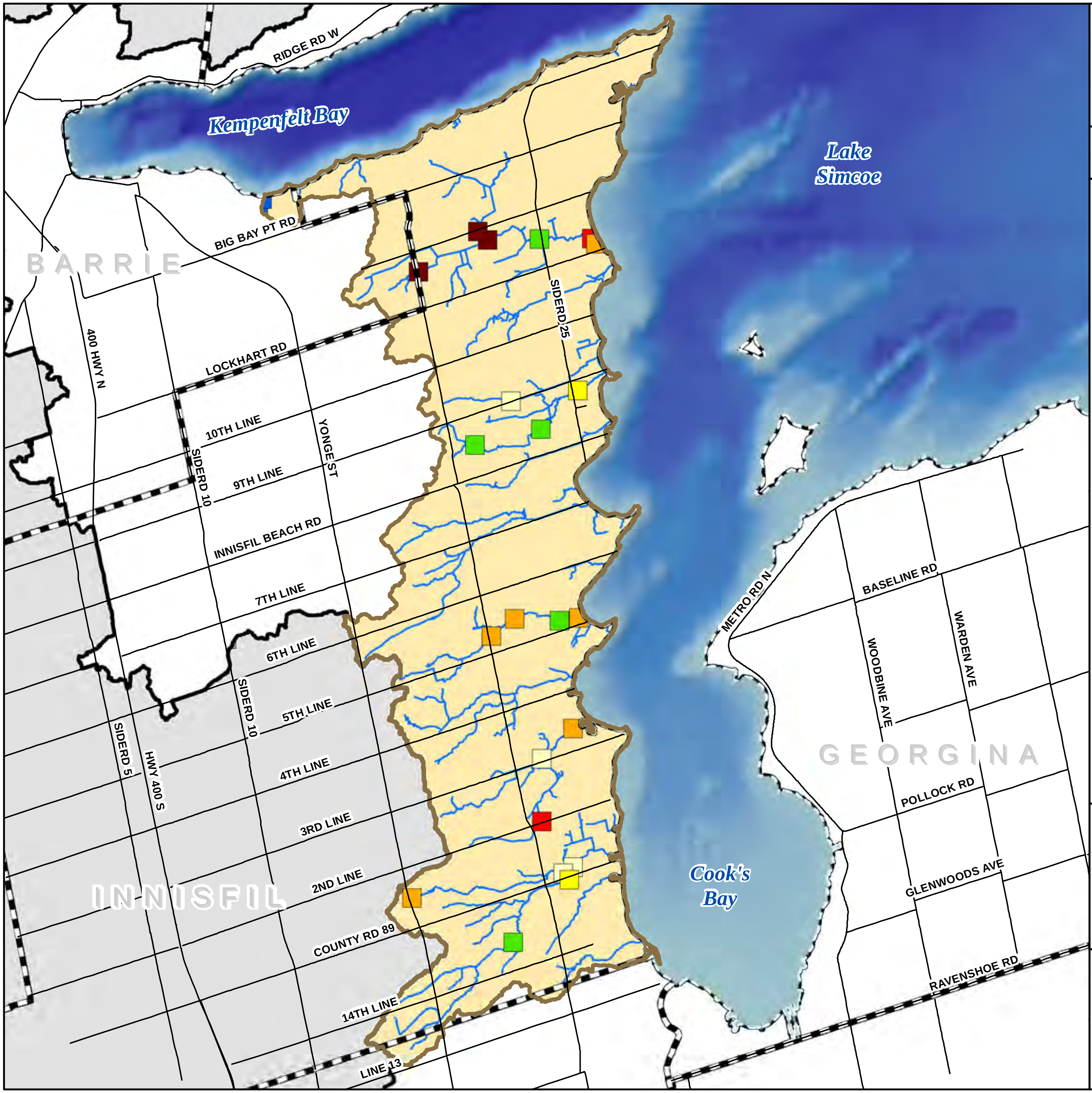
Aquatic insects, or benthic invertebrates, are an ideal indicator of water quality as different species have different tolerances to factors such as nutrient enrichment, dissolved solids, oxygen, and temperature. The presence or absence of certain species is used to determine water quality at a given site. Of the indices developed to assess water quality in relation to benthic invertebrate communities, the Hilsenhoff Biotic Index was selected as it provides a full spectrum of the different levels of organic pollution within a watercourse, which enables watershed managers to document declining watershed conditions by comparing years of data; whereas other indices (such as BioMAP) only provide an ‘impaired’ or ‘unimpaired’ rating.

Benthic invertebrates have been collected from these subwatersheds since 2004 employing a consistent and standard collection method (Jones *et al*., 2004). Figure 5-6 is an assessment of the ecological integrity of the creeks through the composition of the benthic invertebrate communities within the system. This composition is dependent on the quality of the water and the degree of organic pollution. With this method there are seven rankings that can be assigned to a site:

- Excellent: No apparent organic pollution
- Very good: Slight organic pollution
- Good: Some organic pollution
- Fair: Fairly significant organic pollution
- Fairly poor: Significant organic pollution
- Poor: Very significant organic pollution
- Very poor: Severe organic pollution

Figure 5-6 shows that the ecological integrity of the watercourses, based on benthic analysis, varies from good to fairly poor across the Innisfil Creeks subwatershed. Only Sandy Cove Creek has an instance of having poor ecological integrity at a site.

When using both fish and benthic indices to evaluate the ecological integrity of a system, it is likely that there will be some discrepancies between the data. For example, there may be a poor rating of a site by the IBI and a good rating by the Hilsenhoff index. A possible explanation may be that while warm temperatures can limit the number of cold water indicator fish species at a site (resulting in a lower IBI score), some highly sensitive insects are not affected by temperature. There may also be the opposite scenario where IBI gives a good rating and Hilsenhoff a poor rating. This could possibly by explained by the fact that fish are more mobile than benthic invertebrates. In times where habitat conditions have deteriorated (low oxygen, low water levels, high temperatures, or poor water quality), benthic invertebrates are unable to move as quickly into better conditions and whole populations can be wiped out. If this occurs, benthic communities will likely not return the following year, whereas fish will if habitat conditions have improved. The last scenario is at sites where no fish have been caught. Conditions at a site could include low flow, high gradient, or have barriers to fish passage. While these conditions are not favourable to fish, benthic invertebrates can still have healthy populations at these sites, which will be reflected in a higher Hilsenhoff rating.



Ecological integrity of stream sites based on benthic community conditions assessed using the Hilsenhoff Index of Biotic Intergrity (HBI)

Figure 5-5

Legend

Hilsenhof Biotic Index

- 🟦 Excellent
- 🟩 Very Good
- 🟨 Good
- ⬜ Fair
- 🟧 Fairly Poor
- 🟥 Poor
- 🟫 Very Poor
- — Road
- — Municipal Boundary
- 〜 Watercourse

Lake Simcoe Region Conservation Authority

0 0.5 1 2 3 4 5 Kilometres

N

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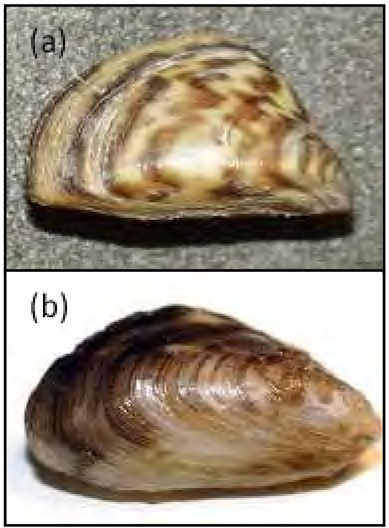
5.2.2 Overview of aquatic communities – Lake Nearshore

In addition to assessing the tributaries within the subwatershed, the nearshore lake communities were also analyzed, as the nearshore zones are critical areas that are linked to both the terrestrial riparian area and to the tributaries and the aquatic communities within them. The nearshore zone for Lake Simcoe is from the shoreline to when the depth reaches 15-20m. This is an important fish feeding, migration, and nursery area; and is also an area that has undergone significant environmental change, including the introduction of a number of invasive species (including zebra and quagga mussels, plants, and zooplankton), changes in the aquatic plant communities, and the impacts of shoreline development and hardening. Part of the mandate of the LSRCA Lake Science Research and Monitoring Program is to assess the environmental status of Lake Simcoe and track any ecological changes; the collected data is being used to set public policy, advise lake managers, and verify environmental guidelines. Included in this mandate are three areas of interest: aquatic plants, sediment phosphorus, and invasive species.

In May 2008, LSRCA carried out a survey of aquatic plants across Lake Simcoe to set a baseline for future change. While previous studies focused on Cook's Bay, an area of high plant biomass, this new study identified four other areas of high biomass. In the Innisfil subwatershed, high plant biomass has been recorded in southern Cook's Bay, and along the southern shore of Kempenfelt Bay (Figure 5-7a). While sandy substrates along the shore from northern Cook's Bay to Big Bay Point do not currently support a high plant biomass, the plant community in this area has been impacted by invasion by eurasian watermilfoil (*Myriophyllum spicatum*), but still contains a relict population of rare waterweed (*Elodea nuttallii*). Routine monitoring is required to detect future ecological changes and present baseline data for environmental management plans.

The second component being analyzed is the amount of phosphorus contained in lake sediments, which was poorly understood prior to the initiation of the LSRCA Lake Science Research and Monitoring Program. Monitoring of sediment phosphorus is undertaken because of the potential for phosphorus release under low dissolved oxygen concentrations in the water (less than 2 mg/L) and this is, thus far, an undetermined source of phosphorus loading. Along the Innisfil shoreline, concentrations vary from total phosphorus (TP) ~1.1 mg/g in Kempenfelt Bay, ~0.87 mg/g south of Big Bay Point to northern Cook's Bay, ~0.85 mg/g in northern Cook's Bay, and ~0.35 mg/g in southern Cook's Bay (Figure 5-7c). These values differ due to substrate type with mud in Kempenfelt Bay holding a higher concentration of phosphorus than the sandy substrates along Lake Simcoe's western shore. In southern Cook's Bay, very low concentrations are due to uptake by aquatic plants, which acquire up to 97% of their nutrient requirements from sediments. Across the lake concentrations range from TP ~0.35 mg/g in Cook's Bay to ~1.40 mg/g near Beaverton (for details on the total phosphorus within the tributaries please refer to **Chapter 3 - Water Quality**)



Two invasive mussel species in Lake Simcoe: (a) zebra mussel; (b) quagga mussel.

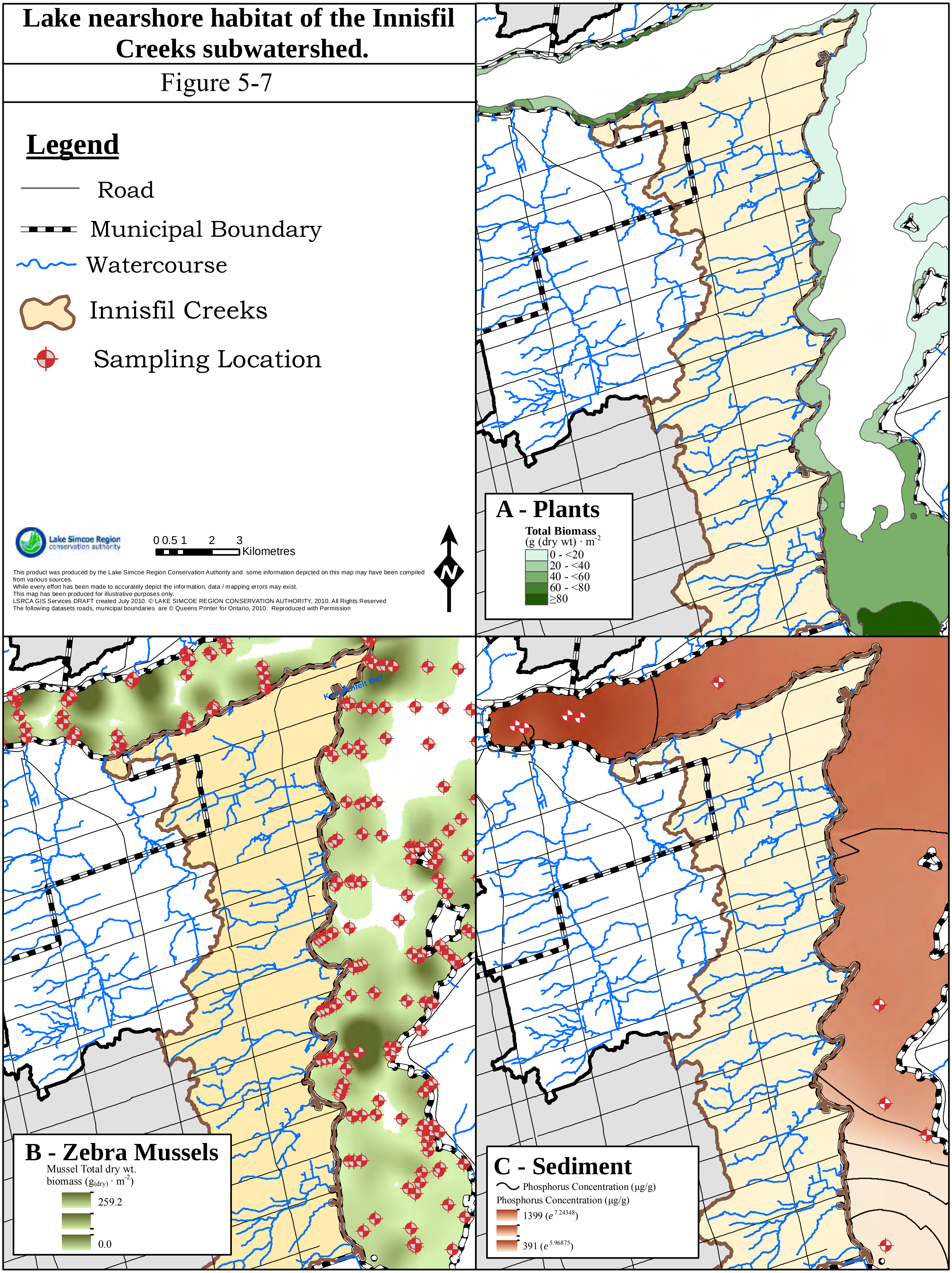
The last component of the LSRCA Lake Science Research and Monitoring Program is monitoring invasive species with the goals of assessing the impact on native biological communities, tracking changes through time, and identifying new risks (a complete list of invasive species within the tributaries and within Lake Simcoe can be found in the Stressors section of this chapter). While some exotic species are studied under other projects (e.g. eurasian milfoil (*Myriophyllum spicatum*) and curly-leaf pondweed (*Potomogeton crispus)* with aquatic plant monitoring, spiny waterflea (*Bythotrephes longimanus*) with our zooplankton projects), a targeted survey was carried out in 2009-10 to supplement the annual benthic invertebrate monitoring and determine the extent of dreissenid mussel (zebra mussel, *Dreissenia polymorpha*; quagga mussel, *Dreissenia rostriformis bugensis*) impact on Lake Simcoe. Since their initial invasions in 1995 (zebra mussel) and 2004 (quagga mussel), these two species have colonized a large portion of the lake area and have caused significant ecological changes, in particular to native food webs, shifted energy flow from shallow to deep water, and increased the penetration of sunlight into the water column. The changes have resulted in a hardening of substrate in shallow water due to mussel shells, a decline in native bivalve species (16 species were recorded in 1926-9, four species are recorded at present – the two invasive mussels and extremely low numbers of two native species which are on the threshold of extirpation in Lake Simcoe), an increase in plant biomass due to deeper light penetration into the water column and a larger area now available for plant colonization. In general, these mussels are limited to sandy or hard substrates in Lake Simcoe, and limited to depths shallower than 20 m. While this trend is followed for most of the Innisfil shoreline (i.e. southern Cook's Bay north to Big Bay Point), Kempenfelt Bay is an interesting exception where living dreissenids have been recorded growing in clumps on softer substrates (i.e. mud and silt) to a maximum depth of 31 m (Figure 5-7b). Further studies are being undertaken to determine a reason for this exception.

Overall, the goal of the LSRCA Lake Science Research and Monitoring Program is to monitor for environmental changes in Lake Simcoe, fill existing data gaps, target emerging environmental issues, and understand linkages between current ecological stressors. In terms of the aspects highlighted within this section, the use of biological indicators highlights a holistic ecosystem approach to lake management. This approach, using diatoms as a rapid assessment tool, evaluates the nutrient runoff to Lake Simcoe from individual tributaries and allows management strategies to be specifically applied. Monitoring of benthic invertebrate and fish communities not only allows the evaluation of ecosystem health in these habitats, but also their development as biological indicators for oxygen levels, contaminants, and nutrients. Nutrient flux from the land to the tributaries to Lake Simcoe is reflected in both the plant biomass and sediment phosphorus levels (higher nutrient supply from tributaries equals more phosphorus in sediments and more plant biomass). In addition, the work with zebra and quagga mussels not only provides monitoring of these invasive species but suggests how they are impacting Lake Simcoe (high amounts of zebra mussels equals high filtering of particles from the water column, allowing greater light penetration and in turn more plant biomass and more offshore nutrients pulled to shallow water habitats).

In terms of rating the condition of the nearshore habitats, based on the three components above, the shoreline along the Town of Innisfil is considered to be in fair condition.

Lake nearshore habitat of the Innisfil Creeks subwatershed.

Figure 5-7



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5.2.3 Rare and endangered species

There are no known aquatic Species at Risk within the Innisfil Creeks subwatershed.

The nearshore habitat from northern Cook's Bay to Big Bay Point, while currently not supporting a high plant biomass due to sandy substrates along its shores, contains a relict population of rare waterweed (*Elodea nuttallii*).

Key Points - Current Aquatic Natural Heritage Status:

- The Innisfil Creeks subwatershed is a diverse area and has 15 main tributaries and two main drains spread throughout the subwatershed. The condition of the creeks varies, with most having fair to poor ecological integrity based on fish and benthic invertebrates, where data is available. Both Strathallan and White Birch Creek have generally good conditions, while Cedar Creek has the poorest conditions.
- While Figure 5-2 shows the general shifts in fish community composition within a system – from sites with cold water species to the next sites with only warm water (generalist) species, currently sufficient data is not available to pinpoint when shifts take place and what caused them to do so.
- Only Sandy Cove and Banks Creeks have historical presence of brook trout (key indicator species), with Sandy Cove Creek being the only creek with current brook trout populations. While no specific studies have been done on the spawning of species for these subwatersheds, there is evidence that brook trout may be successfully spawning and surviving in Sandy Cove Creek. As Banks Creek does not currently have a monitoring station on it, it is unknown whether this population continues to exist today. White Birch Creek though has historical populations of mottled sculpin, as well as current populations. Sandy Cove Creek, Burts Drain, and Leonard's Creek all have current populations as well.
- The condition of the benthic communities varies from good to fairly poor across the Innisfil Creeks subwatershed. Only Sandy Cove Creek has a site rated as poor, indicating very significant organic pollution at that location.
- Of the 15 creeks, six do not have monitoring stations. Additionally, many of the creeks are missing benthic invertebrate data or have sections of the creek that were not covered. The addition of this data may provide further in-depth look at the conditions
- The lake nearshore community around the Town of Innisfil shoreline is in relatively fair condition based on having only moderate plant biomass from northern Cook's Bay to Big Bay Point, moderate sediment nutrient concentrations, and invasive mussel species being limited to depths shallower than 20 m.

5.3 Factors impacting status - stressors

There are a number of land uses, activities and other factors that can have an effect on the health of the aquatic community in the subwatershed. These include:

- Municipal drains,
- Removal of riparian vegetation,
- Water quality and thermal degradation,
- Barriers,
- Bank hardening and channelization,
- Enclosures,
- Uncontrolled stormwater and impervious surfaces,
- Loss of wetlands,
- Invasive species, and
- Climate change.

These factors are discussed in detail below:

5.3.1 Municipal drains

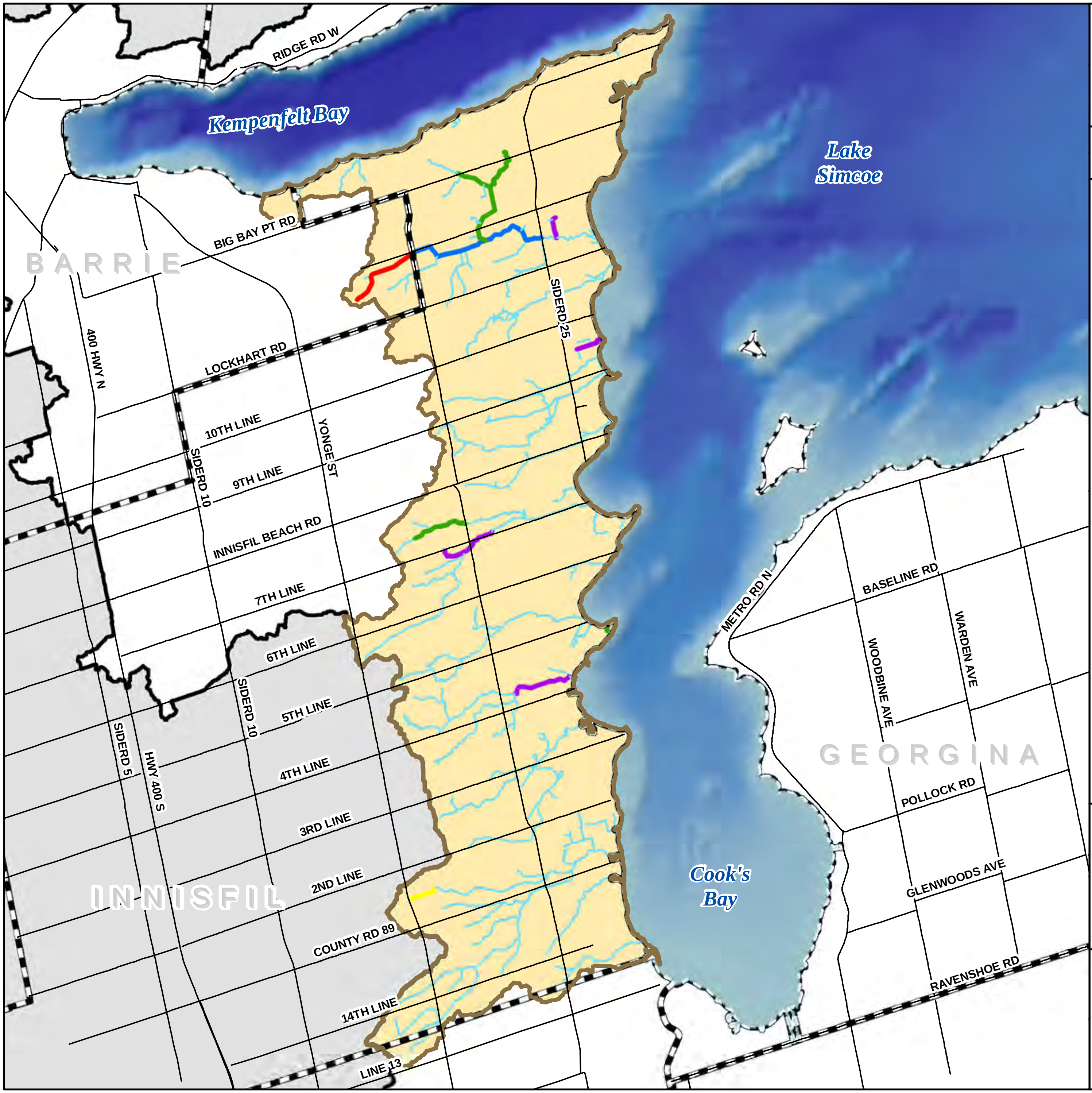
Municipal drains are generally located in rural agricultural areas and are intended to improve the drainage of the surrounding land. Typically they are ditches or closed systems (buried pipes or tiles) and can include structures such as buffer strips, grassed water ways, dykes, berms, stormwater detention ponds, bridges, culverts, and pumping stations. Nowadays, a number of creeks and small rivers have been designated as municipal drains (OMAFRA, 2001).

As these are direct links to watercourses, there are a number of impacts on the aquatic communities. The inputs into the drain consist of both overland flow and tile outlets and can carry contaminants, sediment, and debris into the drain. With little to no riparian vegetation, water temperature is increased and the drain therefore becomes a source of warm water in the watercourse system. Additionally, these drains come to be used as fish habitat. The issue with this is that municipal drains require maintenance to ensure they continue to work properly. While maintenance work is in progress, fish migration can be blocked and water quality can decline. The work itself may either negatively change or destroy fish habitat through altering or removal of the little riparian vegetation present, disrupting and changing bottom substrate composition and altering the width-to-depth ratio.

The construction and maintenance of municipal drains is regulated under the *Ontario Drainage Act,* while the protection of fish habitat is regulated under the federal *Fisheries Act*. To ensure that drains are properly maintained, while fish habitat is minimally impacted, the Department of Fisheries and Oceans (DFO) developed a Class Authorization System. Drains are classified into six types (A, B, C, D, E and F) based on the sensitivity of fish and fish habitat found in the drain and the type of work completed. Types A, B and C are considered to contain fish and fish habitat more resilient to drain maintenance, while Types D and E have fish and habitat that are less resilient and maintenance work is determined on a case by case basis. Type F drains are intermittent and are usually dry for at least two consecutive months in the year. As fish habitat is not an issue here when dry, the only conditions for the maintenance work are that it be completed when dry and that soil is stabilized upon completion of work.

Figure 5-8 illustrates the municipal drains in the Innisfil Creeks subwatershed, based on the drain type classification. This map shows five of the creeks have sections that are designated municipal drains. Forty two percent of Sandy Cove Creek, in the northern part of the subwatershed, is municipal drain. From Sideroad 25 to Sideroad 20 the main branch has been designated as Type D drain, while west of Sideroad 20 it is Type E. In both cases the creek contains sensitive aquatic communities. The main northern branch though, is dry for more than two consecutive months and is therefore classified as a Type F municipal drain. There is also a small northern branch near the mouth that is designated as a Type A drain, where there are no sensitive species or communities.

The other creeks include Burts Drain with 51% designated as Type A municipal drain, Banks Creek with a combined 19% designated as Type A (southern headwater branch) and Type F (northern headwater branch), Carson Creek 12% Type A, and lastly White Birch has 2% of its watercourse designated as Type C municipal drain.



Municipal drains in the Innisfil Creeks subwatershed

Figure 5-8

Legend

- Road
- Municipal Boundary
- Watercourse

Drain Class

- A
- B
- C
- D
- E
- F

Innisfil Creeks Subwatershed

Lake Simcoe Region conservation authority

0 0.5 1 2 3 4 5 Kilometres

N

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5.3.2 Loss of riparian vegetation

While many policies now afford some protection to the riparian areas adjacent to the watercourses, this has not always been the case. In many instances, vegetation in the riparian areas of the subwatershed's watercourses has been removed to accommodate urban development and agricultural activities, leaving the bank vulnerable to erosion due to the removal of the stabilizing influence of the roots of the vegetation. This can result in inputs of sediment into the watercourse, which can settle and smother the substrate, thus eliminating important habitat used by fish for spawning and inhabited by benthic invertebrates. Sediment in suspension in the water can also interfere with the feeding of those fish species that are visual feeders.

Riparian vegetation is also an important source of allochthonous material such as leaves and branches that serve as a food source for benthic invertebrates, and can also provide cover for fish.

In addition, riparian vegetation serves to enhance water quality – it filters the water flowing overland, causing sediment and other contaminants to settle out or be taken up prior to reaching the watercourses; and also helps to moderate water temperatures through the shade it provides. Removal of this vegetation can have an influence on the type of aquatic community able to inhabit the watercourse – a reach that may have been able to support a healthy coldwater community may no longer be able to do so, and the community may shift to cool or warm water community containing less sensitive species.

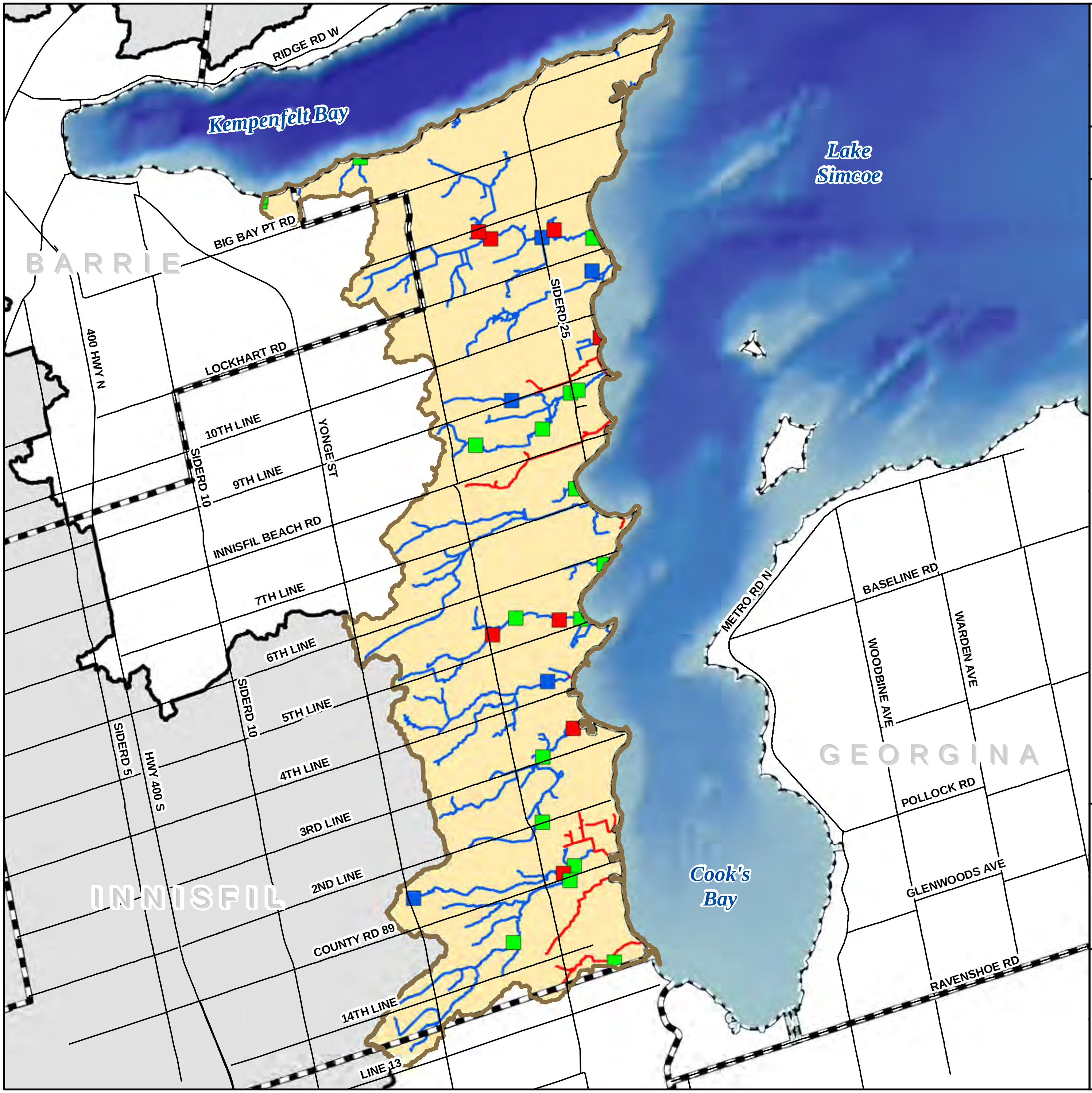
5.3.3 Water quality and thermal degradation

Inputs of contaminants, including high levels of chloride and suspended sediment, to watercourses can be harmful to many species of fish and benthic invertebrates, particularly the more sensitive species. It can force them to leave their habitats, inhibit their growth, or cause die-offs if concentrations of a contaminant get too high.

Specific information on water quality issues pertaining to the Innisfil Creeks subwatershed can be found in **Chapter 3 - Water Quality**.

Thermal degradation of a system can be caused by a number of factors. The first is the removal of riparian vegetation and the shade that it creates. If large portions of a watercourse are shaded, these areas may be key in maintaining cold or cool water temperatures or may be refuges for cool or cold water aquatic species during the hot summer temperatures. Runoff can also cause thermal degradation in a system. As impervious surfaces (such as pavement) heat up from the sun they easily warm any water running over them, creating a warm water source as the water drains into a watercourse, possibly rendering the surrounding waters uninhabitable for coldwater species. Lastly, the detention of water in a pond creates a source of warm water into a system as it increases the surface area of the water that is exposed to sunlight, and keeps it there for a prolonged period of time, leading to warming. Although online ponds are the greatest concern due to their direct impact on the watercourse, offline ponds (including stormwater ponds and detention ponds for irrigation) that discharge to watercourses are also a concern.

Figure 5-9 illustrates the OMNR approved temperature designation of the creeks (and the temperature at which they are managed at based on timing restrictions for in-water works) with current temperature ratings. Where the current ratings differ from OMNR designations (i.e. cool or warm water readings on cold water system) it indicates that the creek is experiencing thermal degradation.



Thermal degradation in the Innisfil Creeks subwatershed.

Figure 5-9

Legend

Road

Municipal Boundary

Timing Restrictions

October 1 to June 1

March 1 to June 30

April 1 to June 30

Current Temperature

🟦 Cold

🟩 Cool

🟥 Warm

Lake Simcoe Region
conservation authority

0 0.5 1 2 3 4 5 Kilometres

N

5.3.4 Barriers

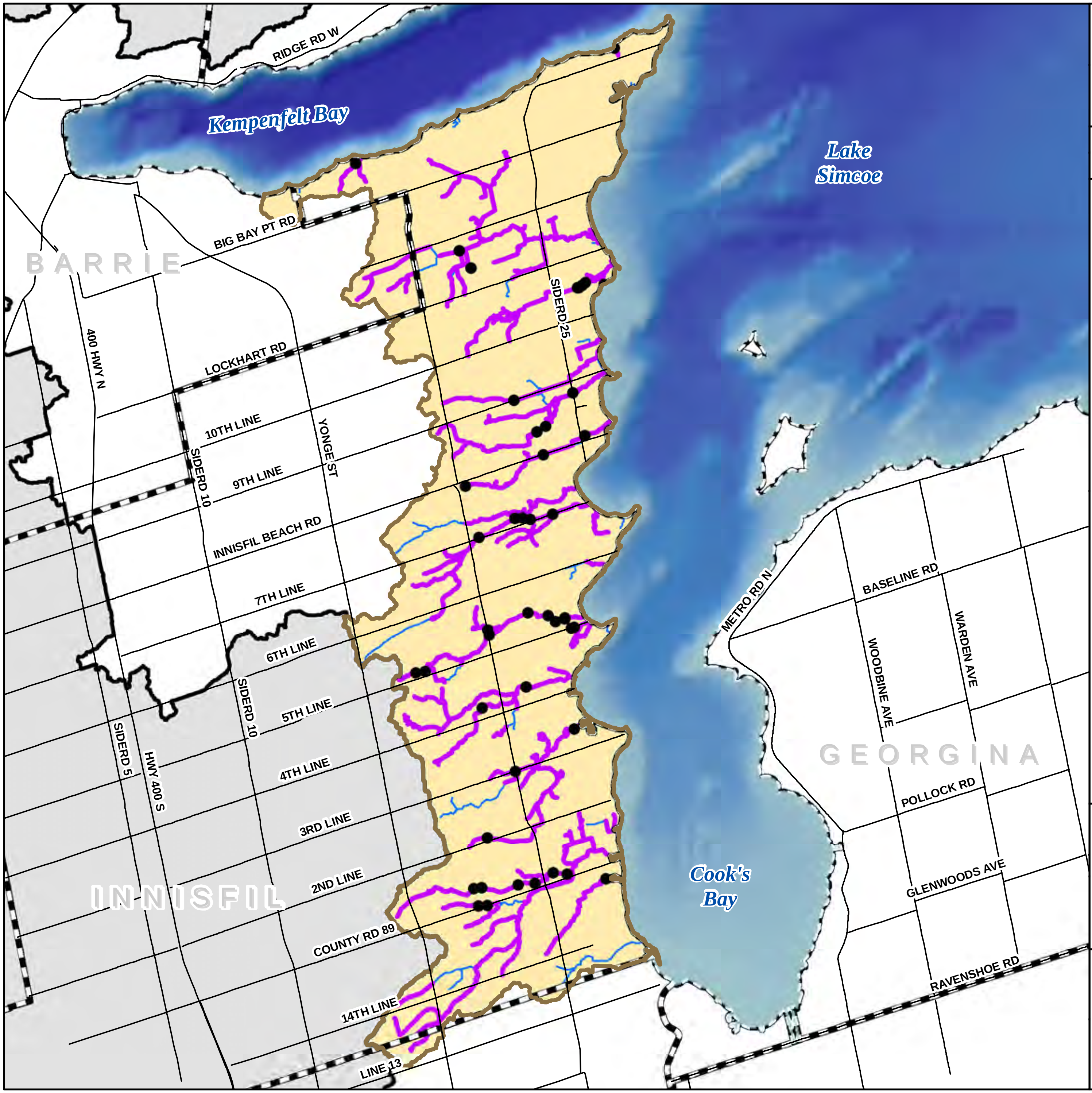
Barriers to fish movement in the form of dams, perched culverts, and enclosed watercourses serve to fragment a fishery by preventing fish from accessing important parts of their habitat. The impoundments created by dams serve to increase water temperatures, raise bacteria levels, and disrupt the natural movement of fish, benthic invertebrates, sediment, and nutrients. The natural movement of each is imperative for a healthy aquatic system.

The Lake Simcoe Basin Best Management Practice Inventory (LSRCA, 2009) looked at barriers to fish movement, which included dams, perched culverts, weirs, and other barriers, and sections of the bank that have been hardened or channelized. The BMP inventory covered 88%, of the watercourses in the Innisfil Creeks subwatershed.

A total of 69 barriers to fish movement have been identified in the Innisfil Creeks subwatershed thus far (Figure 5-10).

Barriers to fish movement in the Innisfil Creeks subwatershed.

Figure 5-10



Legend

● Barrier
— Road
▬ Municipal Boundary
〰 BMP Watercourse Surveyed
〰 Watercourse

Lake Simcoe Region
conservation authority

0 0.5 1 2 3 4 5
Kilometres

N

This product was produced by the Lake Simcoe Region Conservation Authority and some information depicted on this map may have been compiled from various sources. While every effort has been made to accurately depict the information, data / mapping errors may exist.
This map has been produced for illustrative purposes only.
LSRCA GIS Services DRAFT created July 2010.

5.3.5 Bank hardening and channelization

In the past it has been common practice to straighten watercourses to accommodate various land uses, and to harden banks as a way to prevent stream bank erosion and increase 'developable' area. While we now know that these practices are harmful to the environment and can cause more issues that they resolve, there are several areas in the subwatersheds where these practices have been utilized.

Water generally flows more quickly through a channelized section of stream, particularly during high flow events. This increase in flow can have several effects:

- Unstable banks in the channelized section (if they are not hardened)
- Flooding downstream of the channelized section (water is confined to the channel, which results in larger volumes of water flowing more rapidly than under natural conditions being conveyed to downstream sections)
- Changes to the migration patterns of fish (and wildlife)
- Bank erosion downstream of the channelized section
- Sediment deprivation in channelized sections
- Sedimentation downstream of the channelized sections where the flow of water slows

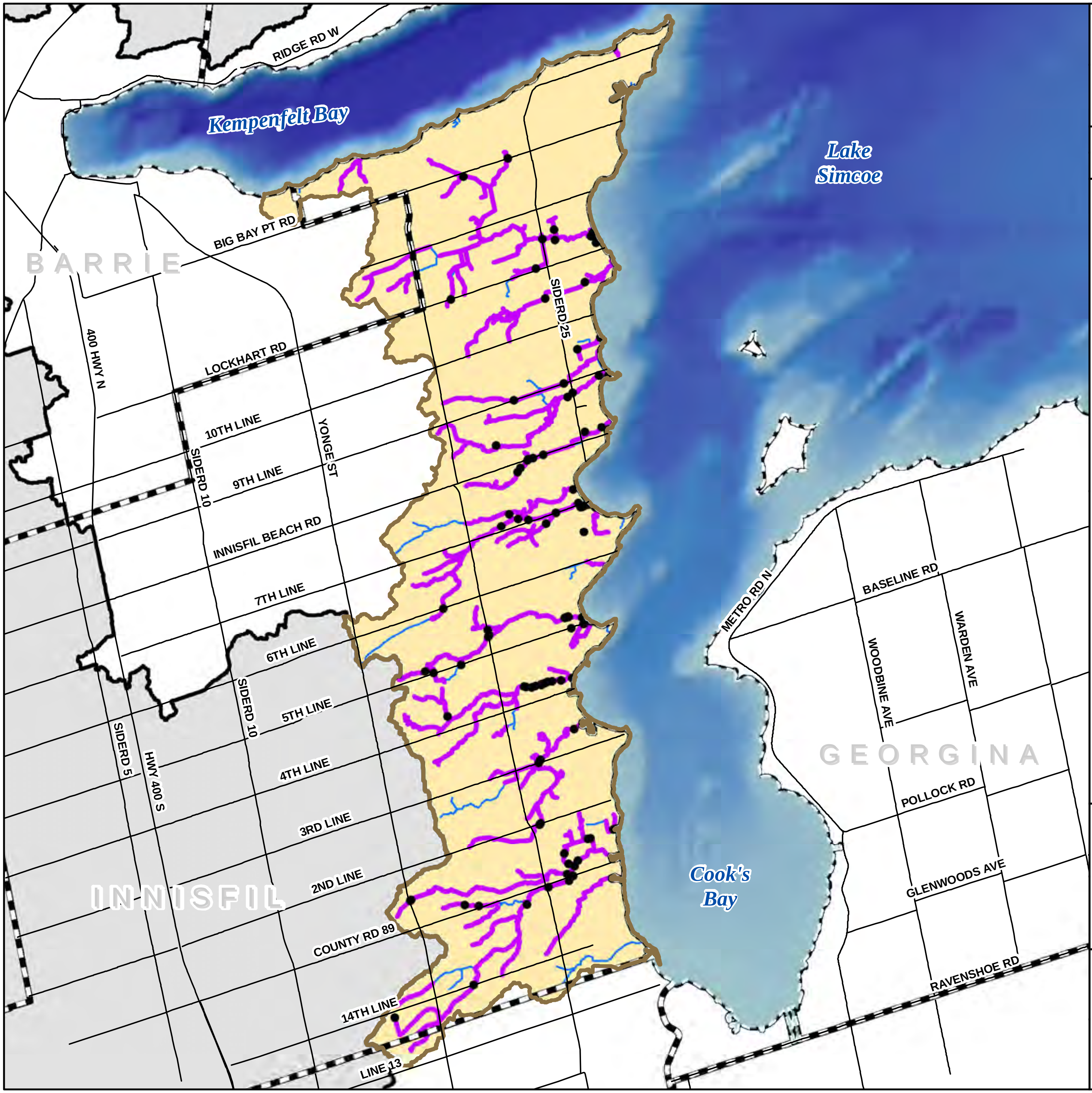
These effects result in the degradation of aquatic habitat. The riffle/pool sequences that occur in natural channels are lost in the channelized section as well as downstream. Much of the natural cover in the watercourse can be lost. Fluctuating flow levels can place stress on the aquatic biota, and in many cases can cause a shift from a more sensitive community to one that is better able to tolerate adverse conditions. Finally, the deposition of sediment as the water slows coming out of the channelized section can blanket the substrate, interfering with spawning activities and affecting the benthic invertebrate community.

There were 183 instances of bank hardening and channelization along sections of stream identified in the Innisfil Creeks subwatersheds through the BMP Inventory; these are depicted in Figure 5-11. Most sites in Innisfil Creeks were located along the main branches and closer to the mouth, though there are a number of sites in the headwaters of most of the creeks.

Of the number of sites identified to have bank hardening (106), 40 were failing. These failing sites should therefore be priorities for restoration activities, though the remaining sites are likely still having habitat impacts and should also be explored as resources allow. As this inventory was completed for the majority of the watercourses (88%) within the Innisfil Creeks subwatershed, the total number of river sections that have been channelized is relatively accurate, but could increase with the study of the sections of the watercourses that were not covered in the first phases of the inventory.

5.3.6 Enclosures

Past development practices allowed for the enclosure or piping of creeks. These enclosures not only create barriers for fish migration and fragment the fish and wildlife populations but also threaten the public through the potential for flooding. While the enclosure of watercourses in the Innisfil Creeks subwatershed is not as prevalent as in the Barrie Creeks subwatershed (located at the west end of Kempenfelt Bay), there are a few instances of it, including a significant portion of Bon Secours Creek and Sylvan Creek.



Bank hardening and /or channelization in the Innisfil Creeks subwateshed.

Figure 5-11

Legend

— Road

▬ Municipal Boundary

〰 Watercourse

● Bank Hardening and or Channelization

〰 BMP Watercourse Surveyed

Lake Simcoe Region conservation authority

0 0.5 1 2 3 4 5 Kilometres

N

LSRCA GIS Services DRAFT created July 2010.

5.3.7 Uncontrolled stormwater and impervious surfaces

Urban stormwater runoff occurs as rain or melting snow washes off streets, parking lots and rooftops of dirt and debris, minor spills, and landscaping chemicals and fertilizers. In the past it was common practice to route stormwater directly to streams, rivers, or lakes in the most efficient manner possible. This practice typically has negative impacts on the receiving watercourse. Over the last two decades these practices have changed and efforts are made to intercept and treat stormwater prior to its entering watercourses or water bodies. However, in many older urban areas stormwater typically still reaches watercourses untreated

As the amount of impervious area increases, the natural water balance is disrupted. Evapotranspiration is decreased as there is little vegetation and the permeable soil surface is paved over; infiltration to groundwater is significantly reduced; and thus the runoff characteristics change. This results in increases in the frequency and magnitude of runoff events, a decrease in baseflow, and an increase in flow velocities and energy (further changes to the hydrologic regime are discussed in greater detail in **Chapter 4 - Water Quantity**). These changes further affect the form of the morphology of the stream, including channel widening, under cutting, sedimentation, and channel braiding.

One of the most significant impacts of stormwater runoff though, is to water quality. Problems with degraded water quality directly affect the aquatic ecosystem. This occurs as pollutants are washed off of streets, parking lots, rooftops and roadways into storm drains or ditches which discharge to watercourses and lakes. Generally, concentrations of pollutants such as bacteria (e.g. *Escherichia coli*, faecal coliform, *Pseudomonas aeruginosa,* and faecal streptococci), nutrients (e.g. phosphorus, nitrogen), phenolics, metals, and organic compounds are higher in urban stormwater runoff than the acceptable limits established in the PWQO (MOE, 1994). Other associated impacts include increased water temperature and the collection of trash and debris.

All of these changes can cause considerable stress to aquatic biota, and can cause a shift from a community containing more sensitive species to one containing species more tolerant of degraded conditions (Figure 5-12).

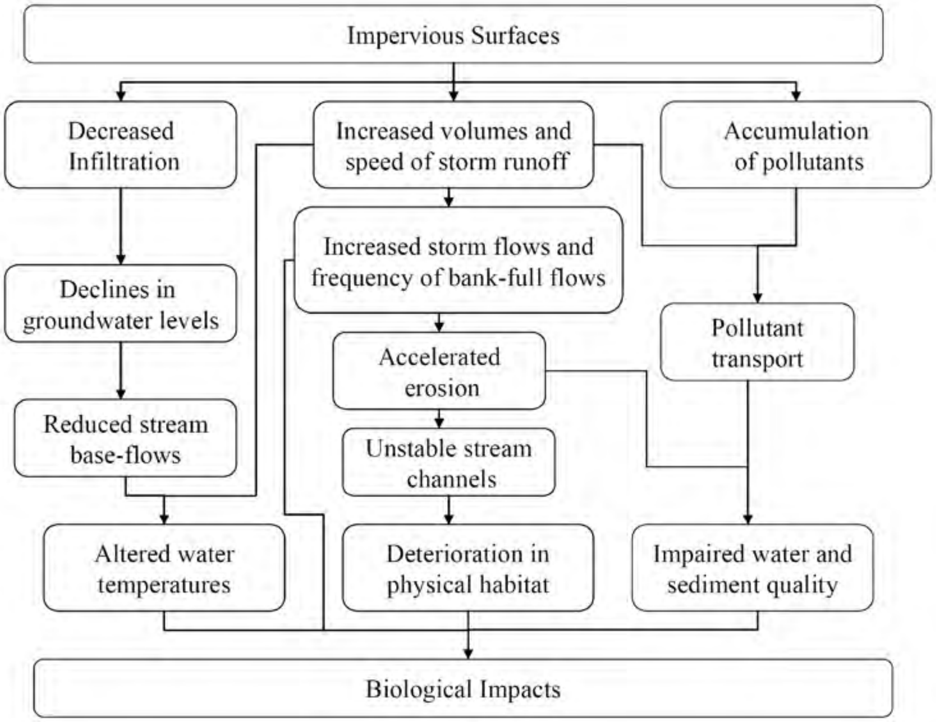


Figure 5-12: Pathways by which impervious surfaces may impact aquatic biological communities (ORMCP Technical Paper Series, #13).

5.3.8 Loss of wetlands

While the current status and stressors to wetlands are covered in more detail in **Chapter 6 - Terrestrial Natural Heritage**, it is important to highlight the significant relationship they have with nearby aquatic systems. Wetlands are important to the aquatic natural heritage system as they store water and reduce flooding, prevent erosion along banks and are a source of groundwater recharge and discharge. They also improve the quality of water that filters through them into the creeks by removing sediments, pathogens, nutrients, and pesticides.

5.3.9 Invasive species

The traits possessed by non-native invasive species, including aggressive feeding, rapid growth, prolific reproduction, and the ability to tolerate and adapt to a wide range of habitat conditions enable them to outcompete native species for food, water, sunlight, nutrients, and space. This may result in the eventual reduction in the number and abundance of native species. The replacement of native species with introduced affects the balance of the ecosystem, as species that relied on the native species for food, shelter and other functions now either have to move to another area with these species, or must utilize another source that is perhaps less desirable. This cycle reverberates throughout the ecosystem, and can be exacerbated by the introduction of additional invasive species. Ecosystems that are already under stress are particularly vulnerable to invasion by non-native species, as the existing ecosystem is not robust enough to maintain viable populations of native species as the invasive species become established. The process may happen more quickly in already disturbed systems than it would in a healthy community.

There are no known invasive species within the Innisfil Creeks subwatershed. However, the round goby (*Neogobius melanostomus*), an invasive species native to Eurasia and transported to the Great Lakes in ballast water was recently transplanted from Lake Erie to Lake Simcoe, most probably via a baitfish transfer. The species has already been noted within the Pefferlaw River and its mouth in Lake Simcoe, the Black River and is anticipated to occupy the Maskinonge River subwatershed (three subwatersheds to the east of Innisfil Creeks) within a few years. Additionally, during the 2011 sampling season, round goby were found at the mouth of both Lovers and Hewitt's Creek (neighbouring subwatersheds to the west). Because of the aggressive and fertile characteristics of the round goby, as well as their recent introduction in neighbouring subwatersheds, it is thought to be likely this species will eventually reach the watercourses in the Innisfil Creeks subwatersheds.

In addition to the round goby, there are also a number of invasive species indentified in Lake Simcoe that can impact the nearshore environments and the tributaries. These include:

- Eurasian Watermilfoil (*Myriophyllum spicatum*),
- Curly-leaf Pondweed (*Potomogeton crispus*),
- Common Carp (*Cyprinus carpio*),
- Rainbow Smelt (*Osmerus mordax*),
- Spiny Waterflea (*Bythotrephes longimanus*),
- Rusty Crayfish (*Orconectes rusticus*),
- Zebra Mussel (*Dreissenian polymorpha*), and
- Quagga Mussel (*Dreissenian rostriformis begensis*).

The LSPP includes a number of polices (7.1-SA to 7.10SA) to prevent the introduction of invasive species into the Lake Simcoe watershed. Of most importance is Policy 7.4-SA that requires that a "watch list" be developed and that response plans for those species on the list be prepared. These response plans will detail the actions that should be taken if the species are detected within the watershed. The following organisms are on the aquatic watch list:

- Fanwort (*Cabomba caroliniana): A* submersed freshwater perennial plant that is extremely persistent and competitive. Under suitable environmental conditions, it can form dense stands, crowding out previously well-established plants.
- European water chestnut *(Trapa natans):* Native to Europe, Asia, and Africa *T. natans* is an invasive aquatic plant that can form dense mats of floating vegetation.
- Water soldier (*Stratiotes aloides):* An aquatic plant commonly sold in the aquarium and water garden industry. The plant is native to Europe and Central Asia, but has been identified in the Trent Severn Waterway near the hamlet of Trent River. Water soldier forms dense large masses of plants which crowd other aquatic plants.

Invasive plant species on aquatic 'watch list': (A) fanwort, (B) European water chestnut, and (C) water soldier. (Photo Credits: Ontario's Invading Species Program)

- Asian carps: The term “Asian carps” refers to four invasive species (bighead, silver, grass, and black carp) that were brought to North America in the 1960s and 70s. Since then they have migrated north through U.S. waterways toward the Great Lakes, replacing native species in their path.
- Viral hemorrhagic septicaemia: A deadly infectious fish disease caused by the viral hemorrhagic septicemia virus. The virus can be spread from fish to fish through water transfer, as well as through contaminated eggs and bait fish from infected waters.

5.3.10 Climate Change

Recent work from an MOE Vulnerability Report for Lake Simcoe watershed wetlands, streams and rivers (Chu, 2010) is suggesting that climate change over the next 90 years will increase stream temperatures 1.3°C above current conditions. This prediction essentially threatens most coldwater streams in the entire Lake Simcoe watershed. A model looked at the likelihood of the subwatersheds being able to retain cold water species in 2055 using maximum air temperatures and groundwater discharge potential (Table 5-2). Those with high groundwater discharge potential could provide thermal refuge for cold water species, despite increasing air temperatures. Long term monitoring will be needed to assess the impacts of climate change to aquatic communities, where the key shifts are taking place and how they might be mitigated.

Table 5-2: Likelihood of watersheds to retain cold water species in 2055 using maximum air temperature projections from the Canadian Global Model 2 A2 scenario and groundwater discharge potential (Source: Chu *et al*., 2008).

	Likelihood to retain cold-water species		
	Low	Mid	High
Maximum air temperature (°C)	>29.34	28.49 – 29.34	<28.49
Baseflow index value	<0.36	0.36-0.54	>0.54

The information suggests that systems like the Innisfil Creeks subwatershed which have medium groundwater potential discharge, as expressed as a base flow index in Table 5-3, might be able to offer thermal refuge for coldwater species, also suggesting that there may be enough resilience to be able to maintain the coldwater attributes of the various creeks within the subwatershed over time.

Table 5-3: Maximum air temperature and groundwater discharge potential characteristics of the subwatersheds that have cold-water stream fish species in the Lake Simcoe watershed. Base flow index values are measures of groundwater discharge potential, values close to 1 indicate high groundwater inflows.

Subwatershed	**Base flow index value**	**Maximum air temperature (°C)**		
		2011-2040	**2041-2070**	**2071-2100**
Innisfil Creeks	0.426	25.90	27.74	28.34

Studies like this highlight the importance of protecting and building more resilience through instream rehabilitation, barrier removal, stream bank planting, the use of natural channel design during channel reconstruction, water quality protection in both urban and rural settings, and wetland protection. However, perhaps the most important way to address the risks of climate change is through the protection and maintenance of the current groundwater recharge-discharge system that supports this subwatershed.

Key Points- Factors impacting Aquatic Habitat – stressors

- There are many stressors to the aquatic natural heritage systems in these subwatersheds, many of which result in a cumulative impact.
- As rural and agricultural land use surrounds the majority of the headwater area of the Innisfil Creeks subwatershed, and is also found along the length of many of its watercourses, the most significant stressors include municipal drains, removal of riparian vegetation, and water quality and thermal degradation.
- Physical changes such as barriers, bank hardening, and channelization also play a large role in determining the current state of the aquatic community in the systems.
- Habitat quality and quantity is also impacted by changes in flow regime resulting from land use changes, stream alterations, municipal drains, loss of nearby wetlands, uncontrolled stormwater, and an increase in impervious surface cover. Increased flow degrades habitat through processes such as bank erosion. Decreased flow can lead to a temporary or permanent reduction in the amount of aquatic habitat present. Poor water quality (indicated by poor benthic scores) and thermal degradation have also negatively impacted the aquatic communities.
- The emerging threat of climate change will interact with all of these threats, creating additive long-term stresses on the aquatic systems. Although research in this area is still emerging, initial predictions suggest the Innisfil Creeks subwatershed may be able to maintain cold water attributes.

5.4 Assessment of Tributaries

5.4.1 Innisfil Creeks subwatershed

As the Innisfil Creeks subwatershed is a diverse area and there are 15 small tributaries (and a number of even smaller creeks, two of which have monitoring stations on them) spread along the subwatershed, they are analyzed individually, where data is available, to give a closer look at the conditions across the subwatershed. Nine of the tributaries and two small creeks (Burts Drain and McLean Creek) are individually assessed based on the aforementioned analyses, as well as incorporating land use and soil information from Figures 2-3 and 2-17, **Chapter 2 – Study Area** and the location of potential discharge and recharge areas on Figures 4-12 and 4-14, **Chapter 4 – Water Quantity**. Stressors in each of the creeks are also included to create a complete picture of the system. The remaining six tributaries do not have fish or benthic data available at this time, but a general analysis of surrounding conditions is included. Where it mentions 'no data available', there may be data on the watercourse collected by sources other than LSRCA (such as consultants), but it has not been collected to a standard to run the fish and benthic indices used within this report.

Strathallan Creek

Strathallan Creek is located at the northern end of the subwatershed, along the shore of Kempenfelt Bay. There is one monitoring site located near the mouth of this cold water system (Figure 5-2). The creek consists of two main branches and the entire system is located in gravelly sandy loam with high infiltration rates. Potential groundwater recharge areas are located along the whole creek, corresponding with the high infiltration rates and a potential discharge area at the headwaters of the western branch, contributing to the cold water attributes of the creek. Surrounding land use consists mainly of natural heritage cover with very small portions of urban development scattered mostly along the eastern branch.

The Index of Biotic Integrity (IBI) evaluation, done on the fish communities to evaluate the ecological integrity of the creek, has assessed the site near the mouth as being in fair condition. Even though this creek has no historic or present record of brook trout (Figure 5-4), there are currently mottled sculpin present (Figure 5-5) indicating that this creek could provide suitable brook trout habitat. Current cool water temperatures recorded at the monitoring sites indicate that a degree of thermal degradation may be occurring (Figure 5-9) within this system. There is one known barrier that may be blocking fish migration upstream (Figure 5-10), but no bank hardening or channelization (Figure 5-11). At present time no benthic invertebrate studies have been completed for this creek.

Longnose dace
(*Rhinichthys cataractae*)

Overall, Strathallan Creek is only moderately stressed at the one monitoring site at the mouth, based on the fish IBI, presence of a cold water species (mottled sculpin), and the lack of bank hardening and channelization. Further studies, including benthic invertebrates, may provide a better idea of the condition of this system.

Sandy Cove Creek

Sandy Cove Creek is the northern most creek in the subwatershed, and drains east into Lake Simcoe. It is a cold water creek with six monitoring stations distributed from the mouth along the main branch to the headwaters and one on a large northern branch. The soil type varies down

Mouth of Sandy Cove Creek

the length of the creek, with the headwaters in loam and loamy sand with moderate infiltration rates, down into the main branch through organics with slow infiltration rates. The northern branch stretches up through organics with both very slow infiltration rates (near confluence with main branch) and high infiltration rates (near the headwaters of the branch). The remainder of the main branch to the mouth goes through fine sandy loam with moderate infiltration rates. There are small amounts of potential recharge areas along the lower main branch and surrounding the headwaters. There are two potential large discharge areas, one in the upper reaches of the main branch and one around the headwaters of the northern branch. The headwaters and two-thirds of the main branch run through natural heritage cover and rural and agricultural land use. As the creek flows down to Lake Simcoe it goes through both natural heritage cover and urban areas.

Brook trout
(*Salvelinus fontinalus*)

Fish were captured at all sites except for one on a small northern tributary near the mouth. Two of the monitoring sites (at the mouth and the 3rd site upstream) had cold water species captured. One site had cold water temperatures recorded, while the other had cool water temperatures. The other four sites had only warm water species present in recorded warm and cold water sections of the creek (Figure 5-2). Based on the IBI analysis of the sites with fish, the ecological integrity is good to fair near the mouth, good at the 3rd site which has brook trout present, decreasing further upstream to fair at the confluence of the main branch and the northern branch, and poor at the headwaters (Figure 5-3). Brook trout have been historically caught at the mouth and the 3rd site upstream, but are now only found at the third site where there is coldwater habitat (Figure 5-4). Approximately equal numbers of adults and young of the year were caught at this site, suggesting that brook trout are successfully spawning and surviving at this site. Mottled sculpin, while not historically found within this system, are currently found at the mouth and same site as the brook trout (Figure 5-5).The analysis of the benthic invertebrate communities (Hilsenhoff) was completed at five of the seven sites and rates the ecological integrity of the creek as fairly poor at the mouth, fairly poor to poor at the confluence of the northern branch, and good at the headwaters (Figure 5-6). The discrepancy between the two indices in the headwater ratings is due to the fact that this area of the creek is narrow and has very little water in it, making it unsuitable habitat for most fish species, but it does have a pocket of wetland just upstream of the sampling site and tall riparian grasses filtering runoff from nearby agriculture, providing good water quality for benthics.

As previously mentioned, this is a cold water creek, but current data show that only the headwater site and one site midstream are still recording cold water temperatures, while the one at the mouth has cool water temperatures. The sites at the mouth and the cold water site midstream are the only ones with cold water fish species present (Figure 5-2). The rest of the monitoring sites have warm water temperatures recorded (Figure 5-9) indicating stressors in the area have lead to thermal degradation of this creek and may be limiting the habitat of cold water fish species. It should be noted that the majority of the creek has also been designated as a municipal drain and will experience maintenance work when necessary (Figure 5-8). From

Sideroad 25 to Sideroad 20 the main branch has been designated as Type D drain, while west of Sideroad 20 it is Type E. In both cases the creek has sensitive aquatic communities and any maintenance work is determined on a case by case basis. The main northern branch though, is dry for more than two consecutive months and is therefore classified as a Type F municipal drain. The drying up of this creek could be one of the reasons that the sites at its confluence with the main branch are experiencing warmer temperatures. In addition, the small northern branch near the mouth (with no fish present) is designated as a Type A municipal drain.

Furthermore, there are two known barriers to fish movement in this system (Figure 5-10), one of which is a dam along a southern branch. As there is no monitoring station beyond the dam, it is unclear what impacts it has on the aquatic communities. Bank hardening and channelization have occurred in various locations along the branches of the creek (Figure 5-11) and historical straightening can be seen by 90° angles of some of the creek branches (i.e. along Sideroad 25).

Overall, aquatic communities are showing signs of being stressed as there is low abundance and diversity of fish in the headwaters and down through the upper reaches, and the benthic invertebrates indicate there is significant organic pollution (with the exception of the headwaters) through the system. The sites nearest the mouth are providing better quality habitat for cold water species, which also happens to be where the creek is not designated as municipal drain.

Mooselanka Creek

Mooselanka Creek, located just south of Sandy Cove Creek, is a coldwater creek and has no monitoring sites (Figure 5-2). The creek flows through a variety of soils. Headwaters are in silty clay loam with slow infiltration rates and flows down through loam (moderate infiltration), fine sandy loam (high infiltration), loamy sand (high infiltration), gravelly sandy loam (moderate infiltration), and finally fine sandy loam around the mouth with moderate infiltration rates. There are few potential recharge areas in the vicinity of the creek and potentially a small discharge area in the headwaters. The majority of the creek is surrounded by urban land use and natural heritage cover, with headwater branches bordered by agricultural and rural land use. There are a few known barriers to fish movement in the lower main branch (Figure 5-10) and bank hardening and channelization has occurred in only a couple locations in the mid and lower reaches (Figure 5-11).

As there are currently no fish, benthic, or current temperature data (collected to LSRCA's standards) available, the ecological integrity of this system was not rated.

Portion of Mooselanka Creek

Burts Drain

Burts Drain, one of the smaller creeks that are not main tributaries, is a small cold water system with one monitoring station. The entire watercourse is located in organic soil with slow infiltration rates. There is one potential recharge area near the mouth and no discharge areas. Land use along the northern banks is natural heritage while the southern banks are within residential areas.

Despite warm water temperature readings, cold water fish species were captured at the monitoring site (Figure 5-2). While there is no historical or current record of brook trout inhabiting the drain (Figure 5-4), mottled sculpin, which require similar habitats, have been caught in recent years (Figure 5-5). The IBI analysis ranks the ecological integrity of the system as fair (Figure 5-3) and currently there are no benthic invertebrate studies available.

Mottled sculpin
(*Cottus bairdi*)

There are no known barriers to fish movement and only two instances of bank hardening and channelization, which are also apparent from the figure, as the branch of the drain are straight and follow 90° angles (Figure 5-10, Figure 5-11). The straightened main branch is designated as a Type A municipal drain. As this indicates there are no sensitive communities here, maintenance work includes brushing of the side slope, clean out of the bottom of the bed, and clean out of debris. Depending on the regularity of work done on the creek, maintenance of the drain may be contributing to the thermal degradation of the site from cold water to the current warm water readings at the monitoring site (Figure 5-9).

Overall, the aquatic communities in Burts Drain are somewhat stressed. Coldwater fish are present, but the abundance and diversity of fish species is low. Additionally, if warm water temperatures persist, this creek may no longer provide suitable habitat for mottled sculpin or other coldwater species. Further studies, including benthic invertebrates, may provide a better idea of the condition of this system.

Leonard’s Creek

Leonard’s Creek is a cold water creek (with one warmwater branch) located just south of Burts Drain and has four monitoring sites located along its branches. Soil type varies greatly along the many branches of this creek going from gravelly sandy loam (high infiltration) and fine sandy loam (moderate infiltration) in the headwaters, down through silty clay loam (slow infiltration), loam (moderate infiltration) and back through fine sandy loam (moderate infiltration) and gravelly sandy loam (moderate infiltration) at the mouth. There are small amounts of potential recharge areas in the headwaters, where infiltration rates are high to moderate, and no potential discharge areas. The main southern branches go through mainly urban land use and small patches of natural heritage cover. The northern branches go through similar land uses near the mouth but have headwaters in primarily rural and agricultural lands.

Leonard’s Creek

Despite being a cold water system, only the site closest to the mouth had cold water species captured (the other three had warm water species) (Figure 5-2). The IBI analysis rated the ecological integrity of the system as good at the site near the mouth, fair for the next site upstream and poor at the headwaters of both the main branches (Figure 5-3). There is no historical or current record of brook trout occupying this creek, but current data show mottled sculpin to be present at the site closest to the mouth (Figure 5-4, Figure 5-5). The Hilsenhoff index differs from the IBI ratings, with the two sites on the main branch and the northern headwater site being rated as fair and the southern headwater site being good (Figure 5-6). Again, this is because the creeks in the headwaters are narrow with minimal water to support

Pumpkinseed
(*Lepomis gibbosus*)

many fish species. The fair ratings of the benthics indicate that there is fairly significant organic pollution and that neighbouring land uses may be impacting the water quality.

As three of the sites record cool water temperatures and only the fourth site on a northern branch has cold water, thermal degradation may be occurring along the main branch (Figure 5-9) and discouraging cold water species. There are also four known barriers to fish movement (Figure 5-10), which may be preventing many species from migrating upstream, and causing the poorer ratings in the IBI. There are only a few instances of recent bank hardening and channelization (Figure 5-11), but historical straightening of the creek can be seen along the 9th Line.

Overall, aquatic communities are showing signs of being stressed as there is low abundance and diversity of fish in the headwaters and benthics indicate there is fairly significant organic pollution (with the exception of the headwaters) through the system. The site closest to the mouth is providing more adequate habitat for cold water species, but as the temperature remains consistently cool to cold throughout the creek, it is unclear why these species are not migrating further upstream.

Bon Secours Creek

Bon Secours Creek consists of one main tributary, located south of Leonard's Creek, and is one of the few warm water creeks in the Innisfil Creeks subwatershed. There are no fish, benthic, or temperature monitoring sites along this creek (Figure 5-2). The headwaters of the creek are in gravelly sandy loam and silty clay loam, with moderate and slow infiltration rates, respectively. The rest of the creek runs through fine sandy loam (moderate infiltration) and loamy sand (high infiltration). A small section at the mouth is in organic soils with moderate infiltration rates. There are potentially small groundwater recharge areas along the upper reach and no discharge areas are identified in the vicinity of the creek.

The headwaters of this creek are surrounded by both golf courses and natural heritage cover. The rest of the creek is surrounded by urban land uses with the mouth located in Innisfil Beach Park. There are three known barriers to fish movement (Figure 5-10) and substantial bank hardening and channelization where the creek has been straightened and runs parallel with Innisfil Beach Road (Figure 5-11).

As there are currently no fish, benthic invertebrate, or current temperature data (collected to LSRCA's standards) available, the ecological integrity of this system was not rated.

Mouth of Bon Secours Creek into Lake Simcoe

McLean Creek

McLean Creek, one of the smaller creeks which are not main tributaries, is a small cold water system with one monitoring station. The creek is entirely within loamy sand with high infiltration rates. There are no groundwater recharge or discharge areas along the creek. Surrounding land use is almost completely urban with headwaters located in a small patch of natural heritage features.

Bluntnose minnow
(*Pimephales notatus*)

Despite being a cold water system, only warm water species have been captured at this site (Figure 5-2). There are also no historical or current record of cold water indicator species, brook trout and mottled sculpin, being present within the creek (Figure 5-4, Figure 5-5). The IBI analysis ranks the ecological integrity of the system as fair (Figure 5-3) and currently there are no benthic invertebrate studies available. The current temperature rating at the monitoring site is cool, indicating there may be thermal degradation of the system (Figure 5-9) that is discouraging cold water species. There are no known barriers to fish movement (Figure 5-10) but channelization and bank hardening has occurred near the mouth (Figure 5-11).

Overall, based on the fish IBI and stressors, the aquatic communities within this system are somewhat stressed due to surrounding land uses. Further studies, including benthic invertebrates, may provide a better idea of the condition of this system.

Banks Creek

Banks Creek is a large coldwater creek located to the south of McLean Creek, with no monitoring sites (Figure 5-2). The creek flows through a variety of soils. The headwaters of the various branches are in organics (moderate infiltration), loamy sand (moderate infiltration), silty clay loam (slow infiltration), and fine sandy loam with moderate infiltration rates. The creek continues to flow down through fine sandy loam into loamy sand with high infiltration rates. There are a few potential recharge areas in the upper branches and two large potential discharge areas at the headwaters of the southern branches corresponding to the low to moderate infiltration rates. The headwaters of the creek and are in both natural heritage cover and surrounded by agricultural and rural land use. The section from mid way down the creek to the mouth is almost entirely urban land use.

There is historic record of Banks Creek having brook trout (Figure 5-4), but as there is no monitoring station on the system, it is unknown whether this population continues to exist today. Banks Creek has five known barriers to fish movement in the mid to upper reaches of the system (Figure 5-10) and there are quite a few instances of bank hardening and channelization in the mid to lower reaches (Figure 5-11). Additionally, part of the headwaters of the large northern branch is designated as a Type F municipal drain (is dry for two consecutive months) and the southern branch as a Type A municipal drain (no sensitive communities) (Figure 5-8). Again, without monitoring stations it is unclear how maintenance work on these sections influences the aquatic communities.

As there are currently no fish, benthic invertebrate or current temperature data (collected to LSRCA's standards) available, the ecological integrity of this system was not rated.

Moyer Creek

Moyer Creek is a small creek south of Banks Creek that flows north into Lake Simcoe. This is a coldwater system with no monitoring sites (Figure 5-2). The creek is in fine sandy loam and loam with moderate infiltration rates. There are no potential groundwater recharge or discharge areas in the vicinity. The headwaters are surrounded mostly by natural heritage cover and a golf course, with urban land use entirely along its western banks. No known barriers to fish movement or instances of bank hardening or channelization are present on this system (Figure 5-10, Figure 5-11).

As there are currently no fish, benthic invertebrate or current temperature data (collected to LSRCA's standards) available, the ecological integrity of this system was not rated.

Sylvan Creek

Sylvan Creek is another small system, located to the east of Moyer Creek and also draining north into Lake Simcoe. This is a warm water system with no monitoring sites (Figure 5-2). The creek is located entirely within fine sandy loam with moderate infiltration rates and there are no potential groundwater recharge or discharge areas in the vicinity. Land use in the area consists of natural heritage cover at the headwaters and along the western bank, with urban land use on the eastern shoreline. As this creek is piped there is no fish, benthic invertebrate, or current temperature data available.

Cedar Creek

Cedar Creek, located south of Moyer and Sylvan Creek, drains to the east into the mouth of Cook's Bay. This coldwater system has headwaters in organic soils with very slow infiltration rates. The rest of the creek flows through loamy sand and fine sandy loam with moderate infiltration rates. There are no potential recharge or discharge areas along the creek and the surrounding land uses are natural heritage cover in the headwaters, transitioning to urban near the mouth.

Despite being a coldwater system, only warm water species have been captured here (Figure 5-2). The IBI analysis ranks the ecological integrity of the system as poor (Figure 5-3) and there are no records of brook trout or mottled sculpin occupying this creek in the past (Figure 5-4, Figure 5-5). Currently there are no benthic invertebrate studies available for the system.

Current temperature data shows the creek to have cool water temperature readings, indicating there may be thermal degradation of the system that has discouraged cold water species from utilizing this creek (Figure 5-9). No known barriers to fish movement or instances of bank hardening or channelization were identified in the BMP inventory for the portion of the stream that was inventoried (Figure 5-10, Figure 5-11).

Overall, the aquatic communities in Cedar Creek are stressed, based on analysis of the fish communities. As water temperatures are still cool and there are no known barriers or instances of bank hardening or channelization, it is unclear what is impacting the system. Further studies, including benthic invertebrates, may provide a better idea of the condition of this system.

Belle Aire Creek

Belle Aire Creek is coldwater system located just south of Cedar Creek and has four monitoring sites located along its main branch. Headwaters are located in loam and fine sandy loam with moderate infiltration rates. The creek continues through the fine sandy loam, with small patches of gravelly sandy loam (moderate infiltration) and organic soils (slow infiltration rates). There are potential recharge areas in the

Belle Aire Creek

headwaters and along parts of the creek. A large potential discharge area is located at the confluence of the two headwater branches and a very small area along the main branch where infiltration is slow. The majority of the creek is surrounded by rural and agricultural land use, with part of the lower reaches in natural heritage cover and the mouth is surrounded by urban land use.

Yellow perch
(*Perca flavescens*)

Of the four monitoring sites, only the two closest to the mouth had any fish captured – all of which were warm water species (Figure 5-2). There is no record of cold water indicator species, brook trout and mottled sculpin, being present within this system in the past (Figure 5-4, Figure 5-5). The IBI analysis rated the ecological integrity of the system as good at the site closest to the mouth and fair at the next site up. The Hilsenhoff analysis on the benthic invertebrate communities is similar with the site closest to the mouth being rated as fair and the next three sites being good, fair, and fairly poor (Figure 5-6). The two sites farthest upstream are surrounded by intensive agriculture and high conductivity readings. Additionally, these sections of the creek are less than 1 m wide and less than 200 mm deep. The high conductivity and low water levels make these sites uninhabitable by fish, as well as creating poor benthic invertebrate habitat.

Two of the sites have cool water temperatures and two have warm water temperatures recorded, despite this historically being a cold water creek, indicating thermal degradation of the system that could be impacting the composition of the aquatic communities (Figure 5-9). There are nine known barriers to fish movement located along the watercourse, with over half clustered in the lower reaches possibly preventing fish from accessing the upper reaches (Figure 5-10). Most of the bank hardening and channelization on the creek has occurred around the mouth, along with a few areas in the upper reaches (Figure 5-11).

Overall, the aquatic communities within Belle Aire Creek are stressed in the headwaters, with no fish present and significant organic pollution (as indicated by benthic scores). The mouth has slightly better conditions for both fish and benthics, but a number of stressors are still impacting the system in this area.

Carson Creek

Carson Creek, located to the south of Belle Aire Creek, is a coldwater system with two monitoring sites near the mouth of the creek. Its headwaters are located in loam and fine sandy loam with moderate infiltration rates, with thin pockets of loamy sand along the creek with high infiltration rates. The creek flows through silty clay loam (slow infiltration) and gravelly sandy loam (moderate infiltration), before going back to fine sandy loam at the mouth (moderate infiltration). There are potential recharge areas in the headwaters and scattered along the upper reaches, while there is one potential discharge area at the headwaters of the southern branch and at the confluence of all the main branches. The majority of the creek is surrounded by rural and agricultural land use, with the lower reaches alternating between natural heritage cover and urban land use.

White sucker
(*Catostomus commersoni*)

Despite coldwater temperatures, both monitoring sites had only warm water species captured (Figure 5-2). There is also no record of brook trout or mottled sculpin occupying the creek in the past (Figure 5-4, Figure 5-5). The IBI analysis of the fish communities rated the ecological integrity of the sites as good near the mouth and fair on the second site (Figure 5-3). Currently there are no benthic invertebrate studies available for the system.

From the mouth to the confluence of the headwater branches, the main section of the creek is designated as a Type A municipal drain (Figure 5-8). This means that there are no sensitive species or communities and maintenance work can include brushing of the side slope, bottom (bed) cleanout, and debris clean out. While there are no sensitive species currently present, work on the creek, as well as other associated stressors with municipal drains, may be preventing these species from utilizing the system. Additionally, there are two known barriers to fish movement in the middle reaches of the creek (Figure 5-10) and intense bank hardening and channelization from the mouth to the confluence of the main branches (Figure 5-11).

Overall, the aquatic communities are moderately stressed, based on fish data and the presence of intense bank hardening and channelization. The inclusion of a benthic invertebrate analysis in future studies may give a broader view of the condition of the creek.

Wilson Creek

Mouth of Wilson Creek

Wilson Creek is located south of Carson Creek and has three monitoring stations located along the main and southern branch. The majority of this coldwater creek is located in silty clay loam with slow infiltration rates. A small portion of the headwaters is in loam (moderate infiltration) and the mouth runs through organics with slow infiltration rates. There is a potential recharge area around the confluence of two headwater branches and a large potential discharge area that encompasses the entire northern headwater branch. There is also a smaller potential discharge area near the mouth. Land use surrounding the creek is composed of agricultural and rural land use around the headwaters and natural heritage cover downstream of the confluence of the two main branches.

Only warm water species were caught at the three monitoring sites (Figure 5-2) and there is no historical record of brook trout or mottled sculpin being present within the creek (Figure 5-4, Figure 5-5). The IBI analysis rated the ecological integrity of the system as good at the site near the mouth, fair at the confluence of the branches and poor on the southern headwater branch (Figure 5-3). Similarly, the Hilsenhoff analysis of the benthic communities rates the site near the mouth as fair, and the following two sites as fairly poor (Figure 5-6).

Creek chub
(*Semotilus atromaculatus*)

Despite being a cold water creek, two of the sites have cool water temperatures and the site at the mouth has warm water temperatures recorded, indicating stressors to the system are causing thermal degradation (Figure 5-9). There are three known barriers to fish movement located near the mouth, just up the main northern branch and close to the headwaters of the southern branch (Figure 5-10). Bank hardening and channelization has occurred near the mouth, at the confluences of the main branches and midway down the southern branch (Figure 5-11). As the BMP inventory did not cover the entirety of the creek, there may be more barriers and stream alterations on the northern branch.

Overall, the aquatic communities within Wilson Creek are under some stress near the mouth, with stream alterations and fairly significant organic pollution (as shown by the benthic invertebrate analysis), but are under more severe stress up into the headwaters where abundance and diversity of fish decrease and organic pollution increases.

White Birch Creek

Mouth of White Birch Creek

White Birch Creek is a large system, with five monitoring sites, that drains to the east into Cook's Bay. This is a mainly coldwater system with a section near the mouth up into a northern branch being warm water. Headwaters are located mostly in loam (moderate infiltration) and silty clay loam (slow infiltration). The main branch flows through fine sandy loam with high to slow infiltration rates. There are large potential recharge areas in the southern headwaters and narrow stretches of potential discharge areas along the main branch and two of the northern tributaries. Agricultural and rural land uses surround all the headwaters, with natural heritage cover and golf courses closer to the water front, into urban land use surrounding the mouth.

Of the five monitoring sites, cold water fish were captured only at two sites. Warm water species were captured at the two sites closest to the mouth and the northern headwater site had no fish captured (Figure 5-2). Although there are no historical or current records of brook trout in the creek, there are both historic and current records of mottled sculpin (Figure 5-4, Figure 5-5). The IBI analysis of the fish communities in White Birch Creek rate the two cool water sites closest to the mouth as good, the warm water site as poor, and the cool water site on the southern branch as fair (Figure 5-3). The Hilsenhoff analysis of the benthic invertebrate communities rates the ecological integrity of the system similarly, with the three sites closest to the mouth as fair and good, the southern branch site as fair and the monitoring site at the northern branch headwaters (with no fish) as fairly poor (Figure 5-6).

The northern headwaters site is classified as a Type C municipal drain (Figure 5-8), indicating no sensitive species or communities are present, and maintenance work includes brushing of side slope, bottom (bed) clean out and full clean out, which partially explains the poor benthic communities and absence of fish species. Additionally, while this is generally a cold water system, the majority of the stations record the creek as a cool water system, with cold water temperatures in the headwaters and one warm water site (not on the warm water branch) between two cool water sites. Temperature difference indicates thermal degradation of the system that could be impacting the current cold water fish communities (Figure 5-9).

There are a number of known barriers to fish movement in this system, the majority of which are along the northern branches, possibly contributing to the lack of fish presence at the headwaters site (Figure 5-10). Bank hardening and channelization has also occurred along much of the main creek and along its various branches (Figure 5-11).

Overall, aquatic communities are showing signs of being stressed in the headwaters and northern branch, where there are either no fish present or, where fish are found, there is a low abundance and diversity; an analysis of the benthic invertebrates show significant organic pollution. Better conditions are found near the mouth, for the most part, with a higher diversity of fish species and lower organic pollution (as indicated by the benthic invertebrate communities).

Gilford Creek

Gilford Creek is a small system to the south of White Birch Creek, which also drains east into Cook's Bay. This is a warm water system with no monitoring sites (Figure 5-2). Almost the entire creek flows through loam (moderate infiltration), with the mouth in fine sandy loam with slow infiltration rates. There is a large potential recharge area from the mouth to halfway up the creek and small areas of potential groundwater discharge at the headwaters. Land use in the area consists of rural and agricultural around the majority of the creek with natural heritage cover and urban land use at the mouth.

There is one known barrier to fish movement at the mouth (Figure 5-10) and no bank hardening or channelization was identified during the BMP inventory (Figure 5-11).

LSRCA field staff visited this creek at the end of August, 2011 and the creek was dry. As such, the ecological integrity of the creek is deemed to be very poor and is unable to support any aquatic communities during the summer months.

Upper Marsh Creek

Upper Marsh Creek is the southern most creek in the Innisfil Creeks subwatershed, and drains to the east into Cook's Bay. The headwaters of this warm water creek are in loam with moderate infiltration rates. It continues to flow downstream through fine sandy loam (slow infiltration) before going into organic soils at the mouth with high infiltration rates. There are no potential recharge areas, but a large potential discharge area surrounds approximately ¾ of the creek. Agricultural and rural land use surround the headwaters but the main part of the creek and mouth are located in protected natural heritage cover (Greenbelt Protected Countryside).

Only warm water species have been captured here (Figure 5-2) and the IBI analysis ranks the ecological integrity of the system as fair (Figure 5-3). There is no record of brook trout or mottled sculpin occupying this creek in the past (Figure 5-4, Figure 5-5) and there are currently no benthic studies available for the system.

The one monitoring site located midway up creek has cool water temperatures recorded, despite being designated a warm water system, this can possibly be attributed to the large potential discharge area surrounding much of the creek.

The BMP inventory did not cover this creek, therefore the number of instances of barriers, bank hardening and channelization and their impacts are unknown at this time.

Overall, the aquatic communities of the system appear to be under some stress as the fish IBI indicated a lower abundance and diversity, but with only one monitoring site, no benthic invertebrate analysis and stream alterations unknown, it is difficult to assess the whole system. Further studies, including benthic invertebrates and an inventory of stream alterations, may provide a better idea of the condition of this system.

Central mudminnow (*Umbra limi*)

5.5 Current Management Framework

Various programs exist to protect and restore aquatic natural heritage values in the Lake Simcoe watershed, ranging from regulatory mechanisms, to funding and technical support provided to private landowners, to ongoing research and monitoring.

Many of these programs already address some of the stresses facing aquatic systems in the Innisfil Creeks subwatershed, as outlined below.

5.5.1 Protection and policy

There are numerous acts, regulations, policies, and plans aimed at maintaining or improving aquatic habitat. These include the *Fisheries Act*, *Endangered Species Act*, the Lake Simcoe Protection Plan, and municipal official plans. This management framework addresses many of the stresses identified in these subwatersheds. In Table 5-4 we categorize 12 such stressors, recognizing that many of these overlap and that the list is by no means complete. The legal effects of the various Acts, policies, and plans on the stressors is categorized as ‘existing policies in place’ (shown in green), or ‘no applicable policies’ (shown in red). The policies included in the table include those which have legal standing and must be conformed to, or policies (such as some of those under the Lake Simcoe Protection Plan) which call for the development of further management tools, research or education programs.

The intent of these regulations, policies and plans are summarized in **Section 1.3 – Current Management Framework**. Readers interested in the details of these regulations, policies and plans are directed to read the original documents.

Mouth of small creek into Kempenfelt Bay

Table 5-4: Summary of current the current management framework as it relates to the protection and restoration of aquatic natural heritage

Stressor affecting aquatic habitat	Lake Simcoe Protection Plan (2009)	Growth Plan for the Greater Golden Horseshoe (2006)	Provincial Policy Statement (2005)	Endangered Species Act (2008)	Ontario Water Resources Act (1990)	Fisheries Act (1985)	Ontario Fisheries Regulations (1989)	LSRCA Watershed Development Policies (2008)	Simcoe County Official Plan (2007)	Town of Innisfil Official Plan (2006)	City of Barrie Official Plan (2009)
Site alteration in wetlands	🟩	🟥	🟩	🟩 4	🟥	🟩 5	🟥	🟩	🟩	🟩	🟩
Loss of riparian areas / shoreline development	🟩 1	🟥	🟩	🟩 4	🟥	🟩	🟥	🟩	🟩	🟩	🟩
Stream alteration (including enclosures and flow diversion)	🟩 1	🟥	🟩	🟥	🟥	🟩	🟥	🟩	🟩 10	🟩 10	🟩 10
Instream barriers	🟩	🟥	🟩	🟥	🟥	🟩	🟥	🟩	🟩 10	🟩 10	🟩 10, 11
Bank hardening	🟩 1	🟥	🟩	🟥	🟥	🟩	🟥	🟩 6	🟩 10	🟩 9	🟩
Impervious surfaces	🟩	🟥	🟩	🟥	🟥	🟥	🟥	🟩	🟥	🟩	🟩
Municipal drains	🟥	🟥	🟥	🟥	🟥	🟩	🟥	🟩	🟥	🟥	🟥
Uncontrolled stormwater	🟩	🟥	🟩	🟥	🟥	🟥	🟥	🟩 7	🟩	🟩	🟩
Interference with groundwater recharge / discharge	🟩	🟥	🟩	🟥	🟥	🟥	🟥	🟩 12	🟩	🟩	🟩
Degradation of water quality (including thermal impacts)	🟩 2	🟥	🟩	🟥	🟩	🟩	🟥	🟩	🟩	🟩 8	🟩
Introduction of invasive species	🟩 3	🟥	🟥	🟥	🟥	🟥	🟩	🟥	🟥	🟥	🟥
Climate change	🟩	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥

🟩 Existing policies in place

🟥 No applicable policies

[1] Regulations only apply to those areas outside designated Settlement Areas

[2] Only contains specific policies and targets about phosphorus reduction, none about other contaminants

[3] Discusses developing proposed regulations, conducting studies/risk assessments, developing response plans, education programs, but nothing banning use/etc

[4] Related to those features that are part of SARO listed species' habitat

[5] Restrictions apply only to direct or indirect fish habitat

[6] Not directly stated, but stream alteration policies would cover this

[7] Stormwater controls required, application must demonstrate every effort made to achieve pre-development hydrologic conditions

[8] Regulations pertain to development over shallow groundwater tables, and impacts to coldwater fish habitat

[9] Unless no net impact can be demonstrated

[10] References Fisheries Act (1985)

[11] Additional regulations apply to the shoreline of Lake Simcoe

[12] Within hydrologically defined Environmentally Significant Areas

Legislation and policy restrictions are the primary source of protection for aquatic natural heritage features in the Lake Simcoe watershed. However, some stresses are better suited to policy and regulation than others. For example, stressors such as climate change and invasive species are hard to regulate; however, activities related to the loss of habitat, or capture and killing of fish are much easier to define and enforce.

The Federal *Fisheries Act* defines fish habitat as “spawning grounds and nursery, rearing, food supply and migration areas on which fish depend directly or indirectly in order to carry out their life process”. Thus, fish habitat includes not only the water itself, but also the physical structure of watercourses, the vegetation along their banks, and factors related to the quality of water.

As such, the *Fisheries Act* prohibits (unless authorized), the installation of dams or other structures within watercourses that obstruct the passage of fish, the modification of a natural watercourse (e.g. straightening, enclosing, or hardening of the shoreline), or the removal of vegetation along the shoreline.

The *Fisheries Act* is further complemented by the Lake Simcoe Protection Plan, which (outside of designated settlement areas) establishes restrictions to development or site alteration within 100 m of the Lake Simcoe shoreline (30 m in already built-up areas, subject to a natural heritage evaluation) (policies 6.1 and 6.2), or within 30 m of wetlands and watercourses, with natural heritage evaluations necessary for development proposed within 120 m of the feature (policies 6.22 – 6.25). Exemptions to these policies are provided for existing uses, municipal infrastructure, and aggregate operations. These activities will be required to demonstrate that they maintain or improve fish habitat in the watercourse, wetland, or riparian area.

Within designated settlement areas, the *Fisheries Act* is complemented by municipal official plans. The Town of Innisfil Official Plan protects aquatic habitats and ecosystem function by prohibiting development within Provincially Significant wetlands outright, as well as prohibiting development within 30 m of the Lake Simcoe shoreline and all watercourses and non-Provincially Significant wetlands, unless the proponent can demonstrate no negative impacts will occur to the feature or its functions (policy 3.1.1). The City of Barrie Official Plan protects sensitive surface water features and their related hydrological functions, by prohibiting development in Provincially Significant wetlands (and other wetlands larger than 0.5 ha), and in valley and stream corridors, with riparian vegetation zones required as necessary to support resident cold water or warm water fish communities (policy 4.7.2.5).

Beyond the protection of aquatic habitat features themselves, processes related to groundwater flow (including both recharge and discharge) are also protected by a suite of policy mechanisms. The Lake Simcoe Protection Plan requires LSRCA (in partnership with MOE and MNR) to define and map ecologically significant groundwater recharge areas throughout the watershed. Ecologically significant groundwater recharge areas are those which are necessary to support coldwater fish habitat or wetlands. Once identified, municipalities are required to incorporate these features into their official plans together with policies to protect, improve, or restore the function of the recharge areas. Currently, LSRCA, in partnership with MNR and MOE, is conducting a pilot study in the Barrie Creeks, Lovers Creek, and Hewitt’s Creek subwatershed areas to test the sensitivity of the different methodologies to identify these ecologically significant groundwater recharge areas. Work on Innisfil Creeks will be completed in the coming years, based on the pilot study.

The City of Barrie Official Plan has such a policy framework in place, to be triggered upon the identification of ecologically significant groundwater recharge areas. These policies include controls over major development and expansion of designated settlement areas. Similarly, the Town of Innisfil Official Plan controls development in significant groundwater recharge areas, by requiring proponents to conduct detailed studies of the recharge area to ensure that the hydrological integrity of the feature is protected during development.

Drainage works such as those permitted under the Provincial *Drainage Act* are exempt from many of the policy provisions provided under the Lake Simcoe Protection Plan and municipal official plans, but are not exempt from the requirements of the Federal *Fisheries Act*. Maintenance of existing designated drains requires class authorization under the *Fisheries Act*, and proposed new drains are subject to full review to ensure no harmful alteration occurs to fish habitat.

For infrastructure or other works occurring in water, the Ontario Ministry of Natural Resources is responsible for determining in-water work timing restrictions to ensure that fish and other aquatic life are permitted to carry out critical life processes undisturbed. These restrictions are based on the presence of warm and cold water thermal fish communities as determined by contemporary thermal regime and fisheries studies.

5.5.2 Restoration and remediation

There is a range of programs operating in these subwatersheds to assist private landowners in improving the environmental health of its tributaries.

The Landowner Environmental Assistance Program (LEAP) is a partnership between the Lake Simcoe Region Conservation Authority, its member municipalities, and the York, Durham, and Simcoe chapters of the Ontario Federation of Agriculture. This program provides technical and financial support to landowners in the Lake Simcoe watershed wanting to undertake stewardship projects on their land. Project types which have traditionally been funded by the LEAP program include removing barriers from streams, adding bottom-draw structures to online ponds, and fencing and planting riparian areas, among others. Since 1989, in addition to projects focused specifically on protecting water quality, LEAP has supported six erosion control and riparian planting projects and three streambank fencing projects in the Innisfil Creeks subwatershed.

The Ontario Ministries of Natural Resources, Environment, and Agriculture, Food and Rural Affairs provide the Lake Simcoe Community Stewardship Program for non-farm rural landowners in the Lake Simcoe watershed. This program is intended to provide non-farm rural residents with financial and technical assistance in implementing projects such as shoreline stabilization, erosion control, and fish habitat improvements, among others. In the Innisfil Creeks subwatershed, this program is implemented in partnership with the Dufferin/South Simcoe Land Stewardship Network and the South Simcoe Streams Network. The Lake Simcoe Community Stewardship Program has implemented 19 shoreline improvement projects in the Innisfil Creeks subwatershed thus far.

The Ontario Ministry of Agriculture, Food and Rural Affairs has also partnered with Agriculture and Agri-Food Canada and the Ontario Soil and Crop Improvement Association to provide the Environmental Farm Program to registered farm landowners throughout the province. This farmer-focused program provides funding to landowners who have successfully completed an Environmental Farm Plan for projects including management of riparian areas, streambank fencing, and nutrient management. Through this program less than five projects that would directly improve aquatic habitat have been implemented in the Town of Innisfil, while none have been completed in the City of Barrie.

In 2008 and 2009, LSRCA field staff surveyed and reported on the majority of the watercourses in this subwatershed, documenting the range of potential stewardship projects that could be implemented to help improve water quality and fish habitat. The Lake Simcoe Basin Best Management Practice Inventory (LSRCA, 2009) found over 300 places where additional riparian planting could be introduced, nearly 70 barriers that should be removed to improve fish passage, several locations along creeks that require additional fencing, and over 200 locations where the streambank was eroding into a creek.

The forthcoming shoreline management strategy, and wetland and riparian area prioritization exercise, will identify and prioritize stewardship opportunities in this subwatershed, specific to the shoreline and inland riparian and headwater areas respectively.

These ongoing stewardship programs will soon be complemented by a forthcoming Voluntary Action Program. Initially, the Lake Simcoe Protection Plan proposed the development of a regulation to prohibit activities that would adversely affect the ecological health of the Lake Simcoe watershed (policy 6.16). Feedback during the initial rounds of consultation in development of this regulation raised concerns about its enforceability, and the need to educate the public on best management practices before taking a regulatory approach. As a result, the MOE reframed the Shoreline Regulation as a Shoreline Voluntary Action Program.

The Shoreline Voluntary Action Program is intended to increase the extent of native vegetation along shorelines, and reduce the use of phosphate-containing fertilizer in the watershed, through a combination of surveys which are aimed at understanding the current range of public knowledge, attitudes, and practices, and outreach to summer camps, landowners, and garden centres.

This voluntary action program is being run as a two year pilot program, with ongoing monitoring to determine the rate of uptake, impacts on phosphorus levels, and impacts on native vegetation along the shoreline. After the pilot program is complete, these results will be reviewed to determine if a voluntary program is sufficient, or if a regulatory approach is necessary.

Riparian buffer planting – Banks Creek

5.5.3 Science and research

An ongoing commitment to applied science and research is necessary to improve our understanding of the extent, character, and function of the fish and other aquatic natural heritage values within the Lake Simcoe watershed. Ongoing monitoring programs led by the MNR and the LSRCA, and periodic research studies conducted by academics, are contributing to our understanding of these values.

The Ministry of Natural Resources has been studying the structure and function of Lake Simcoe's ecosystem, including internal energy dynamics, food web interactions, and the impacts of invasive species and climate change since 1951 when the Lake Simcoe Fisheries Assessment Unit was created. This unit uses a series of research and monitoring programs, including creel surveys, index netting, angler diaries, spawning studies, and water level and temperature monitoring, among others, to meet the needs of fisheries resource managers (as outlined in Philpot *et al.*, 2010).

The Lake Simcoe Region Conservation Authority monitors fish communities, benthic invertebrates, and temperature at a network of sites throughout the watershed. Some of these sites are visited only once, to describe the aquatic system, and some are visited annually to document changes in the health of the tributaries (monitoring sites in these three watersheds are displayed in Figure 5-2).

More recently, the LSRCA began a nearshore monitoring program in the lake, to better understand the connection between watershed land use and the health of the Lake Simcoe ecosystem. This monitoring program includes a study of the aquatic plants, benthic invertebrates, and sediment chemistry in this nearshore zone, some results of which are shown in Figure 5-7.

In addition to these ongoing monitoring programs, numerous scientific and technical reports have been published based on research conducted in the Lake Simcoe watershed. As a result of this combined focus, Lake Simcoe is one of the most intensively studied bodies of water in Ontario. The results of this research have been summarized, in part, in LSEMS (2008) and Philpot *et al.* (2010), and have informed the development of this subwatershed plan.

The Lake Simcoe Protection Plan commits the MNR, MOE, LSRCA and others to continue to invest in research and monitoring related to aquatic communities of Lake Simcoe and its tributaries. Ongoing research is proposed to examine the biological components of the ecosystem, their processes, and linkages, to build on existing knowledge, or address knowledge gaps (policy 3.5). The proposed monitoring program is intended to build on the existing monitoring described above, to describe the fish communities, benthic communities, macrophytes, and/or fishing pressure in the lake, its tributaries, and other inland lakes within the watershed (policy 3.6).

5.6 Management Gaps and Recommendations

It is recognized that many of the undertakings in the following set of recommendations are dependent on funding from all levels of government. Should there be financial constraints, it may affect the ability of the partners to achieve these recommendations. These constraints will be addressed in the implementation phase.

5.6.1 Stewardship implementation – increasing uptake

In addition to protecting existing aquatic habitat, programs which support the stewardship, restoration, or enhancement of aquatic habitat will be critical to meet the targets and objectives of the Lake Simcoe Protection Plan. To that end, Lake Simcoe Stewardship Network has been established to provide a forum that helps identify priorities and coordinate efforts between the multiple organizations undertaking stewardship in the watershed. The Stewardship Network includes the Ministry of Natural Resources, Ministry of the Environment, Ministry of Agriculture, Food and Rural Affairs, Ontario Federation of Agriculture, Ontario Soil and Crop Improvement Association, Lake Simcoe Region Conservation Authority, South Simcoe Streams Network, and watershed municipalities.

> **Recommendation 5-1** – That the MNR, MOE, MAFRA, and LSRCA continue to implement stewardship projects in these subwatersheds, and encourage other interested organizations to do the same.
>
> **Recommendation 5-2** – That governmental and non-governmental organizations continue to improve coordination of programs to: (1) avoid inefficiencies and unnecessary competition for projects, and: (2) make it easier for landowners to know which organization they should be contacting for a potential project, using tools such as a simple web portal.
>
> **Recommendation 5-3** – That the MOE, MNR, LSRCA, and other members of the Lake Simcoe Stewardship Network be encouraged to document completed stewardship projects in a common tracking system to allow efficient tracking, coordinating, and reporting of stewardship work accomplished.
>
> **Recommendation 5-4** – That the Federal, Provincial, and Municipal governments provide consistent and sustainable funding to ensure continued delivery of stewardship programs.
>
> **Recommendation 5-5** – That the MOE, MNR, MAFRA, LSRCA, and other interested members of the Lake Simcoe Stewardship Network support research to determine barriers limiting uptake of stewardship programs in these subwatersheds and share these results with other members of the Lake Simcoe Stewardship Network, to enable agencies and stakeholders to modify their stewardship programming as relevant. This research should include a review of successful projects to determine what aspects led to their success, and how these may be emulated.
>
> **Recommendation 5-6** – That the MOE, MNR, MAFRA, and LSRCA continue to investigate new and innovative ways of reaching target audiences in the local community and engage them in restoration programs and activities (e.g. high school environmental clubs, through Facebook groups, hosting a Lake Simcoe Environment Conference for high schools/science community interaction). The results of these efforts should be shared with the Lake Simcoe Stewardship Network

5.6.2 Stewardship implementation – prioritize projects

Stewardship programs play an important role in meeting the goals and objectives of the subwatershed plans. However, in order to ensure that they are both effective and efficient, stewardship projects should be selected in the context of the priority needs of the Lake Simcoe watershed, and its subwatersheds. An analysis of aquatic habitat has identified bank hardening, barriers, and insufficient riparian cover as some of the most important factors impacting instream habitat. Analogous to terrestrial natural heritage stewardship requirements, a tool is needed to help prioritize stewardship projects. Ideally a single prioritization tool, addressing both aquatic and terrestrial stewardship activities, should be developed.

> **Recommendation 5-7** – That the LSRCA, with the assistance of the MNR and MOE, develop a spatially-explicit decision support tool to assist in targeting aquatic habitat stewardship projects in the Lake Simcoe watershed. In the context of the Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds, this prioritization tool should take into account factors including:
>
> - The need to incorporate each major type of aquatic habitat stressor including bank hardening, barriers, riparian cover, and on-line ponds;
> - The use of best available datasets to identify potential restoration sites, including LSRCA BMP inventory and riparian assessment;
> - Expected improvements to aquatic habitat and therefore fish and benthic community condition, including improved water temperature, increased connectivity for movement within and between tributaries, and shelter.
> - Opportunities to reduce phosphorus loadings in the tributaries in these subwatersheds
> - The relative cost of implementing projects in urban, urbanizing, and agricultural areas, particularly with respect to the cost of implementing retrofit projects in the relatively heavily urbanized City of Barrie.
>
> **Recommendation 5-8** – That prioritized restoration areas be integrated into a stewardship plan that ensures prioritized restoration opportunities are undertaken as soon as feasible. This stewardship plan should incorporate the outcomes of recommendations to improve uptake identified in Recommendations 5-1 through 5-6.

5.6.3 Impacts to Hydrologic Regime

In addition to the stressors on aquatic habitat identified above (barriers, channelization, etc.), the condition of the fish and benthic communities in the Innisfil Creeks subwatershed are also likely being impacted by stream hydrology, including both high or peak flows, and low flow condition. While water quantity and associated recommendations are discussed in detailed within **Chapter 4 – Water Quantity**, the following recommendations are specific to aquatic habitat:

> **Recommendation 5-9** – That the MOE, with assistance from LSRCA, MNR and the University of Guelph, determine in-stream flow regime targets for Barrie, Lovers, Hewitt's, and Innisfil Creeks. These targets should be based on the Guidance Document framework (LSRCA 2010) which is being used for the Maskinonge River subwatershed.

Recommendation 5-10 – That the MOE and MNR, with assistance from LSRCA, develop a strategy to achieve the instream flow regime targets. This strategy should address both high and low flow requirements and provide a plan for implementing strategy recommendations.

Recommendation 5-11 – That the LSRCA work with subwatershed municipalities and MAFRA to examine innovative forms of municipal drain maintenance, or opportunities to create new drains using principles of natural channel design. Furthermore, that the LSRCA work with subwatershed municipalities and MAFRA to decommission municipal drains when the land use changes, removing the need for their use.

5.6.4 Water Quality and Water Temperature

Based on the generally fair to fairly poor benthic invertebrate community scores, water quality in Innisfil Creeks can be considered degraded in some areas. Similarly, the assessment of fish IBI and water temperature indicate that the thermal regime of the creeks is being affected by factors such as loss of riparian cover, increased imperious surfaces and barriers. Recommendations addressing water quality are presented in **Chapter 3 – Water Quality**, and recommendations pertaining to increased water temperature are described in Recommendations 3-17 and 3-18.

5.6.5 Enclosures

Past development practices allowed for the enclosure or piping of various creeks throughout the study area. These enclosures not only create barriers for fish migration and fragment the fish and wildlife populations but also threaten the public through the potential for flooding. In the case of both Bon Secours and Sylvan Creeks, the enclosure of significant parts of the creek mouths has unfortunately curtailed fish migration from Lake Simcoe to the headwaters completely and in the case of the latter, has lead to a complete absence of fish within the system.

Recommendation 5-12 - That the Town of Innisfil, in partnership with the LSRCA, complete an inventory of enclosed or buried streams from which removal of enclosures or “day lighting” can be prioritized.

Recommendation 5-13 - That the Town of Innisfil continue its efforts to day light enclosed streams and establish a funded program based on prioritized list of restoration opportunities, as resources permit.

5.6.6 Monitoring and Assessment

Long term monitoring is required to identify changes and trends occurring in the aquatic community. These on-going annual surveys of fish, invertebrates, stream temperatures, water quality, baseflow, and channel morphology are also intended to provide information that will direct future rehabilitation efforts. Additional environmental characteristics such as brook trout spawning (redd) surveys, field confirmation of groundwater inputs, algae/diatom sampling, lake /tributary interface assessment, as well as an expanded water quality and quantity network will need to be considered to provide the information to look at the system in an integrated and holistic way. A renewed need for regular reporting of the results and a systematic re-evaluation of the program is also required.

Recommendation 5-14 – That LSRCA, with support from Municipalities and the Province, aim for improved spatial and temporal resolution in annual monitoring of aquatic habitat, including water quality, fish and benthic indicators.

6 Terrestrial Natural Heritage

6.1 Introduction

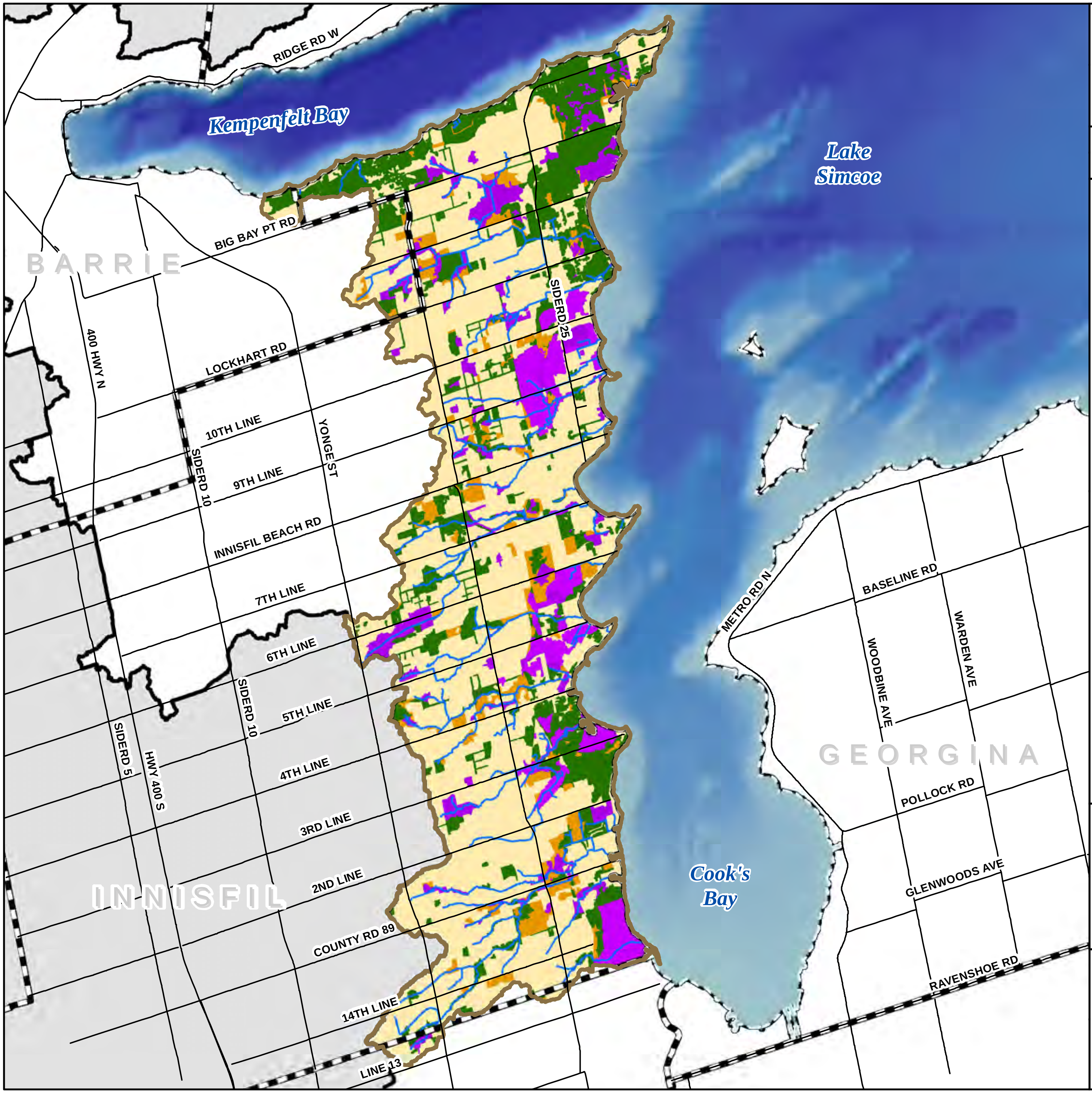
Terrestrial natural heritage features are extremely important components of subwatershed health, as they not only provide habitat for many of the species residing in the subwatershed, but also influence subwatershed hydrology. They are among the most important parts of the ecosystem, and are the most likely to be directly impacted by human activities.

A terrestrial natural heritage system is composed of natural cover (features), natural processes (functions), and the linkages between them. The matrix of agricultural, rural, urban, and natural areas within the Innisfil Creeks subwatershed's terrestrial system interacts with other hydrological and human systems, and serves as habitat for flora and fauna throughout the subwatershed. The system includes not only large tracts of natural features, but also the small features that can be found within urban and agricultural areas. Measuring the quantity, quality, and distribution of natural heritage features within the subwatershed can tell us a great deal about its health. Figure 6-1 details the distribution of natural features in the subwatershed.

Currently, natural heritage features constitute approximately 33% of the Innisfil Creeks subwatershed. This includes 17.1% upland forest, 11.3% wetland, and 5.2% grassland.

Terrestrial natural heritage features in the Innisfil Creeks subwatershed.

Figure 6-1



Legend

- Road
- Municipal Boundary
- Watercourse
- 🟧 Grassland
- 🟪 Wetland
- 🟩 Woodland

Lake Simcoe Region conservation authority

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LSRCA GIS Services DRAFT created July 2010.

6.2 Current status

Terrestrial natural heritage features, as described by the Provincial Policy Statement, include woodlands, wetlands, valleylands, Areas of Natural and Scientific Interest, habitat for endangered species, and wildlife habitat. The Provincial Policy Statement provides direction for the protection of *significant* natural heritage features throughout the Province.

The Lake Simcoe Protection Plan (LSPP) provides further targets for the Lake Simcoe watershed, to:

- Ensure no further loss of natural shorelines on Lake Simcoe;
- Achieve a greater proportion of natural vegetative cover in large high quality patches;
- Achieve a minimum 40 percent high quality natural vegetative cover in the watershed;
- Achieve protection of wetlands;
- Achieve naturalized riparian areas on Lake Simcoe and along streams;
- Restore natural areas or features, and;
- Achieve increased ecological health based on the status of indicator species and maintenance of natural biodiversity

The current state of natural heritage features in the Innisfil Creeks subwatershed can be described, relative to these targets, where data permits.

At 33%, the total natural cover in this subwatershed is slightly below average for the Lake Simcoe watershed, and below the target of 40% high quality natural areas for the entire Lake Simcoe watershed set by the Lake Simcoe Protection Plan. Nearly half of this subwatershed has been converted to agricultural land use, with approximately 15% composed of urban land uses (Figure 2-2). There are clear patterns in development in this subwatershed, with the higher, better drained soils associated with the Peterborough Drumlin Field in the headwaters primarily converted to agriculture, and natural heritage preservation and development focused primarily along the lakeshore, in the Lake Simcoe Lowlands physiographic region (Figure 2-3).

6.2.1 Woodlands

The *Natural Heritage Reference Manual* (OMNR, 2010) lists a variety of important functions associated with woodlands and Larson *et al*. (1999) summarize the importance of woodlots. These important functions can generally be described as follows:

- **Economic Services and Values:** oxygen production, carbon sequestration, climate moderation, water quality and quantity improvements, woodland products, economic activity associated with cultural values
- **Cultural/Social Values:** education, recreation, tourism, research, spiritual and aesthetic worth
- **Ecological Values:** diversity of species, structural heterogeneity, energy (photosynthesis), nutrient and energy cycling.
- **Hydrological Values:** interception of precipitation, reduction of intensity of rainfall runoff, slower release of meltwater from snowpack, shade to water courses

Woodlands include all treed communities, whether upland or wetland. The Ecological Land Classification (ELC) communities that were considered to represent woodlands are forest, swamp, plantation, and cultural woodland (the breakdown of these woodland types is displayed in Figure 6-3 and Table 6-1). Some woodlands in this section are also counted as wetlands later in the chapter (e.g. wooded swamp), as the two terms are not mutually exclusive.

The ecological function of woodlands tends to be influenced by factors relating to fragmentation (the splitting of larger woodlands into ever smaller pieces), patch size (the requirement of woodland pieces to be of a certain area for the maintenance of some functions), woodland quality (such as shape, interior habitat, age, composition, structure, and the presence of invasive species), and total woodland cover (i.e., the woodland area within a jurisdiction or watershed).

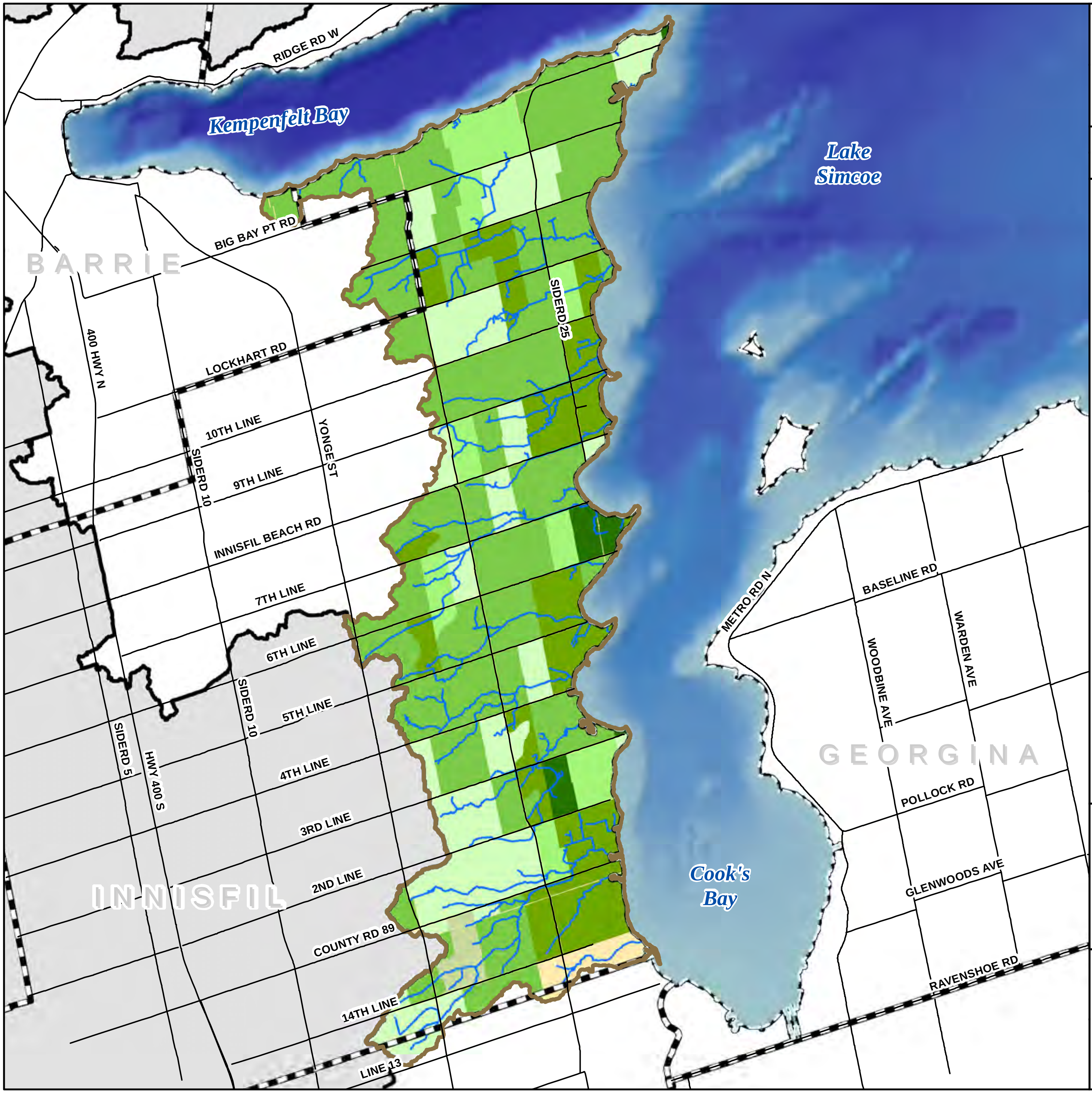
Of these factors there is increasing scientific evidence to show that the total woodland cover of a landscape may exert the most important influence on biodiversity. Obviously, the loss of woodland cover results in a direct loss of habitat of that type. This reduction in habitat can result in proportionally smaller population sizes, and animals in habitat remnants may experience altered dispersal rates, decreased rates of survival, decreased productivity, altered foraging behaviours, and decreased mating opportunities (Fahrig, 2003). Research that has examined the independent effects of habitat loss and habitat fragmentation suggests that habitat loss has a greater effect than habitat fragmentation on the distribution and abundance of birds (Fahrig, 2002) and there is now substantive evidence that total woodland cover is a critical metric (e.g., Austen *et al*., 2001; Golet 2001; Fahrig 2002; Lindenmayer *et al*., 2002; Trzcinski *et al*., 1999; Friesen *et al*., 1998, 1999; Rosenburg *et al*., 1999; Radford *et al*., 2005).

Prior to European settlement the dominant land cover type of Southern Ontario was woodland. Estimates of total pre-settlement woodland cover in Simcoe County, including this subwatershed was 83% (Larson *et al*., 1999). The distribution of this woodland cover, as indicated by notes collected during the first survey of this area is shown in Figure 6-2. By 1955 this had decreased to 32.4%, then increased to 40.2% by 1978 (Larson *et al*., 1999). As of 2009, woodland cover in the Innisfil Creeks subwatershed was 25.7% (Table 6-1).

The Lake Simcoe Protection Plan sets a target of the retention of a minimum of 40% high quality natural vegetative cover in the entire Lake Simcoe watershed, which would include forest, native grassland, and non-forest wetland ecosystems. Clearly, this amount of natural cover cannot be achieved uniformly throughout the watershed, as development pressures are distributed unevenly throughout the watershed. LSRCA's Integrated Watershed Management Plan allows for uneven distribution of woodland cover, while still setting a target of a minimum of 25% forest cover within each of Lake Simcoe's subwatersheds. Forest cover within the Innisfil Creeks subwatershed plan meets this target set by the Integrated Watershed Management Plan, and contributes substantially to meeting the subsequent, and higher, target set by the LSPP.

Pre-settlement vegetation in the Innisfil Creeks subwatershed

Figure 6-2



Legend

Road

Municipal Boundary

Watercourse

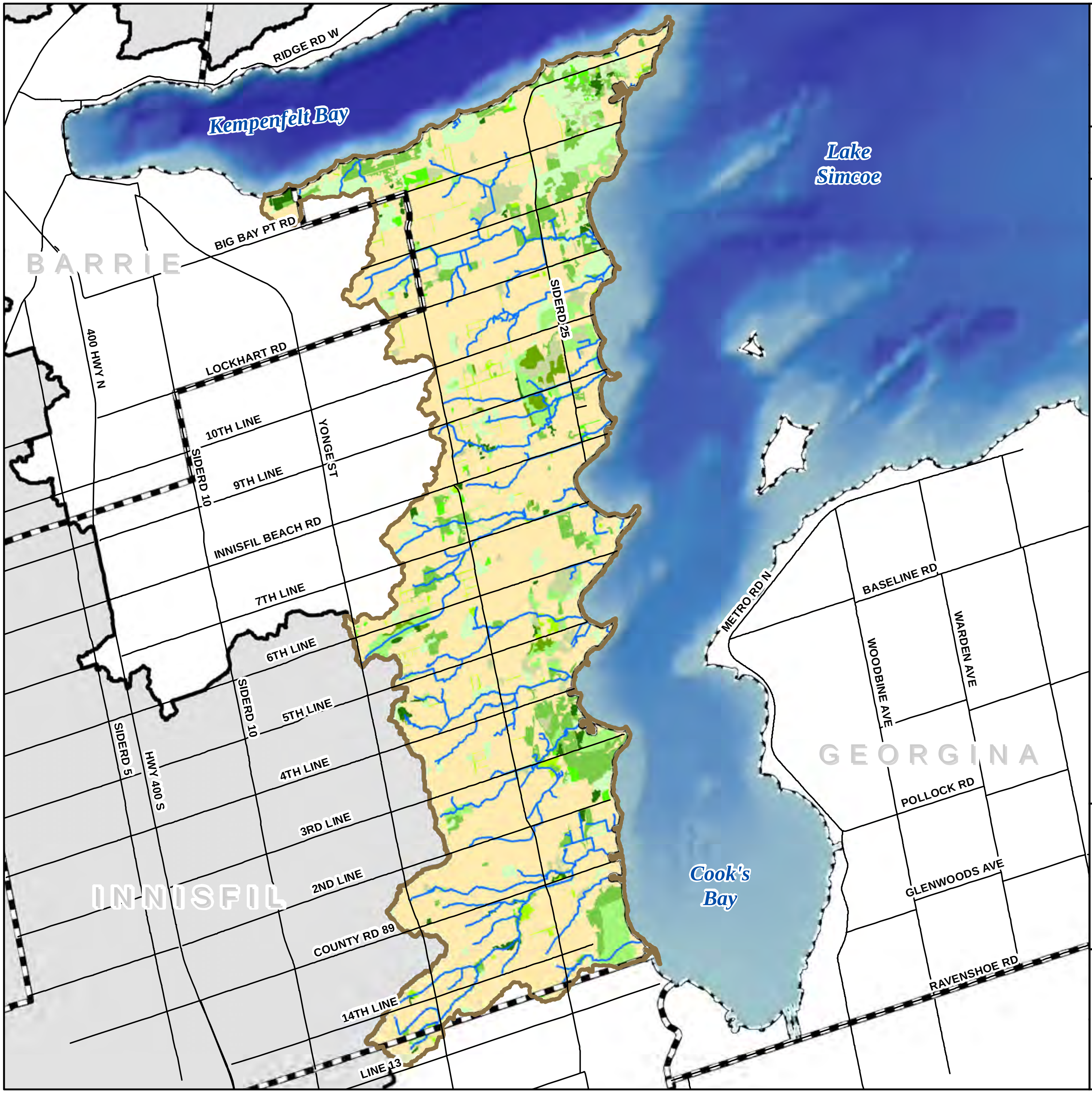
Woodland Type

- Coniferous Forest
- Coniferous Swamp
- Cultural Plantation
- Cultural Woodland
- Deciduous Forest
- Deciduous Swamp
- Mixed Forest
- Mixed Swamp

Lake Simcoe Region conservation authority

Woodland types in the Innisfil Creeks subwatershed.

Figure 6-3



Legend

- Road
- Municipal Boundary
- Watercourse

Woodland Type

- 🟩 Coniferous Forest
- 🟩 Coniferous Swamp
- 🟩 Cultural Plantation
- 🟩 Cultural Woodland
- 🟩 Deciduous Forest
- 🟩 Deciduous Swamp
- 🟩 Mixed Forest
- 🟩 Mixed Swamp

Lake Simcoe Region conservation authority

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Table 6-1: Woodland cover types in the Innisfil Creeks subwatershed.

Woodland Type		Woodland Cover	
		Area (ha)	Area (%)
Upland forest	Cultural Plantation (CUP)	66.6	0.6
	Cultural Woodland (CUW)	122.3	1.1
	Conifer Forest (FOC)	110.0	1.0
	Deciduous Forest (FOD)	824.9	7.7
	Mixed Forest (FOM)	708.0	6.6
Swamp forest	Conifer Swamp (SWC)	76.4	0.7
	Deciduous Swamp (SWD)	360.6	3.4
	Mixed Swamp (SWM)	480.3	4.5
Total upland forest		**1831.8**	**17.1**
Total forest (including both upland and swamp)		**2749.1**	**25.7**
Target (LSPP)[1]		**4286.0**	**40**
Target (LSRCA IWMP)[2]		**2678.75**	**25**

The most common forest types in this subwatershed are deciduous and mixed forests, which are typically found on well drained sandy or loamy sites. Deciduous forests are widespread in this subwatershed, and can be found in a variety of topographic positions. Mixed forests are typically found on the edges of deciduous forests, in swamps, or in areas with a slight topographic slope. It is these slightly cooler microclimatic conditions that allow for the establishment of coniferous trees. As these forests tend to be relatively large, they provide habitat for a range of area-sensitive species such as ovenbird (*Seiurus aurocapillus*), winter wren (*Troglodytes troglodytes*), and wood thrush (*Hylocichla mustelina*) (Bird Studies Canada *et al.*, 2008).

Less common are coniferous forests (including plantations) and coniferous swamps, which account for only 9% of the total woodland in this subwatershed. Coniferous forests can be found on well drained sandy or loamy sites, similar to deciduous forests, but tend to be associated with north facing slopes. Coniferous swamps are typically found in low lying and imperfectly drained sites. The dominance of conifer trees in these woodland types provides habitat for conifer loving species such as red-breasted nuthatch (*Sitta canadensis*), white-breasted nuthatch (*Sitta carolinensis*), and black-capped chickadees (*Poecile atricapillus*) (Bird Studies Canada *et al.*, 2008).

Structural diversity of habitat is a key driver of biodiversity. In woodlands, habitat niches can range from microhabitats such as the surfaces of fissured trunks, leaves and rotting logs to macrohabitat features such as the horizontal layers within the woodland (e.g., supercanopy, canopy, subcanopy). In addition, woodlands are present in a wide variety of topographic settings and soil and moisture regimes. For all of these reasons it is not surprising that many woodland species are obligates (i.e., they are only found in woodlands), or that woodlands

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[1] The Lake Simcoe Protection Plan sets a target of 40% high quality natural vegetative cover (which includes, but is not restricted to, woodlands) for the entire Lake Simcoe watershed

[2] LSRCA's Integrated Watershed Management Plan recommends a target of 25% woodland cover per subwatershed

provide habitat for a wide range of flora and fauna. They form important building blocks of the natural heritage system.

The summary statistics reflecting the percentage of the watershed under forested cover cannot address these more detailed issues related to the diversity and ecological integrity of individual forest patches. These issues relate typically to factors such as forest size, forest age, proximity to other natural areas, topographic heterogeneity, and structural diversity within the forest. Policy 6.48 of the LSPP requires the MNR (in collaboration with the LSRCA, First Nations and Métis communities) to map and identify `high quality` natural areas in the Lake Simcoe watershed. When this policy has been developed and the mapping is completed, more could be said about the distribution of these site-specific quality measures in this study area.

Although the total extent of forest cover in a subwatershed is the primary driver for many forest-dependent ecological processes, some species are also sensitive to the size of remnant forest patches (Robbins *et al.*, 1989; Lee *et al.*, 2002), the amount of 'interior' forest habitat (Burke and Nol, 1998a; Burke and Nol, 2000), and the proximity or connectivity between remnant forest patches (Nupp and Swihart, 2000).

Contiguous woodland areas have been calculated and the distribution of woodland patch sizes is displayed in Figure 6-4. While the total area of woodland represents the amount of forest completely within the subwatershed, the number of patches also includes any patches touching the subwatershed boundary. This methodology was used to avoid underestimating the number of large patches.

Beyond issues of habitat size however, is the issue of amount of interior habitat available. Many species and ecological functions have been shown to be influenced by forest edges, a symptom known as 'edge effect'. These effects can extend up to 20 m into the woodlot for climatic factors such as light, temperature, moisture levels and wind speed (Burke and Nol, 1998b), up to 40 m for the prevalence of non-forest plant species (Matlack, 1994), and 100m or greater for the rate of predation on nesting birds (Burke and Nol, 2000). Although this research has typically been interpreted such that 100m becomes the rule of thumb for differentiating between 'edge' and 'interior' forest habitats, more recent research (Falk *et al.*, 2010) suggests that the impacts of edge effect on predation rates and nest survival in forest-dwelling songbirds may extend over 300m into woodlots.

The bulk of the forest area in the Innisfil Creeks subwatershed is found in large forest blocks (i.e. larger than 10ha) (Figure 6-3, Figure 6-4), including three that are larger than 100 ha in size. There is also a substantial amount of core habitat (defined by that relatively conservative measure of 100m), including one forest which has over 70ha of this 'core' habitat. The three largest areas of woodland that contribute to the bulk of this cover include the mixed swamp at the south end of the subwatershed which forms the northern margin of the Provincially Significant Holland Marsh wetland complex, the large mixed forest at DeGrassi Point, and the large forest complex near Big Bay Point. This last feature is a combination of deciduous and mixed forests, with scattered inclusions of swamp (Figure 6-3).

Despite this prevalence of large forests, 209 of the total 253 woodland patches (i.e. 83%) in the Innisfil Creeks subwatershed are relatively small (<10 ha), representing 27% of the total woodlot cover in this subwatershed (Figure 6-4).

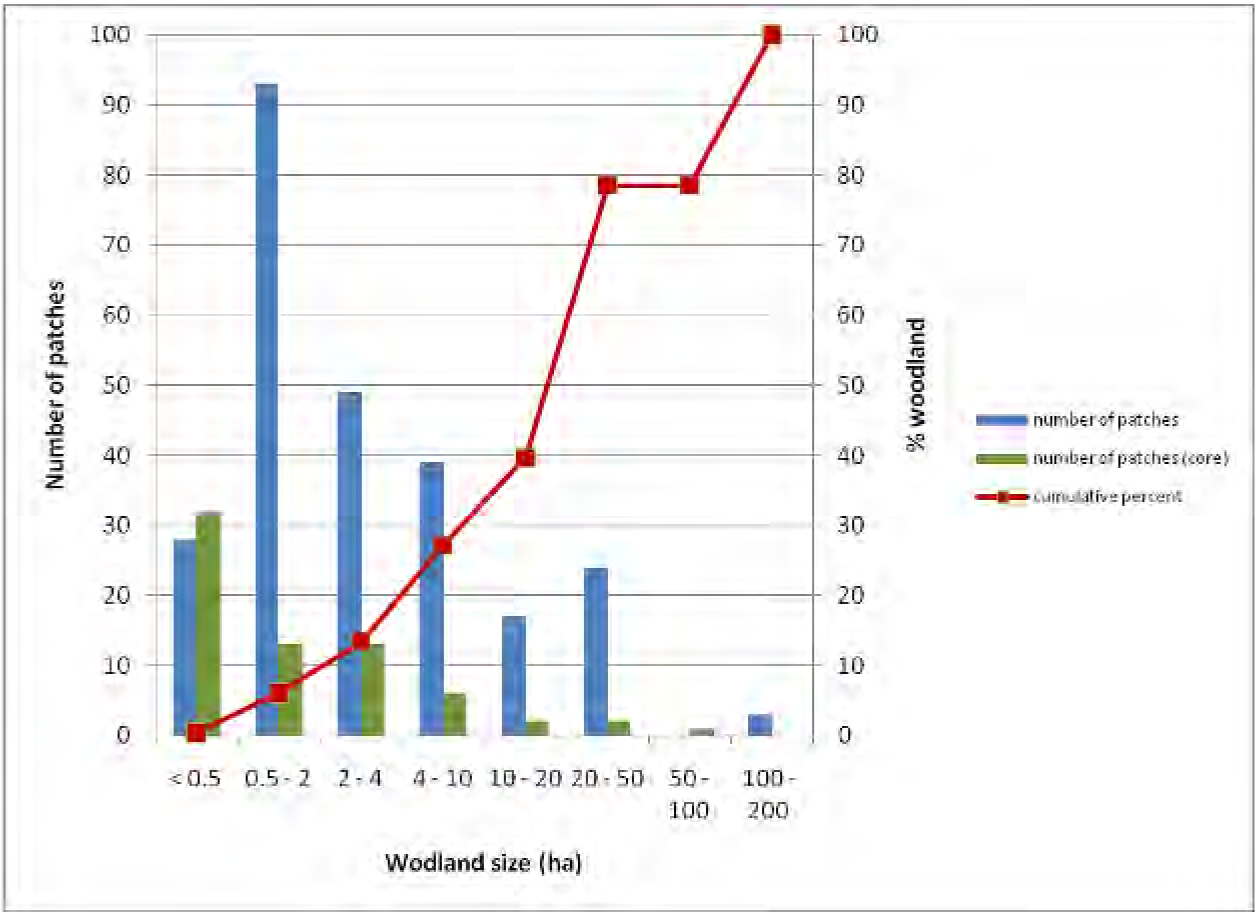


Figure 6-4: **Woodland patch size distribution in the Innisfil Creeks subwatershed.**

Despite the recent evidence of the importance of total forest area for the preservation of wildlife, the importance of maintaining connectivity between woodlands should not be overlooked. Some forest-dwelling species, particularly small mammals, amphibians, and plants, require contiguous forested habitat to allow them to move from one habitat patch to another. Species which are unable to disperse in this way are vulnerable to local extinction, caused by factors such as inbreeding depression, disease epidemic, or mere chance.

6.2.2 Wetlands

The Provincial Policy Statement defines wetlands as lands that are seasonally or permanently covered by shallow water, as well as lands where the water table is close to or at the surface. In either case the presence of abundant water has caused the formation of hydric soils and has favoured the dominance of either hydrophytic or water tolerant plants. The four major types of wetlands are swamps, marshes, bogs and fens.

Wetlands provide numerous functions for an ecosystem. These include (OMNR, 2010):

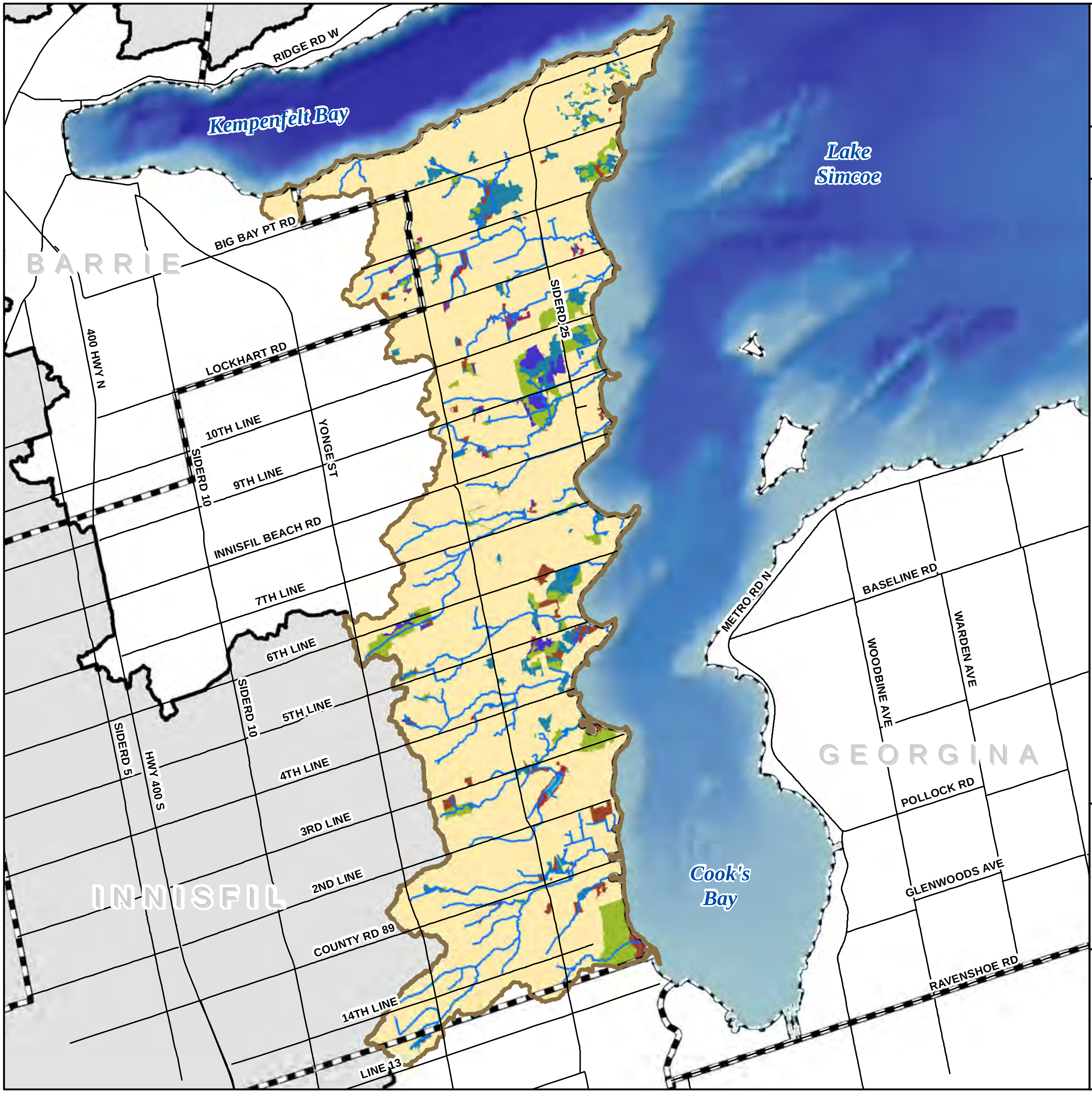
- **Natural water filtration:** by removing contaminants, suspended particles, and excessive nutrients, wetlands improve water quality and renew water supplies

- **Habitat:** wetlands provide nesting, feeding and staging ground for several species of waterfowl and other wildlife including reptiles and amphibians, as well as spawning habitat for fish
- **Natural shoreline protection:** these vegetated areas protect shorelines from erosion
- **Natural flood control:** by providing a reservoir, wetlands help to control and reduce flooding through water storage and retention
- **Contribution to natural cycles:** wetlands provide a source of oxygen and water vapour, thus playing a role in the natural atmospheric and climatic cycles
- **Opportunities for recreation:** these include hiking, birdwatching, fishing, and hunting

In its ‘How Much Habitat Is Enough?’ guidelines (2004), Environment Canada recommends that at least 10% of a watershed be in wetland cover, and that these wetlands should be well dispersed through the area. Subwatersheds that meet these characteristics experience greatly reduced flood frequencies, and more stable base flow. The additional benefits of wetland cover, listed above, are also maintained. In addition, improvements to water quality have been found when wetlands occupy more than 18% of a given watershed, and amphibian and fish communities are more persistent when wetlands occupy more than 30% and 50% of the total watershed area respectively (Detenbeck *et al.*, 1993; Gibbs, 1998; Brazner *et al.*, 2004). Although the Lake Simcoe Protection Plan does not set a quantitative target for wetland cover within the watershed, it identifies the “protection of wetlands” as a target, implying no further loss of wetland beyond that in existence when the LSPP came into force.

It has been estimated that, prior to European settlement, 11.2% of Innisfil, and 2.6% of Barrie were wetlands (DUC, 2010). Wetlands were lost as settlement occurred, reducing their relative cover to 5.6% and 0.7% of Innisfil and Barrie respectively by 1982. Since 1982, wetland loss has slowed considerably (DUC, 2010), presumably as a result of protection measures provided by the Provincial Policy Statement, Conservation Authority regulations, and other mechanisms, although it still occurs at an average rate of 1.5 and 0.5 ha per year in Innisfil and Barrie respectively (DUC, 2010). It should be noted that the Ducks Unlimited study derives their estimates of wetland distribution from soil maps, and underestimates the current extent of wetlands. Thus, they may also underestimate the amount of wetland lost since the time of settlement.

According to data available from the MNR and LSRCA (current as of 2009), there are 1202.8ha of wetland remaining in the Innisfil Creeks subwatershed (Figure 6-5, Table 6-2).



Wetland types in the Innisfil Creeks subwatershed.

Figure 6-5

Legend

— Road

Municipal Boundary

Watercourse

Wetland Type

- Coniferous Swamp
- Deciduous Swamp
- Floating-leaved Shallow Aquatic
- Meadow Marsh
- Mixed Shallow Aquatic
- Mixed Swamp
- Shallow Marsh
- Submerged Shallow Aquatic
- Thicket Swamp

Lake Simcoe Region
conservation authority

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Kilometres

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Table 6-2: Distribution of wetland types in the Innisfil Creeks subwatershed.

Wetland type	Wetland Cover	
	Area (ha)	Area (%)
Meadow marsh (MAM)	42.5	0.4
Shallow marsh (MAS)	47.1	0.4
Floating leaved shallow aquatic (SAF)	0.3	0.003
Mixed shallow aquatic (SAM)	6.5	0.06
Submerged shallow aquatic (SAS)	13.2	0.1
Coniferous swamp (SWC)	76.4	0.7
Deciduous swamp (SWD)	360.6	3.4
Mixed swamp (SWM)	480.3	4.5
Thicket swamp (SWT)	165.3	1.5
Other*	10.7	0.2
Total marsh	**109.6**	**1.0**
Total swamp	**1082.6**	**10.1**
Total	**1202.8**	**11.3**

* ‘Other’ are areas mapped by MNR as being wetlands, but which have not been classified as a wetland community by LSRCA’s Ecological Land Classification map

Like forests, wetland size and proximity to other natural areas has a significant influence on some wildlife species and ecological functions (e.g. Detenbeck *et al*, 1993; Gibbs 1998; Guadagnin & Maltchik, 2006). Contiguous wetland areas have been calculated and the distribution of wetland patch sizes is displayed in Figure 6-6. While the total area of wetland represents the amount of wetland completely within the subwatershed, the number of patches also includes any patches touching the subwatershed boundary. This methodology was used to avoid underestimating the number of large patches.

There are approximately 1202.8 ha of

What is a Provincially Significant Wetland?

The Ontario Wetland Evaluation System was developed by the Ontario Ministry of Natural Resources (1993). It was implemented in a response to an increasing concern for the need to conserve wetland habitats in Ontario. The wetland evaluation system aims to evaluate the value or importance of a wetland based on a scoring system where four principal components each worth 250 points make a total of 1000 possible points.

The four principal components that are considered in a wetland evaluation are the biological, social, hydrological, and special features. Wetlands which score 600 or more total points (or 200 points in the biological or special feature components) are classified as being Provincially Significant. The Province of Ontario, under the Provincial Policy Statement (PPS) protects wetlands that rank as Provincially Significant. The PPS states that *“Development and site alteration shall not be permitted in significant wetlands.”*

wetland in the Innisfil Creeks subwatershed, or approximately 11.3% of the landscape. Wetland types in this subwatershed include large blocks of deciduous and mixed swamp near the lakeshore, in the relatively flat and fine grained mineral soils laid down by glacial Lake Algonquin, and in the headwaters of Banks and Wilson Creeks, and scattered narrow riparian marshes in the mid reaches of many of the creeks (Figure 6-5). Wetland patches in this subwatershed include a few large examples, and many medium and small ones, with each size class contributing roughly equally to the total wetland cover in this subwatershed (Figure 6-6).

There are four wetlands designated as “Provincially Significant” in this subwatershed: the Leonard’s Beach Swamp (a complex of mixed and deciduous swamp near Leonard’s Beach), the Little Cedar Point wetland (which is a complex of several wetland types near Belle Ewart), the Wilson Creek Marsh (which is a mix of swamp and marsh near the mouth of Wilson Creek), and the northern edge of the much larger Holland Marsh Wetland complex (Table 6-3).

Table 6-3: Status of wetlands in the Innisfil Creeks subwatershed.

Status	Wetland Cover	
	Area (ha)	Area (%)
Provincially Significant Wetlands (PSWs)	521.7	4.9
Evaluated Non-Provincially Significant Wetlands*	0	0
Additional wetlands identified using Ecological Land Classification (ELC)	681.1	6.4
Total	**1202.8**	**11.3**

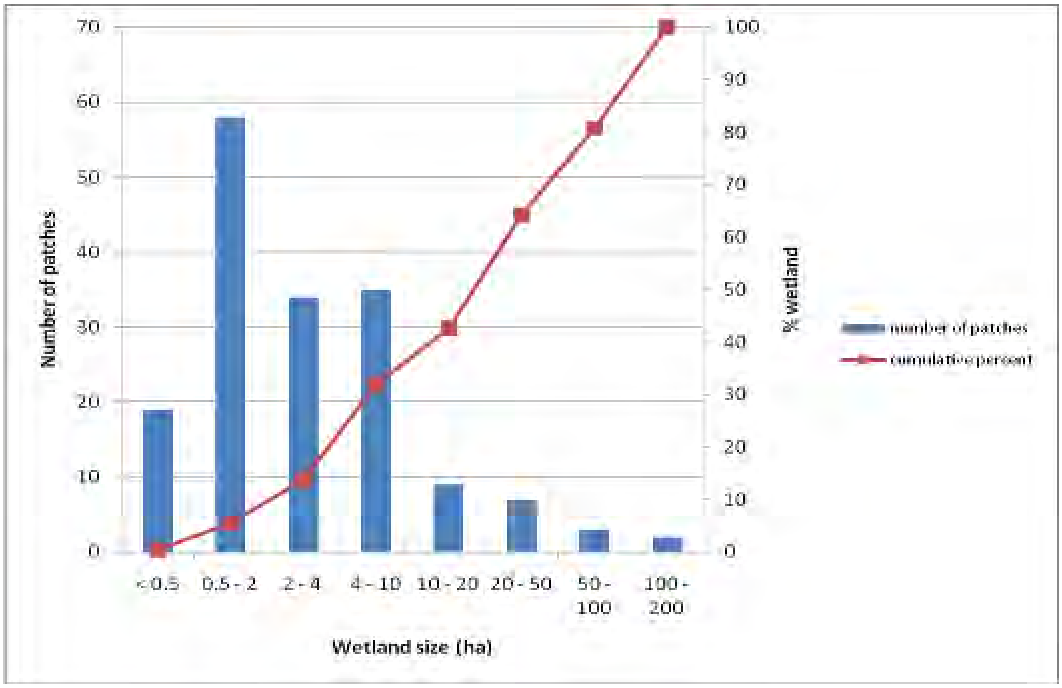


Figure 6-6: Wetland patch size distribution in the Innisfil Creeks subwatershed.

Again, like woodlands, the physical connections between individual wetland patches are extremely important for some species. In the case of wetlands specifically, many species of turtles, frogs, and salamanders require both upland and wetland habitat to meet the needs of their breeding cycle. Preserving these species in a rural-urban landscape like that of the Innisfil Creeks subwatershed requires both habitat types, as well as the physical connectivity between them, be protected.

6.2.3 Valleylands

A valleyland is a natural depression in the landscape that is often, but not always, associated with a river or stream. Valleylands are an important part of the framework of a watershed as the landscape is generally a mosaic of valleylands and tablelands.

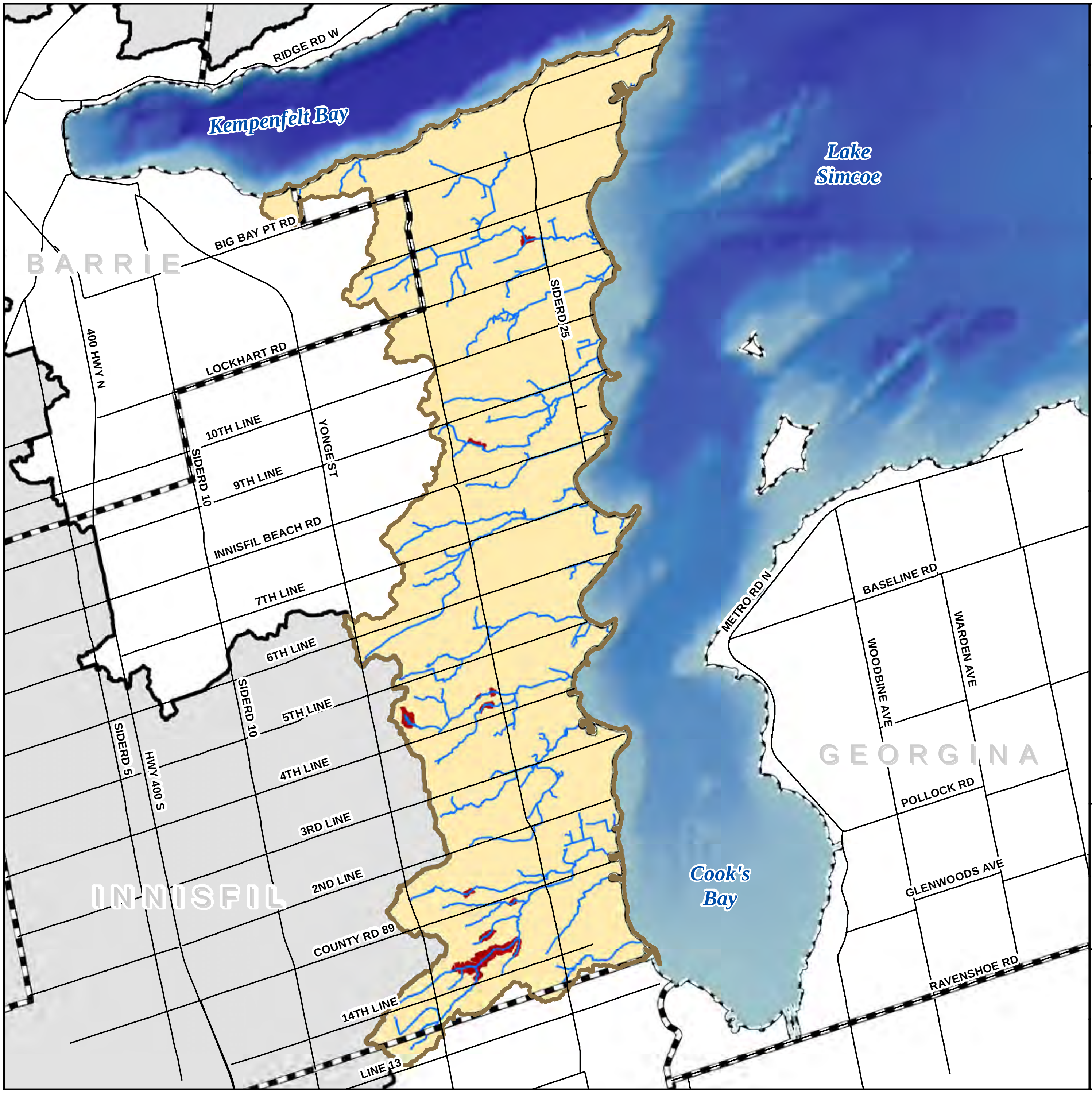
Valleylands provide numerous functions for an ecosystem. These include (OMNR, 2010):

- **Ecological Values:** dispersal and migration of wildlife, microclimate for plant communities
- **Hydrological Values:** movement of surface water, ground water discharge areas, transport of sediment and nutrients, often associated with floodplains
- **Cultural values:** location of aboriginal travel routes, influence current development patterns

There are approximately 98.3 hectares within the Innisfil Creeks subwatershed that meet the definition of valleyland under the draft definitions of Key Natural Heritage Features (MNR, 2011) (Figure 6-7), of which 47.5 ha (or 48.3% is forested). The largest extent of forested ravines in this subwatershed occur in the mid reaches of White Birch Creek, and the headwaters and mid reaches of Carson Creek. Valleylands which aren't forested are either currently under row crop, or had been managed under row crop agriculture, but have since been abandoned and are starting to revert to old field or thicket type communities.

Key valleyland features in the Innisfil Creeks subwatershed.

Figure 6-7



Legend

- ─ Road
- ▬ Municipal Boundary
- 〰 Watercourse
- 🟥 Valleyland

Lake Simcoe Region conservation authority

0 0.5 1 2 3 4 5

Kilometres

N

6.2.4 Riparian and shoreline habitat

The term riparian refers to the area of land adjacent to a stream, river, or lake. These areas provide important fish and wildlife habitats, such as natural linkages among different habitat features that create critically important wildlife migration corridors (Environment Canada, 2004).

Riparian vegetation contributes to ecological function within a watershed in a number of ways:

- The flow of stormwater is slowed, causing sediment to be deposited on land rather than in the river or stream
- The slower moving stormwater has increased opportunity for infiltration into the groundwater, replenishing aquifers and helping to maintain baseflow
- The roots of the plants absorb some of the contaminants contained in stormwater, preventing them from reaching the waterway
- Erosion of the streambank is prevented, as the roots help to keep the soil in place
- Vegetation provides shade, helping to maintain cool stream temperatures
- Falling debris (branches, leaves) from the riparian vegetation provide food and shelter for benthic invertebrates and fish
- The linear nature of these features are extremely important to migrating birds and other terrestrial wildlife travelling throughout the watershed
- The seasonally flooded to hydric nature of most riparian areas provide habitat to specialized plant communities that may not be found elsewhere in the watershed

The Lake Simcoe Integrated Watershed Management Plan (LSRCA, 2008) aspires to have all streams within the watershed naturally vegetated, with a 30 metre buffer containing natural vegetation on either side of the watercourse. Although the Lake Simcoe Protection Plan does not specify a quantitative target, it sets a target of “naturalized riparian areas on Lake Simcoe and along streams”, referring at a minimum to a 30 m width along watercourses and the Lake Simcoe shoreline. The Innisfil Creeks subwatershed is approximately halfway towards that goal, with 49.7% of the 30m riparian zone existing under natural cover (Table 6-4, Figure 6-9).

The second most common land use within the 30m buffer of Innisfil Creeks watercourses is agriculture. As distance increases away from the watercourse, natural heritage cover decreases and agriculture increases, indicative of effort made to preserve natural vegetation along watercourses in this subwatershed. Both low and high intensity development remains constant with distance from the watercourse (Figure 6-8).

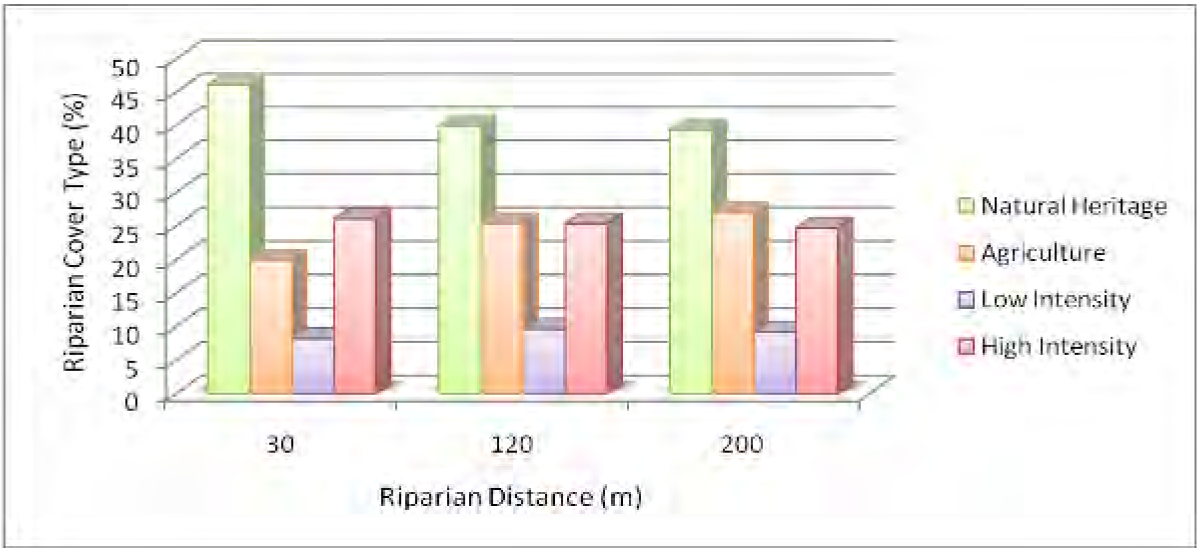


Figure 6-8: Riparian cover percentage per buffer distance.

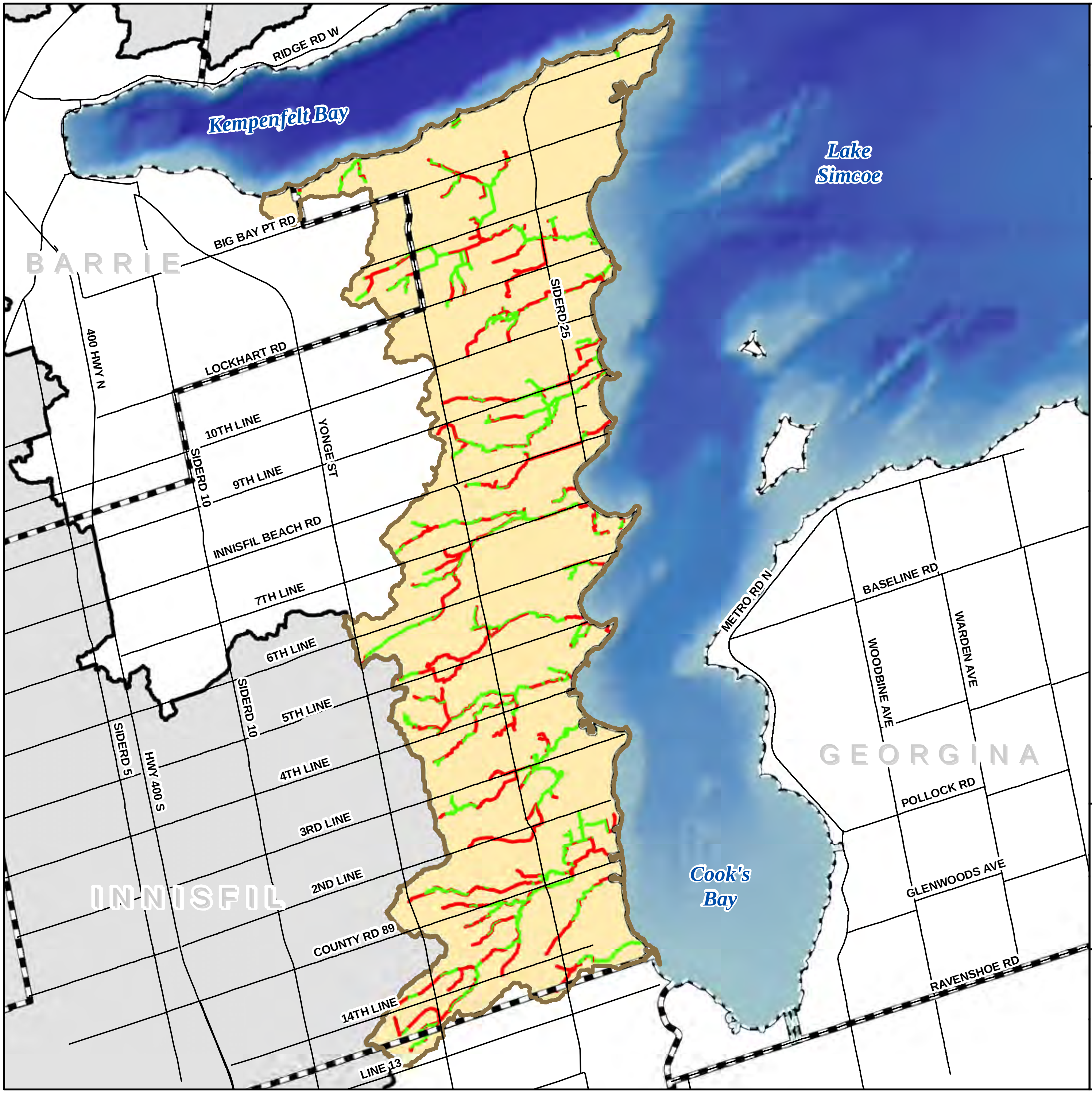
Although neither the Lake Simcoe Protection Plan nor the Lake Simcoe Integrated Watershed Management Plan identify a quantitative target for natural cover along the Lake Simcoe shoreline, the LSPP identifies "no further loss of natural shorelines" as a management target. As of 2009, only 17.7% of the Lake Simcoe shoreline in this subwatershed remained under natural cover.

Table 6-4: Extent of natural vegetation along riparian areas in the Innisfil Creeks subwatershed.

Type of riparian zone	Riparian zone characteristics	
	Length (km)	Natural vegetation cover (%)
Stream banks	149.1	49.7
Lake Simcoe shoreline	46.6	17.7
Both	**195.7**	**45.0**

Riparian and shoreline habitat in the Innisfil Creeks subwatershed.

Figure 6-9



Legend

— Road

▬ Municipal Boundary

Riparian

🟩 Natural Vegetation

🟥 No Vegetation

Lake Simcoe Region conservation authority

0 0.5 1 2 3 4 5 Kilometres

N

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6.2.5 Areas of Natural and Scientific Interest

To encourage the protection of unique natural heritage features and landscapes in southern Ontario, the Ontario Ministry of Natural Resources developed the provincial Areas of Natural and Scientific Interest (ANSI) program.

There are two types of ANSIs, life science and earth science. Life science ANSIs are based on biological and ecological characteristics. Earth science ANSIs are based on geological landform characteristics.

The selection criteria used by the MNR to define ANSIs are:

1. Representation;
2. Diversity;
3. Condition;
4. Ecological function; and
5. Special features.

Candidate sites of each of a list of landform types within each ecodistrict are evaluated and ranked using the criteria above. Those scoring the highest are deemed to be the 'best' example of that landform type in that ecodistrict, and are classified as a Provincially Significant ANSI, and are protected under the Provincial Policy Statement. Candidates with the second highest score are identified as a Regionally Significant ANSI, and are afforded protection in some parts of the province.

There are two life science ANSIs in this subwatershed: a portion of the Holland River Marsh, and the entire DeGrassi Point Prairie Relict (Table 6-5).

The DeGrassi Point Prairie Relict is located in the vicinity of one of the largest forest complexes in the subwatershed. This tallgrass prairie fragment is a relict of a series of such small prairies on the Native portage route between Lake Ontario and the Georgian Bay (Reznicek, 1983). When rediscovered in the early 1970s it consisted of a 1.6 ha open prairie dominated by Indian grass (*Sorghastrum nutans*), and little bluestem (*Schizachyrium scoparium*), surrounded by a stand of red oak and white pine. In recent years, the owners have been quite active about restoring the prairie, through the use of controlled burns. Unfortunately, dog-strangling vine (*Cynanchum rossicum*) has become an extremely invasive at this site, limiting their success in restoration.

The Holland River Marsh is located in the extreme south east corner of this subwatershed, and forms part of one of the largest woodland and wetland features in this subwatershed. The entire ANSI, which also occurs in the East Holland and West Holland subwatersheds, is a large complex formed of fen, marsh, and swamp communities. The portion of the ANSI that occurs in the Innisfil Creeks subwatershed is a mixed swamp on the slightly higher and drier northern margin of the wetland.

Table 6-5: ANSIs found in the Innisfil Creeks subwatershed.

ANSI Name	Significance Level	Status	Life Science/ Earth Science	Total Area (ha)	Area in watershed (ha)
DeGrassi Point Prairie Relict	Provincial	Confirmed	Life	30.9	30.9
Holland River Marsh	Provincial	Confirmed	Life	2412.1	172.1

6.2.6 Species of conservation concern

The frequency of occurrence of all native species of plants, mammals, birds, amphibians, reptiles, and fish in Ontario have been documented by the Ministry of Natural Resources using a series of S-ranks (or Sub-national ranks). Those designated as being provincially rare (i.e. ranked S1-S3) are those which are typically considered as being of 'conservation concern.' Other species may be further protected by designation as being Endangered, Threatened, or of Special Concern under the Federal *Species at Risk* Act or Provincial *Endangered Species Act*.

Species of conservation concern in the Innisfil Creeks subwatershed include:

- Yellow-rattle (*Rhinanthus minor*; S3), a semi-parasitic plant that takes its name from its dry fruit which contains loose seeds, sounding like a rattle when shaken;
- Butternut (*Juglans cinerea*; Endangered) a relatively common tree in the Lake Simcoe watershed which has been heavily impacted by a fungal disease which typically kills the trees as they reach maturity;
- Red-headed woodpecker (*Melanerpes erythrocephalus*; Special Concern) a cavity dweller that is dependent on relatively open savannah-like habitats;
- Chimney swift (*Chaetura pelagica*; Threatened) a bird which nests in unused chimneys, church steeples and other structures;
- Canada warbler (*Wilsonia canadensis*; Special Concern), a bird of dense forests, including early successional forests and swamps;
- Common nighthawk (*Chordeiles minor*; Special Concern), bobolink (*Dolichonyx oryzivorus*; Threatened), and whip-poor-will (*Caprimulgus vociferus*; Threatened) all of which require grassland habitats;
- Snapping turtles (*Chelydra serpentina*; S3; Special Concern) which inhabit large wetlands;
- Blandings turtle (*Emydoidea blandingii*; S3; Threatened), a turtle of shallow weedy ponds;
- Milksnake (*Lampropeltis triangulum;* S3; Special Concern) which, although difficult to find, exist in a wide variety of habitats, and;
- Monarch butterfly (*Danaus plexippus;* Special Concern) a species which is vulnerable to extinction due to its need to migrate to Mexico during the winter months.

6.2.7 Grasslands

In addition to these rare and at-risk species, are rare ecosystems. There is one documented tallgrass prairie remnant in the Innisfil Creeks subwatershed, near DeGrassi Point, dominated by Indian grass (*Sorghastrum nutans*), and little bluestem (*Schizachyrium scoparium*) and which is currently home to eastern meadowlark (*Sturnella magna*; recommended by COSEWIC, not yet listed) (Bird Studies Canada *et al*, 2008). Historic records provide a more detailed plant list of this remnant, including 21 plant species which are rare in the Lake Simcoe watershed, and two which are provincially rare (Ecologistics, 1982; Reznicek, 1983).

Even grasslands dominated by non-native plants (i.e. hayfields or old-field ecosystems) can be home to a number of at-risk species including monarch butterflies, bobolinks, and eastern meadowlark. In fact, grassland-dependent wildlife is experiencing significant population declines in Ontario (McCracken, 2005). There are a number of grasslands scattered throughout this subwatershed, including abandoned agricultural land in ravines near the headwaters, and early successional and old-field type ecosystems adjacent to wetlands or woodlands. In all, documented grasslands represent 5.2% of the Innisfil Creek subwatershed (Figure 6-1, Table 6-6). In addition to the species of conservation concern listed above, other birds inhabiting grasslands in the Innisfil Creeks subwatershed include savannah sparrow (*Passerculus sandwichensis*), vesper sparrow (*Pooecetes gramineus*), common yellowthroat (*Geothlypis trichas*), gray catbird (*Dumetella carolinensis*) and indigo bunting (*Passerina cyanea*) (Bird Studies Canada *et al.*, 2008).

Table 6-6: Distribution of grassland types in the Innisfil Creeks subwatershed.

Grassland type	Grassland Cover	
	Area (ha)	Area (%)
Cultural meadow (CUM)	179.2	1.7
Cultural thicket (CUT)	371.2	3.5
Open tallgrass prairie (TPO)	2.9	0.03
Total	**553.3**	**5.2**

Key Points - Current Terrestrial Natural Heritage Status:

- Natural heritage features represent approximately 33% of the Innisfil Creeks subwatershed. This includes 17.1% of upland forest, 11.3% wetland, and 5.2% grassland
- Natural cover remains along 49.7% of the inland streams and 17.7% of the lakeshore in this subwatershed
- Some of the most significant natural areas in this subwatershed include the Holland Marsh wetland complex (the northern margin of which is within this subwatershed), the forest and prairie complex at DeGrassi Point, and the large forest and wetland complex at Big Bay Point
- The natural heritage component of the assessments of these subwatersheds is relatively data-poor, particularly as it relates to the distribution of flora and fauna throughout the subwatershed

6.3 Factors impacting natural heritage status – stressors

There are numerous factors that can affect terrestrial natural heritage features. They range from natural factors such as floods, fires, and droughts; to human influences, such as land use conversion, water use, the introduction of invasive species, and climate change. Natural factors are generally localized and short in duration, and a natural system is generally able to recover within a relatively short period. Some degree of natural disturbance is often a part of the life cycle of natural systems. Conversely, human influences are generally much more permanent – a forest can not regenerate after it has been urbanized, natural communities have a great deal of difficulty recovering from the introduction of an invasive species, and wetlands may be unable to survive when their water source has been drawn down.

6.3.1 Land use change

Prior to European settlement, the Innisfil Creeks subwatershed was almost entirely covered by upland and wetland forest (Larson *et al.*, 1999; DUC, 2010). The loss of natural habitat and its conversion to agriculture and urban land use began almost immediately upon European settlement, and has been ongoing. This habitat conversion represents the single most significant threat to terrestrial natural heritage features in this subwatershed. By the mid 1950s, roughly two-thirds of the original forest cover had been lost, and converted to agricultural and urban land uses. Since the 1950s, the amount of natural habitat in this subwatershed has changed little, however there has been a gradual increase in urban, and decrease in rural, land uses (Figure 2-2).

Natural heritage features within settlement areas are those most susceptible to land use change, as these areas are experiencing the greatest relative growth pressure, and aren't subject to the higher level of protection provided by policies under the Lake Simcoe Protection Plan. As much of the Lake Simcoe shoreline in Innisfil has been designated settlement area (Figure 2-8), it has the potential to experience some of the greatest growth pressures in this subwatershed.

Notwithstanding the above, the greatest change expected in this subwatershed will be a significant shift from agricultural land uses to more intensive land uses including residential, commercial, and industrial. Thus, the greatest impacts to natural heritage features may be indirect in nature, through changes to the landscape matrix within which extant natural heritage features are situated.

Forests in urban settings are subject to stresses that forests in more rural or agricultural settings aren't, including an increase in predator pressure from house cats and racoons, increased noise levels, increased light pollution, increased levels of ground level ozone, and an increased density of invasive non-native species. As a result, forest-dwelling songbirds and amphibians living in primarily urban landscapes tend to be much less common, and restricted from smaller forests, than those living in primarily rural landscapes (Austen *et al.*, 2001; Homan *et al.*, 2004).

Similarly, wetland-dependent wildlife face additional challenges in primarily urban landscapes. As natural areas are converted to farmland, amphibians make increasing use of irrigation ponds as replacement breeding habitat for lost wetlands, making these ponds critical wildlife habitat in some regions (Hecnar and M'Closkey, 1998). As landscapes convert to urban land uses, amphibians make similar shifts to storm water ponds. However, storm water ponds in many cases can be detrimental to amphibian populations, particularly if they are hypoxic, are surrounded by unsuitable upland habitat, are located near roads, or have high concentrations of petrochemicals. In those cases, storm water ponds can act to suppress amphibian populations beyond the suppression caused by wetland habitat loss alone (Hamer and McDonnell, 2008).

Both Barrie and Innisfil have been identified as `growth centres` under the Provincial Growth Plan for the Greater Golden Horseshoe (OMI, 2012). As such, they have been designated to receive an increase in population of 74,300 (55%) and 23,000 (69%) respectively over the next 20 years (OMI, 2012). As this development proceeds, the stresses associated with the loss and fragmentation of natural habitat will only continue.

6.3.2 Habitat fragmentation

The conversion of natural vegetation to other land uses is perhaps the most obvious stress related to land use change, but the perforation or fragmentation of extant natural areas can be a significant stress as well. One issue of particular concern in urban or suburban areas is the encroachment of estate residential development into forests, and the related decline in forest interior conditions. In some parts of North America, exurban development (also known as estate residential development or non-farm rural land use) is becoming a significant proportion of all development. Many people prefer to locate their houses in or near natural heritage features for the aesthetic appeal, the privacy, and the access to outdoor recreational opportunities. As demonstrated in Figure 6-10, this type of development not only reduces the amount of habitat on the landscape, but can have disproportionate effects on interior forest habitat (i.e. that area more than 100 m from a forest edge).

Example loss of forest interior resulting from estate residential development

Figure 6-10

Legend

🟥 Estate Residential

▨ Woodlands

▨ Interior Forest

Lake Simcoe Region
conservation authority

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This map has been produced for illustrative purposes only.
LSRCA GIS Services DRAFT DC created August 2011.

Based upon studies of birds and mammals, it has been found that this type of development increases habitat that supports human-adapted species at the expense of more sensitive species (Odell and Knight, 2001). Findings by Friesen (1998) found that that the number of houses surrounding a forest undermined its suitability for Neotropical migrants. These species consistently decreased in diversity and abundance as the level of adjacent development increased. Similarly, non-native vegetation is much more common in woodlots near exurban development than in woodlots in more rural or forested landscapes (Hansen *et al.*, 2005).

In the Lake Simcoe watershed as a whole, this type of development has a significant impact on interior forest habitat, with an estimated loss of about 8% of this highly productive wildlife habitat to estate residential development (LSRCA, 2008). A similar pattern is seen in the Innisfil Creeks subwatershed, where approximately 6.5% of the potential interior forest habitat has been lost to estate residential development (Table 6-7).

Table 6-7: Cumulative impact of estate residential development in the Innisfil Creeks subwatershed.

Woodland type	Woodland Cover	
	Pre-estate residential (ha)	Current (ha)
Woodland	1839.2	1831.9
Woodland interior	243.8	228.1

6.3.3 Shoreline development

The Lake Simcoe shoreline has long been a draw for cottage and housing development, but this type of development has impacts on native species and habitats as well. The impacts of shoreline development on fish and aquatic habitats (as described in **Chapter 5 – Aquatic Natural Heritage**) is perhaps best documented, but the clearing of vegetation along shorelines has also been associated with a decline in native songbirds (Clark *et al.*, 1984; Henning and Remsburg 2009), amphibians (Henning and Remsburg 2009), and small mammals (Racey and Euler, 1982), and an increase in non-native species.

Currently, only 17.7% of the shoreline along the Innisfil Creeks subwatershed remains under natural vegetative cover (Table 6-4). This is particularly concerning, as this subwatershed has one of the greatest extents of shoreline of any of Lake Simcoe's subwatersheds (representing nearly one-fifth of the total lakeshore).

Furthermore, the Simcoe County soil map identifies much of the east shore of the Innisfil Creeks subwatershed as being underlain by imperfectly to poorly drained fine-grained mineral soils, which suggests that, before settlement, much of this area was probably composed of wetlands, a suggestion which is also confirmed by reports of early surveyors (Figure 6-2). These wetlands presumably would have had substantial hydrological and natural heritage influences on the Lake, including influences to nutrient cycling, flood regimes, wildlife habitat and food resources for offshore fisheries.

6.3.4 Road development

In addition to the loss and fragmentation of habitat associated with land use change, the development and use of roads can have impacts on natural heritage values as well. Roads can have significant impacts on wildlife communities and the ability of wildlife to move throughout their home ranges. Direct mortality of animals related to roads can be particularly significant for species such as frogs, turtles and salamanders, which are relatively slow moving but need to travel from wetland to upland areas to fulfil the requirements of their breeding cycle (Fahrig and Rytwinski, 2009). Even more mobile animals such as mammals (Findlay and Houlahan, 1997) and birds (Kociolek *et al.*, 2011) can be subject to increased mortality along roads. A preliminary assessment of the risks to wildlife associated with road mortality suggests that many of the roads that bisect forests and wetlands along the Innisfil Creeks lakeshore are associated with a heightened risk of road mortality.

In addition to the direct impacts associated with mortality, roads can decrease the value of adjacent natural areas as breeding habitat, by increasing noise levels and increasing illumination at night (Kociolek *et al.*, 2011), and by acting as a source of chloride or petrochemicals to amphibian breeding ponds (Fahrig and Rytwinski, 2009). Conversely, some scavenger species such as American crows and red-tailed hawks respond positively to the presence of roads, as roads provide a consistent food source for them. Research in the United States and Europe suggests that this 'road effect zone' can extend for hundreds of metres from roads (Forman and Deblinger, 2000). If this is true, the roughly 1 km grid of concession roads in the Innisfil Creeks subwatershed may be impacting all remnant natural heritage areas.

Road development proposed as part of the development in Big Bay Point (as shown on Schedule C of the Innisfil Official Plan) may have substantial impacts to wildlife. This forest is among the largest in the subwatershed, and is composed of a mix of upland and wetland compartments. Amphibians and turtles migrating between these two habitat types are particularly susceptible to road mortality. As part of the development process though, the proponent has been required to identify mitigation measures to protect amphibians, including aligning a proposed collector road to avoid amphibian breeding habitat.

6.3.5 Changes to hydrologic regime

Although the current status of, and stressors on, surface water hydrology are dealt with more fully in **Chapter 4 – Water Quantity**, changes to the hydrological regime in the subwatershed can have impacts on the extent and quality of natural heritage features as well, particularly wetland and riparian ecosystems. These ecosystems and their associated vegetation are dependent upon natural variations in hydrologic conditions such as baseflow rates, seasonal flooding and drainage. Any alteration to the hydrologic regime can lead to loss or changes in the condition of these ecosystem types. Factors leading to changes in hydrologic regime include loss of upland and wetland natural heritage features, and their conversion to impervious cover. This relationship is discussed more fully in **Chapter 4 – Water Quantity**.

Perhaps less obvious, but also important from a natural heritage standpoint, is the introduction of agricultural drains, particularly in remnant natural heritage features. When agricultural drains are introduced to swamps or mesic forests, the water table drops. This lowering of the water table changes the infiltration rate of surface water; in some cases, enough to change the hydroperiod of vernal pools. These small shallow and temporary water bodies are critical breeding habitat for a range of frog and salamander species, as well as stopover habitat for migratory waterfowl. In some areas, the lowering of the water table caused by agricultural drains causes the vernal pools to dry up more quickly, exposing the eggs and tadpoles.

As soil moisture is a major determining factor for the presence or absence of many plant species, lowering the water table can also have significant impacts on plant communities in remnant natural areas. Further, in areas with relatively high levels of residential development such as this subwatershed, many of the plants which colonize rapidly changing areas such as this are non-natives.

There are a number of municipal drains that bisect, and may impact, wetlands in the Innisfil Creeks subwatershed, including the Big Bay Point drain, the Redfern drain, and the 9th Line drain (Figure 5-8).

6.3.6 Invasive species

Non-native species can be a significant threat to biodiversity as well. Some species, when in the absence of predators or disease to check the growth of their populations, can become extremely abundant. This is particularly the case with species which aren't native to North America. Many of these species, when introduced as garden plants or house pets, or inadvertently through international shipping, can become extremely aggressive invasives. The most aggressive of these can reduce biodiversity – by outcompeting native species for food (e.g. red-eared slider), breeding habitat (e.g. house sparrow), sunlight (e.g. dog-strangling vine), or through direct consumption (e.g. emerald ash borer).

Documentation of terrestrial invasive species in this subwatershed is currently limited to:

- Purple loosestrife (*Lythrum salicaria*), a escaped cultivated species which has become widespread in wetlands, and is suspected of decreasing the diversity of native wetland plants
- European starling (*Sturnus vulgaris*), initially released into the wild in Central Park, this species has spread across North America, and outcompetes native species for nesting cavities;
- House sparrow (*Passer domesticus*), another species of European bird introduced to North America by early settlers, and has since become widespread, and;

This short list is no doubt reflective more of a lack of documentation than a lack of invasive species in this subwatershed. The Lake Simcoe Protection Plan recommends the development and implementation of a monitoring program which will document the presence and extent of terrestrial invasive species in the Lake Simcoe watershed. This monitoring program has the potential to make significant contributions to filling this data gap.

The Lake Simcoe Protection Plan has also developed a 'watch list' of invasive species which are not yet in the Lake Simcoe watershed, but which, if they do appear here, are expected to have significant negative impacts on natural areas. Terrestrial species on that list are: kudzu (*Pueraria lobata*), emerald ash borer (*Agrilus planipennis*), Asian long-horned beetle (*Anoplophora glabripennis*), chronic wasting disease, oak wilt, and white nose syndrome.

Within five years of the release of the LSPP (i.e. 2014), the MNR is to develop response plans to address invasive species in the watershed, and those on the watch list.

6.3.7 Trophic cascades

Land use changes can not only affect wildlife populations directly through the loss or disturbance of habitat, they can also be affected indirectly as significant decreases or increases in populations of one species affect species elsewhere in the food web, through processes known as "trophic cascades."

An example of such a trophic cascade is the decrease in songbirds that has been observed as top carnivore populations decrease (Crooks and Soulé, 1999). This trophic cascade occurred because the loss of top predators (in that case coyotes), allowed populations of mid-level predators such as housecats, skunks, and racoons to increase. Although these species aren't at the top of the food chain, they are extremely effective predators, so an increase in their populations led to a significant decline in the populations of their prey (in that case, songbirds). Similar trophic cascades have been observed in wildflowers, nesting songbirds, butterflies, and other invertebrates, by high levels of selective grazing of woodland vegetation as populations of white-tailed deer increase (Cote *et al.*, 2004).

A similar trophic cascade that has recently come to light in Ontario is the decline of songbirds that feed on flying insects. This group, which includes species as diverse as swifts, swallows, nighthawks, and flycatchers, has seen population declines of up to 70% in the past two decades. Although there are a lot of stresses facing these species, the only attribute they share that best explains their concurrent decline is their reliance on flying insects such as bees, wasps, butterflies and moths as a food source. There are a number of factors contributing to the decline of these insects, including light pollution, loss of wetlands and other natural vegetation, declines in water quality, climate change, and increased use of insecticides in urban and rural settings (McCracken, 2008).

6.3.8 Recreation

Despite the social values related to outdoor recreation, if these activities are not properly managed, recreation itself can become a stressor on natural heritage features. Impacts from recreational activities can include increased soil erosion (e.g. Marion and Cole, 1996), destruction of vegetation (Cole, 1995), introduction of invasive species (Potito and Beatty, 2005), and disturbance to resident wildlife (Miller *et al.*, 1998). These impacts can be largely mitigated with the appropriate design and location of trails and other recreational features, and the management of recreational users, to ensure that motorized vehicles and off-leash dogs are prohibited from sensitive sites.

As these subwatersheds develop, these types of impacts will no doubt increase, as the combination of larger populations and small lot sizes will tend to increase the numbers of people looking for opportunities for outdoor recreation. Further, as development proceeds, accessible upland natural areas may become even rarer, concentrating this pressure into increasingly rare remnant habitats. As a result, as development proceeds, the need to manage the impacts associated with outdoor recreation will only intensify.

6.3.9 Climate change

Projections suggest that climate change will have significant impacts on terrestrial natural heritage features in the Lake Simcoe watershed. Recent modeling work was completed for the Lake Simcoe watershed, examining the response of tree species to climate change, as influenced through factors such as the current range of the species, its current local abundance, phenology, and seed production (Puric-Mladenovic *et al.*, 2011). As climates change, the model predicts that balsam fir (*Abies balsamea*), red maple (*Acer rubrum*), yellow birch (*Betula alleghaniensis*), and eastern hemlock (*Tsuga canadensis*) will all exhibit slight decreases in their occurrence in the forests of the Innisfil Creeks subwatershed. In fact, the projected shifts in climate may cause some species which are currently relatively widely distributed to become more narrowly restricted to remaining habitat, including red maple becoming restricted to wetlands, as they shift to areas with moister soil, and yellow birch becoming restricted to ravines, as they shift to areas with cooler and moister microclimates. Other species, notably red oak (*Quercus rubra*), are anticipated to become more common as a result of the warming climate.

Modeling results suggest that forests in cooler microclimates in ravines and north facing slopes, which tend to have a relatively high dominance of eastern hemlock, yellow birch, and American beech, may be among the most sensitive ecosystem to the changing climate. Sadly though, the species which the model suggests are the most vulnerable to climate change are those which we think of as being proto-typically Canadian. Both sugar maple (*Acer saccharum*) (Canada's national symbol), and white pine (*Pinus strobus*) (Ontario's provincial tree) are predicted to experience severe declines in the Innisfil Creeks subwatershed (Puric-Mladenovic *et al.*, 2011).

A separate set of models, developed to assess the vulnerability of wetland ecosystems, suggest that a 'worst case' climate change scenario would have catastrophic impacts on wetlands in the Lake Simcoe watershed. The increases in average annual temperature and decreases in average annual precipitation that are projected to occur by the year 2100 are estimated to make 90% of the swamps and 84% of the marshes in the Lake Simcoe watershed vulnerable to drying. As drying occurs, it is expected that marshes would shift in composition to become swamp (or thicket swamp) type communities, and treed swamps would shift to become mesic forests (Chu, 2011).

In sum, these models suggest that there will be a shift in community composition in the natural areas in the Innisfil Creeks subwatershed, and a net loss of tree species diversity. Unfortunately, natural areas lacking in species diversity tend to be more vulnerable to other threats such as insects, disease, and invasive species, suggesting that the impacts seen to terrestrial natural heritage features may become cumulative in nature.

This loss in native tree species diversity may be mitigated somewhat by the ability of species not currently found here to thrive in the expected new climate. Species found in southern Ontario (such as black maple (*Acer nigrum*)) or the southeastern US (such as black hickory (*Carya texana*)) may become relatively common in forests in these subwatersheds, further influencing the shift in plant community composition. However, the fragmented nature of the landscape that these species would need to cross will no doubt limit their ability to colonize forest remnants, without assisted migration (i.e. planting) (Puric-Mladenovic *et al.*, 2011).

Other, less desirable, species may also be able to respond positively to changing climates as well. Some invasive species are projected to experience a northward range expansion (e.g. kudzu (*Pueraria lobata*), an extremely invasive vine), or experience increased growth rates and biomass (e.g. Eurasian water milfoil (*Myriophyllum spicatum*), a widespread invasive aquatic plant) (Sager and Hicks, 2011).

Predicted impacts of climate change on wildlife are less clear. Some authors (e.g. Walpole and Bowman, 2011) suggest that as average annual temperature increases, more species of both birds and mammals will be able to inhabit the Lake Simcoe watershed. Others caution that, for some species, the disadvantages of climate change may outweigh the advantages. For example, wetland-dependent species may suffer significant population declines as wetlands dry up (Chu, 2011). Similarly, although some migratory birds have been able to take advantage of warmer springs and are migrating earlier, other species appear less able to adapt their behaviour to changing temperature and are vulnerable to not being able to find sufficient food resources or suitable nesting sites later in the season (Burke *et al.*, 2011). These relationships may be even more complicated in these subwatersheds however, as the interacting effects of climate change, landscape fragmentation, and urbanization may constrain the ability of wildlife to colonize habitat areas, and to persist within them.

Key Points – Factors Impacting Terrestrial Natural Heritage - stressors

- There are multiple stressors to natural heritage systems in this subwatershed, many of which interact.
- Over the short term, the greatest stress to natural heritage values is expected to be due to changes in land use. This stress can only be expected to increase as the population in this subwatershed increases.
- In addition to the direct loss of natural areas, development is typically associated with an increase in roads (which can cause mortality in wildlife and disturbance to remaining nearby natural areas), an increase in impervious surfaces (which can affect the hydrology of remnant natural areas), and the loss of natural habitat along shoreline and other riparian areas (which tend to be disproportionately important to wildlife).
- Remnant natural areas in heavily settled landscapes typically face more intense stresses as well, including an increase in the number and diversity of invasive species, increased pressure from recreational users, and trophic cascades caused by changes in food webs and other inter-species relationships.
- The emerging threat of climate change will interact with all of these threats, creating additive long-term stresses on natural areas and wildlife populations. Although research in this area is still emerging, initial predictions suggest a loss of wetlands and wetland-dependent species, and a loss of some of our most-loved species of native trees.

6.4 Current Management Framework

Various programs exist to protect and restore terrestrial natural heritage features in the Lake Simcoe watershed, ranging from regulatory mechanisms, to education programs, to funding and technical support provided to private landowners.

Many of these programs already address some of the stresses facing terrestrial natural heritage in the Innisfil Creeks subwatershed, as outlined below.

6.4.1 Protection and policy

6.4.1.1 Land use planning and policy

Several acts, regulations, policies, and plans have shaped the identification and protection of the terrestrial natural heritage of the Innisfil Creeks subwatershed. Those having most impact on natural heritage features are summarized in Table 6-8. This management framework relates to many different stressors that can potentially affect natural heritage, ranging from direct impacts associated with habitat loss and urban development, to stresses such as climate change and invasive species which are more global in nature.

Table 6-8 categorizes eight such stressors, recognizing that many of these activities overlap and that the list is by no means inclusive of all activities. The legal effects of the various Acts, policies, and plans on the stressors is categorized as ‘existing policies in place’, or ‘no applicable policies’. The policies included in the table include those which have legal standing and must be conformed to, or policies (such as some of those under the Lake Simcoe Protection Plan) which call for the development of further management tools, research or education programs

The intent of these regulations, policies and plans are summarized in **Section 1.3 – Current Management Framework**. Readers interested in the details of these regulations, policies and plans are directed to read the original documents.

Table 6-8 : Summary of the current management framework as it relates to the protection of terrestrial natural heritage.

Stressor affecting the protection and restoration of terrestrial natural heritage	Lake Simcoe Protection Plan (2009)	Growth Plan for the Greater Golden Horseshoe (2006)	Provincial Policy Statement (2005)	Endangered Species Act (2008)	LSRCA Watershed Development Policies (2008)	Simcoe County Official Plan (2007)	Town of Innisfil Official Plan (2006)	City of Barrie Official Plan (2009)
Site alteration in upland natural heritage features	🟩 1,4	🟥	🟩	🟩 6	🟩	🟩 2,4	🟩 2,4	🟩 2,4
Site alteration in wetlands	🟩 1,4	🟥	🟩	🟩 6	🟩 4	🟩 4	🟩 4	🟩 4
Shoreline development	🟩 4	🟥	🟩	🟩 6	🟩	🟩	🟩	🟩
Loss of connectivity between natural heritage features	🟩	🟥	🟩	🟥	🟥	🟩	🟩	🟩 8
Impervious areas	🟩	🟥	🟩	🟥	🟩	🟥 7	🟩	🟩
Climate change	🟩	🟥	🟥	🟥	🟥	🟥	🟥	🟥
Introduction of invasive species	🟩 3	🟥	🟥	🟥	🟥	🟥	🟥	🟥
Protection of species of conservation concern	🟩	🟥	🟩 10	🟩 6	🟩 10	🟩 6, 10	🟩 6, 10	🟩 9, 10

🟩 Existing policies in place

🟥 No applicable policies

[1] Regulations specific to those areas outside settlement areas

[2] Development not permitted in wetlands, *significant* forests, *significant* valleylands (e.g. other than wetlands, features not considered significant are not afforded the same protection)

[3] Discusses developing proposed regulations (to be considered by federal government under fisheries act), conducting studies/risk assessments, developing response plans, education programs, but nothing banning use/etc

[4] Includes the feature plus a designated set back (or 'buffer' or 'adjacent lands')

[5] "Species of conservation concern" identified as an indicator, but not defined or regulated

[6] Specific to Endangered and Threatened species

[7] Targets for impervious cover provided for the Oak Ridges Moraine Conservation Plan area, but not the subject area

[8] "Connectivity" not identified, but if identified would be designated as EP

[9] "Rare species including unique plants", plus Endangered and Threatened

[10] In the context of "Significant Wildlife Habitat"

Legislation and policy restrictions are the primary source of protection for natural heritage features in the Lake Simcoe watershed, guided by the fundamental Provincial planning policies as articulated in the Provincial Policy Statement (PPS). However, some stresses are better suited to policy and regulation than others. For example, natural heritage stressors such as climate change and invasive species are hard to regulate; however, stresses associated with the loss of habitat and conversion to residential or industrial land uses are much easier to control and regulate.

Policy tools to deal with those stresses can be found in Provincial policy (such as the PPS or LSPP), municipal official plans and zoning bylaws, and Conservation Authority Regulations. Together, these documents are intended to provide protection to features that are significant both locally and provincially, while providing clarity to private landowners, and accountability to the electorate.

Further to the guidelines provided by the PPS, the LSPP identifies additional targets for the retention of natural heritage features in the Lake Simcoe watershed. Targets which would constrain development or other land use change include: ensuring no further loss of natural shorelines on Lake Simcoe, achieving protection of wetlands, and achieving naturalized riparian areas on Lake Simcoe and along streams.

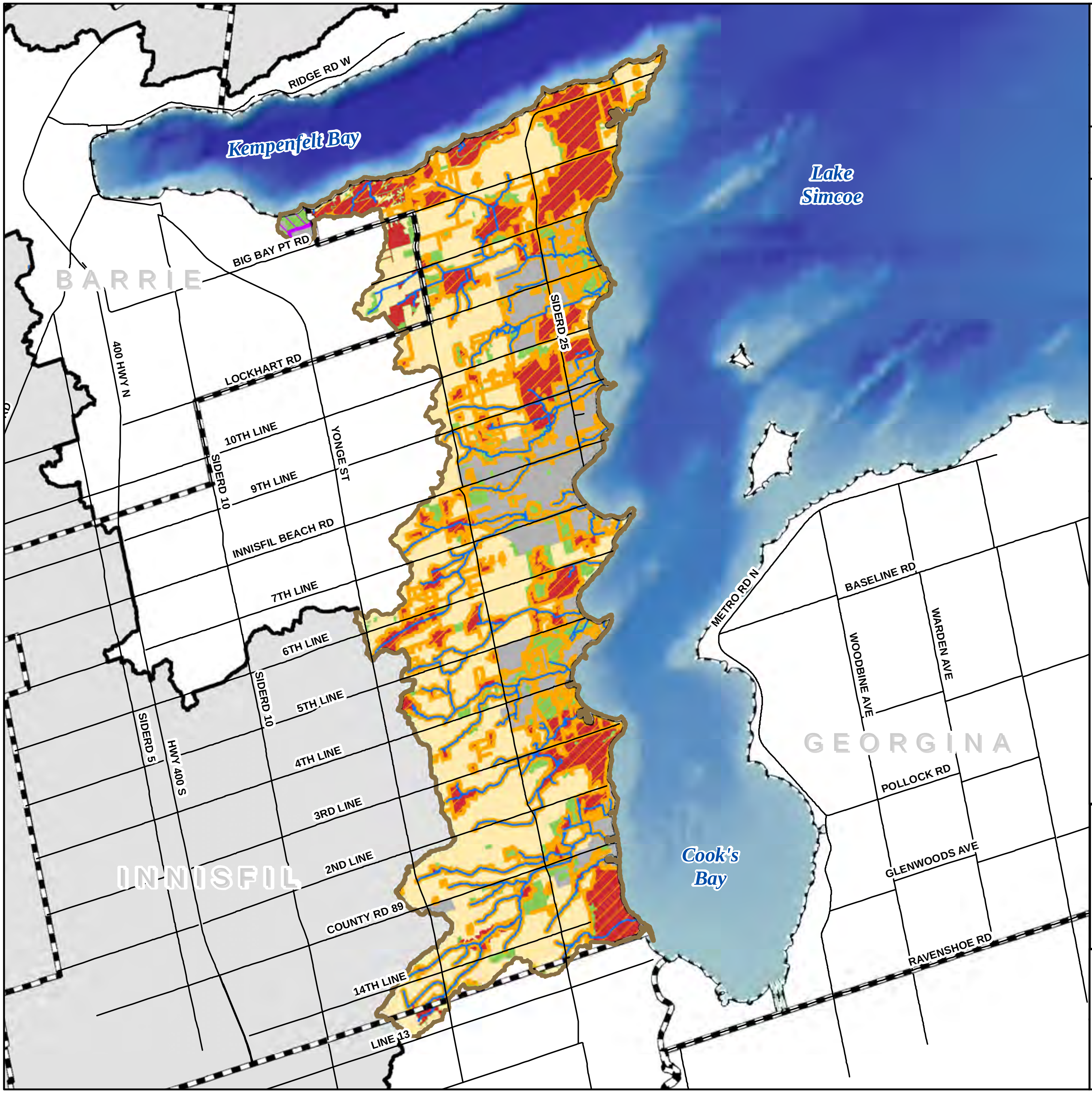
Policies established under the Lake Simcoe Protection Plan will assist in achieving these targets by establishing restrictions to development or site alteration within 100m of the Lake Simcoe shoreline (30m in already built-up areas, subject to a natural heritage evaluation), or within 30m of a key natural heritage feature (i.e. wetlands, significant woodlands, significant valleylands, or natural areas adjacent to Lake Simcoe), with natural heritage evaluations necessary for development proposed within 120m of the feature.

Draft definitions of Key Natural Heritage Features protected by the LSPP include all areas that meet the definition of wetland provided by either the Ontario Wetland Evaluation System or the Ecological Land Classification manual, all woodlands larger than 10 ha in size (or larger than 4 ha in size if they contain late successional tree species more than 100 years old, or are near other Key Natural Heritage Features) and all valleylands that meet specific dimensional requirements (Figure 6-11).

However, the communities of Sandy Cove, Alcona, Lefroy-Belle Ewart, Gilford and Fennell's Corners, as well as the City of Barrie (as described in the 2009 Official Plan) have been designated 'settlement areas' under the Lake Simcoe Protection Plan (Figure 2-8). Policies identified under the Lake Simcoe Protection Plan to protect Key Natural Heritage Features are not applicable within settlement areas, and as such, natural heritage protection policies developed under the municipal official plans and zoning bylaws provide the guidelines on protection of these features within settlement areas.

Preliminary interpretation of Key Natural Heritage Features in the Innisfil Creeks subwatershed

Figure 6-11



Legend

- ▨ Designated by Official Plan (DRAFT)
- ▨ Designated by Official Plan
- 🟥 Key Natural Heritage Features
- 🟩 Natural Heritage
- ■ Settlement Area
- — Road
- ▬ Municipal Boundary
- 〰 Watercourse

Lake Simcoe Region conservation authority

0 0.5 1 2 3 4 5 Kilometres

N

This product was produced by the Lake Simcoe Region Conservation Authority and some information depicted on this map may have been compiled from various sources. While every effort has been made to accurately depict the information, data / mapping errors may exist.
This map has been produced for illustrative purposes only.
LSRCA GIS Services DRAFT created February 2012.

The Town of Innisfil identifies wetlands, ANSIs, valleylands, significant woodlands, significant wildlife habitat, significant habitat of endangered and threatened species, the Lake Simcoe shoreline, and stream corridors as being Environmental Protection Areas under its Official Plan. Development is prohibited in Provincially Significant wetlands or Significant habitat of endangered or threatened species, and development in other Environmental Protection Areas will be subject to an Environmental Impact Statement which must demonstrate that the development will have no negative impacts on the natural feature or its ecological function before development is approved. Thus, the difference between settlement areas and the rest of the Town of Innisfil is that development is restricted, rather than prohibited, in natural heritage features other than Provincially Significant wetlands and habitat of endangered and threatened species.

The City of Barrie has developed a draft Natural Heritage Strategy under their Official Plan, which prohibits development in provincially significant wetlands, habitat of endangered and threatened species, and watercourse and vegetation protection zones. Furthermore, development is prohibited in valleylands, rare vegetation communities, and woodlands larger than 4 ha, unless no negative impact can be demonstrated.

The LSRCA is assisting municipalities in identifying natural heritage systems for inclusion in Official Plan policies with the *Natural Heritage System for the Lake Simcoe Watershed* (Beacon and LSRCA, 2007). This planning tool interprets and applies the Provincial Policy Statement (PPS) to the Lake Simcoe watershed, which when paired with the Natural Heritage Reference Manual (OMNR, 1999), provides comprehensive science-based criteria to identify significant natural heritage features. The *Natural Heritage System* applies these criteria to the Lake Simcoe watershed to provide specific recommendations to LSRCA staff to guide plan review, and to municipalities to assist with Official Plan development.

An additional layer of regulatory control is afforded to wetlands under Ontario Regulation 179/06 (Regulation of development, interference with wetlands and alterations to shorelines and watercourses). Watershed development policies established by LSRCA under that Regulation prohibit development in Provincially Significant wetlands, and restrict development in all other wetlands in the Lake Simcoe watershed.

The end result of these legislation, policy and regulatory restrictions is that 83% of the natural heritage features in the Innisfil Creeks subwatershed has some level of development restrictions applied to them (Table 6-9, Figure 6-11). Remaining exceptions include some small (<10ha) isolated woodlands, and grasslands. Grasslands are difficult ecosystems to protect through policy tools, in part due to the difficulty in mapping those features (and discriminating them from manicured or agricultural lands), due in part to their early successional (and therefore naturally temporary) nature, and the fact that much of the best habitat for grassland-obligate birds and insects occurs on active, though non-intensive, agricultural lands. The City of Barrie has made an attempt to provide some level of protection to grassland habitats in their draft Natural Heritage Strategy, by requiring applicants proposing development in an identified grassland to conduct an Environmental Impact Study prior to any development or site alteration.

Table 6-9: Extent of natural heritage protection policies in the Innisfil Creeks subwatershed.

Natural heritage feature	Natural heritage cover	
	Total existing (ha)	Total with development restrictions (ha)
Upland forests	1831.8	1725.9
Wetlands	1192.1	1192.1
Grasslands	553.3	8.8
Total	**3577.2**	**2926.8**

An assessment of the “extreme-case scenario” for development in these subwatersheds is shown in Figure 6-12. This assessment assumes full build-out in the settlement areas (i.e. all natural heritage features not protected by LSPP, municipal official plan, or Conservation Authority regulation, and all agricultural lands converted to urban land use), and all unprotected natural heritage features outside settlement areas converted to agricultural land use.

This scenario results in a slight increase in the amount of urban land use to support expected population growth in these municipalities, and a slight increase in agricultural land as well. It might be argued that this increase in agricultural land would be necessary to offset farm land lost during build-out of settlement areas, but given the relatively minor contribution that agriculture makes to the local economy (Table 2-4), and our ability to offset lost production with increased agricultural imports, this increase in agricultural land is likely over estimated. This scenario also results in a net loss of natural heritage features in these subwatersheds, to offset these gains in urban and agricultural land use. As mentioned above, natural heritage features vulnerable to development include grasslands and small isolated forests. It should be noted that even under this worst-case scenario, with relatively unrealistic assumptions, existing natural heritage protection policies reduce the loss of existing natural heritage features to a small percentage (Figure 6-12). As such, the greatest impact to natural heritage features in the Innisfil Creeks subwatershed may be those which are more indirect in nature, such as impacts associated with adjacent road traffic, an increase in invasive species, trophic cascades, and other stresses outlined in Sections 6.3.2 to 6.3.9. Unfortunately, these indirect effects are more difficult to control through mechanisms such as municipal Official Plans.

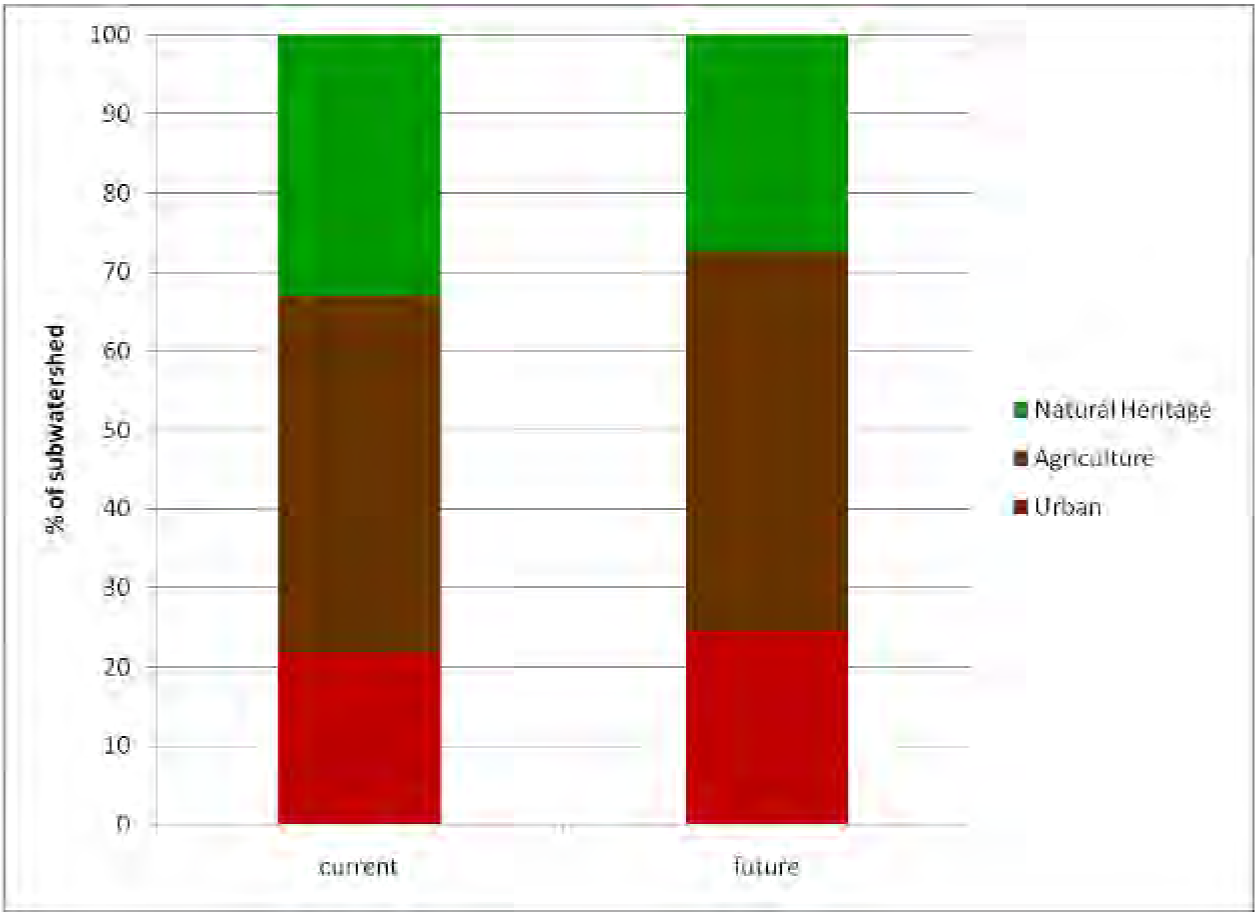


Figure 6-12: Extreme-case scenario of possible land use change in the Innisfil Creeks subwatershed.

6.4.1.2 Acquisition of natural heritage features by public agencies

Several mechanisms exist for the acquisition of natural heritage features by the Lake Simcoe Region Conservation Authority and municipal governments.

The LSRCA has a land securement program which aims to acquire significant natural heritage features in the Lake Simcoe watershed, on a willing buyer – willing seller basis. LSRCA has developed a Natural Heritage System Land Securement Project, which focuses LSRCA's securement efforts by identifying nine land securement priority areas (LSRCA, 2010) which will be actively pursued. One of the priority areas identified in that strategy is the Holland Marsh wetland complex, which extends into the southern extremity of this subwatershed. As described in section 6.2, this wetland complex is one of the largest and most significant natural heritage features in this subwatershed. The LSRCA may also consider receiving donations of relatively large parcels of land elsewhere in the subwatershed, if they meet the criteria of the Conservation Land Tax Incentive Program.

Similarly, Simcoe County has a land acquisition program intended to increase the amount of County Forest holdings. Priority acquisition of land for the County Forest program is given to properties adjacent to existing county forests, and that contribute to both forestry and natural heritage purposes.

The City of Barrie and Town of Innisfil also have parkland dedication targets in their Official Plans. These targets are intended to ensure that as the population grows, opportunities for outdoor recreation grow as well. Although parkland targets are primarily geared towards 'traditional' municipal parks (e.g. soccer fields, baseball diamonds, playgrounds and other manicured greenspace), larger 'regional' parks sometimes include natural heritage features within them. With projected growth in Barrie and Innisfil, by 2031 these municipalities should see an additional 159 ha and 50 ha of 'regional' park established respectively.

6.4.2 Restoration and remediation

There is a range of programs operating in these subwatersheds to assist private landowners in improving the environmental health of their land.

The Landowner Environmental Assistance Program (LEAP) is a partnership between the Lake Simcoe Region Conservation Authority, its member municipalities, and the York, Durham and Simcoe chapters of the Ontario Federation of Agriculture. This program provides technical and financial support to landowners in the Lake Simcoe watershed wanting to undertake stewardship projects on their land. Project types which are funded by the LEAP program include managing manure and other agricultural wastes, decommissioning wells and septic systems, fencing and planting riparian areas, and increasing the amount of wildlife habitat in the watershed, among others. Since 1989, in addition to projects focussed specifically on protecting water quality, LEAP has supported six riparian buffer and five upland tree planting projects in this.

The Ontario Ministries of Natural Resources, Environment, and Agriculture, Food and Rural Affairs provide the Lake Simcoe Community Stewardship Program for non-farm rural landowners in the Lake Simcoe watershed. This program is intended to provide non-farm rural residents with financial and technical assistance in implementing projects such as shoreline stabilization, septic system upgrades, wetland creation, and forest management, among others. In the Innisfil Creeks subwatershed, this program is implemented in partnership with the Dufferin/South Simcoe Land Stewardship Network and the South Simcoe Streams Network. The Lake Simcoe Community Stewardship Program has supported 19 shoreline naturalization projects in the Innisfil Creeks subwatershed thus far.

The Ontario Ministry of Agriculture, Food and Rural Affairs has also partnered with Agriculture and Agri-Food Canada and the Ontario Soil and Crop Improvement Association to provide the Environmental Farm Program to registered farm landowners throughout the province. This farmer-focused program provides funding to landowners who have successfully completed an Environmental Farm Plan for projects including management of riparian areas, wetlands, and woodlands. Through this program, less than five projects that would directly improve terrestrial natural heritage have been implemented in the Town of Innisfil, while none have been completed in the City of Barrie.

In 2008 and 2009, LSRCA field staff surveyed the majority of the watercourses in these subwatersheds, documenting the range of potential stewardship projects that could be implemented to help improve water quality and fish habitat. This survey found over 500 additional places where additional riparian planting could be introduced to the tributaries in this subwatershed.

The forthcoming shoreline management strategy, and wetland and riparian area prioritization exercise, will identify and prioritize stewardship opportunities in this subwatershed, specific to the shoreline and inland riparian and headwater areas respectively.

These ongoing stewardship programs will soon be complemented by a forthcoming Voluntary Action Program. Initially, the Lake Simcoe Protection Plan proposed the development of a regulation to prohibit activities that would adversely affect the ecological health of the Lake Simcoe watershed (policy 6.16). Feedback during the initial rounds of consultation in development of this regulation raised concerns about its enforceability, and the need to educate the public on best management practices before taking a regulatory approach. As a result, the MOE reframed the Shoreline Regulation as a Shoreline Voluntary Action Program.

The Shoreline Voluntary Action Program is intended to increase the extent of native vegetation along shorelines, and reduce the use of phosphate-containing fertilizer in the watershed, through a combination of surveys which are aimed at understanding the current range of public knowledge, attitudes, and practices, and outreach to summer camps, landowners, and garden centres.

Natural Buffer Zone restoration project Bon Secours Creek

This voluntary action program is being run as a two year pilot program, with ongoing monitoring to determine the rate of uptake, impacts on phosphorus levels, and impacts on native vegetation along the shoreline. After the pilot program is complete, these results will be reviewed to determine if a voluntary program is sufficient, or if a regulatory approach is necessary.

6.4.3 Science and research

An ongoing commitment to applied research and science is necessary to improve our understanding of the extent, character, and function of the terrestrial natural heritage features and wildlife within the Lake Simcoe watershed. Applied science and research can include formal scientific studies, citizen scientist-based monitoring programs, and Traditional Ecological Knowledge.

Comparatively less research is being done on terrestrial natural heritage systems, values, and features than is being done on water quality or aquatic habitats, however MNR research scientists are undertaking studies related to characterizing the natural heritage features and ecological processes in the watershed. As with water quality and aquatic research, the Lake Simcoe Science Committee plays a role in reviewing this research and making recommendations to the Minister.

In addition to these specific research projects, the MNR, LSRCA and MOE are developing a terrestrial natural heritage monitoring program which will track the condition of the Lake Simcoe watershed with respect to the targets and indicators set by the Lake Simcoe Protection Plan (and described in Section 6.2). When this data becomes available, and trends become evident, it will help to revise and refine this subwatershed plan at its five year review period.

Ontario, as a Province, is fortunate in that much terrestrial natural heritage monitoring is undertaken by volunteer citizen scientists, which has the potential to complement these other studies. Programs such as the Marsh Monitoring Program, and Breeding Bird Survey coordinated by Bird Studies Canada provide information on long-term trends in wildlife populations throughout Ontario. Unfortunately, neither of these programs have established routes in the Innisfil Creeks subwatershed.

6.5 Management Gaps and Recommendations

As can be seen in the above section, there are a number of programs in place to protect and enhance the natural heritage features in the Innisfil Creeks subwatershed. Despite this strong foundation, there are a number of gaps and limitations in the current management framework that could be improved upon in the future of subwatershed management.

Listed below is an initial 'long list' of recommendations for improving the state of natural heritage values in the Innisfil Creeks subwatershed, for discussion.

It is recognized that many of the undertakings in the following set of recommendations are dependent on funding from all levels of government. Should there be financial constraints, it may affect the ability of the partners to achieve these recommendations. These constraints will be addressed in the implementation phase.

6.5.1 Official Plan conformity

Under Policy 8.4 of the Lake Simcoe Protection Plan, municipalities must amend their official plans to ensure that they are consistent with the recommendations of this subwatershed plan, upon their five-year official plan review.

> **Recommendation 6-1** - That the LSRCA, MOE and MNR assist subwatershed municipalities in ensuring official plans are consistent with the recommendations presented in the Innisfil Creeks subwatershed plan, as approved by the LSRCA Board of Directors. This approval will be subsequent to consultation with municipalities, the subwatershed plan working group, and the general public, as outlined in the *Guidelines for developing subwatershed plans for the Lake Simcoe watershed (May, 2011).*

6.5.2 Revisions in Key Natural Heritage Protection Policies

Policy 6.50 of the LSPP requires the MNR. MOE and LSRCA to establish a monitoring program in relation to the targets and indicators established by that plan for natural heritage and hydrologic features, which includes an indicator related to 'habitat quality'. Although there is currently no site level definition for "high quality" natural vegetation, when this definition becomes available, it has the potential to complement existing natural heritage protection policies in Provincial plans and municipal official plans to ensure that the most high quality natural areas in the Lake Simcoe watershed are protected from incompatible development and site alteration

> **Recommendation 6-3** – That the MNR, MOE, and LSRCA review the terrestrial natural heritage data provided by the comprehensive monitoring program, when it becomes available, to define site level characteristics or indicators of 'high quality' natural heritage features, and provide policy recommendations to subwatershed municipalities (as necessary) to ensure high quality natural heritage features are adequately protected from development and site alteration.

6.5.3 Grassland protection

Grassland habitats are an often overlooked natural heritage feature, and unprotected by natural heritage protection policies. For example, neither the LSPP nor the Provincial Policy Statement accounts for "grasslands" as a type of natural heritage feature. However, as outlined in section

6.2.6, they are disproportionately important for species of conservation concern. Native grasslands are recognized by the Natural Heritage Reference manual, and recommended for inclusion in natural heritage systems designated under municipal official plans as 'rare vegetation communities'. There is one documented tallgrass prairie remnant in this subwatershed near DeGrassi Point.

However, on their own, native grasslands will likely be insufficient to protect grassland dwelling wildlife. There are only three identified native grasslands (i.e. tallgrass prairies or alvars) in the Lake Simcoe watershed, five including the two small remnants listed in the Barrie Creeks, Lovers Creek and Hewitt's Creek Subwatershed Plan. These features are each less than 25 ha in size, and together are less than 30ha in total size. Features this small will be insufficient for the long-term persistence of grassland birds and insects. The protection of non-native grasslands is difficult however, as many of these are abandoned lots or vacant or non-intensive agricultural land, and as such they are often temporary in nature.

The concern in these subwatersheds related to the preservation of habitat for grassland-dependent wildlife is one that is widespread throughout the Province. Within the past year, the bobolink was listed under the Provincial *Endangered Species Act* as being a Threatened species, triggering a protection to its habitat. Because of the conflict that creates with farm operations however, the Provincial government has instituted a three-year exemption for farmers while they study other options for protecting both grassland-dependent birds, and farm businesses

> **Recommendation 6-4 –** That the MNR, MAFRA, LSRCA, subwatershed municipalities, and interested members of the agricultural community review the results of the studies being conducted on methods and policy tools to protect grassland dependent wildlife on active agricultural land as they become available, to determine if they provide solutions for the conservation of grassland habitat which would be applicable for these subwatersheds.
>
> **Recommendation 6-5** – That the City of Barrie and Town of Innisfil, with the assistance of the MNR and LSRCA, give consideration to including policies in their respective Official Plans to contribute to the protection of grassland habitats, as necessary, based on the results of Recommendation #6-6, and recognize the need for balance in the approach to development in urban areas.

6.5.4 Infrastructure as a Key Natural Heritage Feature gap

Infrastructure projects, including roads, sewers, and municipal drains, aren't subject to the Planning Act, and as such are exempt from natural heritage protection policies developed under municipal Official Plans, and are also exempt from natural heritage protection policies under the Lake Simcoe Protection Plan. Protection for natural heritage features with respect to infrastructure projects is provided through the Environmental Assessment process.

> **Recommendation 6-6** – That reviewers of Environmental Assessments for municipal infrastructure in the Lake Simcoe watershed, including subwatershed municipalities, and LSRCA and MOE (when reviewing such documents), give due consideration to the preservation of barrier-free connectivity for wildlife between nearby wetland and upland habitats. This should include due consideration of alternate route configuration, the use of

wildlife crossing structures, and/or the use of traffic calming measures in critical locations.

Recommendation 6-7 – That subwatershed municipalities and the MOE ensure that all Environmental Assessments for municipal infrastructure in the Lake Simcoe watershed give due consideration to the preservation of barrier-free connectivity for wildlife between nearby wetland and upland habitats. This should include due consideration of alternate route configuration, the use of wildlife crossing structures, and/or the use of traffic calming measures in critical locations.

6.5.5 Land securement by public agencies

The protection of a system of natural heritage features by public bodies plays an important role in ensuring the protection of significant and highly vulnerable sites, and in providing natural areas for public use and enjoyment. The provision of publicly-owned natural areas is perhaps particularly important in municipalities with high population densities.

Recommendation 6-8 – That the LSRCA and subwatershed municipalities should continue to secure outstanding natural areas for environmental protection and public benefit, through tools such as land acquisition or conservation easements, and should support the work of Land Trusts doing similar work.

Recommendation 6-9 – That the LSRCA and subwatershed municipalities should continue to refine their land securement decision processes to ensure that they are securing natural areas that are critical to the health of the watershed (or securing and restoring areas which have the potential to become critical to the health of the watershed), but which are otherwise vulnerable to loss through incompatible land uses.

Recommendation 6-10 – That the Federal, Provincial, and Municipal governments provide consistent and sustainable funding to support securement of outstanding natural areas.

6.5.6 Stewardship implementation – increasing uptake

In addition to protecting existing natural heritage features, programs which support the stewardship, restoration, or enhancement of private lands will be critical to meet the targets and objectives of the Lake Simcoe Protection Plan. To that end, programs are provided through partnerships with the Ministry of Natural Resources, Ministry of the Environment, Ministry of Agriculture, Food and Rural Affairs, Ontario Federation of Agriculture, Ontario Soil and Crop Improvement Association, Lake Simcoe Region Conservation Authority, South Simcoe Streams Network and watershed municipalities. Despite this range of players, the uptake of proffered stewardship programs is limited by the number of private landowners who voluntarily participate.

Recommendation 6-11 – That the MNR, MOE, MAFRA, and LSRCA continue to implement stewardship projects in these subwatersheds, and encourage other interested organizations to do the same.

Recommendation 6-12 – That governmental and non-governmental organizations continue to improve coordination of programs to: (1) avoid inefficiencies and unnecessary competition for projects, and: (2) make it easier for landowners to know which organization they should be contacting for a potential project, using tools such as a simple web portal.

Recommendation 6-13 – That the Federal, Provincial, and Municipal governments provide consistent and sustainable funding to ensure continued delivery of stewardship programs.

Recommendation 6-14 – That the MOE, MNR, LSRCA, and other members of the Lake Simcoe Stewardship Network be encouraged to document completed stewardship projects in a common tracking system to allow efficient tracking, coordinating, and reporting of stewardship work accomplished.

Recommendation 6-15 – That the MOE, MNR, MAFRA, LSRCA, and other interested members of the Lake Simcoe Stewardship Network support research to determine barriers limiting uptake of stewardship programs in these subwatersheds and share these results with other members of the Lake Simcoe Stewardship Network, to enable agencies and stakeholders to modify their stewardship programming as relevant. This research should include a review of successful projects to determine what aspects led to their success, and how these may be emulated.

Recommendation 6-16 – That the MOE, MNR, MAFRA, and LSRCA continue to investigate new and innovative ways of reaching target audiences in the local community and engage them in restoration programs and activities (e.g. high school environmental clubs, through Facebook groups, hosting a Lake Simcoe Environment Conference for high schools/science community interaction). The results of these efforts should be shared with the Lake Simcoe Stewardship Network.

6.5.7 Stewardship implementation – prioritize projects

Stewardship programs play an important role in meeting the goals and objectives of the subwatershed plans. However, in order to ensure that they are both effective and efficient, stewardship projects should be selected in the context of the priority needs of the Lake Simcoe watershed, and its subwatersheds. An analysis of natural heritage and hydrological priorities, and an assessment of barriers to uptake as listed above, would allow improved targeting of programs to areas of relatively high need.

Recommendation 6-17 – That the MNR, with the assistance of the MOE and LSRCA, develop a spatially-explicit decision support tool to assist in targeting terrestrial stewardship projects in the Lake Simcoe watershed. In the context of the Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatershed, this decision tool should take into account factors including:

- the need to increase natural vegetation cover along the Lake Simcoe shoreline
- protecting and restoring ecologically significant groundwater recharge areas, to help mitigate the expected impacts of climate change
- opportunities to restore lost wetlands, particularly in the east half of the subwatershed, where the topography has minimal slope, and the area is underlain by fine-grained, poorly-drained soils

- opportunities to increase connectivity across the subwatersheds for dispersing flora and fauna
- the potential for non-forested valleylands, particularly in agricultural areas, as features which could improve wildlife connectivity
- the need to protect and restore grassland habitat, particularly rare native grasslands

Recommendation 6-18 – That the members of the Lake Simcoe Stewardship Network be encouraged to build into their projects relevant provisions for the anticipated impacts of climate change, such as the need to recommend species which are suitable for future climate conditions, and the possibility of an increase in invasive plants, pests, and diseases which may further limit the success of traditional stewardship approaches.

6.5.8 Dealing with indirect impacts

Despite the gaps in existing natural heritage protection policies as noted above, 79% of current natural heritage features in the Innisfil Creeks subwatershed have some level of protection from development or site alteration. As such, the greatest impacts to natural heritage values in this subwatershed in coming years may be indirect, rather than direct, in nature. Forests in urban areas are typically under more stress from invasive species, feral cats, unmanaged recreation, and indirect impacts associated with nearby roads.

Recommendation 6-19 – That the LSRCA, County of Simcoe, City of Barrie, and Town of Innisfil conduct natural heritage inventories, and develop and implement management plans for publicly accessible natural areas that they own, to mitigate potential threats related to invasive species and increased recreation pressure.

Recommendation 6-20 – That the MOE and its partners provide outreach to garden centres, landscapers, and garden clubs regarding the danger of using invasive species in ornamental gardens.

Recommendation 6-21 – That the City of Barrie, the Town of Innisfil and the County of Simcoe, with support from LSRCA, make information available to residents on the impact of human activities on natural areas. Priority issues include the dangers of invasive species, the importance of keeping pets under control, and the importance of staying on trails while in natural areas.

6.5.9 Filling data gaps

Our understanding of the status and pressures related to terrestrial natural heritage features and processes in the Lake Simcoe watershed is relatively limited. Policy 6.50 of the LSPP requires the MNR, LSRCA and MOE to develop a monitoring program for natural heritage features and values in the Lake Simcoe watershed which should contribute significantly to addressing this data gap. This monitoring program could be complemented by the following recommendations to more fully fill data gaps.

Recommendation 6-22 – That the MNR, with the assistance of LSRCA and MOE, complement the proposed monitoring strategy with standardized surveys of the distribution and abundance of terrestrial species at risk throughout the Lake Simcoe watershed.

Recommendation 6-23 – That the MNR, LSRCA, and MAFRA continue to maintain an up-to-date seamless land cover map for the watershed, as defined by the LSPP, with natural heritage features classified using Ecological Land Classification, managed in such a way as to allow change analysis.

Recommendation 6-24 – That the MNR and LSRCA take advantage of data that is already available, by developing a biodiversity database that can collate information reported in EIS and EA reports, information reported in natural area inventories, plot-based data collected in the watershed-wide Vegetation Survey Protocol that is underway, plot-based data collected by citizen-scientists for the Breeding Bird Atlas, and other data as may be available.

Recommendation 6-25 – That the MNR, with the assistance of the LSRCA, take advantage of this soon-to-be compiled data, and develop lists of watershed-rare taxa, and policies to support their protection.

6.5.10 Improving data management

The forthcoming monitoring program identified by the LSPP has the potential to exponentially increase the amount of data on the extent and condition of natural heritage values and features in the Lake Simcoe watershed. However, the number of government agencies contributing to, and utilizing, this database will make data management a significant challenge.

Recommendation 6-26 – That the MNR, LSRCA, and MOE develop a framework to allow effective and efficient management and sharing of data before implementing the comprehensive monitoring program. This framework may include the designation of one agency as the curator of all monitoring data collected in the Lake Simcoe watershed.

6.5.11 Terrestrial Natural Heritage Research Needs

The Lake Simcoe watershed, including the Innisfil Creeks subwatershed, is one of the most rapidly urbanizing watersheds in Ontario. Although there is a substantial suite of policies in place to protect existing natural heritage features from development and site alteration, the effects on those features resulting from intensified development in the surrounding landscape is less well understood.

Recommendation 6-27 – That the Lake Simcoe Science Committee, other levels of government, and academia support research to better understand the stresses to wildlife and wildlife habitat associated with urban development, to allow management responses to be refined. Important questions of interest include: the use of stormwater ponds as amphibian breeding habitat, the importance of remnant natural areas to quality of life for local residents, the indirect impacts of roads on resident and migratory wildlife, and the impacts of high density and low density development on wildlife communities in natural areas. This research may include literature reviews, analysis of data available through the monitoring program, or original, innovative, peer-reviewed research.

7 Integration and Implementation

7.1 Introduction

This subwatershed plan has been developed with technical chapters arranged thematically, to allow us to examine each theme in detail, and to allow this document to address the specific issues identified in Lake Simcoe Protection Plan. This integration chapter, however, is intended to highlight the interactions between water quantity, water quality, terrestrial ecosystems, and aquatic ecosystems, and to describe some of the natural processes supporting biodiversity and watershed health in the Innisfil Creeks subwatersheds. An understanding of how these factors interact is important to gain a full understanding of the watershed ecosystem, and to design conservation programs which are both effective and cost-efficient. To help build this understanding, this chapter examines how some of the key points highlighted in Chapters 3 to 6 interact, through the use of conceptual diagrams. Conceptual diagrams are useful tools which can synthesize complex, detailed information, in a form that is attractive and informative. Conceptual diagrams are 'thought drawings' that provide representations of ecosystems or watersheds, and highlight key attributes and interactions, in a form that is readily understandable by a wide range of audiences (Longstaff *et al*., 2010).

7.2 Groundwater interactions - land cover, groundwater, and aquatic habitats

The amount of precipitation that infiltrates through the soil to contribute to groundwater depends on the permeability of the soil. Groundwater recharge is most significant in areas with coarse highly permeable soils such as sandy or gravelly sites on heights of land, and is often found in the headwaters of watersheds. In the case of the Innisfil Creeks subwatershed, the height of land along its western boundary, as well as the south shore of Kempenfelt Bay, provides significant groundwater recharge (Figure 4-12). When these types of areas are forested, the amount of rainfall that infiltrates into groundwater tends to be greater. Forests promote infiltration by intercepting the rain and reducing the force at which it strikes the soil, and by increasing soil porosity through the actions of root growth and decomposition, and the actions of small mammals and other burrowing wildlife.

The trend in groundwater flow in these subwatersheds parallels that of surface water; from recharge areas in the headwaters, to outflow in Cook's Bay or along the lake shore just north of Cook's Bay. Much of this groundwater flows in either a lower aquifer (a 10-40 m thick layer of coarse sand and gravel deposited in a pre-glacial river channel), an upper aquifer (composed of fine to medium grained sand and gravel near the ground surface, deposited along the shores of glacial Lake Algonquin), or an intermediate aquifer (a 10-30 m deep lens of sandy soils generally lying between the other two, and extending out into Kempenfelt Bay).

This groundwater can be discharged to the surface and become available for use in aquatic or wetland ecosystems, through the process of groundwater discharge. This discharge happens in areas with similarly coarse soil, but where the ground surface lies below the water table, often in depressional areas or in ravines, and can take the form of groundwater seepage or springs. In the Innisfil Creeks subwatershed, many of the river valleys are associated with groundwater discharge from the upper and intermediate aquifers. In such cases, the groundwater discharge makes an important contribution to creek ecosystems, and to riparian wetlands. In fact, many of the wetlands remaining in the Innisfil Creeks subwatershed, including the Provincially Significant Holland Marsh wetland complex and Wilson Creek Marsh, are fed by this groundwater discharge (Figures 4-11 and Figure 6-5). The deep aquifer discharges in Kempenfelt Bay, and (historically) along the lakeshore as well.

This groundwater recharge – discharge relationship can happen over relatively large distances, and is easily overlooked as it happens below ground. While there are only few coldwater stream reaches in the subwatershed, this relationship is a significant link between upland and aquatic features in watersheds, and preserving this relationship is critical to preserving the functioning of surface water features such as watercourses and wetlands.

For some watercourses, particularly small ones, groundwater discharge can be the main contributor to flow during times of limited rainfall. In such cases, the addition of this groundwater obviously plays a role in protecting fish habitat, but even in larger systems, the typically cold discharged groundwater can decrease the temperature of the creek, in some cases maintaining it below the critical temperature needed for healthy reproduction of sensitive species such as brook trout and mottled sculpin. When temperatures exceed their critical maximums, it causes physiological stress on these species, and make may them more susceptible to being outcompeted by species such as suckers, minnows, and brown trout. Even when groundwater discharge is not able to decrease the overall water temperature of the creek below that threshold, it may create small ‘refugia’ habitats in the discharge zone, providing sensitive species a small area of cold water where they can take refuge in during the hottest days of the year. This refugia habitat may explain the continued persistence of mottled sculpin in sections of White Birch Creek where water temperature appears to be too high to meet their habitat requirements (Figure 5-2). With brook trout particularly, groundwater discharge is thought to be a critical habitat factor. Brook trout will only spawn in areas where they can lay their eggs on gravelly substrate that is continually flushed by groundwater. As such, the preservation of groundwater recharge and discharge, even at relatively large distances from creeks, is critical to preserving breeding populations of brook trout.

In areas that have been built up, this groundwater relationship can be interrupted, as more water tends to flow over the surface and less through the ground. This is less of an issue in the Innisfil Creeks subwatershed, as much of the development in this subwatershed has avoided areas of significant groundwater recharge or discharge (Figure 2-3, Figure 4-11, Figure 4-12)

One important measure to ensure the continued protection of this hydrological-ecological relationship is with the identification and protection of Ecologically Significant Groundwater Recharge Areas, which are those areas of groundwater recharge that support the flow of groundwater to ecologically sensitive features such as wetlands and creeks providing habitat for cold water fish species. Once identified, the Lake Simcoe Protection Plan directs municipalities to develop policies in their Official Plans to protect, improve, or restore these features. These ESGRAs are currently being developed for the Innisfil Creeks subwatershed, based on methodologies used in the Barrie Creeks subwatershed.

7.3 Agricultural interactions - land use, streams, and aquatic wildlife

When rain falls and flows over exposed soils on agricultural land, it can cause more erosion than in natural areas due to the lack of vegetation, and to picking up contaminants not present in natural areas. Soil particles eroded by stormwater in agricultural areas often have phosphorus adsorbed to them, particularly if the storm event happens relatively soon after a surface application of fertilizer. As such, agricultural stormwater can contribute both the sediment loads and phosphorus loads in receiving water bodies. In fact historically, the conversion of much of the Lake Simcoe watershed to agricultural land in the mid 1800s caused a spike in phosphorus loadings to the lake (Wilson and Ryan, 1988). Agriculture remains a significant contributor of phosphorus to Lake Simcoe, including from the Innisfil Creeks subwatershed (Louis Berger Group, Inc., 2010). Other contaminants, such as nitrates and metals can also be washed off of agricultural lands and into nearby watercourses.

The addition of contaminant-laden sediment to watercourses can have significant deleterious impacts to aquatic ecosystems. The addition of suspended sediment to watercourses increases the amount of sunlight that is absorbed by the water, and thus can increase water temperature. At high levels, it can also clog or abrade fish gills, impeding their ability to breathe, or cloud the water, reducing the hunting efficiency of visual predators. As the sediment settles out of the water column, it can blanket the substrate, covering important spawning habitat for species such as brook trout, mottled sculpin, white sucker, and others. The addition of the phosphorus adsorbed to sediment contributes to the eutrophication cycle, which is of great concern in the Lake Simcoe watershed. Phosphorus acts as a fertilizer in aquatic ecosystems, causing increased growth of aquatic plants, and most significantly in streams, algae. As the algae decompose, bacteria involved in the decomposition process take dissolved oxygen from the water column. At high levels of algae, this respiration can cause critical declines in the amount of dissolved oxygen in watercourses, making them less suitable as habitat for fish and other aquatic organisms. As an example, phosphorus loading in White Birch Creek could explain why aquatic communities are degraded in its headwaters (Figures 5-3 and 5-6), where agriculture is the predominant land use, and groundwater discharge is limited.

An issue which is specific to the management of agricultural watersheds are agricultural drains. These drains include both open ditches and tile drains which typically are installed in areas with poor natural drainage, to improve agricultural productivity. Ditches, or open drains, are typically straightened to quickly remove water from the area and have limited riparian vegetation. To ensure they continue work properly, they require maintenance that can lead to the alteration or removal of remaining vegetation, and disruption and change to the substrate. In addition, their intended function of rapidly draining wet soil has the unintended consequences of changing the rate and timing of peak flows, and increasing the rate at which phosphorus and sediment travel from agricultural fields to Lake Simcoe. In cases where these drains bisect wetlands, they can cause the water table to drop, decreasing the extent and hydroperiod of ephemeral wetland pools, which can lead to a loss of breeding habitat for frogs and salamanders, and migratory habitat for waterfowl (Figure 7-1)

Another issue particular to agricultural lands is the degradation of water quality and riparian areas where livestock have access to watercourses. The input of urine and manure directly into the water and onto low lying nearby fields, where it can be washed into the watercourse, affects water quality. The livestock can also trample streambanks, which contributes to instability and erosion, and sedimentation in the stream; while livestock in the stream can destroy spawning habitat (Figure 7-1).

In addition to these issues from various farm practices, sewage from the majority of residences in rural areas is treated by private septic systems. As they age, these systems can malfunction and fail, and can be a considerable source of nutrient and bacteria contamination to surface and groundwater (Figure 7-1).

A combination of all of these factors help to explain why the majority of fish communities are poor in the headwaters of many of the creeks, particularly in the southern portion of the subwatershed where creeks are lacking in fish, and only provide habitat for aquatic insects which are tolerant of organic pollution (Figure 5-3, Figure 5-6).

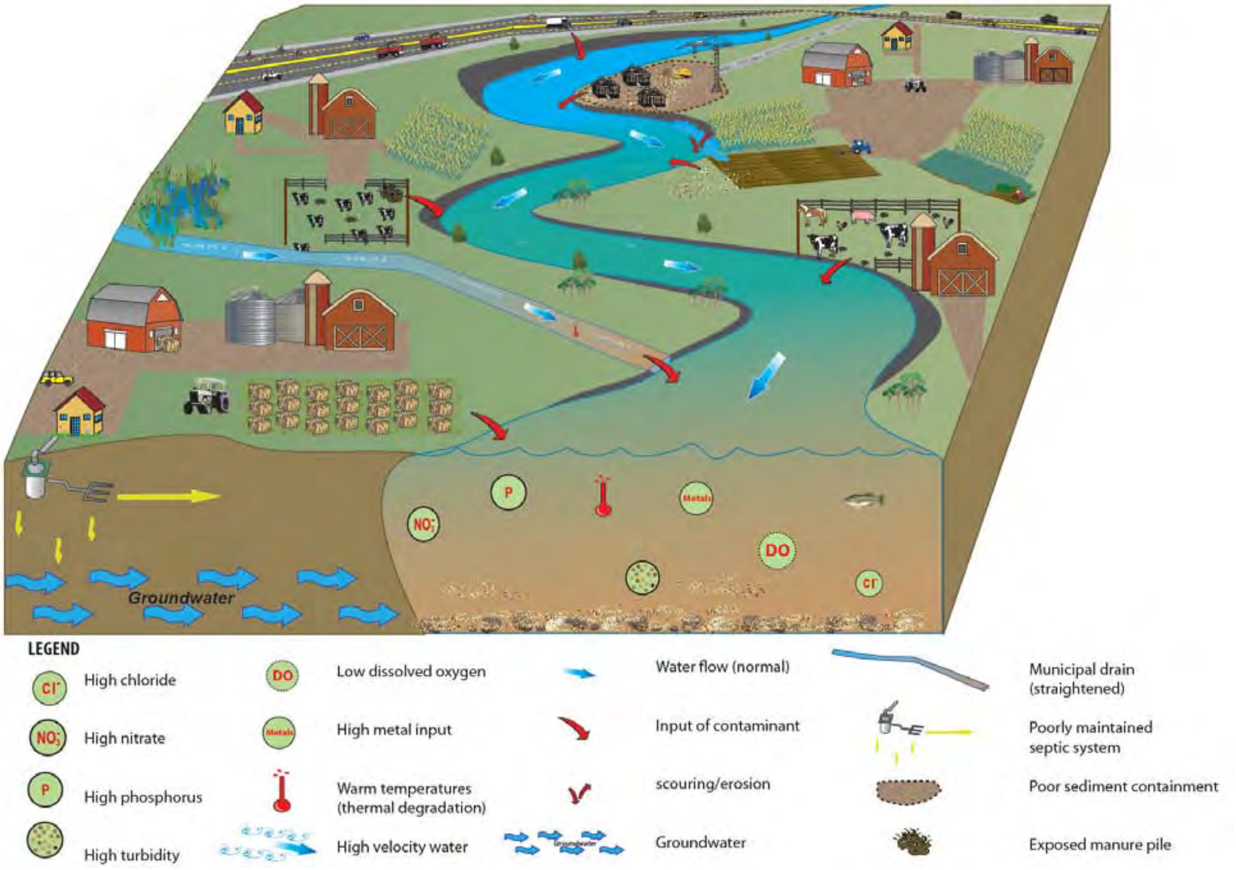


Figure 7-1: Influences of agricultural land use on subwatershed health.

The release of sediment and phosphorus from farm fields can be reduced with the use of cover crops, through minimizing fertilizer application, by fencing streams to prevent livestock access, by providing access to alternate sources of water for livestock, and with the preservation of remnant wetlands and forests. The release of phosphorus and other contaminants from barn yards can be reduced through the proper storage and spreading of manure, and the proper storage and disposal of milkhouse waste. The impacts associated with agricultural drains can be minimized by reducing the frequency of maintenance or by designing them to mimic natural channels. Perhaps the most important and cost effective tool in agricultural landscapes though is the establishment and preservation of riparian buffers along watercourses (Figure 7-2).

Riparian buffers act as an important last line of defence between farm fields and watercourses, slowing the velocity of stormwater, allowing sediment to be deposited within the buffer rather than in the creek, taking up phosphorus and nitrogen by the plants growing in the buffer, and binding the soil on the banks of the river, slowing the rate of erosion caused by stormwater runoff. Unfortunately, in cases like the headwaters for many of the creeks within this subwatershed, such as White Birch and Belle Aire Creeks, where riparian buffers are lacking (Figure 6-9), agricultural impacts on watercourses can be most significant, and are associated with a shift in tributary fish communities.

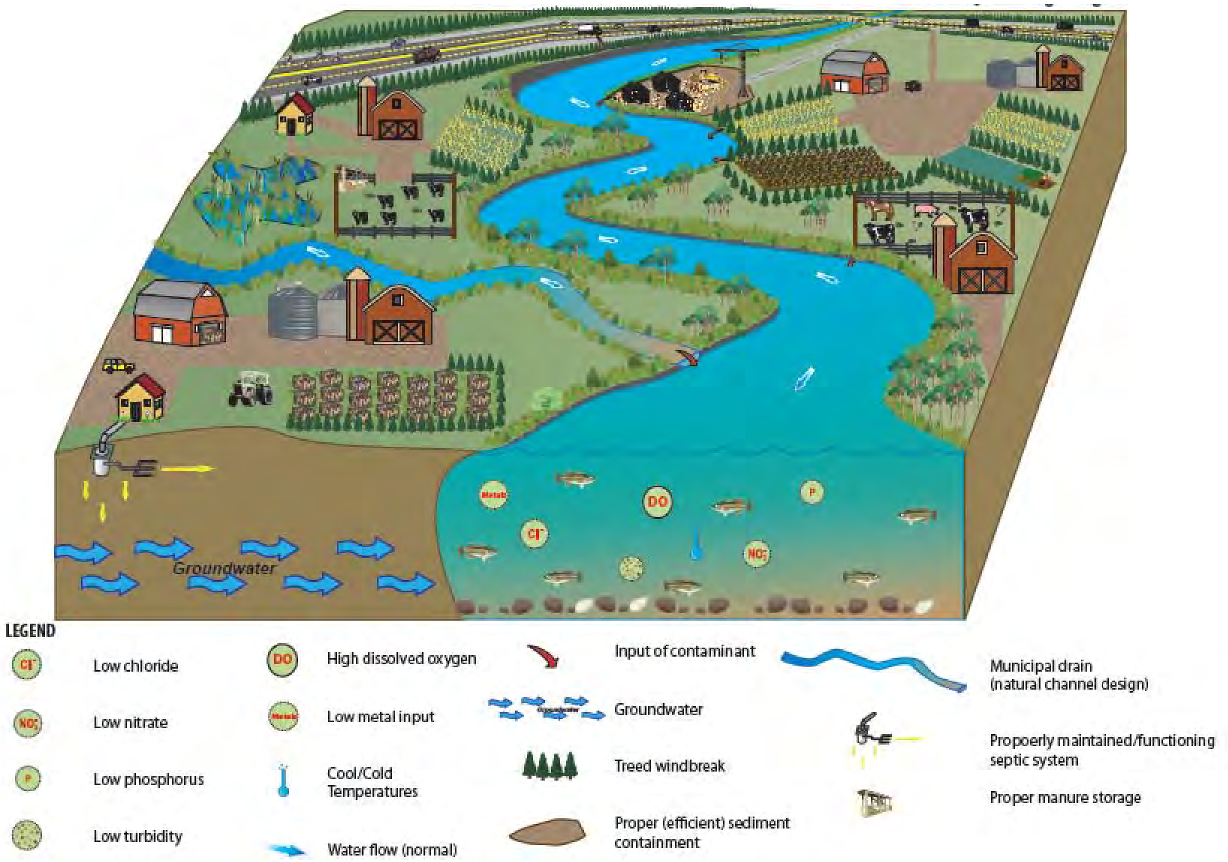


Figure 7-2: An agricultural landscape with appropriate best practices implemented to protect subwatershed health.

A number of stewardship programs have been provided by various government agencies, with the intent of engaging private landowners in undertaking these types of stewardship projects, through increasing awareness of the importance of these actions, and by providing technical and financial assistance to help these voluntary actions. Through such programs, the Lake Simcoe Region Conservation Authority, Ontario Soil and Crop Improvement Association, and their partners have implemented extensive projects in the agricultural areas of the Innisfil Creeks subwatershed, primarily related to stream bank fencing, establishment of riparian buffers, and repairs to failing septic systems (Figure 7-3).

Despite this effort, many more opportunities to increase the amount of stream bank vegetation, reduce barnyard runoff, and restrict livestock access still remain in this subwatershed, and there are many more septic systems which could contribute phosphorus to groundwater as they age, which will require repairs or upgrades (Figure 7-3, Figure 7-4).

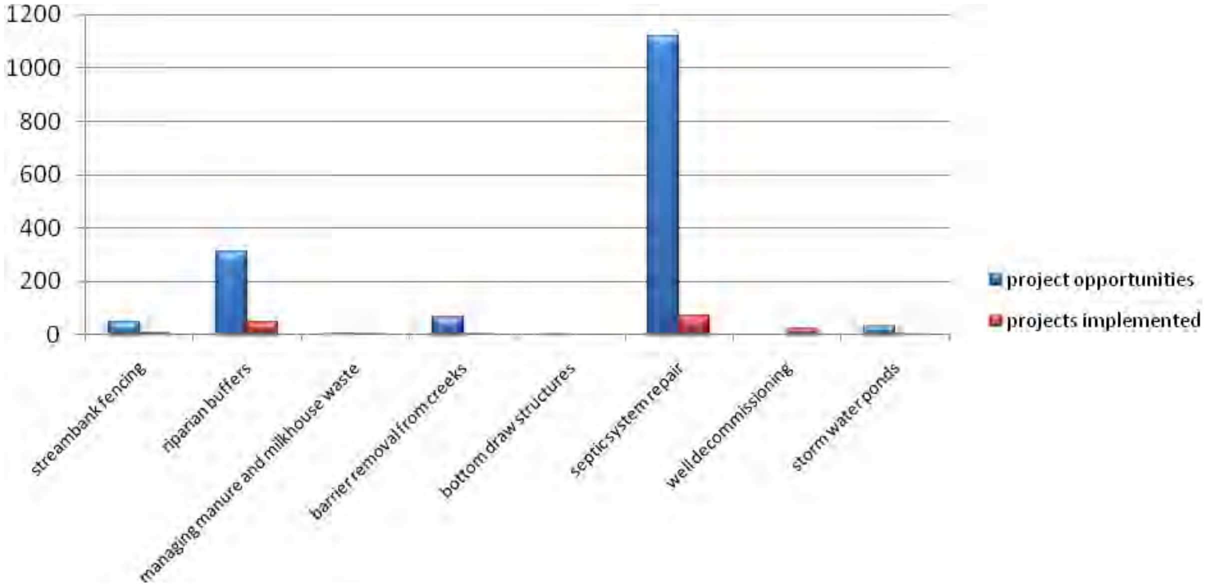
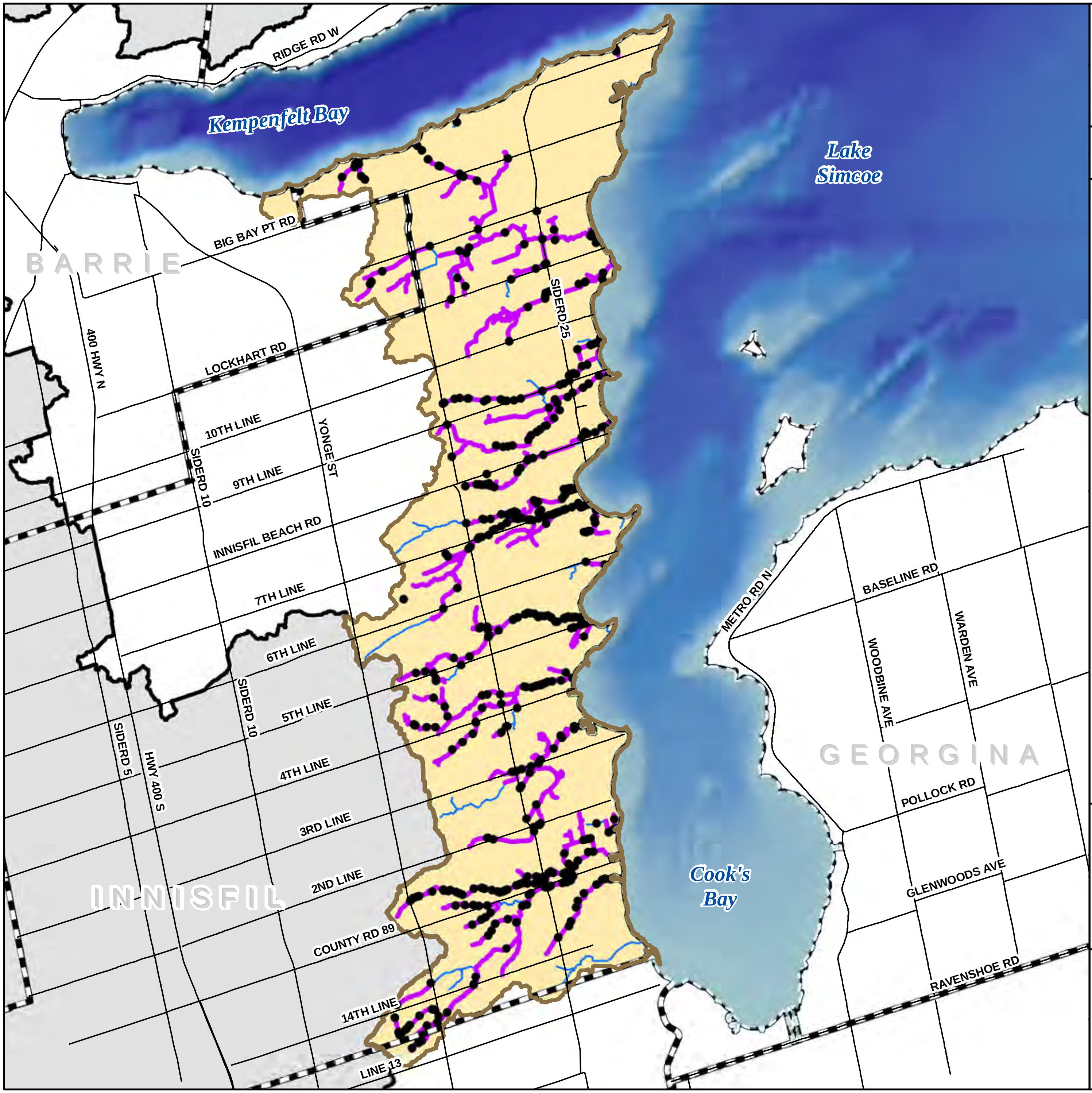


Figure 7-3: Approximate number of stewardship projects completed and stewardship opportunities in the Innisfil Creeks subwatershed. Graph includes projects done both in agricultural and urban settings

Best Management Practices project opportunities in the Innisfil Creeks subwatershed

Figure 7-4



Legend

- Road
- Municipal Boundary
- Watercourse
- ● BMP Opportunities
- BMP Watercourse Surveyed

Lake Simcoe Region conservation authority

0 0.5 1 2 3 4 5 Kilometres

N

7.4 Urban interactions - land use, streams, and aquatic wildlife

When stormwater flows over urban areas, it is susceptible to picking up even more contaminants than in other types of land use. Innisfil Creeks is currently the sixth largest contributor of phosphorus per-hectare to the Lake Simcoe ecosystem (Figure 3-5). As a subwatershed which is expecting significant growth and development, particularly in the headwaters of Sandy Cove Creek, which have recently been annexed by the City of Barrie, many of the stresses associated with urban land use may become more extensive, including a projected increase in loading of phosphorus and chloride in watercourses, and an increase in water temperature. In the near future, when most of this development is expected to occur, these impacts may be more pronounced. Development sites are often stripped of vegetation well in advance of development in an effort to reduce costs as the development is built in phases. These bare soils are then subject to erosion by both wind and water.

As in agricultural landscapes, the contribution of sediment and phosphorus can have deleterious impacts on species living in nearby streams by increasing water temperatures, decreasing levels of dissolved oxygen, and disturbing spawning sites. Other contaminants that occur in stormwater runoff from the urban parts of this subwatershed however include phenolics, metals, and organic compounds (Figure 7-5). At high levels, these contaminants can interfere with enzyme activity in aquatic organisms, leading to changes in behaviour, movement, predator avoidance, feeding rates, reproduction, reduced growth rates or even death.

Complicating matters further is our management of snow. Where, historically, snow would accumulate in the forest, to melt and form a spring freshet, providing flooded areas along the banks of rivers which act as spawning sites for species such as northern pike, it is now diligently cleared from city streets, parking lots and sidewalks, and often relocated to designated disposal sites to improve mobility and decrease risk of injury or car accidents. In many cases, salt is also applied to roads and parking lots to decrease the temperature at which ice freezes. The result of this snow removal however is a significant change to the timing, location, and chemical composition of the spring freshet (Figure 7-5). Increasing concentrations of chloride in watercourses can decrease feeding and growth rates in fish, and in extreme cases, can lead to mortality in fish and other aquatic organisms.

Additionally, as stormwater flows over urban areas, it tends to reach creeks more quickly than it would when flowing over natural areas. As a result, streams can exhibit both a decrease in baseflow levels, and an increase in flow rate and volume during high flow events. The level of urban area in the subwatershed is currently low, and mostly concentrated in the Alcona area; however, there is a significant amount of urban growth slated for the subwatershed, which could lead to these issues being seen in the subwatershed if measures to prevent them are not undertaken. Decreasing baseflows and flashy storm flows can make aquatic environments less suitable as habitat for resident fish, due to a loss of habitat during low flow periods, and an increase in the energy necessary to manoeuvre through the creek during high flow events. This increased velocity can also increase the rate of erosion of exposed soil or streambanks, increasing the amount of sediment that gets deposited in the creek. The flow of stormwater over hardened urban surfaces such as roads, parking lots, and asphalt shingles also tends to increase its temperature. As such, urban stormwater can increase the thermal regime of urban creeks, making them unsuitable habitat for cold water species like brook trout (Figure 7-5).

As in agricultural landscapes, the preservation of native vegetation along watercourses plays an important role in slowing the velocity of stormwater, collecting sediment, capturing phosphorus and nitrogen, and binding the soil on the banks of the river (Figure 7-6). The preservation of native vegetation along roadsides also plays an important role in protecting the health of urban watersheds as well, as windbreaks of this sort help reduce the accumulation of blowing snow on highways, thus reducing the need to apply sand or salt to roads (Figure 7-6).

Other methods of reducing salt application on roads including carefully calibrating the application of salt to the temperature of the road, ensuring that snow disposal sites drain into stormwater management ponds, or to use treatment measures other than chloride in areas that are particularly sensitive to contamination.

One of the standard ways of addressing the concerns associated with urban stormwater runoff is with the use of stormwater ponds. Stormwater ponds are designed to trap sediments, to improve the quality of water which is ultimately released back into the watershed. Without proper maintenance however, stormwater ponds can operate well below their designed efficiency, and contain sediments which are high in concentrations of phosphorus, chloride, heavy metals, and petrochemicals. In extreme cases, during high flow events, some unmaintained stormwater ponds can actually act as a source of contaminants to nearby watercourses. As well, the large surface area of stormwater ponds tends to increase water temperature. As such, stormwater ponds have the potential to negatively impact the thermal regime of nearby watercourses, decreasing habitat values for sensitive fish species (Figure 7-5). Poorly maintained stormwater ponds can also be detrimental to bird and amphibian populations, who often utilize them as breeding habitat as wetlands are lost from urbanizing landscapes. However, if the stormwater ponds are hypoxic, surrounded by unsuitable habitat or roads, or have high concentrations of other contaminants, they can cause reductions in reproduction rates and overall survival for these species. A survey completed in 2010 found that the majority of the stormwater ponds in the Innisfil Creeks subwatershed were operating below their designed efficiency, capturing less phosphorous and sediment from stormwater than intended (Figure 3-8).

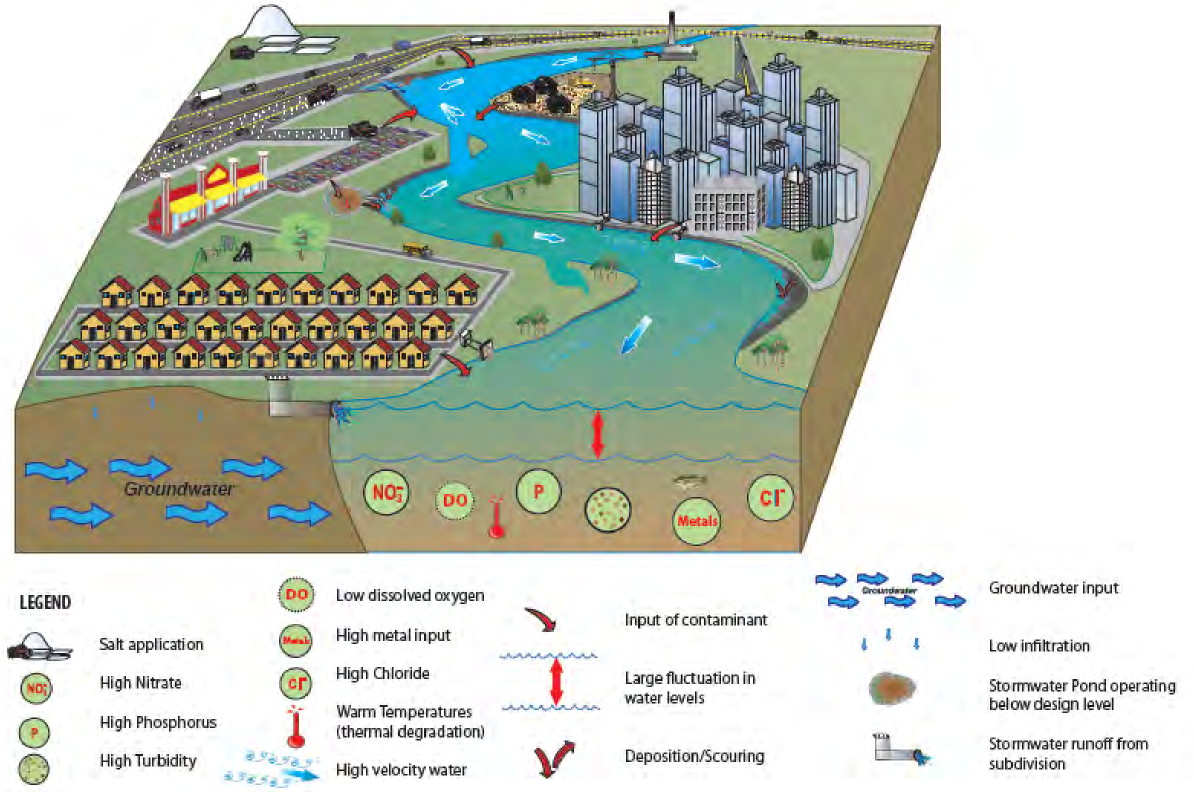


Figure 7-5: Influences of urban land use on subwatershed health.

The best way to manage stormwater runoff in urban areas is to reduce the volume of run-off through the use of Low Impact Development. Low Impact Development (LID) is a term that refers to a suite of innovative design solutions that can be incorporated into new developments, to increase the amount of stormwater than infiltrates into the ground, and decrease the amount that flows over land. Tools in the LID toolbox include green roofs, infiltration swales, permeable pavement, and a greater focus on retaining urban forest cover. Other, secondary treatments include proper site control during construction, ongoing maintenance of stormwater ponds, the upgrade of stormwater ponds built with earlier technology, and the establishment and preservation of riparian buffers (Figure 7-6). Despite the challenges to watershed health associated with projected development in this subwatershed, that development also provides a significant opportunity to implement innovative low impact development techniques, as well as to use innovative design of stormwater management ponds.

A number of urban stewardship projects have already been implemented in these subwatersheds, on both private and municipal lands, including an increase in the extent of native vegetation along urban watercourses and upgrades to outdated stormwater management ponds (Figure 7-3). Like the agricultural areas in these subwatersheds though, many more opportunities still exist to increase the extent of riparian buffers and upgrade stormwater ponds (Figure 7-3, Figure 7-4, Figure 3-10).

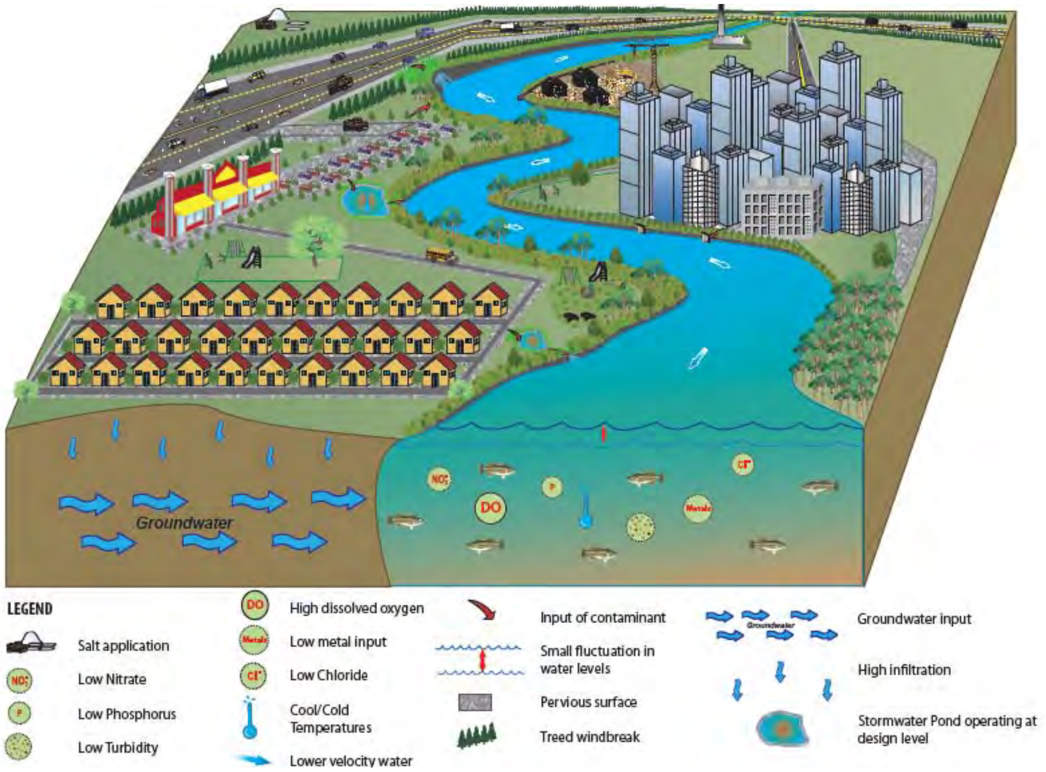


Figure 7-6: An urban landscape with appropriate best management practices implemented to protect subwatershed health.

7.5 In-stream interactions - activities in and near creeks, water quality, and aquatic wildlife

In addition to actions happening across the watershed as whole, actions in or near creeks can have even more direct impacts to hydrologic and ecologic systems. The preservation of riparian buffers along the edges of watercourses or the lake make important contributions to aquatic wildlife, as the plant debris that is dropped into the water body provides an important food source for aquatic invertebrates, which form the base of aquatic food webs, and the shade it provides is important for maintaining cooler water temperature in mid-summer, which is a particularly important factor in providing habitat for species such as brook trout or mottled sculpin. Riparian vegetation also makes an important contribution to terrestrial wildlife as well, acting as a productive source of food for many species, and acting as a migration corridor through landscapes that are often otherwise lacking in native vegetation. When this vegetation is cleared, these benefits are lost.

These impacts can be exacerbated however, when the removal of vegetation is accompanied by other more extreme interventions such as bank hardening, stream channelization, or converting free-flowing streams to underground pipes (Figure 7-7), activities which have been widespread in the Innisfil Creeks subwatershed (Figure 5-11). These types of interventions remove habitat for aquatic species, and increase the velocity of water, causing an increase in erosion downstream of the hardened or enclosed site, or in areas where the hardening begins to fail, which in turn increases sedimentation and phosphorus inputs. In the case of agricultural drains, periodic maintenance intended to promote efficient draining prohibits the establishment of trees along one (or both) sides of the drain, and causes disturbance to fish habitat while maintenance is occurring.

These impacts can also be exacerbated in ponds or reservoirs created by barriers on creeks. Ponds behind barriers increase the amount of area exposed to the sun, and as such increase water temperature, causing potential for further increases in growth of aquatic plants and algae, as well as bacteria, and a decrease in oxygen levels when the plants and algae decompose. Barriers erected on creeks also fragment fish habitat, impeding the seasonal travel of migrant spawners such as white sucker, and impeding the ability of other species to disperse through the drainage network (Figure 7-7). Over time, barriers can lead to a loss in fish biodiversity, as isolated stream reaches become more vulnerable to local extinctions.

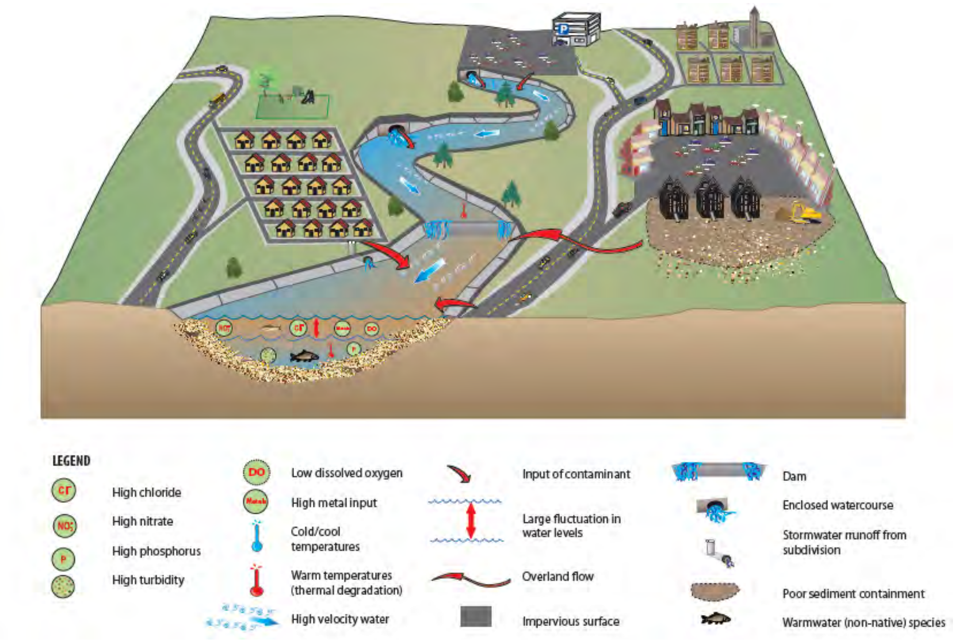


Figure 7-7: Influences of riparian land use on subwatershed health.

Creek-based stewardship activities beyond the establishment of additional riparian vegetation can be difficult however, as projects related to channel restoration can be extremely expensive, and options to establish a naturally meandering channel can be extremely constrained in heavily settled areas. Despite that, the Town of Innisfil and Lake Simcoe Region Conservation Authority have been able to ‘daylight’ a number of streams in Gilford, replacing corrugated steel culverts with vegetated open channels. Many more opportunities to remove barriers from creeks, or naturalize creeks which have been channelized, remain in this subwatershed (Figure 7-3, Figure 7-4).

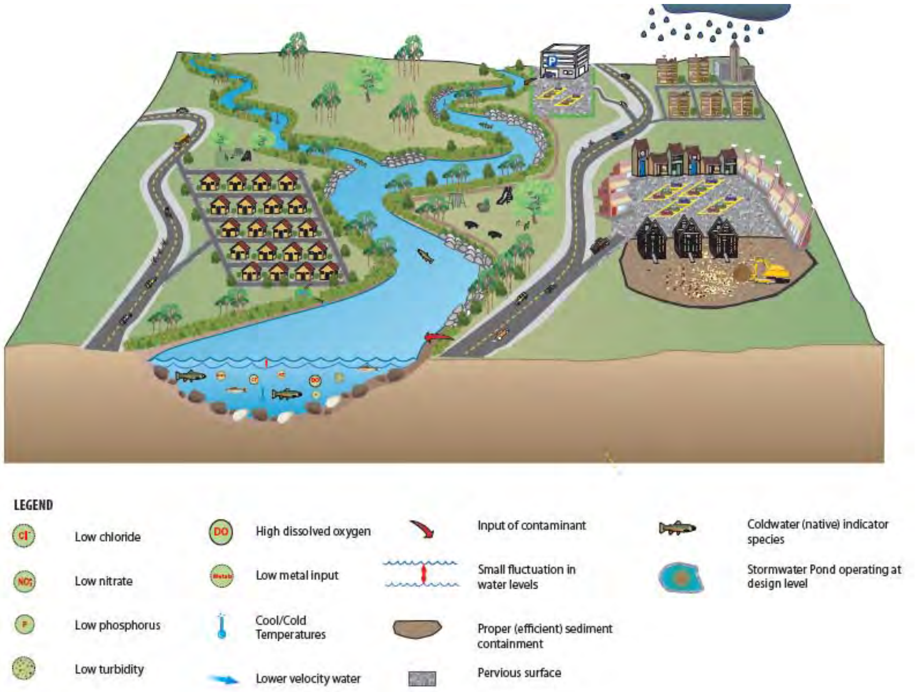


Figure 7-8: Riparian area with appropriate best management practices implemented to protect subwatershed health.

7.6 Shoreline interactions - activities in and near the lakeshore, water quality, and aquatic wildlife

Of particular importance to this subwatershed is the role played by the Lake Simcoe shoreline. In the Innisfil Creeks subwatershed there are, generally speaking, two types of waterfront settings. The first is a relatively urban one, close to amenities, with increased amounts of impervious surfaces, hardened banks, and increased traffic to and from marinas (Figure 7-9). The second is a more rural one, where cottages or permanent residences border the lakefront. While there is less pedestrian and vehicle traffic in this area, there are still instances of bank hardening, and concrete or solid docks (Figure 7-10). In both cases, much of the native vegetation has been removed, and what is left is often mowed right to the water's edge. Septic systems, which support many of the older cottages and houses along the shore, can also be a source of phosphorus to the lake, if not properly maintained.

The loss of this shoreline vegetation has negative impacts on nearshore aquatic communities, through an increase in water temperature and sediment input, and a decrease in input of woody debris (which is an important component of habitat for many aquatic organisms). These impacts can be exacerbated when the shoreline development is accompanied by the installation of concrete, steel, or gabion baskets as retaining walls to prevent erosion or to make the shoreline more conducive for recreation. This loss of natural shoreline and associated aquatic vegetation represents a loss of spawning and feeding habitat for native fish.

This type of shoreline development, in combination with an increase in impervious surfaces, also increases the amount of contaminants in runoff. Increased nutrients and an increase in temperature create an ideal growing situation for algae and aquatic plants, which can be a nuisance to swimmers and boaters, and can also create anoxic conditions for aquatic communities. Shoreline areas are also disproportionately important for terrestrial wildlife as well, as the clearing of shoreline areas for cottages or homes leads to loss of habitat for songbirds, amphibians, turtles and small mammals (Figure 7-9, Figure 7-10).

Although the development of individual shoreline properties may seem small in nature, the cumulative effect of all of these small developments can add up to significant impacts. The Innisfil Creeks shoreline, which represents 18% of the total lakeshore, has already had 82% of its length developed in such a way. The significance of the extent of this development is exacerbated by the fact that historically much of the Innisfil lakeshore was an extensive wetland (Figure 6-2), which would have played a role in buffering the lake from any upstream impacts to the creeks, and may have provided spawning and nursery habitat for fish such as muskellunge, perch, and largemouth bass, as well as providing extensive breeding habitat for waterfowl, herons, and other wetland birds.

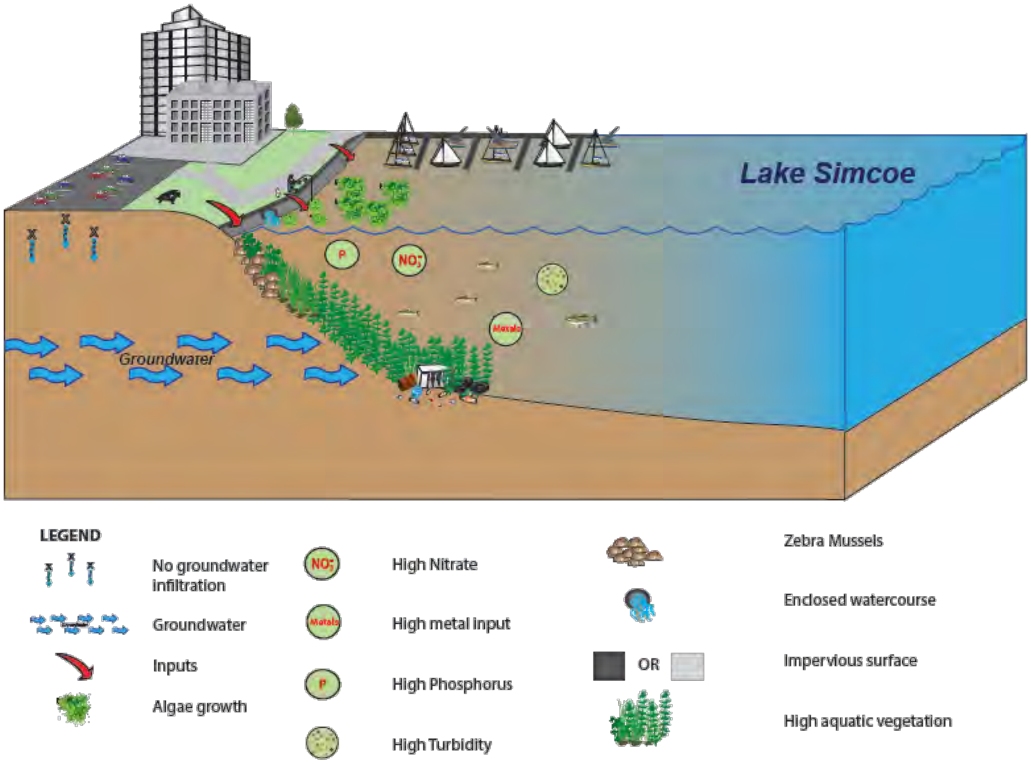


Figure 7-9: Influences of urban shoreline land use on subwatershed health.

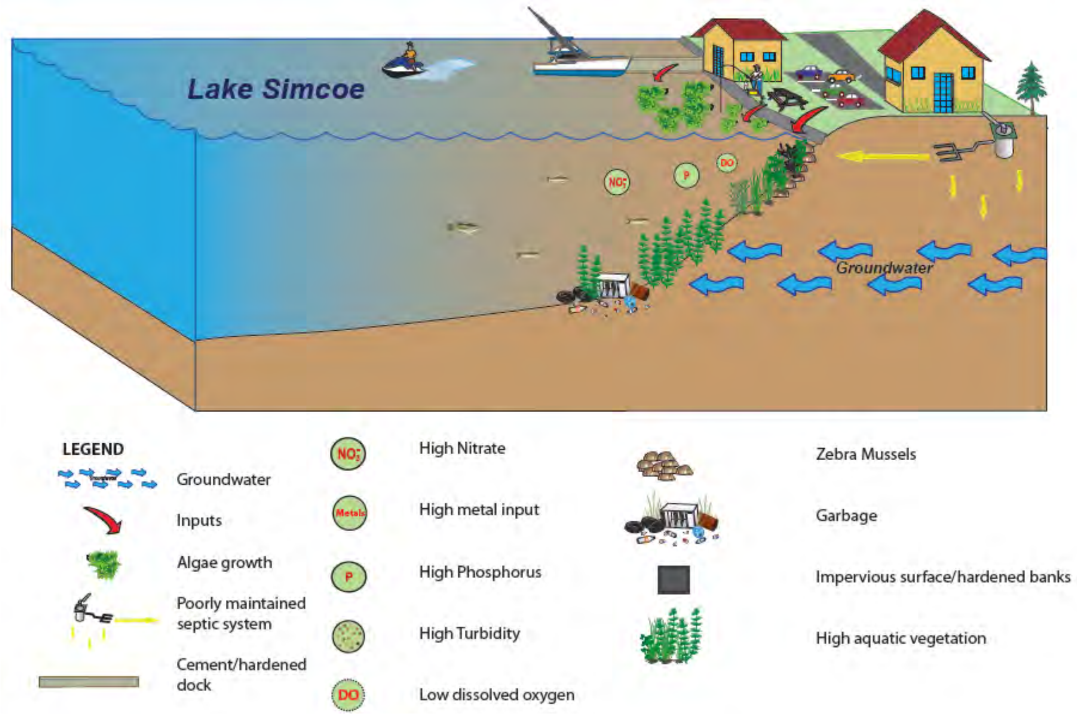


Figure 7-10: Influences of rural shoreline use on subwatershed health.

Stewardship options for shoreline properties are quite similar to those for riparian areas, and include septic system repairs, shoreline naturalization, erosion control projects, and tree planting. Financial and technical support for these types of projects is provided by the MNR and LSRCA.

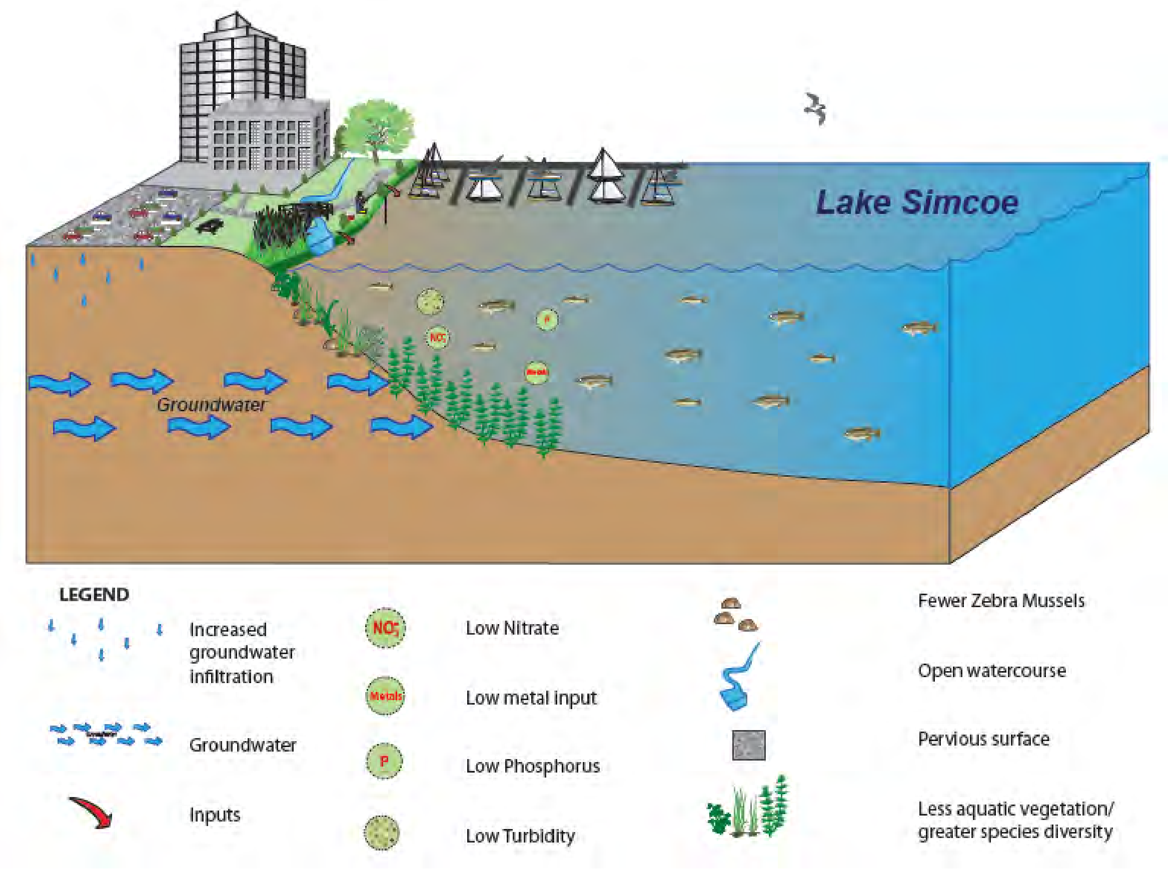


Figure 7-11. Urban shoreline area with appropriate best management practices implemented to protect subwatershed health

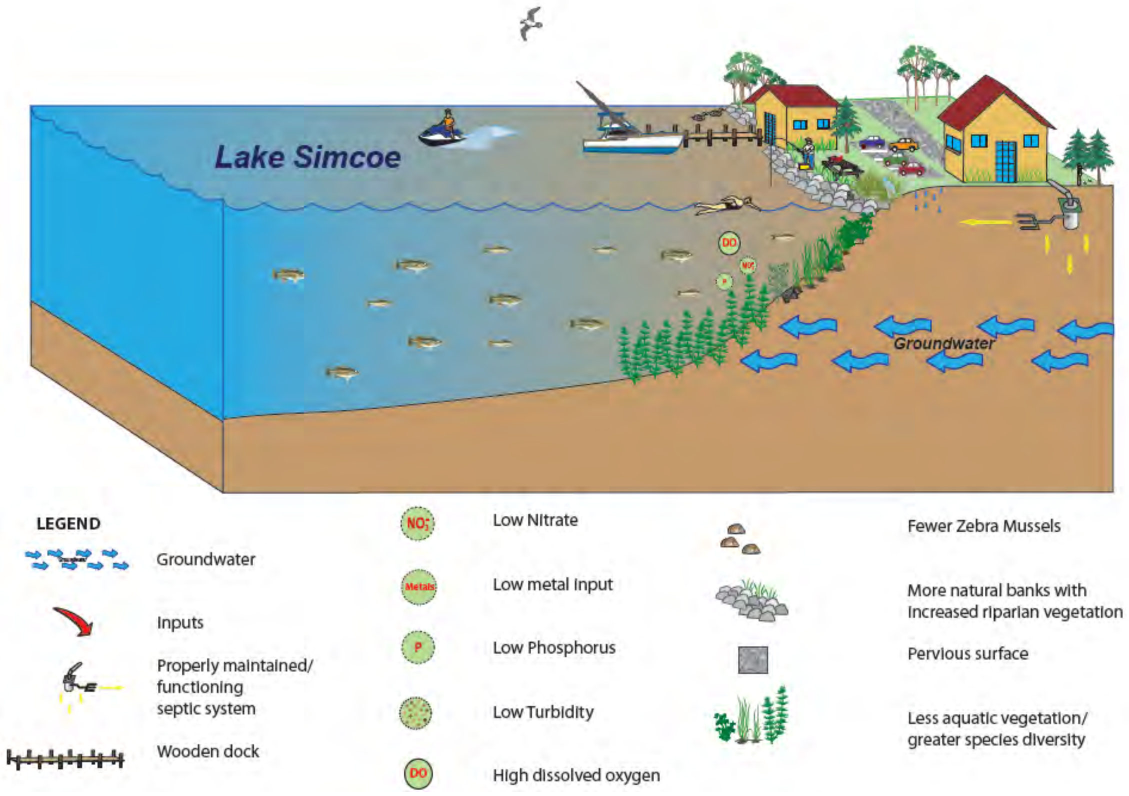


Figure 7-12. Rural shoreline area with appropriate best management practices implemented to protect shoreline health

7.7 Developing an implementation plan

The Innisfil Creeks Subwatershed Plan includes an assessment of the current state of the environment in that subwatershed, the stressors upon its health, and the current management framework to address those stressors. As a result of that assessment, the subwatershed plan has developed a list of recommended actions which, if implemented, would provide additional guidance on the protection and restoration of that subwatershed.

Achieving these recommendations will require the coordinated response of multiple government agencies, and many individual landowners, working together in a multifaceted approach to protecting and improving subwatershed health. To ensure these actions are fostered and coordinated, this subwatershed plan will be complemented with a Subwatershed Implementation Plan, as well as a Subwatershed Working Group.

The Subwatershed Implementation Plan is a brief document, intended to provide the necessary support and direction to achieve a short list of priority recommendations within five years of the completion of this subwatershed plan. To meet that goal, the implementation plan has been written with more specific detail on timelines, deliverables, and the specific steps necessary to achieve those priority recommendations.

This implementation plan will also form the basis of periodic meetings of the Subwatershed Implementation Working Group, which will be made up of the Town of Innisfil, County of Simcoe, City of Barrie, provincial Ministries of the Environment, Natural Resources, and Agriculture, Food and Rural Affairs, as well as the Lake Simcoe Region Conservation Authority, and other relevant stakeholders. These groups, who are the primary lead agencies on the recommendations developed in this plan, will meet periodically to coordinate and report on implementation of the priority recommendations. This group will also assist in periodic review and updates to this subwatershed plan.

8 Combined Recommendations

This chapter provides a compiled list of the recommendations identified in the detailed technical chapters of this subwatershed plan. These recommendations will be brought forward and prioritized in the development of an implementation plan for the Innisfil Creeks subwatershed.

The recommendations in this chapter have been grouped into categories of similar issues. Thus, for example, recommendations derived from the terrestrial natural heritage chapter may be grouped with recommendations derived from the water quality chapter, in cases where they address shared issues. In such cases, the numbering system will allow the reader to trace the recommendation back to the chapter where it originated.

Recommendations in the following list are numbered as chapter number – recommendation number. In cases where a recommendation originated from more than one chapter, it is numbered based on its first occurrence, with all other occurrences listed in parentheses.

It is recognized that many of the undertakings in the following set of recommendations are dependent on funding from all levels of government. Should there be financial constraints, it may affect the ability of the partners to achieve these recommendations. These constraints will be addressed more fully in the implementation phase.

8.1 Protection and Policy

8.1.1 Official Plan consistency

Recommendation 6-1 – That the LSRCA, MOE and MNR assist subwatershed municipalities in ensuring official plans are consistent with the recommendations presented in the Innisfil Creeks subwatershed plan, as approved by the LSRCA Board of Directors. This approval will be subsequent to consultation with municipalities, the subwatershed plan working group, and the general public, as outlined in the *Guidelines for developing subwatershed plans for the Lake Simcoe watershed (May, 2011).*

8.1.2 The adaptive watershed planning process

Recommendation 8-1 – That the LSRCA and other relevant and interested stakeholders establish an implementation working group to assist in coordinating the implementation priority recommendations to address the most significant threats in these subwatersheds.

Recommendation 8-2 (3-21) - That the LSRCA, MNR and MOE analyse and report the results of the existing and proposed water quality, water quantity, and aquatic and terrestrial natural heritage monitoring programs annually, and that the information be used to update the LSRCA Watershed Report Card. Further, stakeholders should be made aware when updates are available, and be provided access to the monitoring data collected via a web portal, to increase distribution and communication of this data.

Recommendation 8-3 – That the LSRCA, with the assistance of the other government agencies and stakeholder groups involved in implementing the recommendations of this subwatershed plan, report on the progress of this implementation annually.

Recommendation 8-4 – Within five years of the completion of this subwatershed plan, that the LSRCA, in collaboration with MOE, MNR, subwatershed municipalities, and other interested and relevant stakeholders, review and update this subwatershed plan.

8.1.3 Protecting Natural Heritage

Recommendation 6-3 – That the MNR, MOE, and LSRCA review the terrestrial natural heritage data provided by the comprehensive monitoring program, when it becomes available, to define site level characteristics or indicators of ‘high quality’ natural heritage features, and provide policy recommendations to subwatershed municipalities (as necessary) to ensure high quality natural heritage features are adequately protected from development and site alteration.

Recommendation 6-4 – That the MNR, MAFRA, LSRCA, subwatershed municipalities, and interested members of the agricultural community review the results of the studies being conducted on methods and policy tools to protect grassland dependent wildlife on active agricultural land as they become available, to determine if they provide solutions for the conservation of grassland habitat which would be applicable for these subwatersheds.

Recommendation 6-5 – That the City of Barrie and Town of Innisfil, with the assistance of the MNR and LSRCA, give consideration to including policies in their respective Official Plans to contribute to the protection of grassland habitats, as necessary, based on the results of Recommendation #6-6, and recognize the need for balance in the approach to development in urban areas.

8.1.4 *Reducing impact of land use – groundwater recharge and discharge*

Recommendation 4-6 - Municipalities shall only permit new development or redevelopment in significant recharge areas, where it can be demonstrated through the submission of a hydrogeological study and water balance, that the existing groundwater recharge will be maintained (i.e. there will be no net reduction in recharge).

Recommendation 4-7 - Municipalities should amend their planning documents to require that runoff in significant recharge areas meet the enhanced water quality criteria outlined in the MOE Stormwater Management Guidance Document, 2003, as amended from time to time, prior to it being infiltrated.

Recommendation 4-8 - That municipalities incorporate the requirement for the re-use or diversion of roof top runoff (clean water diversion) from all new development in significant recharge areas away from storm sewers and infiltrated to maintain the pre-development water balance (except in locations where a hydrogeological assessment indicates that local water table is too high to support such infiltration) in their municipal engineering standards.

Recommendation 4-9 - The MOE should only issue Environmental Compliance Approvals for new storm water management facilities within significant recharge areas that maintain the pre-development groundwater recharge rates and meet the enhanced water quality criteria outlined in the MOE Stormwater Management Guidance Document, 2003, as amended from time to time.

Recommendation 4-10 - The MOE shall only issue Environmental Compliance Approvals for Stormwater Management Facility retrofits within significant recharge areas, that attempt to improve, maintain or restore the pre-development water balance, and meet the enhanced water quality criteria outlined in the MOE Stormwater Management Guidance Document, 2003, as amended from time to time.

Recommendation 4-11 – Municipalities, in collaboration with the Lake Simcoe Region Conservation Authority, shall undertake an education and outreach program focusing on the importance of significant recharge areas, and the actions residents and businesses can take to maximize infiltration from impervious surfaces while minimizing contamination such as salt.

Recommendation 4-12 - The Lake Simcoe Region Conservation Authority should create eligibility for stormwater management retrofits and infiltration projects under the LEAP program within recharge areas.

Recommendation 4-13 - Municipalities shall collaborate with the Lake Simcoe Region Conservation Authority to promote infiltration of clean water in significant recharge areas, and prioritize stormwater retrofits utilizing water quality controls, and ultimately infiltration devices for treated stormwater runoff.

Recommendation 4-14 - The MOE should consider providing financial assistance to implement stormwater management facility retrofits and infiltration projects within significant recharge areas.

Recommendation 4-15 - Municipalities should include significant recharge areas in their assessment of areas vulnerable to road salt, and modify their municipal Salt Management Plans and snow disposal plans as necessary.

8.1.5 Incorporating LSPP objectives in Environmental Assessments

Recommendation 6-6 – That reviewers of Environmental Assessments for municipal infrastructure in the Lake Simcoe watershed, including subwatershed municipalities, and LSRCA and MOE (when reviewing such documents), give due consideration to the preservation of barrier-free connectivity for wildlife between nearby wetland and upland habitats. This should include due consideration of alternate route configuration, the use of wildlife crossing structures, and/or the use of traffic calming measures in critical locations.

Recommendation 6-7 – That subwatershed municipalities and the MOE ensure that all Environmental Assessments for municipal infrastructure in the Lake Simcoe watershed give due consideration to the preservation of barrier-free connectivity for wildlife between nearby wetland and upland habitats. This should include due consideration of alternate route configuration, the use of wildlife crossing structures, and/or the use of traffic calming measures in critical locations.

8.1.6 Promoting Low Impact Development

Recommendation 3-1-That the LSRCA, with the support of the MOE, provide a white paper to subwatershed municipalities describing the range of LID technologies that could potentially be used to mitigate the impacts of development on surface and groundwater quality and quantity. Further, that the LSRCA and subwatershed municipalities identify the barriers associated with the uptake of LID technology and, with the support of MOE, develop recommendations for overcoming these barriers.

Recommendation 3-2 - That the federal and provincial governments provide sufficient financial incentives, or otherwise address barriers identified in Recommendation #3-1, to ensure subwatershed municipalities use Low impact Development (LID) practices and promote the adoption of Smart Growth Urban Design Guidelines.

8.1.7 Improving stormwater management

Recommendation 3-3 - That the subwatershed municipalities, with the assistance of the LSRCA, promote the increased use of innovative solutions to address stormwater management and retrofits such as:

- enhanced street sweeping and catch basin maintenance, particularly in those areas currently lacking stormwater controls;
- improving or restoring vegetation in riparian areas;
- installation of rainwater harvesting; construction of rooftop storage and/or green roofs; the use of bioretention areas and vegetated ditches along roadways;
- the use of soakaway pits, infiltration galleries, permeable pavement and other LID solutions, where conditions permit;

    - the on-going inventory, installation, and proper maintenance of oil grit/hydrodynamic separators combined with the use of technologies to enhance their effectiveness where appropriate;

- **Recommendation 3-6 -** That the subwatershed municipalities complete the Stormwater Management Master Plans as outlined in the LSPP 2011 Comprehensive Stormwater Management Master Plans Guidelines document with particular emphasis on maintenance of facilities, and the need for retrofits where appropriate.

  Recommendation 3-8 - That Official Plans be amended to contain policies that would help minimize impervious surface cover in the Innisfil Creeks subwatershed through requirements such as using low impact development solutions, limiting impervious surface areas on new development, and/or providing stormwater rates rebates and incentives to residential and non-residential property owners demonstrating best practices for managing stormwater.

8.1.8 Managing thermal degradation

Recommendation 3-17– That, as new or retrofit stormwater facilities are constructed, LSRCA work with subwatershed municipalities to reduce potential thermal impacts of those stormwater ponds and to recognize the importance of LID uptake in relation to maintaining stream temperature.

8.1.9 Improving construction practices

Recommendation 3-9 - That the LSRCA and watershed municipalities promote and encourage the adoption of best management practices to address sedimentation and erosion controls during construction and road development.

Recommendation 3-10 - That subwatershed municipalities and LSRCA improve current monitoring and enforcement of site alteration by-laws by undertaking a review of the current program and ensuring that adequate resources are available for the improvements.

8.1.10 Land securement by public agencies

Recommendation 6-8 – That the LSRCA and subwatershed municipalities should continue to secure outstanding natural areas for environmental protection and public benefit, through tools such as land acquisition or conservation easements, and should support the work of Land Trusts doing similar work.

Recommendation 6-9 – That the LSRCA and subwatershed municipalities should continue to refine their land securement decision processes to ensure that they are securing natural areas that are critical to the health of the watershed (or securing and restoring areas which have the potential to become critical to the health of the watershed), but which are otherwise vulnerable to loss through incompatible land uses.

Recommendation 6-10 – That the Federal, Provincial, and Municipal governments provide consistent and sustainable funding to support securement of outstanding natural areas.

8.2 Restoration and remediation

8.2.1 Improving stormwater management

Recommendation 3-4 - That the Province of Ontario, through the implementation of the Lake Simcoe Phosphorus Reduction Strategy, provide significant incentive funding to the relevant municipalities and/or the LSRCA to maintain, construct, and /or retrofit stormwater facilities as identified by the LSRCA Stormwater Rehabilitation program.

Recommendation 3-5 - That the subwatershed municipalities routinely monitor and maintain the design level of existing stormwater facilities. In addition to maintaining design level, criteria for maintenance should also include frequency and exposure to spills and other contaminant sources. Further, that the federal and provincial governments be requested to share in the cost of maintenance.

Recommendation 3-7 - That the LSRCA and its partners recognize that while the construction and/or retrofit of quality control facilities is extremely important, quantity control is also an important consideration in some areas of the Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds; therefore, quantity control facilities should be constructed in those areas where geographical space is limited or other LID options are not feasible. In these situations, federal and provincial governments should provide financial incentives to allow municipalities to complement quantity control stormwater ponds with an enhanced street sweeping program.

8.2.2 Managing water demand

Recommendation 4-1 -That the LSRCA and subwatershed municipalities promote and support low impact design (LID) solutions such as rainwater harvesting, rain gardens, and grey water reuse to manage stormwater and supplement residential water use.

8.2.3 Managing agricultural impacts

Recommendation 3-15 - That the subwatershed municipalities, through the LSRCA, create a roundtable made up of municipalities, LSRCA, MOE, MNR, OFA, NGOs, and related landowner representatives, or through existing frameworks such as the Lake Simcoe Stewardship Network, to determine co-operative ways of implementing phosphorus reduction and improved water quality measures in Hewitt's, Lovers, and Innisfil Creeks, and to develop an 'action plan' for their implementation within the agricultural and rural communities.

Recommendation 5-11 –That the LSRCA work with subwatershed municipalities and MAFRA to examine innovative forms of municipal drain maintenance, or opportunities to create new drains using principles of natural channel design. Furthermore, that the LSRCA work with subwatershed municipalities and MAFRA to decommission municipal drains when the land use changes, removing the need for their use.

8.2.4 Dealing with enclosed watercourses

Recommendation 5-12 - That the Town of Innisfil, in partnership with the LSRCA, complete an inventory of enclosed or buried streams from which removal of enclosures or "day lighting" can be prioritized.

Recommendation 5-13 - That the Town of Innisfil continue its efforts to day light enclosed streams and establish a funded program based on prioritized list of restoration opportunities, as resources permit.

8.2.5 Dealing with indirect impacts to natural areas

Recommendation 6-19 – That the LSRCA, County of Simcoe, City of Barrie, and Town of Innisfil conduct natural heritage inventories, and develop and implement management plans for publicly accessible natural areas that they own, to mitigate potential threats related to invasive species and increased recreation pressure.

Recommendation 6-20 – That the MOE and its partners provide outreach to garden centres, landscapers, and garden clubs regarding the danger of using invasive species in ornamental gardens.

Recommendation 6-21 – That the City of Barrie, the Town of Innisfil and the County of Simcoe, with support from LSRCA, make information available to residents on the impact of human activities on natural areas. Priority issues include the dangers of invasive species, the importance of keeping pets under control, and the importance of staying on trails while in natural areas.

8.2.6 Increasing uptake of stewardship programs

Recommendation 5-1 (6-11) – That the MNR, MOE, MAFRA, and LSRCA continue to implement stewardship projects in these subwatersheds, and encourage other interested organizations to do the same.

Recommendation 5-2 (6-12) – That governmental and non-governmental organizations continue to improve coordination of programs to: (1) avoid inefficiencies and unnecessary competition for projects, and: (2) make it easier for landowners to know which organization they should be contacting for a potential project, using tools such as a simple web portal.

Recommendation 5-3 (6-14) – That the MOE, MNR, LSRCA, and other members of the Lake Simcoe Stewardship Network be encouraged to document completed stewardship projects in a common tracking system to allow efficient tracking, coordinating, and reporting of stewardship work accomplished.

Recommendation 5-4 (6-13) – That the Federal, Provincial, and Municipal governments provide consistent and sustainable funding to ensure continued delivery of stewardship programs.

Recommendation 5-5 (6-15) – That the MOE, MNR, MAFRA, LSRCA, and other interested members of the Lake Simcoe Stewardship Network support research to determine barriers limiting uptake of stewardship programs in these subwatersheds and share these results with other members of the Lake Simcoe Stewardship Network, to enable agencies and stakeholders to modify their stewardship programming as relevant. This research should include a review of successful projects to determine what aspects led to their success, and how these may be emulated.

Recommendation 5-6 (6-16) – That the MOE, MNR, MAFRA, and LSRCA continue to investigate new and innovative ways of reaching target audiences in the local community and engage them in restoration programs and activities (e.g. high school environmental clubs, through Facebook groups, hosting a Lake Simcoe Environment Conference for high schools/science community interaction). The results of these efforts should be shared with the Lake Simcoe Stewardship Network.

8.2.7 Prioritizing stewardship projects

Recommendation 6-17 – That the MNR, with the assistance of the MOE and LSRCA, develop a spatially-explicit decision support tool to assist in targeting terrestrial stewardship projects in the Lake Simcoe watershed. In the context of the Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatershed, this decision tool should take into account factors including:

- the need to increase natural vegetation cover along the Lake Simcoe shoreline
- protecting and restoring ecologically significant groundwater recharge areas, to help mitigate the expected impacts of climate change
- opportunities to restore lost wetlands, particularly in the east half of the subwatershed, where the topography has minimal slope, and the area is underlain by fine-grained, poorly-drained soils
- opportunities to increase connectivity across the subwatersheds for dispersing flora and fauna
- the potential for non-forested valleylands, particularly in agricultural areas, as features which could improve wildlife connectivity
- the need to protect and restore grassland habitat, particularly rare native grasslands

Recommendation 5-7 – That the LSRCA, with the assistance of the MNR and MOE, develop a spatially-explicit decision support tool to assist in targeting aquatic habitat stewardship projects in the Lake Simcoe watershed. In the context of the Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds, this prioritization tool should take into account factors including:

- The need to incorporate each major type of aquatic habitat stressor including bank hardening, barriers, riparian cover, and on-line ponds;
- The use of best available datasets to identify potential restoration sites, including LSRCA BMP inventory and riparian assessment;
- Expected improvements to aquatic habitat and therefore fish and benthic community condition, including improved water temperature, increased connectivity for movement within and between tributaries, and shelter.
- Opportunities to reduce phosphorus loadings in the tributaries in these subwatersheds

- The relative cost of implementing projects in urban, urbanizing, and agricultural areas, particularly with respect to the cost of implementing retrofit projects in the relatively heavily urbanized City of Barrie.

Recommendation 5-8 – That prioritized restoration areas be integrated into a stewardship plan that ensures prioritized restoration opportunities are undertaken as soon as feasible. This stewardship plan should incorporate the outcomes of recommendations to improve uptake identified in Recommendations 5-1 through 5-6.

Recommendation 3-16 - That these spatially-explicit decision support tools be used to prioritize allocation of stewardship resources, so that funds are provided in locations where maximum benefit can be achieved.

8.2.8 Reducing salt use

Recommendation 3-13 - That subwatershed municipalities, with the assistance of the LSRCA, develop or adopt a program such as the Region of Waterloo's "Smart about Salt" program, to educate snow removal contractors and property managers about best practices for reducing salt use while ensuring that public safety is not compromised. Further, that subwatershed municipalities examine the feasibility of adopting a certification program, wherein private contractors could become certified as "smart" salt applicators, reflecting their understanding of the need to balance environmental protection and public safety in snow and ice management, and the feasibility of requiring all contractors working on municipal property to have such certification.

Recommendation 3-14 - Recognizing that increasing concentrations of chloride in watercourses is an emerging issue shared by all municipalities in the Lake Simcoe watershed, that the watershed municipalities, LSRCA, MOE, and MNR form a Salt Working Group as a mechanism to share information on best practices for salt application, methods of increasing public awareness of the environmental impacts of road salt, and the effectiveness of municipal Salt Management Plans.

8.3 Applied science

8.3.1 Reducing salt use

Recommendation 3-11 - That the LSRCA, with the support of subwatershed municipalities, develop a program to determine relative contribution of chloride from road salt application, establish baseline indicators, and examine the effectiveness of current protocols on salt storage, application, and disposal, as outlined in their respective Salt Management Plans, adapting them as necessary.

Recommendation 3-12 - That the LSRCA, with the support of subwatershed municipalities, identify areas within the Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds which are vulnerable to road salt (as outlined by Environment Canada). This assessment may be refined through further examination of relative salt tolerance of local biota. As outlined in Environment Canada's Code of Practice for the Environmental Management of Road Salt, municipalities should examine alternate methods of protecting public safety while reducing environmental impacts in these areas, once identified.

8.3.2 Establishing instream flow targets

Recommendation 4-3 - That the MNR and MOE, in partnership with LSRCA, develop a more detailed surface water budget for the Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds that will provide basis of actions needed to determine ecological (instream) flow targets.

Recommendation 4-4 (5-9) –That the MOE, with assistance from LSRCA, MNR and the University of Guelph, determine in-stream flow regime targets for Barrie, Lovers, Hewitt's, and Innisfil Creeks. These targets should be based on the Guidance Document framework (LSRCA 2010) which is being used for the Maskinonge River subwatershed.

Recommendation 4-5 (5-9) – That the MOE and MNR, with assistance from LSRCA, develop a strategy to achieve the instream flow regime targets. This strategy should address both high and low flow requirements and provide a plan for implementing strategy recommendations.

8.3.3 Increasing our understanding of climate change

Recommendation 3-18 (4-17) -That the LSRCA work with its federal, provincial, and municipal partners to refine the anticipated impacts of climate change in the Lake Simcoe watershed. This information can then be used to develop management strategies to address these impacts. Emphasis at this time should be placed on building ecological resilience in vulnerable subwatersheds through stream rehabilitation, streambank planting, barrier removal, and other BMP implementation in conjunction with the protection of current hydrologic functions.

Recommendation 6-18 – That the members of the Lake Simcoe Stewardship Network be encouraged to build into their projects relevant provisions for the anticipated impacts of climate change, such as the need to recommend species which are suitable for future climate conditions, and the possibility of an increase in invasive plants, pests, and diseases which may further limit the success of traditional stewardship approaches.

Recommendation 4-16 –That the LSRCA, with the assistance of MOE and MNR, develop a fully integrated groundwater and surface water model that is able to take advantage of real-time or near real-time flow data, to predict how stream flow volumes will respond to the seasonal and ecological impacts of climate change, in terms of increase peak flows, reduced baseflows, and increased water demand

8.3.4 *Monitoring and assessment*

Recommendation 3-19 - That the LSRCA enhance the existing monitoring network, through the comprehensive monitoring strategy, to address identified limitations and gaps of the current monitoring program. Review of potential enhancements should consider:

- Undertaking periodic monitoring of toxicants such as pesticides and pharmaceuticals
- Spatial coverage of monitoring stations relative to addressing key monitoring questions such as the relationship between changes in land use cover and changes in water quality and quantity
- Establishing water quality monitoring stations in the headwaters, in addition to the mouths, of the tributaries
- Monitoring additional parameters that are are key indicators of ecosystem health and restoration progress such as brook trout spawning.

Recommendation 5-14 – That LSRCA, with support from Municipalities and the Province, aim for improved spatial and temporal resolution in annual monitoring of aquatic habitat, including water quality, fish and benthic indicators.

Recommendation 6-22 – That the MNR, with the assistance of LSRCA and MOE, complement the proposed monitoring strategy with standardized surveys of the distribution and abundance of terrestrial species at risk throughout the Lake Simcoe watershed.

Recommendation 6-23 – That the MNR, LSRCA, and MAFRA continue to maintain an up-to-date seamless land cover map for the watershed, as defined by the LSPP, with natural heritage features classified using Ecological Land Classification, managed in such a way as to allow change analysis.

Recommendation 6-24 – That the MNR and LSRCA take advantage of data that is already available, by developing a biodiversity database that can collate information reported in EIS and EA reports, information reported in natural area inventories, plot-based data collected in the watershed-wide Vegetation Survey Protocol that is underway, plot-based data collected by citizen-scientists for the Breeding Bird Atlas, and other data as may be available.

Recommendation 6-25 – That the MNR, with the assistance of the LSRCA, take advantage of this soon-to-be compiled data, and develop lists of watershed-rare taxa, and policies to support their protection.

Recommendation 3-22 – That the LSRCA, in collaboration with MNR, MOE, and MAFRA, develop a program for assessing efficacy of new stormwater facilities, stewardship best management practices, and restoration projects, to improve understanding of the effectiveness of stewardship efforts.

8.3.5 Improving data management

Recommendation 4-2 - That the MOE be encouraged to continue to improve the Water Taking Reporting System by integrating the Permit To Take Water (PTTW) database with the Water Well Information System (WWIS) database, and connecting those takings to wells / aquifers to facilitate impact assessment (i.e. the PTTW database needs to be connected to the WWIS database).

Recommendation 6-26 (3-20) – That the MNR, LSRCA, and MOE develop a framework to allow effective and efficient management and sharing of data before implementing the comprehensive monitoring program. This framework may include the designation of one agency as the curator of all monitoring data collected in the Lake Simcoe watershed.

8.3.6 Additional research needs

Recommendation 6-27 – That the Lake Simcoe Science Committee, other levels of government, and academia support research to better understand the stresses to wildlife and wildlife habitat associated with urban development, to allow management responses to be refined. Important questions of interest include: the use of stormwater ponds as amphibian breeding habitat, the importance of remnant natural areas to quality of life for local residents, the indirect impacts of roads on resident and migratory wildlife, and the impacts of high density and low density development on wildlife communities in natural areas. This research may include literature reviews, analysis of data available through the monitoring program, or original, innovative, peer-reviewed research.