Barrie Creeks, Lovers Creek, and Hewitt's Creek Subwatershed Plan

Lake Simcoe Region
conservation authority

2012

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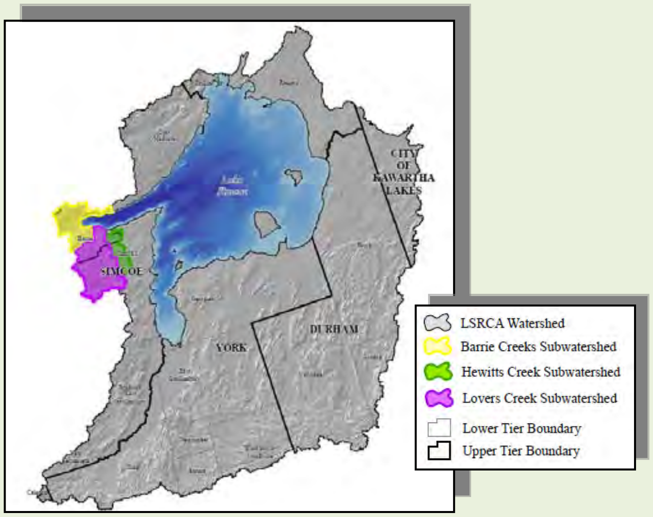
The Barrie Creeks, Lovers Creek, and Hewitt’s Creek Subwatershed Plan (2012)

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.

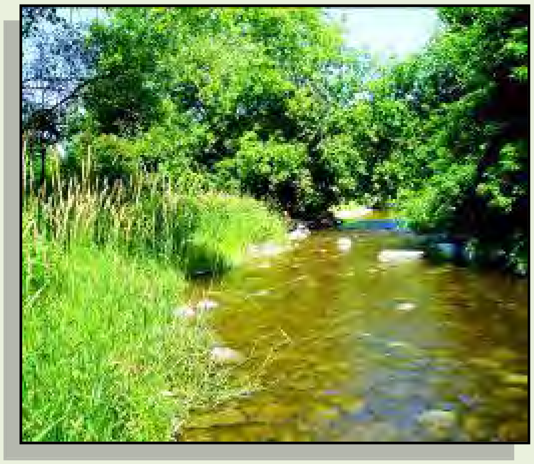
Subwatershed plans are often implemented through the incorporation of policies into municipal planning documents, including Official Plans, and Secondary, District or Community Plans and subsequent development applications.

CONTEXT

- This subwatershed plan looks at three separate subwatersheds: Barrie Creeks, Lovers Creek and Hewitt’s Creek. The Barrie Creeks subwatershed is located in the west central portion of the Lake Simcoe watershed and is roughly 37.5 km^2 in size. Ninety-three percent of the subwatershed is within the City of Barrie, with the Townships of Oro-Medonte in the northeast and Springwater to the northwest accounting for the remaining area. Approximately 75% of the area in the Barrie Creeks subwatershed is developed, with small levels of natural heritage features and agriculture.

- East of the Barrie Creeks subwatershed is the Lovers Creek subwatershed, at 59.9 km^2 in area. Fifty eight percent of its area lies within the Town of Innisfil and the remaining area in the City of Barrie. Thirty five percent of the land in Lovers Creek consists of natural heritage features, including forests, wetlands, and grasslands. Agriculture accounts for 34%, and developed land uses account for 21%.
- The Hewitt's Creek subwatershed is the smallest subwatershed, with a surface area of only 17.5 km^2. Sixty percent of its area lies within the Town of Innisfil, with the remaining area in the southern portion of the City of Barrie. Over half of the Hewitt's Creek subwatershed is occupied by agriculture; and natural heritage features and urban land both occupy close to 20% (respectively) of the subwatershed area.

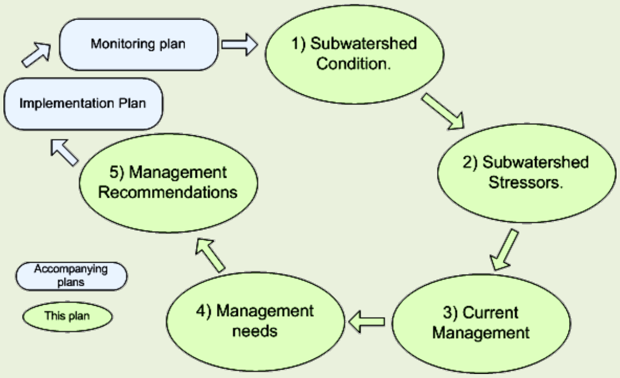
This subwatershed plan was prepared under the direction of the Lake Simcoe Protection Plan (LSPP), which was released by the province in 2009. The LSPP identifies the preparation of subwatershed evaluations/plans as a crucial stage in its implementation. The LSPP states that they "will be critical for 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 Barrie, Lovers, and Hewitt's 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) information. 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, the conservation authority, and community group representatives. The Implementation Plan will become the common work plan used in long term protection and rehabilitation efforts.

STATUS

Water Quality – In each of the three subwatersheds, there are locations that we visit regularly to take samples of the water to be tested for a number of substances, such as phosphorus and suspended sediments. The Lovers Creeks station is the only station in these subwatersheds where we have been collecting data long-term, sampling at the other locations started in 2008.

The majority of the data from the Lovers Creek station indicates that the water quality meets relevant guidelines, although there is a trend towards degrading quality. For example, 35% of samples exceed the phosphorus guidelines in the current data, whereas the historic data for this site shows only 24% exceeding the guideline.

Monitoring sites in Hewitt's Creek and Hotchkiss Creek (in the Barrie Creeks subwatershed) show similar trends, although Hotchkiss shows higher maximum concentrations of phosphorus. Chloride appears to be more of a concern in the Hotchkiss Creek subwatershed, where only 7% of samples meet the chronic exposure guideline, compared to 90% in Hewitt's Creek and 70% in Lovers Creek. In addition, 10% of the samples at the Hotchkiss site actually exceeded the "acute effects" guideline for chloride. Based on recent modelling, the prediction is that these subwatersheds will contribute increasing amounts of phosphorus if nothing is done. The estimates are for phosphorus loading to Lake Simcoe to increase by 6.5%, 43.3%, and 35.5% respectively as a result of the Barrie, Lovers, and Hewitt's Creek subwatersheds, based on the land use changes that are planned.

Water Quantity –

Groundwater flows generally toward Kempenfelt Bay. Research indicates that groundwater discharge is a substantial contributor to the flow in these subwatersheds. The greatest flows have typically been observed during the spring freshet (thaw) that typically occurs in March and April, although the spring thaw itself has diminished in magnitude and duration as a result of the recent warmer winters. With respect to flow characteristics, water levels and flows in Lovers Creek and Hewitt's Creek have been rising very quickly in response to precipitation events and then return to normal quickly after that; likely due to the relatively high degree of urbanization, as well as the small subwatershed size which offers less area for precipitation to be stored and slowly released into streams.

Areas referred to as Significant Groundwater Recharge Areas have been identified 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). This work has been further refined to identify Ecologically Significant Groundwater Recharge Areas, which are areas thought to contribute to features such as coldwater streams and wetlands, for the study area.

Fish Habitat –Fish communities in these subwatersheds vary. Coldwater species, including mottled sculpin and brook trout, have been found in Kidd's, Whiskey, Hotchkiss, Lovers, and Hewitt's Creeks. Others show signs of stress with either no fish caught, or with fish species found that are less sensitive to environmental stresses. It is important to note that a number of sites in very urban areas are still able to support coldwater species, indicating the strong influence of groundwater in maintaining conditions. Benthic invertebrate communities (organisms that live at the bottom of rivers and lakes) also vary widely within the subwatersheds. The healthiest sites are found in Lovers and Hewitt's Creeks. 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 17%, 27%, and 21% of the land area in the Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds, respectively. Woodlands cover 12% of the Barrie Creeks subwatershed, 27% of the Lovers Creek subwatershed, and 15% of the Hewitt's Creek subwatershed. These numbers fall below Environment Canada's Areas of Concern guideline of 30% as a minimum threshold for maintaining woodland dependent biodiversity. The Barrie and Hewitt's Creeks subwatersheds also have low levels of streambank cover, wetland area, and interior forest area; while the Lovers Creek subwatershed is relatively healthier with respect to these parameters. Significant increases in urban area and climate change are of significant concern to the natural environment features in these subwatersheds.

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.

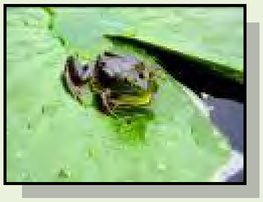


TABLE OF CONTENTS

LIST OF FIGURES

CHAPTER 1

CHAPTER 2

CHAPTER 3

CHAPTER 4

CHAPTER 5

CHAPTER 6

CHAPTER 7

LIST OF TABLES

CHAPTER 2

CHAPTER 3

CHAPTER 4

CHAPTER 5

CHAPTER 6

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 Barrie Subwatershed Plan consists of three separate subwatersheds: Barrie Creeks, Lovers Creek and Hewitt's Creek. As Lovers and Hewitt's Creek subwatersheds are smaller in size, located directly beside the Barrie Creeks subwatershed, and the areas of greatest urban growth are located within the City of Barrie municipal boundaries, they have been included within this subwatershed plan. Figure 1-1 illustrates the location of these subwatersheds within the Lake Simcoe watershed.

The Barrie Creeks subwatershed is located in the west central portion of the Lake Simcoe watershed and is roughly 37.5 km^2 in size, comprising approximately 1.4% of the Lake Simcoe watershed. Major tributaries in the Barrie Creeks subwatershed include Sophia Creek, Kidds Creek, Bunkers Creek, Dyment Creek, Hotchkiss Creek, and Whiskey Creek. None of these creeks form a confluence, and all six creeks drain into Lake Simcoe separately. All of the creeks originate along the subwatershed borders and all flow predominantly through developed, urban areas. Almost the entire subwatershed (93%) is located within the City of Barrie, with the Townships of Oro-Medonte in the northeast and Springwater to the northwest accounting for the remaining area at 5% and 2% respectively. It should be noted that recommendations specifically related to the area in the Township of Oro-Medonte will be addressed in the Oro and Hawkestone Creeks subwatershed plan, which has recently been initiated.

East of the Barrie Creeks subwatershed is the Lovers Creek subwatershed. At 59.9 km^2 in size, it comprises 2.3% of the Lake Simcoe watershed. Lovers Creek is the only named stream within the Lovers Creek subwatershed and it begins in the southern part of the subwatershed, where the headwater portions are channelized, and flows north towards Lake Simcoe. The majority of the subwatershed is within the Town of Innisfil (58%), with the remaining area within the south portion of the City of Barrie (42%).

Hewitt's Creek subwatershed comprises less than 1% of the Lake Simcoe watershed, making it the smallest subwatershed with a surface area of only 17.5 km^2. It is located between the Lovers Creek and Innisfil Creeks subwatersheds and Hewitt's Creek itself is the only named stream in the Hewitt's Creek subwatershed. Originating in the southern, primarily agricultural, portion of the subwatershed, it flows northward towards Lake Simcoe. Hewitt's Creek subwatershed is located mainly in the Town of Innisfil (60%), with the remaining area in the southern portion of the City of Barrie (40%).

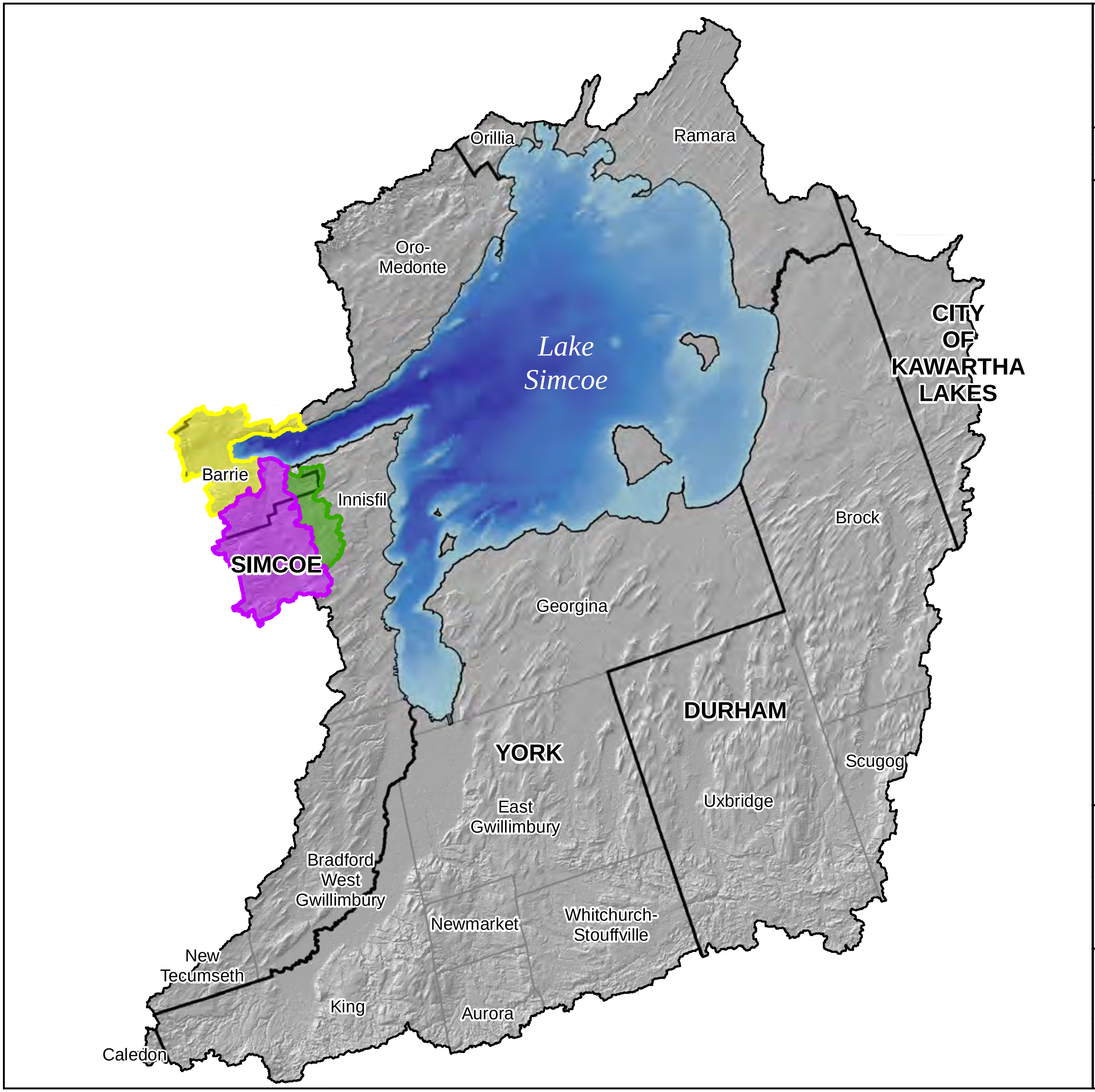
In the Lake Simcoe watershed, the various land uses have had considerable impacts on water quality and quantity, and aquatic and terrestrial habitats. In order to mitigate the impacts of land use changes in each of the subwatersheds, and to prevent future impacts, subwatershed plans are developed. These 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 City of Barrie (includes Barrie Creeks, Lovers Creek and Hewitt's Creek subwatersheds) and Town of Innisfil (includes Innisfil Creek subwatershed) is scheduled for completion in 2012. The evaluation of these subwatersheds will reflect the goal, objectives and targets of the Lake Simcoe Protection Plan and will be tailored to the needs and local issues within each.

Location of the Barrie Creeks, Lovers Creek and Hewitt's Creek subwatershed

Figure 1-1

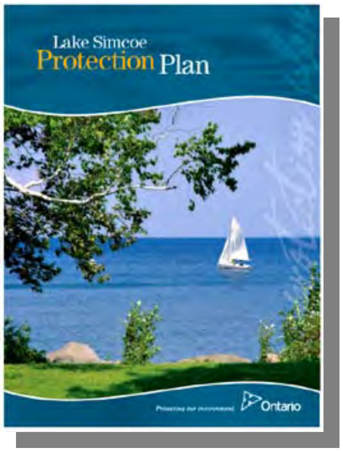


Legend

- LSRCA Watershed
- Barrie Creeks Subwatershed
- Hewitts Creek Subwatershed
- Lovers Creek Subwatershed
- Lower Tier Boundary
- Upper Tier Boundary

Lake Simcoe Region conservation authority

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 (MOE and MNR, 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.

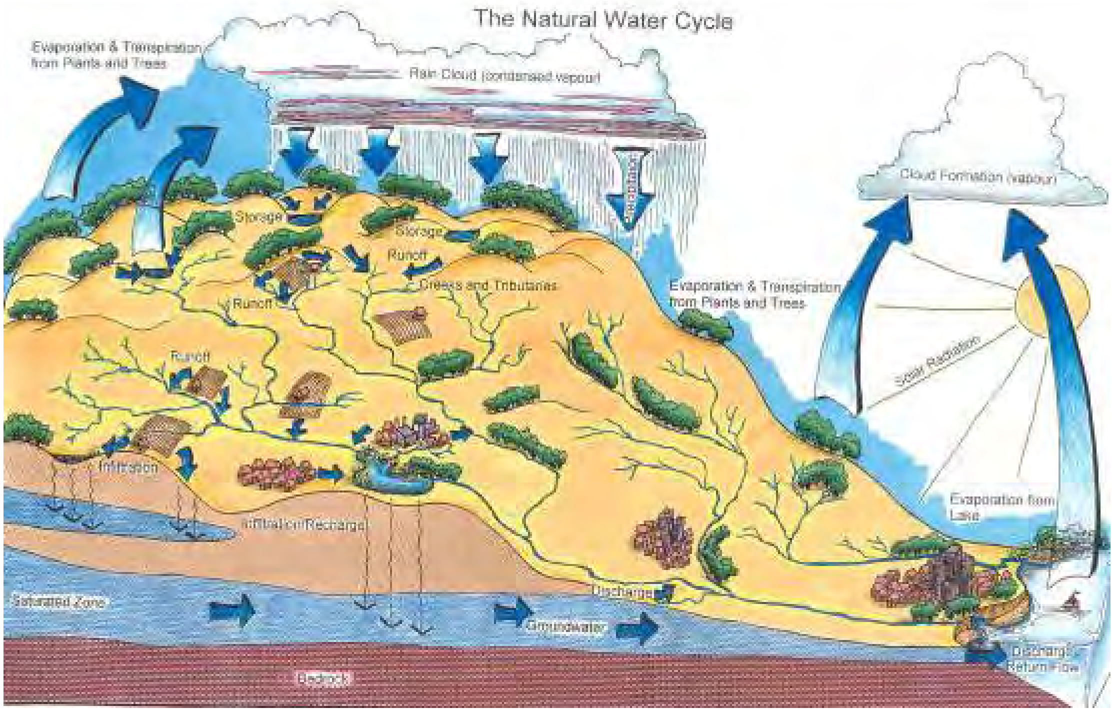
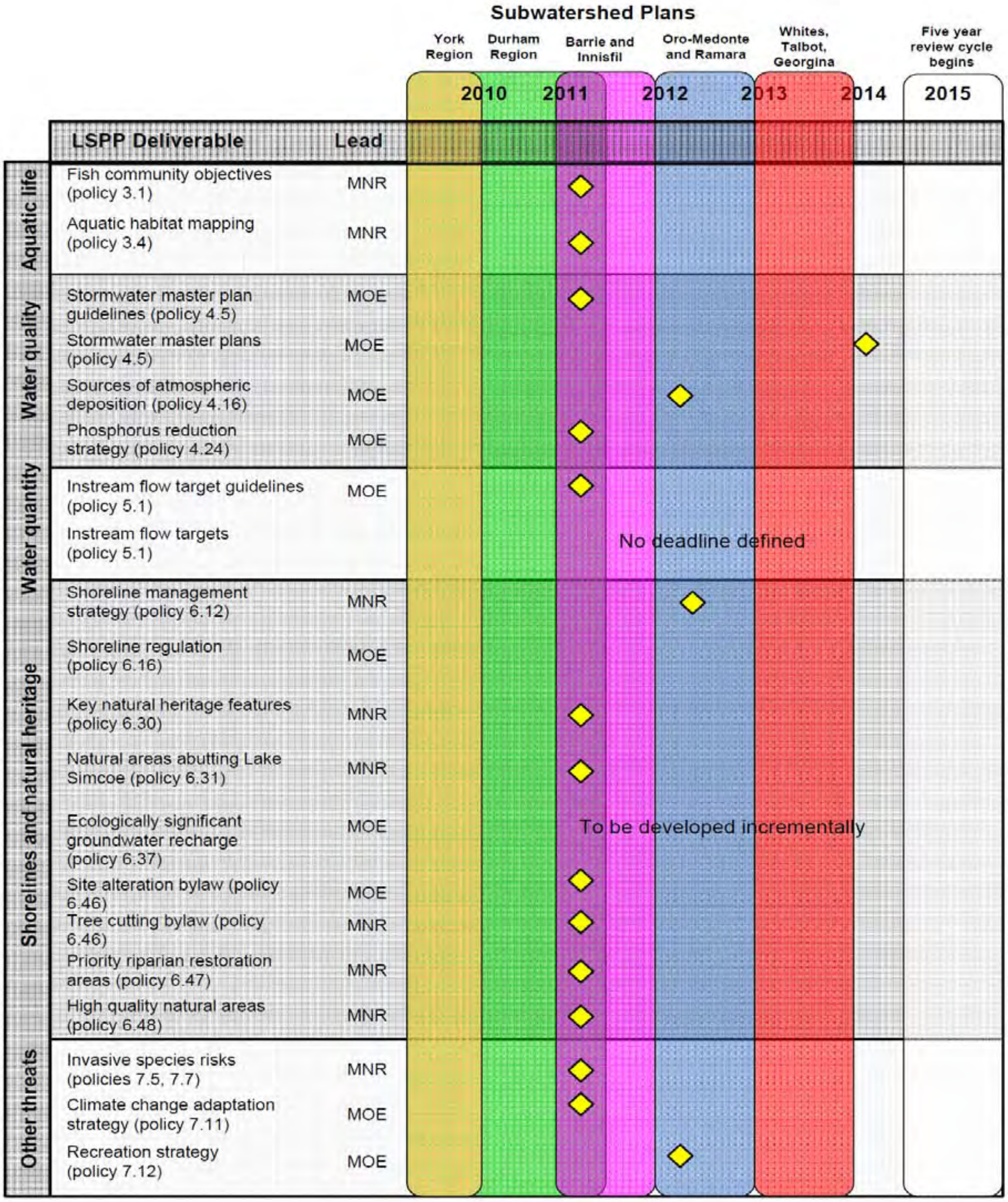


Figure 1-2: The hydrological cycle (image courtesy of Conservation Ontario).

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.



	LSPP Deliverable	Lead	2010	2011	2012	2013	2014	2015
Aquatic life	Fish community objectives (policy 3.1)	MNR		◆				
	Aquatic habitat mapping (policy 3.4)	MNR		◆				
Water quality	Stormwater master plan guidelines (policy 4.5)	MOE		◆				
	Stormwater master plans (policy 4.5)	MOE					◆	
	Sources of atmospheric deposition (policy 4.16)	MOE			◆			
	Phosphorus reduction strategy (policy 4.24)	MOE		◆				
Water quantity	Instream flow target guidelines (policy 5.1)	MOE		◆				
	Instream flow targets (policy 5.1)			No deadline defined				
Shorelines and natural heritage	Shoreline management strategy (policy 6.12)	MNR			◆			
	Shoreline regulation (policy 6.16)	MOE						
	Key natural heritage features (policy 6.30)	MNR		◆				
	Natural areas abutting Lake Simcoe (policy 6.31)	MNR		◆				
	Ecologically significant groundwater recharge (policy 6.37)	MOE		To be developed incrementally				
	Site alteration bylaw (policy 6.46)	MOE		◆				
	Tree cutting bylaw (policy 6.46)	MNR		◆				
	Priority riparian restoration areas (policy 6.47)	MNR		◆				
	High quality natural areas (policy 6.48)	MNR		◆				
Other threats	Invasive species risks (policies 7.5, 7.7)	MNR		◆				
	Climate change adaptation strategy (policy 7.11)	MOE		◆				
	Recreation strategy (policy 7.12)	MOE			◆			

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 City of Barrie, Town of Innisfil, 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.

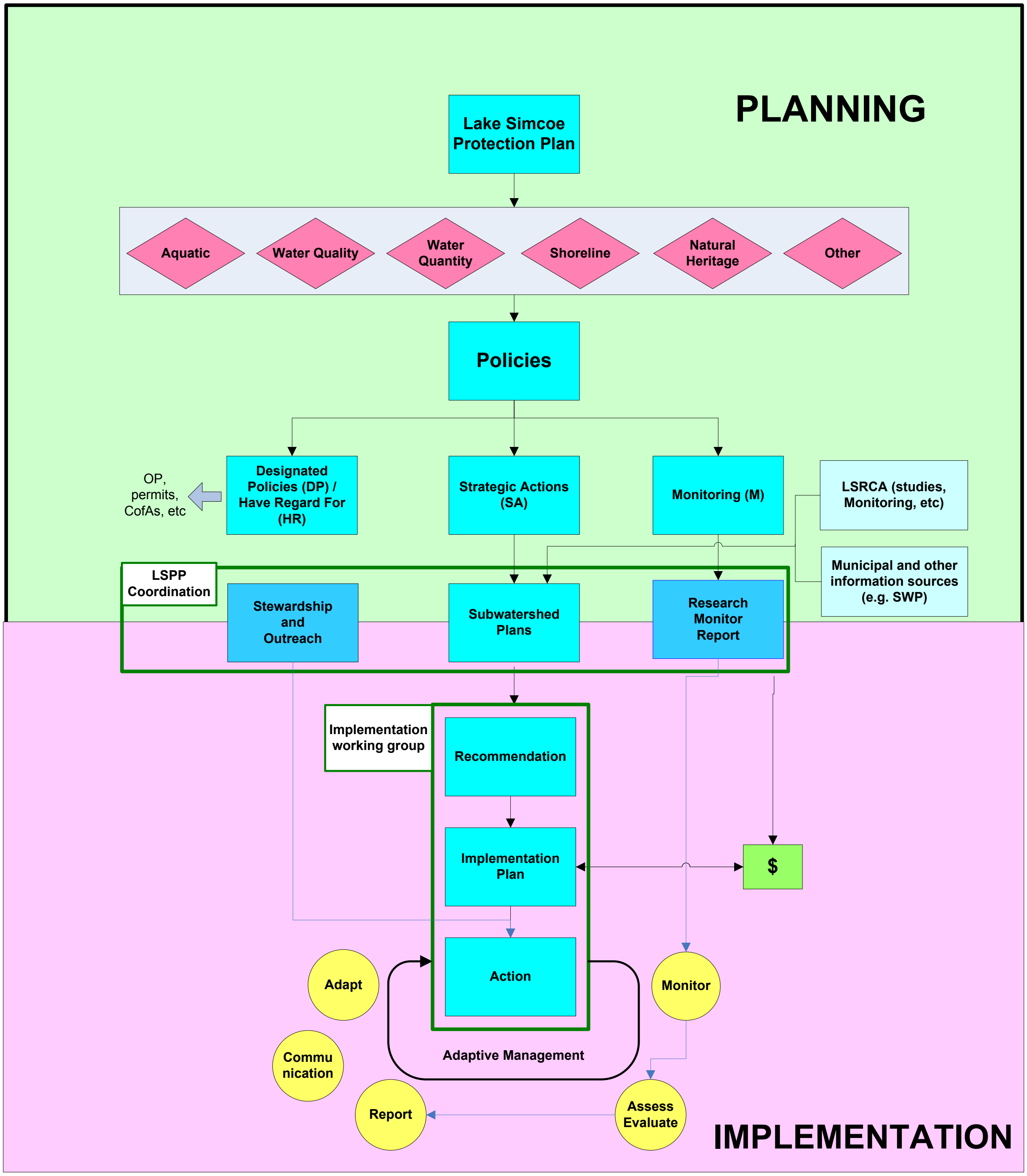


Figure 1-4: Subwatershed planning context

1.6 Retrospective – a history of subwatershed plans in the Lovers and Hewitt's Creeks subwatersheds

Subwatershed planning was initiated in the Lovers and Hewitt's Creeks subwatersheds in 1995, with the development of the *Lovers Creek and Hewitt's Creek Master Watershed Plans*. The LSRCA initiated this study in cooperation with the City of Barrie and the Town of Innisfil. This plan was developed with input from a project steering committee, which consisted of municipal, provincial, and conservation authority staff; and the study team, which consisted of experts from Cumming Cockburn Limited and Charlesworth and Associates.

The plan consisted of five phases and an overall goal to “promote an ecosystem-based approach to environmental and land use planning” (MOEE, 1993). Some of the objectives of the plan included:

- Identification of the natural features and resources in the watershed.
- Identification of appropriate environmental management practices for the watershed, based on targets for the existing natural processes and physical features of the watershed.
- Provision of guidance for the choice of Best Management Practices in the watershed.
- Assessment of the potential impact of change in the watershed on the natural systems and recommendations on how compatibility with the natural environment and watershed functions can be maintained.
- Provision of consistent direction for the review and approval of development in the watershed.
- Provision of an implementation strategy that integrates watershed plan objectives with municipal and agency planning instruments and defines the roles and responsibilities of parties in the watershed.

Overall the plan explored the state of the subwatershed in regard to a number of parameters, including water quality, water quantity, aquatic environment, and terrestrial environment. Management issues were also identified for each of these parameters. The plan makes numerous recommendations to address the management issues that were identified within the subwatershed.

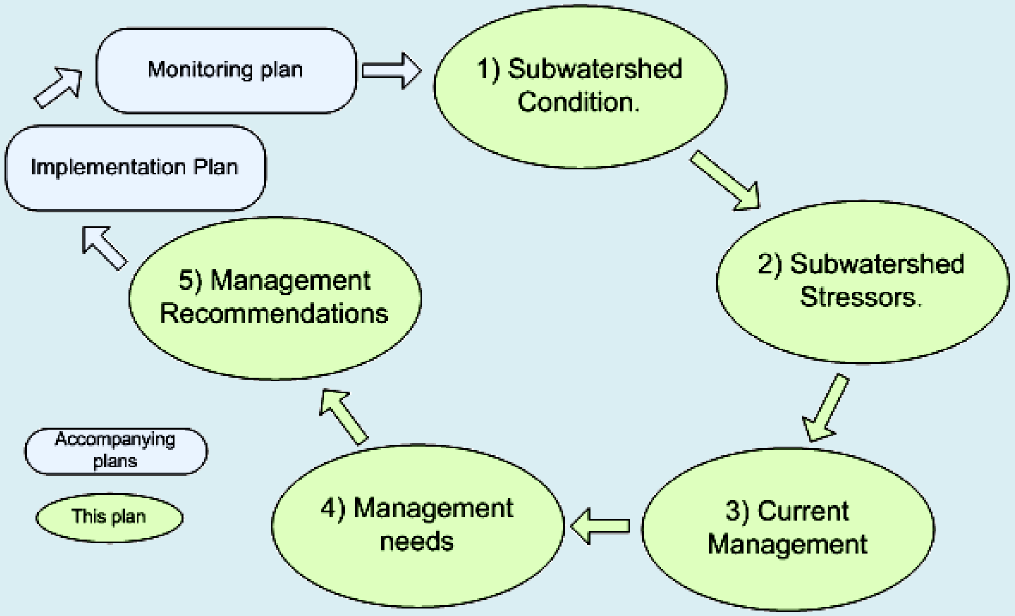
Many of the issues that were discussed in the *Lovers Creek and Hewitt's Creek Master Watershed Plans* are also identified in this plan.

1.7 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).

1.8 How this plan is organized

This plan includes a chapter dedicated to each of the five subwatershed features identified previously, these being water quality, water quantity, aquatic natural heritage, 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 the following text box).



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 Barrie Creeks, Lovers Creek and Hewitt's Creek subwatersheds.

2.1 Location

All of the lands within the Lake Simcoe watershed ultimately drain into Lake Simcoe, via one of the tributary rivers. The Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds are three of the 18 subwatersheds that make up the Lake Simcoe watershed. All three drain into Kempenfelt Bay, a western arm of Lake Simcoe, which is approximately 37.8 km^2 in size, or about 5.5 % of Lake Simcoe (Figure 2-4).

The Barrie Creeks subwatershed is located almost entirely within the City of Barrie, with small portions falling into the Townships of Oro-Medonte and Springwater. Within the subwatershed boundaries there are six major tributaries draining separately into Lake Simcoe. As previously mentioned in **Chapter 1 - Introduction**, all of the creeks originate along the subwatershed borders and flow predominantly through developed, urban areas. One creek, Sophia, flows directly through the downtown area of Barrie. While this subwatershed lies in one of the more densely populated areas in Lake Simcoe, the entire subwatershed only covers an area of approximately 37.5 km^2 with a total watercourse length (including all branches) of 53.8 km (about 1.3 % of the total combined watercourse length of the entire Lake Simcoe watershed). Figure 2-1 is a depiction of the subwatershed and its land uses.

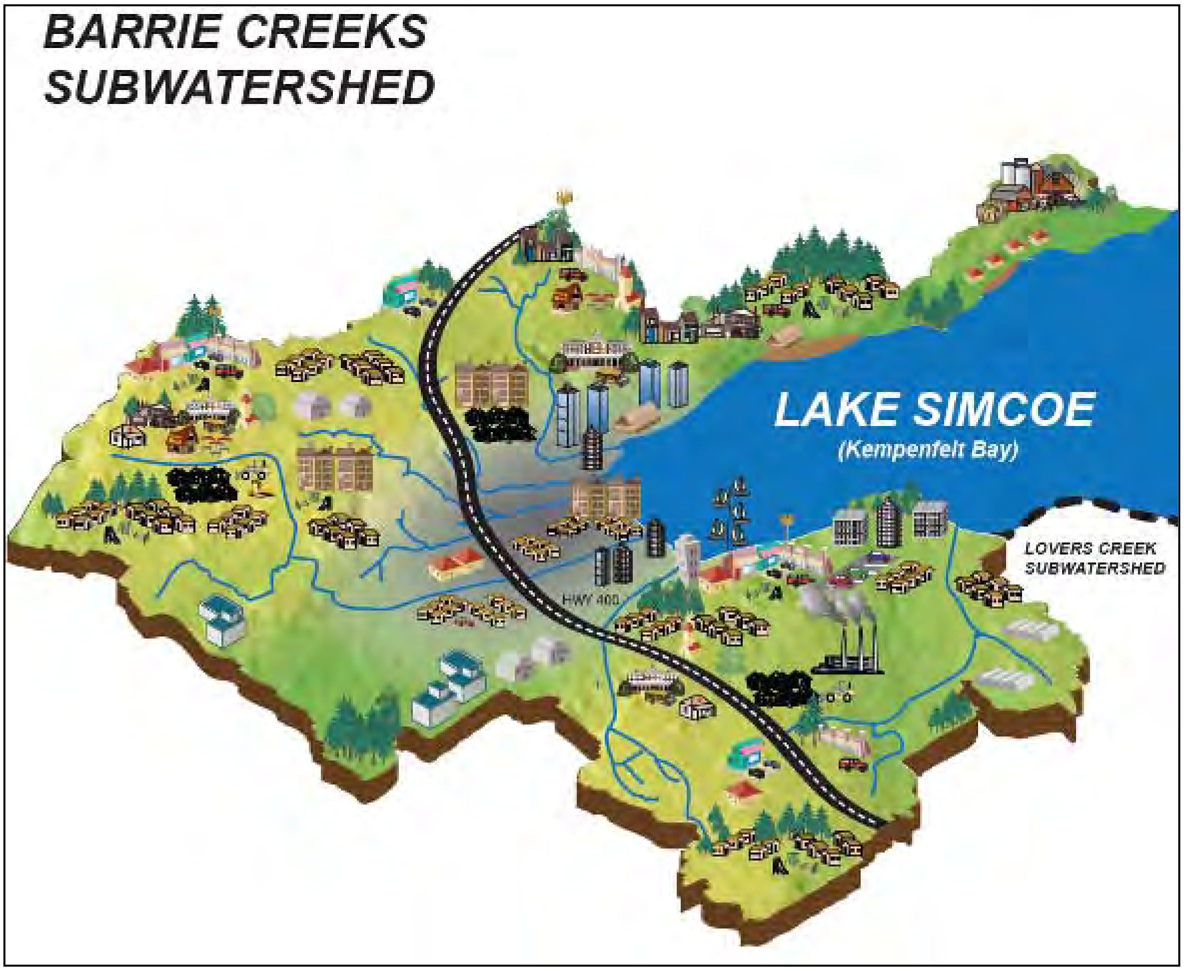


Figure 2-1: Depiction of the Barrie Creeks subwatershed

To the east of Barrie Creeks is the Lovers Creek subwatershed, with just over half of its land mass in the Town of Innisfil and the rest in the City of Barrie. Unlike the Barrie Creeks subwatershed, Lovers has only one main tributary that has a total combined length of 93.1 km (includes all branches) or about 2% of the total combined watercourse length of the entire Lake Simcoe watershed. With headwaters located in the southern part of the subwatershed (south of Innisfil Beach Road), it flows in a northerly direction until draining into Lake Simcoe. Within the boundaries of this 59.9 km^2 subwatershed, there are the two main settlement areas and the only major road running through the subwatershed is Highway 400. The land uses are relatively evenly split between agriculture, natural heritage, and urban and built up areas. Figure 2-2 depicts the subwatershed and the land uses found within it.

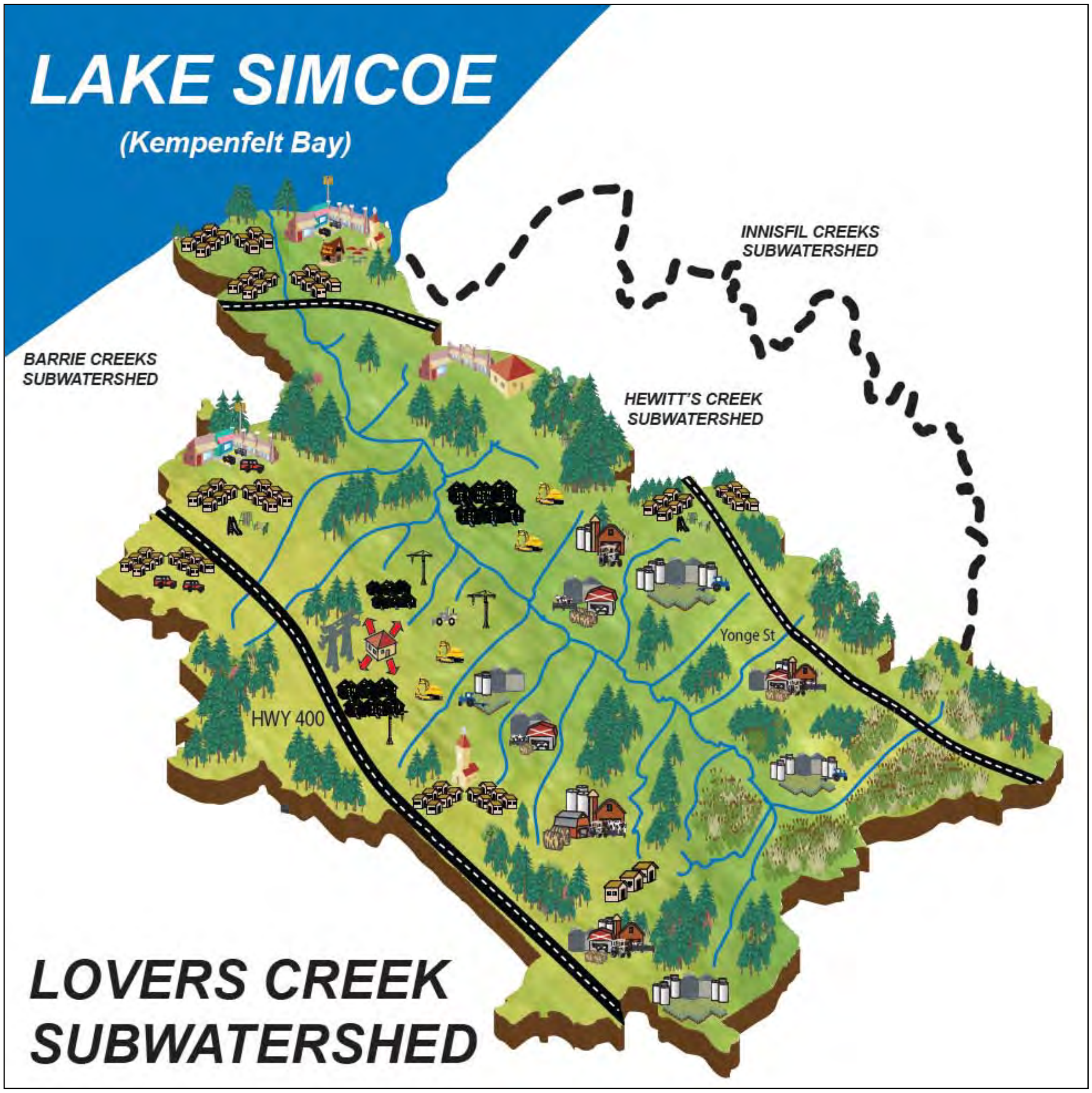


Figure 2-2: Depiction of the Lovers Creek subwatershed

The last subwatershed within this plan is the Hewitt's Creek subwatershed, located further to the east, in between the Lovers Creek and Innisfil Creeks subwatersheds. Like the Lovers Creek subwatershed, the Hewitt's Creek subwatershed has only one main tributary, Hewitt's Creek, draining into Lake Simcoe on the south shore of Kempenfelt Bay. The subwatershed has a total combined watercourse length of 23.6 km (about 0.6% of the total combined watercourse length of the entire Lake Simcoe watershed) with the main tributary headwaters located in the south, in primarily agricultural surroundings. The majority of the 17.5 km^2 subwatershed is located within the Town of Innisfil with the remaining portion in the City of Barrie. The subwatershed and its landuses are depicted below in Figure 2-3.

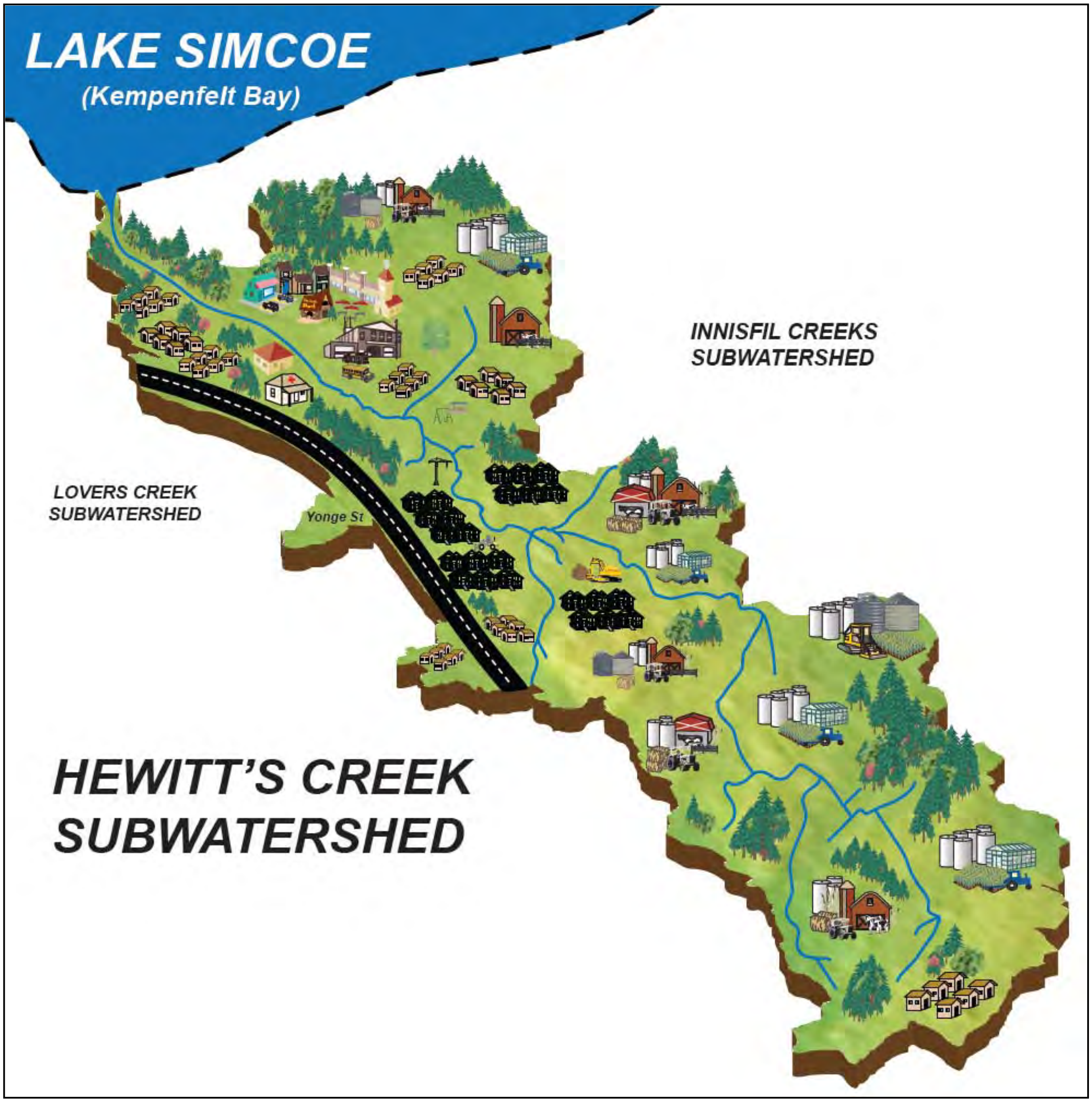


Figure 2-3: Depiction of the Hewitt's Creek subwatershed

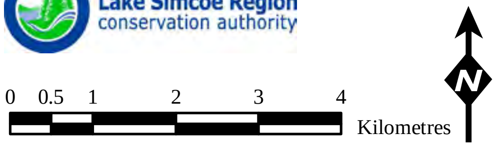
The Barrie Creeks, Lovers Creek and Hewitt's Creek subwatersheds

Figure 2-4

Legend

—	Road
▬	Municipal Boundary
〰	Watercourse
🟪	Barrie Creeks
🟩	Hewitts Creeks
🟧	Lovers Creeks

Lake Simcoe Region conservation authority



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. Barrie Creeks is located mostly within the City of Barrie (with very small portions in the Townships of Oro-Medonte and Springwater), while both the Lovers and Hewitt's Creeks subwatersheds have land in the City of Barrie and the Town of Innisfil.

Population within the 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 5 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 4 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).

The Town of Innisfil, while not seeing the same increase in the number of residents as the City of Barrie, did have a higher percent increase, expanding 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 not as mobile, 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 municipal population from each municipality and total population density for each of the subwatersheds is presented in Table 2-1.

Table 2-1: Population and population density within the Barrie Creeks, Lovers Creek and Hewitt's Creek subwatersheds (Data Source: Stats Canada, 2011 Census)

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)
Barrie Creeks	37.53	City of Barrie	135,711	63,124	63,209	1,684
		Township of Oro-Medonte	20,078	64		
		Township of Springwater	18,223	21		
Lovers Creek	59.95	City of Barrie	135,711	19,370	21,698	362
		Town of Innisfil	33,079	2,328		
Hewitt's Creek	17.52	City of Barrie	135,711	8,493	9,391	536
		Town of Innisfil	33,079	898		

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 City of Barrie and Town of Innisfil populations, 15 years and over, and their education attainment compared to that of the provincial standings.

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

	City of Barrie	Town of Innisfil	Province of Ontario
No certificate; diploma or degree	22 %	27 %	22 %
High school certificate or equivalent	29 %	29 %	27 %
Apprenticeship or trades certificate or diploma	9 %	13 %	8 %
College; CEGEP or other non-university certificate or diploma	24 %	20 %	18 %
University certificate or diploma below the bachelor level	3 %	3 %	4 %
University certificate; diploma or degree	13 %	9 %	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 addition of these annexed lands, the City of Barrie gained an additional (approximate) 500 residents.

2.2.2 Land Use

Land use within the Barrie Creeks, Lovers Creek and Hewitt's Creek subwatersheds has been divided up into 11 classes including intensive and non-intensive agriculture, rural development, industrial, and natural heritage features (Figure 2-5 to Figure 2-7). Land uses with 0% coverage in a subwatershed were not reported.

The Barrie Creeks subwatershed is one of the most urbanized subwatersheds in the Lake Simcoe basin with approximately 63% of the land use being urban. This includes commercial, estate residential, institutional and other various urban land uses. The smallest land uses include rural development (1%), railway (1%) and active aggregate (2%).

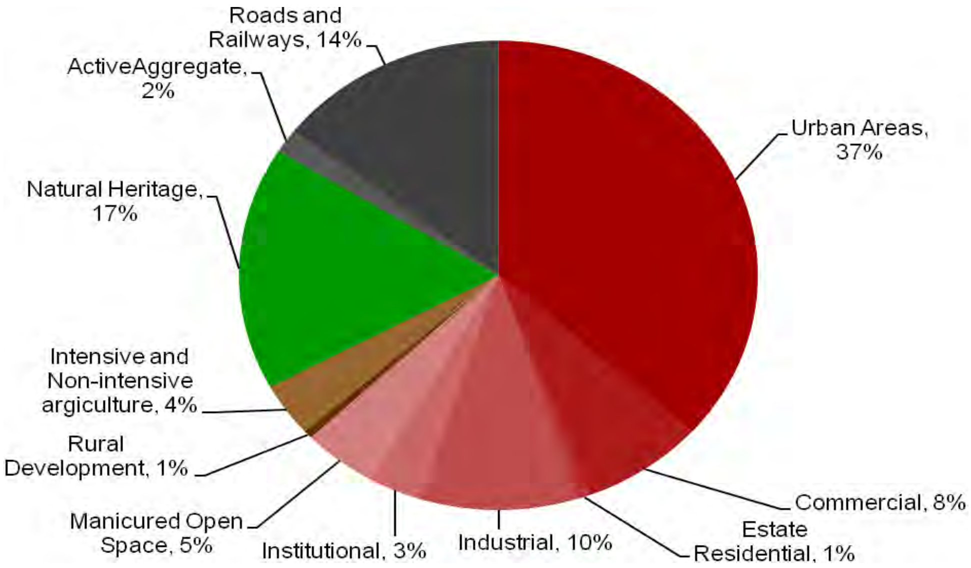


Figure 2-5: Land use distribution within the Barrie Creeks subwatershed.

Unlike the Barrie Creeks subwatershed, the largest land use in the Lovers Creek subwatershed is tied between natural heritage features (35%) and intensive and non-intensive agriculture (34%). There is a much smaller percentage of urban land use (21%) than in the Barrie Creeks subwatershed. Other land uses occupying smaller areas include manicured open space (1%), golf courses (2%) and rural development (2%).

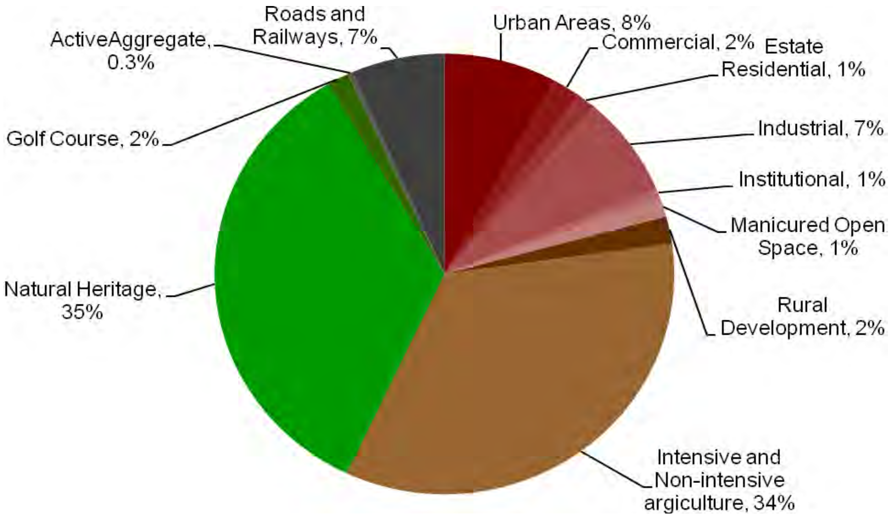


Figure 2-6: Land use distribution within the Lovers Creek subwatershed.

Within the Hewitt's Creek subwatershed the largest land use is intensive and non-intensive agriculture, composing 52% of the area. This is followed by natural heritage features (21%) and urban land use (19%), with small amounts of land residential (1%) and manicured open space (1%).

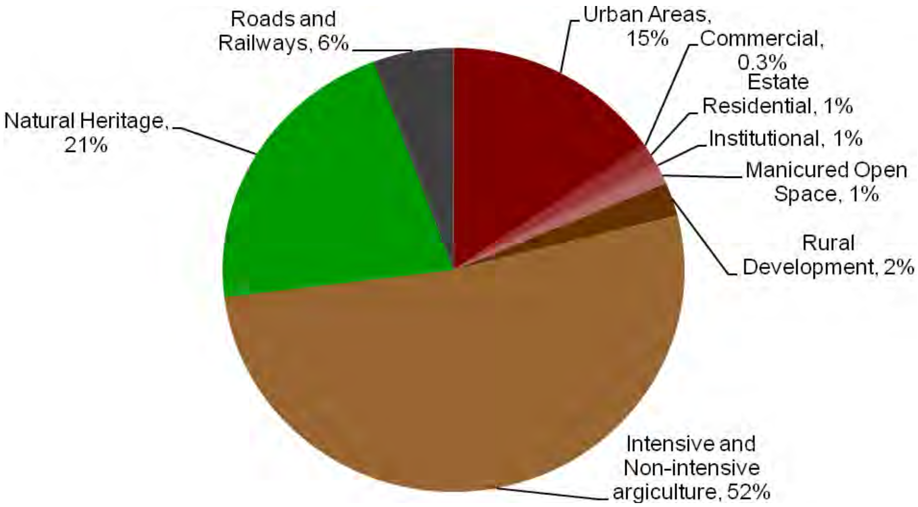
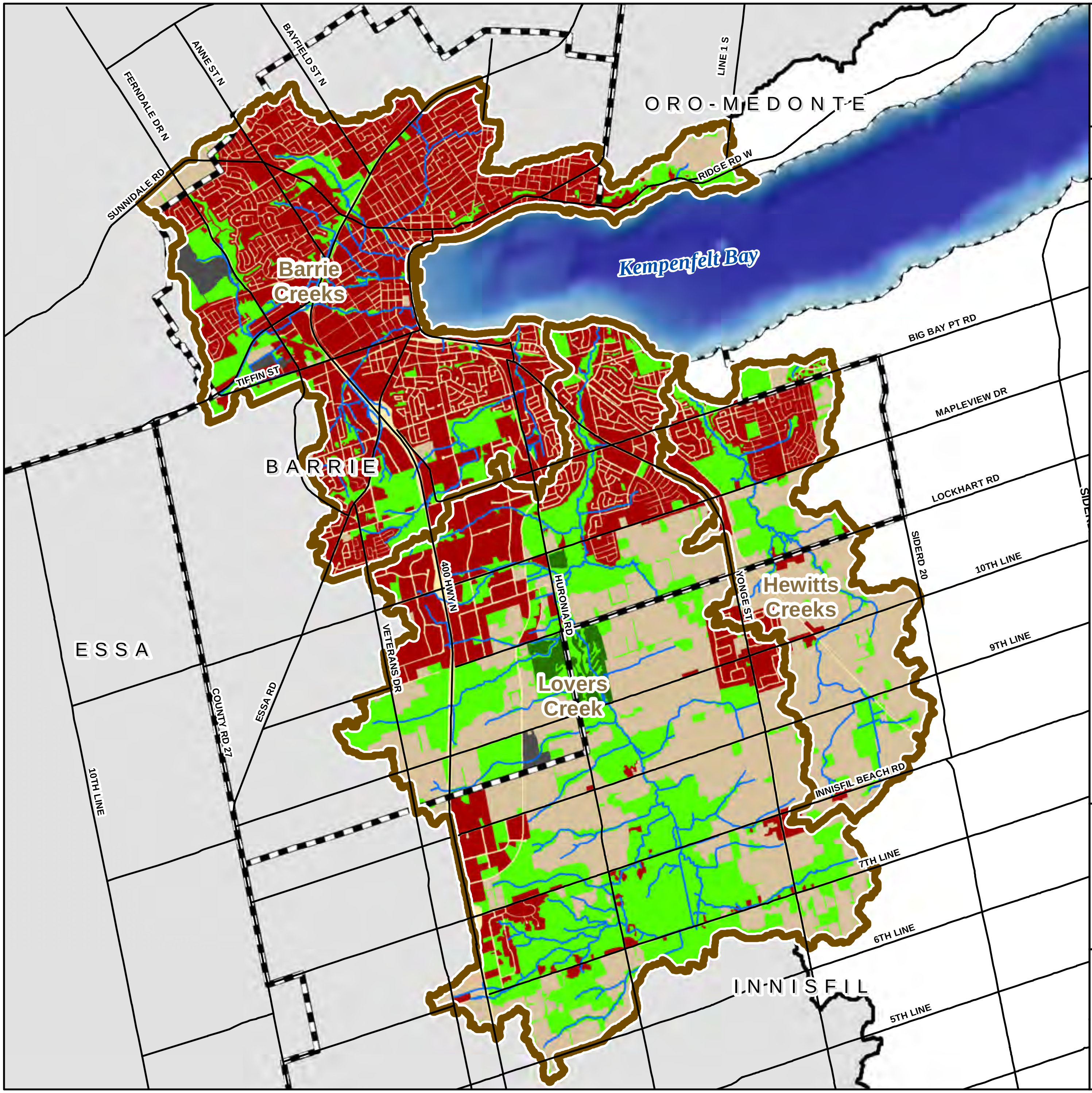


Figure 2-7: Land use distribution within the Hewitt's Creek subwatershed.

The distributions of land uses within the three subwatersheds can be seen in Figure 2-8.



Land uses in Barrie Creeks, Lovers Creek and Hewitt's Creek subwatersheds

Figure 2-8

Legend

- ― Road
- ▬ Municipal Boundary
- 〰 Watercourse

Land Use

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

Lake Simcoe Region conservation authority

0 0.5 1 2 3 4 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.

To see how these three subwatersheds compare to the other subwatersheds within the Lake Simcoe watershed Figure 2-9 to Figure 2-11 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 Barrie Creeks, Lovers Creek and Hewitt's Creek subwatersheds are outlined in black.

For urban land use (Figure 2-9), the Barrie Creeks has the highest percentage (63%) while Whites Creek subwatershed in the eastern part of the watershed has the lowest (1%). Lovers and Hewitt's Creek have the third and fourth highest percentages (21% and 19%, respectively), with only the East Holland subwatershed having a higher percentage (26%).

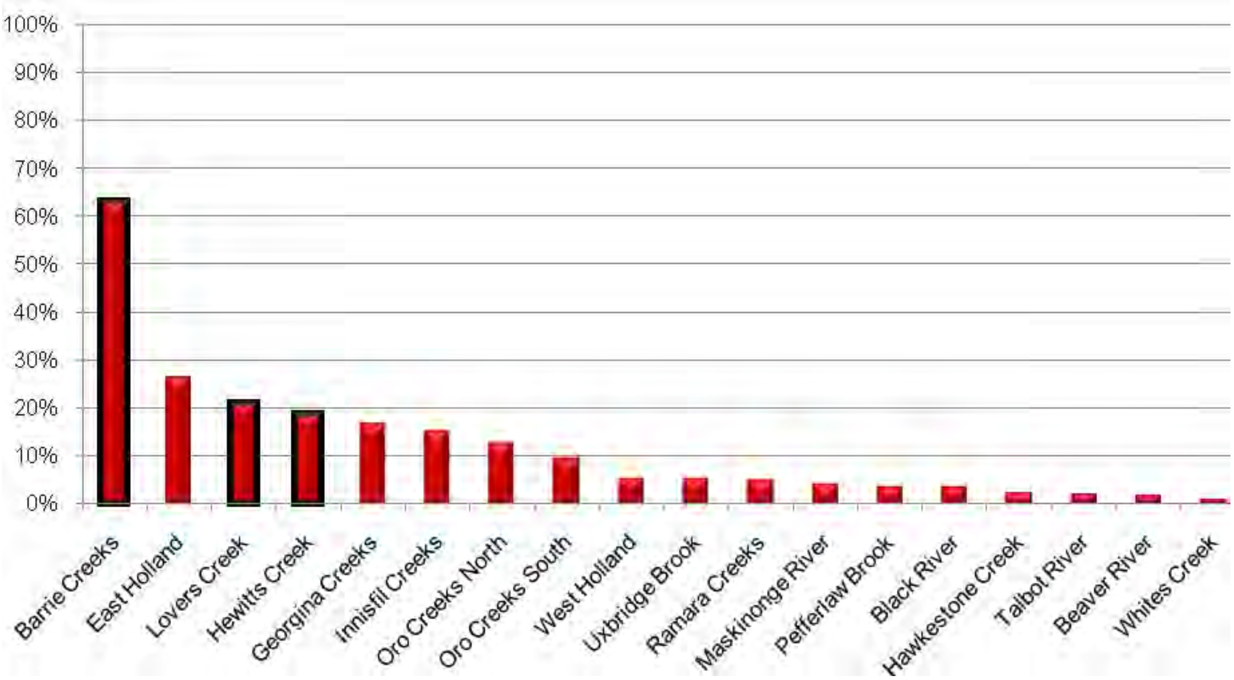


Figure 2-9: Urban land use in the Lake Simcoe subwatersheds.

The subwatershed with the highest percentage of natural heritage land cover is Hawkestone Creek (57%) in the south-west of the watershed, while the Barrie Creeks subwatershed has the lowest percentage (17%). Hewitt's Creek subwatershed has the third lowest percentage with 21%, while the Lovers Creek subwatershed sits midway with natural heritage features consisting of 35% of its land cover (Figure 2-10).

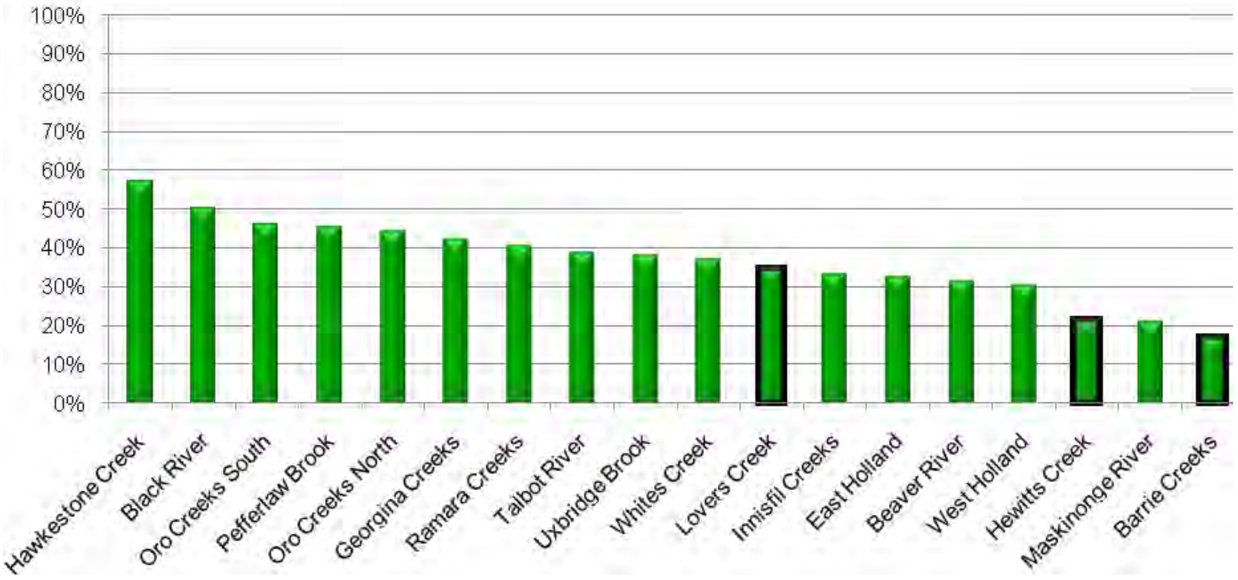


Figure 2-10: Natural heritage land cover in the Lake Simcoe subwatersheds.

Figure 2-11 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%. The Barrie Creeks subwatershed has the lowest (5%) percentage of rural landuse, with a large percentage gap between it and of the second lowest subwatershed (East Holland subwatershed) which has 34%. The Lovers Creek subwatershed is third lowest with 36%, while the Hewitt's Creek subwatershed is at the higher end of the scale with 54% rural land use.

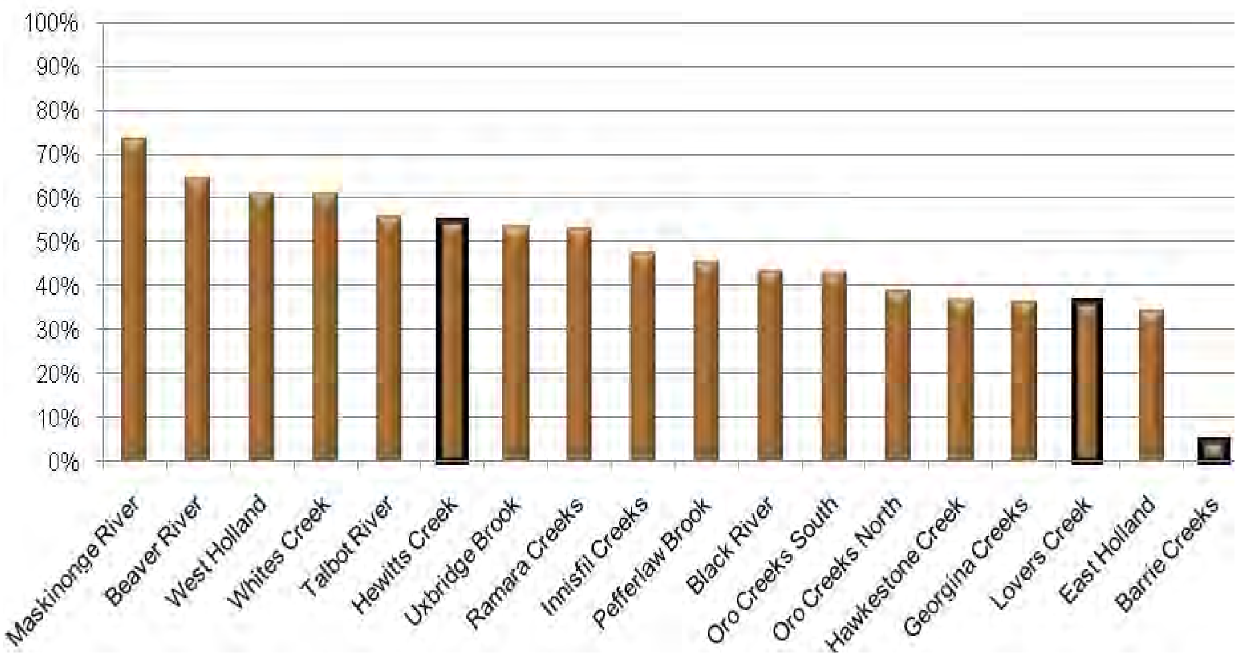


Figure 2-11: Rural land use in the Lake Simcoe subwatersheds.

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 Barrie Creeks subwatershed is significantly above the upper limit threshold, with 75% impervious surface. The Lovers and Hewitt’s Creeks subwatersheds, on the other hand are above the 10% guideline, but are below the upper limit threshold with approximately 29% and 26% impervious surface, respectively. As these subwatersheds haven’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 the water quality. Figure 2-12 illustrates the impervious cover within these subwatersheds.

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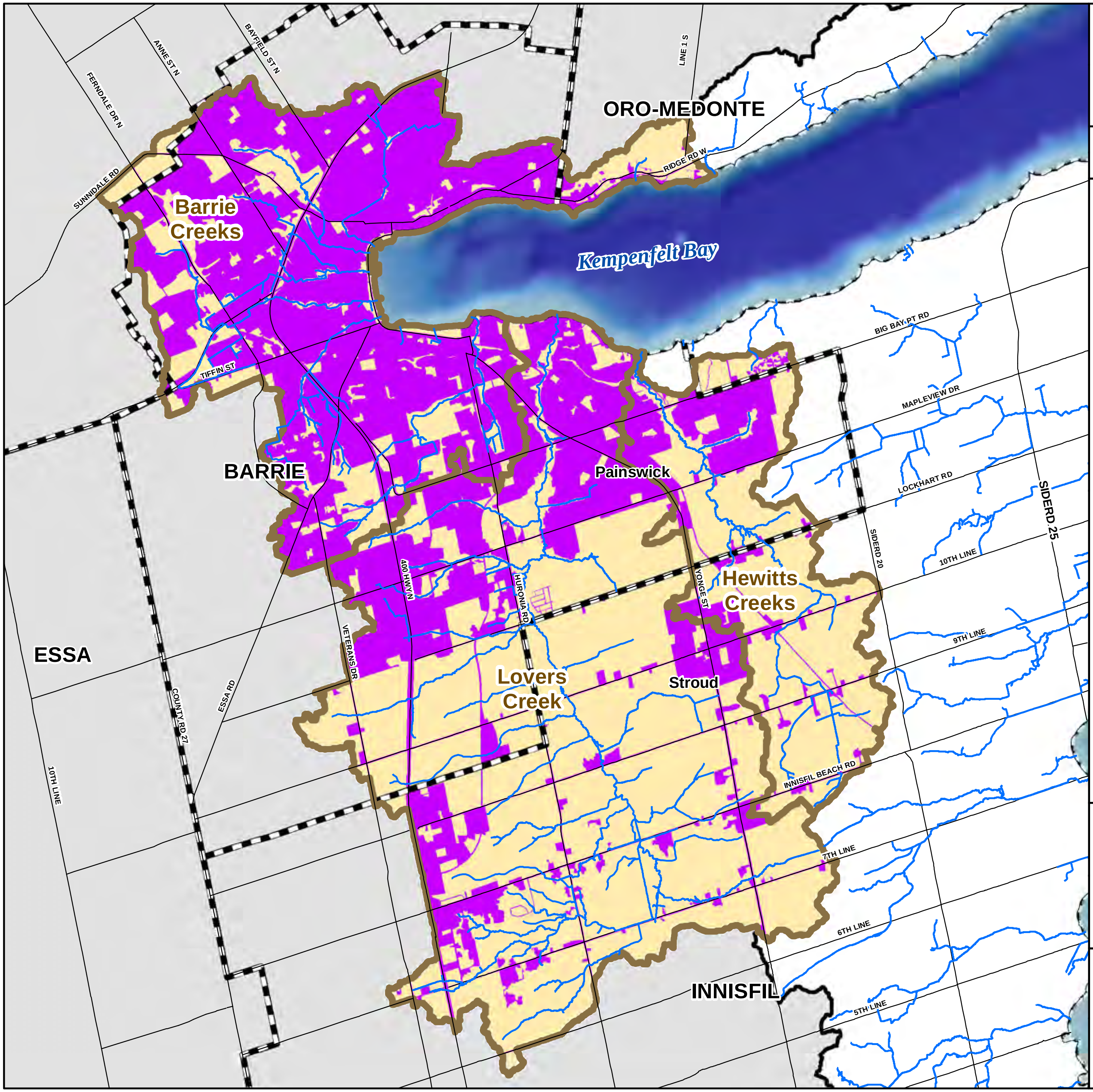
[1] For the majority of this report, impervious surfaces do not include features such as wetlands. These are sometimes considered impervious in hydrogeological models, such as those presented in **Chapter 4 – Water Quantity**.



Impervious cover in the Barrie Creeks, Lovers Creek and Hewitt's Creek subwatersheds

Figure 2-12

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 Kilometres

N

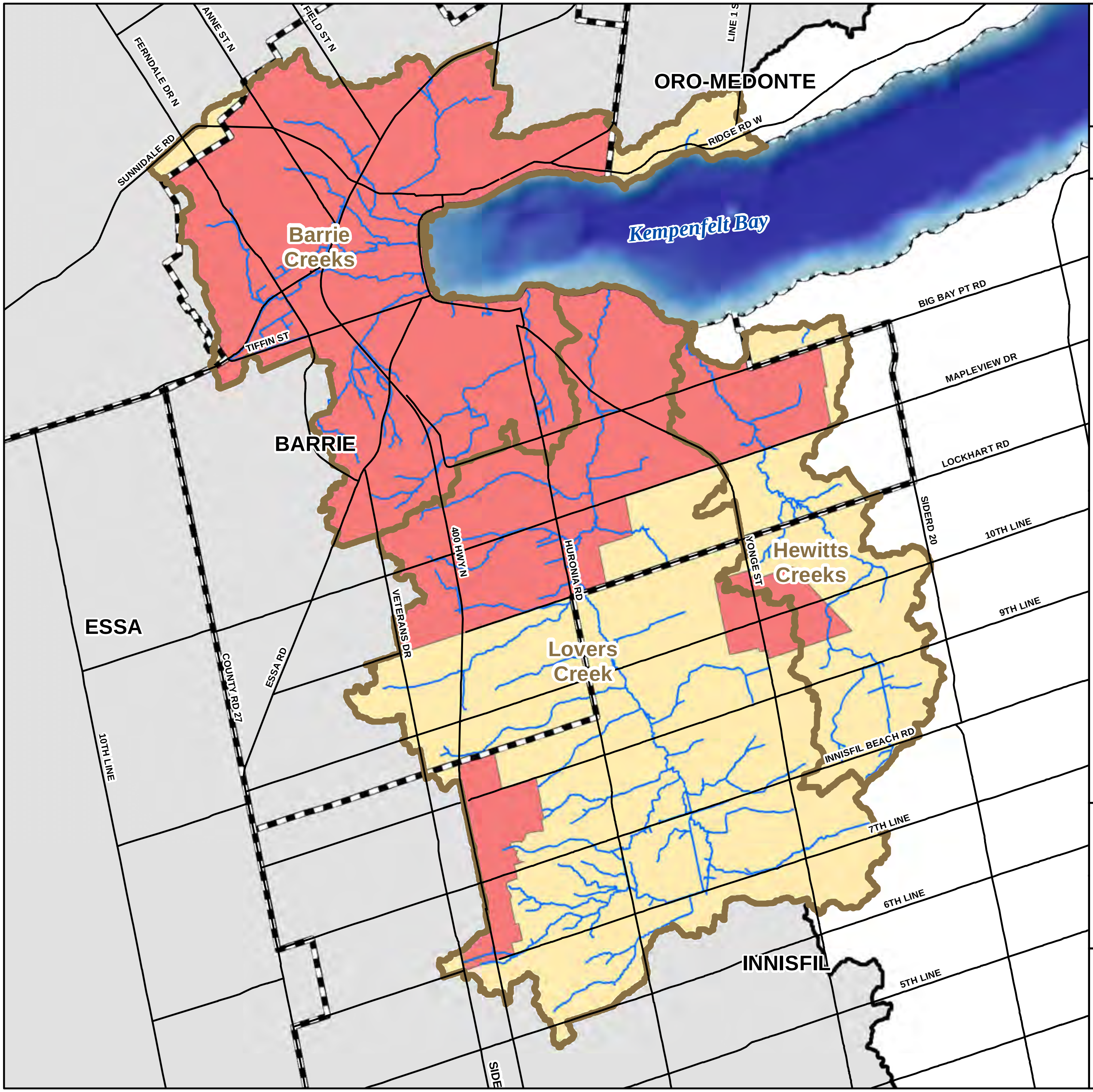
2.2.2.2. Settlement Areas

The City of Barrie is one of the major urban areas within these three subwatersheds, as well as in the Lake Simcoe watershed. Other built up areas within the Barrie Creeks, Lovers Creek and Hewitt's Creek subwatershed include the waterfront development along the Town of Innisfil shoreline. Compared to past population projections, the Lake Simcoe watershed population continues to grow faster than originally anticipated (LSEMS, 1995). Urban growth 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 10,000 private dwellings in the City of Barrie. In the Town of Innisfil there was an increase of approximately 840 private dwellings (Statistics Canada, 2001 and 2006). Settlement areas are shown in Figure 2-13.

Even with a growing population, there are still a large number of residents who work outside their municipality, county and even province and Canada. Approximately half of the residents of the City of Barrie (49%) work within the City and the others work outside of it or have no fixed work address (51%). 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 within the municipality (Table 2-3). The City of Barrie could also be considered a bedroom community for some of the larger cities, such as the City of Toronto.

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

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



Settlement areas in the Barrie Creeks, Lovers Creek and Hewitt's Creek subwatersheds

Figure 2-13

Legend

— Road

▬ Municipal Boundary

〰 Watercourse

🟥 Settlement

Lake Simcoe Region conservation authority

0 0.5 1 2 3 4 Kilometres

N

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 have 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 ones with the lowest included construction and manufacturing (5.4%) while business services saw a 0.7% decrease (Table 2-4).

The City of Barrie, with more residents working within the municipality, saw an increase in all industries with the largest percent increase 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 City of Barrie and the Town of Innisfil (Data Source: Statistics Canada, 2001 and 2006).

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

* Red font indicates a decrease

2.3 Human Health and Wellbeing

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 2-14 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 wellbeing to watershed management.

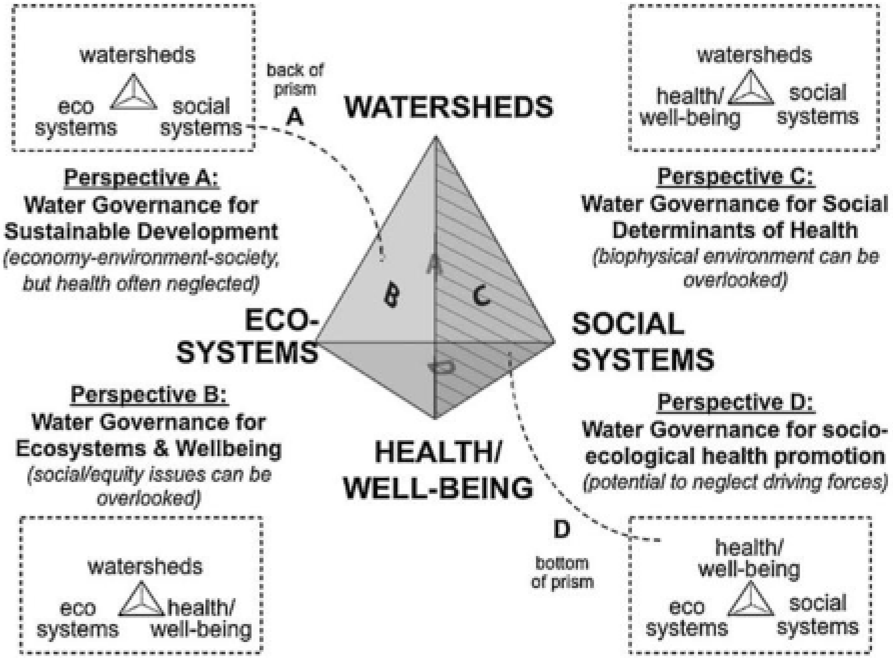


Figure 2-14: Watershed Governance Prism (Parkes *et al,*. 2010).

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.

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 these subwatersheds 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 forest 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: 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 year olds who spent less time doing near-work activities (reading, drawing, etc) and more time doing outdoor activities were 2 to 3 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 Barrie Creeks subwatershed there are a large number of parks open to the public (see http://www.barrie.ca/Living/ParksTrails/Pages/Parks.aspx for full list) both within town and along the waterfront, as well as the Waterfront Trail which links the downtown area with municipal parks and residential areas, and is great for walking, biking or rollerblading. There are also a number of City-owned natural heritage lands available for recreation. These include the Gables, Lackie's Bush, Shear Natural Area, Audrey Milligan Pond, Dymentss Creek Natural Area, Sunnidale Park, Sandy Hollows Ravine and the Berczy Street Natural Area, in addition to parts of the waterfront that protect natural areas and provide recreational trails.

The City of Barrie also has a number of City-owned natural areas in the Hewitt's and Lovers Creek subwatersheds, including: the Hewitt's Creek Ravine and Wilkin's Way along the lower reaches of Hewitt's Creek and the Lovers Creek Ravine along the lower reaches of Lovers Creek. Both these areas protect forested valleylands and have recreational trails. Additionally, the headwaters of Lovers Creek are located in the Blauxham Tract of the Simcoe County Forest, which also has recreational trails.

For the lands with the Town of Innisfil, there are a number of parks and waterfront recreational opportunities available which include baseball diamonds, soccer pitches, swimming areas, play structures and walking trails. The full list of parks and trails in the Town of Innisfil is available at http://www.town.innisfil.on.ca/Parks-and-Trails.

There are no Provincial Parks or Conservation Areas in any of these subwatersheds.

2.3.1.2. Mental

In addition to physical health benefits, there is 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 benefits 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 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 *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, 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[2]. 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 is one system in Barrie Creeks, two in Lovers Creek and one in Hewitt's Creek subwatersheds. All are groundwater supply systems, with the exception of the Barrie Water Treatment Plant in the Lovers Creek subwatershed. While a large portion of the Barrie Water Treatment Plant Intake Protection Zone (IPZ) is located along the northern shore of the Innisfil Creeks subwatershed, the IPZ-2 stretches down within the Lovers Creek subwatershed and has therefore been accounted for in this subwatershed plan. The Barrie Water Treatment Plant provides drinking water to the City of Barrie residents and is located in the municipal boundaries of the City of Barrie. Table 2-5 breaks down the number of drinking systems, municipal wells and surface intakes for each subwatershed.

Table 2-5: Number of drinking water systems, wells and surface water intakes.

Subwatershed	Number of Drinking Water Systems	Number of Municipal Supply Wells	Number of Municipal Surface Water Intakes
Barrie Creeks subwatershed	1	15	0
Lovers Creek subwatershed	2	2	1
Hewitt's Creek subwatershed	1	3	0

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[2] Information for the Barrie, Lovers and Hewitt's Creek subwatersheds can be found in the Approved Lakes Simcoe and Couchiching-Black River Source Protection Area Assessment Report, Part 1: Lake Simcoe. Chapters 8 and 10 of this Assessment Report are specific to the City of Barrie and Town of Innisfil.

Each of the drinking water systems in Table 2-5 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 4 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).
    - WHPA-D: 25-year tot capture zone
- Similarly, an IPZ is the area around a surface water intake and includes 3 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 a 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 Approved South Georgian Bay Lake Simcoe Source Protection Region Assessment Reports.

Both the City of Barrie and the Town of Innisfil 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. Of the four systems within these subwatersheds, two are in the City of Barrie (Barrie Well Supply and the City of Barrie Water Treatment Plant) and two are in the Town of Innisfil (Innisfil Heights Well Supply and Stroud Well Supply).

The Barrie Well Supply, consisting of 15 wells, had a total of 546 significant drinking water threats identified on 447 property parcels. The significant threats identified were associated with a variety of land uses, with a large number associated with the handling and storage of Dense Non-Aqueous Phase Liquids. Additionally, the City of Barrie Well Supply had two drinking water issues and six drinking water conditions identified. A drinking water issue is parameter that is at a concentration that may result in the deterioration of the quality of water for use as a source of drinking water or if there is a trend of increasing concentrations of the parameter and a continuation of that trend that would results in the deterioration of the quality of water as a source of drinking water (MOE, 2008 [Technical Rule 114. (1)[a-b]). The indentified drinking water issues include chloride at Well 3A and chloride and sodium at wells 11, 12 and 14. Drinking water conditions on the other hand refer to existing contaminations associated with a past activity that has the potential to affect the quality of drinking water. The six conditions identified for the Barrie Well Supply are not linked with the drinking water issues and are related to trichloroethylene (TCE) (2), petrohydrocarbons (1), BTEX (benzene, toluene, ethylbenzene and xylenes) and PHCs (petroleum hydrocarbons) (2) and vinyl chloride (1) (SGBLS-SPC, 2011).

No drinking water issues, conditions or significant drinking water threats were identified for the Barrie Water Treatment Plant.

The Innisfil Heights Well Supply has two wells located in the southern end of the Lovers Creek subwatershed in the Town of Innisfil. A total of 10 significant drinking water threats were identified in association with 4 land parcels. These threats reflect a variety of land uses, from residential to agricultural to commercial. No drinking water issues or conditions were identified (SGBLS-SPC, 2011)

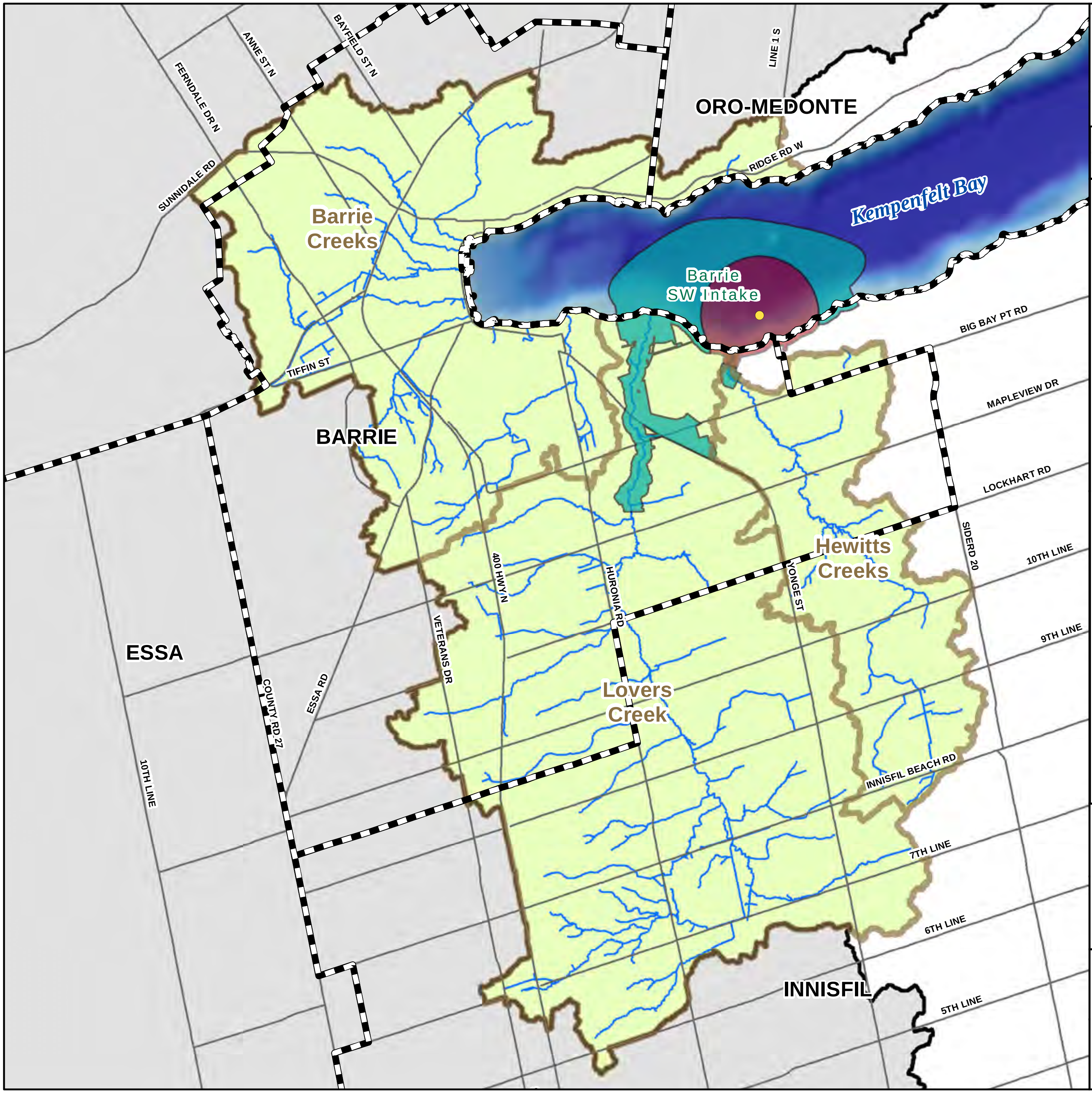
Lastly, the Stroud Well supply, with three wells and located in central western part of the Hewitt's Creek subwatershed, had 32 significant drinking water threats associated with 32 land parcels. Significant threats were mainly associated with individual sewage systems. No drinking water issues or conditions were identified (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 2-15 (Note: The IPZ-3 is not included for this figure).

Vulnerable areas (WHPA/IPZ) located within the Barrie Creeks, Lovers Creek and Hewitt's Creek subwatersheds

Figure 2-15



Legend

- ▬ Road
- ▬ Municipal Boundary
- 〰 Watercourse
- 🟥 IPZ-1 (1000m)
- 🟦 IPZ-2 (2-hrs time of travel)
- 🟫 WHPA-A (100m)
- 🟧 WHPA-B (2-yrs tot)
- 🟧 WHPA-C (5-yrs tot)
- 🟫 WHPA-C1 (10-yrs tot)
- 🟨 WHPA-D (25-yrs tot)

Lake Simcoe Region conservation authority

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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.

The 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 Barrie Creeks, Lovers Creek and Hewitt's Creek subwatersheds, 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 2-6: Summary of non-market ecosystem service values by land cover type (2010 values).

Land Cover Type	Total Barrie Creeks subwatershed value ($million/yr)	Total Lovers Creek subwatershed value ($million/yr)	Total Hewitt's Creek subwatershed value ($million/yr)	Total Lake Simcoe basin value ($million/yr)
Cropland	0.05	1.07	0.49	54.52
Forest	1.51	4.48	0.87	207.93
Forest/ Wetlands*	1.18	10.43	1.31	466.64
Wetlands	0.57	2.54	0.28	176.12
Grasslands	0.12	0.63	0.21	22.49
Hedgerows/ Cultural Woodland	0.13	0.23	0.04	6.31
Pasture	0.09	0.31	0.09	41.80
Urban Parks	0.16	0.16	0.01	3.18
Water**	0.001	0.01	0.00003	1.54
Total	**3.80**	**19.85**	**3.31**	**980.53**

* This includes treed swamps.

** This does not include the value of Lake Simcoe

As has been demonstrated, the natural systems of the Barrie Creeks, Lovers Creek and Hewitt's Creek subwatersheds 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 $3.8 million for the Barrie Creeks subwatershed, $19.8 million for Lovers Creek subwatershed and $3.3 million for Hewitt's Creek 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. Barrie Creeks was $1.5 million and $1.1 million, Lovers Creek $4.5 million and $10.4 million and Hewitt's Creek $0.87 million and $1.3million.

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, provides people with a 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 by 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 provide 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 Barrie area. A generalized description of the bedrock geology, quaternary geology, and conceptual stratigraphic units within the Barrie, Lovers, and Hewitt's Creeks subwatersheds 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 towards 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 these subwatersheds.

Verulam Formation

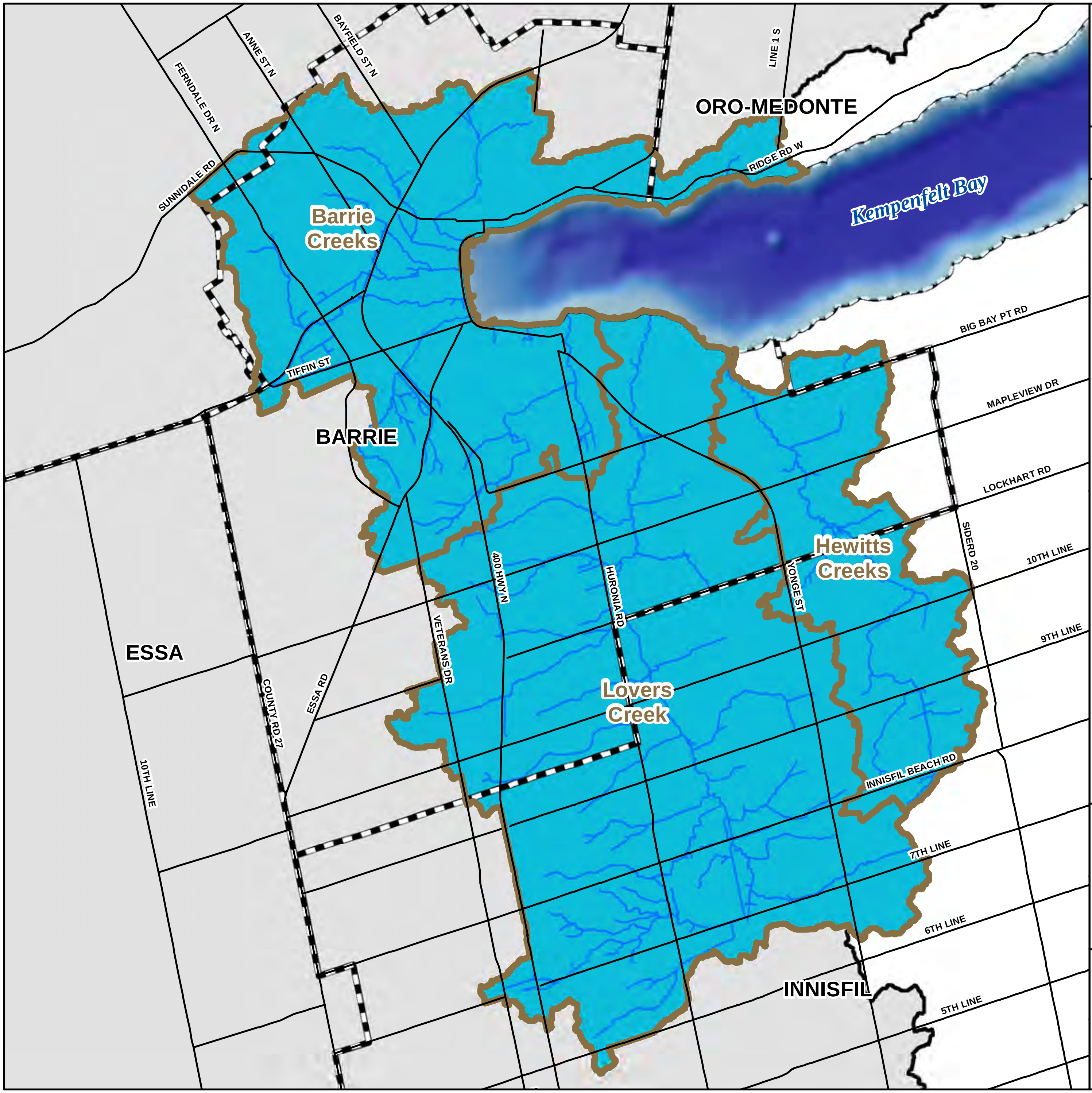
The oldest Paleozoic rocks underlying the subwatersheds are those of the Verulam Formation. This formation occurs along the shoreline of Kempenfelt Bay and expands west of the City of Barrie. A small portion also extends down to a small area south of Cook's Bay. The formation is a member of the Simcoe Group (which is represented as [blue] on Figure 2-16). Within the subwatershed 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 towards Kempenfelt Bay, underlying most of the southern portions of the subwatersheds. The formation is represented as (blue) on Figure 2-16. Within the subwatershed the Lindsay Formation tends to be less than 67 m thick and is richly fossiliferous, indicating that the depositional environment was a shallow to deep marine environment (Thurston *et al*., 1992).

Bedrock geology in the Barrie Creeks, Lovers Creek and Hewitt's Creek subwatersheds

Figure 2-16



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
Kilometres

N

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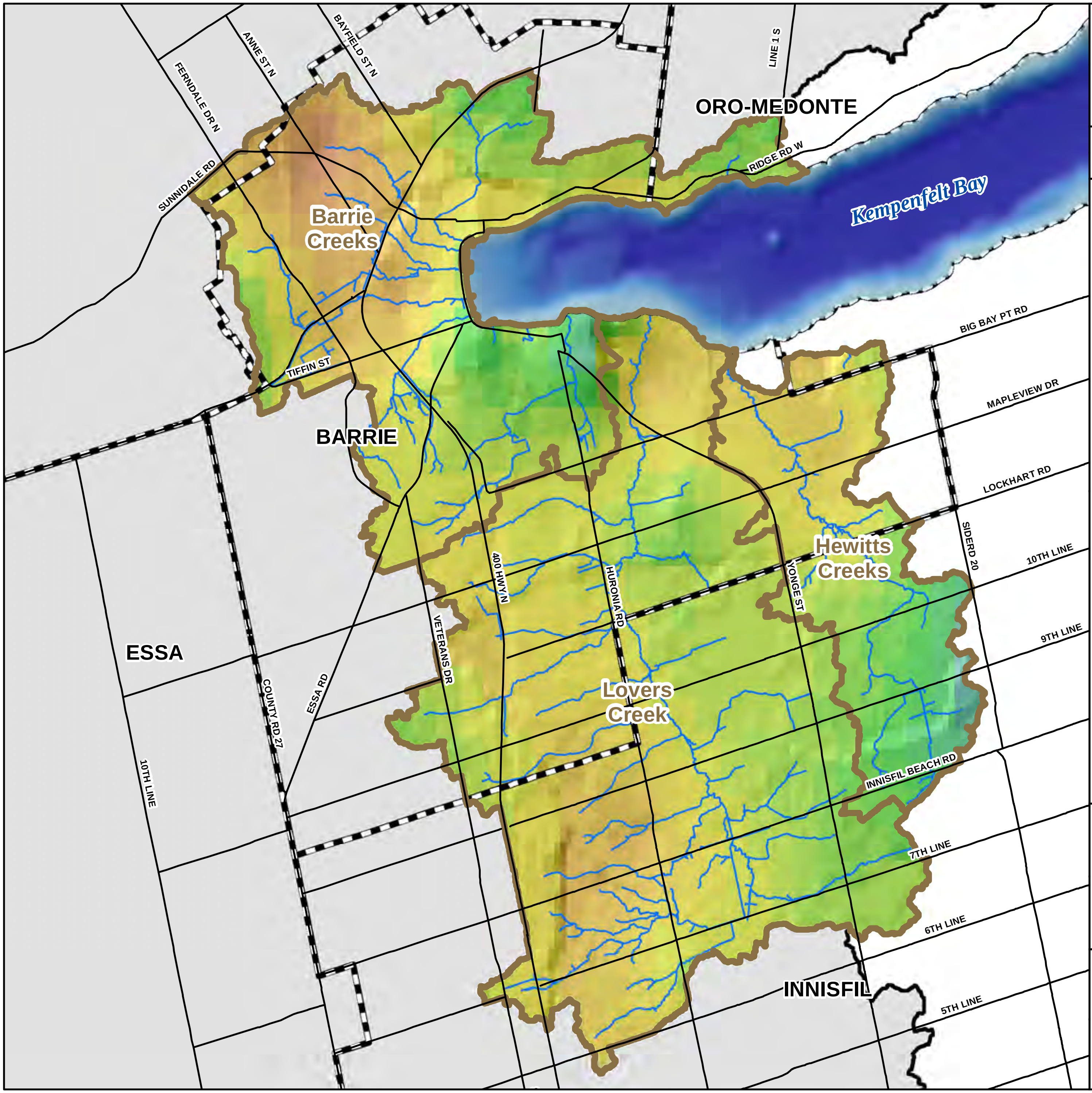
2.4.1.2. Bedrock Topography

The bedrock surface of the subwatersheds has a general elevation range of 105 to 149 mASL (Figure 2-17). 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, which as mentioned above is comprised primarily of limestone that is easily erodible. These valleys are believed to be a result of fluvial activity prior to glaciation, approximately 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, which is thought to be a tertiary-aged river network that extended from Georgian Bay to Lake Ontario (Brennan *et al*., 1998; Sharpe *et al*., 2004). Recent interest has been generated over the Laurentian Channel (also referred to as the Laurentian Valley), driven primarily by the attempt to locate additional sources of potable water as the 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.

A tributary valley to the main Laurentian Valley is interpreted to occur beneath the subwatersheds extending from Kempenfelt Bay west towards Angus. This channel is referred to as the Kempenfelt Bay Channel. There is another major channel, named the Innisfil channel, that originates near Kempenfelt Bay but which occurs largely within the Nottawasaga Valley watershed. It dissects the Simcoe Uplands in this area and trends to the southwest (DRAFT GRIPS, 2008).



Bedrock topography in the Barrie Creeks, Lovers Creek and Hewitt's Creek subwatersheds

Figure 2-17

Legend

Road

Municipal Boundary

Watercourse

Bedrock Top Elv (m)

<100	118	142
102	120	144
104	122	146
106	124	148
108	126	150
110	128	200
112	130	250
114	132	300
116	134	350
	136	400
	138	>400
	140	

Lake Simcoe Region conservation authority

0 0.5 1 2 3 4 Kilometres

N

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2.4.1.3. Quaternary Geology

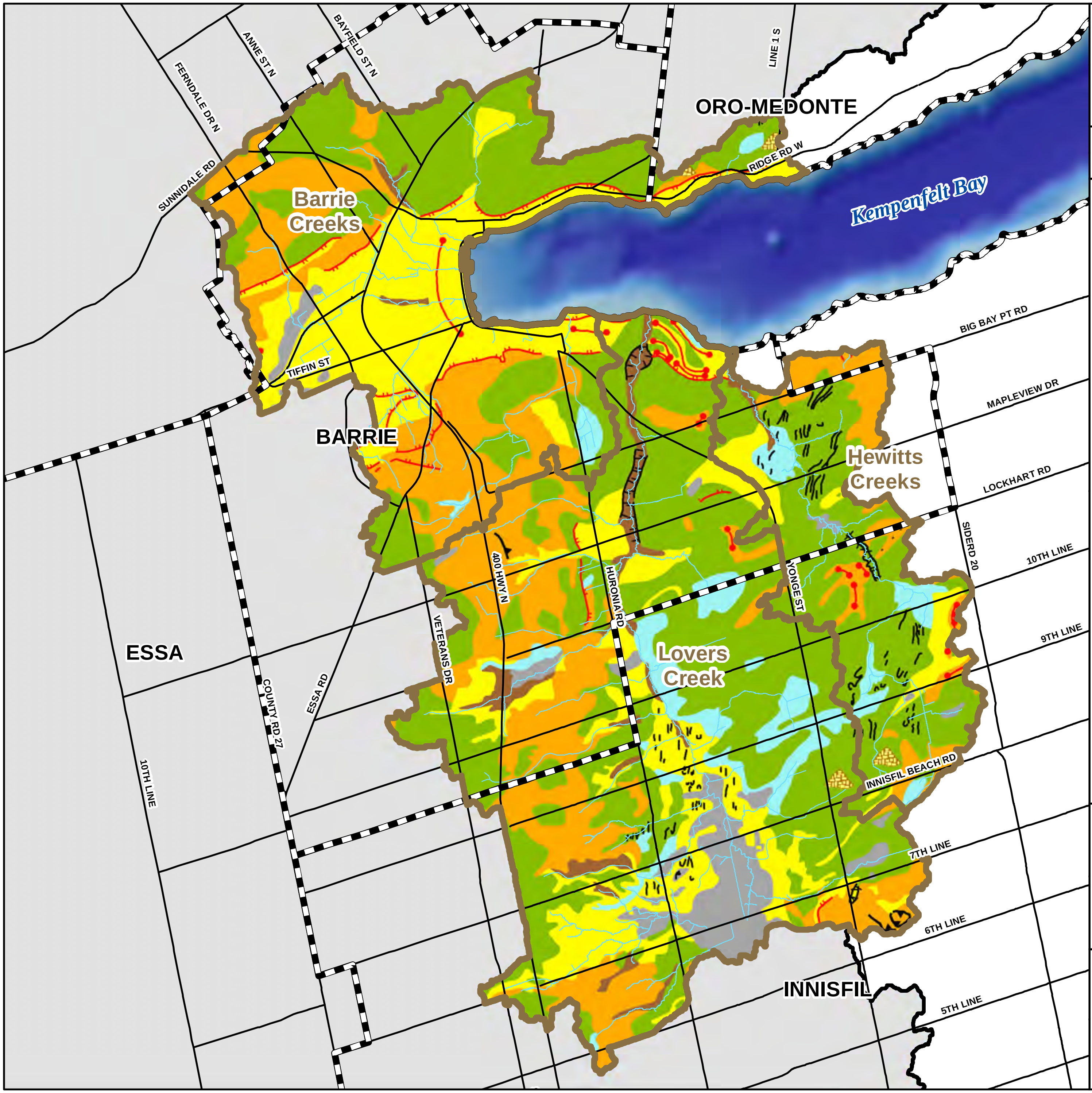
Glacial History

The bedrock within the Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds is overlain by unconsolidated sediments, known as the overburden, which was deposited during the Quaternary Period. The Quaternary period is the most recent time period of the Cenozoic Era on the geologic time scale. The Quaternary Period can be 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, Illinoian, 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 by the Laurentide Ice Sheet during the Wisconsinan glaciation. 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 subwatershed 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 2-18.

Quaternary Sediment Thickness

Within the subwatersheds the Quaternary sediment thickness is the difference between the ground surface and the bedrock surface, as determined from borehole and water well information within the subwatershed. Figure 2-19 shows the thickness ranges from approximately 83 to 191 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 along the shoreline of Kempenfelt Bay.



Surficial geology in the Barrie Creeks, Lovers Creek and Hewitt's Creek subwatersheds

Figure 2-18

Legend

— Road

▬ Municipal Boundary

〰 Watercourse

Surficial Geology Features

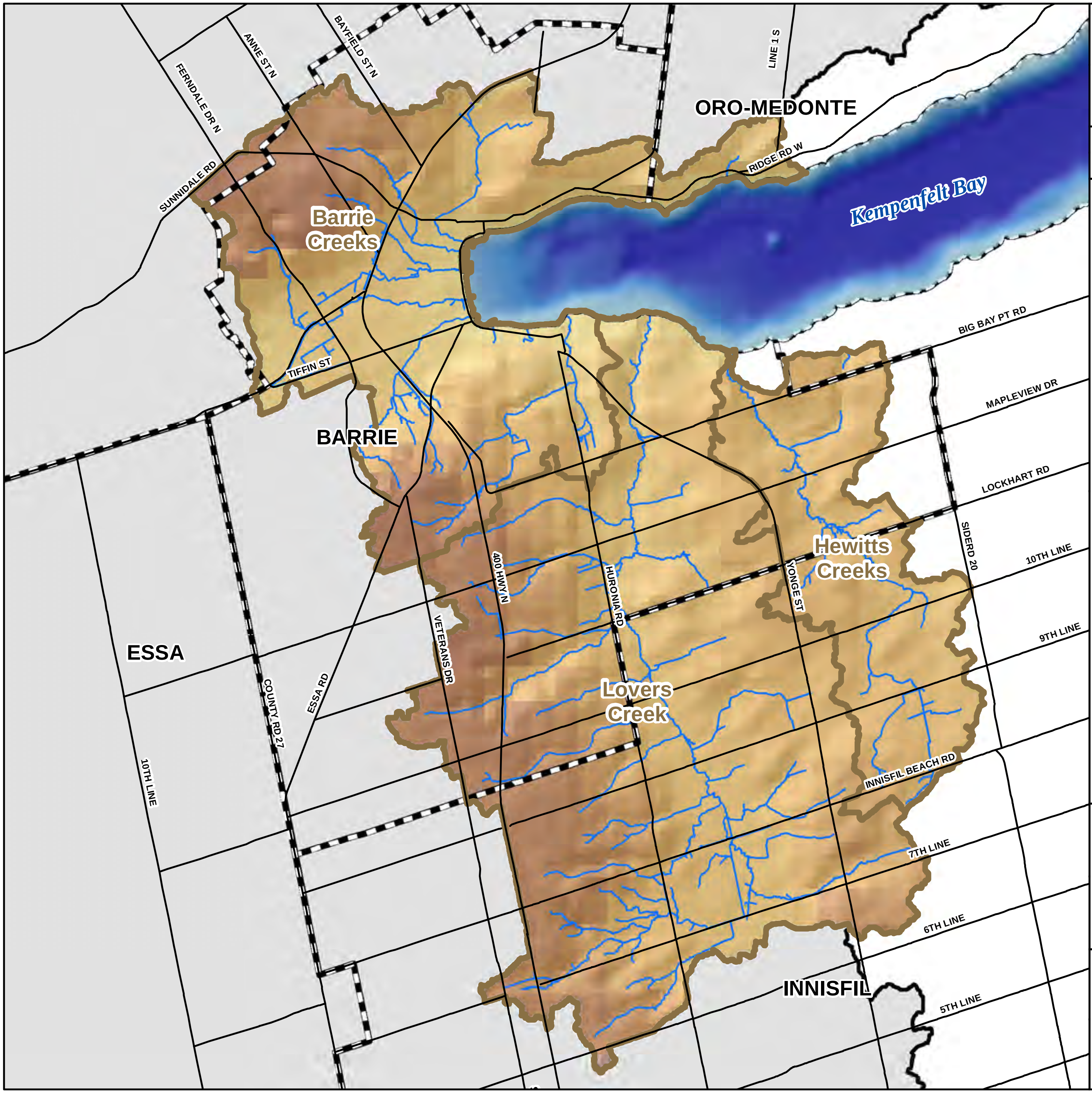
- ▲ drumlin
- — beach
- — bluff
- > > > > eskern
- ▼ icslope
- — ribl
- ┬┬┬ terrace
- 🟩 5b: Stone-poor, carbonate-derived silty to sandy till
- 🟧 6: Ice-contact stratified deposits
- 🟦 8a: Massive-well laminated
- 🟨 9b: Littoral-foreshore deposits
- 🟨 9c: Foreshore-basinal deposits
- 🟫 12: Older alluvial deposits
- 🟫 19: Modern alluvial deposits
- ⬜ 20: Organic deposits

Lake Simcoe Region
conservation authority

0 0.5 1 2 3 4
Kilometres

N

LSRCA GIS Services DRAFT created July 2010.



Overburden thickness in the Barrie Creeks, Lovers Creek and Hewitt's Creek subwatersheds

Figure 2-19

Legend

Road

Municipal Boundary

Watercourse

Overburden Thickness (m)

50	115	170
60	120	175
70	125	180
80	130	185
85	135	190
90	140	195
95	145	200
100	150	210
105	155	220
110	160	230
	165	240

Lake Simcoe Region conservation authority

0 0.5 1 2 3 4 Kilometres

N

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2.4.1.4. Hydrostratigraphy

The geology of the subwatersheds 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 subwatersheds 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 2-20, was completed by AquaResource *et al.* (2011) for the City of Barrie Tier 3 Water Budget and Risk Assessment. The conceptual model builds upon previous models built for the South Simcoe Groundwater Studies (Golder, 2004). Four regional aquifers have been defined throughout the City of Barrie and Southern Simcoe County. 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 hydrostratigraphic framework is provided below.

Figure 2-22 and 2-23 below show typical cross sections through the City of Barrie depicting the key features of the geologic and hydrogeologic system. Figure 2-22 shows a southwest to northeast cross section, whereas Figure 2-23 shows a north-south cross section. Key components of the geologic system include (1) the Kempenfelt Bay channel extending in an east-west direction from Kempenfelt Bay towards Angus; (2) thick deposits associated with the upland areas; and (3) the thinning of confining layer 3 in the City of Barrie core.

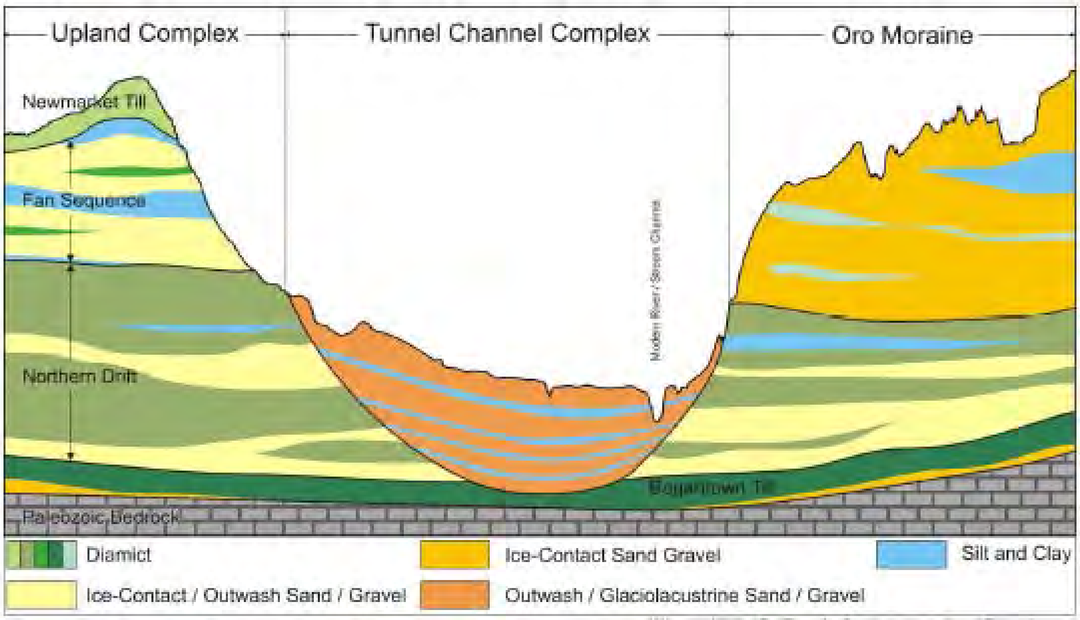


Figure 2-20: Generalized conceptual stratigraphy of upland complexes, lowland tunnel channel complexes and the Oro Moraine (AquaResource *et al*., 2011).

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 Barrie to Angus. 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 and adjacent aquifer. It does not readily yield water to wells or springs, but stores ground water.

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 towards 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 aquifer is complex in the central core of Barrie, where it consists of inter-layered sand and silt/clay materials. 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 and Aquifer 4 (A3 & A4)

The A3 and A4 aquifers are in direct contact with one another in the central City of Barrie area and towards the west, and will therefore be discussed together. The A3/A4, commonly referred to as the lower aquifer, is the primary supply source for the City of Barrie's drinking water. The lower 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 40m. The elevation of the A4 aquifer in the Barrie area ranges from approximately 115 to 160 mASL. The A4 part of the lower aquifer is a channelized unit in the Barrie area, corresponding to the tunnel channel theorized to extend from Barrie to Angus. Stratigraphic equivalents of this deep aquifer extend to the upland areas, and are typically thinner and less transmissive (AquaResource *et al.*, 2011).

Confining Layer 3 (C3)

Confining Layer 3 is thin to absent throughout much of the City of Barrie. Where present the layer is composed of fine-grained silts and clays (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.

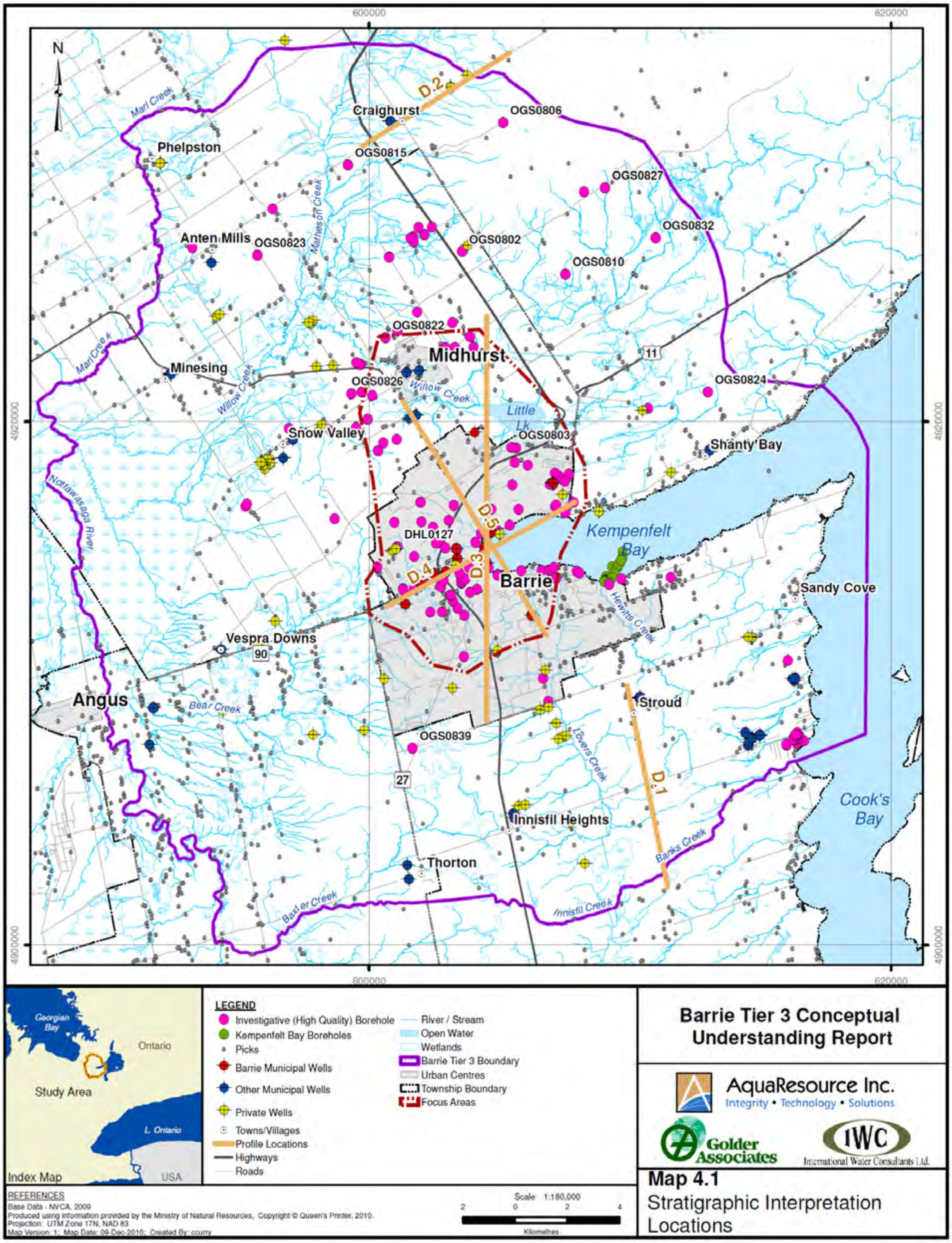


Figure 2-21: Stratigraphic Interpretation Locations through the City of Barrie (AquaResource *et al.*, 2011).

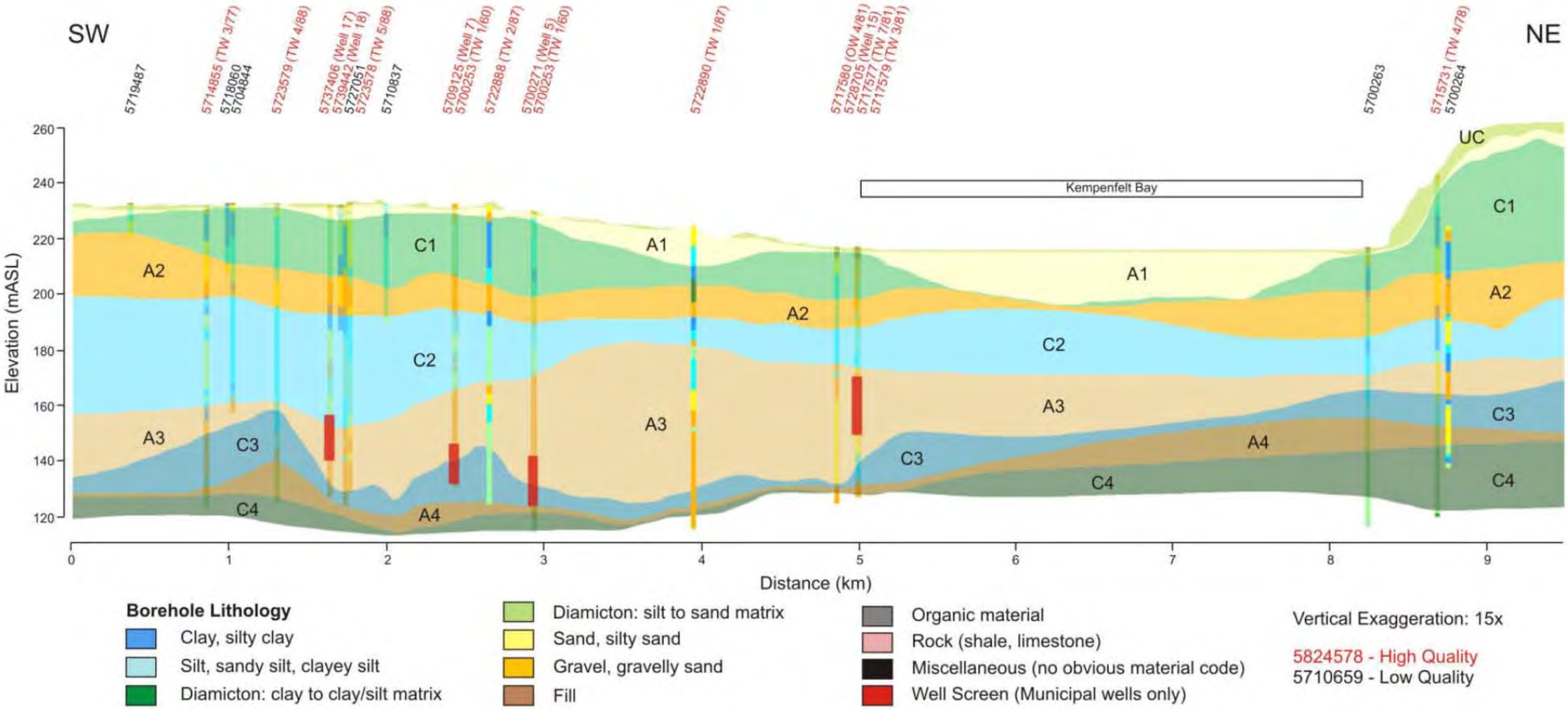


Figure 2-22: Southwest to northeast cross-section through the City of Barrie (AquaResource *et al.*, 2011).

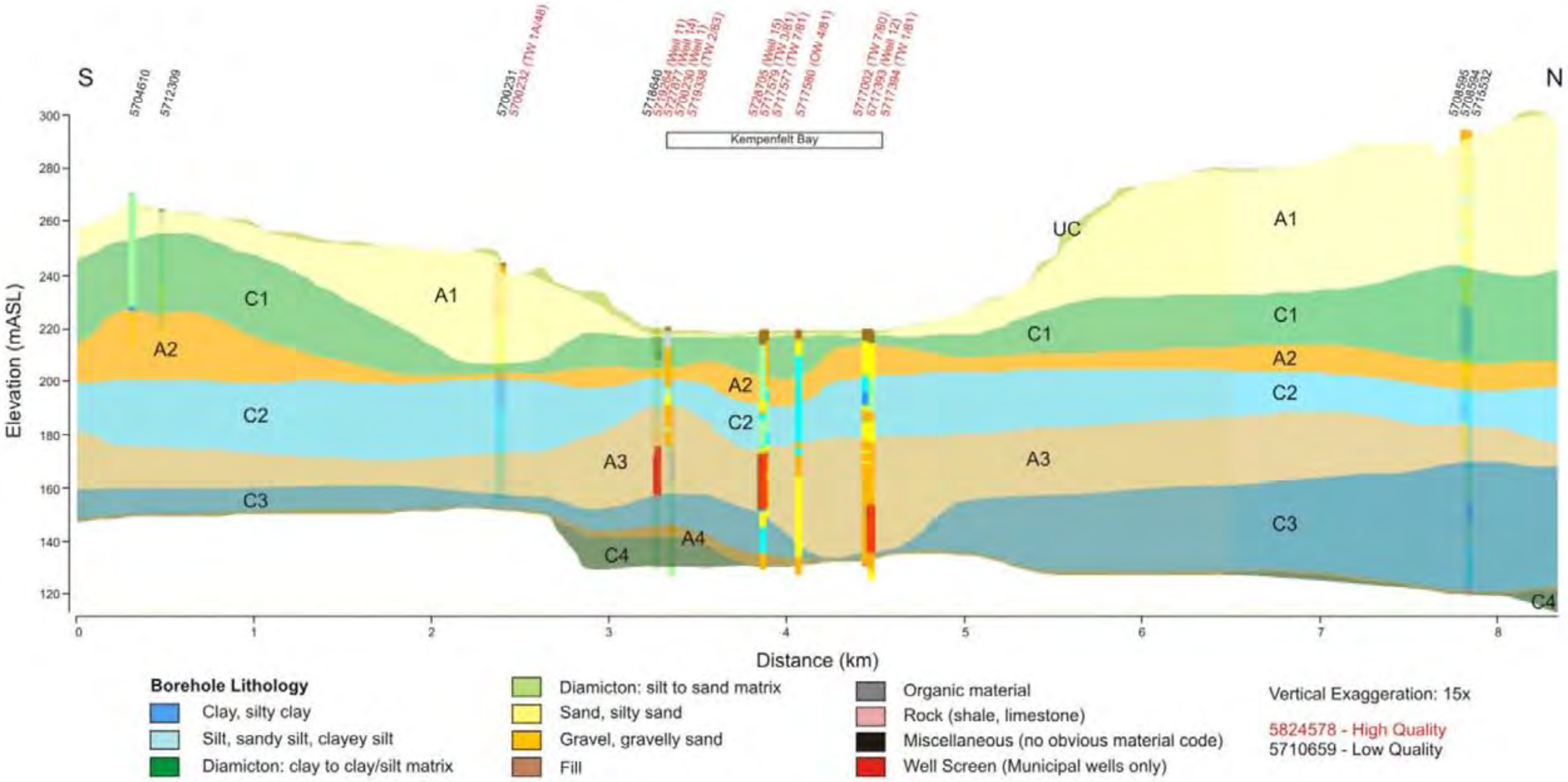


Figure 2-23: South to north cross-section through the City of Barrie (AquaResource *et al*., 2011).

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 Barrie Creeks, Lovers Creek and Hewitt's Creek subwatersheds 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), three physiographic regions are found within the subwatersheds: the Simcoe Uplands, the Simcoe Lowlands, and the Peterborough Drumlin Field (Figure 2-24).

Simcoe Uplands

The Simcoe Uplands is a physiographic region located in the northern portion of the Barrie Creeks subwatershed and is defined as distinct upland areas of rolling till plains that are broken up by steep-sided, flat-floored valleys. In the Barrie area these valleys tend to be oriented from east to west. By and large, the steep-walled valleys, such as Kempenfelt Bay and Innisfil Creek Valley, represent a system of tunnel valleys with a deposition of a variety of coarse and fine grained sediment (AquaResource & Golder, 2009). The Simcoe Uplands generally make up the topographic highs, rising up to 100 m above the adjacent Simcoe Lowlands.

Simcoe Lowlands

The Simcoe Lowlands is the physiographic region that comprises narrow stretches of land at the northern part of Lovers and Hewitt's Creeks subwatersheds, along the shoreline of Kempenfelt Bay. It also continues on from the shoreline through the centre of the Barrie Creeks subwatershed from the lake shore to the low-lying area to the west. 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 south-eastern portion of the Barrie Creeks subwatershed, and the majority of Lovers and Hewitt's Creek subwatershed. This 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 subwatersheds closely corresponds to their physiographic regions. The topographic features of the Barrie Creeks, Lovers Creek and Hewitt's Creek subwatersheds 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 316 metres above mean sea level (mASL), at Highway 400 and Mapleview in Barrie, to 216 mASL along the shores of Kempenfelt Bay (Figure 2-25).

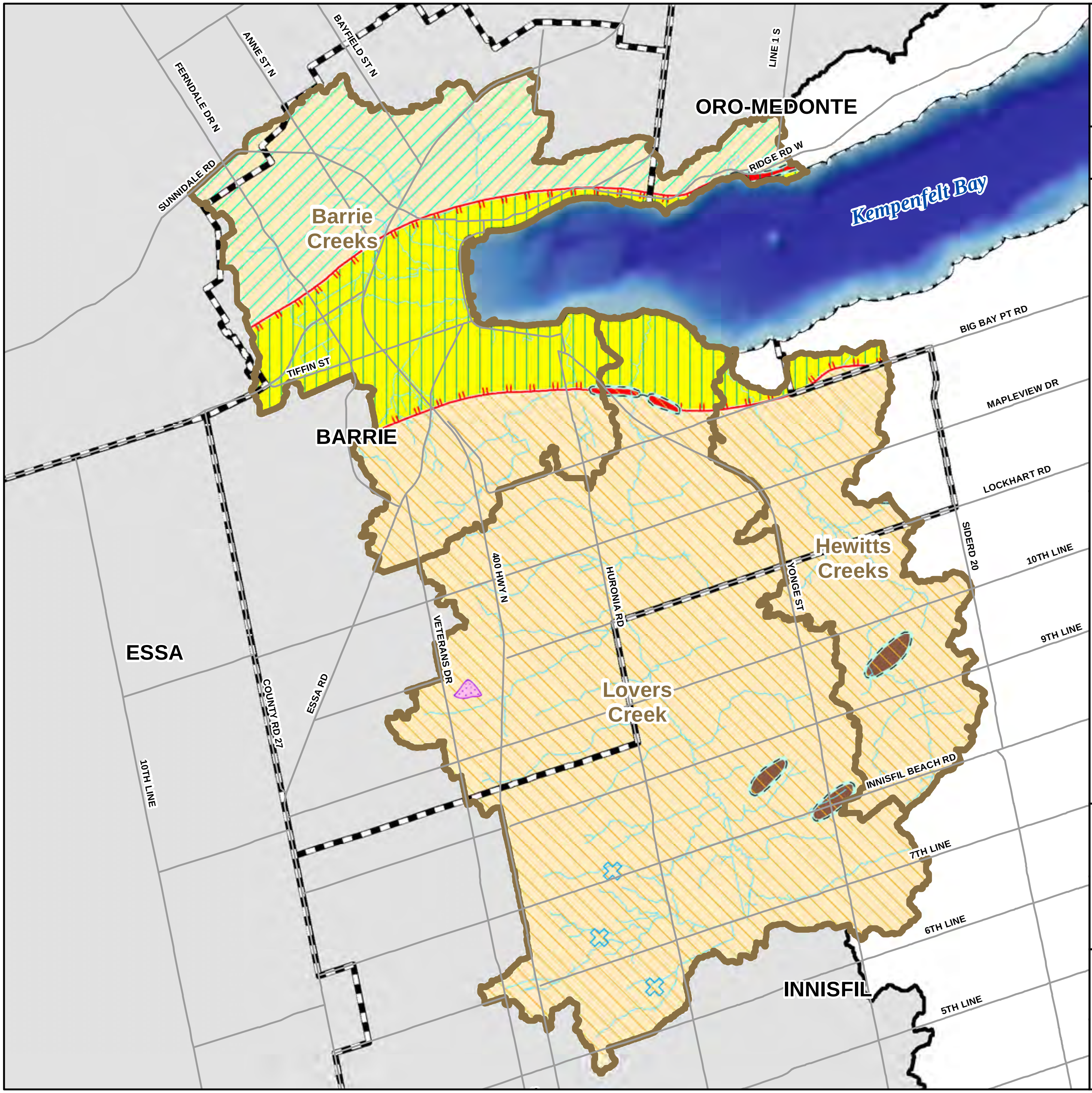
Through the City of Barrie core there is a southwest-northeast trending valley, creating a unique topographic feature, associated with a number of wetland complexes. The most prominent of these is the Bear Creek Wetland located in the western portion of the city, straddling the Lake Simcoe watershed and the Nottawasaga Valley watershed.

2.4.2.3. Soils

The soils present within the subwatersheds influence the type and productivity of the vegetation communities commonly 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 subwatersheds 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 of an area with finer textured soils. 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 2-26 depicts the spatial distribution of the soil types present throughout the subwatersheds.

Physiography in the Barrie Creeks, Lovers Creek and Hewitt's Creek subwatersheds

Figure 2-24



Legend

- Road
- Municipal Boundary
- Watercourse

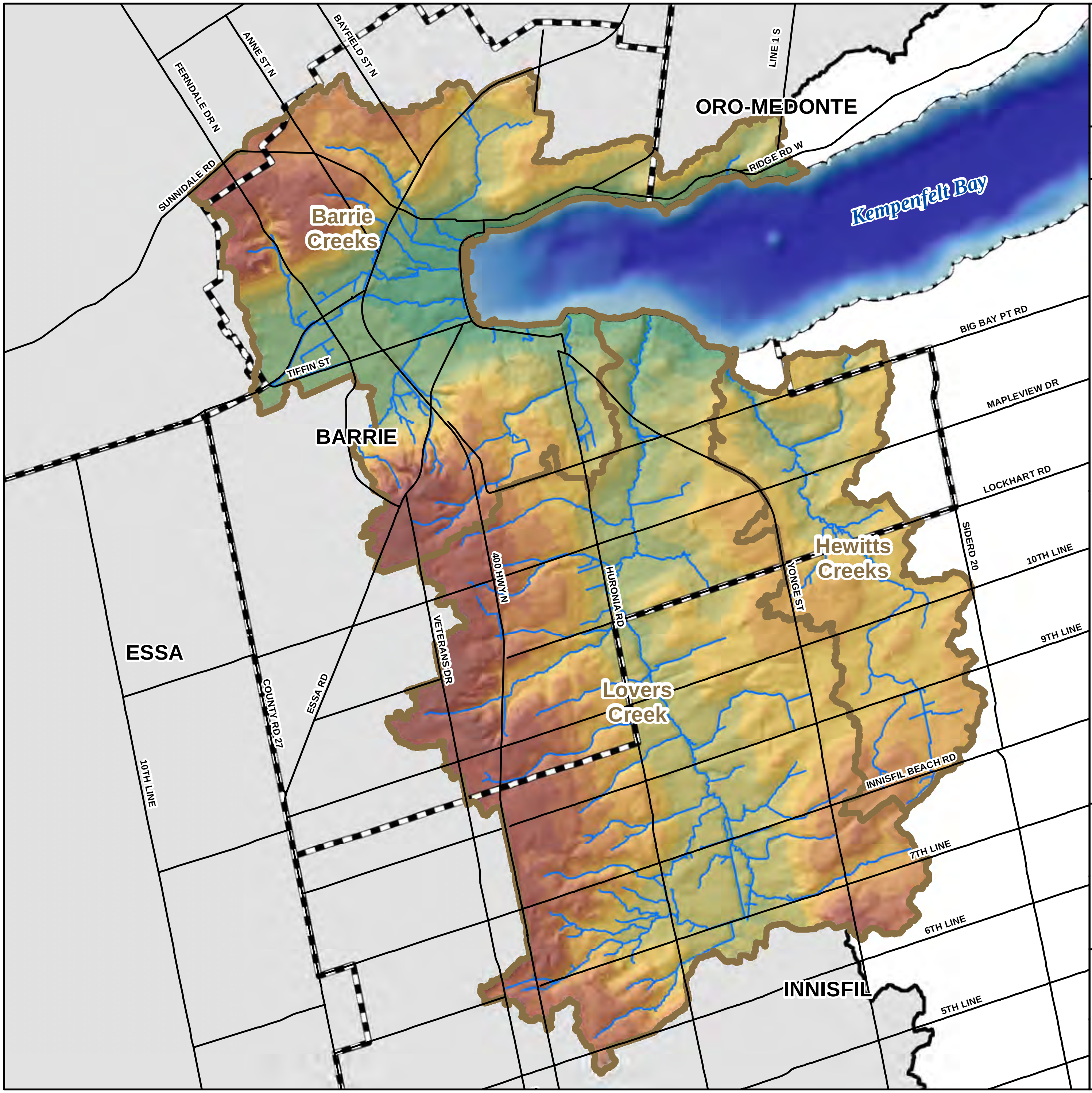
Physiography Features

- ✕ Dissected terrain
- ▲ Mud flow scars
- Contact
- Shorecliff
- ▨ Simcoe Uplands
- ▥ Simcoe Lowlands
- ▨ Peterborough Drumlin Field
- 🟥 Beach
- 🟫 Drumlin
- 🟨 Sand Plain
- ▢ Till Plain (Drumlinized)

Lake Simcoe Region conservation authority

0 0.5 1 2 3 4 Kilometres

N



Ground surface topography in the Barrie Creeks, Lovers Creek and Hewitt's Creek subwatersheds

Figure 2-25

Legend

Road

Municipal Boundary

Watercourse

Ground Surface Elevation (m)

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

Lake Simcoe Region conservation authority

0 0.5 1 2 3 4 Kilometres

N

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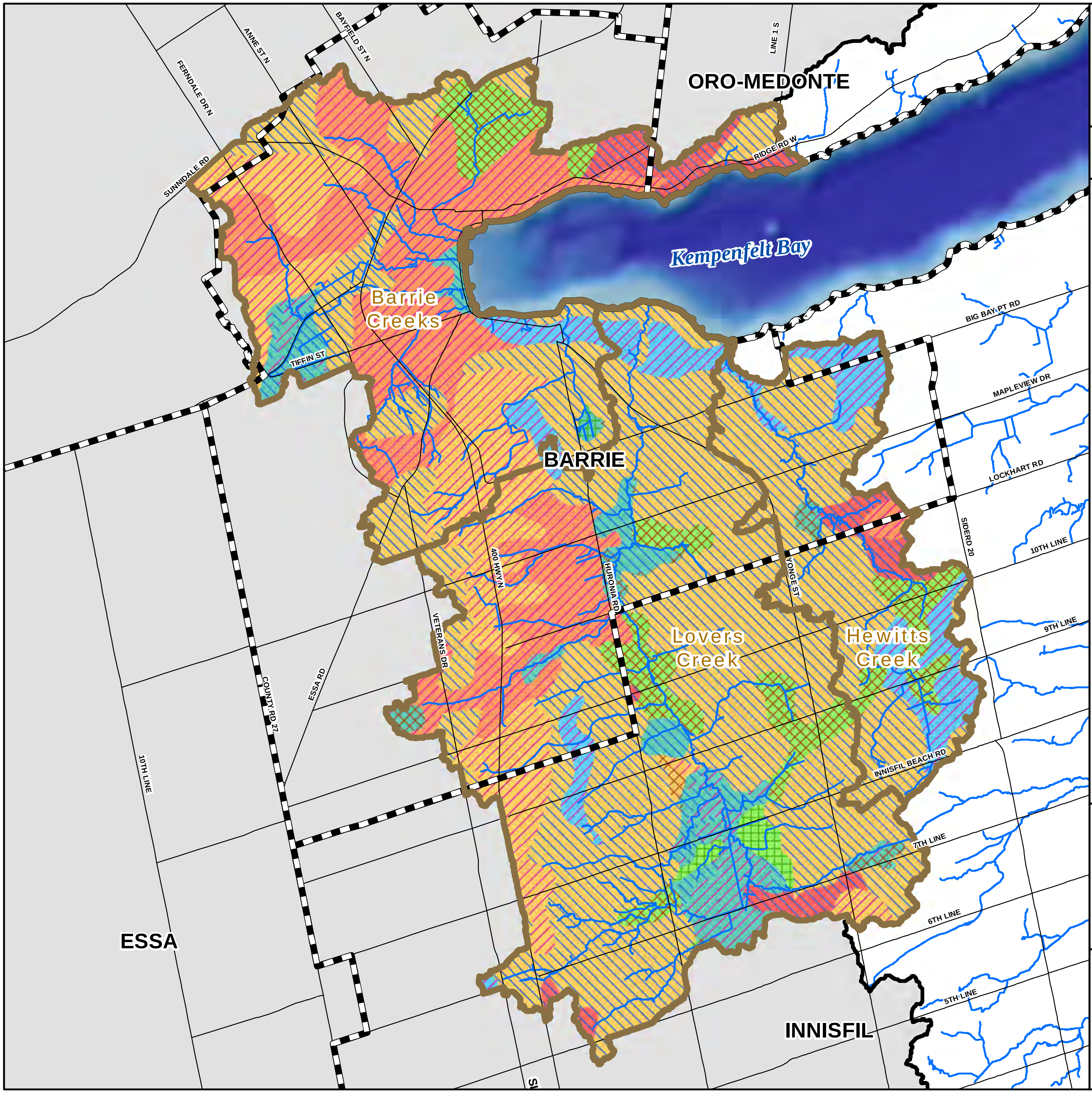
Soils in the Barrie Creeks, Lovers Creek and Hewitt's Creek subwatershed

Figure 2-26



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
- 🟥 LOAMY
- 🟧 LOAMY SAND
- 🟩 SILTY CLAY LOAM
- 🟪 CLAY LOAM
- 🟩 ORGANIC

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0 0.5 1 2 3 4 Kilometres

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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 the 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 eroded, 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 through other studies, some relevant information was available. 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 subwatersheds 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. The stream order of a watershed is determined by the stream order of its outlet.

Table 2-7 presents the stream order and the total length of the creek within the Barrie Creeks, Lovers Creek and Hewitt's Creek subwatersheds. To allow for more detailed reporting, the Barrie Creeks subwatershed has been divided up into the six major tributaries (Bunkers, Whiskey, Kidd's, Dyments, Hotchkiss and Sophia), as well as two smaller creeks (Holgate and Huronia).

Table 2-7: Barrie Creeks, Lovers Creek and Hewitt's Creek subwatersheds stream order and stream length.

Creek	Stream Order	Length of Creek per Order (m)	% of Creek per Order
Barrie Creeks			
Bunkers Creek	1st	4,481	55
	2nd	2,127	26
	3rd	1,602	19
	TOTALS	***8,210***	***100***
Whiskey Creek	1st	4,813	40
	2nd	5,210	43
	3rd	2,116	17
	TOTALS	***12,139***	***100***
Kidd's Creek	1st	2,570	52
	2nd	2,346	48
	TOTALS	***4,916***	***100***

Creek	Stream Order	Length of Creek per Order (m)	% of Creek per Order
Dyments Creek	1st	5,469	48
	2nd	2,893	26
	3rd	2,934	26
	TOTALS	***11,296***	***100***
Hotchkiss Creek	1st	6,166	56
	2nd	2,044	19
	3rd	1,009	9
	4th	1,786	16
	TOTALS	***11,004***	***100***
Sophia Creek	1st	1,891	38
	2nd	3,037	62
	TOTALS	***4,929***	***100***
Barrie Creeks (Holgate and Huronia)	1st	1,352	100
	TOTALS	***1,352***	***100***
Lovers Creek			
Lovers Creek	1st	46,855	50
	2nd	24,367	26
	3rd	8,573	9
	4th	13,326	14
	TOTALS	***93,122***	***100***
Hewitt's Creek			
Hewitt's Creek	1st	8,656	37
	2nd	4,706	20
	3rd	10,197	43
	TOTALS	***23,559***	***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, watersheds with high drainage densities are characterized by greater peak flows, high suspended sediments and bed loads, and steep slopes (Dunne and Leopold, 1978). The average drainage density of the Barrie Creeks subwatershed is almost 20% greater than the average Lake Simcoe watershed drainage density (Table 2-8). This indicates potentially greater relief and increased erosion compared to other subwatersheds. The high drainage densities of the Barrie Creeks subwatershed agrees well with subwatershed slopes with the greatest drainage density and slopes belonging to Hotchkiss and Bunkers Creeks. However, Dyments Creek exhibits a considerably high drainage density (1.810 km/km^2) and a low average stream slope (0.93%), which is likely due to the exclusion of the headwater reach that had been enclosed during urbanization. Kidd's Creek is also an anomaly with a very low drainage density and a moderate average stream slope; this is likely the result of the entombment of the stream during urbanization decreasing the stream length and consequently the drainage density. Hewitt's Creek has a slightly lower drainage density than the Lake Simcoe watershed average and a considerably lower drainage density than the other Barrie Creeks. This is consistent with the topography of the subwatershed. Hewitt's Creek drains a subwatershed orientated north-south with headwaters that drain gentle slopes dominated by agricultural land use with no stream entombment and low levels of stream channel alteration. Similarly, Lovers Creek also drains a subwatershed oriented north-south with the greatest topographic gradients near Lake Simcoe. Lovers Creek subwatershed has undergone more urbanization than Hewitt's Creek with more stream enclosement and channel alteration likely resulting in the slightly greater drainage density.

Table 2-8: Barrie Creeks, Lovers Creek and Hewitt's Creek subwatersheds stream length, watershed area and drainage density.

Creek	Stream Length (km)	Watershed Area (km^2)	Drainage Density (km/km^2)
Bunkers Creek	8.210	3.856	2.129
Whiskey Creek	12.139	6.151	1.973
Kidd's Creek	4.916	5.791	0.849
Dyments Creek	11.296	6.242	1.810
Hotchkiss Creek	11.004	4.502	2.444
Sophia Creek	4.929	3.840	1.284
**Barrie Creeks (at subwatershed level)	52.494	30.381	1.728
Lovers Creek	93.112	58.595	1.589
Hewitt's Creek	23.559	17.515	1.345
***Simcoe Watershed Avg	3672.254	2515.891	1.460

***Excludes small unnamed creeks.*

****The Lake Simcoe watershed average includes the subwatersheds of: Beaver River, Black River, East Holland River, Georgina Creeks, Georgina Island, Hawkestone Creek, Hewitt's Creek, Innisfil Creeks, 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 receiving waters, 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 in Figure 2-27 in relation to underlying surficial geology and features (discussed in Section 2.4.2) and only represent the main branch.

Figure 2-27 illustrates the stream profile of six of the Barrie Creeks (Sophia, Bunkers, Hotchkiss, Kidd's, Dyments and Whiskey), from headwater elevation (length = 0) down to Kempenfelt Bay (elevation = 220). Average gradient ranges from a lower gradient (0.93 % gradient for Dyments Creek) to a relatively steep medium gradient (2.32 % for Bunkers Creek). The rest fall somewhere in between those values (1.15 %, 1.38 %, 1.47 % and 1.59 % for Sophia, Whiskey, Kidds and Hotchkiss, respectively).

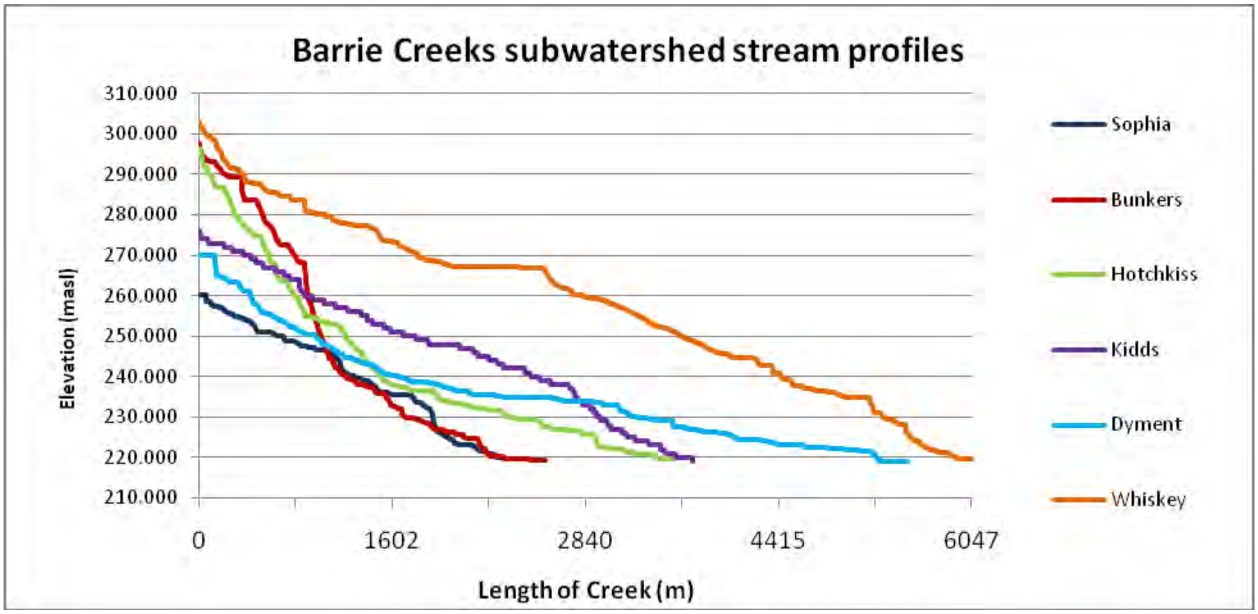


Figure 2-27: Barrie Creeks subwatershed stream profiles.

The main branch of Lovers Creek runs almost due north and all tributaries from both the east and west sides of the creek are relatively straight. While a stream profile is currently not available the gradient between the headwaters and the mouth of the creek is a gentle 0.08% with a total fall of 77 m from its highest elevation at 300 mASL.

Similarly, Hewitt's Creek runs in a general due north direction with tributaries coming in from the east and west. While a stream profile is also currently not available for Hewitt's Creek the gradient between the headwaters and the mouth of the creek is a relatively low 0.27% with a total fall of 62.5 m from its highest elevation at 282 mASL.

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 2-28 illustrates the percentage of stream bank along Whiskey, Hotchkiss, and Kidd's Creeks that are unstable, moderate or stable.

All three creeks tend to have a higher percentage of stable stream banks and a low percentage of moderate bank stability. Whiskey Creek has close to equal amounts of unstable and stable stream bank at four of the sites. The other two (WHYB and WHYE) have much higher percentages of stable stream bank. Site WHYA is the site closest to the mouth of the creek, with the remaining sites distributed upstream to WHYF which is located near the headwaters. Land use in this area is mostly urban but there are two natural heritage areas that the creek runs through.

Hotchkiss Creek has three sites (HC04, HC05 and HC06) with a high amount of stable stream bank, and very small amounts (less then 13%) of moderate and unstable stream banks. The other three sites have varying degrees of stability, with site HC01 having almost equal amounts of unstable, moderate and stable stream bank. Site HC01 is located closest to the mouth and is surrounded by urban land use. The other sites are along the branches of the creek, with site HC06 the farthest south. The only natural heritage area is in the vicinity of site HC04.

Lastly, Kidd's Creek has lower percentage of moderate and unstable stream bank at all of its sites, with the exception of site KC03, which has a high percentage of unstable stream banks. Site KC06 is closest to the headwaters and is located, along with site KC04, in a natural heritage area that contains a large portion of the creek before it runs beneath Highway 400. Site KC03 is the first site reached after passing beneath the highway, in a high intensity urban area as the creek continues down to the mouth (Site KC01).

It should be noted that these sites (along with those in Lovers and Hewitt's) were randomly chosen, where possible, and provide a general representation of the stream bank conditions.

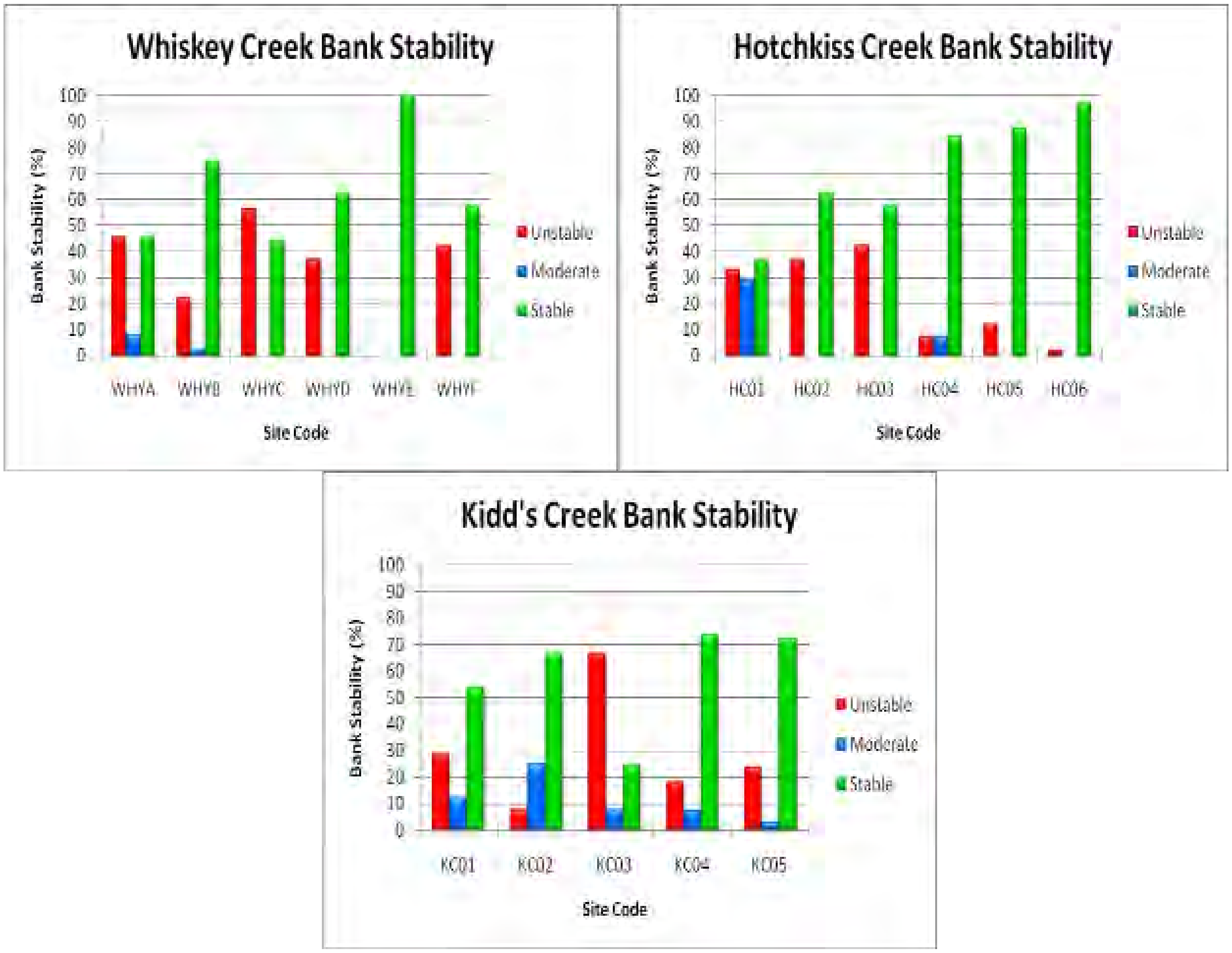


Figure 2-28: Percentage of stream bank that is unstable, moderate, or stable for three creeks within the Barrie Creeks subwatershed

Figure 2-29 illustrates the percentage of stream bank at 14 sites along Lovers Creek that are unstable, moderate or stable. At nine of the sites, there are a higher percentage of stable stream banks, while two (LOV1I and LOV1J) have a higher percentage of unstable stream banks and three (LOV1E, LOV1G and LOV1L) have higher moderate stability stream banks. Sites LOV1M and LOV1N are located at the headwaters and sites are distributed down the main watercourse and on branches to the mouth (Site LOV1A). For the most part the creek runs through natural heritage areas, surrounded by agriculture, until flowing north towards Kempenfelt Bay and the more highly urbanized areas.

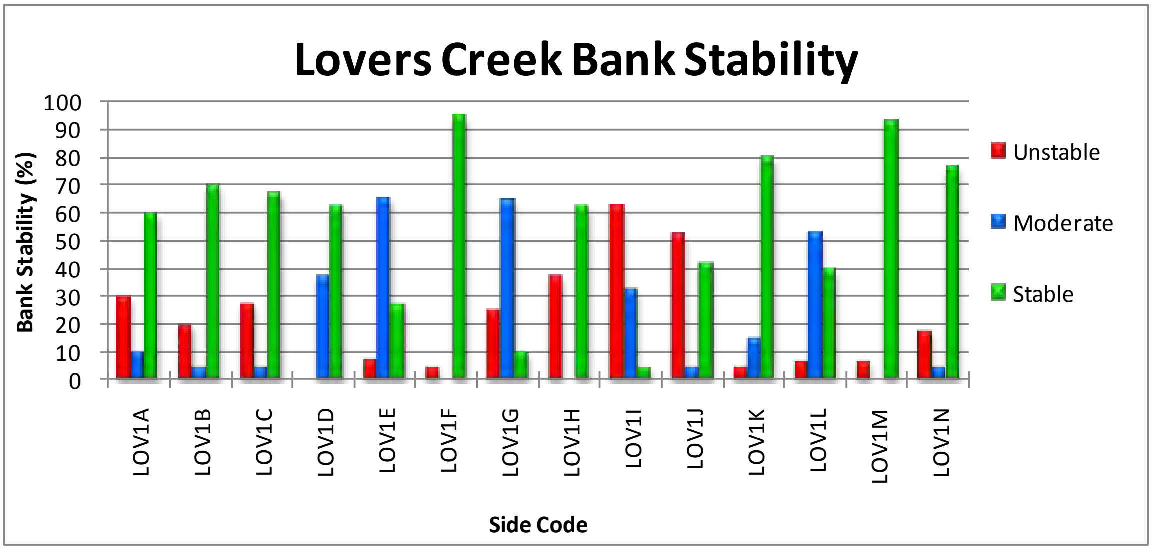


Figure 2-29: Percentage of stream bank that is unstable, moderate, or stable for fourteen sites along Lovers Creek.

Figure 2-30 illustrates the percentage of stream bank at five sites along Hewitt's Creek that are unstable, moderate or stable. At four of the sites, there are a higher percentage of stable stream banks, while site HEW1C has higher percentage of moderate stability stream banks. Site HEW1E is located in halfway up the creek, with the rest of the sites scattered downstream until HEW1A at the mouth. Upper reaches of the creek run through natural heritage areas, as well as agricultural lands, before the more urbanized areas near Kempenfelt Bay

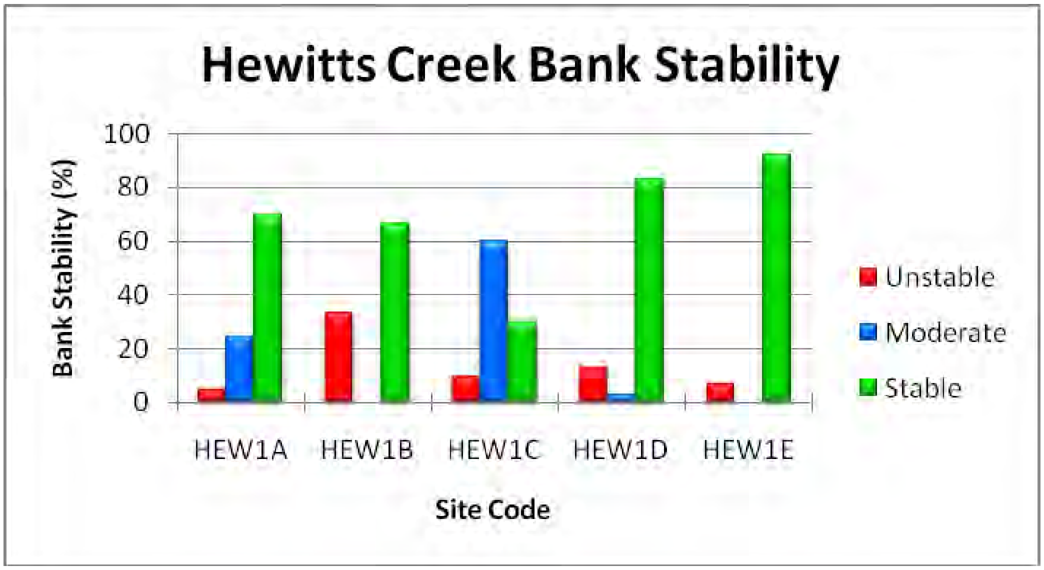


Figure 2-30: Percentage of stream bank that is unstable, moderate, or stable for five sites along Hewitt's Creek.

2.6 Climate and Climate Change

2.6.1 Current climate conditions and trends

The Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds lie within the Simcoe and Kawartha Lakes climatic region as defined by Brown *et al*. (1980). The climate within the City of Barrie 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 City of Barrie and surrounding municipalities.

Table 2-9 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 2-31). 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 921mm/yr. It should be noted that precipitation patterns have become less predictable in recent years, which could perhaps be due to climate change.

Long-term climate data was obtained from Environment Canada stations shown on Figure 2-31 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.

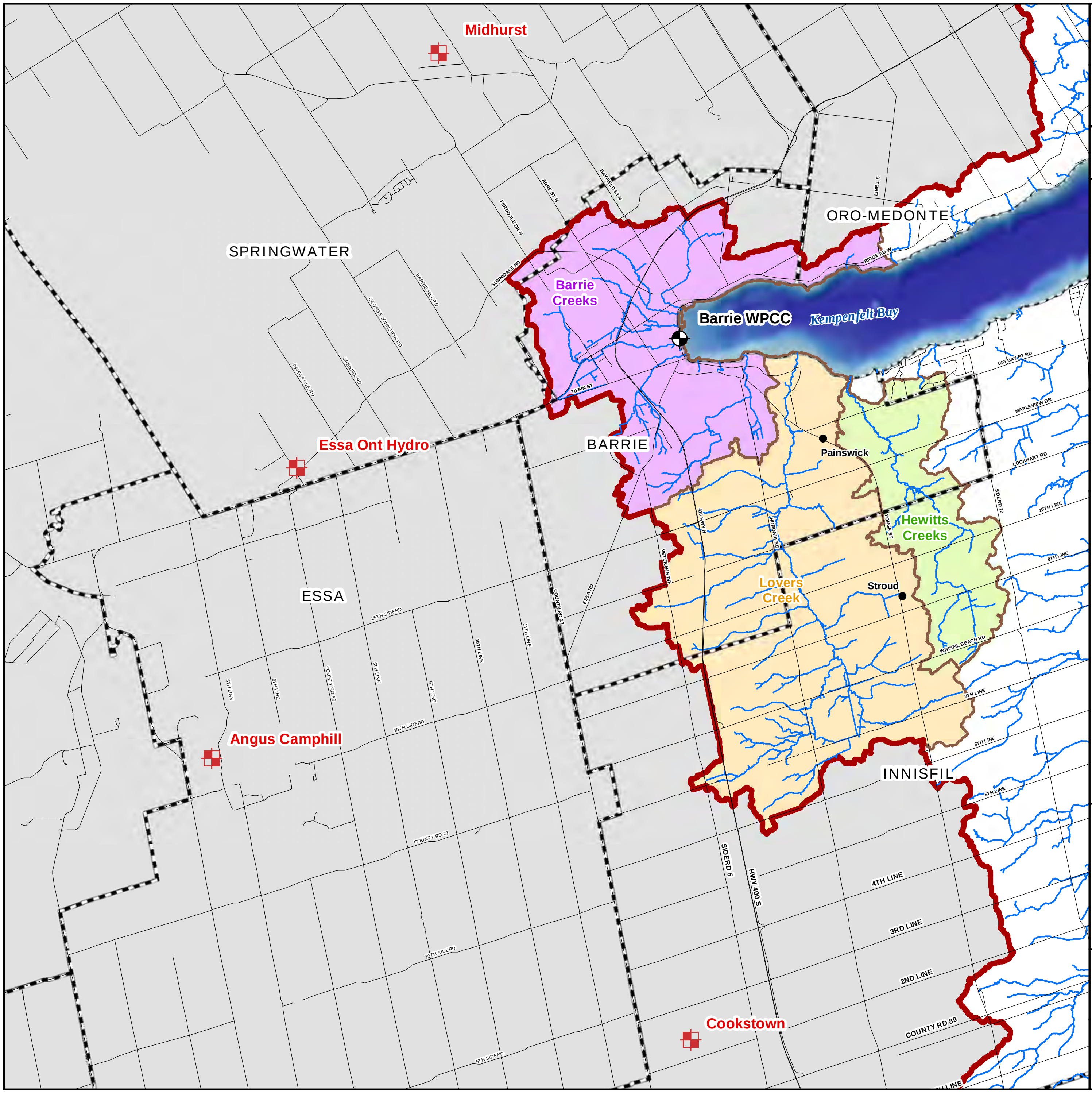
Table 2-9: Summary of climate normals (1971-2001) for the City of Barrie and surrounding area (modified from AquaResource and Golder, 2010).

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
** Climate station is located within the subwatershed plan study area

Location of climate stations in and around the Barrie Creeks, Lovers Creek and Hewitt's Creek subwatersheds

Figure 2-31



Legend

Climate Station

- LSRCA Station
- NVCA Station
- Road
- Municipal Boundary
- Watercourse
- Lake Simcoe Watershed
- Barrie Creeks
- Hewitts Creeks
- Lovers Creeks
- Nottawasaga Valley Conservation Authority

Lake Simcoe Region conservation authority

0 0.5 1 2 3 4

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.

2.6.1.1. Temperature

To examine temperature trends for the past 60 years, the daily average air temperature was averaged for each year to produce Figure 2-32 to compare the average annual, average maximum annual, and average minimum annual air temperature. Figure 2-32 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.

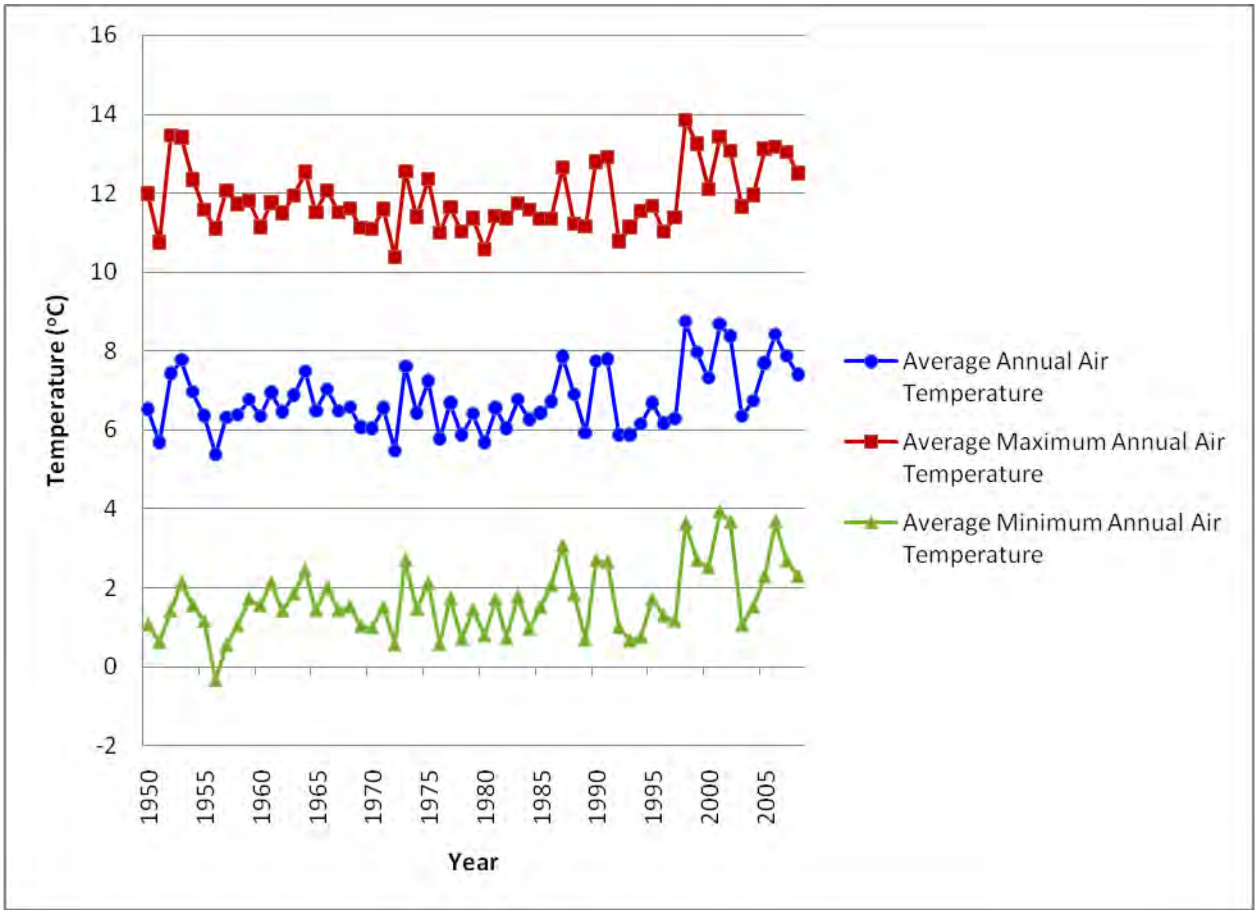


Figure 2-32: Comparison of the average annual, maximum and minimum temperatures at the Barrie WPCC Meteorological Monitoring Station (1950-2008). Source: SGBLS, 2012.

Figure 2-33 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.

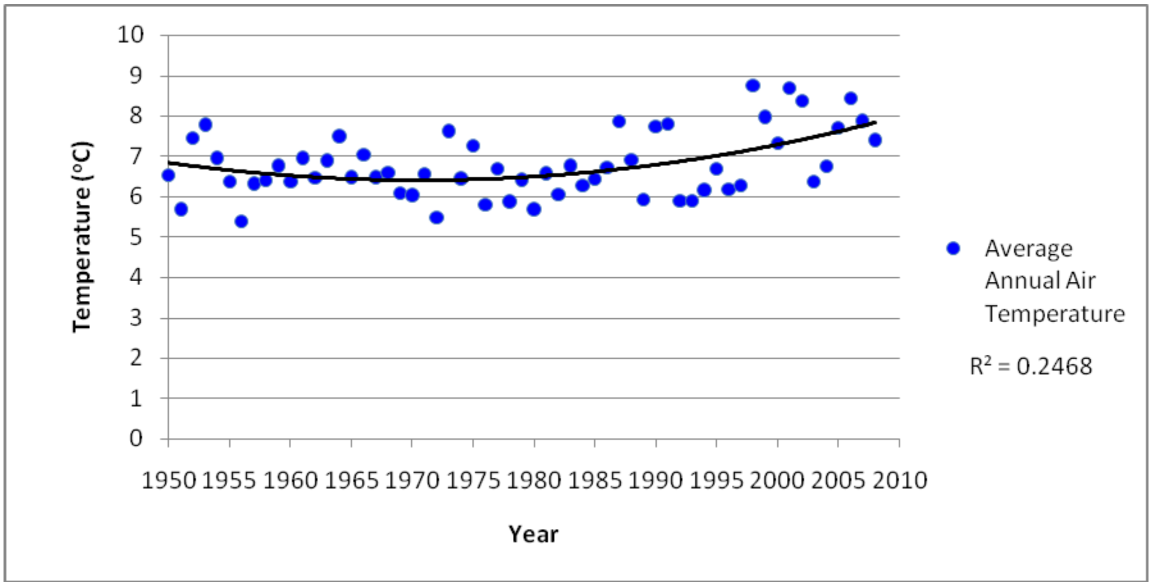


Figure 2-33: Average annual temperature at the Barrie WPCC Meteorological Monitoring Station (1950-2008). Source: SGBLS, 2012.

2.6.1.2. Precipitation

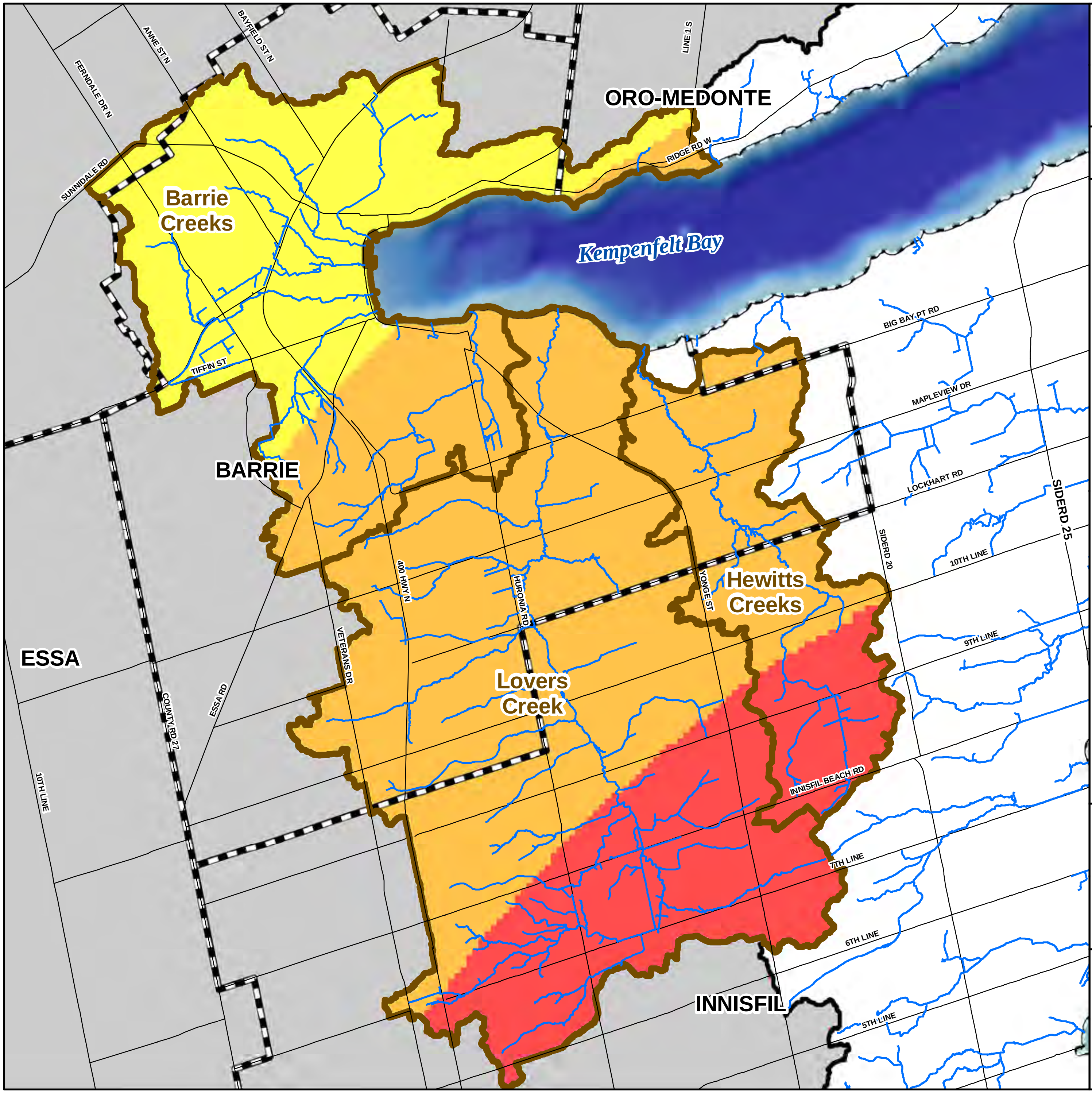
Precipitation is the driving force of the hydrological cycle, influencing aquatic and wetland habitats, as well as urban storm water management needs.

Figure 2-34 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 2-35 and shows the amount that fell as rain and the amount that fell as snow in each month. Figure 2-36 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 Barrie Creeks, Lovers Creek and Hewitt's Creek subwatersheds as distributed by PRMS

Figure 2-34



Legend

Road

Municipal Boundary

Watercourse

Subwatershed

Observed Annual Average Precipitation (mm/yr)

🟥 975 - 980

🟧 980 - 985

🟨 985 - 990

Lake Simcoe Region conservation authority

0 0.5 1 2 3 4 Kilometres

N

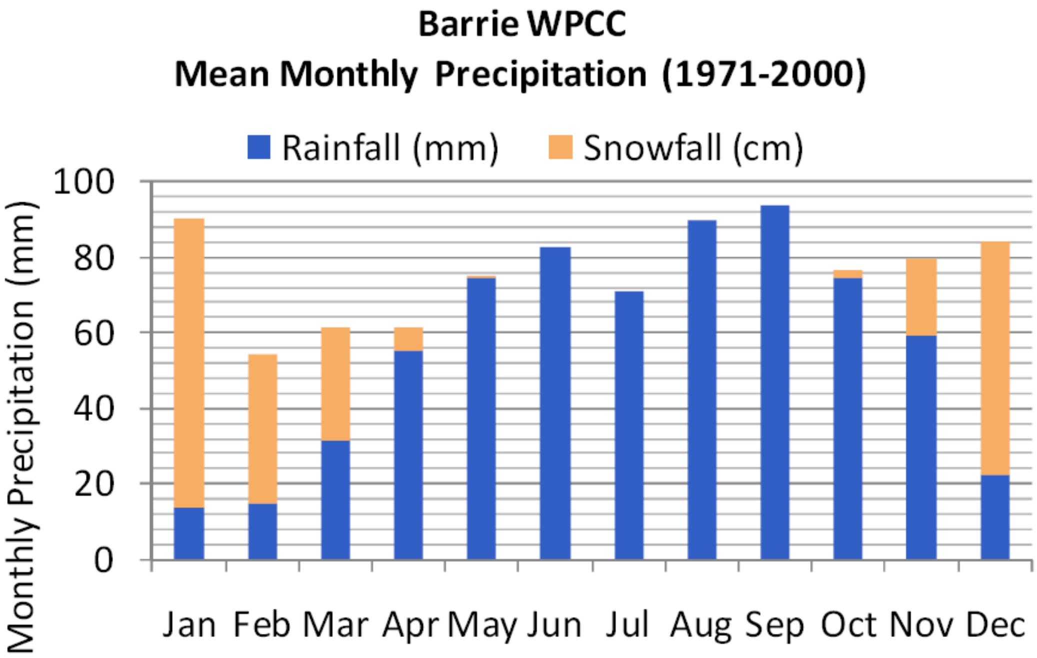


Figure 2-35: Mean monthly precipitation as snowfall and rainfall for Barrie WPCC station (AquaResource *et al*., 2011). Note: The water storage capacity of 1 cm of snow pack is equivalent to 1 mm of rainfall.

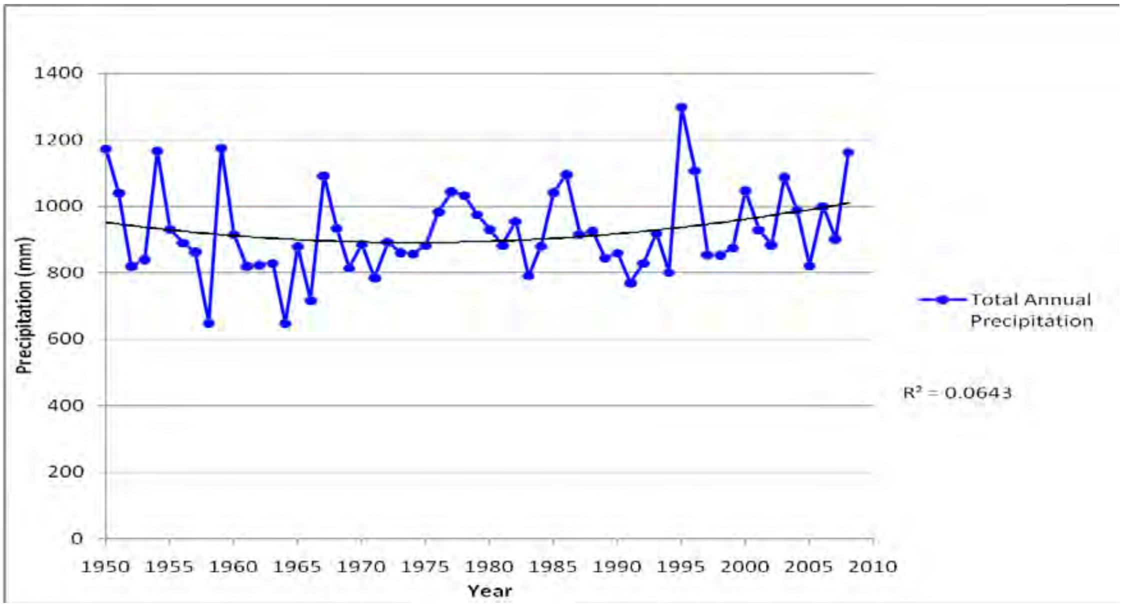


Figure 2-36: Total annual precipitation at the Barrie WPCC Meteorological Monitoring Station (1950 - 2008). Source: SGBLS, 2012.

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). For the purpose of this subwatershed plan, the focus will be on Kempenfelt Bay (and to some extent the main basin) as this is the area most closely connected to the subwatersheds within the study area.

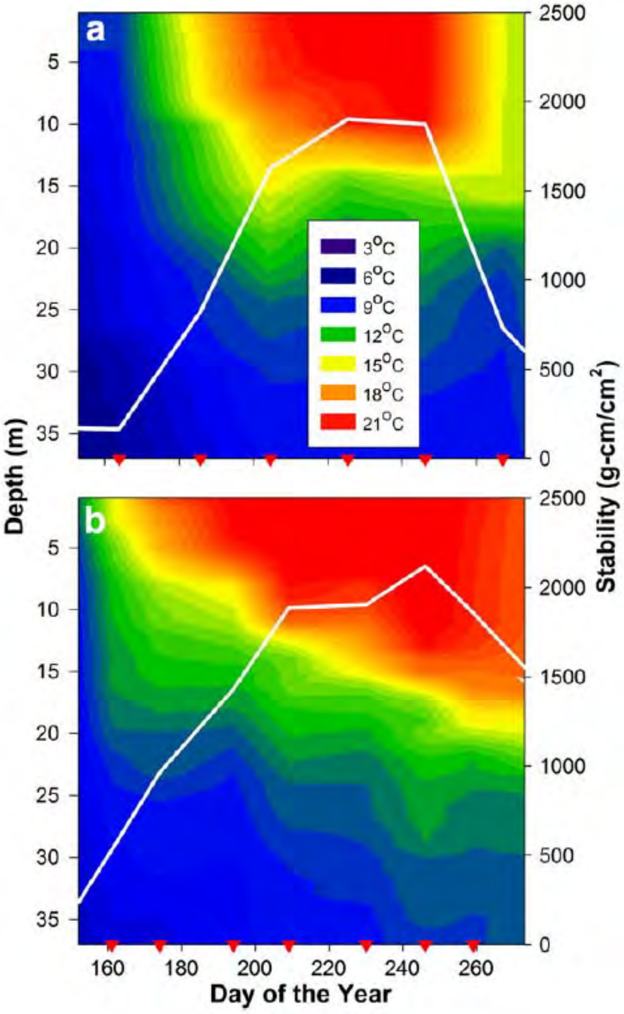


Figure 2-37: Seasonal water column temperature contour in degrees Celsius) and stability (white line) in Kempenfelt Bay in 1980 (a) and 2002 (b). Red triangles show the sampling dates along the x-axis. Source: Stainsby *et al.*, 2011.

Out of the three sampling areas, Kempenfelt Bay generally has higher thermal stability due to its deeper depths (max 42m; mean 26m), whereas Cook's Bay tends to have lower thermal stability because of its shallower depths (max 21m; mean 8m) 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 2-37 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 2-38 illustrates the timing of the onset of stratification in Kempenfelt Bay (Figure 2-38a) and the main basin (Figure 2-38b). 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 2-38a) than it was in 1980. In the main basin, stratification is occurring approximately 13 days earlier (Figure 2-38b).

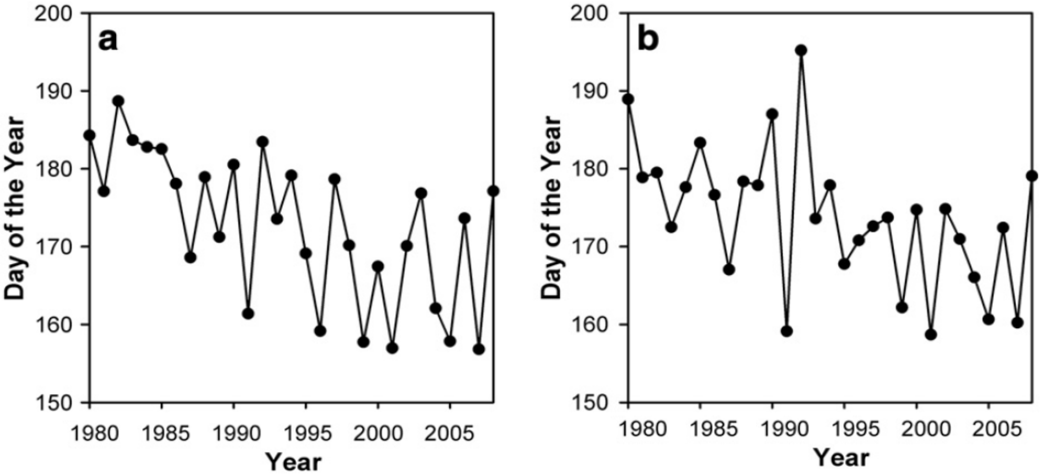


Figure 2-38: The timing of the onset of stratification in (a) Kempenfelt Bay and (b) the main basin. Source: Stainsby *et al.*, 2011.

When looking at the fall turnover, Figure 2-39 shows it to be occurring later and later each year. Between 1980 and 2002, mixing of the water column in the fall is occurring approximately 15 days later in Kempenfelt Bay (Figure 2-39a) and approximately 18 days later in the main basin (Figure 2-39b).

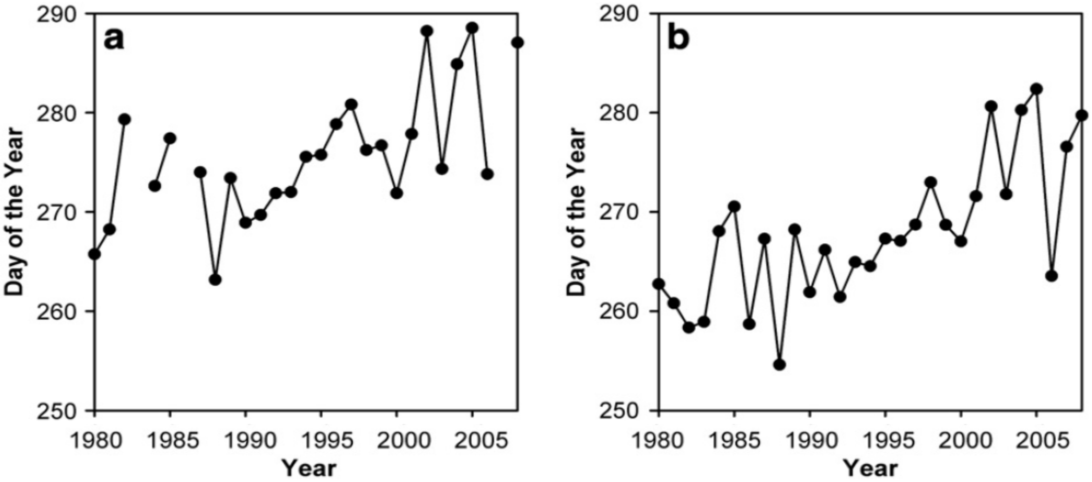


Figure 2-39: The timing of fall turnover in (a) Kempenfelt Bay and (b) the main basin. Source: Stainsby *et al.*, 2011.

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). In Kempenfelt Bay and the main basin of Lake Simcoe, the water column remains stratified approximately 33 days longer in 2008 than in 1980 (Figure 2-40a and b).

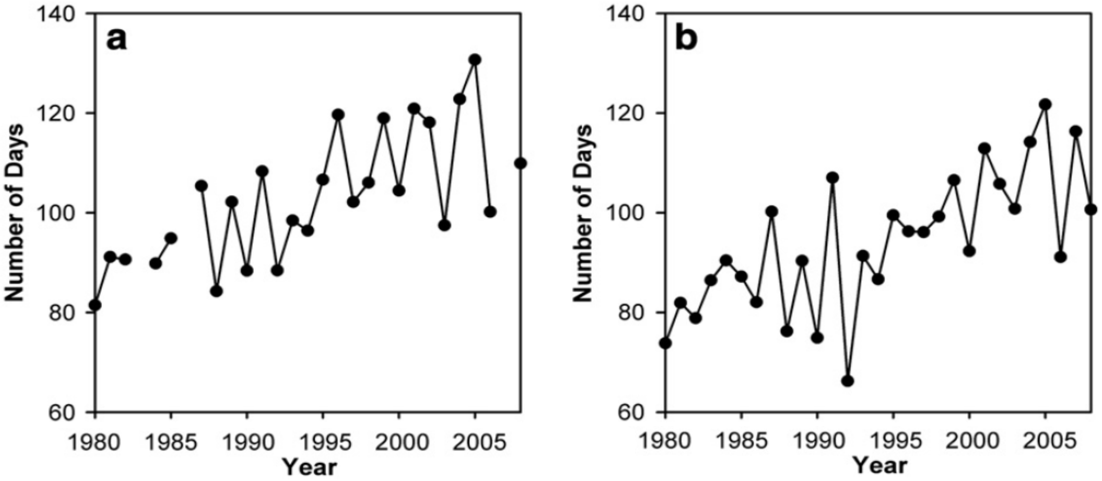


Figure 2-40: The length of the stratified period in (a) Kempenfelt Bay and (b) the main basin. Source: Stainsby *et al.*, 2011.

Many of the impacts already being observed in the Lake Simcoe watershed counteracts 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, improvement of construction practices, as well as 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 2-11 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 2-10: 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 2-12 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 2-11: 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 on 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 was conducted by LSRCA in 2004, and then annually since 2007 at all 14 Provincial Groundwater Monitoring Network (PGMN) wells located throughout the Lake Simcoe watershed. Each sample was analyzed for 41 chemical parameters including metals, nutrients, and general chemistry. None of the PGMN wells lie within the Barrie Creeks, Lovers Creek or Hewitt's Creek subwatersheds (Figure 3-1).

However, the City of Barrie has numerous groundwater monitoring sites located throughout the city and 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 identify 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 Barrie Creeks, Lovers Creek and Hewitt's Creek subwatersheds 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 Lovers Creek under the Provincial Water Quality Monitoring Network (PWQMN). A further three stations are sampled under the Lake Simcoe Protection Plan (LSPP): another on Lovers Creek, one on Hotchkiss Creek (selected to be representative of the watercourses in the Barrie Creeks subwatershed) and one on Hewitt's Creek (Figure 3-1). Samples under the PWQMN program are collected eight times a year on a monthly basis during the ice-free period and analyzed for 32 chemical parameters. Samples collected under the LSPP are analyzed for 12 parameters and are collected year round, every three weeks in the winter months (December to March) and every two weeks from April to November. Samples from both programs are analyzed in 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 (CCME, 2001). 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 Barrie Creeks, Lovers Creek and Hewitt's Creek subwatersheds 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 Barrie Creeks, Lovers Creek and Hewitt's Creek subwatersheds

Figure 3-1

Legend

Road

Municipal Boundary

Watercourse

Water Quality Stations (PWQMN)

Water Quality Stations (LSPP)

Lake Simcoe Region conservation authority

0 0.5 1 2 3 4 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.

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 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 five years in Barrie Creeks and seven years in Lovers and Hewitt's Creeks (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 City of Barrie and Town of Innisfil are monitored every year, from June until the end of August, to ensure that the water is safe for swimmers (in terms of bacteria). 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 includes 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).

3.2.3 Groundwater Quality Status

Within the Barrie Creeks subwatershed, WHPAs have been delineated for the Barrie Well Supply. An assessment of potential Significant Threats was undertaken within each WHPA, with potential threats associated with the handling and storage of fuel and dense non-aqueous phase liquids[1] being the most common threat identified (SGBLS, 2011).

In addition, Drinking Water Issues were identified at Well 3A (associated with chloride) and Wells 11, 12, and 13 (associated with chloride and sodium). A Drinking Water Issue is identified when a contaminant in the raw water is found to be at a concentration that may result in the deterioration of the quality of the water for use as a source of drinking water, or has a trend for increasing concentration.

At Well 3A, chloride concentrations show an increasing trend, with the projected 50 year concentration trend indicating that the Ontario Drinking Water Standards (ODWS) limit may be reached. Additionally, at this Well, there appears to be a steepening trend in chloride concentrations in the recent monitoring data. Wells 11, 12, and 13 all have elevated chloride concentrations, with the projected 50 year concentration trend suggesting that the ODWS limit may be reached at all three wells. Additionally, Wells 11 and 12 also show increasing trends for sodium, which, based on the projected 50 year trend, is also expected to exceed the ODWS limit (Golder, 2010).

There were also six Drinking Water Conditions identified for this supply system associated with trichloroethylene (TCE) (2), petrohydrocarbons (1), BTEX (benzene, toluene, ethylbenzene and xylenes) and PHCs (petroleum hydrocarbons) (2), and vinyl chloride (1). These conditions are existing contaminations associated with a past activity that have the potential to affect the quality of drinking water (SGBLS, 2011).

In the Lovers Creek subwatershed, WHPAs have been delineated for the Innisfil Heights Well Supply. An assessment of potential Significant Threats was undertaken within each WHPA, with potential threats associated with a variety of land uses, from residential to agricultural to commercial. No Drinking Water Issues or Conditions were associated with this system (SGBLS, 2011).

Lastly, within the Hewitt's Creek subwatershed, WHPAs have been delineated for the Stroud Well Supply. An assessment of potential Significant Threats was undertaken within each WHPA, with potential threats associated individual sewage systems being the most common threat identified. No Drinking Water Issues or Conditions were associated with this system (SGBLS, 2011).

For more in-depth information on the drinking water systems in these subwatersheds, 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 B and Appendix I for the City of Barrie and Town of Innisfil, respectively.

Groundwater seep

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[1] Dense non-aqueous phase liquids are a class of chemicals that are slightly soluble in water and are therefore often observed as a separate "oil-like" phase in the subsurface. These chemicals have been used in large quantities for decades in industrial and commercial application such as dry cleaning, cleaning/degreasing solvents, electronics, aerosols, plastics, pesticides, pharmaceuticals, wood preservation, asphalt operations, varnishes and the repair of motor vehicles and equipment. These chemicals can also be found in small quantities in common household products (i.e. adhesives and cleaners).

3.2.4 Surface Water Quality Status

Of the water quality stations in the study area, the Lovers Creek station has the longest period of record, running from 1974 to present. This data set allows for current conditions and trends to be compared to historical data to examine changes in water quality over time. Key parameters for the station period of record show historic water quality to be generally good, with the majority of samples meeting the relevant quality guidelines (Table 3-2). The data shows the trends for both zinc and copper to be decreasing, while trends for chloride, phosphorus, and nitrate are increasing over the period of record. Although increasing trends in chloride and nitrate can be seen in most of the Lake Simcoe watershed stations, Lovers Creek is one of only two stations to show an increasing trend in phosphorus concentrations in the historic data. This however is in large part due to the low historical phosphorus concentrations at Lovers Creek which were also somewhat unique when compared to other Lake Simcoe tributaries at that time. See phosphorus section (3.2.4.1) for further explanation.

Hewitt's Creek

When looking at current conditions (2006 to 2010) (Table 3-3) the majority of samples are meeting the relevant quality guidelines, however, for chloride, phosphorus, TSS, and iron, the percentage of samples meeting the guidelines has decreased (compared to the long-term trends). Chloride and phosphorus concentrations continue to show increasing trends (2002 – 2010), as do zinc and copper concentrations. Of all the parameters examined, only nitrate concentrations show a decreasing trend. The current data set indicates that water quality in the Lovers Creek system is declining, a trend which is further emphasized when compared with the historic data set. In part this trend is likely due to landuse changes in the lower half of the system from rural and agricultural to industrial, commercial, and residential beginning in 1954, when the city limits extended to include 104 ha of land located between Highway 400 on the west and north, Anne St to the east, and Tiffin St to the south. Unless mitigation measures are put in place, it is likely that water quality issues within the systems will continue to shift as a result of the land use changes (i.e. as urban areas replace agriculture, metals may continue to rise and become a greater issues, while nitrate may continue to 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.

Pond draining into Lovers Creek

Table 3-2: Historic surface water quality conditions for Lovers Creek compared to other tributaries within the Lake Simcoe watershed.

Monitoring Station	Historic Conditions (Entire Station Record) Percentage of samples that meet objectives: Orange = median Concentration >objective Green = median Concentration < objective							Historical Trends Analysis (entire station record)[+] 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 (1965 – 2010)	98 🟩	4 🟧	92 🟩	88 🟩	53 🟩	97 🟩	85 🟩	🟧	🟩	🟧	🟩	n/d	🟩	🟩
Tannery Creek (1965 – 2010)	65 🟩	9 🟧	85 🟩	n/d	39 🟧	77 🟩	73 🟩	🟩	🟩	🟩	n/d		🟩	🟩
Mt. Albert Creek (1971 – 2010)	99 🟩	9 🟧	100 🟩	n/d	65 🟩	99 🟩	89 🟩	🟧	🟩	🟧	n/d		🟩	🟩
Beaver River (1972-2010)	100 🟩	63 🟩	99 🟩	94 🟩	90 🟩	98 🟩	85 🟩	🟧	🟩	🟧	🟩		🟩	🟩
Pefferlaw (1973-2010)	100 🟩	49 🟧	100 🟩	97 🟩	91 🟩	97 🟩	84 🟩	🟧	🟩	🟧	🟩		🟩	🟩
Lovers Creek (1974-2010)	90 🟩	76 🟩	99 🟩	91 🟩	84 🟩	95 🟩	83 🟩	🟧	🟧	🟧	▨		🟩	🟩
Schomberg (1977-2010)	100 🟩	9 🟧	97 🟩	75 🟩	39 🟧	97 🟩	76 🟩	🟧	🟩	🟩	n/d		🟩	🟩
Maskinonge River (1985-2010)	94 🟩	15 🟧	99 🟩	93 🟩	34 🟧	92 🟩	91 🟩	🟧	🟧	🟧	🟧		🟩	▨
East Holland (1993-2010)	46 🟩	2 🟧	100 🟩	45 🟧	8 🟧	90 🟩	80 🟩	🟧	▨	n/d				
Black River (1993-2010)	99 🟩	39 🟧	100 🟩	99 🟩	75 🟩	98 🟩	98 🟩	🟧	▨	n/d				
Hawkestone Creek (1993-2010)	100 🟩	89 🟩	100 🟩	97 🟩	92 🟩	100 🟩	98 🟩	🟧	▨	n/d				
Uxbridge Brook (2002-2010)	100 🟩	33 🟧	98 🟩	93 🟩	80 🟩	98 🟩	98 🟩							
Objective	128 mg/L	0.03 mg/L	2.9 mg/L	30 mg/L	300 µg/L	20 µg/L	5 µg/L							

Note: Monitoring of zinc and copper generally started in the early 1980s. There were no data for metals where stations were monitored under the LSSP program but not PWQMN (Kettleby, North Schomberg, Talbot and Whites).

[+] Where trends were not listed for TSS or iron for stations with early monitoring (1960s or 1970s), either monitoring for those parameters started after 2000 or there were large gaps in the data (~10 years). For stations monitored starting 1993, nitrate, TSS and metals were not monitored until after 2000.

[++] Chloride started in 1993 for Pefferlaw.

Table 3-3: Current water quality conditions for Lovers Creek compared to other tributaries within 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 are 2000 to 2010
** All trends for this station are 2003-2010

Water quality data for Hotchkiss Creek and Hewitt's Creek has been collected since 2008. While this data set is not yet long enough to examine for trends it was compared with water quality guidelines for chloride, phosphorus, nitrate, and TSS. Compared with the same time period at Lovers Creek, concentrations of phosphorus, nitrogen, and TSS are fairly similar across the three stations. One exception is Hotchkiss Creek, which has higher maximum concentrations of phosphorus, more regularly, than Lovers Creek or Hewitt's Creek (shown in Figure 3-4). Hotchkiss Creek also deviates from Lovers Creek and Hewitt's Creek in chloride concentrations.

Where 90% of samples at Hewitt's Creek and 70% of samples at Lovers Creek meet long term exposure chloride guidelines, only 7% of the samples collected at Hotchkiss Creek meet the objective (Table 3-4). The CWQG also use a short term, or acute, exposure guideline of 586 mg/L which estimates the point at which severe effects to the aquatic ecosystem are likely to occur over a 24 to 96 hour exposure period (Table 3-1). From 2008 to 2010, nine samples (10%) exceeded this guideline at Hotchkiss Creek while no exceedances occurred at Lovers Creek or Hewitt's Creek.

Table 3-4: Surface water quality comparison for Lovers, Hewitt's, and Hotchkiss Creeks (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**
Hewitt's Creek	90	55	82	89
Hotchkiss Creek	7	59	99	86
Lovers Creek	70	60	100	87
Objective	128 mg/L	0.03 mg/L	2.9 mg/L	30 mg/L

3.2.3.1. Phosphorus

As the historic concentrations at Lovers Creek are unusually low compared to just about everywhere else in the watershed, it is one of the few tributaries showing an increasing trend in phosphorus concentrations when examining the entire period of record. While this is a concern, it is important to realize that while more rapid development in the subwatershed is likely causing this increase, the total phosphorus load from the Lovers Creek subwatershed only makes up 1.4% of the total load going into Lake Simcoe each year (discussed further in the Stressors section of this chapter). For comparison, the Beaver River, which today has relatively low concentrations and shows a declining trend, had much higher concentrations through the 1970s and 1980s, the majority of which exceeded the guideline (Figure 3-2).

Reading & Interpreting Box Plots

A box plot presents a data set in graphical form. The shaded portion of the box represents the middle 50% of the data set showing where the majority of the values fall and the spread of the data. The line in the box is the median (50th percentile) of the data set. The whiskers show the lower and upper quartiles of the data set. The points above and below the whiskers represent outliers in the data set at the 5th and 95th percentile. A red line has also been included to highlight the applicable guideline for the parameter.

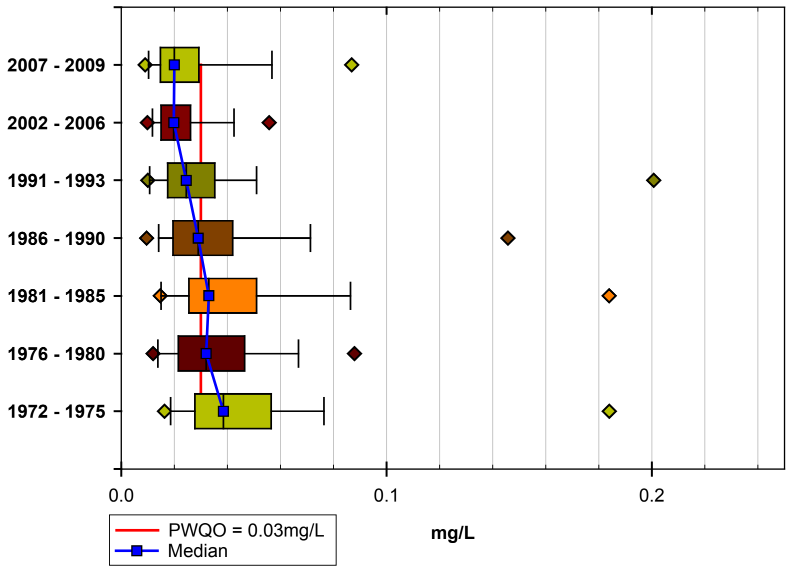

Figure 3-2: Beaver River phosphorus concentrations (mg/L) 1972-2009, presented for comparison to Lovers Creek phosphorus concentration (Figure 3-3).

In contrast, the majority of phosphorus concentrations in Lovers Creek in the 1970s, 1980s, and mid 1990s were below the guideline (Figure 3-3) and showed no trend. This is also evident in the guideline compliance table (Table 3-2) where Lovers can be seen to be one of the stations with the greatest proportion of samples complying with guidelines at 76%. This decreases to 65% compliance in the current data (Table 3-3) as a result of the increasing trend in phosphorus concentrations since the mid 1990s. However, the median of the 2006 to 2010 data set is still below the PWQO at 0.02mg/L with a maximum value of 0.505 mg/L.

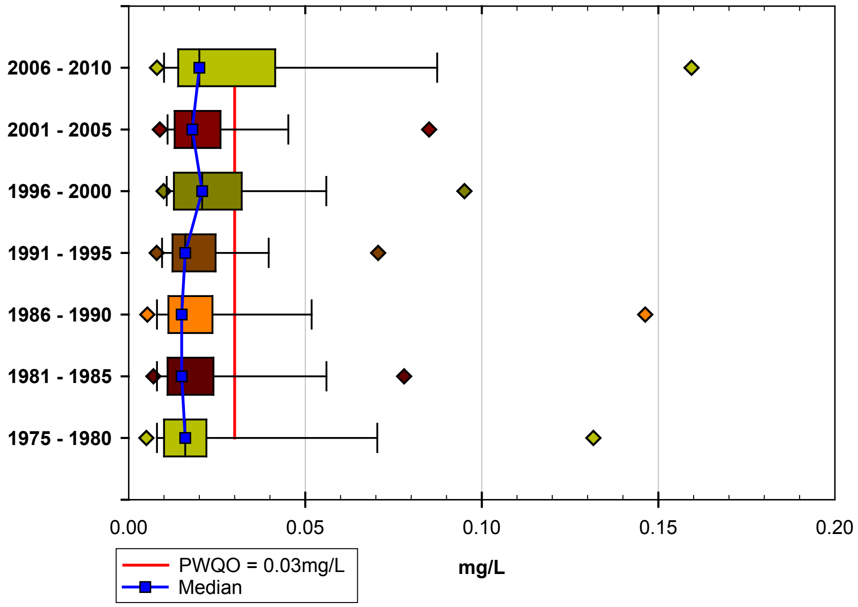

Figure 3-3: Lovers Creek phosphorus concentrations (mg/L) 1975-2010.

The short period of record at Hotchkiss and Hewitt's Creek does not allow for trend analysis. As previously mentioned, water quality data for Hotchkiss Creek and Hewitt's Creek have been collected only since 2008. While this data set is not yet long enough to examine for trends, it is compared to water quality guidelines for a number of parameters, along with the same time period for Lovers Creek. Figure 3-4 shows the phosphorus concentrations on these two systems are slightly higher than Lovers Creek with fewer samples complying with the PWQO. The highest concentrations are recorded at Hotchkiss Creek, which is located in an intensely developed subwatershed and, due to the age of the development, there are relatively few stormwater controls on this particular system to mitigate stormwater runoff quality and quantity. Because the vast majority of the Hotchkiss catchment is comprised of urban landuses (and in turn impervious surfaces), the creek has been observed to react very quickly to rain events, making it very difficult to capture runoff events. It is expected that as the period of record increases for Hotchkiss, and a greater number of runoff events are captured, the spread of the data will increase along with the high end concentrations.

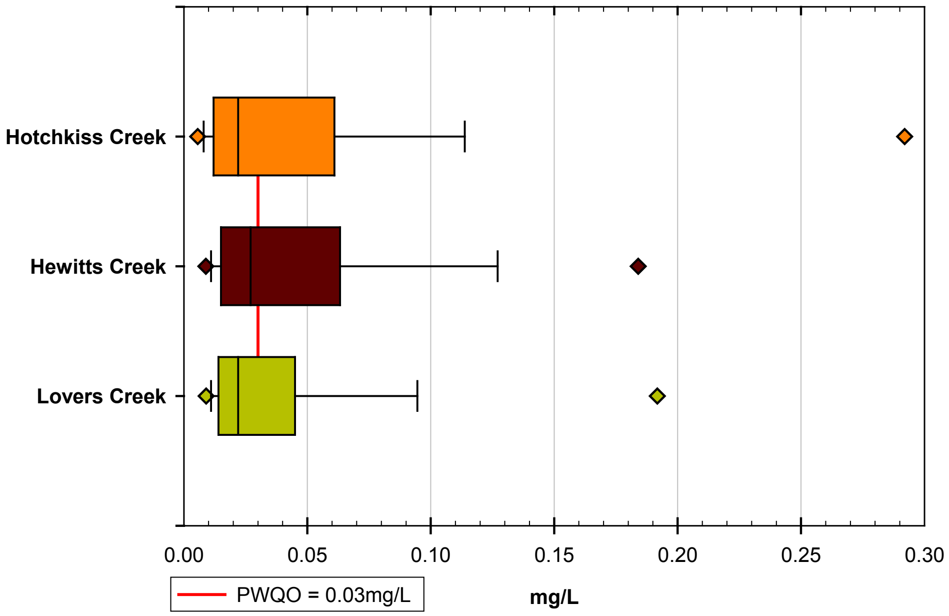

Figure 3-4: Lovers, Hewitt's, and Hotchkiss Creek phosphorus concentrations 2008 – 2010 (mg/L).

3.2.3.2. Chloride

The *Canadian Environmental Protection Act* has defined road salts containing chloride as toxic (2001). This was based on research that found that the large amount of road salts being used can negatively impact ground and surface water, vegetation, and wildlife. While elevated chloride levels are primarily found around urban centres, chloride levels have been found to be steadily increasing across the Lake Simcoe watershed, and throughout Ontario, including waters that could be considered pristine northern rivers (LSRCA, 2007) as well as in Lake Simcoe itself (Eimers and Winter, 2005).

While Lovers Creek does not show exceedances of the acute toxicity guideline of 586 mg/L, 33% of 2006 – 2010 samples exceed the long term exposure guideline (Table 3-3). As Figure 3-5 shows, the rapidly increasing trend at Lovers Creek likely means the number of samples exceeding the acute toxicity guideline will likely increase and chloride will increasingly become a limiting factor on ecosystem health for this system.

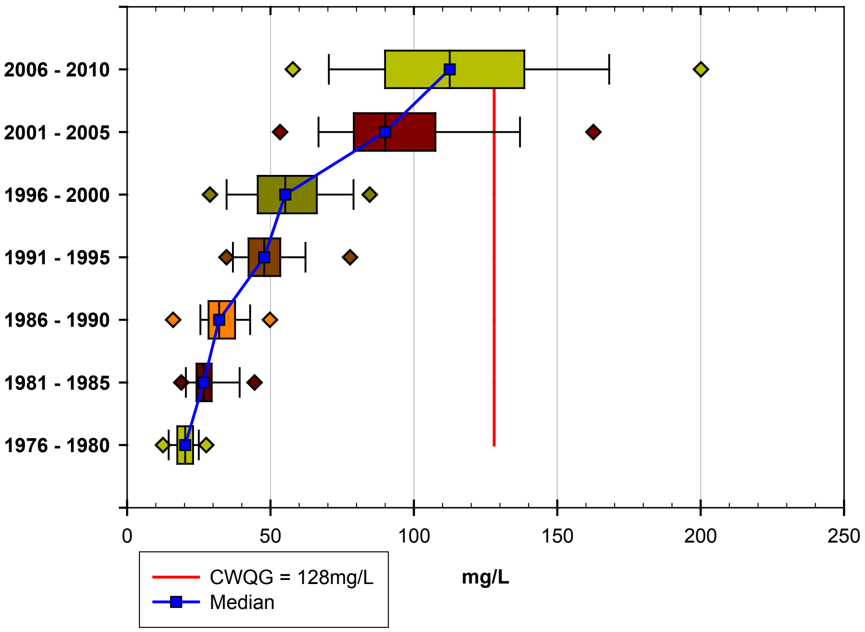

Figure 3-5: Lovers Creek chloride concentrations 1976 - 2010 (mg/L)

In Hotchkiss Creek, where there is a high proportion of the catchment in urban land use with Highway 400 bisecting it, road salt appears to be the main cause of the high chloride concentrations. As such, the short record for Hotchkiss Creek shows chloride to be the predominant water quality concern for the system, with 93% of the samples exceeding the water quality objectives (Table 3-4), of which nine samples (10%) exceeded the acute toxicity guideline over the three years of record. No exceedances of the acute toxicity guideline occurred at Lovers or Hewitt's Creeks.

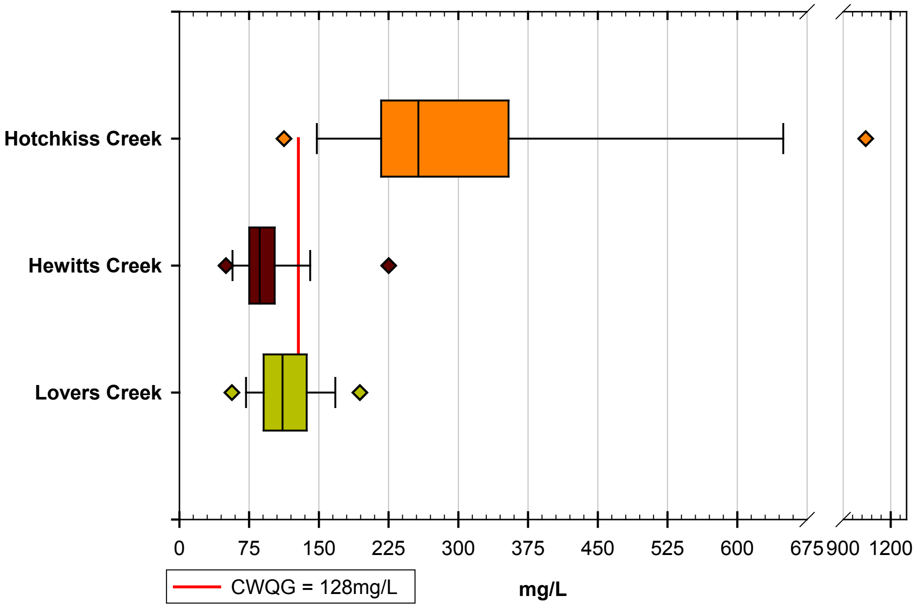

Figure 3-6: Lovers, Hewitt's, and Hotchkiss Creeks chloride concentrations (mg/L) 2008 – 2010.

3.2.3.3. Total Suspended Solids

Total suspended solids (TSS) is a measure of the material in suspension in the water column. This is an important measure because, as outlined in Table 3-1, TSS can act as a transport mechanism for a variety of other parameters, some in a benign form such as clay bound aluminum while others such as phosphorus can cause excessive nutrient loading downstream. Excessive amounts of TSS will also have negative impacts on fish and benthic organisms.

High TSS concentrations would be expected during and following rain events as soil from pervious areas and accumulated grit and dirt from impervious surfaces are washed into streams. Water quality sampling conducted during predominantly dry weather conditions will usually indicate a lower occurrence of TSS exceedances.

The Canadian Council of Ministers of the Environment (CCME) has set an interim guideline for TSS of 30 mg/L (CWQG, 1999). As Figure 3-7 shows, TSS has not been an issue at Lovers Creek for much of the period of record. While the 2007 – 2010 period of record shows a greater spread in the data, this has not been enough to influence the trend which has remained stable in both the historic and current data. The values in the 2007 – 2010 period do stand out against the record as having a number of higher values but these are not unprecedented. Looked at with phosphorus and chloride trends, the data shows the condition of Lovers Creek water quality is changing.

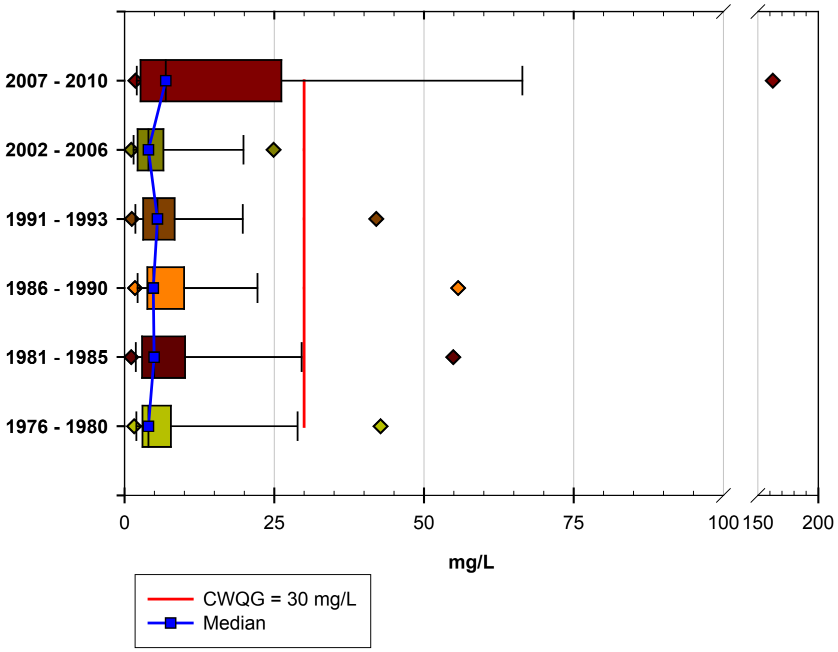

Figure 3-7: Lovers Creek total suspended solids concentrations 1976-1993, 2002-2010 (mg/L).

Total suspended solids data from 2008 to 2010 for Lovers, Hewitt's, and Hotchkiss Creeks show the highest concentrations are occurring at Hotchkiss Creek (Figure 3-8). As with phosphorus, the high proportion of the Hotchkiss catchment that is developed along with the lack of stormwater controls is likely a leading cause of the high TSS concentrations. Hotchkiss Creek had also seen a great deal of channel realignment and large sections flow through enclosed pipes. This will serve to increase water velocities, and, when combined with the high proportion of impervious surface, will see runoff move very quickly through the system. These processes will quickly transport surface sediment and debris to the creek, exacerbate channel erosion, and keep particulate in suspension, all of which lead to higher TSS concentrations in the system.

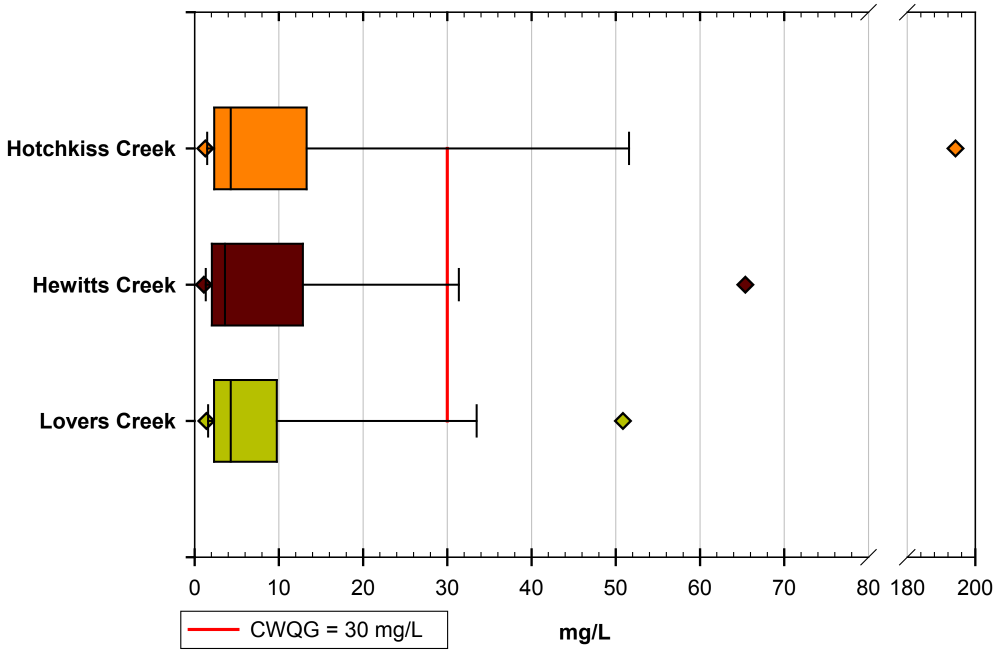

Figure 3-8: Lovers, Hewitt's, and Hotchkiss Creeks TSS concentrations (mg/L) 2008-2010.

3.2.3.4. 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 3-5 and Table 3-6 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 not to 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 the release of a toxic chemical release.

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	-	
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

In the Town of Innisfil, there were no beach closures in the 2006-2011 period of record. The only beach that had no advisory postings was Killarney Beach. Each of the other seven beaches had at least one advisory posting, with Alcona North Beach having one advisory, and 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 3-6).

Table 3-6: 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	-	
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

Key points – Current Water Quality Status:

- There are no Provincial Groundwater Monitoring Sites within these three subwatersheds
- Within Barrie Creeks, the Barrie Well Supply (groundwater) had Drinking Water Issues identified in Well 3A (associated with chloride) and Wells 11, 12, and 13 (associated with chloride and sodium). Additionally, six Drinking Water Conditions were identified for this groundwater supply in association with trichloroethylene (TCE) (2), petrohydrocarbons (1), BTEX (benzene, toluene, ethylbenzene and xylenes) and PHCs (petroleum hydrocarbons) (2), and vinyl chloride (1).
- Potential Significant Drinking Water Threats associated with the Barrie Well Supply are mainly associated with handling and storage of fuel and dense non-aqueous phase liquids. For Innisfil Heights (located in Lovers Creek), potential Significant Drinking Water Threats are associated with a variety of land uses, while those in the Stroud Well supply (located in Hewitt's Creek) were mainly associated with individual sewage systems.
- For surface water, chloride, phosphorus, zinc, and copper show increasing trends in concentrations with chloride showing the strongest trend. Historically zinc and copper showed decreasing trends which has reversed over the last decade. Additionally, historically, nitrate trends were increasing, but current data shows a decreasing trend.
- The majority of water quality samples collected at Lovers Creek meet the relevant water quality objectives.
- When examining the entire period of record, Lovers Creek has seen an increasing trend in phosphorus and an exponentially increasing trend in chloride, with 33% of the 2006-2010 samples exceeding the PWQO long term exposure guideline.
- TSS has not been a problem in Lovers Creek for much of the period of record, but 2007-2010 samples show a greater spread in data, with some samples showing significantly higher concentrations than have historically been observed.
- Based on the 2008-2010 data available for Hewitt's Creek:
    - Slightly higher median phosphorus concentration than Lovers and Hotchkiss Creeks for the same time period
    - Lowest concentration of chloride compared to Lovers and Hotchkiss
    - Lower TSS concentrations than Hotchkiss, but higher than Lovers
- Based on the 2008-2010 data available for Hotchkiss Creek:
    - The highest concentration of phosphorus (compared to Lovers and Hewitt's Creeks) was recorded in this system
    - Only 7% of the samples were below the PWQO long term exposure guideline for chloride and 10% of samples exceeded the acute toxicity guidelines.
    - Had the highest concentration of TSS, compared to Lovers and Hewitt's Creeks for the same time period.
- In 2011, there were two advisory postings at Minets Point Beach, one at Wilkins Beach and two at Leonard's Beach. Beaches 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 beyond the capacity of the natural filtration capability of the soils, resulting in impacts to groundwater. 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, and 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 Barrie Well Supply is seeing elevated concentrations of chloride and sodium at a number of its wells. These concentrations can be attributed to large quantities of road salt used in the dense urban areas during the winter months. Past activities have also created contaminations in the groundwater related to TCE, petrohydrocarbons, BTEX, PHCs, and vinyl chloride.

In the Innisfil Heights and Stroud Well Supplies, no contaminants were identified as Drinking Water Issues or Conditions, however possible Significant Threats were identified related to a variety of land uses (Innisfil Heights) and individual septic systems (Stroud).

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 5%, 36%, and 54% of the Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds, respectively. Runoff from pastures and crop land, as well as wind, which erodes topsoil, contributes to the phosphorus loading in mostly the Lovers Creek and Hewitt's Creek subwatersheds. Urban land use on the other hand use makes up 63%, 21%, and 18% of the Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds, and a considerable contribution to the phosphorus loading (particularly in Barrie Creeks) through stormwater runoff (discussed further in Section 3.3.2.9).

Phosphorus load estimates were originally calculated in the *Assimilative Capacity Studies* (ACS)*, 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 tables (Table 3-7 to Table 3-9) present 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, which are particularly important in the highly urbanized subwatersheds, such as Barrie Creeks. 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 is presented for each subwatershed.

The primary source of phosphorus in the Barrie Creeks subwatershed under existing conditions is derived from high intensity development land uses (58%) and point sources (38%). Under the approved growth scenario, there is a projected increase in total phosphorus loads of 6.5% without the implementation of agricultural BMPs (does not consider urban BMPs). The projected phosphorus load under the approved growth scenario can be reduced by 0% through the implementation of agricultural BMPs (Table 3-7). Under existing conditions, the Barrie Creeks subwatershed is the highest contributor of total phosphorus to Lake Simcoe (Figure 3-9). Under the committed growth scenario it is expected to be third highest contributor of total phosphorus, as the growth and development expected in both the East and West Holland subwatersheds puts them as the top two contributors to the lake (Figure 3-10) (Berger, 2010a).

Table 3-7: Phosphorus loads by source for the Barrie 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	17	17	0	17	0	0
Crop Land	36	32	-4	32	0	0
Turf-Sod	0	0	0	-	0	0
Tile Drainage	0	0	0	0	0	0
Low intensity development	12	10	-2	10	0	0
High intensity development	4,810	5,704	894	5,704	0	0
Septics	84	84	0	84	0	0
Polder	0	0	0	0	0	0
Quarry	1	1	0	1	0	0
Unpaved road	0	0	0	0	0	0
Transition	5	2	-3	2	0	0
Forest	1	0	-1	0	0	0
Wetland	0	0	0	0	0	0
Stream bank	81	77	-4	77	0	0
Groundwater (shallow subsurface flow)	53	65	12	65	0	0
Point sources	3,131	2,774	-357	2,774	0	0
TOTAL	**8,231**	**8,766**	**535**	**8,766**	**0**	**0%**

▨ *- 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.*

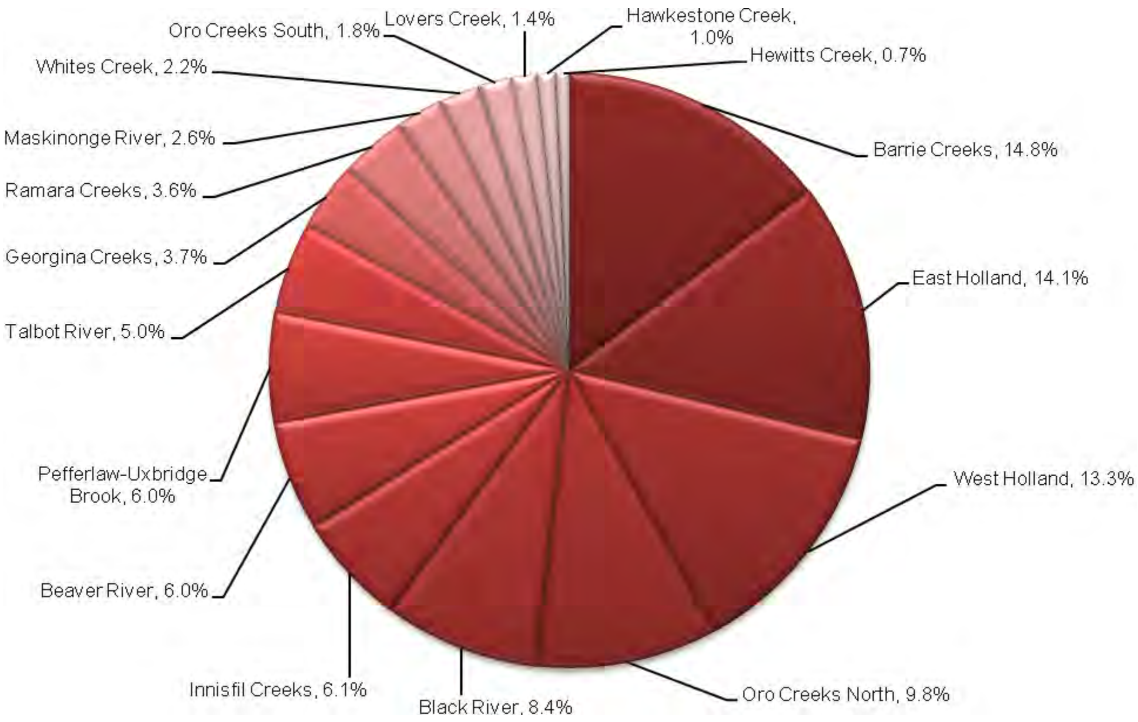

Figure 3-9: Percent phosphorus loads to Lake Simcoe per subwatershed under current conditions (data: Berger, 2010).

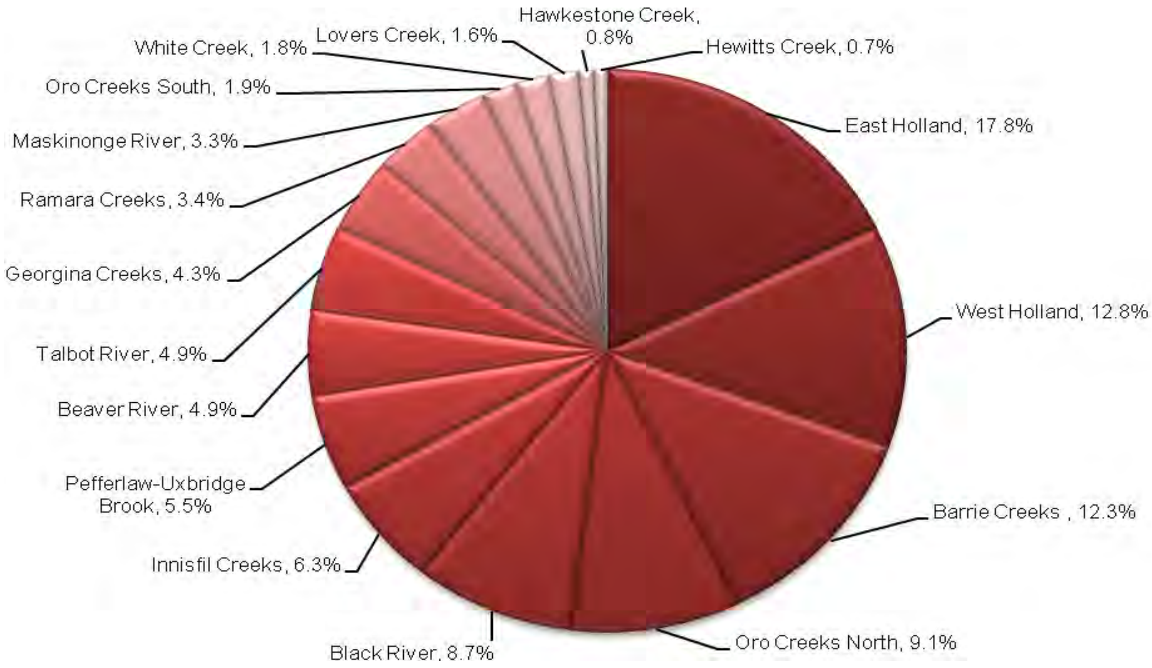

Figure 3-10: Percent phosphorus loads to Lake Simcoe per subwatershed under committed growth scenario (data: Berger, 2010).

The primary source of phosphorus in the Lovers Creek subwatershed, under existing conditions, is derived from high intensity development (42%). Under the approved growth scenario, there is a projected increase in total phosphorus loads of 43% 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 5.1% through the implementation of agricultural BMPs (Table 3-8). Taken together, this suggests that even with agricultural BMP implementation, under the committed growth scenario, phosphorus loading will still increase by 36% compared to the current estimated load if all committed growth plans are implemented. Under existing conditions, the Lovers Creek subwatershed is the third lowest contributor of total phosphorus to Lake Simcoe (Figure 3-9). Under the committed growth scenario, while still seeing an increase in total phosphorus, it is expected to still be third lowest contributor of total phosphorus (Figure 3-10) (Berger, 2010).

Table 3-8: Phosphorus loads by source for the Lovers Creek subwatershed associated with agriculture BMP scenarios (Berger, 2010).

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	23	16	-7	15	-1	-6%
Crop Land	243	190	-53	137	-53	-28%
Turf-Sod	14	13	-1	13	0	0
Tile drainage	0	0	0	0	0	0
Low intensity development	16	15	-1	15	0	0
High intensity development	343	757	414	757	0	0
Septics	12	12	0	12	0	0
Polder	0	0	0	0	0	0
Quarry	1	1	0	1	0	0
Unpaved road	0	0	0	0	0	0
Transition	3	2	-1	2	0	0
Forest	7	5	-2	5	0	0
Wetland	0	0	0	0	0	0
Stream bank	77	80	3	74	-6	-7.5%
Groundwater (shallow subsurface flow)	70	68	-2	68	0	0
Point sources	0	0	0	0	0	0
TOTAL	**808**	**1,158**	**350**	**1,099**	**-59**	**-5%**

▨ *- 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.*

Hewitt's Creek flowing through agricultural lands.

Lastly, the primary source of phosphorus in the Hewitt's Creek subwatershed, under existing conditions, is derived from crop land (37%). Under the approved growth scenario, there is a projected increase in total phosphorus loads of 35.5% 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 7% through the implementation of agricultural BMPs. Taken together, this suggests that with agricultural BMP implementation, under the committed growth scenario, phosphorus loading will still increase by 26% compared to the current estimated load if all committed growth plans are implemented. Under existing conditions, the Hewitt's Creek subwatershed is the lowest contributor of total phosphorus to Lake Simcoe (Figure 3-9). Under the committed growth scenario, while still seeing a small increase in total phosphorus, it is expected to still be the lowest contributor of total phosphorus (Figure 3-10) (Berger, 2010).

Table 3-9: Phosphorus loads by source for the Hewitt's Creek subwatershed associated with agriculture BMP scenarios (Berger, 2010).

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	6	3	-3	2	-1	-33%
Crop Land	140	121	-19	87	-34	-28%
Turf-Sod	0	0	0	0	0	0
Tile drainage	34	31	-3	31	0	0
Low intensity development	1	1	0	1	0	0
High intensity development	94	260	166	260	0	0
Septics	0	0	0	0	0	0
Polder	0	0	0	0	0	0
Quarry	0	0	0	0	0	0
Unpaved road	1	1	0	1	0	0
Transition	8	5	-3	5	0	0
Forest	23	19	-4	19	0	0
Wetland	0	0	0	0	0	0
Stream bank	6	7	1	6	-1	-14%

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)
Groundwater (shallow subsurface flow)	64	64	0	64	0	0
Point sources	0	0	0	0	0	0
TOTAL	**377**	**511**	**134**	**475**	**-36**	**-7%**

▨ *- 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.*

Another way to look at the phosphorus loading of each subwatershed is the amount per year per hectare. Figure 3-11 illustrates this, showing that while the total phosphorus loading to Lake Simcoe from the Barrie Creeks and East Holland River subwatersheds are roughly equal (Figure 3-9), Barrie Creeks contributes almost seven times more per hectare. Barrie Creeks is actually the highest contributor per hectare, almost three times Oro Creeks North which is the second highest contributor per hectare in the Lake Simcoe watershed.

Although Hewitt's Creek has the lowest percent total phosphorus loading to the Lake (Figure 3-9), it falls in the middle of Figure 3-11, contributing more phosphorus per year per hectare than eight of the other subwatersheds. Lovers Creek is ranked 6th lowest per hectare despite being 3rd lowest in total phosphorus loads per year.

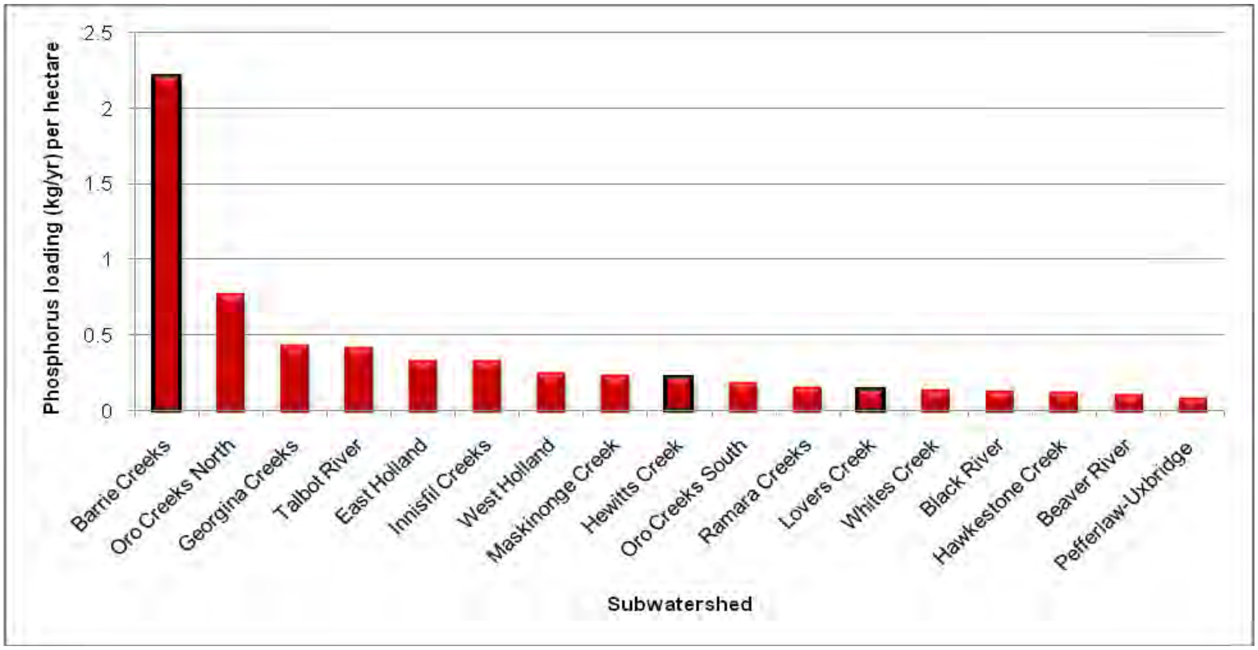

Figure 3-11: Phosphorus loading (kg/yr) per hectare under current conditions for each Lake Simcoe subwatershed (data: Berger, 2010).

Additionally, the subwatersheds can be split up further into catchments, each named by the tributaries they contain. The Barrie Creeks subwatershed has three catchments, with areas ranging from 426.5 ha (Barrie Creeks 1) to 2006.1 ha (Bunkers/ Dyments/ Sophia/ Kidds Creek). As there is only one tributary in the Lovers Creek and Hewitt’s Creek subwatersheds, they have only one catchment each (same area as the subwatershed).

As already mentioned, an overall potential reduction of 0%, 5.2%, and 7% can be achieved through the implementation of agricultural BMPs for the Barrie Creeks, Lovers Creek, and Hewitt’s Creek subwatersheds, respectively. 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 priority areas for phosphorus reduction. Figure 3-12, Figure 3-14 and Figure 3-16 illustrate the total phosphorus loads per catchment, based on the agricultural BMP scenario, while Figure 3-13, Figure 3-15, and Figure 3-17 illustrate the target total phosphorus loads for each catchment. The difference between the two figures for the Barrie Creeks, Lovers Creek, and Hewitt’s Creek subwatersheds is a further 67.1%, 70.9%, and 72.7% reduction, respectively, 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 3-10 lists each of the 11 catchments based on this ranking system.

Table 3-10: Classification of catchments in prioritization tiers (Berger, 2010).

Subwatersheds	Catchments*			
	Tier 1 (highest priority)	Tier 2	Tier 3	Tier 4 (lowest priority)
Barrie Creeks Subwatershed		Bunkers/ Dyments/ Sophia/ Kidds Creek	Barrie Creeks 1	
		Hotchkiss/ Whisky Creek		
Lovers Creek		Lovers Creek		
Hewitt’s Creek		Hewitt’s Creek		

** Catchments are illustrated in following figures*

Figure 3-12: **Barrie Creeks subwatershed agricultural BMP scenario total phosphorus loads (Berger, 2010).**

Figure 3-13: Barrie Creeks subwatershed target total phosphorus loads (Berger, 2010).

Figure 3-14: Lovers Creek subwatershed agricultural BMP scenario total phosphorus loads (Berger, 2010).

Figure 3-15: Lovers Creek subwatershed target total phosphorus loads (Berger, 2010).

Figure 3-16: Hewitt's Creek subwatershed agricultural BMP scenario total phosphorus loads (Berger, 2010).

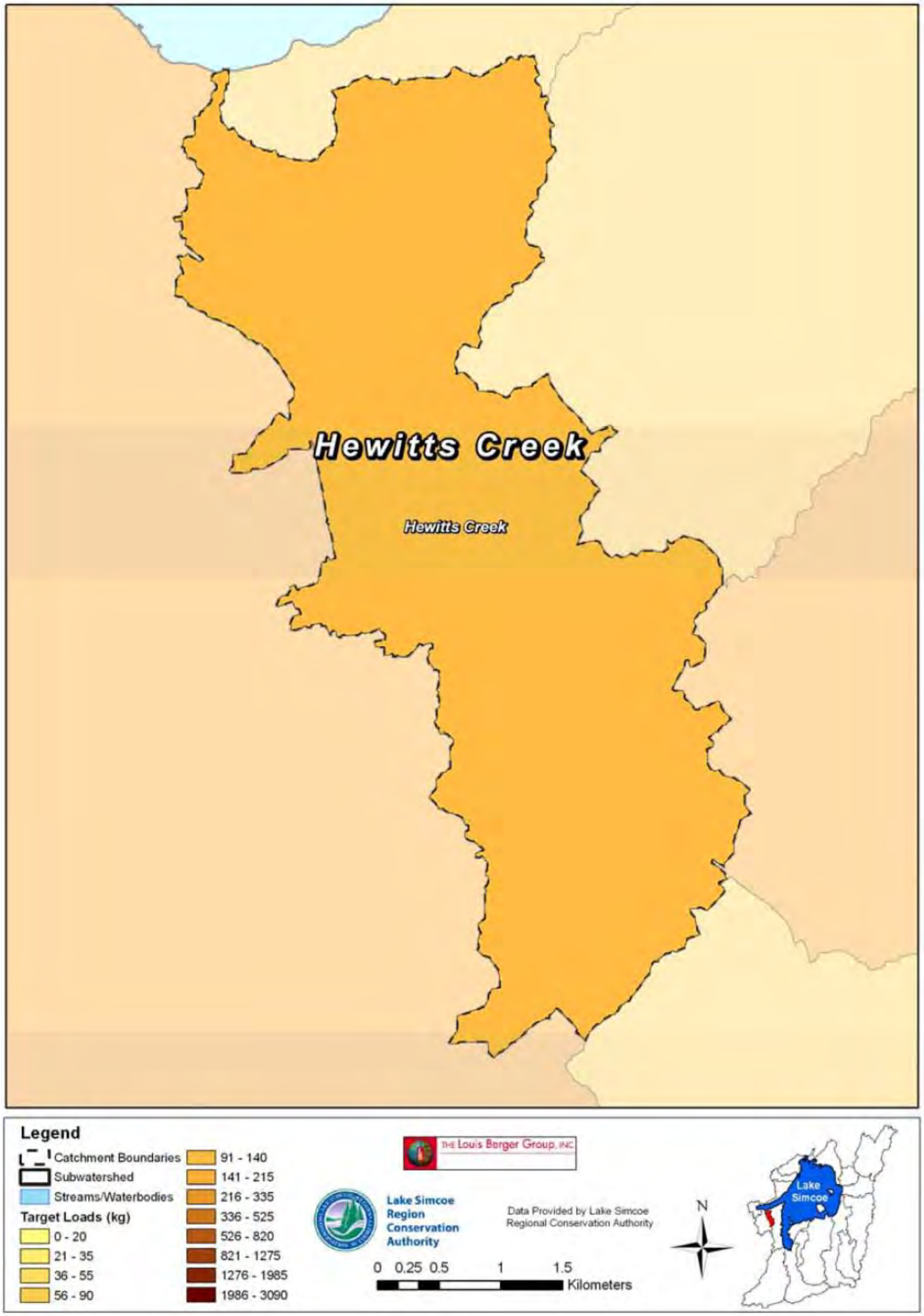

Figure 3-17: Hewitt's Creek subwatershed target total phosphorus loads (Berger, 2010).

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).

Chloride loads have been modelled for Lovers Creek, using the data from water quality samples combined with flow data, as well as a few other tributaries for comparison. Lovers Creek, as shown in green in Figure 3-18, had increasing loads from 2001-2006, after which there is a decrease the following year (chloride loads for 2007-2010 are currently being analyzed and will be included in updated versions of this report). The other three subwatersheds also saw a decrease in chloride loads during the 2006-2007 sampling period. Given that the urban area of the subwatershed is anticipated to expand in the coming years, it can be expected that these loads will also continue to increase unless new practices are instituted to reduce them.

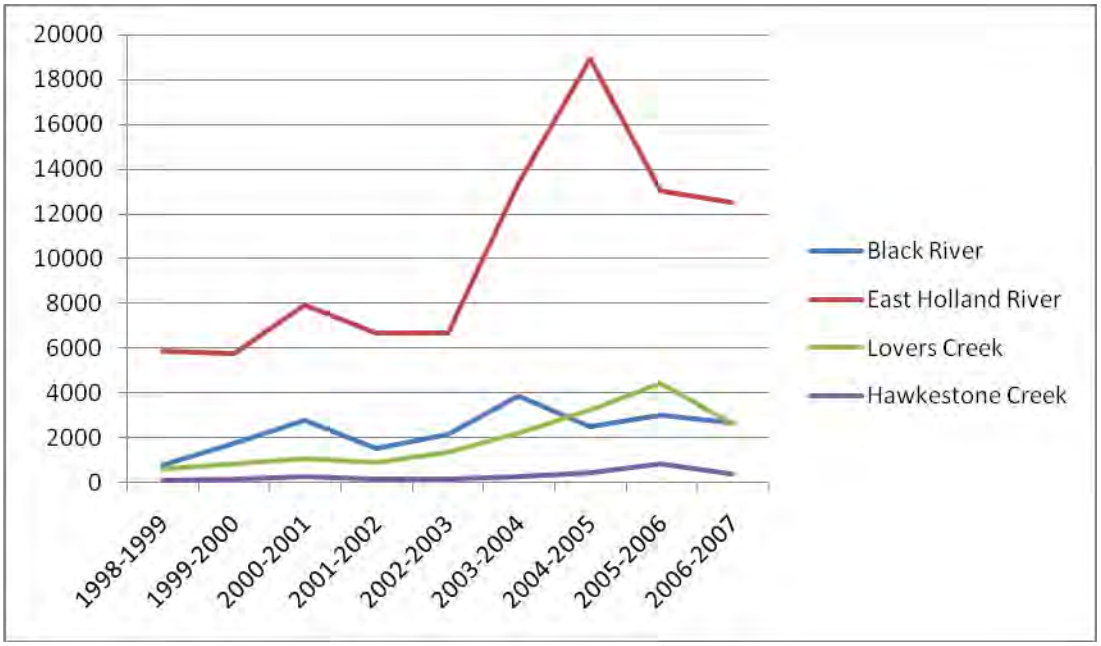

Figure 3-18: Modelled chloride loads for several Lake Simcoe subwatersheds (tonnes/year) (1998-2007)

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 particles 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 Barrie Creeks, Lovers Creek and Hewitt's Creek subwatersheds:

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 these subwatersheds, 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 these subwatersheds, 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 allow 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 subwatershed.

The LSRCA initiated sampling for pesticides, hydrocarbons, and heavy metals in the Barrie Creeks (Hotchkiss Creek) and Lovers Creek subwatersheds in 2004 with the Toxic Pollutant Screening Program. Both water and sediment were collected at Hotchkiss Creek in which guideline exceedances of some Polycyclic Aromatic Hydrocarbon compounds were recorded in both media. Pesticides were not detected in Hotchkiss Creek samples while hydrocarbons (oil and gas) and heavy metals were detected only in the sediment sample but did not exceed guidelines. In the Lovers Creek water sample none of the pollutants analyzed for were detected.

Golf course within the Lovers Creek subwatershed.

3.3.2.6. Metals

Metals are found almost everywhere and are persistent within the environment. While some are naturally occurring, 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 Cook's 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 Bay, 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 deposit 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. 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 Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds, urban land use makes up 63%, 21%, and 18% of total land use, respectively. 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, 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 Lovers and Hewitt's Creeks subwatersheds are above the 10% guideline, but are below the upper limit threshold with approximately 29% and 26% impervious surface, respectively. As these subwatersheds haven'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 Barrie Creeks subwatershed however, is substantially above the upper limit threshold, with 75% impervious surface.

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.
>
> **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 Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds include the City of Barrie and the communities of Alcona, Stroud, Gilford, and Lefroy in the Town of Innisfil. In the City of Barrie approximately 62% of the stormwater is uncontrolled, 22% has quantity control only, and the remaining 16% is controlled by Level 1, 2, 3, or 4 stormwater facilities. In

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

the urban areas in the Town of Innisfil, 67% of the stormwater is uncontrolled, while 14% has quantity control only and the remaining 19% is controlled by Level 1, 2, 3, or 4 stormwater facilities (Table 3-12, Figure 3-22).

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 56, and 46 retrofit opportunities in the City of Barrie and Town of Innisfil, respectively (this number may differ slightly from the report as these totals include different scenarios). The number of retrofit opportunities per subwatershed and the percentage of phosphorus that will be prevented from entering the watercourses, and ultimately the lake, are presented in Table 3-11 and illustrated in Figure 3-23.

Table 3-11: Retrofit opportunities by subwatershed.

Subwatershed	City of Barrie	Town of Innisfil*	Percent (%) difference in phosphorus loading (kg/yr)
Barrie Creeks	41	0	30%
Lovers Creek	14	13	53%
Hewitt's Creek	1	2	45%

**The remaining 31 retrofit opportunities in the Town of Innisfil are located in the Innisfil Creeks subwatershed.*

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 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 two ponds surveyed in the Barrie Creeks subwatershed, one was originally designed to meet Level 1 criteria and one to meet Level 2 criteria. When the ponds were surveyed in 2010, one was still operating at Level 1, but the other had dropped down to Level 3 efficiency (Figure 3-19).

Stormwater Pond – BAR-SW42

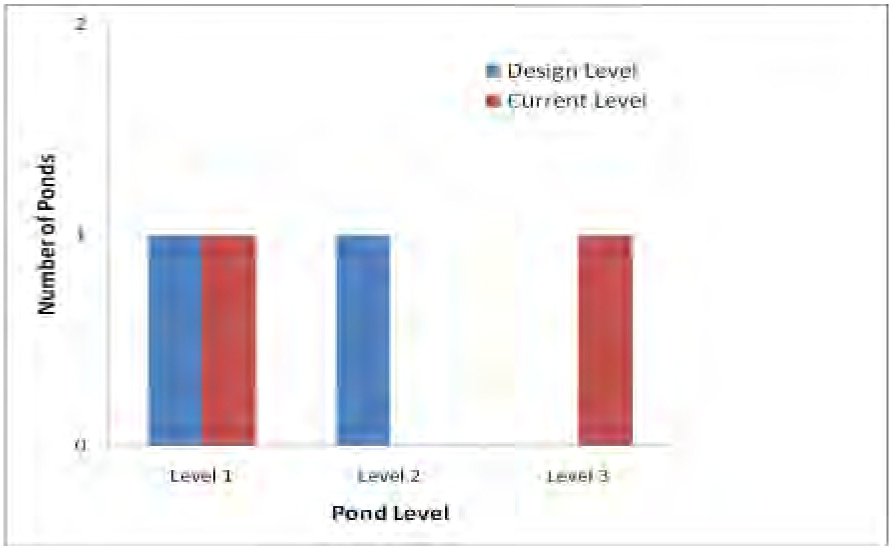


Figure 3-19: Barrie Creeks - pond design efficiency level vs. 2010 surveyed efficiency level.

Stormwater Pond – BAR-SE86

In the Lovers Creek subwatershed, 10 ponds were originally designed to meet Level 1 criteria and one to meet Level 2 criteria. Based on the 2010 survey, only six are now operating at a Level 1, four at a Level 2 and one at a Level 3 (Figure 3-20).

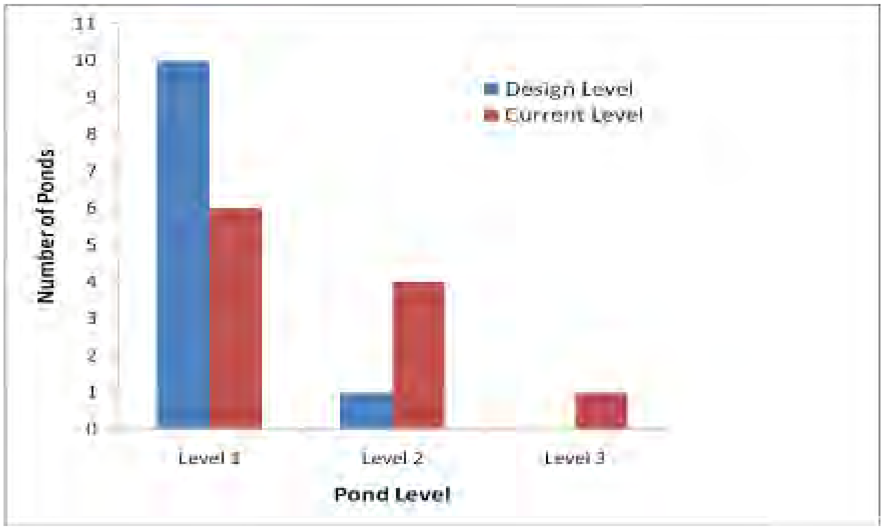


Figure 3-20: Lovers Creek - pond design efficiency level vs. 2010 surveyed efficiency level.

Lastly, for the Hewitt's Creek subwatershed there are five ponds that were originally designed to meet Level 1 criteria. When surveyed in 2010, only one was still a operating as a Level 1, while the other four were operating at Level 2 (3) and Level 3 (1) efficiency (Figure 3-21).

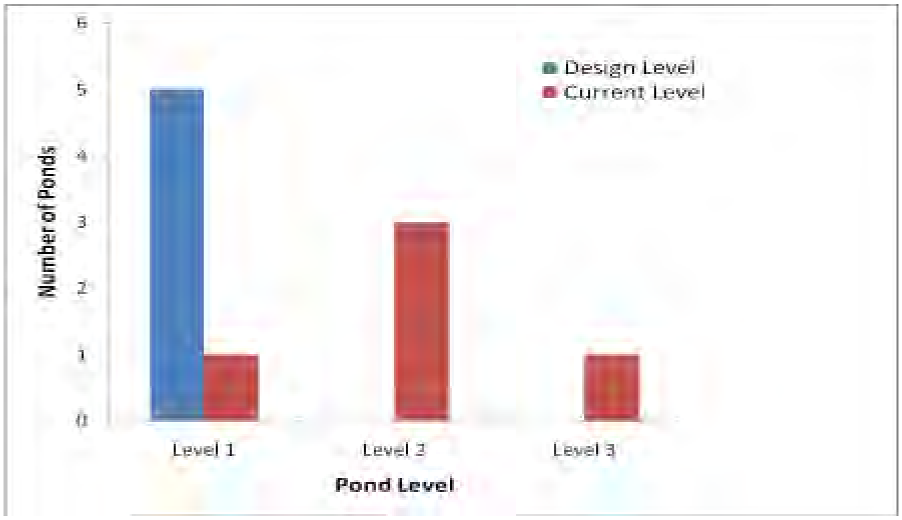


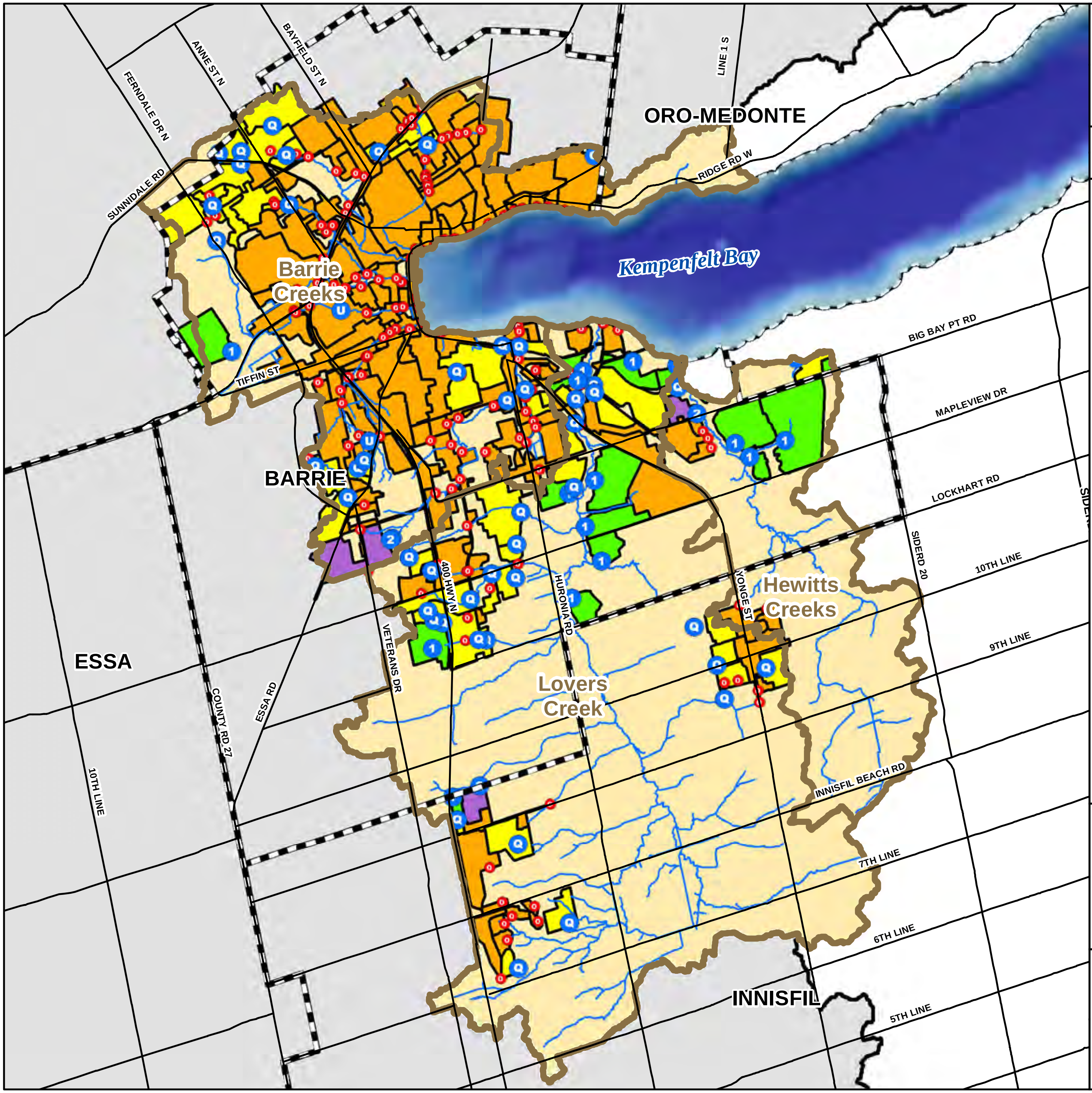
Figure 3-21: Hewitt's Creek - pond design efficiency level vs. 2010 surveyed efficiency level.

Stormwater pond – BAR-SE2

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

Table 3-12: Controlled vs. uncontrolled stormwater catchments in the City of Barrie and Town of Innisfil.

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)
City of Barrie	198	3957.4	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
Town of Innisfil	181	2116.9	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
Totals	**379**	**6074.3**	**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 Barrie Creeks, Lovers Creek and Hewitt's Creek subwatersheds

Figure 3-22

Legend

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

Lake Simcoe Region conservation authority

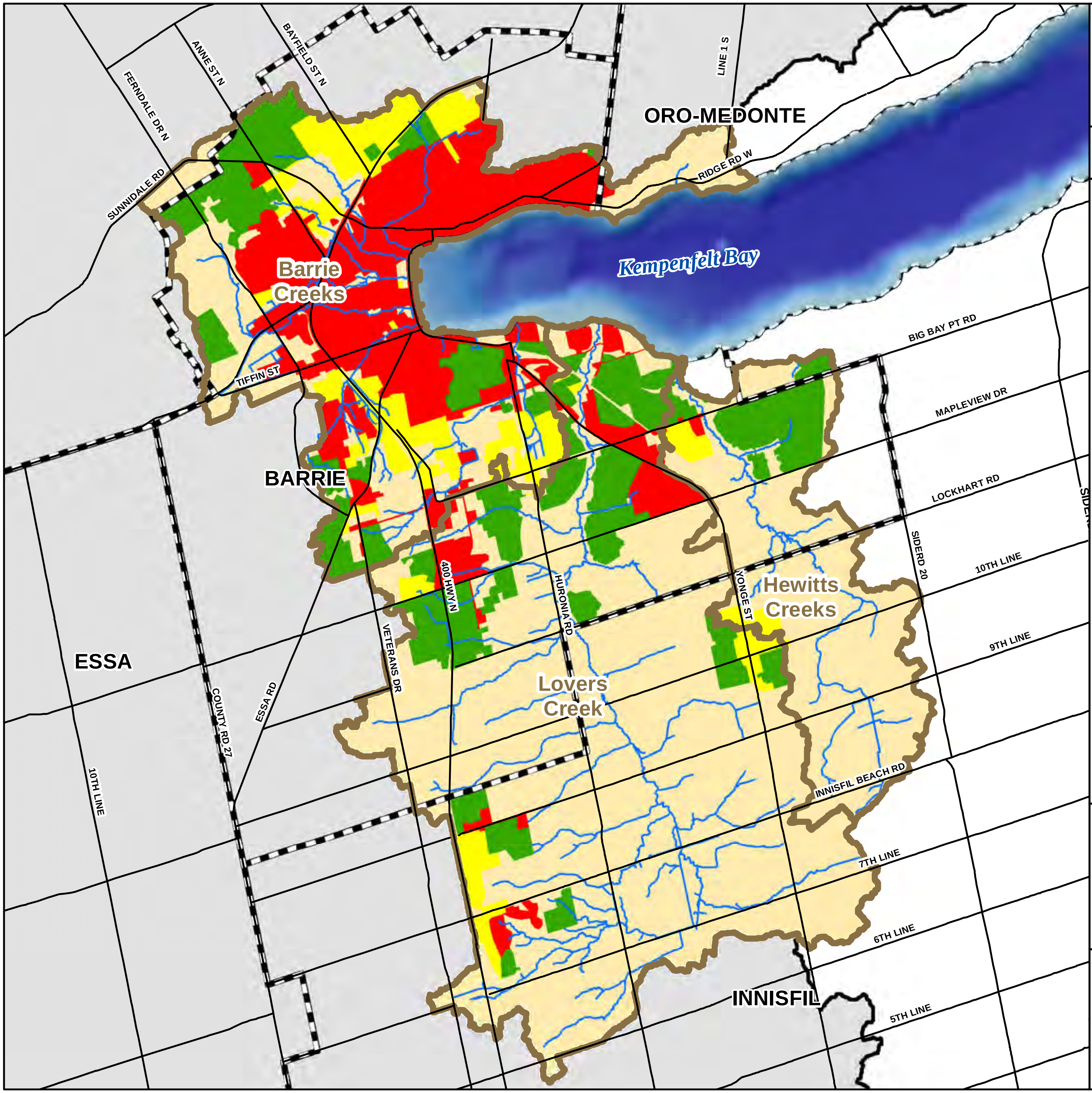
0 0.5 1 2 3 4 Kilometres

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 in the Barrie Creeks, Lovers Creek and Hewitt's Creek subwatersheds

Figure 3-23



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 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.

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 on which to undertake recreational activities.

3.3.2.11. Climate Change

While it is 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 3-24 to Figure 3-26 show two different climate scenarios (based on different models) and how they will impact the total phosphorus loads in the coming years. The climate change scenario outputs initially reported 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. Figure 3-24 illustrates the current 'baseline' value for Barrie Creeks. Both scenarios show phosphorus load increases, with most occurring after 2041.

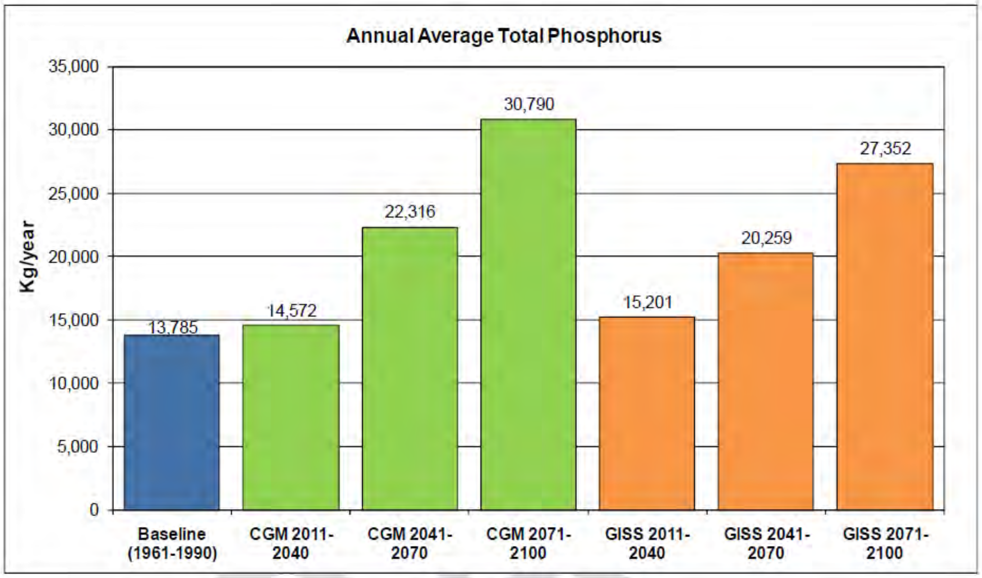


Figure 3-24: Base case land use applied to climate change scenarios for total phosphorus loads in the Barrie Creeks subwatershed (Berger, 2011).

For the Lovers Creek subwatershed, both models show a decrease from 'baseline' to 2070, with a marked increase after that time (Figure 3-25)

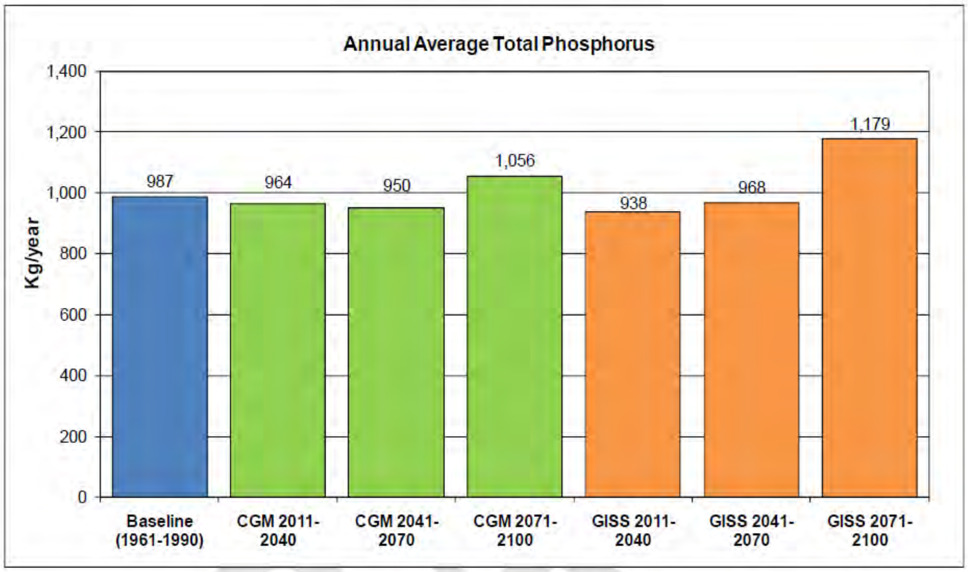


Figure 3-25: Base case land use applied to climate change scenarios for total phosphorus loads in the Lovers Creek subwatershed (Berger, 2011).

Lastly for the Hewitt's Creek subwatershed (Figure 3-26), both scenarios show slight increases, which steepens after 2070.

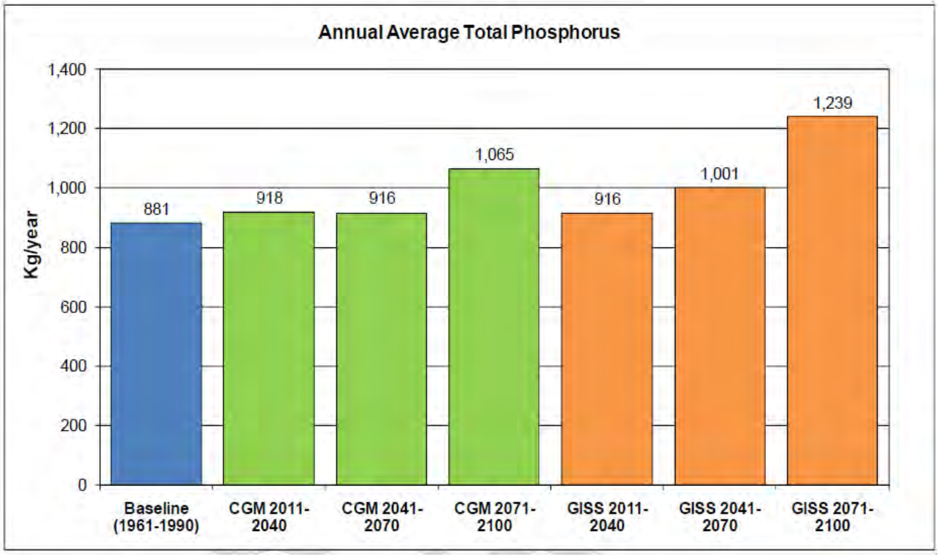


Figure 3-26: Base case land use applied to climate change scenarios for total phosphorus loads in the Hewitt's Creek subwatershed (Berger, 2011).

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**, respectively.

***Key points – Factors Impacting Water Quality - Stressors*:**

- Groundwater within the Barrie Well Supply (located in Barrie Creeks) is being impacted by elevated levels of chloride and sodium at a number of wells
- Past activities in the City of Barrie have also created contaminations in the groundwater related to TCE, petrohydrocarbons, BTEX, PHCs, and vinyl chloride.
- No contaminants were identified as Drinking Water Issues or Conditions in the Innisfil Heights and Stroud Well Supplies.
- The primary source of total phosphorus in the Barrie Creeks subwatershed is high intensity development land uses (58%). Under the approved growth scenario in the ACS modelling, there is a projected increase in total phosphorus loads of 6.5% if agricultural BMPs were not implemented.
- The primary source of total phosphorus in the Lovers Creek subwatershed is high intensity development (42%). Under the approved growth scenario in the ACS modelling, there is a projected increase in total phosphorus loads of 43% if agricultural BMPs are not implemented.
- The primary source of total phosphorus in the Hewitt’s Creek subwatershed is crop land (37%). Under the approved growth scenario in the ACS modelling, there is a projected increase in total phosphorus loads of 35.5% if agricultural BMPs are not implemented.
- When comparing the phosphorus loads (kg/yr) per hectare of the subwatersheds in the Lake Simcoe watershed, Barrie Creeks is the largest contributor per hectare, almost three times greater than the second highest.
- While Hewitt’s Creek has the lowest percent total phosphorus loading to Lake Simcoe it contributes more phosphorus per year per hectare than eight of the other subwatersheds. Lovers Creek is ranked 6th lowest per hectare despite being 3rd lowest in total phosphorus loads per year.
- Most of the chloride in the subwatersheds comes from the use of road salt, with the estimated annual loads increasing in recent years with the growing urban areas, particularly in Barrie Creeks. It is expected that this load 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 that, based on climate change scenarios, will increase phosphorus in the Barrie Creeks and Hewitt’s Creek subwatersheds.

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 Barrie Creeks, Lovers Creeks, and Hewitt's Creek subwatersheds, as outlined in the following sections.

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 3-13 we categorize nine 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 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 **Chapter 1 - Introduction**. Readers interested in the details of these regulations, policies and plans are directed to read the original documents.

Table 3-13: 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, working 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 3-13, 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 3-13, 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 these subwatersheds, including four septic system upgrades and four well decommissionings in the Barrie Creeks subwatershed, three septic system upgrades, four well decommissionings, and two storm water pond retrofits in the Lovers Creek subwatershed, and six septic system upgrades and one well decommissioning in the Hewitt's Creek subwatershed.

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 to improve water quality have been completed in the City of Barrie, while in the Town of Innisfil, approximately 35 have been implemented.

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 sites in these three subwatersheds 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 Barrie, Lovers, and Hewitt's 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 Barrie, Lovers, and Hewitt's Creeks subwatersheds, 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 dependent on baseflow contributions for the ecological requirements of those systems, within the Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds.

> **Recommendation 3-1 -** That the LSRCA develop a discussion paper for MOE that will: (1) describe the range of LID technologies that could potentially be used to mitigate the impacts of development on surface and groundwater quality and quantity; (2) identify the barriers associated with the uptake of LID technology and, (3) with the support of MOE, identify opportunities for overcoming these barriers.
>
> **Recommendation 3-2 -** That LSRCA develop an action plan to address barriers associated with the implementation of LIDs.

3.5.2 Surface Water

3.5.2.1. Urban - improving stormwater

Within the City of Barrie (excluding the recently annexed lands) it has been calculated that 62% of the urban area does not have any stormwater control, 22% has quantity control only, and the remaining 16% 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 levels 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, particularly in areas lacking adequate stormwater controls, and lacking conventional retrofit opportunities, 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, be encouraged to support, through financial or other measures, municipalities and/or the LSRCA to maintain, construct, and /or retrofit stormwater facilities as identified by the LSRCA Stormwater Rehabilitation program.

Recommendation 3-5 - Given the high rate of phosphorus loading per hectare in the Barrie Creeks subwatershed, that the MNR, MOE, and LSRCA make the Barrie Creeks subwatershed a priority for stewardship projects intended to reduce phosphorus loading. Further, that the MOE, LSRCA, and City of Barrie make stormwater retrofits and the use of LID solutions in the Barrie Creeks subwatershed a priority, due to their significant potential to reduce phosphorus loading.

Recommendation 3-6 - 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.

Recommendation 3-8 - That Official Plans be amended to contain policies that would help minimize impervious surface cover in Barrie, Lovers and Hewitt's Creeks subwatersheds 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 these subwatersheds 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 review and, where necessary, revise current monitoring, enforcement, and reporting on site alteration and tree cutting by: 1) undertaking a review of the current programs and actions, 2) encouraging the allocation of adequate resources for the improvements, and 3) monitoring and reporting on results.

3.5.2.3. Urban – reducing salt (chloride)

Chloride concentrations with Lovers Creek have been increasing since monitoring was initiated in the 1970s, however the rate of increase has escalated in the last 15 years to the point where levels regularly exceed the guidelines. While there is insufficient long-term trend data for other creeks, monitoring at Hotchkiss Creek since 2008 shows that chloride rarely (7% of the samples collected) meets the standards, and often (10% of the time) exceeds Canadian Water Quality Guidelines for acute toxicity. This analysis highlights that despite the municipalities having Salt Management Plans, elevated chloride levels are already an issue in many of the tributaries, and is likely impacting the health of aquatic communities.

> **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 the LSRCA, in collaboration with subwatershed municipalities, develop and deliver a salt education program, to increase awareness and understanding of the importance of salt management by snow removal contractors, property managers, and the general public.
>
> **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 27% and 34% of phosphorus loads can be attributed to agriculture in the Hewitt's and Lovers Creek subwatersheds, respectively. Recent water quality monitoring (2008 to 2010) within these two creeks has shown that phosphorus concentrations regularly exceed the provincial standards. Considering the current concentrations of phosphorus in Hewitt's and Lovers Creek, and the high proportion that can be attributed to agricultural sources, actions leading to reduction in agricultural phosphorus loads to these two creeks is 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) provide 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 Natural Heritage**. 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 species 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 Natural Heritage**. 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 quality monitoring station within Lovers and Hewitt's Creek, and one station within Hotchkiss Creek representing the many smaller creeks within the Barrie 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 Hewitt's Creek and Lovers Creek
- Monitoring additional parameters that 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 Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds have altered the hydrologic cycle (Figure 4-1), including changes to the surface flow volumes, annual flow patterns, and the risk of flooding.

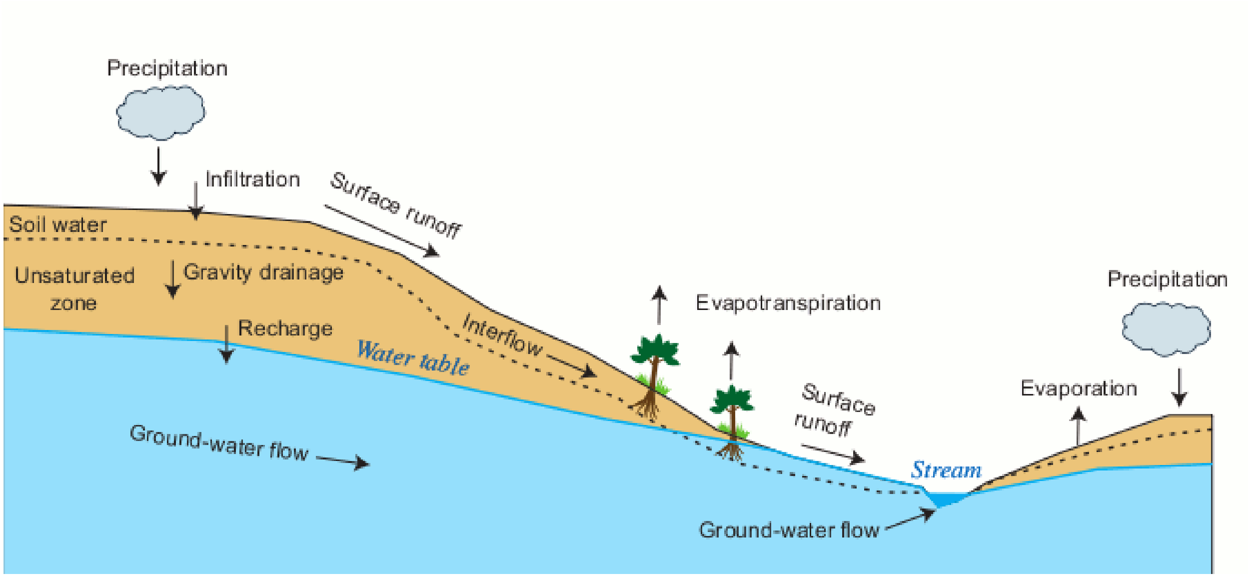


Figure 4-1: Hydrologic cycle (USGS, 2008).

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 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 subwatersheds. 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 Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds include the urban, rural, natural cover (e.g. wetlands, woodlands, and grasslands), golf courses, and aggregate extraction (Figures 2-5 to 2-7 in **Chapter 2 – Study Area and Physical Setting**). 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 ground water table allows for a constant flow of surface water in these areas.

As the population continues to grow, urbanized areas are expanding, resulting in widespread areas of impervious surfaces. These impervious surfaces lead to a decrease in the time 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 subwatersheds exist under natural conditions making them less vulnerable to extreme changes in climatic events; for example the time it takes to reach peak 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 Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds both surface and groundwater are used for a variety of purposes, including municipal water supply, agricultural and industrial 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 as part of the Source Water Protection initiatives required under the Clean Water Act (discussed in Section 4.3).

4.1.2 Previous Studies

Information from several groundwater and water budget studies were used to assess the hydrogeology of the Barrie Creeks, Lovers Creek and Hewitt's Creek subwatersheds. 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 (SSGP), 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 SSGP (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 Barrie Area. These include a groundwater (FEFLOW - Finite Element subsurface FLOW system) and surface water model (PRMS - Precipitation Recharge Modelling System) used in the Tier 2 Water Budget and Water Quantity Stress Assessment that includes the Barrie Creeks, Lovers Creek and Hewitt's Creek subwatersheds. This is a regional model that encompasses the entire Severn Sound, Nottawasaga Valley and the western portion of the Lake Simcoe Source Protection Areas. Conversely, the groundwater modelling completed for the City of Barrie Tier 3 Water Budget and Water Quantity Risk Assessment is a local model that encompasses the Barrie Creeks, Lovers Creek and Hewitt's Creek subwatersheds. Although every effort was made to use the information from the most current Tier 3 Water Budget, the model and various aspects of the study were still underway when this document was produced and therefore information presented in the following sections are mainly the results of the Tier 2 Water Budget and Water Quantity Stress Assessment, with a combination of results from the following water budget studies:

- 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 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 on 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, operate and maintain 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 Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds 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 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).

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 subwatersheds contain 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. These aquifers are commonly unconfined, however locally some are confined by overlying till sheets of finer-grained bedding such as the Borden-Barrie aquifer that supplies most of the municipal wells. Within the subwatersheds, 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. Those confined to deep tunnel-channel valley aquifers are usually overlain by fine-grained deposits (i.e., the Borden-Barrie aquifer) and are particularly well suited for water supply. Till plains in the subwatersheds represent localized and regional aquitards that act to slow the rate of vertical movement of groundwater (and potential contaminants) to underlying aquifers (AquaResoure *et al*., 2011).

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 subwatersheds, with A1 mainly constrained to upland areas. A deep, highly-transmissive aquifer is found under the central portion of the City of Barrie within the tunnel-channel deposits associated with the lowland area. This aquifer extends in an east-west direction from Kempenfelt Bay west toward the Angus-Borden area (referred to as the Barrie-Borden aquifer). The fining-upwards sequence of this deposit generally results in this aquifer being confined from shallow aquifers by overlying silt and clay aquitard deposits. This has historically resulted in flowing artesian conditions, particularly along the banks of Kempenfelt Bay. The aquifer system and hydrostratigraphy within the subwatersheds 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 subwatersheds (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.

Initial hydraulic conductivity estimates were based on a number of aquifer tests completed for most of the municipal wells in Barrie. 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
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 shallow and deep groundwater equipotentials within the subwatersheds; recognizing that groundwater flow is perpendicular to equipotentials (at least within the same aquifer); they can be used to approximate groundwater flow directions. These figures were derived from the South Simcoe Groundwater Study and are based on observed water levels in observation and pumping wells (AquaResource *et al*., 2010).

Based on the contours in Figure 4-2 and Figure 4-3, water levels throughout the subwatershed are shown to mimic topography. Groundwater flow is predicted to converge on Kempenfelt Bay from a flow divide that generally follows the model boundary outline toward the west and southern edge of the City of Barrie and the City boundary to the north. Groundwater recharging west of this divide generally flows toward the Nottawasaga River basin. Groundwater gradients within the shallow groundwater regime typically range from 4 m/km to 6 m/km; however, gradients of up to 19 m/km have been measured on the flanks of the Oro Moraine (Golder, 2004).

It is hypothesized that shallow groundwater flow from the upland areas north and south of the Bear Creek Wetland sustain this wetland, year-round. A review of available baseflow monitoring from the Bear Creek Wetland illustrates a seasonal fluctuation in baseflow that strongly corresponds with climatic changes throughout the 2007-2008 period (I.W.S S., 2009). A review of the stratigraphic surfaces across the valley also supports this hypothesis as Aquifer A1 is delineated to thin dramatically from the north and south uplands to the lowland area where the wetland is located. This shallow flow system is also expected to be sustaining many of the cold water creeks located within the City of Barrie (e.g., Whiskey, Hotchkiss, and Kidds Creeks).

A comparison of Figure 4-2 and Figure 4-3 can be used to identify the vertical hydraulic gradients and potential flow directions within the subwatershed. This comparison generally shows the direction of vertical hydraulic gradients to be downward within the majority of the subwatershed area, and particularly throughout the upland areas. However, upward gradients are also evident, particularly beneath the City Centre, along the shore of Kempenfelt Bay. Wells located along this shoreline (e.g., Wells 1 and 2) historically flowed when drilled and are currently returning to this state now that local pumping has ceased. Similarly, upward hydraulic head differences are mapped to occur along the western boundary of the model area beneath the Minesing Wetland (AquaResource *et al*., 2010).

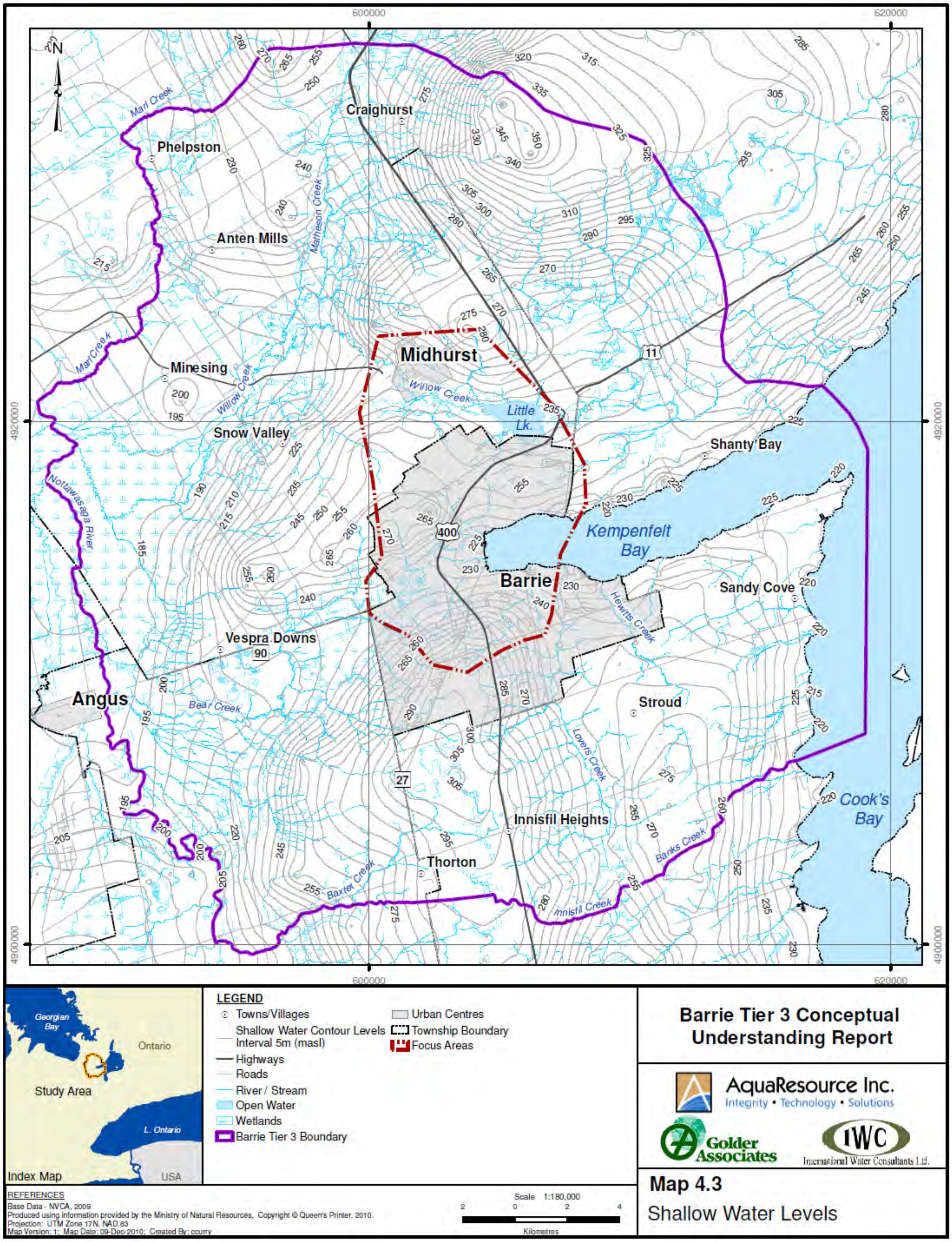


Figure 4-2: Shallow water levels (AquaResource *et al*, 2010).

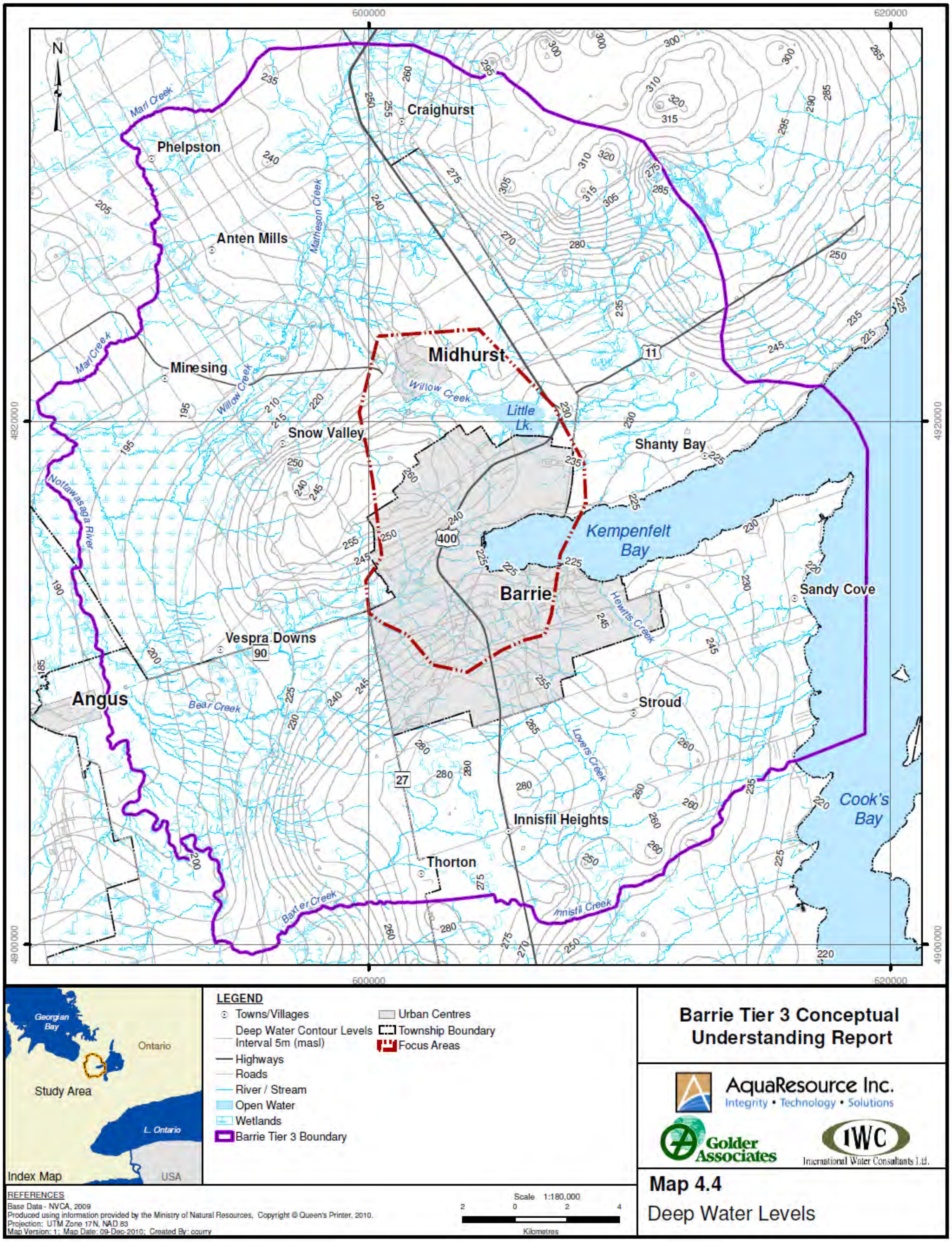


Figure 4-3: **Deep water levels (AquaResource *et al*., 2010).**

4.2.4 Streamflow

The Barrie Tier 3 Model and related data compilation covers an area well beyond the boundaries of the Barrie, Lovers, and Hewitt's Creeks subwatersheds. Figure 4-4 shows the locations of the major streams in the model area as defined by land surface topography. The figure also shows the location of the stream gauges monitored by LSRCA and City of Barrie that were used in the model calibration. The Lovers Creek and Hewitt's Creek gauges are located approximately 500 m and 100 m upstream of their respective mouths. A continuous record of water elevation (stage) is monitored using a constant flow bubbler and datalogger at Lovers Creek and an area velocity sensor and datalogger at Hewitt's Creek. The continuous stage record is converted to discharge (volume per unit time) using an established stage-discharge relationship. The Lake Simcoe Region Conservation Authority (LSRCA) has operated the Lovers Creek gauge from 2002 to present and the Hewitt's Creek gauge from 2009 to present. There are three stream gauges operated by the City of Barrie that have been included in the model, Sophia Creek, Kidds Creek, and Bunkers Creek, which have been in operation since 2004.

The Lovers Creek gauge is located 100 m from the outlet of Lovers Creek and drains 60 km^2, while the Hewitt's gauge drains 17.5 km^2. There is measured streamflow data from 2001-2009. Prior to 2001, streamflow at this location was estimated based on different models the LSRCA uses to estimate ungauged drainage areas. These models consisted of a regression relationship and area prorated flow for all gauge areas (AquaResource *et al*., 2010).

Stantec consulting completed a creek flow monitoring assessment for the City of Barrie in 2009 and 2010 (Stantec, 2010). Stantec collected data from 2009 to 2010 on Sophia Creek, Kidds Creek, and Bunkers Creek. Continuous (5 min) streamflow data from March to November are available along these creeks. Data were also collected at three locations along Lovers Creek in October and November 2009 (AquaResource *et al*., 2010).

Gauge locations, period of record, and streamflow statistics for the period of record are presented in Table 4-3. The Lovers Creek daily average discharge for the 2002 to 2010 period of record is 0.712 m^3/s, (2002-2010) and the Hewitt's Creek daily average discharge for the 2010 water year (June 1, 2009 to May 31, 2010) is 0.161 m^3/s. Figure 4-5 and Figure 4-6 illustrate the temporal distribution of flow for the Lovers Creek gauge. Historically, the greatest flows were observed during the spring freshet (March-April), although in recent years large temperature related events have increased in frequency during early winter, decreasing the magnitude and duration of the typical freshet.

Figure 4-7 displays monthly minimum, mean, and maximum discharges for the Lovers Creek period of record with the last three years plotted individually. This figure illustrates the recent shift in flow regime observed in the Lake Simcoe watershed where the typical March/April freshet is decreasing in magnitude and larger events, typically temperature related, are occurring during January/February.

Table 4-3: Flow statistics for gauged catchments in the model area.

Gauge ID	Gauge Name	Start Year	End Year	Catch-ment Area (km^2)	Mean Total Flow (m^3/s)	90th Low Flow (Q_{90}) (m^3/s)	Median Flow (Q_{50}) (m^3/s)
LS0101	Lovers Creek at Tollendal	2002	Present	60.0	0.712	0.154	0.440
LS0202	Hewitt's Creek at Camelot	2009	Present	17.5	0.161	0.057	0.101

*Flow statistics have been generated by LSRCA for the combined continuous record.

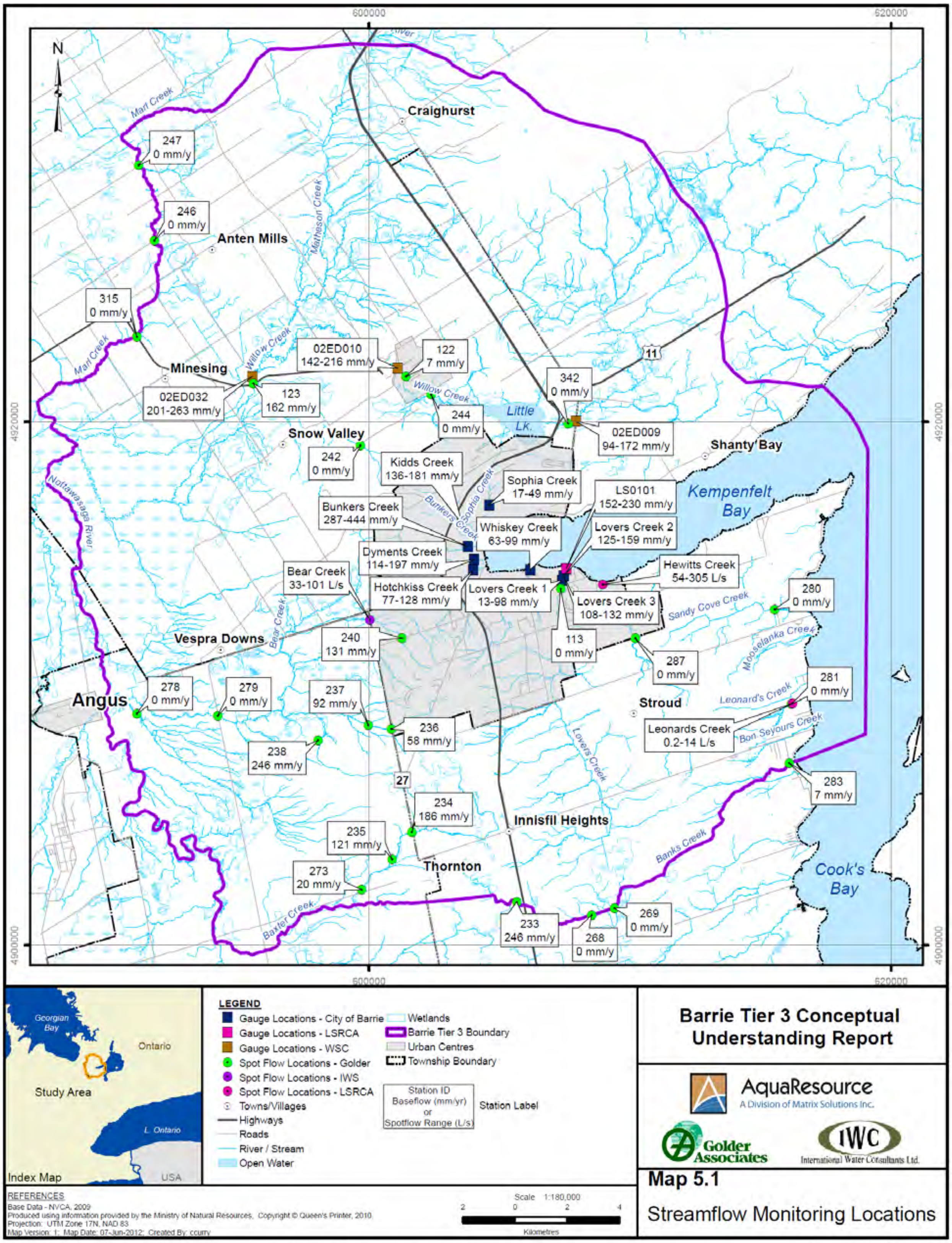


Figure 4-4: Streamflow monitoring stations (AquaResource *et al*., 2010).

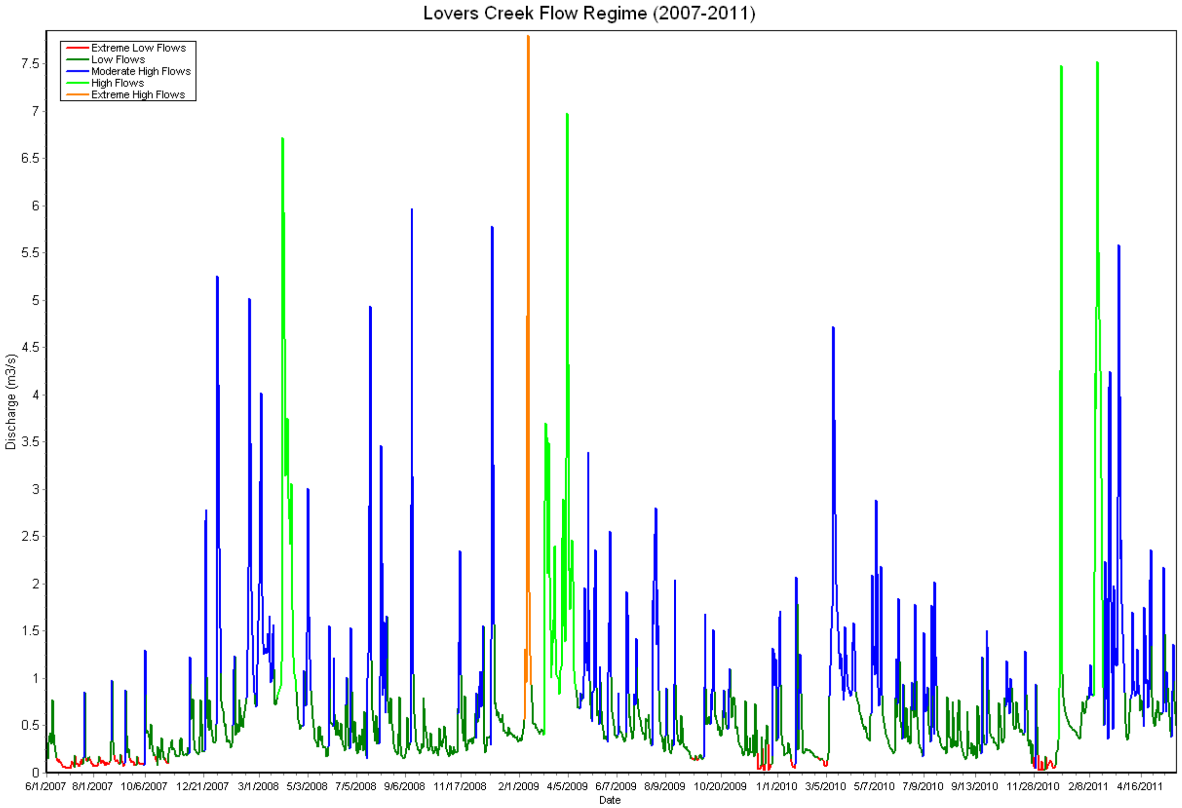


Figure 4-5: Lovers Creek flow regime, extreme low flows are flows with a return interval of 10 years, low flows are less than the 75th percentile flow, moderate flows are greater than the 75th percentile flow, high flows have a return interval of 2 years, and extreme high flows have a return period of 10 years or more.

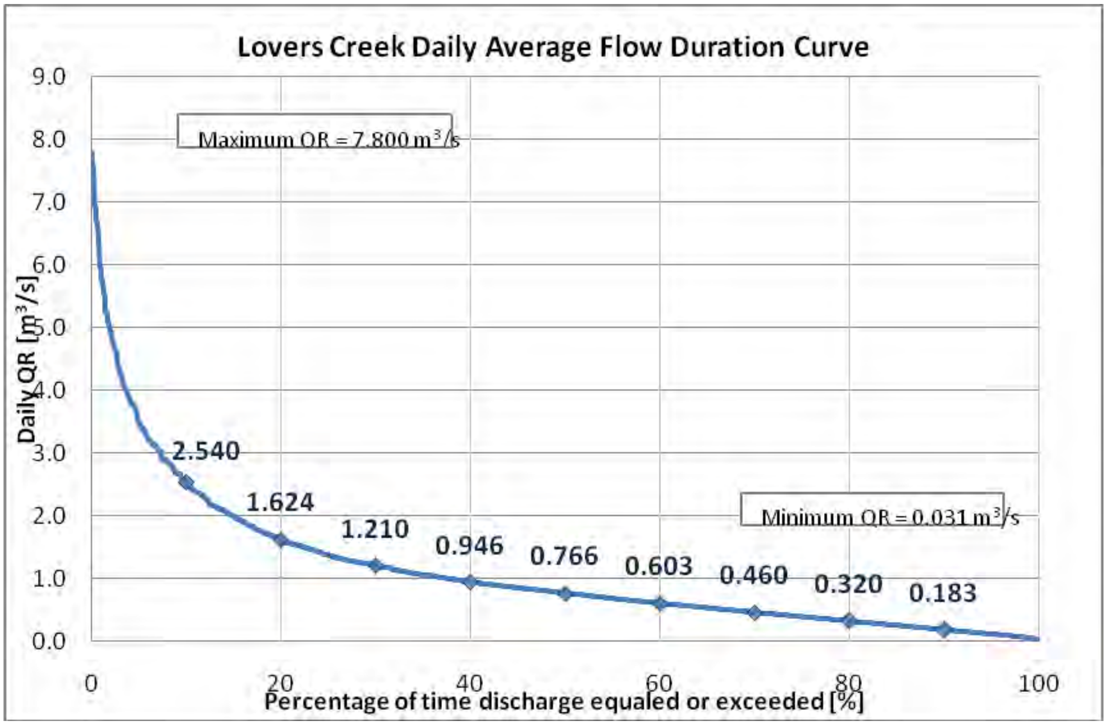


Figure 4-6: Lovers Creek daily average flow duration curve for 2009-2011 period of record.

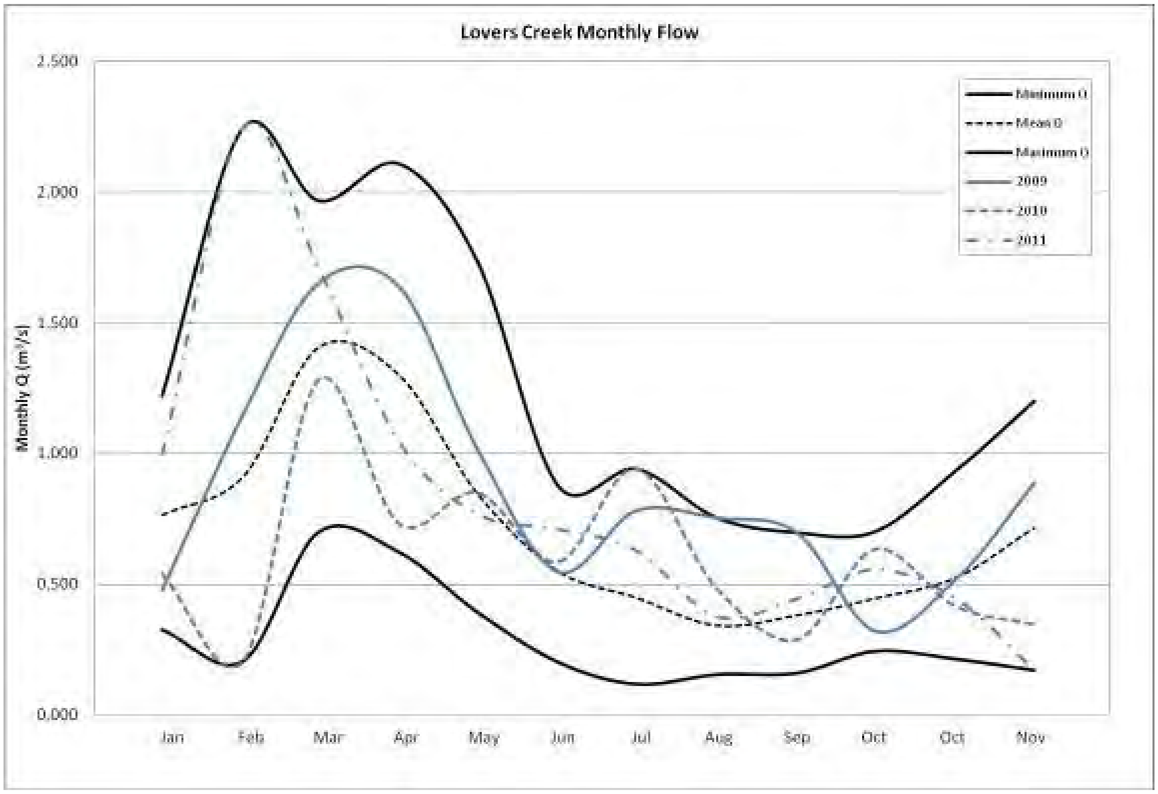


Figure 4-7: Monthly minimum, mean, and maximum discharge for the Lovers Creek gauge including the 2009 – 2010 monthly record (LSRCA, 2012).

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.

Figure 4-8 displays a hydrograph of daily discharge for the Lovers Creek and Hewitt's Creek gauges for the June 2009 to June 2010 period plotted with daily precipitation from the Shanty Bay Environment Canada meteorological station. Both systems demonstrate a rapid response to precipitation events and typically short recession to baseflow conditions, likely due to the relatively high degree of urbanization, increased slope and small size/lack of storage of the Lovers Creek and Hewitt's Creek watersheds compared to other Lake Simcoe subwatersheds.

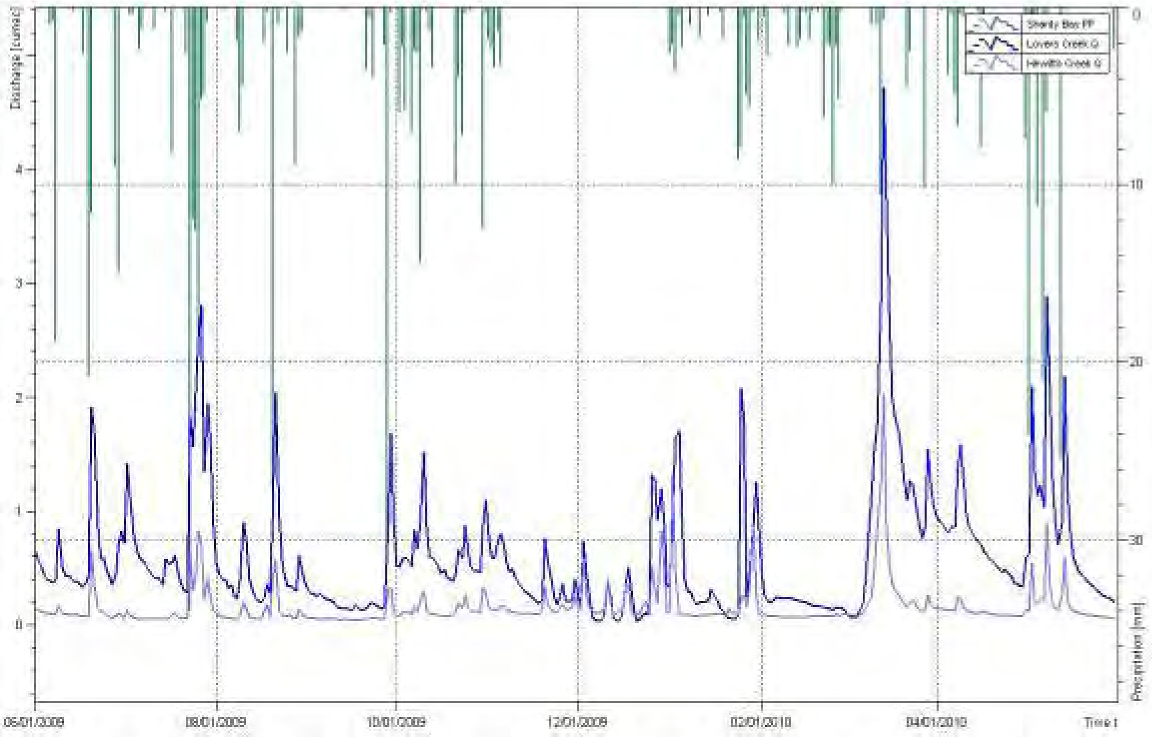


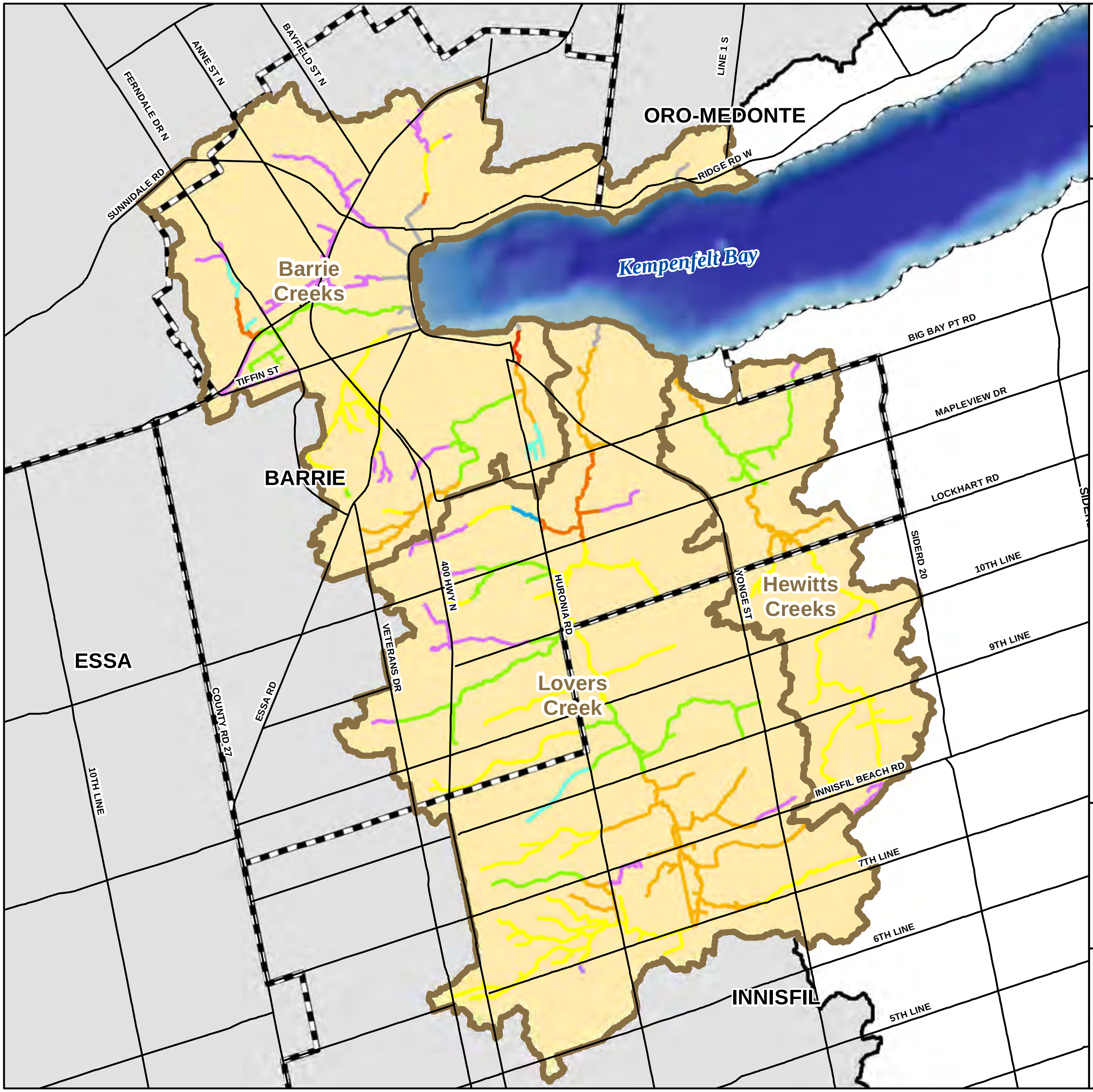
Figure 4-8: Daily average discharge for the Lovers and Hewitt's Creeks hydrometric station and daily precipitation from Environment Canada's Shanty Bay Meteorological Station (June 2009 - April 2010).

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 too few are present in the Barrie, Lovers, and Hewitt's Creeks subwatersheds to accurately describe baseflow across the entire subwatersheds. For this reason discrete baseflow measurements were conducted on the Barrie Creeks, Lovers Creek, and Hewitt's Creek in June 2005. The results for the 2005 survey conducted by the LSRCA are illustrated in the following Figure 4-9.

Discharge measures were performed 72 hours after precipitation to ensure they were representative of baseflow. For the purpose of analysis each measure was compared to the closest upstream measure to determine if the reach between the measures was gaining or losing flow. Gaining reaches indicate groundwater contribution to the stream while losing reaches could indicate water taking, groundwater infiltration, or impoundments. Although no strong spatial distribution of gaining reaches is apparent, Figure 4-9 does indicate a greater number of gaining than losing reaches within the Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds, suggesting that groundwater discharge is a substantial contributor to the aforementioned subwatersheds' flow regimes. This is supported by the baseflow index for Lovers Creek that indicates that more than 60% of the Lovers Creek flow is contributed by groundwater. Moreover, groundwater influence on these reaches is also evidenced in the thermal stability of the streams and in the coldwater fish species they support (see **Chapter 5 - Aquatic Habitat**).



Baseflow in the Barrie Creeks, Lovers Creek and Hewitt's Creek subwatersheds

Figure 4-9

Legend

— Road

▬ Municipal Boundary

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 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.

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 only a few long-term gauges within the study area and not all significant stream tributaries are monitored.

The groundwater discharge areas produced from the model are shown on Figure 4-10. 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 4-11) 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.

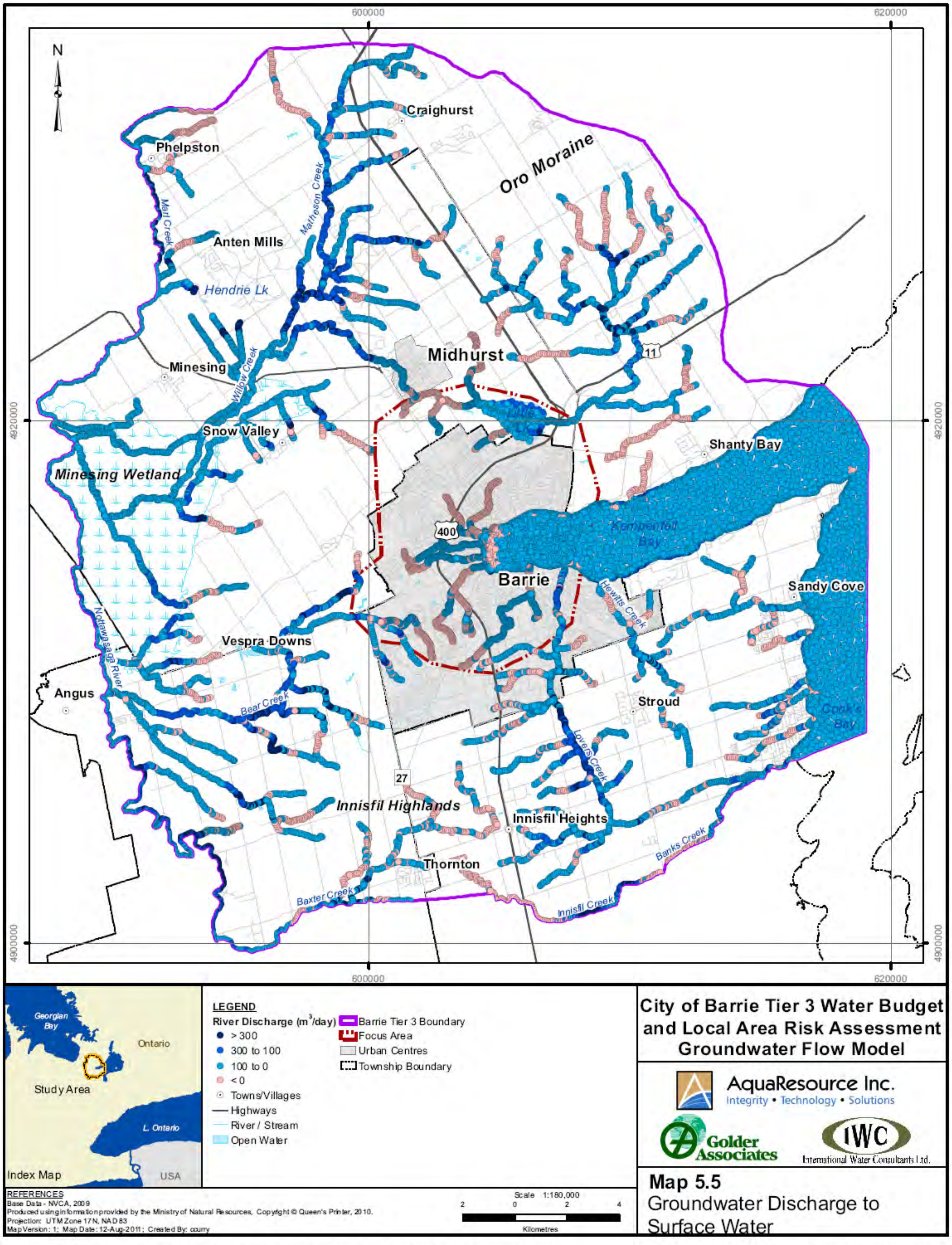


Figure 4-10: Groundwater discharge to surface water simulated from the FEFLOW model (AquaResource *et al*., 2011).

Potential discharge in the Barrie Creeks, Lovers Creek and Hewitt's Creek subwatersheds

Figure 4-11

Legend

Road

Municipal Boundary

Watercourse

Subwatershed

River Discharge (m^3/day)

- ● > 300
- ● 300 to 100
- ● 100 to 0
- ● < 0

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 help 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.
- Currently there are a number of municipal observation wells within the subwatersheds that are being monitored on a regular basis by the City of Barrie. These wells are located away from production wells, and therefore tend to reflect aquifer response to the overall Barrie well system withdrawals. The data show excellent aquifer performance with essentially stable conditions or slight declines in response to increased withdrawals. Seasonally, water levels respond to the variation in production with lower levels during the summer and recovering water levels in the spring and fall/winter. TW1/87 is located in the Barrie core area and shows that overall average annual levels and minimum levels have not changed significantly during the 10 year monitoring period. Furthermore, based on the reported static level of 222.2 mbgs in April 1987, spring levels remain similar or only slightly less after 20 years. The other area monitoring locations show generally similar results, which demonstrates that aquifer performance remains satisfactory with no evidence of over pumping (AquaResource *et al*., 2010).

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 subwatersheds, 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 subwatersheds 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 4-12. The figure illustrates rates of recharge within the Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds 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 tighter soils (i.e. silts/tills, and clays). The urbanized areas within the City of Barrie have lower recharge rates due to the impervious fraction, which limits the volume of water that can infiltrate. In the subwatersheds, the groundwater system plays a major role in determining groundwater recharge. In groundwater discharge areas (i.e. wetlands), recharge is zero or very low as the water table is at or near 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

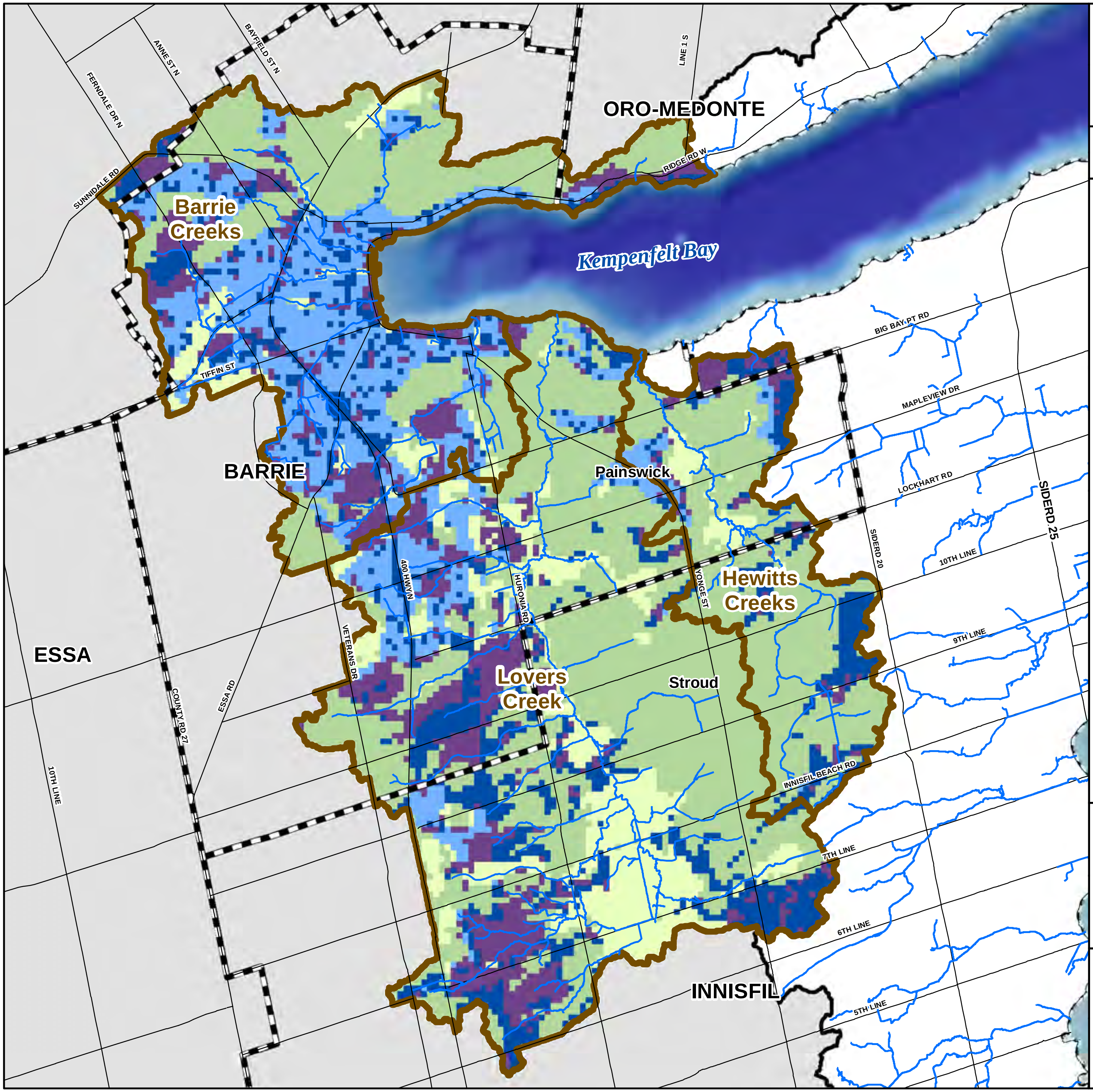
Significant Groundwater Recharge Areas (SGRAs) can be described as areas that can effectively move water from the surface through the unsaturated soil zone to replenish available groundwater resources. The mapping of these recharge zones is necessary to ensure the sustainability of groundwater supplies. 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 Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds, 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 4-13 represent a recharge rate of 189 mm/yr. A comparison of Figure 2-18 indicates that the most significant areas for groundwater recharge within the Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds are associated with surficial sand and gravel deposits and range between 300-500 mm/yr.

Simulated average annual groundwater recharge (mm/yr) in the Barrie Creeks, Lovers Creek and Hewitt's Creek subwatersheds

Figure 4-12



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 October 2011.

Significant Groundwater Recharge Areas in the Barrie Creeks, Lovers Creek and Hewitt's Creek subwatersheds

Figure 4-13

Legend

Road
Municipal Boundary
Watercourse
Subwatershed
Significant Groundwater Recharge Areas

Lake Simcoe Region conservation authority

0 0.5 1 2 3 4 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 August 2011.

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 have been delineated for the Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds by Earthfx (2012) using the FEFLOW model developed by AquaResource (2010) for the Tier 2 Water Budget. LSRCA identified a range of features deemed to be ecologically significant within the Barrie, Lovers, and Hewitt Creek subwatersheds. These include headwater streams, cold water fisheries, wetlands, and brook trout and mottled sculpin spawning locations. From these features reverse particle tracking was conducted by releasing virtual particles at a specified starting point within the subwatersheds (wetlands and coldwater stream reaches). The groundwater model then tracks the particles back through the aquifer until the point of entry is reached. As an example, Figure 4-14 shows the backward particle tracking from Lovers Creek within the FEFLOW model. The study also evaluated various methodologies regarding particle placement and sensitivity to variations in placement. A cluster-analysis technique was developed and tested to assess the significance of the particle endpoint distributions. In addition, the sensitivity of model results to small changes in model parameters was evaluated.

Representative simulations were completed using backward particle tracking from coldwater streams and wetlands. The ESGRA results from these simulations are shown in Figure 4-15. In Figure 4-16 the ESGRAs delineated by particle endpoint cluster analysis are compared against the SGRAs mapped previously and provided by the LSRCA. From this analysis, it can be seen that the particle clusters loosely correlate with area of mapped SGRAs. In both Hewitt's and Lovers Creeks, ESGRAs are dispersed around their catchments roughly extending to the tips of the headwater tributaries; whereas in the Barrie Creeks area, little of the recharge that occurs in the catchment is modelled to discharge in any streams. Forward particle tracking performed in this exercise showed a large portion of recharge is directed toward the intakes of City of Barrie municipal wells rather than to streams. Similarly, contributing areas to wetlands also appear non-extent in the Barrie Creeks watershed compared with the Hewitt and Lovers watersheds (Earthfx, 2012).

Although backward-tracked particles originating in streams covered more area than those from wetland features, it can be observed that, in general, they originate from similar locations. By comparing Figure 4-15 and Figure 4-16 it is apparent that there are large discrepancies between the ESGRAs mapped from particle clusters and the SGRAs mapped in previous efforts (ARI and Golder, 2010). SGRAs may not be coincident with the ESGRAs mapped from particle clusters for the following reasons (Earthfx, 2012):

1. High recharge rate predicted by surface water models alone cannot indicate ecological significance because of the complexity of the groundwater flow paths
2. The FEFLOW model used here was not specifically designed with the intention of analysing near-surface hydrological process and flow pathways.

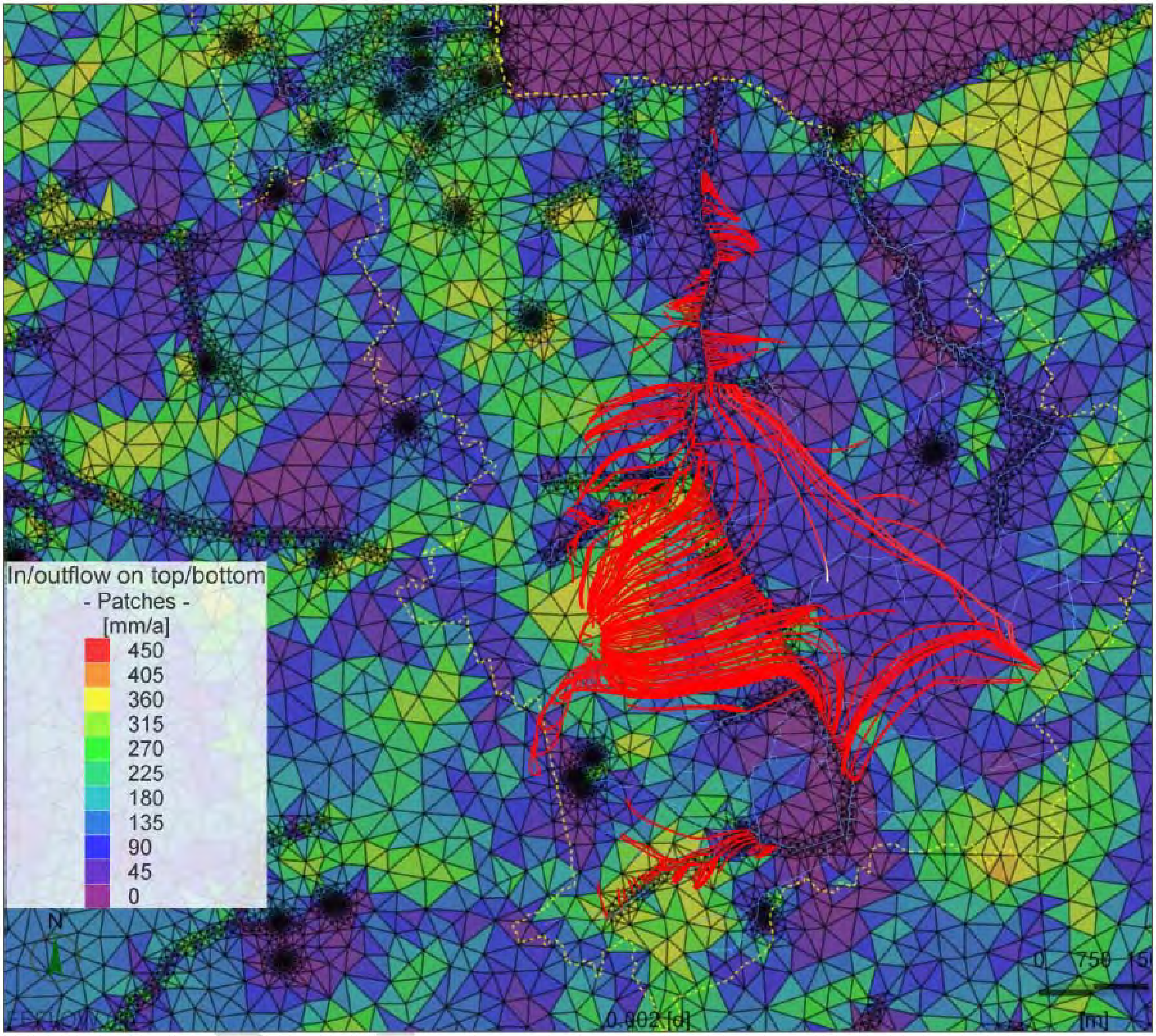


Figure 4-14: Screenshot of FEFLOW reverse particle tracking from Lovers Creek, with recharge (Earthfx, 2012).

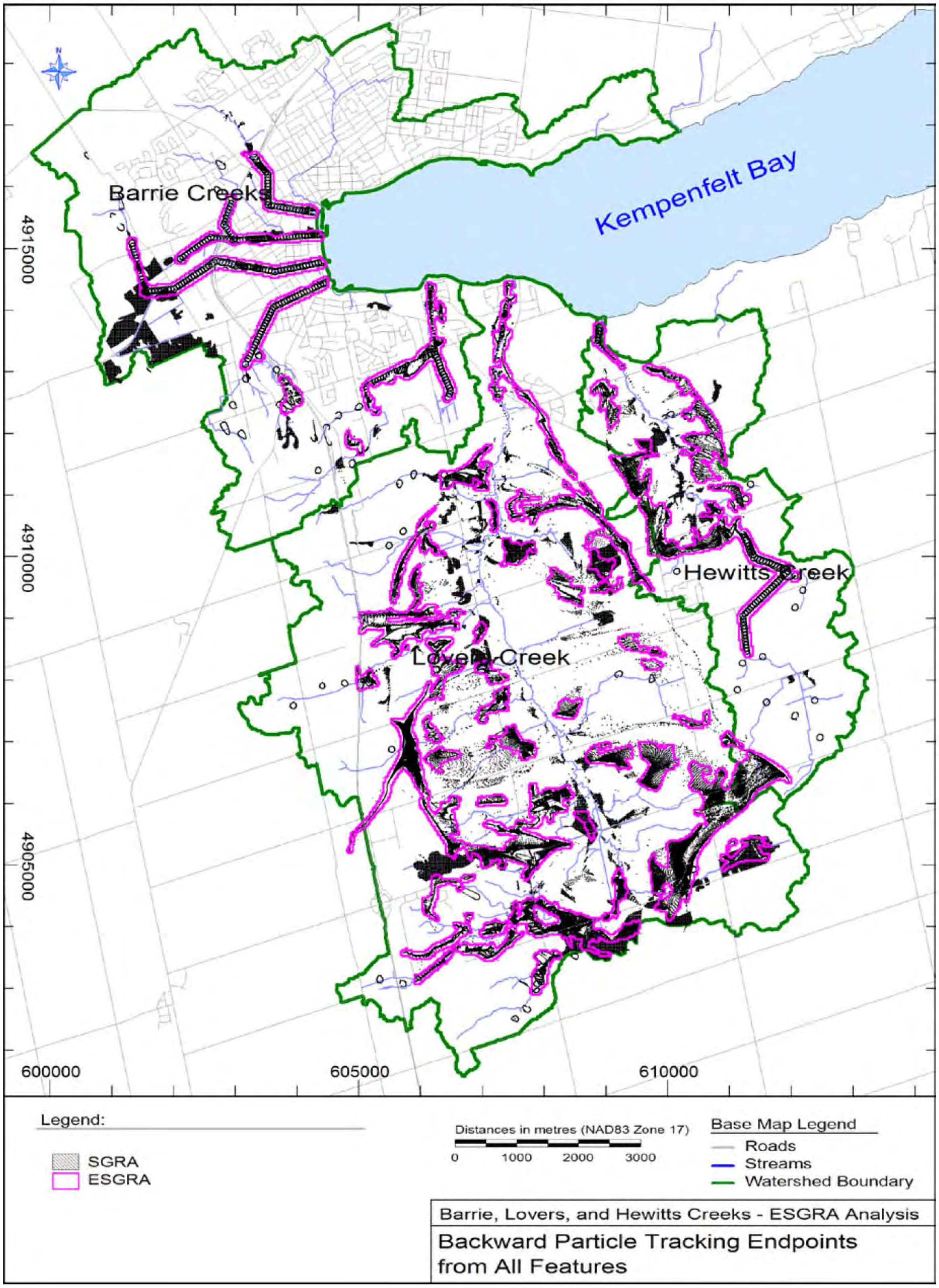


Figure 4-15: Final ESGRAs defined by backward tracking from all modelled features streams/wetlands (Earthfx, 2012).

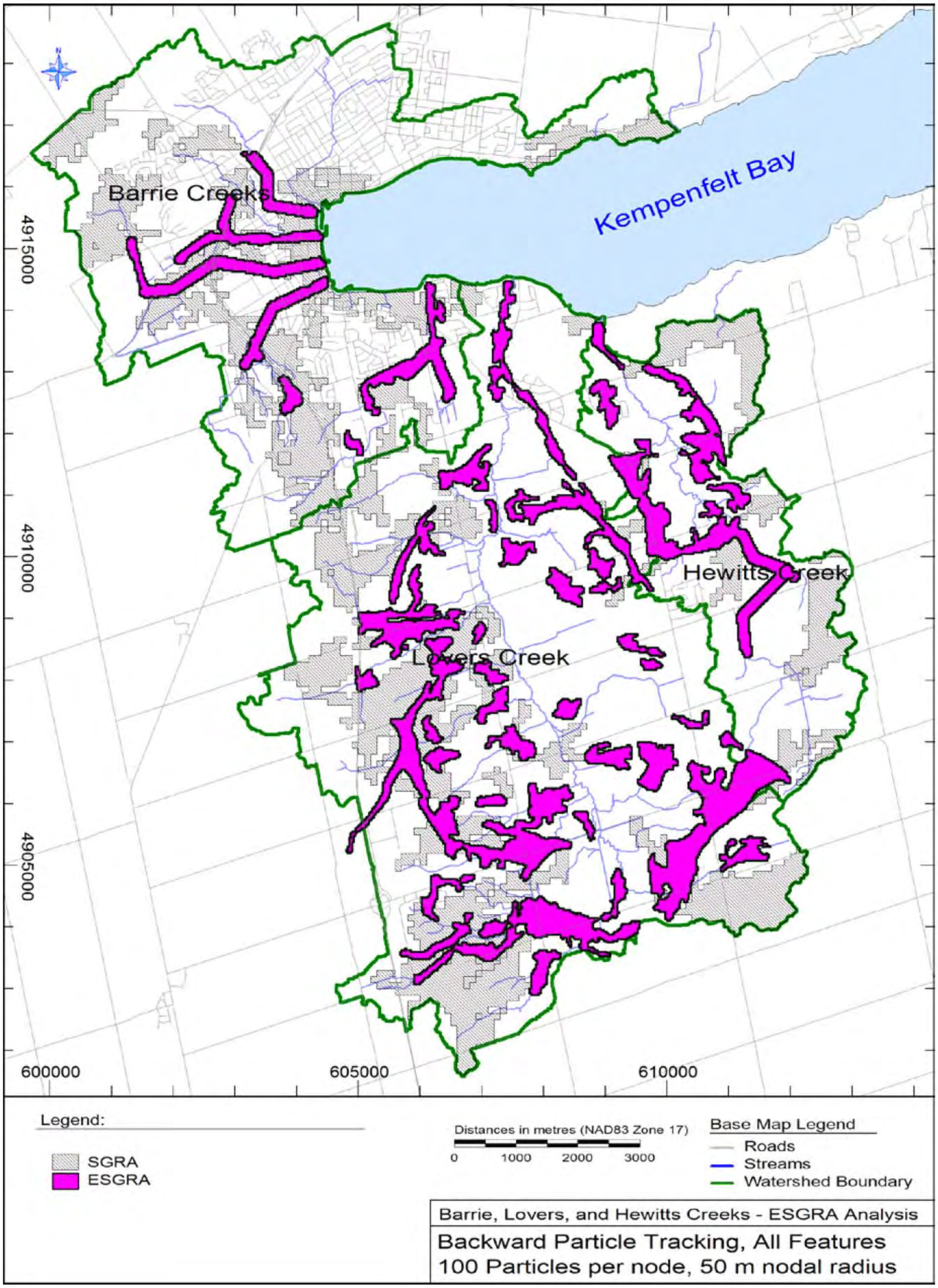


Figure 4-16: ESGRAs defined by backward tracking from all features (i.e. streams/wetlands) compared with mapped SGRAs (Earthfx, 2012).

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 2-31, **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 4-17.

Average net annual evapotranspiration (mm/yr) in the Barrie Creeks, Lovers Creek and Hewitt's Creek subwatersheds

Figure 4-17

Legend

- Road
- Municipal Boundary
- Watercourse
- Subwatershed

Observed Annual Average Evapotranspiration (mm/yr)

High : 747

Low : 190

Lake Simcoe Region conservation authority

0 0.5 1 2 3 4 Kilometres

N

LSRCA GIS Services DRAFT TF created December 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 4-18. 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.

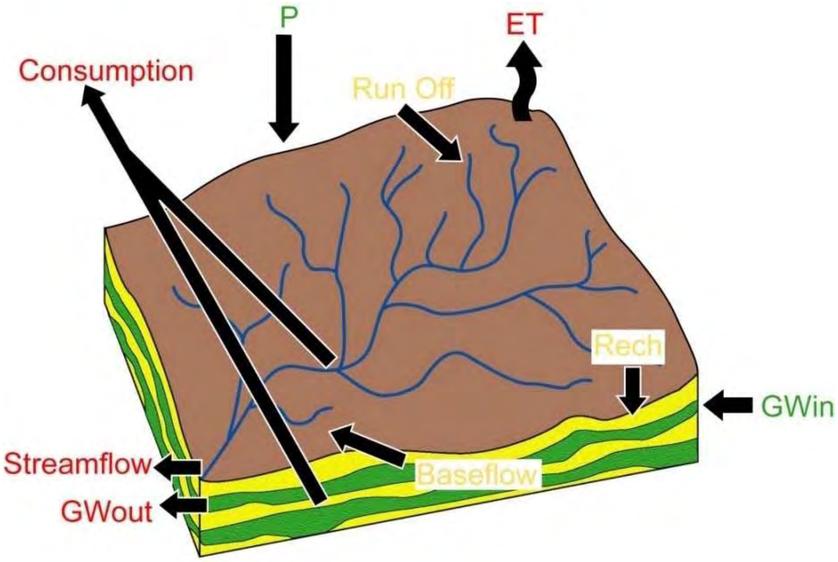


Figure 4-18: Water budget components

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

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

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)

∆S = 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 Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds. The findings of the water budget study are discussed below.

4.3.1 Local Water Budget Initiatives

The water budget methodology presented in this chapter includes an assessment of existing hydrologic conditions within the subwatershed using both a conceptual model and numerical modelling information developed through the SWP program (as discussed above).

Water budgets are generally developed using an approach that estimates the amount and location of water conceptually; however they can be refined by using surface and groundwater models. These models are referred to as numerical models and use mathematical equations to approximate existing hydrogeologic conditions. While models can quantify the various components of the hydrologic cycle they can also be used to estimate the direction of groundwater or surface water flow within a subwatershed, and therefore aid in the identification of potentially stressed areas. Numerical model outputs are intended to provide estimates of possible conditions that may exist within the subwatershed; these estimates or predictions may point to possible areas of concern and may also be considered when providing solutions to identified problems.

AquaResource and Golder (2010) and AquaResource *et al*. (2011) completed the water budget studies on behalf of the LSRCA, which included the Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds in support of the water budget requirements under the Clean Water Act, 2006.

A Tier Two Water Budget and Water Quantity Stress Assessment was completed in 2010.The project objectives were to provide estimates of each component of the hydrologic cycle for the subwatershed based on various land and water use scenarios and to confirm the stress classification for the subwatersheds classified in the Tier One Stress Assessment as having a moderate or significant potential for stress. Estimates were completed using a surface water model (PRMS) and a three-dimensional numerical groundwater flow model (FEFLOW).

The groundwater and land use scenarios analysed within this study include:

- Current conditions – current land use and groundwater use;
- Future conditions – future land use and groundwater use;
- 10-year drought scenario;
- Climate change scenario

Additional water budget efforts are currently underway within the Barrie study area. These include completion of a Tier Three Water Budget and Local Area Risk Assessment for any municipal water supply systems present within subwatersheds classified as having a moderate or significant potential for stress in the Tier Two Assessment. As part of this assessment, vulnerable areas are delineated for municipal drinking water systems, water quantity risks associated with these areas are estimated, and moderate or significant drinking water threats within these areas are identified.

4.3.2 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 developed for the South Georgian Bay West Lake Simcoe study area, which includes the Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds. This groundwater model incorporated the enhanced knowledge of the geologic surface and sub-surface gained from the conceptual model discussed in the previous section. The model domain encompasses the Nottawasaga Valley and Severn Sound watersheds in their entirety as well as the western portion of the Lake Simcoe watershed. Additionally, the model was also built to extend to the areas beneath Georgian Bay and Kempenfelt Bay, resulting in a total coverage area of 5416 km^2 (AquaResource and Golder, 2010).

The FEFLOW modelling code was selected for use because of its ability to simulate physical features, and follow naturally complex boundary conditions. This model runs very efficiently requiring fewer calculation points to achieve the same level of precision as with finite difference model codes. The model elements also have the ability to conform to the pronounced vertical variation of the hydrostratigraphic layers. The stable water table simulation the model performs allows for a more accurate depiction of the shallow subsurface, this allows the modeller to focus on conceptual issues rather than numerical issues.

The water budgets and stress assessment are calculated using the estimated values for groundwater supply and reserve simulated in the numerical FEFLOW model. Water budgets and stress assessments are conducted to determine a subwatershed's potential stress level, with the ultimate goal of sustaining a water supply.

The parameters used in the water budget were simulated using the numerical FEFLOW model. This included simulations of groundwater recharge under steady state conditions, consumptive demand estimates determined from recorded pumping rates, groundwater discharge to streams, and the inter-basin transfer of groundwater.

The results of the water budget are shown on Table 4-4. The value for groundwater recharge indicates how much recharge the subwatersheds were simulated to receive annually. The negative values for groundwater takings indicate that both Barrie Creeks and Hewitt's Creek subwatershed are experiencing a net loss of water due to groundwater pumping. A negative value for groundwater discharge to streams indicates that flow is leaving the groundwater system and entering the surface water system. This is observed in both Barrie Creeks and Hewitt's Creek subwatersheds. A positive value for inter-basin transfer indicates that the subwatershed is experiencing a net in-flux of groundwater. This is observed in the Barrie Creeks subwatershed. Conversely a negative net in-flux value indicates that a subwatershed is experiencing a net loss of groundwater flow. This is observed in Hewitt's Creek subwatershed, where some of the groundwater flow is supporting the ecological health of adjacent subwatershed. The values in the water budget form the foundation for the stress assessment calculations.

Table 4-4: Water budget summary by subwatershed (AquaResource and Golder, 2010).

Subwatershed	Area (km^2)	Groundwater Recharge (L/s)	Groundwater Takings* (L/s)	Inter-Basin Transfer (L/s)	Cross-Boundary Transfer (L/s)	Total Discharge to Surface Water (L/s)	Breakdown of Groundwater Discharge to Surface Water (L/s)			
							Discharge to Streams	Discharge to Wetlands and Inland Lakes	Discharge to Georgian Bay	Discharge to Lake Simcoe
Hewitt's & Lovers Creek	74	312	-19	-97	0	-200	-191	0	0	-9
Barrie Creeks (includes a small portion of Willow Creek that contains Barrie Wells)	53	251	-468	339	0	-125	-5	-100	0	-21

*refers to water demand

4.3.3 Water Demand Estimation

The water demand component of the water budget refers to water taken as a result of an anthropogenic activity (e.g. municipal drinking water takings, private water well takings, as well as other permitted takers). 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 Barrie, Hewitt's, and Lovers Creek subwatersheds assessed as part of the Tier Two Stress Assessment (AquaResource and Golder, 2010).

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 and Golder, 2010).

The consumptive groundwater demand was estimated for both permitted (e.g. municipal, industrial, and commercial water users) and groundwater takings that don't require a permit (i.e. domestic water users extracting less than 50,000 L/day and agricultural water users). Table 4-5 shows the number of groundwater takings by subwatershed and water use sector. Figure 4-19 and Figure 4-20 show the average annual and monthly maximum consumptive groundwater demand estimates, respectively, for each Tier Two Stress Assessment subwatershed. These estimates are used to compute the subwatershed potential stress under existing conditions (AquaResource and Golder, 2010).

Reported pumping rates were used to generate the municipal demand, while other permitted water demand was estimated by combining the permitted rate with the months of expected active taking. Non-permitted water demand was estimated by area pro-rating the non-permitted demand estimate from the Tier One stress assessments (SGBLS, 2009). 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. Existing and future water demand can be found in Table 4-6. The consumptive factors used are outlined in Table 4-11.

Table 4-5: Number of groundwater takings by subwatershed and water use sector (AquaResource and Golder, 2010).

ID	Subwatershed	Agricultural	Commercial	Industrial	Miscellaneous	Recreational	Remediation	Water Supply	Total
28	Hewitt's & Lovers Creek	0	12	0	0	0	0	5	17
22	Barrie Creeks (includes a small portion of Willow Creek that contains Barrie Wells)	0	0	1	2	0	5	14	22

Table 4-6: Current and future demand by subwatershed and well field (AquaResources and Golder, 2010).

Municipality	Community	Wellfield	Subwatershed	Current Volume Pumped (L/s)	Future Volume Pumped (L/s)
Barrie		Barrie	Barrie Creeks	458.3	677
Innisfil	Innisfil Heights	Innisfil Heights	Hewitt's Creek	3.9	6.2
	Stroud	Stroud	Hewitt's Creek	5.8	9

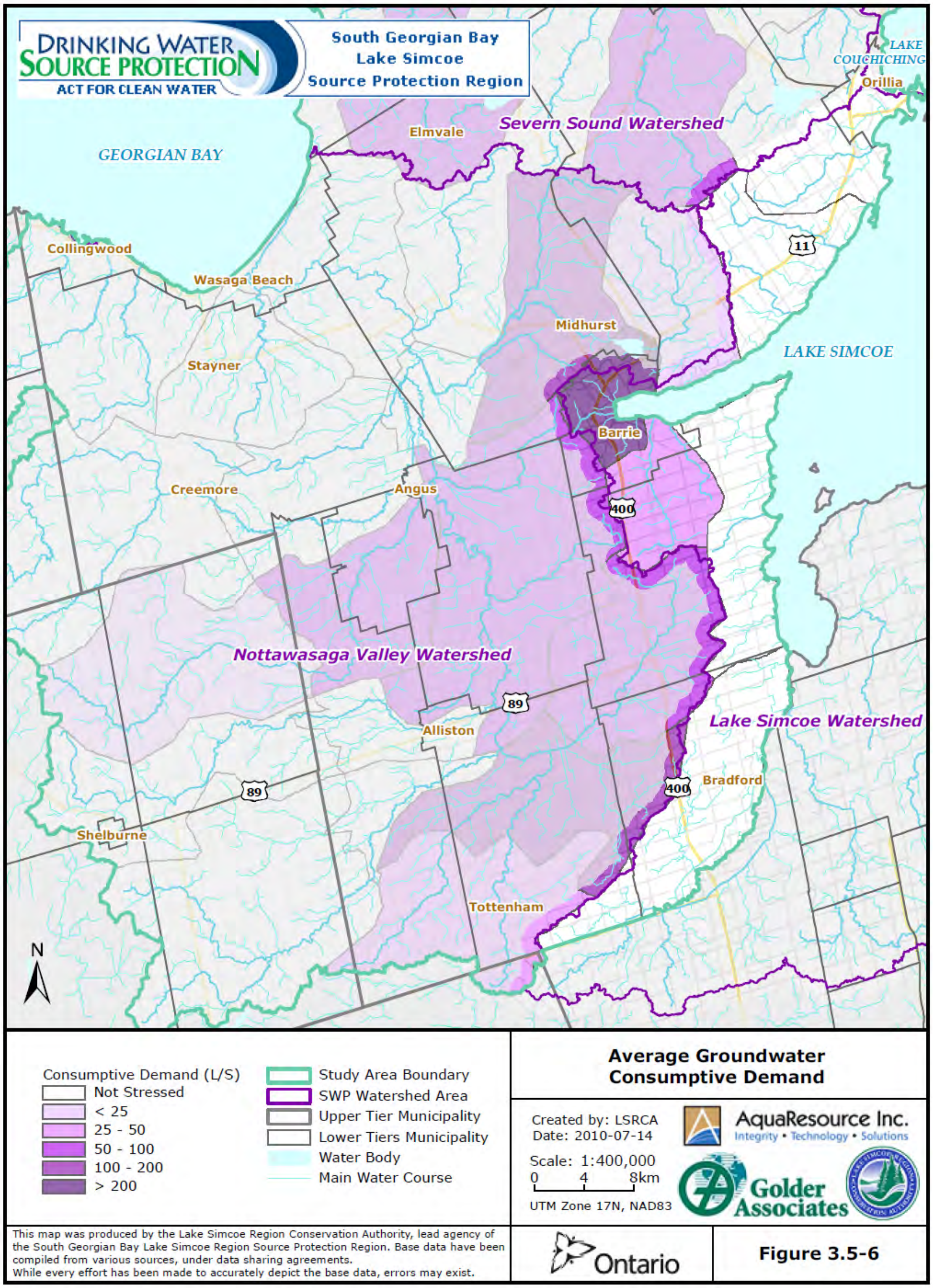


Figure 4-19: Average groundwater consumptive demand (AquaResource and Golder, 2010).

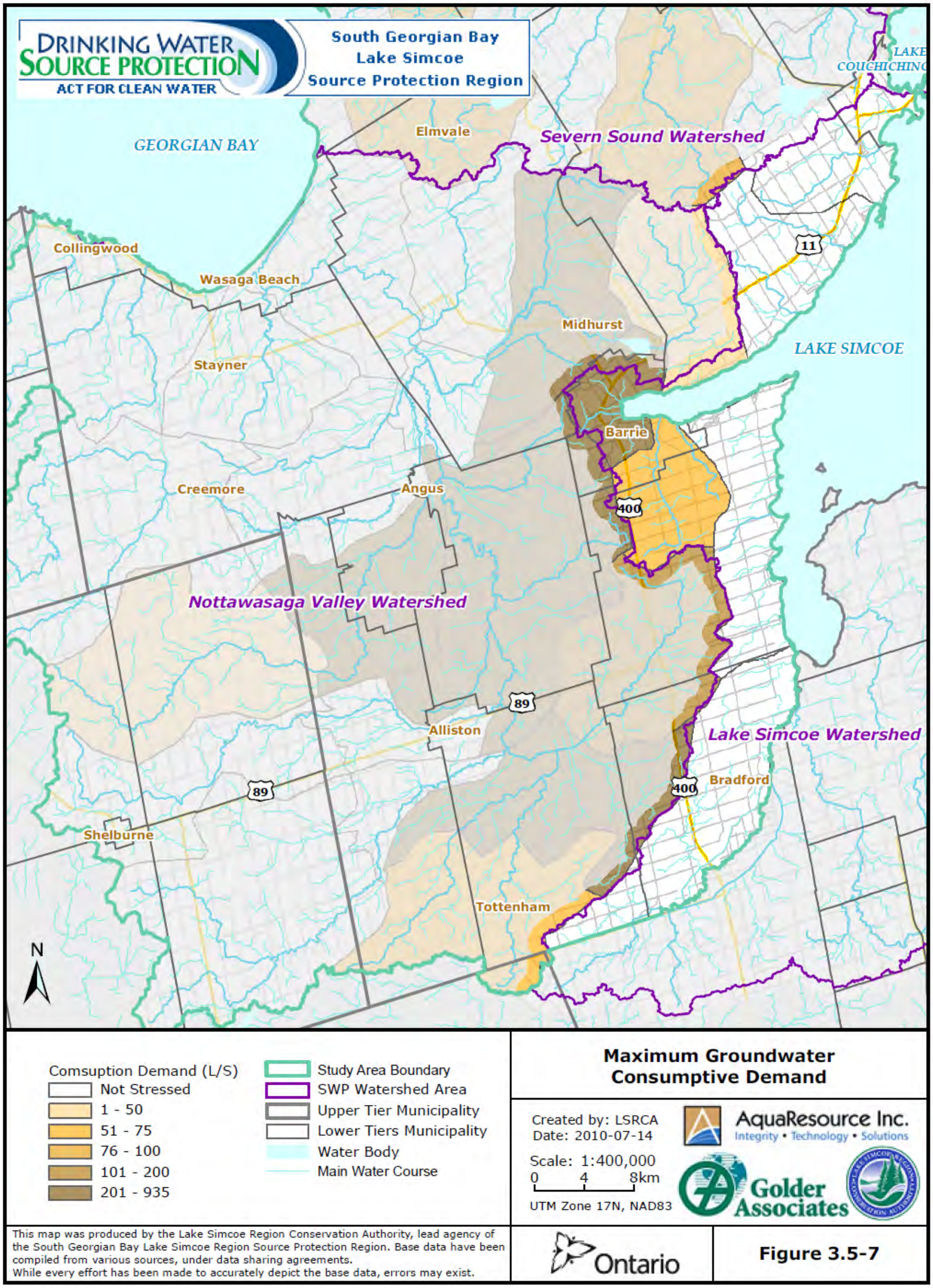


Figure 4-20: Maximum groundwater consumptive demand (AquaResource and Golder, 2010).

Permitted Water Demand

There are a number of large groundwater and surface water takings within the subwatershed that require a Permit to Take Water for uses such as industrial and golf course irrigation. Some of the water pumped for these uses is lost to evapotranspiration while some may infiltrate back to the subsurface as irrigation return flow (actual consumption, i.e. water removed from the subwatershed, will differ by the specific application).

The most important source of consumptive demand information was the MOE PTTW database and actual municipal water use data. Municipal and other water supplies are obtained from both surface water (lakes and rivers) and groundwater. 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. Permits are not required to take water for domestic purposes, livestock watering, or firefighting.

Information from the January 2008 PTTW program database was used to estimate actual water demands. Figure 4-21 above shows the locations of all permitted groundwater takings within the Study Area.

Table 4-7 shows the maximum permitted takings by subwatershed. 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.

Table 4-7: Maximum permitted takings by subwatershed (AquaResource and Golder, 2010).

ID	Subwatershed	Area	Maximum Permitted Takings	
		km^2	(L/s)	(mm/yr)
28	Hewitt's & Lovers Creek	74	182	77
22	Barrie Creeks (includes a small portion of Willow Creek that contains Barrie Wells)	53	1,308	771

Groundwater takings (m3/day) within the Barrie Crreks, Lovers Creek, and Hewitt's Creek subwatersheds

Figure 4-21

Legend

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 October 2011.

Municipal Water Supply

Municipal water supplies represent the largest water use within the study area. As such, accurate estimates of municipal water use are a critical component of the consumptive water demand estimate. For the Tier Two Stress Assessment, reported municipal pumping rates were obtained from a variety of sources.

Table 4-8 lists 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. In addition, Table 4-8 summarizes the total municipal groundwater takings by subwatershed for municipal water supply purposes. As seen in these tables, the highest municipal demand is in Barrie Creeks despite the fact that it is the smallest subwatershed (AquaResource and Golder, 2010).

Table 4-8: Summary of municipal systems (AquaResource and Golder, 2010).

Municipality	Community	Municipal System / Wellfield	Subwatershed(s)	Year of Data	Source of Data	Annual Volume Pumped (L/s)
Barrie	Barrie	Barrie	Middle Nottawasaga	2008	NVCA	0.0
			Barrie Creeks	2008, 2009	NVCA, City of Barrie	458.3
Innisil	Innisfil Heights	Innisfil Heights	Hewitt's & Lovers Creek	2008	Tow n of Innisfil	3.9
	Stroud	Stroud	Hewitt's & Lovers Creek	2008	Town of Innisfil	5.8

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

Non-permitted water demand was estimated by area pro-rating the non-permitted water demand estimated in the Tier One Water Budget and Stress Assessment. The estimated non-permitted water takings in the Lake Simcoe watershed include agriculture needs and unserviced domestic use. The non-permitted water takings are found in Table 4-9.

The non-permitted estimated agriculture water demand includes water used for livestock watering, equipment washing, and any other agriculture 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. The estimates were area pro-rated to match the boundaries of the Tier Two subwatersheds. 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 new subwatersheds. 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 4-9: Non-permitted agriculture and unserviced domestic water use (AquaResource & Golder, 2010).

Subwatershed	Non-Permitted Agricultural Demand (L/s)	Unserviced Domestic Water Use (L/s)	Total Non-Permitted Water Use	
			(L/s)	(mm/yr)
Hewitt's & Lovers Creek	0.4	1.4	1.8	0.8
Barrie Creeks (includes a small portion of Willow Creek that contains Barrie Wells)	0.7	0.9	1.7	1.0

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 4-10, 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).

Table 4-10: 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

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 4-11 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 4-11, 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 4-11: 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

Category	Specific Purpose	Consumptive Factor	Category	Specific Purpose	Consumptive Factor
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			

4.3.4 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 subwatersheds that have gauged flow stations, the 10th percentile of stream flow (Q90) was used as the reserve value. For surface water within ungauged subwatersheds 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 subwatersheds. This flow value is most representative for reserve, as it is the flow value that is exceeded 90 percent of the time.

Within ungauged subwatersheds, 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 within 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, land and water use. Monitoring groundwater levels can help 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 subwatersheds show that there are cross boundary groundwater flows within the major aquifer systems that support the City of Barrie's main 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 subwatersheds occur within the western portion of the subwatersheds and is associated with high permeability (sand & gravel) materials.
- Surface water flows are a function of overland runoff and groundwater discharge (baseflow). The hydrographs for Lovers and Hewitt's Creeks show that both systems demonstrate a rapid response to precipitation events and typically short recession to baseflow conditions, likely due to the relatively high degree of urbanization, increased slope and small size/lack of storage of the Lovers Creek and Hewitt's Creek watersheds compared to other Lake Simcoe Watersheds.
- An examination of the Baseflow Index at a yearly scale shows that greater than 60% of the flow in the Lovers Creek comes from baseflow as opposed to surface runoff. This suggests that groundwater discharge is a substantial contributor in this subwatershed and is a good indication of stable year round flow, which is important for maintaining the ecological functions of the Creek.
- The ESGRA areas are seen to loosely correlate with the areas of mapped SGRAs. In both Hewitt's and Lovers Creeks, ESGRAs are dispersed around their catchments roughly extending to the tips of the headwater tributaries; whereas in the Barrie Creeks area, little of the recharge that occurs in the catchment is modelled to discharge in any streams.

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 risk 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

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 these studies and more information can be obtained from the following reports: SGBLS (2009), AquaResources and Golder (2010), and AquaResources *et al*. (2010).

Considerable effort was made in the Tier 1 (SGBLS, 2009), Tier 2 (AquaResource and Golder, 2010), and ongoing Tier 3 (AquaResources *et al*., 2010) water budgets discussed in previous sections to document the various sources of water demand. Table 4-12 and Table 4-14 summarize the monthly consumptive demand by subwatershed and the percentage of Consumptive Water Demand by Sector per subwatershed.

Table 4-12 and Table 4-13 indicates that the Barrie Creeks subwatershed has a high demand for every month. This is because the Barrie Creeks subwatershed is supplying all of the municipal water for the City of Barrie with the exception of one well located in the Willow Creek subwatershed. Hewitt's and Lovers Creek subwatersheds show increased consumptive demand from May to September. This is a result of increased seasonal uses from commercial uses (e.g. golf courses), livestock/domestic use, and municipal water supply uses.

Table 4-14 provides estimates of current annual consumptive groundwater use for the subwatersheds. Currently permitted uses account for 99% of the consumptive groundwater demand within the Barrie Creek subwatersheds and 52% within Hewitt's and Lovers Creeks subwatersheds. Agriculture accounts for 0% of the groundwater consumption, and domestic uses accounts for 0%. These values are not predicted to change much in the future.

Table 4-12: Consumptive demand by subwatershed (AquaResource and Golder, 2010).

Subwatershed	Consumptive Demand (L/s)													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg	Max
Hewitt's & Lovers Creek	14	14	14	16	24	30	30	28	28	21	14	14	21	30
Barrie Creeks (includes a small portion of Willow Creek that contains a Barrie well)	447	417	432	473	510	514	522	498	495	460	437	428	470	522

Table 4-13: Monthly percent water demand (existing conditions) (AquaResource and Golder, 2010)

Subwatershed	Monthly Percent Water Demand (%)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Hewitt's & Lovers Creek	5	5	5	5	8	10	10	9	9	7	5	5
Barrie Creeks (includes a small portion of Willow Creek that contains a Barrie well)	**73**	**68**	**70**	**77**	**83**	**84**	**85**	**81**	**81**	**75**	**71**	**70%**

Table 4-14: Percentage of consumptive water demand by sector per subwatershed (AquaResource and Golder, 2010).

Subwatershed	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.
Hewitt's & Lovers Creek	-	-	39%	5%	-	-	-	-	-	-	-	47%	9%	48%	52%
Barrie Creeks (includes a small portion of Willow Creek that contains a Barrie well)	-	-	-	-	<1%	-	<1%	-	2%	-	-	98%	<1%	<1%	99%

Table 4-6 compares the current and future demand results from the Tier 2 Water Budget Assessment. To evaluate the water demand under future conditions, the consumptive water demand was estimated for a future population throughout each municipality's planning horizon. In general, this planning horizon is intended to extend to the year 2031, however in some cases the planning horizons did not extend that far. In those cases the best available information was applied. LSRCA staff worked with municipalities to coordinate and assemble future rates for each municipal system wherever possible. 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.

Municipal Water Supplies

Table 2-5 within Section 2.3.2.1 and Table 4-8 discuss the municipal water supply systems found within the study area. There are three municipal groundwater supply systems within the study area that service the City of Barrie, Innisfil Heights, and Stroud. The municipal water takings account for approximately 99% of the estimated total groundwater taking within the Barrie subwatershed and 52% within Hewitt's and Lovers subwatersheds. Municipal well locations are shown on Figure 4-22. The data presented in this report were analyzed to estimate actual annual average pumping rates which are often less than the permitted rates. The numerical groundwater flow model, discussed in Section 4.3.1 incorporated average pumping rates where the data were available.

Future municipal water demand was estimated for each municipal groundwater supply system in the Tier Two Stress Assessment subwatersheds; however the Percent Water Demand under future conditions was computed for only those subwatersheds identified in as having a low potential for stress under existing conditions. Table 4-6 contains the estimated existing and future water demand and the percent change from existing municipal water demand.

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.

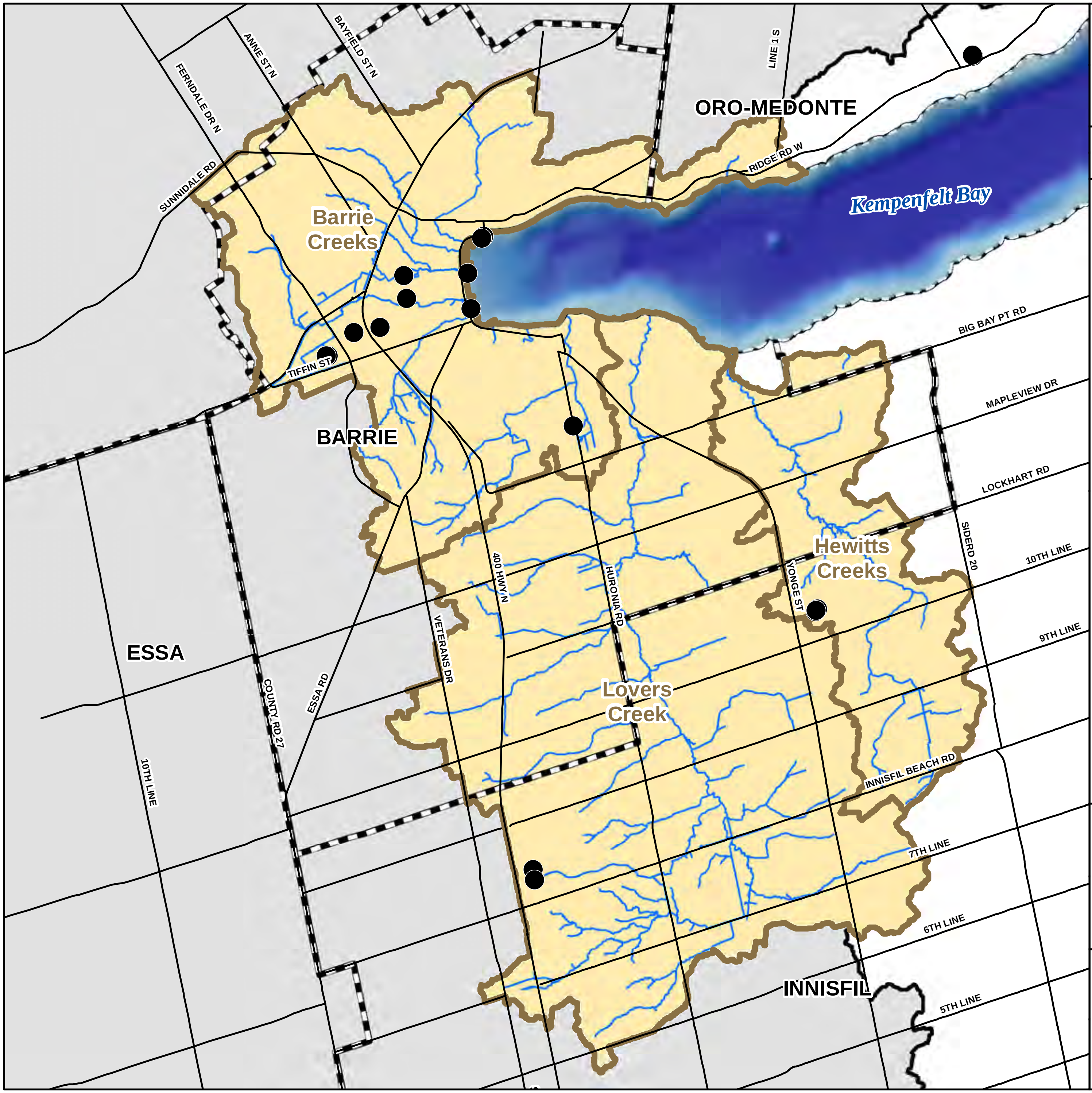
Other Permitted Uses

Table 4-5 outlines the number of permitted groundwater takings by subwatershed and by water use sector. For the Lovers and Hewitt's Creek subwatersheds the non-municipal permits account for the majority of permits issued, with the highest number being the commercial sector. Conversely, for the Barrie Creeks subwatershed less than half of the permits issued are from non-municipal water uses. Some of these include industrial and remediation.

Some of the water pumped for industrial, agriculture, and golf course irrigation is lost to the atmosphere via evapotranspiration. While some may infiltrate back to the subsurface as irrigation return flow, actual consumption (i.e. water removed from the watershed), will differ by the specific application. In general, reported pumping rates do not consider the consumptive nature of the taking, as the permit holders are required to report total pumping but not the returned water volume. As such, in order to obtain consumptive demand, the reported rates were modified by a consumptive factor, as outlined in Section 4.3.3 and shown in Table 4-11 to Table 4-14.

Municipal supply wells in the Barrie Crreks, Lovers Creek, and Hewitt's Creek subwatersheds

Figure 4-22



Legend

- Road
- Municipal Boundary
- Watercourse
- ● Municipal Well

Lake Simcoe Region conservation authority

0 0.5 1 2 3 4 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.

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 Barrie Creeks, Lovers Creek and Hewitt's Creek subwatersheds has been divided up into 10 classes including intensive and non-intensive agriculture, rural development, industrial, and natural heritage features (Figures 2-5 to 2-7 in Chapter 2). Land uses with less than 1% coverage of a subwatershed were not reported.

The Barrie Creeks subwatershed is the most urbanized subwatershed in the Lake Simcoe basin with approximately 63% of the land use being urban. This includes commercial, estate residential, institutional, and various other urban land uses. The smallest land uses include rural development (1%), railway (1%), and active aggregate (2%).

Impervious Surfaces

Impervious areas were estimated based on the land use data for the Lake Simcoe basin as well as for the Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds. Table 4-15 illustrates the percentage of impervious land cover within the basin (the surface of the lake was not included for the purpose of this analysis) and within the Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds. Wetlands and waterbodies within the subwatershed were treated as 100% impervious. This decision is based on the assumption that groundwater is discharging to the wetland over most of the year and, thus, groundwater recharge is not occurring. In addition, these land types have standing water for most of the year, and it was assumed that changes in storage are negligible, preventing infiltration through the soil. It should be noted that although the most accurate available land use information was used, these numbers will continue to change as development occurs.

Table 4-15: Comparison of impervious land cover within the Lake Simcoe watershed and the Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds.

	Area (km^2)	Impervious (km^2)**	Impervious (%)**
Lake Simcoe watershed	2,601*	238	9.2
Barrie Creeks	37.5	28.2	75.1%
Hewitt's Creek	17.5	4.5	25.7%
Lovers Creek	59.9	17.1	28.5%

** Area does not include the surface of Lake Simcoe*

*** Wetlands have been included in the impervious surface calculation*

Land Use and Significant Groundwater Recharge Areas

Significant Groundwater Recharge Areas 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 4-23 and Figure 4-24 show the land use distribution within the SGRA portion of the Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds. As shown on the figures the subwatersheds contain high levels of impervious (hardened) surfaces due the urban areas. Urban land uses (urban, institutional, industrial, and commercial) comprise approximately 23% of the landuses within the SGRAs, most of which are within the City of Barrie.

Natural heritage features also comprise approximately 23% 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 13% of landuse within the subwatershed.

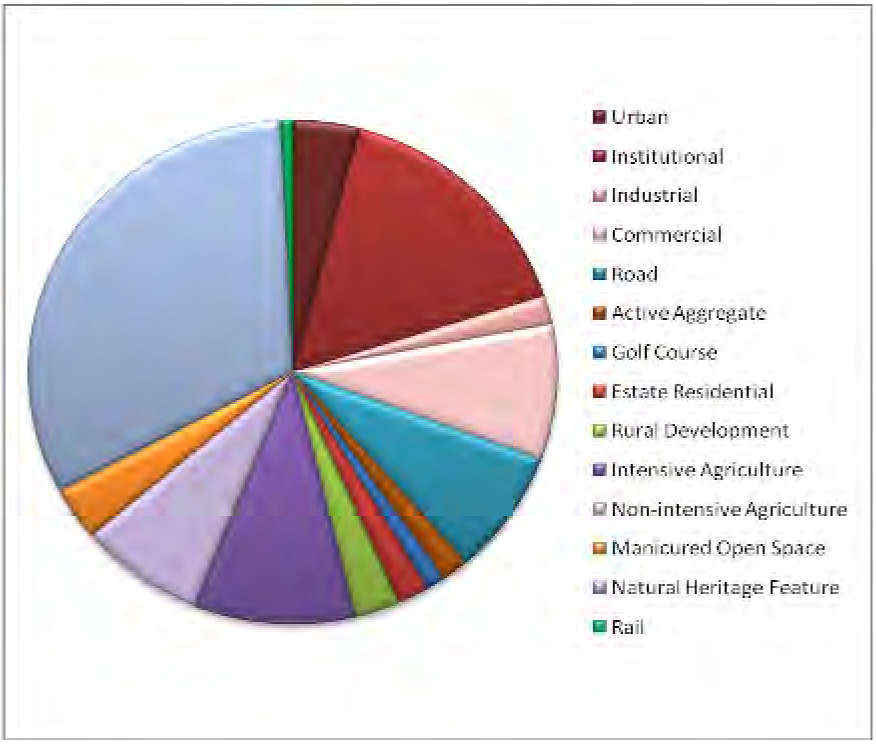


Figure 4-23: Land use distribution within Significant Groundwater Recharge Areas for the Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds.

Future Land Use Projections

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 the subwatersheds, the total recharge volume was decreased, assuming that any additional urbanized area would have 50% impervious cover. Table 4-16 presents the estimated future land use changes as well as the resulting changes in recharge.

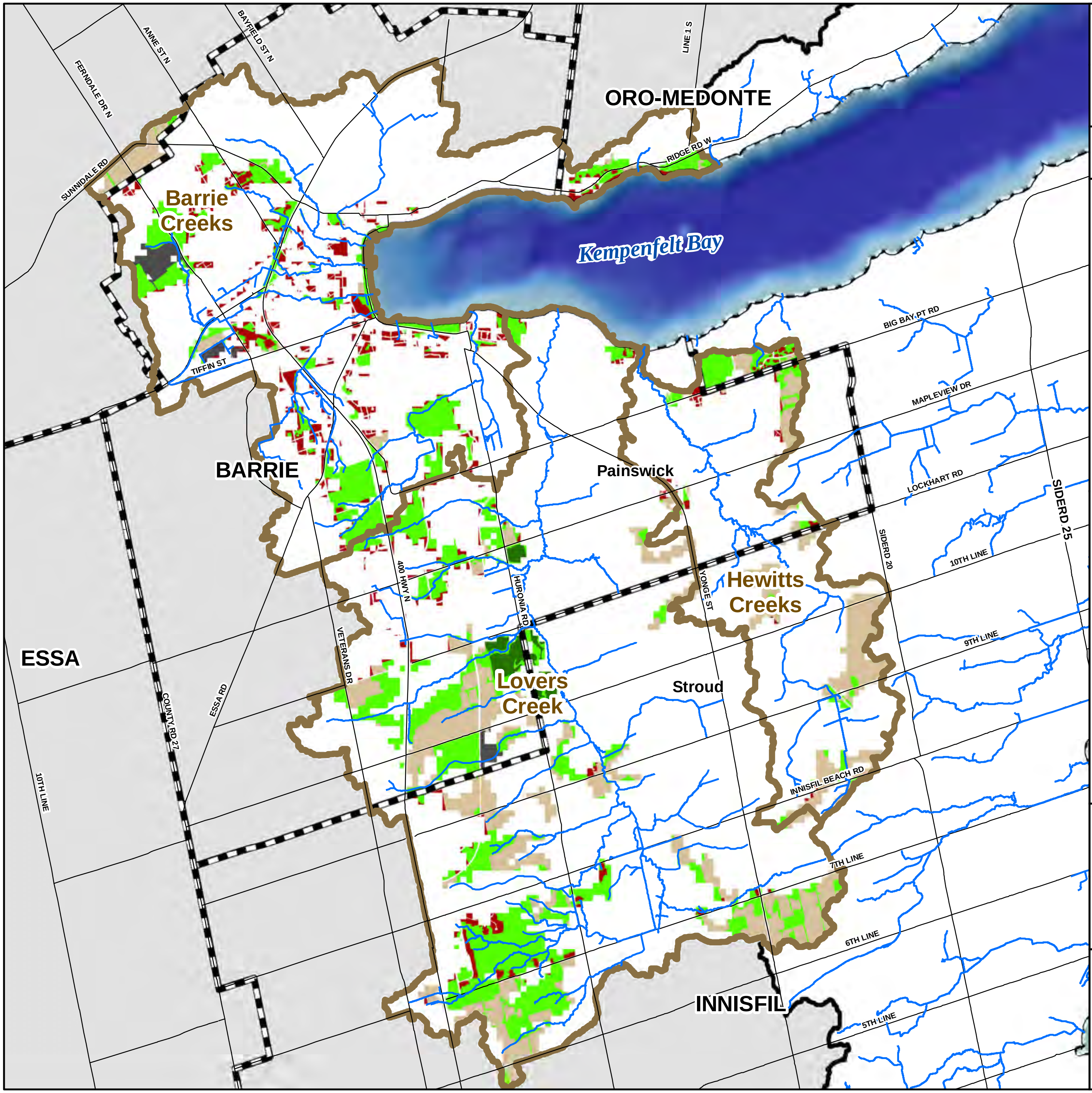
Table 4-16: Future land use changes and recharge rate estimates

Subwatershed	Percent Increase in Urban Area	Estimated Existing Average Recharge		Estimated Future Average Recharge		Percent Change in Recharge
	(%)	(L/s)	(mm/yr)	(L/s)	(mm/yr)	(%)
Lovers and Hewitt's Creek	7.2%	312	133	301	128	-4%

* Note: no future assessment was completed for Barrie Creeks due to it already having a high percent water demand in the current assessment.

Spatial distribution of landuse within Significant Groundwater Recharge Areas in the Barrie Creeks, Lovers Creek and Hewitt's Creek subwatersheds

Figure 4-24



Legend

— Road

▬ Municipal Boundary

〰 Watercourse

◯ Subwatershed

Land Use

🟥 Urban

🟫 Rural

🟩 Natural Cover

🟩 Golf Course

⬛ Aggregate

Lake Simcoe Region
conservation authority

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 August 2011.

4.4.3 Climate

The climate of the Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds 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 these studies and more information can be obtained from the following reports; SGBLS (2009), AquaResources and Golder (2010), and AquaResources *et al*. (2010).

Tier 1 Water Budget Results

The Tier 1 Water Budget Study (LSRCA, 2009) conducted a comparison of current conditions and future demand, on both an average annual and monthly basis. The completion of the analysis helps to determine whether stress on the groundwater and surface water resources can be anticipated under various scenarios. 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 (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.

Results of the current and future groundwater stress assessment using annual average demand are shown in Table 4-17 and Table 4-18. Both Hewitt's and Lovers Creeks were found not to be stressed with regard to average annual stress for current demand, while Barrie Creeks was found to have a significant potential for stress. For future demand Hewitt's Creek subwatershed was found to have a moderate potential for stress, while Barrie Creeks maintained the significant potential for stress.

Results of the current monthly surface and groundwater stress assessments are shown in Table 4-19. Only Barrie Creeks were found to have a potential for stress with regard to groundwater on a monthly basis. The lack of seasonal changes in stress levels are a result of a fairly consistent groundwater supply and consistent municipal pumping for water supply, which makes up the majority of water demand.

Overall, the results provide a reasonable assessment of the annual groundwater and monthly surface and groundwater supply and demand conditions. As a result of the current and future average annual stress assessment the Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds advanced to a Tier 2 assessment per the Clean Water Act Technical Rules. The following sections will discuss the results of the Barrie Creeks, Lovers Creek, and Hewitt's Creek Tier 2 Water Budget.

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 predicted baseflow discharge to the streams in the subwatershed

Table 4-17: Tier One results - current annual groundwater stress assessment (SGBLS, 2009)

Subwatershed	Area	Precip	AET	Surplus Water	Annual Mean Flow		Baseflow		Available Supply				Reserve				Groundwater Consumption		GW Stress
									GW		SW		GW		SW				
	km2	mm/a	mm/a	mm/a	m3/s	mm/a	m3/s	mm/a	mm/a	m3/s	mm/a	m3/s	mm/a	m3/s	mm/a	m3/s	m3/a	mm/a	%
Hewitts Creek	18	890	562	328	0.1	240	0.1	114	202	0.1	302	0.2	11	0.00	71	0.04	257,000	15	8%
Lovers Creek	60	873	560	313	0.4	232	0.2	112	194	0.4	195	0.4	11	0.01	74	0.14	610,000	10	6%
Barrie Creeks	38	905	563	341	0.3	226	0.1	110	226	0.3	218	0.3	11	0.01	73	0.09	13,220,000	352	164%

Note: Values rounded for presentation purposes 🟩 10 - 24% of available supply being taken AET - Actual Evapotranspiration
🟧 25% or more of available supply being takei GW - Groundwater
SW - Surface Water

Table 4-18: Tier One results - future annual groundwater stress assessment (SGBLS, 2009).

Subwatershed	Area	Precip	AET	Surplus Water	Annual Mean Flow		Baseflow		Available Supply				Reserve				Groundwater Consumption		GW Stress
									GW		SW		GW		SW				
	km2	mm/a	mm/a	mm/a	m3/s	mm/a	m3/s	mm/a	mm/a	m3/s	mm/a	m3/s	mm/a	m3/s	mm/a	m3/s	m3/a	mm/a	%
Hewitts Creek	18	890	562	328	0.1	240	0.1	114	202	0.1	302	0.2	11	0.00	71	0.04	357,000	20	11%
Lovers Creek	60	873	560	313	0.4	232	0.2	112	194	0.4	195	0.4	11	0.01	74	0.14	928,000	15	8%
Barrie Creeks	38	905	563	341	0.3	226	0.1	110	226	0.3	218	0.3	11	0.01	73	0.09	13,231,000	353	164%

Note: Values rounded for presentation purposes 🟩 10 - 24% of available supply being taken AET - Actual Evapotranspiration
🟧 25% or more of available supply being takei GW - Groundwater
SW - Surface Water

Table 4-19: Tier One results - current monthly groundwater stress assessment (SGBLS, 2009).

Subwatershed	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lovers Creek	5%	4%	5%	5%	5%	8%	8%	8%	8%	4%	4%	5%
Barrie Creeks	168%	151%	170%	167%	168%	160%	164%	164%	159%	166%	162%	168%
Hewitt's Creek	8%	7%	8%	8%	8%	8%	8%	8%	8%	7%	8%	8%

Moderate	Significant
>25% & < 50%	>50%
>20% & <50%	>50%

Tier 2 Water Budget Results

The objectives and approach of the Tier 2 Water Budget Assessment are similar to those of the Tier 1 in that the overall goal is to quantify water supply, reserve, and demand. Once these budget components are estimated the "percent water demand" equation and stress level assessment screening thresholds are the same between Tiers. The methods used to quantify the water budget components, however, are more robust in a Tier 2 study (AquaResource and Golder, 2010).

The Tier 2 Water Budget for the Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds (AquaResource and Golder, 2010) conducted a comparison analysis of existing, planned, and future conditions for average annual, monthly basis, and two-year drought scenarios. The completion of the analysis helps to determine whether stress on the groundwater resources can be anticipated under various scenarios. 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. 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.

Existing Conditions

The percent water demand was calculated for the Barrie Creeks and Hewitt's Creek subwatersheds using estimates of groundwater supply, reserve, and consumptive demand. The water demand used in the stress assessment is discussed in Sections 4.3.3 and 4.4.1. The estimated consumptive demand for permitted and non-permitted users was used in calculating the subwatershed's potential for stress under existing conditions. The groundwater supply component for the stress assessment was calculated as being the average annual recharge plus the lateral inflow of groundwater to the subwatershed. The groundwater reserve component of the stress assessment was calculated to be 10% of the estimated groundwater discharge to streams. The volume of groundwater discharge on a subwatershed basis was estimated using the FEFLOW numerical model and is illustrated on Figure 4-10. The figure illustrates that the Lake Simcoe portion of the study area discharges very little groundwater on an annual basis, less than 500 L/s.

The results of the existing conditions stress assessment are shown on Table 4-20, Table 4-21, and Table 4-22. The existing conditions stress assessment indicated that the Barrie Creeks subwatershed has the potential to be significantly stressed, whereas the Hewitt's and Lovers did not.

Table 4-20: Groundwater stress assessment - existing conditions (AquaResource and Golder, 2010).

Subwatershed	Groundwater Supply (L/s)			Ground water Reserve (L/s)	Consumptive Demand (L/s)		Month of Max Demand	Percent Water Demand (%)	
	Recharge	Flow In	Total Supply		Annual Average	Monthly Maximum		Annual Average	Monthly Maximum
Hewitt's & Lovers Creek	312	0	312	19	21	30	June	7%	10%
Barrie Creeks (includes a small portion of Willow Creek that contains a Barrie well)	251	362	614	0	470	522	July	**77%**	**85%**

Table 4-21: Monthly stress assessment - existing conditions (AquaResource and Golder, 2010).

Subwatershed	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Hewitt's & Lovers Creek	5%	5%	5%	5%	8%	10%	10%	9%	9%	7%	5%	5%
Barrie Creeks (includes a small portion of Willow Creek that contains a Barrie well)	73%	68%	70%	77%	83%	84%	85%	81%	81%	75%	71%	70%

Table 4-22: Groundwater stress classification - existing conditions (AquaResource and Golder, 2010).

Subwatershed	Potential Stress (Average Demand)	Potential Stress (Maximum Demand)	Evaluate Planned Conditions	Municipal Water Supply Systems
Hewitt's & Lovers Creek	Low	Low	**Yes**	Innisfil Heights, Stroud
Barrie Creeks (includes a small portion of Willow Creek that contains a Barrie well)	**Significant**	**Significant**	No	Barrie

Planned Conditions

Other than The City of Barrie's one planned municipal well (Well #19) that is located just outside of the study area in the Nottawasaga Valley watershed (Figure 4-22), there are no other planned systems/wells within the study area. The planned scenario was not evaluated for the Barrie Creeks subwatershed, as the Barrie Water Supply System is already identified as significantly stressed in the existing conditions scenario (AquaResource and Golder, 2010).

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 (Figure 4-23) 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 land use conditions were also estimated to determine a future average annual recharge rate to be used as the water supply term in the stress assessment calculations. Any changes to future rates were assumed to be based on change in urban land use alone (AquaResource and Golder, 2010). The estimated future recharge rates as a function of land use changes are displayed in Table 4-16.

The results of the future conditions stress assessment are shown on Table 4-24 and Table 4-25. The future conditions indicate that the Hewitt's Creek subwatershed remains at a low potential for stress. As a result, the Hewitt's Creek subwatershed was required to undergo the drought assessment scenario.

Table 4-23: Future groundwater municipal demand estimates (AquaResource and Golder, 2010).

Municipality	Community	Wellfield	Subwatershed	Existing Volume Pumped (L/s)	Future Volume Pumped (L/s)	Data Source and Comment on Increase in Future Demand
Innisfil	Innisfil Heights	Innisfil Heights	Hewitt's and Lovers Creek	3.9	6.2	MTO Population Growth
	Stroud	Stroud	Hewitt's and Lovers Creek	5.8	9.0	MTO Population Growth

Table 4-24: Groundwater stress assessment - future conditions (AquaResource and Golder, 2010).

Subwatershed	Future Groundwater Supply (L/s)			Groundwater Reserve (L/s)	Future Consumptive Demand (L/s)		Future Percent Water Demand	
	Recharge	Flow In	Total Supply		Annual Average	Monthly Maximum	Annual Average	Monthly Maximum
Hewitt's and Lovers Creek	301	0	301	19	26	36	**9%**	13%

Table 4-25: Groundwater stress classification - future conditions (AquaResource and Golder, 2010).

Subwatershed	Potential Stress (Average Demand)	Potential Stress (Maximum Demand)	Evaluate Drought Conditions	Major Municipal Water Supply System
Hewitt's and Lovers Creek	Low	Low	**Yes**	Innisfil Heights, Stroud

Drought Scenario

With respect to the Technical Rules (MOE, 2008a), the purpose of the drought scenario is to identify any subwatershed having municipal wells with the potential to be affected by a drought. The subwatershed is classified as having a moderate potential for stress if either of the following circumstances occurs within the subwatershed during either observed or simulated drought conditions (Rule 35.2e):

(i) the groundwater level in the vicinity of a well was not at a level sufficient for the normal operation of the well; or

(ii) the operation of a well pump was terminated because of an insufficient quantity of water being supplied to the well.

The Technical Rules identify the need for both a two year and ten year drought scenario (Rule 35.2. f/g). These scenarios are designed to capture probable periods of drought conditions; both short- and long- duration droughts. With the surface water simulation producing groundwater recharge estimates for the 1970-2005 time period, the impacts of short and long duration drought within this time period can be assessed. Furthermore, the scenarios need to be assessed for both existing and planned systems.

The years of 1998-1999 represent a recorded period of low precipitation, for which estimated recharge is available from the HSP-F and PRMS simulations. Since this information is readily available, the two-year and ten-year scenarios were evaluated simultaneously.

To complete the drought assessment, simulated continuous groundwater recharge from the PRMS streamflow generation models is used as transient recharge input to the FEFLOW groundwater flow model. Groundwater recharge is simulated based on units of similar hydrologic response (i.e. areas with similar soil type, land use, and climate) for both models. For the purposes of the groundwater drought scenario, the most dominant response unit was used as a representative hydrologic response over the study area, namely forested areas over coarser soils (for a).

The monthly variability in recharge estimates was examined from the 1970-2005 simulation for a sample area. The 12-month moving average of the monthly recharge, which removes monthly variability to highlight more significant trends, was looked at. The 1998-1999 drought is clearly evident in this sample period, as is the relatively low recharge conditions that occurred throughout the 1970s.

The FEFLOW steady-state groundwater flow model was configured to use the time series of monthly recharge for the complete 1970-2005 simulation. Water levels resulting from the steady-state groundwater flow simulation were set as initial conditions for the 1970-2005 transient simulation. Within each month, the FEFLOW groundwater flow model adjusts the simulation timestep automatically to achieve a proper numerical solution. The groundwater-flow model was configured to export the minimum simulated groundwater level at each municipal well during the simulation.

The results of the drought assessment are shown in Table 4-26. As noted above, the drought assessment is performed using transient recharge rates coupled with both existing and planned pumping rates for the municipal wells within subwatersheds listed in Table 4-26. In this table, the estimated available drawdown and the maximum simulated drawdown over the 1970-2005 period are shown for each municipal well. The available drawdown was estimated based on the assumption that the pump intake is located 2 m above the top of the screened interval (as reported in the Well Water Information System or estimated from available information). If the maximum drawdown is greater than the available drawdown, the well is interpreted to be susceptible to drought conditions and could potentially experience climatic conditions that would deplete its ability to pump at the specified rate. As seen in Table 4-26, there are no municipal wells susceptible to drought conditions under existing or planned pumping conditions; no wells are predicted to experience drawdown that would exceed their estimated available drawdown. As such, the drought assessment does not affect the overall stress level assignment, and the Hewitt's Creek subwatershed remains at a low potential for stress.

Table 4-26: Results of groundwater drought scenario - maximum drawdown (AquaResource and Golder, 2010).

Subwatershed	Municipality	Municipal System	Well Name	Existing Pumping		Planned Pumping		Drought Concern
				Available Drawdown (m)	Maximum Drawdown (m)	Available Drawdown (m)	Maximum Drawdown (m)	
Hewitt's Creek	Innisfil	Innisfil Heights	Well 2	41	28	41	28	N
Hewitt's Creek	Innisfil	Innisfil Heights	Well 3	35	29	35	29	N
Hewitt's Creek	Innisfil	Stroud	Well 1	83	49	83	49	N
Hewitt's Creek	Innisfil	Stroud	Well 2 Standby	79	42	79	42	N
Hewitt's Creek	Innisfil	Stroud	Well 3	82	46	82	46	N

Key points – Factors Impacting Water Quantity status - stressors:

- The water demand estimates for the Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds 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 total groundwater demand from all sources in the Barrie, Lovers, and Hewitt's Creek subwatersheds is 14.8 M m^3/yr.
- Municipal water supply accounts for 98% of the consumption within the Barrie Creek subwatershed. Within Lovers and Hewitt's Creek subwatersheds, municipal water supply accounts for 47%, commercial 44%, and livestock and rural domestic use accounts for 9% of consumption.
- The Barrie Creek subwatershed is predominantly urban while Lovers and Hewitt's Creek are predominantly rural with settlement areas. The subwatersheds contain 75%, 28%, and 25% impervious surfaces, respectively, which is proportional to the amount of urban area.
- The Tier 1 water budget estimated that the current surface water use within the Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds is 1454 m^3/yr, 337,588 m^3/yr, and 9775 m^3/yr respectively, which represents 3.5%, 0.03%, 0.34% of the available surface water supply for those subwatersheds.
- The Tier 2 water budget estimated the current groundwater use for the Barrie Creeks subwatershed is 14,820,000 m^3/yr, which represents 77% of the available annual groundwater supply. The current groundwater use for Lovers and Hewitt's subwatersheds is 662,256 m^3/yr, which is 7% of the available annual groundwater supply. Future groundwater use is projected to increase to 9% of the available groundwater supply for Lovers and Hewitt's.
- The Tier 2 water budget indicated that the Barrie Creeks subwatershed is stressed from a groundwater perspective and requires a more comprehensive review through a Tier 3 Water Budget and Water Quantity Risk Assessment for the City of Barrie. The Tier 3 study is draft at the time this report has been completed but initial results show the Local Area as being classified as having a Low Risk Level. That is, all consumptive water users and potential reductions to groundwater recharge with the Local Area are not classified as significant water quantity threats.
- The preliminary model results from the Tier 3 study indicate where groundwater discharge is predicted to be most sensitive to land use change, and where the City of Barrie and LSRCA may wish to direct efforts to maintain groundwater recharge in the future.
- Initial work on setting targets for maintaining flow regimes that are sufficient to meet ecological needs has been completed for the Lovers Creek. More work needs to be done to fully understand the flow regimes of all of the study subwatersheds before before extending this methodology and setting targets for all three.

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 4-27 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.

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 4-27: 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 4-27, a number of Acts, plans, and policies already exist to protect the quantity of surface and ground water in the Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds. Most of these policy tools are directed toward 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 management. 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 500 m^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 that 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 subwatersheds, which include the Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds. 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 at 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 ground water 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 (Figures 4-15 and 4-16).

In order to support water budgeting and other watershed-scale modelling, 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 subwatersheds. 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, there are a number of regulations and municipal requirements aimed at protecting water quantity of the Barrie, Lovers and Hewitt's Creeks subwatersheds 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 Barrie, Lovers and Hewitt's Creeks subwatersheds, 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 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 – 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, with assistance from LSRCA and MNR, 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 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 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 subwatersheds 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 load 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 Barrie Creeks, Lovers Creek and Hewitt's Creek 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 Barrie Creeks, Lovers Creek and Hewitt's Creek subwatersheds 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 33, 32 and 21 species, respectively, have been captured from the Barrie Creeks, Lovers Creek and Hewitt's Creek subwatersheds 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 large order systems containing such species as largemouth bass (*Micropterus salmoides*) 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 below illustrates the combination of maximum air temperatures versus water temperature at 4pm (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.

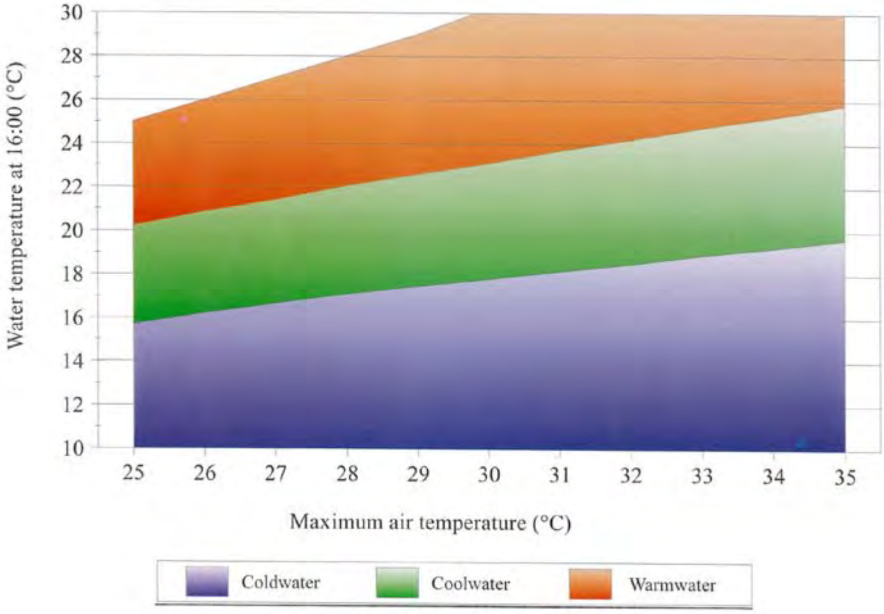


Figure 5-1: Cold, cool and warm water trout stream temperature ranges (Stoneman and Jones, 1996).

Table 5-1: Fish species captured in the Barrie Creeks, Lovers Creek and Hewitt's Creek subwatersheds from 1975-2011.

Fish Species	Barrie Creeks						Lovers Creek	Hewitt's Creek
	Sophia Creek	Kidd's Creek	Bunkers Creek	Dyments Creek	Hotchkiss Creek	Whiskey Creek		
Rainbow trout *(Oncorhynchus mykiss)* ^	*No Fish Captured*						░	
Brook trout *(Salvelinus fontinalis)*		▓			█	▓	▓	░
Rainbow smelt (Osmerus mordax) ^						░		
Northern pike (Esox lucius)		▓	▓					
Central mudminnow *(Umbra limi)*				▓		█	▓	
Common white sucker *(Catostomus commersoni)*			▓	▓	░	█	▓	░
Northern redbelly dace *(Phoxinus eos)*			▓	▓	░	█	▓	▓
Finescale dace (Phoxinus neogaeus)			▓		░		█	░
Brassy minnow *(Hybognathus hankinsoni)*			▓		░		░	▓
Hornyhead chub *(Nocomis biguttatus)*					░		░	░
River chub *(Nocomis micropogon)*							░	
Golden shiner *(Notemigonus crysoleucas)*						░		
Emerald shiner *(Notropis atherinoides)*			▓		█	░	░	
Common shiner *(Luxilus cornutus)*				▓			▓	▓
Blackchin shiner *(Notropis heterodon)*							░	
Blacknose shiner *(Notropis heterolepis)*							░	░
Spottail shiner *(Notropis hudsonius)*			▓			▓		
Rosyface shiner *(Notropis rubellus)*							░	
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)*				▓	░		▓	▓
Stoneroller *(Campostoma anomalum)*					░			
Silver shiner *(Notropis photogenis)*							░	
Brown bullhead *(Ameriurus nebulosus)*							░	
Brook stickleback *(Culaea inconstans)*			▓	▓	░		▓	▓
Trout-perch *(Percopsis omiscomaycus)*			▓		░			
Rock bass *(Ambloplites rupestris)*		▓	▓			░	░	▓
Pumpkinseed *(Lepomis gibbosus)*		▓	▓	▓	█	░	░	▓
Smallmouth bass *(Micropterus dolomieu)*						░	░	

Fish Species	Barrie Creeks						Lovers Creek	Hewitt's Creek
	Sophia Creek	Kidd's Creek	Bunkers Creek	Dyments Creek	Hotchkiss Creek	Whiskey Creek		
Largemouth bass *(Micropterus salmoides)*							░	░
Black crappie *(Pomoxis nigromaculatus)*^						░		
Yellow perch *(Perca flavescens)*		▓	▓					
Rainbow darter (*Etheostoma caeruleum)*							░	
Iowa darter *(Etheostoma exile)*						░	░	░
Johnny darter *(Etheostoma nigrum)*								░
Logperch *(Percina caprodes)*						░		
Mottled sculpin *(Cottus bairdi)*					░	▓	▓	░
Slimy sculpin *(Cottus cognatus)*						░	░	░

■	**Captured historically (before 1990)**
▓	**Captured historically and present day (before and after 1990)**
░	**Captured present day (after 1990)**

^ = Not native to Lake Simcoe Watershed

** = Invasive species*

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 most of the watercourses. Despite this, cold water species, such as brook trout and mottled sculpin, can be found across all three subwatersheds. There are also a number of sites that either have only warm water species or no fish species at all. The dams depicted on the map also 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 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 each of the subwatersheds, as well as a number of sites that were rated as having poor ecological integrity. It is also important to note that all headwater sites within the Barrie Creeks subwatershed had no fish captured.

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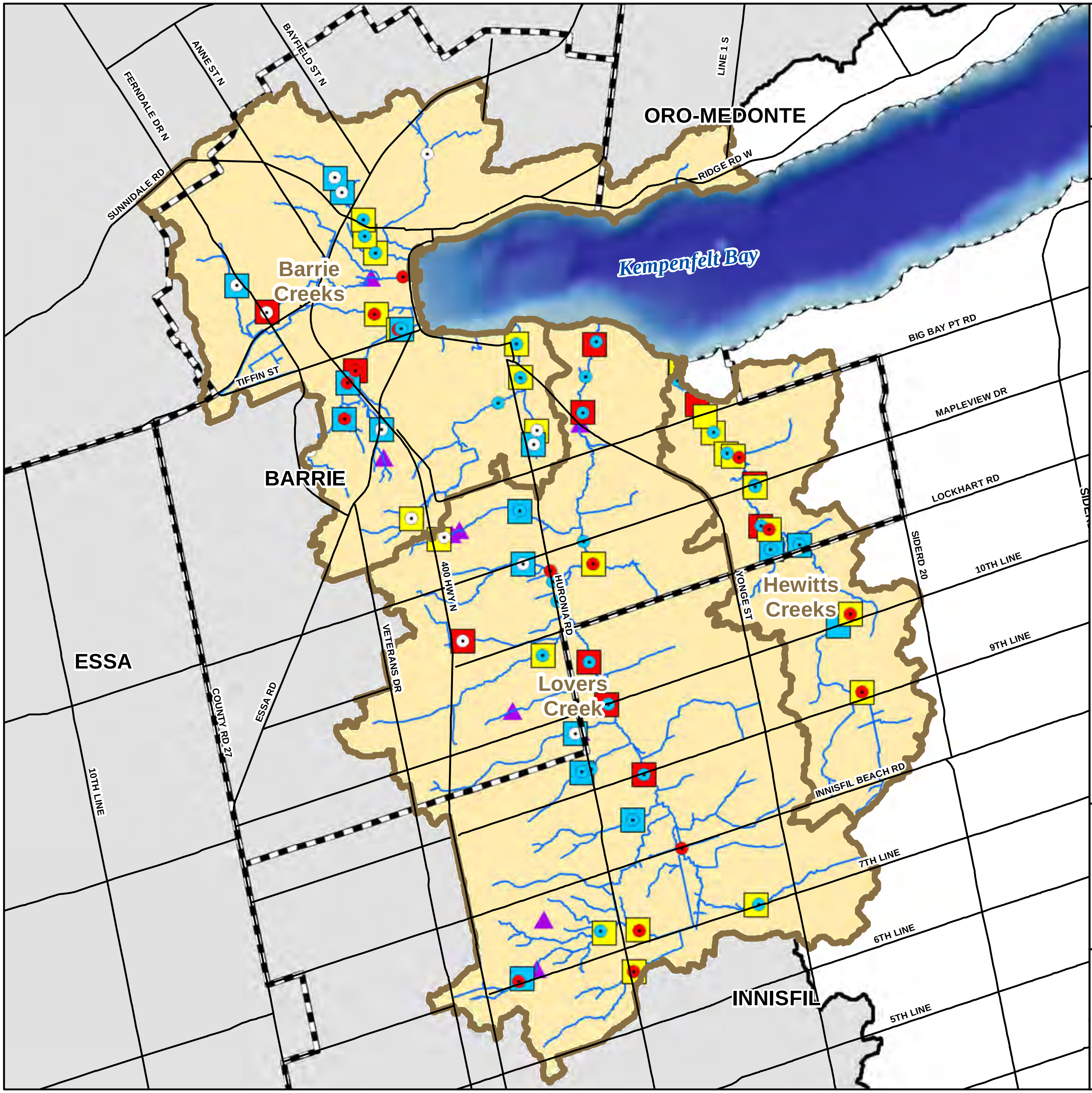
[1] Cold water species are indicators of cold water habitat. Coldwater species found in these subwatersheds include: rainbow trout*, brook trout, rainbow smelt *, mottled sculpin and slimy sculpin (*not native to Lake Simcoe watershed). All others listed in Table 5-2 are either cool or warm water species.

[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.



Occurrence of fish communities in relation to measured water temperature instream

Figure 5-2

Legend

▲ Dam

Fish

- ● Cold
- ○ No Fish
- ● Warm

Temperature

- 🟦 Cold
- 🟨 Cool
- 🟥 Warm

— Road

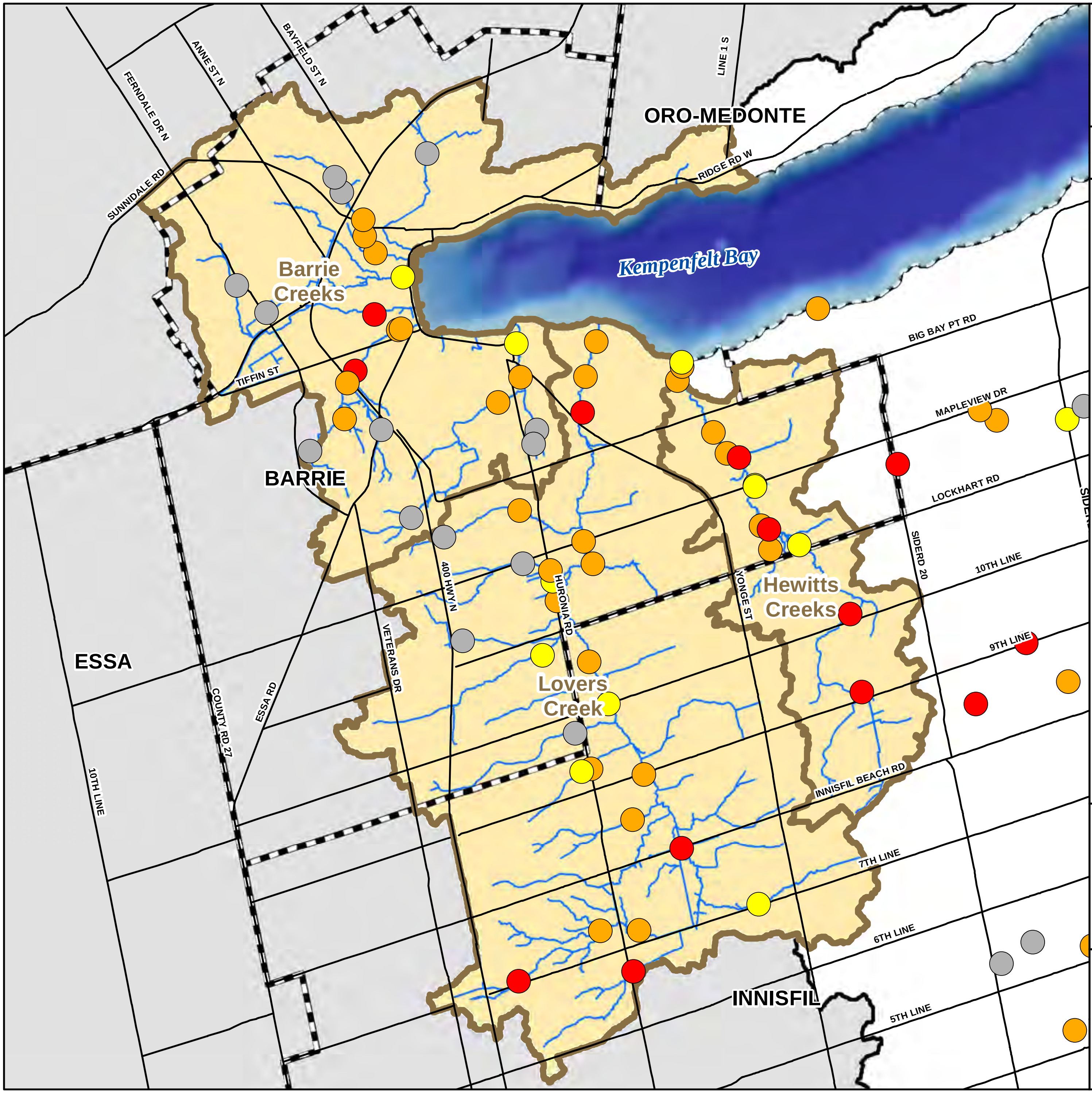
▬ Municipal Boundary

〰 Watercourse

Lake Simcoe Region conservation authority

0 0.5 1 2 3 4 Kilometres

N



Ecological integrity of stream sites based on fish community conditions assessed using an Index of Biotic Integrity (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 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 2011.

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 Barrie Creeks, Lovers Creek and Hewitt's Creek subwatersheds, 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). Only Hotchkiss Creek no longer has brook trout.

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.

Brook Trout (*Salvelinus fontinalis*)

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.

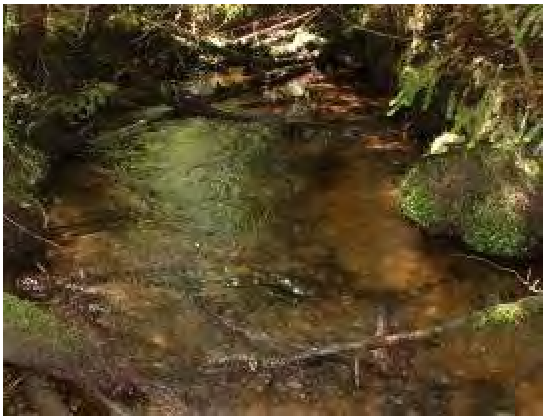
Groundwater-based streams tend to be less variable both in flow and temperature. Because groundwater originates below ground surface, it is not subject to the extremes in heat and cold that a watercourse would be. Typically the temperature of groundwater is cooler in the summer and warmer in the winter 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 spawning over groundwater upwelling site

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, changes in pH and decreases in water quality. These changes are most often related to changes in land use through land development or intensified 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 also another significant factor, 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 Barrie Creeks, Lovers Creek and Hewitt's Creek subwatersheds

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 Kilometres

N

Historic and current presence of mottled sculpin in the Barrie Creeks, Lovers Creek and Hewitt's Creek subwatersheds

Figure 5-5

Legend

— Road

▬ Municipal Boundary

〰 Watercourse

■ Current Mottled Sculpin

▲ Historic Mottled Sculpin

Lake Simcoe Region conservation authority

0 0.5 1 2 3 4 Kilometres

N

5.2.1.2 Benthic invertebrate community

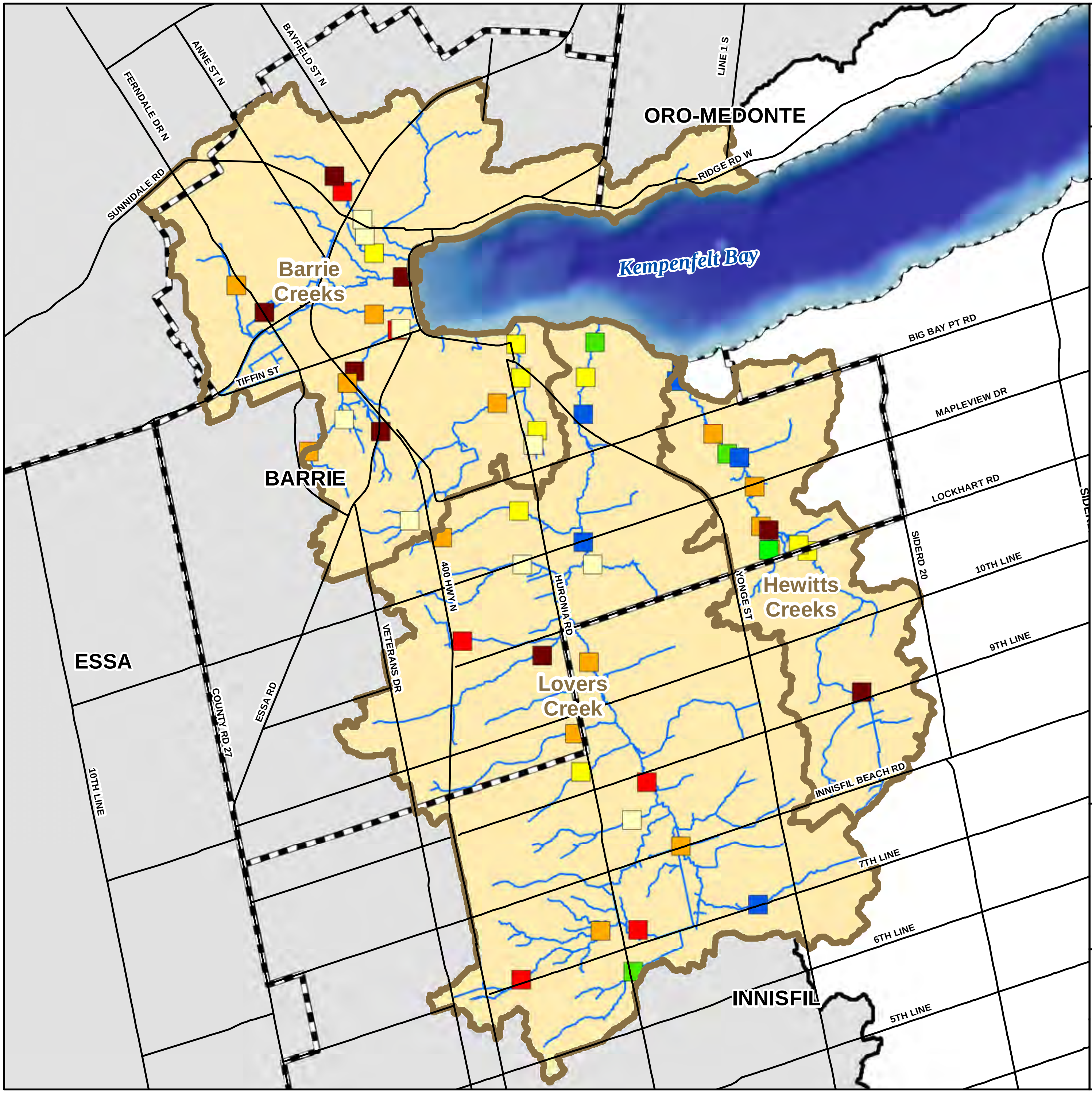
Aquatic insects, or benthic invertebrates, are an ideal indicator of water quality as different species have different tolerances to factors such as nutrient enrichment, dissolved solids, oxygen and temperature. The presence or absence of certain species is used to determine water quality at a given 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 poor across the Barrie Creeks subwatershed. Lovers Creek has a number of sites with very good ratings and one site with excellent conditions. Hewitt's Creek is mainly rated as fair to good, with the site closest to the mouth being excellent and the site closest to the headwaters rated as poor.

When using 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 to 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 Biotic Index (HBI)

Figure 5-6

Legend

Hilsenhoff 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 Kilometres

N

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5.2.1.3 Algae as an indicator of ecological condition

An additional study completed only in Lovers Creek was to look at the algae composition. Siliceous microalgae such as diatoms (Bacillariophyta) and scaled-chrysophytes (Chrysophyta) are key biological indicators of ecological status and environmental change in freshwater habitats. In addition to having well quantified responses to many limnological variables, they have a rapid response time to changing conditions (less than 24 hours) and can be used as an inexpensive tool for rapid environmental assessments. The LSRCA Lake Science Research and Monitoring Program has, since May 2008, been developing these algal groups as key indicators in monitoring environmental conditions in Lake Simcoe and its tributaries. The importance of these indicators has been recognized by the development of an Ontario Provincial Algae Bioassessment Protocol, and their inclusion and wide application across the United States and Europe. In general, these indicators can detect statistically significant environmental changes which directly impact the biological communities of the ecosystem of interest.

To date, results of the study have successfully reconstructed measured environmental conditions. The most successful environmental variables are: Index of Development ($r^2 = 0.45$)[3]; pH ($r^2 = 0.53$); alkalinity ($r^2 = 0.66$); nutrients (total phosphorus, $r^2 = 0.50$; total Kjehldahl nitrogen, $r^2 = 0.60$); specific conductance ($r^2 = 0.79$); and metal contamination (e.g. aluminum $r^2 = 0.51$). Further work includes fine tuning the species – variable calibration set, and using other biological indicators (e.g. thecamoebians [group of unicellular protozoa in the water that are sensitive to environmental changes], which are successful at reconstructing oxygen concentrations and detecting hypoxic / anoxic events which can result in fish kills). Results specific to the samples taken in Lovers Creek are available in Section 5.4.2.

Future work will be to narrow down what species give the most accurate results, so that eventually these samples can be used to determine what the changes are in the system. Once finalized, this type of sampling is faster and more economical than the multiple water chemistry samples currently taken today.

5.2.2 Overview of aquatic communities – Lake Nearshore

In addition to assessing the tributaries within the subwatersheds, 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, one of which is the Barrie

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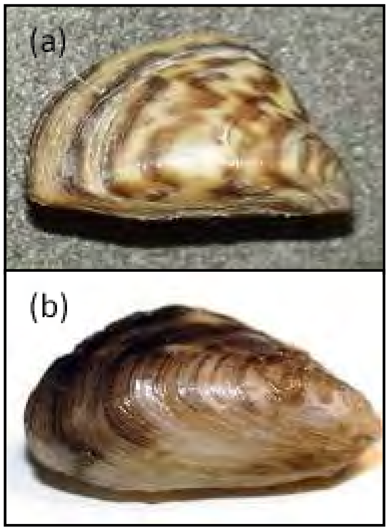
[3] r^2 values are a measure of how well the model reconstructs the variable and ranges from 0 (no correlation) to 1 (perfect correlation).

shoreline, in particular on the south shore of Kempenfelt Bay (Figure 5-7a). While this area has a very small zone available for aquatic plant colonization due to the quick drop in depth, excess nutrient run-off into Lake Simcoe (the Barrie Creeks subwatershed contributes an estimated 4.5[4] tonnes of phosphorus per year, while Lovers and Hewitt's contribute 0.8 and 0.4 tonnes of phosphorus per year, respectively[5] [values are based on modelled, three year average from 2004-2007]), soft substrates, and the high light transparency of the water provide optimal conditions for plant growth. If the aquatic plant community changes in this area correspond to those in Cook's Bay, then the biomass of aquatic plants has increased three-fold since the 1980s as well. This is likely due to zebra mussels (*Dreissenia polymorpha*) clearing the water and creating ideal habitat for plant growth. The invasive species, eurasian watermilfoil (*Myriophyllum spicatum*), likely invaded this area and displaced any native species.

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 Barrie shoreline, mean sediment nutrient concentrations are relatively high with total phosphorus (TP) ~1.1 mg/g, likely due to soft, muddy substrates which hold more nutrients than coarser grained sediments (Figure 5-7c). For comparison, across the lake concentrations range from TP ~0.35 mg/g in Cook's Bay to ~1.4 mg/g near Beaverton. (For details on the total phosphorus within the tributaries please refer to **Chapter 3 - Water Quality**).

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



Two invasive mussel species in Lake Simcoe: (a) zebra mussel; (b) quagga mussel.

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[4] This total does not include Water Pollution Control Plants (WPCP) or septic systems
[5] This total does not include septic systems

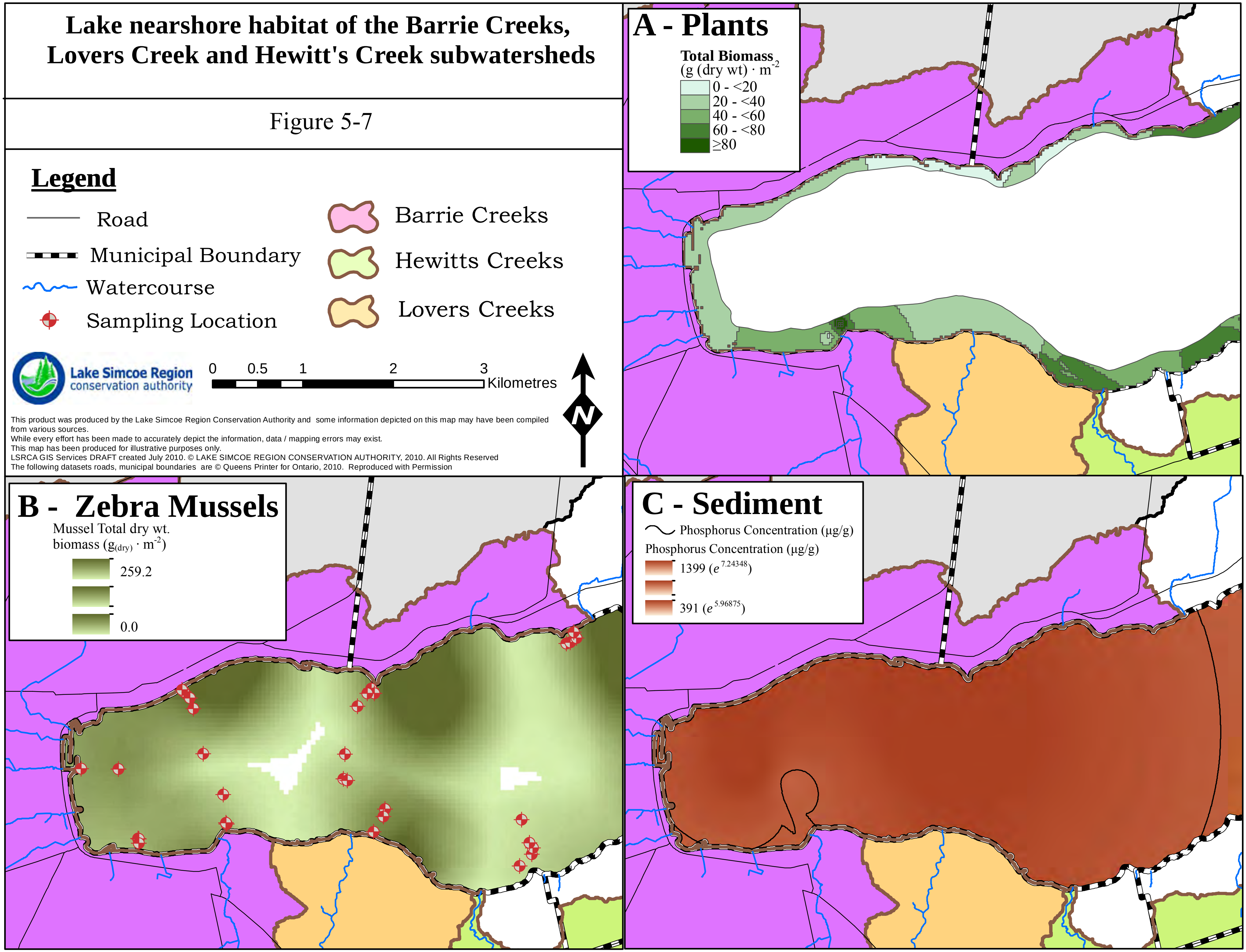
initial invasions in 1995 (zebra mussel) and 2004 (quagga mussel), these two species have colonized a large portion of the lake area and have caused significant ecological changes, in particular to native food webs, shifted energy flow from shallow to deep water, and increased the penetration of sunlight into the water column. The changes have resulted in a hardening of the 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. Along the Barrie shoreline, Kempenfelt Bay is an exception with dreissenids being found growing in clumps on softer substrates 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 listed, the shoreline along the City of Barrie is considered to be in poor condition.

Lake nearshore habitat of the Barrie Creeks, Lovers Creek and Hewitt's Creek subwatersheds

Figure 5-7



5.2.3 Rare and Endangered Species

There are no known aquatic Species at Risk in the Barrie Creeks, Lovers Creek, or Hewitt's Creek subwatersheds.

Key Points - Current Aquatic Natural Heritage Status:

- While there are no specific studies on the spawning of species for these subwatersheds, there is evidence indicating that brook trout may be successfully spawning and surviving in Kidd's and Whiskey Creek.
- Barrie Creeks is a diverse area with six main (and two smaller) tributaries spread across the subwatershed. The conditions of the creeks varies from Sophia Creek, which is in the poorest condition with no fish having been captured and much of the watercourse being altered, to Whiskey and Kidd's Creek, which both have generally good conditions near the mouth but poorer conditions closer to the headwaters.
- Kidd's, Hotchkiss and Whiskey Creeks all have historical presence of brook trout (a key indicator species), with only Hotchkiss no longer having a current population. Hotchkiss does have historical and current presence of mottled sculpin though, as does Whiskey Creek.
- The condition of Lovers Creek, with 26 monitoring stations, varies along the main branch and along the tributaries. Fish and benthic data are somewhat different in their results. Along the main branch fish communities average around 'fair'. For benthic communities, sites are ranked as 'very good' near the mouth, while they vary between 'fairly poor' and 'good' in the headwaters on the various branches.
- Lovers Creek has both historical and current presence of the key indicator species, brook trout and mottled sculpin. Each of current populations are in the same areas as their historic populations, with the exception of brook trout which are no longer found in the headwaters
- Hewitt's Creek, with 14 monitoring sites, also has a varied rating along the main branch, but averages around fair. Even though there are few barriers to fish movement and little bank hardening or channelization, the ecological integrity of the system, based on the analyses of the fish and benthic communities, range from poor to excellent.
- Hewitt's Creek has both historical and current presence of the key indicator species, brook trout and mottled sculpin, with each of current populations in the same areas as their historic populations.
- 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 data is not available to pinpoint when shifts take place and what caused them to do so.
- The lake nearshore community around the City of Barrie shoreline is in relatively poor condition based on having a substantial increase in plant biomass, high sediment nutrient concentrations and presence of aquatic invasive species.

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:

- Barriers,
- Bank hardening and channelization,
- Enclosures,
- Flow diversion,
- Uncontrolled stormwater and impervious surfaces,
- Municipal drains,
- Removal of riparian vegetation,
- Water quality and thermal degradation,
- Loss of wetlands,
- Invasive species, and
- Climate change.

These factors are discussed in detail in the following sections:

5.3.1 Barriers

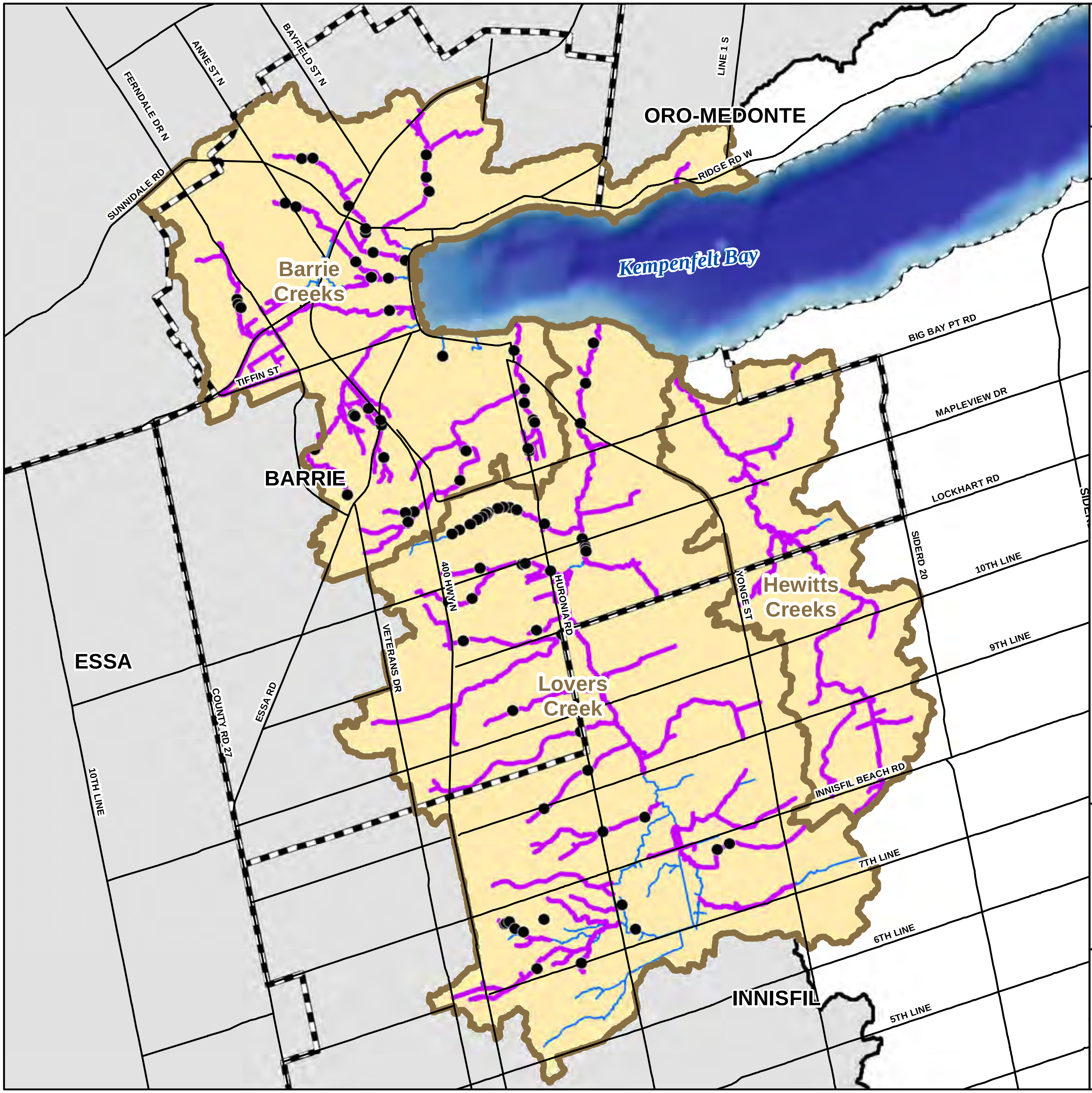
Barriers to fish movement in the form of dams, perched culverts, and enclosed watercourses serve to fragment the fish community by preventing fish from accessing important parts of their habitat. The impoundments created by dams serve to increase water temperatures, raise bacteria levels, and disrupt 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 92%, 76% and 100% of the watercourses in the Barrie Creeks, Lovers Creek and Hewitt's Creek subwatersheds, respectively.

The BMP Inventory has identified 40, 56, and 3 barriers to fish movement, respectively, in the Barrie Creeks, Lovers Creek and Hewitt's Creek subwatersheds thus far (Figure 5-8).

Barriers to fish movement in the Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds

Figure 5-8



Legend

●	Barrier
—	Road
▬ ▬	Municipal Boundary
〰	BMP Watercourse Surveyed
〰	Watercourse

Lake Simcoe Region conservation authority

0 0.5 1 2 3 4 Kilometres

N

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5.3.2 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.

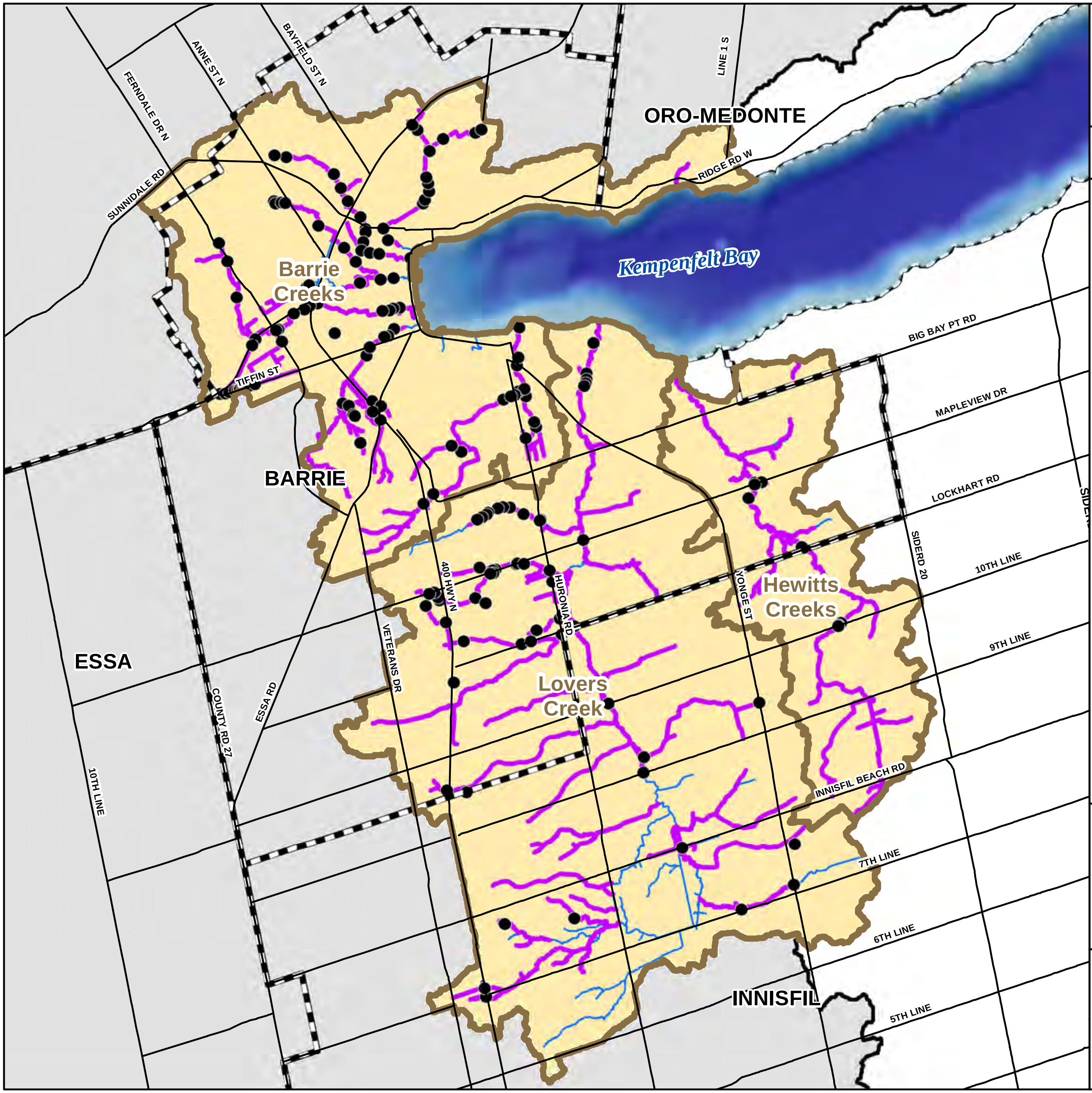
Water generally flows more quickly through a channelized section of stream, particularly during high flow events. This increase in flow can have several effects:

- 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 section
- Sedimentation downstream of the channelized section 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 144, 66 and 9 channelized and hardened sections of stream identified in the Barrie Creeks, Lovers Creek and Hewitt's Creek subwatersheds through the BMP Inventory. These are depicted in Figure 5-9. Most sites in Barrie Creeks were located along the main branches. On Lovers Creek, channelized and hardened sections were mainly found around the north western branches, with a few scattered along the main branch. All nine of the documented channelized and hardened sections of Hewitt's Creek were found along the main branch.

Of the number of sites identified to have bank hardening (99, 59, and 9 in the Barrie Creeks, Lovers Creek and Hewitt's Creek subwatersheds respectively) 52, 17, and 1 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 (92%, 76%, 100%) within the Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds, the total number of river sections that have been identified as 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.



Bank hardening and / or channelization in the Barrie Creeks, Lovers Creek and Hewitt's Creek subwatershed

Figure 5-9

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
Kilometres

N

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Figure 5-10: Example of barrier, bank hardening, and channelization on Kidd's Creek downstream of Thompson St, Barrie.

5.3.3 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 Kidd's and Sophia Creeks, the enclosure of a significant part of the mouth of creek 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.

The City of Barrie and partners have conducted several projects wherein these enclosures have been removed or "day lighted". This practice should continue to be encouraged and supported.

5.3.4 Flow diversion

Past development practices have facilitated the diversion of flows from one watershed to another. This is the case in both Kidd's and Hotchkiss Creeks wherein a significant portion of the drainage has been moved from the Nottawasaga River watershed into the Lake Simcoe watershed. Watercourses suffer as these flows must be attenuated by a system that was not naturally "designed" to handle increased flows. This practice leads to increased erosion, advanced and frequent changes to channel morphology and a change of temperature regimes. This practice is no longer permitted by regulating agencies.

5.3.5 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 waterbodies. 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 (discussed in more depth in **Chapter 3 – 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 5-11).

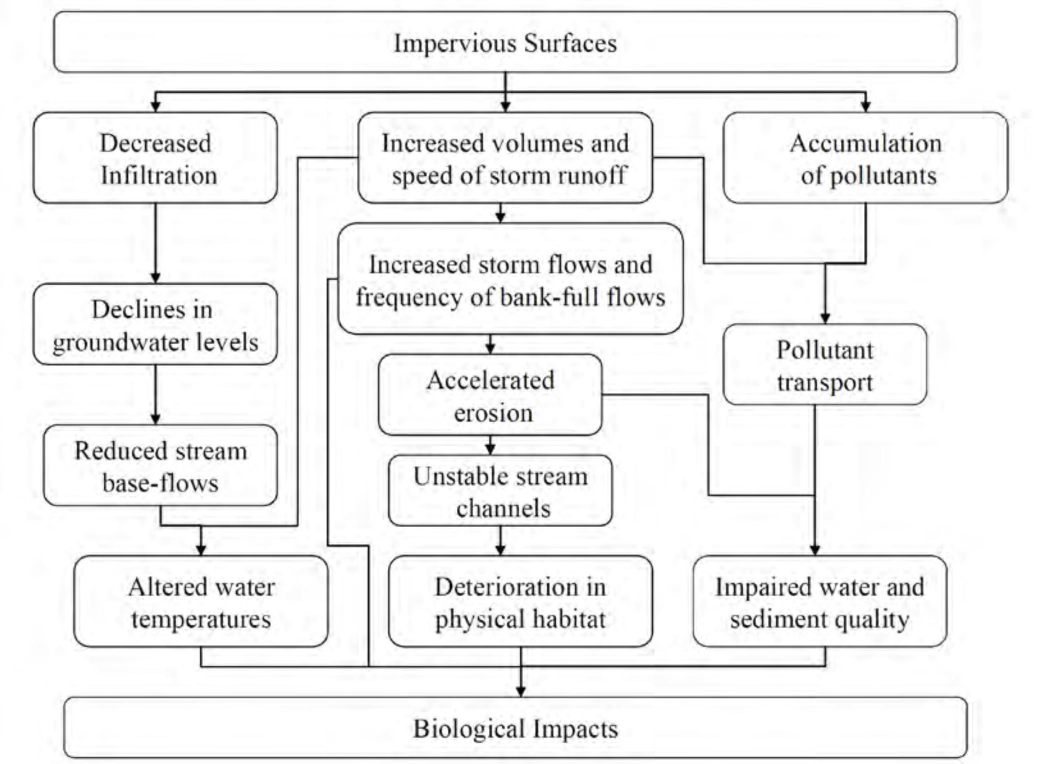

Figure 5-11: Pathways by which impervious surfaces may impact aquatic biological communities (ORMCP Technical Paper Series, #13).

5.3.6 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. Currently, 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 5-12 illustrates the municipal drains in the Lovers Creek and Hewitt's Creek subwatersheds, based on their drain type classification. There are no municipal drains in the Barrie Creeks subwatershed.

The upstream portion of Lovers Creek (from Lockhart Rd to the headwaters), which is approximately 11% of the total stream length, has been designated as Type D municipal drain. Similarly, Hewitt's Creek, from Lockhart Rd to headwaters, has been designated as municipal drain. As this section (29% of the creek) is dry for more than two consecutive months during the year, it is a Type F municipal drain.

Municipal drains in the Barrie Creeks, Lovers Creek and Hewitt's Creek subwatersheds

Figure 5-12

Legend

— Road

▬ Municipal Boundary

〰 Watercourse

Drain Class

〰 A

〰 B

〰 C

〰 D

〰 E

〰 F

⬭ Subwatersheds

Lake Simcoe Region conservation authority

0 0.5 1 2 3 4 Kilometres

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5.3.7 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.

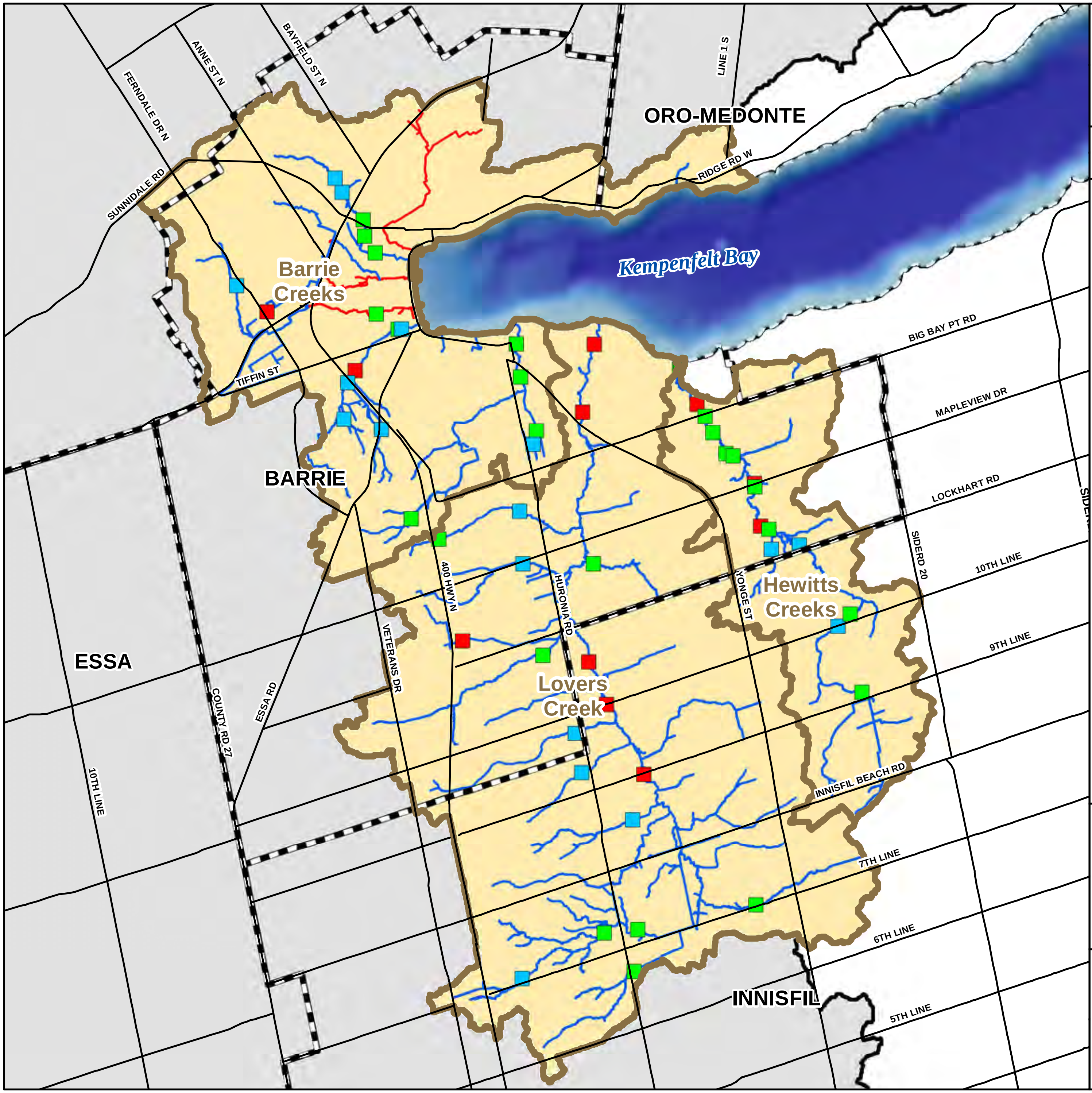
5.3.8 Water quality and thermal degradation

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 these subwatersheds 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 a refuge 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 5-13 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 Barrie Creeks, Lovers Creek and Hewitt's Creek subwatersheds

Figure 5-13

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

Kilometres

N

5.3.9 Loss of wetlands

While the current status and stressors to wetlands are covered are 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.

5.3.10 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.

Up until 2010, there were no known invasive fish species within the Barrie Creeks, Lovers Creek and Hewitt's Creek subwatersheds. During the 2011 sampling season, round goby (*Neogobius melanostomus*) was found at the mouth of both Lovers and Hewitt's Creek. The round goby is native to Europe and was released into Canadian waters via ballast from international ships. Round gobies are an aggressive and fertile sculpin-like species that can out-compete native species for space and food. It is suspected that bait fisherman may have been responsible for importing this fish from Lake Erie and the Lake St. Clair Drainage, an illegal source of baitfish for Lake Simcoe.

To date, the only invasive benthic invertebrate species that has been caught is in the Lovers Creek subwatershed is the rusty crayfish, a species native to the Ohio, Kentucky, and Tennessee regions. It is thought to have been introduced in the 1960s by non-resident fishermen who used it as bait. Rusty crayfish have a number of characteristics that are cause for concern: they feed heavily on aquatic plants and other benthic invertebrates, thus disturbing the dynamics of the ecosystem - they are competition for native crayfish as well as juvenile fish; aggressively chase native species from the best daytime hiding spots, leaving the native crayfish more vulnerable to predation; and are also more aggressive when under attack by fish and are thus less likely to be preyed upon. In addition, they are able to mate with native species of crayfish, a process that may hasten the local extinction of the native species.

There have also been 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*),
- Round Goby (*Neogobius melanostomus*),
- Spiny Waterflea (*Bythotrephes longimanus*),
- Rusty Crayfish (*Orconectes rusticus*),
- Zebra Mussel (*Dreissenian polymorpha*),
- 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 (A).
- 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 (B).
- 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 (C).

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 towards 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.

5.3.11 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 are likely still going to be able to 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 subwatersheds such as the Barrie Creeks and Lovers Creek subwatersheds, which have high groundwater potential discharge, as expressed as a base flow index in Table 5-3, could offer thermal refuge for coldwater species, also suggesting that there may be enough resilience to be able to maintain the coldwater attributes in the Barrie Creeks and Lovers Creek subwatersheds over time. Hewitt's Creek on the other hand has a low base flow index, indicating that the likelihood of retaining cold water species is low.

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**
Barrie Creeks	0.663	25.79	27.51	28.14
Lovers Creek	0.594	25.83	27.63	28.22
Hewitt's Creek	0.350	25.84	27.62	28.20

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 these subwatersheds.

Key Points – Factors Impacting Aquatic Natural Heritage – stressors:

- There are many stressors to the aquatic natural heritage systems in these subwatersheds, many of which result in a cumulative impact.
- Physical changes such as barriers, bank hardening, channelization and the removal of riparian vegetation are some of the most significant stressors in these subwatersheds, particularly in Barrie Creeks. Historical changes, such as the diversion of flows and enclosures of stream sections also play a large role in the current conditions of the systems.
- Habitat quality and quantity are also impacted by changes in flow regime resulting from land use changes, stream alterations, municipal drains, loss of nearby wetlands (particularly in the headwaters), 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.
- Up until 2010, there were no known invasive fish species within the Barrie Creeks, Lovers Creek and Hewitt's Creek subwatersheds, but during the 2011 sampling season round goby was found at the mouth of both Lovers and Hewitt's Creek. The only invasive benthic invertebrate species that has been caught is in the Lovers Creek subwatershed and is the rusty crayfish. If these invasive populations increase, it is likely they will negatively affect native communities by occupying and/or destroying the habitat of native species, consuming their eggs and young, and by out-competing them for resources
- The emerging threat of climate change will interact with all of these threats, creating additional long-term stresses on the aquatic systems. Although research in this area is still emerging, initial predictions suggest the Barrie Creeks and Lovers Creek subwatersheds may have enough resilience to maintain cold water attributes, while Hewitt's Creek is at risk of losing its cold water fish communities.

5.4 Assessment of Tributaries

As described in the following sections, each of the creeks is individually assessed based on the aforementioned analyses, as well as incorporating land use and soil information from Figures 2-8 and 2-26, **Chapter 2 – Study Area** and potential recharge and discharge areas on Figures 4-13 and 4-11, **Chapter 4 – Water Quantity**. Stressors in each of the creeks are also included to create a complete picture of the system. 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.

5.4.1 Barrie Creeks subwatershed

As the Barrie Creeks subwatershed is a diverse area and the six main (and two smaller) tributaries are spread across the subwatershed, they are assessed individually to give a closer look at the conditions across the subwatershed.

Sophia Creek

Sophia Creek, located at the northern end of the Barrie Creeks subwatershed, is a warm water creek with one monitoring site (Figure 5-2). Its headwaters are located in a silty clay loam soil with very slow infiltration rates. Further downstream, from the midpoint to the mouth, the soil type changes to loamy sand with high infiltration rates. Corresponding with the slow infiltration rates, there is a potential discharge area along the left branch of the headwaters, as well as in the lower reach, while in areas of higher infiltration (closer to the mouth) there are a few small potential recharge areas. The IBI analysis on the fish communities, based on the one monitoring site, indicates that the ecological integrity at that site is in very poor condition as no fish have been captured (Figure 5-3). Benthic invertebrate studies have not been completed for this creek.

As the entire creek is surrounded by urban land use, the aquatic habitats within this system have been adversely affected by urban development. The headwaters of this creek dry up during the summer months and much of the watercourse is enclosed, with three consecutive barriers to fish movement where it is open, starting midway up the watercourse to the confluence of the headwater branches (Figure 5-8). A large portion of the creek has also been altered by bank hardening or channelization, including the headwaters and the previously mentioned discharge area (Figure 5-9). These stressors, in combination with historical stream alterations and low flow, have created an extremely poor system that is unlikely to be able to support a healthy aquatic community.

Kidd's Creek

Kidd's Creek is a cold water system located to the west of Sophia Creek, with five monitoring sites. The entire system is located in loamy sand with high infiltration rates. Areas of potential recharge are located across the headwaters and main branch until Hwy 400, while potential discharge areas are along the lower reach, all downstream of Hwy 400. The upper reaches of the creek are in natural heritage settings, with all of the headwaters in a large online quantity stormwater management (SWM) pond. The majority of the lower reach is surrounded by urban land use.

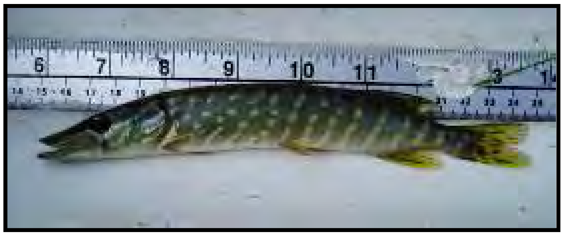
The Index of Biotic Integrity (IBI) evaluation done on the fish communities to evaluate the ecological integrity of the creek labels the portion of the creek downstream of Hwy 400 as 'fair'. The two sites closest to the headwaters (upstream of Highway 400) had no fish captured (Figure 5-3). Fish species are unable to access these upstream sites because of barriers, dams and enclosed sections. Poor water quality and limited water quantity may also cause fish to be absent from the stream. Looking at the Hilsenhoff (benthics) index, the creek ranges from fairly poor at the site closest to the headwaters, up to good for the next three sites and fair for the site closest to the mouth (Figure 5-6).

Historically brook trout were caught upstream of the 400, but are now found only at the three sites downstream of the 400. The majority of the brook trout caught were young of the year, indicating that this indicator species is successfully using this stream to spawn (Figure 5-4). Additionally, with discharge areas in the lower reaches, there may be upwellings in the area that would support cold water species, such as brook trout, and maintain their resident population in this area.

Mouth of Kidd's Creek into Kempenfelt Bay

Downstream of Hwy 400 water temperatures increase from cold to cool water temperatures, indicating thermal degradation of the system could be occurring after passing under the highway (Figure 5-13). There are seven barriers to fish movement, with one right at the mouth and the rest spread out along the creek (Figure 5-8). Much of the main section of the creek has had its banks hardened or channelized (Figure 5-9).

From **Chapter 2 – Study Area**, we know that the creek is an anomaly with a very low drainage density and moderate average stream slope. This can likely be attributed to parts of the creek being enclosed during urbanization which has subsequently decreased the stream length and in turn the drainage density. Results of having a lower drainage density include slower velocities and less riffle areas, creating less than ideal habitat for benthic invertebrates and some fish species. Additionally, with the headwaters in a SWM pond, any heavy precipitation events cause a large quantity of water, moving at higher than normal velocities, to push through the upper reaches creating an unstable environment for both fish and benthic communities.



Northern pike (*Esox lucius*)

Overall, the aquatic habitat of Kidd's Creek downstream of Hwy 400 is in fairly good condition based on the presence of cold water species in the lower reaches and rather healthy benthic communities. Despite cold water temperatures, the reaches upstream of Hwy 400 are in poorer condition, due to barriers and the SWM pond in the headwaters, indicated by the lack of fish presence and poorer benthic conditions.

Bunkers Creek

Bunkers Creek is located in the centre of the Barrie Creeks subwatershed and has two monitoring stations (one at the mouth and one in the southern branch headwaters). With the steepest slope of all the Barrie Creeks, it has the second highest drainage density, creating a more 'flashy' system during precipitation events. Both the northern and southern branches are cold water, but the southern, main branch changes to warm water habitat downstream of Hwy 400. The northern branch remains cold water until connecting with the main branch. The soil type varies along the creek. Near the mouth, the soil is organic with moderate infiltration rates, the middle and northern branch headwaters are in loamy sand (high infiltration rates), while the southern headwaters are in sandy loam with moderate infiltration rates. There are a few potential recharge areas along the northern branch (corresponding with the high infiltration rates), but the majority of the creek has potential discharge areas, which correspond to the coldwater branches. It may also indicate that the main branch, which is historically warm water, may have cold water attributes along its length.

Fish were only captured at the site closest to the mouth and consisted only of warm water species. A dam located along the southern branch (just before the confluence of the two branches) and the enclosed sections of the creek may be preventing fish from reaching the second monitoring site at the end of that branch (Figure 5-2). No brook trout, mottled sculpin or other cold water species were captured in historical or current data for this creek (Figure 5-4, Figure 5-5). The IBI analysis on the fish communities, based on the site closest to the mouth, indicate that the ecological integrity at that site is good (Figure 5-3), while the Hilsenhoff analysis on the benthic communities, based on both the site near the mouth and site at the headwaters, suggest that it is poor (Figure 5-6). As mentioned previously, a possible reason for the discrepancy between the ratings for the fish and benthic communities is that fish are more mobile than then benthic invertebrates and can move easily if habitat quality decreases. With a 'flashy' system like this, there may be inputs that cause periodic stress to the creek, impacting sessile species while mobile ones remain healthy. While the fish community appears to be healthy at the mouth, no fish are present in the headwaters and it is likely that the system is under more constant stress that shows more readily in the benthic communities.

In addition to the dam, there are approximately five more barriers to fish movement (Figure 5-8) as well as bank hardening and channelization along a significant portion of the creek (Figure 5-9). Thermal degradation of the system is another potential source of stress on the system as warm water temperatures are recorded at the site in the southern headwaters that are historically a cold water section of the creek (Figure 5-13). As most of the creek is surrounded by urban land use, with only small sections having natural heritage cover, urban development is likely also impacting the system.

Yellow perch (*Perca flavescens*)

Overall, aquatic communities are showing signs of being stressed as benthics are poor and fish have not been captured in the upper reaches. Despite having discharge areas along most of the creek that would typically be associated with cold upwelling areas, no cold water species have been captured. Only the site near the mouth had a good rating for fish and this is likely due to the abundance and diversity of lake species present, and does not likely reflect the condition of Bunkers Creek much beyond this point.

Dyments Creek

Dyments Creek is located in the south central area of the Barrie Creeks subwatershed and has two monitoring stations (one near the mouth and one near the headwaters of the northern branch). From the headwaters to Hwy 400, the creek is a coldwater system, while downstream of Hwy 400 to the mouth it is warm water. Soil type varies along the creek with the northern branch headwaters in loamy sand (high infiltration), southern branch headwaters in organics (moderate to high infiltration), and the main branch coming east through sandy loam (moderate infiltration), into loamy sand (high infiltration) ending with the mouth in organics (moderate infiltration). Potential recharge areas are located at the northern branch headwaters where there is high infiltration, while potential discharge areas are found from the confluence of the branches to the mouth of the creek into Kempenfelt Bay. Land use around the creek varies from urban around the mouth and main branch, to natural heritage cover along the headwater branches and aggregate land use along the northern branch headwaters.

No fish were captured at the headwaters monitoring site, and those captured at the site closest to the mouth were all warm water species (Figure 5-2). No brook trout, mottled sculpin or other cold water species were captured in historical or current data for this creek (Figure 5-4, Figure 5-5). The IBI analysis of the fish community at the site near the mouth indicates that the ecological integrity of the creek is poor at this location (Figure 5-3). This is confirmed by the Hilsenhoff analysis of benthics, which also indicated that the site near the mouth is fairly poor (Figure 5-6), a decrease from the fair rating given to the site close to the headwaters.

Pumpkinseed (*Lepomis gibbosus*)

There are four barriers to fish movement, one near the mouth and three up the northern branch (Figure 5-8). Bank hardening and channelization had occurred along portions of the creek and despite having a low average stream slope (0.93%), this creek exhibits an extremely high drainage density (1.810 km/km^2) that is likely due to the exclusion of the headwater reach that had been enclosed during urbanization (Figure 5-9). At the monitoring site upstream of Hwy 400, the creek was recorded as being coldwater habitat, increasing only to cool water after passing under the highway. Although this part of the creek is managed as a warm water system, it seems it has cold water attributes along its length, perhaps due to the surrounding potential discharge areas. As such, it does not appear that thermal degradation is causing stress to the aquatic communities (Figure 5-13).

Overall, Dyments Creek has stressed aquatic communities, with poor fish conditions near the mouth and zero fish presence in the headwaters, degraded benthic communities (indicating significant organic pollution) and stream alterations along its length.

Hotchkiss Creek

Hotchkiss Creek is a cold water system located in the southern part of the Barrie Creeks subwatershed and has seven monitoring sites spread out from the mouth to up near the headwaters. With the second steepest slope of all the Barrie creeks, Hotchkiss has the highest drainage density. The creek runs mostly through loamy sand (high infiltration), with a small section in the upper reaches in sandy loam (moderate infiltration) and the area surrounding the mouth of the creek being organics (moderate infiltration). There are a few potential recharge areas mainly near the headwaters, while potential discharge areas are focused around the lower portion and mouth. Mostly urban land use surrounds the creek with small patches of natural heritage cover in the vicinity of the headwaters.

Mouth of Hotchkiss Creek into Kempenfelt Bay

No fish were captured at the two sites closest to the headwaters and the majority of the other sites had only warm water species (Figure 5-2). The monitoring site closest to the mouth had cold water species captured, including mottled sculpin which has historically been caught in this creek as well (Figure 5-5). Brook trout were captured back in 1975, but have not been found since (Figure 5-4). The IBI analysis of those sites with fish has generally described the creek as being in 'fair' condition, with the exception of the site after Hwy 400 which is listed as having poor ecological integrity (Figure 5-3). The analysis of the benthic community (Hilsenhoff) is a little more variable with the two sites closest to the headwaters being listed as poor and fairly poor, becoming fair at the site upstream of Hwy 400 and poor at the next site downstream. There is a slight increase in quality to fairly poor at the next site, and the monitoring site closest to the mouth is characterized as good (Figure 5-6).

Of the five sites with temperature loggers, only the one located downstream of Hwy 400 recorded warm water temperatures. The thermal degradation at this site could be discouraging cold water species from migrating further upstream where temperatures are cold (Figure 5-13).There is a dam at the end of one of the eastern tributaries, but as no fish were captured downstream of this point it is likely not blocking any fish passage at the current time. Other barriers to fish movement are along the upper tributaries and near the headwaters (Figure 5-8). Bank hardening and channelization are present along the lower reaches and the upper tributaries (Figure 5-9). Some of the alterations are historic changes from when flows were diverted away from the Nottawasaga Basin to this system.

White sucker (*Catostomus commersoni*)

Overall, there is a range of conditions along Hotchkiss Creek, with stressed aquatic communities in the headwaters, where both fish and benthic indices are poor, and slightly better conditions mid reach and at the mouth. The main area of concern is in the vicinity of the site downstream of the passage under Hwy 400, as there is apparent thermal degradation, low abundance and diversity of fish, and significant organic pollution (as determined by the benthic index).

Holgate Creek

Holgate Creek, located east of Hotchkiss Creek, is a coldwater creek and has no monitoring sites (Figure 5-2). The creek flows through gravelly sandy loam with high infiltration rates and is surrounded by urban land use. There is a potential recharge area across most of the creek and a small sliver of potential discharge area at the mouth.

This creek was not surveyed in the LSRCA BMP Inventory (2009), but there is one known barrier at the headwaters. Because the majority of the creek is enclosed there is no fish, benthic or current temperature data available and it is very unlikely that there is any suitable aquatic habitat within this system.

Huronia Creek

Huronia Creek is a coldwater system located between Holgate and Whiskey Creek with no monitoring stations (Figure 5-2). The creek flows through gravelly sandy loam with high infiltration rates and is mostly surrounded by urban land use with natural heritage features in its headwaters. Potential recharge areas cover most of the creek, while there are no potential discharge areas.

This creek was not surveyed in the LSRCA BMP Inventory (2009) and the instances of barriers, bank hardening and channelization are unknown. Like Holgate Creek, the majority of the creek is enclosed and subsequently there is no fish, benthic or current temperature data available. It is unlikely that there is any suitable aquatic habitat within this system.

Whiskey Creek

Whiskey Creek is the most south-eastern creek in the Barrie Creeks subwatershed and has six monitoring sites along its length. This is a cold water system with most of the creek flowing through sandy loam soils with moderate to high infiltration rates. There are small sections in gravelly, sandy loam (high infiltration) and the headwaters of the eastern branch are in organics with very slow infiltration rates. Potential recharge areas are down the length of the creek, with a small potential discharge area on the eastern tributary and the headwaters of the main branch. While urban land use surrounds much of the creek, it does flow through large patches of natural heritage cover and all of the headwaters are located in an online SWM pond.

No fish were caught at the monitoring site closest to the headwaters, or at the two on the eastern tributary. Both coldwater and warm water species were caught at all three of the remaining sites close to the mouth (Figure 5-2). Historically both brook trout and mottled sculpin have been found in the lower reaches of this system and are still found there today at the site closest to the mouth and third site upstream (Figure 5-4, Figure 5-5). Current data shows that the majority of individuals caught are adults at the site closest to mouth, while the majority were young of the year at the third site upstream, indicating the presence of groundwater discharge near this site. It also indicates that this indicator species is successfully using this creek to spawn. The site at the mouth is classified as a cool water site, and while no temperature data is available for the third site, it is possible that temperature may be different at this site. If there is a difference, the brook trout may be partitioned based on different habitat requirements at different life stages. Based on the IBI analysis of the sites with fish the ecological integrity is good near the mouth of the creek but decreases farther upstream to only fair (Figure 5-3). Benthic analysis (Hilsenhoff) shows slightly different results with it being fair at the mouth, good in the mid lower regions and fair at the headwaters (Figure 5-6).

Logperch (*Percina caprodes*)

There are barriers to fish movement down the eastern tributary and centred around the confluence of the headwater branches (Figure 5-8) which are most likely responsible for the apparent absence of fish beyond the third site upstream. Sites with bank hardening and channelization are mainly found on the lower reach of the main tributary, near the mouth, and at the confluence of the main branch and the eastern tributary (Figure 5-9). While the creek still has cold water attributes, the recording of cool water temperatures at four of the five sites with temperature loggers suggests there may be thermal degradation occurring within this system (Figure 5-13).

Overall, aquatic communities are relatively unstressed near the mouth as cold water indicator species are present and are likely successfully spawning and surviving. Further upstream though, conditions decline for fish communities until the headwaters where there are no fish species present. The indices for benthic invertebrates show fairly significant organic pollution at the headwater sites, indicating the SWM pond that the headwaters are located in may be adversely impacting the system.

5.4.2 Lovers Creek subwatershed

Lovers Creek

Lovers Creek subwatershed has one main cold water tributary with a total of 26 monitoring sites located along the main branch and along smaller branches. The headwaters of the creek are in organic soils with high infiltration rates, flowing down into silty clay loam (slow infiltration rates) and more organics (moderate infiltration rates). The lower third of the creek to the mouth flows through sandy loam with moderate infiltration rates. Adjacent soils include loamy sand and gravelly sandy loam with moderate to high infiltration rates. There are a few small potential recharge areas along the centre of the creek and large potential discharge areas at the headwaters, mid reach and smaller amounts all along the lower reach to the mouth. Land use along almost the entire creek is natural heritage cover. Surrounding the natural heritage cover that borders the creek is rural and agricultural land cover from the headwaters to almost 2/3rds of the way downstream and urban land near the mouth of the creek.

No fish were captured at four of the monitoring sites. These sites are all located along western branches of the main tributary. There are two dams downstream of one of these sites, potentially stopping any fish from passing. Despite recorded warm water temperatures at some sites, coldwater species have been found at 16 of the sites from the mouth to the headwaters, while only warm water species were captured at the remaining six sites (Figure 5-2). Historically, brook trout have been captured all along Lovers Creek and a number of its tributaries. Current data shows that, for the most part, brook trout occupy the same habitats with a few exceptions. They are not currently found as far up the western section of the headwaters and not as far up the western branch which has the two dams. As they are still found at the site below the dams, it is possible the dams now block off potential brook trout habitat (Figure 5-4). Mottled sculpin have been found up much of the creek in the past and current data shows they have expanded their range further upstream into the headwaters (Figure 5-5). Analyses of the fish communities (IBI) showed five sites with poor ratings, four with good (mainly on the western

Central mudminnow (*Umbra limi*)

branches) and the rest, where fish were captured, to have fair ecological integrity (Figure 5-3). The Hilsenhoff analysis gives slightly higher ratings, with most of the lower reaches ranging from very good to fair, and the headwaters alternating between good and fairly poor (Figure 5-6).

In total there are eight dams on Lovers Creek and a number of other barriers to fish movement. These barriers are mainly on the tributaries, especially on the western branch closest to the headwaters which has the two dams at the end (Figure 5-8). Areas of bank hardening are focused more around the lower reaches, particularly on some of the western branches off the main creek in the headwater area (Figure 5-9). The upper reaches of Lovers Creek, from Lockhart Rd to the headwaters, is designated as a Type D municipal drain, with sensitive species and/or communities present. Any drain maintenance work is approved on a project by project basis to ensure minimal impact on the aquatic communities (Figure 5-12). In addition, despite this being a coldwater system, warm water temperatures are recorded down the main branch, with cold and cool water sites on the smaller branches, indicating thermal degradation of the system is occurring (Figure 5-13).

An analysis of the algae at the second site on the main branch downstream of the headwaters has also been completed. Again as these are the initial stages of the study, the focus was to see if the diatom-inferred values for several key environmental indicators were the same as instrument measured values. Analysis of diatom-inferred values showed a very good relationship with measured variables (Table 5-4). The diatom community is dominated by species typical of nutrient-rich flowing waters (*Achnanthes minutissima, Cocconeis placentula, Cyclotella meneghiana, Cymbella affinis, Fragilaria crotonensis, Nitzschia palea*) (Table 5-4).

Table 5-4: Comparison of diatom-inferred and recorded data for key environmental indicators at Lover's Creek, May 2009.

Variable	Diatom-inferred value	Measured value
pH	8.1	8.1
Temperature (^{o}C)	18.9	17.9
Dissolved Oxygen (mg/L)	9.3	9.1
Total Phosphorus (mg/L)	0.03	n.a.
Total Kjehldahl Nitrogen (mg/L)	0.74	n.a.
Index of Development	1.8	

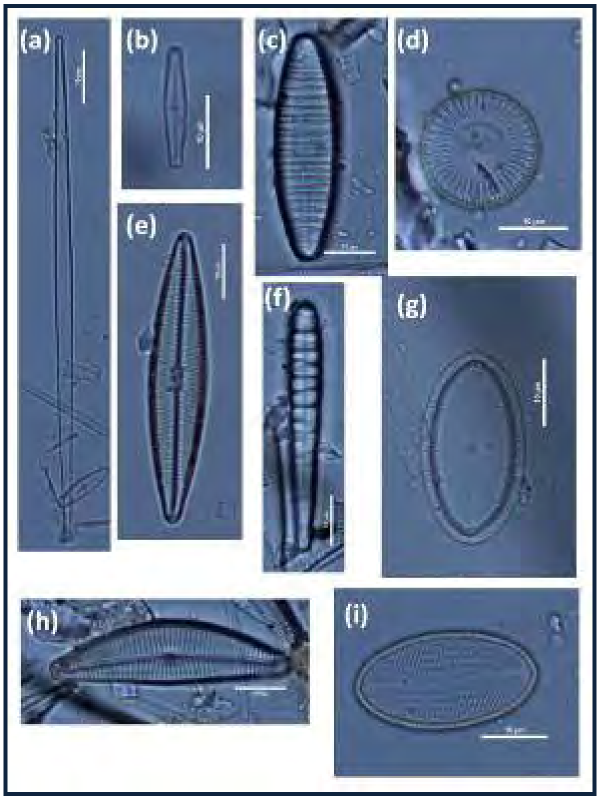


Figure 5-14: Photographs of key diatom taxa recorded from monitoring sites in Lover's Creek: (a) *Fragilaria sp.*, (b) *Achnanthes minutissima*, (c) *Diatoma vulgaris*, (d) *Cyclotella meneghenian*a, (e) *Navicula sp*., (f) *Meridion circulare*, (g) *Cocconeis sp*., (h) *Cymbella affinis*, (i) *Cocconeis sp*.

Overall, the aquatic communities along the main channel of Lovers Creek are not severely stressed but are being impacted by various stressors. Some of the upper reaches have marshy areas with mucky substrate and a low slope, which is poorer habitat for benthic invertebrates and not ideal for most fish species. Similar conditions can be found in the tributaries, with some sites being better due to groundwater inputs, while others had no fish due to low flows.

Areas of cobble/boulder substrate and high water velocities (riffles) can be found at the site closest to the mouth and the third site upstream (where the fish and benthic indices differ). This type of habitat is great for species of benthic invertebrates that cling to the rocks and collect particles that flow past them, but not for fish as they typically don't like constant high water velocities that force them to expend a lot of energy to stay in the area. While there were some fish found at these sites, there was low species diversity, with the fish captured being mainly Longnose Dace (which prefer high flows), resulting in a low score in the IBI index.

One of the unique features of the Lovers Creek subwatershed is that it has one site – LOV101 – that has long term trends (2002 to 2010) available for coldwater fish abundance, benthic studies and IBI. The benefit of this is that in addition to a snapshot of the current conditions of the creek, long term data at this site can show how results have changed over an 8-year period. Results are presented in the following section.

Long Term Trends at Site LOV101 of Lovers Creek

Site LOV101 is the monitoring site closest to the mouth of Lovers Creek. Data has been collected at this site since 2002 and is available up until 2010. Long term trends are available for IBI scores from 2003 to 2010, the correlation of effort spent versus amount of mottled sculpin captured (2003-2010) and the comparison of Hilsenhoff versus EPT (the difference between the Hilsenhoff and EPT index is that Hilsenhoff is an index that uses all the family groups of insects to evaluate the organic pollution in a stream, while EPT uses Ephemeroptera, Plecoptera and Tricoptera – or shredders - as a percent of the entire sample of invertebrate to assess health) trends from 2002 to 2010.

Figure 5-15 illustrates the long term IBI trends for Site LOV101. Based on the score rating mentioned previously, it can be seen that on average the site has a 'fair' rating. In 2003 and 2007, it had a rating of good. In 2005 though, there was a noticeable drop in the ecological integrity of the site down to a 'poor' rating. During this year, the fish community had low diversity, no top predators, no brook trout and an overall low abundance of fish.

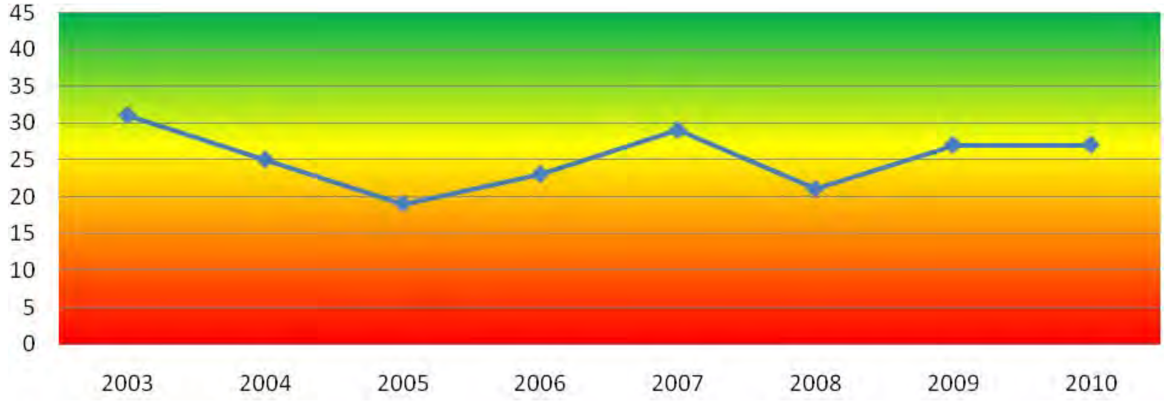


Figure 5-15: Lovers Creek IBI Scores for Site LOV101 (2003 - 2010).

Mottled sculpin
(*Cottus bairdi*)

While long term data was not available for brook trout (the only record is one caught in 2010), it was for mottled sculpin, which are also a cold water species and occupy habitat similar to that used by brook trout. When years of data are compared, it is expected that with increased effort spent to capture fish there is a corresponding increase in the amount (weight) of fish caught. Changes in the community are indicated when effort increases but weight decreases (indicating that mottled sculpin populations have decreased) or when effort decreases and weight increases (indicating that mottled sculpin populations have increased). In 2006, the effort spent electrofishing increased but the overall weight of all the fish caught decreased, suggesting that populations had dropped that year. In 2008 and 2009, there was a decrease in effort and an increase in weight, suggesting that whatever decrease was seen two years prior had rebounded (Figure 5-16).

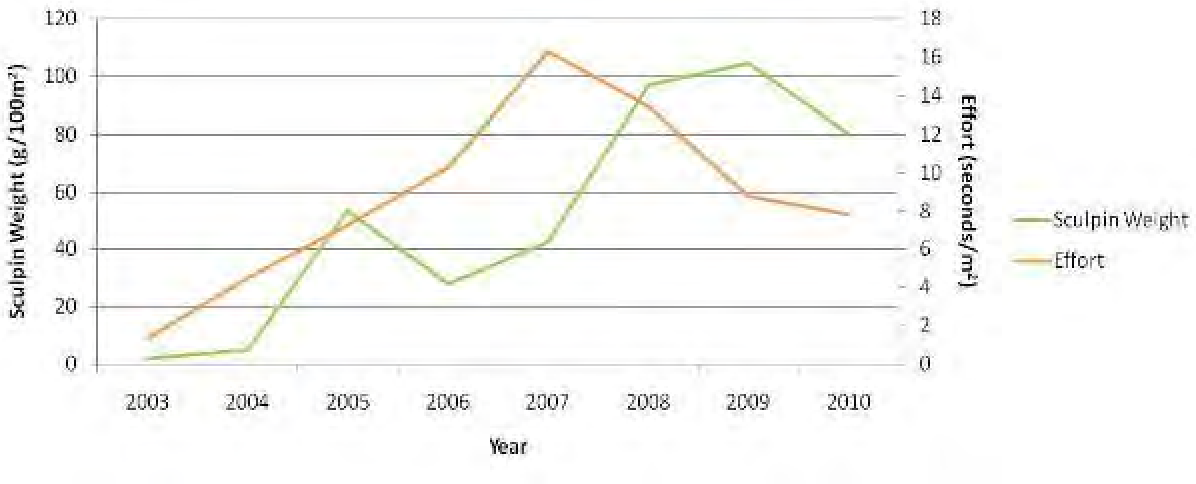


Figure 5-16: Mottled sculpin abundance at Site LOV101 (2003-2010).

The final long term data assesses the benthic community at Site LOV101. Here the Hilsenhoff Biotic Index is compared against the EPT (Ephemeroptera, Plecoptera and Tricoptera) Index. Because of this, there may be some discrepancies between the two indices. It can be seen in Figure 5-17 that the Hilsenhoff Index is relatively stable from 2002 to 2010, whereas the EPT Index has more pronounced fluctuations over the years. Water quality appears to be good in 2004, but there is a general decrease from that point on. The Hilsenhoff does reflect the same changes in water quality as the EPT, but with less extreme fluctuations.

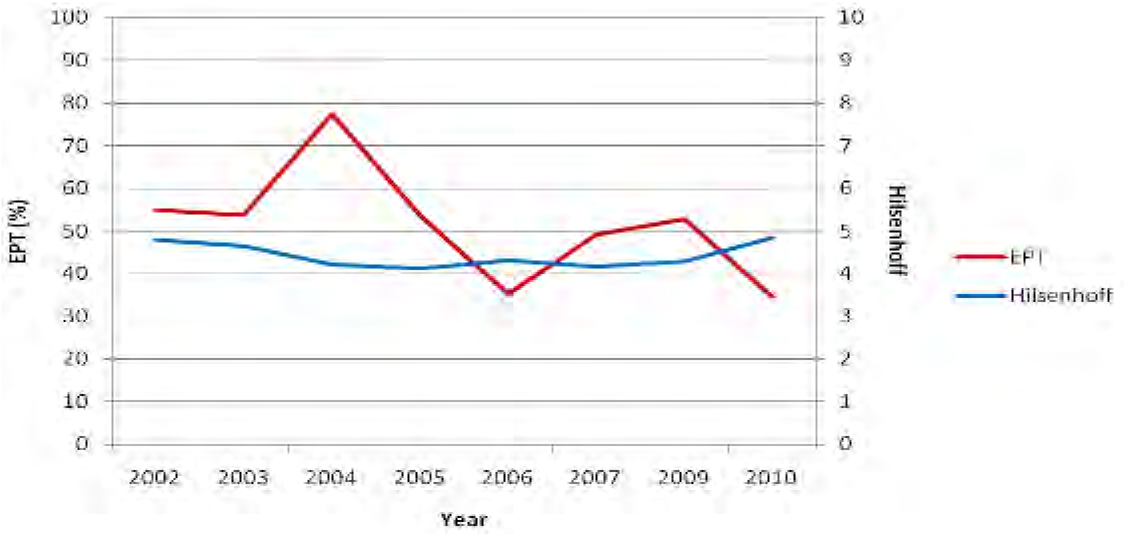


Figure 5-17: Benthic indices trends for Site LOV101 (2002-2010).

5.4.3 Hewitt's Creek subwatershed

The Hewitt's Creek subwatershed has one main coldwater tributary with a total of 14 monitoring sites spread out along its main reach and one site on a western branch. Headwaters are located in gravelly sandy loam with high infiltration rates and silty clay loam with slow infiltration rates. It continues through sandy loam and loam with moderate infiltration rates, before going back to gravelly sandy loam with high infiltration for the last 3rd of the creek. There are a few recharge areas located around the headwaters, with discharge areas focused mainly around the lower half of the creek and one area about ¼ of the way downstream from the headwaters. The headwaters and upper half of the creek are surrounded by rural land use, changing to natural heritage cover at the mouth. This natural heritage cover is surrounded by rural and urban land use though, in the form of residential areas and agricultural fields.

Hewitt's Creek

Coldwater species were found at 10 of the 14 monitoring sites, and warm water species were captured at the site closest to the headwaters and evenly spread out down the main branch of the creek (Figure 5-2). There is historic data indicating brook trout and mottled sculpin presence within Hewitt's Creek as far back as 1975 and their distribution is very similar to their current day ranges (Figure 5-4, Figure 5-5). Analysis of the fish communities (IBI) showed that the four sites with only warm water species have poor ecological integrity, while the majority were listed as fair with two sites being listed as good (Figure 5-3). The Hilsenhoff analysis indicates poor ecological integrity at the site closest to the headwaters, but rates the rest of the creek as mainly good or fair, and excellent at the mouth (Figure 5-6).

There are three barriers to fish movement (Figure 5-8) and very little bank hardening and channelization along the creek and its branches (Figure 5-9). The upper half of the creek from Lockhart Rd to the headwaters has been designated as a Type F municipal drain as this section is dry for more than two consecutive months of the year (Figure 5-12). Full clean out and vegetation removal is allowed for this type of drain, as long as the creek is dry and all disturbed soil is stabilized upon completion of the maintenance work. While this is a cold water creek, cool water temperatures are noted throughout the entire system with two cold water sites and one warm water site recorded, possibly indicating that the system may be experiencing thermal degradation (Figure 5-13).

Overall, the presence of coldwater indicator species indicates that Hewitt's Creek still has the necessary cold water attributes to sustain these communities, as well as benthics, but is stressed by urban development near the mouth and surrounding rural land uses.

Brook trout (*Salvelinus fontinalis*)

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 Barrie, Lovers and Hewitt's Creeks subwatersheds, as outlined in the following sections.

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 5-5 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 **Chapter 1- Introduction**. Readers interested in the details of these regulations, policies and plans are directed to read the original documents.

Mouth of Lovers Creek into Kempenfelt Bay

Table 5-5: 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 designated settlement areas) establishes 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) (policies 6.1 and 6.2), or within 30m of wetlands and watercourses, with natural heritage evaluations necessary for development proposed within 120m 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.

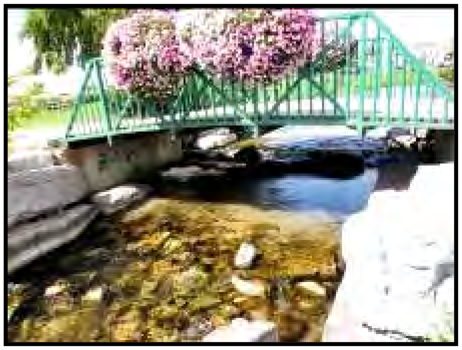
Within designated settlement areas, the *Fisheries Act* is complemented by municipal official plans. The City of Barrie Official Plan protects sensitive surface water features and their related hydrological functions, by prohibiting development in Provincially Significant wetlands (and other wetlands 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). The Town of Innisfil Official Plan protects aquatic habitats and ecosystem function by prohibiting development outright in Provincially Significant wetlands, as well as prohibiting development within 30m 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).

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.

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* or the Provincial Regulation on development and interference with wetlands (O. Reg. 179/06). 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.



Heritage Park – City of Barrie

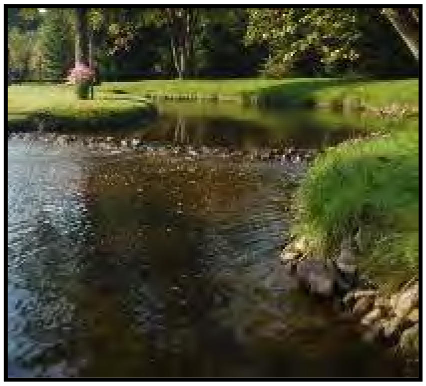
5.5.2 Restoration and remediation

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 focussed specifically on protecting water quality, LEAP has supported five riparian buffer plantings in the Barrie Creeks subwatershed, one riparian buffer project, and one bottom-draw installation on an online pond in the Lovers Creeks subwatershed, and five projects including streambank fencing and riparian restoration in the Hewitt's Creek 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 Barrie Creeks, Lovers Creek and Hewitt's Creek subwatersheds, 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 three shoreline improvement projects in the Barrie 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 no projects that would directly improve aquatic natural heritage have been completed in the City of Barrie, while less than five have been implemented in the Town of Innisfil.



Small barrier to fish movement and lack of riparian vegetation

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. The Lake Simcoe Basin Best Management Practice Inventory (LSRCA, 2009) found over 200 additional places in these three subwatersheds where additional riparian planting could be introduced, nearly 100 barriers that should be removed to improve fish passage, several locations along creeks that require additional fencing, and 200 locations where the creek channel had been hardened or straightened, which could be mitigated to improve fish habitat.

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.

In addition to these voluntary programs, development proposals adjacent to stream corridors in the City of Barrie have the potential to trigger an assessment of the feasibility of watercourse rehabilitation. As the City gets redeveloped and intensified over the coming years, this could become a powerful mechanism for addressing some of the more significant challenges related to enclosed, channelized, or otherwise hardened streams, which are currently so prevalent.

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 landuse 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 previously, 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 work collaboratively with other interested organizations, through the Lake Simcoe Stewardship Network, 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 public motivations and 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 in this chapter (barriers, channelization etc), the condition of the fish and benthic communities in the Barrie Creeks, Lovers Creek and Hewitt's Creek subwatersheds 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, with assistance from LSRCA and MNR, 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 the suitability of using the *Drainage Act* to protect and restore the ecological function of watercourses

5.6.4 Water Quality and Water Temperature

Based on the generally fair to fairly poor benthic invertebrate community scores, water quality in Barrie Creeks, Lovers Creek and Hewitt's Creek 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 3-18 and 3-19.

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 Kidd's and Sophia Creeks, the enclosure of a significant part of the mouth of creek 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 City of Barrie, 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 City of Barrie 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.

Recommendation 5-15 – That the LSRCA, with support from subwatershed municipalities and the Province, investigate the reasons for the significant shift in biotic community and thermal regime seemingly associated with Hwy 400. This investigation should make recommendations as to how any identified impacts may be mitigated.

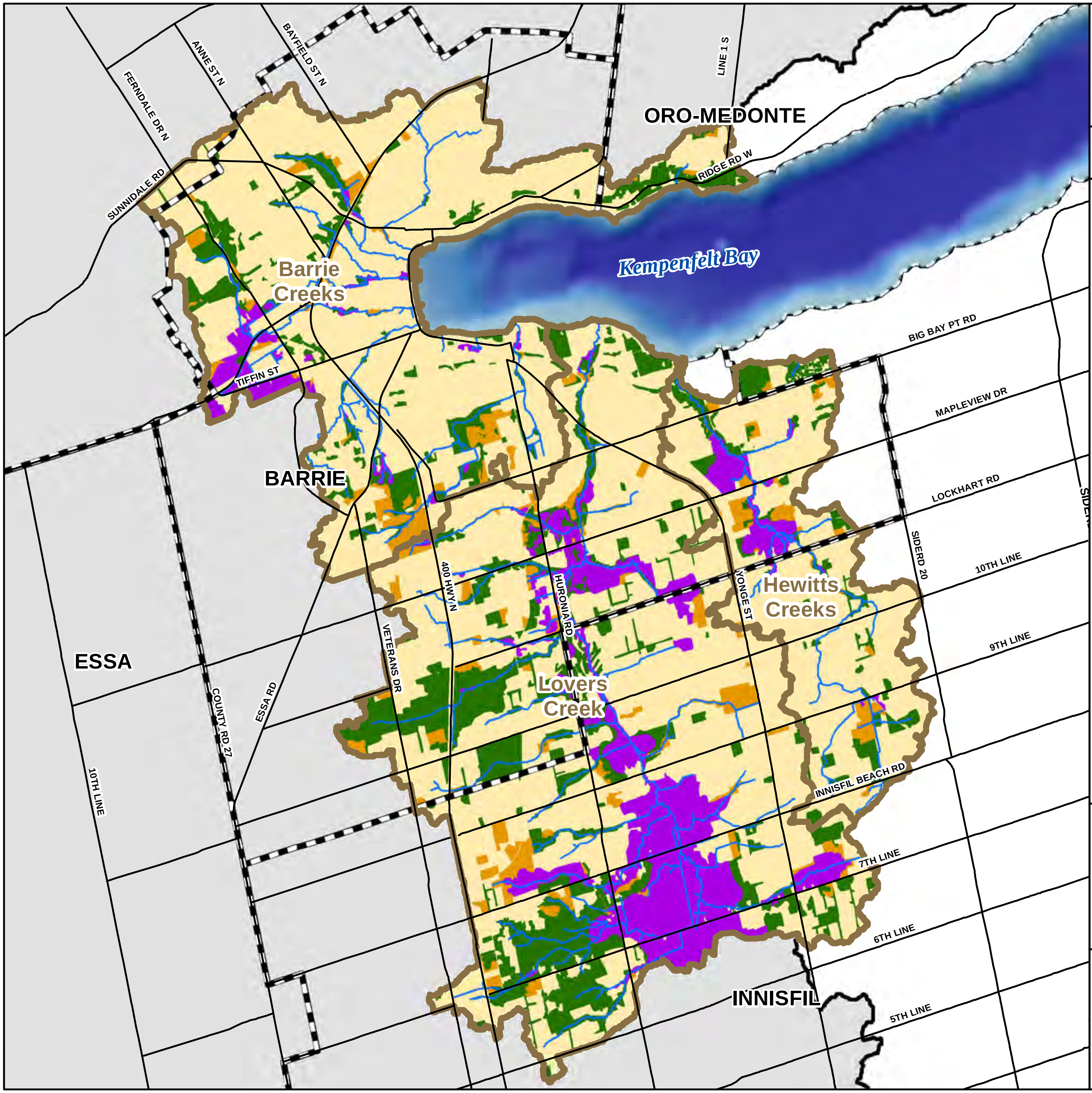
6 Terrestrial Natural Heritage

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 Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds' terrestrial system interacts with other hydrological and human systems, and serves as habitat for flora and fauna throughout the subwatersheds. 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 subwatersheds can tell us a great deal about its health. Figure 6-1 details the distribution of natural features in the subwatersheds.

Currently, natural heritage features account for 16.7% of the Barrie Creeks subwatershed (composed of 3% wetland, 9.8% upland forest, and 3.9% grassland), 34.5% of the Lovers Creek subwatershed (composed of 13.5% wetland, 16.7% upland forest, and 4.3% grassland), and 21.3% of the Hewitt's Creek subwatershed (composed of 5.6% wetland, 11% upland forest, and 4.7% grassland).



Terrestrial natural heritage features in the Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds

Figure 6-1

Legend

- ─ Road
- ▬ Municipal Boundary
- 〰 Watercourse
- 🟧 Grassland
- 🟪 Wetland
- 🟩 Woodland

Lake Simcoe Region conservation authority

0 0.5 1 2 3 4 Kilometres

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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.
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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 Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds can be described, relative to these targets, where data permits.

At 17%, 35%, and 21% respectively, the total natural cover in the Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds is below average for the Lake Simcoe watershed as a whole, and substantially lower than the target of 40% high quality natural areas for the entire Lake Simcoe watershed set by the Lake Simcoe Protection Plan. Much of the remainder of the area of these subwatersheds has been converted to agricultural, industrial, or urban land uses, with urban development dominating much of the Barrie Creeks subwatershed, and the near-lake portion of the Hewitt's and Lovers Creeks subwatersheds (Figures 2-5, 2-6, and 2-7, **Chapter 2 – Study Area**).

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, nutrient and energy cycling
- **Hydrological Values:** interception of precipitation, reduction of intensity of rainfall runoff, slower release of melt water from snowpack, shade to watercourses

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 Table 6-1 and Figure 6-3). 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).

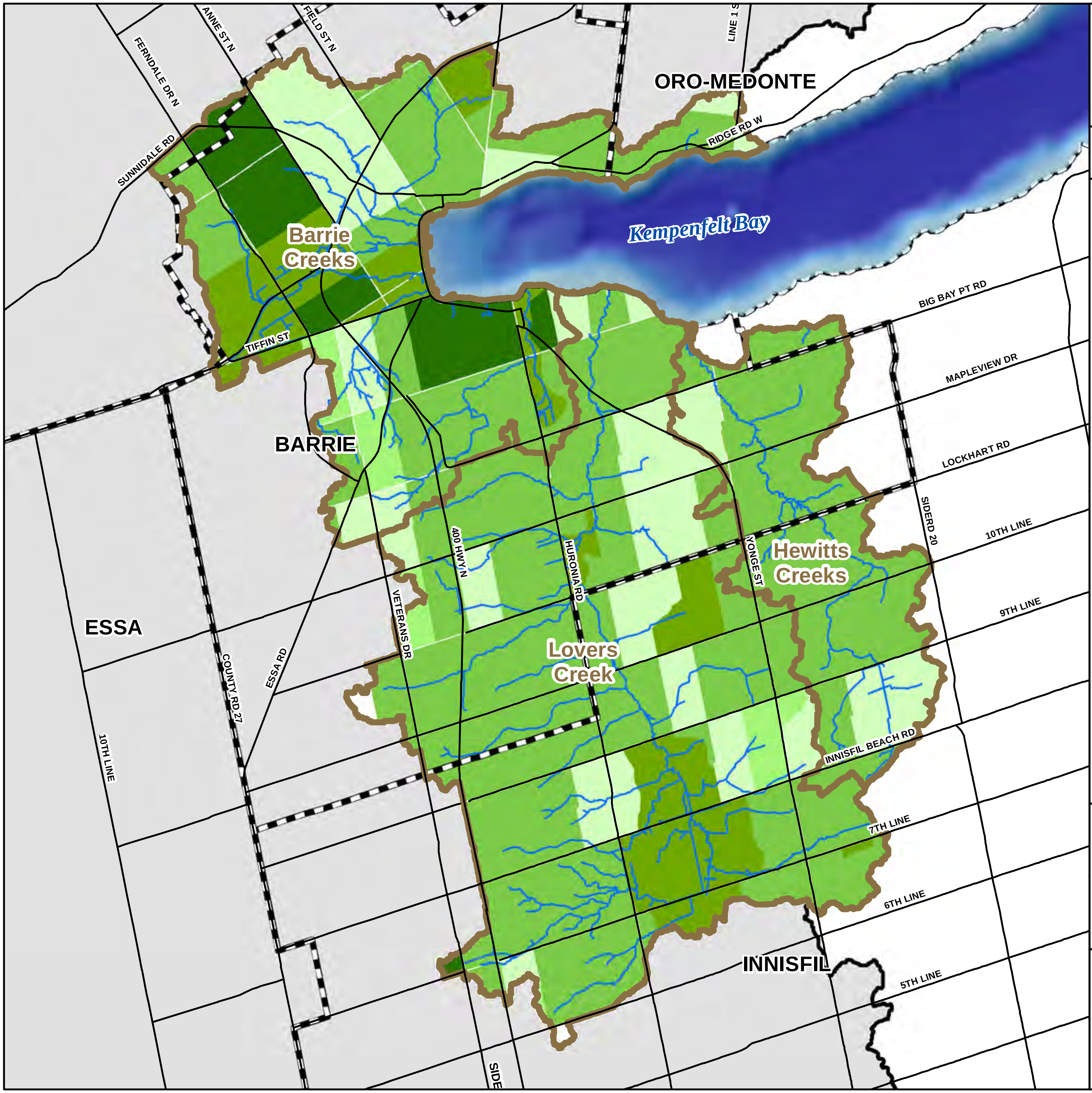
Of these factors there is increasing scientific evidence to show that the total woodland cover of a landscape may exert the most important influence on biodiversity. Obviously, the loss of woodland cover results in a direct loss of habitat of that type. This reduction in habitat can result in proportionally 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. An estimate of total pre-settlement woodland cover in Simcoe County, including these subwatersheds, 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). In 1993 approximately 25% of the Lovers Creek and 13% of the Hewitt's Creek subwatersheds remained under forest cover (LSRCA, 1993). As of 2009, woodland cover in the Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds was 11.6%, 26.7%, and 15.3%, respectively (Table 6-1). The slight increases in forest cover in the Lovers and Hewitt's Creeks subwatersheds may be a result of reforestation efforts or natural forest regeneration, or may be due to improvements in mapping technology in the intervening decades providing more accurate values.

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. Existing forest cover within the Barrie Creeks and Hewitt's Creek subwatersheds is well below even this substantially lower target.

Pre-settlement vegetation in the Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds

Figure 6-2



Legend

— Road

▬ Municipal Boundary

〰 Watercourse

Woodland Type

🟩 Coniferous Forest

🟩 Coniferous Swamp

🟩 Cultural Plantation

🟩 Cultural Woodland

🟩 Deciduous Forest

🟩 Deciduous Swamp

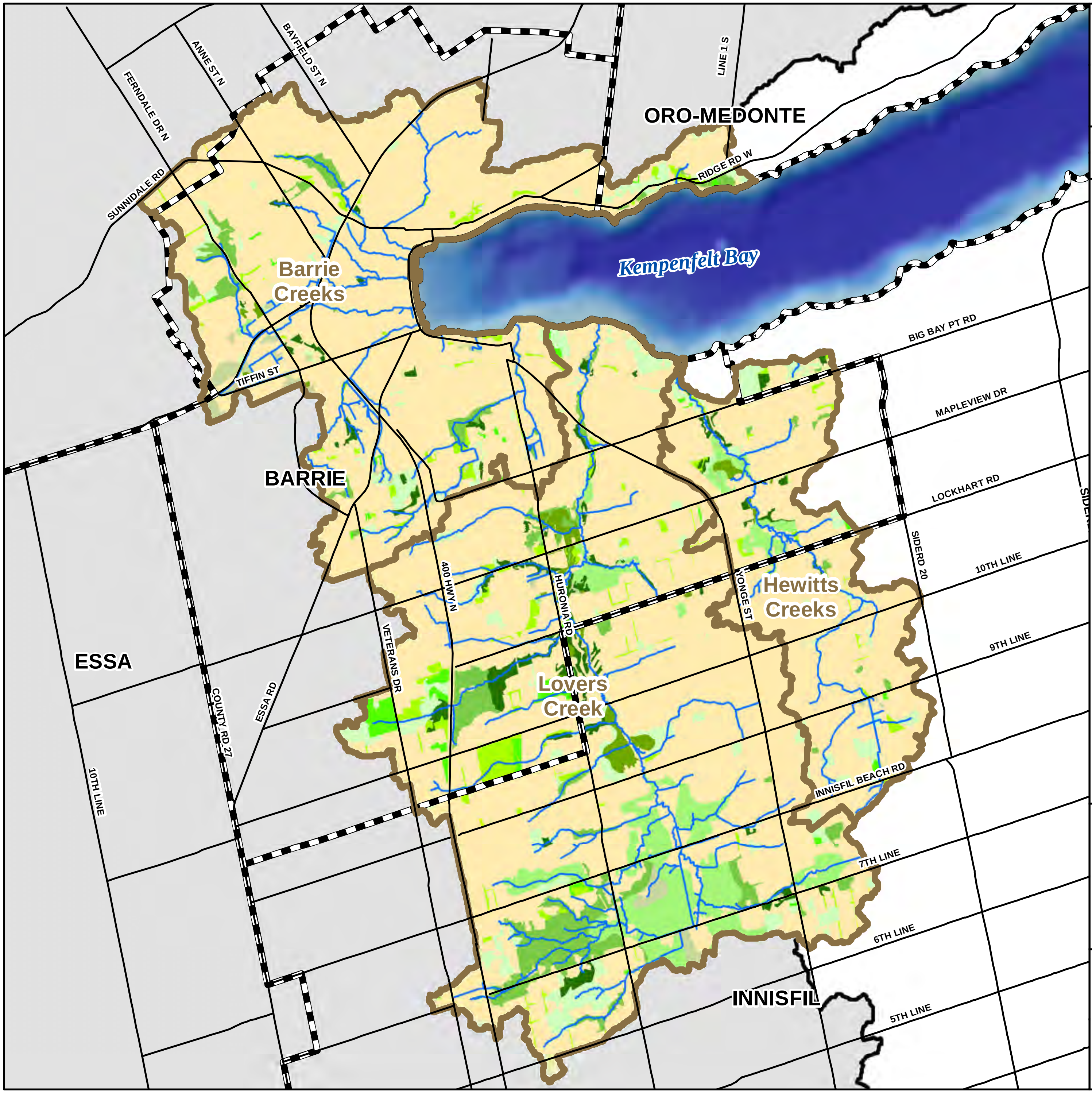
🟩 Mixed Forest

🟩 Mixed Swamp

Lake Simcoe Region conservation authority

Woodland types in the Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds

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

0 0.5 1 2 3 4 Kilometres

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Table 6-1: Woodland cover types in the Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds.

Woodland Type		Woodland Cover					
		Barrie Creeks		Lovers Creek		Hewitt's Creek	
		Area (ha)	Area (%)	Area (ha)	Area (%)	Area (ha)	Area (%)
Upland forest	Cultural Plantation (CUP)	10.1	0.3	78.7	1.3	7.1	0.4
	Cultural Woodland (CUW)	79.9	2.1	144.8	2.4	27.1	1.5
	Conifer Forest (FOC)	31.7	0.8	132.4	2.2	30.8	1.8
	Deciduous Forest (FOD)	137.3	3.7	315.2	5.3	115.0	6.6
	Mixed Forest (FOM)	109.5	2.9	330.9	5.5	13.2	0.8
Swamp forest	Conifer Swamp (SWC)	6.0	0.2	88.5	1.5	10.7	0.6
	Deciduous Swamp (SWD)	57.5	1.5	47.1	0.8	4.8	0.3
	Mixed Swamp (SWM)	4.4	0.1	464.0	7.7	60.1	3.4
Total upland forest		**368.5**	**9.8**	**1002.0**	**16.7**	**193.2**	**11.0**
Total forest		**436.4**	**11.6**	**1601.6**	**26.7**	**268.8**	**15.3**
Target (LSPP)[1]		**1500.0**	**40.0**	**2396.0**	**40.0**	**700.0**	**40.0**
Target (LSRCA IWMP)[2]		**937.5**	**25.0**	**1497.5**	**25.0**	**437.5**	**25.0**

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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

The most common forest types in the Barrie Creeks subwatershed are cultural woodlands (which refers to young or early successional forests, often dominated by species such as trembling aspen, eastern white cedar, or red cedar), and deciduous and mixed forests. Similarly, the most common woodlands in the Lovers Creek subwatershed are deciduous and mixed forests, and in the Hewitt's Creek subwatershed are deciduous forests (Table 6-1). Deciduous and mixed forests are found typically on well drained sandy loam sites. Deciduous forests are found more typically on relatively flat ground around the crest of the glacial meltwater valley extending from the tip of Kempenfelt Bay (Figure 2-22, **Chapter 2 – Study Area**), while mixed forests are more common on areas with steeper slopes (including ravines, and the side of that glacial valley) which have slightly cooler microclimates (Figure 6-3).

Relatively uncommon in these subwatersheds are coniferous woodlands (including forests, swamps, and plantations), which account for only 17% of the total woodland. These uncommon forest types provide habitat for unique wildlife communities, particularly those which prefer coniferous woodlands, such as pine warbler (*Dendroica pinus*), Cooper's hawk (*Accipiter cooperii*), and blue jay (*Cyanocitta cristata*) (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 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 mapping complete, 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 distributions of woodland patch sizes are displayed in Figure 6-4, Figure 6-5, and Figure 6-6. 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. If only patches within the subwatershed boundaries were considered, the number of large patches would be underestimated.

The Barrie Creeks subwatershed is characterized by a large number of small forest patches (Figure 6-3, Figure 6-4). There are a total of 117 separate patches of woodland in this subwatershed, 90% of which are small (less than 10 ha in size). Despite their small size, collectively these small fragments represent half of the subwatershed's total forest cover. The largest remaining patch of woodland in the subwatershed is a 42 ha deciduous forest north of Shanty Bay Road in the Township of Oro-Medonte.

Similarly, the Hewitt's Creek subwatershed is also a subwatershed characterized by a large number of small scattered forests (Figure 6-3, Figure 6-6). Of the 54 woodland patches in this subwatershed, 50 are less than 10 ha in size. Together, these small forests represent 60% of the total forest cover in this subwatershed. The largest woodlot in this subwatershed is the 30 ha St Paul's Swamp.

The Lovers Creek subwatershed has more large forest patches than the other two subwatersheds (Figure 6-3, Figure 6-5), including the Lovers Creek Provincially Significant Wetland, which is over 160 ha in size. However, even in this subwatershed, 130 of the total 148 woodland patches (i.e. 88%) are less than 10 ha in size, representing approximately one-third of the forest cover in this subwatershed.

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 woodland 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.

Even in using the relatively conservative measure of 100m, it can be seen that relatively few such "core" areas exist within the Barrie Creeks or Hewitt's Creek subwatersheds (Figure 6-4, Figure 6-6). In fact, only six such core habitat areas are located in the Barrie Creeks subwatershed, the largest of which is only 2.2 ha in size. Similarly, the Hewitt's Creek subwatershed also has only six such core areas, although the largest is nearly 9 ha in size. In both of these subwatersheds then, existing woodlands are primarily small, scattered, and edgy in nature.

The Lovers Creek subwatershed remains a bit of an exception to this general pattern (Figure 6-5). The existence of relatively large blocks of forest cover in the headwaters of this subwatershed has allowed for the existence of 31 patches of core habitat, including one which is over 70 ha in size, suggesting that it may be particularly productive habitat for forest-dwelling birds.

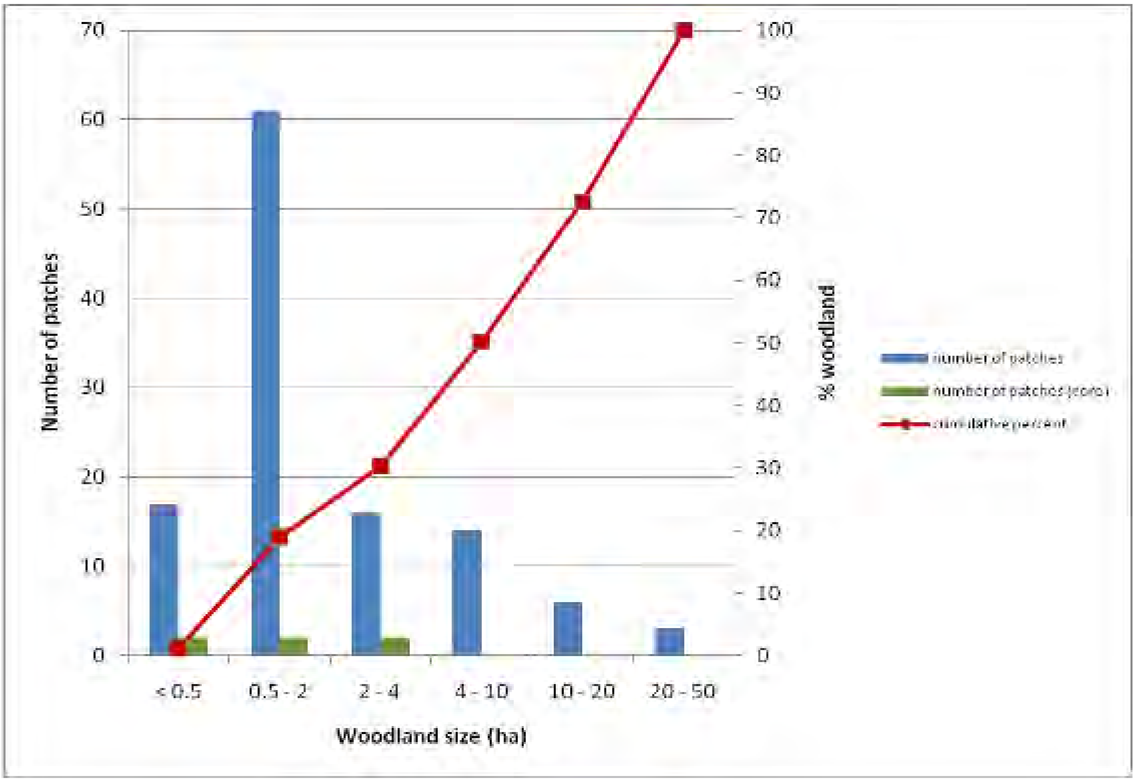


Figure 6-4: Woodland patch size distribution in the Barrie Creeks subwatershed.

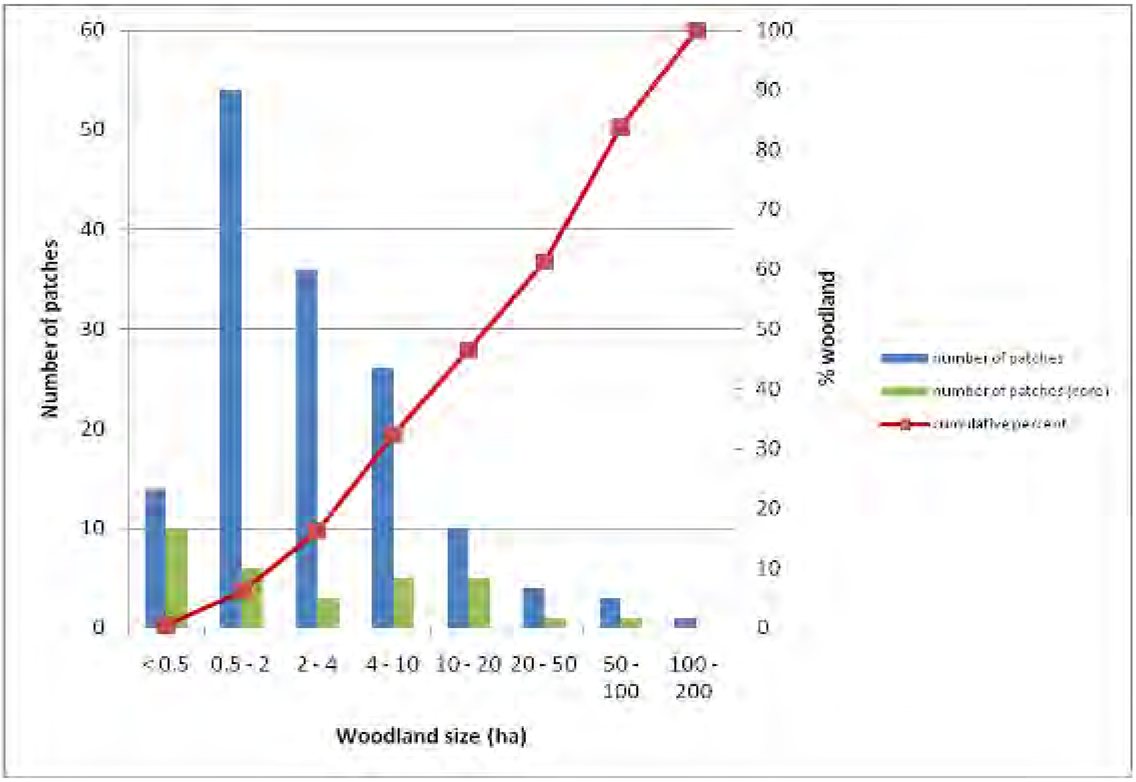


Figure 6-5: Woodland patch size distribution in the Lovers Creek subwatershed.

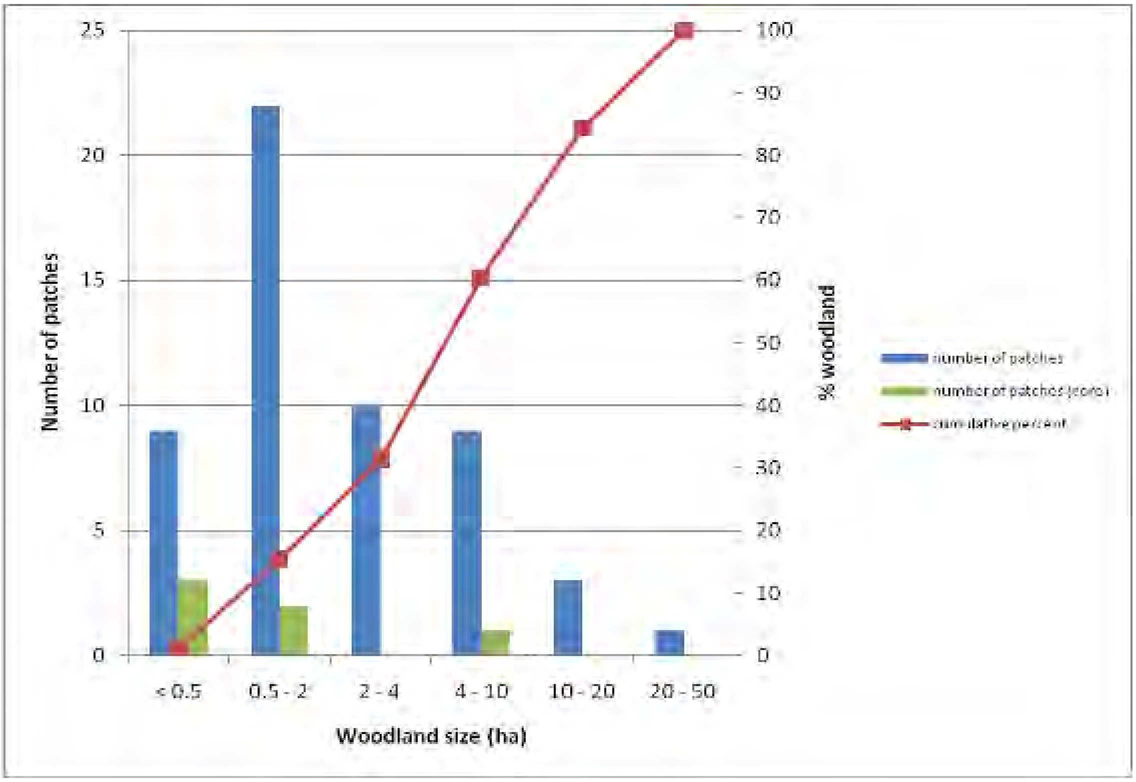


Figure 6-6: Woodland patch size distribution in the Hewitt's Creek subwatershed.

Despite the recent evidence of the importance of total forest area for the preservation of wildlife, the importance of maintaining physical 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 somewhat 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.

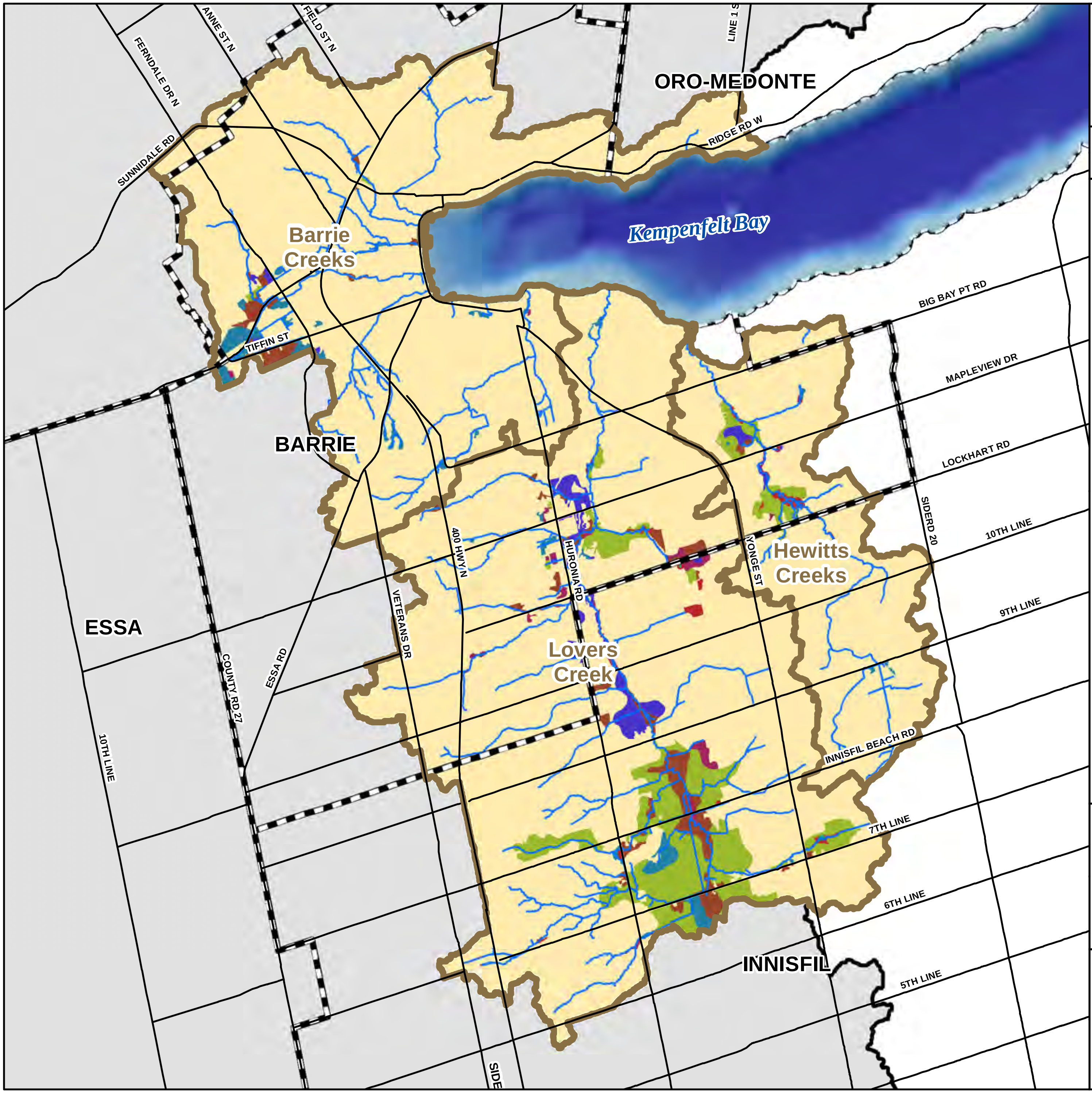
Wetlands provide numerous functions for an ecosystem. These include (OMNR, 2010):

- **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, bird watching, 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.

Wetland types in the Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds

Figure 6-7



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

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0 0.5 1 2 3 4 Kilometres

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It has been estimated that, prior to European settlement, 2.6% of Barrie and 11.2% of Innisfil were wetlands (DUC, 2010). Wetlands were lost as settlement occurred, reducing their relative cover to 0.7% and 5.6% of Barrie and Innisfil, 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 still occurred at an average rate of 0.5 and 1.5 ha per year in Barrie and Innisfil respectively (DUC, 2010). It should be noted that the Ducks Unlimited study derives its estimates of wetland distribution from soil maps, and underestimates the current extent of wetlands in these subwatersheds. 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 114.4 ha, 808.5 ha and 98.6 ha of wetland remaining in the Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds, respectively (Figure 6-7, Table 6-2).

Table 6-2: Distribution of wetland types in the Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds.

Wetland type	Wetland Cover					
	Barrie Creeks		Lovers Creek		Hewitt's Creek	
	Area (ha)	Area (%)	Area (ha)	Area (%)	Area (ha)	Area (%)
Meadow marsh (MAM)	2.0	0.05	45.3	0.8	7.5	0.4
Shallow marsh (MAS)	1.3	0.03	14.1	0.2	11.6	0.7
Mixed shallow aquatic (SAM)			1.2	0.02		
Submerged shallow aquatic (SAS)	0.8	0.02				
Coniferous swamp (SWC)	6.0	0.2	88.5	1.5	10.7	0.6
Deciduous swamp (SWD)	57.5	1.5	47.1	0.8	4.8	0.3
Mixed swamp (SWM)	4.4	0.1	464.0	7.7	60.1	3.4
Thicket swamp (SWT)	42.4	1.1	148.3	2.5	3.9	0.2
Other*	1.3	0.1	200.8	3.3	5.1	0.3
Total marsh	**4.1**	**0.1**	**60.6**	**1.0**	**19.1**	**1.1**
Total swamp	**110.3**	**2.9**	**747.9**	**12.5**	**79.5**	**4.5**
Total	**114.4**	**3.0**	**808.5**	**13.5**	**98.6**	**5.6**

* '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 6-8 to Figure 6-10. 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 115.7 ha of wetland in the Barrie Creeks subwatershed, which is approximately 3.1% of the landscape, composed of a scattering of small riparian wetlands along Kidds Creek, Bunker Creek, Dyments Creek, Hotchkiss Creek, and Whiskey Creek (Figure 6-7, Figure 6-8), with a median size of only 1.5 ha. The total wetland cover within this subwatershed though is dominated by the unevaluated wetlands contiguous with the Provincially Significant Bear Creek wetland. This wetland feature accounts for 50% of the total wetland cover remaining in this subwatershed (Figure 6-7). The Bear Creek wetland complex is the only evaluated wetland in the Barrie Creeks subwatershed; approximately 27 ha of this provincially significant wetland is within this subwatershed, and forms the headwaters of Dyments Creek (and also forms part of the headwaters of the adjacent Bear Creek subwatershed which flows into Georgian Bay). The remainder of the wetlands have been identified by LSRCA in their natural heritage system mapping, but have never been evaluated under the Provincial system.

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."*

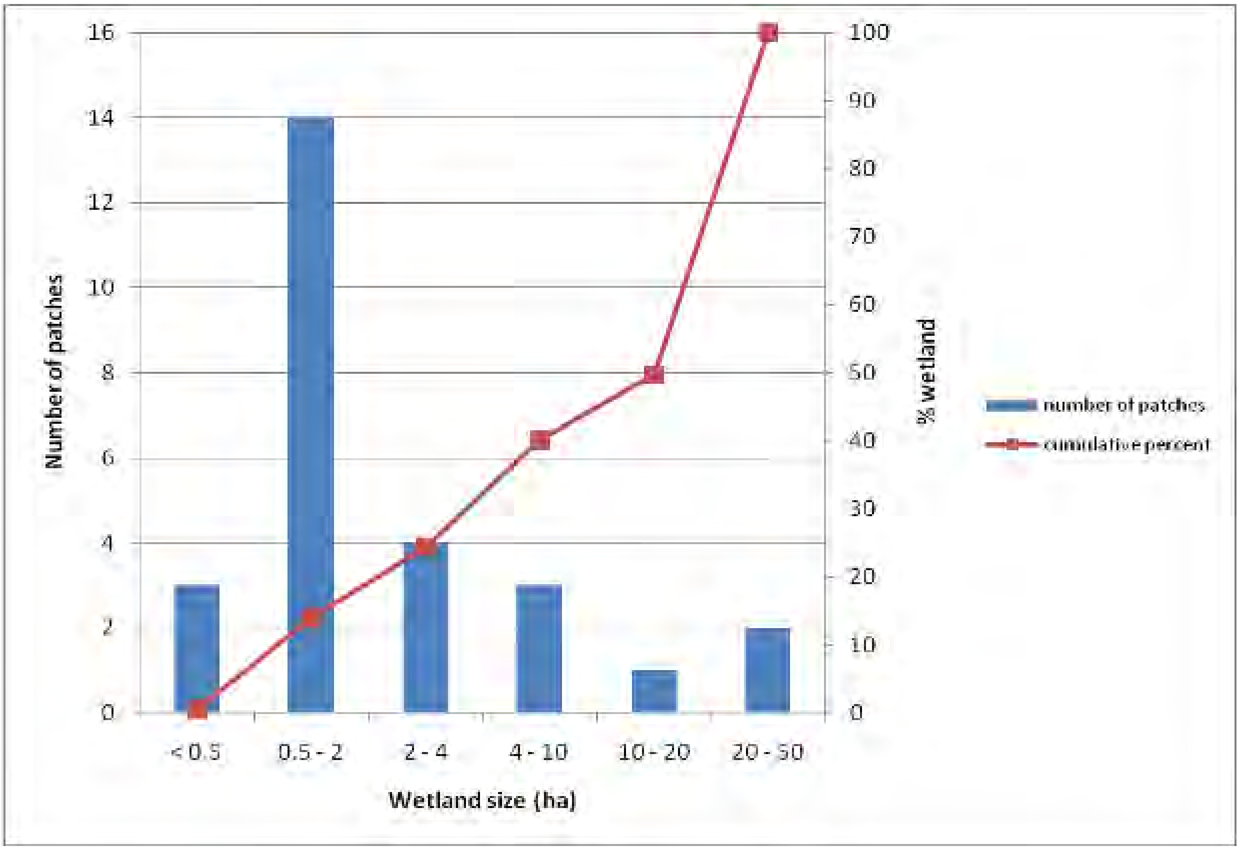


Figure 6-8: Wetland patch size distribution in the Barrie Creeks subwatershed.

There are approximately 1009.3 ha of wetland in the Lovers Creek subwatershed, which is approximately 16.8% of the landscape (Figure 6-1). Wetlands in this subwatershed are dominated by the extremely large Lovers Creek Provincially Significant wetland complex in the headwaters, supplemented by a scattering of other smaller, primarily riparian wetlands along the main branch of Lovers Creek (Figure 6-7, Figure 6-9).

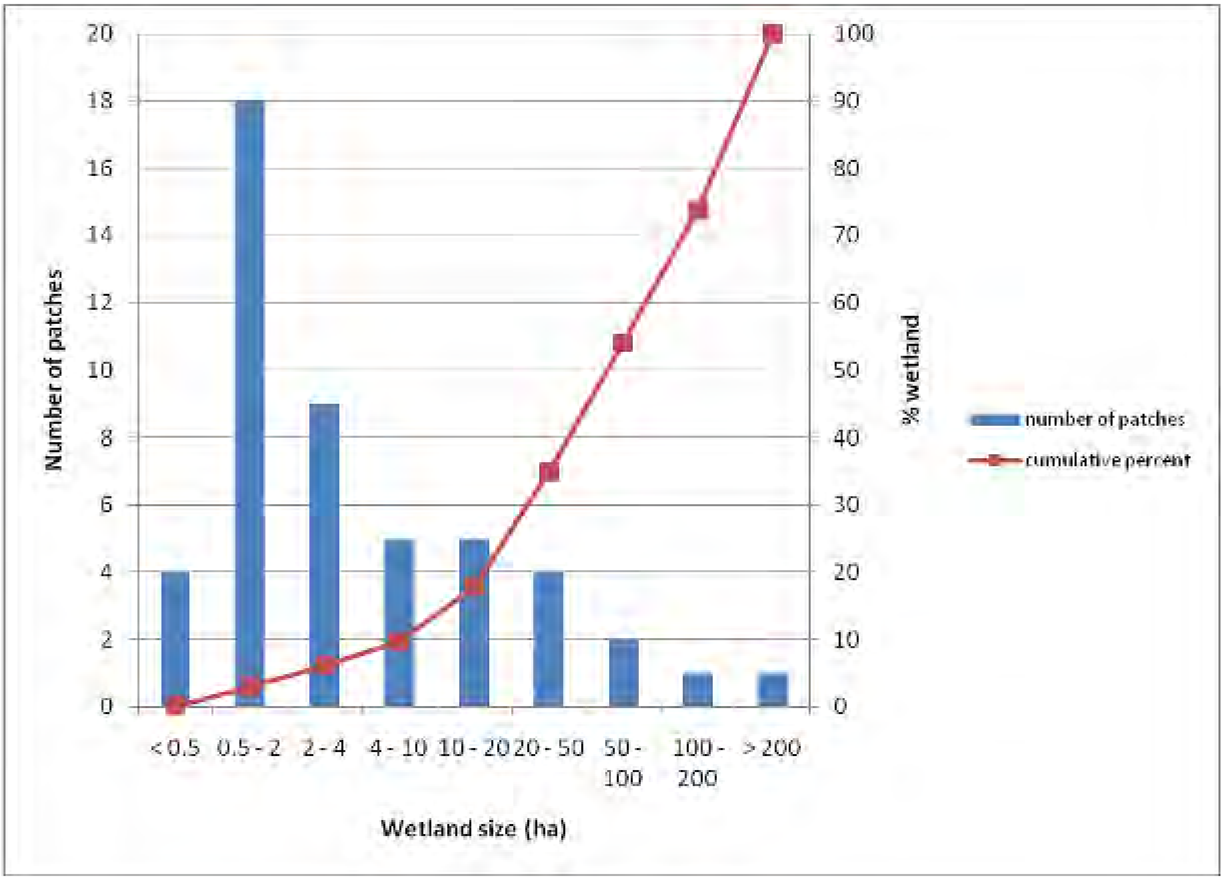


Figure 6-9: Wetland patch size distribution in the Lovers Creek subwatershed.

There are only eight wetland patches remaining in the Hewitt's Creek subwatershed, totalling 103.7 ha (or 5.9% of the landscape) (Figure 6-7, Figure 6-10). The wetland composition of this subwatershed is almost entirely dominated by two wetlands – the St Paul's Swamp wetland complex, located where two branches of the creek merge, and an unevaluated wetland immediately north of it. Together, these two remnants represent over 90% of the total wetland in this subwatershed.

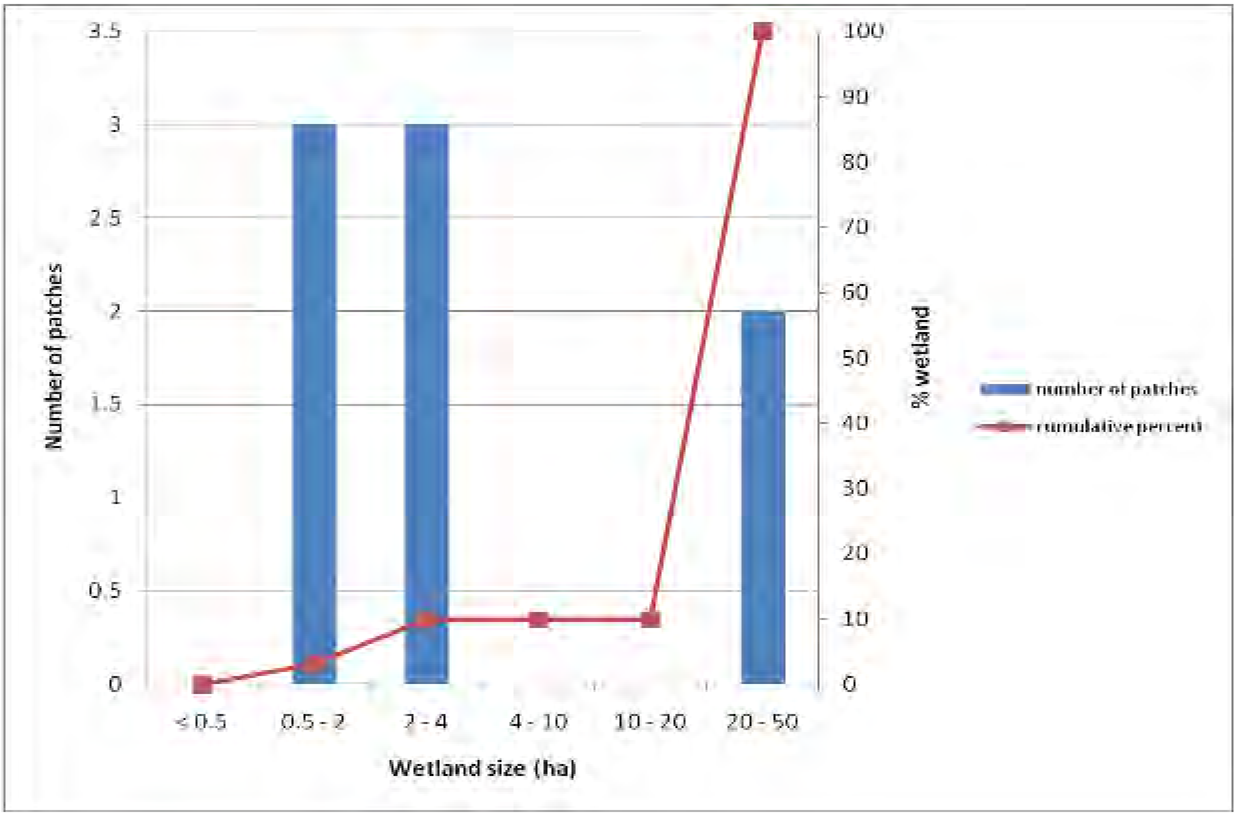


Figure 6-10: Wetland patch size distribution in the Hewitt's Creek subwatershed.

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 these subwatersheds requires that 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 131 hectares within the Barrie Creeks subwatershed that meet the definition of valleyland under the draft definitions of Key Natural Heritage Features (MNR, 2011) (Figure 6-11), of which 55% is forested. Most of these forested valleylands have been acquired by the City of Barrie, and form part of their network of city parks and greenspaces. Notable examples of this include the Sandy Hollow Ravine, Sunnidale Natural Area, and Lackies Bush.

There are 34.9 ha of significant valleyland in the Hewitt’s Creek subwatershed, of which 24.6 ha (or 70.5%) is forested. Due to the topography in this subwatershed, these significant valleylands are predominantly near its mouth on Kempenfelt Bay, and form part of the City owned Wilkin’s Walk Natural Area.

The Lovers Creek subwatershed, as the largest of the three subwatersheds, also has the greatest amount of significant valleyland, at approximately 331 ha. Of this, 232.9 ha (or 70.3%) remains forested. Unlike the other two subwatersheds however, the majority of these valleylands are located in the privately owned headwater areas; one of which is bisected by Highway 400 (Figure 6-11).

6.2.4 Riparian and shoreline habitat

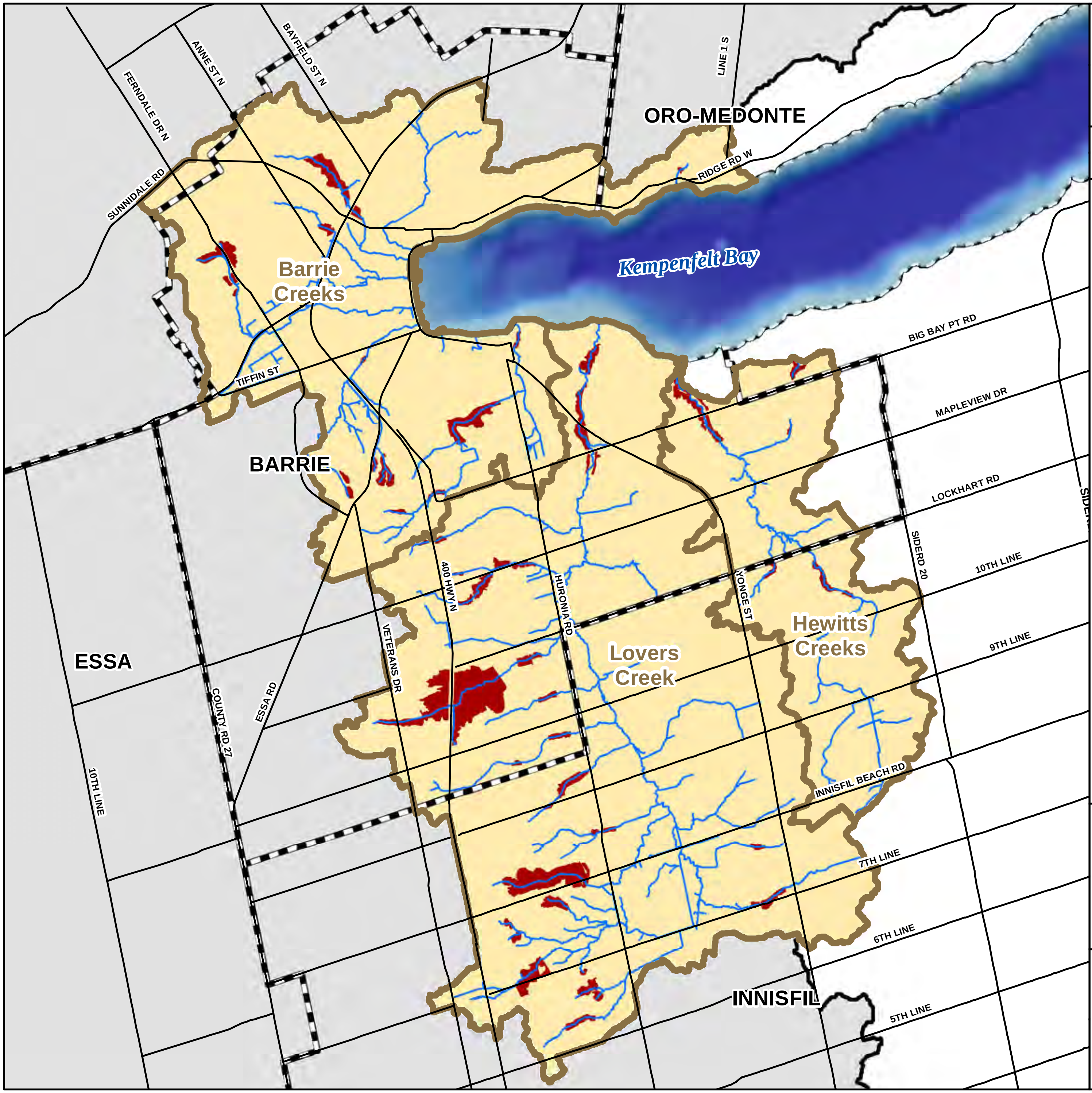
The term riparian refers to the area of land adjacent to a stream, river, or lake. These areas provide important fish and wildlife habitats, such as natural linkages among different habitat features that create critically important wildlife migration corridors (Environment Canada, 2004).

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 seasonal flooding of most riparian areas provides habitat to specialized plant communities that may not be found elsewhere in the watershed

Key valleyland features in the Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds

Figure 6-11



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 January 2012.

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 to a minimum to a 30m width along watercourses and the Lake Simcoe shoreline.

Of the three subwatersheds, Lovers Creek has the most well-buffered riparian areas, with 71% of the 30 m riparian zone existing under natural cover. The Barrie Creeks and Hewitt's Creek subwatersheds are less well buffered, with 35% and 52% respectively (Table 6-3, Figure 6-15).

The land use within the 30 m buffer for the Barrie Creeks watercourses is mainly high intensity development and natural heritage cover. As distance increases away from the watercourse, natural heritage cover decreases at the same rate that the high intensity development increases, indicative of some effort to retain natural vegetation along watercourses in this highly urbanized subwatershed. Percentage of riparian buffer that is agriculture or low intensity development land use remains relatively low and constant as distance away from the watercourse increases (Figure 6-12).

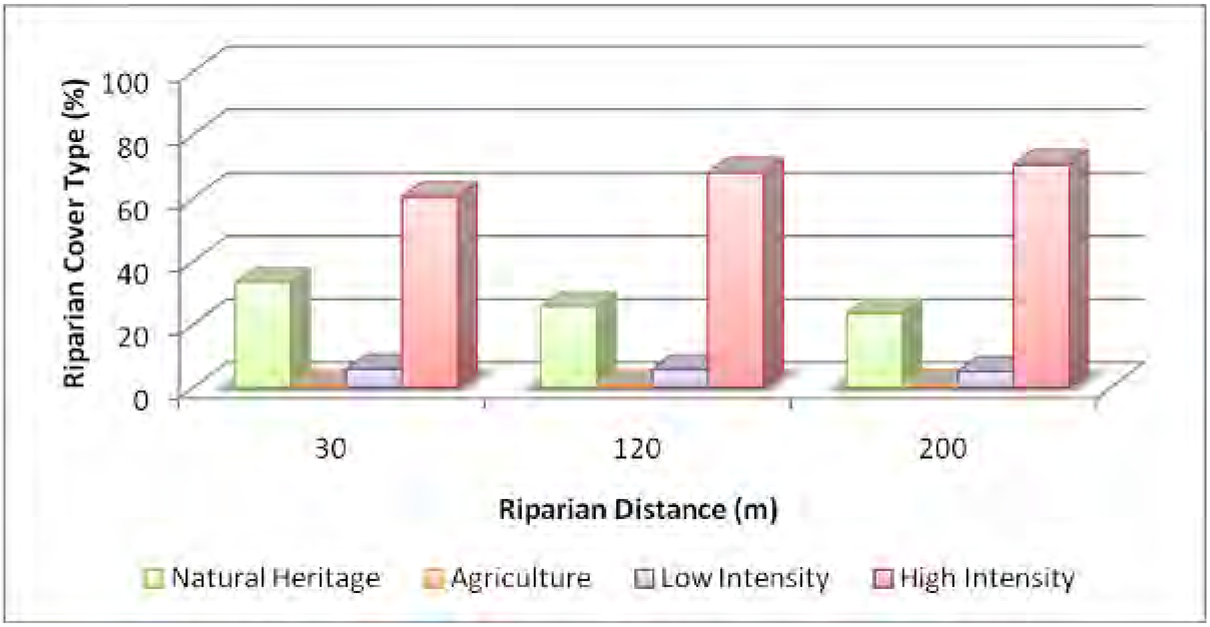


Figure 6-12: Riparian cover percentage per buffer distance for Barrie Creeks.

The 30 m riparian area within the Lovers Creek subwatershed is primarily composed of natural heritage cover which decreases somewhat as distance from the watercourses increases. Percentage of agriculture and high intensity development are relatively similar within the 30m riparian buffer, with both slightly increasing with the increased distance away (Figure 6-13).

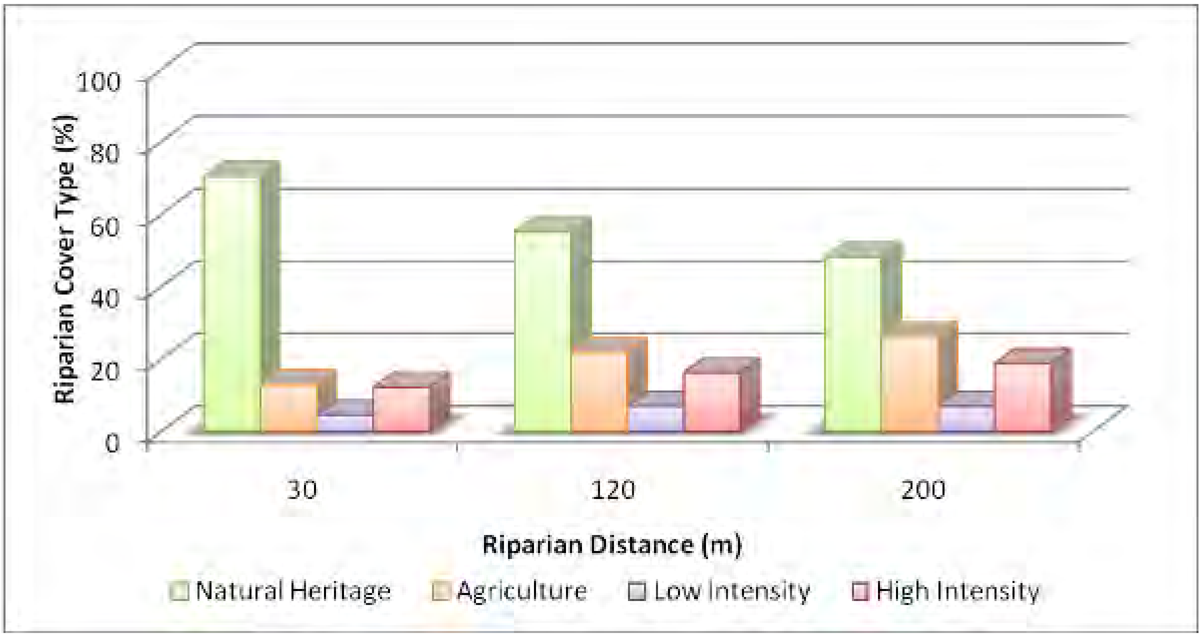


Figure 6-13: Riparian cover percentage per buffer distance for Lovers Creek.

The 30 m riparian area of the total watercourse length for Hewitt's Creek subwatershed is primarily natural heritage cover. The second highest land use within the riparian buffer is agriculture, which steadily increases as the riparian distance increases, while natural heritage cover decreases. The percentage of high intensity development, while being comparatively low, almost doubles from the 30 m riparian buffer to 200 m buffer (Figure 6-14).

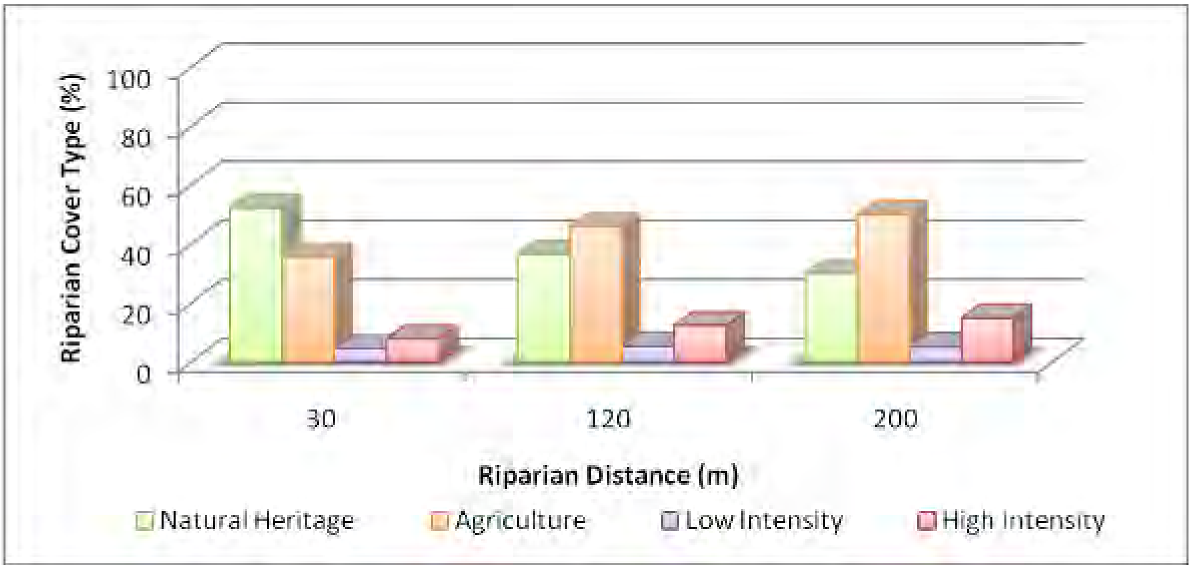
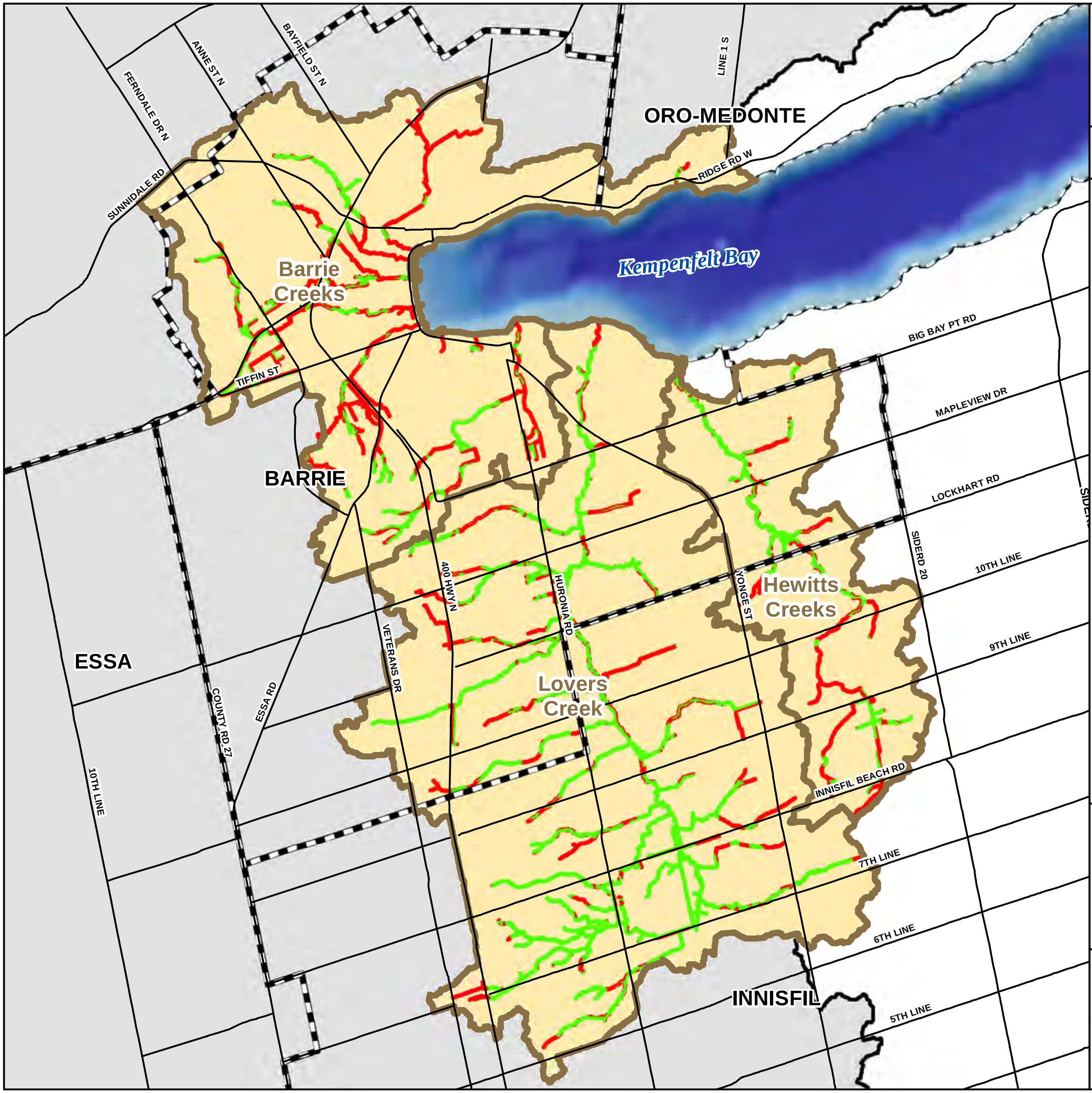


Figure 6-14: Riparian cover percentage per buffer distance for Hewitt's Creek.

Riparian and shoreline habitat in the Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds

Figure 6-15



Legend

—	Road
▬ ▬	Municipal Boundary

Riparian

🟩	Natural Vegetation
🟥	No Vegetation

Lake Simcoe Region conservation authority

0 0.5 1 2 3 4 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 2011.

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, fully 98% of the shoreline in front of the Hewitt's Creek subwatershed remained under natural cover. The more extensive shorelines of the Barrie Creeks and Lovers Creek subwatersheds have experienced heavier development pressures, and only 13% and 21% of the linear shoreline of these subwatersheds, respectively, remain under natural cover.

Table 6-3: Extent of natural vegetation along riparian areas in the Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds.

	Natural vegetation in riparian zone		
	Barrie Creeks (%)	Lovers Creek (%)	Hewitt's Creek (%)
Stream banks	35	71	52
Lake Simcoe shoreline	13	21	98
Both	**34**	**70**	**52**

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 is only one ANSI in these subwatersheds; a small portion of the Allandale Lake Algonquin Bluffs Life Science ANSI can be found along the steeply sloping area near Wildwood Trail and Ferndale Drive in the westernmost extremity of the Barrie Creeks subwatershed (Table 6-4).

The Allandale Lake Algonquin Bluffs has been identified as an ANSI as it is situated on the shoreline of glacial Lake Algonquin, and represents the least disturbed and most vegetatively diverse bluff complex in ecodistrict 6E-8 (Hanna, 1984).

In addition to the protection provided to ANSIs by the PPS, this particular ANSI is owned by the City of Barrie as the Ardagh Bluffs Natural Area.

Table 6-4: ANSIs found in the Barrie, Lovers, and Hewitt's Creeks subwatersheds.

ANSI Name	Significance Level	Status	Life Science/ Earth Science	Total Area (ha)	Watershed (area in watershed)
Allandale Lake Algonquin Bluffs	Provincial	Confirmed	Life	550.1	Barrie Creeks (2.7 ha)

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 Barrie Creeks subwatershed include:

- Fogg's goosefoot (*Chenopodium foggii*; S2), a ruderal plant species often found growing in sandy or rocky forest edges;
- 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;
- Chimney swift (*Chaetura pelagica*; Threatened) a bird which nests in unused chimneys, church steeples and other structures;
- Snapping turtles (*Chelydra serpentina*; S3; Special Concern) which inhabit large wetlands;
- 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.

Species of conservation concern noted in the Lovers and Hewitt's Creeks subwatersheds include:

- Milksnake (*Lampropeltis triangulum;* S3; Special Concern) which, although difficult to find, exist in a wide variety of habitats;

- 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;
- 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;
- Snapping turtles (*Chelydra serpentina*; S3; Special Concern) which inhabit large wetlands;
- Blanding's turtle (*Emydoidea blandingii,* Threatened) a turtle of small wetlands;
- Bobolink (*Dolichonyx oryzivorus*, Threatened) which nest in hayfields and other grasslands, and;
- The aerial insectivores common nighthawk (*Chordeiles minor*, Threatened) and whip-poor-will (*Caprimulgus vociferus*, Threatened).

6.2.7 Grasslands

In addition to these rare and at-risk species, are rare ecosystems. There are a few documented remnants of pre-settlement tallgrass prairie ecosystem within Barrie, including at least one in the Barrie Creeks subwatershed. These small relict ecosystems are dominated by big bluestem (*Andropogon gerardii*), Indian grass (*Sorghastrum nutans*), and little bluestem (*Schizachyrium scoparium*). Historic records provide a more detailed plant list of these remnants, including 17 plant species which are rare in the Lake Simcoe watershed (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 (*Sturnella magna*; recommended by COSEWIC, not yet listed). In fact, grassland-dependent wildlife are experiencing significant population declines in Ontario (McCracken, 2005). There are scattered grasslands throughout these three subwatersheds, primarily on the margins of woodlands or swamps, including two substantially large ones in the south end of the Barrie Creeks subwatershed (Figure 6-1, Table 6-5).

Table 6-5: Distribution of grassland types in the Barrie Creeks, Lovers, Creek and Hewitt's Creek subwatersheds.

Grassland type	Grassland Cover					
	Barrie Creeks		Lovers Creek		Hewitt's Creek	
	Area (ha)	Area (%)	Area (ha)	Area (%)	Area (ha)	Area (%)
Cultural meadow (CUM)	41.8	1.1	211.4	3.8	69.5	4.0
Cultural thicket (CUT)	104.6	2.8	45.6	0.8	11.8	0.7
Total	**146.4**	**3.9**	**257.0**	**4.3**	**81.3**	**4.7**

Key Points - Current Terrestrial Natural Heritage Status:

- The Barrie Creeks subwatershed is the most stressed subwatershed in the Lake Simcoe watershed, with respect to natural heritage features. Due to urban development in this subwatershed, only 17% of it remains in natural cover. Most of what is remaining is found in small fragments, surrounded by urban land use.
- The Lake Simcoe Protection Plan allows for uneven distribution of natural heritage features (associated with the uneven distribution of people) throughout the Lake Simcoe watershed, by setting natural heritage targets for the Lake Simcoe watershed as a whole.
- The Barrie Creeks subwatershed contains approximately 11.6% forest cover and 3% wetland cover. Natural riparian cover remains along 35% of the inland streams and 13% of the lakeshore in this subwatershed.
- The Lovers Creek subwatershed is in relatively good condition with respect to remnant natural areas (although still only about average for the Lake Simcoe watershed as a whole). Approximately 35% of the subwatershed remains in natural cover, situated in a landscape dominated by agricultural land uses.
- The Lovers Creek subwatershed contains approximately 26.7% forest cover and 13.5% wetland cover, much of which is accounted for in a large Provincially Significant swamp in the headwaters of the subwatershed. Natural cover remains along 71% of the inland streams and 21% of the lakeshore in this subwatershed.
- The headwaters of the Hewitt's Creek subwatershed are located in a primarily agricultural landscape, while the mouth of the subwatershed is in a primarily urban setting. Despite these pressures, 21% of the subwatershed remains under natural cover.
- The Hewitt's Creek subwatershed contains approximately 15.3% forest cover and 5.6% wetland cover. Natural riparian cover remains along 52% of the inland streams and 98% of the lakeshore in this subwatershed.
- 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 cannot 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 Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds were 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 these subwatersheds.

By the mid 1950s, roughly two-thirds of the original forest cover had been lost. Today, extant natural habitat remains at roughly the same amount in the Lovers Creek subwatershed (35%), with the majority of the rest of the subwatershed converted to agricultural and urban land uses (Figure 2-6, **Chapter 2 – Study Area**). The Hewitt's Creek subwatershed has dropped to 21% natural habitat, with over half of the subwatershed under agricultural land use (Figure 2-7, **Chapter 2 – Study Area**). The Barrie Creeks subwatershed is predominantly urban development (48%), with only 17% of the subwatershed remaining as natural habitat (Figure 2-5, **Chapter 2 – Study Area**).

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. Ecosystem types that are under this type of pressure include deciduous forests (in both the Lovers and Hewitt's Creek subwatersheds), and coniferous and mixed forests (in the Lovers Creek subwatershed). As almost the entire Barrie Creeks subwatershed has been designated a 'settlement area', all of its natural heritage features will experience this greater level of stress.

Notwithstanding the above, the greatest change expected in these subwatersheds will be a significant shift from agricultural land uses to more intensive landuses 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 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 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 vegetation 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 6-16, 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).

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).

Example loss of forest interior resulting from estate residential development

Figure 6-16

Legend

🟥 Estate Residential

🟩 Woodlands

▨ Interior Forest

Lake Simcoe Region conservation authority

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). These impacts are much less pronounced in these subwatersheds though. The Barrie Creeks and Hewitt's Creek subwatersheds have lost essentially no core habitat as a result of development of this sort (Table 6-6); this however, may be related to the fact that so little core habitat remains in these subwatersheds, and what does still remain is primarily in public ownership. Even in the Lovers Creek subwatershed though, where proportionally more core habitat remains, very little has been subject to estate residential development (Table 6-6).

Table 6-6: Cumulative impact of estate residential development in the Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds.

Woodland type	Woodland Cover					
	Barrie Creeks		Lovers Creek		Hewitt's Creek	
	Pre-estate residential (ha)	Current (ha)	Pre-estate residential (ha)	Current (ha)	Pre-estate residential (ha)	Current (ha)
Woodland	369.0	368.5	1004.0	1002.0	193.5	193.2
Woodland interior	17.2	17.2	195.0	193.6	16.0	15.9

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, the lakeshore along the Hewitt's Creek subwatershed, although short, is substantially unaltered; 98% of it remains under some sort of natural habitat. The lakeshore in the Barrie Creeks and Lovers Creek subwatersheds however, has been subject to intense urban development. Currently, only 21% and 13% of the shoreline in the Lovers Creek and Barrie Creeks subwatersheds remain forested, respectively. Although much of Barrie's shoreline is publicly owned, it is managed primarily as manicured green space, and has only minimal contributions to natural heritage values.

Furthermore, the Simcoe County soil map identifies much of the Barrie waterfront as being underlain by 'muck' soil, suggesting that historically there was a substantial wetland at the tip of Kempenfelt Bay, a suggestion which is also supported by early survey records (Figure 6-2). The loss and infilling of natural areas along this waterfront thus may have had direct impacts such as loss of wildlife habitat, as well as indirect impacts to the health of Kempenfelt Bay associated with the loss of this natural buffer.

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. 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 of course, 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), suggesting that relatively all of the natural heritage features remaining in the Barrie Creeks subwatershed may be exhibiting these types of impacts. In fact, by this assessment, only the relatively large Lovers Creek wetland in the headwaters of the Lovers Creek subwatershed remains unimpacted by disturbance associated with road traffic.

The proposed connection of the two ends of Bryne Drive in the City of Barrie (as shown on Schedule D of the Barrie Official Plan) may cause some of the impacts noted above. This planned road extension will bisect a 100 ha natural area, composed of a mix of deciduous and coniferous forests, deciduous swamp, thicket, and meadow ecosystems.

Furthermore, as the Secondary Plan is established for the land recently annexed by the City of Barrie, additional concerns related to road development may arise.

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. The water table drops when agricultural drains are introduced to swamps or mesic forests. 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 these subwatersheds, many of the plants which colonize rapidly changing areas such as this are non-natives.

The most significant instance of a municipal drain potentially impacting a natural heritage feature in these subwatersheds is in the headwaters of the Lovers Creek subwatershed. The main branch of the Lovers Creek has been designated a municipal drain and channelized through much of the Lovers Creek swamp.

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 a garden plant 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 resources such as 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 these subwatersheds is currently limited to:

- Garlic mustard (*Alliaria petiolata*), a widespread plant common in forest understories that suppresses native plants by exuding chemical compounds from their roots;
- European buckthorn (*Rhamnus cathartica*), a shrub often found along the edges (and even occasionally in the centres) of forests. This shrub was initially planted as a hedge species, but its seeds are widely dispersed by birds, and its rapid growth rate allows it to outcompete other shrubs and young trees;
- 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 which was introduced to North America by early settlers, and has since become widespread, and;
- House finch (*Carpodacus mexicanus*), is native to western North America. A flock of house finches was released in eastern North America in the 1940s, and the species has since become well established and widespread.

This short list is no doubt reflective more of a lack of documentation than a lack of invasive species. 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 are not 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, and 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 many 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 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*), American beech (*Fagus grandifolia*), yellow birch (*Betula alleghaniensis*), white cedar (*Thuja occidentalis*) and eastern hemlock (*Tsuga canadensis*) will all exhibit slight decreases in their occurrence in the forests of the Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds. 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 microclimate. 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 Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds (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 projected to occur by the year 2100 is 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. Interestingly however, these same models suggest that the swamps and marshes in the Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds will be more resilient to projected changes in climate, due to the role of ground water discharge in maintaining these wetland features (Chu, 2011).

In sum, these models suggest that there will be a shift in community composition in the natural areas in the Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds, and a net loss of tree species diversity. Unfortunately, natural areas lacking in biodiversity 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 being unable 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 these subwatersheds, many of which interact.
- Over the short term, the greatest impact to natural heritage values is expected to be due to changes in land use. These impacts can only be expected to increase as the population, and thus the developed area, in these subwatersheds 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 Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds, as outlined in the following sections.

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 Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds. Those having most impact on natural heritage features are summarized in Table 6-7. 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 6-7 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 are 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 6-7: 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 (30 m in already built-up areas, subject to a natural heritage evaluation), or within 30 m 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.

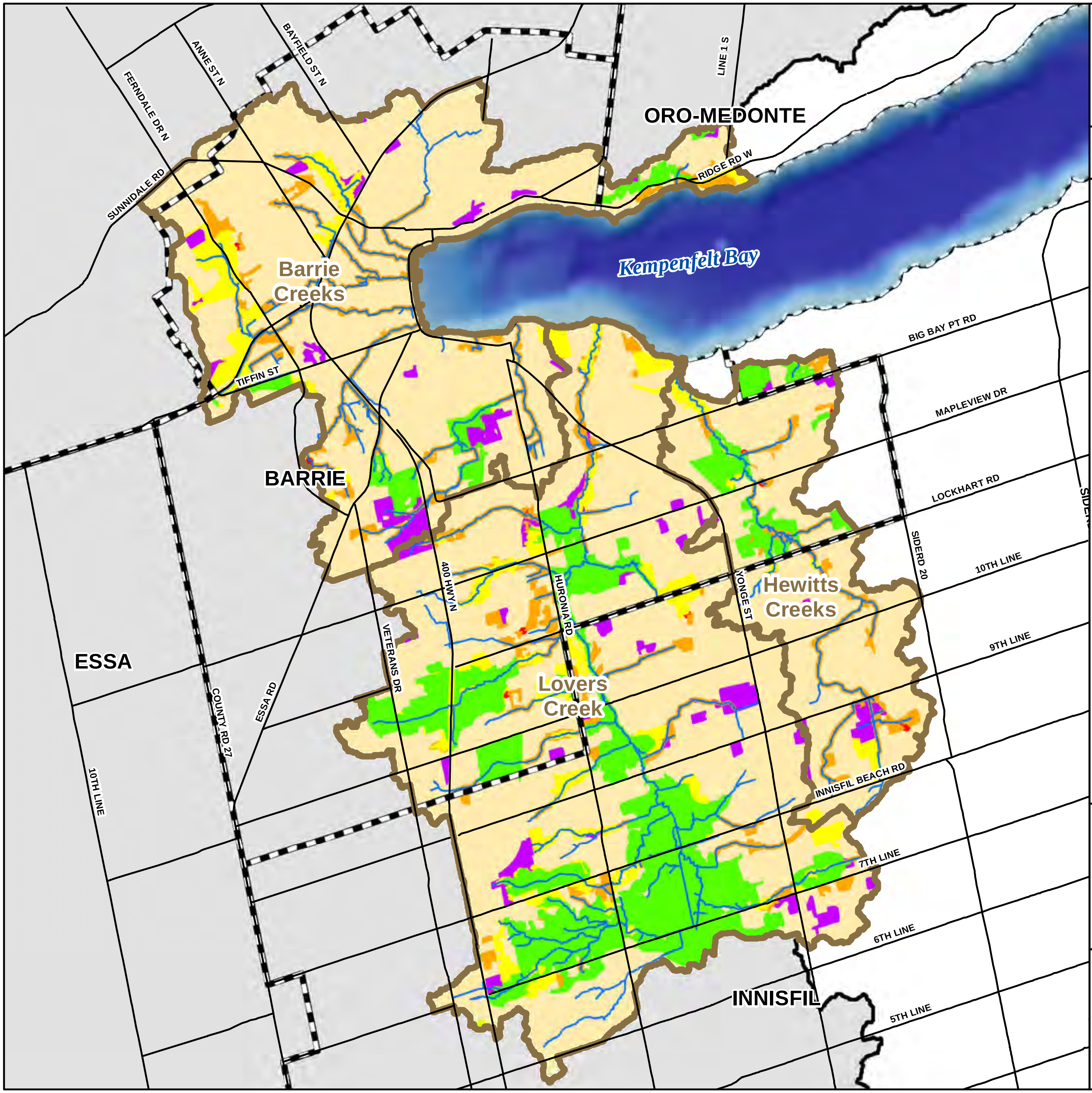
Draft definitions of Key Natural Heritage Features protected by the LSPP include all areas that meet the definition of wetland provided by either the Ontario Wetland Evaluation System or the Ecological Land Classification manual, all woodlands larger than 10 ha in size (or larger than 4 ha in size if 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 6-17).

However, the boundary of the City of Barrie (as described in the 2009 Official Plan) meets the criteria of 'settlement area' under the Lake Simcoe Protection Plan (Figure 2-9, **Chapter 2 – Study Area**). 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 City's Official Plan and zoning bylaw provide the guidelines on protection of these features within City boundaries.

The City of Barrie Official Plan attempts to maintain or enhance the long term environmental quality of the City of Barrie, while recognizing that the City is the principal urban centre of the region. The City has developed a draft Natural Heritage Strategy under their Official Plan to assist in striking that balance between protection and urban development. That draft Strategy 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.

Preliminary interpretation of Key Natural Heritage Features in the Barrie Creeks, Lovers Creek, andHewitt's Creek subwatersheds

Figure 6-17



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 2011.

Within the boundaries of the Town of Innisfil, the communities of Innisfil Heights and Stroud have been designated settlement areas by the municipal official plan (Figure 2-13, **Chapter 2 – Study Area**). Similar to the City of Barrie, in these communities LSPP policies to protect natural heritage features do not apply, and thus the municipal Official Plan and zoning bylaw become the primary tools for protecting natural heritage values.

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 there will be 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. It should be noted however, that no wetland features have been identified as existing in either Innisfil Heights or Stroud.

The LSRCA is assisting municipalities in identifying natural heritage systems for inclusion in Official Plans with their *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 recommendations 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 are that 71%, 87% and 69% of the natural heritage features in the Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds, respectively, have some level of development restrictions applied to them (Table 6-8, Figure 6-11). Remaining exceptions include some small (<10 ha) 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 occur 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 6-8: Extent of natural heritage protection policies in the Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds.

Natural heritage feature	Natural heritage cover					
	Barrie Creeks		Lovers Creek		Hewitt's Creek	
	Total existing (ha)	Total with development restrictions (ha)	Total existing (ha)	Total with development restrictions (ha)	Total existing (ha)	Total with development restrictions (ha)
Upland forests	368.5	333.1	1002.0	960.9	193.2	152.6
Wetlands	114.4	114.4	808.5	792.3	98.6	98.6
Grasslands	146.4	7.5	257.0	40.3	81.3	6.0
Total	**629.3**	**455**	**2067.5**	**1793.5**	**373.1**	**257.2**

An assessment of the "extreme-case scenario" for development in these subwatersheds is shown in Figure 6-18. This assessment assumes full build-out in the settlement areas and the annexed lands (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 in the Barrie Creeks subwatershed, and a substantial increase in the Lovers Creek and Hewitt's Creek subwatersheds (associated with the annexed lands). This scenario also results in net decreases in both agricultural land and natural heritage features to offset the projected urban growth. As mentioned above, natural heritage features vulnerable to development include grasslands and small isolated forests. The extent of urban intensification projected in these subwatersheds suggests that the indirect impacts associated with urban intensification, 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 may become even more significant stressors in these subwatersheds in the future. Unfortunately, these indirect effects are more difficult to control through mechanisms such as municipal Official Plans.

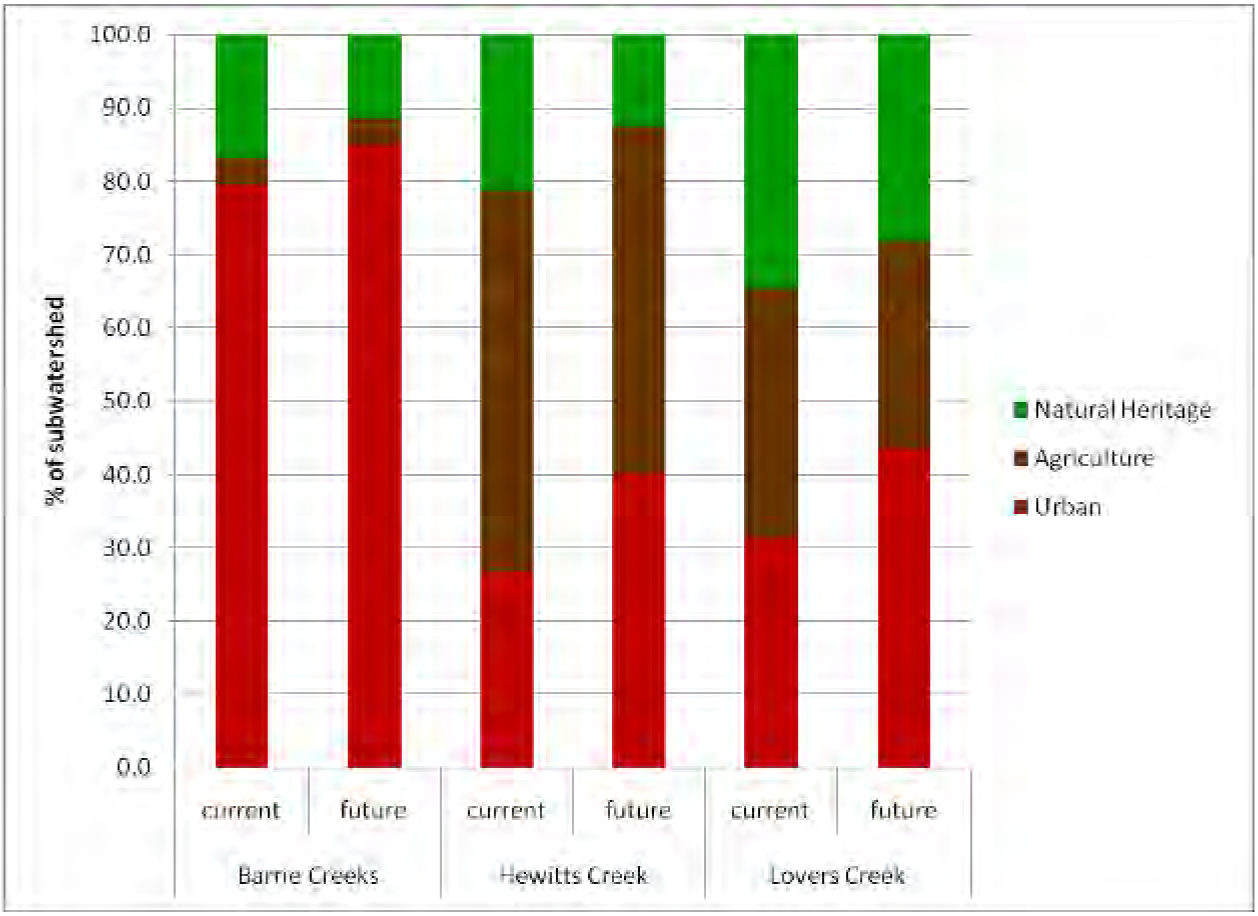


Figure 6-18: Extreme-case scenario of possible land use change in the Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds.

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. Although none of these priority areas are within the Barrie Creeks, Lovers Creek, or Hewitt's Creek subwatersheds, the LSRCA may consider receiving donations of relatively large parcels of land, 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 are 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 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, in addition to projects focussed specifically on protecting water quality, LEAP has supported five riparian buffer and one upland tree planting in the Barrie Creeks subwatershed, one riparian and four upland tree plantings in the Lovers Creeks subwatershed, and three riparian plantings in the Hewitt's Creek 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, septic system upgrades, wetland creation, and forest management, among others. In the Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds, 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 three shoreline improvement projects in the Barrie 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, no projects that would directly improve terrestrial natural heritage have been completed in the City of Barrie, while in the Town of Innisfil less than five have been implemented.

In 2008 and 2009, LSRCA field staff surveyed the majority of the watercourses in these subwatersheds through the Best Management Practices Inventory Program, documenting the range of potential stewardship projects that could be implemented to help improve water quality and fish habitat. This survey found over 200 additional places in these three subwatersheds where additional riparian planting could be introduced.

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.

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 Barrie Creeks, Lovers Creek, or Hewitt's Creek subwatersheds.

Key Points – Current Management Framework Protecting Terrestrial Natural Heritage

- The suite of natural heritage protection policies provided under the Lake Simcoe Protection Plan and municipal official plans provide relatively comprehensive protection for natural heritage features in these subwatersheds. Exceptions include grasslands and some small isolated forests.
- Wetlands are effectively protected in these subwatersheds, with the exception of development or site alteration associated with municipal infrastructure.
- Existing natural vegetative cover along the shoreline and in the riparian zone of the tributaries is protected by policies provided under the Lake Simcoe Protection Plan and municipal official plans
- The Ministry of Natural Resources, Lake Simcoe Region Conservation Authority, and South Simcoe Streams Network provide programs to assist private landowners in improving natural heritage features on their property. A major focus of these programs is in increasing natural vegetative cover along the shoreline and in the riparian zone of tributaries.
- Despite the existence of these programs, uptake has been limited in these subwatersheds. The forthcoming Shoreline Voluntary Action Program may help increase uptake, by increasing public awareness of the value of shoreline ecosystems, increasing public awareness of the existence of funding and technical assistance programs, and by conducting surveys to determine barriers to public uptake.
- The incomplete protection provided to grasslands and small forests in these subwatersheds, and lack of uptake of block-planting assistance provided through stewardship programs, will limit the ability of these subwatersheds to contribute to meeting the LSPP goal of 40% high quality vegetative cover

6.5 Management Gaps and Recommendations

As can be seen in the previous sections, there are a number of programs in place to protect and enhance the natural heritage features in the Barrie Creek, Lovers Creek, and Hewitt's Creek subwatersheds. 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 Barrie Creeks, Lovers Creek, and Hewitt's Creek 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 Barrie Creeks, Lovers Creek and Hewitt's Creek 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 are two documented tallgrass prairie remnants in these subwatersheds; one is in the City-owned Allandale Park, and one is privately owned property in the Township of Oro-Medonte (note: this area will be addressed through the development of the Oro and Hawkestone Creeks Subwatershed Plan, which has recently been initiated).

> **Recommendation 6-4 –** That the City of Barrie confirm the existence of the tallgrass prairie remnant in Allandale Park and, if a remnant still persists, develop and implement a management plan for its preservation and enhancement, and examine opportunities to provide interpretive values for the public.

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 above. 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 City of Barrie's draft Natural Heritage System has a progressive approach to deal with the problem of conservation of non-native grassland habitats, requiring proponents to do an EIS prior to development of 'cultural meadows' or 'cultural thickets' contiguous with woodland or wetland habitats.

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 6-5 –** 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 6-6** – 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.
>
> **Recommendation 6-7** – As proposed in the Background and Options report commissioned by the City of Barrie for the recently annexed lands, that the City of Barrie consider the potential of including some grassland or meadow habitat (defined as 'open country' in that report) in the forthcoming natural heritage system for the annexed lands.

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 6-8** – That the proponents and reviewers of all Environmental Assessments recognize the intent and targets of the Lake Simcoe Protection Plan when developing and assessing alternatives to the proposed undertaking.
>
> **Recommendation 6-9** – 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.

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 such as Barrie with high population densities.

> **Recommendation 6-10** – 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 6-11** – That the LSRCA and subwatershed municipalities, with the assistance of the MNR, 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 6-12** – 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 6-13 – That the MNR, MOE, MAFRA, and LSRCA continue to implement stewardship projects in these subwatersheds, and work collaboratively with other interested organizations, through the Lake Simcoe Stewardship Network, to do the same.

Recommendation 6-14 – 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 6-15 – That the Federal, Provincial, and Municipal governments provide consistent and sustainable funding to ensure continued delivery of stewardship programs.

Recommendation 6-16 – 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 6-17 – That the MOE, MNR, MAFRA, LSRCA, and other interested members of the Lake Simcoe Stewardship Network support research to determine public motivations and 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 6-18 – 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 6-19 – 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 riparian cover along the tributaries of the Barrie Creeks and Hewitt's Creek subwatersheds

- The need to increase the extent of natural shoreline along the lakeshore in the Barrie Creeks and Lovers Creek subwatersheds
- Protecting and restoring ecologically significant groundwater recharge areas, to help mitigate the expected impacts of climate change
- Opportunities to restore lost wetlands, particularly on City-owned property along the Kempenfelt Bay shoreline, where historic records indicate extensive bay mouth wetlands
- Opportunities to increase connectivity across the subwatersheds for dispersing flora and fauna
- The need to protect and restore grassland habitat, particularly rare native grasslands
- The need to reduce phosphorus loadings to the tributaries in these subwatersheds.

Recommendation 6-20 – 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 likelihood 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, over 70% of current natural heritage features in the Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds have some level of protection from development or site alteration. As such, the greatest impacts to natural heritage values in these subwatersheds 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 6-21 – 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 6-22 – That the MNR and its partners provide outreach to garden centres, landscapers, and garden clubs regarding the danger of using invasive species in ornamental gardens.

Recommendation 6-23 – 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.

Recommendation 6-24 – That the City of Barrie and Town of Innisfil give preference to native species when selecting trees to be planted in boulevards, parks, and other municipal lands.

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 6-25** – 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 6-26** – 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 6-27** – 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 6-28** – 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 6-29** – 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 Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds, 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 6-30** – 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 Barrie Creeks, Lovers Creek, and Hewitt’s Creek 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 (Figure 7-1). In the case of the Barrie Creeks and Lovers Creek subwatersheds, the height of land along their western boundary, where Highway 400 is situated, provides significant groundwater recharge (Figure 4-13). 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. They also increase 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 or near Kempenfelt Bay. However, unlike surface water, some of the groundwater flowing through the Barrie Creeks subwatershed originates outside of the watershed, on the Oro Moraine, or to the west in the Nottawasga River watershed. Much of this groundwater flows in either an upper aquifer (composed of fine to medium grained sand and gravel near the ground surface, deposited along the shores of glacial Lake Algonquin), an intermediate aquifer (a 10-30 m deep lens of sandy soils generally lying between the other two, and extending out into Kempenfelt Bay), or a lower aquifer (a 10-40 m thick layer of coarse sand and gravel deposited in a pre-glacial river channel),

This groundwater can be discharged to the surface, and become available for use in aquatic or wetland ecosystems, through the process of groundwater discharge (Figure 7-1). This discharge happens in areas with similarly coarse soil, but in areas 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 Barrie Creeks, Lovers Creek, and Hewitt’s Creek subwatersheds, 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 Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatershed, including the Provincially Significant Lovers Creek Swamp, are fed by this groundwater discharge (Figure 4-11 and Figure 6-7). These aquifers discharge into 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. This relationship however is one of the most significant links 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 may make them more susceptible to being outcompeted by more generalist 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 during the hottest days of the year. This refugia habitat may explain the continued persistence of brook trout in Kidds Creek, the main branch of Lovers Creek, and the north end of Hewitt's Creek, where they persist although water temperature appears to be too high to meet their habitat requirements. 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 (Figure 7-1). 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 (Figure 7-1). In the case of these three subwatersheds, this may be most noticeable in the City of Barrie, which, because of its relatively low topographic position and loamy, sandy soils, historically had been a large area of groundwater discharge, supporting a large swamp at the mouth of Kempenfelt Bay. As the City was filled and developed, the groundwater discharge was altered. Much of the groundwater now flows into Kempenfelt Bay, with the exception of the few remaining natural areas and creeks.

Where it still exists however, groundwater discharge in the City plays an important role in mitigating some of the other urban stressors on stream ecosystems. For example, Kidds Creek in the City of Barrie, which is stressed by factors related to surrounding land use, hardened banks, barriers, and enclosed sections, still supports a reproductive population of brook trout. Their ability to persist in this stream is thought to be because of the mitigating influence of groundwater discharge. Conversely, it is also important to preserve the remaining groundwater recharge areas within and around the City, particularly those identified as significant groundwater recharge areas, as they are necessary for replenishing the groundwater that is critical for maintaining these coldwater streams. Figure 4-24 displays the land use in these significant recharge areas.

One important measure to protect 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.

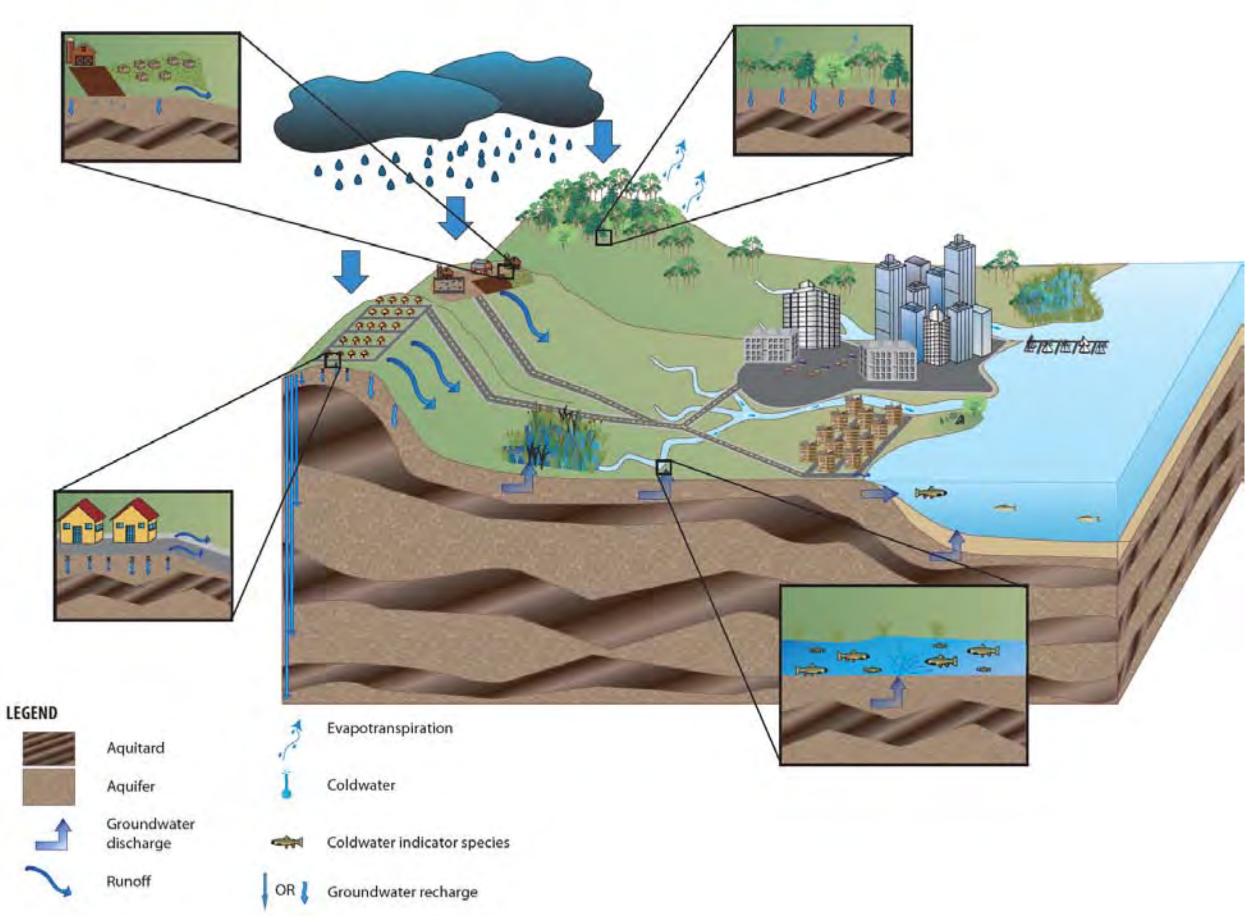


Figure 7-1: Groundwater interactions in the Barrie Creeks, Lovers Creek and Hewitt's Creek subwatersheds.

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 a relative lack of vegetation cover, 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 (Figure 7-2). As such, agricultural stormwater can contribute to 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 (Louis Berger Group, Inc., 2010), and, as the largest land use in the Hewitt's Creek subwatershed, is the largest contributor of phosphorus to Hewitt's Creek. 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. Suspended sediment in 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 the amount of dissolved oxygen in watercourses to decline to critical levels, making them less suitable as habitat for fish and other aquatic organisms (Figure 7-2).

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 to work properly, they require maintenance, which 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 volume of phosphorus and sediment travelling from agricultural fields to Lake Simcoe. As an example, the conversion of much of the headwaters of Hewitt's Creek from natural watercourses to agricultural drains, and the resulting loss in water storage in the summer, would help to explain why aquatic communities are degraded in these watercourses (Figure 5-3, Figure 5-6, Figure 5-12). 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 7-2).

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 7-2).

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 7-2).

Fortunately, the remnants of natural vegetation along many of the watercourses flowing through agricultural land in these subwatersheds (Figure 6-15) act to buffer these impacts somewhat. Riparian buffers act as an important last line of defence between farm fields and watercourses, slowing the velocity of stormwater and 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 (Figure 7-3). Unfortunately, in cases like the headwaters of the Hewitt's Creek subwatershed (Figure 6-15), where riparian buffers are lacking, agricultural impacts on watercourses can be most significant, and associated with a shift in tributary fish communities.

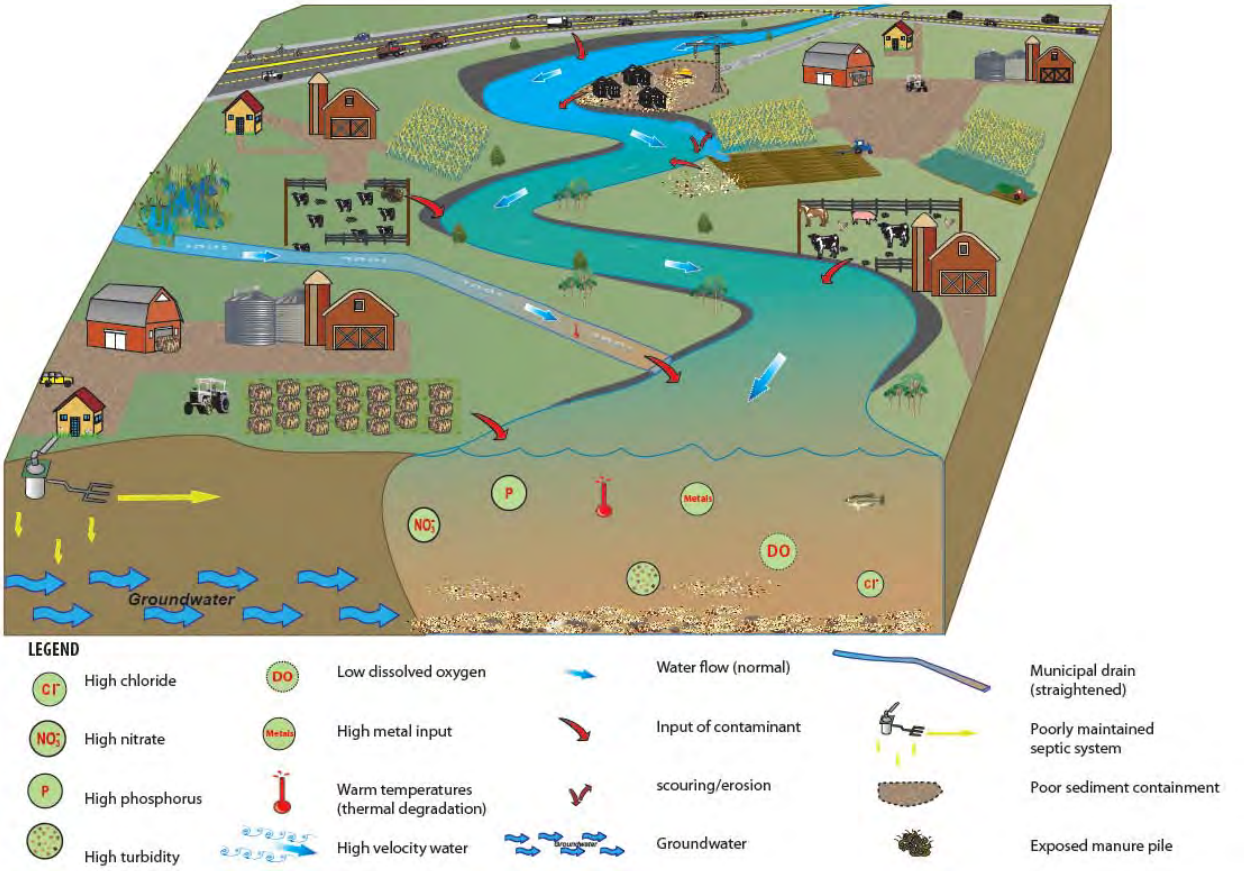


Figure 7-2: Influences of agricultural land use on subwatershed health.

The release of sediment and phosphorus from farm fields can also be reduced with the use of cover crops, by minimizing fertilizer application, by fencing streams to prevent livestock access, 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 (Figure 7-3).

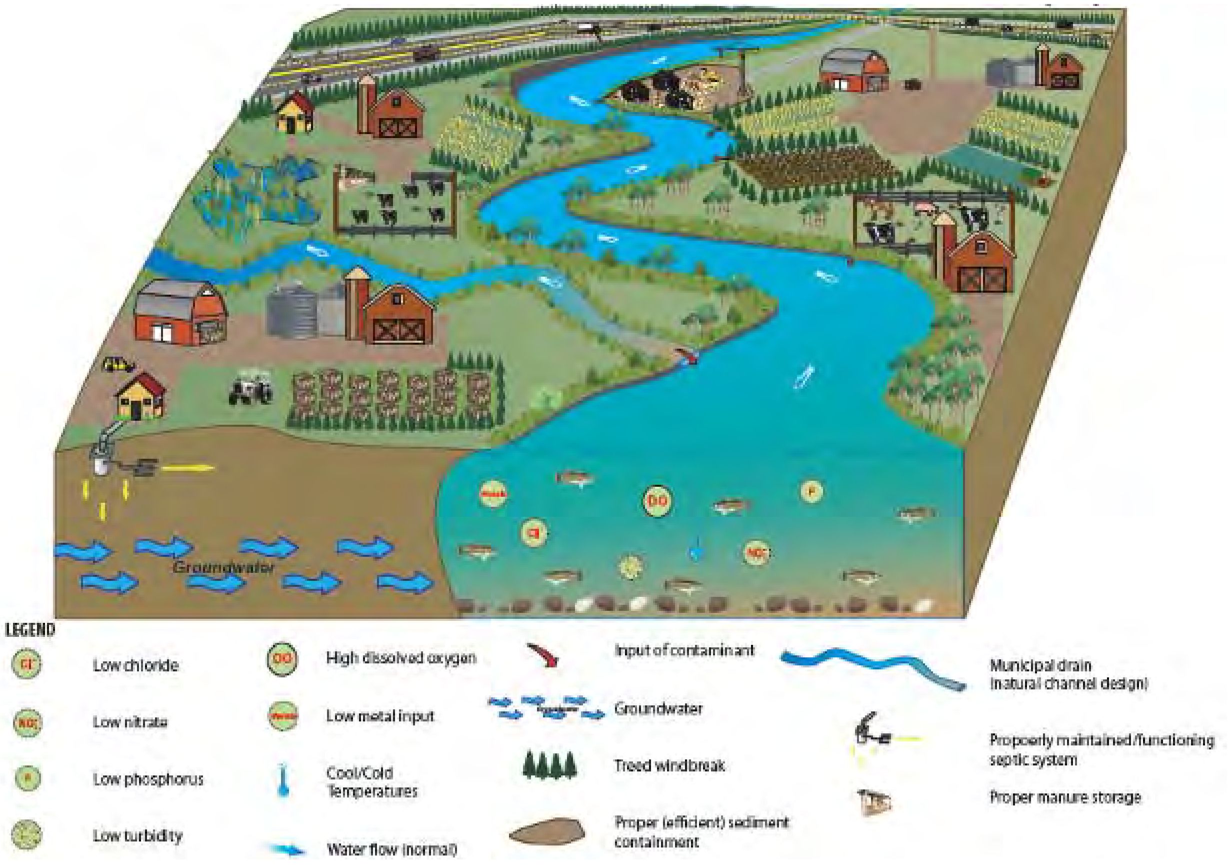


Figure 7-3: An agricultural landscape with appropriate best management practices implemented to protect subwatershed health

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 Lovers Creek and Hewitt's Creek subwatersheds, primarily related to stream bank fencing, establishment of riparian buffers, repairs to failing septic systems, and improved management of manure and milkhouse waste (Figure 7-4, Figure 7-5, Figure 7-6).

Despite this effort, many more opportunities to increase the amount of stream bank vegetation, reduce barnyard runoff, and restrict livestock access still remain in these subwatersheds, and there are many more septic systems which could contribute phosphorus to groundwater as they age, which will require repairs or upgrades (Figure 7-4, Figure 7-5, Figure 7-6, Figure 7-7).

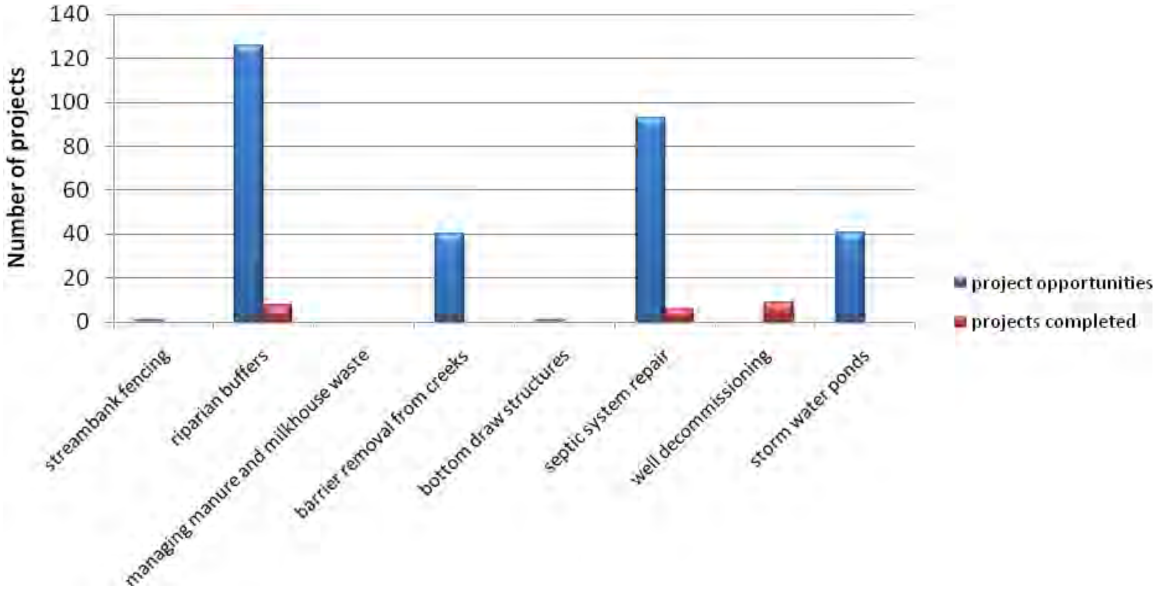


Figure 7-4: Approximate number of stewardship projects completed and stewardship opportunities in the Barrie Creeks subwatershed. Graph includes projects done both in agricultural and urban settings

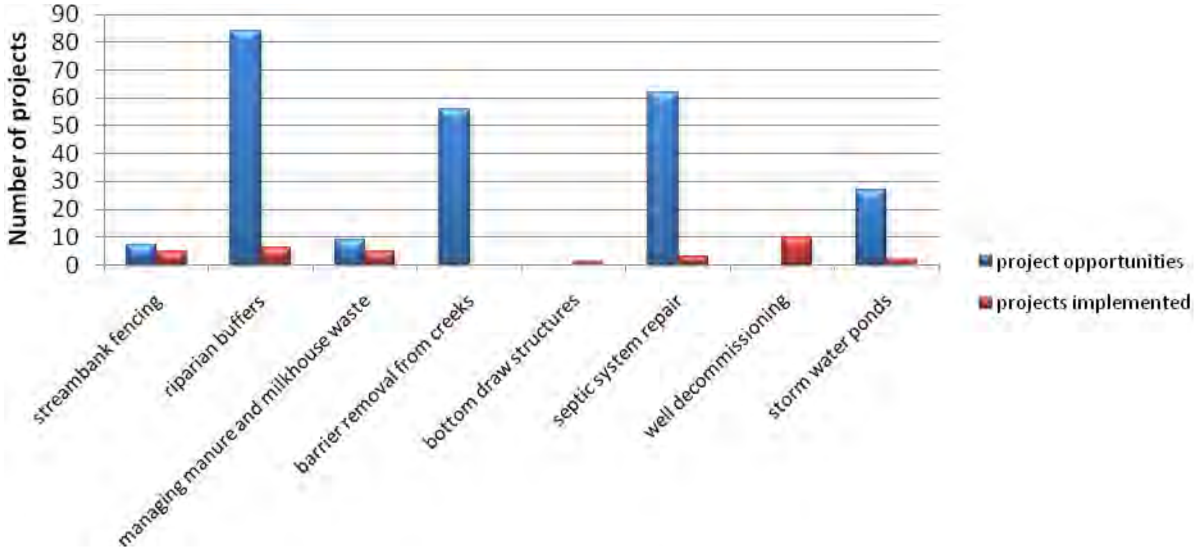


Figure 7-5: Approximate number of stewardship projects completed and stewardship opportunities in the Lovers Creek subwatershed. Graph includes projects done both in agricultural and urban settings

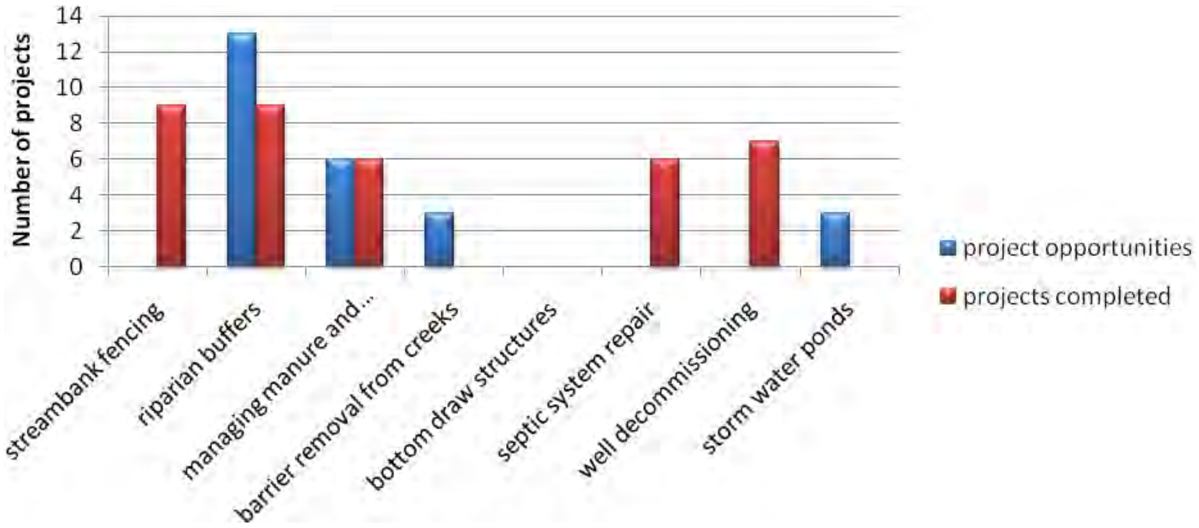
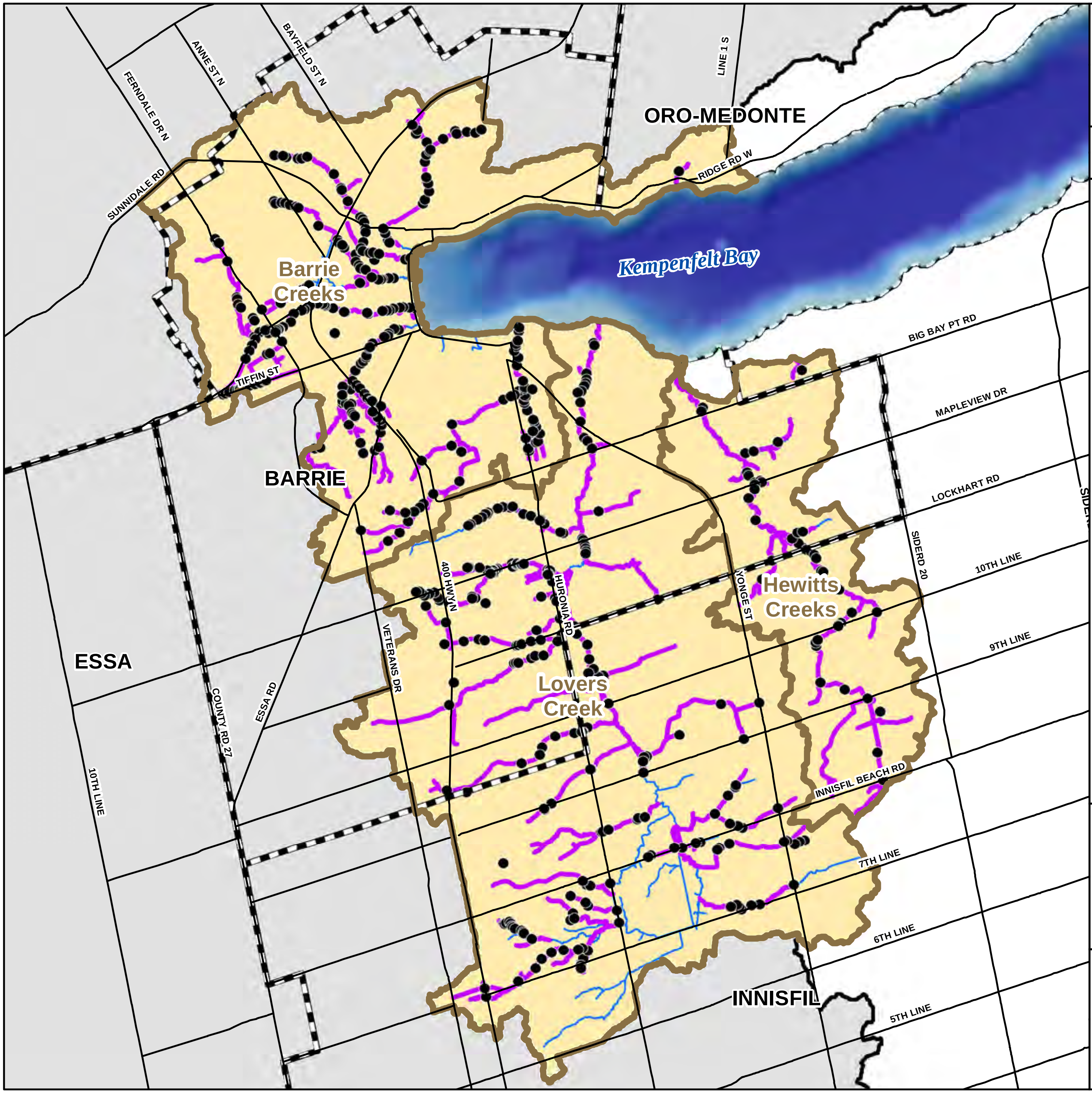


Figure 7-6: Approximate number of stewardship projects completed and stewardship opportunities in the Hewitt's Creek subwatershed. Graph includes projects done both in agricultural and urban settings

Best Management Practices project opportunities in the Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds

Figure 7-7



Legend

Road

Municipal Boundary

Watercourse

● BMP Opportunities

BMP Watercourse Surveyed

Lake Simcoe Region conservation authority

0 0.5 1 2 3 4 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.

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 (Figure 7-8). In fact, the Barrie Creeks subwatershed, which is the most heavily urbanized subwatershed in the Lake Simcoe watershed, is also the largest per-hectare contributor of phosphorus to the Lake Simcoe ecosystem (Figure 3-11).

As an area which is expecting significant growth and development, particularly in the Lovers and Hewitt's Creek subwatersheds, which have recently been annexed by the City of Barrie, many of the stresses associated with urban land use may become more extensive (Figure 6-18), 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 these subwatersheds however include phenolics, metals, and organic compounds (Figure 7-8). 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.

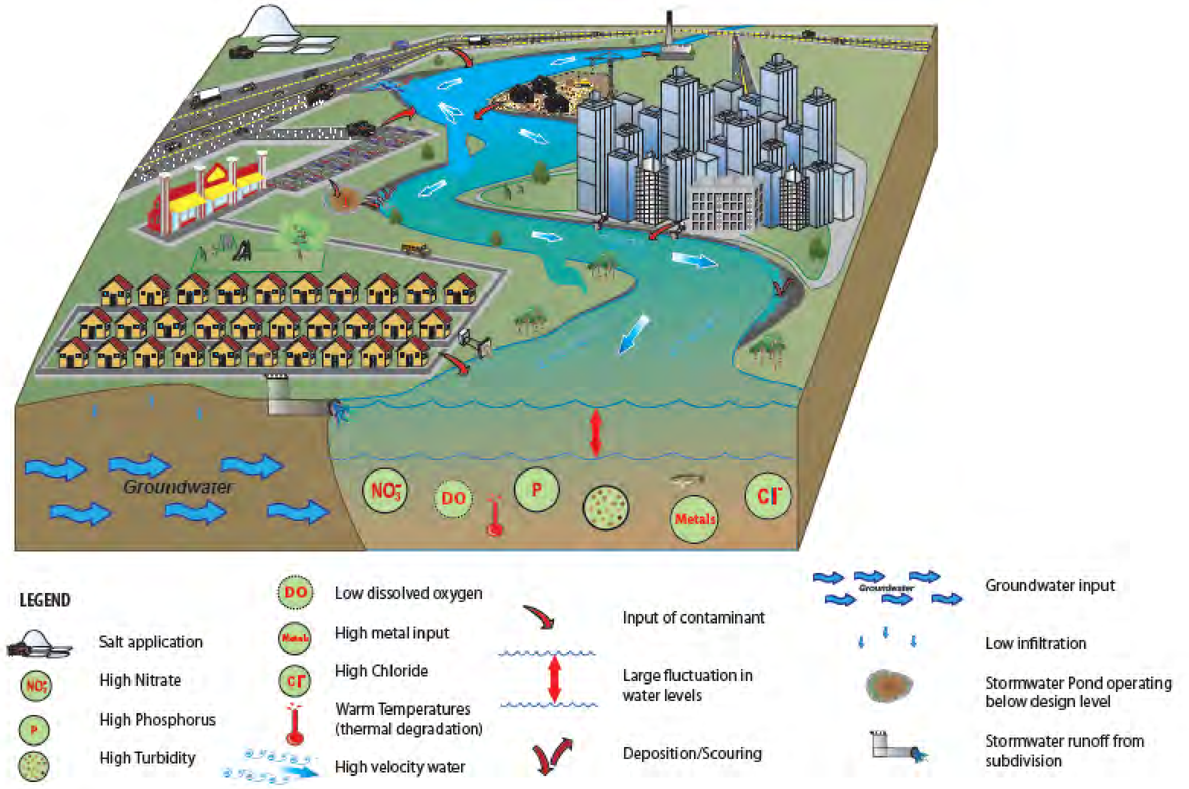


Figure 7-8: Influences of urban land use on subwatershed health

Complicating matters further is our management of snow. Where, historically, snow would accumulate in the forest, 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 or muskellunge, 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 7-8). Increasing concentrations of chloride in watercourses can decrease feeding and growth rates in fish, and in creeks like Hotchkiss Creek, which regularly experiences acute chloride concentrations, can lead to widespread 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. Both of these stresses 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 also can increase the rate of erosion of exposed soil or streambanks, increasing the amount of sediment that gets deposited in the creek, and can increase the transport of contaminants. 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 7-8).

The influence of development in these subwatersheds extends into Kempenfelt Bay as well. Urban runoff from these subwatersheds has led to increased concentrations of phosphorus, chloride, cadmium, chromium, copper, mercury, nickel, lead, and zinc in the nearshore zone of Kempenfelt Bay. The increased phosphorus loading, in combination with the soft substrates and high transparency of water in the Bay, has lead to a three-fold increase in aquatic plant growth in the Bay over the past thirty years. Although the deep, cold, and groundwater-fed nature of Kempenfelt Bay mitigates the impacts of these watershed inputs, the nearshore area along the City of Barrie is in poor condition.

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 7-9). 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 7-9).

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, ensure that snow meltwater does not drain directly into storm sewers, or to use treatment measures other than chloride in areas that are particularly sensitive to contamination.

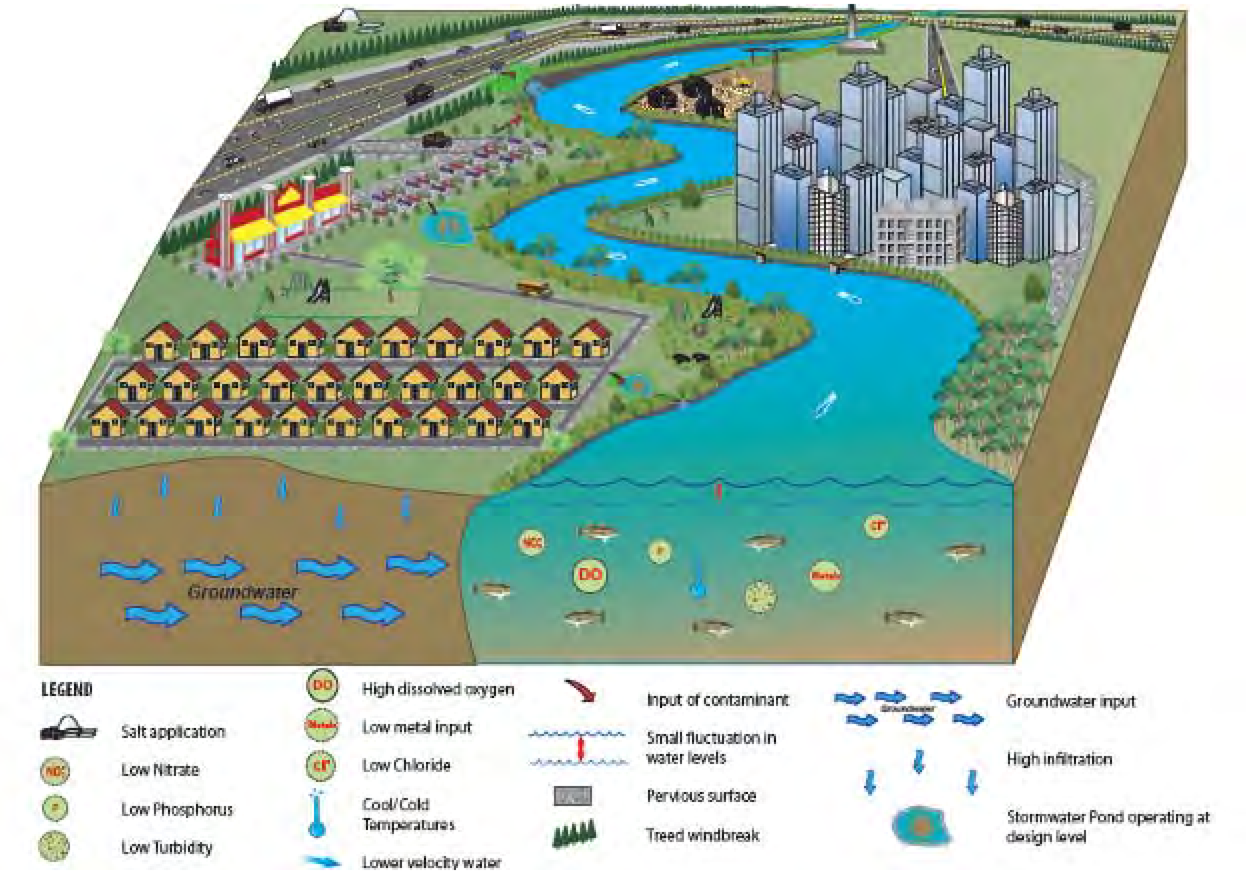


Figure 7-9: An urban landscape with appropriate best practices implemented to protect subwatershed health

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 in order 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. A survey completed in 2010 found that less than half of the stormwater ponds in these subwatersheds were operating below their designed efficiency, capturing less phosphorous and sediment from stormwater than intended (Figure 3-19, Figure 3-20, Figure 3-21). 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. 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 (Figure 7-8).

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 that 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 7-9). Despite the challenges to watershed health associated with projected development in Barrie and Innisfil, that development also provides a significant opportunity to implement innovative low impact development techniques, as well as to use innovative design for 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 7-4, Figure 7-5, Figure 7-6). 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 7-4, Figure 7-5, Figure 7-6, Figure 7-7, Figure 3-23).

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. The shading provided by vegetation along the banks, particularly for small streams like many of the tributaries in these three subwatersheds, plays an important role in reducing 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. In fact, given the extent of the road network in these subwatersheds, riparian zones provide some of the best opportunities to maintain and increase connectivity for wildlife.

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. 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 (Figure 7-10). 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.

Figure 7-10: Influences of riparian land use on subwatershed health

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. Over time, barriers can lead to a loss in fish biodiversity, as isolated stream reaches become more vulnerable to local extinctions (Figure 7-10). It is the result of in-stream activities such as these, particularly the establishment of barriers along the streams, which is most likely the reason that no fish have been found in many of the headwater reaches in the Barrie Creeks subwatershed. Septic systems, which support many of the rural residences in these subwatersheds, can also be a source of phosphorus to nearby watercourses, if not properly maintained.

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 in heavily developed areas such as Barrie, options to establish a naturally meandering channel can be extremely constrained. Despite that, the Lake Simcoe Region Conservation Authority, the City of Barrie, and their partners have supported the restoration of the mouth of Kidd's Creek in downtown Barrie, which included opening up 300m of the creek that had previously been enclosed in a pipe under a parking lot. Despite that exciting project, many more opportunities to remove barriers from creeks, naturalize creeks which have been channelized, or even enclosed in pipes, remain in these subwatersheds (Figure 7-4, Figure 7-5, Figure 7-6, Figure 7-7, Figure 7-11).

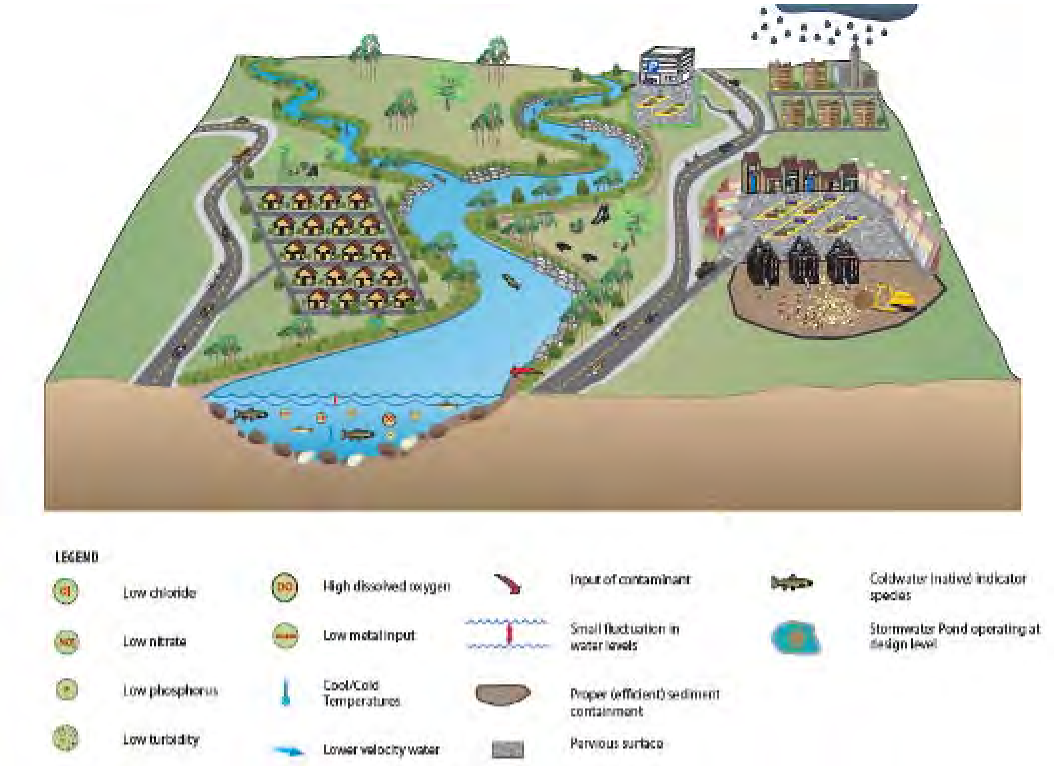


Figure 7-11: Riparian area with appropriate best practices implemented to protect subwatershed health

7.6 Shoreline interactions - activities in and near the lakeshore, water quality, and aquatic wildlife

Of particular importance to these subwatersheds is the role played by the Lake Simcoe shoreline. As the shoreline associated with these subwatersheds is located within the City of Barrie, it has been the focus of development and public use for nearly a century, which has led to an increase in the extent of impervious surfaces and hardened banks, and increased population levels (Figure 7-12). Along much of its length, most of the native vegetation has been removed from the shoreline, and what is left is often mowed right to the water's edge.

The loss of 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). Unfortunately, this loss of vegetation is often exacerbated with other works along the shoreline, such as the installation of concrete, steel, or gabion baskets as retaining walls to prevent erosion or to make the shoreline more conducive for recreation. The loss of the natural shoreline and associated aquatic vegetation associated with this construction means a loss of spawning and feeding habitat for native fish (Figure 7-12).

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.

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 Barrie Creeks, Lovers Creek, and Hewitt's Creek shoreline, which represents 6% of the total lakeshore, has already had 83% of its length developed in some way. In fact, developments in the Barrie Creeks shoreline area may be more significant than in any other subwatershed in the Lake Simcoe basin. Historically, much of the mouth of Kempenfelt Bay, where downtown Barrie is now, was an extensive swamp (Figure 6-2) 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.

Fortunately, continual inputs of groundwater from these subwatersheds' aquifers play an important role in protecting the health of Kempenfelt Bay. This groundwater acts to decrease water temperature in the Bay, and dilute the concentrations of nutrients and metals exported by the Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds. It is the influence of this continual groundwater input that makes Kempenfelt Bay one of the most productive fish habitats in Lake Simcoe.

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 (Figure 7-13). Financial and technical support for these types of projects is provided by the MNR and LSRCA.

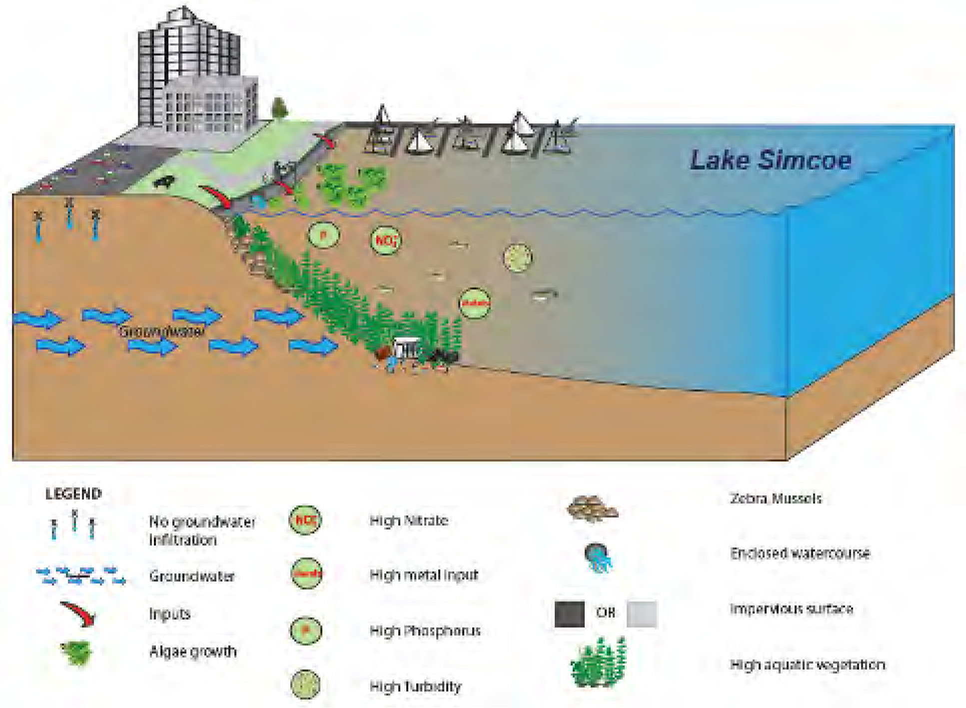


Figure 7-12: Influences of shoreline land use on subwatershed health

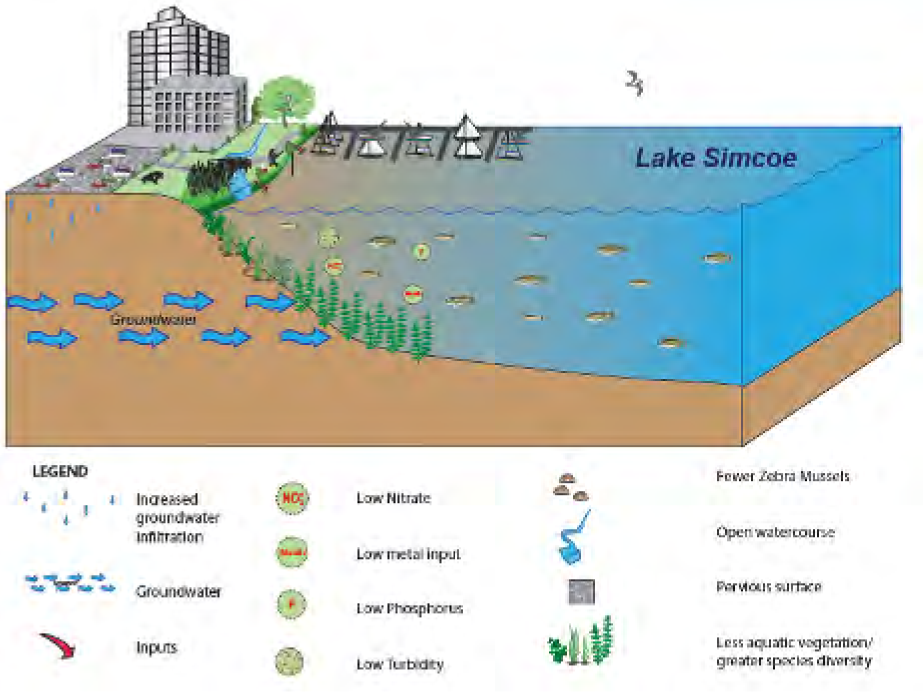


Figure 7-13: Shoreline area with appropriate best practices implemented to protect subwatershed health

7.7 Developing an implementation plan

The Barrie Creeks, Lovers Creek, and Hewitt’s Creek 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 City of Barrie, Town of Innisfil, County of Simcoe, 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 Barrie Creeks, Lovers Creek, and Hewitt's Creek subwatersheds.

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 Barrie Creeks, Lovers Creek and Hewitt's Creek 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 6-2 – Recommendation 6-2, which relates to mitigation for the loss of natural heritage features through development, remains in discussion with LSRCA's partners

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 City of Barrie confirm the existence of the tallgrass prairie remnant in Allandale Park and, if a remnant still persists, develop and implement a management plan for its preservation and enhancement, and examine opportunities to provide interpretive values for the public.

Recommendation 6-5 – 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 6-6 – 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.

Recommendation 6-7 – As proposed in the Background and Options report commissioned by the City of Barrie for the recently annexed lands, that the City of Barrie consider the potential of including some grassland or meadow habitat (defined as 'open country' in that report) in the forthcoming natural heritage system for the annexed lands.

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 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.

8.1.5 Incorporating LSPP objectives in Environmental Assessments

Recommendation 6-8 – That the proponents and reviewers of all Environmental Assessments recognize the intent and targets of the Lake Simcoe Protection Plan when developing and assessing alternatives to the proposed undertaking.

Recommendation 6-9 – 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.

8.1.6 Promoting Low Impact Development

Recommendation 3-1-That the LSRCA develop a discussion paper for MOE that will: (1) describe the range of LID technologies that could potentially be used to mitigate the impacts of development on surface and groundwater quality and quantity; (2) identify the barriers associated with the uptake of LID technology and, (3) with the support of MOE, identify opportunities for overcoming these barriers.

Recommendation 3-2 - That LSRCA develop an action plan to address barriers associated with the implementation of LIDs.

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, particularly in areas lacking adequate stormwater controls, and lacking conventional retrofit opportunities, 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 3-7 - 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 Barrie, Lovers and Hewitt's Creeks subwatersheds 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 review and, where necessary, revise current monitoring, enforcement, and reporting on site alteration and tree cutting by: 1) undertaking a review of the current programs and actions, 2) encouraging the allocation of adequate resources for the improvements, and 3) monitoring and reporting on results.

8.1.10 Land securement by public agencies

Recommendation 6-10 – 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 6-11 – That the LSRCA and subwatershed municipalities, with the assistance of the MNR, 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 6-12 – 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, be encouraged to support, through financial or other measures, municipalities and/or the LSRCA to maintain, construct, and /or retrofit stormwater facilities as identified by the LSRCA Stormwater Rehabilitation program.

Recommendation 3-5 - Given the high rate of phosphorus loading per hectare in the Barrie Creeks subwatershed, that the MNR, MOE, and LSRCA make the Barrie Creeks subwatershed a priority for stewardship projects intended to reduce phosphorus loading. Further, that the MOE, LSRCA, and City of Barrie make stormwater retrofits and the use of LID solutions in the Barrie Creeks subwatershed a priority, due to their significant potential to reduce phosphorus loading.

Recommendation 3-6 - 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 the suitability of using the *Drainage Act* to protect and restore the ecological function of watercourses.

8.2.4 Dealing with enclosed watercourses

Recommendation 5-12 - That the City of Barrie, 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 City of Barrie 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 6-21 – 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 6-22 – That the MNR and its partners provide outreach to garden centres, landscapers, and garden clubs regarding the danger of using invasive species in ornamental gardens.

Recommendation 6-23 – 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.

Recommendation 6-24 – That the City of Barrie and Town of Innisfil give preference to native species when selecting trees to be planted in boulevards, parks, and other municipal lands.

8.2.6 Increasing uptake of stewardship programs

Recommendation 5-1 (6-13) – That the MNR, MOE, MAFRA, and LSRCA continue to implement stewardship projects in these subwatersheds, and work collaboratively with other interested organizations, through the Lake Simcoe Stewardship Network, to do the same.

Recommendation 5-2 (6-14) – 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 (6-16) – 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 (6-15) – That the Federal, Provincial, and Municipal governments provide consistent and sustainable funding to ensure continued delivery of stewardship programs.

Recommendation 5-5 (6-17) – That the MOE, MNR, MAFRA, LSRCA, and other interested members of the Lake Simcoe Stewardship Network support research to determine public motivations and 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 (6-18) – 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 6-19 – 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 riparian cover along the tributaries of the Barrie Creeks and Hewitt's Creek subwatersheds
- The need to increase the extent of natural shoreline along the lakeshore in the Barrie Creeks and Lovers Creek subwatersheds
- Protecting and restoring ecologically significant groundwater recharge areas, to help mitigate the expected impacts of climate change
- Opportunities to restore lost wetlands, particularly on City-owned property along the Kempenfelt Bay shoreline, where historic records indicate extensive bay mouth wetlands
- Opportunities to increase connectivity across the subwatersheds for dispersing flora and fauna
- The need to protect and restore grassland habitat, particularly rare native grasslands
- The need to reduce phosphorus loadings to the tributaries in these subwatersheds.

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 3-17 - 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 the LSRCA, in collaboration with subwatershed municipalities, develop and deliver a salt education program, to increase awareness and understanding of the importance of salt management by snow removal contractors, property managers, and the general public.

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 (5-10) – That the MOE, with assistance from LSRCA and MNR, 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 6-20 – 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 likelihood 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 increased 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 Hewitt's Creek and Lovers Creek
- Monitoring additional parameters that are key indicators of ecosystem health and restoration progress such as brook trout spawning.

Recommendation 6-25 – 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 6-26 – 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 6-27 – 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 6-28 – 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 6-29 (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 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 5-15 – That the LSRCA, with support from subwatershed municipalities and the Province, investigate the reasons for the significant shift in biotic community and thermal regime seemingly associated with Hwy 400. This investigation should make recommendations as to how any identified impacts may be mitigated.

Recommendation 6-30 – 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.