Pefferlaw River Subwatershed Plan

Lake Simcoe Region
conservation authority

DURHAM
REGION

2012

Pefferlaw River Subwatershed Plan

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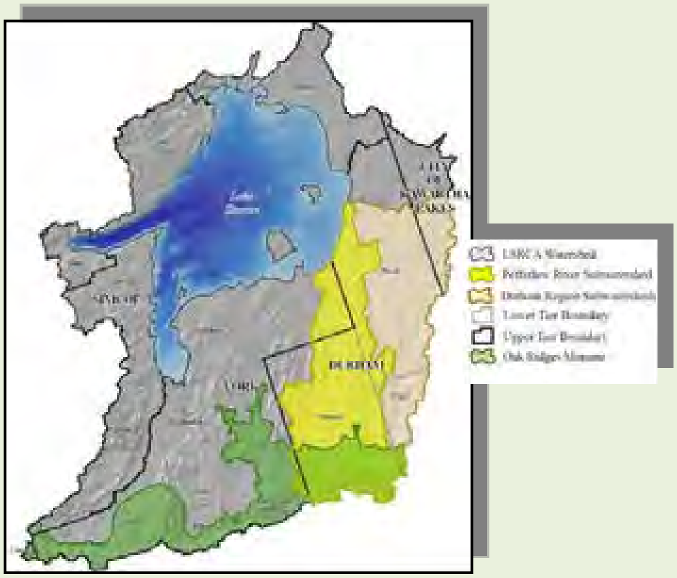
Pefferlaw River Subwatershed Plan (2012)

Executive Summary

CONTEXT



The Pefferlaw River is located almost entirely within the Regional Municipality of Durham. A small portion of the subwatershed in located in York Region. The subwatershed is 425 km^2 in area, and lies approximately 44km in length in a south-north direction from the Oak Ridges Moraine to Lake Simcoe. Neighbouring subwatersheds include the Black River to the west and the Beaver River to the east. The tributaries of the Pefferlaw River include the Main Branch, flowing northward from a point south of the community of Uxbridge, and the Uxbridge Brook branch that flows northward and joins together with the Main Branch in the Township of Georgina, just north of the Township of Uxbridge. It should be noted that these two tributaries are normally treated as two separate subwatersheds (Pefferlaw Brook and Uxbridge Brook). However, they have been combined for subwatershed planning purposes as the Pefferlaw River subwatershed.

Situated within the subwatershed boundaries are the Townships of Brock, Scugog, Uxbridge, and Georgina which include the communities of Pefferlaw, Udora, Sandford, and Siloam. The Pefferlaw River subwatershed is considered to be a rural subwatershed in the Lake Simcoe basin with only 5.5% of the land use being urban area. The largest land use is rural/agricultural at approximately 48%, and secondly natural cover at 43%. The municipalities within the Pefferlaw River subwatershed have undergone little change over the last several years. A small amount of growth (2.2%) is proposed for this subwatershed in the next 20 years, with the majority of the growth (977 ha) consisting of high intensity development.

The Pefferlaw River Subwatershed Plan has been written to comply with the requirements under the Oak Ridges Moraine Conservation Act and Conservation Plan Regulation (ORMCP, O.Reg. 140/02). The ORMCP required that all municipalities with subwatersheds originating on the Oak Ridges Moraine (ORM) prepare a subwatershed plan for each subwatershed. Durham Region commissioned the Lake Simcoe Region Conservation Authority (LSRCA) to complete these plans for the Beaver and Pefferlaw River subwatersheds.

It is important to note that the LSRCA's Integrated Watershed Management Plan (IWMP) (2008) and the Province's Lake Simcoe Protection Plan (LSPP) (2009) have 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 Pefferlaw River subwatershed; these two reports are meant to complement each other. The LSPP, released by the Province in 2009, similarly aims to be a comprehensive plan to protect and restore the ecological health of the lake and its subwatersheds. While the Pefferlaw River Subwatershed Plan was not written to address the LSPP subwatershed plan requirements, it is consistent with the themes and policies, and in some instances includes studies and information resulting from the LSPP.

APPROACH

The initial focus of this subwatershed planning exercise involved the use of an ecosystem approach. This approach attempts to take into consideration all of the components of the environment in the characterization of the subwatershed. These components include the movement of water through the system, the land use, climate, geology, and all of the species that are living in the system. These ecosystem components are all intricately related, and changes in any can have significant effects on the others.

In this case, the characterization of the Pefferlaw River subwatershed included the analysis of water quality, water quantity, aquatic habitat, fluvial geomorphology and terrestrial habitat information for the Pefferlaw River. In the document, each chapter follows an identical format loosely structured around a *pressure-state-response* framework. Each chapter initially describes the current condition (*state*), secondly describes the stressors likely contributing to the current condition (*pressure*), and finally provides recommendations in the context of the current management framework (*response)*.

Based on these considerations and the related recommendations, a separate implementation plan needs to be developed by subwatershed stakeholders (municipal, provincial, federal, public) to act upon the recommendations made within the subwatershed plan. It is intended that the Implementation Plan will become the common work plan to be used in long term protection and rehabilitation efforts.

STATUS

Water Quality – While water quality is not a major concern compared to other tributaries in the Lake Simcoe Basin, total phosphorus regularly exceeds the objectives. There have also been occasions where suspended sediment concentrations below Uxbridge were high enough to have acute effects on aquatic life. Even though chloride levels are relatively low, there is an increasing long term trend. The primary source of chloride is road salt. Additionally, under the modelled growth scenario there is a projected increase in phosphorus loads of 15% without the implementation of agricultural and urban BMPs.

Water Quantity – Due to the presence of permeable surface soils and hummocky topography, the Oak Ridges Moraine is the primary recharge area to the underlying groundwater aquifers of the Pefferlaw River subwatershed. Groundwater is generally moving from the topographic highs associated with the ORM towards the topographic lows associated with the major stream channels and Lake Simcoe. Most noticeable in this subwatershed are the numerous strong gaining reaches in the headwaters of the Pefferlaw River system originating on the Oak Ridges Moraine. Groundwater influence on these reaches is also evidenced in the thermal stability of the streams and in the coldwater fish species they support. The area from the middle of the system to the mouth of the Pefferlaw River is characterized by minimal gaining reaches and some stretches of losing reaches. The Pefferlaw River subwatershed has seen little change over the period of time for which the Base Flow index has been calculated, which likely accounts for the stability of baseflow, which varies less than 4% over the period of record. The slight variation is likely due to climatic influence. Even when examined at a yearly scale, the Index consistently shows that greater than 50% of the flow in the Pefferlaw River comes from baseflow as opposed to surface runoff. This is a good indication of stable year round flow, which is important for maintaining the ecological functions of the river. In extremely dry years, such as the conditions experienced in 2007, flow levels were lower than average and modelling predicted that the Uxbridge Brook portion of the subwatershed was considered to be moderately stressed in July and August. The contribution of baseflow explains the ability of the Pefferlaw system to better withstand dry conditions compared to other subwatersheds. It should be noted that locally, the Uxbridge Brook reach has been seen to respond very quickly to a precipitation event and return to baseflow shortly thereafter. Although the contributing catchment is small, it does have a relatively steep topography, and within the Town of Uxbridge, there is an increase in impervious surface and a lack of stormwater controls. An early August storm flow event that yielded a dramatic peak at Udora (main branch) also produced multiple peaks in the Uxbridge system highlighting the more flashy nature of the Uxbridge system upstream.

Aquatic Habitat - The fish communities in the Pefferlaw River and its tributaries range from cold groundwater-supported headwater communities featuring species such as brook trout (*Salvelinus fontinalis*) and mottled sculpin (*Cottus bairdii*), to diverse warm, large order systems that support species like largemouth bass (*Micropterus salmoides*) and brown bullhead (*Ameiurus nebulosus*). The area of the lake-river confluence is also used extensively by large spawning runs of emerald shiners from Lake Simcoe both in spring and fall. A total of 45 species of fish have been captured from the Pefferlaw River system since 1930. In general, the Pefferlaw River subwatershed has relatively stable unimpaired benthic communities in the headwaters and mid reaches. This is likely due to the relatively healthy coldwater tributaries, consistent groundwater inputs and limited urban development in this part of the system. However, there are some sites (located mainly along the north eastern branches) where the indices show ‘impaired’ conditions. These locations are primarily affected by sediment inputs from agriculture and elevated stream temperatures (on-line ponds) which lead to a reduction in the diversity of invertebrates at those sites. Across the subwatershed, stream temperatures are affected by dams and the absence of streambank vegetation which, as a consequence, are affecting the availability of coldwater habitat conditions. It will be important to build ecological resilience through stream rehabilitation, streambank planting, wetland protection and restoration, and treating urban inputs. These efforts will improve habitat conditions in addition to improving both water quality and hydrologic function.

Fluvial Geomorphology – Based on an assessment of representative stream reaches, few issues were encountered when looking at stream discharge, the sediment regime, substrate composition and streambank conditions of the Pefferlaw River. Because there has been little change in the overall land use, very little geomorphic change is evident. There is some evidence of erosion, basal scour and instream debris jams but those are more site specific locations (e.g.

Town of Uxbridge) which are likely a result of urban issues such as uncontrolled stormwater and increased impervious surface.

Terrestrial Natural Heritage – The terrestrial natural heritage features in the Pefferlaw River subwatershed include woodlands, wetlands, grasslands, and riparian habitat. Woodlands are treed areas that may contain coniferous trees, deciduous trees, or a mixture of both. Woodlands may also include swamps, which are wooded areas that are seasonally inundated with water. The four different types of wetlands are swamp, marsh, fen, and bog. Grasslands, which include tallgrass prairies, cultural meadows, cultural thickets and savannahs, are dominated by grasses rather than by trees. No tallgrass prairies have been identified in the Pefferlaw River Subwatershed. Riparian habitat refers to all habitats within a stream corridor or valley, particularly the vegetation on a stream bank. Natural heritage features make up the estimated 43% natural cover component of land use. Currently the Pefferlaw River subwatershed supports 32.7% woodland cover. This is above the Environment Canada's AOC guideline of 30% as a minimum threshold for maintaining woodland dependent biodiversity. Forest interior habitat is also prominent (12% existing vs. 10% minimum target) and wetlands at 16.9% cover are also above the EC target. Emphasis should be placed on protecting the existing terrestrial features while working toward increasing these features and their related functions to add resilience to the ecosystem for dealing with invasive species, climate change and other stressors.

NEXT STEPS

Recommendations are provided in each chapter of this Subwatershed Plan. An overall Implementation Plan will be the outcome of those recommendations. A process is currently being developed to engage municipal, public, provincial and federal partners to work together to identify and prioritize actions that will be needed to be undertaken in the next five year period to improve the health of the Pefferlaw River subwatershed. It is expected that monitoring of those actions and commitments will be used as a measure of the progress that is expected to occur.

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1 Background, Management Setting and Approach

1.1 Introduction

The Pefferlaw River is a large subwatershed draining into the eastern portion of Lake Simcoe. It consists of two smaller subwatersheds, Pefferlaw Brook and Uxbridge Brook, which have been looked at separately in previous studies. For the purpose of this subwatershed plan though, they are studied together as the Pefferlaw River subwatershed (as the two systems join together to form the Pefferlaw River), with exception in **Chapter 5 - Water Quantity**, where water budget modelling studies have separated them out (the areas that each encompasses are illustrated in Figure 2-1, of **Chapter 2 – Study Area and Physical Setting**).

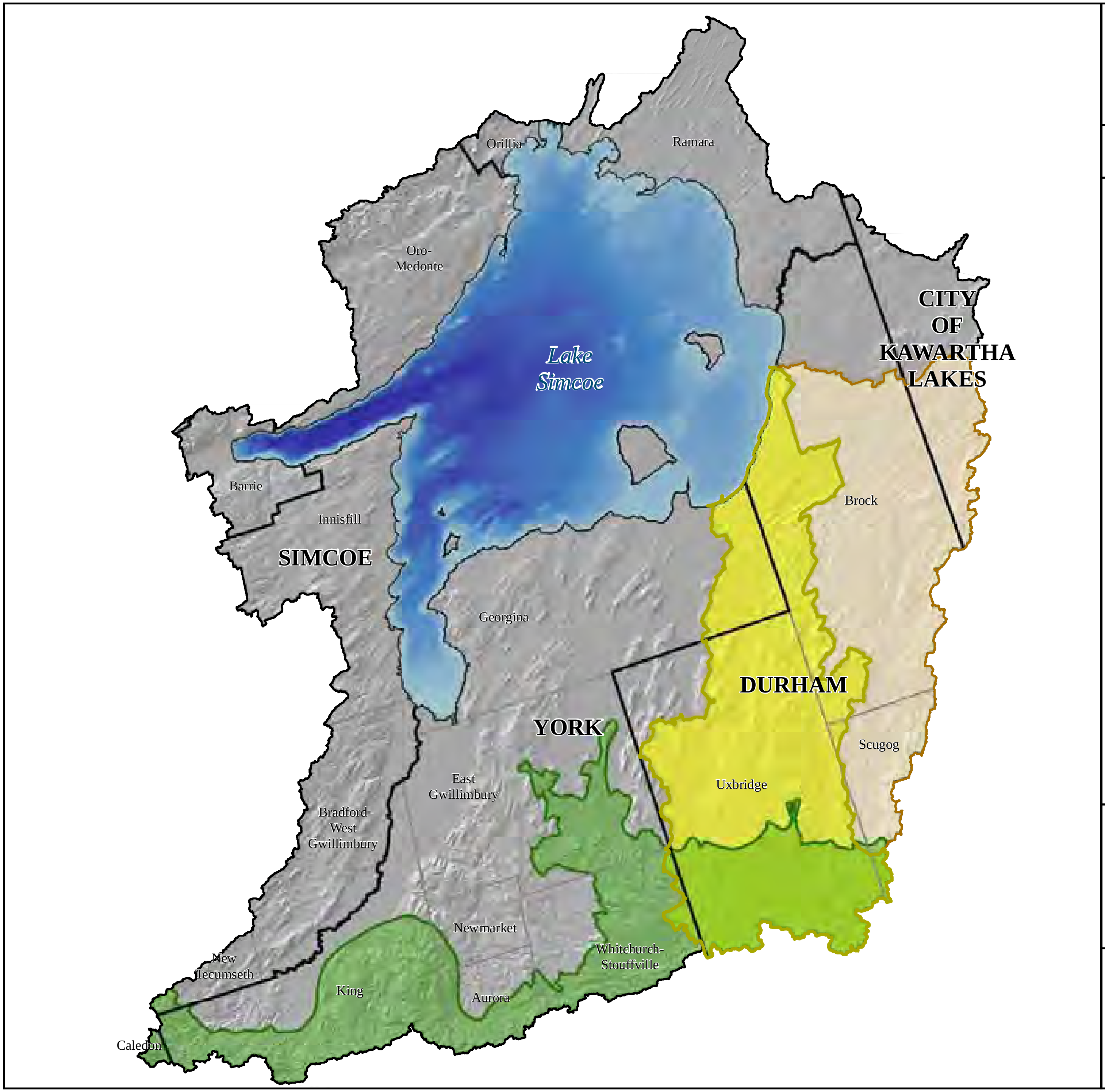
Close to half of the subwatershed area is occupied by agriculture, which is the major land use, and there are several, mainly small, urban areas throughout the subwatershed. The subwatershed is 446.2 km^2 in area, with 89% of the subwatershed falling within Durham Region, and 11% within York Region. The municipalities found in the subwatershed are the Townships of Uxbridge, Brock, and Scugog, and the Towns of Georgina, Whitchurch-Stouffville, and East Gwillimbury (Figure 1-1).

The headwaters of the Pefferlaw River originate on the Oak Ridges Moraine, through mainly forest and wetland areas, which are surrounded by agriculture. Small pockets of golf courses, aggregate operations, and small communities are also spread throughout the headwater areas on the Oak Ridges Moraine. Aside from the urban area of the Town of Uxbridge, the land use through the middle reaches of the subwatershed is dominated by agriculture, although the majority of the watercourses flow through wetlands and forests. As the river flows downstream toward the mouth, the western portion is dominated by large swaths of wetland and forest until it reaches the community of Pefferlaw, while the east side tends still to have a higher proportion of agriculture.

The land uses within this subwatershed have had impacts on its health. Water quality has deteriorated due to the inputs of harmful substances from both rural and urban areas and a significant amount of natural cover has been removed to accommodate these land uses.

In order to mitigate the impacts of land use changes in a subwatershed, 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 also provide a framework within which sustainable development can occur.

As part of the requirements through the Oak Ridges Moraine Conservation Act and Conservation Plan Regulation (ORMCP, O.Reg. 140/02), all municipalities with subwatersheds originating on the Oak Ridges Moraine (ORM) are required to develop a subwatershed plan for each subwatershed. Durham Region has commissioned the Lake Simcoe Region Conservation Authority to complete these plans for their subwatersheds. The Durham Region subwatersheds that originate on the ORM are the Pefferlaw River and the Beaver River. The watershed planning requirements of the Act and Conservation Plan Regulation represent an opportunity to strengthen a long established watershed management partnership between Durham Region and its conservation authorities. Durham Region has gone beyond their requirements under the ORMCP with the development of these subwatershed plans for the entire subwatershed area, not just the portion that lies on the Oak Ridges Moraine.



Location of the Pefferlaw River subwatershed

Figure 1-1

Legend

⬜ LSRCA Watershed
🟨 Pefferlaw River Subwatershed
🟧 Durham Region Subwatersheds
☐ Lower Tier Boundary
☐ Upper Tier Boundary
🟩 Oak Ridges Moraine

Lake Simcoe Region conservation authority

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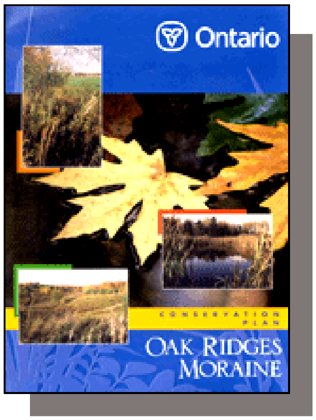
This product was produced by the Lake Simcoe Region Conservation Authority and some information depicted on this map may have been compiled from various sources. While every effort has been made to accurately depict the information, data / mapping errors may exist.
This map has been produced for illustrative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

1.2 Oak Ridges Moraine Conservation Plan



The Oak Ridges Moraine Conservation Plan was developed in 2001, and is an ecologically based plan that provides land use and resource management direction for the 190,000 hectares of land and water that fall on the Oak Ridges Moraine (ORM), 12,111 ha of which lies within the Pefferlaw River subwatershed. The ORM is one of Ontario's most significant landforms. It stretches from the Trent River in the east to the Niagara Escarpment in the west and divides the subwatersheds draining south into Lake Ontario from the subwatersheds draining north to Lake Simcoe. It has a unique concentration of environmental, geological, and hydrological features that make its ecosystem vital to south-central Ontario, including:

- Clean and abundant water sources
- Healthy and diverse plant and animal habitat
- An attractive and distinct landscape
- Prime agricultural areas
- Sand and gravel resources close to market.

Because of its location across the Greater Toronto Area, the ORM is under increasing pressure for new residential, commercial, industrial, and recreational uses which compete with the present natural environment.

The province of Ontario developed the Oak Ridges Moraine Conservation Plan (ORMCP), after recognizing the vital importance of this feature to southern Ontario and the intense pressure that was being placed on it. The authority to establish the ORMCP comes from the Oak Ridges Moraine Conservation Act (2001), which established objectives for the plan.

The ORMCP was established to provide land use and resource management direction for the land and water within the Moraine. The government's vision for the Oak Ridges Moraine is that of "a continuous band of green, rolling hills that provides form and structure to south-central Ontario, while protecting the ecological and hydrological features and functions that support the health and well-being of the region's residents and ecosystems". To achieve this vision, the ORMCP sets out a number of objectives:

a) protecting the ecological and hydrological integrity of the Oak Ridges Moraine Area;

b) ensuring that only land and resource uses that maintain, improve or restore the ecological and hydrological functions of the Oak Ridges Moraine Area are permitted;

c) maintaining, improving or restoring all the elements that contribute to the ecological and hydrological functions of the Oak Ridges Moraine Area, including the quality and quantity of its water and its other resources;

d) ensuring that the Oak Ridges Moraine Area is maintained as a continuous natural landform and environment for the benefit of present and future generations;

e) providing for land and resource uses and development that are compatible with the other objectives of the plan;

f) providing for continued development within existing urban settlement areas and recognizing existing rural settlements;

g) providing for a continuous recreational trail through the Oak Ridges Moraine Area that is accessible to all including persons with disabilities;

h) providing for other public recreational access to the Oak Ridges Moraine Area; and

i) any other prescribed objectives.

The *Oak Ridges Moraine Conservation Act, 2001* directs municipalities to bring their Official Plans into conformity with the ORMCP and to ensure that the planning decisions they make conform to the Plan. The policies include:

- Strict limitations on the activities that can be undertaken in Natural Core and Natural Linkage Areas
- Protecting key natural heritage features and hydrologically sensitive features by setting out minimum vegetation protection zones and minimum areas of influence around the features. Most activities are not permitted in minimum vegetation protection zones, and applicants are required to demonstrate that activities within the minimum area of influence will have no negative impact on the feature
- Requiring planning, design and construction practices that will maintain, improve, or restore the health, diversity, size, and connectivity of features on the moraine for developments adjacent to these features
- Municipalities are required to develop subwatershed plans (i.e. this plan) for river systems originating on the Moraine, including a water budget and conservation plan, land and water use and management strategies
- The protection of water quality and quantity
- Protection for landform conservation areas (such as steep slopes, kames, kettles, ravines, and ridges)

1.3 Subwatershed plan requirements within the ORMCP

As described above, the ORMCP requires subwatershed plans to be developed for every river or stream system that originates on the Moraine. These requirements are set out in policies 24 and 25 as follows.

Watershed plans

24. (1) Every upper-tier municipality and single-tier municipality shall, on or before April 22, 2003, begin preparing a watershed plan, in accordance with subsection (3), for every watershed whose streams originate within the municipality's area of jurisdiction.

(2) The objectives and requirements of each watershed plan shall be incorporated into the municipality's official plan.

(3) A watershed plan shall include, as a minimum,

> *(a) a water budget and conservation plan as set out in section 25;*
>
> *(b) land and water use and management strategies;*

(c) a framework for implementation, which may include more detailed implementation plans for smaller geographic areas, such as subwatershed plans, or for specific subject matter, such as environmental management plans;

(d) an environmental monitoring plan;

(e) provisions requiring the use of environmental management practices and programs, such as programs to prevent pollution, reduce the use of pesticides and manage the use of road salt; and

(f) criteria for evaluating the protection of water quality and quantity, hydrological features and hydrological functions.

25. (1) Every upper-tier municipality and single-tier municipality shall, on or before April 22, 2003, begin preparing a water budget and conservation plan, in accordance with subsection (2), for every watershed whose streams originate within the municipality's area of jurisdiction.

(2) A water budget and conservation plan shall, as a minimum,

(a) quantify the components of the water balance equation, including precipitation, evapotranspiration, groundwater inflow and outflow, surface water outflow, change in storage, water withdrawals and water returns;

(b) characterize groundwater and surface water flow systems by means of modelling;

(c) identify,

(i) targets to meet the water needs of the affected ecosystems,

(ii) the availability, quantity and quality of water sources, and

(iii) goals for public education and for water conservation;

(d) develop a water-use profile and forecast;

(e) evaluate plans for water facilities such as pumping stations and reservoirs;

(f) identify and evaluate,

(i) water conservation measures such as public education, improved management practices, the use of flow-restricting devices and other hardware, water reuse and recycling, and practices and technologies associated with water reuse and recycling,

(ii) water conservation incentives such as full cost pricing, and

(iii) ways of promoting water conservation measures and water conservation incentives;

(g) analyse the costs and benefits of the matters described in clause (f);

(h) require the use of specified water conservation measures and incentives;

(i) contain an implementation plan for those specified measures and incentives that reconciles the demand for water with the water supply;

(j) provide for monitoring of the water budget and water conservation plan for effectiveness.

1.3.1 Retrospective – a history of subwatershed plans in the Pefferlaw River subwatershed

A subwatershed plan was developed for the Uxbridge Brook tributary of the subwatershed in 1997. This plan was developed with input from a project steering committee, which consisted of municipal, provincial, and conservation authority staff; a public advisory committee; and LSRCA staff who conducted monitoring and compiled the information that went into the plan. The goal of the plan was ‘to maintain and enhance the health and quality of the Uxbridge Brook ecosystem by developing a strategy to ensure that impacts associated with future and existing growth within the watershed are minimized and that existing land use activities degrading the ecosystem’s health be identified and addressed.’ This goal was simplified into two guiding principles:

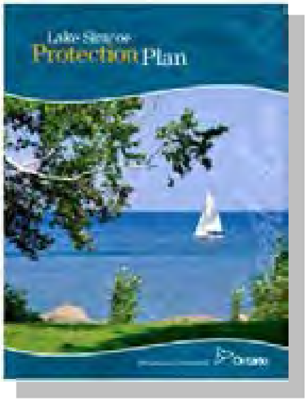
1) Protect what is healthy
2) Restore what is degraded.

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

1.4 The Broader Subwatershed Planning Context

This subwatershed plan has been written firstly to comply with the requirements under the ORMCP. However there are other documents that have influenced and fed into the development of this plan and its recommendations. The LSRCA’s Integrated Watershed Management Plan (2008) and the Province’s Lake Simcoe Protection Plan (2009) are the two main documents aside from the ORMCP that have guided this plan’s development.

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 for the smaller scale Pefferlaw River subwatershed; these two reports are meant to complement each other.



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 subwatershed. Its priorities include restoring the health of aquatic life, improving water quality, maintaining water quantity, improving ecosystem health by protecting and rehabilitating important areas, and addressing the impacts of invasive species, climate change, and recreational activities. In a similar manner as the ORMCP, policies 8.1SA to 8.4SA of the LSPP require development of subwatershed plans for priority subwatersheds within the Lake Simcoe basin. The LSPP does not stipulate what information should be included in the plans, but states that where appropriate, other LSPP strategies and plans be incorporated. While this plan was not produced to address the LSPP subwatershed plan requirements, it is consistent with the themes and policies, and in some instance includes studies and information resulting from the LSPP.

There are many other regulations related to the protection and restoration of Lake Simcoe and its subwatersheds, and obviously 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 Greenbelt Plan) while others are very specific (e.g. The Endangered Species Act); (2) the legal effect of policies they contain–policies fall into two broad categories, those legally requiring conformity, and those with no legal requirement but stating the need to "have regard for"; (3) the geographic area they represent–most cover the entire Lake Simcoe basin, however the Greenbelt Act and the ORMCP have defined geographic boundaries which do not follow subwatershed boundaries; 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 policies related to that particular subwatershed feature (e.g. water quantity or aquatic habitat).

Figure 1-2 depicts the relationship between this subwatershed plan and the documents that have guided and contributed to its development. This subwatershed plan specifically addresses phase 2 on this diagram – preparation of subwatershed plans and associated recommendations. It also depicts the proposed implementation plan (phase 3), which will provide details of a plan to undertake the recommended actions.

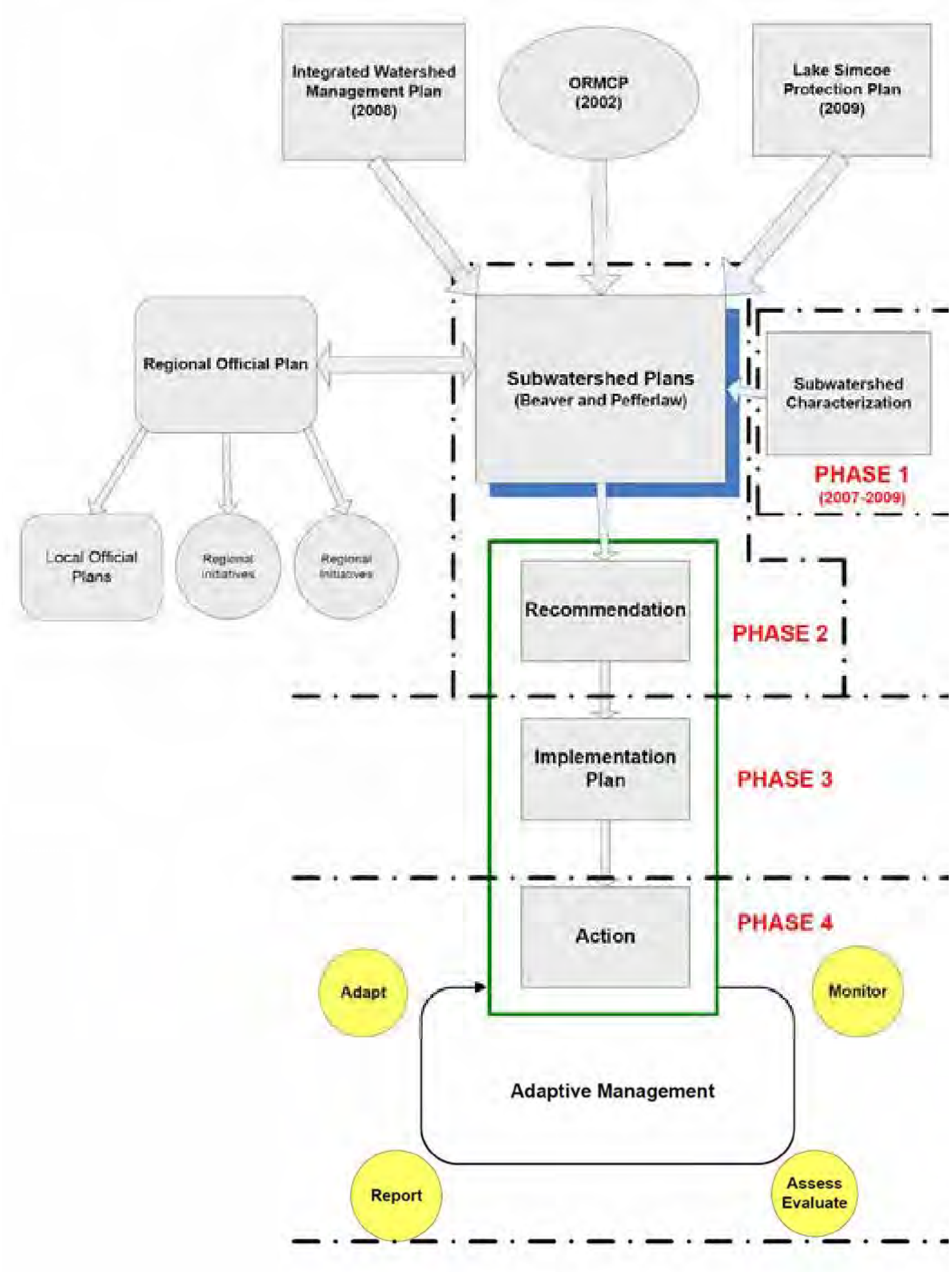


Figure 1-2: Subwatershed planning context.

1.5 Approach to completing the Pefferlaw River Subwatershed Plan

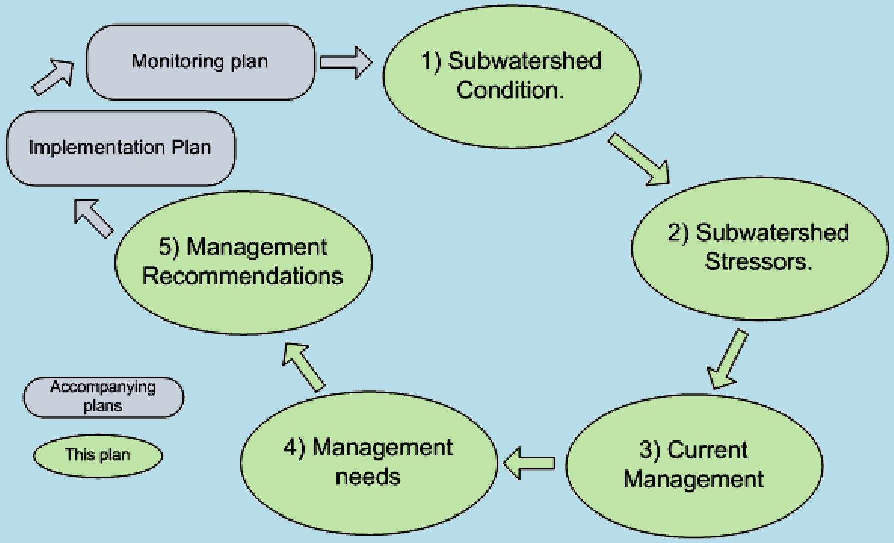
The initial focus of the subwatershed planning exercise has involved the completion and summarization of subwatershed characterization work (PHASE 1, Figure 1-2). It also involved the development of water quality, quantity, aquatic, and terrestrial habitat models to assess the environmental impacts associated with potential changes in the landscape. This important information is then incorporated into the process of formulating management options and recommendations for the subwatershed plans (PHASE 2, Figure 1-2).

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, 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.

Based on these considerations and the related recommendations, a separate implementation plan has to be developed by various stakeholders (municipal, provincial, federal, public) to act upon the recommendations made within the subwatershed plan (PHASE 3, Figure 1-2). This document will become the common work plan to be used in long term protection and rehabilitation efforts.

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

This plan includes a chapter dedicated to each of the five subwatershed features identified above, these being water quality, water quantity, aquatic habitat, fluvial geomorphology, 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 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 stewardship and restoration efforts. The plan has also been prepared to address the subwatershed plan requirements of policies 24 and 25 of ORMCP. How and where this plan meets these requirements is highlighted in Table 1-1.

To conclude, 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.

Table 1-1: Summary of how this plan addresses the ORMCP requirements for development of a subwatershed plan.

ORMCP Policy 24	How and where addressed within the subwatershed plan
(3) A watershed plan shall include, as a minimum:	
(a) a water budget and conservation plan as set out in section 25;	Chapter 5 provides a range of information pertaining to water quantity, water budgets and stress assessment for the Pefferlaw River Subwatershed. This includes: - surface and ground water budget and stress assessment based on supply and demand estimates; - characterization of surface and groundwater flow based on measured and modeled information (e.g. surface flow measures, PRMS, YPDT/CAMC) - Current annual and season stress assessment; future (forecast) annual stress assessment - Identified factors impacting stress levels (e.g. municipal, domestic, permitted consumptions); - Identified significant groundwater recharge areas - Provided a series of recommendations to address identified management gaps.
(b) land and water use and management strategies;	Current status of land use and those factors impacting land use, especially in relation to terrestrial natural heritage features are identified within Chapter 8. Terrestrial natural heritage / land use management strategies are addressed by summarizing the current management framework and identifying current gaps in related policies and restoration and protection measures. This gap analysis, in conjunction with assessment of current impacts, forms the basis of a management strategy. Within this subwatershed plan, ‘strategies’ are presented as a series of recommendations. Similarly water use is presented in Chapter 4 (water quality) and Chapter 5 (water quantity), with an assessment of current management, gaps in management, and recommendations forming the basis of the management strategy and future implementation plan.
(c) a framework for implementation, which may include more detailed implementation plans for smaller geographic areas	Overall framework for completion of subwatershed plans, relationship to other related policies and plans, and implementation are provided in Chapter 1. At the onset of this work it was agreed with Durham Region that a detailed implementation plan would be a separate stand alone document. Completion of the detailed implementation plan is pending a direction and funding from Durham Region.
d) An environmental monitoring plan	Environmental monitoring plan part of LSRCA core business, and forms the basis of the information presented in Chapters 4 to 9. Further, environmental monitoring is being addressed during development of comprehensive monitoring strategy under the direction of LSPP. Many chapters also include recommendations to improve environmental monitoring, in particular to track response of the subwatershed to management recommendations.
(e) provisions requiring the use of environmental management practices and programs, such as programs to prevent pollution, reduce the use of pesticides and manage the use of road salt;	In the context of this subwatershed plan “provisions” are given in the form of recommendations that have be drafted to address gaps in current management practices. Chapter 4 provides a series of recommendations related to prevention of pollution, in particular total phosphorus. Further, Chapter 4 identifies increasing trends in chloride levels and provides a number of recommendations to help reduce this stress. With the introduction of the Cosmetic Pesticide Pan in 2009, prevention of pesticides was not addressed in the plan.
(f) Criteria for evaluating the protection of water quality and quantity, hydrological features and hydrological functions.	Whenever possible established criteria were used to benchmark status and trends of water quantity and quality. Water quantity criteria applied were established through Source Water Protection and Tier 2 water budgets (See Chapter 5). Provincial water quality objectives were routinely used of evaluating water quality parameters (See Chapter 4). Environment Canada’s “How much habitat is enough” guidelines, 2004 were used for terrestrial habitat.

2 Study Area and Physical Setting

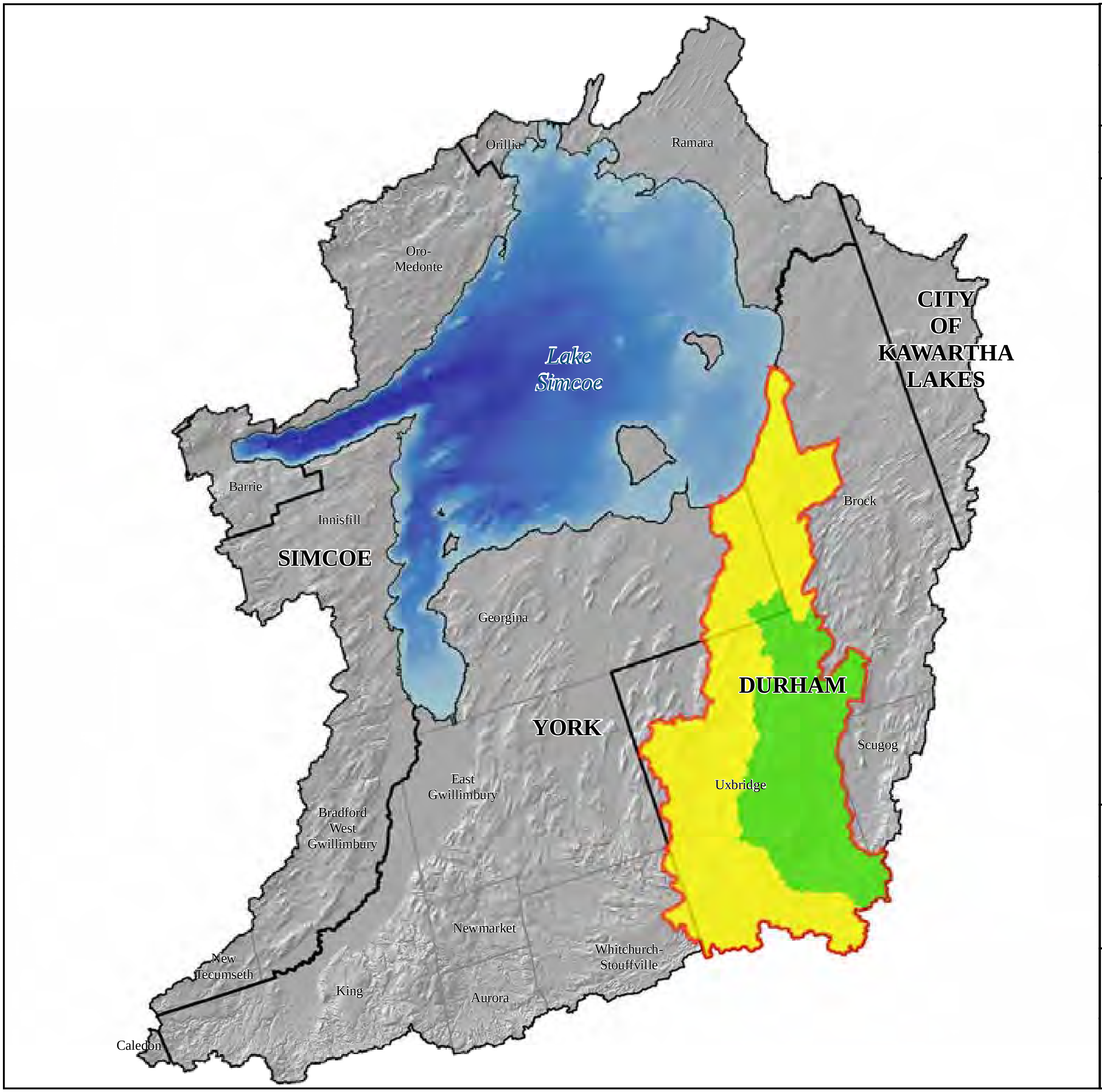
2.1 Location

The Pefferlaw River subwatershed is located almost entirely within the Regional Municipality of Durham. A small portion of the subwatershed is located within the Regional Municipality of York. Situated within the subwatershed boundaries are the Townships of Brock, Scugog, Uxbridge, and Georgina which include the communities of Pefferlaw, Udora, Sandford, and Siloam. The subwatershed covers an area of approximately 425 km^2 (Figure 2-1), with a length of approximately 44 km in a north-south direction, extending from the Oak Ridges Moraine in the south to Lake Simcoe in the north. Neighbouring subwatersheds include the Black River to the west and the Beaver River to the east. The Pefferlaw River subwatershed is a combination of the smaller Pefferlaw Brook and Uxbridge Brook subwatersheds. The subwatersheds were combined for subwatershed planning purposes as the Pefferlaw River because Uxbridge Brook is a major tributary of the Pefferlaw River.

The Pefferlaw subwatershed is a rural subwatershed in the Lake Simcoe basin with only 5.5% of the land use being urban area. The largest land use is designated as rural/agricultural at approximately 48%, and secondly natural cover at 43%. The distribution of various land uses can be seen in Figure 2-2. The remainder of the breakdown of the land use of the subwatershed is shown in Figure 2-3.

Subwatersheds that make up the Pefferlaw River

Figure 2-1



Legend

- LSRCA Watershed
- Pefferlaw River Subwatershed
- 🟨 Pefferlaw Brook Subwatershed
- 🟩 Uxbridge Brook Subwatershed
- Lower Tier Boundary
- Upper Tier Boundary

Lake Simcoe Region conservation authority

0 1 2 4 6 8 10
Kilometres

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This map has been produced for illustrative purposes only.
LSRCA GIS Services DRAFT created June 2011.

The following datasets municipal boundaries are
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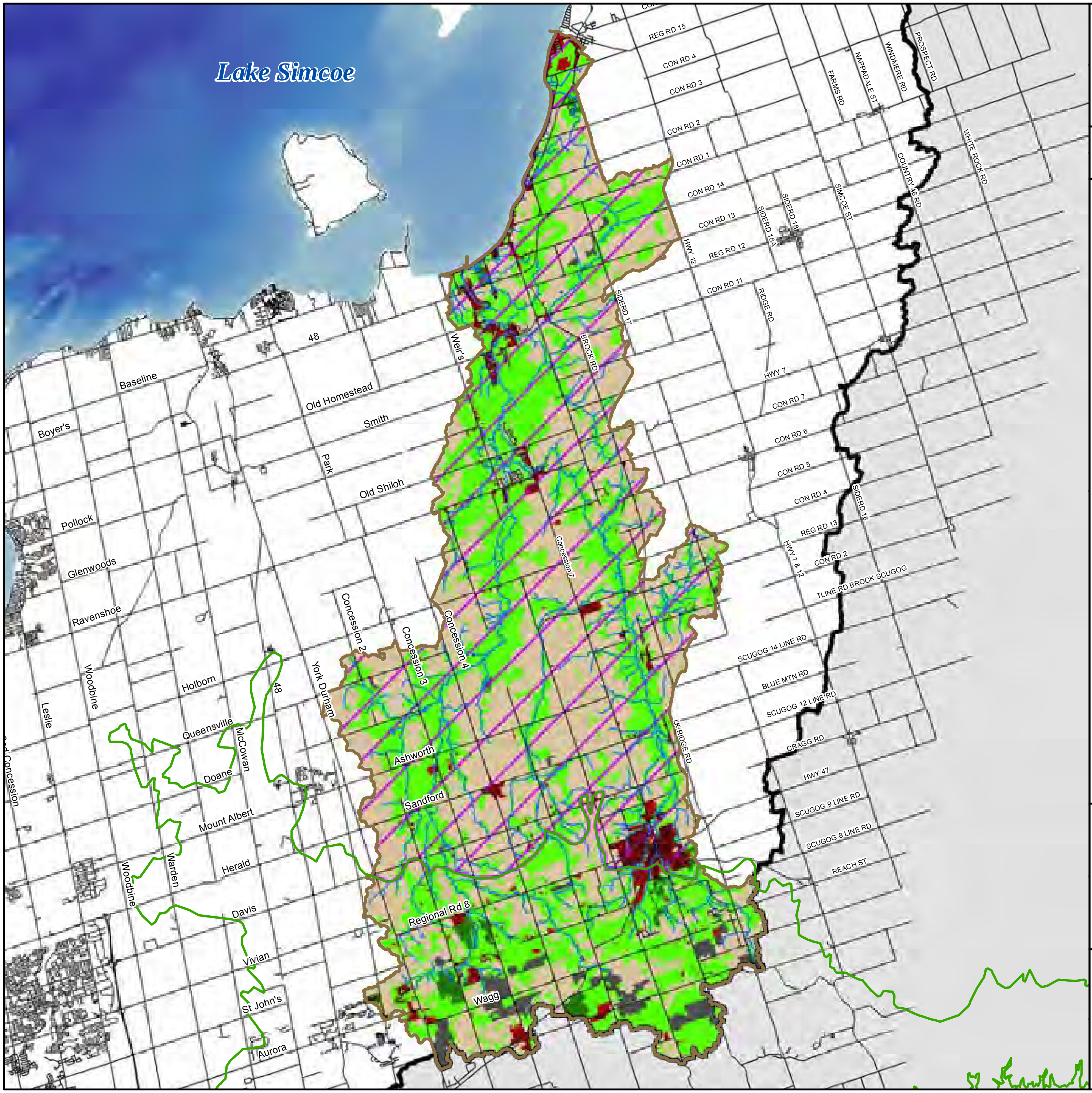

Land use distribution in the Pefferlaw River subwatershed

Figure 2-2

Legend

— Road

LSRCA Watershed Boundary

Greenbelt (Protected Country Side)

Oak Ridges Moraine

Land Use

🟥 Urban

🟫 Rural

🟩 Natural Cover

🟩 Golf Course

⬛ Aggregate

〰 Watercourse

Lake Simcoe Region conservation authority

0 1 2 4 6 8 10

Kilometres

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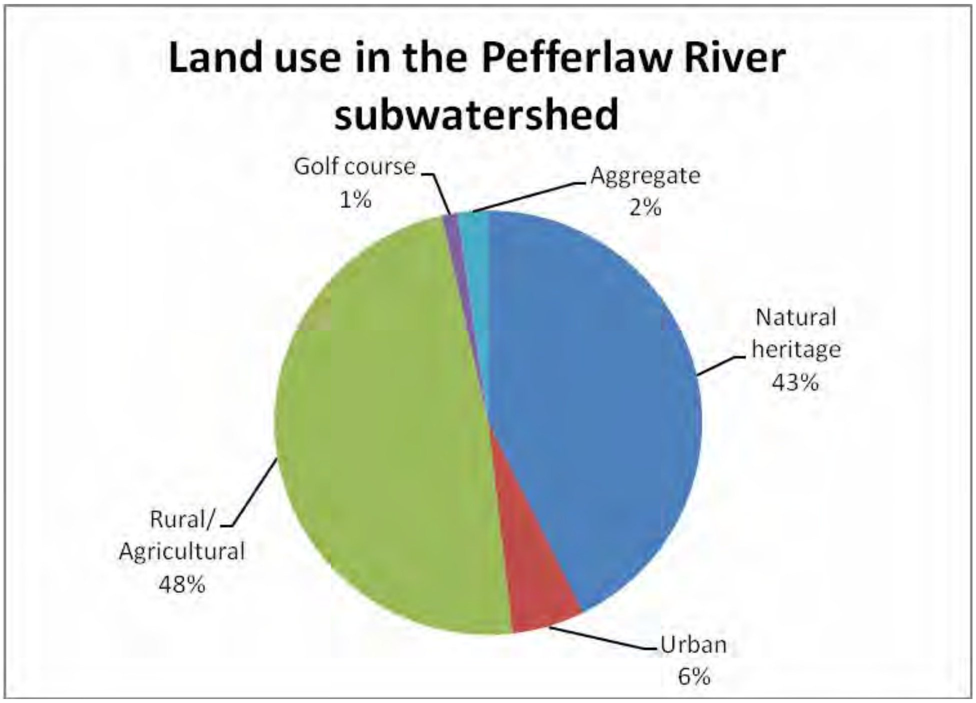


Figure 2-3: Land use distribution within the Pefferlaw River subwatershed.

To see how the Pefferlaw River and Uxbridge Brook compare to the other subwatersheds within the Lake Simcoe watershed Figure 2-4 to Figure 2-6 illustrates all the Lake Simcoe subwatersheds from the one with the highest percentage of urban, natural heritage and rural land uses to the subwatershed with the smallest percentage. The Pefferlaw River and Uxbridge Brook are outlined in black.

For urban land use (Figure 2-4), the Barrie Creeks in the western part of the watershed has the highest percentage (63%) while Whites Creek subwatershed in the eastern part of the watershed has the lowest (1%). Both the Pefferlaw River and Uxbridge Brook are in the mid to lower range with 4% and 5%, respectively.

The municipalities within the Pefferlaw River subwatershed have undergone little change over the last several years. A small amount of growth (2.2%) is proposed for this subwatershed, with the majority of the growth (977 ha) consisting of high intensity development (L. Berger Group, 2010).

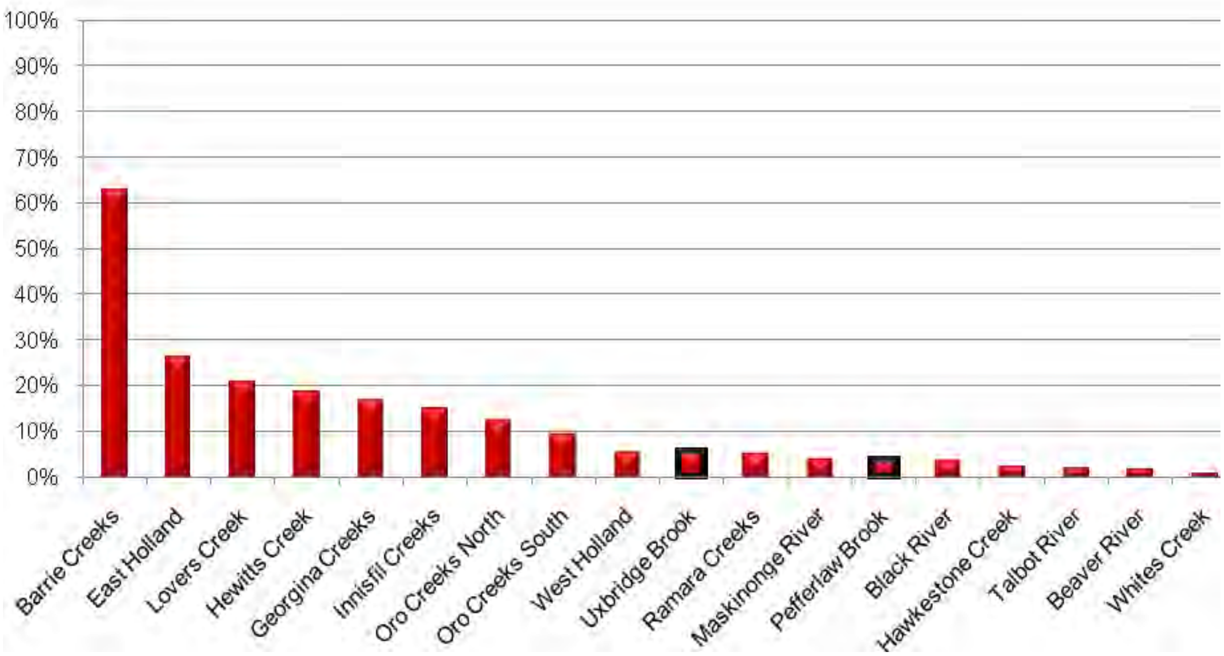


Figure 2-4: Urban land use in the Lake Simcoe subwatersheds.

The subwatershed with the highest percentage of natural heritage land cover is Hawkestone Creek (57%) in the south-west of the watershed, while the Barrie Creeks subwatershed in the west has the lowest percentage (17%). Pefferlaw Brook has 4th highest percentage of natural heritage land cover (45%), while Uxbridge Brook is in the mid range (38%) (Figure 2-5).

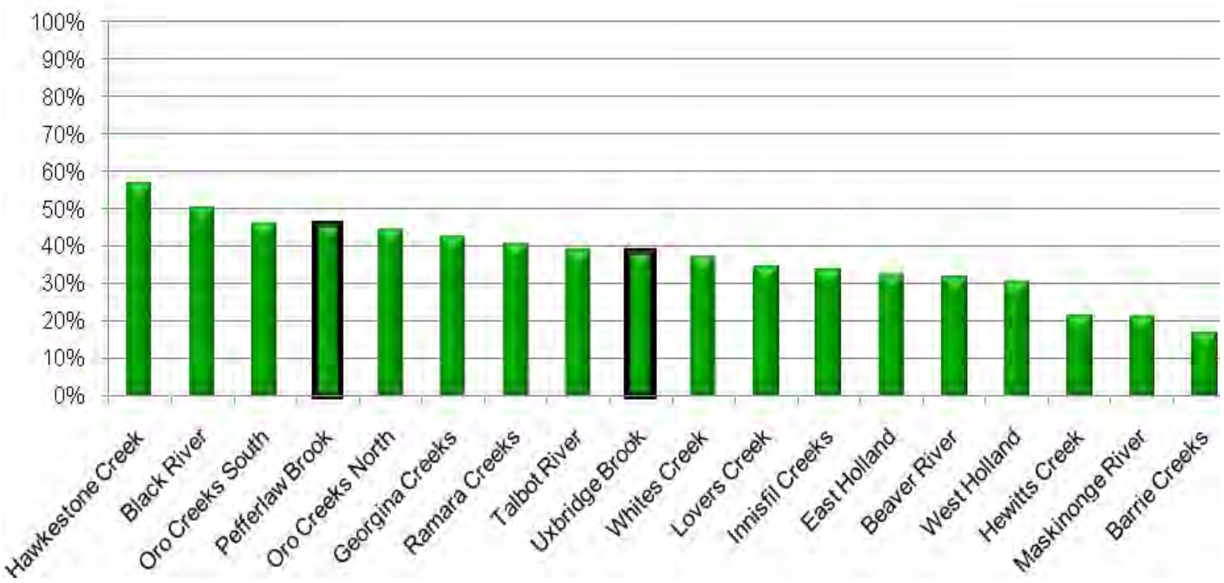


Figure 2-5: Natural heritage land cover in the Lake Simcoe subwatersheds.

Figure 2-6 illustrates the rural land use in the Lake Simcoe subwatersheds. The Maskinonge River subwatershed in the southern part of the watershed has the highest percentage with 73%. The Barrie Creeks subwatershed has the lowest (4%) percentage of rural landuse, with a large percentage gap between it and of the second lowest subwatershed (East Holland subwatershed) which has 34%. Both the Pefferlaw and Uxbridge Brooks are in the middle of the scale with 45% and 53% rural land use, respectively.

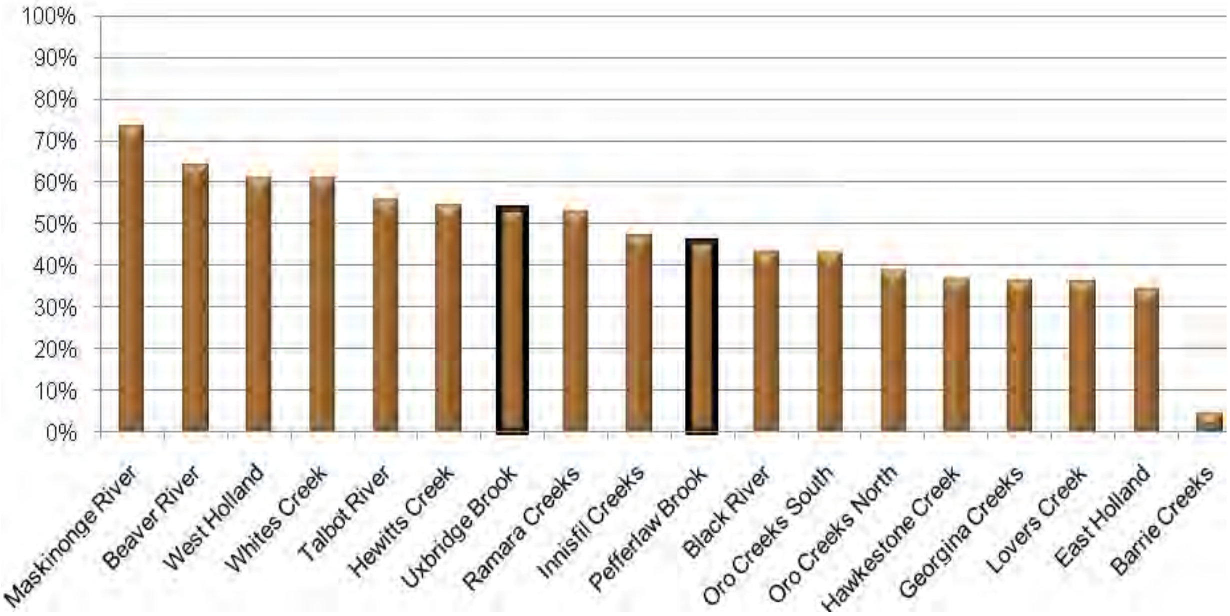


Figure 2-6: Rural land use in the Lake Simcoe subwatersheds.

Also of note is the Pefferlaw River subwatershed has approximately 11% impervious (hardened[1]) surface (Figure 2-7). This number is just above the recommended 10% impervious level (Environment Canada AOC Guidelines, 2005) for a healthy watershed, which suggests that the physical attributes that support the health of the subwatershed may be under slight stress.

2.2 Drainage

All of the lands within the Lake Simcoe watershed ultimately drain into Lake Simcoe, via one of the tributary rivers. The Pefferlaw River subwatershed is one of 18 subwatersheds that drain into Lake Simcoe.

The subwatershed is drained by the Pefferlaw River, which flows generally in a northerly direction and drains into Lake Simcoe. The headwaters originate from discharge springs and seepages along the northern flanks of the Oak Ridges Moraine. It is also one of five major tributaries that account for 60 percent of the total drainage to Lake Simcoe.

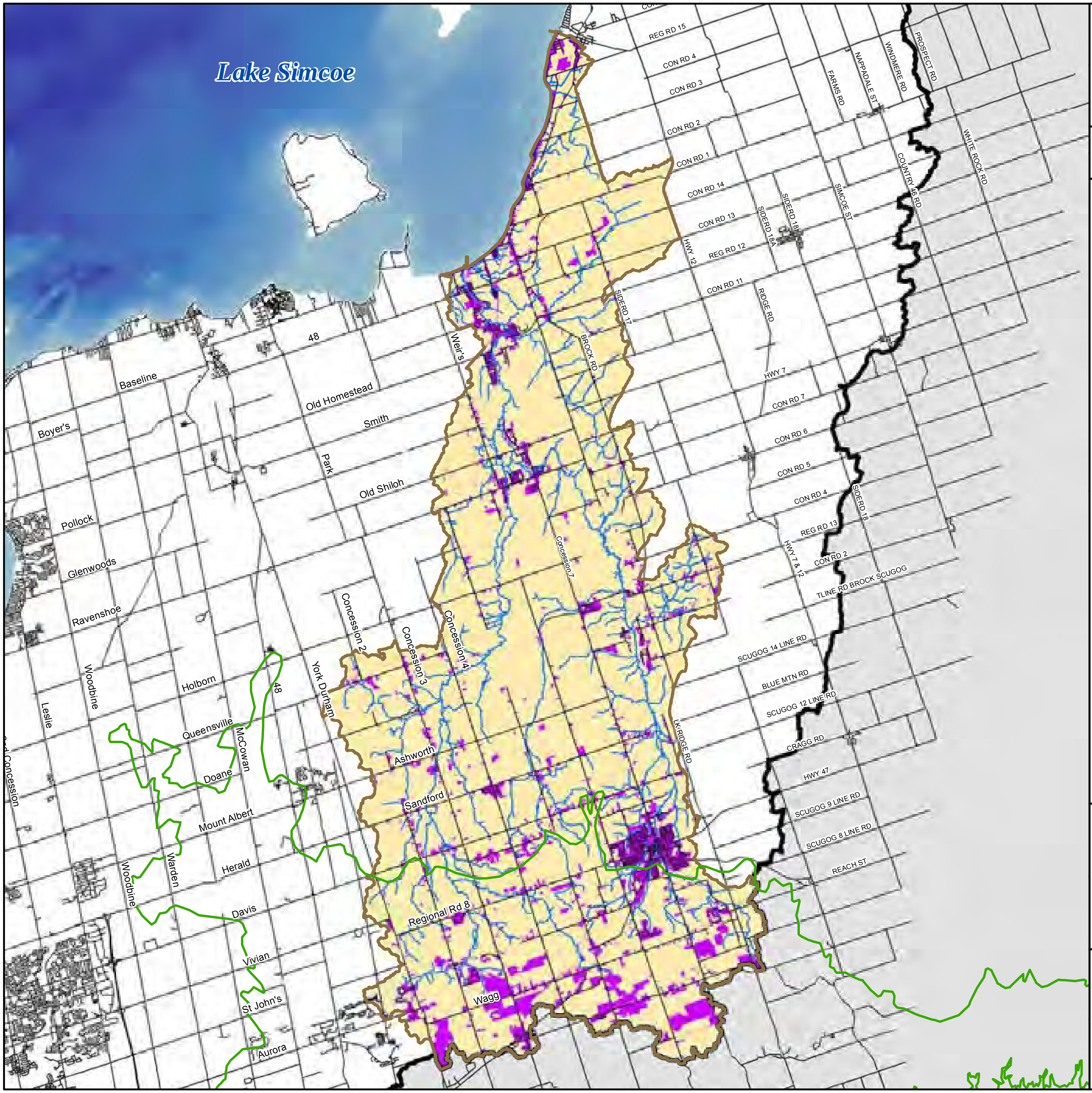
The main branches of the Pefferlaw River include the Main Branch, flowing northward from a point south of the community of Uxbridge, and the Uxbridge Brook Branch that flows northward and joins together with the Main Branch in the Township of Georgina, just north of the Township of Uxbridge (Figure 2-8).

---

[1] Does not include features such as wetlands that are sometimes considered impervious in hydrogeological models (as demonstrated in **Chapter 5 – Water Quantity**)

Hardened Surfaces in the Pefferlaw River Subwatershed

Figure 2-7



Legend

- Road
- Watercourse
- Hardened Surface

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

- LSRCA Watershed Boundary
- Oak Ridges Moraine

Lake Simcoe Region conservation authority

0 1 2 4 6 8 10 Kilometres

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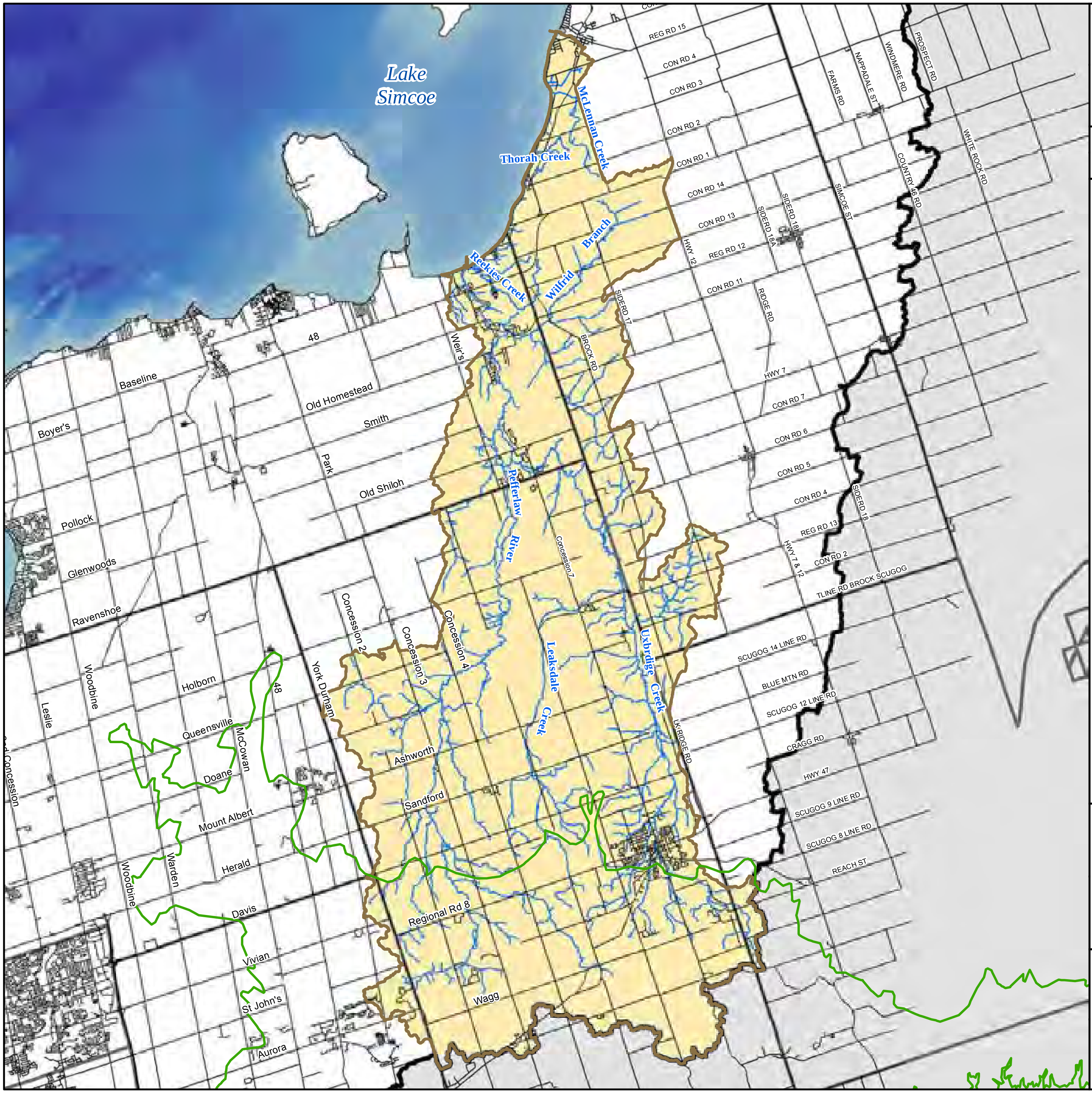
Named Tributaries in the Pefferlaw River subwatershed

Figure 2-8



Legend

- Road
- Watercourse
- LSRCA Watershed Boundary
- Oak Ridges Moraine

Lake Simcoe Region conservation authority

0 1 2 4 6 8 10 Kilometres

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2.3 Topography and Physiography

2.3.1 Topography

The topographic features of the Pefferlaw River subwatershed are related to its geological history, including significant glacial events. The ground surface topography within the Pefferlaw River subwatershed ranges from 397 metres above mean sea level (mASL) at the Oak Ridges Moraine, to approximately 220 mASL at the Lake Simcoe shoreline Figure 2-9.

The ORM is located along the southern portion of the subwatershed. It is characterized by hummocky terrain that ranges from approximately 265 to 397 mASL. These hummocky areas associated with the ORM often act as areas of focused recharge. Areas of higher elevation extending north of the ORM are associated with till uplands that are dissected by "tunnel channel" valleys. Local areas of higher elevation are associated with the numerous northeast and north-northeast trending drumlins located on the till uplands and in some of the valleys (Earthfx, 2010).

2.3.2 Physiography

The physiographic regions within the Pefferlaw River subwatershed are a direct result of deposition and erosion during glacial and post-glacial events, and closely correspond to the topography discussed above. According to Chapman and Putnam (1984), three physiographic regions are found within the subwatershed: the Oak Ridges Moraine (ORM), the Simcoe Lowlands, and the Peterborough Drumlin Field (Figure 2-10). The ORM generally makes up the topographic highs, while the Simcoe Lowlands make-up the low areas within the subwatershed.

Oak Ridges Moraine

Headwaters of the Pefferlaw River (Oak Ridges Moraine)

The headwaters of the streams flowing into Lake Simcoe from the south are located on the most widely recognized feature in the watershed, the Oak Ridges Moraine. The Oak Ridges Moraine is a significant physiographic feature that lies between the Trent River and the Niagara Escarpment. It is a total length of approximately 160 km, and has topographic elevations ranging from 305 to 395 mASL. The peak of the moraine forms the surface water divide separating flow towards Lake Simcoe from flow towards Lake Ontario.

The Oak Ridges Moraine is comprised of rolling sandy hills, hummocky topography and closed depressions that form the source of the headwaters to major streams that drain off the moraine. The moraine within the subwatershed consists primarily of surficial sand and gravel deposits, although it may contain considerable thickness of silt locally and is covered in places by a thin “veneer” of till. The moraine can reach a thickness of 219 m locally. The ORM represents the most significant groundwater recharge area in Durham Region and serves as the headwaters for the major streams that drain the area (e.g. Pefferlaw River, Uxbridge Brook, and Beaver River).

A unique feature of the Oak Ridges Moraine is the lack of surface drainage. Precipitation in this area either infiltrates to replenish the groundwater system or returns back to the atmosphere via evapotranspiration. It is at the northern and southern flanks of the moraine where the groundwater emerges as springs or seepages, creating the headwaters of the subwatersheds originating on the moraine, including the Pefferlaw River. The high infiltration capacity of the moraine makes it one of the most important recharge zones in southern Ontario, and within the Pefferlaw River subwatershed.

Simcoe Lowlands

The northern and western areas of the subwatershed fall within the Lake Simcoe basin portion of the Simcoe Lowlands physiographic region (Figure 2-10). The topographic elevations within this region range from 218 to 260 mASL. The region extends from the ORM northward to Lake Simcoe, and 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, consist of lacustrine sand, silt, and clay. The area is also bordered by Lake Algonquin shoreline cliffs, beaches, and terraces (Chapman and Putnam, 1984).

Peterborough Drumlin Field

The Peterborough Drumlin Field extends north of the ORM to east of Lake Simcoe into the Nottawasaga basin. The Peterborough Drumlin Field regime occurs within the south-central and eastern portions of the Lake Simcoe watershed. The mid to eastern areas within the subwatershed are characterized by this region.

The limestone bedrock in this area is covered by a sandy till that thins to the north. The region is noted for its drumlins, drumlinized hills, and eskers (Chapman and Putnam, 1984). The area is cut by deep valleys with wide, swampy bottoms which are occupied by north-flowing streams. The drumlins trend northeast to southwest, coincident with the direction of ice flow into the Lake Ontario basin. The drumlins are located both in the upland areas and in the lowland areas where they may have formed islands in the glacial lake (Earthfx, 2010).

Silty and clayey soils predominate in the drumlin field and limit groundwater recharge. The steep-sided drumlins influence the drainage patterns by increasing runoff and confining streams to the low-lying areas between the hills. Sandy alluvium deposits host many riparian wetland complexes in the valleys between the till uplands of the Peterborough Drumlin Field (Earthfx, 2010).

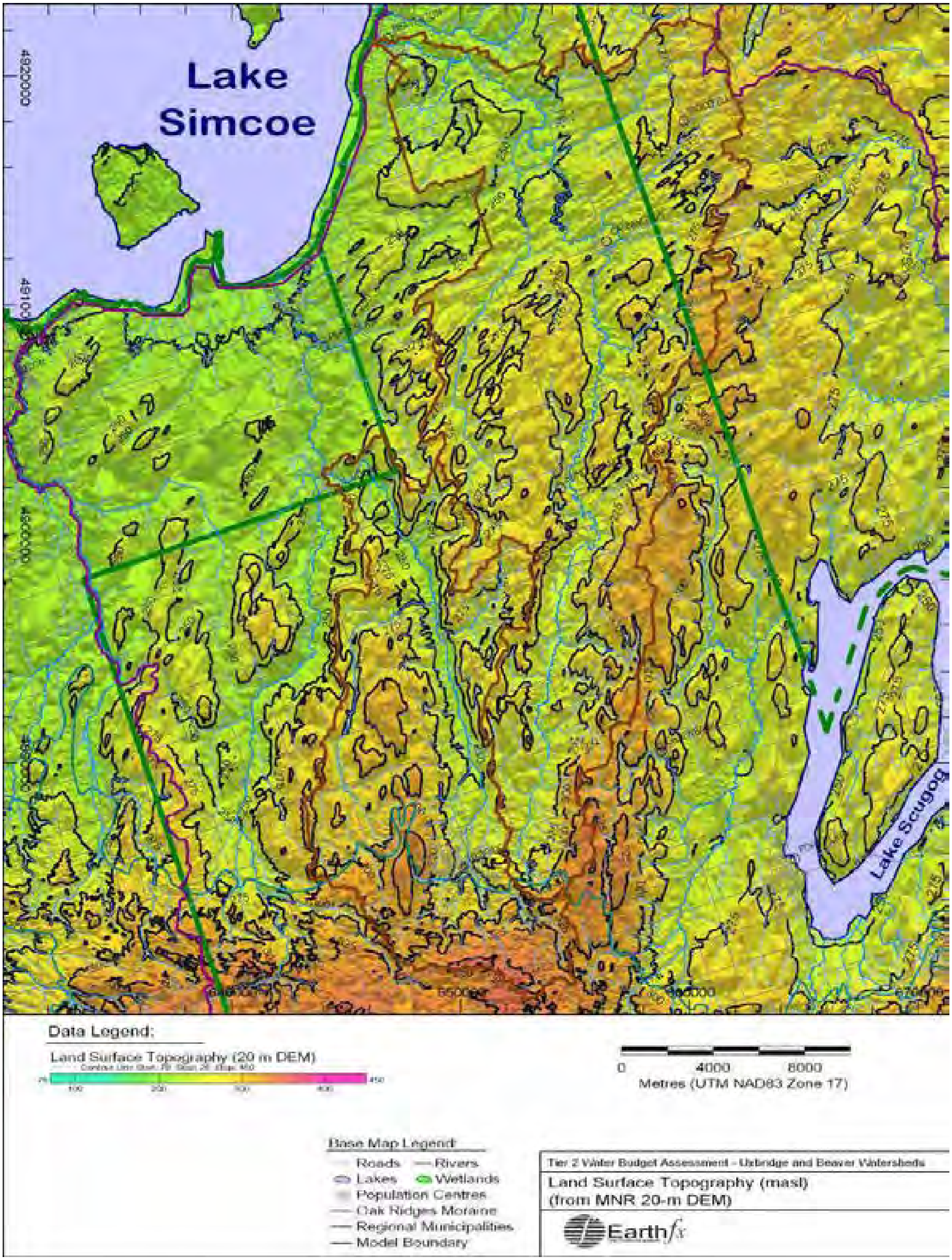


Figure 2-9: Ground surface topography in the study area (Earthfx, 2010).

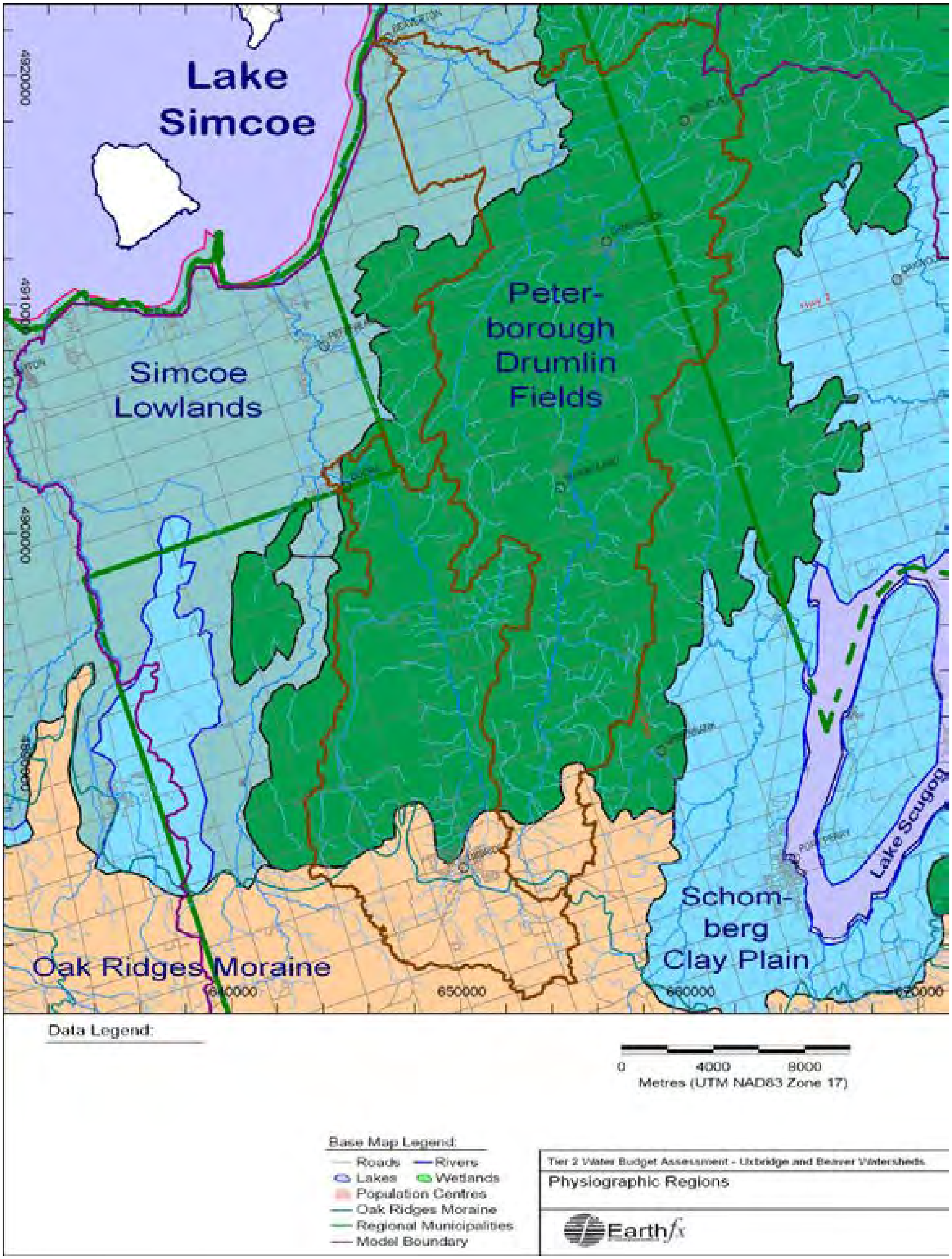


Figure 2-10: Physiographic regions within the study area (Earthfx, 2010).

2.4 Geology

There have been a number of studies that have lead to the geologic understanding in the area. A generalized description of the bedrock geology, quaternary geology, and conceptual stratigraphic units within the Pefferlaw River subwatershed is provided below. For more detailed information the reader is referred to Liberty (1969), Karrow (1989), Johnson *et al*. (1992) and Barnett (1992).

The geology of the Pefferlaw River subwatershed is complex and has been influenced by a number of glacial events. Bedrock topography, which has a significant influence on the nature and extent of deeper aquifer units, has been mapped using data obtained from the MOE's digital water well records. Overburden thickness has also been estimated as the difference between bedrock and ground surface elevation. Areas of thicker overburden generally correspond to moraine or 'hummocky topography' features.

2.4.1 Bedrock Geology

The bedrock within the study area consists of a succession of Middle to Late Ordovician carbonate rocks and shale, typically with gradational unit contacts, which rests unconformably on the Precambrian basement and dips gently to the southwest. The basement complex is composed of metamorphic rocks of the Central Metasedimentary Belt of the Grenville Province (Easton, 1992). The bedrock surface expression of the geologic units within the study area is shown in Figure 2-11.

The Middle Ordovician Sedimentary rock deposits make up the Simcoe Group, which consists of five formations. Each of the five formations is represented within the regional conceptual understanding model. However, only two of the formations (Verulam and Lindsay) are found within the subwatershed. The Upper Ordovician deposits found within the subwatershed consist of the Blue Mountain Formation.

Shadow Lake Formation

The oldest Paleozoic unit within the model boundary is the Shadow Lake Formation, which regionally is composed mainly of silty, dolomitic, or calcareous sandstone and terrigenous mudstone with occasional silty to sandy dolostone interbeds. Typically the Shadow Lake Formation is 2 to 3 metres (m) thick, but can reach a thickness of 15 m. The Shadow Lake Formation does not subcrop in the study area but is generally considered a regionally significant aquifer unit where it shallows to the north.

Gull River Formation

The Shadow Lake Formation grades upward into the Gull River Formation, which is mainly a fine-grained limestone but locally is argillaceous, silty, or dolomitic. The Gull River Formation has been subdivided into two members; the lower member contains interbedded limestone and silty dolostone.

Bobcaygeon Formation

The next unit in the sequence is the Bobcaygeon Formation, which is predominantly dark to light grey, brown to blue grey interbedded micritic to coarse-grained limestone. It is generally more fossiliferous than the Gull River Formation and ranges from 7 to 87 m thick.

Verulam Formation

The oldest Paleozoic rocks underlying the subwatershed are those of the Verulam Formation. The Verulam Formation gradationally overlies the Bobcaygeon Formation and is a member of the Simcoe Group (Figure 2-11). The formation is of Middle Ordovician age (approximately 450 million years ago) and consists of interbedded micritic to coarse-grained fossiliferous limestone with interbeds of calcareous shale. It is thin to medium bedded and 32 m to 65 m thick (Johnson *et al*., 1992). This formation subcrops in the northernmost part of the study area (Figure 2-11).

Lindsay Formation

The Lindsay Formation overlays the Verulam Formation and subcrops in the central part of the study area. The formation is also of Middle Ordovician age and a member of the Simcoe Group (Figure 2-11). The Lindsay Formation has a thickness of up to 67 m thick and is richly fossiliferous, which indicates that the depositional environment was a shallow to deep marine environment (Thurston *et al*., 1992).

Blue Mountain Formation

The Blue Mountain Formation (formerly the Whitby Formation) overlies the Lindsay Formation (Figure 2-11). The youngest Paleozoic rock unit in the area is the Blue Mountain Formation and it subcrops in the southern part of the study area beneath the ORM (Figure 2-11). The formation is Upper Ordovician in age (approximately 420 million years ago) and is present in the eastern and southeastern parts of the subwatershed. The formation consists of a blue-grey, poorly fossiliferous, non-calcareous shale up to 60 m thick (Thurston *et al*., 1992).

2.4.2 Bedrock Topography

The bedrock surface of the Pefferlaw River subwatershed has a general elevation range of 175 to 225 mASL, Figure 2-12. The bedrock surface is thought to have been the result of a long period of non-deposition and/or erosion activity that occurred between the deposition of the sedimentary bedrock and the overlying sediments.

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

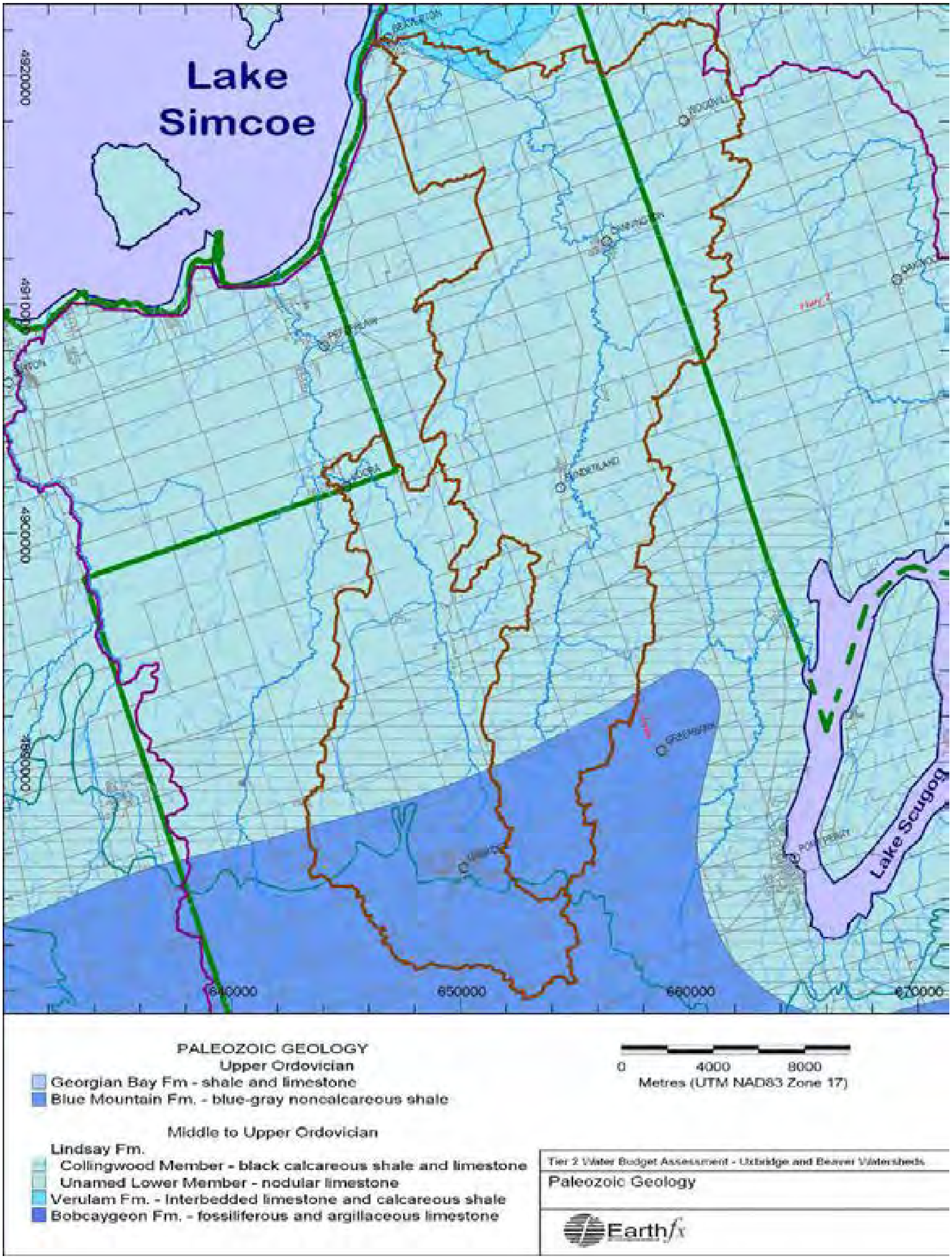


Figure 2-11: Bedrock geology within the study area (Earthfx, 2010).

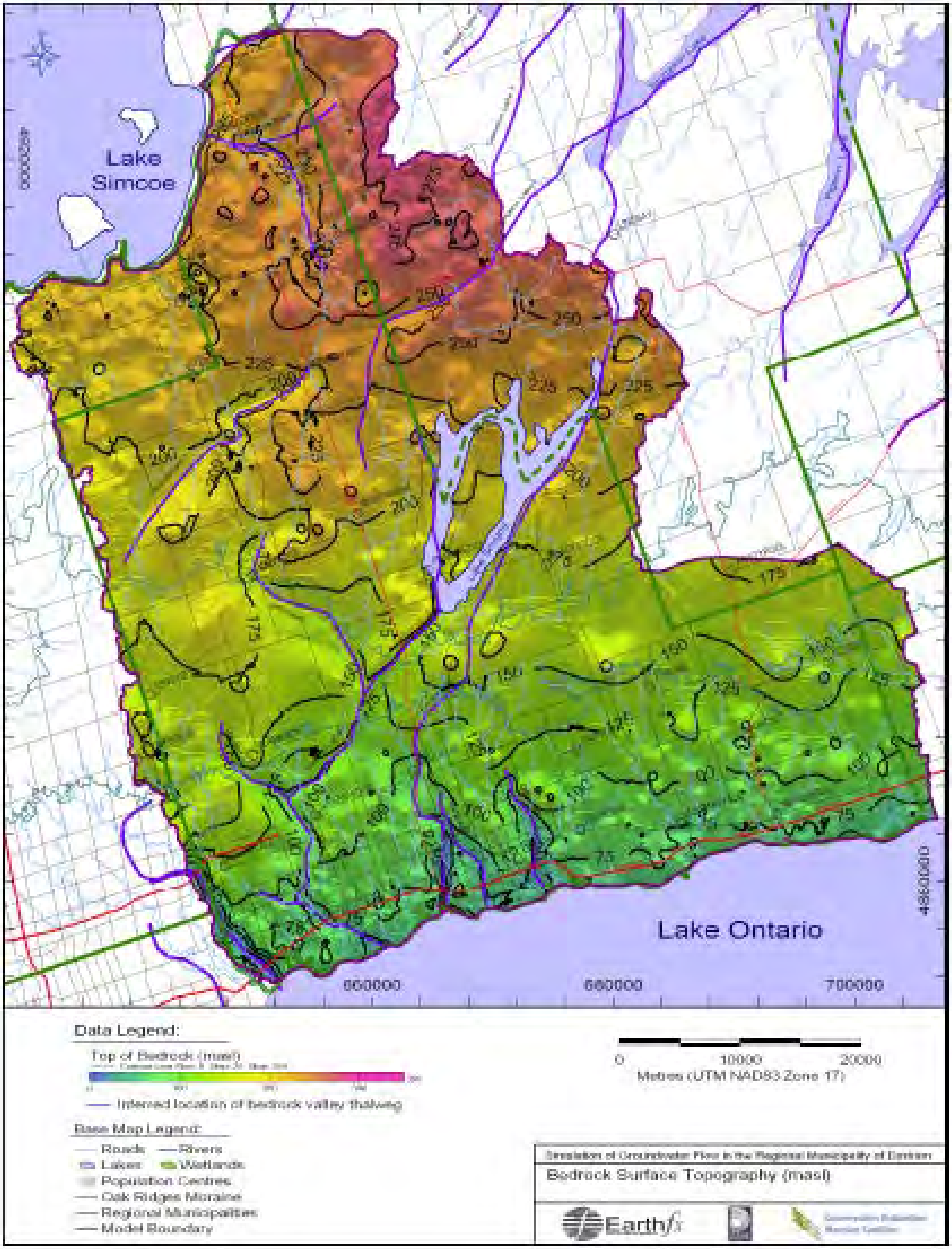


Figure 2-12: Elevation of the top of the bedrock surface (in masl) as interpolated from borehole data (Earthfx, 2009).

2.4.3 Quaternary Geology

Glacial History

The bedrock within the Pefferlaw River subwatershed is overlain by a succession of sediments, known as the overburden, which was deposited during the Quaternary Period by glacial, fluvial, and lacustrine processes over the last 135,000 years. The Quaternary deposits are shown schematically in Figure 2-13 and mapped in Figure 2-14 based on data provided by the Ontario Geological Survey (OGS, 2003; Barnett and Henderson, 1995; Barnett, 1996) and the GSC (Brennand *et al*., 1997, Sharpe, *et al*., 1997).

The Quaternary Period can be further divided into the Pleistocene (Great Ice Age) and the Holocene (Recent) Epochs. During the Pleistocene, at least four major continental-scale glaciations occurred, which include, from youngest to oldest, the Wisconsinan, 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 Pefferlaw River subwatershed. 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).

The stratigraphy of the surficial deposits within the subwatershed is extremely complex, particularly in the ORM area where the deposits are very thick and are a direct result of the complex glacial history over the last 115,000 years.

Quaternary Sediment Thickness

Within the subwatershed the Quaternary sediment thickness is the difference between the ground surface and the interpolated bedrock surface. The thickness of the Quaternary sediments has been determined from borehole and water well information within the subwatershed. Figure 2-15 shows the thickness ranges from approximately 25 to 175 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 and beneath the ORM), while the thinnest areas of Quaternary deposits occur at the north end of the subwatershed, near the shore of Lake Simcoe. In addition, areas of thicker overburden generally correspond to moraine and ‘hummocky topography’ features, as shown in Figure 2-15.

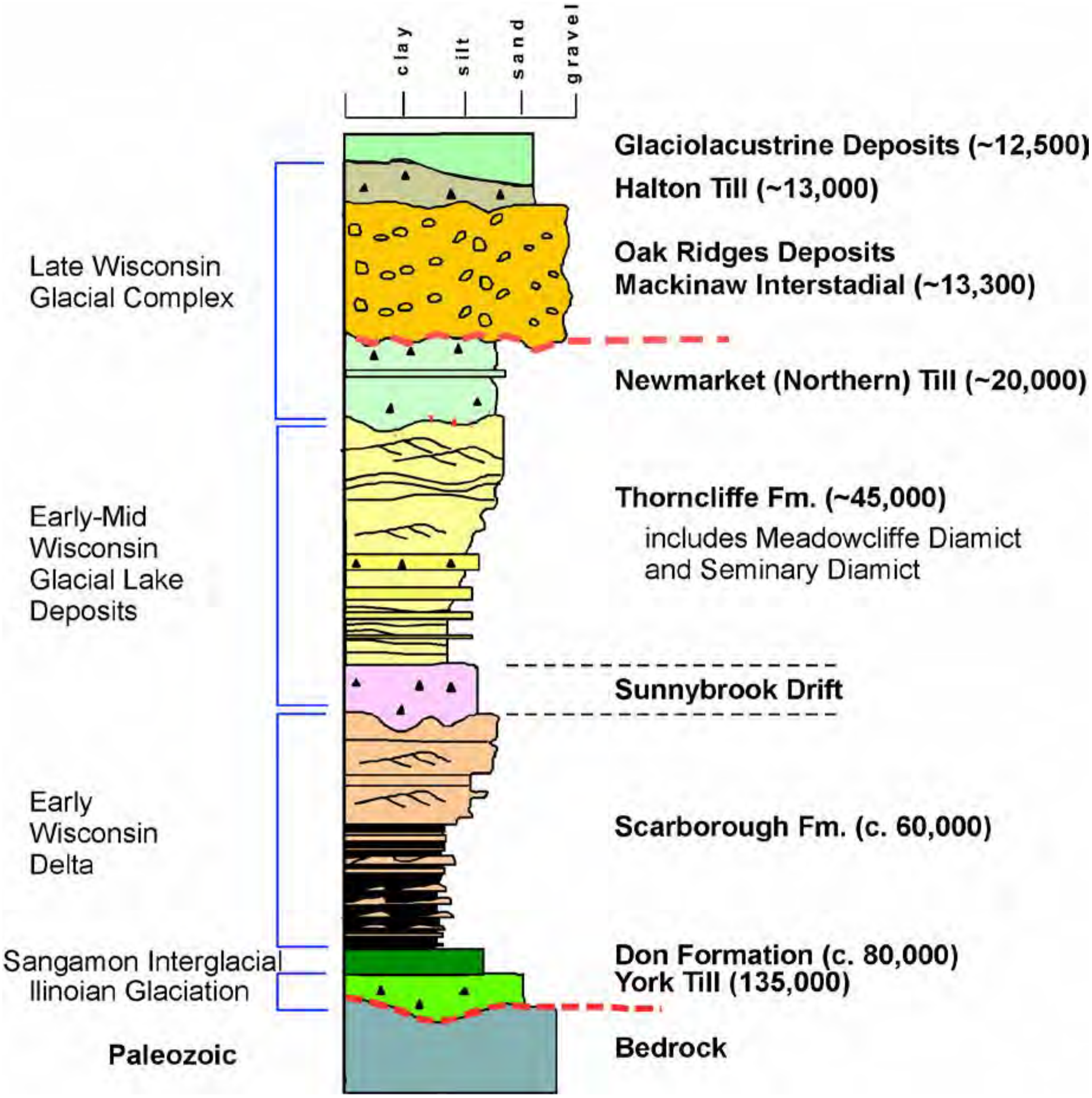


Figure 2-13: Quaternary deposits underlying the Oak Ridges Moraine (deeper overburden units may be missing north of the ORM). (from Eyles, 2002).

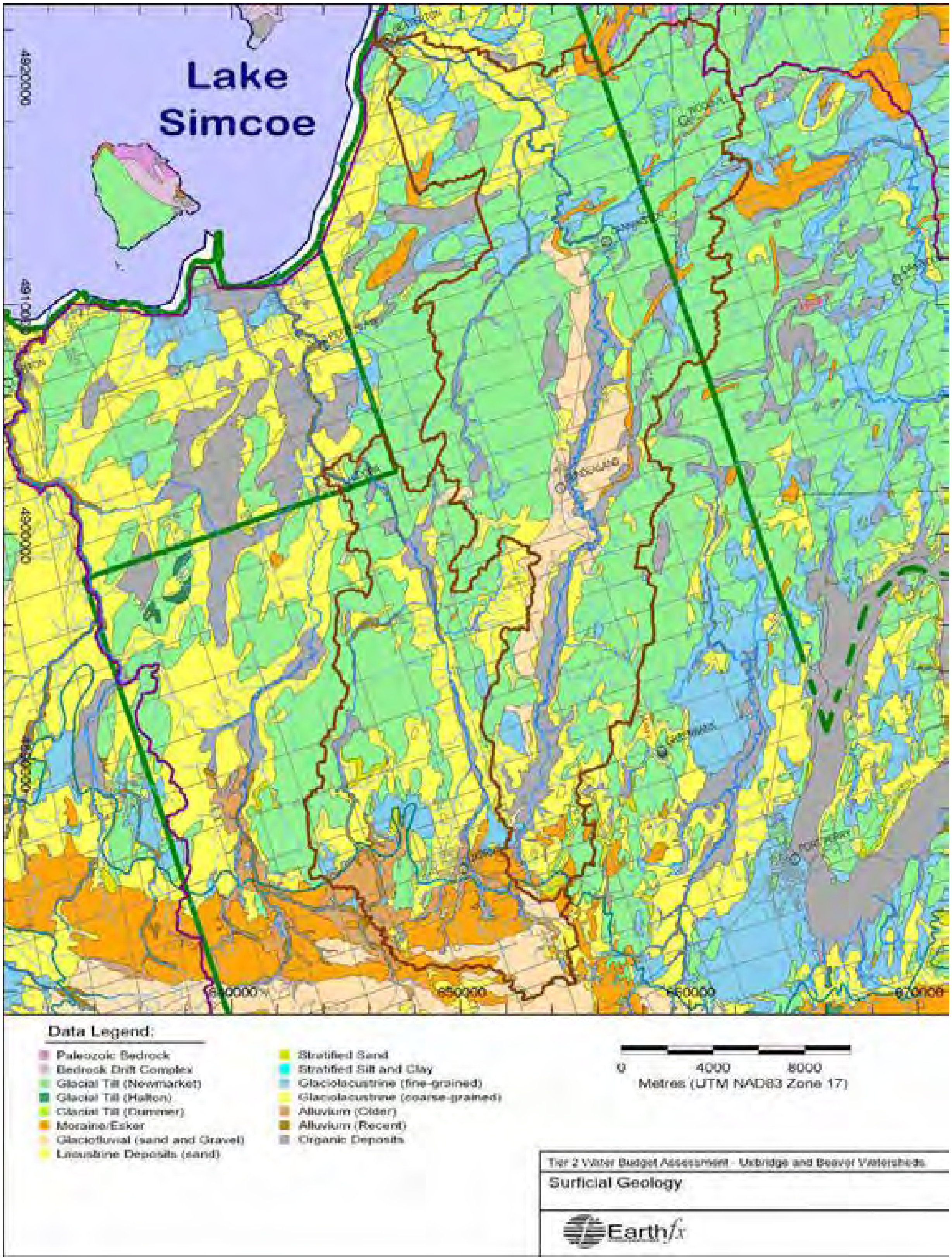


Figure 2-14: Quaternary geology in the study area (digital mapping from OGS, 2003) (Earthfx, 2010).

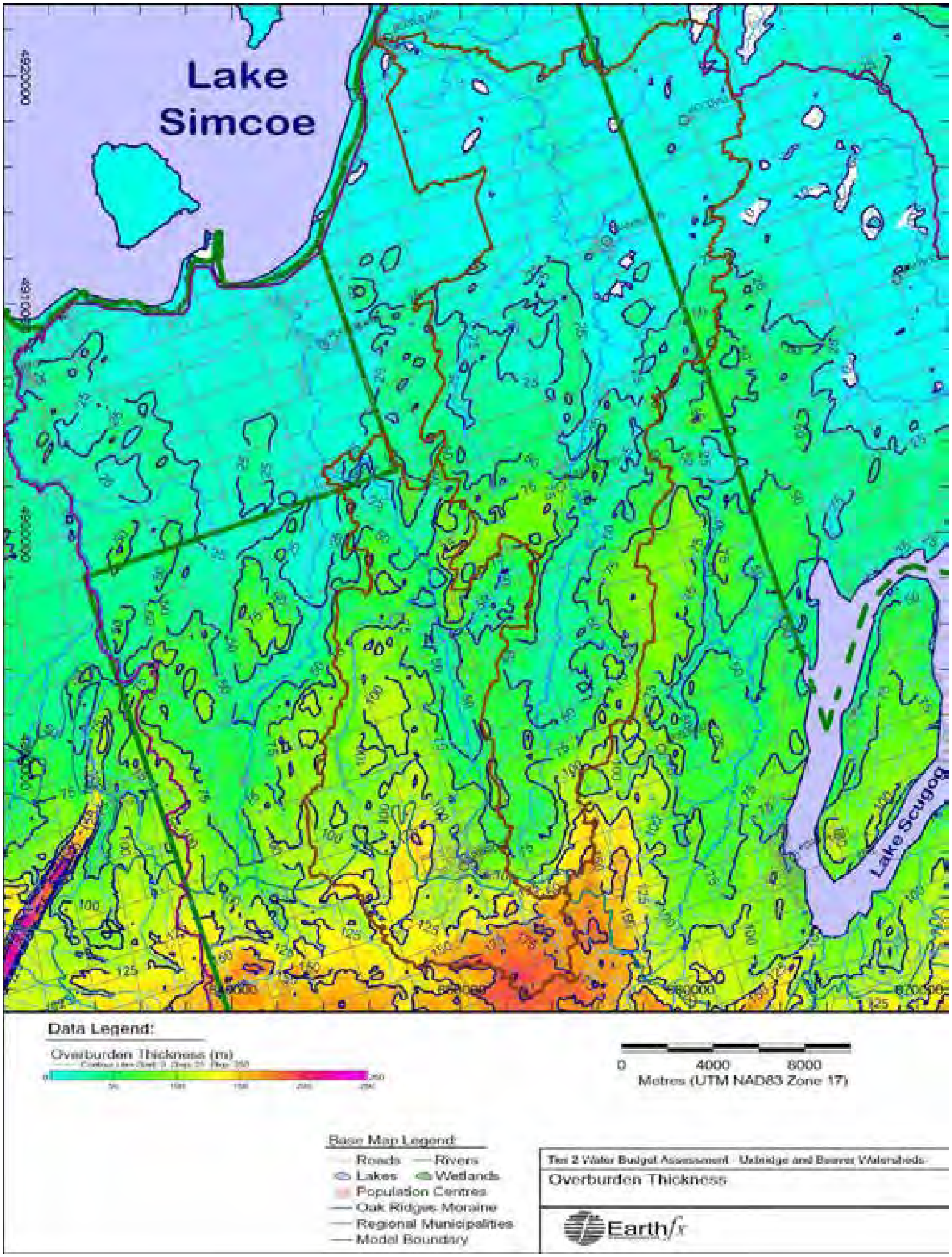


Figure 2-15: Overburden thickness, in metres (Earthfx, 2010).

2.4.4 Stratigraphy

The stratigraphy of the surficial deposits within the Pefferlaw River subwatershed is complex as a result of the glacial history. There are a number of ongoing initiatives to understand the local stratigraphy. 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 2-16, was completed using exposed sediment along the Lake Ontario bluffs and in the Don Valley brickyard (Eyles, 2002). In addition, a conceptual understanding of the stratigraphic framework was completed for the ORM area by the Geological Survey of Canada (GSC) and later refined by the Conservation Authorities Moraine Coalition York-Peel-Durham-Toronto Groundwater Study (CAMC-YPDT). The GSC constructed a five-layer geologic model of the moraine based in part on the stratigraphy of the Scarborough Bluffs. The CAMC-YPDT group combined the two stratigraphic models presented above to produce a ten-layer geologic model, shown in Figure 2-16. Further information can be obtained from Earthfx *et al*. (2011).

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

1. Surficial deposits and/or weathered Halton Aquitard
2. Halton Aquitard (south of ORM); Late Stage lacustrine (north of ORM)
3. Oak Ridges Aquifer Complex (ORAC)
4. Upper Newmarket Aquitard or Tunnel Channel Silts
5. Inter-Newmarket Sediments (INS) or Tunnel Channel Sands
6. Lower Newmarket Aquitard
7. Thorncliffe Aquifer Complex
8. Sunnybrook Aquitard
9. Scarborough Aquifer Complex (SAC)
10. Weathered Bedrock

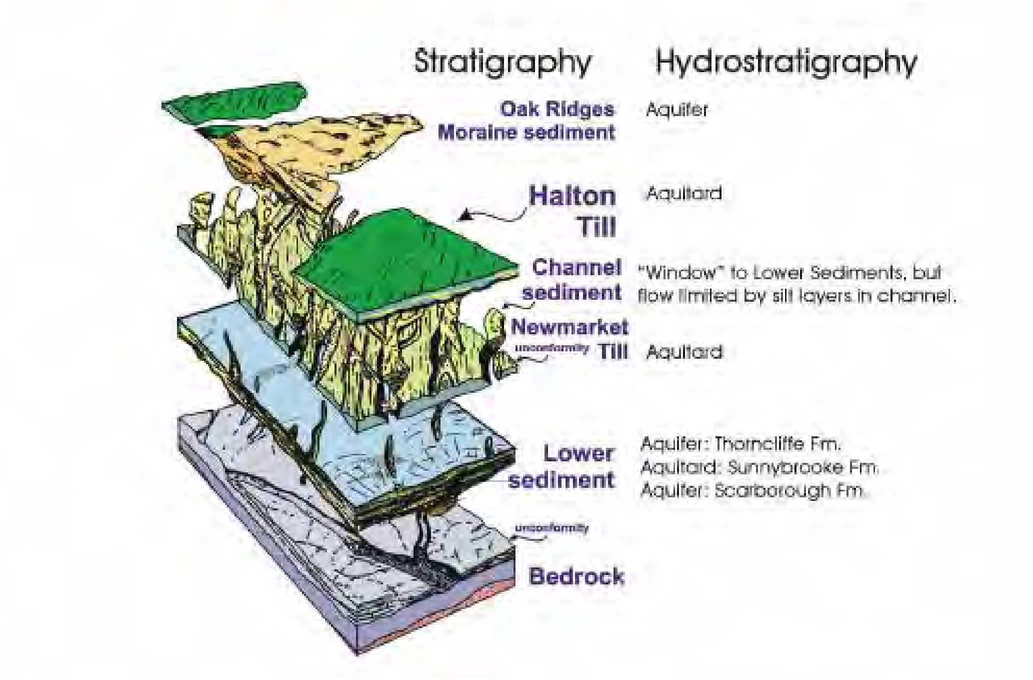


Figure 2-16: GSC stratigraphic framework of the ORM region (Sharpe *et al.,* 1999).

The Don Formation and underlying York Till and Don Formation have not been mapped within the watershed due to lack of deep borehole information that would be necessary to delineate these deposits since they are only within lows on the bedrock surface.

Scarborough Formation

The oldest Quaternary deposit of significant (mappable) thickness present within the subwatershed is the Scarborough Formation, or equivalent to the Scarborough Formation, as mapped in outcrop in areas to the south. The Scarborough Formation marks the start of the Wisconsinan glaciation, approximately 100,000 years ago.

The Scarborough Formation (or equivalent) was formed by fluvio-deltaic processes leading to deposition of a lower clay layer overlain by sands showing varieties of cross-beddings. The unit is often absent or thin in areas with relatively high bedrock surface elevations and tends to be thickest in the bedrock valleys. The unit is patchy in the northern part of the subwatershed and more continuous east of Greenbank and west of Uxbridge in the southern part of the study area (Wexler *et al*., 2009).

Sunnybrook Drift

The Sunnybrook Drift (or equivalent) overlies the Scarborough Formation and consists of clast-poor silt and clay deposited by glacial and lacustrine processes and is also patchy in the northern part of the study area (i.e. north of Sunderland) and more continuous to the south. This formation was deposited in close proximity to an ice sheet as it finally reached the subwatershed about 45,000 years ago (Earthfx and Gerber, 2008).

Thorncliffe Formation

The Thorncliffe Formation (or equivalent) was deposited approximately 45,000 years ago and consists of sedimentary deposits of silt-clay rythmites and cross-laminated and cross-bedded sands (Earthfx and Gerber, 2008). It is generally found within lows of the underlying stratigraphy. South of the study area, this unit largely consists of glaciolacustrine deposits of sand, silt, and clay. The unit can be over 80 m thick below the ORM in the south but is thin to absent in the north.

Newmarket Till

The Newmarket Till, which consists of the Upper and Lower Newmarket Tills and/or equivalent units and the Inter-Newmarket Sediments (INS), overlies the lower sedimentary sequences described above. The Newmarket Till is a dense diamict unit deposited when the Laurentide ice sheet was at its maximum extent, approximately 18-20,000 years ago. Regionally, this unit can be up to 100 m thick but is generally 20-30 m thick. The Newmarket Till is an important formation as it hydraulically separates the upper and lower aquifers and serves as a protective barrier to the deeper groundwater resources in the area.

The Lower Newmarket Till forms an extensive regional confining unit south of Cannington while the Upper Newmarket Till is mainly present in the till highlands. The INS is thicker and relatively continuous across the study area except where it has been eroded in the process of "tunnel channel" formation. The overall thickness of the Newmarket Till Aquitard ranges from 0 to 65 m within the subwatershed (Earthfx, 2010).

Channel Sediments

Following its deposition, the Newmarket Till was subject to erosional processes by glacial meltwater that modified the upper surface of the till. In some locations, the processes fully or partially eroded through the till. These features have been termed tunnel channels by the GSC, who believe these erosional events occurred beneath glacial ice (Sharpe *et al*., 2004).

The tunnel channels were mapped in the Core Model area in Kassenaar and Wexler (2006) and updated by CAMC for the Durham area. The tunnel channels are typically infilled by fining-upward sequences of sands and silts deposited as meltwater energy waned (Figure 2-17). These channel zones are significant in that they can provide a direct hydraulic connection between the upper and lower aquifers. The upper units (i.e. the ORAC, INS, and Upper and Lower Newmarket Tills) often outcrop along the edges of the till highlands which bound the tunnel channels north of the ORM (Earthfx, 2010).

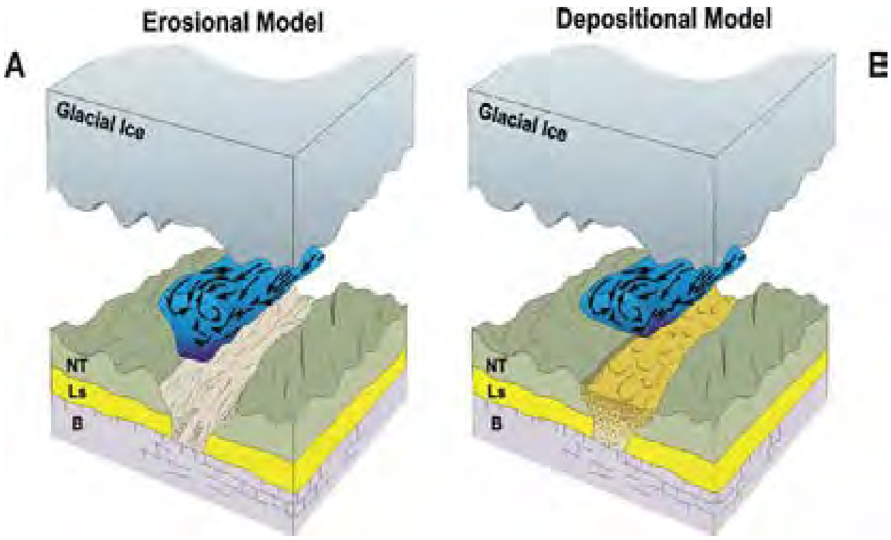


Figure 2-17: Interpreted erosional and depositional process in the tunnel channels (GSC).

Oak Ridges Aquifer complex and/or Mackinaw Interstadial deposits

The Oak Ridges aquifer complex occurs above the Newmarket Till and is the most prominent geologic feature in the subwatershed. The Oak Ridges aquifer complex is an interlobate glacial deposit that largely consists of sand and gravel layers that can be up to 150 m thick. To the north and south of the ORM, sand units overlying the Newmarket Till have been categorized as belonging to the Mackinaw Interstadial deposits. Mackinaw Interstadial sediments generally only occur locally within areas of low topography upon the surface of the underlying Newmarket Till (Earthfx and Gerber, 2008).

Surficial deposits and/or weathered Halton Till

The last glacial advance in the area, approximately 13,000 years ago, led to deposition of the Halton and Kettleby Tills which generally have a silt to clayey-silt matrix. These till deposits overlie the ORM and Mackinaw Interstadial units.

Figure 2-18 shows the extent of the Durham model which includes the Beaver River and the locations of key cross sections. Figure 2-19 and Figure 2-20 show typical cross sections depicting the key features of the geologic and hydrogeologic system. Figure 2-19 shows a west-east cross section through the study area. Figure 2-20 shows a north-south cross section through the study area.

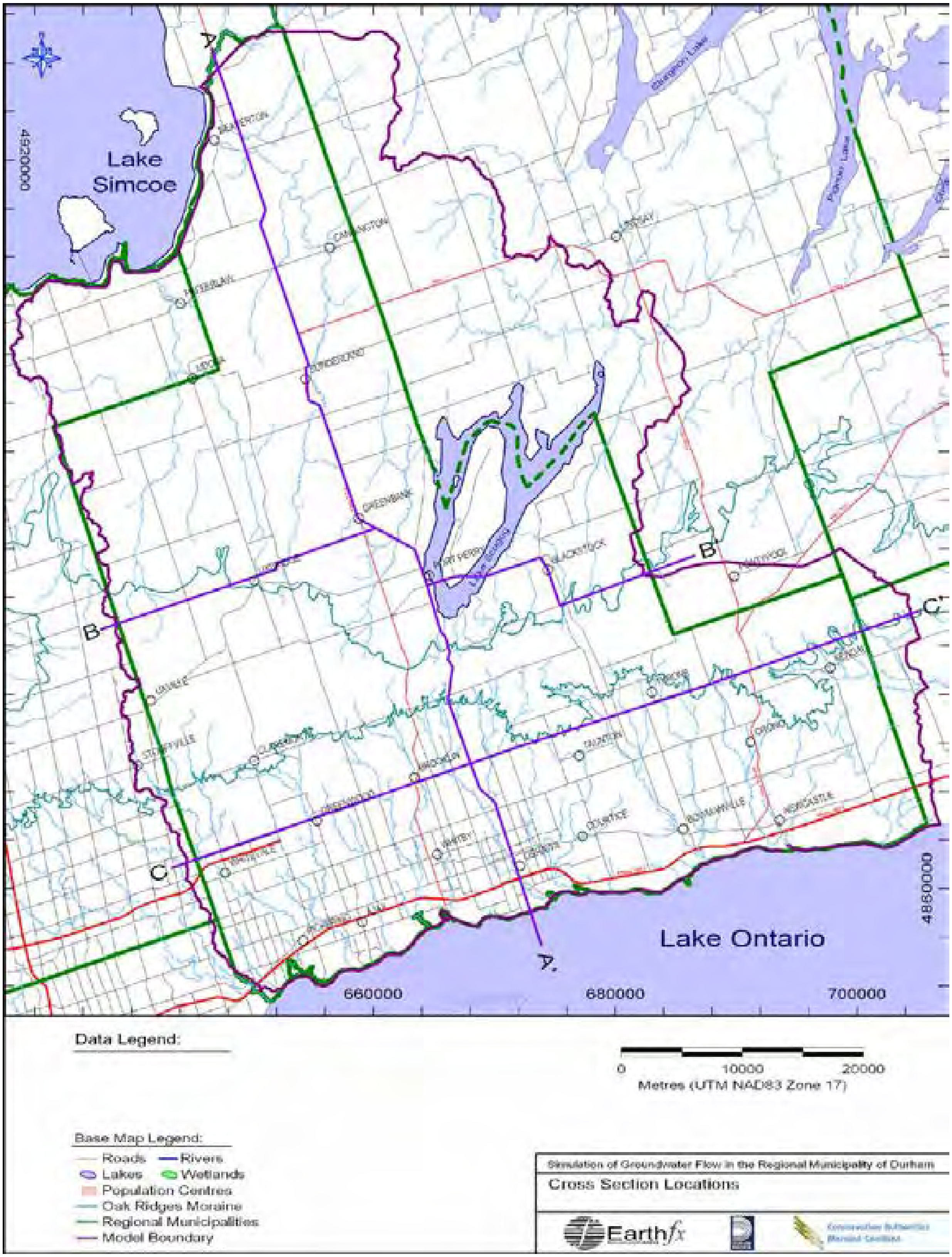


Figure 2-18: Location of cross-section lines (west-east cross-section line shown in Figure 2-19 and north-south cross section line shown in Figure 2-20).

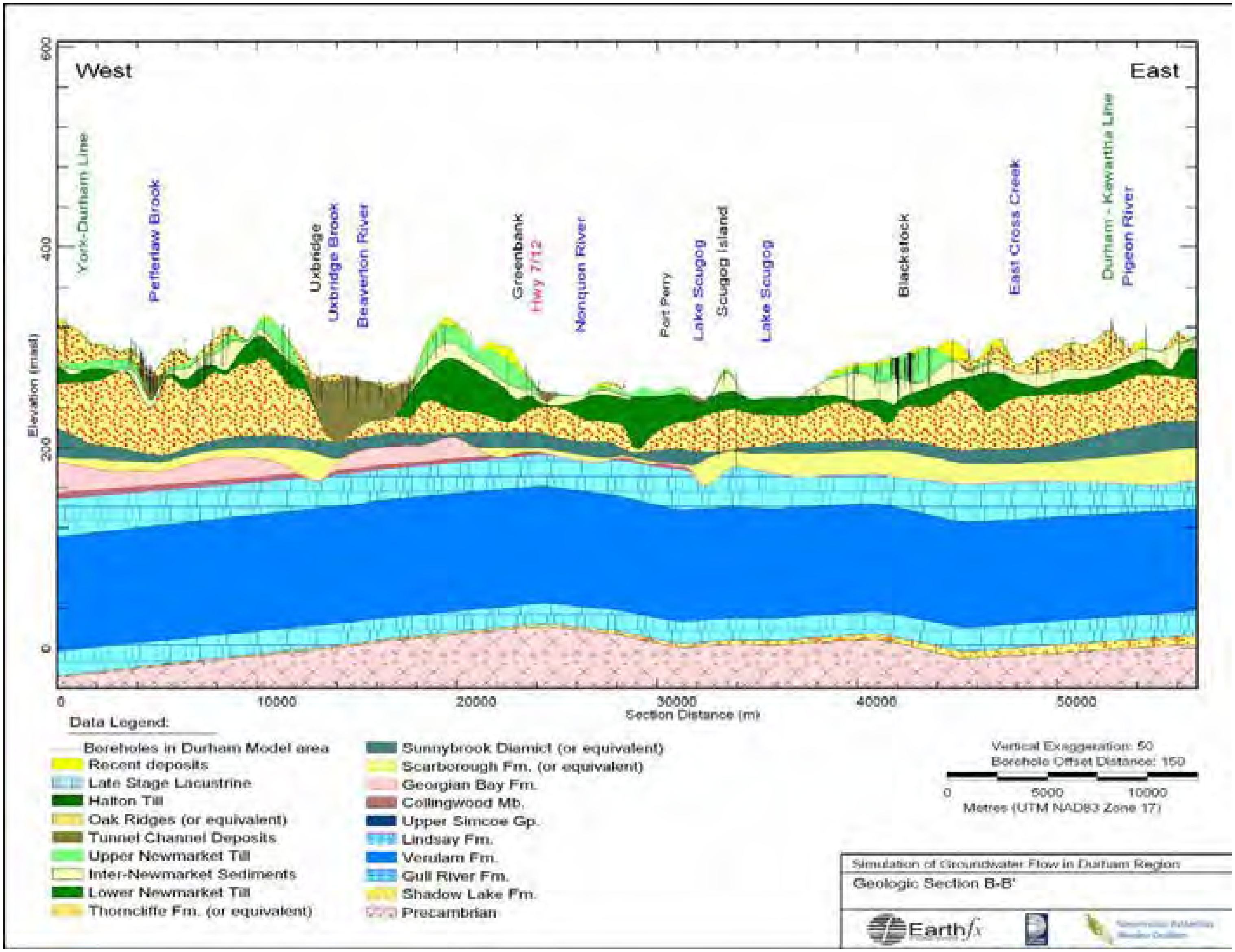


Figure 2-19: Geologic cross-section B-B' (west to east) (Earthfx, 2006).

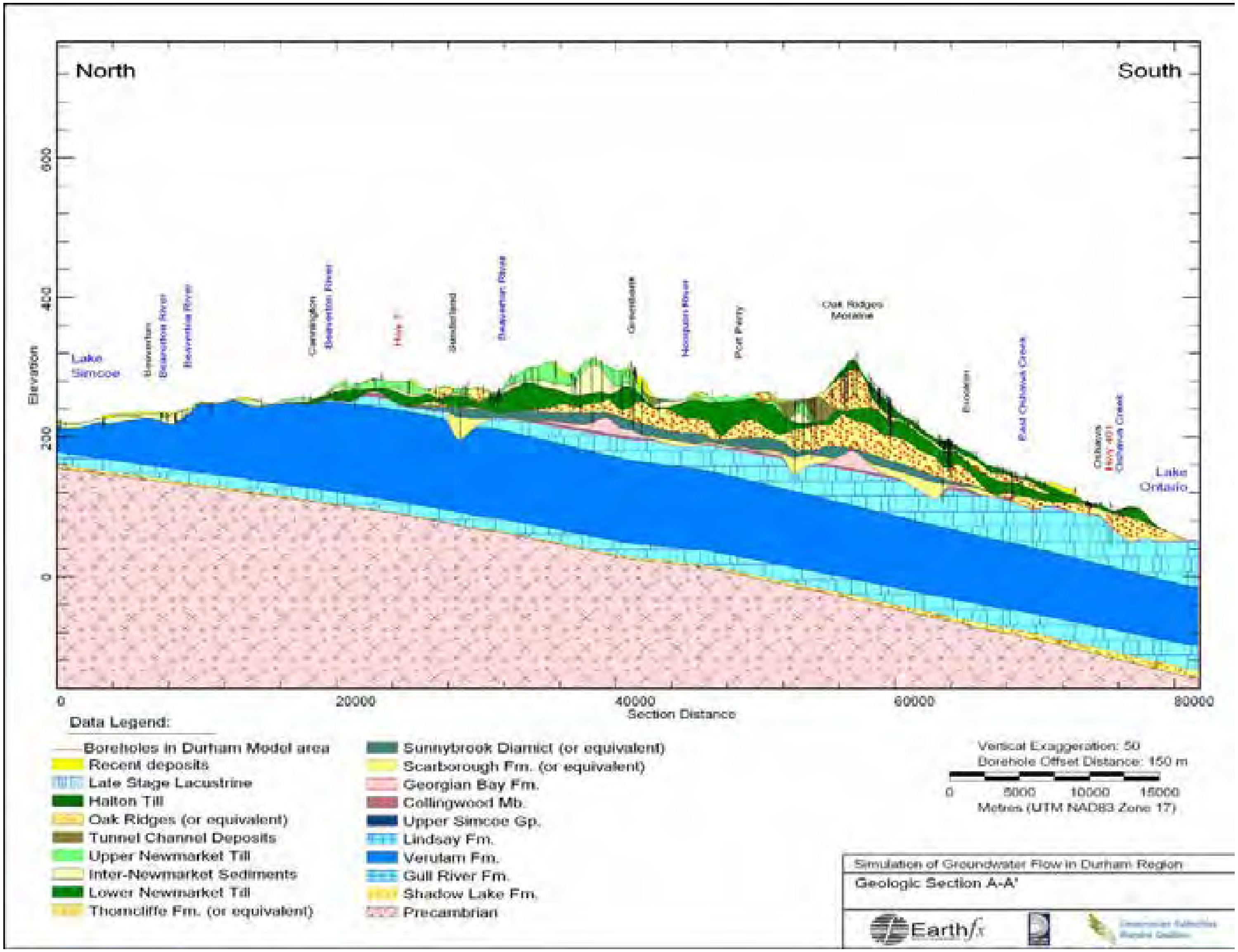


Figure 2-20: Geologic cross section A-A' (north to south) (Earthfx, 2009).

3 Best Management Practices

3.1 Introduction

The remaining chapters of this plan characterize the current condition of the five main subwatershed features (water quality, water quantity, stream geomorphology, aquatic habitat, and terrestrial natural heritage), and identify some of the stressors leading to their current condition. For each of these features, objectives have been recommended along with specific targets to achieve them. While the actions required to meet these targets may include prohibition or restriction of specific activities, especially in environmentally sensitive areas, it will also require expanded use of best management practices (BMPs). Best management practices can be defined as those measures intended to provide an on-the-ground practical solution to pollution and other environmental impacts from all sources and sectors. BMP refers to operational activities, physical controls, or educational measures that are applied to reduce the discharge of pollutants or impacts (US EPA, 2004).

In this chapter we provide an overview of current urban and rural/agricultural BMPs that can be applied within the Pefferlaw River subwatershed. The chapter concludes by highlighting BMP opportunities within the Pefferlaw subwatershed, resulting from two recent studies by the LSRCA – Lake Simcoe Basin Best Management Practice Inventory Phase I (2009) and the Lake Simcoe Basin Stormwater Management and Retrofit Opportunities (2008).

Best Management Practices and Phosphorus Loading

As phosphorus is the main contaminant of concern in the Lake Simcoe watershed, many of the BMPs being implemented throughout the watershed are intended to help reduce phosphorus loading. The 2006 Assimilative Capacity Study, and the follow up report on subwatershed phosphorus loads which was completed in September of 2010 (which are further discussed in **Chapter 4 - Water Quality**), highlight the important role that these activities play in improving water quality in the lake and its tributary rivers. Through these studies, the consultant team undertaking the modelling work evaluated the changes in phosphorus loading under two scenarios, the current land use and the future approved land use (which accounted for approved growth in municipal official plans for a 20 to 25 year planning horizon) to estimate what the change in phosphorus loading would be with this future scenario. This exercise included estimating the phosphorus load for the future growth scenario both with and without the implementation of certain best management practices. The established agricultural best management practices evaluated through this exercise included:

Row Crops

- Crop residue management
- Strip cropping/contour farming
- Crop rotation
- Cover crops
- Nutrient management

Hay/Pasture

- Nutrient management

Agricultural (Shared)

- Vegetated buffer strips along watercourses
- Fencing along watercourses
- Streambank stabilization

Together with the consultants and agricultural representatives, LSRCA staff estimated the reasonable potential for uptake of each of the BMPs listed above in each subwatershed. These estimates were measured against information such as land use mapping and information from Statistics Canada on farming practices in the watershed. This information was then modelled to determine the potential reduction in phosphorus loading that could be attained through the implementation of the BMPs. However, there was little existing information for a number of the BMPs (for example, the length of stream on which bank stabilization techniques had been used was unknown, as was the number of farms currently practising nutrient management). Therefore, while these estimates represent a good first step, more detailed research is needed in order to refine these numbers. Increased efforts are now being undertaken through the phosphorus targeting exercise under the Lake Simcoe Protection Plan.

The study found that, with the full implementation of the BMPs, there could be a decrease in phosphorus loading of approximately 300 kg in the Pefferlaw River subwatershed under the approved growth scenario. Without the implementation of these BMPs, the phosphorus load would increase by approximately 500 kg. This highlights the importance of implementation of BMPs in concert with the development that is slated for the subwatershed. Considering that there is growth slated for many of Lake Simcoe’s subwatersheds, where in some cases the implementation of traditional BMPs may not be able to mitigate the increase in phosphorus load, this also underscores the importance of researching and utilizing new and innovative BMPs, as well as low impact development practices that will help to achieve further loading reductions in the subwatershed. A number of these practices are described in this chapter. The LSRCA has been at the forefront of phosphorus reduction practices and technology; this must continue in order to improve upon the state of the lake and its watershed.

3.2 Rural/Agricultural Best Management Practices and Controls - Phosphorus Reduction Opportunities

There are a number of Best Management practices that can be implemented in a rural setting to help improve water quality and quantity. These include manure storage and management, private septic system repair or replacement, construction of bypass channels or bottom draws for online ponds, streambank erosion control, cover cropping, tree and shrub planting, installation of cropland erosion control structures, clean water diversion, livestock access restriction, and the completion of nutrient management plans. Funding and professional assistance is available through the LSRCA’s Landowner Environmental Assistance Program (LEAP) for a number of these activities. Each of these BMPs is discussed in this chapter and more detail can be found at http://www.lsrca.on.ca/leap/projects/ .

3.2.1 Streambank Erosion Control

Vegetation is often removed from streambanks in order to accommodate various activities (e.g. farming, urban development, etc.). This leaves the streambank vulnerable to erosion, which can affect the aquatic ecosystem and can be a source of phosphorus. Depending on the soil type, stormwater runoff and high flows in the watercourse can result in bank slumping and the loss of valuable land. The planting of trees and shrubs along a stream bank will prevent erosion by helping to bind the soil in place and slowing the flow of stormwater.

3.2.2 Cropland Erosion Control Structures

These BMP projects are undertaken to reduce soil erosion, and to protect watercourses and waterbodies. Not only will they reduce the loss of valuable topsoil, but will reduce the deposition of soil particles containing phosphorus and other contaminants into the lake and watershed. They can include grass waterways to slow the flow of water and cause sediment to settle; water and sediment control basins; terraces, which are built on a steep slope to enhance water retention and reduce erosion; and drop structures.

3.2.3 Cover Cropping

Cover cropping is a practice whereby plants are grown on agricultural lands where the fields would normally be left bare in between crops. Cover cropping can be used as a tool to manage soil fertility, soil quality, weeds, pests, and diseases.

Soil fertility can be improved through cover cropping – the cover crop takes up nutrients in the soil and maintains them in an inorganic form which is less likely to wash away during snow melt or precipitation events. These nutrients are then re-incorporated into the soil as the cover crop is decomposed, and made available to the newly planted crop, which is seeded over the residue of the cover crop. When used for cover crops, certain species (e.g. legumes) can be a significant source of nitrogen to the soil, as they have the capability to fix nitrogen. This can reduce, or in some cases negate, the need for chemical fertilization.

Soil quality is also improved through the use of cover crops as there are increases in organic matter; water holding capacity, as it reduces the rate and quantity of water that drains off the field; and nutrient holding and buffering capacity. As an added benefit it can also lead to increased soil carbon sequestration. Soil erosion is also reduced, as the roots help to create large soil aggregates and also hold the soil in place, and the plant material covers the soil surface when the cover crop dies off. Again, this helps to reduce the amount of soil and its associated contaminants from reaching surface water through wind and water erosion.

3.2.4 Conservation Tillage

The traditional tillage method for agricultural operations generally involves tilling the soil in the fall after the completion of the harvest, and again in the spring to prepare for planting. This can result in high levels of soil erosion and nutrient loss, as large soil aggregations are broken up and left vulnerable to erosion, and the plant material which would normally aid in holding the soil in place is ploughed under during tillage. Conservation tillage is a practice where less or no tillage is undertaken, and a higher percentage of the plant residue is left on the field. This has several benefits: it requires less work and fuel, the stubble of the previous year’s crop helps to hold the soil in place, increases moisture retention and infiltration, and increases the organic matter content of the soil.

There are some challenges associated with conservation tillage. These include soil compaction, increased need for pesticides to reduce the amount of weeds (which would normally be tilled under), carryover of diseases, and a possible increase in saturated or flooded soils, which can delay planting.

3.2.5 Livestock Access Restriction

Livestock that have access to watercourses can impact the water quality and affect the riparian area. The input of urine and manure directly into the water and onto low lying areas in the riparian area where it can be washed into the watercourse affect water quality. The livestock can trample streambanks, which contributes to instability, erosion, and sedimentation in the stream; while livestock in the stream can destroy spawning habitat. These issues can be avoided with the installation of fencing along watercourses to exclude livestock; cattle crossings; and alternate water sources, such as nose pumps.

3.2.6 Clean Water Diversion

These systems direct clean melt water and/or precipitation away from potential sources of contamination including manure storage and exercise yards. These consist of systems such as eaves troughs, ditches, or trenches; rainwater collection systems; or any other permanent technique for preventing rain and snow from becoming contaminated.

3.2.7 Milkhouse Waste Management

Milkhouse wastewater includes excess milk, the soap and acids used to clean equipment and kill bacteria, manure, and, dirt. This waste water, when released to surface waters, can have significant impacts to water quality. There are methods, such as adding the washwater into manure storage and installing treatment trenches and milkhouse wastewater treatment systems in combination with management practices. A common management practice is to save the first flush of milk washwater and use it as a diluted feed back to calves. These methods will prevent wastewater from being discharged to surface waters.

3.2.8 Manure Storage and Management

Manure from beef and dairy operations is very high in nutrients, such as phosphorus, and bacteria. If left on the field, it can easily seep into ground and surface water sources with snow melt and/or precipitation. This can have considerable environmental and health impacts. Manure is stored in order to allow its application at the most beneficial time for crops, and to apply the manure at an appropriate time to minimize potential environmental impacts. The type of manure storage facility depends on what is being stored. Storage facilities can consist of open storage structures with runoff containment or roofed structures for solid manure, concrete or steel storage tanks for liquid manure, earthen manure storage and runoff storage, and the containment of runoff from exercise yards.

3.2.9 Private Septic Systems

Waste 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 bacterial contamination to surface and groundwater. Malfunctions and failures of septic systems can be detected through regular inspections – if a problem is detected it should be resolved in a timely manner to minimize environmental impacts. The LEAP provides funding for septic system repair or replacement for those systems within 100 metres of the lake or a watercourse in the watershed, as this is the zone where malfunctions can have the greatest impact. The Lake Simcoe Protection Plan also contains recommendations about required septic system inspections in order to reduce nutrient inputs from this source.

3.2.10 Wellhead Protection and Well Decommissioning

Wellhead protection is undertaken in order to reduce the risk of contamination of well water by implementing proper construction and maintenance practices and safeguards for existing wells. Wellhead projects that can be undertaken include grading and permanently seeding the soil surface around the well, sealing the space around the well, upgrading or replacing a dilapidated well casing and/or extending a well casing 16 inches above the finished ground level, installing proper well caps, and earth moving to ensure that water is directed away from the well head.

Wells left unused or abandoned without being properly decommissioned leave the groundwater supply vulnerable to contamination. Wellhead decommissioning is undertaken in order to prevent groundwater contamination via improperly abandoned or unused wells. This is completed by properly plugging unused wells by a licensed well contractor.

3.2.11 Bypass Channels and Bottom Draw Structures for Online Ponds

Online ponds, created by damming a watercourse, can cause a host of issues on the watercourse. They can increase water temperatures, raise bacteria levels, and disrupt the natural movement of fish, invertebrates, sediment, and nutrients. The natural movement of each is imperative for a healthy aquatic system. It is possible to reduce or negate the environmental impacts caused by an online pond without the complete removal of the pond (which is important if the pond is used for irrigation). This can be accomplished either through the construction of a bypass channel around the pond or a bottom draw structure in the pond. A bypass channel is essentially a redirection of the watercourse around the pond, where the majority of the flow is diverted away from the pond, but enough flow is left going into the pond to maintain it. A bottom draw structure can be constructed where it would not be possible to put a bypass channel. These structures draw water from the cooler bottom waters of the pond, and this is discharged downstream to the watercourse, rather than the warm top waters from the pond flowing over the dam. While this does not negate the issues caused by the pond, it does improve conditions in the waters downstream of the pond.

Elgin Pond, Uxbridge

3.3 Urban Environments – Stormwater BMPs

3.3.1 Background

Urban stormwater runoff occurs as rain or melting snow washes 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 this has changed and efforts are made to intercept and treat stormwater prior to its entering watercourses or water bodies. However, in many older urban areas stormwater typically still reaches watercourses untreated.

Urban stormwater runoff is also greatly affected by land use type. Commercial and industrial areas usually have more impervious area (e.g. paved parking lots, sidewalks, roof tops) than any other type of land use and consequently generate more urban runoff and pollution. In sharp contrast are open areas that have little, if any, paved surface area. In these areas, the natural hydrologic cycle occurs whereby water can infiltrate down into the ground to be filtered by the soil before entering local streams and watercourses or continue deeper to recharge the ground water aquifer.

The impact of stormwater runoff on stream ecosystems has been well documented and in almost every instance is detrimental to the health of local rivers and streams. Impacts to watercourses have been categorized as follows (Scheuler, 1992):

- changes to stream hydrology (flow),
- changes to stream form (channel morphology),
- degraded water quality, and
- aquatic habitat.

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 surfaces are paved over; infiltration to groundwater is significantly reduced; and thus the runoff characteristics change. This change results in increases in the frequency and magnitude of runoff events, a decrease in baseflow, and an increase in flow velocities and energy. These changes further affect the form or morphology of the stream, including channel widening, down cutting, sedimentation, and channel braiding. These changes occur due to the increase in the erosive force associated with the increase in stream flow. As the velocity of a stream increases, the erosive force is transferred to the streambanks, which may begin to erode. If the banks are well vegetated or armoured, the erosive force can be transferred to the stream bottom and down cutting of the streambed can occur. This erosion will result in additional sediment and bedload being introduced into the stream system causing a further imbalance. When deposited along the inside bend of a river, this additional sediment may transfer even more force along the outside bend. Further deposition can occur where the river gradient flattens out and results in the creation of a braided channel. All of these changes can have significant impacts on the biological community in the watercourses (Figure 3-1).

Subwatersheds with less than 10% imperviousness should be able to maintain surface water quality and quantity and preserve aquatic species density and biodiversity, as recommended in the Environment Canada's Areas of Concern (AOC) Guidelines (2005). The Pefferlaw River subwatershed is just above this value with 11% impervious (hardened) surface, indicating that the system may experience some stress. The AOC Guidelines further recommend an upper limit of 30% as a threshold for degraded systems that have already exceeded the 10% impervious guideline.

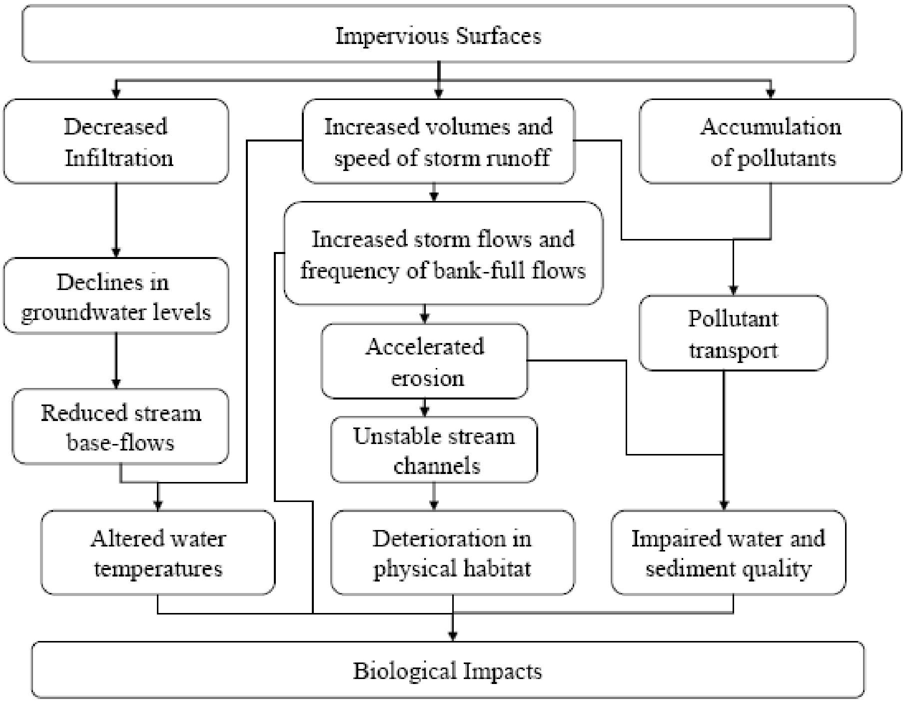


Figure 3-1: Pathways by which impervious surfaces may impact aquatic biological communities (ORMCP Technical Paper Series, #13)

One of the most significant environmental impacts of stormwater runoff is to water quality. Problems with degraded water quality directly affect the aquatic ecosystem, recreational opportunities, and aesthetics. This occurs as pollutants are washed off of streets, parking lots, rooftops, and roadways into storm drains or ditches which discharge to rivers, streams, and lakes. 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). Other harmful impacts include increased water temperature and the collection of trash and debris.

It is a combination of all the previously mentioned changes (hydrology, channel morphology, and water quality) that influence stream ecology and health. Impacts on the aquatic community range from the outright destruction of habitat to reductions in stream productivity and species diversity. The destruction of habitat can occur as spawning beds, nursery areas, and structure are covered with sediment. Another way in which habitat can be destroyed is through thermal degradation. Coldwater streams are defined as having stable water temperatures that generally do not exceed 20°C, even in the warm summer months. Stormwater runoff can reach temperatures exceeding 30°C because it is draining off of warm pavement. These inputs of warm water can significantly impact the temperature regime within cold water systems. The reduced infiltration of precipitation due to the impervious surfaces can also result in lower groundwater levels, and a potential reduction in the amount available to be discharged as baseflow. Streams that once flowed permanently may become intermittent, and flow can disappear altogether.

For the reasons just listed, the Lake Simcoe Protection Plan, 2009 (LSPP) sets out specific requirements for the management of stormwater in existing and planned settlement areas, through the preparation of comprehensive Stormwater Management Master Plans. Under Policy 4.5-SA, the municipalities of the Lake Simcoe watershed must prepare and implement these Master Plans (*Comprehensive Stormwater Management Master Plan Guidelines*, LSRCA, 2011). In addition, any application for new major development must demonstrate how phosphorus loadings and changes in water balance between pre-development and post-development will be minimized.

3.3.2 Stormwater Control

There are various methods of controlling stormwater runoff, from small-scale single lot controls to larger scale end-of-pipe stormwater management facilities (SWMF). The most common types of SWMF include wet ponds, dry ponds, and artificial wetlands.

Based on the Stormwater Practices Manual (MOE, 1994, 2003), there are various levels of stormwater control established to ensure the protection of receiving waters (e.g. watercourse, ditch, lake). These guidelines were produced by the Ministry of Environment taking into consideration concerns from the Ministry of Natural Resources (MNR) (Fish Habitat Protection Guidelines for Developing Areas, 1994). Four levels of protection were established focusing on the ability of SWM pond to control and remove suspended solids.

> **Level 1** is the most stringent level of protection designed to protect habitat which is essential to the fisheries productivity (e.g. 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 to be considered for any new development, only for instances where uncontrolled urban areas can implement some SWMF to improve environmental health.

It is important to realize that, while these guidelines are specific to suspended solids, other pollutants such as bacteria, metals, and nutrients (e.g. phosphorus) are reduced by the same controls. Due to severe water quality problems in Lake Simcoe, and the potential destruction of the coldwater fishery (e.g. Lake Trout [*Salvelinus namaycush]*), the entire watershed has been deemed a special policy area. As a result, all new development in the watershed since 1996 has been required to construct SWMF that meet the most stringent criteria or Enhanced Level 1 protection. This special policy designation was a result of a recommendation contained in the Lake Simcoe Environmental Management Strategy (LSEMS) “Our Waters, Our Heritage, 1995” report, which deals exclusively with efforts to reduce phosphorus inputs to Lake Simcoe.

Dry ponds, also referred to as quantity control facilities, provide negligible water quality improvement benefits, instead acting to control and slowly release stormwater runoff to receiving water bodies. These facilities reduce the risk of flooding and mitigate hydrologic and channel morphology impacts associated with stormwater runoff.

However, as described in a recent study, many stormwater ponds in the Lake Simcoe watershed have not been maintained and their level of efficiency/protection has dropped significantly (LSRCA, 2011). In addition, during dry, hot summer conditions, many of the ponds displayed low oxygen levels to a point where hypoxic/anoxic conditions were present during the daytime. In any case, the intent to retain suspended solids, reduce phosphorus loads, and protect fish habitat are being compromised by the existing conditions of many of the ponds.

3.3.3 Urban Environments – Employing Other Urban Best Management Practices and Stormwater Control Measures

There are some sections of existing urban areas where stormwater pond retrofits are not possible. These are largely the older sections of towns including the downtown core, commercial and industrial areas that were built long before stormwater management practices were developed. To ensure that these areas are addressed, existing control measures such as street sweeping should be undertaken along with newer, innovative, and less conventional BMPs. Often referred to as Low Impact Development (LID) practices, their intent is to retain water on-site to be re-used and/or redirected as both conservation and hydrologic reset measures.

Street Sweeping

Street sweeping is practiced in most municipalities within the subwatershed. Street sweeping involves mechanically removing dirt and debris from streets and parking lot surfaces, thereby reducing the amount of pollutant available to be washed into area watercourses during rain or snow melt events. While the effectiveness of street sweeping for pollutant removal is thought to be relatively low compared to other accepted stormwater BMPs (the estimated removal rate from a recent Environment Canada study is 10 – 30 grams per curb kilometre [Rochfort *et al*., 2007]), this method does have the benefit from a water quality perspective in that it can be undertaken in areas where structural stormwater controls do not exist. Therefore, efforts to target additional street sweeping programs specifically within these uncontrolled areas will result in more effective water quality control. Targeted street sweeping in the uncontrolled areas in the Town of Uxbridge would result in an estimated phosphorus reduction of 5 to 15 kilograms per year, depending on the removal rate.

Rainwater Harvesting

Canadians could be considered one of the more wasteful societies in the world with regard to water. For example, the use of potable water for flushing toilets and irrigating lawns and cropland is a waste of a valuable resource. One method of reducing this wasteful use of water is rainwater harvesting, which involves the collection and storage of rainwater, usually from rooftops and other hard impermeable surfaces. The water can then be stored in tanks and used for non-potable uses such as washing cars, irrigating lawns, and flushing toilets. The storage tanks can range from a barrel at the bottom of a home’s downspout to a large industrial-size facility with multiple tanks, pipes, pumps, and controls.

In addition to the conservation of potable water, the benefits of rainwater harvesting include reducing pollution from stormwater runoff and flood control. Collecting and storing stormwater decreases the volume and rate of runoff, which reduces the potential for the runoff to pick up pollution, as well as reducing the risk of flooding.

The use of rain barrels to collect rooftop runoff for watering lawn and gardens has become increasingly popular in recent years. While the widespread use of this practice, combined with downspout disconnection and other water conservation measures, will reduce the demand for water at peak times and reduce the potential for stormwater related issues, a more aggressive and targeted approach is recommended to achieve significant improvements for the purpose of stormwater management. For example, in the City of Portland, water harvesting for the purpose of stormwater management is encouraged through reduced development fees if the stormwater runoff is retained on site. This has led many commercial, industrial, and institutional landowners to undertake water harvesting projects based on the reduced fee and savings associated with a decrease in water use.

There are some concerns with large scale water harvesting, particularly with cost, maintenance, and public acceptance. Another concern is the potential harmful impact of these large-scale takings on baseflow and maintaining environmental flows to surface waters. These concerns can be mitigated by conducting a proper water balance for the affected site to ensure that there is adequate water to support baseflow.

Ditches/Grassed Swales

In the past, subdivisions were not built with curb and gutters which connected to storm sewers, but simple ditches to convey water away from roads and homes. Ditches have a number of benefits over curb and gutter systems. They are much less expensive to construct, reduce the size required for stormwater management facilities, allow water to infiltrate into the ground, and provide some snow storage during the winter months. The main drawbacks of ditches are that they use more space and are not as easy to maintain as curb and gutters.

The use of ditches and grassed swales is now making a comeback as resource managers and planners have realized the environmental benefits. Ditches and grassed swales have been estimated to remove 30% of the phosphorus, 70% of the suspended solids, and greater than 50% of certain metals and hydrocarbons contained in urban runoff (Low Impact Development Center, 2003 http://www.lowimpactdevelopment.org/).

When grassed swales and ditches are combined with bioretention facilities or infiltration galleries, there can be a greater benefit to water quality and quantity. These areas require more routine maintenance than do curb and gutter systems, and are therefore more costly, but the planting of native grasses, shrubs, and trees can also be undertaken to add aesthetic value and can significantly improve the public’s acceptance of these features.

Roof Top Storage/Green Roofs

Providing roof top storage to retain rainfall is a common practice currently employed within the GTA and the Lake Simcoe watershed. The concept is to reduce the amount of runoff and subsequent pollution resulting from a building/structure. Roof top runoff is also controlled using a combination of other BMPs such as infiltration galleries, soakaway pits, and bioretention facilities. The section below provides detail on these technologies.

Green roofs were developed as an alternative to the above mentioned practices for treating roof top runoff. Green roofs have been described as the creation of a contained green space on a roof for the purpose of improving water quantity and quality control. Green roofs are constructed by first placing an impermeable membrane on the roof top followed by a drainage medium and soil. The roofs are then planted with a variety of ground covers. Research conducted into green roofs has documented that there are additional benefits associated with their construction. These include reduced energy consumption and cost, improved air quality, and a reduction in the urban heat island effect.

Soakaway Pits, Infiltration Galleries, Bioretention, and Permeable Pavement

These BMPs, while varied, have a common objective – to reduce surface water runoff by infiltrating water back into the ground. They are more useful for quantity control than the improvement of quality, as they reduce peak runoff and flooding, and maintain the water balance. There is also a benefit to water quality, as they minimize water contamination by reducing the volume of runoff.

Soakaway Pits

These are the smallest and least expensive of these BMPs. They are designed to control roof top runoff from smaller buildings. They should be located well away from building foundation drains, and require well-drained soils. They are sized according to the amount of roof runoff they will receive – a typical soakaway pit is 4-5 ft square, 3-4 ft deep, and can be covered in grass or stone. This is one of the few BMPs that a homeowner can install, with instructions for their construction easily accessible on the internet.

Infiltration Galleries

Infiltration galleries can include trenches, chambers, and large basins. They are generally designed to control larger volumes of runoff and are often twinned with some form of sediment control when involved with treating parking lot runoff. This ensures that they do not become plugged and increases their operational lifetime.

Bioretention

Bioretention is a BMP that is designed to control water quantity and improve water quality using the chemical, biological, and physical properties of plants, microbes, and soils to removal pollutants from stormwater runoff and facilitate its infiltration. They are generally used in parking lots, road medians, and in conjunction with grassed swales, and can be significantly less expensive than traditional stormwater BMPs. While the design may vary, they generally consist of a grass buffer strip, sand bed, ponding area, organic layer or mulch layer, planting soil, and plants. They are designed such that runoff (usually as sheet flow from a parking area, though they can be adapted to receive flow from a curb and gutter system) first reaches the grass buffer, where the flow of water is slowed and some particulates are filtered out. It then flows into a sand bed, which further slows the flow, and spreads the runoff along the length of the ponding area. The ponding area is designed for the water to pond to a depth of approximately 15 cm, where it is stored and may undergo a number of natural processes; it then infiltrates into the soil within approximately four days (US EPA, 1999). The processes that can take place in a bioretention facility include (Prince George's County, 2007):

- Sedimentation
- Adsorption of pollutants to soil particles
- Filtration
- Volatilization of hydrocarbons and other pollutants
- Plant uptake
- Cooling of runoff water
- Decomposition
- Phytoremediation
- Bioremediation
- Storage capacity

These facilities are not appropriate for some areas, such as those where the water table is within 1.8 m of the ground surface. There have been some concerns with their use in cold climates as the soil may freeze, preventing runoff from infiltrating into the soil during the winter months, though a recent study by the Toronto and Region Conservation Authority's Sustainable Technologies Evaluation Program (TRCA, 2008) found that the bioretention area was an effective means for draining melt water, so long as it is designed to prevent freezing at the inlet of the area. Temperatures generally remained above freezing in the bioretention area due to microbial activity in the soil and an insulating layer of snow. Other considerations include the salt tolerance of the plants used in the area, the phosphorus content of the soil (if this is high, the bioretention area may actually contribute to phosphorus loading), and the annual inspection and maintenance requirements.

Permeable Pavement

Permeable pavement is another option for reducing runoff through infiltration, particularly from parking lots, which can generate large volumes of runoff. Forms of permeable pavement include porous pavement, cement pavers, and other turf grass pavers. While there are obvious benefits to reduce runoff and prevent flooding and erosion problems, there can be concern over potential groundwater contamination from the oils, metals, and other contaminants that accumulate on pavement. However, if the appropriate studies are undertaken to ensure that the site is appropriate, this technology has the potential to reduce the effects of development on the hydrologic regime of a development site.

Oil Grit/Hydrodynamic Separators

A typical oil/grit separator (OGS) operates by settling sediments and large debris out of stormwater runoff, and ultimately separating oils from the water. The units generally consist of 3-4 chambers, each designed for a specific function. The first chamber, referred to as the Grit Chamber, settles coarse sediment and large debris by slowing the flow of the water and screening larger debris with a trash rack. From there, the stormwater moves to the second chamber, the oil chamber, which traps and separates surface oils and grease from the stormwater runoff. This separation occurs because oil is lighter than water and floats on the surface. The discharge pipe is located near the bottom of the chamber, allowing the oil to pool on the surface and be contained. The third chamber houses the stormwater outlet pipe that discharges the overflow to the storm drain system.

These systems are effective at removing oil and sediment, but their capacity for phosphorus removal is low. Therefore, they should be used in combination with other stormwater practices. Another important consideration is maintenance – their efficiency is dependent upon regular maintenance. This involves cleaning them out at least twice per year and as necessary after major storm events. The maintenance costs can be high because they can contain hazardous materials which need to be safely disposed of.

Some manufacturers have tried to increase the effectiveness of OGS for removing particulate and oil as well as additional contaminants such as phosphorus. An example of this is Imbrium Systems Incorporated's Jellyfish System. Systems such as this should be explored through pilot projects in the urban and industrial areas of the subwatershed.

Road Salt

Road salt has become an increasingly important issue as the urban areas of the Lake Simcoe watershed expand. The Canadian Environmental Protection Act defined road salt containing chloride salts as toxic under the Act (Environment Canada, 2001). Analysis of surface water quality throughout the Lake Simcoe watershed shows an increasing trend in chloride concentrations (see Water Quality section). The use, storage and application of road salt as well as disposal of snow should be conducted in accordance with the *Code of Practice for the Environmental Management of Road Salts* (Environment Canada, 2004). To reduce the area of roads requiring salt during the winter, and also to limit the amount of impervious area, municipalities should also explore the feasibility of varying road widths – narrower streets could be used on less travelled routes to reduce impervious area, rather than simply using a standard width. Alternatives to the use of road salt should also be explored.

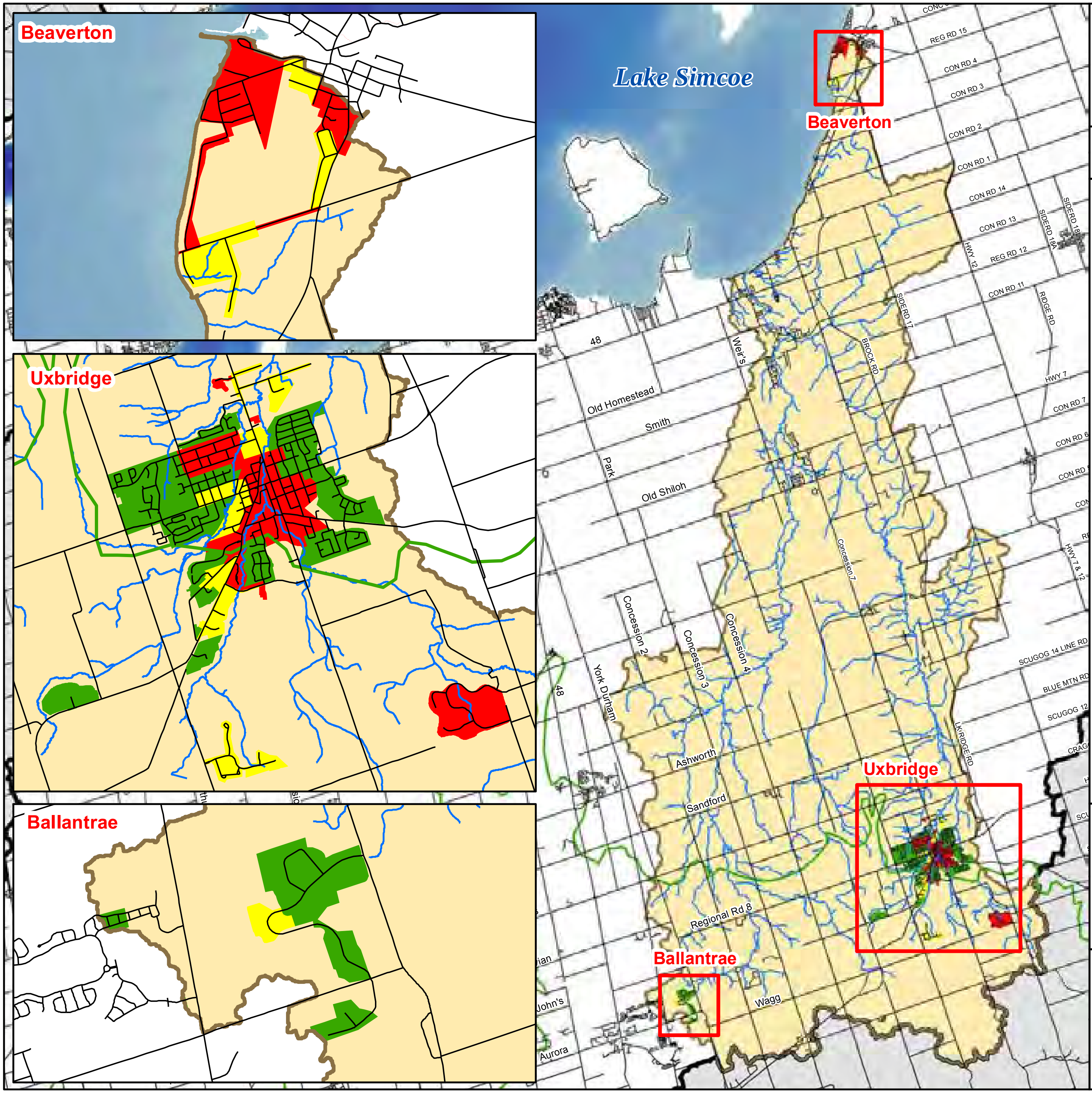
3.4 Opportunities for BMPs in the Pefferlaw River subwatershed

3.4.1 Urban BMP opportunities

The *Lake Simcoe Basin Stormwater Management and Retrofit Opportunities* report (LSRCA, 2008) identified and evaluated opportunities to control phosphorus from existing urban areas. In these 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 a higher level of control (i.e. Level 1). The report identified a total of 16 retrofit opportunities in the two urban areas in the Pefferlaw River subwatershed (Figure 3-2). These have the potential to prevent almost 34% of the phosphorus contained in stormwater from entering the river, and ultimately the lake (Figure 3-3). Details on these retrofits can be seen in the LSRCA report *Lake Simcoe Basin Stormwater Management and Retrofit Opportunities*, published in 2007.

Stormwater retrofit opportunities in the Pefferlaw River subwatershed

Figure 3-2



Legend

- Road
- Watercourse
- Oak Ridges Moraine
- LSRCA Watershed Boundary

Storm Watersheds

- 🟩 Controlled
- 🟨 Uncontrolled, Retrofit Opportunity
- 🟥 Uncontrolled, No Retrofit Opportunity

Lake Simcoe Region conservation authority

0 1 2 4 6 8 10 Kilometres

N

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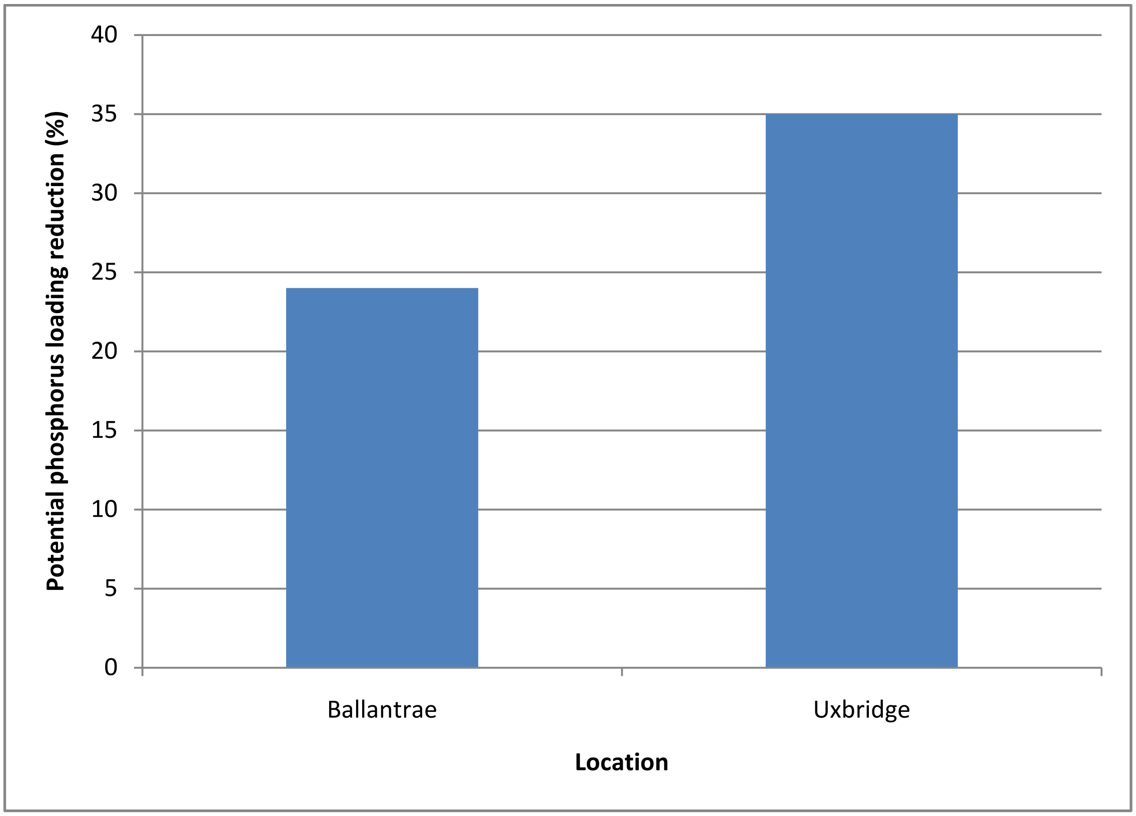


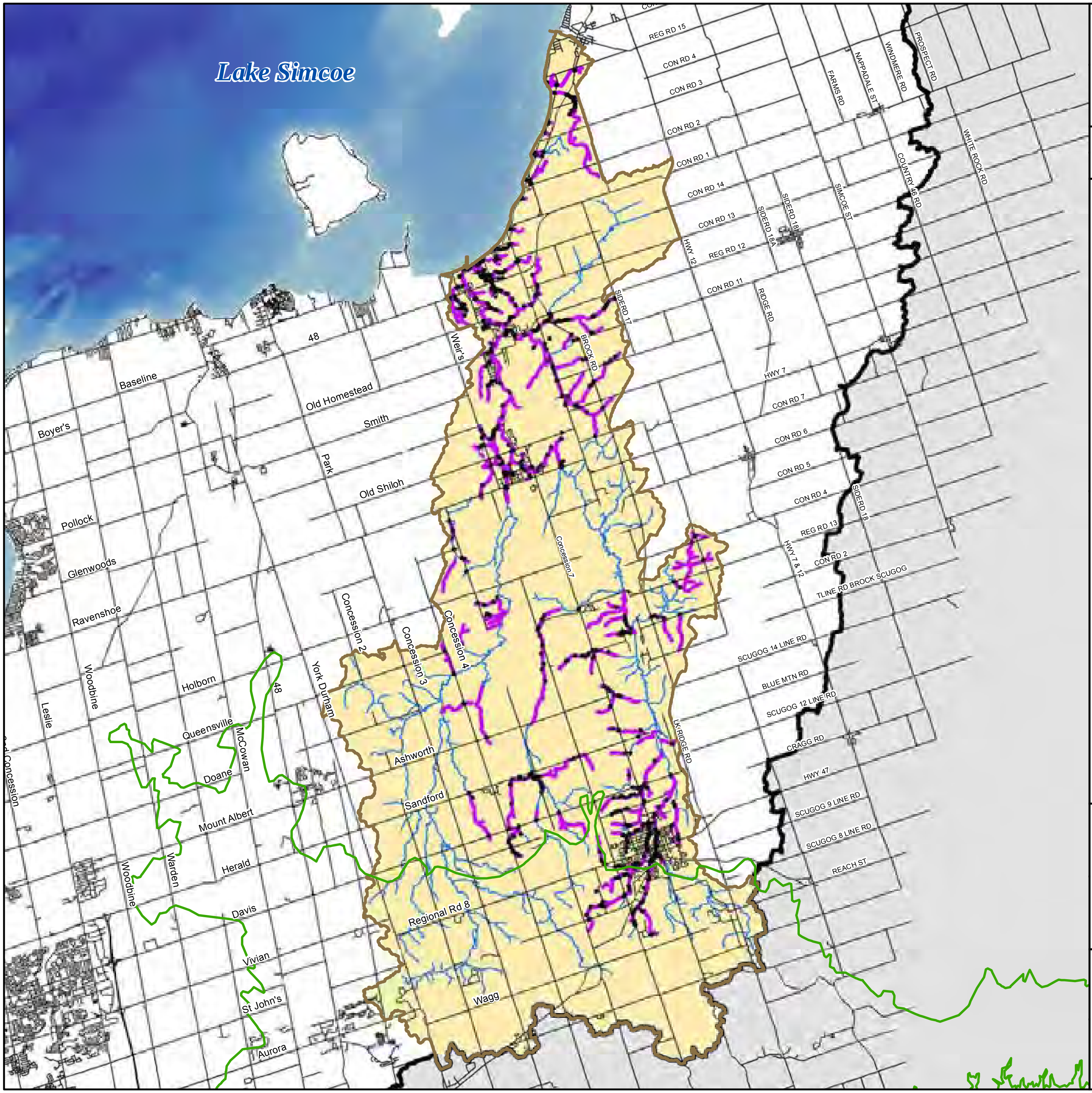
Figure 3-3: Estimated reduction in phosphorus loading as a result of completing the 16 stormwater retrofit opportunities identified in the urban areas of the Pefferlaw River subwatershed

3.4.2 Stream Corridor BMP Opportunities

During the summers of 2008 and 2009, the Lake Simcoe Region Conservation Authority (LSRCA) conducted a Best Management Practices (BMP) Inventory, spanning 17 sections of the 18 subwatersheds within the Lake Simcoe basin (LSRCA, 2010). The purpose of the BMP Inventory was to identify opportunities for the reduction of nutrients or improvements to fish habitat within the Lake Simcoe basin. Three priority areas were identified to focus the scope of the Inventory. These three areas are agriculture, tributary, and urban. Agriculture areas include any farming and agricultural operations; tributary areas include tributaries of all orders with a variety of land use, excluding urban and agriculture; and urban areas include any section of watercourse within an urban environment, including drains, stormwater outfalls, and any other sources of nutrients that could require the implementation of BMPs to improve conditions. The BMP Inventory identified 4,814 waypoints containing 17,125 BMP opportunities throughout the entire Lake Simcoe watershed. The Pefferlaw Brook and Uxbridge Brook subwatersheds were considered separately, with 17% and 30% of the subwatersheds being surveyed, respectively (Figure 3-4). The total results for the Pefferlaw and Uxbridge Brooks have been combined, and yield a total of 2,641 BMP opportunities being identified in the survey area, with the largest proportion of BMP opportunities being related to insufficient riparian cover (14.2%), culverts (e.g. culverts at road crossings, under driveways, and under farm equipment crossings) (11%), destabilizing land use (9.6%) and bank erosion (8.2%) – see Figure 3-5 f for the breakdown of the types of opportunities in the subwatershed.

BMP opportunities within the Pefferlaw River subwatershed

Figure 3-4



Legend

- Road
- Watercourse
- BMP Watercourse Surveyed
- ● BMP Opportunities
- LSRCA Watershed Boundary
- Oak Ridges Moraine

Lake Simcoe Region conservation authority

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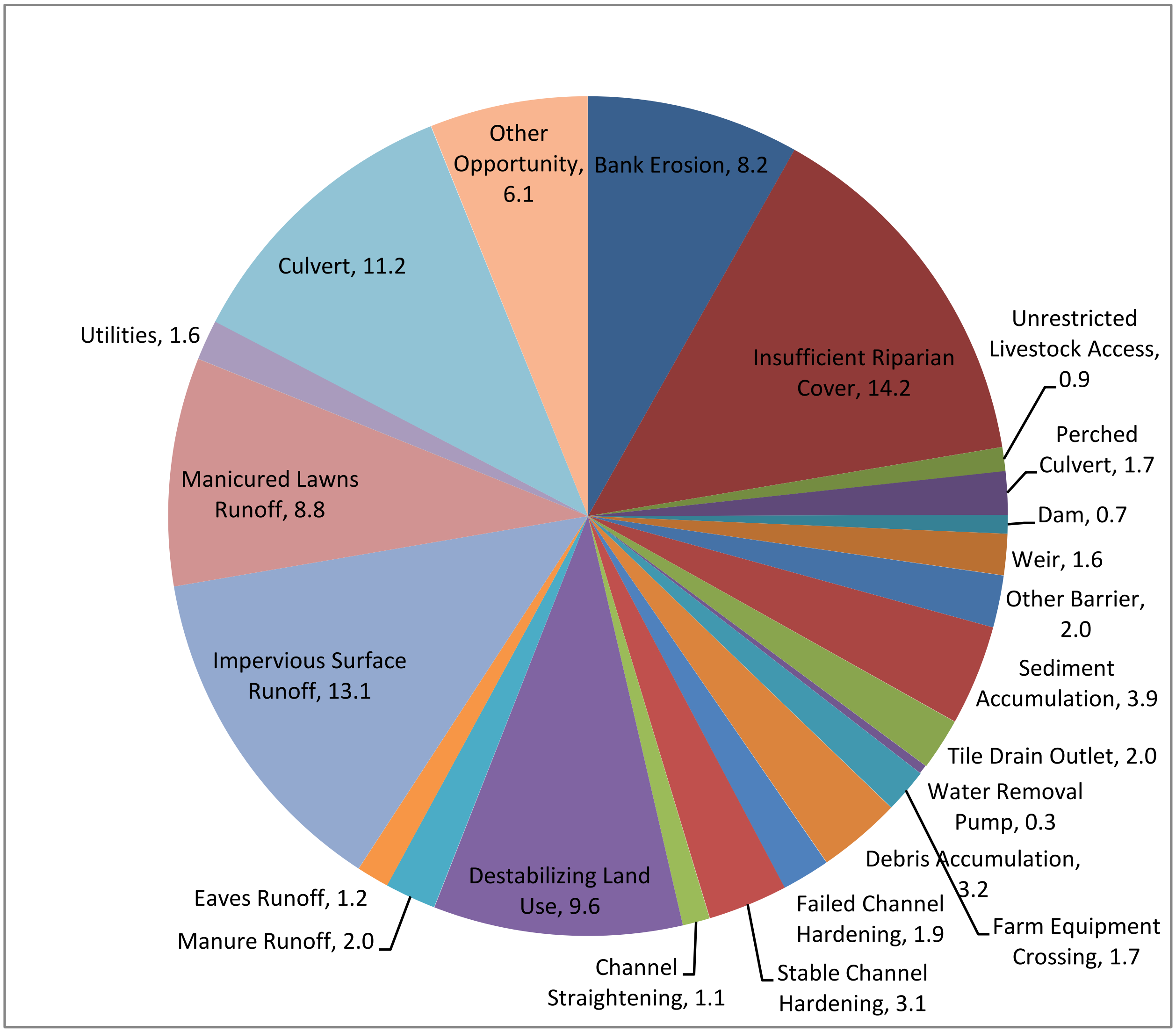


Figure 3-5: Types and percentage of stream corridor BMP opportunities identified in the Pefferlaw River subwatershed during the survey

4 Water Quality – Surface and Groundwater

4.1 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 the 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. Surface water quality results are compared to guidelines relating to the protection of the aquatic ecosystem. Some of the water quality variables of greatest concern in the Pefferlaw River subwatershed are summarized in Table 4-1.

4.2 Current Status

4.2.1 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 within the entire Lake Simcoe watershed. Each sample was analyzed for 41 chemical parameters including metals, nutrients and general chemistry. There are two groundwater monitoring sites in the Pefferlaw River subwatershed (Figure 4-1).

4.2.2 Measuring Surface Water Quality and Water Quality Standards

Surface water quality is currently sampled at two stations within the Pefferlaw River subwatershed. One station is located in the community of Pefferlaw (PWQMN and LSEMS) and the other is located downstream of the community of Uxbridge (PWQMN only; Figure 4-1). Monitoring began at Pefferlaw in 2002 for PWQMN and 1993 for LSEMS. In Uxbridge Brook, monitoring began in 2002 for PWQMN; it is not currently monitored for LSEMS. Data is also reported for two historical stations; a PWQMN station was located where the main branch of the river crosses Highway 48 from 1972 to 1993, and LSEMS data was collected from 1996 to 2001 at the Uxbridge PWQMN station. There was a focus on sampling low flow conditions in the historical PWQMN program, but there was a shift in focus to include storm event sampling for the current PWQMN program; the LSEMS program always included storm event sampling. Samples at the current stations are collected eight times a year on a monthly basis during the ice-free period for PWQMN and every two weeks during the ice-free period (every three weeks otherwise) for LSEMS. PWQMN samples are unfiltered whereas LSEMS are filtered (except for sampling for Total Suspended Solids (TSS)) with a coarse 80µm mesh to remove large debris. The inclusion of LSEMS samples aids in covering the period of record more completely (i.e. the 1993-2002 gap in PWQMN data and also the lack of PWQMN samples collected during the winter months).

Each sample, analyzed for numerous chemical parameters including nutrients and trace metals in the Laboratory Services Branch of the Ministry of Environment, is assessed using the Provincial Water Quality Objectives (PWQO) (Ministry of Environment, 1994, 2009). 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 (Canadian Council of Ministers of the Environment, 1999). 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.

Table 4-1: 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 the 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 (2009): 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 can originate naturally from erosion of geological formations and glacial lacustrine deposits and anthropogenically from areas of soil disturbance, including construction sites and farm fields, lawns, gardens, eroding stream channels, and grit accumulated on roads	CCME (1999): CWQG = 25 mg/L + background (approx. 5 mg/L) for short term (<25 hr) exposures and 5 mg/L + background for long term exposure (e.g., 30 days) during conditions where clear flow is expected; 25 mg/L + background (if between 25 - 250 mg/L) at any time during high flow. EPA (1973(and EIFAC (1965): no harmful effects on fisheries below 25 mg/L

Variable	Effects	Sources	Objective/Guideline
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 Cadmium: 0.5 μg/L Chromium: 8.9 μg/L Aluminium: 75 μg/L for clay free soils; 100 μg/L (CWQG)

4.2.3 Groundwater Quality Status

Groundwater quality is measured regularly at the two monitoring wells in the Uxbridge Brook tributary. Routine monitoring does not display any significant issues or exceedances of the commonly measured suite of parameters. The wells were sampled for a more extensive suite of contaminants in 2004, including a number of pesticides, and this survey did not reveal any exceedances. Routine monitoring will be continued to detect any trends in the water quality data in these wells.

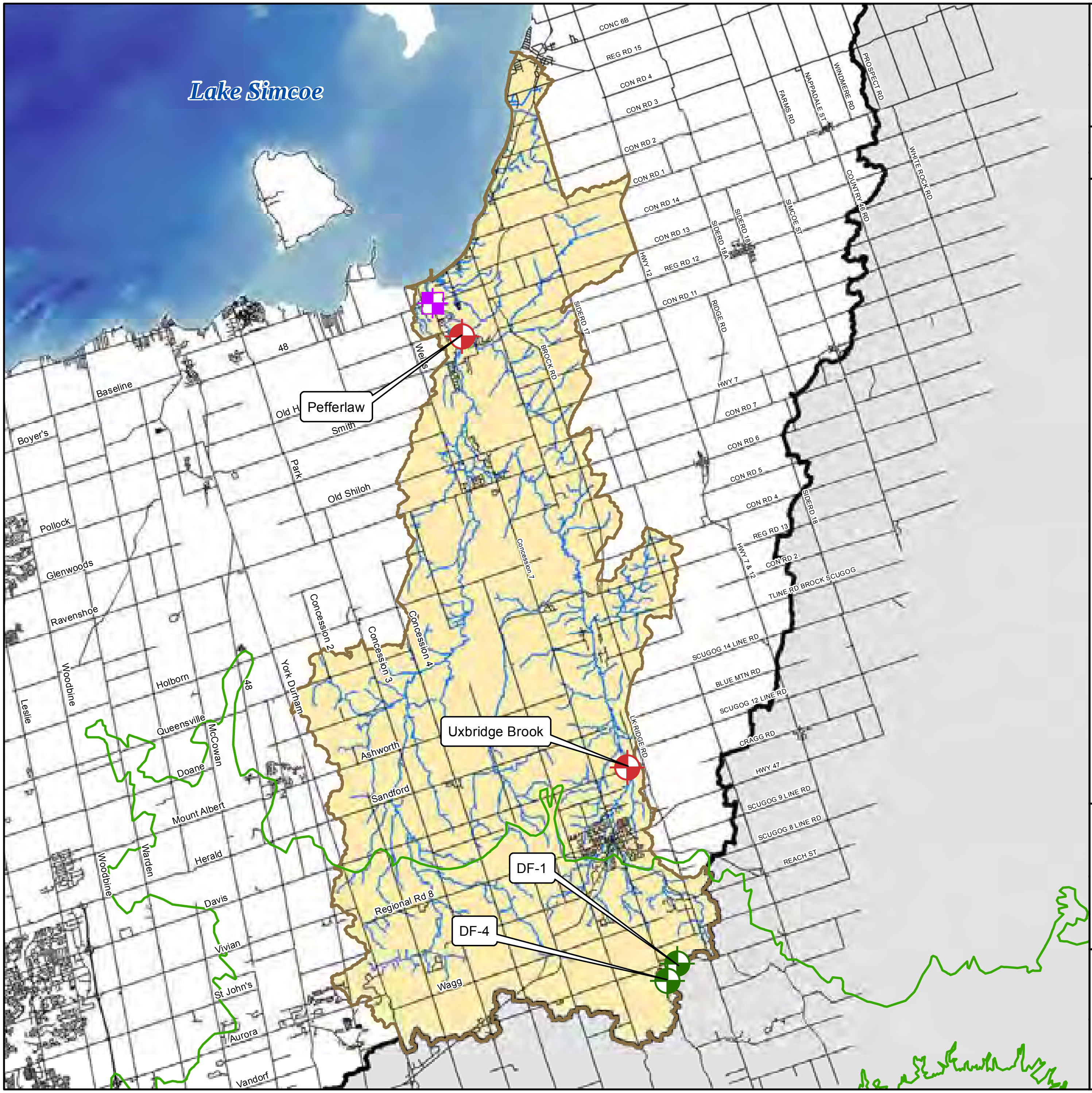
4.2.4 Surface Water Quality Status

Analysis of data collected between 2006 to 2010 shows that median concentrations of chloride, nutrients, total suspended solids, and trace metals are below the objective at the Pefferlaw station (Table 4-2). This station emerges as the one of the least impacted stations in the Lake Simcoe watershed, next to Beaver River and Hawkestone Creek. Forty-seven percent of samples, however, exceeded the phosphorus guideline, with concentrations ranging up to 0.136 mg/L. High phosphorus levels in the subwatershed are mainly attributed to agricultural areas (48% of landuse in the subwatershed is agricultural) but as discussed below, the Town of Uxbridge is also a source. These subwatersheds also have a substantial amount of natural features (43% of landuse is comprised of natural heritage features); less phosphorus is exported from these types of areas than urban or agricultural areas. Long-term trend analysis (1965-2010) shows decreasing trends for phosphorus, total suspended solids, zinc, and copper. Chloride and nitrate, on the other hand, show increasing trends. Short-term trends (2002-2010) show no significant trends for phosphorus, nitrate, total suspended solids, or zinc, but do show increasing trends for both chloride and copper (Table 4-2).

Water quality observed at the Uxbridge Brook station indicates that it is not negatively impacted except by high phosphorus concentrations. The median phosphorus concentration was above the guideline, and 69% of samples exceeded the objective, with concentrations ranging up to 0.390 mg/L. High phosphorus levels here occur because the station is downstream from the urban community of Uxbridge, and therefore receives stormwater runoff and effluent from the Water Pollution Control Plant. There also is a substantial amount of agriculture in the surrounding areas. Currently there is no data available for long-term trend analysis at the Uxbridge Brook station. Short-term trend analysis between 2002 and 2010 though, shows no significant trends for any of the parameters except chloride, which shows an increasing trend (Table 4-2).

Provincial Water Quality monitoring sites in the Pefferlaw River subwatershed

Figure 4-1



Legend

⊕ Water Quality Stations

⊕ Groundwater Wells

▞ Historic Water Quality Station

— Road

〰 Watercourse

◯ LSRCA Watershed Boundary

◯ Oak Ridges Moraine

Lake Simcoe Region conservation authority

0 1 2 4 6 8 10 Kilometres

N

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Table 4-2: A comparison of the surface water quality of Pefferlaw Brook and Uxbridge Brook to other tributaries within the Lake Simcoe watershed.

Monitoring Station	Current Conditions							Trends Analysis											
	2006 – 2010							Long-term (1965-2010)$^+$						Short-term (2002-2010)					
	Chloride	Phosphorus	Nitrate	TSS	Iron	Zinc	Copper	Chloride	Phosphorus	Nitrate	TSS	Zinc	Copper	Chloride	Phosphorus	Nitrate	TSS	Zinc	Copper
West Holland River	🟩 95	🟧 8	🟩 97	🟩 89	🟩 76	🟩 100	🟩 91	🟧	🟩	🟧	🟩	🟩	🟩	🟩	▨	▨	🟩	▨	🟧
Tannery Creek	🟩 60	🟧 9	🟩 100	🟩 66	🟧 34	🟩 94	🟩 89	🟩 *	🟩	🟩	n/d	🟩	🟩	🟩	🟧	🟩	🟧	▨	🟧
Mt. Albert Creek	🟩 100	🟧 14	🟩 100	🟩 74	🟩 56	🟩 100	🟩 94	🟧	🟩	🟧	n/d	🟩	🟩	🟧	🟧	▨	🟧	▨	🟧
Beaver River	🟩 100	🟩 74	🟩 98	🟩 95	🟩 83	🟩 97	🟩 100	🟧	🟩	🟧	🟩	🟩	🟩	▨	▨	▨	▨	▨	🟧
Pefferlaw	🟩 100*	🟧 53*	🟩 100	🟩 97	🟩 89	🟩 97	🟩 97	🟧	🟩	🟧	🟩	🟩	🟩	🟧	▨	▨	▨	▨	🟧
Lovers Creek	🟩 67	🟩 65	🟩 100	🟩 87	🟩 65	🟩 100	🟩 97	🟧	🟧	🟧	▨	🟩	🟩	🟧	🟧	🟩	▨	🟧	🟧
Schomberg	🟩 100	🟧 19	🟩 98	🟩 79	🟧 33	🟩 100	🟩 94	🟧	🟩	🟩	n/d	🟩	🟩	🟧	▨	🟩	▨	▨	🟧
Maskinonge River	🟩 92	🟧 6	🟩 100	🟩 93	🟧 17	🟩 97	🟩 83	🟧	🟧	🟧	🟧	🟩	▨	▨	▨	▨	n/d		
East Holland	🟩 33	🟧 3	🟩 100	🟧 44	🟧 3	🟩 89	🟩 71	🟧	▨	n/d				▨	▨	🟩	▨	▨	🟧
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	n/d						🟧	▨	▨	▨	▨	▨
Objective	128 mg/L	0.03 mg/L	2.9 mg/L	30 mg/L	300 µg/L	20 µg/L	5 µg/L	**Orange = Increasing** **Grey = no significant trend** **Green = Decreasing**											

() = Percentage of samples that meet objectives
Orange = median Concentration >objective
Green = median Concentration < objective

*denotes that LSEMS and PWQMN data were used

+Although current water quality conditions were reported to 2009, trend analysis was completed to 2008, as there would not have been a noticeable change in trend with one additional year of data. Trend information will be updated as the subwatershed plan is updated (approximately five years)

Phosphorus

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 10th and 90th percentiles 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.

There is a decreasing trend in phosphorus at the Pefferlaw Brook station (Figure 4-2; Table 4-2) but there is insufficient data to determine a trend for Uxbridge Brook since sampling was initiated there in the mid-1990s (Figure 4-3). This decrease may be attributed to improved farming practices, the implementation of BMPs through programs such as LSRCA's LEAP, or improved stormwater controls. However, compared to the PWQO of 0.03 mg/L, 47% of samples at Pefferlaw Brook and 69% of Uxbridge Brook samples exceed the guideline in the current 2002 to 2006 data set. This shows that while phosphorus concentrations have been improving, water quality is still impaired. There was a focus on sampling low flow conditions in the historical PWQMN program. Low concentrations would generally be expected during low flow, but the higher concentrations during that period further support a marked change in conditions (i.e. the more recent period including high and low flows would be expected to have higher concentrations on average than the historic period, but doesn't).

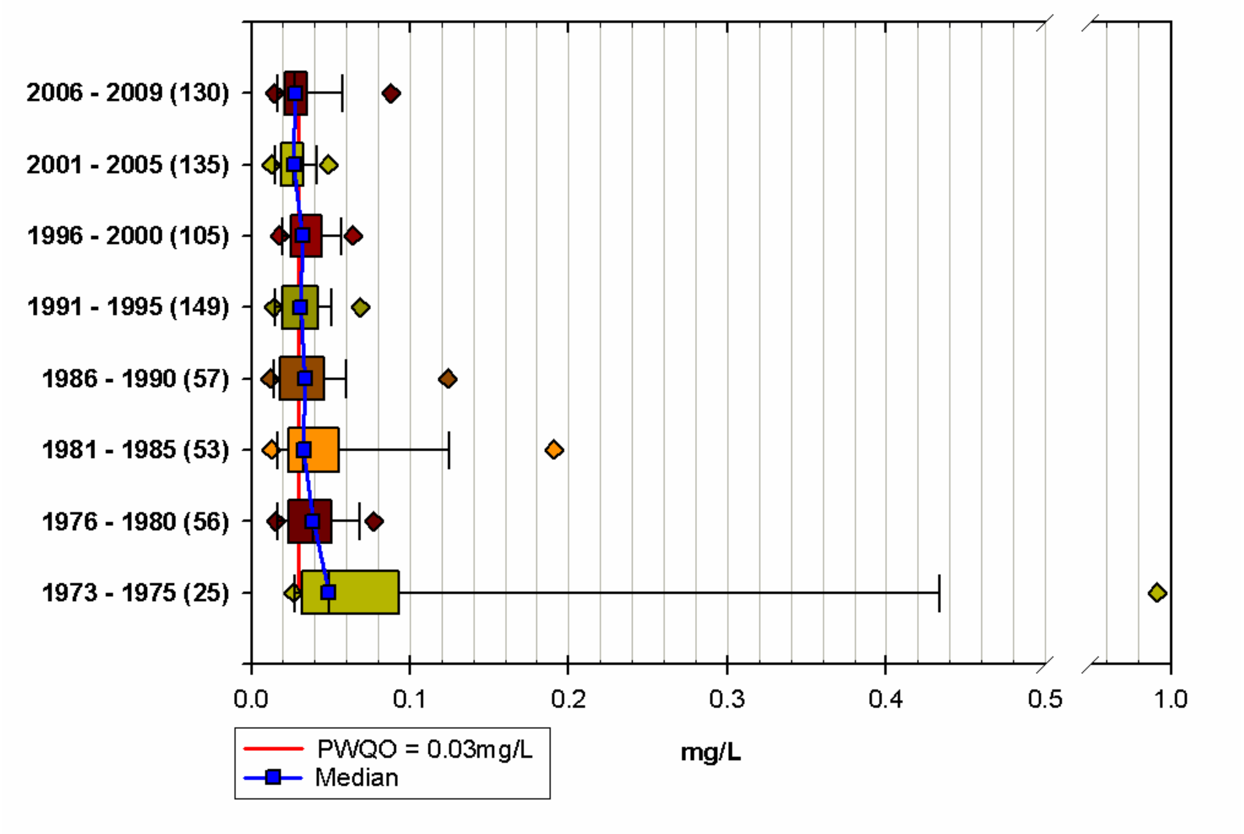


Figure 4-2: Pefferlaw Brook phosphorus concentrations (mg/L; 1973-2009). Quantity of samples for each time range is listed in brackets.

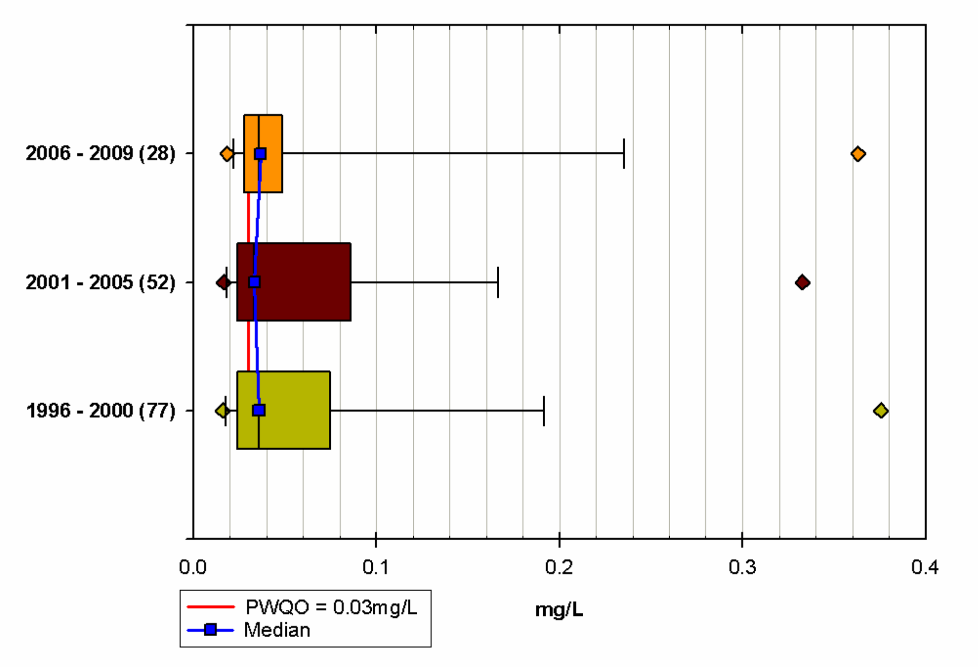


Figure 4-3: Uxbridge Brook phosphorus concentrations (mg/L; 1996-2009). Quantity of samples for each time range is listed in brackets.

Chloride

The Canadian Environmental Protection Act has defined road salts containing chloride as toxic under the Act (2001). This was based on research that found that the large amounts 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 what could be considered pristine northern rivers (LSRCA, 2007) as well as in Lake Simcoe itself (Eimers and Winter, 2005). The Pefferlaw River subwatershed is not a heavily urbanized subwatershed (approximately 6% of the land use in the subwatershed is urban), but still displays increasing chloride concentrations (see Figure 4-4 and Figure 4-5, which display results for the Pefferlaw Brook and Uxbridge Brook, and Table 4-2). The inclusion of LSEMS samples allows for the examination of chloride concentrations during the winter when chloride concentrations are increased from road salting (PWQMN program does not run through winter). None of the samples were above the CCME guidelines (128 mg/L; Table 4-2).

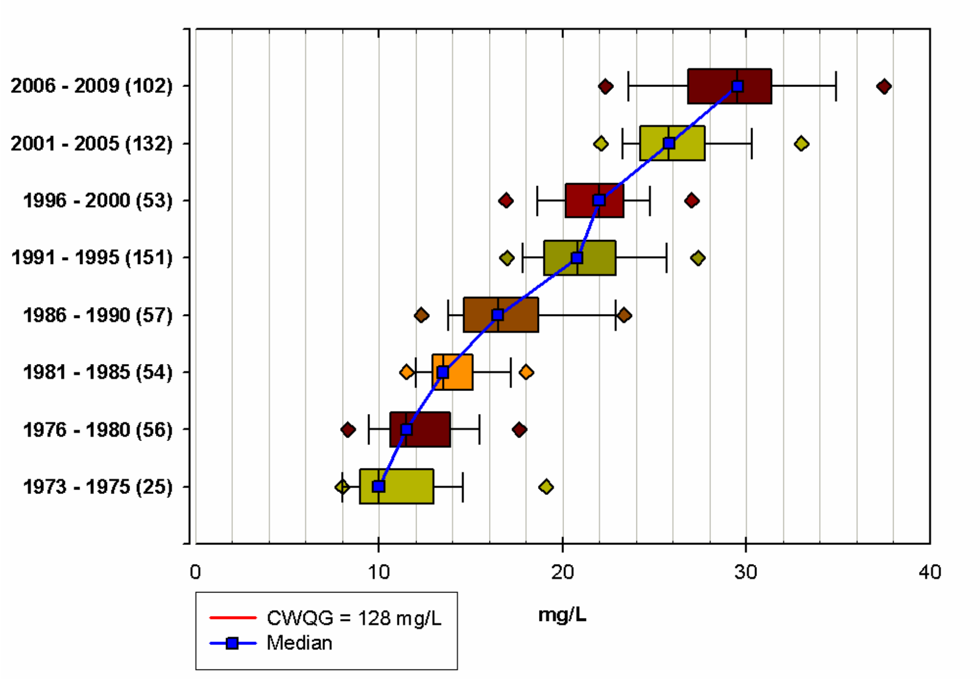


Figure 4-4: Pefferlaw Brook chloride concentrations (mg/L; 1973-2009). Quantity of samples for each time range is listed in brackets.

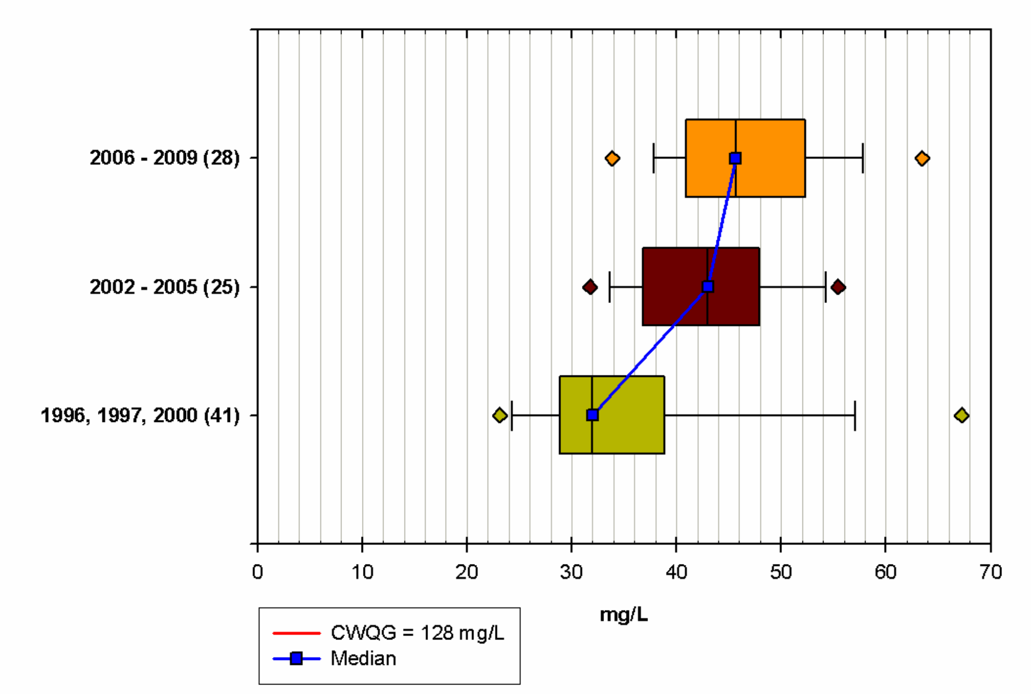


Figure 4-5: Uxbridge Brook chloride concentrations (mg/L; 1996, 1997, 2000, 2002-2009). Quantity of samples for each time range is listed in brackets.

Total Suspended Solids

Total Suspended Solids (TSS) is a measure of the material (silt, clay, fine particles of organic and inorganic matter, soluble organic compounds, plankton, and other microscopic organisms) in suspension in the water column (CCME, 1999). This is an important measure because 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 (Table 4-1). 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.

Natural background TSS concentrations can vary from system to system due to differences in bed material (e.g. sand/silt vs. rocky/cobble), slope, and system morphology. For this reason the Canadian Water Quality Guideline (CWQG) suggests natural background concentrations are determined for the system of interest upon which the guideline can then be applied. While natural background levels are difficult to determine for the Pefferlaw River due to long-term anthropogenic influence, low flows tend to be 5 mg/L. High flow conditions are less clear and therefore the minimum background suggested by CWQG will be used (25 mg/L; Table 4-1) to identify potential problems. Using this information, sampled concentrations can be compared to the CWQG which are then calculated as 30 mg/L and 10 mg/L for short-term and long-term low flow conditions, respectively, and 50 mg/L for high flow.

Examination of the Pefferlaw River (in Pefferlaw) TSS data set yields concentrations above 10 mg/L (but below 30 mg/L) that were typically associated with increased flows. These concentrations were seen to decrease in lower flows between the samples indicating that there was not long-term exposure. There were series of samples with increased concentrations in the summer (dry conditions), indicating that the concentrations may have remained elevated for greater than one month; this would likely be due to anthropogenic activities such as agriculture. Only 1% of the data were above 30 mg/L (but lower than 50 mg/L) and 1% were above 50 mg/L (but less than 100 mg/L) and these occurred during high flows (Figure 4-6). In summary TSS concentrations for the Pefferlaw River stations do not appear to be of concern.

For the Uxbridge Brook water quality station, the median value for each box was below 10 mg/L, but 41% of the data was above. Flow data were not available for Uxbridge until 2006; therefore flows at the Pefferlaw gauge downstream were referenced prior to that. All concentrations above 10 mg/L were during increased flows and concentrations decreased to background during low flows. Fifteen percent of the data were above 50 mg/L, ranging up to 267 mg/L (Figure 4-7). These high concentrations indicate that there are periods when aquatic life may be adversely affected.

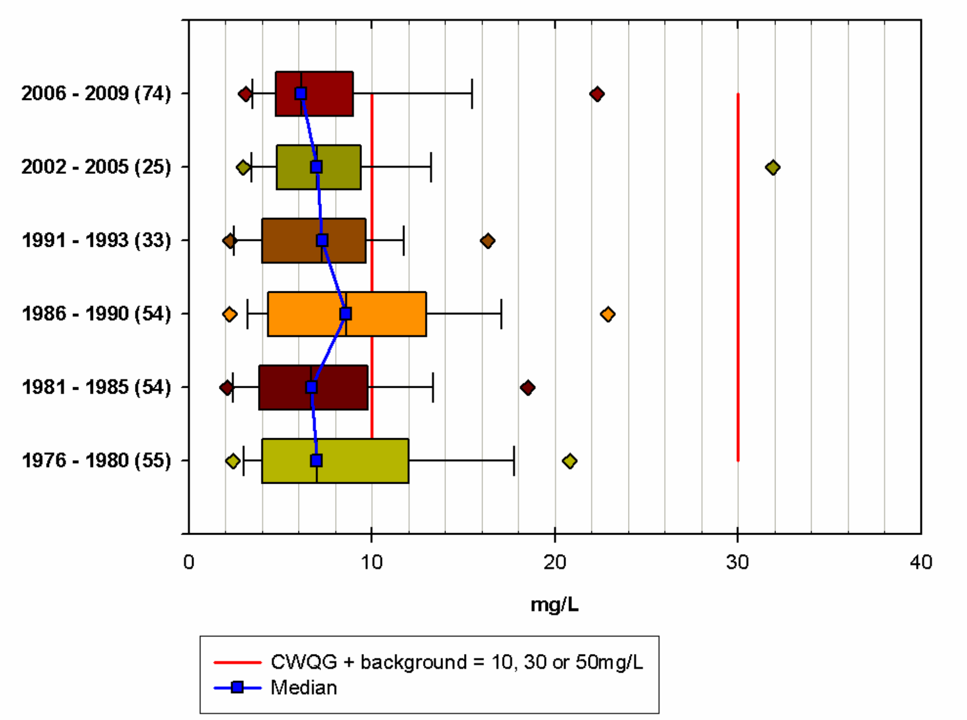


Figure 4-6: Pefferlaw Brook total suspended solids concentrations (mg/L; 1976-1993, 2002-2009). Quantity of samples for each time range is listed in brackets.

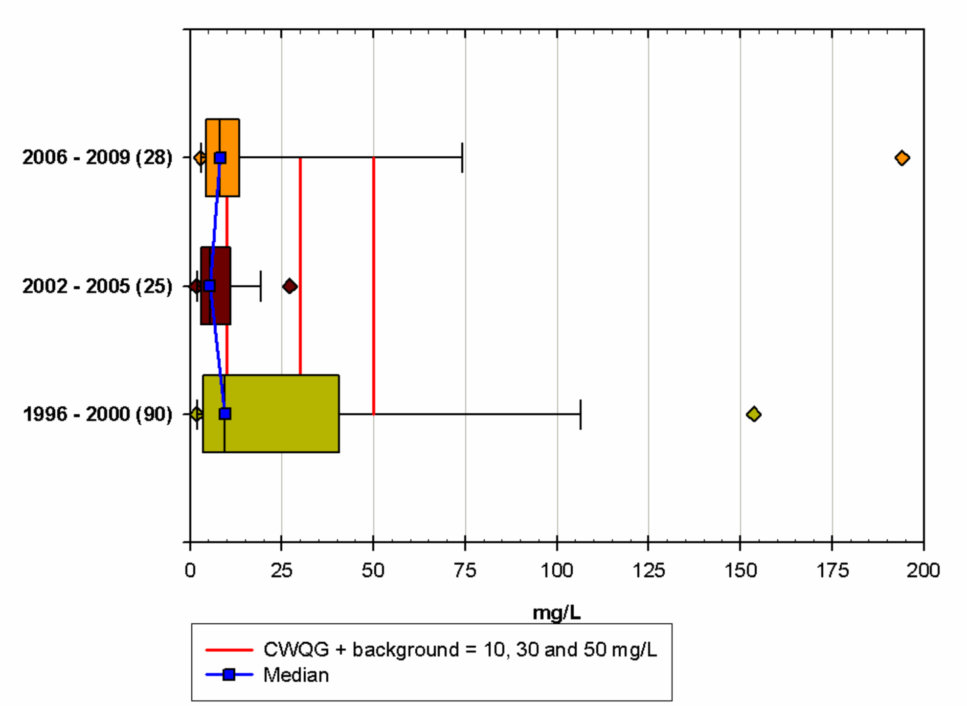


Figure 4-7: Uxbridge Brook total suspended solids concentrations (mg/L; 1996-2009). Quantity of samples for each time range is listed in brackets.

Water Temperature

Increasing and/or fluctuating stream water temperatures, due mainly to impervious surfaces, the lack of streambank vegetation, or on-line ponds, can cause a number of issues. These include decreased dissolved oxygen concentrations, thermal stress to sensitive fish and benthic invertebrate species, and the increased growth of algae.

Based on the MNR/DFO protocol entitled "*A Simple Method to Determine the Thermal Stability of Southern Ontario Trout Streams*" (Stoneman, C.L. and M.L. Jones 1996, Figure 4-8), water temperature is monitored throughout the Lake Simcoe watershed to evaluate each stream's thermal stability. Summer stream temperatures are also collected to develop a geographic and temporal temperature profile in each stream of interest aimed at monitoring and rehabilitating those systems.

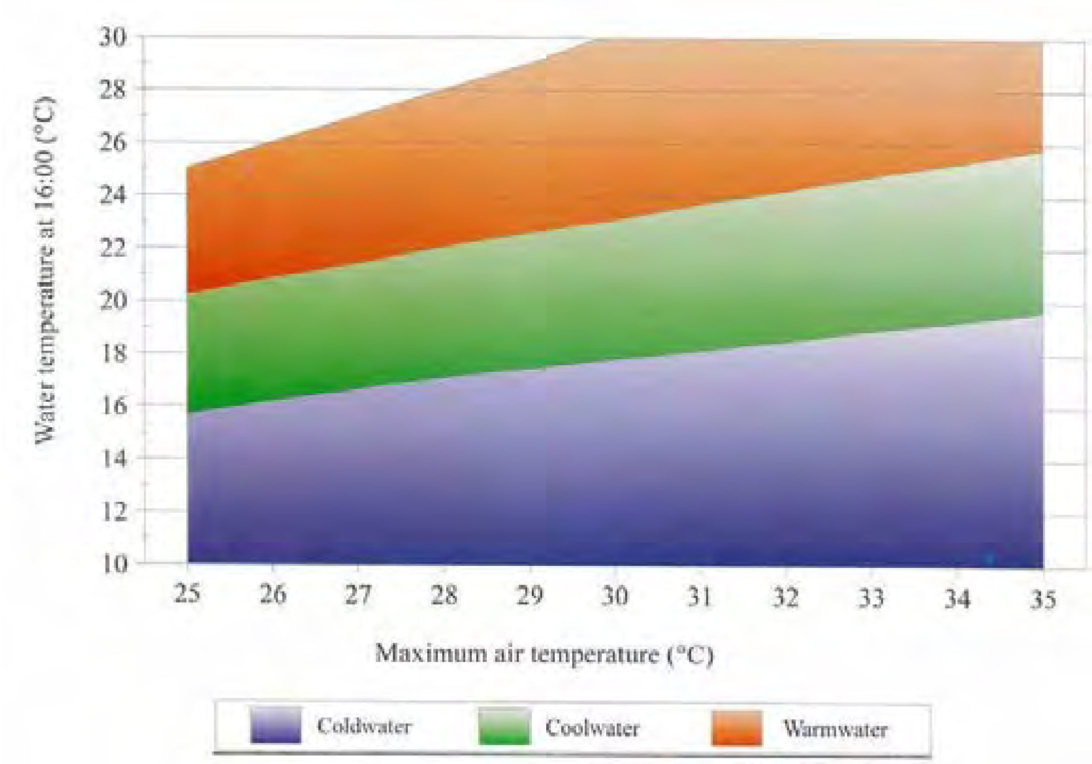


Figure 4-8: Cold, cool and warm water criteria for thermal ranges of trout streams (Stoneman and Jones, 1996).

Water temperatures in the Pefferlaw River subwatershed are monitored routinely using in-stream data loggers, which record the temperature at regular intervals throughout the summer. These data are collected at stations located throughout the subwatershed.

Temperature Collections

The MNR/DFO protocol suggests that trout streams are considered to be coldwater if they have an average maximum summer temperature of approximately 14 degrees Celsius. Cool water sites are considered to have average maximum summer temperatures of 18 degrees Celsius. Warm water sites have an average maximum daily water temperature of 23 degrees Celsius.

To monitor these temperatures, electronic data loggers are installed throughout the Lake Simcoe watershed during the hot summer months. They are installed in late May/early June and then retrieved in late September/early October each year. The loggers are used to monitor the daily fluctuations in water temperature of the watercourse over the summer. They are set to take a temperature reading every hour for the entire study period. Periodic checking of the loggers throughout the summer is necessary for quality control purposes, Once the loggers are retrieved in early fall from the various stream locations, the data is downloaded and then compared to the air temperature data over the same period of time. Using an Excel spreadsheet, the maximum, minimum, and mean temperatures for each day are graphed. There is some emphasis placed on the daily high temperatures and average maximum temperatures, specifically in cold water stream conditions. The various trout streams are then able to be classified as cold, cool, or warm (See Figure 6-1, **Chapter 6 - Aquatic Habitat**). 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.

Key points - Current Water Quality Status:

- Few issues have been found in the Pefferlaw River groundwater, which are compared with drinking water guidelines.
- Few surface water quality parameters from the Pefferlaw and Uxbridge stations have failed to meet the established objectives or guidelines. The Pefferlaw station emerges as the one of the least impacted stations in the Lake Simcoe watershed, next to Beaver River and Hawkestone Creek.
- Median total phosphorus concentrations in surface water are above the PWQO at the Uxbridge station. There is no decreasing trend in phosphorus concentrations at this station, as there has been at a number of other Lake Simcoe water quality stations, including the Pefferlaw station.
- Median total chloride concentration levels in surface water are well below the Canadian Water Quality Guidelines, though it should be noted that an increasing trend of chloride is obvious in the long term data for the Pefferlaw Brook station (not enough data available for long term trends in Uxbridge Brook). Short term trends also show increasing concentrations for both Pefferlaw and Uxbridge stations.
- Concentrations of suspended sediment at the Pefferlaw Brook station are not a concern; however, there have been periods at the Uxbridge station where concentrations may have been high enough to adversely affect aquatic life

4.3 Factors impacting status – stressors

4.3.1 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 though, 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. Also, if a contaminant source is located near a discharge area, there may not be sufficient time and distance for natural filtering to occur. Additionally, there are some parameters, including iron and chloride, which are naturally found within some groundwater aquifers.

Groundwater quality can also be impacted by anthropogenic factors. In rural areas, levels of contaminants including bacteria, phosphorus, nitrates, and road salt can become elevated where the groundwater is beyond the capacity of the natural filtration capability of the soils. Sources of contaminants in these areas are fertilizers, improperly functioning septic systems, manure storage facilities, and road salt application. In urban areas, groundwater can be subject to contamination by road salt, hydrocarbons, metals, phosphorus, and other nutrients. Groundwater contamination becomes an issue where it is discharged to the surface and is used by animals or humans.

As a requirement of the *Clean Water Act, 2006*, Source Water Protection Authorities are required to determine the vulnerability of aquifers to water quality stressors and identifying potential threats to drinking water supply. Results of this vulnerability and threats assessment are presented in the Lakes 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. Within the Pefferlaw River subwatershed WHPAs have been delineated for the Uxbridge municipal supply wells. An assessment of potential Significant Threats was undertaken within each WHPA, with potential threats associated with handling and storage of fuel, and dense non-aqueous phase liquids being the most common threat identified (SGBLS, 2011).

4.3.2 Surface Water

<u>Natural Influences</u>

Natural features in the environment generally serve to maintain water quality conditions. Naturally vegetated areas including grasslands, meadows, and woodland areas tend to improve the quality of water as it flows over land. The stems and roots of the vegetation slow the flow of water, enabling soil particles and other contaminants to be deposited, and increasing the amount of runoff that is infiltrated into the soil. Water is filtered as it flows through the soil to the groundwater. Wetlands slow the flow of water, provide storage, and can absorb some contaminants, including nutrients such as phosphorus, and thus have a natural filtering ability.

The inputs of clean cool groundwater into lakes and streams also serve to improve water quality, by diluting the concentration of any pollutants in the portion of the flow coming from surface water.

Rural and Urban Influences

The prevalent land use in the Pefferlaw River subwatershed is rural/ agricultural, which occupies approximately 48% of the land area. There are a number of water quality issues that are associated with agriculture. Runoff from pasture and cropland can contain high levels of nutrients, sediment, and bacteria; and wind can erode topsoil with its associated contaminants. All of these substances can end up in local watercourses if the appropriate BMPs are not implemented. These BMPs can include conservation tillage, cover cropping, maintaining vegetated riparian buffers, cattle fencing, and the appropriate use of fertilizers and pesticides.

A relatively small percentage (close to 6%) of the Pefferlaw River subwatershed is comprised of urban areas, and approximately 11% of the subwatershed is impervious, which is just above the AOC proposed 10% impervious guideline. There is some growth in the urban areas, slated for this subwatershed, but this will account for only approximately 2.2% of the subwatershed area. It will be important to minimize the amount of impervious area and its impacts within the subwatershed as there can be numerous impacts to water quality associated with these areas. Runoff in urban areas, particularly those built prior to the requirement for stormwater management, can carry a host of pollutants to local watercourses. These pollutants build up on roads, driveways and parking lots, and even lawns, and are washed to watercourses during precipitation events. The pollutants that can be carried by urban stormwater runoff include nutrients and pesticides from lawns, parks, and golf courses; road salts; tire residue; oil and gas; sediment; and nutrients and bacteria from pet and wild animal faeces. Paved surfaces increase the volume and velocity of surface runoff, which leads to streambank erosion, contributing more sediment to watercourses. 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, otherwise these new developments would be contributing additional phosphorus to the system. 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.

Urban areas in the Pefferlaw River subwatershed include Uxbridge and Ballantrae. In addition, a portion of the Pefferlaw subwatershed falls within the west side of the municipal boundary of Beaverton. Of the 63 stormwater catchments in the urban area, there are only 12 Level 1, the most stringent type of quality control, stormwater ponds. In Uxbridge, 32 of the 43 ‘areas’ have no controls, representing 53% of the total catchment area. In Ballantrae, the situation is much better in that 75% of the area is protected by Level 1 design. In Beaverton area, none of the 16 catchments have any controls (*The Lake Simcoe Basin Stormwater Management and Retrofit Opportunities report*, LSRCA, 2007).The majority (57%) of the subwatershed's stormwater flows uncontrolled to the Pefferlaw River and its tributaries (see Figure 4-9, Figure 4-10, Table 4-3).

In addition, the *Stormwater Maintenance and Anoxic Conditions Investigation Report* (LSRCA, 2011), discovered that many stormwater ponds in the Lake Simcoe watershed are not being maintained. As an example, stormwater ponds in and around the community of Uxbridge have not been maintained and their level of efficiency/protection has dropped significantly (LSRCA, 2011). They are literally filling in with sediment. In addition, during dry, hot summer conditions, many of the ponds displayed low oxygen levels to a point where hypoxic/anoxic conditions were present during the daytime. In any case, the intent to retain suspended solids and sediment, reduce phosphorus loads and protect fish habitat are being compromised by the existing conditions of many of the ponds. The report indicated that the existing stormwater ponds require an improved maintenance program.

Previously, the *Lake Simcoe Basin Stormwater Management and Retrofit Opportunities* report (LSRCA, 2007) identified and evaluated opportunities to control phosphorus from existing urban areas. In these 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 a higher level of control (i.e. Level 1). The 2007 BMP report identified a total of 16 retrofit opportunities in the two urban areas in the Pefferlaw River subwatershed. These have the potential to prevent almost 34% of the phosphorus contained in stormwater from entering the river, and ultimately the lake (Figure 3-2, **Chapter 3 – Best Management Practices**). Details on these retrofits can be seen in the LSRCA report *Lake Simcoe Basin Stormwater Management and Retrofit Opportunities*, published in 2007.

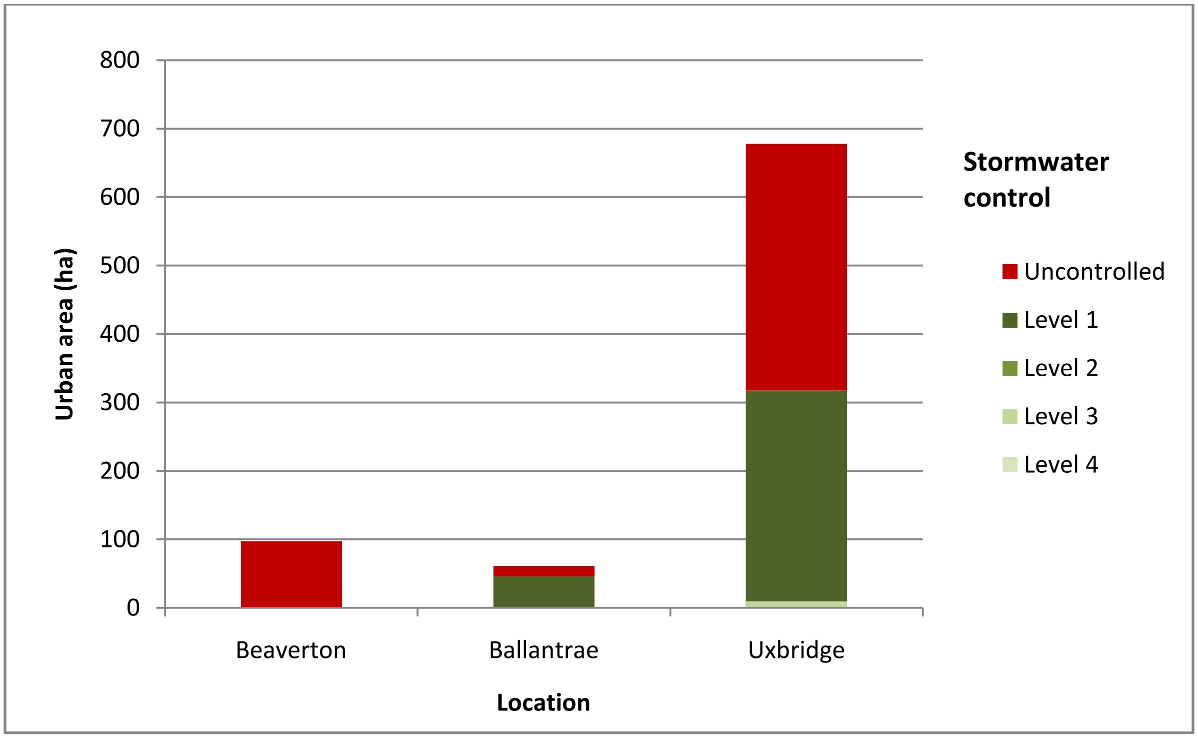


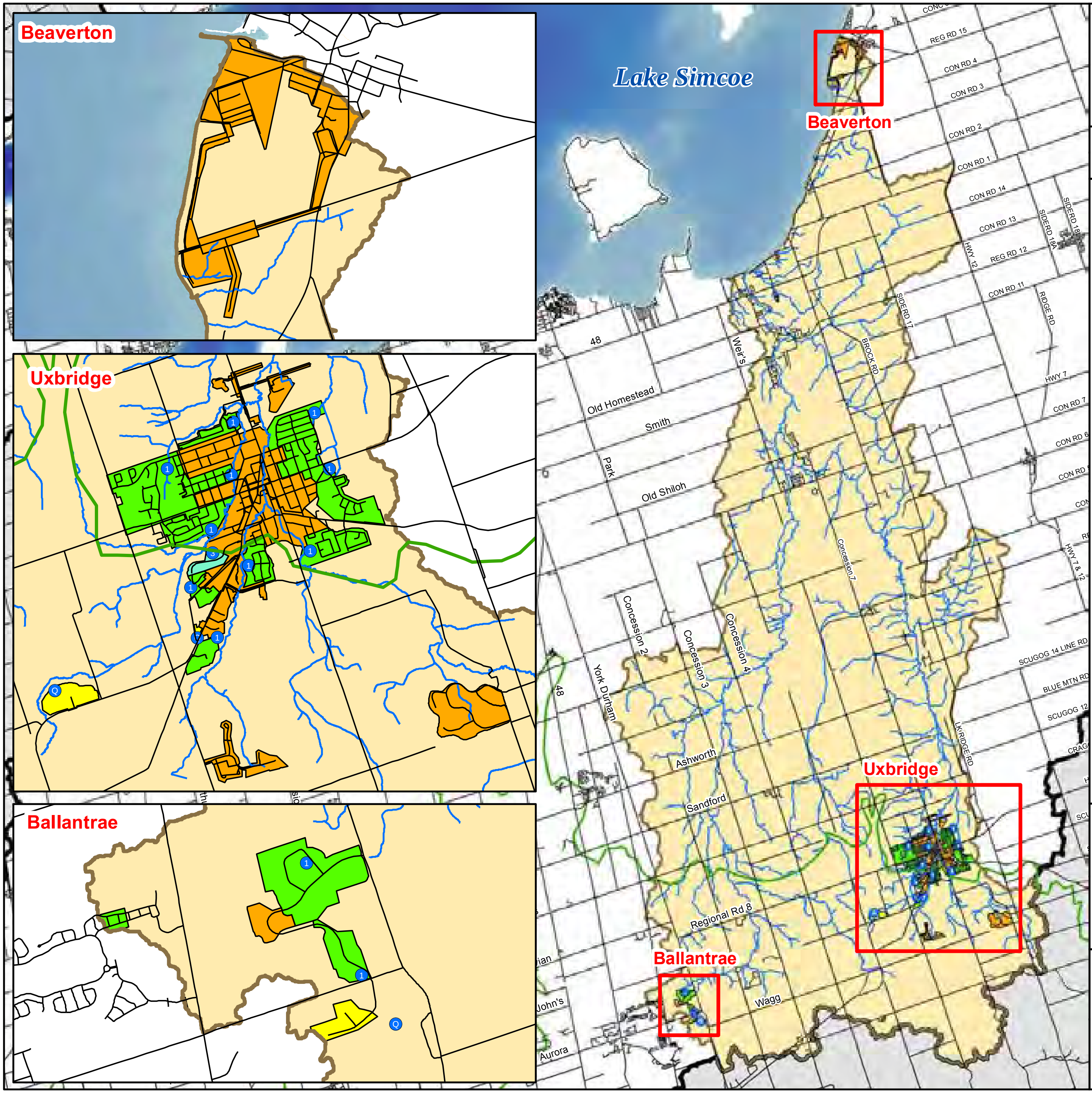
Figure 4-9: Area of stormwater control in urban regions of the Pefferlaw River subwatershed.

Table 4-3: Controlled vs. uncontrolled stormwater catchments in the Pefferlaw River subwatershed.

Location	Total number of catchments	Total urban area	Uncontrolled (including quantity control)			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)
Uxbridge	43	677.7	32	360	53	10	308.6	46	0	0	0	1	9.2	1	0	0	0	11	317.8	47
Beaverton	16	97.3	16	97.3	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ballantrae	4	61.3	2	15.3	25	2	46	75	0	0	0	0	0	0	0	0	0	2	46	25
Totals	**63**	**836.3**	**50**	**472.6**	**57**	**12**	**354.6**	**42.4**	**0**	**0**	**0**	**1**	**9.2**	**1.1**	**0**	**0**	**0**	**13**	**363.8**	**43.5**

Stormwater control in the Pefferlaw River subwatershed

Figure 4-10



Legend

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

— Road

— Municipal Boundary

〰 Watercourse

▢ LSRCA Watershed Boundary

▢ Oak Ridges Moraine

Lake Simcoe Region conservation authority

0 1 2 4 6 8 10 Kilometres

N

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

Recreation

Natural areas such as streams and rivers are a popular location for recreational activities such as hiking, boating and snowmobiling. If not managed correctly and undertaken in a responsible manner, these activities can reduce the ecological condition and 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 are increasing as a result of increasing population and diminishing natural heritage lands.

Phosphorus

Phosphorus load estimates are those calculated during the Assimilative Capacity Study. This study has since been updated by the original authors, the Louis Berger Group, in a report completed in September, 2010, entitled '*Estimation of the Phosphorus Loadings to Lake Simcoe*.' A watershed model (CANWET) that estimates nutrient loads based on inputs such as land use, precipitation, and soil type was used for both the ACS and the updated study. The following table (Table 4-4) presents the average yearly phosphorus load derived from each source in the subwatershed under current conditions, the approved growth scenario, and the approved growth scenario with implementation of agricultural BMPs (does not consider urban BMPs.

Currently, the most significant contributors of the total runoff load of phosphorus in the Pefferlaw River subwatershed are cropland, which contributes 28.3%; hay and pasture at 13.2%; and high intensity development at 11%. These contributions are considered to be at least somewhat controllable through the implementation of agricultural BMPs. Other significant contributors that are uncontrollable are groundwater (which, for this study, is shallow subsurface flow, not contributions from deeper aquifers), and runoff from streambanks.

The full build out of the approved growth scenario, without the implementation of established agricultural BMPs, would result in a predicted increase in phosphorus loads of approximately 515 kg, from 3,437 kg to 3,952 kg. However, with the implementation of the full suite of agricultural BMPs that have been identified for the subwatershed, this increase could be reduced by over 300 kg, to a total load of 3,617 kg. This is an increase of 180 kg from the current load.

Based on the modelled phosphorus loads, the Pefferlaw subwatershed contributes approximately 3,400 kg of phosphorus to the lake each year, or approximately 6% of the annual load. The most significant contributors in the Lake Simcoe watershed include the East Holland River, West Holland River, and the Barrie Creeks subwatersheds.

Table 4-4: Phosphorus loads by source in the Pefferlaw River subwatershed associated with agricultural BMP scenarios (based on modeling conducted by Louis Berger Group).

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	453	445	-8	438	-7	-1.5%
Crop Land	973	942	-31	654	-288	-30.6%
Turf-Sod	8	8	0	8	0	0
Low intensity development	258	191	-67	191	0	0
High intensity development	381	659	278	659	0	0
Septics	216	216	0	216	0	0
Quarry	32	32	0	32	0	0
Unpaved road	23	23	0	23	0	0
Transition	23	21	-2	21	0	0
Forest	1	1	0	1	0	0
Wetland	8	8	0	8	0	0
Stream bank	458	508	50	468	-40	-7.9%
Groundwater (shallow subsurface flow)	425	423	-2	423	0	0
Point sources	178	476	298	476	0	0
TOTAL	**3,437**	**3,952**	**516**	**3,617**	**-335**	**-8%**

The Pefferlaw River subwatershed can also be split into 34 catchments, each named by the tributaries they contain. The catchments' areas range from 53.8 ha (Pefferlaw River 5) to 4,344.8 ha (Leaksdale Creek). As already mentioned, an overall potential reduction of 8.5% can be achieved through agricultural BMPs. However, to achieve the basin wide total phosphorus target of 44 T/year, the CANWET watershed model also produced targets for individual subwatersheds. These were further narrowed down to catchment level targets to give a better idea of which areas need to be focused on for phosphorus reduction. Figure 4-11 illustrates the total phosphorus loads per catchment, based on the agricultural BMP scenario, while Figure 4-12 illustrates the target total phosphorus loads for each catchment. The difference between the two is a further 77.9% reduction from the agricultural BMP scenario to the required (modelled) target loads.

To prioritize areas for phosphorus reduction, each catchment area was assessed based on the amount of phosphorus that needs to be reduced to reach the target, and the associated unit cost ($/kg). For instance, a catchment which contributes relatively high phosphorus loads, but can be reduced at a lower cost is a higher priority that 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 4-5 lists each of the 34 catchments based on this ranking system.

Table 4-5: Classification of Catchments in Prioritization Tiers (Berger, 2010).

Subwatersheds	Catchments			
	Tier 1 (highest priority)	Tier 2	Tier 3	Tier 4 (lowest priority)
Pefferlaw River Subwatershed		Pefferlaw River 10	Pefferlaw River 11	Pefferlaw River 1
		Pefferlaw River 15	Pefferlaw River 12	Pefferlaw River 17
		Pefferlaw River 6	Pefferlaw River 13	Pefferlaw River 2
		Pefferlaw River 7	Pefferlaw River 14	Pefferlaw River 3
		Wilfred Branch 1	Pefferlaw River 16	Pefferlaw River 5
		Wilfred Branch 2	Pefferlaw River 18	Wilfred Branch 3
		Leaksdale Creek	Pefferlaw River 19	
		Uxbridge Brook 1	Pefferlaw River 20	
		Uxbridge Brook 3	Pefferlaw River 4	
		Uxbridge Brook 4	Pefferlaw River 8	
			Pefferlaw River 9	
			Reekies Creek	
			Thorah/ McLennan Creek	
			Uxbridge Brook 2	
			Uxbridge Brook 5	
			Uxbridge Brook 6	
			Uxbridge Brook 7	
			Uxbridge Brook 8	

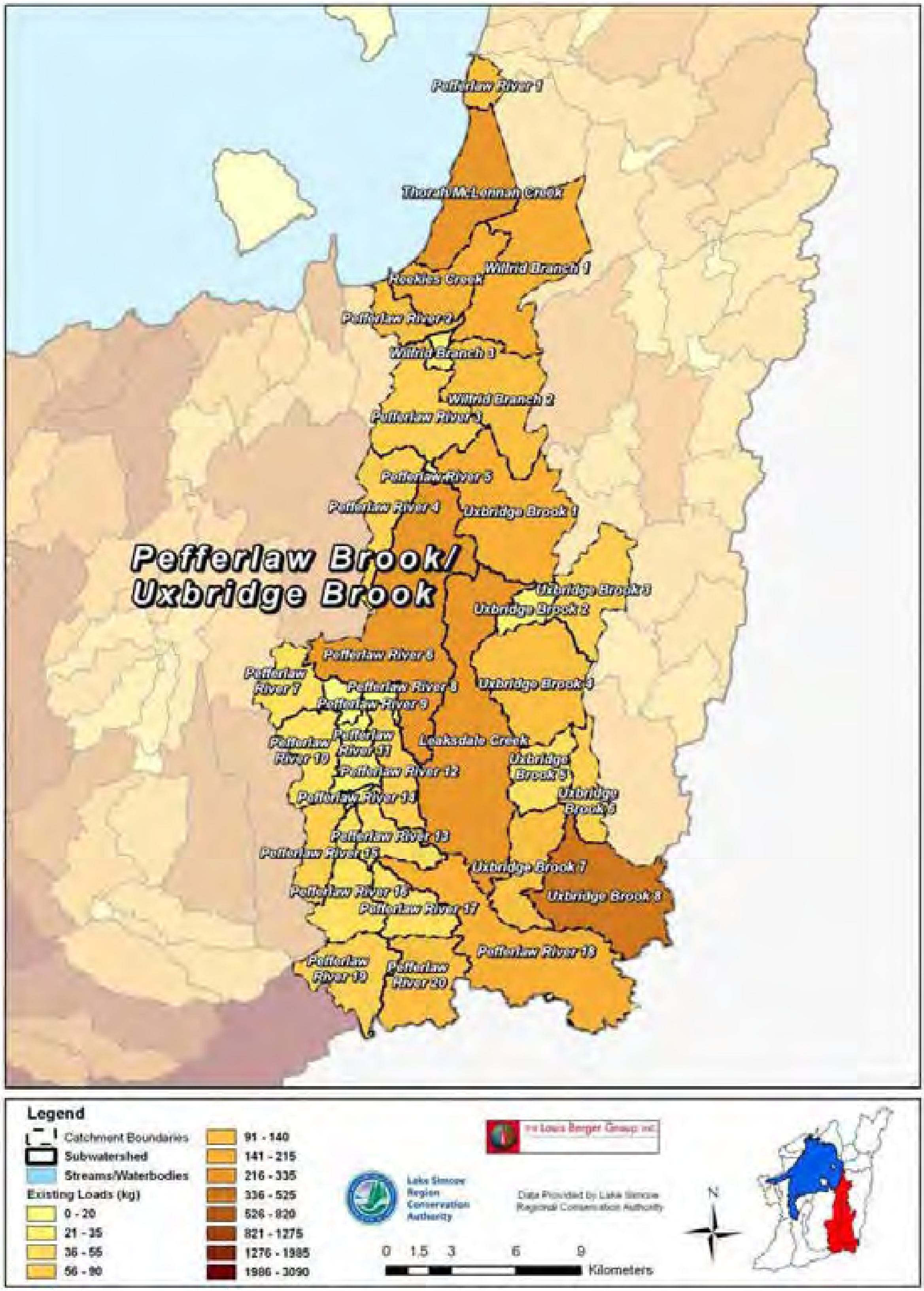


Figure 4-11: Pefferlaw River subwatershed agricultural BMP scenario total phosphorus loads (Berger, 2010).

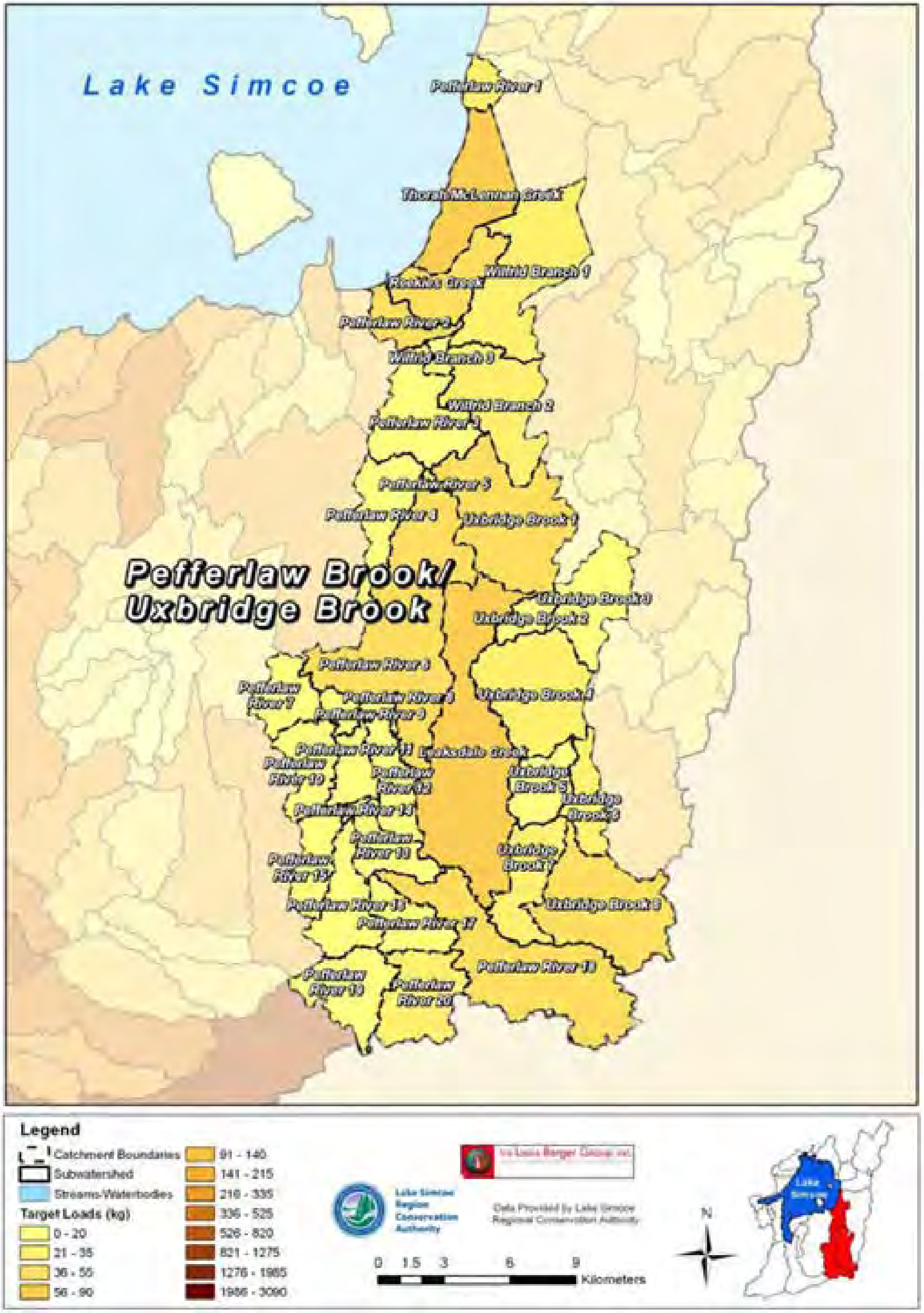


Figure 4-12: Pefferlaw River subwatershed target total phosphorus loads (Berger, 2010).

Chloride

The main source of chloride, in its various compounds, in the environment is from road salt. 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 the Pefferlaw River using the data from water quality samples combined with flow data. As can be observed in Figure 4-13 these loads have been increasing in recent years. 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.

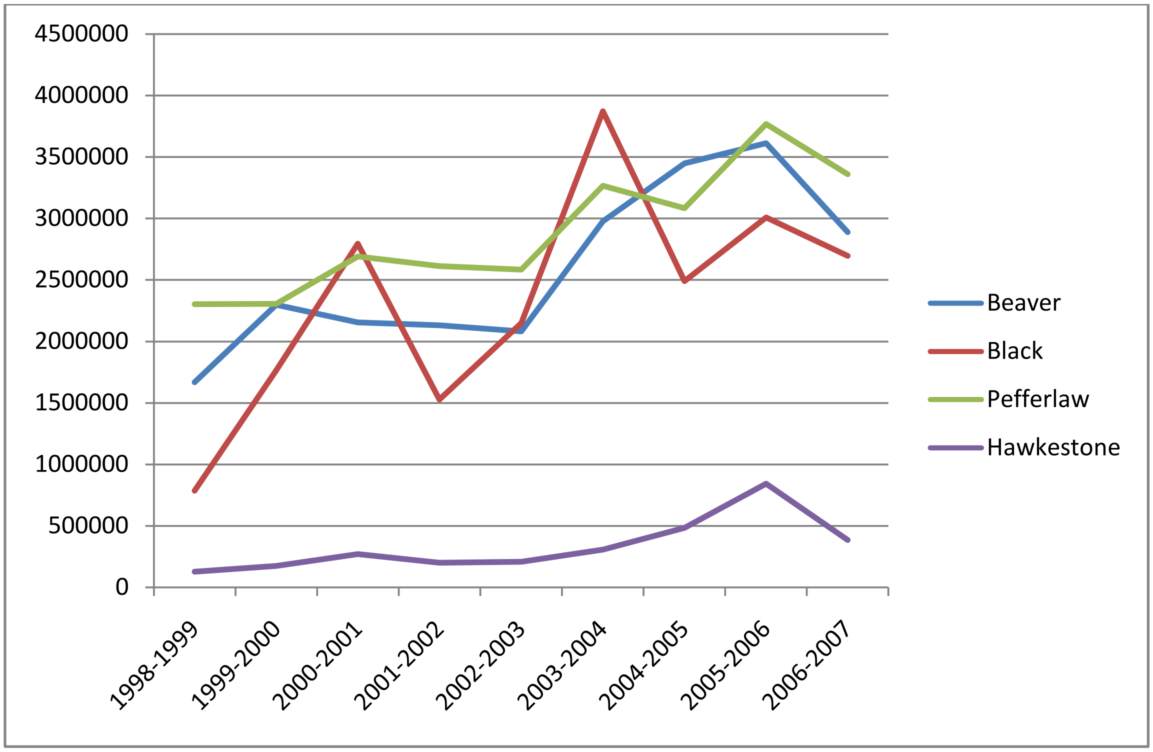


Figure 4-13: Modelled chloride loads for several Lake Simcoe subwatersheds (tonnes/year)

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 6 - Aquatic Habitat**.

There are a number of sources of sediment in the Pefferlaw River subwatershed:

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, many farmers also remove treed windbreaks and much of the riparian vegetation, both of which help to prevent soil erosion, along watercourses flowing through their properties in order to maximize the cultivable land. 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.

Urban areas: The use of sand and 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.

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.

Water temperature – 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 6 – Aquatic Habitat** discusses the impact of thermal degradation on survival of cold water fish such as brook trout.

Climate change is expected to impact stream temperatures dramatically. Predicted changes include increases in air temperatures, increases in rainfall in winter and spring, and a lack of water (rainfall) in the summer. The recently published MOE Vulnerability Report for Lake Simcoe watershed wetlands, streams, and rivers (Chu, 2010) suggests that several streams in the Lake Simcoe basin may not be able to support coldwater habitat in the future due to the loss of baseflow, through increases in stream temperature, changes in timing of the spring freshet, and changes in wetland composition. Further related information can be found in **Chapter 6 – Aquatic Habitat**.

Pesticides

Given the large proportion of the subwatershed with agricultural land uses, as well as the urban areas, pesticide use is a concern in the subwatershed. While pesticide 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 subwatershed's surface waters. 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).

It should be noted that a Toxic Pollutant Screening study was conducted by LSRCA in 2004. Locations in the Uxbridge Brook and Pefferlaw Brook catchments were sampled. Results indicated that pesticides were not found at detectable levels.

Key points – Factors Impacting Water Quality - Stressors:

- The primary sources of total phosphorus in the Pefferlaw River subwatershed are cropland (28.3%), hay and pasture lands (13%), and high intensity development (11%). Under the approved growth scenario, there is a projected increase in total phosphorus loads of 15% without the implementation of agricultural BMPs.
- Most of the chloride in the subwatershed comes from the use of road salt, with the estimated annual loads increasing in recent years with the growing urban area in the subwatershed, although this increase will be much less than in more urban subwatersheds. It is expected that this load will continue to increase into the future as the urban area continues 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. This is a trend that can be expected to increase in the coming years as the amount of impervious area increases.

4.4 Current Management Framework

4.4.1 Protection and Policy

There are numerous acts, regulations, policies and plans aimed at maintaining or improving water quality. These include the Provincial Policy Statement, the Ontario Water Resources Act, the Greenbelt Plan, Growth Plan for the Greater Golden Horseshoe, the Oak Ridges Moraine Conservation Plan, the Lake Simcoe Protection Plan, and the Nutrient Management Act.

This management framework relates to many different stressors that can potentially affect water quality, ranging from the discharge of material to urban development. In Table 4-6 we categorize 12 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 this management framework broadly fall into one of two categories. The first broad category we define as those having little or no legal standing and are referred to as General or Have Regard to Statements in Table 4-6 and are shown in blue. The second category includes those that have legal standing and must be conformed to; these are referred to as Regulated / Existing Targets in Table 4-6 and are shown in green. In many cases an act, regulation, policy, or plan does not relate to the activity specified, these are shown in red.

Table 4-6 : Summary of current regulatory framework as it relates to the protection and restoration of water quality

Stressor affecting water quality	Oak Ridges Moraine Conservation Plan (2002)	Greenbelt Plan (2005)	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)	York Region Official Plan (2008)	Durham Regional Official Plan (2008)
Growth, development and site alteration	🟩	🟩	🟩	🟦	🟦	🟥	🟥	🟥	🟥	🟩	🟩	🟩
Application of road salt	🟦	🟦	🟥	🟦	🟥	🟥	🟦 3	🟥	🟥	🟥	🟥	🟩 8
Loss of natural heritage features	🟩	🟩	🟩	🟦	🟦	🟥	🟥	🟥	🟥	🟩	🟩	🟩 9
Stormwater	🟩 1	🟦	🟩	🟦	🟦	🟥	🟩	🟥	🟥	🟩	🟩 6	🟩
Impervious surface	🟩	🟩	🟦	🟥	🟦	🟥	🟥	🟥	🟥	🟦	🟩 7	🟩 10
Discharge of material	🟥	🟥	🟥	🟥	🟥	🟩	🟩	🟩	🟩	🟥	🟦	🟦
Agriculture	🟥	🟦	🟦	🟦	🟦	🟩	🟥	🟥	🟥	🟥	🟦	🟦
Restoration	🟦	🟦	🟦	🟥	🟦	🟥	🟥	🟥	🟩	🟩	🟦	🟩
Septic systems	🟩	🟥	🟩	🟥	🟦 2	🟥	🟩 4	🟥	🟥	🟩 5	🟩	🟩
Climate change	🟥	🟥	🟦	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟦

🟦	🟩	🟥
General/Have regard to statement	Regulated/Existing targets	No applicable policies

[1] Gives specifics of what stormwater management plans are to include, however 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] Policies apply within Greenbelt Natural System, key natural heritage features, woodlands and key hydrologic features and their associated vegetation protection zones.

[7] Applies within ORM planning area

[8] ROP has provisions to prohibit/restrict storage of road salt within municipal wellhead protection areas and areas of high aquifer vulnerability as identified in the ROP.

[9] Policies apply within Greenbelt Natural System, key natural heritage features, woodlands and key hydrologic features and their associated vegetation protection zones.

[10] Applies in Major Open Space Areas (including key natural heritage and hydrologic features) and in the Oak Ridges Moraine planning area (outside of the Settlement Area)

In this section we provide a summary of the various acts, regulations, policies and plans as they pertain to activities affecting water quality. This summary is to give context to *future management considerations* and the *opportunities and recommendations to improve water quality*. This summary is not intended to be comprehensive in terms of all the legislative pieces that relate to water quality, or of the acts, regulations, policies, and plans that are discussed below – the reader is directed to each act, regulation, policy, or plan for a full assessment of how it relates to water quality.

Oak Ridges Moraine Conservation Plan (2002)

Among the objectives of the Oak Ridges Moraine Conservation Plan is to maintain, improve, or restore all of the elements that contribute to the ecological and hydrological functions of the ORM area, including the quality and quantity of its water and its other resources.

With respect to water quality, this plan:

- Requires a natural heritage evaluation to demonstrate that the development or site alteration will have no adverse effects on key natural heritage features or their ecological functions, and to specify a minimum vegetation protection zone to ensure that the features are protected.
- Prohibits development and site alteration in hydrologically sensitive features such as streams, wetlands, kettle lakes, and seepage areas, and associated vegetative protection zone.
- Prohibits development and site alteration outside of Settlement Areas if it would cause the total percentage of the area of the subwatershed with impervious cover to exceed 10 per cent. Approval authorities should strive to maintain at least 30 per cent of the area outside of Settlement Areas in self-sustaining vegetation.
- Requires applications for major development include a sewage and water system plan that demonstrates that the quantity and quality of ground and surface water will be maintained, and that the project will comply with the applicable watershed plan.

The plan also includes specific requirements for Stormwater Management such as:

- Applications for development are required to demonstrate that planning, design and construction practices that protect water resources will be used, including minimizing the removal of vegetation, grading, and soil compaction; keeping all sediment that is eroded during construction within the site.
- Stormwater Management Plans are to provide for an integrated treatment train approach that uses a planned sequence of methods of controlling stormwater and minimizing its impact by techniques that include lot level controls, conveyance controls, and end-of-pipe controls.
- Municipal development standards shall incorporate planning, design and construction practices that will reduce the portions of lots and sites that have impervious surfaces, and provide the flexibility to use alternative stormwater management techniques such as directing roof discharge to rear yard ponding areas and using grassed swales.
- The minimum standard for water quality is that 80 per cent of suspended solids shall be removed from stormwater runoff as a long-term average.
- Disposal of stormwater into a kettle lake is prohibited and new stormwater management ponds are prohibited within key natural heritage features and hydrologically sensitive features.

Lake Simcoe Protection Plan (2009)

The Lake Simcoe Protection Plan (LSPP) sets out very ambitious targets for improving water quality in the lake and its tributary rivers and streams, and a number of policies for achieving these targets.

The water quality targets in the Lake Simcoe Protection Plan are:

- To achieve 7 mg/L dissolved oxygen in Lake Simcoe (which equates to a phosphorus load to the lake from all sources of approximately 44 tonnes/year).
- Reduce pathogen loading to eliminate beach closures
- Reduce contaminants to levels that achieve Provincial Water Quality Objectives or better

The policies to achieve these targets include those around stormwater, septic systems, construction and aggregate extraction activities, and the development of a phosphorus reduction strategy. These are outlined in further detail below.

With regard to stormwater the LSPP requires:

- Preparation and implement comprehensive stormwater management master plans for each settlement area in the Lake Simcoe watershed.
- Municipalities are to incorporate policies related to reducing stormwater runoff volume and pollutant loadings from major development and existing settlement areas into their official plans.
- Applications for major development must be accompanied by a stormwater management plan that demonstrates, among other requirements:
    - That an integrated treatment train approach will be used
    - How changes between the pre- and post-development water balance will be minimized
    - How phosphorus loadings will be minimized
- Every owner and operator of a new stormwater management works to inspect and maintain the works on a periodic basis.

In regards to *Septic Systems,* the LSPP requires development of a proposal for a regulation under the Ontario Building Code Act to:

- Designate the lands within 100 metres of the Lake Simcoe shoreline, other lakes and any permanent stream of the watershed, as a prescribed area for required septic system maintenance and re-inspections.
- Investigate new standards for septic systems.
- Place limitations on when and where new septic systems can be built within this 100 metre buffer around the lake and its streams and rivers.

The LSPP contains policies to minimize the impacts from exposed soils at construction and mineral aggregate sites. These policies require municipalities to ensure that the following measures are incorporated into subdivision and site plan agreements:

- the removal of vegetation, grading, and soil compaction; and stipulating that the removal of vegetation is not to occur more than 30 days prior to grading or construction

- structures to control and convey runoff are in place and exposed soils are seeded once construction is complete
- sediment and erosion controls are implemented effectively

Phosphorus Reduction Strategy

As phosphorus has been identified as the main water quality concern in the Lake Simcoe watershed, the Lake Simcoe Protection Plan required the completion of a Phosphorus Reduction Strategy (PRS) aimed at limiting inputs into the watershed. The Ministry of the Environment, in partnership with other watershed organizations and stakeholders, developed the Phosphorus Reduction Strategy, which was released in June of 2010. This strategy accounts for all of the major contributing sources of phosphorus in the watershed, and highlights a number of actions that are designed to achieve proportional reductions from each source. The goal is to move from today's phosphorus load of 72 T/yr total load to 44 T/yr in the future, with the ultimate goal of achieving a dissolved oxygen concentration of 7 mg/L in the deepest parts of the lake. The strategy sets a series of interim reductions over the next 35 years, and will be reassessed every five years at a minimum to ensure that the approach taken is appropriate, given any new science and information that may become available, and the strategy can then be adapted to reflect this new information.

The PRS strongly supports the continuation and enhancement of stewardship activities as an overarching piece in the effort to reduce phosphorus loads in the watershed. It also contains strategy directions around reducing phosphorus loads from sewage treatment plans, though these are not discussed here in detail, as they do not pertain specifically to actions that can be taken in the subwatershed. The PRS details a number of recommendations around each of the significant contributors of phosphorus in the watershed. These are outlined below. If more detail is sought, the reader is referred to the original document.

Urban stormwater runoff

Actions in the PRS aimed at limiting phosphorus inputs from urban stormwater runoff include:

- Undertaking stormwater retrofits for existing developments – these retrofits will be based on the 2007 LSRCA study
- Using Low Impact Development practices, which decrease areas of impervious surface and promote on-site water retention to enhance the percolation of water through the soil. The use of these practices also help to lower the temperature and decrease the volume of runoff entering stormwater management facilities
- Moving to no net phosphorus from new development (this is identified as a strategic action under the PRS). The province would work with applicable stakeholders to demonstrate how this would be met.
- Encouraging the use of new and innovative methods for controlling phosphorus loads from stormwater, and reducing barriers to using these methods and practices

Rural and agricultural sources of phosphorus

Model projections estimate that 5 T/yr of phosphorus could be reduced from agriculture and rural loads to tributaries through participation in stewardship programs. The strategic action around meeting this phosphorus reduction involves:

- Encouraging continued best management practices through stewardship activities to continue to reduce the phosphorus load from rural and agricultural sources. The Strategy will revisit strategic voluntary actions at the scheduled plan update

The PRS cites a number of LSPP policies related to rural and agricultural sources of phosphorus that, when undertaken, will serve to reduce phosphorus loads from these sources.

On-site sewage systems within 100 metres of Lake Simcoe

Septic (or on-site sewage) systems within 100 metres of the shore of Lake Simcoe are estimated to contribute 4.4 tonnes of phosphorus to the lake each year. The PRS links to several LSPP policies related to limiting phosphorus contributions from this source. These include:

- Developing a proposal for a regulations under the *Ontario Building Code Act, 1992*, to designate the lands within 100 m of the Lake Simcoe shoreline and any permanent streams within the watershed as prescribed areas for mandatory on-site sewage system maintenance re-inspections
- Consideration of new standards for on-site sewage systems and evaluation of new treatment technologies
- Placing restrictions on the construction of on-site sewage systems or subsurface sewage works within 100 metres of Lake Simcoe or any of its permanent watercourses

Atmospheric deposition of phosphorus

Atmospheric phosphorus accounts for approximately 27% of the current load to Lake Simcoe. While much of this falls directly on the lake, there is also deposition in the lake’s tributaries, which are accounted for in the calculation of the tributary load to the lake. The PRS does identify a number of actions around better identifying the sources of atmospheric phosphorus, and reducing the impact of this load in the subwatershed. The strategic actions contained in the PRS related to atmospheric deposition are:

- Continuing and expanding the use of focused stewardship opportunities to implement BMPs that can help address both urban and agricultural sources of airborne phosphorus
- Working with the aggregate and development industries to help identify partnership-based approaches to filling information gaps and building scientific knowledge and recommendations on BMPs
- Working with the aggregate and development industries to identify opportunities for phosphorus reduction, while examining ways to increase the use of BMPs

The PRS also discusses undertaking research to more accurately calculate the distribution and sources of atmospheric loading, and to identify the most effective opportunities to reduce atmospheric deposition.

Monitoring and compliance

Monitoring of annual phosphorus loads is an essential part of measures the success of the actions taken to reduce phosphorus in the watershed. This monitoring program includes a number of instream monitoring stations, atmospheric deposition collectors, meteorological stations, in-lake water quality stations, and year round analysis of water collected at municipal water treatment plants.

The PS identifies a number of legislative and regulatory frameworks that are in place to mitigate phosphorus sources. Achieving the phosphorus reduction targets set out in the PRS and in the LSPP will require all stakeholders to assume responsibility and be accountable for their actions. Compliance with the existing regulations and controls will be essential.

Research, modelling, and innovation

Research and modelling will be necessary to further the understanding of the contributions of phosphorus from various sources in the watershed, as well as to track the success of phosphorus reduction initiatives. This work will support the adaptive management aspect of the PRS – as the strategy is reviewed, the newest information can be used to make the necessary changes to achieve the greatest level of phosphorus reduction.

Innovation will be another important aspect of achieving the ambitious phosphorus reduction goals that have been set for the watershed. Research and development of innovative technologies to reduce inputs from new developments, maintaining water balance, and treating stormwater runoff will be necessary in order to continue to achieve loading reductions when traditional practices are not possible or have already been implemented. Other technologies, such as reusing treated wastewater effluent and stormwater runoff and water quality trading are also being explored. As new technologies are developed and their feasibility confirmed, their use can be incorporated into the strategy as it is updated and adapted into the future.

Additional Policies

The LSPP also contains a number of other policies which, while not directly related to water quality but, will help to protect and enhance water quality in the Pefferlaw River subwatershed when they are implemented. These include:

Water conservation and efficiency initiatives, which will reduce surface runoff and improve the efficiency of sewage treatment plants and septic systems

- Natural heritage targets around shorelines, the amount of high quality vegetative cover and riparian cover, the protection of wetlands and other important features, restoration of natural areas or features, and overall ecological health
- Consideration of climate change and its potential effects throughout the Lake Simcoe watershed
- The coordination of stewardship efforts throughout the watershed in order to capitalize on the strengths of the various partners; increase effectiveness in cost-sharing, communication and co-marketing; enhance stewardship opportunities; and champion key new initiatives, technologies, and BMPs

Greenbelt Plan (2005)

One of the stated goals of the Greenbelt Plan is the ‘protection, improvement or restoration of the quality and quantity of ground and surface water and the hydrological integrity of watersheds.’ This goal is supported by a number of policies in the plan that relates to the Protected Country side areas of the Greenbelt.

The Water Resource System Policies requires:

- Planning authorities to provide for a comprehensive, integrated and long-term approach for the protection, improvement or restoration of the quality and quantity of water,

- Municipalities are required to protect vulnerable surface and ground water areas, such as wellhead protection areas, from development that may adversely affect the quality and quantity of ground and surface waters.
- Policies specifically related to Stormwater Management Infrastructure include:
- Stormwater management ponds are prohibited in key natural heritage features or key hydrologic features or their vegetation protection zones.
- Applications for development and site alteration shall be accompanied by a stormwater management plan which demonstrates that:
  - Planning, design and construction practices will minimize vegetation removal, grading and soil compaction, sediment erosion and impervious surfaces
  - Where appropriate, and integrated treatment approach shall be used to minimize stormwater management flows and structures through such measures as lot level controls and conveyance techniques such as grass swales
  - The objectives of a stormwater management plan are to avoid, minimize and/or mitigate stormwater volume, contaminant loads and impacts to receiving water courses in order to protect water quality, minimize the disruption of pre-existing (natural) drainage patterns and prevent increases in stream channel erosion.

The plan also contains policies specifically related to natural heritage features which would also have an influence on water quality. See **Chapter 6 – Aquatic Habitat** and **Chapter 8 – Terrestrial Natural Heritage** for more information.

Growth Plan for the Greater Golden Horseshoe (2006)

Policies within this plan will help to maintain and/or improve water quality by directing development to built-up areas and those areas that already have municipal water and wastewater systems. Perhaps most important with regard to surface water quality are the Growth Plan's policies around Water and Wastewater. These include the following:

- The construction of new, or expansion of existing, municipal or private communal water and waste water systems should only be considered where the following conditions are met:
  - Strategies for water conservation and other water demand management initiatives are being implemented in the existing area
  - Plans for expansion or for new services are to serve growth in a manner that supports achievement of the intensification target and density target
- Municipalities that share an inland water source and/or receiving water body, should coordinate their planning for potable water, stormwater, and wastewater systems to ensure that water quality and quantity is maintained or improved
- Municipalities are encouraged to implement and support innovative stormwater management actions as part of redevelopment and intensification

The Growth Plan also supports and builds on the protection offered to natural features in plans such as the Greenbelt and ORMCP. Municipalities are encouraged to identify and develop policies to protect natural features, the linkages between, and areas that complement them.

Provincial Policy Statement (2005)

Policies that are directly related to maintaining and/or improving water quality in the Provincial Policy Statement (PPS) include:

- Planning authorities shall protect, improve, or restore the quality of water by implementing necessary restrictions on development and site alteration to:
    - Protect municipal drinking water supplies
    - Protect, improve or restore vulnerable surface water and groundwater, sensitive surface water features and sensitive groundwater features, and their hydrologic functions, including:
        - Promoting the efficient and sustainable use of water resources
        - Ensuring stormwater management practices minimize stormwater volumes and contaminant loads, and maintain or increase the extent of vegetative and pervious sites
- Growth should be directed to promote the use of existing sewage and water services, ensuring that these services can be provided in a manner that can be sustained by the water resources on which they rely, and that protects human health and the natural environment.
- Growth is to be focused in settlement areas which, if implemented, should limit the amount of natural area removed, thus maintaining their functions. Development and site alteration are not permitted in features such as significant wetlands, woodlands and ANSIs, or the lands adjacent to them, unless it can be demonstrated that there will be no negative impacts on the natural features or their functions.

Nutrient Management Act (2002)

The goal of the Act is to set standards for nutrient management on farms that create nutrients (such as manure, biosolids, and fertilizers) and for farms that use these materials. The Act and its regulations are currently limited to farms that create over 300 nutrient units (one nutrient unit is equivalent to the amount of nutrient that is created by approximately one cow), or those smaller farms that are expanding and will be generating over 300 nutrient units.

Farms that generate manure are required to complete a Nutrient Management Strategy – a document that shows how much manure and/or other materials prescribed by the regulation are produced, how they will be stored, and where they will be used. Farms that use or store manure or other prescribed substances on their land, but do not generate manure for removal are required to complete a Nutrient Management Plan. These plans include many similar components to the Nutrient Management Strategies, but must also include contingency plans for situations such as weather preventing the application of the material on the field or if storage becomes too full.

This Act gives current best management practices the force of law, and creating comprehensive, enforceable, province-wide standards to regulate the management of all land-applied materials containing nutrients. Specific regulations of this Act include:

- Restrictions on how and where farmers can apply nutrients to their land.
- Setbacks from sensitive features such as wells and streams are required for new barns that will be storing manure.

Ontario Water Resources Act (1990)

With respect to water quality, the Ontario Water Resource Act (OWRA):

- Requires that construction of new water works (including sewage treatment works and stormwater management facilities) or alterations to existing works may proceed only after a Certificate of Approval under Section 53 of the Act has been issued by the MOE. This enables MOE to track the amount of pollutant being discharged into the water, and ensures that project designs meet the proper specifications.
- Prohibits the discharge of material of any kind into waters (or on the shore or bank of a water body) that may impair the quality of water
- States that every person that discharges or causes or permits the discharge of any material of any kind into or in any waters or on any shore or bank thereof or into or in any place that may impair the quality of the water of any waters is guilty of an offence.

The OWRA also supported the development of water quality of objectives to provide the basis upon which the limits of the uses of water resources can be established in order to protect water quality. The Provincial Water Quality Objectives (PWQO) established under this directive, provides a series of goals, policies, and guidelines intended to assist those making decisions under or related to the OWRA and the Environmental Protection Act (see EPA on the following page). For example, they give directions that assist in defining site specific effluent limits, which may then be incorporated into Certificates of Approval or control orders. The policies and guidelines do not have any formal legal status.

The PWQOs are numerical and narrative criteria which serve as chemical and physical indicators representing a satisfactory level for surface waters and groundwater (where it discharges to the surface). PWQOs are set at a level of water quality which is protective of all forms of aquatic life and all aspects of the aquatic life cycle during indefinite exposure to the water. PWQOs are intended to provide guidance in making water quality management decision such as the designation of surface waters which should not be further degraded. They are used to assess ambient water conditions, infer use impairment, assist in assessing spills, and to monitor the effectiveness of remedial actions. The publication states that meeting the PWQO is a minimum requirement, and that considerations such as ecosystem health, the additive effects of more than one chemical, or the protection of other uses may lead to more stringent requirements.

Environmental Protection Act (1990)

The main policy of the Environmental Protection Act (EPA) that will help to protect water quality is that '…a person shall not discharge a contaminant or cause or permit the discharge of a contaminant into the natural environment, if the discharge causes or may cause an adverse effect.' This does not apply to discharges that are authorized under this Act or the OWRA if the discharge does not cause and is not likely to cause an adverse effect. It also does not apply to a discharge of a contaminant that arises when animal wastes are disposed of in accordance with normal farming practices, when the only adverse effect that is caused or may be caused is the impairment of the quality of the natural environment for any use that can be made of it.

The EPA enables a Director of the MOE to:

- order someone who causes or allows the discharge of a contaminant that results in injury, damage, or endangerment to land, water, property, animal or plant life, or human health or safety to prevent or repair the injury or damage or (if water supplies are threatened) provide temporary or permanent water supplies.

- require a person who owns a property or has management of an undertaking to put in place equipment and/or precautionary measures to be in place to prevent the discharge of a contaminant or to minimize its impact if it is released into the environment.
- issues stop orders or control orders where a contaminant has been released in a concentration or level that exceeds that prescribed by the regulations.

Clean Water Act (2006) – Source Water Protection

While its aim is to protect sources of drinking water, a number of the initiatives included the Clean Water Act will help to improve water quality throughout the subwatershed. The goals of the Act are to identify threats to drinking water, and then implement changes to reduce or remove those threats. A Source Protection Plan will be prepared for each Source Protection Area. This plan may set out significant threat policies to which planning decisions must conform – they will affect future activities and land use planning around wellheads and water intakes. The plan may also provide for the prohibition of certain activities and the use of risk management plans to impose conditions on certain activities, and may include policies for which municipalities must have regard in other vulnerable source water areas such as moraines, aquifers, headwaters and recharge areas. Implementation of Source Protection Plans will include the incorporation of the Plan's policies into municipal Official Plans, changes to zoning by-laws, and inspections and enforcement.

LSRCA Watershed Development Policies (2008)

Although not extensive, the LSRCA Watershed Development Policies do address the protection of water quality. Policies include:

- Requiring Enhanced Level 1 stormwater quality protection for all new developments in the watershed
- Requiring erosion and sediment control plans for plans of subdivision
- Protecting environmentally significant areas, wetlands and floodplains (as permitted under its mandate) and their functions, which will maintain water quality

York Region Official Plan (2009)

York Region's Official Plan (OP) includes a number of policies related to the protection of the quality of both ground and surface water. The policies within the OP related to water quality include:

- The preparation of a comprehensive regional water strategy for both piped services and surface and groundwater sources that will include long-term protection strategies, enhancement guidelines and monitoring requirements;
- That the natural quality and hydrological characteristics of watercourses and lakes (including water quality and temperature) will be maintained, and that development be designed with the goal of maintaining water balance
- Directing development away from sensitive surface water and groundwater features
- Continuing to partner with other regions and conservation authorities to study, analyze, and monitor ground and surface water resources to ensure a unified approach to protecting and enhancing water quality and quantity
- Monitoring the quantity and quality of surface and ground water systems in York Region, in co-operation with local municipalities and conservation authorities) by:

  - Assessing the sustainability of current activities and land uses
  - Identifying areas that are susceptible to, or currently experiencing, water quality and quantity problems
- Requiring local municipalities to establish policies and programs to protect, enhance, and monitor water systems
- Encouraging agricultural land management practices that minimize the application of pesticides and nutrients
- Working with partners in the implementation of stormwater management initiatives
- Requiring the preparation of comprehensive stormwater management plans as a component of secondary plans
- Requiring that development have an integrated and innovative approach to water management, be water efficient, and maximize stormwater quality, quantity, and infiltration through an integrated treatment approach
- Encouraging innovative approaches to stormwater within secondary plans
- Requiring owners and operators of stormwater management works to inspect, maintain, and monitor effluent quality on a periodic basis
- Working with local municipalities and LSRCA in the preparation and implementation of comprehensive stormwater master plans for each settlement area within the Lake Simcoe watershed by 2014
- Working in partnership with local municipalities, conservation authorities, adjacent municipalities and other agencies to co-ordinate watershed planning initiatives and implement watershed plan objectives; and supporting the goals and objectives of watershed plans

In addition to these policies, York Region’s protection of the regional Greenlands System will help to ensure that the functions of the Region’s natural features, such as the filtering effect of wetlands, will continue to protect and enhance water quality.

Durham Regional Official Plan (2008)

In considering development applications, the impacts on surface water and groundwater resources are to be examined in order to maintain and/or enhance these resources in sufficient quality and quantity to meet the needs of the Region’s residents on a sustainable basis. The policies contained within Durham Region’s Official Plan around surface and groundwater resources include:

- Requiring an examination of the impacts on surface water and groundwater resources in the consideration of development applications in order to maintain and/or enhance such resources in sufficient quality and quantity to meet the existing and future needs of the Region’s residents on a sustainable basis
- Placing restrictions on development within key hydrologic features and their associated vegetated protection areas
- Promoting and supporting water resource conservation and management initiatives
- Ensuring that local municipalities require stormwater management plans as part of pre-servicing development proposals

- Promoting groundwater infiltration, where appropriate, through improved stormwater design
- Encouraging development that maintains hydrological functions and minimizes direct alteration to groundwater flows
- Requiring that development applications to demonstrate the groundwater quality and quantity will be protected, improved, or restored in areas where groundwater discharge could be impacted
- Requiring development applications that require a permit to take water, or that have the potential to impact water quantity to be accompanied by a study verifying that there is a sufficient water supply to support the proposed use and, on a cumulative sustainable basis, confirm that there will not be a negative impact on surrounding water users and the natural environment which cannot be appropriately mitigated
- The OP also contains a number of policies around the protection of Wellhead Protection Areas and Highly Vulnerable Aquifers (these policies may be updated/refined through the source water protection process)

Local municipal policies and bylaws

Each local municipality within the subwatershed will have bylaws and requirements regarding site alteration and requirements for erosion and sediment control during and after construction. The reader should consult the individual municipality for information related to these requirements.

4.4.2 Restoration and Remediation

There are a range of programs operating in this subwatershed 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 include managing manure and other agricultural wastes, decommissioning wells and septic systems, fencing and planting riparian areas, and increasing the amount of wildlife habitat in the watershed, among others. Since 1989, LEAP has supported a number of projects specifically aimed at improving water quality in this subwatershed, including 20 fencing projects, improvements to manure storage (7) and milk house waste (1), 34 septic system upgrades, 8 stormwater pond decommissionings, 36 well decommissionings and 16 wellhead protection projects.

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.

In 2008 and 2009, LSRCA field staff surveyed some of the watercourses in this subwatershed, documenting the range of potential stewardship projects that could be implemented to help improve water quality and fish habitat. This survey found over 660 places in this subwatershed where runoff was entering creeks, and potentially impacting water quality.

4.4.3 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.

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 in 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).

4.5 Gaps and Recommendations

Clearly there are already numerous legislations, regulations and municipal requirements aimed at protecting water quality in the Pefferlaw River subwatershed. 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 water quality in the Pefferlaw River subwatershed, and outlines recommendations to help fill these gaps.

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

4.5.1 Groundwater (Hydrogeologic and Hydrologic)

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

Recommendation #1 - That the Pefferlaw River subwatershed municipalities promote Low Impact Development (LID) practices and the adoption of Smart Growth Urban Design Guidelines within the watershed for new developments to further mitigate the impacts of urban development.

Recommendation #2 - That the municipalities in the Pefferlaw River subwatershed in cooperation with LSRCA, work to protect those hydrologic functions that are currently supporting the Pefferlaw River high quality coldwater ecosystem e.g. groundwater quality and quantity, baseflow, instream habitat, streambank corridors and wetlands.

Recommendation #3 - That the LSRCA in cooperation with the subwatershed municipalities improve the characterization of the surface-groundwater interaction (including water quality) in Ecologically Significant Groundwater Areas and Highly Vulnerable Aquifers within the Pefferlaw River subwatershed.

Recommendation #4 - That the municipalities through LSRCA continue to promote and educate the public about private well maintenance and offer technical support for private well decommissioning within the Pefferlaw River subwatershed.

4.5.2 Surface Water

Urban - improving stormwater

Despite the fact that there are relatively few urban areas in the Pefferlaw River subwatershed (4% of total area), those few areas are having an impact on water quality. For example, over 18% of the phosphorus loads from the Pefferlaw River subwatershed reaching Lake Simcoe can be attributed to high and low intensity development (not including point sources).

There is very little urban stormwater control in the two of the four urban areas. In Uxbridge, 32 of 43 stormwater ponds have no controls. Beaverton does have any controls. Pefferlaw and an area in the vicinity of Ballantrae are relatively better, each with two of four facilities with some sort of control. While some policies are in place to address this issue within existing plans such as LSPP, the following recommendations would provide additional improvements to stormwater management or assist in the implementation of the existing policies:

Recommendation #5 - That the municipalities of the Pefferlaw River subwatershed are encouraged to work with the LSRCA and the development industry to promote the increased use of innovative solutions to address stormwater management such as soakaway pits, infiltration galleries, permeable pavement and other LID solutions. When new facilities are recommended, reduction of thermal impacts of those stormwater ponds will be considered in their design.

Recommendation #6 - That the municipalities of the Pefferlaw River subwatershed support the on-going inventory, installation and proper maintenance of oil grit/hydrodynamic separators combined with the use of technologies to enhance their effectiveness where this is appropriate; and where practical and feasible, enhance measures to control TSS.

Recommendation #7 - That the Province of Ontario, through the implementation of the Lake Simcoe Phosphorus Reduction Strategy, provide significant incentive funding to the related municipalities and/or the LSRCA to maintain, construct and /or retrofit stormwater facilities as identified by the LSRCA Stormwater Rehabilitation program.

Recommendation #8 - That the LSRCA strongly encourage routine maintenance of existing stormwater facilities by municipalities and continue to undertake the completion of stormwater retrofit projects in partnership with municipalities, subject to budget allocations. The criteria for maintenance should 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 undertaking retrofit projects throughout the watershed.

Recommendation #9 - That the federal and provincial governments provide financial incentives to allow municipalities to implement an enhanced street sweeping program targeted to uncontrolled urban areas.

Urban – reducing salt (chloride)

While most water quality parameters measured meet the Provincial standards for the vast majority of the time in the Pefferlaw River subwatershed, increased trends in chloride have been observed and if this trend continues unchecked could in the future lead to levels being above the CCME guidelines.

There is no legislation that specifically regulates the application of road salt. The ORMCP, Greenbelt Plan, Growth Plan for the GGH, and the OWRA address it either through broad ‘have regard for’ policies, or general water quality statements.

These are very general policies that in no way require the management of road salt and its impacts to water quality and aquatic biota. While urban areas have not been expanding to the same degree in the Pefferlaw River subwatershed as in others, there has been some growth, and the increasing chloride concentrations are not unexpected.

Recommendation #10 - That the LSRCA, municipalities and NGO’s undertake a program to raise awareness and to educate property owners and property managers about salt management, and work with snow removal contractors to encourage their adoption of the salt applicator’s license program, recognizing that public safety remains paramount.

Recommendation #11 - That the municipalities in conjunction with the LSRCA review the locations of their snow disposal sites and investigate innovative ways of reducing the impacts of excess chloride through the use of storage facilities such as wetland cells and/or stormwater treatment facilities.

> **Recommendation #12 -** Recognizing that increasing concentrations of chloride in watercourses is an emerging issue shared by all municipalities in the Lake Simcoe watershed, that 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.

Urban – construction practices

Even though projected growth in the Pefferlaw River subwatershed is not going to be extensive, some urban growth and construction is expected. Deterioration of stream water quality can occur during the construction phase as exposed soils are very susceptible to runoff and wind erosion, particularly if codes of practice and/or approved plans are not followed.

> **Recommendation #13 -** That the LSRCA and partner municipalities promote the adoption of sustainable site alteration and construction practices in the Lake Simcoe watershed through the preparation of a construction phase code of best management practices that is updated as necessary to ensure contemporary standards are maintained.

Recommendation #14 - That the partner municipalities and LSRCA improve current monitoring and enforcement of site alteration by-laws by undertaking a review of the current programs and developing a funding model that ensures adequate resources are available for improvements.

4.5.3 Agriculture

Agriculture is the largest single land use within the subwatershed, and correspondingly one of the largest sources of pollutants to the Pefferlaw River. Approximately 40% of phosphorus loads to the river can be attributed to agricultural practices. However, modelling shows that over 30% reduction in phosphorus loads is achievable through identified BMP implementation.

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 contaminants created and/or stored on farms. Other policies relate to the protection of agricultural resources, but few relate to the management of contaminants 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 wind rows, and leaving riparian buffers intact, there are a number of available programs to assist farmers to implement these programs. In particular, the LSRCA’s Landowner Environmental Assistance Program (LEAP) provides guidance and funding for a number of types of projects. Other gaps in current management include policies requiring livestock to be fenced and kept out of watercourses, an activity that causes numerous water quality issues as well as causing bank instability. Finally, there are no policies requiring farmers to test soils to ensure that the use of fertilizer is actually required. This may be resulting in unnecessary nutrient application and increased inputs of nutrients into the Pefferlaw River.

Recommendation #15 - That the watershed municipalities seek opportunities for input with existing Committees established through the LSPP for example, to encourage co-operative ways to implement phosphorus reduction measures within Lake Simcoe's watersheds and to develop 'action plans' for their implementation within the agricultural and rural communities.

Recommendation #16 -That a stewardship initiative is developed and implemented to offer incentives and work with landowners in the Pefferlaw River subwatershed.

Recommendation #17 - That in order to deal with the predicted increases in P loading (Pefferlaw R. @515kg), and to help address the high P concentrations in Lake Simcoe and as part of the Phosphorus Reduction Strategy in the LSPP, the LSRCA and its partners need to research innovative methods of P reductions and encourage MOE to explore water quality trading. The local agricultural community and landowners need to be engaged directly in this dialogue.

Recommendation #18 - That the LSRCA continue to offer, and where possible expand upon, stewardship incentives in the agricultural community of the Pefferlaw River subwatershed to deal with manure, management, milk house wastes, chemical and fuel storage, and water use and reuse.

Recommendation #19 - That the Federal, Provincial and Municipal governments provide consistent, long-term and sustainable funding to ensure continued delivery of stewardship programs.

Recommendation #20 - That the Province provide increased funding to support the current Environmental Farm Plan program and its 'on the ground' local improvements.

Recommendation #21 - That the OMAFRA, OFA, and landowner representatives in conjunction with LSRCA investigate changing trends in agricultural production within the Pefferlaw River subwatershed and to provide innovative BMP's for those new specialty crops such as Asian vegetables to the agricultural community.

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 6 - Aquatic Habitat**.

4.5.4 Water Temperature – thermal degradation

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

It is important to 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 – Water Quantity** and **Chapter 6 – Aquatic Habitat**.

4.5.5 Monitoring and Assessment

Currently there are only two surface water and two ground water quality monitoring stations within Pefferlaw River subwatershed. Obviously there is a need to provide improved and expanded information on temporal and spatial change in water quality within the watershed. 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 #22 - That the LSRCA continue to maintain and/or enhance the existing monitoring network. This sampling should be continued into the future to assess the state of water quality in the Pefferlaw River subwatershed, and to determine/monitor any trends (including seasonal trends), emerging contaminants, or new substances of concern that may arise. At a minimum, the Toxic Pollutants Screening Study (LSRCA, 2004) should be repeated, but in a more targeted way to assess pesticides and pharmaceuticals based on land use.

Recommendation #23 - That expansion of the PWQMN or another more appropriate water sampling program should be considered in the Lake Simcoe watershed to capture proposed land use changes that could impact water quality. This enhanced monitoring would be used to capture data that is representative of the entire Pefferlaw River subwatershed e.g. from headwaters to mid reaches to the mouth at Lake Simcoe.

Recommendation #24 - That the current LSRCA monitoring network be reviewed annually to ensure it meets the surveillance/compliance goals of the monitoring strategy and as required, allow for special projects to be undertaken to address emerging trends.

Recommendation #25 - That water quality results are analyzed and reported annually and that the information be used to update the LSRCA Watershed Report Card. Further, stakeholders should be provided access to the water quality data collected via a web portal to increase distribution and communication links.

5 Water Quantity (surface and groundwater)

5.1 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 the 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 surface water bodies.

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, and it can be the only source of water.

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.

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. 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 Pefferlaw River subwatershed have altered the hydrologic cycle (Figure 5-1), including changes to the surface flow volumes, annual flow patterns and the risk of flooding. For the purposes of this chapter the Pefferlaw River study area has been subdivided into the Pefferlaw Brook and Uxbridge Brook (major tributary to the Pefferlaw River) study areas (Figure 2-1, **Chapter 2 – Study Area and Physical Setting**).

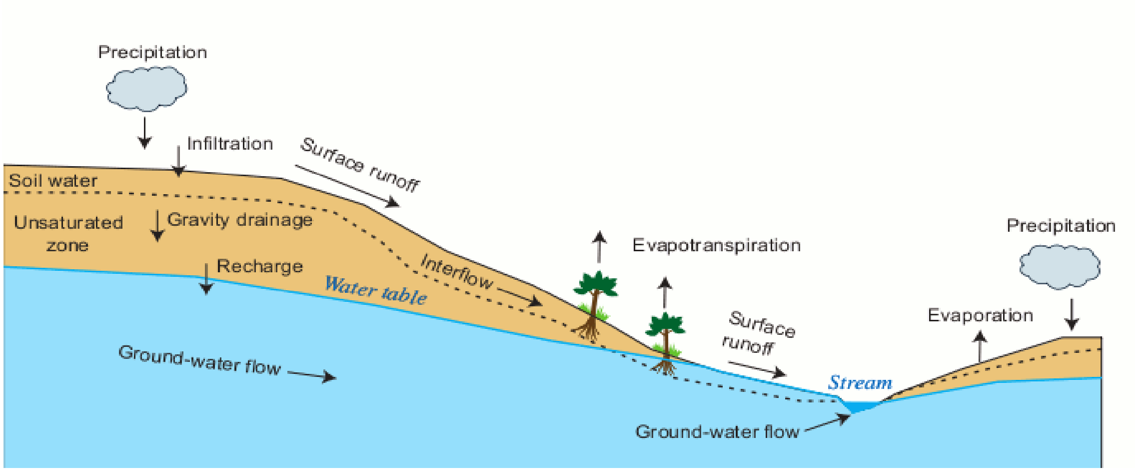


Figure 5-1: Hydrologic cycle (USGS, 2008).

5.1.1 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.

<u>Climate</u>

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. An intense storm event, where a large quantity of precipitation falls over a short time, will direct most of the precipitation overland, as will a significant snowmelt event. This type of event is observed in March or April snowmelts or the onset of spring rains in April or May. There are 15 climate stations within or in close proximity to the Pefferlaw River and Uxbridge Brook subwatersheds with historic records greater than 10 years (Earthfx, 2010a). The area is characterized by having mean precipitation ranging between 725 and 1,003 millimetres per year (mm/yr) and averaged 856 mm/yr (Earthfx, 2010a). However, it should be noted that precipitation patterns have become less predictable in recent years, perhaps due to climate change. For example, in the last five years within the Lake Simcoe basin alone there have been three 100 year storm events.

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. Several factors other than the physical characteristics of water, soil, snow and plant surfaces also affect the evapotranspiration process. The important factors include net solar radiation, surface area of open bodies of water, wind speed, density and type of vegetative cover, availability of soil moisture, root depth, reflective land-surface characteristics, and season.

<u>Geology</u>

Geology also has a significant influence on groundwater quantity. The underlying geology and the type of soil present at the surface will determine how much water will infiltrate during a precipitation event. 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. The surficial geology is an important factor in determining the amount of water that flows to and within a watercourse.

<u>Land Use and Land Cover</u>

Land cover is an important factor that can strongly influence both surface and groundwater quantity because it 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 or hardened surfaces, 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 because of development, which can result in decreased discharge to wetlands and streams.

The surface water in this subwatershed flows from the topographic highs in the Oak Ridges Moraine north to Lake Simcoe. The land types present in the subwatershed will influence how much water remains at the surface and how fast it will be flowing. The land types present in the subwatershed include the Oak Ridges Moraine, wetlands, woodlands, and grasslands. The wetlands are found in areas of topographic lows, where the groundwater often intersects the surface in these areas. The intersection of the surface with the groundwater table allows for a constant flow of surface water throughout these areas. Since the wetlands are in areas of topographic lows water flow in the areas will be relatively slow compared to the slopes of the Oak Ridges Moraine.

As the population continues to grow, urbanized areas are expanding, resulting in wide spread 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 subwatershed exist under natural conditions making them less vulnerable to extreme changes in climatic events; for example, time to peak flow will not occur as rapidly. As impervious surfaces increase in area, peak flow can also increase as water cannot infiltrate into the ground, and therefore runs off into surface water bodies, increasing the risk of flooding particularly during the spring freshet. The Pefferlaw Brook and Uxbridge Brook subwatersheds currently have a low percentage of hardened surfaces, and few development pressures.

Water Use

In the Pefferlaw Brook and Uxbridge Brook subwatersheds both surface and groundwater is used for a variety of purposes, including municipal water supply, agricultural, 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 amount of water takings to ensure the water 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, 2006 (discussed in Section 5.5.6).

5.1.2 Previous Studies

Information from several groundwater and water budget studies was used to assess the hydrogeology of the Pefferlaw Brook and Uxbridge Brook subwatersheds. The following are a list of key studies and reports that have influenced the information provided in this chapter:

York Peel Durham Toronto/Conservation Authorities Moraine Coalition (YPDT/CAMC) Groundwater Study

In 2000, the nine conservation authorities having jurisdiction on the ORM (Credit Valley, Nottawasaga Valley, Toronto and Region, Lake Simcoe Region, Central Lake Ontario, Kawartha, Ganaraska Region, Otonabee, and Lower Trent) formed a coalition to investigate common issues pertaining to the groundwater flow systems associated with the ORM. The coalition is referred to as the Conservation Authorities Moraine Coalition (CAMC).

Around the same time, the regional municipalities of York, Peel, and Durham and the City of Toronto (YPDT), through a planning led process, were also looking at the common issues they faced with respect to development issues on the ORM. The need for more environmental protection on the moraine and greater access to groundwater related information was highlighted.

In 2001, the two groups came together to look at groundwater issues in a broad regional context. The project is referred to as the YPDT/CAMC Groundwater Management Program. The overall goal of this program is to provide a hydrogeological analysis of the system that will support water resource management of the subwatersheds that drain off the ORM. The three main technical components that form the foundation of the analysis system consist of:

1. A database of all water related information;
2. A geologic and hydrogeologic interpretation of the subsurface stratigraphy including development and refinement of a conceptual model; and
3. A numerical groundwater flow model. To date, four numerical models have been created. These four models, termed: i) the Core Model; ii) the Regional Model, iii) the Durham Model, and iv) the West extension Model, have different geographical extents and different resolutions. Three of the models cover the south and east parts of the Lake Simcoe Watershed.

This modelling work is documented in the report completed by Earthfx (2006) and was used extensively throughout this report and forms the basis for much of the water budget work that was completed for Source Water Protection studies and the Pefferlaw River subwatershed Plan.

YPDT-CAMC Durham Model Development - Simulation of Groundwater Flow in the Regional Municipality of Durham

To advance the understanding of the groundwater system in the Regional Municipality of Durham, a numerical model (referred to as the “Durham Model”) was developed in the municipality to simulate groundwater flow through the YPDT-CAMC partnership mentioned previously. The development of this model represents an extension of the Core Model conceptual understanding into the Durham Region area and is described in detail by Earthfx (2010b).

The Durham Model covers a large area from the south shore of Lake Simcoe down to Lake Ontario, east of Hwy 48 (Markham Rd.) to beyond Lake Scugog (Figure 5-2). This model uses ten layers to represent aquifers and aquitards in the over-burden and shallow, weathered bedrock. The model has a uniform 100-m cell size to better represent spatial variability of aquifer properties and groundwater interaction with streams. The model simulates groundwater flow in multiple subwatersheds surrounding the Uxbridge and Pefferlaw River catchments and therefore provides an independent means of estimating lateral inflows and outflows across subwatershed boundaries. This model was originally constructed as a steady state model to simulate long-term average flows. The model was refined and modified, for the purposes of this study, to analyze transient groundwater response to drought conditions as required in the Tier 2 water budget analysis (Earthfx, 2010b).

Lake Simcoe Basin PRMS Model Development

In 2008 the Lake Simcoe Region Conservation Authority commissioned the development of a surface water model of the Lake Simcoe Basin by Earthfx (2010a). The model was developed to determine the volume of recharge occurring within the watershed as part of the Source Water Protection program. This model, which covers the Uxbridge and Beaver subwatersheds (Figure 5-2), was developed using the Precipitation Recharge Modelling System (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.

Although the stream gauge coverage was very limited in the northern portions of the basin both the Beaver River and Uxbridge Brook had long-term stream gauges that encompassed the majority of their respective catchment areas. The local calibration of the PRMS model for the Beaver River and Uxbridge Brook area was given special attention in anticipation of the Tier 2 study (and in part due to better data availability (Earthfx, 2010a).

Source Water Protection Water Budget Studies

Much of the information presented throughout this chapter has been extracted from and is consistent with preliminary information, data and modeling results developed and reported through several Source Water Protection (SWP) water budget studies:

- Preliminary Conceptual water budget (SGBLS, 2007)
- Tier 1 Water Budget and Water Quantity Risk Assessment (SGBLS, 2009)
- Final Draft Tier 2 Water Budget Analysis and Water Quantity Stress Assessment of the Uxbridge Brook and Beaver River Subwatersheds (Earthfx, 2011a)

These reports were developed consistent with 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. Due to the overlapping information, every effort has been made to maintain a consistent interpretation of information reported in this chapter with that reported under the above documents. It should be noted that, while the Tier 2 study was used extensively in this report, it only covers the Uxbridge Brook tributary to Pefferlaw River subwatershed. A separate water budget study has been completed for the Pefferlaw River subwatershed, as discussed below.

Pefferlaw River Water Budget ORMCP Study

The Pefferlaw River Water Budget study was completed by Earthfx, 2011b to fulfill the requirements of the Oak Ridges Moraine Conservation Plan (ORMCP) and the Lake Simcoe Protection Plan. The requirements of the ORMCP include:

- identifying and evaluating the quantitative targets needed to maintain aquatic ecosystems and maintain hydrological functions; and
- where possible provide recommendations to assist in achieving these targets and providing recommendations for monitoring of water budget effectiveness.

The study made use of existing groundwater and surface water models developed for Source Water Protection purposes to determine the water budget, under various scenarios. The use of existing models provided an opportunity to maintain a consistent interpretation within this subwatershed plan.

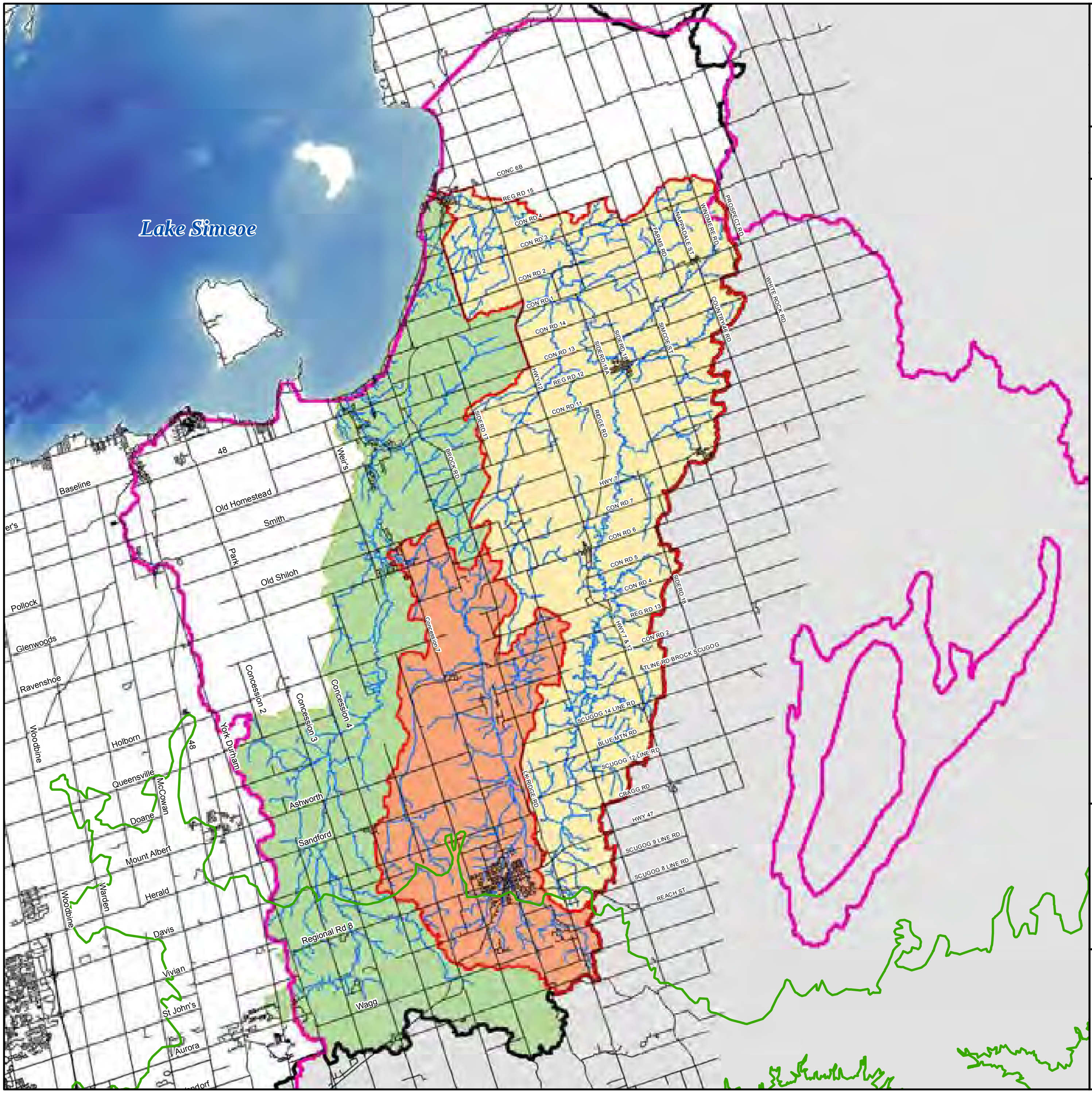
Lake Simcoe Region Conservation Authority Surface Water Monitoring Program

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 Ministry of the Environment, 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.

Pefferlaw Brook, Uxbridge Brook and Beaver River subwatershed within the Durham Model and PRMS Boundaries

Figure 5-2



Legend

- Road
- Watercourse
- Study Area
- Model Boundaries
- LSRCA Watershed Boundary
- Oak Ridges Moraine
- Beaver River
- Pefferlaw Brook
- Uxbridge Brook

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 July 2011.

5.2 Current Status

5.2.1 Hydrogeologic Setting

The hydrogeology of Pefferlaw Brook and Uxbridge Brook subwatersheds are shaped by the stratigraphic framework discussed in **Chapter 2 – Study Area and Physical Setting**. In order to characterize the hydrogeological conditions across the ORM the CAMC-YPDT (Conservation Authorities Moraine Coalition- York, Peel, Durham, Toronto) study group constructed a database containing streamflow, climate, borehole, and water well information. The database was used in the development of a hydrostratigraphic framework represented in the Durham model.

A critical first step in developing the groundwater flow model was the interpretation and creation of the hydrostratigraphic layers (i.e. the aquifer and aquitard layers). The hydrostratigraphic model layers in the overburden generally followed the geologic layering described in **Chapter 2 – Study Area and Physical Setting**. Till formations act as aquitards while the sandier units generally behave as aquifers. The hydrostratigraphic layers differ from the geologic layers in the bedrock; the bedrock stratigraphic layer includes both an upper weathered bedrock aquifer and a deeper, unweathered bedrock aquitard (Earthfx, 2010b).

A listing of the final ten integrated hydrostratigraphic units represented in the Durham Model is shown below. Six layers represent aquifers or aquifer complexes while the other four layers represent aquitards. The channel silts and sands refer to the sediments infilling the tunnel channels where erosional processes have removed some of the earlier deposits. The term “aquifer complex” was used in Kassenaar and Wexler (2006) to describe units with mostly moderate to high permeability sediments that may or may not be laterally continuous but are likely derived from similar depositional processes. For example, the term Thorncliffe Aquifer Complex (TAC) is used to describe material that is believed to be mostly within the Thorncliffe Formation (or equivalent) that is mainly sand and silty sand, but also includes smaller-scale bodies of silt or silty-clay. Additional effort, described further on, was directed at assigning hydraulic conductivity values to the different zones within the aquifer units based on test data and lithology.

Layer 1: Surficial deposits and/or weathered Halton Aquitard

Layer 2: Halton Aquitard (south of ORM); Late Stage Lacustrine (north of ORM)

Layer 3: Oak Ridges Aquifer Complex (ORAC)

Layer 4: Upper Newmarket Aquitard or Tunnel Channel Silts

Layer 5: Inter-Newmarket Sediments (INS) or Tunnel Channel Sands

Layer 6: Lower Newmarket Aquitard

Layer 7: Thorncliffe Aquifer Complex

Layer 8: Sunnybrook Aquitard

Layer 9: Scarborough Aquifer Complex (SAC)

Layer 10: Weathered Bedrock.

During the development of the Durham Model the Newmarket Till was subdivided into three units:

- Upper Newmarket Till Aquitard;
- Inter-Newmarket Sediment (INS) Aquifer, and

- Lower Newmarket Aquitard

There remains some uncertainty as to whether the Upper Newmarket Till is present south of the moraine. South of the moraine the INS, if present, must also be thinner than in the north. The presence of the Halton Till and Mackinaw Interstadial sands on the south flank of the moraine further obscures and complicates the identification and differentiation of the tills. The hydrostratigraphic model for the Durham area has been constructed with the assumption that the Upper Newmarket and INS are both missing south of the moraine (Earthfx, 2009).

The groundwater system within the subwatershed consists of three principal aquifers: 1) the upper aquifer system or Oak Ridges aquifer complex (*Layer 3*) occurs within deposits of the ORM, 2) the intermediate aquifer or Thorncliffe aquifer complex (*Layer 7*) occurs within the Thorncliffe formation; and 3) the deep aquifer system or Scarborough aquifer complex (*Layer 9*) occurs within the deposits of the Scarborough formation (Figure 2-8 and 2-9, **Chapter 2 – Study Area and Physical Setting**).

The Thorncliffe and Scarborough aquifers are separated from the Oak Ridges aquifer by the Newmarket Till (*Layers 4 through 6)*. The Newmarket Till effectively forms a protective barrier for the deeper aquifers. However, within this subwatershed this aquitard has been breached by erosive processes, resulting in Channel Aquifers, also referred to as tunnel channels. These tunnel channels were infilled with sand and silt deposits as melt water energy waned. The nature of the infill material is important for understanding the groundwater flow system as it determines the amount of transfer between the shallow and deeper aquifer systems. It has been estimated that the rate at which water can move through these channels is an order of magnitude greater than that of the Newmarket Till aquitard. Refer to Figure 2-9 and 2-10 (**Chapter 2 – Study Area and Physical Setting**) for a hydrogeologic profile of the Pefferlaw and Uxbridge Brooks. From the diagram the location of the three aquifer complexes can be observed. The interpreted location of the tunnel channels within the subwatershed are shown in Figure 2-10 (**Chapter 2 – Study Area and Physical Setting**).

The conceptual model of stratigraphic units within the subwatershed was presented in Figure 2-8 and Figure 2-9 **Chapter 2 – Study Area and Physical Setting**. As a result of the model the cross sectional profile of the Durham Region was created, and is representative of the Pefferlaw River subwatershed (Figure 2-14 and Figure 2-15, **Chapter 2 – Study Area and Physical Setting**).The profile demonstrates how the thickness and depth of the aquifer complexes varies throughout the region.

5.2.2 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 (*also referred to as observed groundwater levels*). Within the model reasonable estimates of hydraulic conductivity were assigned to each material based on published literature (Freeze and Cherry, 1979). Coarse grained materials (sands and gravels) were assigned a higher hydraulic conductivity than finer grained materials (silts and clay). Figure 5-3 through Figure 5-12 display the spatial distribution of hydraulic conductivities within each aquifer and aquitard in the subwatershed.

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. Storage in a confined aquifer is derived from two sources. Water is slightly compressible and will expand slightly as the pressures in the aquifer drop. The soil matrix is also slightly compressible and water can be squeezed from the pore space when pressures in the aquifer decrease. This occurs when the fluid pressure decreases, the inter-granular stresses increases to balance the constant overburden stress and the aquifer matrix is compressed. In an unconfined aquifer, the water yielded by gravity drainage as the water table declines is also considered to be a form of release of water from groundwater storage. The amount of water yielded from unconfined storage is generally orders of magnitude larger than that from compressive storage (Earthfx, 2011a). The following section (5.2.3) will discuss how these properties influence groundwater flow.

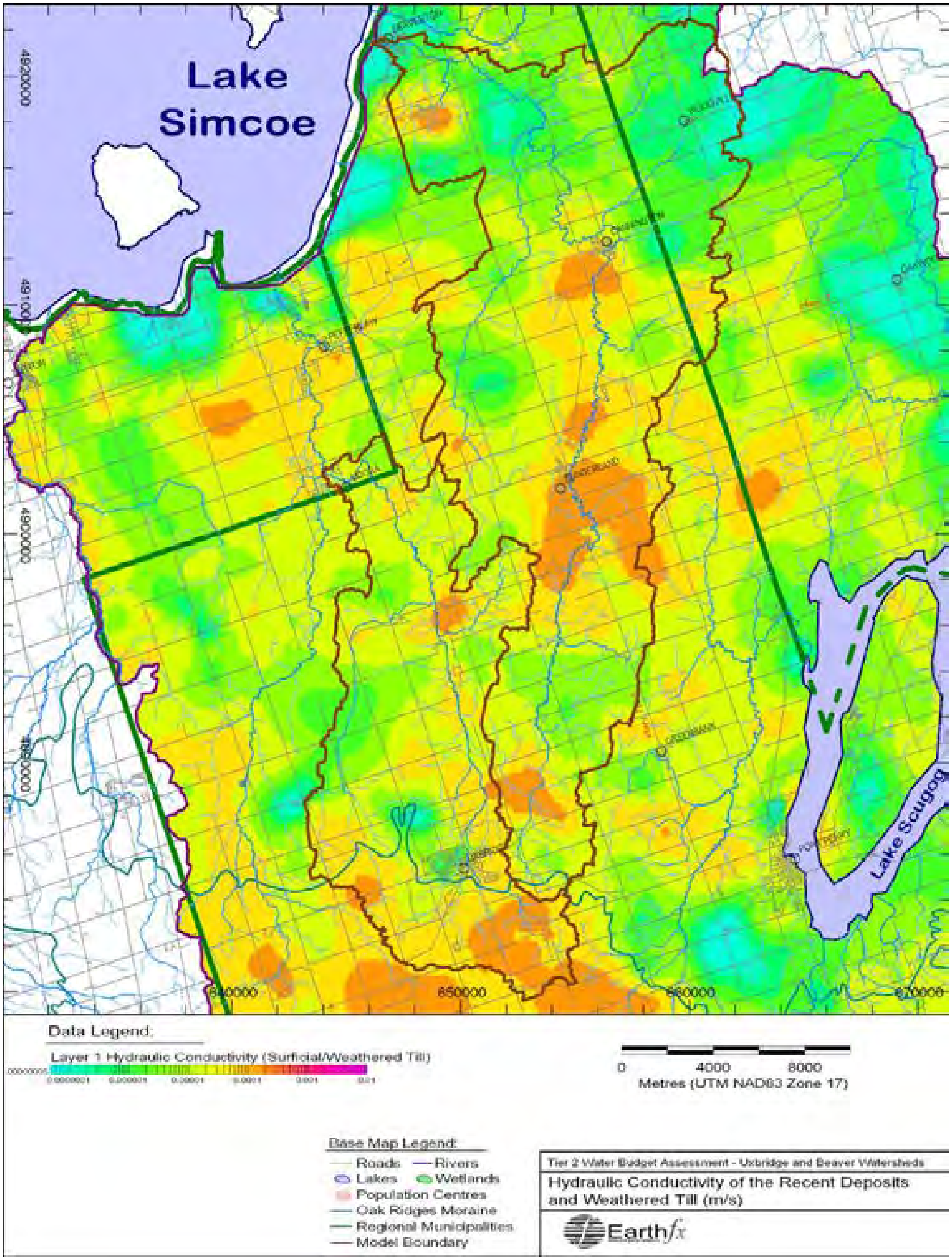


Figure 5-3: Hydraulic conductivity, in m/s, for Layer 1 (Recent Deposits and weathered till) (Earthfx, 2011a)

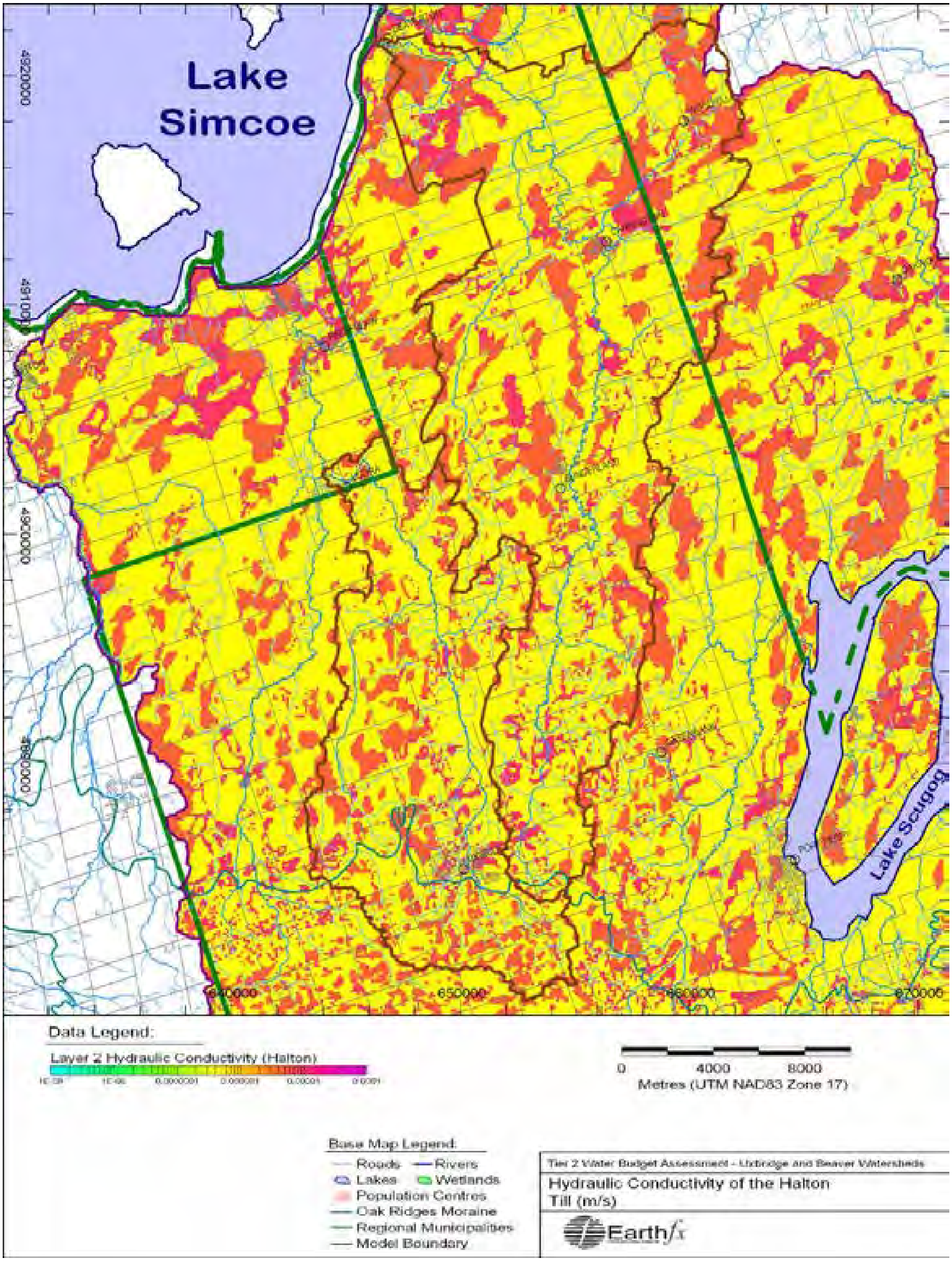


Figure 5-4: Hydraulic conductivity, in m/s, for Layer 2 (Halton Till) (Earthfx, 2011a).

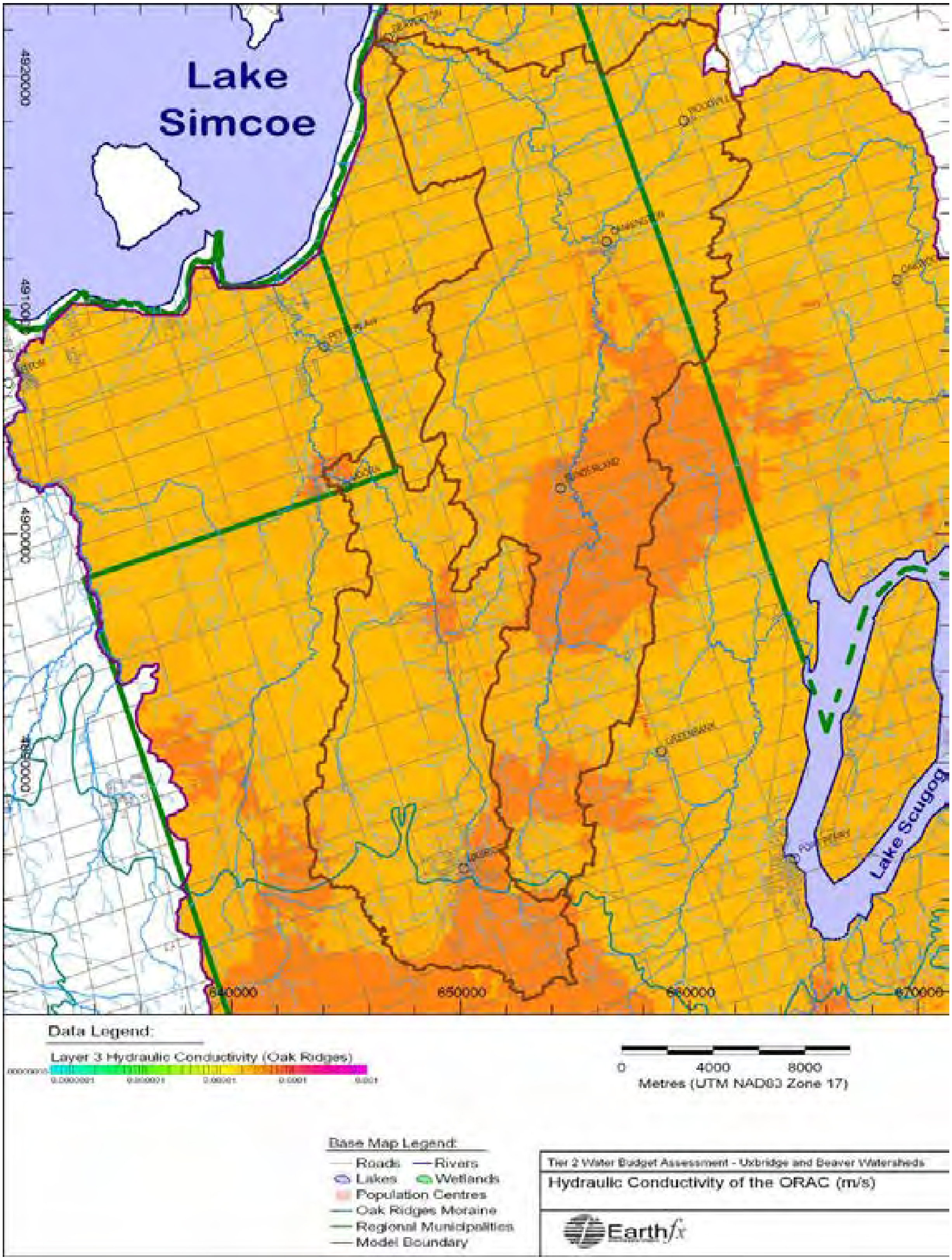


Figure 5-5: Hydraulic conductivity, in m/s, for Layer 3 (ORAC) (Earthfx, 2011a).

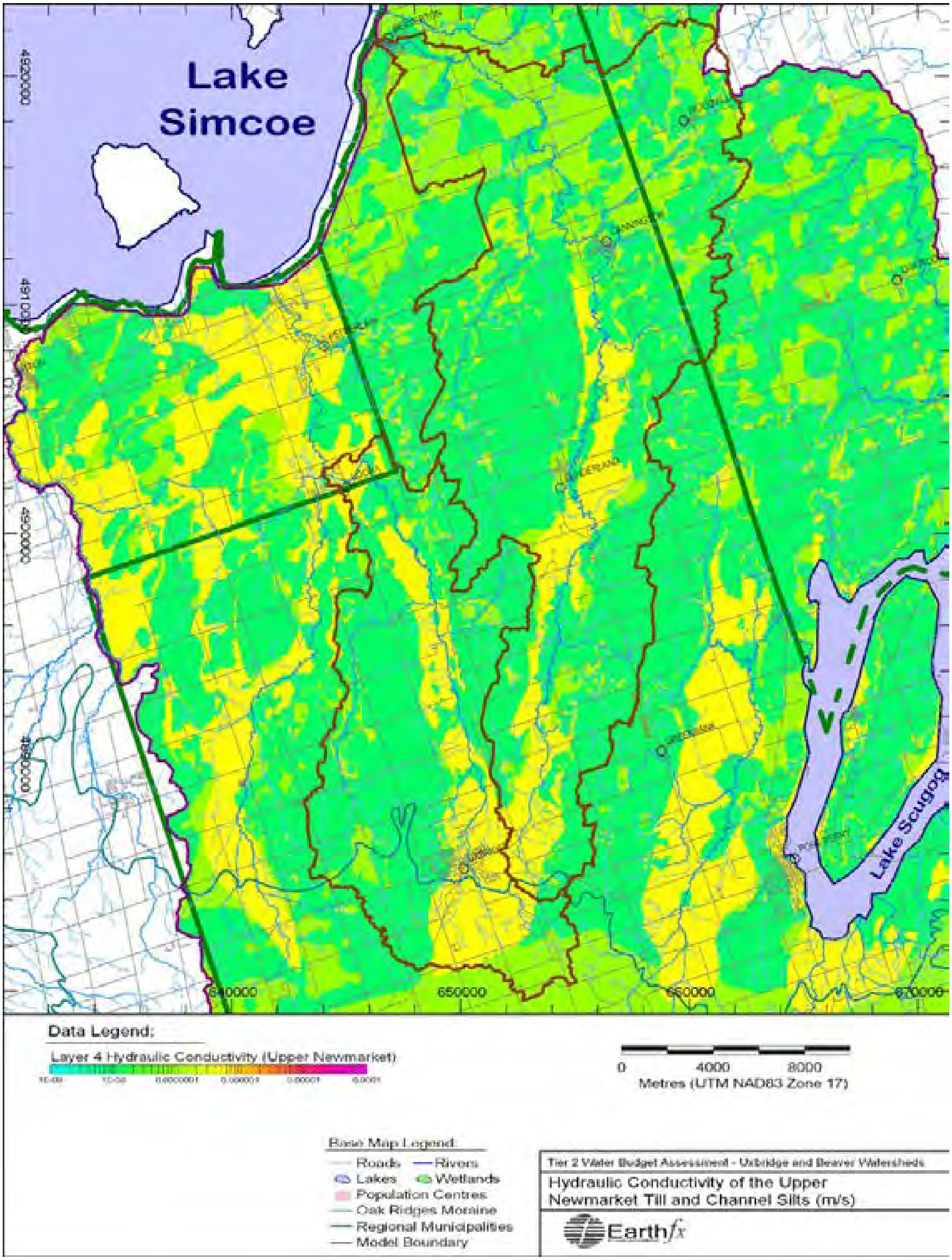


Figure 5-6: Hydraulic conductivity, in m/s, for Layer 4 (Upper Newmarket Till and Channel Silts) (Earthfx, 2011a).

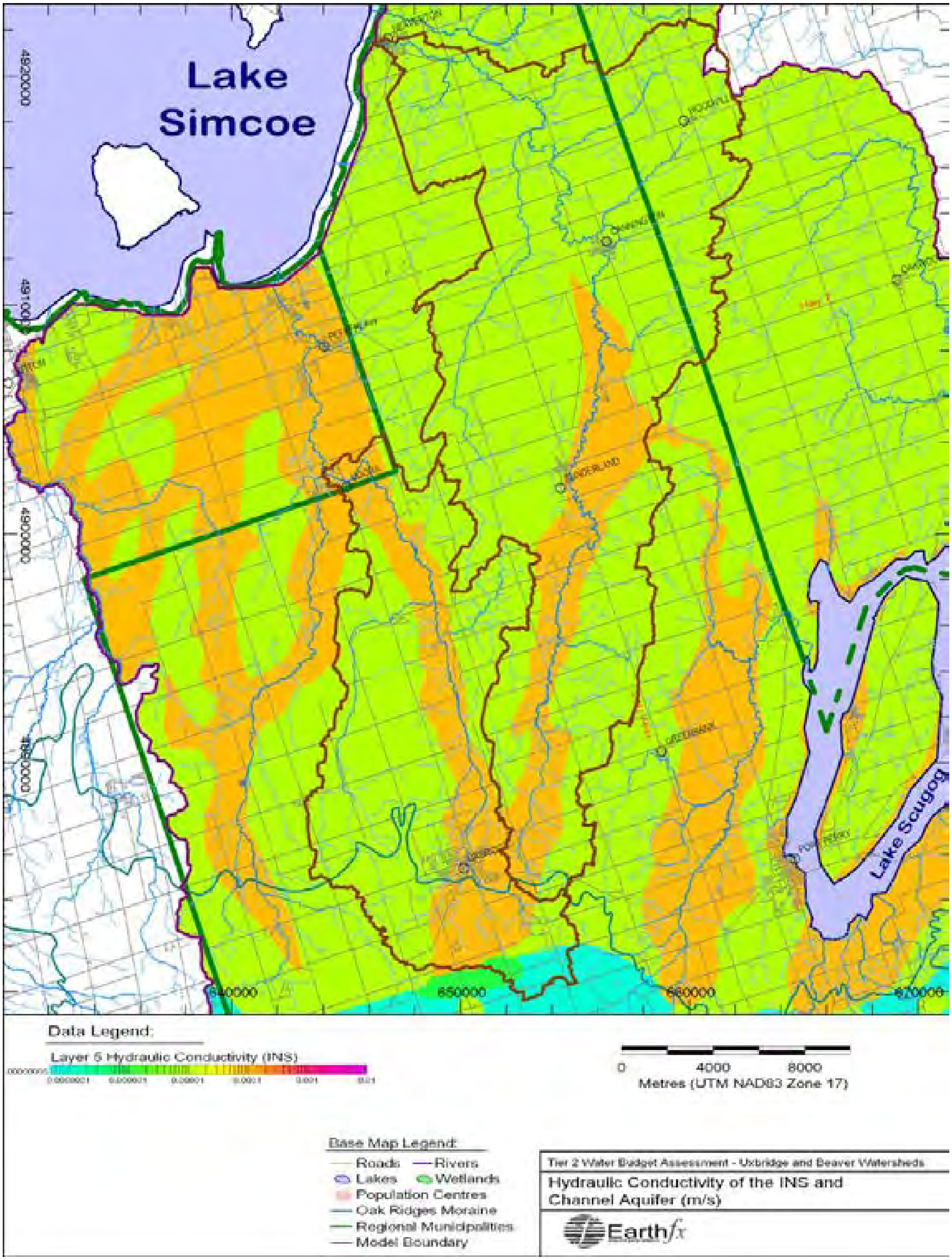


Figure 5-7: Hydraulic conductivity, in m/s, for Layer 5 (INS and Channel Aquifer) (Earthfx, 2011a).

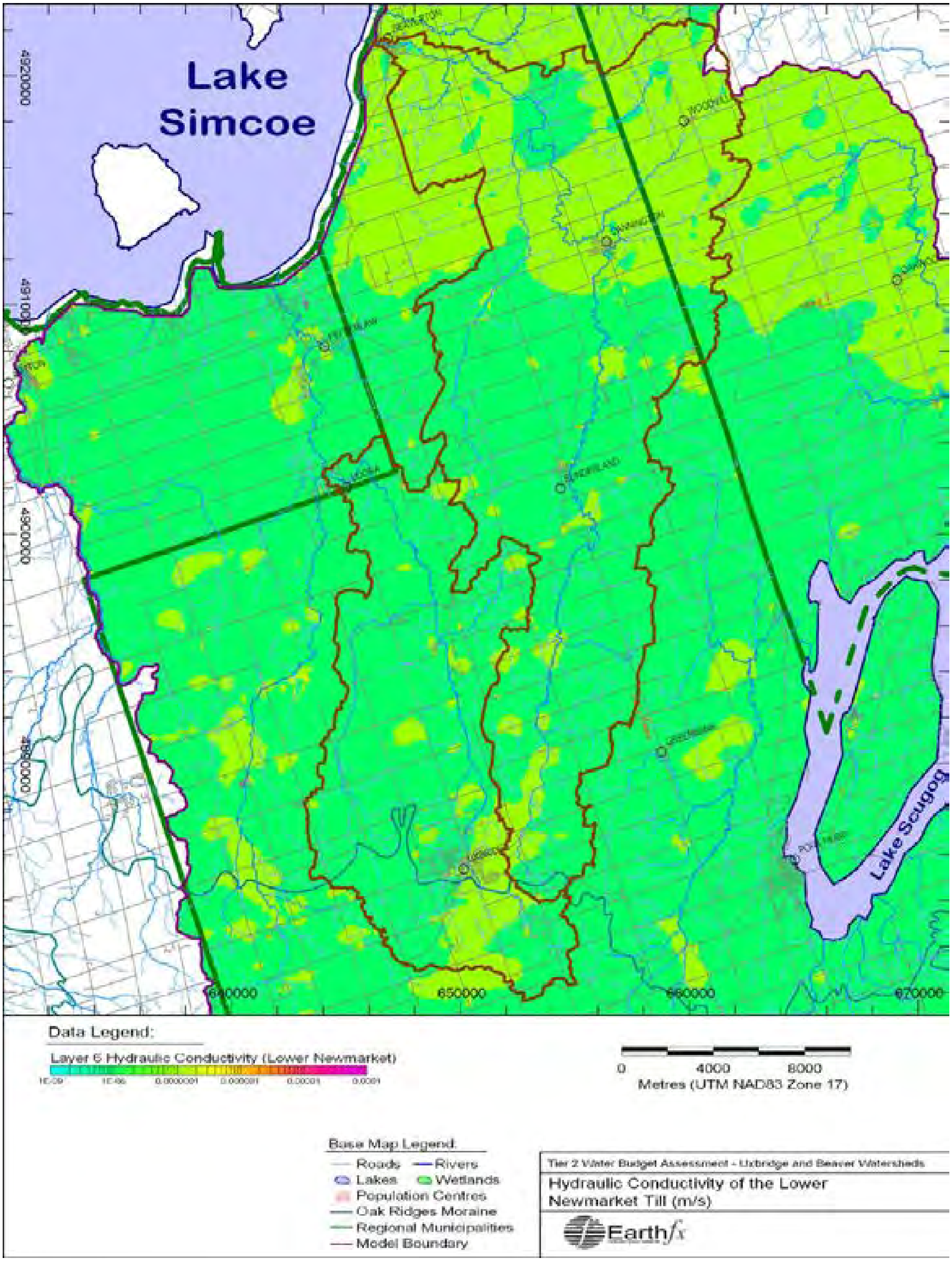


Figure 5-8: Hydraulic conductivity, in m/s, for Layer 6 (Lower Newmarket Till) (Earthfx, 2011a).

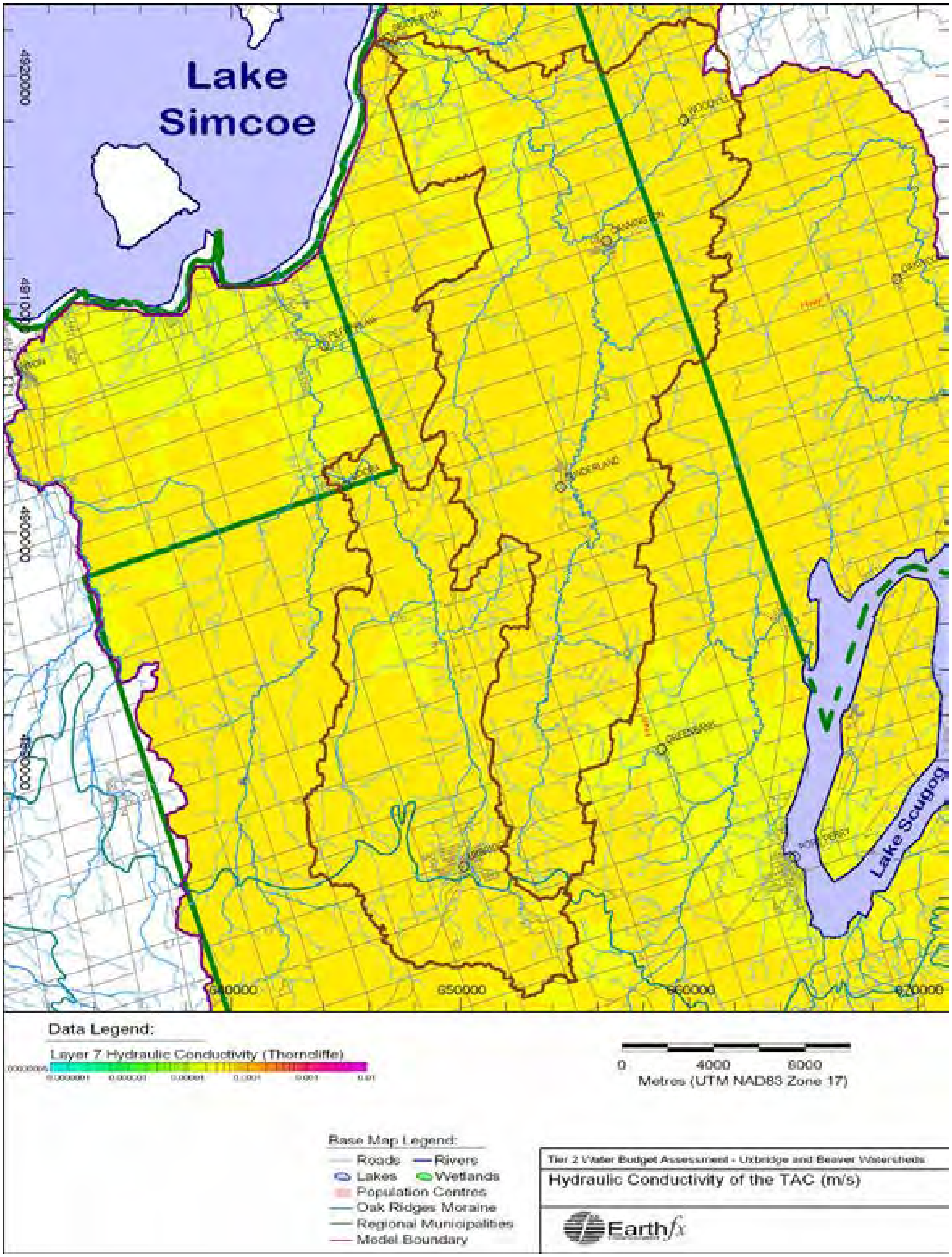


Figure 5-9: Hydraulic conductivity, in m/s, for Layer 7 (TAC) (Earthfx, 2011a).

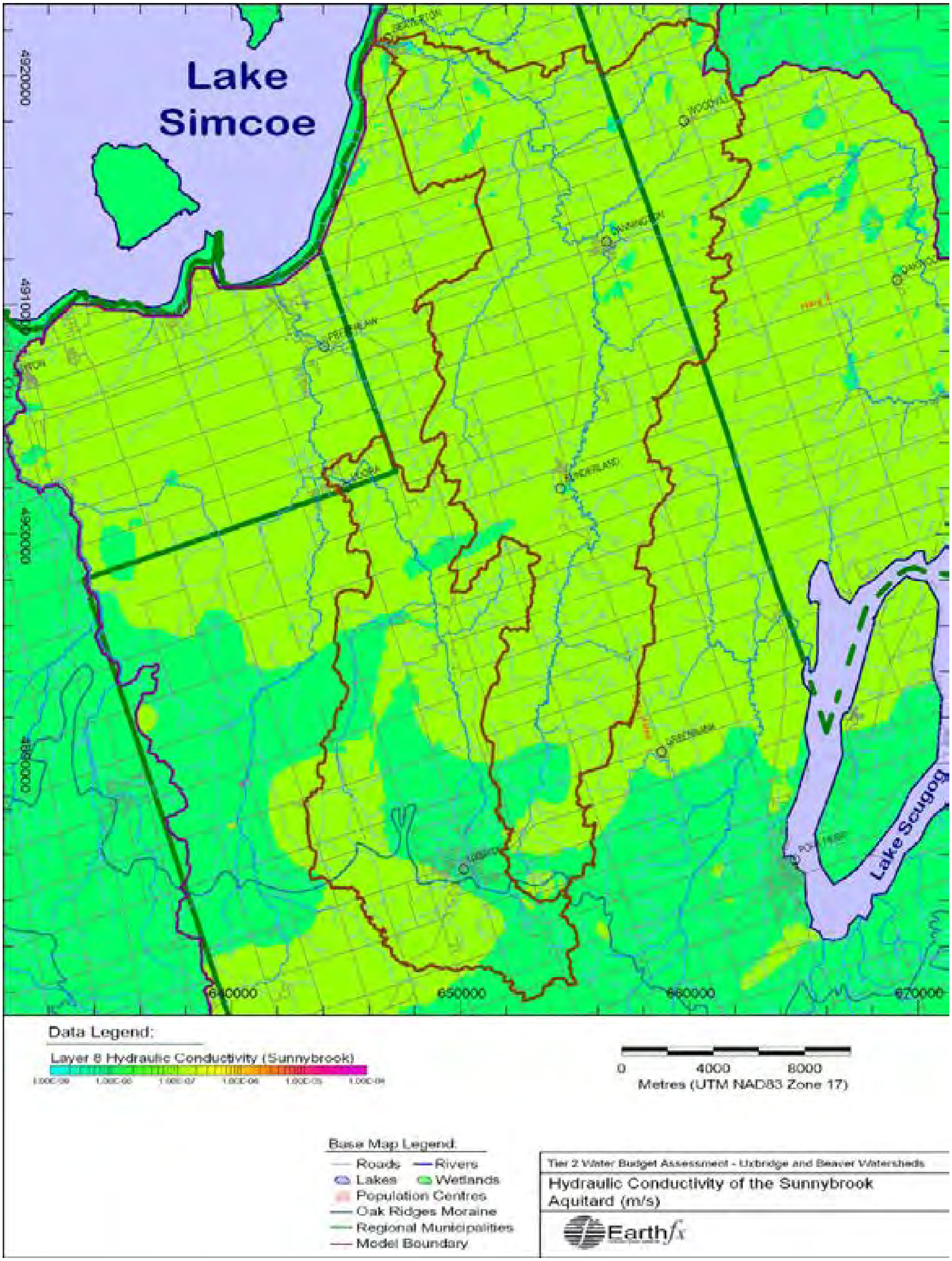


Figure 5-10: Hydraulic conductivity, in m/s, for Layer 8 (Sunnybrook aquitard) (Earthfx, 2011a).

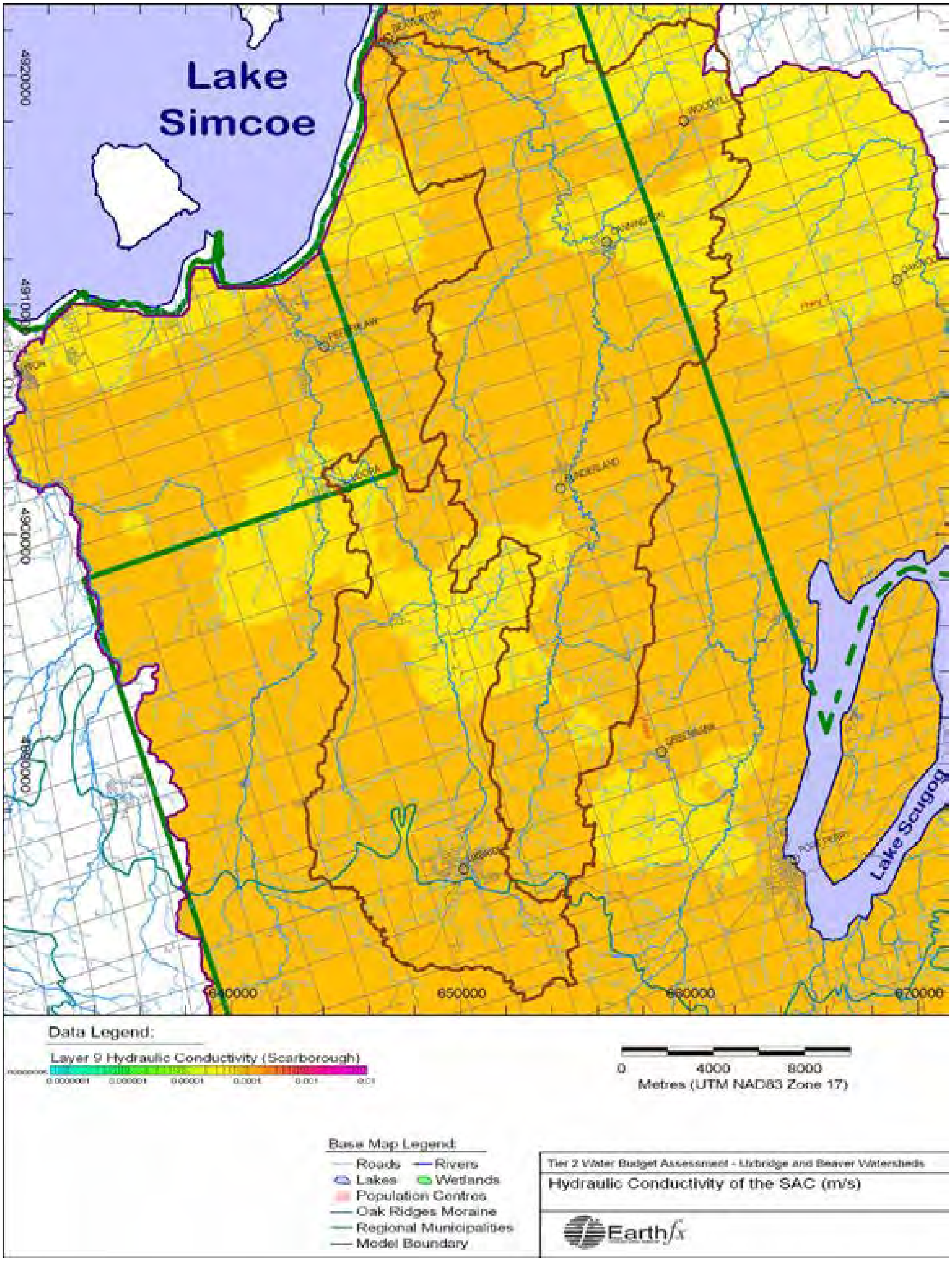


Figure 5-11: Hydraulic conductivity, in m/s, for Layer 9 (SAC) (Earthfx, 2011a).

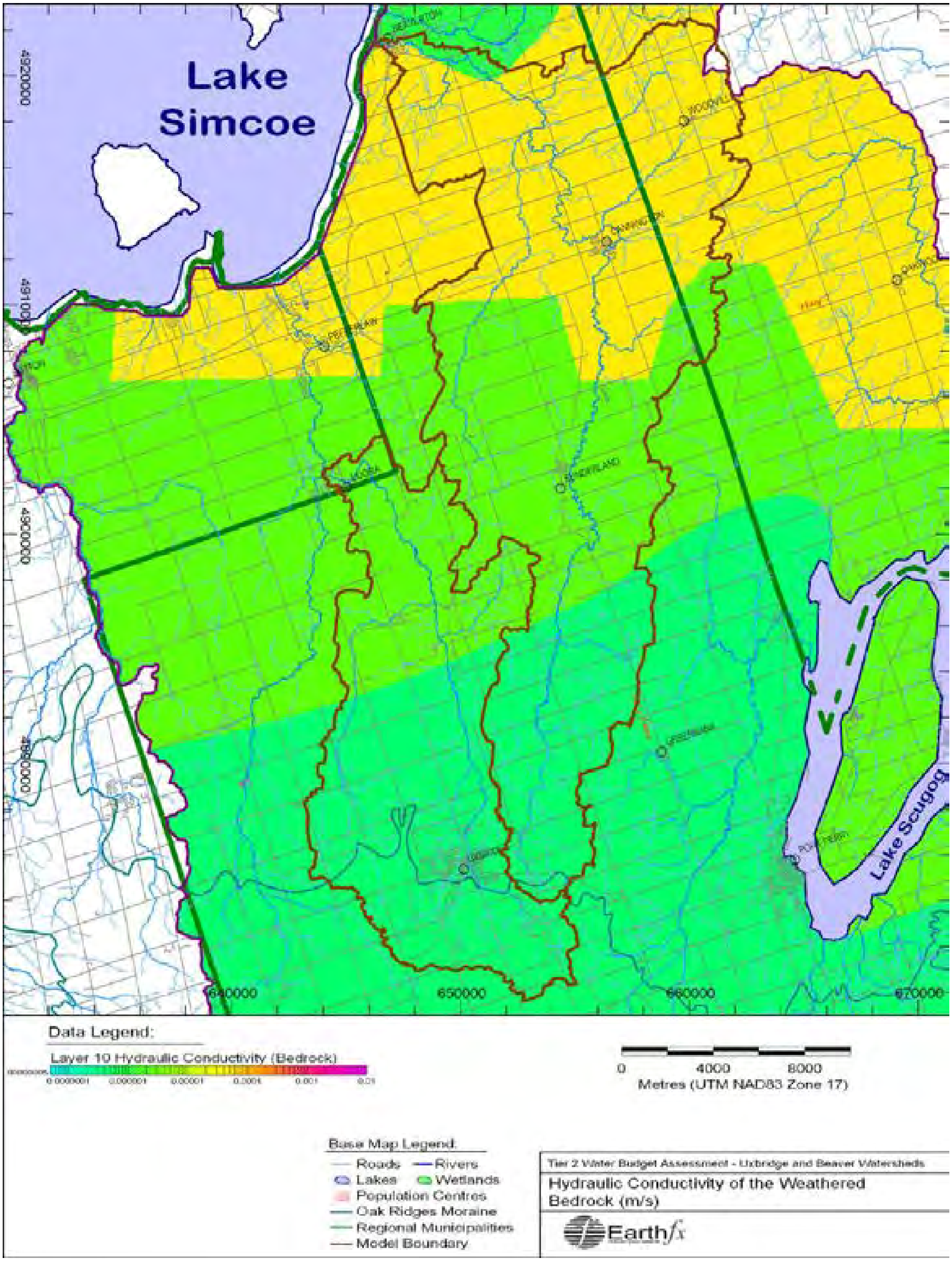


Figure 5-12: Hydraulic conductivity, in m/s, for Layer 10 (Weathered Bedrock) (Earthfx, 2011a).

5.2.3 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 formations mentioned in Section 5.2.2. 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. Simulated and observed water levels are shown in Figure 5-13 and Figure 5-14 for the ORAC and INS respectively. Contours of hydraulic head have been drawn over the water levels to illustrate the direction of shallow groundwater flow.

Groundwater flow within the deep groundwater flow system comprised of the Thorncliffe (Figure 5-15) and Scarborough (Figure 5-16) aquifer complexes exhibit a similar, but more subdued, pattern to the shallow flow system, with flow converging on the lower reaches of the major streams. The southern boundary of the study area along the ORM appears to approximate a groundwater flow divide for all three aquifer complexes. It should be noted that the potentiometric surface for the Scarborough Aquifer Complex is the least certain as it is based on fewer data points than the two overlying aquifers, which may explain the lack of clear channel flow dominated systems in the observed data (Earthfx & Gerber, 2008).

Due to the presence of permeable surface soils and hummocky topography, the Oak Ridges Moraine is the primary recharge area to the underlying aquifers. Groundwater flow within the three major aquifer systems is generally from the topographic highs associated with the ORM towards the topographic lows associated with the major stream channels and Lake Simcoe. In the shallow groundwater flow system, groundwater flow patterns are influenced by ground surface topography, but are more significantly influenced by the stream network. Local deflections in flow direction towards tributary streams and their associated valleys occur in all three aquifers (Earthfx & Gerber, 2008).

A geologic profile in the general north-south direction from the Oak Ridges Moraine to Lake Simcoe (Figure 5-17 to Figure 5-19) shows the various components of the hydrogeologic system in this subwatershed.

Groundwater is exchanged between the different aquifers as leakage across the aquitards. The direction of vertical flow depends on the relative heads in the different aquifers. Leakage rates vary locally depending on the magnitude of the vertical gradients and on the thickness and hydraulic conductivity of the confining units. Leakage is downward beneath the ORM, especially where the Newmarket Till is thin. Gradients are generally downward over most of the study area and are steepest where the Newmarket Till is thickest. Local reversals in the gradient are noted in the vicinity of streams where water levels in the upper aquifer are depressed in the northwest along the Lake Simcoe shoreline although the data to support these observations is sparse (Earthfx, 2001a).

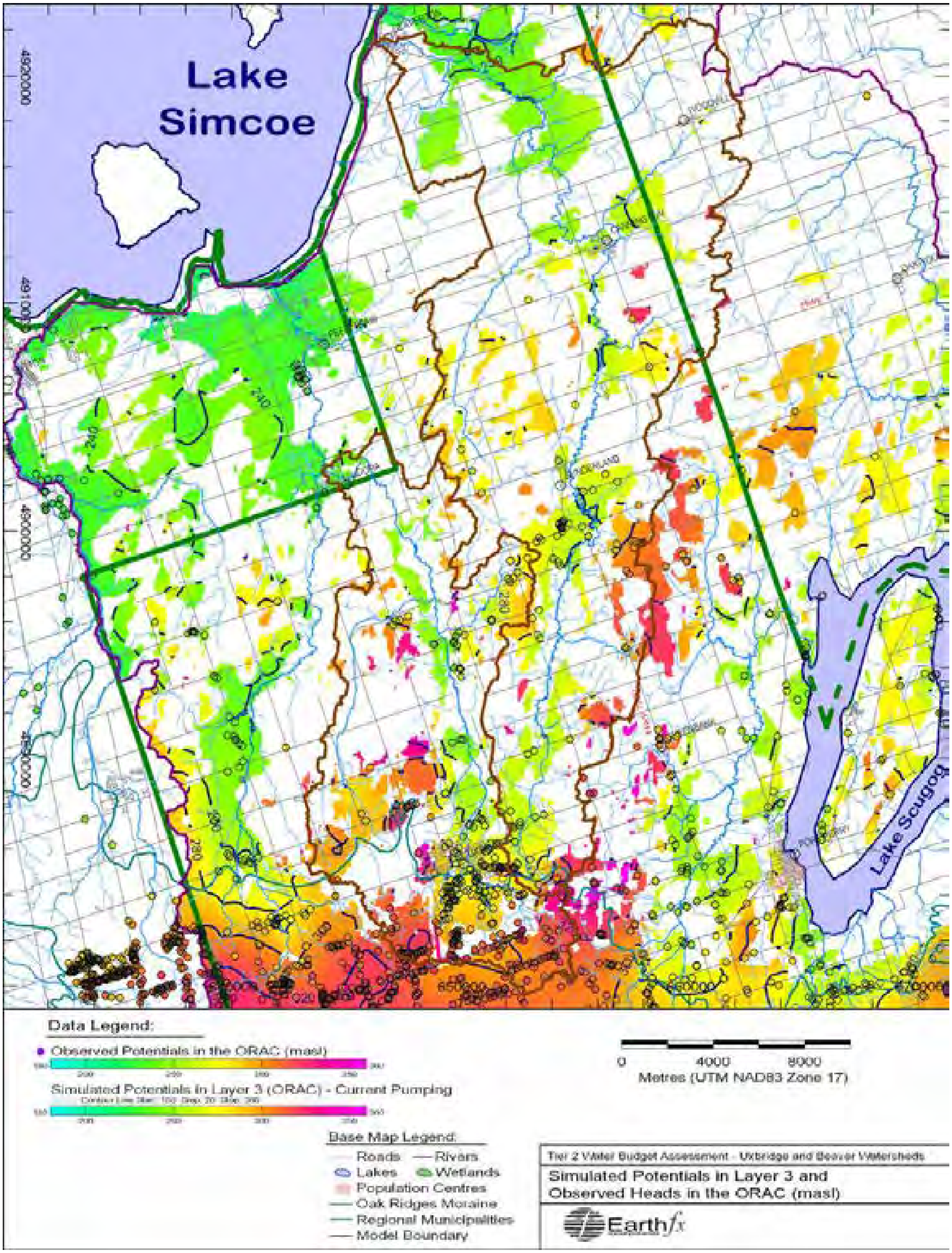


Figure 5-13: Simulated and observed water levels in Layer 3 (ORAC) - current conditions (Earthfx, 2011a).

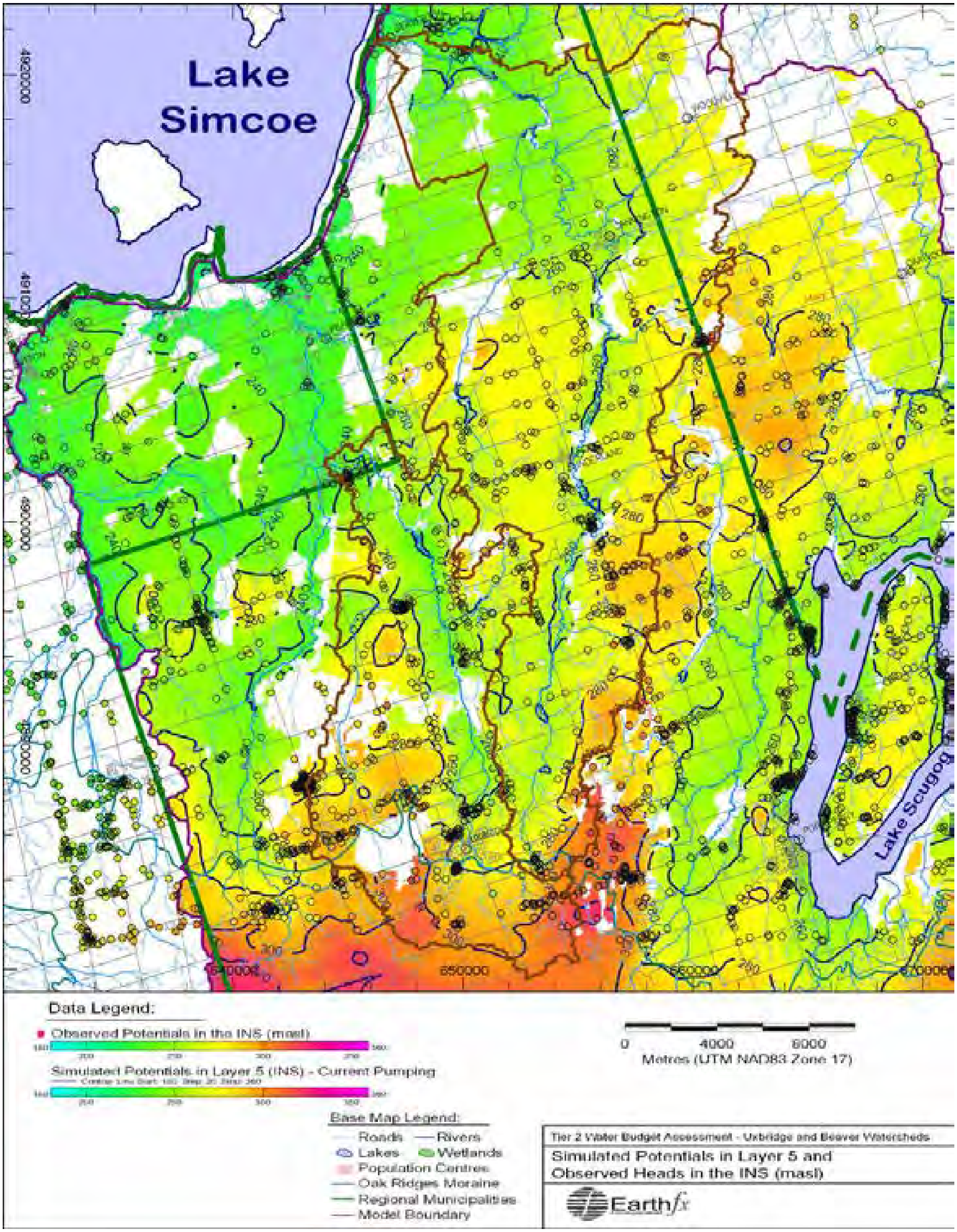


Figure 5-14: Simulated and observed water levels in Layer 5 (INS)-current conditions (Earthfx, 2010a).

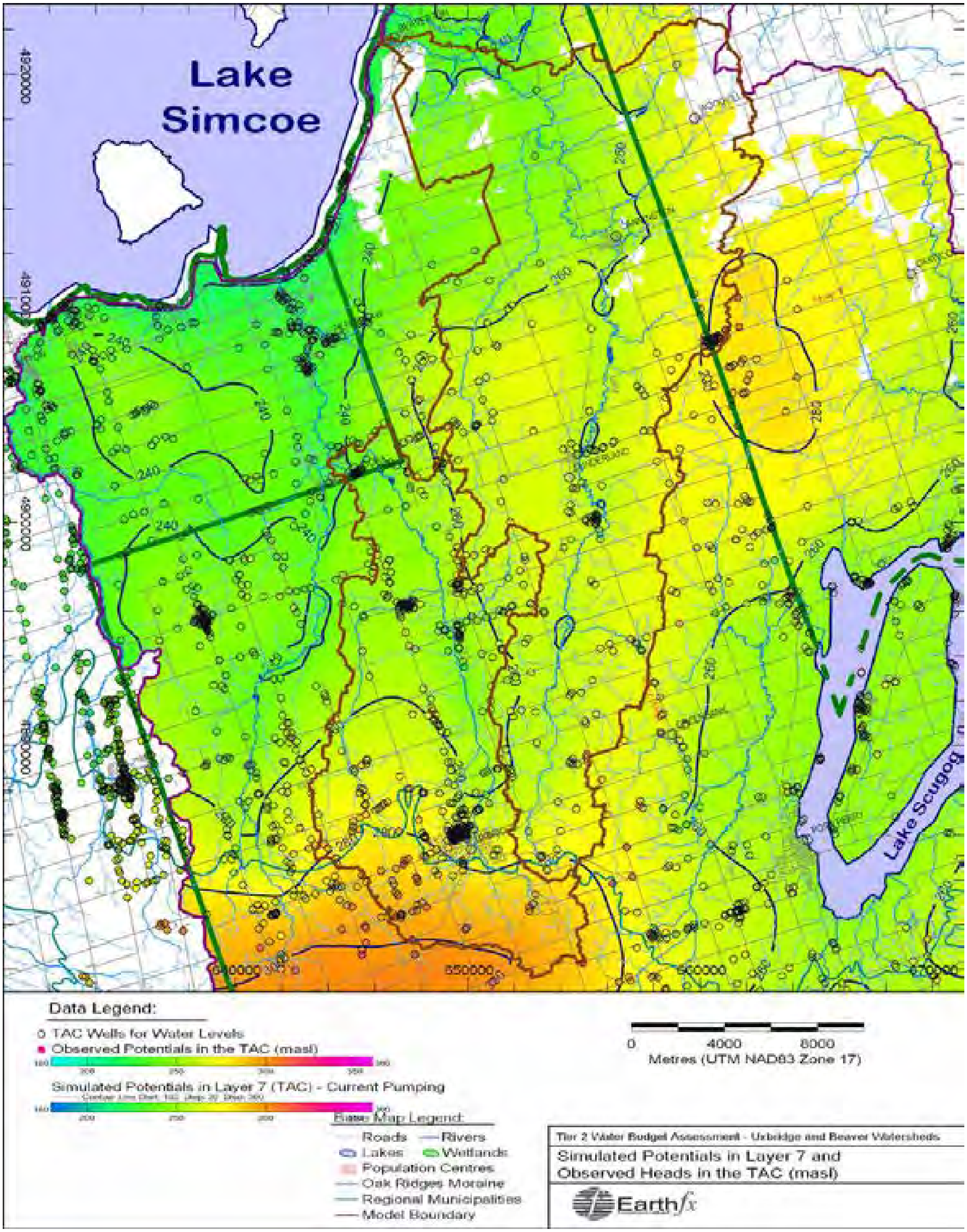


Figure 5-15: Simulated and observed water levels in Layer 7 (TAC)-current conditions (Earthfx, 2011a).

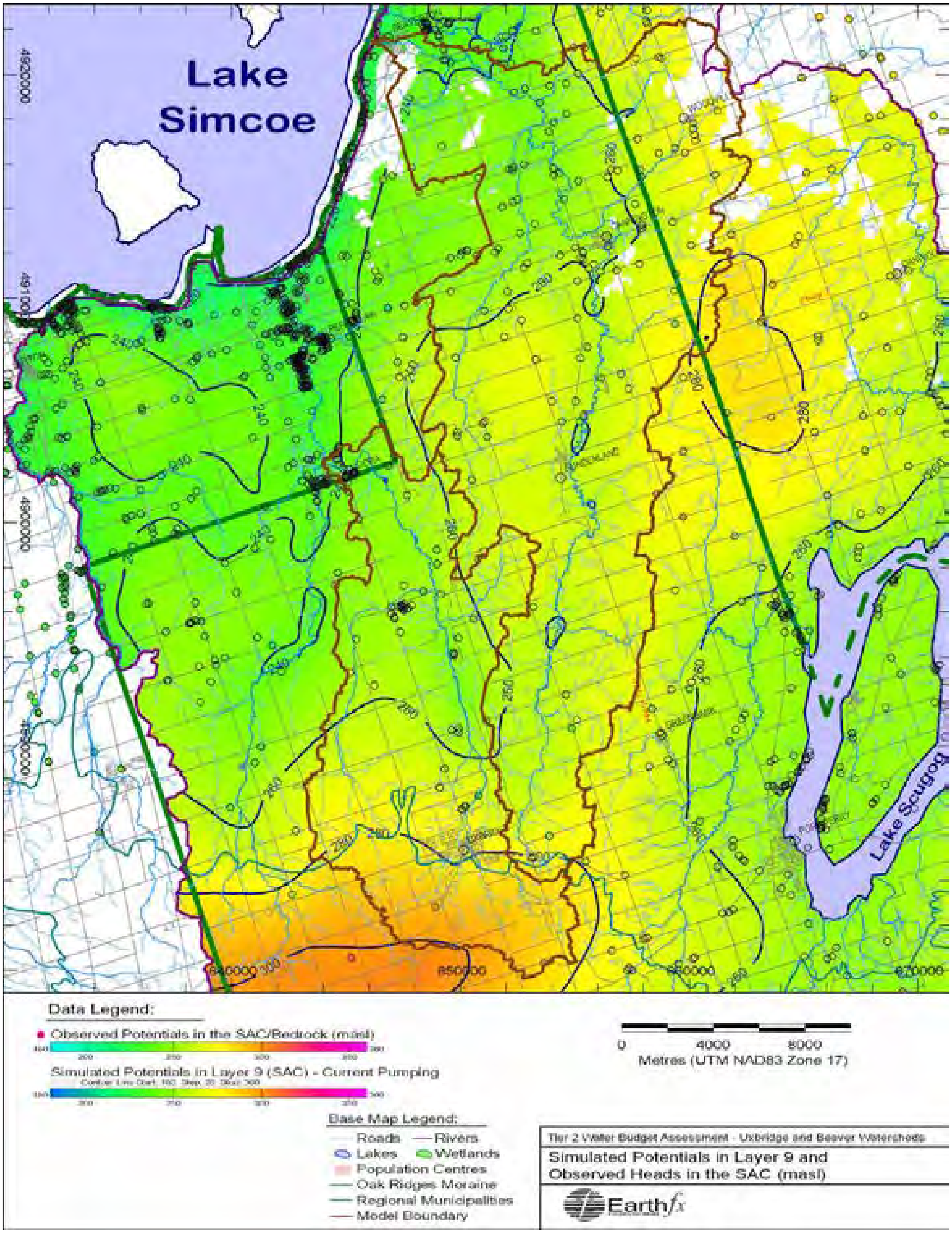


Figure 5-16: Simulated and observed water levels in Layer 9 (SAC)-current conditions (Earthfx, 2011a).

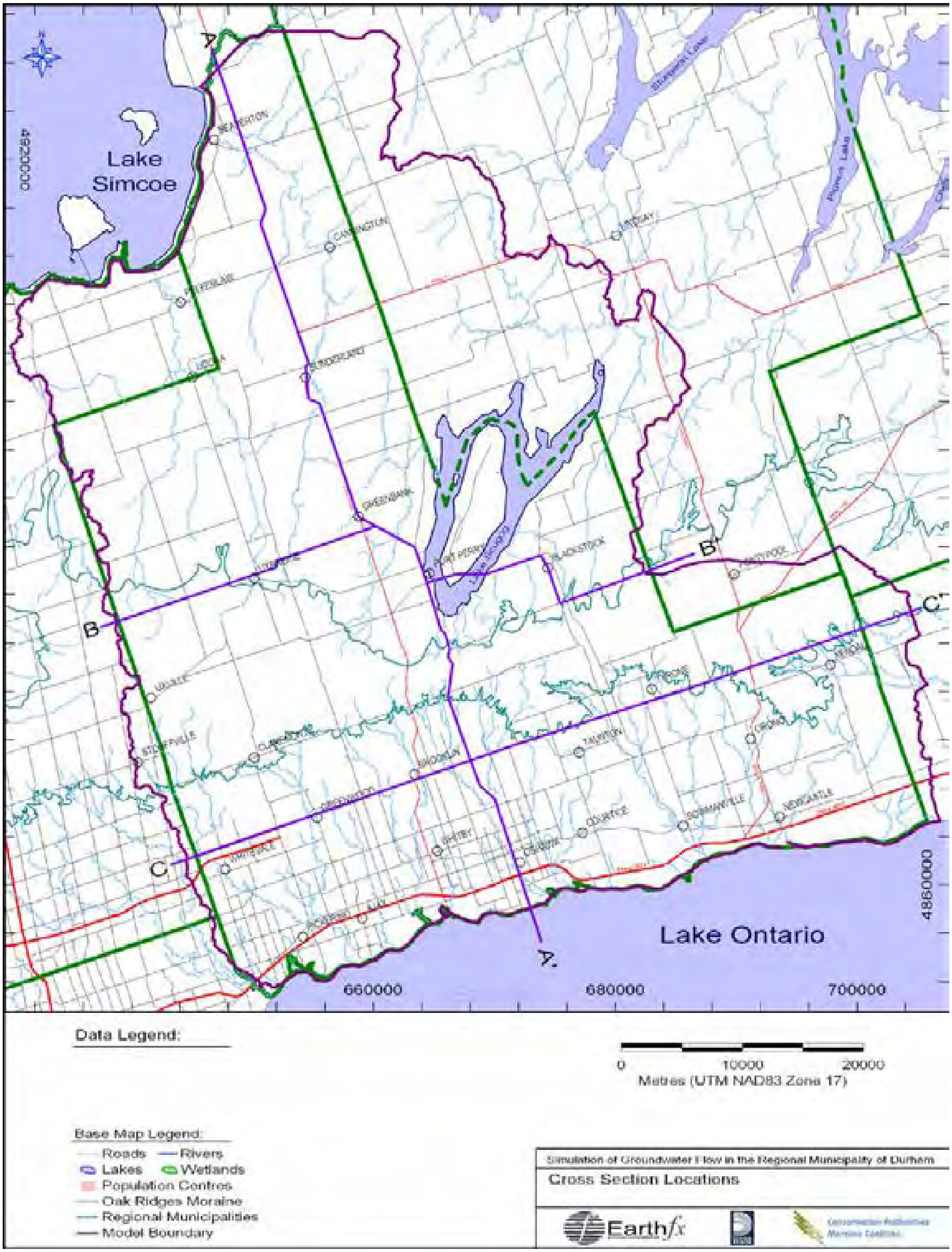


Figure 5-17: Location of cross-section lines (Earthfx, 2011a).

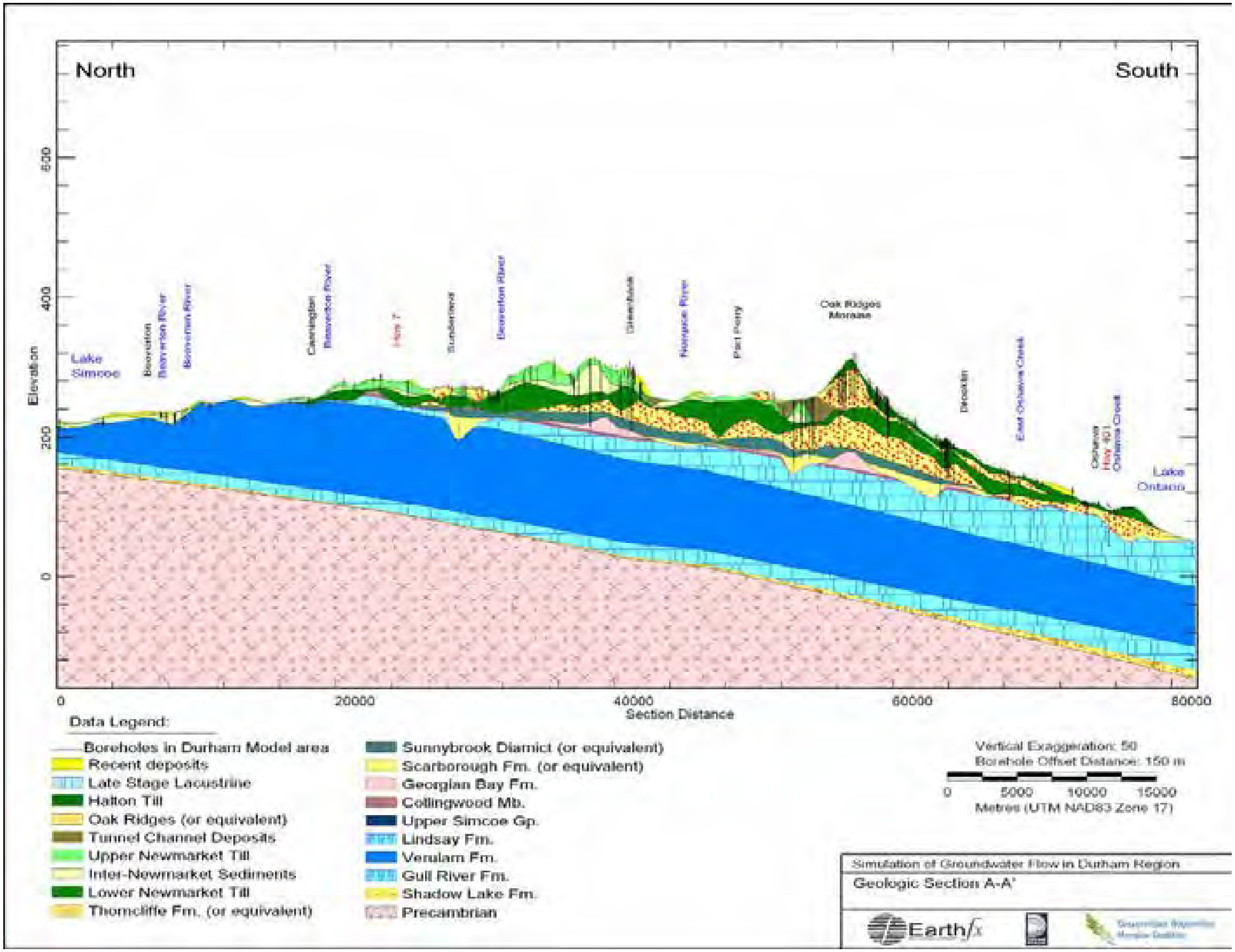


Figure 5-18: Geologic cross section A-A' (north to south) (Earthfx, 2009).

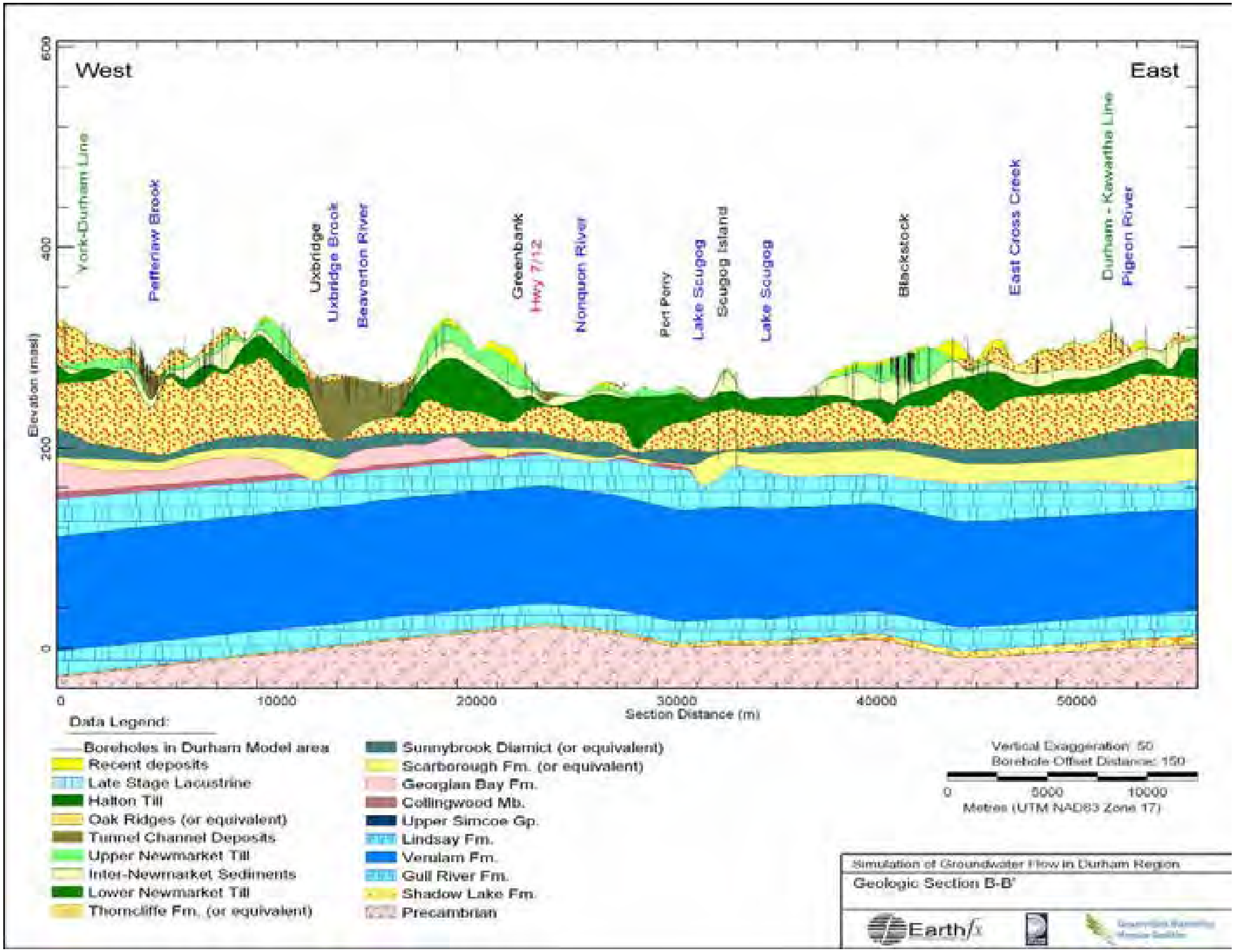


Figure 5-19: Geologic cross section B-B' (west to east) (Earthfx, 2009).

5.2.4 Streamflow

The Durham Model and related data compilation covers an area well beyond the boundaries of Pefferlaw Brook and Uxbridge Brook study subwatersheds. Figure 5-20 shows the locations of the major streams in the model area and their catchment area as defined by land surface topography. Figure 5-20 also shows the location of the HYDAT stream gauges monitored by Environment Canada. There is one stream gauge each within each of the Pefferlaw Brook and Uxbridge Brook subwatersheds; the station on the main branch of Pefferlaw River just north of the hamlet of Udora has been in operation since 1987, and the station on the Uxbridge Brook tributary has been in operation since 2006.

Gauge locations, their period of record, and streamflow statistics for the period of record are presented in Table 5-1. The mean daily discharge for the Udora station is 3.162 m^3/sec between 1969 and 2010.

The Uxbridge gauge (02EC101) is located immediately downstream of a mill pond, with regulated flow characterized by a relatively flat mean-daily hydrograph (Figure 5-21). Although baseflow separation techniques are not applicable to regulated gauges, total volumes for 02EC101 have been well matched. Here, the model is under-predicting total volumes. The sources of this extra water probably include the Uxbridge Water Pollution Control Plant (WPCP), which adds roughly 3,000 m^3/d; four un-decommissioned flowing wells that discharge directly into Uxbridge Brook (2,500 m^3/d); and the dewatering operations of the many gravel pits located within the catchment. Due to the relative size of this catchment, these inputs likely add significantly to the discharge at gauge 02EC101 (Earthfx, 2010a).

In addition, the Uxbridge (02EC101) gauge is unique because the majority of its contributing area falls within the ORM. The ratio of the 90th percentile low flow to the median flow (Q_{90}:Q_{50}) suggests that the reach is regulated, which is the case, as there is a mill pond immediately upstream of the gauge. Still, based on the 95th percentile low flow (Q_{95}) rates, recharge on the ORM must be at least 350 mm/yr, more than double the recharge estimated by PRMS over the entire Uxbridge Brook subwatershed (Earthfx, 2010a).

The Udora gauge (02EC103/02EC018) (Figure 5-22) is the only long-term gauge (02EC018 replaced 02EC103 sometime in 1987 and both are located at the same location) whose contributing area contains the entire Uxbridge Brook subwatershed. Predominant land uses are agriculture, forest, and wetland. Although there are many communities, the catchment remains relatively un-urbanized with only 7% of the catchment covered by rural and urban development (Earthfx, 2010a).

Figure 5-23 displays monthly mean flow for period of record (the last three years are plotted individually, and the rest of the data is shown as mean, minimum, and maximum levels). This figure gives a good indication of the spread of river flows in the subwatershed.

Table 5-1: Flow statistics for gauged catchments in the model area (Earthfx, 2011a).

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)
02EC011	Beaverton River Near Beaverton	1966	1993	282	2.838	0.303	1.270
02EC018	Pefferlaw Brook Near Udora	1987	2005	332	2.945	1.020	2.080
02EC101	Uxbridge Brook At Uxbridge	1970	1985	24.3	0.364	0.275	0.327
02EC103	Pefferlaw Brook Near Udora	1969	1986	332	3.285	1.150	2.210
Combined	Pefferlaw Brook Near Udora	1969	2010	332	3.162	1.100	2.200

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)
continuous records*							

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

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 5-22 displays a hydrograph of daily flow at the Udora flow station for a period of 2008 plotted against daily precipitation. Based on the size of the contributing catchment and in comparison with other subwatersheds in the Lake Simcoe basin the Pefferlaw River shows good storage capacity. The river can be seen to respond to most precipitation events with a slow gentle rise and descent in water levels. An intense event in early August followed by an additional five rainy days shows a dramatic elevation in flow; however, even here the flow follows a steep but stable increase. In contrast Figure 5-21 displays the Uxbridge Brook flow gauge for the same period. The contributing catchment for this gauge is smaller, has relatively steeper topography, and within it is the Town of Uxbridge, with its associated increase in impervious surface. Flow can be seen to respond quickly to a precipitation event and return to baseflow shortly thereafter. The early August event that yielded a dramatic peak at Udora elicits multiple peaks in the Uxbridge system highlighting the more flashy nature of the system.

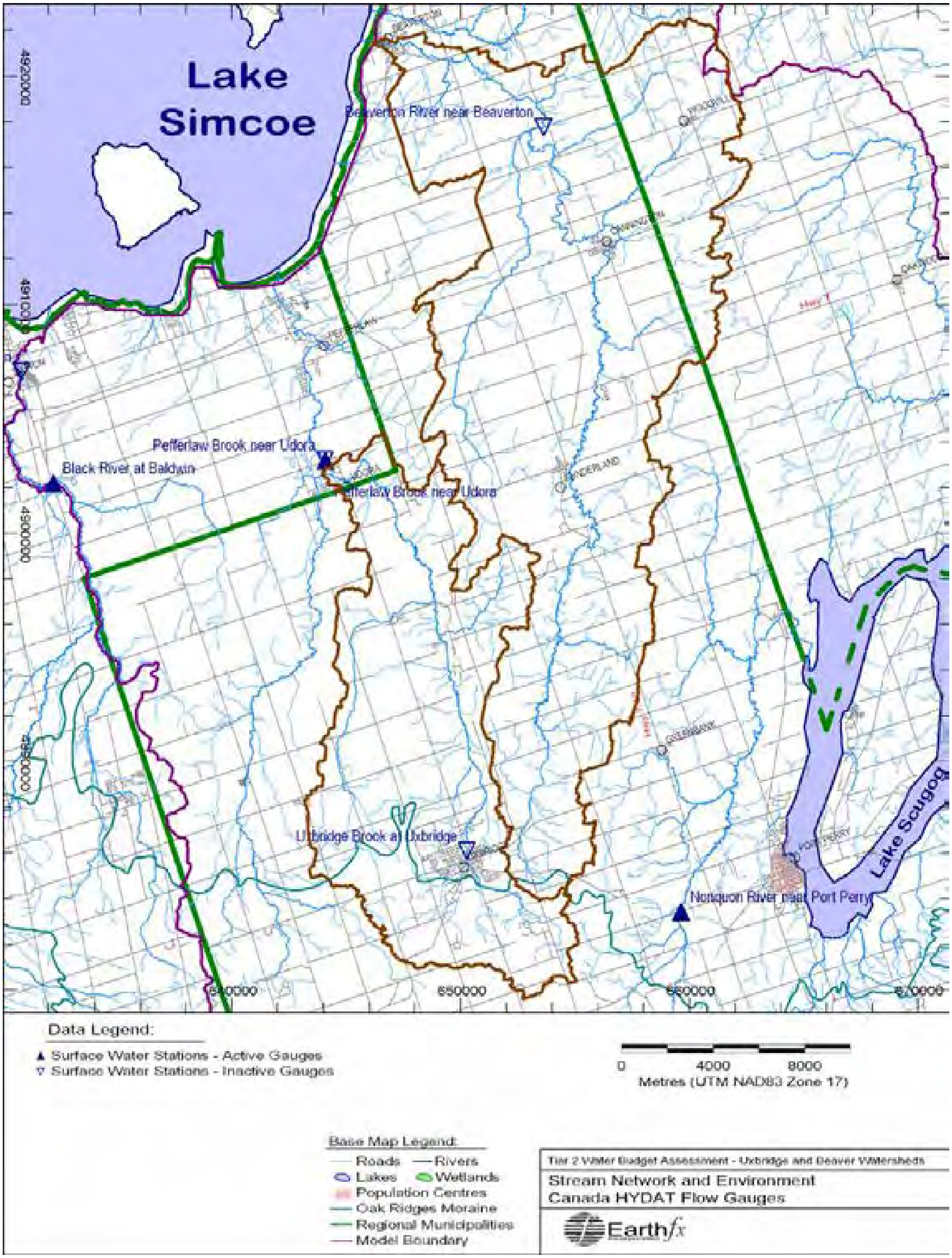


Figure 5-20: Streams in the study area and Environment Canada HYDAT flow gauges (Earthfx, 2010a).

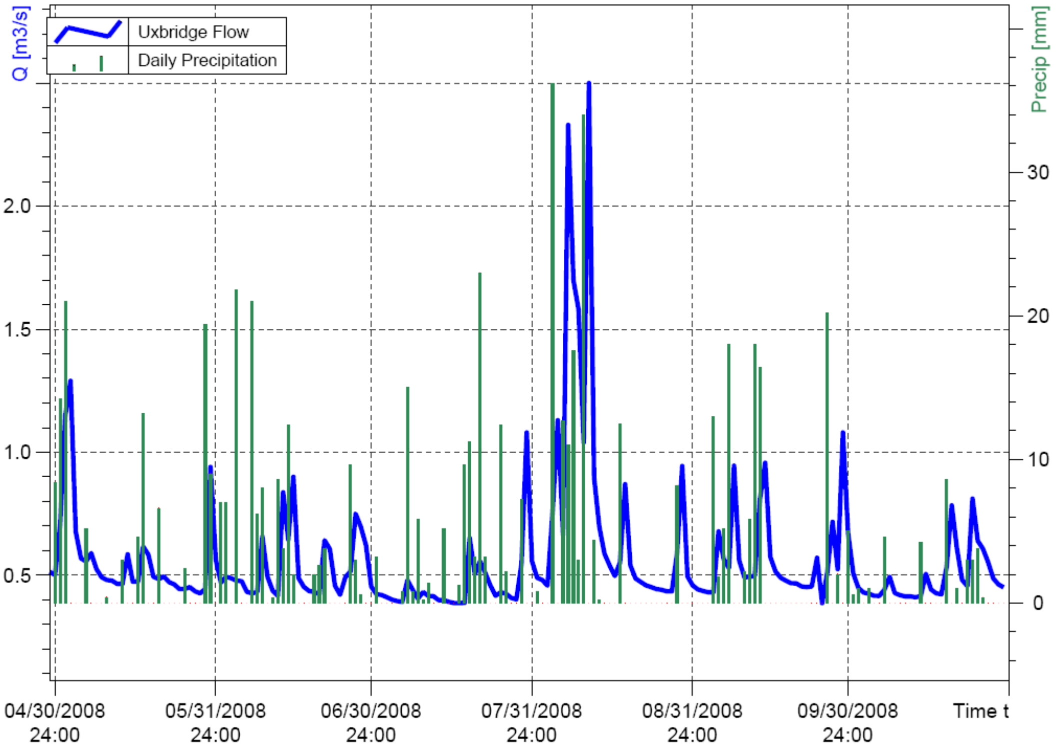


Figure 5-21: Daily flow at the Uxbridge Brook flow station and daily precipitation (April-September, 2008).

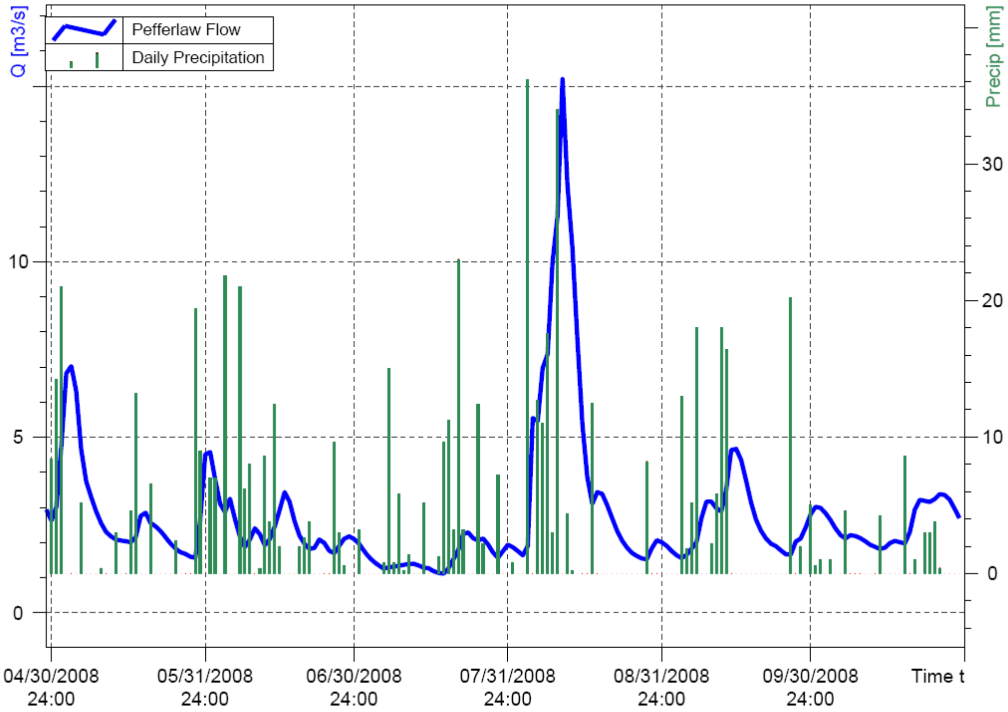


Figure 5-22: Daily flow at the Udora River flow station and daily precipitation (April- September, 2008).

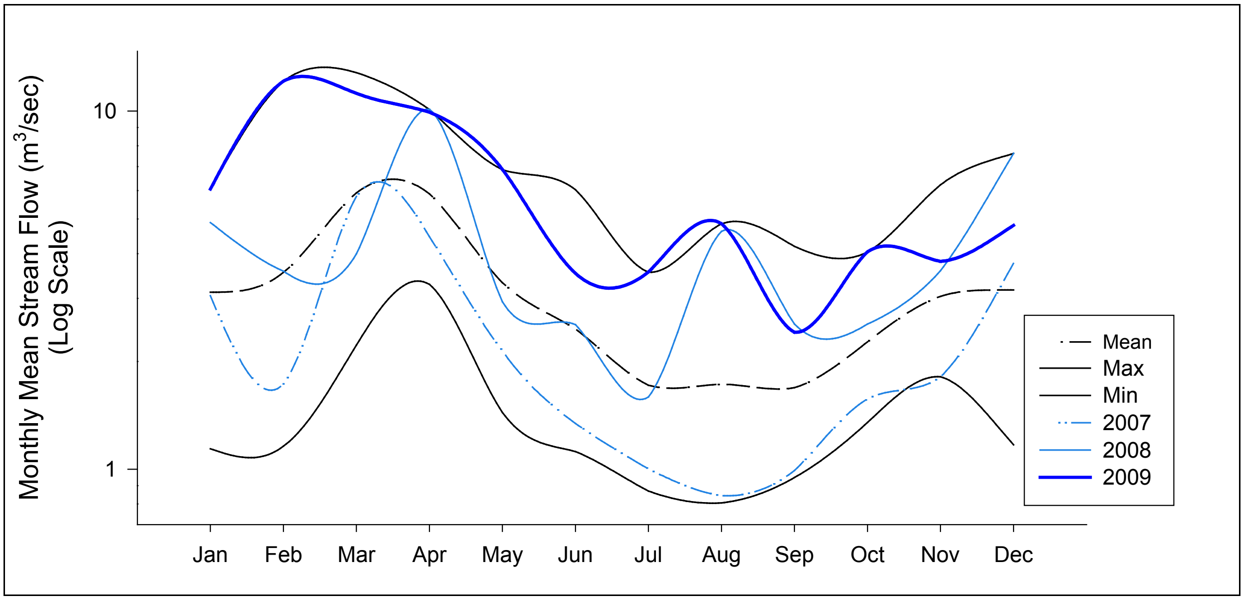


Figure 5-23: Monthly mean flow in the Pefferlaw River and Uxbridge Brook subwatersheds.

Baseflow

Baseflow is 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 there are too few to accurately describe baseflow across the entire subwatershed. For this reason spot baseflow discharge measurements were conducted on the Pefferlaw and Uxbridge Brook subwatersheds in July of 2004. Low flow stream surveys have also been conducted by the Geological Survey of Canada (GSC), and Conestoga Rovers and Associates (CRA, 2003), for the CAMC-YPDT ORM study. The results for the 2004 survey conducted by the LSRCA are illustrated in the following figure.

Low flow streamflow surveys measure the discharge at various points along a river reach during a period without influence from storm events. All or most of the flow in the stream during this period of time is assumed to represent groundwater discharge. The objective of these surveys was to identify those reaches receiving significant groundwater discharge (gaining reaches) and to determine relative rates of groundwater discharge to the various ungauged tributaries and stream reaches. This technique will also allow losses (losing reaches) to be identified, where flow decreases from upstream to downstream due to either anthropogenic influence, infiltration, or a combination of both.

Most noticeable in the Pefferlaw River subwatershed are the numerous strong gaining reaches in the headwaters originating on the Oak Ridges Moraine. 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 6 - Aquatic Habitat**). The area from the middle of the system to the mouth of the river is characterized by minimal gaining reaches and some stretches of losing reaches.

Discharge measures were collected 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 be due to water taking, groundwater infiltration, or impoundments. Figure 5-25 displays the active ground and surface water takers in relation to the gaining and losing reaches. Most of the active water takers are located in the vicinity of gaining reaches and a few are located within the vicinity of minimally gaining and losing reaches.

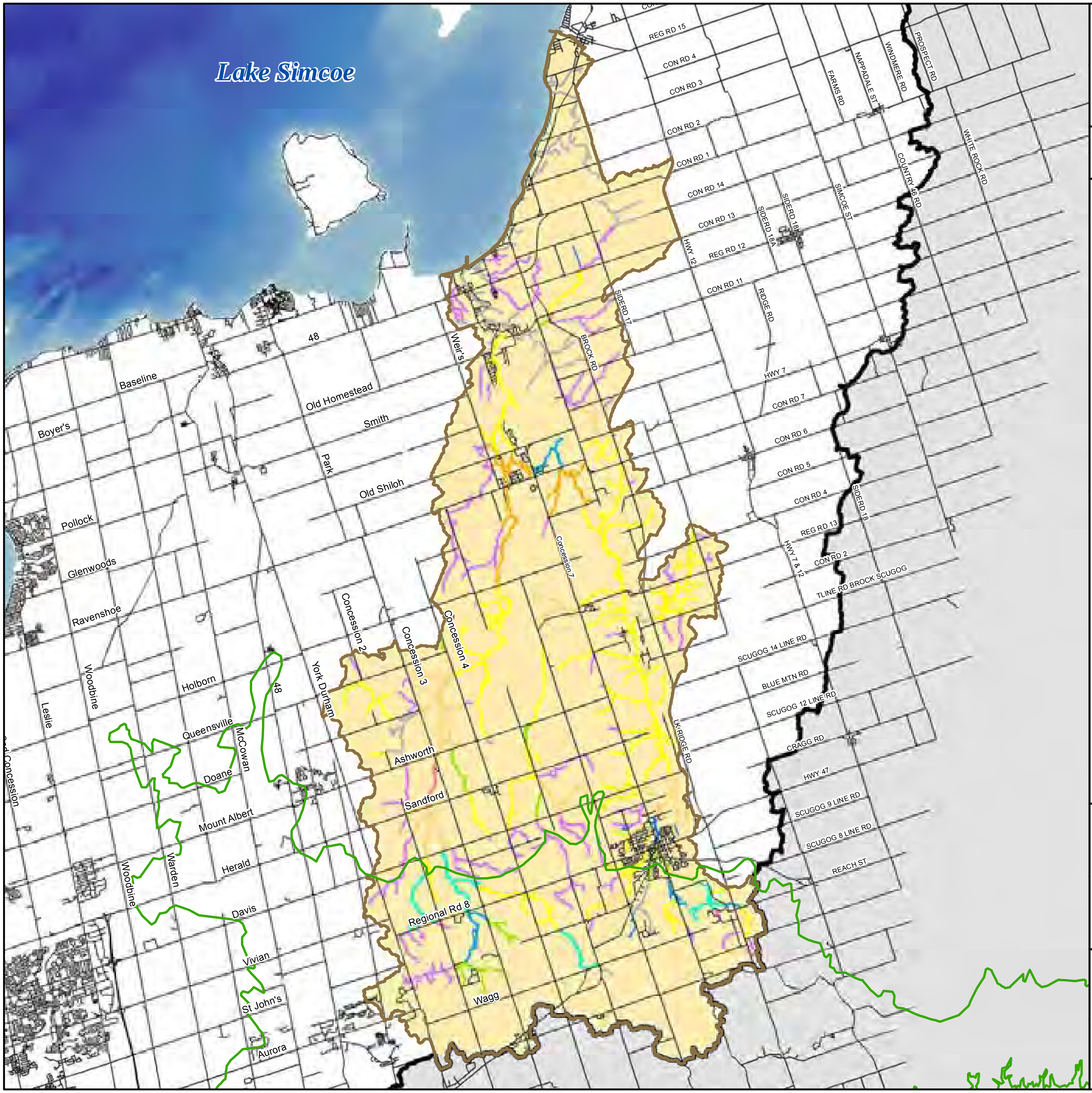
Discharge to streams can be determined through a groundwater flow model, baseflow separation applied to long-term flow gauge data, or from spot flow measurements if no other data is available. The component of streamflow that can be attributed to groundwater discharge was estimated by the groundwater flow model and baseflow separation techniques. An example of the hydrograph separation results using this methodology is shown in Table 5-2 and Figure 5-26. The model provided a better estimate of groundwater discharge to streams and the results ranged from 1.407 to 2.346 m3/sec, more than half of the total streamflow (Earthfx, 2010a). The calculated average annual groundwater discharge for the Pefferlaw River is 1.861 m^3/sec based on the HYDAT record, 60.5% of the average annual discharge for the 1987 to 2010 period of record.

Table 5-2: Baseflow estimates for gauged catchments. Please note that both equivalent recharge and the Baseflow Index (BFI) were calculated based on estimated average baseflow (Earthfx, 2010a).

Gauge ID	Gauge Location	Average Total Flow (m^3/s)	Estimated Minimum Average Baseflow (m^3/s)	Estimated Maximum Average Baseflow (m^3/s)	Equivalent Recharge (mm/yr)	BFI
02EC011	Beaverton River Near Beaverton	2.838	1.407	2.346	221	0.70
02EC018	Pefferlaw Brook Near Udora	2.945	1.441	2.489	197	0.71
02EC101	Uxbridge Brook At Uxbridge	0.364	0.178	0.332	389	0.82
02EC103	Pefferlaw Brook Near Udora	3.285	1.499	2.792	216	0.69

Gaining and losing reaches within the Pefferlaw River subwatershed

Figure 5-24



Legend

- Road
- LSRCA Watershed Boundary
- Oak Ridges Moraine

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

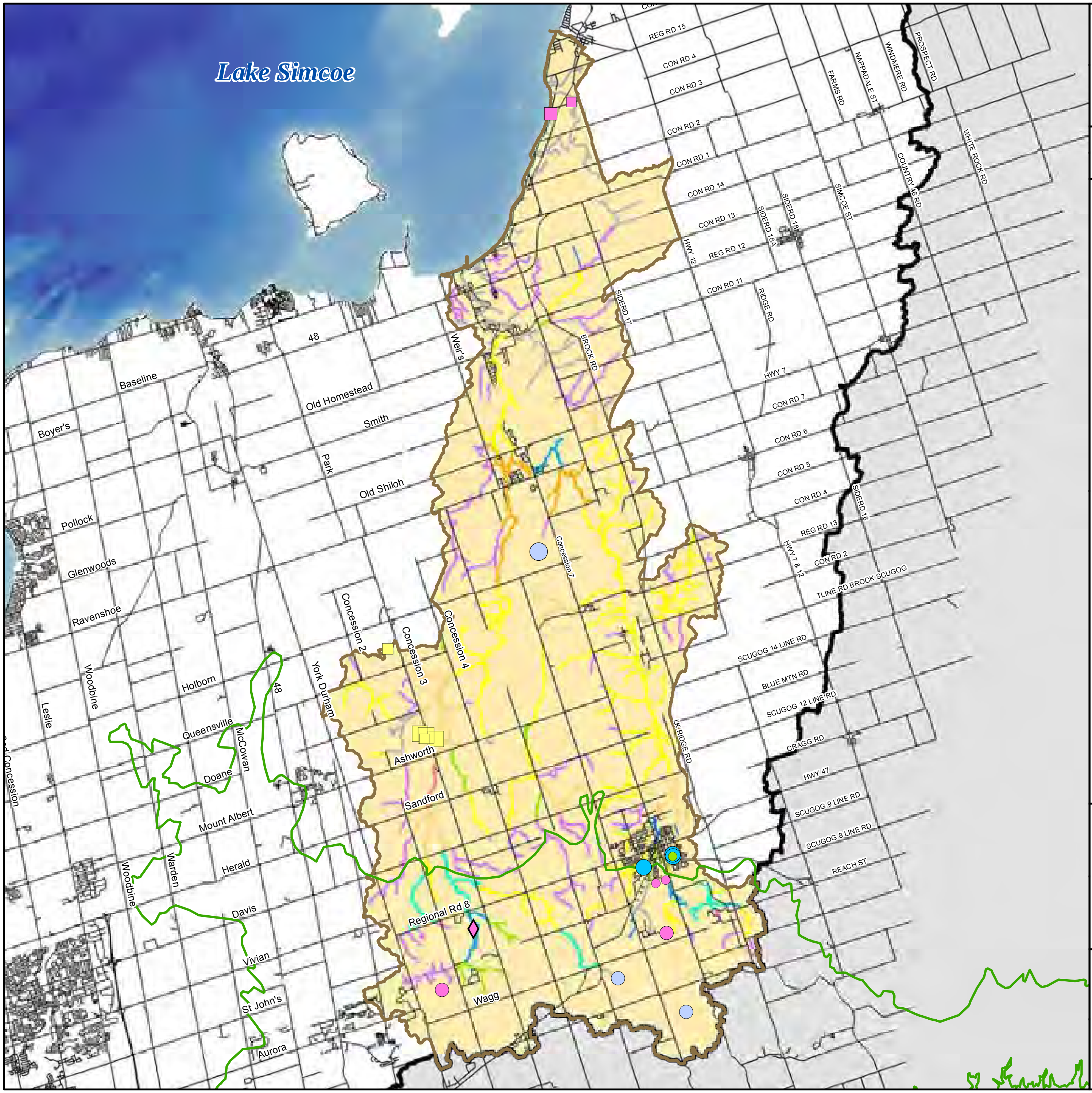
0 1 2 4 6 8 10
Kilometres

N

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

Gaining and losing reaches in relation to permitted ground and surface water takers

Figure 5-25



Legend

Water Use

- ● Agricultural
- ● Commercial
- ● Construction
- ● Industrial
- ● Miscellaneous
- ● Recreational
- ● Remediation
- ● Water Supply

Max M3/Day

- ○ <= 500
- ○ 501 - 1000
- ○ 1001 - 2000
- ○ 2001 - 5000
- ○ > 5000

Taking Type

- ○ Ground Water
- ◇ Surface Water
- ☐ Both Sources

Base Flow (L/s/km)

- > -25
- -10 to -20
- -5 to -10
- 0.01 to 5
- -0.01 to -5
- 5 to 10
- 10 to 20
- 20 to 30
- > 45
- DSL
- No data

Lake Simcoe Region conservation authority

0 1 2 4 6 8 10
Kilometres

N

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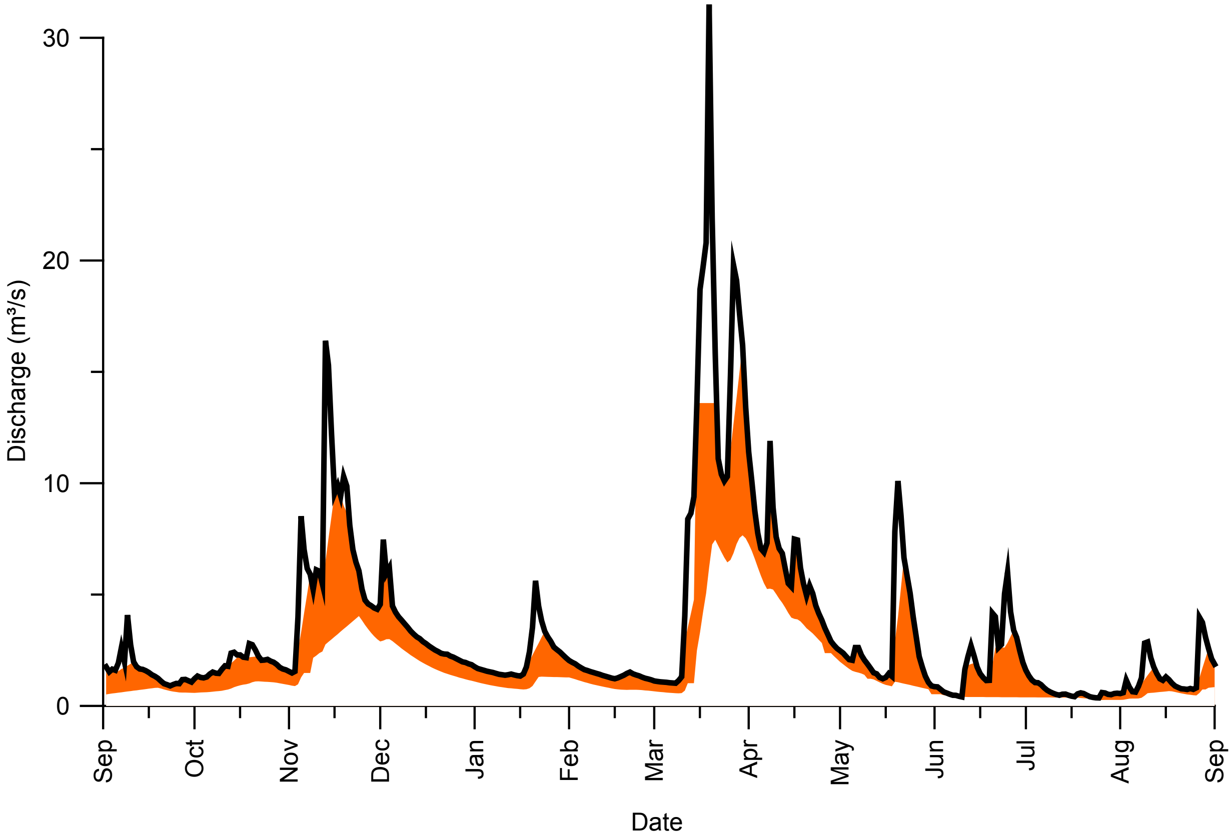


Figure 5-26: Sample hydrograph of 02EC011: Beaverton River near Beaverton during WY1986. Area shaded in orange represents the range of expected baseflow discharge from 12 automatic baseflow separation techniques.

One method of analyzing whether anthropogenic activities have affected streamflow volumes over time is to construct plots of cumulative annual streamflow versus time. Deviation from a straight line on the cumulative plot suggests the possibility that natural (e.g. climate) or anthropogenic factors have affected streamflow.

The Pefferlaw River subwatershed has seen little change over the period of time for which the Base Flow index has been calculated, which likely accounts for the stability of baseflow, which varies less than 4% over the period of record (Figure 5-27). The slight variation is likely due to climatic influence. Even when examined at a yearly scale the Index consistently shows that greater than 50% of the flow in the Pefferlaw River comes from baseflow as opposed to surface runoff. This is a good indication of stable year round flow, which is important for maintaining the ecological functions of the river. Even in extremely dry years, such as the conditions experienced in 2007, flow levels were lower than average, but neighbouring rivers such as the East Holland, which has experienced a decline in baseflow contribution, recorded record low flow levels. The contribution of baseflow explains the ability of this system to better withstand dry conditions such as these.

The ability of a river system to withstand drought depends largely on the baseflow volume the system can generate.

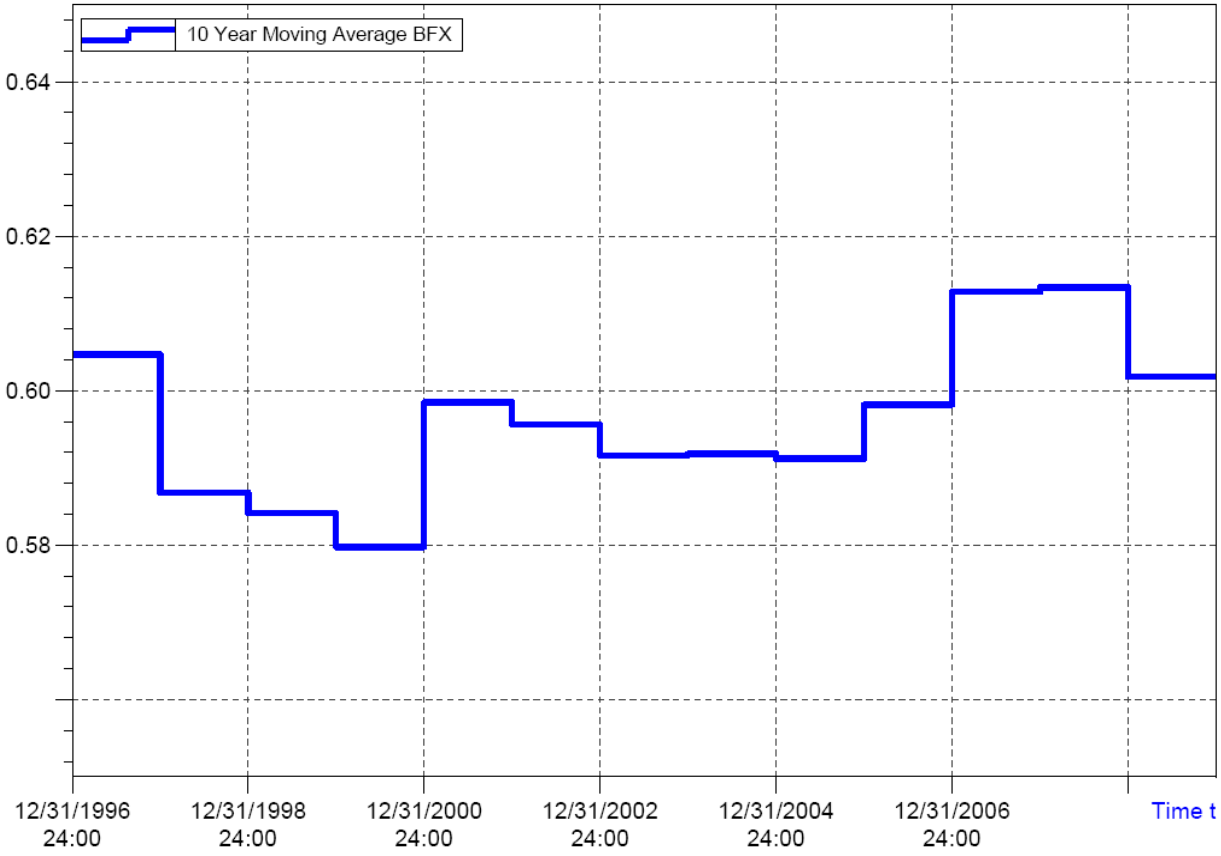


Figure 5-27: Pefferlaw River baseflow index (10 year moving average) from the Udora gauge (LSRCA, 2011).

5.2.5 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 5.2.4 there are only a few long-term gauges within the study area and not all significant stream tributaries are monitored.

A discharge map (Figure 5-28) was created using the potentiometric surface produced from shallow wells in the MOE water well database in conjunction with the topographic mapping. Potential discharge zones are where the water levels are within two metres of the surface (topographic mapping).

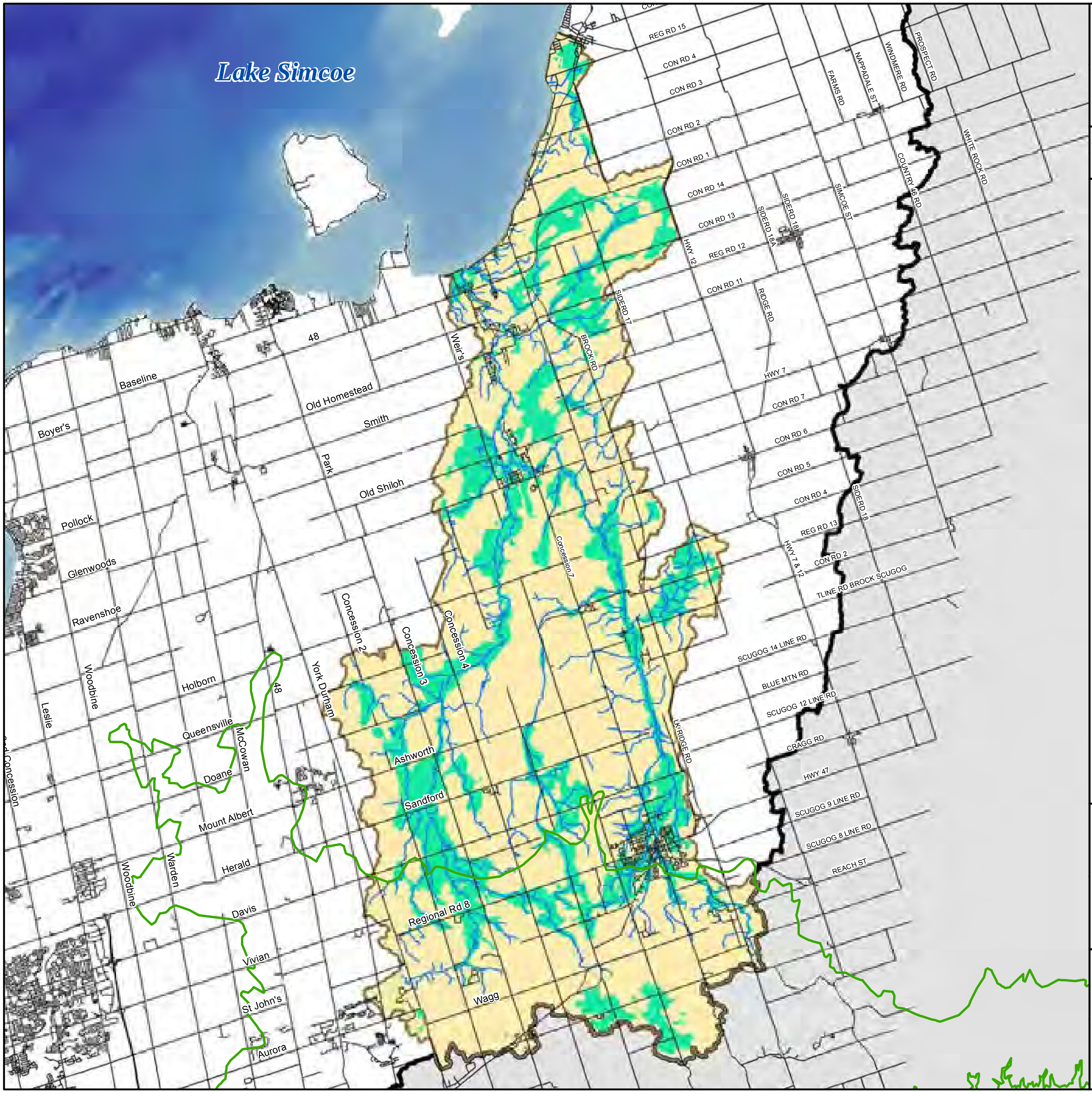
Figure 5-29 shows a map of simulated groundwater discharge to streams, in L/s, for each model cell that is intersected by a stream reach. Cell-by-cell discharge values can be summed up along a reach to get the net discharge to the stream reach. Values were summed up over the contributing area to the Environment Canada gauges to calculate the total simulated groundwater discharge. Table 5-3 compares the MODFLOW model predicted estimate of the groundwater discharge to the calculated baseflow at the three key gauges in the model area. Dams and wetlands can interfere significantly with automated baseflow separation algorithms, as they regulate (slow) flow in a manner that cannot be differentiated from groundwater discharge patterns. A dam is known to be located upstream of the Uxbridge gauge and there are numerous wetlands upstream of the Pefferlaw stream gauge (Figure 8-1, **Chapter 8 – Terrestrial Natural Heritage**), which would attenuate runoff in a manner that would interfere with the baseflow separation processing, increasing the estimated baseflow. Also included in Table 5-3 is the PRMS estimate of baseflow for the subwatersheds. This estimate does not take into account lateral groundwater inflows and outflows, but is not affected by dams. In summary, the MODFLOW model predicted baseflow is a little lower than some of the processed estimates from the total flow hydrographs, however the model calibration result is reasonable (Earthfx, 2010a).

Table 5-3: Comparison of observed baseflow to simulated groundwater discharge to streams (Earthfx, 2010a).

Stream Gauge Name	Period of Record (Years)	Lower Estimated Baseflow Separation (L/S)	Upper Estimated Baseflow Separation (L/S)	Estimated Baseflow from PRMS (L/S)	MODFLOW Simulated Baseflow (L/s)
Beaverton River Near Beaverton	17	1392	2282	1081	889
Pefferlaw Brook Near Udora	15	1441	2321	2094	1793
Uxbridge Brook At Uxbridge	9	178	324	266	137

Potential Discharge to Streams within the Pefferlaw River Subwatershed

Figure 5-28



Legend

Road

Watercourse

Oak Ridges Moraine

LSRCA Watershed Boundary

Discharge Areas

Lake Simcoe Region conservation authority

0 1 2 4 6 8 10

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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LSRCA GIS Services DRAFT created July 2010.

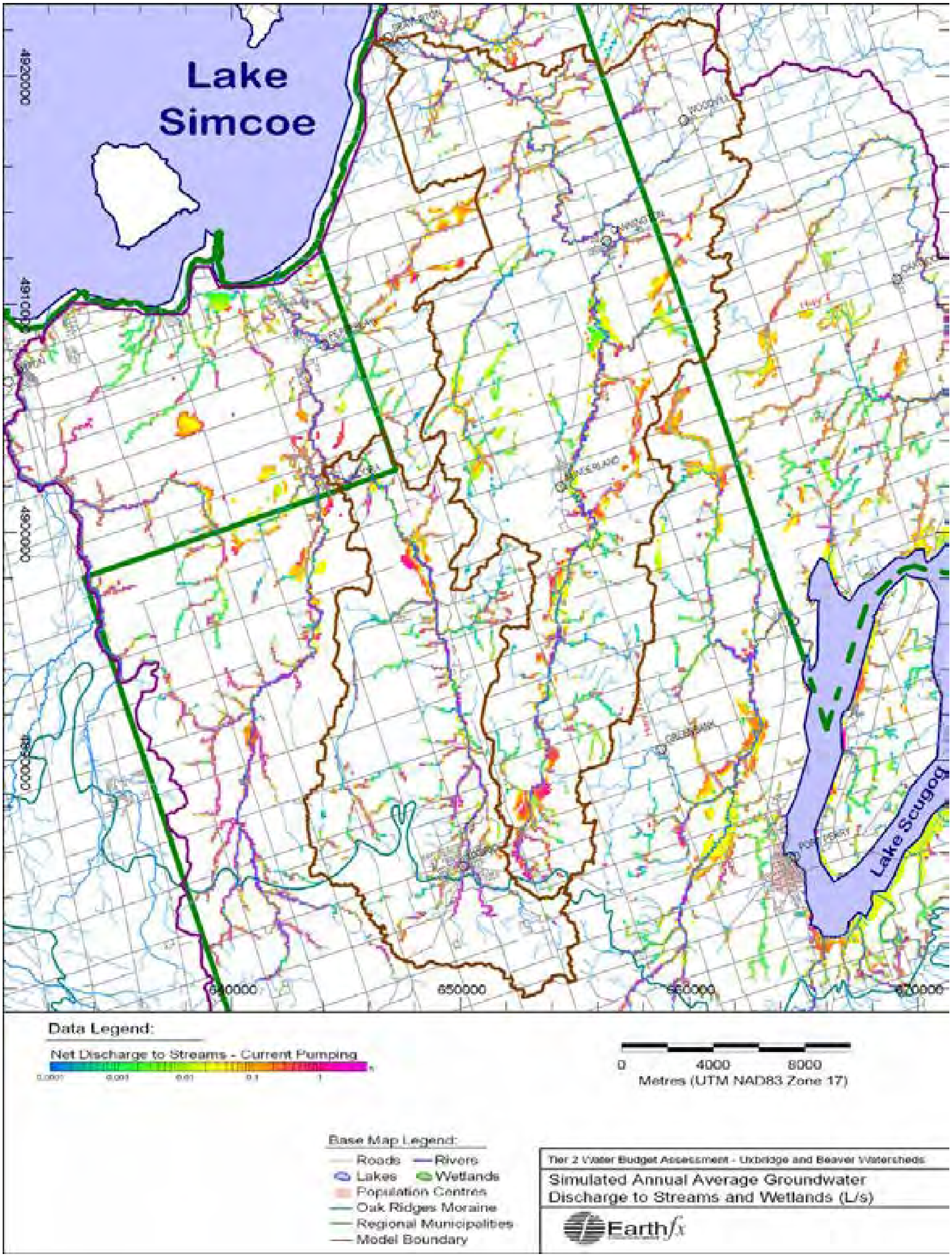


Figure 5-29: Simulated groundwater discharge to streams and wetlands (l/sec) (Earthfx, 2011a).

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 understand 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.
- Under the Provincial Groundwater Monitoring Network (PGMN), the LSRCA, in partnership with the Ministry of Environment, currently operates two monitoring wells within the Pefferlaw River subwatershed. Well W039 is completed to a depth of 18.5 m and is screened in an intermediate sand aquifer, while Well W032 is completed to a depth of 35 m and is screened in a deep sand aquifer. Both wells are interpreted to be screened in the Inter-Newmarket Aquifer.

5.2.6 Groundwater Recharge

Groundwater is replenished as precipitation or snowmelt infiltrates into the ground surface. 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 ORM, infiltration rates are increased.

The mappings of these 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 5-30 (Earthfx, 2010a).

Significant Groundwater Recharge Areas

Significant 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 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.

Significant Groundwater Recharge Areas were developed for the entire Lake Simcoe watershed to meet the technical requirements under the Clean Water Act, 2006. The recharge areas were delineated by using the PRMS – surface water model developed for the Tier Two water budget discussed in Section 5.1.2 (Earthfx, 2010b). Significant Groundwater Recharge Areas 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 5-31 represent a recharge rate of 189 mm/yr.

The most significant areas for groundwater recharge within the Pefferlaw River subwatershed are associated with the Oak Ridges Moraine and surficial sand and gravel deposits and range between 300-450 mm/yr, as shown in Figure 5-30 and Figure 5-31.

Ecologically Significant Groundwater Recharge Areas

Ecologically Significant Groundwater Recharge Areas (ESGRAs) are identified areas of land that are responsible for replenishing groundwater systems (landscape recharge areas), and those that support sensitive areas like coldwater streams and significant wetlands. Preliminary ESGRA capture zones have been delineated for both the Pefferlaw Brook and Uxbridge Brook subwatershed using reverse particle tracking.

The 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 (Figure 5-32). The particle tracks shown in Figure 5-32 illustrate a distinct groundwater flow divide that shows no apparent correlation with the surface water divides. The groundwater model also has the ability to track the time it takes the particles to reach the surface. Figure 5-33 displays a compilation of capture zones (1yr, 5yrs, 10yrs, 100 yrs, and 1000 yrs). The travel time of recharge to many of the provincially significant wetlands is typically greater than 10 years. At the headwaters of the western branch of Pefferlaw Brook, the reverse particle tracks from two stream reaches show a distinct connection with some recharge zone. As was seen with the provincially significant wetlands, the distance traveled from the recharge zone to the stream reaches is short but the travel is long (Earthfx, 2011b). Reverse particles tracks from features closer to Lake Simcoe appear to fan out laterally; normal to the stream valley indicating that recharge is following the surface topography. It is only when discharge points are situated near the ORM that their particle tracks tend to diverge from topography (Earthfx, 2011b).

The next step in finalizing the preliminary ESGRA mapping involves running a sensitivity analysis and creating a final map that highlights the critical portions of the landscape that need to be protected to ensure the sustainability of the sensitive features.

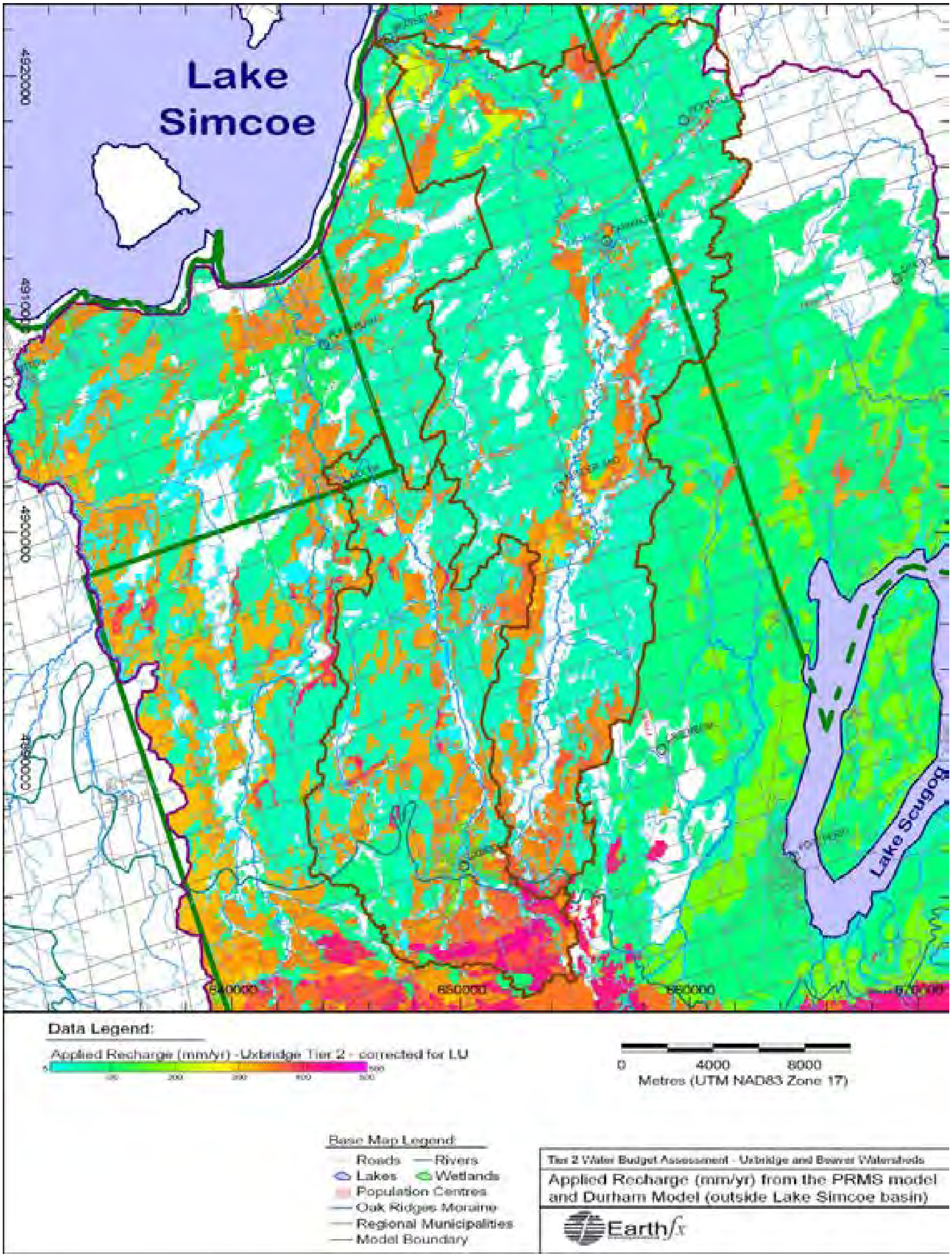
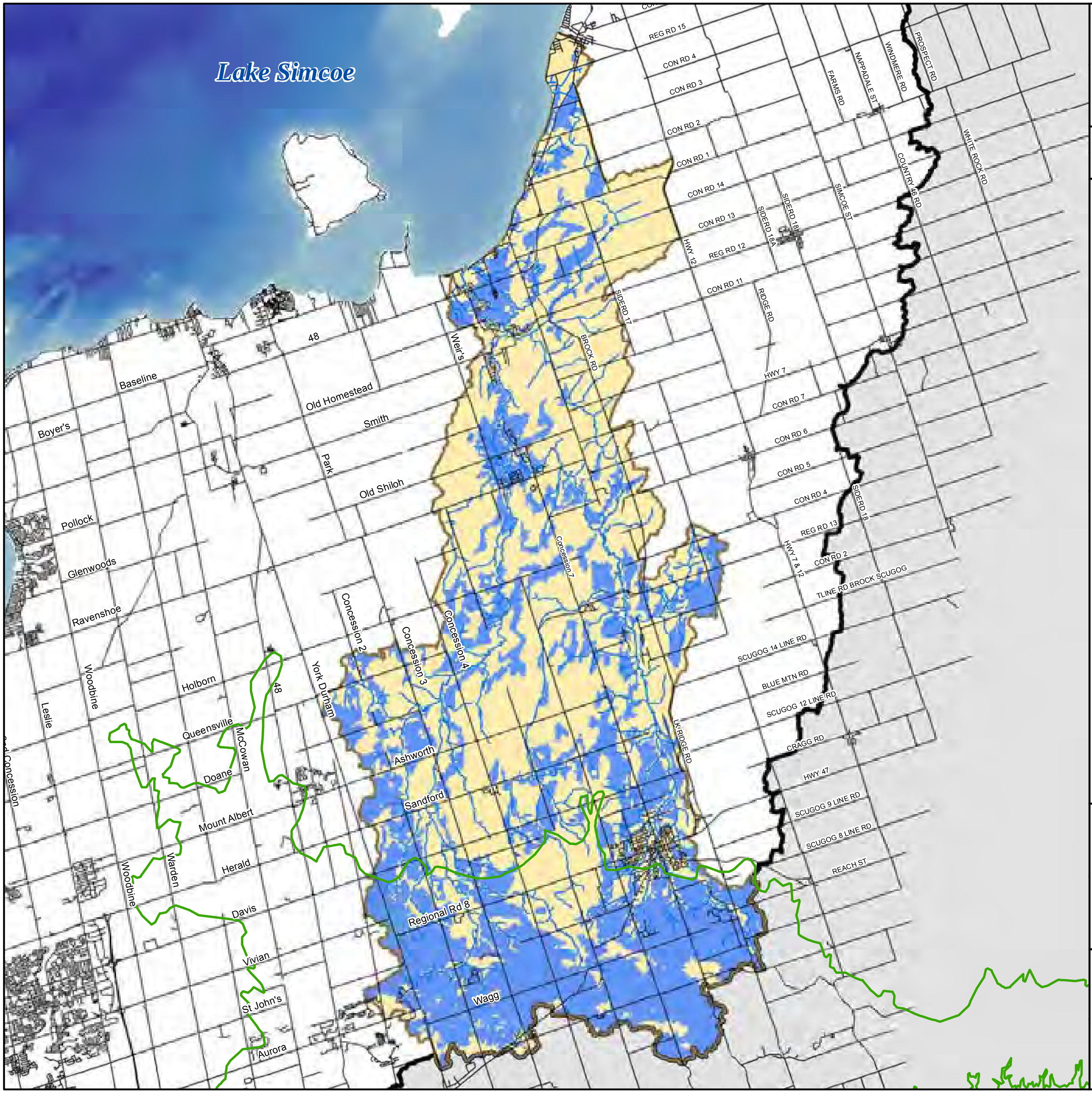


Figure 5-30: PRMS estimated annual average recharge within the Lake Simcoe watershed (mm/yr) (Earthfx, 2010a).



Significant Groundwater Recharge Areas within the Pefferlaw River subwatershed

Figure 5-31

Legend

— Road

〰 Watercourse

Oak Ridges Moraine

LSRCA Watershed Boundary

Significant Groundwater Recharge Areas

Lake Simcoe Region conservation authority

0 1 2 4 6 8 10

Kilometres

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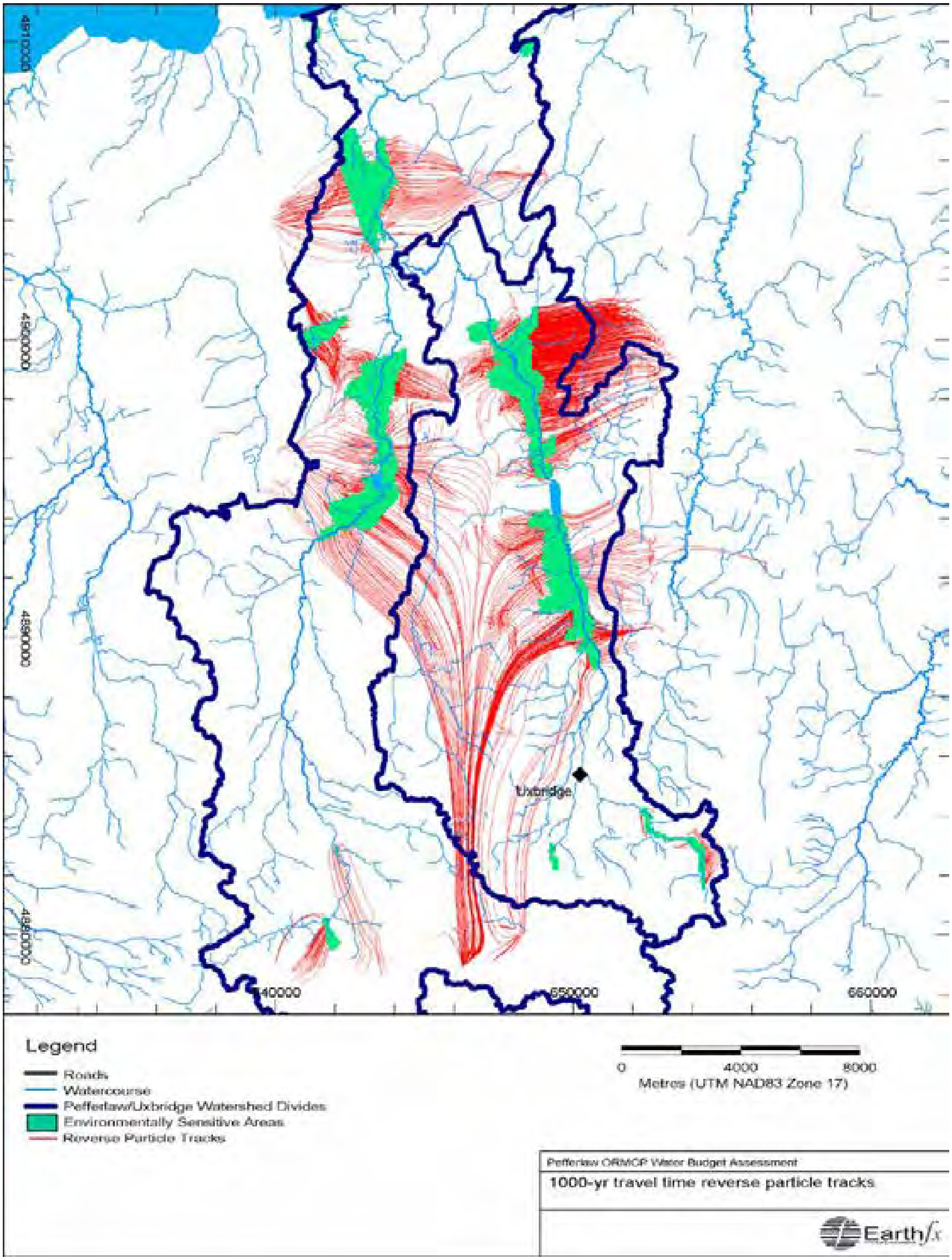


Figure 5-32: Sample reverse particle tracking from environmentally sensitive areas. Particles are traced back 1000 years (Earthfx, 2011b).

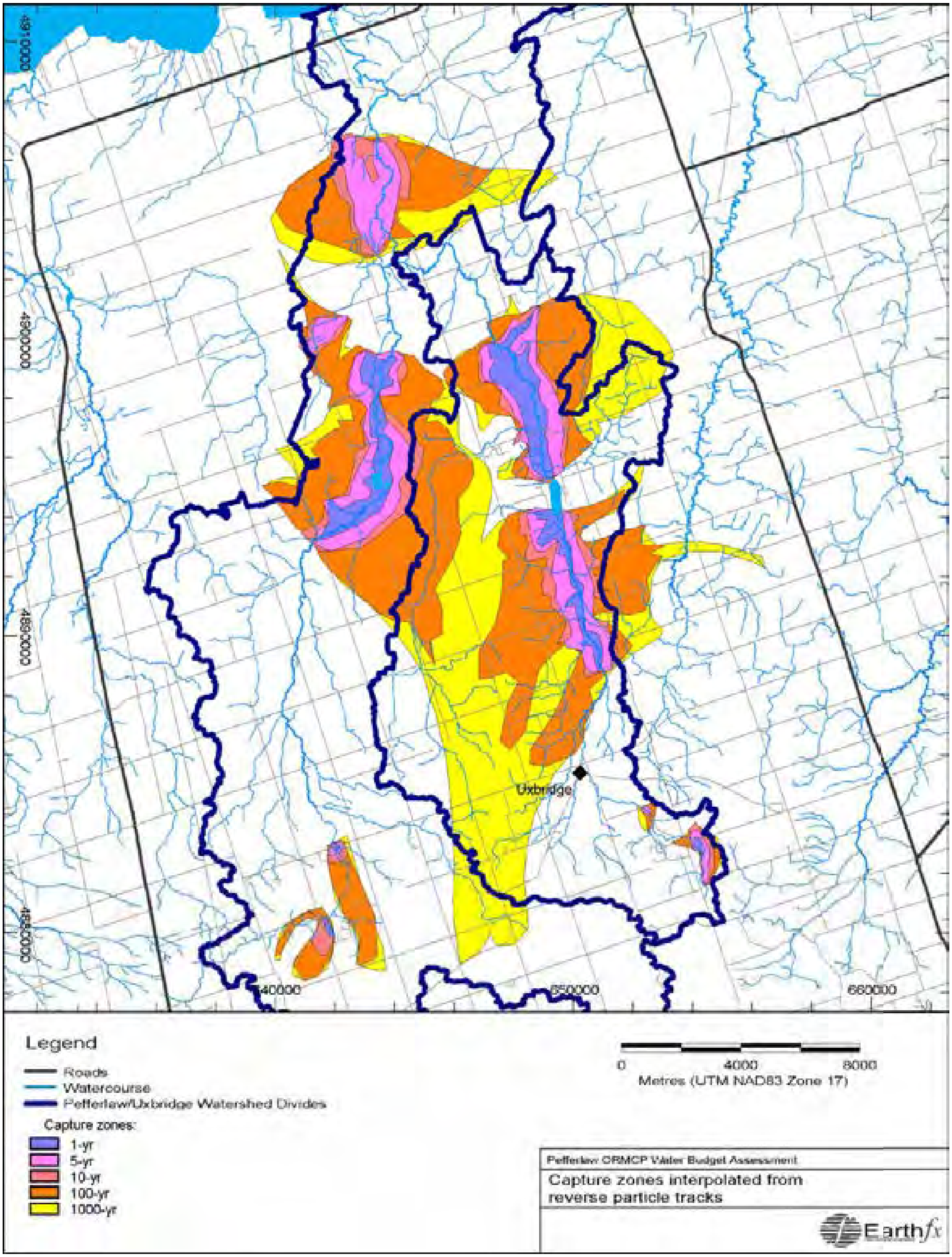


Figure 5-33: Capture zone results from reverse particle tracking analysis (Earthfx, 2011b).

5.2.7 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.

The PRMS model utilized long-term climate data obtained from Environment Canada including daily maximum and minimum temperature, precipitation, and solar radiation, for the 28-year period from January 1, 1975 to December 31, 2002. Daily precipitation data was obtained from 28 Environment Canada climate stations with long-term records (Figure 5-34). Daily temperature data (minimum and maximum values) for the same period were obtained from 26 stations.

Mean annual precipitation in the immediate region ranged between 750 millimetres per year (mm/yr) at Toronto Island A (6158665) to 1,180 mm/yr at Dwight (6082178). Figure 5-35 illustrates the spatial distribution of annual precipitation over the Tier 2 study area as averaged over the study period and interpolated by the PRMS model. The data show that annual average precipitation is higher is fairly uniform across the subwatershed.

Monthly averages of maximum daily temperatures for the period 1975 to 2002 ranged from -6.5°C to 27.0°C, while monthly averages of minimum daily temperatures ranged from -17.0°C to 16.5°C. The mean daily temperature for January (typically the coldest month) ranged from -11.8°C at Dwight to -4.4°C at Toronto Island A. The mean daily temperature for July (typically the warmest month) ranged from 18.0°C at Dwight to 21.1°C at Toronto (Earthfx, 2010a).

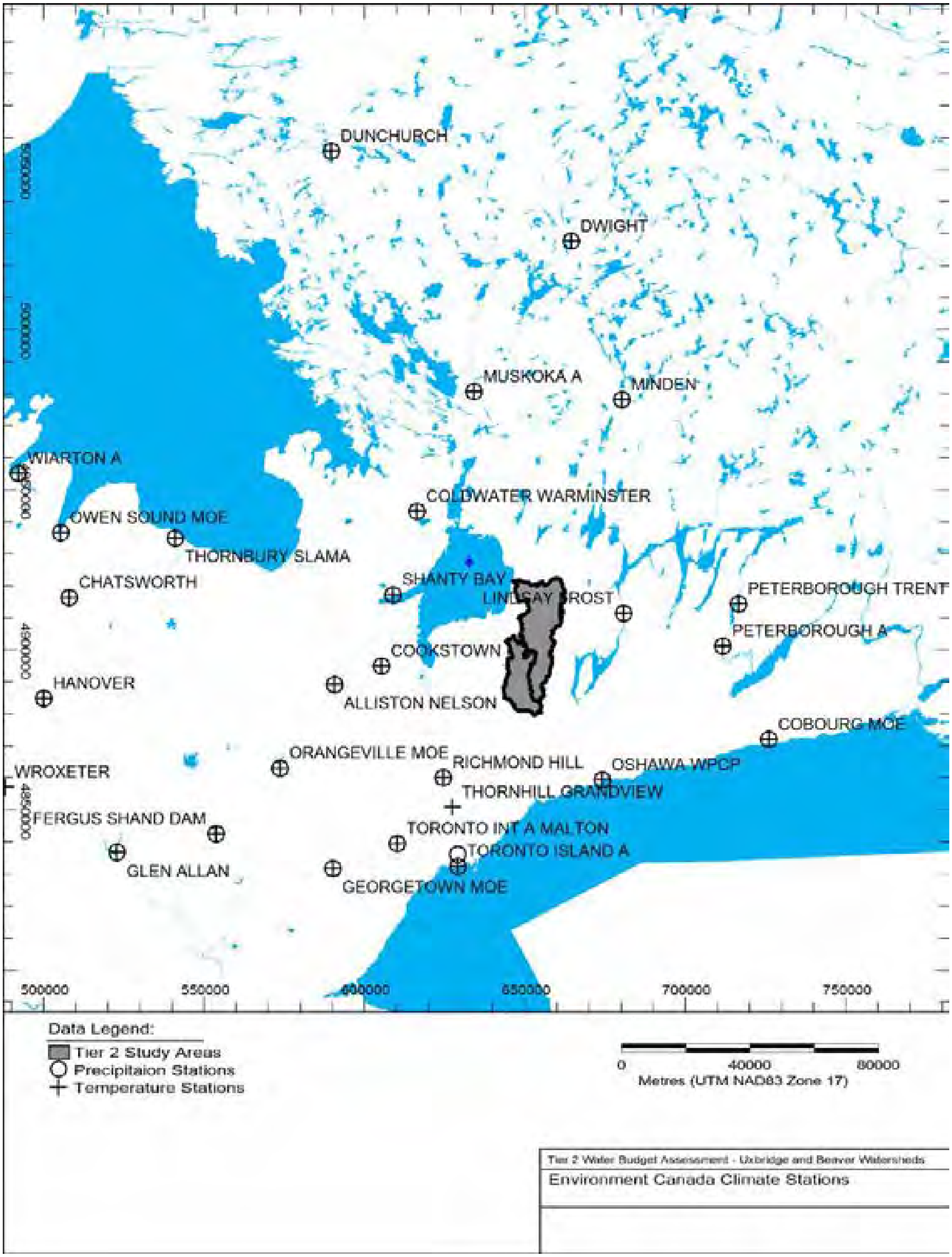


Figure 5-34: Distribution of Environment Canada meteorological stations used in the PRMS model (Earthfx, 2011a).

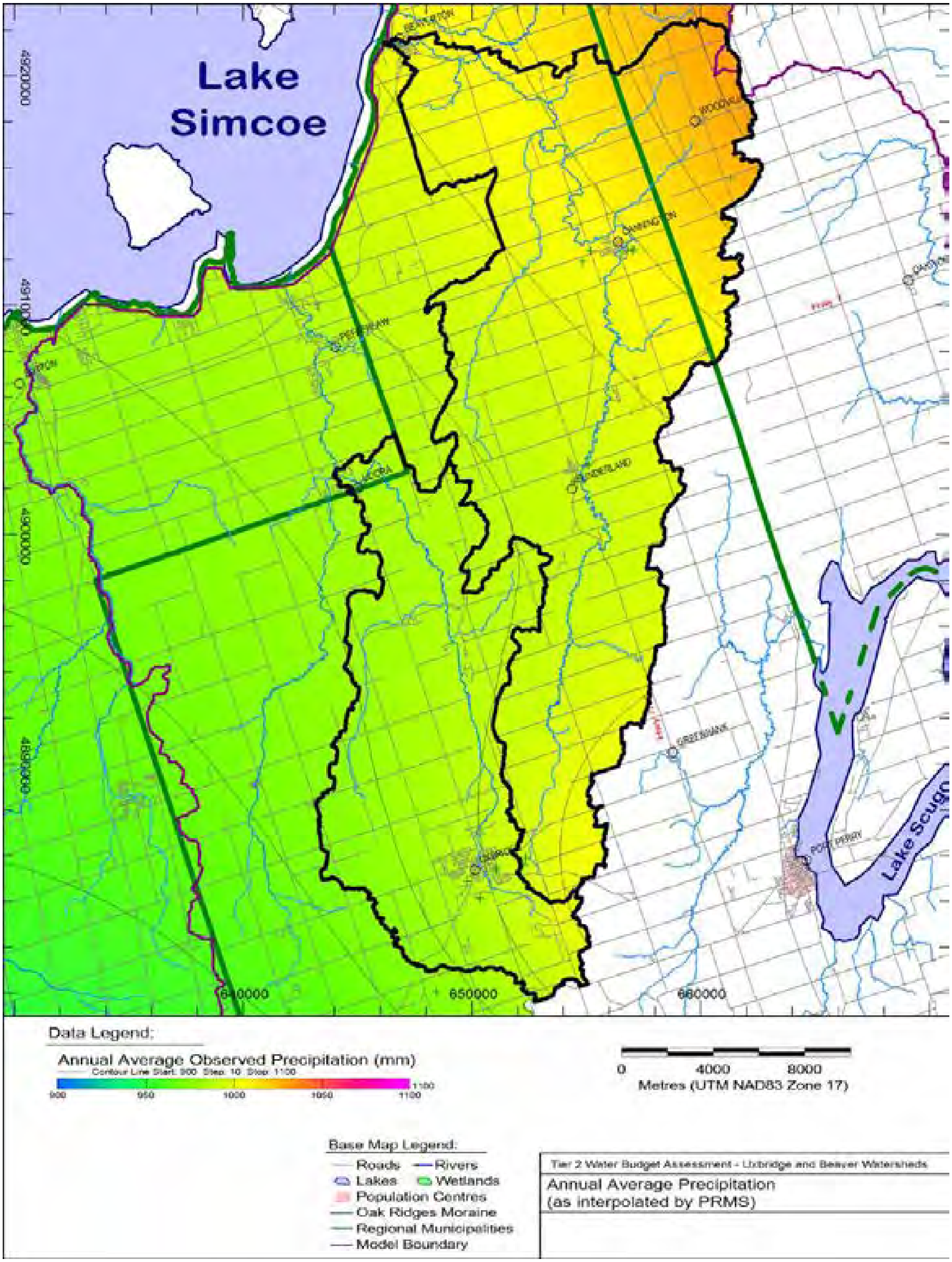


Figure 5-35: Annual precipitation in mm/yr as distributed by PRMS (Earthfx, 2011a).

Evapotranspiration

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 characteristic 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, evapotranspiration is accounted for as a loss to the system in the water budget calculation.

Within the PRMS model, daily pan evaporation data was simulated from nine Environment Canada climate stations: Washago (6119325); Bowmanville OTS IHD (6150830); Burketon Mclaughlin IHD (6151042); Long Sault IHD (6154611); Toronto MET Res Stn (6158740); Toronto New International A (6158749); Lindsay Frost (6164433); Peterborough Trent University (6166455); and Claremont Field Centre (61515DE) (Figure 5-34). Pan evaporation data from these stations were available for only 26% of the model period, and were therefore only used for comparison purposes. On average, the available pan data from these nine stations demonstrated that there is the potential to evaporate approximately 1,085 millimetres per year over the watershed between the period of 1975 and 2002. It must also be noted that these stations did not report evaporation losses between the months of December to March, inclusive (Earthfx, 2010a).

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 evapotranspiration occurring over the watershed is displayed on Figure 5-36.

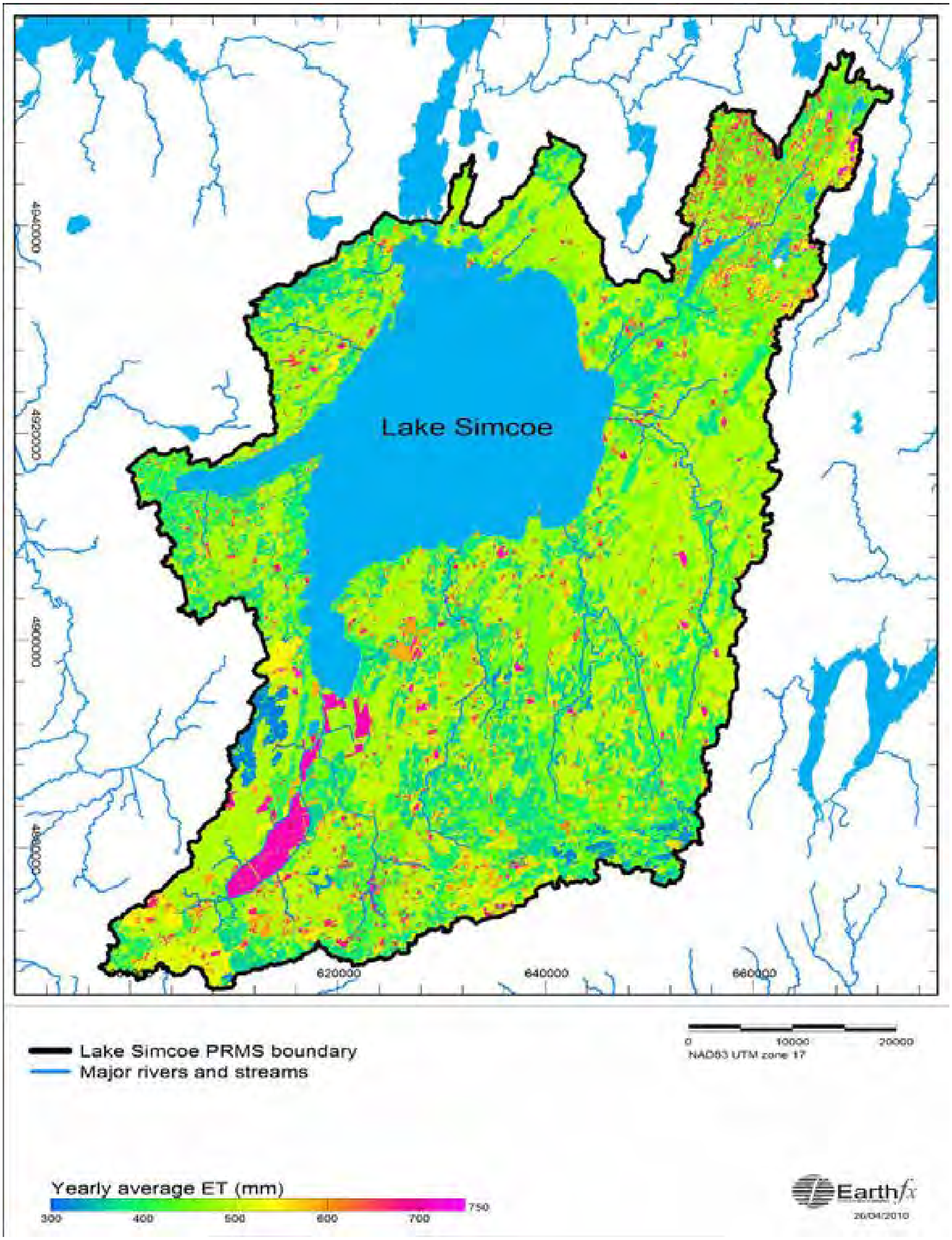


Figure 5-36: Average net annual evapotranspiration (Earthfx, 2010a).

5.3 Water Budget and Stress Assessment

A water budget characterizes the hydrologic conditions within a subwatershed by quantifying the various elements of the hydrologic cycle, including precipitation, interception, and evapotranspiration. 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.

The following section describes how the input and output values of the water budget equation were determined for the Pefferlaw Brook and Uxbridge Brook subwatersheds. The findings of the water budget study are discussed within Section 5.4.Earthfx (2010a) completed the water budget study on behalf of the LSRCA, which included the Beaver River and Uxbridge Brook subwatersheds in support of the water budget requirements under the Clean Water Act, 2006. The water budget addresses the requirements set out in the Oak Ridges Moraine Conservation Plan.

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)

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

Source: (OMOE, 2005b)

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 determine if the subwatersheds could be potentially under stress (i.e. water demand out weighs water supply). Estimates were completed using a surface water model (PRMS) and a three-dimensional numerical groundwater flow model (MODFLOW).

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

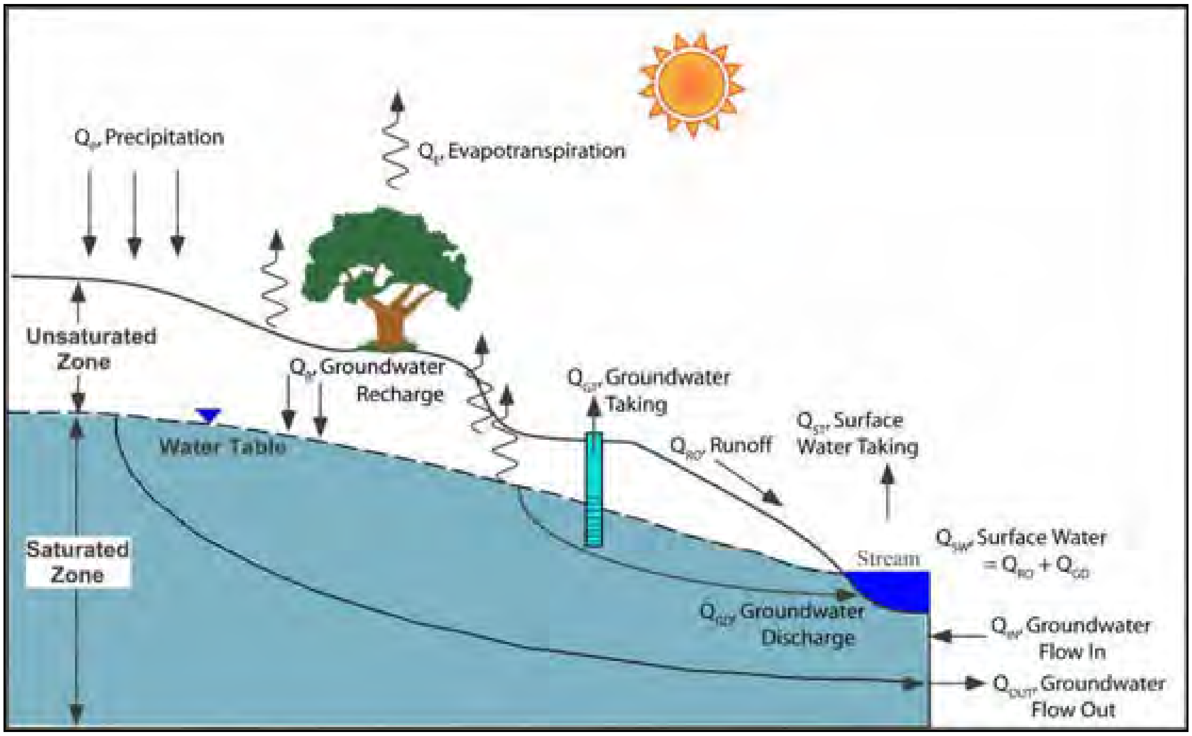


Figure 5-37: Water Budget components (Earthfx, and Gerber, 2008).

5.3.1 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 Source Water Protection program and the CAMC-YPDT Groundwater study (discussed in Section 5.1.2).

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 that use mathematical equations to approximate existing hydrogeologic conditions. While models can quantify the various components of the hydrologic cycle they can be also 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.

The numerical model used to assess the Pefferlaw Brook and Uxbridge Brook subwatersheds was developed through the CAMC-YPDT study group and is referred to as the Durham Model. The Durham Model is an expansion of the previous modelling work (i.e. 2006 Core Model) undertaken by the CAMC-YPDT study group. More detail on the development of both the Core Model and the Durham Model can be found in Earthfx (2006) and Earthfx (2009).

The Durham Model was created using the United States Geological Survey (USGS) MODFLOW code to solve the equations for groundwater flow (McDonald and Harbaugh, 1988; Harbaugh and McDonald, 1991). The model was created using geologic data supplied by the Ontario Geologic Survey and the Geologic Survey of Canada. Since the Durham Model is unable to predict the surface water components necessary to complete a detailed water budget analysis, a surface water model was used.

The PRMS model was used in the Tier 2 and Pefferlaw ORMCP study to assess and to quantify the following surface water components necessary to complete the water budget (Earthfx, 2010b, 2011):

- Precipitation;
- Interception;
- Surface water runoff;
- Infiltration;
- actual evapotranspiration (ET);
- groundwater recharge; and
- baseflow.

The surface water components of the water budget and PRMS simulation of them is discussed within Section 5.2. Figure 5-2 shows both the Durham Model and the PRMS Model boundaries. Further information about the models and their limitations can be obtained from Earthfx (2009), Earthfx (2010a) and Earthfx (2010b).

5.3.2 Water Supply Estimation

The water supply component of the stress assessment was estimated using a numerical groundwater flow model developed for the CAMC-YPDT Groundwater Management project for the Regional Municipality of Durham. The 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 a large area extending from the South of Lake Simcoe down to Lake Ontario, east of Highway 48 (Markham Rd.) to beyond Lake Scugog (Figure 5-2).

The model has a uniform 100-m cell size to better represent spatial variability of aquifer properties and groundwater interaction with streams. The model simulates groundwater flow in multiple subwatersheds surrounding the Pefferlaw River and Uxbridge Brook catchments that are the focus of this study and; therefore, provides an independent means of estimating lateral inflows and outflows across subwatershed boundaries. This model was originally constructed as a steady state model to simulate long-term average flows (Earthfx, 2010a).

The Durham model was built using the United States Geological Survey MODFLOW modelling code. This modelling code was selected because it is well-suited for modelling regional flow in complex multi-layered aquifer systems. In addition the MODFLOW code is recognized worldwide and has been extensively peer reviewed to verify for accuracy in groundwater flow simulation. The model was calibrated to match the observed stream baseflow measurements as well as observed water levels (Earthfx, 2010b). The model is also able to accurately predict drawdown at a pumping well (Earthfx, 2006).

Water supply is the amount of water available at any given instant for use as a water supply. 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. Surface water supply thus involved 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 groundwater recharge term was determined from the PRMS simulations. The individual cell-by-cell PRMS recharge values were summed for each of the subwatersheds. The total recharge for each subwatershed is tabulated in Table 5-4 (Earthfx, 2010a).

In the Tier 2 study lateral inflows into the Uxbridge Brook subwatersheds was calculated by summing the predicted MODFLOW inter-cell flux across the subwatershed boundaries. A visual representation of the lateral flux can be seen by looking at the ground water flow gradients, as indicated on the MODFLOW potentiometric surface maps (Figure 5-13 through Figure 5-16). The total lateral inflow (Q_{in}), in all layers, was calculated. Per the guidance for the Tier 2 study the lateral *outflows* were not subtracted from the inflows for the Uxbridge Tier 2 study. The total current and future lateral inflow for each subwatershed is tabulated in Table 5-4 and Table 5-5, respectively (Earthfx, 2010a).

Together, the PRMS groundwater recharge and MODFLOW predicted lateral inflows from the water supply term in the Tier 2 calculation. Table 5-4 and Table 5-5 present the current and future water supply estimates used in the water budget calculation.

Table 5-4: Current Water Supply and Reserve Estimates for Uxbridge Brook (Earthfx, 2011a).

Sub-watershed	Area	Model Recharge		Q_{in}		Baseflow		Reserve (10% baseflow)	
	km^2	mm/yr	m^3/s	mm/yr	m^3/s	mm/yr	m^3/s	mm/yr	m^3/s
Uxbridge Brook	161.3	171	0.87	44	0.22	50	0.26	5	0.026
Pefferlaw Brook	285	196	1.77	-	-	264	2.39	26.4	0.239

**Current and Future water supply estimates for Uxbridge Brook were taken from the Tier 2 study (Earthfx, 2011a), while the current Pefferlaw supply estimates were taken from the Water Budget completed for the ORMCP (Earthfx, 2011b). Values of lateral inflow were not extracted from the Groundwater model as part of the Pefferlaw Water Budget study.*

Table 5-5: Future Water Supply Estimates for Uxbridge Brook (Earthfx, 2011a).

Sub-watershed	Area	Model Recharge		Q_{in}		Baseflow		Reserve (10% baseflow)	
	km^2	mm/yr	m^3/s	mm/yr	m^3/s	mm/yr	m^3/s	mm/yr	m^3/s
Uxbridge Brook	161.3	171	0.87	46	0.23	47	0.24	5	0.24

**Note that the Pefferlaw River was not assessed for future water supply as it contains no municipal drinking water systems.*

5.3.3 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 database, population estimates, and water well records. Water demand was assessed for all Lake Simcoe subwatersheds in SGBLS (2009) and was reviewed and refined as part of the Tier 2 study for Uxbridge Brook only.

Demand from other non-permitted water use sectors was also estimated. Three types of non-permitted uses were estimated, including estimates of unserviced population consumption, agricultural irrigation, and agricultural livestock consumption. For future scenarios, the consumptive demand was adjusted by increasing unserviced population demand, taking into account population growth estimates for Durham Region. The Tier 2 analysis assumes that the other permitted demands will remain constant with time with no change in the water supply except where significant land-use changes are anticipated (Earthfx, 2010a).

Permit To Take Water (PTTW)

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 Permit to Take Water (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) requires that any person or business taking more than 50,000 litres of surface or groundwater per day (L/day) are required by law to obtain a Permit To Take Water (PTTW) from the Ministry of the Environment (MOE). Permits are not required to take water for domestic purposes, livestock watering, or firefighting. Significant efforts have been made to quantify the amount of water takings within the subwatersheds through studies such as LSRCA Tier 1 Water Budget (2009), and the Uxbridge, Beaver Tier 2 Water Budget (Earthfx, 2010a).

Verifying and estimating actual consumption is difficult, but recent legislation (387/04) now requires that actual extraction rates be recorded and over time the actual demand estimates will improve. Actual water use was received for some of the permitted water users in the Lake Simcoe subwatersheds. The data for the Uxbridge and Beaver River subwatersheds were reviewed, corrected as needed, and incorporated into this study to update the water use estimates where possible. A list of the most recent PTTW information is presented in Table 5-7 through Table 5-9. Best available location data for groundwater water permits are shown in Figure 5-38 (Earthfx, 2010a).

Municipal Water Supply

There are three municipal water supply wells that service one community within the Pefferlaw River study area. Data on average daily water takings from most of the municipal wells within the subwatershed were obtained directly from Durham Region and were used to estimate actual annual average pumping rates. Actual pumping rates are often significantly less than the permitted rates. The numerical groundwater flow model, discussed previously, incorporated average pumping rates where the data were available.

Non-Permitted Water Use - Agriculture Consumption

Under the Ontario Water Resources Act (Revised Statutes of Ontario 1990, Chapter O.40), farmers using 50,000 litres or less per day, and farmers who are taking water for livestock watering but not storing the water, are exempt from obtaining a PTTW, and are therefore non-permitted agricultural consumers. To estimate this agricultural consumption MOE Guidance Module 7 (MOE, 2007) has suggested using water use coefficients documented by deLoe (2001, 2005). The 2001 data compiled by deLoe has been allocated to subwatersheds using area weighting to estimate subwatershed water use as per the following process.

Census data calculated based on municipalities has been used to derive the area within a subwatershed which is agricultural. Area-weighting was then used to determine how to allocate the above calculated areas to subwatersheds. For example, if 50% of Township A is in subwatershed X, then the assumption is that 50% of the water use in Township A occurs within subwatershed X. Since most subwatersheds cross municipal boundaries, the above calculations have been completed for all subwatersheds and townships, and totals have been compiled for each subwatershed. This differs from the recommended methodology outlined by deLoe (2001), in that area weighting assumes that the agricultural area is evenly distributed within each subwatershed.

The coefficients derived by deLoe (2005) have then been applied to each type of agricultural use to provide a total seasonal and total annual average for each subwatershed. Although this method provides an estimate of water consumption, there is no method to differentiate what is taken from groundwater versus surface water. For the purposes of this report, estimated agricultural taking was considered in both the surface water and groundwater stress assessments to yield the most conservative estimate. Refinement of the agricultural taking through subwatershed-specific Statistics Canada census data will be undertaken in the Tier Two analysis for those parts of the region that are identified as having a water quantity stress.

Non-Permitted Water Use - Unserviced Domestic Water Use

Municipal water supply services are typically not available within rural areas and therefore residents and businesses rely solely on private water wells or surface water to meet their water needs.

For the purposes of this report an assumption has been made that all households in the study area not serviced by municipal water are obtaining water from a private well. To derive an estimate of the average volume of groundwater used for domestic purposes, the 2006 Statistics Canada census data were used to determine the “un-serviced” population within each subwatershed relying on private wells. This un-serviced population was then multiplied by a per-capita usage of 335 L/day, based on the recommendation within Guidance Module 7 (MOE, 2007). A relatively low consumptive factor (0.2) has been used to calculate water consumption, as residences on private wells most often utilize a private septic system, which returns the majority of water used to the local subsurface. This variable of the water consumption calculation is a relatively small proportion of the overall subwatershed demand and therefore the variation of household use is not a factor that will change the outcome of the stress assessment significantly; therefore this somewhat simple method is suitable for this assessment.

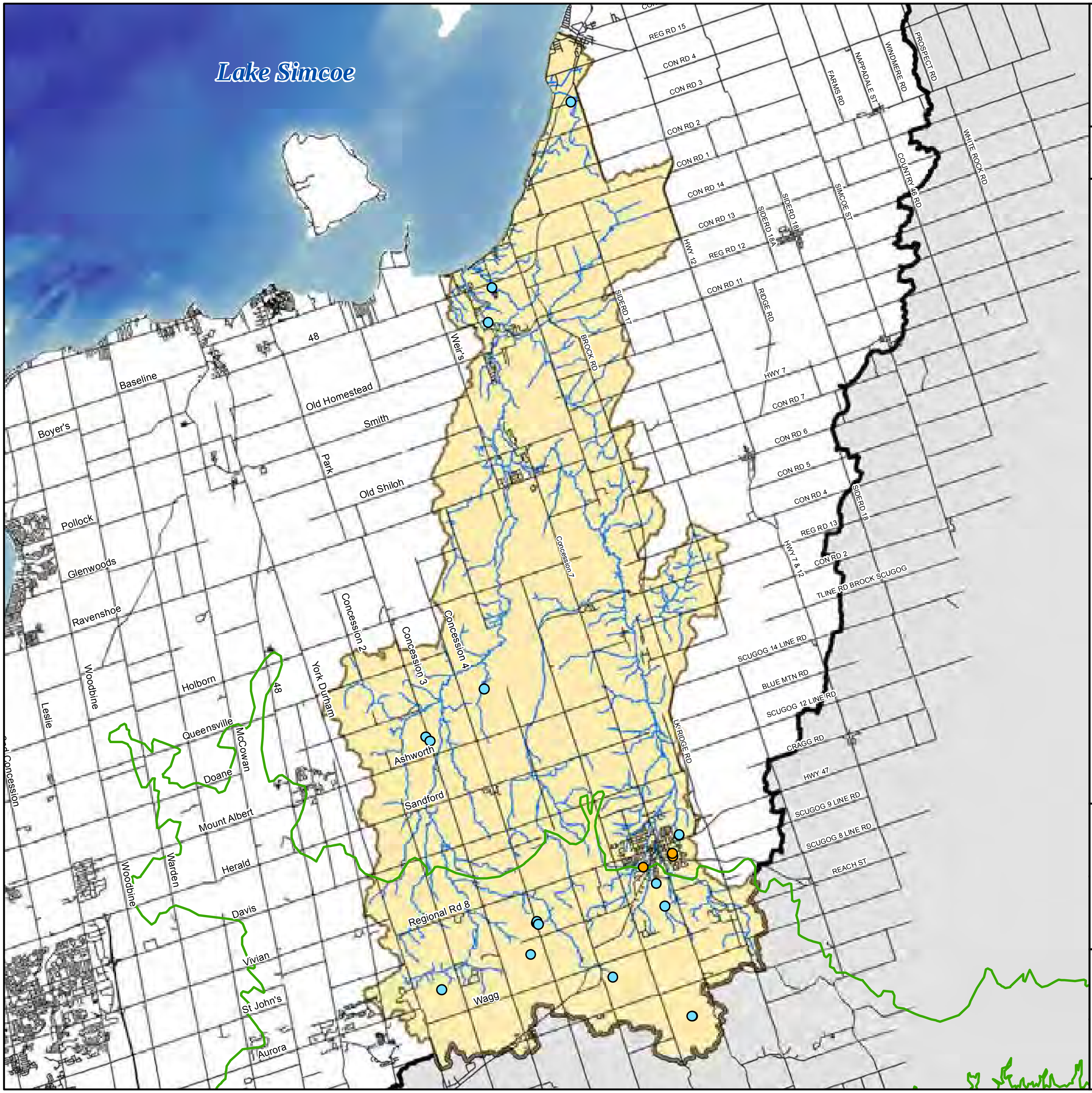
Monthly Correction Factor and Consumption Correction Factor

Many water permit holders do not require the use of water at a constant rate throughout the year. For example, there are a number of golf courses, aggregate washing, and communal permits within the Pefferlaw and Uxbridge Brooks study area. As noted, many of the permits in the study area are limited by time, with only a few of them allowing pumping on all 365 days of the year. The time-limited permits were allocated to months based on individual analysis of the permit.

The selected consumptive demand factors were applied to the PTTW permits based on the default values (Table 5-6) provided in the MOE Guidance Module (MOE, 2007). The consumption factor for the unserviced population was estimated at 20% (80% of the water is returned to the subwatershed through the septic system). This value is consistent with water supply consumption values listed in Table 16 of the Guidance Module. The consumption factor for the un-permitted agricultural use (primarily livestock, including dairy operations) was estimated as 80% (Earthfx, 2010a).

Table 5-6: Consumptive Use Factors (MOE, 2007).

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



Groundwater takings within the Pefferlaw River subwatershed

Figure 5-38

Legend

— Road

〰 Watercourse

🟩 Oak Ridges Moraine

⬛ LSRCA Watershed Boundary

● Municipal Supply Wells

● Non-Municipal Supply Wells

Lake Simcoe Region conservation authority

0 1 2 4 6 8 10

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.
This map has been produced for illustrative purposes only.
LSRCA GIS Services DRAFT created July 2010.

Table 5-7: Current Monthly Consumption for Uxbridge Brook (Earthfx, 2011a).

PERMIT NUMBER	WELL NAME	TYPE OF USE	Average Pumping m^3/day	Months of Taking	m^3/a	Consumptive Factor	Consumptive Demand	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Municipal wells																				
0765-6BDQKL	Uxbridge MW5	Municipal	2,807	12	1,025,257	1.00	1,025,257	87,017	79,298	87,017	84,210	87,017	84,210	87,017	87,017	84,210	87,017	84,210	87,017	1,025,257
0765-6BDQKL	Uxbridge MW6	Municipal																		
0765-6BDQKL	Uxbridge MW7	Municipal																		
TOTALS:								87,017	79,298	87,017	84,210	87,017	84,210	87,017	87,017	84,210	87,017	84,210	87,017	1,025,257
Groundwater																				
4176-5XJR68 (99-P-3083)	Foxbridge Golf Club	Golf Course Irrigation	191	4	23,276	0.70	16,293	-	-	-	-	-	4,006	4,140	4,140	4,006	-	-	-	16,293
94-P-3029	Pedersen Aggregates	Aggregate Washing	150	7	32,100	0.25	8,025	-	-	-	-	1,163	1,125	1,163	1,163	1,125	1,163	1,125	-	8,025
95-P-3010	Wooden Sticks Country Club	Golf Course Irrigation	358	4	43,642	0.70	30,549	-	-	-	-	-	7,512	7,763	7,763	7,512	-	-	-	30,549
96-P-3025	Lafarge	Aggregate Washing	409	7	87,488	0.25	21,872	-	-	-	-	3,168	3,066	3,168	3,168	3,066	3,168	3,066	-	21,872
TOTALS:								-	-	-	-	4,331	15,710	16,233	16,233	15,710	4,331	4,191	-	76,740
Surface Water																				
92-P-3049	Pond	Sod Farm	176	4	21,435	0.90	19,292	-	-	-	-	-	4,744	4,902	4,902	4,744	-	-	-	
TOTALS:								-	-	-	-	-	4,744	4,902	4,902	4,744	-	-	-	19,292
Domestic Use		Other - Water Supply	0.335	12	463,128	0.20	92,626	7,867	7,169	7,867	7,613	7,867	7,613	7,867	7,867	7,613	7,867	7,613	7,867	92,689
Agricultural Use		Other - Agriculture	1,427	12	521,358	0.80	417,086	35,424	32,281	35,424	34,281	35,424	34,281	35,424	35,424	34,281	35,424	34,281	35,424	417,372
TOTALS:								130,308	118,748	130,308	126,104	134,638	146,558	151,443	151,443	146,558	134,638	130,295	130,308	1,631,349

Notes
*Municipal taking data has been obtained from the municipality
**PTTW data has been ontained from a 2006 version of the MOE PTTW database

Table 5-8: Future Monthly Consumption for Uxbridge Brook (Earthfx, 2011a).

PERMIT NUMBER	WELL NAME	TYPE OF USE	Average Pumping m^3/day	Months of Taking	m^3/a	Consumptive Factor	Consumptive Demand	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Municipal wells																				
0765-6BDQKL	Uxbridge MW5	Municipal	3,721	12	1,359,095	1.00	1,359,095	115,351	105,118	115,351	111,630	115,351	111,630	115,351	115,351	111,630	115,351	111,630	115,351	1,359,095
0765-6BDQKL	Uxbridge MW6	Municipal																		
0765-6BDQKL	Uxbridge MW7	Municipal																		
TOTALS:								115,351	105,118	115,351	111,630	115,351	111,630	115,351	115,351	111,630	115,351	111,630	115,351	1,359,095
Groundwater																				
4176-5XJR68 (99-P-3083)	Foxbridge Golf Club	Golf Course Irrigation	191	4	23,276	0.70	16,293	-	-	-	-	-	4,006	4,140	4,140	4,006	-	-	-	16,293
94-P-3029	Pedersen Aggregates	Aggregate Washing	150	7	32,100	0.25	8,025	-	-	-	-	1,163	1,125	1,163	1,163	1,125	1,163	1,125	-	8,025
95-P-3010	Wooden Sticks Country Club	Golf Course Irrigation	358	4	43,642	0.70	30,549	-	-	-	-	-	7,512	7,763	7,763	7,512	-	-	-	30,549
96-P-3025	Lafarge	Aggregate Washing	409	7	87,488	0.25	21,872	-	-	-	-	3,168	3,066	3,168	3,168	3,066	3,168	3,066	-	21,872
TOTALS:								-	-	-	-	4,331	15,710	16,233	16,233	15,710	4,331	4,191	-	76,740
Surface Water																				
92-P-3049	Pond	Sod Farm	176	4	21,435	0.90	19,292	-	-	-	-	-	4,744	4,902	4,902	4,744	-	-	-	
TOTALS:								-	-	-	-	-	4,744	4,902	4,902	4,744	-	-	-	19,292
Domestic Use		Other - Water Supply	0.335	12	625,253	0.20	125,051	10,621	9,679	10,621	10,278	10,621	10,278	10,621	10,621	10,278	10,621	10,278	10,621	125,136
Agricultural Use		Other - Agriculture	1,427	12	521,358	0.80	417,086	35,424	32,281	35,424	34,281	35,424	34,281	35,424	35,424	34,281	35,424	34,281	35,424	417,372
TOTALS:								161,396	147,078	161,396	156,189	165,726	176,643	182,531	182,531	176,643	165,726	160,380	161,396	1,997,635

Notes
*Municipal taking data has been obtained from the municipality
**PTTW data has been ontained from a 2006 version of the MOE PTTW database

Table 5-9: Current monthly consumption for Pefferlaw Brook (SGBLS, 2009).

PERMIT NUMBER	WELL NAME	TYPE OF USE	Average Pumping m^3/day	Months of Taking	m^3/a	Consumptive Factor	Consumptive Demand	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Groundwater																				
01-P-3010	Well	Golf Course Irrigation	31	4	3,747	0.70	2,623	-	-	-	-	-	647	668	668	647	-	-	-	
4754-5WGJS4	TW1	Golf Course Irrigation	1,034	4	125,791	0.70	88,054	-	-	-	-	-	21,712	22,436	22,436	21,712	-	-	-	
96-P-3025	Well 1	Aggregate Washing	494	7	105,074	0.25	26,269	-	-	-	-	3,825	3,701	3,825	3,825	3,701	3,825	3,701	-	
96-P-3040	Well	Bottled Water	393	12	143,445	1.00	143,445	12,183	11,004	12,183	11,790	12,183	11,790	12,183	12,183	11,790	12,183	11,790	12,183	
97-P-3011	Well	Bottled Water	250	12	91,250	1.00	91,250	7,750	7,000	7,750	7,500	7,750	7,500	7,750	7,750	7,500	7,750	7,500	7,750	
	Green Acres Trailer Park	Communal	2	12	694	0.20	139	12	11	12	11	12	11	12	12	11	12	11	12	
No permit	Green Acres Trailer Park	Communal	2	12	694	0.20	139	12	11	12	11	12	11	12	12	11	12	11	12	
96-P-3004	R. Mc Arthur/ McArthur Bait	Other	131	12	47,751	0.10	4,775	406	366	406	392	406	392	406	406	392	406	392	406	
Groundwater		Irrigation	215	4	26,114	0.90	23,502	-	-	-	-	-	5,795	5,988	5,988	5,795	-	-	-	
97-P-3002	Sanwell Nurseries Limited	Irrigation	36	4	4,352	0.90	3,917	-	-	-	-	-	966	998	998	966	-	-	-	
97-P-3002	Sanwell Nurseries Limited	Irrigation	21	4	2,611	0.90	2,350	-	-	-	-	-	580	599	599	580	-	-	-	
97-P-3002	Sanwell Nurseries Limited	Irrigation	8,667	4	1,054,495	0.90	949,045	-	-	-	-	-	234,011	241,812	241,812	234,011	-	-	-	
TOTALS:					1,606,018		1,335,508	20,362	18,392	20,362	19,705	24,187	287,117	296,687	296,687	287,117	24,187	23,407	20,362	1,338,572
Surface water																				
01-P-3010	Lake Simcoe	Golf Course Irrigation	804	4	97,857	0.70	68,500	-	-	-	-	-	16,890	17,453	17,453	16,890	-	-	-	
94-P-3029	Pond	Aggregate Washing	463	7	98,474	0.25	24,618	-	-	-	-	3,584	3,469	3,584	3,584	3,469	3,584	3,469	-	
99-P-3039	Pond	Golf Course Irrigation	1,781	4	216,664	0.70	151,665	-	-	-	-	-	37,397	38,643	38,643	37,397	-	-	-	
8508-63LLFX	Irrigation Ponds	Sod Farm	904	4	109,987	0.90	98,988	-	-	-	-	-	24,408	25,222	25,222	24,408	-	-	-	
TOTALS:					522,981		343,771	-	-	-	-	3,584	82,164	84,903	84,903	82,164	3,584	3,469	-	344,770
Domestic Use		Other - Water Supply	0.335	12	541,067	0.20	108,213	9,191	8,301	9,191	8,894	9,191	8,894	9,191	9,191	8,894	9,191	8,894	9,191	108,213
Agricultural Use		Other - Agriculture	4,282	4	520,953	0.80	416,762	-	-	-	-	-	102,763	106,189	106,189	102,763	-	-	-	417,904
TOTALS:								29,553	26,693	29,553	28,600	36,962	480,938	496,969	496,969	480,938	36,962	35,770	29,553	2,209,459

Notes

*Municipal taking data has been obtained from the municipality

**PTTW data has been ontained from a 2006 version of the MOE PTTW database

5.3.4 Water Reserve Estimation

The MOE Guidance Module (MOE, 2007) defines water reserve as that portion of water required to support other water uses within the watershed including both ecosystem requirements (instream flow needs) as well as other human uses (aside from permitted uses). Examples of other human uses could include dilution for sewage treatment plant discharge, hydroelectric power needs, recreation, and navigation needs. 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 (Earthfx, 2011a).

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, Guidance Module 7 recommends a simplified estimation method whereby the reserve is estimated as at least 10% of the existing groundwater discharge (Earthfx, 2010a).

There are several alternative methods for estimating groundwater discharge. Discharge can be determined either through (1) a groundwater flow model, if available; (2) baseflow separation applied to long-term flow gauge data, or (3) from spot flow measurements if no other are data available. While separated baseflow values for Pefferlaw Brook and Uxbridge Brook are provided in Table 5-2; the MODFLOW model provides a better estimate of groundwater discharge to streams (Earthfx, 2011a).

The groundwater reserve was estimated as 10% of the MODFLOW simulated groundwater discharge to streams. This baseflow estimate is shown spatially in Figure 5-24. Estimated reserves for the two Tier 2 subwatersheds are provided in Table 5-4 and Table 5-5. Since the model was run under steady-state conditions, these values represent long-term average flows (Earthfx, 2010a).

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, and 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, and measuring 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 Pefferlaw River show that on a regional scale groundwater flow within the major aquifer systems is generally from the topographic highs associated with the ORM towards the topographic lows associated with the major stream channels and Lake Simcoe.
- 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 areas can be described as areas that can effectively move water from the surface through the unsaturated soil zone to replenish available groundwater resources. The mapping of these recharge zones show that the most significant recharge within the subwatershed occurs on the ORM.
- Surface water flows are a function of overland runoff and groundwater discharge (baseflow). The Pefferlaw Brook hydrograph shows that the river is able to respond to most precipitation events with a slow gentle rise and descent in water levels. In contrast the hydrograph for Uxbridge Brook shows that the river responds quickly to a precipitation event and returns to baseflow shortly thereafter.
- The groundwater model estimated that more than half of the total stream flow has been attributed to groundwater discharge (baseflow) within the Pefferlaw River subwatershed.
- An examination of the Baseflow Index at a yearly scale consistently shows that greater than 50% of the flow in the Pefferlaw River comes from baseflow as opposed to surface runoff. This is a good indication of stable year round flow, which is important for maintaining the ecological functions of the river.
- With minimal urban growth and impervious surfaces, the amount of water available for infiltration to the groundwater system has remained relatively constant.

5.4 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.

5.4.1 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), Earthfx Inc. (2009), and Earthfx (2010a).

Considerable effort was made in the Tier 1 (SGBLS, 2009) and Tier 2 (Earthfx, 2010a) water budgets discussed in previous sections to document the various sources of water demand.

Table 5-10 summarizes the current groundwater takings in the Pefferlaw Brook and Uxbridge Brook subwatershed. Surface and groundwater takings within the subwatersheds include the following uses:

- Municipal supply
- Agricultural use
- Private domestic supply
- Other permitted takings (e.g. industrial use, golf course irrigation.

Table 5-10: Estimates of annual current consumptive groundwater use for the Pefferlaw Brook and Uxbridge Brook (SGBLS, 2009 and Earthfx, 2010a). *Values have been rounded for display purposes

Subwatershed	Municipal		Domestic		Permits		Agriculture		Total
	(m^3/a)	%	(m^3/a)	%	(m^3/a)	%	(m^3/a)	%	(m^3/a)
Pefferlaw Brook*	-	0	108,000	6	1,339,000	72	418,000	22	1,865,000
Uxbridge Brook	1,025,000	64	93,000	6	77,000	5	417,000	26	1,612,000

Table 5-11: Estimates of annual future consumptive groundwater use for the Pefferlaw Brook and Uxbridge Brook (SGBLS, 2009 and Earthfx, 2010a).

Subwatershed	Municipal		Domestic		Permits		Agriculture		Total
	(m^3/a)	%	(m^3/a)	%	(m^3/a)	%	(m^3/a)	%	(m^3/a)
Pefferlaw Brook*	-	0	146,000	8	1,339,000	70	418,000	22	1,903,000
Uxbridge Brook	1,359,000	69	125,000	6	77,000	4	417,000	21	1,978,000

**Pefferlaw values taken from the Tier 1 study (LSRCA, 2009), while the Uxbridge values were updated in the Tier 2 study (Earthfx, 2010a).Values have been rounded for presentation purposes.*

Table 5-10 and Table 5-11 provide estimates of current and future annual consumptive groundwater use for the subwatershed. Currently permitted uses account for 72% of the consumptive groundwater demand within the Pefferlaw Brook subwatershed. Agriculture accounts for 22% of the groundwater consumption, and domestic uses accounts for 6%. These values are not predicted to change much in the future. Within the Uxbridge Brook subwatershed municipal supply currently accounts for 64% of consumptive groundwater use. Agriculture, domestic and permitted uses account for the remaining 26%, 6%, and 5% respectively. In the future municipal demand is anticipated to see a slight increase

Table 5-7 and Table 5-8 include the final current and future total groundwater demand values tabulated on a monthly basis. Monthly demand is relatively uniform over the year, with minor increases in the summer months due to golf course irrigation and aggregate washing practices.

The Tier 2 future demand analyses consider only increases in municipal demand and un-serviced domestic consumption. The population-adjusted calculation details for the future water demand scenarios were completed assuming a 35% increase to represent the unserviced future demand. No other components of the water demand were increased with the exception of the municipal pumping wells whose anticipated future takings were supplied by the LSRCA. Unserviced human consumptive demand is a small proportion (6-8%) of the total current water demand, so the impact of population growth is small with regard to personal water consumption from private wells (Earthfx, 2010a).

Municipal Water Supplies

There are three municipal water supply wells that service one community within the Uxbridge Brook subwatershed. The municipal water takings account for approximately 64% of the estimated total groundwater taking within the subwatershed. Municipal well locations are shown on (Figure 5-38). 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 5.3, incorporated average pumping rates where the data were available.

Agricultural

The predominant land use type is agriculture, covering 48% of the study area (See **Chapter 8 - Terrestrial Natural Heritage System** for further information on land use). The total consumption for agricultural use is estimated at 835,000 m^3/yr, which is approximately 24% of the total water taking within the subwatershed. However, this water for irrigation is consumed only through the growing season, from May through mid-October. Therefore, the average daily water consumption for the growing season can be much higher. This water is used mainly for irrigation and in some cases livestock watering. The agricultural water supply is derived from both ground and surface water resources. Some of the water used for irrigation will return back to the groundwater system as an irrigation return flow, and some will be lost to the atmosphere due to evapotranspiration. Water extracted for irrigation generally leads to an overall water loss in a water budget.

Other Permitted Uses

The rolling hills of the Oak Ridges Moraine have made the southern end of the subwatershed an ideal setting for golf courses. Several golf courses have a permit to supply water for irrigation within the Pefferlaw and Uxbridge Brooks subwatersheds. As with the agricultural irrigation some of the water applied over the golf course will infiltrate back into the ground water system, and some will be lost to the atmosphere through evapotranspiration.

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). Water consumption rates from these wells are shown in Table 5-10 and more detailed information in Table 5-7.

5.4.2 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 will often have 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. Current land use for the study area is based on interpretation of the land use data (Earthfx, 2010a)

The predominant land use type is agriculture, covering 59% of the study area. Of this, 44% is intensive row crops while 18% and 13% is non-intensive hay and pasture, respectively. Natural areas, such as forests (i.e., coniferous, deciduous, mixed, sparse, etc.) and wetlands (i.e., swamps, fens, bogs, marshes, open aquatic, etc.) also cover much (34%) of the study area. Settled areas (i.e., urban, rural, transportation, golf courses, etc.) cover only 5.6% of the model area (Earthfx, 2010a). Note that the agricultural land use statistics presented here may not be consistent with **Chapter 8 – Terrestrial Natural Heritage** as the model was constructed using 2008 land use data.

Impervious areas were estimated based on the land use data for the Lake Simcoe basin as well as for the Pefferlaw Brook and Uxbridge Brook subwatersheds. Table 5-12 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 Pefferlaw Brook and Uxbridge Brook subwatersheds. Wetlands and waterbodies within the subwatershed were treated as 100% impervious. The 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 5-12: Comparison of impervious land cover within the Lake Simcoe watershed and Pefferlaw River and Uxbridge Brook subwatersheds.

	Area (km^2)	Impervious (km^2)	Impervious (%)
Lake Simcoe watershed	2,601*	238	9.2
Pefferlaw River and Uxbridge Brook subwatersheds	446.3	34.7	7.8

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

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

The following will discuss the various landuses within the Pefferlaw River subwatershed in the context of Significant Groundwater Recharge Areas. The subwatershed contains a low level of impervious (hardened) surfaces due to the lack of urban areas. Urban areas comprise 1% of the landuses within Significant Groundwater Recharge Areas and rural development comprises 5% (Figure 5-39 and Figure 5-40).

Agriculture practices, like urban development, can influence the quantity of both surface and groundwater within a watershed. Agricultural land use leaves the ground in a more natural state allowing for groundwater infiltration to occur. Intensive and non-intensive agricultural land uses account for almost half of the landuses within the Significant Groundwater Recharge Areas at 21% and 23% respectively (Figure 5-39 and Figure 5-40). When groundwater infiltration occurs in agricultural and rural areas the ground can become supersaturated following a prolonged precipitation event leading to the ponding of water at the surface. In the pre and post growing season the land is left open allowing for increased erosion and runoff following a precipitation event. During the growing season a large volume of water will be lost to the atmosphere through evapotranspiration. The water lost through evapotranspiration is removed from the ground as the plants draw the water up through their root system.

As mentioned in Section 5.4.1 agricultural practices also place a huge demand on the water supply for livestock watering and irrigation. The water used for irrigation is often supplied by groundwater and surface water where available. To obtain a surface water supply many farms construct on-line ponds. On-line ponds are built in an existing water course and allow water to flow in and out. The volume of water in the pond is controlled by a berm or other form of control structure. On-line ponds restrict the natural streamflow as a large volume of water becomes contained in the pond. When surface water is unavailable large volumes of water are pumped from the ground. Some of the water used for irrigation infiltrates back into the groundwater system.

Natural Heritage features comprise the largest landuse within the Significant Groundwater Recharge Areas at 40% (Figure 5-39 and Figure 5-40). The natural heritage features leave the landscape in a natural state promoting infiltration. Active aggregate operations are the next largest land use within the Significant Groundwater Recharge Areas at 5%. Future land development plans should focus on promoting land use activities that maintain and protect the recharge occurring within the Significant Groundwater Recharge Areas.

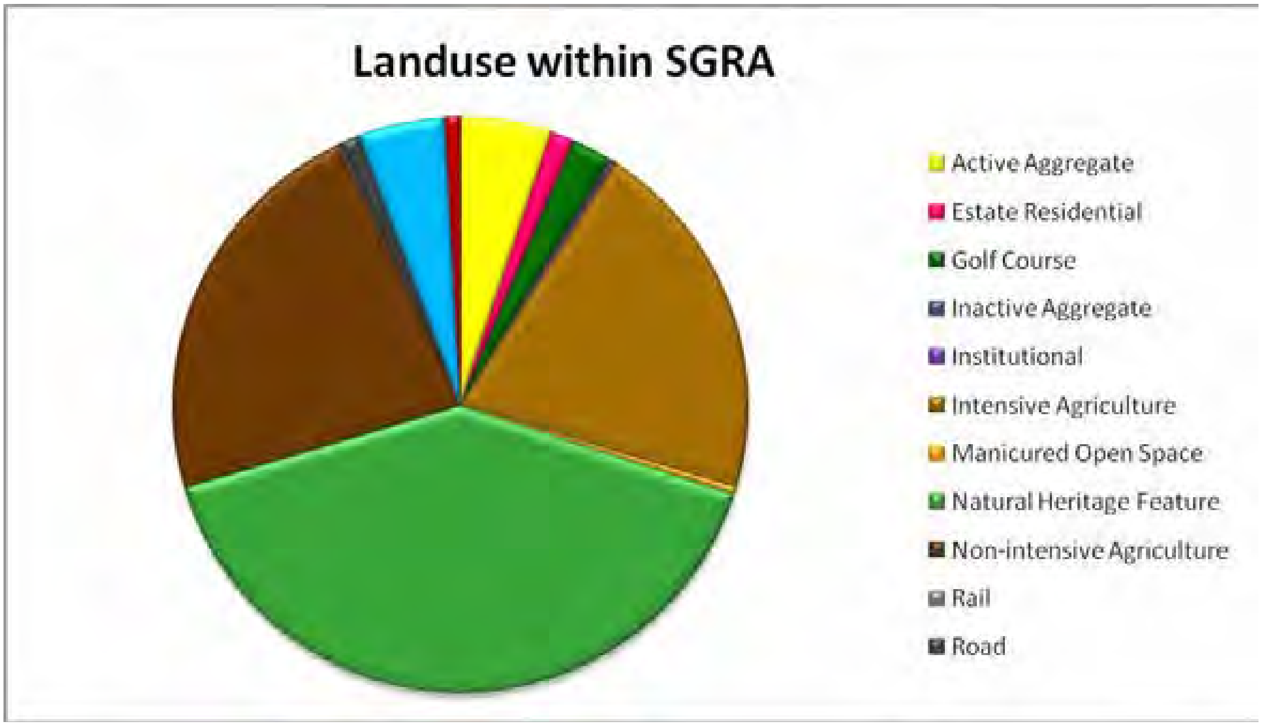
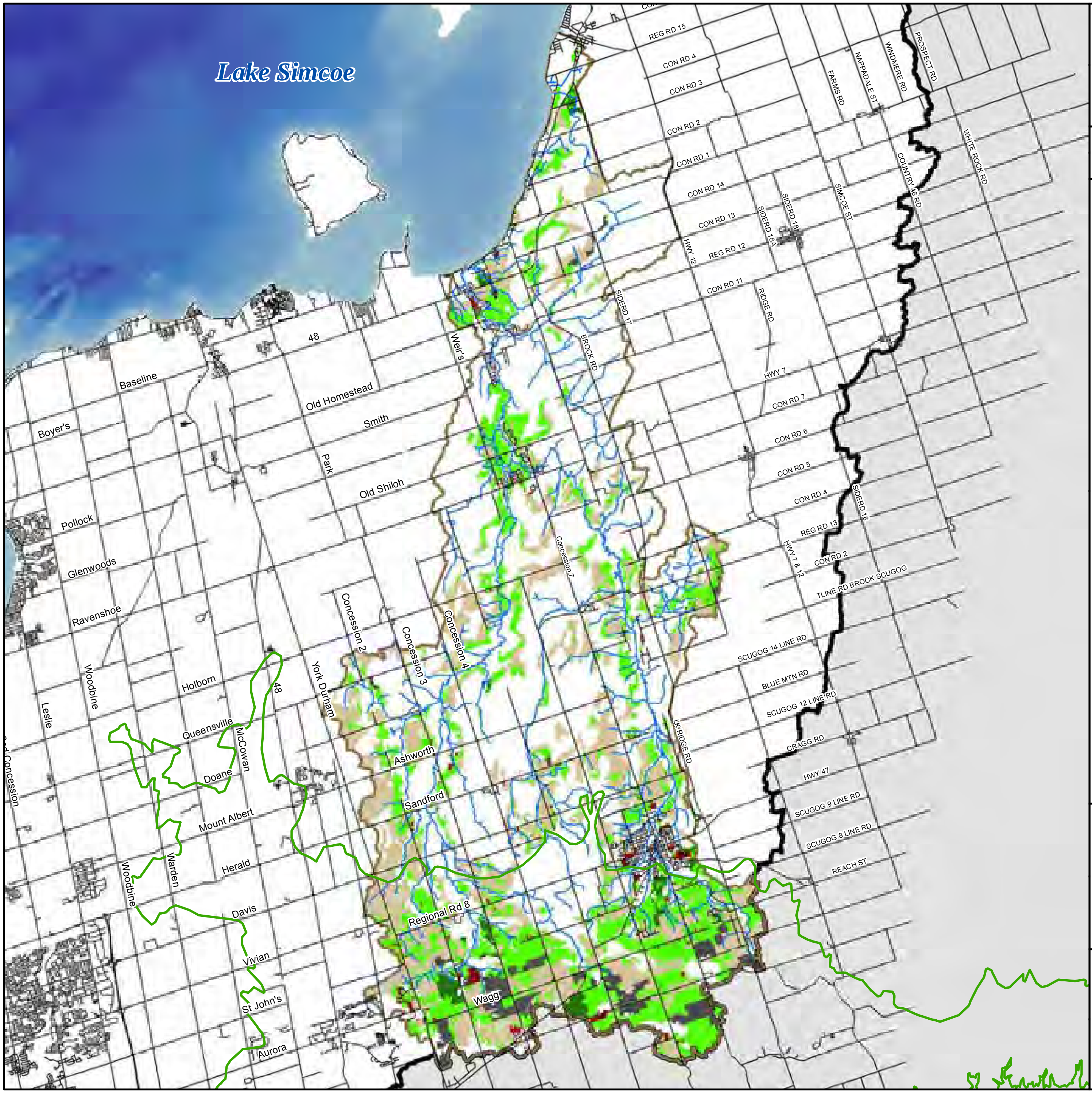


Figure 5-39: Land use distribution within Significant Groundwater Recharge Areas

Landuse within Significant Groundwater Recharge Areas in the Pefferlaw River subwatershed

Figure 5-40



Legend

— Road

〰 Watercourse

Oak Ridges Moraine

LSRCA Watershed Boundary

Land Use

🟥 Urban

🟫 Rural

🟩 Natural Cover

🟩 Golf Course

⬛ Aggregate

Lake Simcoe Region conservation authority

0 1 2 4 6 8 10

Kilometres

N

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

5.4.3 Climate

The climate of the Pefferlaw Brook and Uxbridge Brook 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.

5.4.4 Water Budget Estimates

Potential water quantity stress is being estimated on a subwatershed basis through the Source Protection Planning process. Several water budget initiatives have been undertaken to identify potential water quantity stress within the Pefferlaw Brook and Uxbridge Brook subwatersheds. 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), Earthfx Inc. (2009), Earthfx 2010a and Earthfx 2011.

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 blue text box). The major components of the water budget have been estimated and tabulated as described in the preceding section, including water supply, water demand, and water reserve.

The percentage of quantity demand can be expressed as in the following equation:

$$\%WaterDemand = \frac{Q_{DEMAND}}{Q_{SUPPLY} - Q_{RESERVE}}$$

where:

Q_{Demand} = amount of water consumed (pumped);

Q_{Supply} = recharge plus lateral groundwater inflow into the subwatershed (Qr + Qin); and

$Q_{Reserve}$ = the portion of available surface water or groundwater reserved for other needs such as navigation, assimilative capacity, and ecosystem health. This is estimated as 10% of the model predicted baseflow discharge to the streams in the subwatershed

Results of the current and future groundwater stress assessment using annual average demand are shown in Table 5-13 and Table 5-14. Both Pefferlaw and Uxbridge were found not to be stressed with regard to average annual stress for current demand. For future demand the Uxbridge Brook subwatershed was found to have a moderate potential for stress.

Results of the current monthly surface and groundwater stress assessments are shown in Table 5-15. Both Pefferlaw and Uxbridge Brooks were found not to be stressed with regard to groundwater on a monthly basis. Seasonal changes in stress levels are a result of increased pumping for irrigation (domestically, commercially, or for agriculture), and less available water during dryer summer months.

Within the summer months, surface water stress assessments indicate a moderate potential for surface water stress within the Pefferlaw Brook subwatershed. These elevated values are attributed to low available supply values calculated using the Tessmann method. For example, Pefferlaw Brook in July has a total flow of 1.05m^3/s and the value calculated using Tessmann's method for reserve[1] is 0.68 m^3/s. This estimates the available supply to be 0.37 m^3/s. It can be seen that this available supply affords little taking before it is considered stressed. Although it has been recognized that these values are exaggerated they have not been adjusted to a lower reserve, as the outcome does not induce a Tier 2 study under the Clean Water Act Technical Rules. Overall, the results provide a reasonable assessment of the annual groundwater and monthly surface and groundwater supply and demand conditions, and the methodology can identify catchments with elevated levels of stress.

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[1] Reserve is defined as the water that is required to be protected to support other uses within the subwatershed including ecosystem needs and other human uses such as sewage assimilation, hydroelectric power production and navigation (MOE, 2007).

Table 5-13: Current Annual Stress Assessment (SGBLS, 2009)

Subwatershed	Area	Precip	AET	Surplus Water	Annual Mean Flow		Baseflow		Available				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	%
Pefferlaw Brook	285	852	561	291	2.5	275	1.4	151	166	1.5	206	1.9	15	0.14	96	0.9	1,865,000	7	4%
Uxbridge Brook	161	831	560	271	1.6	311	0.9	180	140	0.7	234	1.2	18	0.09	108	0.6	1,438,000	9	7%

Note: Values rounded for presentation purposes

10 - 24% of available supply being taken

25% or more of available supply being taken

AET - Actual Evapotranspiration
GW - Groundwater
SW - Surface Water

Table 5-14: Future Annual Stress Assessment (SGBLS, 2009).

Subwatershed	Area	Precip	AET	Surplus Water	Annual Mean Flow		Baseflow		Available				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	%
Pefferlaw Brook	285	852	561	291	2.5	275	1.4	151	166	1.5	206	1.9	15	0.14	96	0.9	1,903,000	7	4%
Uxbridge Brook	161	831	560	271	1.6	311	0.9	180	140	0.7	234	1.2	18	0.09	108	0.6	3,370,615	21	17%

Note: Values rounded for presentation purposes

10 - 24% of available supply being taken

25% or more of available supply being taken

AET - Actual Evapotranspiration
GW - Groundwater
SW - Surface Water

Table 5-15: Current Monthly Surface and Groundwater Stress Assessment (SGBLS, 2009).

Month	Pefferlaw Brook		Uxbridge Brook	
	GW	SW	GW	SW
January	1%	0%	6%	0%
February	1%	0%	6%	0%
March	1%	0%	7%	0%
April	1%	0%	7%	0%
May	1%	0%	7%	0%
June	11%	25%	9%	10%
July	11%	34%	9%	14%
August	11%	34%	9%	14%
September	11%	27%	9%	10%
October	1%	0%	6%	0%
November	1%	0%	6%	0%
December	1%	0%	6%	0%

Stress Assessment Thresholds

	Moderate	Significant
Groundwater	>25% & < 50%	>50%
Surface Water	>20% & <50%	>50%

As a result of the current and future average annual stress assessment the Uxbridge Brook subwatershed advanced to a Tier 2 assessment per the Clean Water Act Technical Rules. The Pefferlaw Brook is exempt from undergoing a Tier 2 under the Clean Water Act as it contains no municipal drinking water systems even through it indicated a moderate potential for stress with respect to surface water. The following sections will discuss the results of the Uxbridge Brook Tier 2 Water Budget and the Pefferlaw Brook ORMCP water budget. Both water budgets were simulated using the same model.

Uxbridge Brook Tier 2 Water Budget Results

The objectives and approach of the Tier 2 Water Budget Assessment is similar to that 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 (Earthfx, 2010a).

The Uxbridge Brook Tier 2 Water Budget (Earthfx, 2010a) conducted a comparison analysis of current and future conditions for average annual, monthly basis, and two-year drought conditions. 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.

Results of the stress assessment for annual average demand under future conditions are shown in Table 5-16. Monthly stress assessments presented in Table 5-17 and Table 5-18 suggest that the Uxbridge Brook subwatershed is not stressed from a groundwater perspective. The percent water demand indicates that there is 1% change in overall groundwater demand between current and future conditions (Earthfx, 2010a).

The focus of the drought scenario was to simulate the drawdown in the municipal wells over a time period of two years using current and future pumping rates, with zero recharge. Drawdown in the vicinity of the municipal wells was less than 3 m for both current and future pumping rates. As can be seen on Figure 5-41, the largest drawdown occurs in the headwaters area under the Oak Ridges Moraine. Discharge areas along the major streams exhibit no drawdown (shown in white on Figure 5-41). Transient simulation results show that because of the high available storage, the available drawdown in the wells, and the relatively short drought period (2-years), the wells do not fail under drought conditions and the stress conditions do not change from those presented in Table 5-17 and Table 5-18.

Table 5-16: Current and Future annual Stress Assessment for the Uxbridge Brook Subwatershed. Please note that values have been rounded for presentation purposes (Earthfx, 2010a).

	Area	Model Recharge		Q_{in}		Baseflow		Reserve (10% baseflow)		Groundwater Consumption		GW Stress
	km^2	mm/yr	m^3/s	mm/yr	m^3/s	mm/yr	m^3/s	mm/yr	m^3/s	m^3/yr	mm/yr	%
Current	161.3	171	0.87	44	0.22	50	0.26	5	0.026	1,612,000	10.0	5%
Future	161.3	171	0.87	46	0.23	47	0.24	5	0.024	1,978,000	12.3	6%

Table 5-17: Monthly current stress assessment for the Uxbridge Brook subwatershed (Earthfx, 2010a).

Stress Assessment - Current									
Month	Recharge	Qin	Baseflow		Reserve (10% baseflow)		Groundwater Demand		GW Stress
	mm/mo	mm/mo	mm/mo	m^3/s	mm/mo	m^3/s	m^3/mo	mm/mo	%
Jan	14.3	7.6	12.8	0.79	1.28	0.079	130,308	0.81	4%
Feb	14.3	7.6	12.8	0.79	1.28	0.079	118,748	0.74	4%
Mar	14.3	7.6	12.8	0.79	1.28	0.079	130,308	0.81	4%
Apr	14.3	7.6	12.8	0.79	1.28	0.079	126,104	0.78	4%
May	14.3	7.6	12.8	0.79	1.28	0.079	134,638	0.83	4%
Jun	14.3	7.6	12.8	0.79	1.28	0.079	141,814	0.88	4%
Jul	14.3	7.6	12.8	0.79	1.28	0.079	146,541	0.91	4%
Aug	14.3	7.6	12.8	0.79	1.28	0.079	146,541	0.91	4%
Sep	14.3	7.6	12.8	0.79	1.28	0.079	141,814	0.88	4%
Oct	14.3	7.6	12.8	0.79	1.28	0.079	134,638	0.83	4%
Nov	14.3	7.6	12.8	0.79	1.28	0.079	130,295	0.81	4%
Dec	14.3	7.6	12.8	0.79	1.28	0.079	130,308	0.81	4%

Note: Values rounded for presentation purposes

🟧	25 - 50% of available supply being taken
🟥	50% or more of available supply being taken

Table 5-18: Monthly future stress assessment for the Uxbridge Brook subwatershed (Earthfx, 2010a).

Stress Assessment - Future									
Month	**Recharge**	**Qin**	**Baseflow**		**Reserve (10% baseflow)**		**Groundwater Demand**		**GW Stress**
	mm/mo	**mm/mo**	**mm/mo**	**m³/s**	**mm/mo**	**m³/s**	**m³/mo**	**mm/mo**	**%**
Jan	14.3	7.6	12.3	0.76	1.23	0.076	161,396	1.00	5%
Feb	14.3	7.6	12.3	0.76	1.23	0.076	147,078	0.91	4%
Mar	14.3	7.6	12.3	0.76	1.23	0.076	161,396	1.00	5%
Apr	14.3	7.6	12.3	0.76	1.23	0.076	156,189	0.97	5%
May	14.3	7.6	12.3	0.76	1.23	0.076	165,726	1.03	5%
Jun	14.3	7.6	12.3	0.76	1.23	0.076	171,899	1.07	5%
Jul	14.3	7.6	12.3	0.76	1.23	0.076	177,629	1.10	5%
Aug	14.3	7.6	12.3	0.76	1.23	0.076	177,629	1.10	5%
Sep	14.3	7.6	12.3	0.76	1.23	0.076	171,899	1.07	5%
Oct	14.3	7.6	12.3	0.76	1.23	0.076	165,726	1.03	5%
Nov	14.3	7.6	12.3	0.76	1.23	0.076	160,380	0.99	5%
Dec	14.3	7.6	12.3	0.76	1.23	0.076	161,396	1.00	5%

Note: Values rounded for presentation purposes

🟧	25 - 50% of available supply being taken
🟥	50% or more of available supply being taken

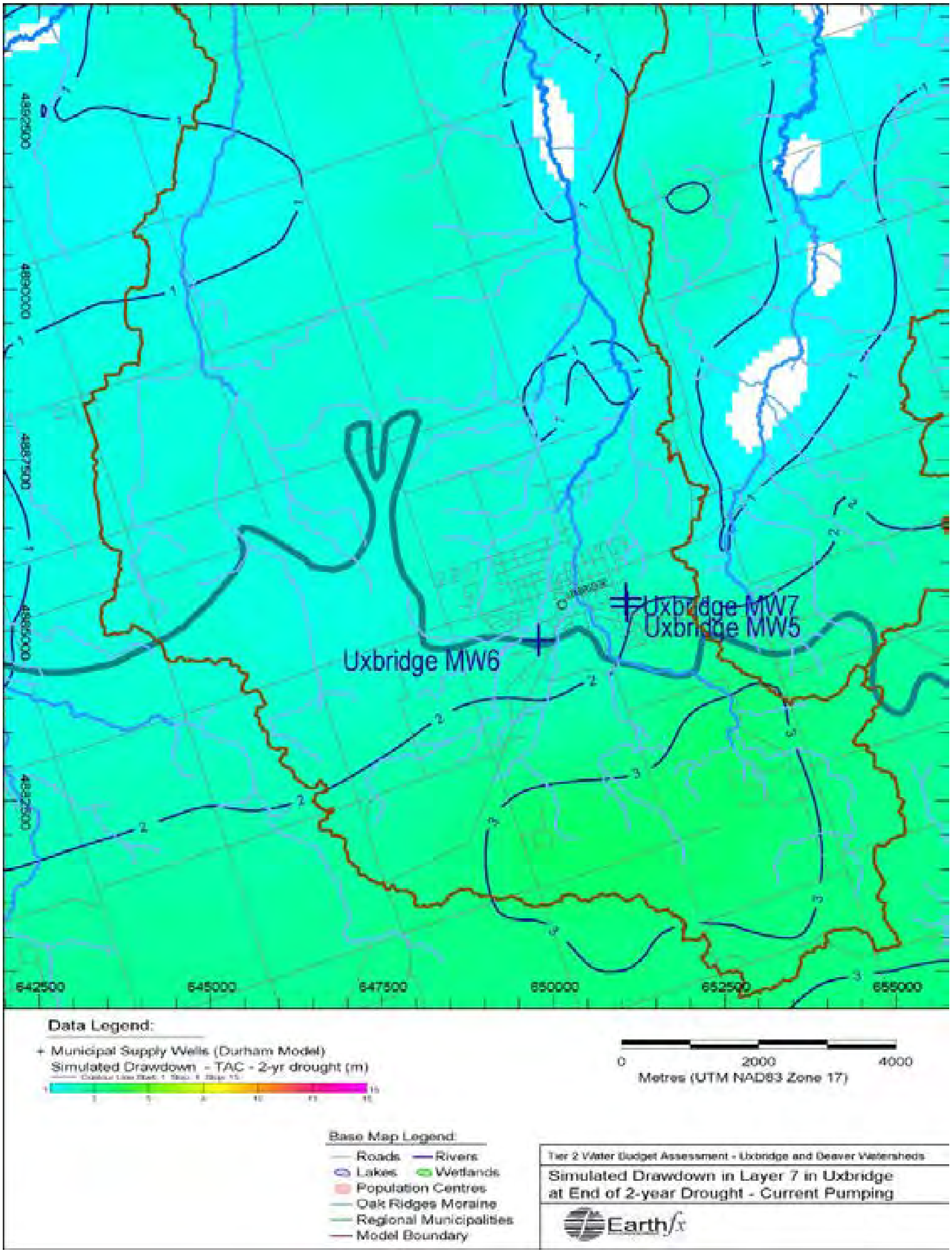


Figure 5-41: Simulated drawdown at the end of a 2-year drought- Uxbridge area, existing pumping (Earthfx, 2011b).

Pefferlaw River ORMCP Water Budget Results

The Pefferlaw ORMCP study simulated how the subwatershed will respond to a period of extreme low precipitation and climate change based on forecasted conditions. The results of the scenarios were then compared to baseline (pre-development) conditions.

To simulate pre-development (historical) conditions all developed lands were set as 100% pervious within the model. By doing this much of the recharge reduced from development can be maintained, subsequently representing a rough estimate of the recharge regime. However, there are shortcomings to assuming everything pre-development was 100% pervious. For example, it is likely that prior to development and agriculture the study area was covered by forest and wetland, the extent of which, however, is unknown. Increased vegetation results in increased interception loss, decreased soil-zone evapotranspiration (ET) rates, and changes to soil characteristics; therefore, pre-development conditions modelled in this fashion may result in a slight overestimation of the actual pre-development recharge (Earthfx, 2011b).

The drought scenario was simulated to determine the potential impacts of extreme low precipitation. The drought was simulated using a synthetic precipitation data set produced using records from the 1930s, the driest decade recorded in Ontario, and current temperate and solar radiation data. This was done because:

- This data does not exist in completion in the 1930s;
- It is reasonable to use current temperatures as they are higher than in the 30s, as a result the drought simulation will be more conservative; and
- It is assumed that precipitation volumes and temperatures are independent at the monthly/annual time scale to which model results are presented.

The climate change scenario was simulated using forecasted changes in precipitation and temperatures collected from the Environment Canada Canadian Regional Climate Model (CRCM) version 4.2.3. Average monthly total precipitation and mean temperature were calculated from the forecasted 2060 and 2080 climate period and were compared with the monthly recorded averages from 1975 to 2002.

Changes in precipitation predicted by the CRCM model tended to have increased precipitation in the winter season, and reduced precipitation during the summer months ranging between -20 to 40 millimetres per month.

Comparative results for the model scenarios are presented in Table 5-19. For the period of 1975-2002, the Pefferlaw watershed receives approximately 981 mm/yr. During the baseline simulation, where the model area was assumed to be completely pervious, two-thirds of this precipitation was lost either to ET or interception. One-fifth percolated to the groundwater table, and the remainder became runoff discharged to streams (Earthfx, 2011c).

Table 5-19: Pefferlaw Brook Water Budget Results (Earthfx, 2011b).

	Baseline	Change from baseline	
		drought	climate change
Observed Precipitation	981	-27% (-262)	8% (75)
Interception Loss	191	-26% (-50)	-1% (-1)

	Baseline	Change from baseline	
		drought	climate change
Actual ET	468	-17% (-79)	6% (27)
Runoff	127	-28% (-36)	35% (44)
Recharge	196	-51% (-100)	11% (22)
Baseflow (m3/s)	2.39	-50% (-84)	12% (20)

Note: All values are presented in mm/yr unless otherwise stated. The values shown within the drought and climate change columns indicate the change from baseline conditions as a percent increase or decrease and change in mm/yr.

The drought condition caused a 27% decrease in annual precipitation, which was roughly the same reduction found for interception and runoff. A less-severe 17% decrease in ET occurred during the drought scenario. A dramatic decrease of 50% in recharge and baseflow discharge to streams was reported, indicating that the Pefferlaw River is quite sensitive to drought conditions from a water resources standpoint. Baseflow discharge when extrapolated over both the Pefferlaw and Uxbridge Brook subwatersheds tends to be 25 mm/yr less than modelled recharge. The ability for the model to simulate a baseflow volume which exceeds groundwater recharge is evidence of groundwater flow which crosses surface water catchment area boundaries (Earthfx, 2011c).

The climate change scenario saw an 8% increase in annual precipitation, however its impact to other hydrological elements was much more variable. With only a 6% increase in ET and negligible changes in losses from interception, the majority of the increased precipitation had to be divided between runoff and groundwater recharge. Recharge increased 11% from baseline conditions, showing the forecasted climate change can be beneficial from a water supply standpoint. The greatest impact due to climate change was overland run-off, incurring a 35% increase. Although this scenario has greater extents of imperviousness than the baseline scenario, which may have some influence on this increase, the overall extents impervious areas are negligible. It is also worth mentioning that much of this increased runoff would occur during storm events that occur infrequently; therefore the likely consequence would be more frequent peak flows that are higher in magnitude, which could have devastating consequences to lotic and riparian habitat.

***Key points – Factors Impacting Water Quantity status - stressors*:**

- The water demand estimates for the Uxbridge Brook and Pefferlaw River subwatersheds suggests that water demand is relatively uniform over the year, with minor increases in the summer months due to some seasonal permitted uses.
- The total groundwater demand from all sources in the Pefferlaw River and Uxbridge Brook subwatersheds is 3.5 M m^3/yr.
- Permitted and domestic wells account for 78% of the current groundwater consumption within the Pefferlaw Brook subwatershed. The remaining consumption is for agriculture at 22%. Within the Uxbridge Brook subwatershed municipal supplies account for 64% of the current groundwater consumption. The remaining consumption is for agriculture (26%), permits (5%) and domestic purposes at 6%.
- The predominant land use type is agriculture, covering 59% of the study area. The total consumption for agricultural use is estimated at 835,000 m^3/yr, which is approximately 24% of the total water taking within the subwatershed.
- The Pefferlaw River and Uxbridge Brook subwatersheds are predominantly rural with settlement areas accounting for less than 6% of the total area. The subwatershed contains a low level of impervious surfaces due to the lack of urban areas.
- The Tier 1 water budget estimated the current surface water use with the Pefferlaw River and Uxbridge Brook subwatersheds is 967,000 m^3/annum, which represents 10% of the available surface water supply. During the summer months (June-September) the subwatershed exhibited a moderate potential for surface water stress. However, as there are no municipal surface water intakes within the subwatershed it did not progress to a Tier 2.
- The Tier 1 water budget for the Pefferlaw Brook subwatershed estimated the current groundwater use is 1,865,000 m^3/annum, which represents 4% of the available groundwater supply. Future groundwater use is projected to be 1,903,000 m^3/annum which represents 4% of the available groundwater supply. Overall, the Tier 1 indicated that the Pefferlaw Brook subwatershed is not stressed from a groundwater perspective.
- The Tier 2 water budget for the Uxbridge Brook subwatershed estimated the current groundwater use is 1,612,000 m^3/annum, which represents 5% of the available groundwater supply. Future groundwater use is projected to be 1,978,000 m^3/annum which represents 6% of the available groundwater supply. Overall, the Tier 2 indicated that the subwatershed is not stressed from a groundwater perspective.

5.5 Current Management Framework

5.5.1 Protection and Policy

Oak Ridges Moraine Conservation Plan (2001)

The objectives of the Oak Ridges Moraine Conservation Plan include maintaining, improving or restoring all of the elements that contribute to the ecological and hydrological functions of the ORM area, including the quality and quantity of its water and other resources.

The policies of this Plan that will protect the quantity of water resources include:

- Municipalities are required to complete water budgets and conservation plans which include:
    - Quantification of components of the water balance equation
    - Characterization of the groundwater and surface water flow systems
    - Identification of targets to meet the water needs of the affected ecosystems; the availability, quantity and quality of water sources; and goals for public education and for water conservation
    - Development of a water-use profile and forecast
    - Identification and evaluation of various water conservation measures
    - Requirement for the use of specified water conservation measures and incentives
    - Plans for implementation and monitoring
- Development and site alteration is prohibited in hydrologically sensitive features and their related minimum vegetation protection zones. This includes streams, wetlands, kettle lakes, and seepage areas and springs, with exceptions for activities such as fish and wildlife management, conservation projects, transportation and infrastructure, and low-intensity recreational uses.
- Except with respect to land in Settlement Areas, development and site alteration with respect to land in a subwatershed are prohibited if they would cause the total percentage of impervious area in the subwatershed to exceed 10 per cent. Planning authorities are also to consider the desirability of having at least 30 per cent of the area of a subwatershed in natural self sustaining vegetation. Within Settlement areas, planning authorities should consider the importance of ensuring that natural vegetation is maintained, and improved or restored wherever possible, and should attempt to keep impervious surfaces to a minimum.

The ORMCP also contains policies for the protection of key natural heritage features and their functions, similar to those for hydrologically sensitive features. By protecting the ecosystem holistically, the implementation of the ORMCP will help to conserve water resources and ensure that there is enough available to sustain the needs of the ecosystem as well as those who reside within it.

Greenbelt Plan (2005)

One of the Greenbelt Plan’s Environmental goals is the ‘protection, improvement or restoration of the quality and quantity of ground and surface water and the hydrological integrity of watersheds.' This goal is supported by a number of policies that relate to the Protected Countryside areas of the Greenbelt.

The following policies related to water quantity apply for lands within the Natural Heritage System of the Protected Countryside:

- New development or site alteration shall demonstrate that:
    - There will be no negative effects on…key hydrologic features
    - The removal of other natural features…should be avoided
    - The disturbed area of any site does not exceed 25%, and impervious surfaces do not exceed 10% of the developable area
- Where non-agricultural uses are contemplated, applicants shall demonstrate that:
    - At least 30% of the total developable area will remain or be returned to natural self-sustaining vegetation (this will encourage infiltration and slow runoff), and that buildings and structures are to occupy less than 25% of the total developable area of the site

Policies of the Water Resources system (within the Protected Countryside) that relate to water quantity include:

- Planning authorities shall provide for a comprehensive, integrated and long-term approach for the protection, improvement or restoration of the quality and quantity of water
- Cross-jurisdictional and/or cross-watershed impacts should be considered, and should be integrated with ORM subwatershed plans.
- Municipalities shall protect vulnerable surface and groundwater areas

The Greenbelt Plan also limits development in Key Natural Heritage Features and Key Hydrologic Features, which will protect the important watershed functions that they perform:

- Development and site alteration are not permitted within these features, including any associated vegetation protection zone (with some exceptions, such as conservation and flood control works)

Lake Simcoe Protection Plan (2009)

The Water Quantity policies of the Lake Simcoe Protection Plan (LSPP) focus on ensuring sufficient water supply to maintain healthy aquatic ecosystems and promoting the conservation and efficient use of water.

They include:

- The MOE and MNR will be developing in-stream flow targets for water quantity stressed watersheds in the Lake Simcoe basin. This includes the development of targets for in-stream flow regimes and water extraction limits, and will build on watershed information and assessments developed through the Drinking Water Source Protection Program.
- The MAFRA, in cooperation with key stakeholders, will assist and encourage water conservation and efficiency efforts in the agricultural community through stewardship programs aimed at promoting the adoption of BMPs

- The MOE will work with other water use sectors (including recreational, commercial, and industrial users) to encourage the development and implementation of water conservation and efficient use practices.

LSPP policies around stormwater management will also help to protect water quantity. Applications for major development will be required to include a stormwater management plan, which demonstrates, among other things, consistency with water budgets; an integrated treatment train approach to minimize stormwater management flows and reliance on end-of-pipe controls through measures such as source and lot-level controls and conveyance techniques; and how anticipated changes in water balance will be minimized.

The LSPP also provides protection to key natural heritage and hydrologic features which will, in turn, protect their functions related to water quantity.

Growth Plan for the Greater Golden Horseshoe (2006)

Under its policies for managing growth, the Growth Plan specifies that population and employment growth will be accommodated by directing growth to built-up areas through intensification – this may help to limit the spread of impervious area, reducing its impacts on stream flow and infiltration to groundwater. Specific policies within this plan related to water quantity include:

- That the construction of new, or the expansion of existing, municipal or private communal water and wastewater systems should only be considered where the following conditions are met:
    - Strategies for water conservation and other water demand management initiatives are being implemented in the existing area
    - Plans for the expansion or for new services are to serve growth in a manner that support the achievement of the intensification target and density target
- Municipalities that share an inland water source and/or receiving water body should coordinate their planning for potable water, stormwater and wastewater systems to ensure that water quality and quantity is maintained or improved.
- Municipalities are encouraged to implement and support innovative stormwater management actions as part of redevelopment and intensification
- Municipalities will develop and implement official plan policies and other strategies in support of the following conservation objectives:
    - Water conservation, including water demand management for the efficient use of water; and water recycling, to maximize the reuse and recycling of water

Provincial Policy Statement (2005)

Policies that are directly related to the management of water quantity in the PPS include:

- Implementing necessary restrictions on development and site alteration to
    - Protect municipal drinking water supplies (i.e. quantity)
    - Protect, improve or restore vulnerable surface and groundwater, sensitive surface water features and sensitive groundwater features and their hydrologic functions

  - Maintaining linkages and related functions among surface water features, groundwater features, hydrologic functions and natural heritage features and areas
  - Promoting efficient and sustainable use of water resources, including practices for water conservation and sustaining water quality
- Directing growth to promote the use of existing sewage and water services, ensuring that these services can be provided in a manner that can be sustained by the water resources on which they rely, and that protects human health and the natural environment
- Focusing growth in settlement areas, a policy which, if implemented, should limit the amount of natural area removed, thus maintaining the natural functions of these areas. Development and site alteration are not permitted in features such as significant woodlands and ANSIs, or the lands adjacent to them, unless it can be demonstrated that there will be no negative impacts on the natural features or their functions
- Ensuring stormwater management practices minimize stormwater volumes and contaminant loads, and maintain or improve the extent of vegetative and pervious surfaces

<u>Clean Water Act (2006)</u>

The recently enacted Clean Water Act (CWA) ensures the safety of drinking water by identifying potential risks to local water sources. A key focus of the CWA is to identify where long-term municipal water supplies could be threatened, identify the causes of concern and possible management strategies that will ultimately aid in the development of the source protection plans.

The Ministry of Environment (2009) indicates that this legislation is designed to promote voluntary initiatives but does require mandatory action where needed. The legislation sets out a basic framework for communities to follow in developing an approach to protecting their water supplies that works for them:

Identify and assess risks to the quality and quantity of drinking water sources and decide which risks are significant and need immediate action, which need monitoring to ensure they do not become significant, or which pose a low or negligible risk.

Develop a source protection plan that sets out how the risks will be addressed. Broad consultation will involve municipalities, conservation authorities, property owners, farmers, industry, businesses, community groups, public health officials, First Nations and the public in coming up with workable, effective solutions.

Carry out the plan through existing land use planning and regulatory requirements or approvals, or voluntary initiatives. Activities that pose a significant risk to drinking water sources may be prohibited or may require a site specific risk management plan. This plan will set out the measures that a property owner will take to ensure the activity is no longer a threat.

Stay vigilant through ongoing monitoring and reporting to measure the effectiveness of the actions taken to protect drinking water sources and ensure they are protected in the future.

<u>Ontario Water Resources Act (1990)</u>

Section 34 of the Ontario Water Resources Act (OWRA) deals with the issue of water taking. The OWRA stipulates that a person shall not take more than 50,000 litres of water on any day by any means except in accordance with a permit issued by the Director (the permit is issued under Section 34 (1) of the OWRA. This policy applies to all uses except for domestic or farm purposes, which includes ordinary household purposes or the watering of livestock, poultry, home gardens, or lawns; or to use for firefighting. The irrigation of crops grown for sale is not included under ‘domestic and farm purposes.’ A permit is however required for takings for domestic and farm purposes if the amount of water taken exceeds 379,000 litres per day.

A Director has discretion to issue, refuse to issue, or cancel a permit, and can impose a number of terms and conditions in issuing a permit as he or she considers proper, and can also alter the terms and conditions of a permit after it has been issued.

The following are some of the terms and conditions that a Director may include in a permit:

- Limiting the amount and rate of water taking
- Governing the manner in which water may be taken
- Governing the return, after use, of water taken under the permit
- Governing the monitoring and reporting of the amount, rate, use, and effects of water taking (including effects on water quantity and quality)
- Governing the use and conservation of water taken, including requiring the implementation of specified measures to promote the efficient use of water or reduce the loss of water through consumptive use or to prepare a water conservation plan
    - Requiring the holder to implement specified measures to prevent the water taking from causing interference with other water takings and/or to remedy any interference with other water takings that is caused by the water taking under the permit

Section 34 (4) of the OWRA states that where the taking of water for any purpose, other than for domestic or farm use or for firefighting, interferes, in the opinion of a Director, with any public or private interest in any water, the Director may…prohibit the person from so taking water without a permit issued by the Director.

LSRCA Watershed Development Policies (2008)

LSRCA’s Watershed Development Policies address issues of water quantity in a number of ways:

- Requiring Enhanced Level 1 stormwater controls of all new developments
- Noting that stormwater management plans accompanying development proposals must make all feasible efforts to maintain pre-development infiltration and evapotranspiration rates to the receiving watershed
- Stipulating that peak discharges are to be controlled to a minimum of pre-development levels
- Requiring a minimum 24-hour detention of runoff from a 25 mm storm for erosion protection and baseflow maintenance
- Protecting natural features, thus promoting infiltration for the slow release of water after storm events and the maintenance of aquifer levels

York Region Official Plan

York Region's Official Plan (OP) includes a number of policies related to the protection of the quality of both ground and surface water. The policies within the OP related to water quantity include:

- The preparation of a comprehensive regional water strategy for both piped services and surface and groundwater sources that will include long-term protection strategies, enhancement guidelines and monitoring requirements;
- That the natural quality and hydrological characteristics of watercourses and lakes (including water quality and temperature) will be maintained, and that development be designed with the goal of maintaining water balance
- To direct development away from sensitive surface water and groundwater features
- To continue to partner with other regions and conservation authorities to study, analyze, and monitor ground and surface water resources to ensure a unified approach to protecting and enhancing water quality and quantity
- To monitor the quantity and quality of surface and ground water systems in York Region, in co-operation with local municipalities and conservation authorities) by:
    - Assessing the sustainability of current activities and land uses
    - Identifying areas that are susceptible to, or currently experiencing, water quality and quantity problems
- Requiring local municipalities to establish policies and programs to protect, enhance, and monitor water systems
- To work with the province, local municipalities, conservation authorities and other in establishing procedures for water taking permits that protect and enhance water resources
- To require the preparation of comprehensive master environmental servicing plans as part of secondary plans to protect and enhance the natural hydrologic function of water systems. These plans will emphasize water reuse and incorporate innovative technologies with the goal that the water balance and hydrologic functions will be maintained
- Working with partners in the implementation of stormwater management initiatives
- Requiring the preparation of comprehensive stormwater management plans as a component of secondary plans, and encouraging innovative approaches to stormwater management within secondary plans
- That development have an integrated and innovative approach to water management, be water efficient, and maximize stormwater quality, quantity, and infiltration through an integrated treatment approach
- Work with local municipalities and LSRCA in the preparation and implementation of comprehensive stormwater master plans for each settlement area within the Lake Simcoe watershed by 2014
- Requiring all new buildings to achieve 10% greater water efficiency than the Ontario Building Code, and encouraging all new buildings to achieve 20% greater efficiency
- To restrict the use of potable water for lawn watering
- Requiring the installation of rainwater harvesting and re-circulation/reuse systems on all new residential buildings for outdoor irrigation and outdoor water use

- Encouraging the use of water efficient, drought resistant landscaping by:
    - providing a minimum 6" of topsoil
    - installing drought resistant sod
    - providing landscape features that minimize the demand for water and chemicals by utilizing native and drought resistant species
    - installing permeable driveway surfaces
- Encouraging all developments to incorporate green roofs into building design
- Supporting the goals and objectives of subwatershed plans

In addition to these policies, York Region's protection of the regional Greenlands System will help to ensure that the functions of the Region's natural features, such as the water retention and infiltration capacity of natural features such as wetlands and forests, will continue to protect and enhance water quantity within the subwatershed.

Durham Regional Official Plan (2008)

The policies contained within the Durham Regional Official Plan around water quantity include:

- Requiring an examination of the impacts on surface water and groundwater resources in the consideration of development applications in order to maintain and/or enhance such resources in sufficient quality and quantity to meet the existing and future needs of the Region's residents on a sustainable basis
- Placing restrictions on development within key hydrologic features and their associated vegetated protection areas
- Promoting and supporting water resource conservation and management initiatives
- Ensuring that local municipalities require stormwater management plans as part of pre-servicing development proposals
- Promoting groundwater infiltration, where appropriate, through improved stormwater design
- Encouraging development that maintains hydrological functions and minimizes direct alteration to groundwater flows
- Requiring that development applications to demonstrate the groundwater quality and quantity will be protected, improved, or restored in areas where groundwater discharge could be impacted
- Requiring development applications that require a permit to take water, or that have the potential to impact water quantity to be accompanied by a study verifying that there is a sufficient water supply to support the proposed use and, on a cumulative sustainable basis, confirm that there will not be a negative impact on surrounding water users and the natural environment which cannot be appropriately mitigated
- The OP also contains a number of policies around the protection of Wellhead Protection Areas and Highly Vulnerable Aquifers (these policies may be updated/refined through the source water protection process)

5.5.2 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 to those programs will have benefits related to reducing evaporation and increasing groundwater recharge. These projects are described in more detail in chapters 4, 6, and 8.

The Environmental Farm Plan program, which is a partnership between the Ontario Ministry of Agriculture, Food and Rural Affairs, Agriculture and Agri-Food Canada, and the Ontario Soil and Crop Improvement Association, does support projects specifically directed to managing water use on farms. Projects supported through the Environmental Farm Plan include infrastructure to support water use efficiency, including both in-barn and irrigation equipment, and support for establishing off-line irrigation ponds to reduce water taking demands on surface water features. Through that program, over twenty projects have been implemented to improve water use efficiency on farms in Brock and Uxbridge Townships and the Town of Georgina.

5.5.3 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 their 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. The Lake Simcoe Protection Plan has directed the MOE, MNR, and LSRCA to follow up on this study with the identification of ‘Ecologically Significant Groundwater Recharge Areas.’ This new class of recharge area is to be identified based on ecological interactions, rather than volume of water. To identify these areas, reverse particle tracking models will be 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.

In order to support water budgeting and other watershed-scale modeling, LSRCA manages a network of 12 climate stations (including precipitation gauges), and 15 surface water flow stations (in partnership with the Water Survey of Canada). These stations provide monthly stream flow data, which can be used to monitor mean, median, and baseflow conditions for many of Lake Simcoe’s 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).

5.6 Gaps and Recommendations

As can be seen in the previous section, there are a number of pieces of legislation, regulations, and municipal requirements aimed at protecting the water quantity within the Pefferlaw River subwatershed. Despite this strong foundation, there are a number of gaps and limitations in the management framework that need to be considered. This section provides an overview of factors that need to be considered in the future management of the Pefferlaw River subwatershed, in addition to some relevant recommendations to address those.

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 Water demand

The Tier 1 study treated the Pefferlaw River subwatershed as Uxbridge Brook and Pefferlaw Brook subwatershed. Results of the Tier 1 surface assessments indicate a moderate potential for stress within the Pefferlaw Brook subwatershed during the summer months. The stress related to low available supply values during the summer months relative to continued demand.

Both the Tier 1 and Tier 2 groundwater stress assessments for current (annual & monthly), future and drought scenarios indicated a low level of stress, largely because of the high available storage.

One of the limitations in managing water demand is the Permit to Take Water (PTTW) process. These permits are only required when a user is taking more than 50,000 L/day, and are not required for most domestic and agricultural uses. This makes it difficult to track the cumulative use for a subwatershed, contributing to the potential surface water stress identified.

> **Recommendation #26 -** That the MOE be encouraged to continue to improve the WTRS (Water Taking Reporting System) by integrating the Permit To Take Water (PTTW) database with the Water Well Information System (WWIS) database, and connect those takings to wells/aquifers to facilitate impact assessment i.e. the PTTW database needs to be connected to the WWIS (Water Well Information System) database.
>
> **Recommendation #27 -** That the MOE be encouraged to exercise their authority to restrict PTTW where emergency conditions dictate (e.g. low water response).
>
> **Recommendation #28 -** That the Low Water Response program continue to ensure that water supply and ecosystem integrity can be protected and maintained in low water conditions; further that the Low Water Response system be used to reinforce communication and provide consistent messaging and better adoption of water restrictions during dry or drought periods.
>
> **Recommendation #29 -** That the MOE be encouraged to consider sensitive hydrogeologic and hydrologic features (e.g. wetlands, SGRAs, coldwater reaches, losing and gaining reaches, ESRGAs in the future) identified in the Pefferlaw River subwatershed plan, in the review of PTTW applications.
>
> **Recommendation #30 -** That the MOE be encouraged to routinely audit water takers to determine if they are in compliance with their PTTW, or to ensure permits are obtained when necessary.

Recommendation #31 - That the MOE through the PPTW process, investigate and implement innovative ways to reduce demand on surface waters during peak summer use. Options such as: promoting the taking of groundwater where appropriate; use of deeper wells; and if possible capturing spring stream flow or tile drainage in off-line storage facilities e.g. linear wetland for use during low flow periods, should be considered. The amount available for capture during spring flow should be determined through the development of ecological flow targets.

Recommendation #32 - That the LSRCA and the partner municipalities promote and support water conservation and reuse initiatives. These initiatives should have an emphasis on reducing water demand during the summer months and drought periods, and to incorporate low impact design (LID) solutions such as rainwater harvesting, and grey water reuse.

Recommendation #33 - That the LSRCA with the support of the municipalities and the Province improve the PRMS model outputs by maintaining and improving the surface water monitoring network through the strategic installation of more stream gauges.

5.6.2 Ecological Flows

The Lake Simcoe Protection Plan contains a policy around maintaining adequate flows, with the development of in-stream flow targets, also referred to as an Ecological Flow regime) for water quantity stressed subwatersheds. It does not, however, stipulate timelines for any subwatershed other than the Maskinonge River, it is therefore not clear when this work and any associated limitations on water takings would be in place, or how they would be enforced and by whom.

Recommendation #34 - That the MOE and its local partners develop and implement more specific PTTW requirements in ‘stressed’ subwatersheds to meet, when defined, the instream flow regime for that system. In addition, that the MOE and its local partners will ensure all permits related to ‘stressed’ subwatersheds will receive a full review, such that MOE can determine if >10% baseflow is sufficient protection at least until the ecological flow regime has been determined.

Recommendation #35 - That the MNR and MOE in conjunction with LSRCA develop a more detailed surface water budget for the Pefferlaw River subwatershed that will provide basis of actions needed to determine instream flow targets.

Recommendation #36 - That the MOE and MNR with assistance from LSRCA determine ecological flow targets for the Pefferlaw River. These E-flow targets should be based on the Guidance Document framework (LSRCA 2010) which is being used for the Maskinonge River subwatershed.

Recommendation #37 - That based on long term monitoring of brook trout index spawning locations (refer to Recommendation # 56, Chapter 6 - Aquatic Habitat), use that information as a field verification for groundwater-baseflow interaction (volume, location, temperature) and in future Ecologically Significant Groundwater Recharge Area work.

5.6.3 Reducing Impact of Land Use

Land cover can 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 building roofs that increases runoff and evaporation. 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 quality and quantity of both ground and surface water in the subwatershed. At present the majority of land use with the Pefferlaw River SGRAs is natural heritage or agriculture, however this may change in the future as new development proceeds or ecologically significant recharge areas are defined.

Recommendation #38 - That the municipalities amend their Official Plans, if deemed necessary, to recognize recharge zones in maintaining the quantity and quality of groundwater required for a healthy watershed.

Recommendation #39 - That the LSRCA and its partners complete the ESGRA (Ecologically Significant Groundwater Recharge Areas) mapping as soon as possible.

Recommendation #40 - That the municipalities attempt to achieve a Post-development infiltration equals Pre-development infiltration policy within SGRAs and once developed, ESGRAs.

Recommendation #41 - That the municipalities adopt policies for the protection of ESGRA's under the LSPP Policy 6.38 into their Official Plans, once completed.

5.6.4 Climate Change

Climate varies across the Lake Simcoe watershed, both spatially and temporally, with local variation created by such factors as topography, prevailing winds, and proximity to Lake Simcoe. An understanding of long-term climate trends including daily maximum and minimum temperature, precipitation, evaporation, and solar radiation is required to adequately assess how future climatic changes will influence the hydrologic and hydrogeologic systems.

Recommendation #42 - That the MOE and MNR in cooperation with the LSRCA and input from municipal partners develop a transient and preferably a fully-integrated model with full river-routing capabilities to investigate the seasonal implications and ecological impacts of climate change, in terms of increase peak flows, reduced baseflows and increased water demand.

Recommendation #43 - That the MOE and MNR will develop a Risk Management Framework for climate change for the Pefferlaw River subwatershed.

Recommendation #44 - That the LSRCA seek input from 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 the Pefferlaw River subwatershed (vulnerable) through stream rehabilitation, streambank planting, barrier removal and other BMP implementation in conjunction with the protection of current hydrologic functions.

6 Aquatic Habitat

6.1 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. Types of aquatic habitats within the Pefferlaw River subwatershed are identified in Table 6-1.

Table 6-1: A summary of aquatic environments found in the Pefferlaw River subwatershed and its habitat features.

Aquatic Environment	Habitat Features	Examples in the Pefferlaw Subwatershed
Rivers and streams	• Vegetation • Food sources – algae, benthic invertebrates, fish • Flow • Cover • Spawning/nursery habitat • Vegetation • Water quality • Temperature refugia	Main branch of the Pefferlaw River and Uxbridge Brook tributary
Lakes	• Temperature refugia • Shelter • Spawning/nursery habitat	• Wagner Lake • Electric Light and Uxbridge Ponds • Mud Lake
Wetlands	• Spawning/nursery habitat	• Upper and Lower Uxbridge Brook Wetland Complex • Pefferlaw-Udora Wetland Complex • Lower Pefferlaw Wetland Complex

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.

6.2 Current Status

To assess the impact of the aforementioned stresses on the biological community, monitoring of the fish and benthic invertebrate communities is undertaken at sites throughout the subwatershed. The results of these studies are discussed in the following sections.

6.2.1 Fish Community

Study of the health of the fish community of the Pefferlaw River subwatershed provides an important window into the health of the aquatic system as a whole. Fish are sensitive to a great number of stresses including water quality, temperature, flows, and the removal of instream 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 within the subwatershed, and will help to identify and guide restoration works.

The Pefferlaw River and its tributaries have been subject to fisheries studies, with 169 known fisheries data collection points within the system. These sites have not only been explored by the MNR and LSRCA but also by private industry in support of various development proposals. Sampling by the LSRCA is completed using backpack Electrofishers following procedures outlined in the Stream Assessment Protocol for Southern Ontario Version 7 (Stanfield, 2005).

A total of 45 species have been captured from the Pefferlaw River since 1930 (Table 6-2). The fish communities in the Pefferlaw River and its tributaries range from cold headwater communities featuring such species as brook trout (*Salvelinus fontinalis*) (see text box) 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 area of the lake-river interface is also used extensively by large spawning runs of emerald shiners (*Notropis atherinoides*), both in spring and fall (MNR, 2010).

Generally, the Pefferlaw River displays cold to coolwater tributaries feeding a warmer western main branch, however, most of the system is managed as a coldwater fishery with several exceptions. Figure 6-1 displays coldwater fish habitat suitability based on water temperature records and the presence or absence of coldwater (blue sites) and warmwater (red sites) species of fish. The main branch of the Pefferlaw and the most eastern tributary downstream of the Hamlet of Udora is considered warmwater habitat. The northern regions of the subwatershed downstream of the Main Street Dam (located on Main Street in the Town of Georgina) and the Reekies Creek tributary are classified as warmwater migratory habitat as these areas are managed by the MNR to accommodate spring walleye (*Sander vitreus*) spawning. Where sites are black, this indicates that stream temperatures were not recorded during sampling, the sampling was infrequent or the species caught can live in both warm or cold water habitats, making the status as ‘not enough data and in need of further study’.

Figure 6-2 illustrates the distribution of brook trout in the subwatershed. An overview of the importance of coldwater streams and the presence of brook trout is provided in the following text box. It should be noted that Pefferlaw Brook continues to support a resident brook trout population and its related coldwater community. However, while remaining tributaries are cold enough to support coldwater species like mottled sculpin downstream of Udora, Uxbridge Brook does not contain brook trout downstream (north) of Davis Drive. Non-native brown trout (*Salmo trutta*) and rainbow trout (*Oncorhynchus mykiss*) can be found in those reaches of Uxbridge Brook downstream of Uxbridge as well. It is speculated that competition from the non-native trout species and the thermal influence of Wagner Lake in the reach upstream of Udora are likely responsible for the absence of brook trout in that section of Uxbridge Brook, but further surveys are warranted.

Table 6-2: Fish species captured in the Pefferlaw River subwatershed 1930-2007.

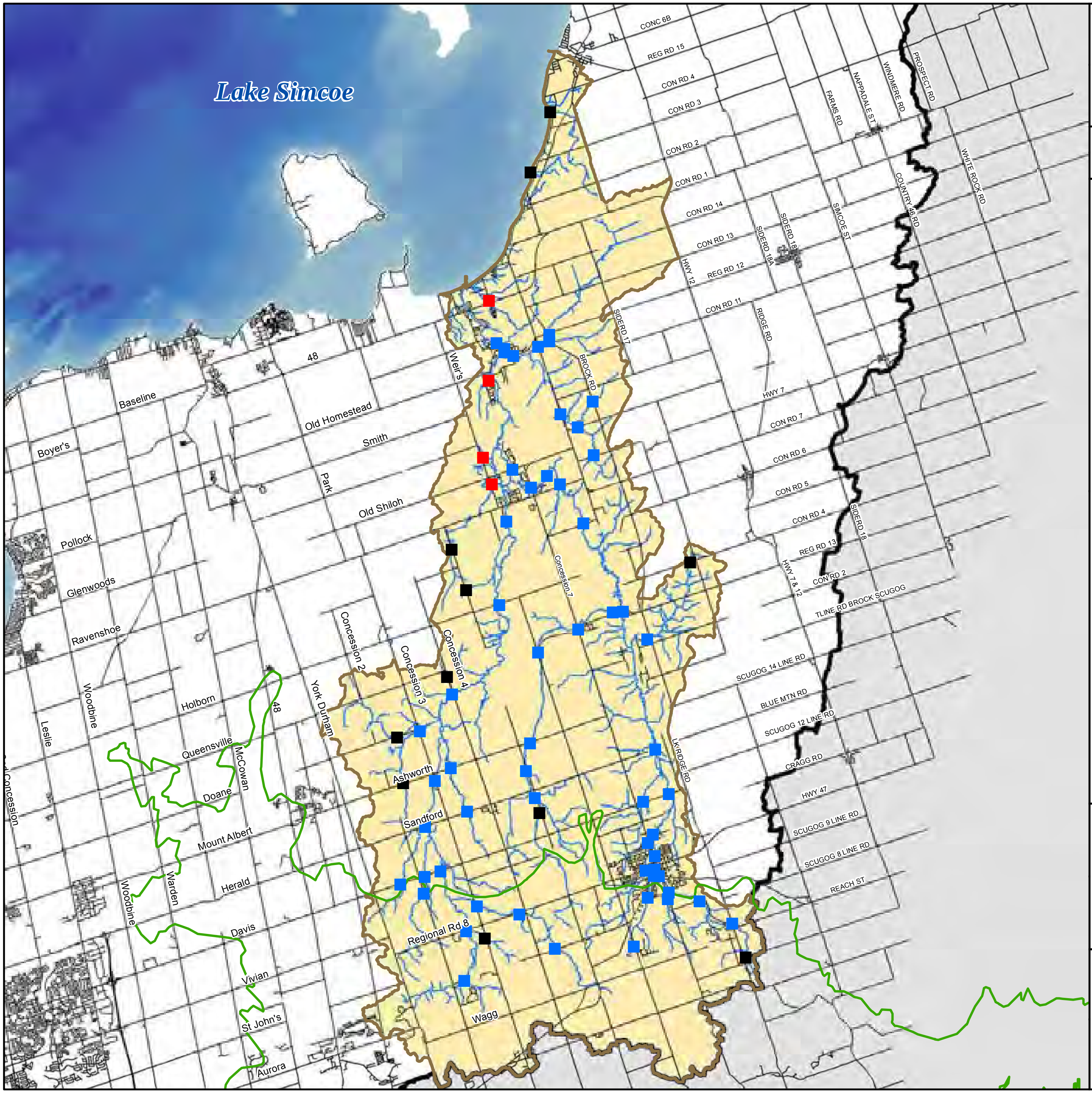
Species	**Scientific Name**
Rainbow trout	*Oncorhynchus mykiss*
Brook trout	*Salvelinus fontinalis*
Brown trout	*Salmo trutta*
Ciscoe	*Coregonus artedi*
Muskellunge	*Esox masquinongy*
White sucker	*Catostomus commersoni*
Northern hog sucker*	*Hypentelium nigricans*
Central mudminnow	*Umbra limi*
Northern redbelly dace	*Phoxinus eos*
Finescale dace	*Phoxinus neogaeus*
Brassy minnow	*Hybognathus hankinsoni*
Hornyhead chub	*Nocomis biguttatus*
River chub	*Nocomis micropogon*
Golden shiner	*Notemigonus crysoleucas*
Common shiner	*Luxilus cornutus*
Blacknose shiner	*Notropis heterolepis*
Rosyface shiner	*Notropis rubellus*
Spotfin shiner	*Cyprinella spiloptera*
Bluntnose minnow	*Pimephales notatus*
Fathead minnow	*Pimephales promelas*
Blacknose dace	*Rhinichthys atratulus*
Longnose dace	*Rhinichthys cataractae*
Creek chub	*Semotilus atromaculatus*
Pearl dace	*Margariscus margarita*

Species	Scientific Name
Central stoneroller	*Campostoma anomalum*
Yellow bullhead*	*Ameiurus natalis*
Brown bullhead	*Ameiurus nebulosus*
Stonecat	*Noturus flavus*
Brook stickleback	*Culeae inconstans*
Rock bass	*Ambloplites rupestris*
Green sunfish*	*Lepomis cyanellus*
Pumpkinseed	*Lepomis gibbosus*
Smallmouth bass	*Micropterus dolomieu*
Largemouth bass	*Micropterus salmoides*
White crappie*	*Pomoxis annularis*
Yellow perch	*Perca flavescens*
Walleye	*Sander vitreus*
Greenside darter~	*Etheostoma blennioides*
Rainbow darter	*Etheostoma caeruleum*
Iowa darter	*Etheostoma exile*
Johnny darter	*Etheostoma nigrum*
Blackside darter	*Percina maculata*
Round goby*	*Neogobius melanostomus*
Mottled sculpin	*Cottus bairdi*
Slimy sculpin	*Cottus cognatus*

* = Non-native invasive species

~ = Non-native species to the Lake Simcoe watershed. This species is native to Ontario however, and is a species of Special Concern provincially.

Brown trout



Coldwater fish presence and habitat suitability in the Pefferlaw River subwatershed

Figure 6-1

Legend

Classification
- 🟦 Coldwater Fish Species Captured
- 🟩 Coldwater Temperatures Recorded
- 🟥 Warmwater Species Captured / Temperatures Recorded
- ⬛ Not Enough Data
- — Road
- ~ Watercourse
- LSRCA Watershed Boundary
- Oak Ridges Moraine

Lake Simcoe Region conservation authority

00.51 2 3 4 5
Kilometres

N

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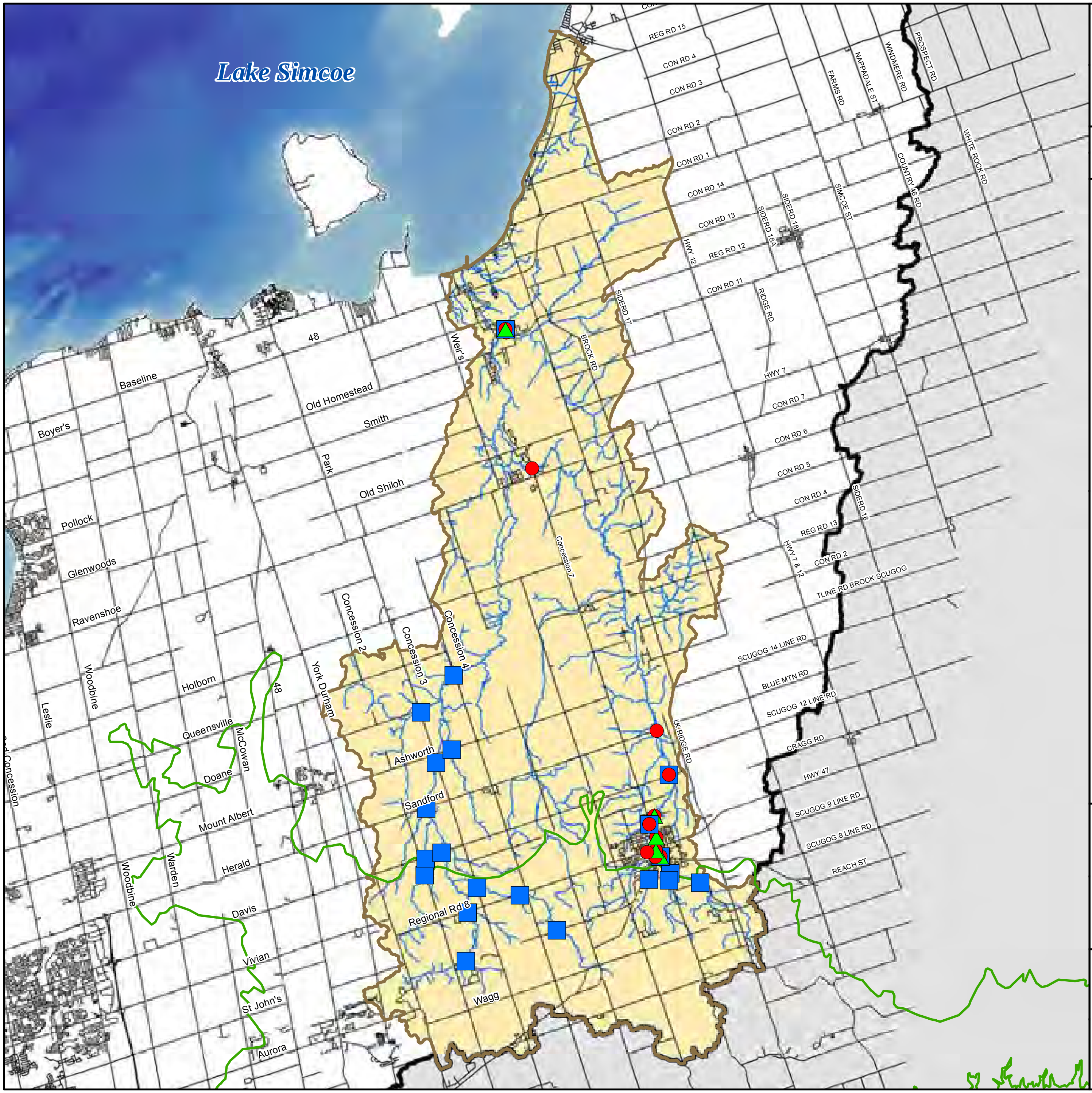
Brook trout distribution in the Pefferlaw River subwatershed

Figure 6-2



Legend

Species

- 🟦 Brook Trout
- ● Brown Trout
- ▲ Rainbow Trout
- Road
- Watercourse
- LSRCA Watershed Boundary
- Oak Ridges Moraine

Lake Simcoe Region conservation authority

0 1 2 4 6 8 10

Kilometres

N

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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 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 stressor, 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.

Brook trout spawning over groundwater upwelling site

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 upwellings 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 enhancing 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.

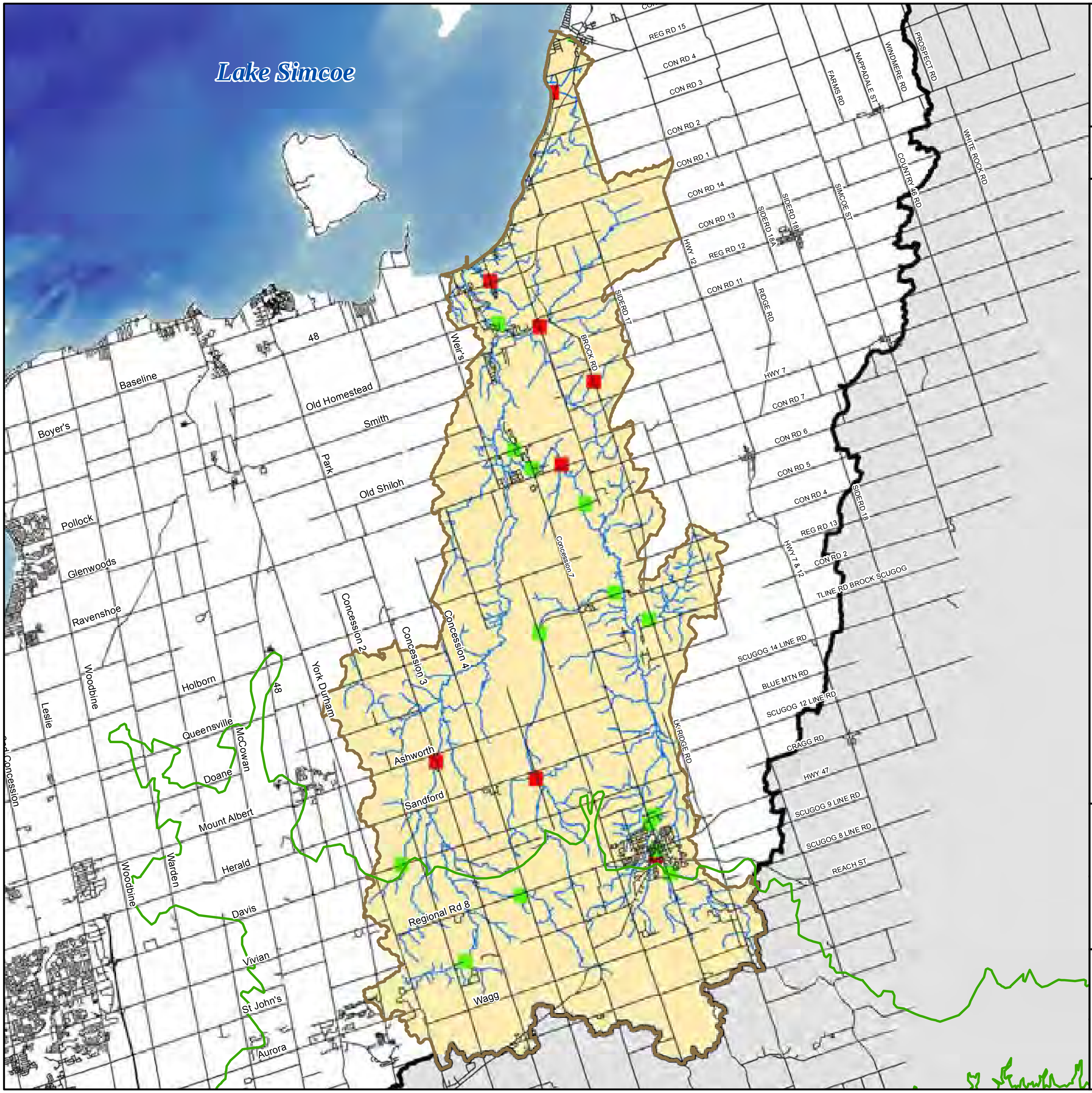
6.2.2 Benthic Invertebrate Community

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 can be used to determine water quality at a given site. Of the indices developed to assess water quality in relation to benthic invertebrate communities, BioMAP was selected as it provides a means to locate pollution sources without the large investment of time and resources required by some other indices.

Benthic invertebrates have been collected from the Pefferlaw River subwatershed since 2004 employing a consistent and standard collection method (Ministry of the Environment and Conservation Ontario, 2003). Figure 6-3 is a compilation, standardization, and summary of this data with the results reported as “Impaired” or “Unimpaired”. In general, based on seven years of data, the Pefferlaw River subwatershed has been found to have relatively stable unimpaired benthic communities in the headwaters and mid reaches. This is likely due to the relatively healthy coldwater tributaries and limited urban development in this system. However, Figure 6-3 also demonstrates that there are some sites (located mainly along the north eastern branches) where the indices show ‘impaired’ conditions. These locations are primarily affected by sediment inputs from agriculture and elevated stream temperatures (on-line ponds) which lead to a reduction in the diversity of invertebrates at those sites. In total, there are seven long-term monitoring sites located throughout the subwatershed. Monitoring of these sites is expected to continue in order to track trends and change in the conditions of the Pefferlaw River subwatershed.

Benthic invertebrate sites in the Pefferlaw River subwatershed

Figure 6-3



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6.2.3 Invasive Aquatic Species

The recently introduced round goby (*Neogobius melanostomus*), the common carp (*Cyprinus carpio*), and the rusty crayfish (*Orconectes rusticus*) are the invasive aquatic species that are known to have been found in the subwatershed.

Case Study: Introduced Species

The round goby (*Neogobius melanostomus*) 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, such as the yellow perch, for space and food. The round goby was first discovered in the Pefferlaw River by an astute angler in August of 2004. LSRCA and the Ontario Ministry of Natural Resources (MNR) confirmed the presence of round goby in June 2005 when 33 were captured below the Pefferlaw dam during reference site electrofishing and within Lake Simcoe in the vicinity of Morning Glory Swamp. Despite extensive sampling above both Pefferlaw dams, round goby were not found above these structures.

The MNR had to make the difficult decision to try to eradicate this dangerous invader from the Pefferlaw River. In partnership with various private and public organizations, including LSRCA, MNR staff collected and transferred as many native fish as possible from below the Pefferlaw Dam to the waters of Georgina Island in mid-October, 2005. An application of the pesticide Rotenone was conducted October 17 – 21, 2005 by licensed applicators and dead fish were removed from the system. Unfortunately, as of 2009, round gobies have been extensively captured by electrofishing in the Black River to the east and the Beaver River to the north. MNR and local anglers have also noted capture of Gobies in the vicinity of Georgina and Thorah Islands.

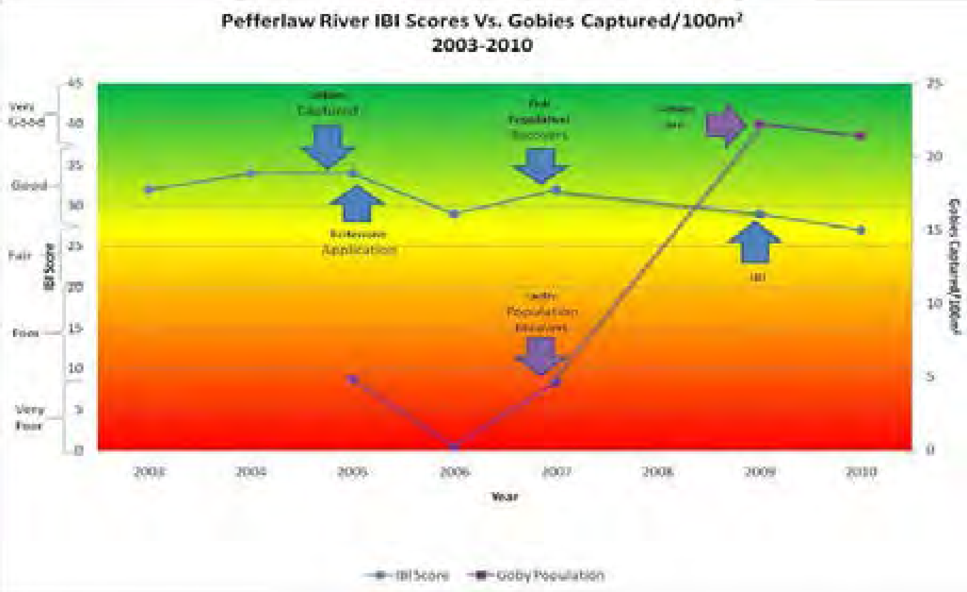


Figure 6-4: Round goby colonization in Pefferlaw River.

LSRCA and MNR will continue to monitor the spread of this species; however, it would appear that their establishment throughout the lake and its tributaries is inevitable.

Case Study: Introduced Species (*cont'd*)

It is suspected that bait fishermen 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. Other species have been captured that lend credence to this theory. Northern hog sucker (*Hypentelium nigricans*), yellow bullhead (*Ameiurus natalis*), green sunfish (*Lepomis cyanellus*), greenside darter (*Etheostoma blennioides*) and white crappie (*Pomoxis annularis*) are all native and common to Lakes Erie and St. Clair, not Lake Simcoe, and have been found in the Pefferlaw only since 2004. The OMNR have bolstered their enforcement of baitfish laws to both baitfish dealers and anglers in the Lake Simcoe basin.

Introduced Salmonids are also part of the capture of the Pefferlaw River. Rainbow trout (*Oncorhynchus mykiss*) was introduced into Ontario waters in the late 1800s from the west coast of Canada. The rainbow trout residing in the Pefferlaw River are primarily escapees from private and commercial ponds. Brown trout (*Salmo trutta*) are native to European waters and have been stocked into Ontario streams since 1913. There are no records of legal brown trout introduction in the system.

As both species are economically viable and sought after by anglers their introduction is not considered harmful. Great care must be exercised, however, as both species can compete for food and space at the expense of native fish such as brook trout (*Salvelinus fontinalis*). This is especially prevalent in the case of the voracious brown trout as they tend to out-compete brook trout for food sources. Both species share the same ecological niche and spawn at approximately the same time of year.

6.2.4 Species at Risk

The only aquatic Species at Risk that is known to reside in the Pefferlaw River subwatershed is the greenside darter. The species is currently considered to be a species of "Special Concern" by the Province of Ontario. However, it holds no special status with the federal government, meaning that the only protection afforded to the species are the usual provisions for habitat under the *Fisheries Act*.

As noted in the Case Study, the greenside darter was most probably transported from its natural Canadian range in the St. Clair River Basin to Lake Simcoe as part of an illegal baitfish transfer.

First captured in the lower Pefferlaw River in 2003, the capture numbers of greenside darters increased exponentially until 2005, but have been absent since then at that site. As the largest member of the bottom-dwelling *Etheostoma* genus (Darters), greenside darters may have been particularly susceptible to the Rotenone application in the fall of 2005. There are also indications that other bottom dwelling species such as Iowa Darter (*Etheostoma exile*) may also have been lost due to the rotenone application (Figure 6-4).

In addition, several species of potentially "Threatened" or "Endangered" mollusc species have been identified as present in the subwatershed by Fisheries and Oceans Canada. However, none are currently listed under the *Species at Risk Act* and, therefore, have no special status as of this publication.

Key Points - Current Aquatic Habitat Status:

- Fish communities range from cold headwater communities to diverse warm large order systems (mainly in the north western branches of the river). Most of the system is managed as coldwater. The lower regions downstream of the Main Street dam are classified as warmwater migratory
- There is extensive seasonal use in the lake-river interface by emerald shiners
- Fisheries data indicates that for the most part, coldwater systems support coldwater communities, but the presence of stressors such as dams and the removal of streambank vegetation increase ambient stream temperatures significantly, restricting the habitat available for cold water species such as brook trout.
- The subwatershed generally supports benthic invertebrate communities that are stable and unimpaired. This is likely due to the high level of healthy coldwater tributaries and limited urban development, resulting in higher water quality and habitat conditions.
- There is one aquatic Species at Risk, the greenside darter, found within the subwatershed.
- The subwatershed was the first site in the Lake Simcoe basin where round goby were found.

6.3 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:

- Changes to instream habitat and habitat fragmentation
- Removal of riparian vegetation
- The introduction of invasive species
- Impacts to the hydrologic regime
- Municipal drains
- Water quality and thermal degradation / climate change

These factors are discussed in detail in the following sections:

6.3.1 Changes to Instream Habitat and Habitat Fragmentation

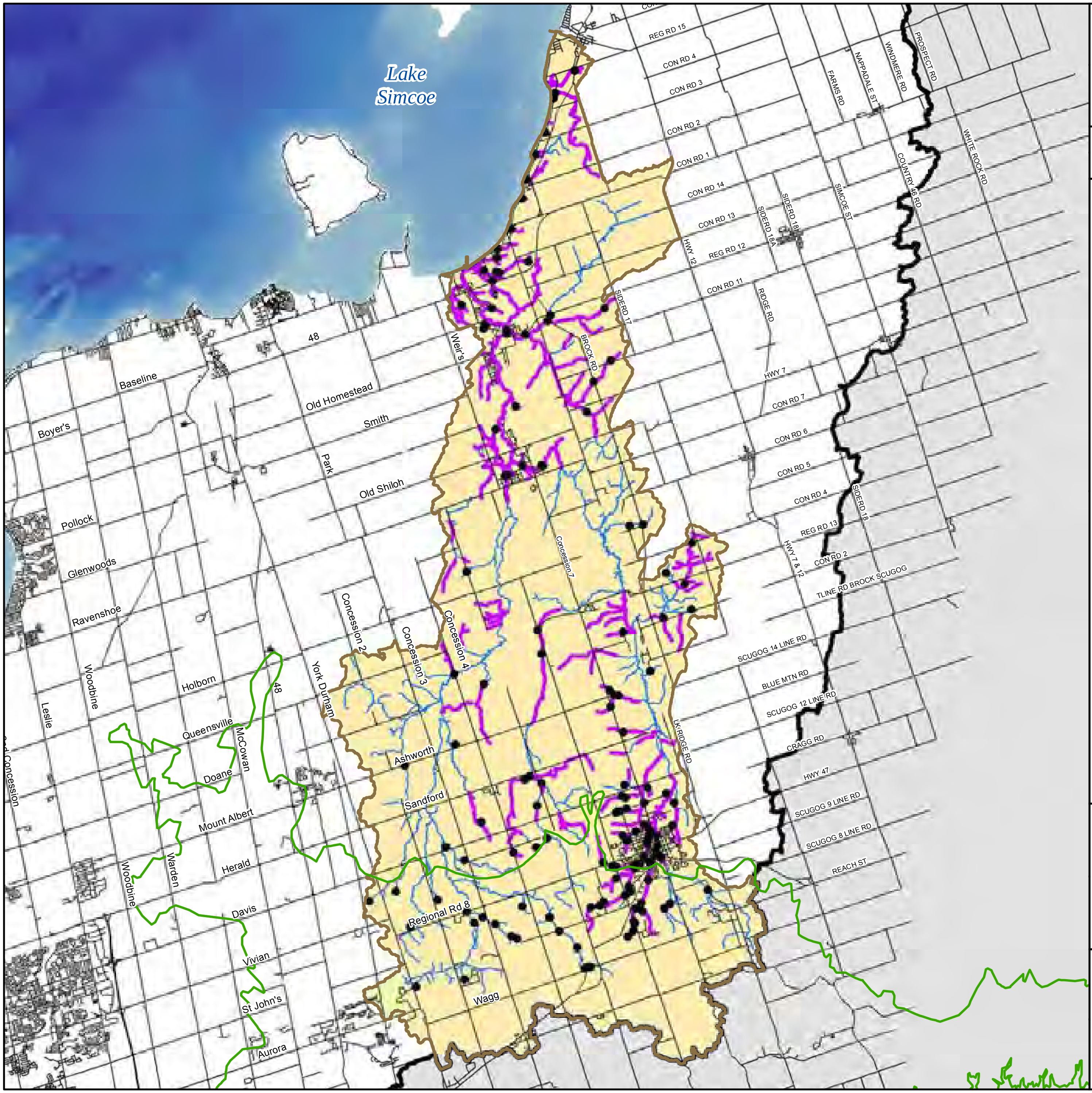
Barriers

Barriers to fish movement in the form of dams, perched culverts, and enclosed watercourses serve to fragment a fishery by preventing fish from accessing important parts of their habitat. The impoundments created by dams serve to warm water temperatures, raise bacteria levels, and disrupt the natural movement of fish, invertebrates, sediment, and nutrients. The natural movement of each is imperative for a healthy aquatic system.

One hundred and fifty-eight such barriers to fish movement have been identified in the Pefferlaw River subwatershed through the BMP Inventory. They take many forms ranging from dams and on-line pond structures, such as those at the Elgin Pond and Pefferlaw Dam, to perched culverts (Figure 6-5). Many are located in the headwaters around Uxbridge. As this inventory was only completed for 44% of the Pefferlaw River stream length, the total number of barriers may be significantly greater.

Known barriers to fish movement in the Pefferlaw River subwatershed

Figure 6-5



Legend

● Barrier

― Road

〰 BMP Watercourse Surveyed

〰 Watercourse

LSRCA Watershed Boundary

Oak Ridges Moraine

Lake Simcoe Region conservation authority

0 1 2 4 6 8 10 Kilometres

N

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6.3.2 Bank Hardening and Channelization

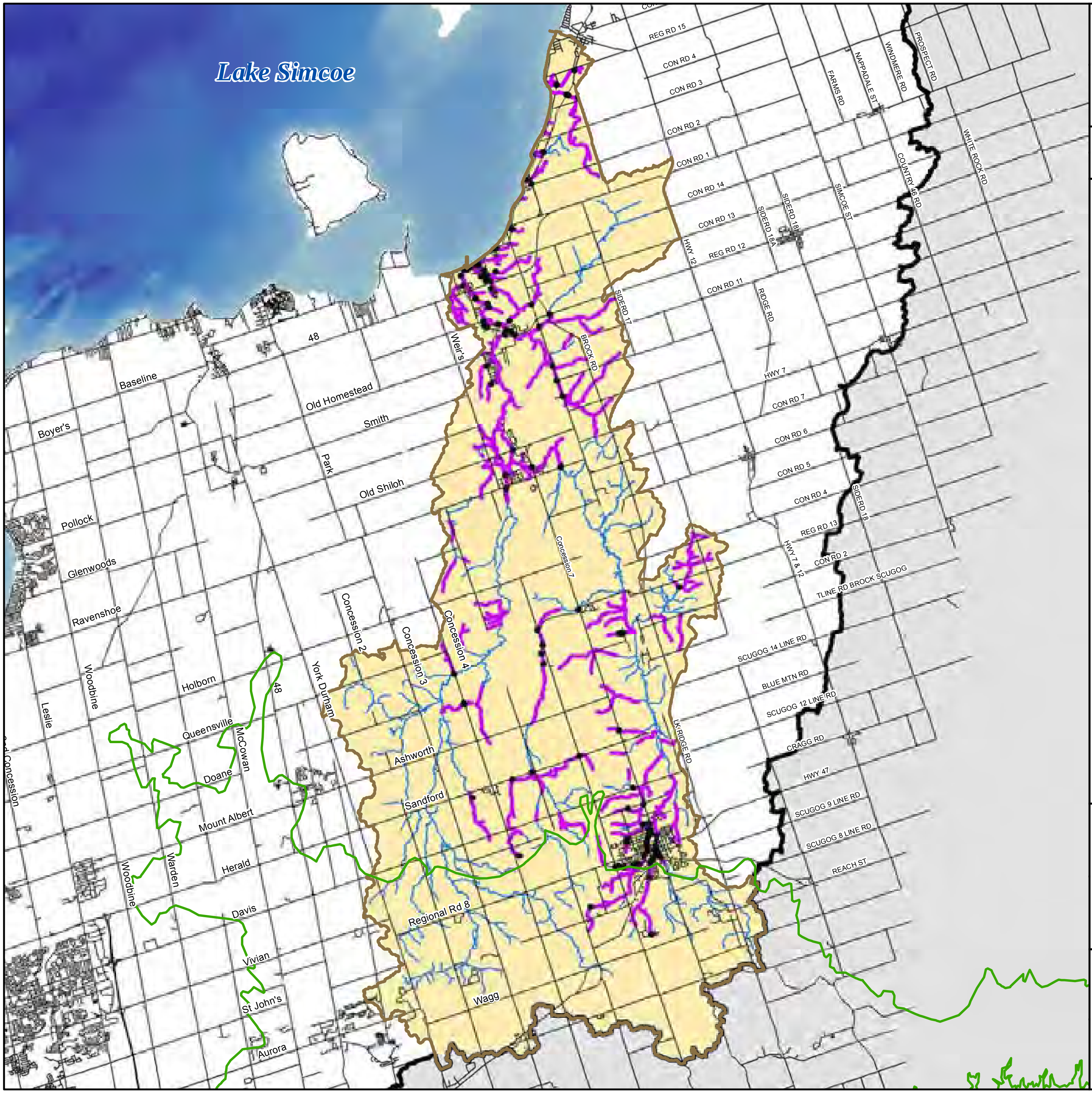
In the past, it has been common practice to straighten watercourses to accommodate various landuses, and to harden banks with a view to prevent streambank erosion. While we now know that these practices are harmful to the environment and can cause more issues than they resolve, there are several areas in the subwatershed 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)
- Bank erosion downstream of the 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 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 130 channelized and hardened sections of stream identified in the Pefferlaw River subwatershed through the BMP Inventory; these are depicted in Figure 6-6. Most sites were located in either the area surrounding Uxbridge or the lower reaches of the subwatershed. Of these, 49 (38%) were failing, meaning that the attempt to stabilize the channel had failed. The remaining sites (62%) were in fair condition. The 49 failing sites would therefore be priorities for restoration activities, though the remaining sites are likely still having habitat impacts and should also be explored as resources allow. An additional 28 sites had also been straightened, but their banks had not been hardened. As this inventory was only completed for 44% of the Pefferlaw River stream length, the total number of river sections that have been channelized may be significantly greater.



Bank hardening and channelization in the Pefferlaw River subwatershed

Figure 6-6

Legend

● Bank Hardening and or Channelization

— Road

BMP Watercourse Surveyed

Watercourse

LSRCA Watershed Boundary

Oak Ridges Moraine

0 1 2 4 6 8 10
Kilometres

N

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6.3.3 Removal of Riparian Vegetation

While many policies now afford some protection to the riparian areas adjacent to 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 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 their 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 a cool or warm water community containing less sensitive species.

A recent study entitled 'Riparian Analysis and Prioritization for Naturalization', LSRCA 2010, compiled an assessment of the riparian (streambank) condition of the Pefferlaw River subwatershed. The subwatershed was split into the Pefferlaw River and Uxbridge Brook (Figure 6-7 and Figure 6-8).

The Pefferlaw Brook included Thorah Creek, McLennan Creek, Reekies Creek, and the Wilfred Branch. Of the more than 276 km of watercourse, more than 73% of that total length has a 30m vegetated bank.

Pefferlaw Brook

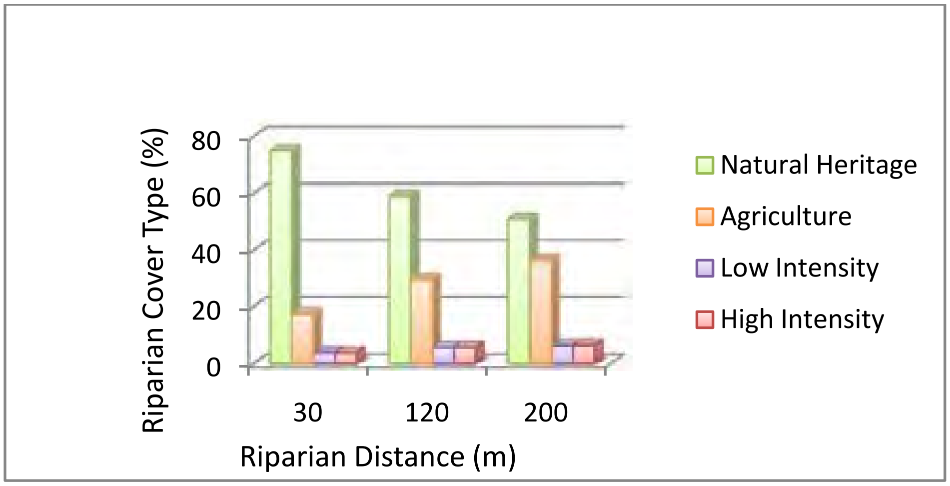


Figure 6-7: Land use cover % per buffer distance for the Pefferlaw Brook.

The Uxbridge Brook catchment included Uxbridge Brook and Leaskdale Creek as its only named tributary. Leaskdale Creek forms the major western tributary that flows into the Uxbridge

Brook near the town of Leaskdale. The Uxbridge Brook forms a confluence with Pefferlaw River at the town of Udora, at the northern end of the subwatershed.

The Uxbridge Brook catchment contains more than 216 km of watercourse, of which 75% retains a 30m vegetated streambank.

Uxbridge Brook

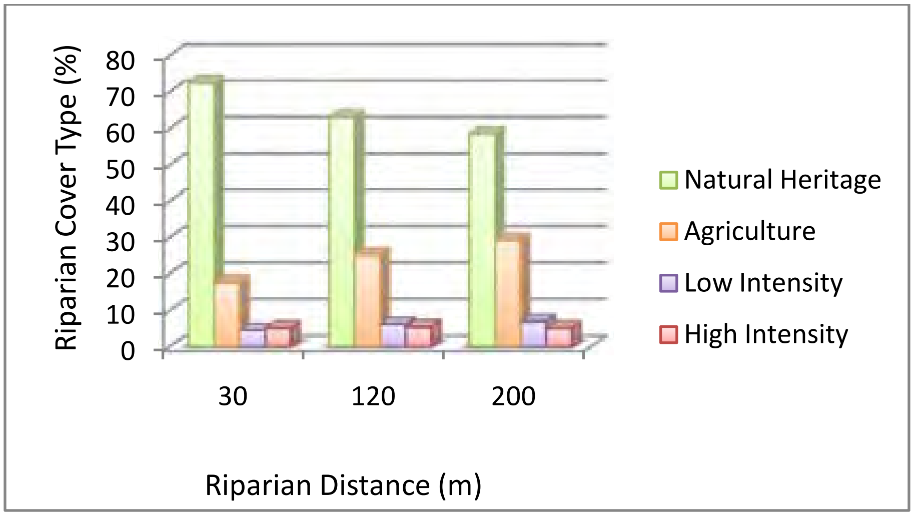
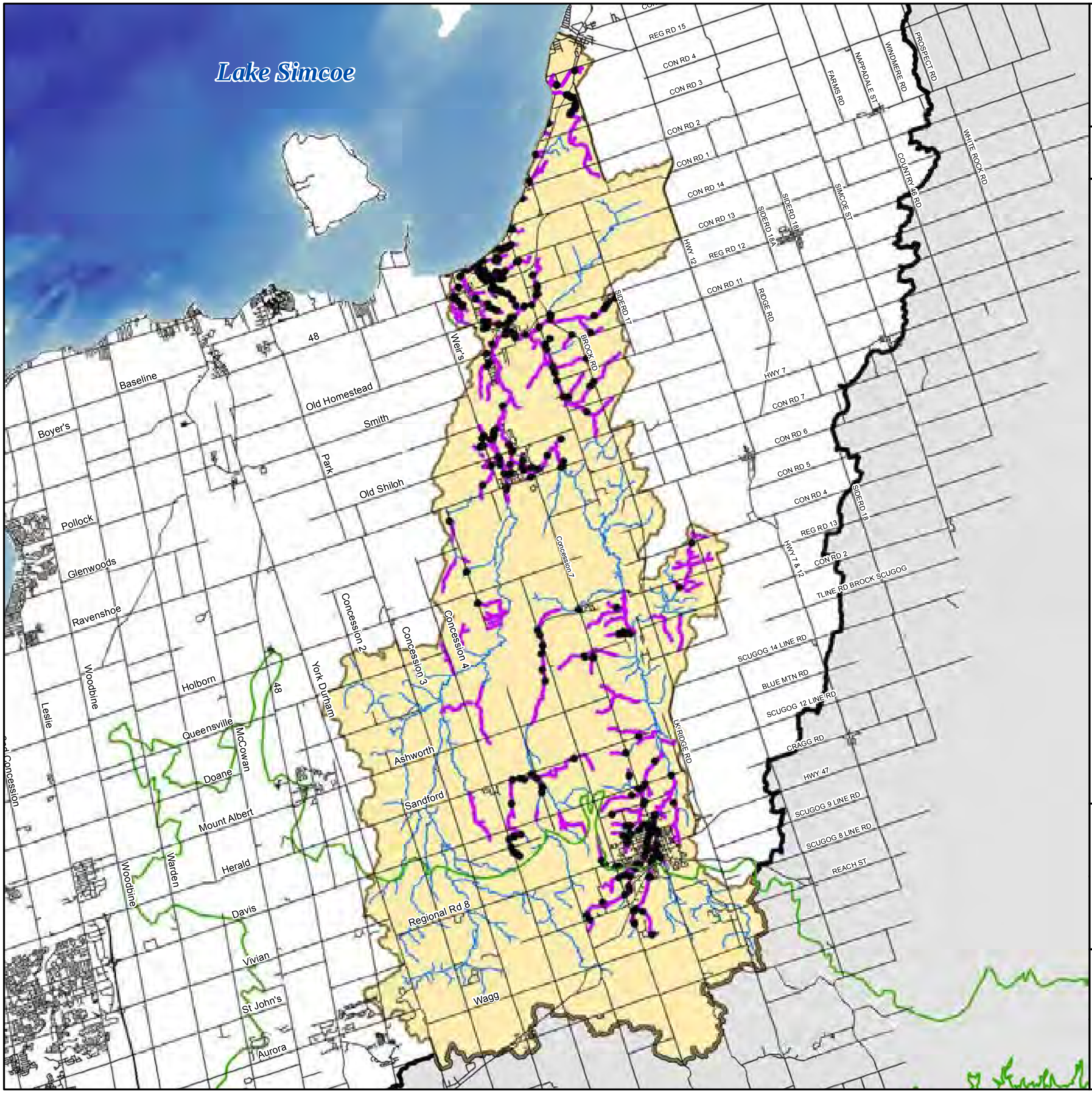


Figure 6-8: Land use cover % per buffer distance for the Uxbridge Brook.

All of this suggests that, in many cases, agriculture is allowing for a maximum 30m riparian buffer in the Pefferlaw subwatershed.

Nevertheless, in the Pefferlaw River subwatershed, there were at least 375 sites identified through the LSRCA BMP Inventory as having insufficient riparian vegetation. Rehabilitation of these locations typically includes the planting of native grasses, shrubs, and trees along the streambank. The wider the area planted, the more beneficial the technique. Optimum retired and/or planted width is approximately 30m. These accounted for approximately 14% of the BMP opportunities identified through the inventory. These sites are displayed in Figure 6-9.



Sites identified in the Pefferlaw River subwatershed as having insufficient riparian vegetation

Figure 6-9

Legend

● Insufficient Riparian Vegetation

Road

BMP Watercourse Surveyed

Watercourse

LSRCA Watershed Boundary

Oak Ridges Moraine

Lake Simcoe Region conservation authority

0 1 2 4 6 8 10

Kilometres

N

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6.3.4 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 the 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.

As has been discussed, the most worrisome aquatic invasive species to be found in the subwatershed is the round goby. Other non-natives to the Lake Simcoe watershed include northern hog sucker, yellow bullhead, green sunfish, white crappie and rusty crayfish.

It should be noted that the Lake Simcoe Protection Plan (2009) has developed a ‘Lake Simcoe Invasive Aquatic Species Watch List’ of aquatic species which are not yet in the Lake Simcoe watershed. However, if they do appear in the watershed, they are expected to have significant negative impacts on the aquatic ecosystem. Those species include:

- Fanwort (*Cabomba caroliniana):* A submersed freshwater perennial plant that is extremely persistent and competitive. Under suitable environmental conditions, it can form dense stands, crowding out previously well-established plants.
- European water chestnut *(Trapa natans):* Native to Europe, Asia, and Africa, *T. natans* is an invasive aquatic plant that can form dense mats of floating vegetation.
- Water soldier (*Stratiotes aloides):* An aquatic plant commonly sold in the aquarium and water garden industry. The plant is native to Europe and Central Asia, but has been identified in the Trent Severn Waterway near the hamlet of Trent River. Water soldier forms dense large masses of plants which crowd other aquatic plants.
- 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.

The following section (Current Management Framework) summarizes the LSPP policies that address invasive species. Of these, the requirement to develop response plans for the watch list species is a priority (Policy 7.4-SA).

6.3.5 Impacts to the hydrologic regime

Changing hydrologic conditions, including the reduced baseflow and the peak flows brought about by increasing levels of impervious surfaces and water takings, 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. Changes to the hydrologic regime are discussed in greater detail in **Chapter 5 - Water Quantity**.

Under the ORMCP, there was encouragement to develop in-stream flow targets for subwatersheds. In order to move forward, a guidance document has been developed to provide a framework and the most current advice on determining ecological flows in the Lake Simcoe watershed. The document, entitled “Towards a Framework for Determining Ecological Flows and Water Levels in the Lake Simcoe Watershed – A Guidance Document” (LSRCA, 2011), outlines an approach that should be applied to each subwatershed. It recognizes that a great deal of future work and research is required to determine the most appropriate flow regimes for these systems.

There is an obvious need to develop an ecological flow regime in each system. As described in the LSRCA report mentioned above, “It is essential that we work towards meeting human needs and at the same time maintain the integrity of aquatic ecosystems. Aquatic ecosystems provide numerous values to society such as: water supply, natural water treatment, sediment transport, moderation of floods and droughts, habitats that support biodiversity, healthy populations of commercially important native species, recreational opportunities, and aesthetic values”

Environmental (or ecological) flow assessment involves the determination of the flow regime required (or the acceptable departure from the original flow regime) to maintain specified, valued features of the ecosystem (Tharme, 2003).

Natural variations in flows (both within and between years) are needed to maintain and restore the natural form and function of streams (Holling and Meffe, 1996; Poff *et al.*, 1997; Stanford *et al.*, 1996). Consideration of a single, minimum threshold flow, to the exclusion of other ecologically relevant flows, is no longer an acceptable approach to instream flow management.

It is also necessary to go beyond maintaining “means” or a subdued replica of the natural hydrograph because of the important functions of extreme flows (IFC, 2002; Petts and Maddock, 1994; Stalnaker, 1994; Hill *et al.*, 1991). Poff *et al.*, (1997) reminded the science community that “half of the peak discharge will not move half of the sediment, half of the migration motivational flow will not move half of the fish and half of an overbank flow will not inundate half of the floodplain”.

In addition to stream flow magnitudes, characteristics of the hydrologic regime including frequency, timing and duration, rate of change, and sequences of flows also play important roles in regulating ecological processes. The ecological response to changes in a hydrologic regime will depend upon the degree to which critical characteristics deviate from natural ranges. For example, if changes are too great, the life-cycle needs of native species may not be met. They may be displaced by non-native species, and energy flow through the ecosystem may be modified (Stanford *et al.*, 1996).

Water levels or flows within certain ranges may be needed to maintain:

- Habitat conditions (e.g. water depth, which influences “living space”)
- Channel and floodplain morphology
- Substrate characteristics (e.g. particle size distribution and looseness)
- Water quality characteristics (e.g. water temperature and dissolved oxygen levels)

A range of flows provides various hydraulic connections that support various ecological functions and processes

In the case of the Pefferlaw River subwatershed, the large amount of groundwater discharge sustains the coldwater habitats of this system. Efforts are required to maintain those functions that provide the baseflow benefits on a long term basis.

6.3.6 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).

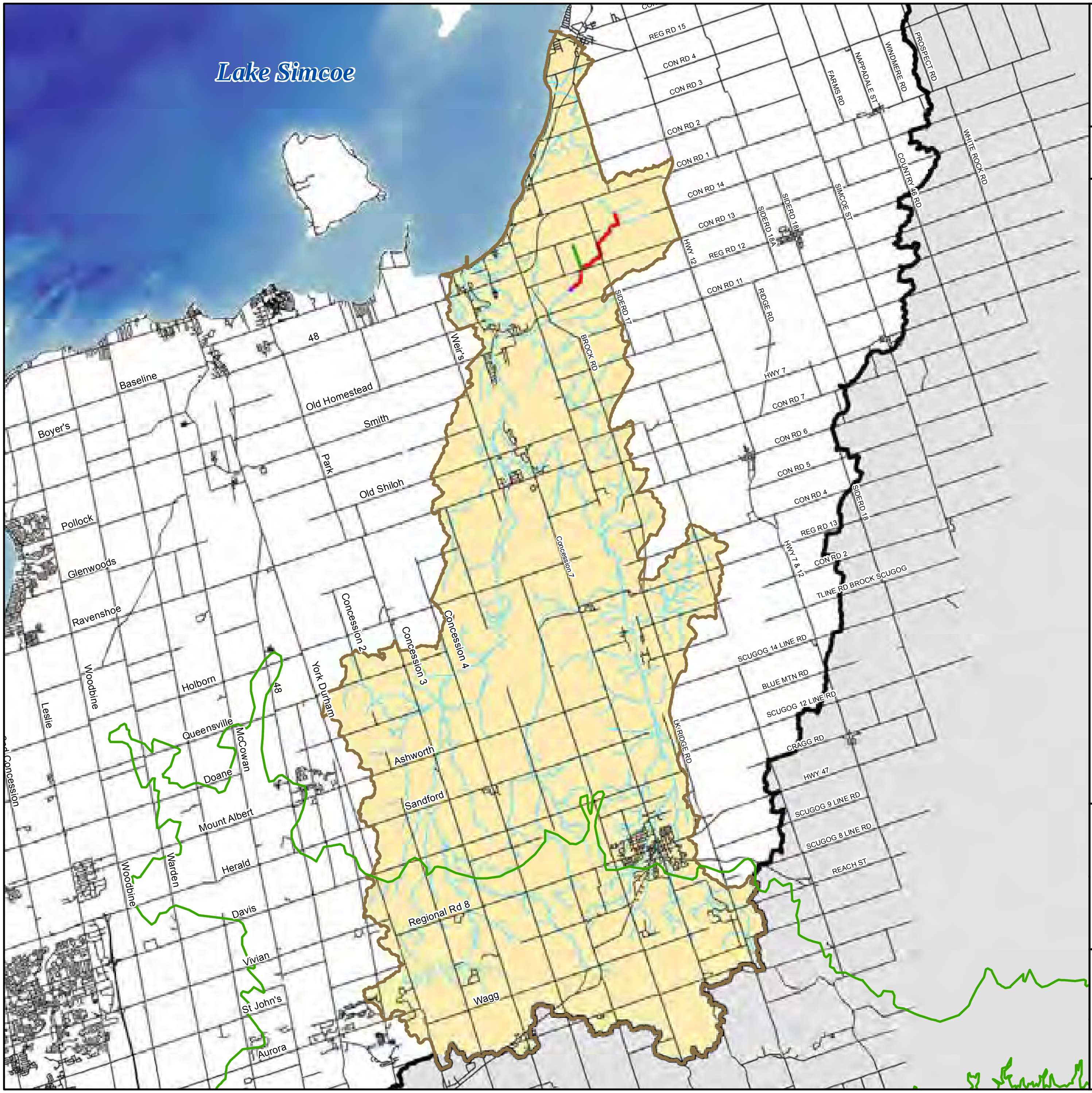
As these are direct links to watercourses, there are a number of impacts on the aquatic communities. The inputs into the drain consist of both overland flow and tile outlets and can carry contaminants, sediment, and debris into the drain. With little to no riparian vegetation, water temperature is increased and the drain 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 alteration 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 6-10 illustrates the municipal drains in the Pefferlaw River subwatershed, based on their drain type classification. There are only two classified municipal drains in the subwatershed. One is considered to be an ‘E’ drain and one is an ‘F’ drain. Both are located in the northeast corner of the subwatershed in Brock Township.

Municipal Drains in the Pefferlaw River Subwatershed

Figure 6-10



6.3.7 Water quality and thermal degradation / climate change

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. In addition, the removal of riparian vegetation and the shade it creates, as well as the warming of water as it drains from paved areas, causes 'thermal pollution' in watercourses, and can make some waters uninhabitable by coldwater species.

In looking at the information provided on Figure 6-2 and Figure 6-3, the impact of on-line barriers is evident. Most, if not all, of the 'impaired' benthic sites have a barrier in close proximity (and upstream) to the station location. Sites downstream of instream barriers typically exhibit increased stream temperatures, reduced water quality, reduced dissolved oxygen levels, less fine bed materials in the substrate, and a stream channel that is geomorphically out of balance. These effects are reflected in the benthic invertebrate population being considered 'impaired'.

In addition, 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. Based on a model that looked at maximum air temperatures and groundwater discharge potential, the information suggests that in watersheds like the Pefferlaw River subwatershed, which has high groundwater potential discharge, (as expressed as a base flow index in the study), the groundwater conditions should offer thermal refuge for coldwater species. This suggests that there may be enough resilience to be able to maintain the coldwater attributes of the Pefferlaw River over time. This also suggests the importance of protecting and building more resilience through instream rehabilitation, barrier removal, stream bank planting, use of natural channel design during channel reconstruction, water quality protection in both urban and rural settings, and wetland protection. However, perhaps the most fundamental way to address the risks of climate change is through the protection and maintenance of the current groundwater recharge-discharge system that supports the Pefferlaw River subwatershed.

More specific information on water quality issues can be found in **Chapter 4 – Water Quality**.

Key Points- Factors impacting Aquatic Habitat – stressors

- Physical changes such as artificial barriers, online ponds, channelization, and removal of riparian vegetation are some of the most significant stressors to Pefferlaw River aquatic habitats– e.g. there are 158 known barriers, a total of 130 stream sections that have been channelized and hardened (additional 28 were just straightened), and 375 sites lacking riparian vegetation, as identified through the BMP inventory.
- Habitat quality and quantity is also impacted by changes in flow regime resulting from land use changes and water taking. 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.
- Protection of the existing hydrologic conditions supporting the baseflow characteristics in the Pefferlaw subwatershed will likely allow coldwater conditions to persist despite the impacts of climate change
- Building hydrologic resilience through stream rehabilitation, barrier removal, and riparian and tree planting is needed for sustainability of the coldwater features
- Increased chloride and suspended solids concentrations are degrading Pefferlaw River aquatic habitat, especially for sensitive species. An additional water quality concern is the thermal degradation occurring due to land use changes (online ponds, impervious areas) and future climate change predictions. These issues are discussed in more detail within **Chapter 4 - Water Quality**.
- Invasive fish and invertebrate species are negatively affecting native communities by occupying and/or destroying the habitat of native species, consuming their eggs and young, and by out-competing them for resources

6.4 Current Management Framework

6.4.1 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 Greenbelt Plan, Growth Plan for the Greater Golden Horseshoe, the Oak Ridges Moraine Conservation Plan, and the Lake Simcoe Protection Plan. This management framework relates to many different stressors that can potentially affect aquatic habitat, with activities ranging from the loss of riparian areas to urban development. In Table 6-3 we categorize 11 such stressors, recognizing that many of these overlap and that the list is by no means inclusive of all stressors. The legal effects of this management framework broadly fall into one of two categories. The first broad category we define as those having little or no legal standing and are referred to as General or Have Regard to Statements in Table 6-3 and are shown in blue. The second category includes those that have legal standing and must be conformed to; these are referred to as Regulated / Existing Targets in Table 6-3 and are shown in green. In many cases an act, regulation, policy or plan does not have policies of either category that relate to the activity specified, these are shown in red.

Table 6-3: Summary of current management framework as it relates to the protection and restoration of aquatic habitat.

Stressor affecting aquatic habitat	Oak Ridges Moraine Conservation Plan (2002)	Greenbelt Plan (2005)	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)	York Region Official Plan (2008)	Durham Regional Official Plan (2008)
Growth, development and site alteration	🟩	🟩	🟩	🟦	🟦	🟦	🟥	🟥	🟥	🟩	🟩	🟩
Introduction of invasive species	🟥	🟥	🟦 3	🟥	🟥	🟥	🟥	🟥	🟩	🟥	🟥	🟥
Loss of natural heritage features	🟩	🟩	🟩	🟦	🟦	🟩 7	🟥	🟩 9	🟥	🟩	🟩	🟩
Loss of riparian areas	🟩 1	🟩 1	🟩 4	🟥	🟦	🟩 7	🟥	🟩	🟥	🟩	🟩	🟩
Stream alteration	🟩 2	🟩 2	🟩 4	🟥	🟥	🟥	🟥	🟩	🟥	🟩	🟦	🟦
Instream barriers	🟩 2	🟩 2	🟩 4	🟥	🟥	🟥	🟥	🟩	🟥	🟩	🟦	🟦
Bank hardening	🟩 2	🟩 2	🟩 4	🟥	🟥	🟥	🟥	🟩	🟥	🟩 10	🟦	🟦
Changing hydrologic conditions	🟦	🟦	🟩 5	🟦	🟦	🟥	🟩	🟥	🟥	🟩 11	🟦	🟦
Degradation of water quality (including thermal impacts)	🟦	🟦	🟩 6	🟦	🟦	🟥	🟥	🟥	🟥	🟦	🟦	🟦
Restoration	🟦	🟦	🟦	🟥	🟦	🟦 8	🟦	🟦	🟦	🟩 12	🟦	🟦 13
Climate change	🟥	🟥	🟦	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟦

🟦 General/Have regard to statement 🟩 Regulated/Existing targets 🟥 No applicable policies

[1] Protected through required buffers around streams/waterbodies

[2] Development/site alteration restricted within 30 metres of streams, presumably would prohibit channelization, other in-stream and riparian activities

[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] Implied under buffer restrictions

[5] Instream flow targets and water conservation, but nothing around impervious areas/higher peak flows

[6] Only contains specific policies and targets about phosphorus reduction, none about other contaminants

[7] Related to those features that are part of SARO listed species' habitat

[8] Person holding a permit to conduct an activity may be required to rehabilitate habitat damaged/destroyed in undertaking the activity; is also mentioned in policy pertaining to Species at Risk in Ontario Stewardship Program

[9] would only apply to those areas that can be classified as fish habitat

[10] Not directly stated, but stream alteration policies would cover this

[11] stormwater controls required, application must demonstrate every effort made to achieve pre-development hydrologic conditions

[12] Required for valleyland applications, may be required in other cases

[13] Required in some instances, but generally encouraged

In this section we provide a summary the various acts, regulations, policies and plans as they pertain to activities affecting aquatic habitat. This summary is to give context to *future management considerations* and the *opportunities and recommendations*. This summary is not intended to be comprehensive in terms of all the pieces of the management framework that relate to aquatic habitat, or of the acts, regulations, policies and plans that are discussed in the following sections – the reader is directed to each act, regulation, policy, or plan for a full assessment of how it relates to aquatic habitat.

Oak Ridges Moraine Conservation Plan (2002)

This plan designates Natural Core and Natural Linkage Areas for the purpose of maintaining and improving the ecological integrity of the plan area. Approximately 3,900 ha (or 17%) of the subwatershed is designated ORMCP Natural Core and Linkage areas. The policies that apply in the Natural Core and Linkage Areas include:

- Every application for development or site alteration shall identify planning, design and construction practices that ensure that buildings or site alterations do not impede the movement of plants and animals among key natural heritage features (a designation which includes fish habitat), hydrologically sensitive features and adjacent land.
- A minimum area of influence and minimum vegetation protection zone, which are 30 metres and 120 metres, respectively. An application for development or site alteration within the minimum area of influence that relates to a key natural heritage feature, but is outside of that feature and the minimum vegetation protection zone, are to be accompanied by a natural heritage evaluation. A natural heritage evaluation shall:
    - Demonstrate that the development or site alteration will have no adverse affects on the key natural heritage feature or the related ecological functions
    - Identify planning, design and construction practices that will maintain and, where possible, improve or restore the health, diversity and size of the key natural heritage feature and its connectivity with other key natural heritage features
    - Demonstrate how connectivity within and between key natural heritage features will be maintained and, where possible, improved or restored before, during and after construction
    - Determine if the dimensions of the minimum vegetation protection zone as specified in the ORMCP are sufficient, and specify the dimensions necessary to provide for the maintenance and, where possible, improvement or restoration of natural self-sustaining vegetation within it

Policies related to water conservation and the protection of water quality and quantity will have the added benefit of helping to maintain a great number of important natural heritage features, such as wetlands (see **Chapter 4 – Water Quality** and **Chapter 5 – Water Quantity**).

The ORMCP also details a number of requirements for those uses that are permitted within Natural Core and Linkage Areas, such as gravel pits, agricultural uses, and low-intensity recreational uses to ensure that they have minimal impact on these important areas.

Lake Simcoe Protection Plan (2009)

The Lake Simcoe Protection Plan (LSPP) includes numerous designated policies that will help protect aquatic habitat: Those related to the protection of permanent and intermittent streams include:

- Restrictions to structures along or within streams if it impedes flow or harmfully alters fish habitat.
- Requires any shoreline alteration required for drainage or stabilization only be completed if remediation will maintain natural stream contours and a vegetated riparian area will be established (with the exception of agricultural activities that are not required to establish riparian areas).
- Any development and site alteration within 120 m of a stream should integrate with stewardship and remediation activities.

The policies in the plan that will support healthy aquatic communities in Lake Simcoe's tributaries (such as those in the Pefferlaw River subwatershed) include:

- The development of fish community objectives, to be used by public bodies to inform decisions relating to the management of land, water and natural resources, increase the resilience of the aquatic communities to future impacts of invasive species and climate change, and ensure sustainable resource use and social benefit
- The completion of baseline mapping of aquatic habitat will be completed, building on existing monitoring programs and established databases
- The development and implementation of an annual aquatic community monitoring program, which will build upon existing monitoring programs in order to support an adaptive management approach

The LSPP also deals explicitly with issues around invasive species, with a target of preventing the introduction of new invasive species in the watershed. The policies aimed at meeting this target include:

- The delivery of annual information and education programs for the general public and key stakeholders on how to prevent the spread of, and how to detect, invasive species
- The development of a community based social marketing project to identify effective methods to engage stakeholders for the purpose of modifying their behaviour to reduce the introduction and spread of invasive species
- The development of a regulatory proposal that would require anglers who are fishing with live bait in the Lake Simcoe watershed to only use live bait caught in the watershed
- The completion of a study to evaluate the potential risk of movement of invasive species through the Trent-Severn Waterway resulting from natural dispersal and boat traffic
- A mobile boat wash/education program will be developed and implemented

LSPP policies described in other chapters of this plan, particularly around the protection of natural heritage features and water quality and quantity, as described in their respective chapters, will also support healthy aquatic environments throughout the watershed.

Greenbelt Plan (2005)

One of the stated goals of the Greenbelt Plan is the protection, maintenance and enhancement of natural heritage, hydrologic and landform features and functions, including the protection of habitat for flora and fauna, as well as protecting and restoring natural and open space connections.

Wetlands, seepage areas and springs, fish habitat, permanent and intermittent streams, lakes, and significant woodlands, are all considered to be key natural heritage or key hydrologic features. Under the policies for the Natural Heritage System areas, the Plan states that:

- The minimum vegetation protection zone shall be a minimum of 30 metres wide measured from the outside boundary of these key natural heritage feature or key hydrologic features. Thus, areas within the Greenbelt boundaries within the Pefferlaw River require a minimum 30 metre buffer.
- For development or site alteration within these features, as permitted by the Plan's policies, the application shall demonstrate that there will be no negative effects on Key Natural Heritage or Key Hydrologic Features, and that connectivity shall be maintained or enhanced wherever possible.
- The amount of disturbed and impervious area of sites where development and site alteration is permitted is limited; stating that they should not exceed 25 and 10 per cent of the site's developable area, respectively.
- Applicants are to demonstrate, where non-agricultural uses are contemplated, that
    - At least 30 per cent of the total developable area will remain in or be returned to natural, self-sustaining vegetation
    - Connectivity along the system and between key natural heritage and hydrologic features located within 240 metres of each other is maintained or enhanced
    - Buildings and structures are not to occupy more than 25 per cent of the total developable area

There are also a number of policies under the Water Resource System area of the Natural System that relate to the protection and enhancement of fish habitat. These are discussed in greater detail in **Chapter 4 – Water Quality** and **Chapter 5 – Water Quantity**. The external connections policies in the Water Resource System section includes encouraging planning approaches that increase or improve fish habitat and to avoid, minimize or mitigate the impacts associated with urban runoff, and the integration of watershed planning and management approaches for lands both within and beyond the Greenbelt.

Growth Plan for the Greater Golden Horseshoe (2006)

The Growth Plan does not contain any policies related to aquatic habitat, except that the population density target calculation will exclude such areas as fish habitat and other natural heritage and hydrologic features that are otherwise protected through measures such as the Provincial Policy Statement or applicable Official Plans.

Provincial Policy Statement (2005)

By focusing growth within settlement areas and away from significant or sensitive resources, the implementation of the Provincial Policy Statement (PPS) will help to protect aquatic habitat within the Pefferlaw River subwatershed. The policies that support this in the PPS include:

- Directing growth to settlement areas and requiring planning authorities to identify and promote opportunities for intensification and redevelopment
- Supporting a coordinated, integrated and comprehensive approach between municipalities when dealing with managing natural heritage and water resources, and ecosystem, shoreline and watershed related issues.

Under its ‘Wise Use and Management of Resources’ policies, the PPS specifies that:

- Natural heritage features and areas (which includes fish habitat, among other features) shall be protected for the long term
- The diversity and connectivity of natural features in an area, and the long-term ecological functions and biodiversity of natural heritage systems, should be maintained, restored or, where possible, improved, recognizing the linkages between and among natural heritage features and areas, and surface and groundwater features
- Development and site alteration shall not be permitted in fish habitat except in accordance with provincial and federal requirements.

Policies around the protection of water resources will also protect quality aquatic habitat for biota. See **Chapter 4 – Water Quality** for PPS policies related to protecting water quality and **Chapter 5 – Water Quantity** for policies related to protecting water quantity.

Endangered Species Act (2008)

The purposes of the Endangered Species Act (ESA) are to protect species that are at risk and their habitats, as well as promoting the recovery of those species. Through the implementation of the policies of the ESA, protection will be afforded to the aquatic habitats of the Pefferlaw River subwatershed’s rarest species thus helping to preserve the subwatershed’s biodiversity. These policies state that no person shall:

- Kill, harm, harass, capture or take a living member of a species that is listed on the Species at Risk Ontario (SARO) list as an extirpated, endangered, or threatened species
- Possess, transport, collect, buy, sell, lease, trade or offer to do the same with any specimen (living or dead) or part of a species that is listed on the SARO list as an extirpated, endangered, or threatened species
- damage or destroy the habitat of a species listed as endangered, threatened, or extirpated

The policies of the ESA also require that a recovery strategy be prepared for each of the species on the SARO list as an endangered or threatened species. These strategies are to include an identification of the habitat needs of the species, a description of the threats to the survival and recovery of the species. The ESA includes a policy that states that the precautionary principle should be used in the development of recovery plans – where there is a threat of significant reduction or loss of biological diversity, a lack of full scientific certainty should not be used as a reason for postponing measures to avoid or minimize such a threat.

Ontario Water Resources Act (1990)

The issuance of Permits to Take Water occurs under the Ontario Water Resources Act (OWRA). In relation to aquatic habitat, the OWRA states (see section 34 (1)) that when issuing permits, a MOE Director should consider the following:

i. The impact or potential impact of the water taking on
    a. the natural variability of water flow or water levels
    b. minimum stream flow
    c. Habitat that depends on water flow or water levels, and

ii. Groundwater and surface water and their interrelationships that affect or are affected by…the water taking or proposed water taking, including its impact or potential impact on water quantity or quality.

As discussed in **Chapter 5 - Quantity**, the issuance of permits to take water is the responsibility of the Ministry of the Environment. It is only necessary to obtain a permit for water takings exceeding 50,000 L/day, and permits are not required for takings for household use or for watering livestock and poultry. While this legislation specifically addresses the quantity of water, as well as the quality with respect to certain activities, the management of water resources can have a significant influence on the health of aquatic habitat. This is discussed in greater detail in **Chapter 5 - Water Quantity**.

Fisheries Act (1985)

The *Fisheries Act* is federal legislation that deals with the management of Canada's fisheries resources and the conservation and protection of fish and fish habitat. Section 35 of the *Act* states that no one may carry on any work or undertaking that results in the harmful alteration, disruption or destruction (known as a HADD) of fish habitat, unless authorized to do so by the Minister of Fisheries and Oceans Canada. It is among the oldest and strongest environmental legislation in the country. The enforcement of this Act limits the work that can be done in and around a watercourse, including channelizing and hardening activities, relocation of stream channels, and the creation of barriers, thus ensuring that habitat quality is protected and that aquatic systems do not become fragmented.

Ontario Fisheries Regulation (1989) (created under the federal Fisheries Act)

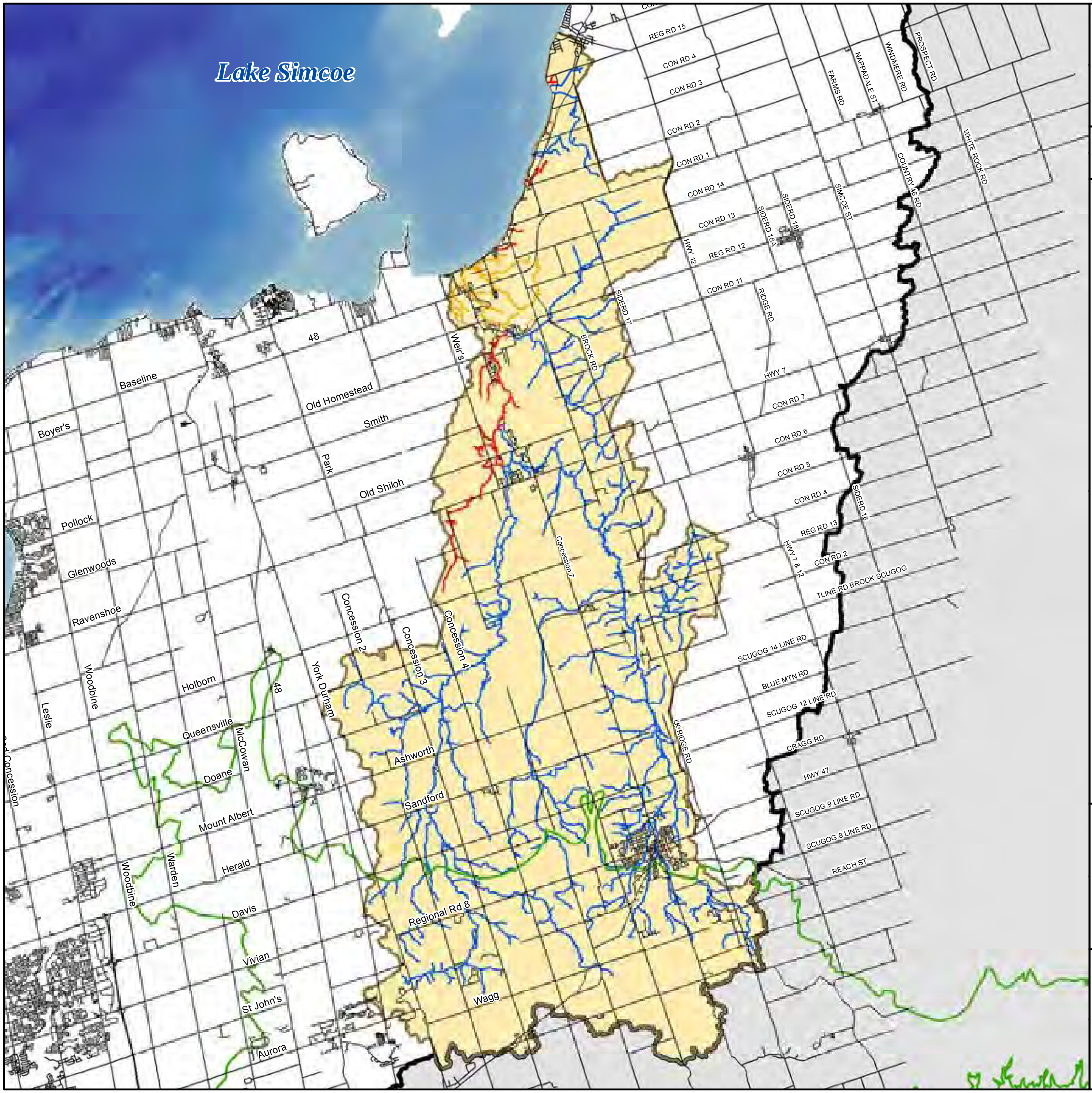
These regulations set out the rules around fishing (both recreational and commercial) and possessing fish in the province of Ontario. Aside from rules around fishing licenses, fishing quotas and acceptable methods, the regulations most applicable to this subwatershed plan mainly focus on preventing the introduction of invasive species and protection of endangered species, and include:

- Regulation 6 (1) states that no person shall possess a live invasive fish without a license.
- Regulation 28 states that it is illegal for anyone to deposit live fish into a body of water other than the body of water from which they were caught. There is also a specific regulation regarding bait fish – it is illegal to release baitfish into any waters, or within 30 metres of any waters.
- Regulation 29 stipulates that it is against the regulations for any person to use as bait or even possess for use as bait, an invasive species.
- Regulation 7 (1) states that no person shall fish for or possess a specially protected fish without a license.

The enforcement of these regulations, though difficult, is an important tool for preventing the introduction and spread of invasive species and the protection of endangered species in the subwatershed.

In-water Works Restrictions

The Ontario Ministry of Natural Resources (MNR) is responsible for determining in-water works restrictions such that fish and other aquatic life are permitted to carry out their 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 Figure 6-11.



Timing restrictions for in-water works

Figure 6-11

Legend

Timing Restrictions

- — October 1 to June 1
- — March 1 to June 30
- — April 1 to June 30
- — Road
- LSRCA Watershed Boundary
- Oak Ridges Moorine

Lake Simcoe Region conservation authority

0 1 2 4 6 8 10
Kilometres

N

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

LSRCA Watershed Development Policies (2008)

The Authority requires an undisturbed vegetative buffer strip running consistently along both sides of all watercourses. The buffer is to be measured perpendicularly outwards from the edge of the annual average high water mark as follows: a) a minimum 15 metre buffer for all watercourses, b) a minimum 30 metre buffer for all coldwater or marginally coldwater (coolwater) watercourses. Where watercourses have not been studied as to thermal regimes or fish population, the 30 metre buffer will be required. Note that this policy has largely been superseded by LSPP which requires a minimum 30m vegetative protective zone for all key natural heritage and hydrological features.

Durham Regional Official Plan (2008)

To protect aquatic habitat, the Durham Regional Official Plan:

- Specifies a minimum 30 metre buffer for fish habitat, and requires that applications for development within 120 metres of fish habitat complete an environmental impact study to determine whether the buffer should be wider than 30 metres in order to protect that feature and its functions
- Provides the same protection for other natural features such as forests and wetlands, which will maintain and enhance the state of aquatic habitat
- In assessing development, the Region requires that streams and their adjoining lands be retained in or rehabilitated to a natural state and that fish and wildlife habitat are protected, and also discourages alterations to watercourses.

Additional legislation and policies that address aquatic habitat issues

The policies discussed in the water quantity, water quality, and natural heritage chapters, if implemented, will all serve to protect and enhance the quality and quantity of aquatic habitat in the Pefferlaw River. Readers should refer to these chapters for specific information around the policies that protect the quality and quantity of water that the aquatic community depends on, as well as the protection of the amount and quality of natural heritage features and their functions.

6.4.2 Restoration and Remediation

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

The Ontario Ministries of Natural Resources (MNR), 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 Pefferlaw River subwatershed, this program is implemented in partnership with the Durham Land Stewardship Council (DLSC). The DLSC has completed five shoreline buffer projects and one septic system replacement since 2009

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.

In 2008 and 2009, LSRCA field staff surveyed 44% of the watercourses in this subwatershed, documenting the range of potential stewardship projects that could be implemented to help improve water quality and fish habitat. This survey found over 375 additional places in this subwatershed where additional riparian planting could be introduced, 158 barriers that should be removed to improve fish passage, 24 locations along creeks that require additional fencing, and 130 locations where the creek channel had been hardened and 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, the 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 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).

Central stoneroller

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 6-1).

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.

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. The proposed monitoring program is intended to build on the existing monitoring described above, to describe the fish communities, benthic communities, macrophytes, and/or fishing pressure in the lake, its tributaries, and other inland lakes within the watershed.

6.5 Management Gaps and Recommendations

As can be seen in the previous section, there are a number of pieces of legislation, regulations, and municipal requirements aimed at protecting the aquatic habitat of the Pefferlaw River. Despite this strong foundation, there are a number of gaps and limitations in the management framework that need to be considered. This section provides an overview of factors that need to be considered in the future management of the Pefferlaw River subwatershed, in addition to some relevant recommendations to address those.

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 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 ORMCP and eventually the Lake Simcoe Protection Plan. To that end, in recent months the 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, watershed municipalities and related committees.

> **Recommendation #45 -** That the MNR, MOE, OMAFRA, and LSRCA continue to implement stewardship projects in the Pefferlaw River subwatershed, and encourage other interested organizations in doing the same.
>
> **Recommendation #46 -** That governmental and non-governmental organizations should continue to improve coordination of programs to: (1) avoid inefficiencies and unnecessary competition for projects, and: (2) make it easier for landowner to know which organization they should be contacting for a potential project, using tools such as a simple web portal.
>
> **Recommendation #47 -** That the Federal, Provincial and Municipal governments provide consistent, long term and sustainable funding to ensure continued delivery of stewardship programs.
>
> **Recommendation #48 -** That the MOE, MNR, OMAFRA, and LSRCA support research to determine barriers limiting uptake of stewardship programs in these subwatersheds, share these results with members of the Lake Simcoe Stewardship Network, and revise stewardship programs or stewardship outreach 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 #49 -** That the MOE, MNR, OMAFRA, and LSRCA investigate new and innovative ways of reaching target audiences in the local community and engage/involve 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. Results of these efforts should be shared with members of the Lake Simcoe Stewardship Network, municipal councils and agricultural groups.

6.5.2 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 in the Pefferlaw River subwatershed has identified bank hardening (130 sites), barriers (158 sites), and insufficient riparian cover (approx. 1/4 of the subwatershed, and at least 375 sites) 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 #50 -** That the LSRCA, in collaboration with MNR and MOE, should develop a spatially-explicit prioritization tool to assist in targeting stewardship aquatic habitat projects in the Lake Simcoe watershed. In the context of the Pefferlaw River subwatershed, this decision tool should take into account:
>
> - The need to incorporate each major type of aquatic habitat stressor including bank hardening, barriers, riparian cover and on-line ponds;
> - 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, increase connectivity for movement within and between tributaries, and shelter.
>
> **Recommendation #51 -** That prioritized restoration areas be integrated into development of a stewardship plan that ensure prioritized restoration opportunities are undertaken in consultation with landowners as soon as feasible. This stewardship plan needs to incorporate outcomes of recommendations to improve uptake identified in Recommendations 45 through 48.
>
> **Recommendation #52 -** In alignment with recommendation 50 and 51, LSRCA shall seek input from municipal partners to improve stream connectivity through a priority setting exercise specific to barrier/dam removal or retrofitting. It must be noted that priority setting exercise needs to include the recognition of the need to partition and/or restrict other competitive species of fish (e.g. brown trout, rainbow trout, round goby) from existing brook trout populations. Upon completion of the ‘reconnection’ program, LSRCA and partners will develop a communications plan for its implementation.

6.5.3 Impacts to Hydrologic Regime

The Pefferlaw River and its related wetlands are dependent on relatively stable baseflows supported by groundwater inputs. Variations/reductions in flow can be caused by impervious surfaces, inadequate stormwater management, poor urban development design, water taking activities such as irrigation, and impacts of municipal drains. Determining the flow regime required to support the existing aquatic ecosystem is critical for the future management of water in the Pefferlaw River subwatershed. While water quantity and associated recommendations are discussed in detailed within **Chapter 5 – Water Quantity**, the following recommendations are specific to aquatic habitat:

Recommendation #53 - That the LSRCA with assistance from MNR and MOE establish ecological flows targets (also known and E-flows or in-stream targets) for the Pefferlaw River. These ecological flow targets should be based on the framework established for the Maskinonge River. Once established, E-flows should form the basis of strategy to achieve suitable E-flow within the Pefferlaw River. This strategy should also protect baseflow and location of upwellings in order to maintain thermal stability.

Recommendation #54 - That the LSRCA work with the municipalities and OMAF to promote innovative forms of cost effective municipal drain maintenance, or opportunities to create new drains using principles of natural channel design. Look for opportunities to decommission when the land use changes.

6.5.4 Water Quality and Water Temperature

While most water quality parameters measured meet the provincial standards for the vast majority of the time in the Pefferlaw River subwatershed, increasing trends in chloride have been observed. In addition, increases in stream temperature, whether they are due to impervious surfaces, lack of riparian vegetation, reduction of groundwater contributions, or climate change, negatively affect the distribution and existence of coldwater resources like brook trout due to their restrictive thermal requirements.

Recommendations addressing water quality issues are presented in **Chapter 4 – Water Quality**, and recommendations pertaining to increasing stream temperatures are also described above e.g. Recommendations #50 and #53. In addition, **Chapter 5 - Water Quantity**, contains recommendations related to protecting the existing hydrologic and hydrogeologic regime so existing physical coldwater attributes can be monitored and protected.

6.5.5 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 #55 - That the LSRCA with support and input from Municipalities, the Province, and private interests aim for improved spatial and temporal resolution in annual monitoring of aquatic habitat, including water quality, fish and benthic indicators.

Recommendation #56 - That the LSRCA, with support and input from Municipalities and the Province, undertake a baseline assessment of brook trout spawning areas within representative reaches of the Pefferlaw River, and from this, develop a routine monitoring program to continually assess natural reproduction and survival of aquatic communities.

Recommendation #57 - That the LSRCA and the Ministry of Natural Resources continue current cooperative fish community monitoring, assess information gaps and work together to quantify and assess the quality of critical fish habitats in the lake and its tributaries.

Recommendation #58 - In conformance with the LSPP, that the Ministry of Natural Resources lead the development of fish community goals and objectives for Lake Simcoe and its tributaries, in conjunction with the LSRCA and input from partner municipalities and to identify recommendations and develop an implementation plan containing priority enhancement opportunities for the Pefferlaw River.

7 Fluvial Geomorphology

7.1 Introduction and background

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

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

7.1.1 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. The amount of water in a natural watercourse is influenced by both climate and geology. The amount of water delivered to the surface of a watercourse, as well as how and when it arrives is influenced by climate. Typical patterns are high flow events during the spring freshet, and low flow conditions during the winter and summer months.

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

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

7.2 Current Status

The geomorphology of the Pefferlaw and Uxbridge Brooks was assessed in 2007 by PARISH Geomorphic Ltd (2007). The assessment was completed separately for the Pefferlaw and for the Uxbridge, as they have traditionally been treated as separate subwatersheds. Therefore, results from both are presented in this chapter.

This assessment involved two components: desktop analysis and field reconnaissance. The desktop analysis involved classifying the streams into stream order, valley segmentation, reach breaks (for 3rd and higher order streams), belt width corridor delineation, and historic analysis using aerial photography (2002) and other digital datasets such as watercourses, contour lines (5 m interval), quaternary geology, soils, roads, landuse, and subwatershed boundaries (Table 7-1). Desktop analysis also involved assessing historical changes in the planform. In this case three sets of aerial photographs, spanning 42, years were used. The field reconnaissance component of the assessment built upon the desktop analysis by field truthing random reaches to confirm the results of the desktop work and identify areas of unusual channel conditions such as excessive erosion or deposition.

Table 7-1: A summary of geomorphologic features investigated.

River Feature	Description	Method
Planform	The shape of a watercourse as viewed from above	Assessment of historical aerial photos
Stream Order	A measure of the degree of stream branching within a watershed	Assessment of aerial photos
Valley Segments	Relatively homogenous sections of watercourses that exhibit distinct and similar physical elements	Assessment of aerial photos
Reach Break Determination	Reaches are lengths of channel that display similarity with respect to valley setting, planform, floodplain materials, and land use or land cover.	Assessment of aerial photos
Meander Belt Width	The stream corridor that the river channel potentially has had in the past and, more importantly, could occupy in the future	Assessment of aerial photos
Rapid Geomorphic Assessment	Assesses the geomorphic condition of the reach by evaluating the occurrence of four geomorphic processes: aggradation, degradation, widening, and planform adjustment	Field survey
Rapid Stream Assessment Technique (RSAT)	Assesses the overall stability of the reach from both a geomorphic and ecological perspective by evaluating channel dimensions	Field survey

7.2.1 Planform

An analysis of historical aerial photographs was used to identify changes in channel planform (Parish Geomorphic Ltd 2001). Aerial photographs from three sets of coverages, 1959/61, 1976, and 2002, spanning 42 years were used. Google Earth images were used to determine land use for areas where there was incomplete coverage for 2002 images. Aerial photography helps to identify natural changes and human alterations in channel planform, and changes in land use. Migration rates are usually calculated to determine rates of change along a river (PARISH Geomorphic Ltd, 2001). However, as this study was a high-level survey of the subwatersheds, the air photo resolution was insufficient to accurately calculate migration rates. Furthermore, these river systems are fairly stable and there were few examples of extreme planform change to facilitate migration rate calculations. Planform was examined for all three study years.

Planform change in Pefferlaw Brook was examined in its entirety for 1959/61 and 1976 and for the partial coverage of 2002. In general the planform in Pefferlaw Brook appeared to be fairly stable, with small amounts of change observed, with regard to the shape of the meanders, in the 1959/61 and 1976 aerial photographs. Due to a lack of air photo coverage, this could not be confirmed with the 2002 aerial photographs.

In the Uxbridge Brook very little change in land use and channel planform has occurred. Land use in the subwatershed has remained largely agricultural with large woodlots, particularly surrounding the streams themselves. There was some increase in urban area near the confluence of Uxbridge Brook and Pefferlaw Brook between the 1959/61 and 1976 aerial photographs between Victoria Road and Ravenshoe Road. There was no additional increase between 1976 and 2002. The only coverage available for 2002 is at this confluence where the urban area appears to have increased in size slightly between Victoria Street and Ravenshoe Road therefore this was complemented with Google Earth images for land use assessment purposes. Meander planform was examined for 1959/61 and 1976 however no obvious change to channel planform was observed, even in very sinuous reaches. Uxbridge Brook appeared to be very stable overall.

7.2.2 Stream Order

Stream order is a measure of the degree of stream branching within a watershed; a first-order stream is an unbranched tributary, a second-order stream is a tributary formed by the connection of two or more first-order streams, a third-order stream is a tributary formed by the connection of two or more second-order streams, and so on. Stream orders for the Pefferlaw and Uxbridge Brooks were calculated manually as part of the desktop exercise.

Bifurcation ratio is the rate at which a stream divides, which influences the pattern of sediment delivery and the shape of the hydrograph. Bifurcation ratio values between three and five are typical for areas in southern and eastern Ontario with glacial deposits (Chorley, 1969). The Pefferlaw River falls within these typical ratio values, with a bifurcation ratio of 3.82. The Uxbridge Brook is slightly above this value with a bifurcation ratio of 5.37. However, when these two systems are treated as a single subwatershed, the combined bifurcation ratio is 4.33, which falls well within the expected values for a system in this area. Stream order and average bifurcation ratio for the subwatershed can be seen in Table 7-2.

Table 7-2: Summary of stream orders and bifurcation ratio for the Pefferlaw Brook and Uxbridge Brook.

Orders	Pefferlaw Brook	Uxbridge Brook	Pefferlaw and Uxbridge combined
1	193	149	342
2	43	35	78
3	9	6	15
4	3	1	4
5	1		0
Average Bifurcation Ratio	**3.82**	**5.37**	**4.33**

7.2.3 Valley Segments

Valley segments are defined as relatively homogenous sections of watercourses that exhibit distinct and similar physical elements. As such, valley segment boundaries are determined by primary features of the watersheds such as topography, geology, climate, and hydrography/drainage networks (Kilgour and Stanfield, 2000). Climate is considered to have only minor influence on local scales and was not considered as part of the valley segment assessment.

The attributes that were used to identify valley segment breaks were defined by the differences in stream slope, catchment size, and surficial geology. These properties were categorized using GIS software, and subsequently overlaid to determine the locations of valley segment breaks, although some adjustments to correct errors due to GIS issues were necessary.

Valley segments were delineated using a hierarchy of rules as outlined by Kilgour and Stanfield (2000), whereby segments were first partitioned based on the drainage network/hydrography. Segment boundaries were identified where two tributaries merged, resulting in an increase based on the Horton System (1945). Digital mapping was used to determine and allocate stream order. All third-order (and larger) streams were considered in this subwatershed due to the large catchment size. Additional segment boundaries were also placed where watercourses crossed a boundary that separated two distinct geological units of differing porosity (e.g. sandy material to clayey material), provided the boundaries were not in conjunction with an existing hydrological junction. Finally, segments were also identified where gradients changed dramatically within one of the previously identified segments. This typically occurred where channels dramatically changed confinement, such as where it passed onto a large floodplain.

A total of 42 valley segments were identified within the Pefferlaw Brook, ranging in length from as short as 173 metres (Segment 15) to as long as 16,410 metres (Segment 26). The Uxbridge Brook had 41 valley segments ranging in length from 107 metres (Segment 17) to 6,551 metres (Segment 24). (See Parish Geomorphic Ltd., 2007 for location of valley segments).

7.2.4 Reach Break Determination

Reaches are lengths of channel (typically ranging between 200 m and 2 km in length) that display similarity with respect to valley setting, planform, floodplain materials, and land use or land cover. Reach length will vary in scale given that the morphology of low-order watercourses traverse a smaller distance compared to higher-order watercourses. The delineation of reaches along a drainage network is beneficial, as it enables grouping and the identification of general reach characteristics. It is also an ideal starting point from which the effect of subwatershed changes can be assessed.

At the reach scale, characteristics of the river corridor (i.e. valley setting, vegetation, etc.) exert a direct influence on channel form, function, and processes (PARISH Geomorphic Ltd., 2001). At this scale, the watercourse strives to obtain a form that is in quasi-equilibrium with the physical properties of its local setting and the hydrologic and sediment regimes. For example, a comparison of two reaches situated immediately up and downstream of each other but in different physical settings (i.e. scrubland versus forest) may exhibit considerable variation in channel form. Location of reach breaks are presented in Figure 7-1 and Figure 7-2.

7.2.5 Meander Belt Width

The meander belt width represents the stream corridor that the river channel potentially has had in the past and, more importantly, could occupy in the future. This is determined by identifying the spatial extent of the meander pattern within a reach. Widths are measured at right angles to the trend of the valley. Additional factors, such as remnant channel (ox-bow lakes) and meander scars also assist in identifying the maximum extent the channel may occupy within its floodplain.

As part of best management practices, it is imperative to establish maximum allowable setbacks as a means to preserve stream margin habitats, including floodplains and wetland environments. Encouraging setbacks such as vegetation buffer strips in zoning regulations and controlling urban and agricultural development in the stream corridor will minimize potential property damage while enhancing and protecting overall natural habitat.

In the Pefferlaw River subwatershed, the meander belt widths were greatest (201 to 310 metres) in the upper regions, downstream of Pefferlaw Road (Figure 7-1). Narrowest meander belt widths (0 to 30 metres) tended to occur in the headwaters of the subwatershed, such as in the vicinity of Davis Drive, in and around York/Durham Line and Concession Roads 2 and 3.

In the Uxbridge Brook, the meander belt widths were greatest (151 to 200 metres) in the upper mid-regions of the tributary, between Ashworth Road and Concession Road 4, east of Lakeridge Road (Figure 7-2). Narrowest meander belt widths (0 to 25 metres) were scattered throughout the headwater areas (e.g. upstream of Davis Drive near Main St. in Uxbridge; near Sandford Road in the vicinity of Concession 6; and at Regional Road 14 west of Sideroad 17).

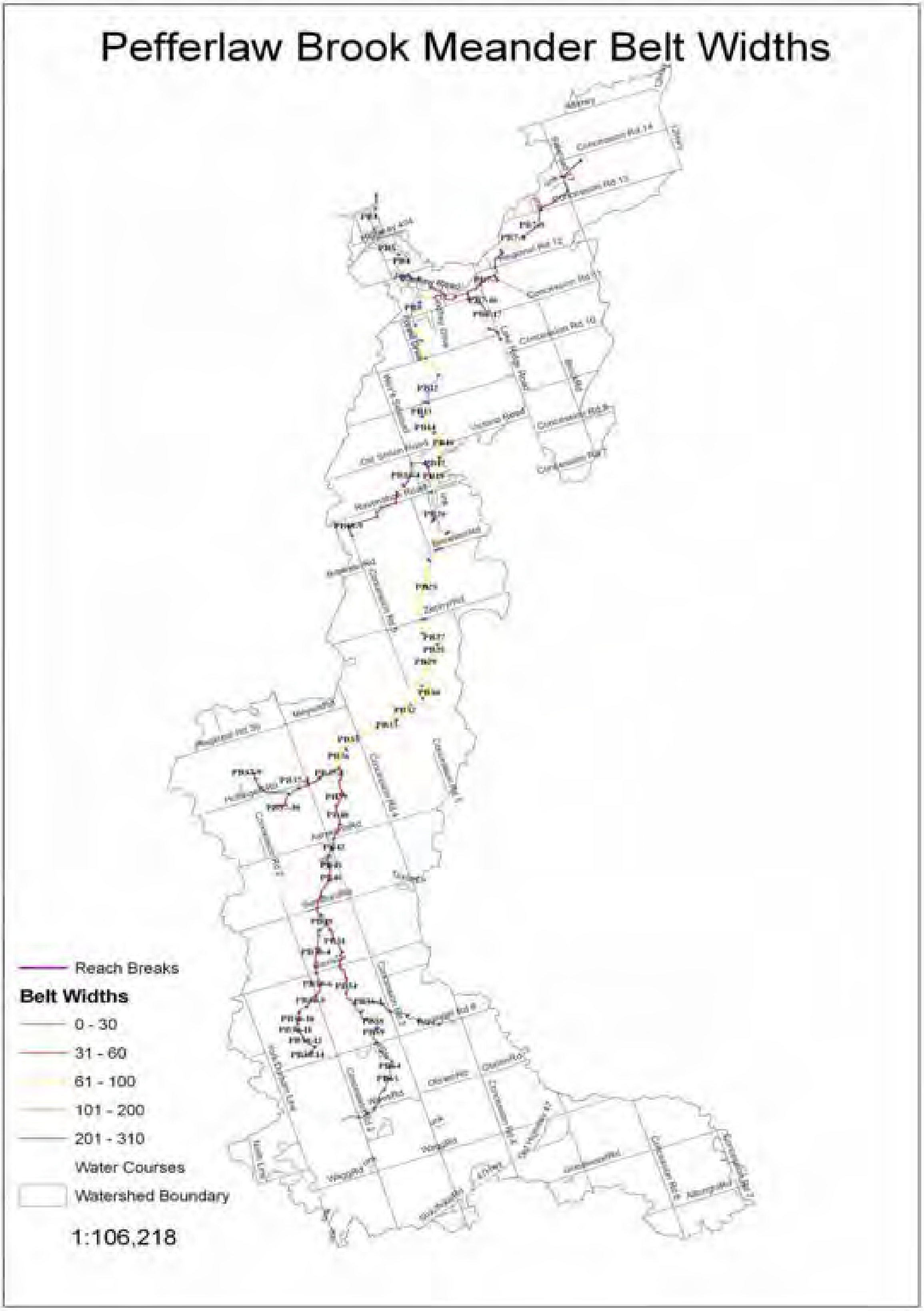


Figure 7-1: Pefferlaw Brook reach break and meander belt width (Parish Geomorphic Ltd, 2007).

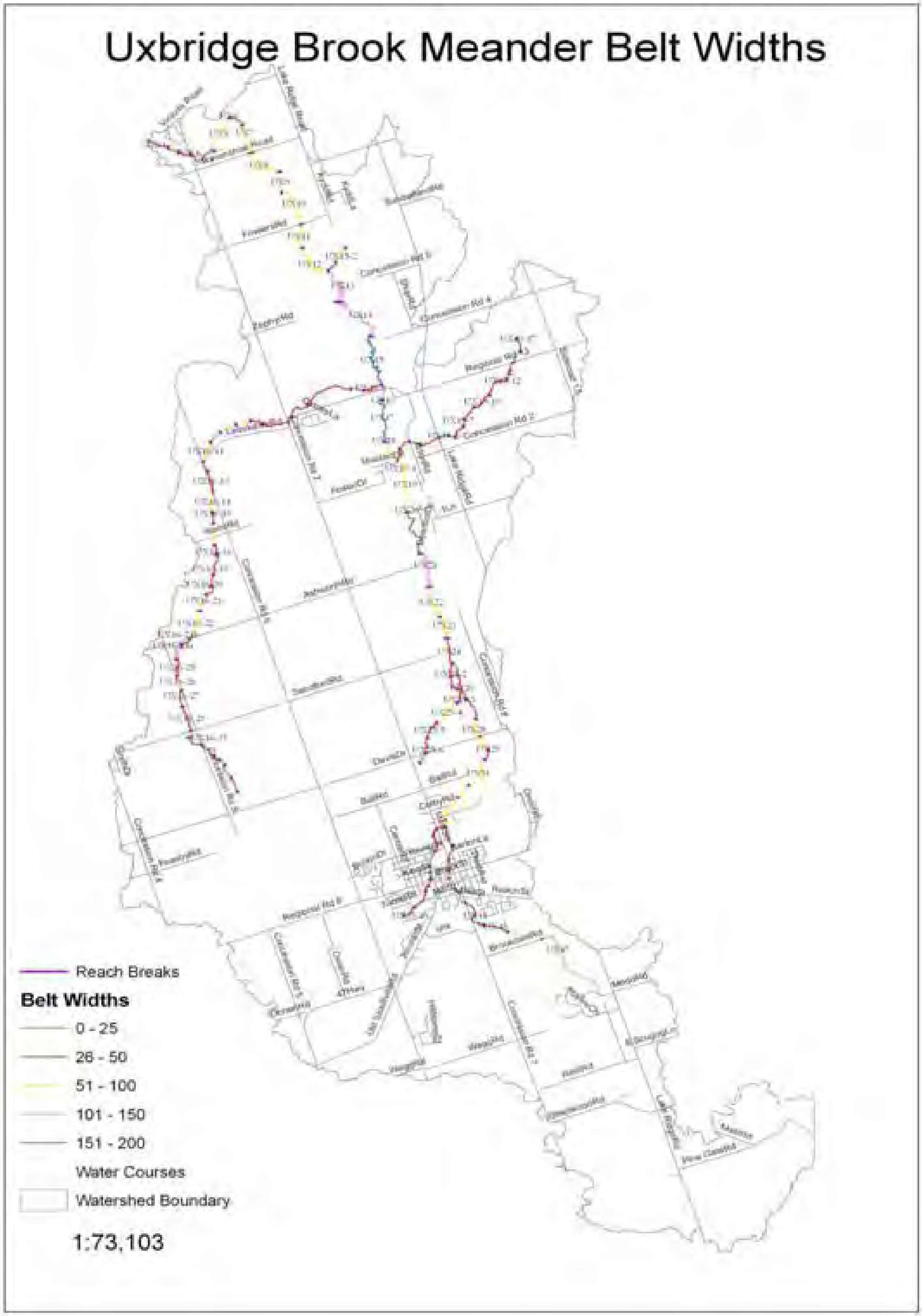


Figure 7-2: Uxbridge Brook reach break and meander belt width (Parish Geomorphic Ltd, 2007).

7.2.6 Field Reconnaissance

Due to the large area and high number of reaches in the Pefferlaw River subwatershed (including the Uxbridge Brook tributary), walking all of the reaches was not feasible. A variety of methods were used to determine the reaches that would be walked. Rapid stream assessments were carried out to verify features observed in aerial photographs (such as changes in landuse and planform). A matrix was constructed to identify representative reaches to be walked based on catchment area and stream gradient, both of which have a significant influence on reach characteristics. Sites were selected to ensure there was representation from combinations of small, medium, and large catchment areas and low, moderate, and high channel gradient.

A Rapid Geomorphic Assessment (RGA) assesses the geomorphic condition of the reach by evaluating the occurrence of four geomorphic processes: aggradation, degradation, widening, and planform adjustment. A score is determined for each process and the four scores are averaged to yield an RGA score (Table 7-3).

Table 7-3: RGA scores and their definitions.

RGA Score	State description	Geomorphic condition
0 - 0.20	in regime	Reach is in good condition, in a state of dynamic equilibrium
0.21 – 0.4	transitional	Showing signs of stress and that it may undergo an adjustment
>0.4	adjustment	Geomorphology is adjusting or changing to new conditions

A Rapid Stream Assessment Technique (RSAT) assesses the overall stability of the reach from both a geomorphic and ecological perspective by evaluating channel dimensions, substrate composition of riffles and pools, and evaluating the quality of available habitat in the reach based on physical, chemical, and biological criteria. Each category is given a rating of excellent, good, fair, or poor with an associated numerical value. These values are summed to give an RSAT score (Table 7-4)

Table 7-4: RSAT scores and their definitions.

RSAT Score	Stability rating
<20	low stability rating
20-35	a moderate level of stability
>35	a high stability rating

In some cases, the RGA and RSAT scores may appear to be contradictory as some reaches yield good RGA scores and poor RSAT scores. However, RGA scores rate the stream purely from a geomorphic perspective whereas RSAT scores rate the stream from an ecological perspective. Therefore streams that flow through agricultural areas will often receive scores indicating that they are fairly stable as they are often highly vegetated but will score poorly on the RSAT due to poor water quality and low scores on the biological criteria, which will lower the overall score.

Pefferlaw Brook

Nine reaches were evaluated throughout the Pefferlaw Brook area. RGA score revealed two thirds of the reaches to be ‘transitional’ or under stress, with the dominant channel process being channel widening. This was evidenced by leaning trees, large organic debris, exposed roots, and scour on inside meander bends. RSAT scores indicated that 70% of the reaches walked were moderately stable.

The reaches of this subwatershed flow through both residential and agricultural areas. Buffer zones were lacking in the residential areas and were composed of a mixture of tall and short grasses and herbaceous vegetation in those areas not affected by farmland and residential land uses. Moderate levels of erosion were observed for a third of the reaches. Riffle features were composed of a mixture of cobbles, gravel and pebbles with a sand matrix. The pool features were made up of silt, sand and pebbles, with some larger cobble particles intermixed. There were some areas where basal scour had uncovered clay along the toe of the banks. Entrenchment and gradient were low throughout most of the subwatershed. Low gradients and slow drainage contributed to a wide floodplain area. The low relief created woody debris obstructions that in turn hindered channel flow. As a result, much of this area consisted of low-lying banks and evidence of widening. The results of the analysis are presented in Figure 7-3.

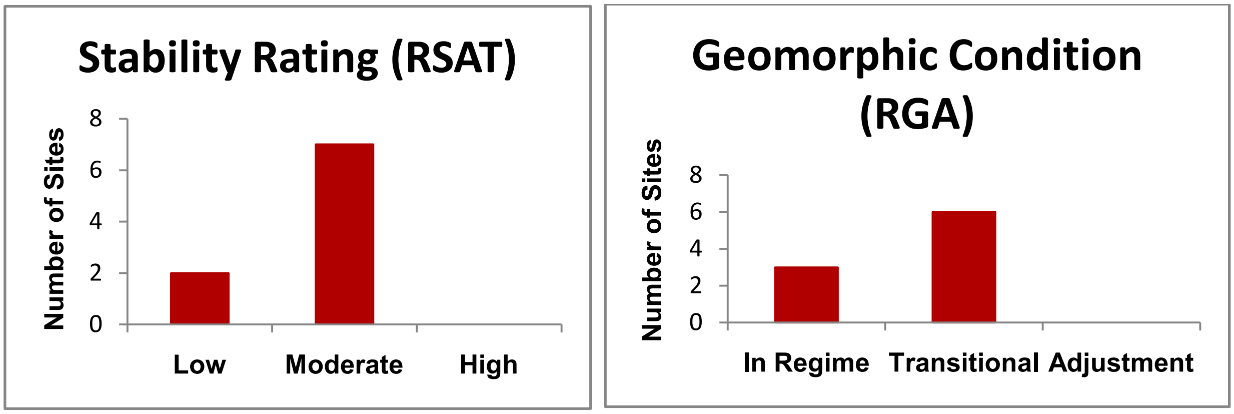


Figure 7-3: Geomorphic condition and stability rating of the Pefferlaw Brook.

Uxbridge Brook

Seven reaches in the Uxbridge Brook area were evaluated. RGA scores revealed the majority (six) of the reaches walked to be ‘in regime’ and low to moderate levels of stability were observed throughout the reaches. Channel widening was the dominant process occurring in this area. RSAT scores indicated that only three out of seven reaches had moderate stability, while the rest were considered to be low. Land use in this area is primarily agricultural with some forested areas, particularly surrounding the main branch of Uxbridge Brook. The downstream reaches flow through more residential areas where there are areas of manicured lawn to the river’s edge.

Riffle-pool sequences were well defined and maintained throughout the subwatershed. Substrate in the pools consisted primarily of sands and silts with some cobble and gravel material. Riffle materials were generally coarser and composed principally of pebbles, gravels and cobbles. Gabion baskets and armour stone was also observed at several locations in some of the reaches. The results of the analysis are presented in Figure 7-4.

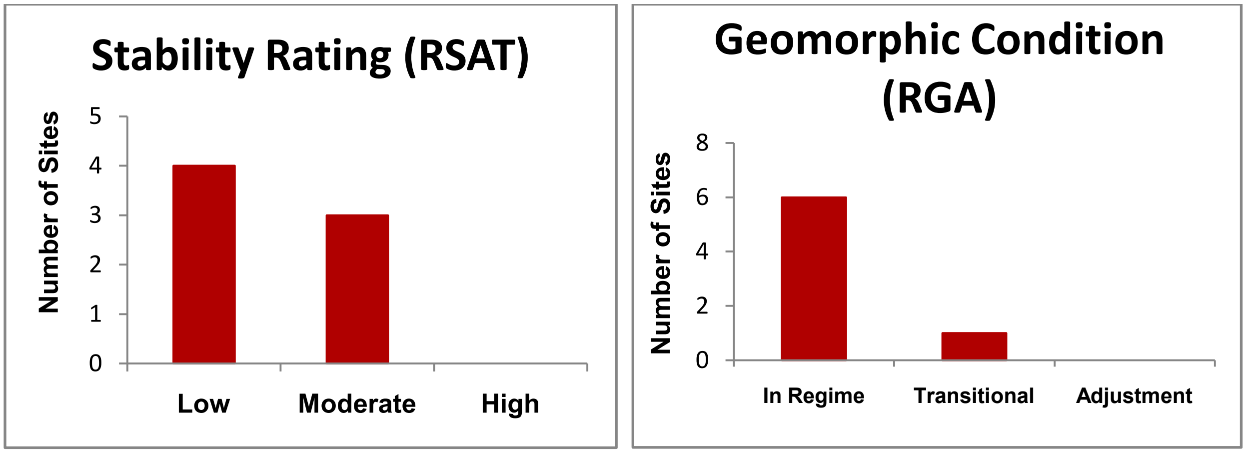


Figure 7-4: Geomorphic condition and stability rating of the Uxbridge Brook.

In general, the Pefferlaw Brook subwatershed (including the Uxbridge Brook tributary) has not been greatly impacted by urbanization and remains in relatively good condition.

Along the Pefferlaw River, there are a few instances where the system is being impacted. In residential areas, bank instability is caused by the abundance of boat slips, manicured lawns and minimal riparian vegetation. A few of the reaches displayed undercut banks and basal scouring on the inside of meander bends, as well as accumulation of organic debris in areas. Detailed descriptions of the conditions found in each of the Pefferlaw Brook reaches can be seen in Table 7-5. Figure 7-5 to Figure 7-7 highlight some of these conditions.

Within the Uxbridge Brook and surrounding areas, land use is mainly agricultural but with sections of forest along reaches (Figure 7-8), as well as some urban area in the Town of Uxbridge. There were several instances of bank stabilization techniques used in the tributary, including riprap, retaining walls, and gabion baskets, some of which had been undermined. Examples of channel disturbances observed in the system include manicured lawns, cattle access and vehicle crossing in some areas, resulting in instability. Several organic debris jams were also noted. Detailed descriptions of the conditions found in each reach can be seen in Table 7-6. Figure 7-9 and Figure 7-10 highlight some of the conditions in the subwatershed.

Table 7-5: Fluvial geomorphology assessment: field observations in the Pefferlaw Brook.

Reach Name	Location	RSAT	RGA	Length (m)	Riffle Substrate	Pool Substrate	Erosion	Notes
PB5	South of Hwy 48	15.0	0.28	1221.67	NA	Silt/sand/cobble		Manicured lawn, boat slips and docks. Residential development near the river.
PB 7-4	West of Lakeridge Road	22.0	0.36	760.02	Cobbles, gravel and pebbles	Sands	Moderate – leaning trees, large organic debris in channel, exposed tree roots, basal scour on inside of meander bends and both sides through the riffle	Surrounding land use was agricultural with cattle grazing in channel, undercut and basal scouring on inside of meander bends, bank heights increased downstream
PB 7-5	East of Lakeridge Road	24.5	0.28	692.44	Cobbles	Cobbles	Moderate – leaning trees and exposed roots, large organic debris in channel	Exposed clay on toe of outside of meander bends, agricultural banks are slumping, high flow channel near Brock Rd
PB 11	South of Old Homestead Road	27.5	0.11	789.41	Boulders, cobbles and gravel	Silt and fine sands	Low – leaning trees and exposed roots	Manicured lawn downstream in reach, residential surrounding land use, major woody debris, lots of boggy emergent areas along bank
PB 16	South of Old Shiloh Road	27.0	0.11	593.55	Gravel, pebbles and cobbles	Silt and sands	Low – leaning trees and exposed tree roots	Also evidence of large organic debris in the channel.
PB 26	South of Zephyr Road	27.0	0.16	603.66	Sand and small gravel	Sand and small gravel	Low – leaning trees and exposed roots, basal scour on the inside of the meander bends	Basal scour on inside of meander bends, manicured lawn to edge of banks, in-stream vegetation and clams observed in the channel.
PB 42	Between Ashworth Road and Concession Road 3	25.0	0.29	410.47	Sand and pebbles	Sand and pebbles	Leaning trees, exposed tree roots and occurrence of large organic debris	In-stream vegetation observed, large woody debris jam in channel
PB 50-6	South of Davis Drive	17.0	0.25	436.1	Sand	Gravel, pebble and sand	Moderate – evidence of fallen trees, exposed roots and occurrence of large organic debris	Coarse materials in riffles embedded and poor longitudinal sorting of bed materials. Length of basal scour greater than 50% through reach.
PB 59	North of Regional Road 8	25.5	0.21	736.33	Gravel and pebbles	Pebbles and very fine sand		Poor under-story vegetation, basal scour observed, major artificial obstruction in channel.

Figure 7-5: Pefferlaw Brook Reach PB5: docks and boat slips.

Figure 7-6: Pefferlaw Brook Reach PB7-4: surrounding land agricultural, minimal vegetation along watercourse.

Figure 7-7: Pefferlaw Brook Reach PB50-6: scouring of banks.

Table 7-6: Fluvial geomorphology assessment: field observations in the Uxbridge Brook.

Reach Name	Location	RSAT	RGA	Length (m)	Riffle Substrate	Pool Substrate	Erosion	Notes
UX4	East of Concession Road 7	19.5	0.18	732	Cobble, pebble, sand and boulders	Cobble	Low – leaning trees and exposed tree roots.	Formation of medial bars. Suspended armour layer visible in bank and channel worn in to undisturbed overburden. Armour stone on right bank upstream of bridge. Manicured lawn, rip rap support and residents taking water from channel.
UX33	North of Sandy Hook Road	19.0	0.08	677	Cobble, gravel and pebble	Sand, silt and gravel	Low – exposed tree roots.	Channel worn into undisturbed overburden. Construction on lot next to left bank of channel, no silt fence to creek. Creek hitting bridge at right bank. Exposed clay on right bank.
UX35-6	North of Brock Street West	16.0	0.10	230	Cobble, boulders, pebble and gravel	Silt, cobble, pebble and sand	Low – leaning trees and exposed tree roots.	Suspended armour layer visible in bank. Channel right in town next to rail bed. Very narrow corridor with steep banks. Gabions on right bank, undercut banks, and small vegetation buffer. Wire fencing laid on right bank.
UX16-18	Between Weirs Road and Ashworth Road	9.0	0.27	549	Cobble and pebble	Silt and sand	Moderate – fallen and leaning trees. Bar forms reworked / removed.	Coarse materials in riffles embedded, poor longitudinal sorting of bed materials and siltation in pools. Evolution of pool-riffle form to low bed relief form. Thalweg alignment out of phase meander form. Cattle access, vehicle crossing and no riparian.
UX13	Between Fowlers Road and Regional Road 13	28.5	0.11	1574.00	Pebble, gravel, sand	Sand and fine sand	Leaning trees and large organic debris.	Beaver activity in channel. Major woody debris and in-stream vegetation.
UX14	Between Fowlers Road and Regional Road 13	28.5	0.07	1859	Pebble, gravel and sand.	Sand	Occurrence of large organic debris.	Formation of islands. Lots of in-stream vegetation. Bank material is silt and sand. Has a very wide flood plain.
UX15	North of Regional Road 13	30.5	0.20	1829	Cobble, pebble and sand	Medium sand and fine sand	Leaning trees and exposed tree roots. Occurrence of large organic debris.	Formation of islands and medial bars. Large floodplain lined with spruce trees. Signs of beaver activity. Lots of in-stream vegetation.

Figure 7-8: Uxbridge Brook Reach UX33.

Figure 7-9: Uxbridge Brook Reach UX13: large organic debris.

Figure 7-10: Uxbridge Brook Reach UX4: manicured lawns on water's edge.

Key Points – Current Fluvial Geomorphology Condition

- In general, the Pefferlaw River subwatershed has not been greatly impacted by land use changes and remains in relatively good condition.
- An assessment of geomorphic condition (RGA) shows that two thirds of the sites surveyed one the main branch were in state of transition, with the dominant channel process being channel widening. In the Uxbridge tributary, six out of the seven sites were found to be 'in-regime' or stable and in reasonably good condition.
- There are, however, several impacted sections within the watershed, and the existing and planned urban areas in the subwatershed will likely continue to stress the system.

7.3 Factors impacting status - Stressors

The changes exerted by humans on natural landscapes can significantly alter the geomorphic processes in watercourses. Land use changes result in a shift in the balance of runoff, evapotranspiration, and infiltration of precipitation. The removal of trees and other natural cover for agriculture will result in a reduction in evapotranspiration; while the paving of natural surfaces for urbanization will reduce the amount of surface water infiltrating into the ground and cause an increase in runoff. As discussed in previous chapters, urbanization in areas such as the Town of Uxbridge, as well as in the agricultural and rural areas of the subwatershed can have impacts on stream flow and the natural flow and migration of river systems. Particularly in urban areas where impervious surfaces are concentrated, typically there is a decrease in time to peak flow following a rain event, a lessening of seasonal variation in flow rates, and a decrease in baseflow rates. Each of these effects can lead to changes in stream geomorphology as they all influence erosion and deposition processes. Fortunately, when looking at the overall Pefferlaw River watershed, at this time there is 11% imperviousness rating which is just over the 10% Environment Canada guideline to healthy watersheds.

Land use changes will also alter the sediment regime in the watercourse, which will contribute to unnatural shifts in the geomorphology of stream and river systems, resulting in changes far beyond those experienced in a system in dynamic equilibrium. The changes also tend to occur much more quickly than they would in a natural system, and can result in impacts to the biotic communities living in and around the watercourse, public safety issues, and damage to property.

The effects of land use changes on instream function and the ability to self regulate can be exacerbated by additional activities directly adjacent to or within watercourses. In urban areas, the common practice of straightening and realigning stream channels in order to accommodate development eliminates natural habitat and enhances channel instability, because the new channel form lacks the natural adjustment mechanisms that would maintain stability. In agricultural areas, channels are often realigned and channelized to maximize the area available for crops, riparian vegetation is often removed, and land is tilled up to the edge of the bank. The results of these practices are unstable banks, the loss of natural channel form and correction ability, and the loss of habitat. The extent to which the Pefferlaw River subwatershed’s streams have been channelized is discussed in more detail in **Chapter 6 - Aquatic Habitat**. Most of the surveyed sites were located in either the area surrounding Uxbridge or the lower reaches of the subwatershed. Approximately 49% of those sites surveyed were failing, meaning that the attempt to stabilize the channel had failed.

While the land use changes that have been and continue to be undertaken in the Lake Simcoe watershed have caused channel instability and erosion; the methods traditionally used to manage these issues have themselves caused problems. The use of engineered solutions to protect banks and stream channels such as hardening the river bed and/or banks with concrete, riprap, gabion baskets, or armourstone; and weirs and other structures to control flows often fail, as the structures are undermined by the watercourse as it moves to adjust to changing conditions. These structures also reduce the quality and quantity of riparian and aquatic habitat. The hardening of the watercourse increases the velocity of flows, and reduces the potential for natural attenuation of flows along the length of the watercourse. This serves to exacerbate the impacts of urban land uses, resulting in failure of the structures and ongoing degradation of the stream, resulting in the continual need for repair of existing structures, and damage elsewhere in the system that also requires repair. Based on a preliminary survey, Figure 6-6 (**Chapter 6 – Aquatic Habitat**) illustrates the extent of channelization and hardening that has occurred on the banks of the watercourses in the Pefferlaw River subwatershed.

It should be noted that traditional stormwater management practices have also interfered with natural processes. The goal has commonly been to remove stormwater as quickly and efficiently as possible and convey it to a watercourse. To accomplish this, many watercourses have had their banks hardened and channelized. This has resulted in increased flow velocities and volumes, and most often causes erosion in downstream areas that do not have the natural ability to accommodate these flows. Of the 63 stormwater catchments in the urban areas of Uxbridge, Pefferlaw and the western portion of Beaverton, there are only 12 of 63 (19%) Level 1 stormwater control ponds. In addition, the Stormwater Maintenance and Anoxic Conditions Investigation Report, LSRCA 2011, discovered that many stormwater ponds in the Lake Simcoe watershed are not being maintained. As an example, some stormwater ponds in and around the community of Uxbridge have filled in with sediment and their level of efficiency/protection has dropped significantly (LSRCA, 2011), to the point of providing limited to no quantity or quality controls. Issues with stormwater are further discussed in **Chapter 3 – Best Management Practices**, **Chapter 4 – Water Quality**, and **Chapter 5 – Water Quantity**.

7.3.1 Recreation

Natural areas such as streams and rivers are a popular location for recreational activities such as hiking, boating, and snowmobiling. If not managed correctly and undertaken in a responsible manner, these activities can impair ecological condition in the watercourse. Impacts from recreational activities can include increased bank instability and erosion, loss of riparian area resulting in an increase in input of total suspended solids (TSS) and pollution and an increase in runoff as the banks are pounded down from man-made trails. Stresses on these sensitive areas are increasing as a result of increasing population and diminishing natural heritage lands that can be used for these activities.

7.3.2 Mitigating Issues Associated with Land Use Changes

It has become increasingly understood that, in many cases, engineered structures may not be the best solution for mitigating streambank erosion. There has been an increasing consideration of the natural geomorphic processes that shape watercourses, as well as consideration for ecological conditions and potential impacts on those areas that lie upstream and downstream in the design and construction of erosion protection works. It is now common practice to re-route watercourses that have been straightened and/or hardened, through a practice called “Natural Channel Design.” Through this practice, channels are designed to mimic natural conditions, taking into account what is understood of the physical conditions in the watercourse. This creates habitat, and will also help to prevent further impacts in the downstream sections of the watercourse. Figure 7-11 displays a site where natural channel design was implemented and Figure 6-6 (**Chapter 6 – Aquatic Habitat**) identifies opportunities for removing channels and hardened stream banks.

Figure 7-11: An example of Natural Channel Design.

Key Points – Factors Impacting Fluvial Geomorphology - stressors

- In the agricultural portion of the subwatershed, channels are often realigned and channelized to maximize the area available for crops, riparian vegetation is often removed, and land is tilled up to the edge of the bank. The results of these practices are unstable banks, the loss of natural channel form and function, and the loss of habitat.
- The 11% impervious surface level is over the Environment Canada guideline, but is comparatively much better than other Lake Simcoe subwatersheds, with most of the imperviousness related to Uxbridge
- Urbanization within the watershed is leading to increased flow velocities and volumes (higher and more frequent peak flows and lower baseflows) which cause erosion in downstream areas that do not have the natural ability to accommodate these flows. The removal of riparian vegetation and the straightening and realigning of streams like Uxbridge Brook creates issues of bank instability and eliminates natural habitat.
- Using innovative stream channel design as an alternative to previously used techniques holds much promise in restoring some of these systems.

7.4 Current Management Framework

7.4.1 Protection and Policy

While the majority of the policies in the relevant acts, regulations and plans relate to water quality and quantity and natural heritage, the implementation of a number of these policies will have the added benefit of protecting riparian areas and other natural features that help to maintain stable watercourses, or by helping to reduce some of the stresses that cause channel movement and bank instability, such as large volumes of storm water. This management framework includes the Fisheries Act, Endangered Species Act, the Greenbelt Plan, Growth Plan for the Greater Golden Horseshoe, the Oak Ridges Moraine Conservation Plan, and the Lake Simcoe Protection Plan. This management framework relates to many different stressors that can potentially affect stream geomorphology, including stream alteration, urban development, and site alteration. In Table 7-7 we categorize eight such stressors, recognizing that many of these stressors overlap and that the list is by no means inclusive. The legal effect of this management framework broadly falls into one of two categories. The first broad category we define as having little or no legal standing and are referred to as General or Have regard to Statements in Table 7-7 and are shown in blue. The second category includes those that have legal standing and must be conformed to; these are referred to as Regulated / Existing Targets in Table 7-7 and are shown in green. In many cases an act, regulation, policy, or plan does not relate to the activity specified, these are shown in red.

Table 7-7: Summary of the current management framework as it relates to the protection and restoration of stream geomorphology.

Stressor affecting stream geomorphology	Oak Ridges Moraine Conservation Plan (2002)	Greenbelt Plan (2005)	Lake Simcoe Protection Plan (2009)	Growth Plan for the Greater Golden Horseshoe (2006)	Provincial Policy Statement (2005)	Fisheries Act (1985)	Ontario Water Resources Act (1990)	LSRCA Watershed Development Policies (2008)	York Region Official Plan (2008)	Durham Regional Official Plan (2008)
Development and site alteration	🟩	🟩	🟩	🟦	🟦	🟩	🟥	🟩	🟩	🟩
Impervious surfaces	🟩	🟩	🟦	🟥	🟥	🟩	🟥	🟦	🟩 4	🟩 6
Removal of riparian vegetation	🟩	🟩	🟩	🟥	🟦	🟩	🟥	🟩	🟩	🟩
Stormwater controls	🟩	🟦	🟩	🟦	🟦	🟥	🟩	🟩	🟩 5	🟦
Channelization/stream alteration	🟩	🟩	🟩	🟥	🟥	🟩	🟥	🟩 1	🟦	🟦
Bank hardening	🟩	🟩	🟩	🟥	🟥	🟩	🟥	🟩 2	🟦	🟦
Restoration	🟦	🟦	🟦	🟥	🟦	🟦	🟥	🟩 3	🟦	🟦 7
Climate change	🟥	🟥	🟦	🟥	🟥	🟥	🟥	🟥	🟥	🟦

🟦 General/Have regard to statement	🟩 Regulated/Existing targets	🟥 No applicable policies

[1] Would be considered in some cases, but generally discouraged
[2] Not a policy directly addressing bank hardening, but follows from policies regarding stream alteration
[3] Required for valleyland applications, may be required in other cases (case-by-case basis)
[4] Within ORM planning area, the Greenbelt Natural Heritage System, and the Major Open Space Area designations
[5] Specific policies within ORM planning area, otherwise this is a 'have regard to'
[6] Within Major Open Space Areas and Greenbelt Natural Heritage System
[7] Required in some instances, otherwise it is encouraged

In this section we provide a summary of the various acts, regulations, policies and plans as they pertain to activities affecting stream geomorphology. This summary is to give context to *future management considerations* and the *opportunities and recommendations to improve stream geomorphology and stability*. This summary is not intended to be comprehensive in terms of all the legislative pieces that relate to stream geomorphology, or of the acts, regulations, policies and plans that are discussed below – the reader is directed to each act, regulation, policy, or plan for a full assessment of how it relates to stream geomorphology.

Oak Ridges Moraine Conservation Plan (2002)

This plan designates Natural Core and Natural Linkage Areas for the purpose of maintaining and improving the ecological integrity of the plan area. Approximately 7,245 ha (or 16%) of the subwatershed is designated ORMCP Natural Core and Linkage areas. The policies that apply in the Natural Core and Linkage Areas include:

- Development and site alteration are prohibited if they would cause the impervious area of the subwatershed, outside of designated settlement areas, to exceed 10%.
- A minimum area of influence and minimum vegetation protection zone around key natural heritage features (such as wetlands or fish habitat) and hydrologically sensitive features (such as a stream), which are 30 metres and 120 metres, respectively. An application for development or site alteration within the minimum area of influence that relates to a key natural heritage feature, but is outside of that feature and the minimum vegetation protection zone, are to be accompanied by a natural heritage and/or hydrological evaluation. These evaluations are required to:
    - Demonstrate that the development or site alteration will have no adverse affects on the feature or the related functions
    - Identify planning, design and construction practices that will maintain and, where possible, improve or restore the health, diversity and size of the feature and its connectivity with other key natural heritage features
    - Determine if the dimensions of the minimum vegetation protection zone as specified in the ORMCP are sufficient, and specify the dimensions necessary to provide for the maintenance and, where possible, improvement or restoration of natural self-sustaining vegetation within it

The ORMCP requires applications for major development to demonstrate how the removal of vegetation will be kept to a minimum, which will help to promote infiltration; and also to minimize the amount of impervious area on the site.

The ORMCP also details a number of requirements for those uses that are permitted within Natural Core and Linkage Areas, such as gravel pits, agricultural uses, and low-intensity recreational uses to ensure that they have minimal impact on these important areas.

Lake Simcoe Protection Plan (2009)

The implementation of a number of the policies in the Lake Simcoe Protection Plan will benefit conditions in the subwatershed with respect to fluvial geomorphology.

The Stormwater Management policies will likely have the greatest benefit. Among these that relate to fluvial geomorphology are:

- Municipalities are to prepare and implement comprehensive stormwater management master plans for each settlement area. These are to include:

  - An evaluation of the cumulative environmental impact of stormwater from existing and planned development
  - A determination of the effectiveness of existing stormwater management works at reducing the negative impacts of stormwater on the environment
  - An examination of stormwater retrofit opportunities
- Municipalities are to incorporate into their official plans policies related to reducing stormwater runoff volume, including:
  - Encouraging the implementation of a hierarchy of source, lot-level conveyance and end-of-pipe controls
  - Encouraging the implementation of innovative stormwater management measures
  - Allowing for flexibility in development standards to incorporate alternative community design and stormwater techniques
  - Support implementation of source control programs, which are targeted to exiting areas that lack adequate stormwater controls
- Stormwater management works that are established to serve new major development shall not be permitted unless the works have been designed to satisfy the *Enhanced Protection Level* specified by MOE
- Owners of stormwater control structures are required to inspect and maintain the works to ensure they are functioning properly

The LSPP also contains policies around water conservation and efficiency. This includes requiring municipalities to identify and evaluate methods for promoting water conservation such as water reuse and recycling, which will reduce the volume and velocity of stormwater runoff.

There are also policies which place limitations and restrictions around placing structures and altering the shore of watercourses within the Lake Simcoe watershed. Where works are allowed, the proposal must enhance ecological features; and minimize erosion, sedimentation, and the introduction of excessive nutrients or other pollutants and utilize planning and design practices that maintain and improve water quality.

The MNR and LSRCA are required to delineate priority areas for riparian area restoration. The implementation of these restoration works will help to provide stability to the watercourses in the Pefferlaw River subwatershed.

Greenbelt Plan (2005)

Among the goals stated for the Environmental Protection area of the Greenbelt is the protection, maintenance and enhancement of natural heritage, hydrologic and landform features and functions. Although this does not state the protection of the stability of watercourses, that will be one of the outcomes of achieving this goal. Applications for development under Greenbelt Plan Policies are required to demonstrate that:

- There will be no negative effects on key natural heritage or hydrologic features
- Connectivity is maintained or enhanced wherever possible
- Removal of other natural features…should be avoided

- The disturbed area of any site does not exceed 25% and the impervious surface does not exceed 10% of the total developable area

Though these policies do not apply in the Greenbelt's identified Settlement Areas, they will help to limit impacts outside of settlement areas.

The Greenbelt Plan also limits development and site alteration within key natural heritage features and key hydrologic features, and identifies a minimum vegetative protection zone around them to afford further protection.

The Plan also encourages municipalities to support planning approaches that establish or increase the extent of vegetation protection zones in natural, self sustaining vegetation; increase or improve fish habitat; and avoid or minimize the impacts associated with urban runoff.

Growth Plan for the Greater Golden Horseshoe (2006)

While the Growth Plan does not deal directly with issues of fluvial geomorphology, there are policies within it that, when implemented, will help to prevent these issues. Most notable among these:

- Municipalities are encouraged to implement and support innovative stormwater management actions as part of their redevelopment and intensification activities.
- The identification of natural systems for the Greater Golden Horseshoe and the potential development of additional policies for their protection. The protection of these natural systems and their associated functions will help to mitigate storm flows and maintain stable watercourses.
- Water conservation measures, including water recycling, are encouraged. The widespread adoption of these practices will reduce the volume of stormwater flowing to watercourses, helping to prevent issues such as instability and erosion.

Provincial Policy Statement (2005)

By encouraging development patterns that protect resources and the quality of the natural environment, such as directing growth within settlement areas and away from significant or sensitive resources, the policies of the PPS can help to protect the stability of the subwatershed's watercourses. Relevant policies include:
Settlement areas are to be the focus of growth.

- Natural heritage features and areas shall be protected for the long term
- The diversity and connectivity of natural features in an area, and the long term ecological function and biodiversity of natural heritage systems should be maintained, restored or, where possible, improved, recognizing the linkages between and among natural heritage features and areas, surface water features and groundwater features.
- Restrictions on development in features such as natural heritage features such as significant woodlands and valleylands, significant wildlife habitat, and fish habitat, or lands adjacent to these features.
- Planning authorities are to protect, improve, or restore the quality and quantity of water by (not all listed):

  - Implementing necessary restrictions on development to protect, improve or restore vulnerable surface and groundwater features, sensitive surface water features and their hydrological functions
  - Maintaining linkages and relative functions among surface water features, groundwater features, hydrologic functions, and natural heritage features and areas
  - Ensuring stormwater management practices minimize stormwater volumes…and maintain or increase the extent of pervious surfaces
- Development shall generally be directed away from hazardous land adjacent to river, stream and small inland lake systems which are impacted by flooding and/or erosion hazards.

Ontario Water Resources Act (1990)

The Ontario Water Resources Act deals with the approval of stormwater management works under Section 53. Under this Act, the MOE reviews applications for stormwater works, and provides a Certificate of Approval if the application and associated studies are deemed to be sufficient.

Fisheries Act (1985)

The *Fisheries Act* is federal legislation that deals with the management of Canada’s fisheries resources and the conservation and protection of fish and fish habitat. Section 35 of the *Act* states that no one may carry on any work or undertaking that results in the harmful alteration, disruption or destruction (known as a HADD) of fish habitat, unless authorized to do so by the Minister of Fisheries and Oceans Canada. It is among the oldest and strongest environmental legislation in the country. The enforcement of this Act limits the work that can be done in and around a watercourse, including channelizing and hardening activities, relocation of stream channels, and the creation of barriers, thus ensuring that habitat quality is protected and that aquatic systems do not become fragmented.

Through an agreement with the Department of Fisheries and Oceans (DFO), the LSRCA administers the *Fisheries Act* through its permitting process. LSRCA staff, acting on behalf of DFO, review applications for proposed works occurring in and around water and provide guidance and ensure that the works adhere to the requirements of the *Act*. Where in-water works are permitted, LSRCA staff work closely with the proponent to ensure that there is no loss of fish habitat due to the works, and that the works have minimal impact during the time that the site is disturbed

LSRCA Watershed Development Policies (2008)

The Authority requires an undisturbed vegetative buffer strip running consistently along both sides of all watercourses. The buffer is to be measured perpendicularly outwards from the edge of the annual average high water mark as follows: a) a minimum 15 metre buffer for all watercourses, b) a minimum 30 metre buffer for all coldwater or marginally coldwater (coolwater) watercourses. Where watercourses have not been studied as to thermal regimes or fish population, the 30 metre buffer will be required. Note that this policy has largely been superseded by LSPP which requires a minimum 30m vegetative protective zone for all key natural heritage and hydrological features.

These required buffers will help to maintain the integrity of streambanks, thus protecting their form and function.

Durham Regional Official Plan (2008)

With respect to policies that will contribute to the stability of watercourses, the Durham Regional Official Plan:

- Stipulates a minimum 30 metre vegetation protection zone around key natural heritage and hydrologic features such as streams, wetlands and significant woodlands – development and site alteration are not permitted in these areas, with the exception of activities such as fish and wildlife management, flood management activities, infrastructure and some agricultural uses. The OP also requires an environmental impact study for proposed development and site alteration within 120 metres of any other key natural heritage or hydrologic feature to determine the appropriate minimum vegetation protection zone in addition to the prescribed 30 metres.
- Requiring that lakes and streams and their adjoining lands be retained in or rehabilitated to a natural state, that fish and wildlife habitat be protected, and that alterations to natural drainage systems and sediments entering a watercourse are minimized
- Provides protection to woodlands and wetlands to provide environmental, recreational, and economic benefits to the Region
- Discourages alterations to watercourses
- Ensures that stormwater management plans are prepared by area municipalities where appropriate
- Promotes groundwater infiltration through improved stormwater management design

7.5 Gaps and Recommendations

Several stream reaches (2/3rd of the sample sites) of the Pefferlaw Brook are considered to be 'stressed', that is to say there is evidence of the stream being out of equilibrium and in transition. Some of the reaches assessed had poor bank definition and exposed clay in the channel bed. There were several examples of bank stabilization techniques such as armour stone walls in response to erosion from uncontrolled urban stormwater. In other residential areas, lawns were manicured to the water's edge, resulting in further bank instability. Several debris jams were also noted. Other channel disturbances observed in the system included row crops planted on the top of the stream bank, as well as direct livestock access in a number of instances, contributing to erosion, sediment release and a lack of definition of channel banks.

In contrast, the Uxbridge portion of the subwatershed is considered to be stable or 'in regime' at six of the seven sample sites, which implies that this part of the subwatershed is in reasonably good condition. Within the Uxbridge Brook and surrounding areas, land use is mainly agricultural but with sections of forest along reaches. The relatively small urban area in the Town of Uxbridge is contributing to changes in the channel form and sediment regime through impacts from stormwater. There were several instances of bank stabilization techniques used in the tributary, including riprap, retaining walls, and gabion baskets, some of which had been undermined. Examples of channel disturbances observed in the system include manicured lawns, cattle access and vehicle crossing in some areas, resulting in instability. Several organic debris jams were also noted.

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.

> **Recommendation #59 -** That the LSRCA and with input from municipal partners, in locations where channel stability is already considered to be 'low', assess those specific sites, develop priorities, assess the possibility of using 'new'/innovative solutions and then repair.
>
> **Recommendation #60 -** That the LSRCA continue to work with owners of recently documented channelized reaches of stream (see BMP inventory) to develop priority list and implement solutions, such as Natural Channel Design.
>
> **Recommendation #61 -** That the LSRCA with input from its municipal partners develop a complimentary fluvial geomorphic monitoring program to be used as a long term assessment tool in order to evaluate change (beyond the natural flow regime) in the channel geometry and/or sediment character of the Pefferlaw River and to identify potential causes of that change.

It should be noted that Chapters 3 to 6 include several related recommendations that consider changes in stream flow and sediment delivery which are ultimately reflected in the physical characteristics (fluvial geomorphology) of the stream, in this case the Pefferlaw River subwatershed. It is important that the information collected in the 'collective' or comprehensive monitoring program described in those chapters be both complimentary and integrated as measures of change over time.

8 Terrestrial Natural Heritage

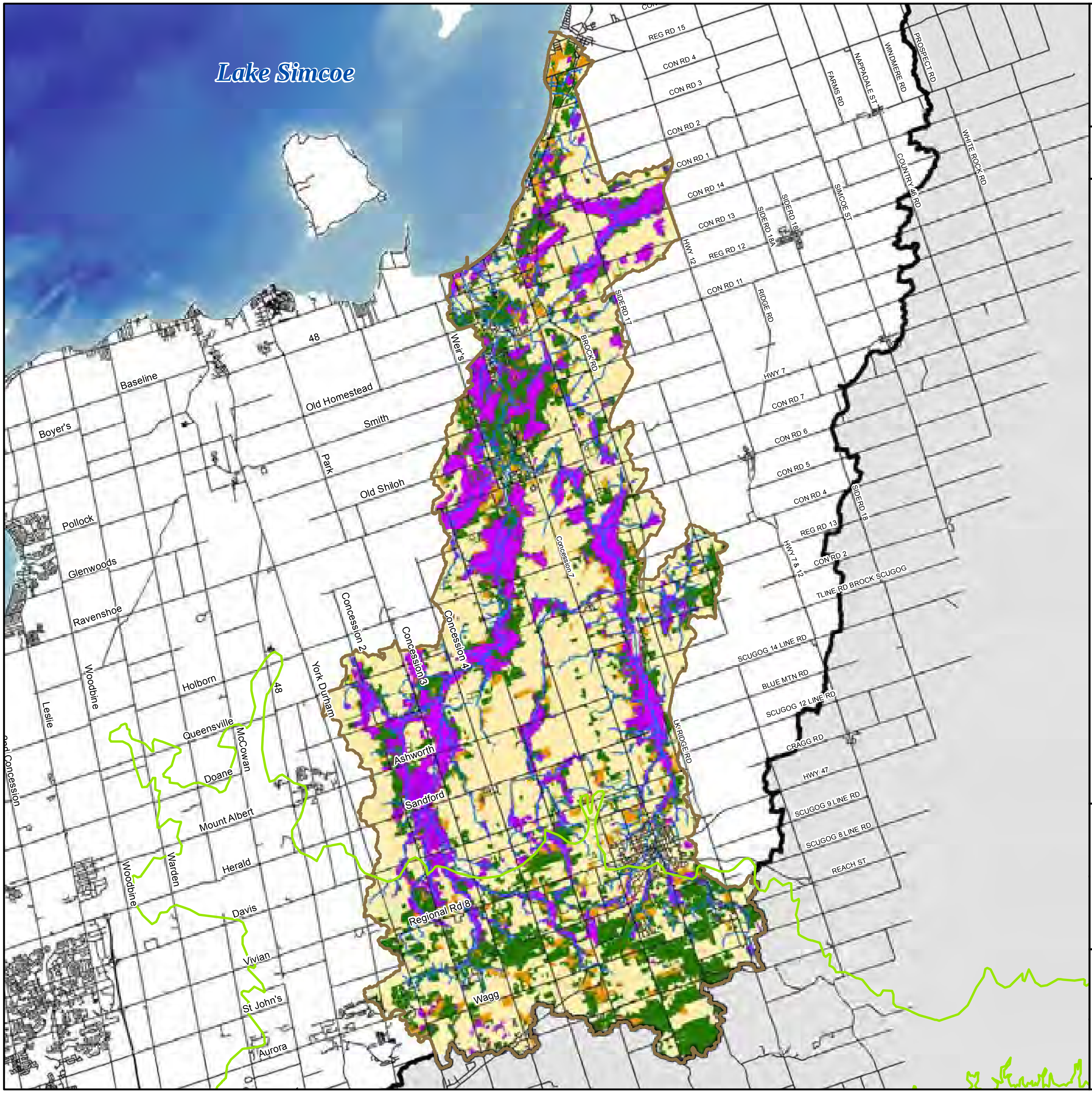
8.1 Introduction

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 Pefferlaw River subwatershed's terrestrial system interacts with other hydrological and human systems, and serves as habitat for flora and fauna throughout the subwatershed. The system includes not only large tracts of natural features, but also the small features that can be found within urban and agricultural areas. Measuring the quantity, quality and distribution of natural heritage features within the subwatershed can tell us a great deal about its health. Figure 8-1 details the distribution of natural features in the subwatershed. This chapter describes the natural heritage features of the Pefferlaw River subwatershed, detailing the current conditions; and also describes the Natural Heritage System (NHS) that has been developed by the LSRCA and Beacon Environmental to protect the integrity of the natural heritage features throughout the Lake Simcoe watershed. The NHS is discussed in detail in Section 8.4.7.

The terrestrial natural heritage features in a subwatershed include woodlands, wetlands, and grasslands. Woodlands are treed areas that may contain coniferous trees, deciduous trees, or a mixture of both. Woodlands may also include swamps, which are wooded areas that are seasonally inundated with water. The condition of the subwatershed's woodlands is described in Section 8.2.1. The four different types of wetlands are swamp, marsh, fen and bog. These are described in further detail in Section 8.2.2. Grasslands, which include tallgrass prairies, cultural meadows, cultural thickets, and savannahs, are dominated by grasses rather than by trees. Savannahs and prairies are among the rarest ecosystems in southern Ontario. The LSRCA's Ecological Land Classification (ELC) information was used to quantify the natural heritage information for this subwatershed plan. This information classifies features to the Community Series level of the ELC System. To accomplish this, the natural heritage features were delineated into polygons based on similar broad level vegetation communities using aerial photography interpretation. A number of these polygons were then field checked to verify the accuracy of the air photo interpretation.

The level of natural cover in the Pefferlaw River subwatershed is 42.8%. At this level, the natural features could be expected to undertake the natural functions that would help to maintain subwatershed health. The distribution of natural cover throughout the subwatershed can be seen in Figure 8-1.



Terrestrial natural heritage features in the Pefferlaw River subwatershed

Figure 8-1

Legend

- Grassland
- Wetland
- Woodland
- Road
- Watercourse
- LSRCA Watershed Boundary
- Oak Ridges Moraine

0 1 2 4 6 8 10 Kilometres

N

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

8.1.1 Woodlands

Woodlands include all treed communities, whether upland or wetland. The 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 8-1). Some woodlands in this section are also counted as wetlands later in the chapter (e.g. wooded swamp), as the two terms are not mutually exclusive.

Prior to European settlement, the dominant land cover type in southern Ontario was woodland. Estimates of total cover in this area were in the 80% range. Much of this woodland has now been removed and replaced with land uses such as agriculture and urban. The current distribution of woodlands in the Pefferlaw River subwatershed is depicted in Figure 8-1.

The *Natural Heritage Reference Manual* (OMNR, 2010) lists a variety of important functions associated with woodlands and Larson *et al*. (1999) summarize the importance of woodlots. These important functions can generally be described as follows:

- **Economic Services and Values:** oxygen production, carbon sequestration, climate moderation, water quality and quantity improvements, woodland products, economic activity associated with cultural values
- **Cultural/Social Values:** education, recreation, tourism, research, spiritual and aesthetic worth
- **Ecological Values:** diversity of species, structural heterogeneity, energy (photosynthesis), nutrient and energy cycling.

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. These can range from talus slopes to heavy clay soils; from saturated organics to very dry sandy soils. 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.

In an overview of the science regarding the function of woodlands the LSRCA NHS document discusses in detail factors relating to fragmentation (the splitting of larger woodlands into even 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 (Brooker and Brooker, 2002). Research that has examined the independent effects of habitat loss *versus* 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).

Interior forest

Forest interior habitat is the part of a wooded area that is deeper than 100 metres from the perimeter of the woodland. Areas within the first 100 metres from the perimeter of a forest are considered to be ‘edge’ habitat and less suitable for species that require deeper forests. Many of these species are declining as their interior habitat disappears. Certain bird species such as the northern parula, black and white warbler, and blackburnian warbler for example, avoid small fragmented forests when breeding. In smaller forests they are subject to predators, parasites, harsh winds, lack of food, and a higher susceptibility to fire and human interference.

Through its Area of Concern guidelines, Environment Canada recommends that interior forest cover at least 10% of the area of a subwatershed, which would ensure that sufficient habitat is available for more sensitive species that require this habitat. The Pefferlaw River subwatershed currently has close to 12% interior forest.

8.1.2 Wetlands

Environment Canada defines wetlands as lands that are seasonally or permanently covered by shallow water, including lands where the water table is at or close to the surface. These areas include swamps, marshes, bogs, and fens (of these types, the Pefferlaw River subwatershed contains fens, marshes, and swamps). The characteristics and area of each wetland type are described in Section 8.2.2. Environment Canada estimates that 70% of the original wetlands of southern Ontario have been lost, making it imperative to protect what remains of these important ecosystems wherever possible.

Wetlands provide numerous functions for an ecosystem. These include (Environment Canada, 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, and fishing

In its ‘How Much Habitat Is Enough?’ guidelines (2004), Environment Canada recommends that at least 10% of a watershed be in wetland cover, (Pefferlaw subwatershed has 16.9%) and that these wetlands should be well distributed across the area. When these levels are seen in a subwatershed, flooding is greatly reduced and baseflow is maintained. The additional benefits of wetland cover, listed above, are also maintained.

8.1.3 Grasslands

Although the term grassland is most associated with Canada's Prairie Provinces, grasslands are also found in southern Ontario. Historically, grasslands were found from Ontario's southernmost tip to as far north as Georgian Bay (Hamilton Naturalists Club, 2007). These types of grasslands are defined as grass-dominated areas that have few to no trees, including prairies and savannahs. However, for its purposes, the Lake Simcoe Region Conservation Authority (LSRCA) uses a more broad definition for grassland and, following the Ecological Land Classification (ELC) method, includes true grasslands (TPO/TPS/TPW) as well as cultural meadows (CUM) and cultural thickets (CUT); this does not include pasture lands, which, to the extent possible, are mapped separately within the Lake Simcoe watershed as an agricultural use (i.e., they are actively grazed by livestock) (Beacon and LSRCA, 2007). Cultural meadows and cultural thickets within the Lake Simcoe watershed tend to be ecosystems that are in transition from an open, disturbed system to a more forested state and are generally dominated by non-native cool season grasses, native and non-native forbs, and a variety of native and non-native shrubs; shrub cover may vary from 0 to 100%. Despite the fact that grasslands are often dominated by non-native flora, many native flora and fauna species use them. Some of the rarest breeding birds in the province occupy some or all of these grassland community types, including the Henslow's Sparrow (*Ammodramus henslowii*), the Golden-winged Warbler (*Vermivora chrysoptera*), the Short-eared Owl (*Asio flammeus*) and the Loggerhead Shrike (*Lanius ludovicianus*) (Environment Canada, 2005; Birds Ontario, 2007). Indeed, many of these species (e.g., Bobolink [*Dolichonyx oryzivorus*], Upland Sandpiper [*Bartramia longicauda*], Vesper Sparrow [*Pooecetes gramineus*] and Eastern Meadowlark [*Sturnella magna*]) are not found in any other habitat types and are therefore considered habitat specialists. Presumably, in pre-settlement times these species were confined to habitats such as burns, previously flooded areas, prairie habitats, and then, today, in human-altered environments (Beacon and LSRCA, 2007). Some authorities consider that the decline of grassland birds in North America has been more pronounced than the decline of any other group of birds (NHS, 2007). Species like the Greater Prairie Chicken (*Tympanuchus cupido*) and the Karner blue butterfly (*Lycaeides melissa samuelis*) have already become extirpated from Canada (Tall Grass Ontario, 2007).

8.1.4 Riparian habitat

Riparian habitat refers to all habitat within a stream corridor or valley, particularly the shrubs and trees, on a stream bank. 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 helps to maintain river and stream health 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

Environment Canada's guidelines recommend that 75% of stream length should be naturally vegetated, and that a 30 metre buffer containing natural vegetation on either side of a watercourse is the ideal width for maintaining the health of the watercourse. LSRCA's Watershed Report Cards reflect this target, with those subwatersheds with greater than 75% of the area within a 30 metre buffer of a watercourse in natural vegetation receiving a grade of 'A. With 73.5% of its riparian area having a 30 m buffer of natural vegetation, the Pefferlaw River subwatershed received a 'B' in the 2009 report card.

8.1.5 Unique features in the Pefferlaw River subwatershed

Within the Pefferlaw River subwatershed, there are a number of unique natural heritage features. These include Areas of Natural and Scientific Interest (ANSIs), Environmentally Sensitive Areas, significant wildlife habitat, and unique ecosystems that are perhaps not found in many places in the Lake Simcoe watershed. Some of these features are afforded protection under the current planning framework, whereas others are simply identified because of their unique characteristics.

The ANSI program was developed by the Ontario Ministry of Natural Resources to encourage the protection of unique natural heritage features and landscape in southern Ontario.

There are two types of ANSIs, life science and earth science. Life Science ANSIs are based on biological and ecological characteristics, while 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
5) Special features

ANSIs can be designated with one of two levels of significance, regional or provincial. These levels are based on ecoregions and ecodistricts. Provincial significance relates to the whole province, while regional significance is assigned at the ecoregional level.

8.2 Current Status

At 42.8%, the Pefferlaw River subwatershed has a relatively healthy level of natural cover, and has one of the highest coverage's in the watershed. The natural heritage cover is also greater than the Lake Simcoe Protection Plan (LSPP) goal for 40% high quality natural vegetation. A fairly large proportion of the subwatershed's natural cover has been converted to agriculture, which occupies approximately 48.3% of the subwatershed area. The subwatershed's urban area is fairly small, occupying 5.5% of the subwatershed area. The remaining breakdown of the subwatershed's land use can be seen in Figure 2-3, **Chapter 2 – Study Area and Physical Setting**.

8.2.1 Woodlands

The ELC communities that were considered to represent woodland are forest, swamp, plantation, and cultural woodland (the breakdown of these types is displayed in Table 8-1). Some woodlands are counted in both the woodland and wetland sections (e.g. wooded swamps) as the two terms are not mutually exclusive.

Woodlands occupy 14,611.5 ha, or 32.7% of the subwatershed. Note that wooded wetlands, or swamps, are included in both the woodland and wetland calculations, as they are not mutually exclusive -- swamp woodland account of over 38% of the woodlands present. Of the woodland in the subwatershed, approximately 2,251.7 ha, or 15.4% are considered to be of lower ecological quality (i.e. plantations, which can be considered standing crops) or are cultural woodlands, which have broken canopies. While these areas may not be as beneficial ecologically as other woodland types, they still have high intrinsic value as they are part of a functioning landscape. They also present opportunities for future restoration projects.

At 32.7%, the woodland cover is just above the suggested minimum threshold for woodland cover. Overall, the literature indicates that the minimum threshold for maintaining woodland dependent biodiversity is 30% (e.g. Environment Canada's AOC guidelines). The current forest cover target in Durham Region is 30%, while that identified in York Region's OP is 25%, though the 2005 Significant Woodlands Study recommends reviewing this target and refers to the Environment Canada guideline. It will be important to maintain this woodland cover into the future in order to maintain the health of the Pefferlaw River subwatershed. In addition, the quality of this woodland habitat could be enhanced over time by promoting natural succession in plantations and cultural woodlands – by replacing plantation species as they are harvested or die off, the biodiversity and habitat value of these areas will be improved.

Table 8-1: Woodland cover types in the Pefferlaw River subwatershed (PRS).

Woodland Type	Woodland Cover			
	Area in sub-watershed (ha)	Cover within subwatershed (%)	Cover by woodland type (%)	Percentage of Lake Simcoe total for each woodland type found in PRS
Cultural Plantation (CUP)	1,490.6	3.3	10.2	28.4
Cultural Woodland (CUW)	761.1	1.7	5.2	19.2
Conifer Forest (FOC)	1,653.5	3.7	11.3	38.0
Deciduous Forest (FOD)	2,484.6	5.6	17.0	14.8
Mixed Forest (FOM)	2,564.4	5.7	17.6	19.5
Conifer Swamp (SWC)	1,373.2	3.1	9.4	37.5
Deciduous Swamp (SWD)	1,168.3	2.6	8.0	9.2
Mixed Swamp (SWM)	3,115.8	7.0	21.3	29.7
Total	**14,611.5**	**32.7**		**33.6**

The most prevalent woodland types within the Pefferlaw River subwatershed are mixed swamp, with 21.3% of the woodland area, and mixed and deciduous forest, which occupy 17.6% and 17.0% of the woodland cover, respectively. Many of the subwatershed's watercourses flow through mixed swamp, with particularly large areas found along the main branch of the river. Much of the mixed swamp in the subwatershed can be found along its watercourses, as well as other types of swamp. Mixed and deciduous forest patches are found throughout the subwatershed, but the largest patches/concentration of patches can be found in the downstream section of the subwatershed, as well as on the ORM. The subwatershed contains 28% of the Lake Simcoe watershed's plantation area, likely due to the high concentration of plantation area associated with the ORM.

Forest Interior

The Pefferlaw River subwatershed contains close to 12% interior forest habitat. At this level, the subwatershed exceeds Environment Canada's recommended target of 10%. It will be important to protect as much of this important habitat as possible, in order to ensure that the sensitive species mentioned earlier in the chapter are supported in this subwatershed, and that the level does not slip below the recommended minimum for this type of habitat.

Durham Regional Forest

The Durham Regional Forest is located in the headwaters of the Pefferlaw Brook subwatershed, on the crest of the Oak Ridges Moraine, just south of the Town of Uxbridge. This 596 ha (1473 ac) forest is owned by the Region of Durham, and managed by the Lake Simcoe Region Conservation Authority, with input from a Stakeholder Advisory Committee. The Forest is also part of a larger complex of public protected areas on the moraine, including the East Duffins Headwaters owned by Toronto and Region Conservation Authority, and the Town of Uxbridge's Countryside Preserve.

Early settlers, unaware of the soil conditions on the moraine, cleared the original forest. By the early 1900s the combination of exposed sand and droughty conditions led to severe erosion here and elsewhere on the moraine. In 1911, Ontario County (now Durham Region) began purchasing these lands, and began reforesting them with help from the Department of Lands and Forests beginning in 1926. Since that time, forest management efforts have continued to support forest restoration in these tracts. Selective thinning to remove mature conifers from the forest has promoted the establishment of a greater diversity of native deciduous trees. Currently the forest consists of a mix of remnant plantations, hardwood and mixed wood stands.

The forest provides important ecological services including a contribution to watercourse base flows and groundwater recharge by protecting vital recharge areas, providing flood protection for the watersheds that flow from the properties, and offering a wide variety of educational opportunities. In addition, the forest provides habitat for a wide range of wildlife species, many of whom require large forests such as this for breeding habitat. In fact, inventory work done by LSRCA staff indicates that the Durham Regional Forest is one of the most significant areas of wildlife habitat managed by the Authority.

Over the years, 60 km of non-motorized recreational trail have been created at Durham Regional Forest, drawing an estimated 40,000 visitors annually from throughout the Greater Toronto Area.

8.2.2 Wetlands

There are approximately 7,539.5 ha of wetland in the Pefferlaw River subwatershed, which is approximately 16.9% of the landscape (Figure 8-1). Of these wetlands, approximately 47% have not been evaluated using the Ontario Wetland Evaluation System (Table 8-2) and therefore have not yet been determined to be Provincially Significant or not. The majority of the Pefferlaw River's evaluated wetlands are of provincial significance, which account for 15.7% of the Lake Simcoe watershed's Provincially Significant Wetlands (PSW – see text box). While wetlands can be found throughout the subwatershed, a higher proportion is observed throughout the southern and central reaches of the subwatershed than in the north eastern portion. Many of the subwatershed's headwater streams are surrounded by wetlands, and much of the main branch on the south-central portion is surrounded by wetland. The following wetlands have been evaluated and were found to be provincially significant: Uxbridge Brook Headwater Wetland Complex, Sanford Wetland Complex, Upper Uxbridge Brook Wetland Complex, Lower Uxbridge Brook Wetland Complex, North Goodwood Wetland Complex, East Musselman Wetland Complex, Pefferlaw-Udora Wetland Complex, Lower Pefferlaw Brook Wetland Complex, Gibson Hill Swamp, and parts of the Zephyr-Egypt Wetland Complex and Morning Glory Swamp. Wetlands found to be locally or regionally significant are: Victoria Corners Wetland Complex; Leaskdale Swamp Wetland Complex; Upper Pefferlaw Brook Wetland Complex #2, #4, #5 and #6; Vallentyne Wetland Complex; Brock-1 Wetland Complex; Brock-3 Wetland Complex; Riverview Beach Wetland Complex; Port Bolster Swamp; and a very small portion of the McLennan Beach Wetland.

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. Based on scoring a wetland can fall into one of two classes, Provincially Significant or Locally Significant. It takes 600 total points or full points (200) in any one component for a wetland to be classed as 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."*

At 16.9%, wetland cover in this subwatershed is higher than the 10% target outlined by Environment Canada. In addition to the habitat offered by the wetlands, this high wetland cover has other benefits such as flood retention and enhancement of water quality.

Table 8-2: Wetlands in the Pefferlaw River subwatershed (PRS).

Status	Area (ha)	Percentage of PRS wetlands	Percentage of subwatershed
Provincially Significant Wetlands (PSWs)	3,972.6	52.7	8.9
Evaluated Non-Provincially Significant Wetlands*	16.8	0.2	0.04
Additional wetlands identified using Ecological Land Classification (ELC)	3,550.1	47.1	8.0
Total	**7,539.5**		**16.9**

** There may be a slight margin of error (<1%) in the evaluated wetland area due to slight differences in the mapping data obtained from different sources*

The Pefferlaw River subwatershed contains three of the four wetland types found in the Lake Simcoe watershed – fen, marsh, and swamp. The most significant contributor to wetland cover is swamp, which accounts for over 89% of the subwatershed's wetland cover. Marshes account for approximately 9% of wetland cover, while fens have much lower cover, with 0.3% of wetland cover. This distribution, and descriptions of the different wetland types, can be seen in Table 8-3 below.

Table 8-3: Wetland distribution in the Pefferlaw River subwatershed.

Wetland Type	Area (ha)	Percentage of Wetlands	Characteristics (source: Environment Canada)
Fen	23.0	0.3	A high water table with slow internal drainage. Fens are not as low in nutrients as bogs and as a result are more productive. Although fens are dominated by sedges they may also contain shrubs and trees.
Marsh	647.8	8.6	Periodically or permanently covered by standing or slowly moving water. Marshes are rich in nutrients and are characterized by an emergent vegetation of reeds, rushes, cattails and sedges.
Swamp	6,742.1	89.4	Swamps are dominated by shrubs or trees. They may be flooded seasonally or for long periods of time. Swamps are both nutrient rich and productive.
Other	126.6	1.7	These are wetlands that have been identified through interpretation of aerial photography, but have not been interpreted to the community level.

The Pefferlaw River subwatershed has a relatively high proportion of the Lake Simcoe watershed's swamp (19.1%), but has lower amounts of marsh (9.9%) and fen (0.3%). Overall, the subwatershed contains just over 17% of the Lake Simcoe watershed's wetland area.

Although the Pefferlaw River subwatershed presently has 16.9% wetland cover it is important that the present area of wetland is maintained. As previously mentioned in Section 8.1.2, it is recommended that a subwatershed (in this case, the Pefferlaw River subwatershed) should have at least 10% wetland cover. This percentage indicates that the subwatershed is in relatively fair shape from a hydrological and biological perspective, although there are other factors, such as distribution of wetlands within the subwatershed, which are also important (Environment Canada, 2004).

8.2.3 Grassland cover

There are only five identified native grasslands (i.e. tallgrass prairies or alvars) in the Lake Simcoe watershed. These features are each less than 25 ha in size, and together are less than 30ha in total size. No native grassland has been identified in the Pefferlaw River subwatershed.

The Ontario Ministry of Natural Resources (MNR) has indicated that grassland areas 10ha or larger provide habitat for many of the declining breeding grassland bird species (NHS, 2007). For example, the Vesper Sparrow (*Pooecetes gramineus*) is positively correlated with increasing area, and the Brown Thrasher (*Toxostoma rufum*) is a rarity in habitat patches less than 4 ha (Cavitt and Haas, 2000; NHS, 2007). Within the Pefferlaw River subwatershed there is approximately 2,448.3ha of mapped grassland, consisting of cultural savannah (CUS), cultural meadow (CUM), and cultural thicket (CUT) (see Table 8-4). These grasslands are found within a landscape predominantly consisting of an agricultural / treed matrix and are fragmented into approximately 548 separate patches, with the largest being 56ha in size.

Table 8-4: Grassland area within the Pefferlaw River subwatershed.

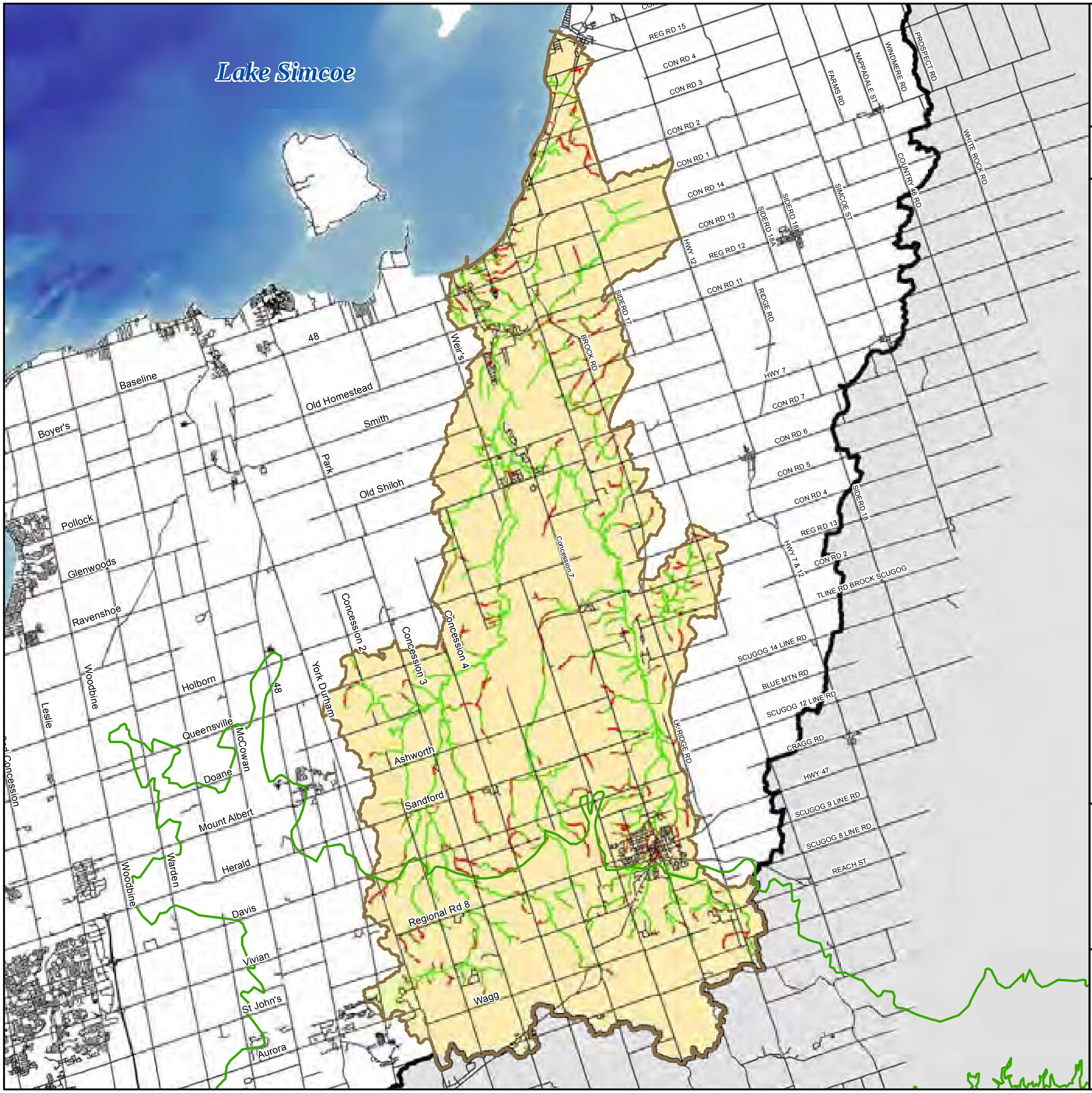
Habitat Type	Area
Cultural Meadow	656ha
Cultural Thicket	693ha
Cultural Savannah	22ha

8.2.4 Riparian cover

There is a relatively healthy level of natural cover within a 30 metre buffer on either side of the Pefferlaw River subwatershed’s watercourses (Figure 8-2). Approximately 73.5% of the buffer area in the subwatershed consists of natural cover. While this does fall short of the target of 75%, there is a relatively high amount of natural cover to perform the functions associated with a natural buffer. With the exception of the urban areas of the subwatershed that may be paved within this area, it would not be difficult to undertake stewardship projects on properties abutting the Pefferlaw’s watercourses to increase the level of riparian cover and move it toward the target (See Figure 6-9 (**Chapter 6 – Aquatic Habitat**) for the location of riparian restoration opportunities).

Riparian Habitat in the Pefferlaw River subwatershed

Figure 8-2



Legend

Road

Riparian

Natural Vegetation

No Vegetation

LSRCA Watershed Boundary

Oak Ridges Moraine

Lake Simcoe Region conservation authority

0 1 2 4 6 8 10 Kilometres

N

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

8.2.5 Unique habitats in the Pefferlaw River subwatershed

ANSIs

The Pefferlaw River subwatershed presently has two confirmed provincially significant ANSIs, the Duclos Point Park Reserve and Adjacent Lands, which is a Life Science ANSI, and the Musselman Lake Kettle Complex, which is an Earth Science ANSI. There are also three confirmed regionally significant Life Science ANSIs, the Pefferlaw Brook Swamp, the Zephyr Creek Swamp, and a portion of the Wilfred Bog ANSI. In addition, there are eight candidate ANSIs in the subwatershed.

Table 8-5: ANSIs found in the Pefferlaw River subwatershed (PRS).

ANSI Name	Significance Level	Status	Life Science/ Earth Science	Total Area (ha)	Area in PRS (ha)	% of PRS
Duclos Point Park Reserve and Adjacent Lands	Provincial	Confirmed	Life Science	402.5	19.0	0.04
Musselman Lake Kettle Complex	Provincial	Confirmed	Earth Science	378.6	178.1	0.40
Pefferlaw Brook Swamp	Regional	Confirmed	Life Science	1,177.0	1,177.0	2.63
Zephyr Creek Swamp	Regional	Confirmed	Life Science	3,317.1	588.0	1.32
Wilfred Bog	Regional	Confirmed	Life Science	49.2	23.4	0.05
Gibson’s Hill Fen and Swamp	Provincial	Candidate	Life Science	107.3	107.3	0.24
Duclos Point Park Reserve and Adjacent Lands	Provincial	Candidate	Life Science	7.0	7.0	0.02
Goodwood Bogs	Provincial	Candidate	Life Science	10.9	10.9	0.02
Musselman Lake Kettles	Provincial	Candidate	Earth Science	249.5	71.0	0.16
Uxbridge-Glen Major Forests	Provincial	Candidate	Life Science	1,330.6	243.2	0.54

ANSI Name	Significance Level	Status	Life Science/ Earth Science	Total Area (ha)	Area in PRS (ha)	% of PRS
Utica Bogs	Provincial	Candidate	Life Science	31.0	21.1	0.05
Pefferlaw-Uxbridge Headwaters	Regional	Candidate	Life Science	976.0	976.0	2.18
Uxbridge Lobe Glacial River Deposits	Provincial	Candidate	Earth Science	125.4	43.0	0.10
Total				8,162.1	3,465.0	7.75

8.2.6 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 consider as being of ‘conservation concern.’ Other species may be further protected by designation as being Endangered (END), Threatened (THR), or of Special Concern under the Federal *Species at Risk* Act or Provincial *Endangered Species Act*.

Species of conservation concern in the Pefferlaw River subwatershed include:

- Loggerhead shrike (*Lanius ludovicianus*; S2, END): A robin-sized song bird with a robust hooked bill and black face mask. Threats include intensive farming practices, roads, reforestation, and development.
- Horned clubtail (*Arigomphus cornutus*; S3): A clubtail dragonfly that generally prefers slow streams and rivers with vegetated banks, as well as meadows and woodlands to forage for food.
- Schweinitz’s sedge (*Carex schweinitzii*; S3): Found in wetlands, moist woodlands, and moist riparian habitat. Threats include loss of suitable habitat.
- 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.

Key Points - Current Terrestrial Natural Heritage Status:

- The subwatershed has approximately 43% natural cover
- Woodland cover in the subwatershed is 32.7%, with over 38% of this being swamp woodlands.
- Wetlands occupy approximately 16.9% of the subwatershed. Just over half of these (~53%) are provincially significant, while 47% have not been evaluated using OWES. The Pefferlaw River's wetlands are mainly located in the central section, just downstream of the ORM, and the northern portion, just upstream of the river mouth.
- Forest interior habitat is currently close to 12% in the subwatershed.
- Approximately 73.5% of the area within a 30 m buffer of the subwatershed's watercourses is in natural cover. While this is a very healthy level, it falls just short of the Environment Canada target of 75%.
- There are no native prairie grasslands identified within the Pefferlaw River subwatershed and only 2,448.3ha of mapped grassland, consisting of cultural savannah, cultural meadow, and thicket.
- Thirteen ANSIs fall within the subwatershed – five of these are approved (Duclos Point Park Reserve and Adjacent Lands, Musselman Lake Kettle Complex, Pefferlaw Brook Swamp, Zephyr Creek Swamp, and Wifred Bog). Of these, only the small portion of the Duclos Point Park Reserve and Adjacent Lands (19 ha) and Musselman Lake Kettle Complex within the subwatershed are provincially significant.

8.3 Factors impacting natural heritage status – Stressors

There are numerous factors that can affect natural heritage features. They range from natural factors such as floods, fires, and droughts; and human influences, such as the outright destruction of the feature, 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 paved over, 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. The Natural Heritage System for the Lake Simcoe Watershed (Beacon and LSRCA, 2007) provides an important tool for reducing the impact of human influences by ensuring that the functions of natural systems can be preserved and/or restored.

8.3.1 Land use changes and habitat fragmentation

Natural features are the second largest land use type in the Pefferlaw River subwatershed at approximately 43%; the remaining 57% of the subwatershed's area has been changed to other uses (Figure 2-3, **Chapter 2 – Study Area and Physical Setting**). The majority of the remaining land has been converted to agriculture, which now occupies 48% of the entire subwatershed area.

Land use change not only affects the direct area under change but the quality and integrity of surrounding natural heritage areas, due to processes such as habitat fragmentation, changes in hydrologic regimes, and increased probability of the introduction of invasive species. As such, many of the remaining areas categorized as natural heritage have degraded ecological condition and habitat functionality.

Based on future land use projections, urban areas are only anticipated to expand by approximately 2.2%, an increase of 977 ha. The majority of this increase is attributable to high intensity development. This development will mainly occur on areas currently with hay/pasture, row crops, sod farm, woodlands, transitional, and a small area of wetland (Louis Berger Group, 2010).

Although the total extent of natural cover in a subwatershed is the primary driver for many ecological processes, some species are sensitive to the size of patches, the amount of 'interior' habitat, and the proximity or connectivity between remnant patches.

Contiguous woodland areas have been calculated and the distributions of woodland patch sizes are displayed in the following graph (Figure 8-3). While the total area of woodland represents the amount of forest completely within the subwatershed, the number of patches includes any patches touching the subwatershed rather than those that are entirely within the subwatershed. This methodology was used because it is important to properly capture the number of large forest patches. If only patches within the subwatershed boundaries were considered, the number of large patches would be underestimated.

The Pefferlaw River subwatershed is characterized by a large number of small forest patches (Figure 8-3). There is a total of 800 separate patches of woodland in this subwatershed, 78% of which are small (less than 10 ha in size). However, because of the presence of a few larger woodlands, collectively these small fragments represent only 10% of the subwatershed's total forest cover. Of the larger woodland patches remaining, 15 are between 100 and 200 ha in size, and 18 are over 200 ha, with the largest two areas being 701 and 114 ha.

The land use in the subwatershed can also be described in terms of imperviousness (the inability for water/moisture to permeate the surface). Subwatersheds with less than 10% imperviousness are generally able to maintain surface water quality and quantity and preserve the density and biodiversity of aquatic species, as recommended in Environment Canada's Areas of Concern Guidelines (2005). In the Pefferlaw River, approximately 11% of the area is impervious, which is just above the Environment Canada target. While imperviousness is not the only measure or indicator of water quality and aquatic biodiversity, hydrology is of particular importance in the Pefferlaw River subwatershed given the high proportion of high quality wetlands and areas of woodlands (many of which are associated with wetlands). It will be important to ensure that impervious area does not dramatically increase in this subwatershed in order to protect its health. The impacts of impervious surfaces are discussed further in **Chapter 3 - Best Management Practices.**

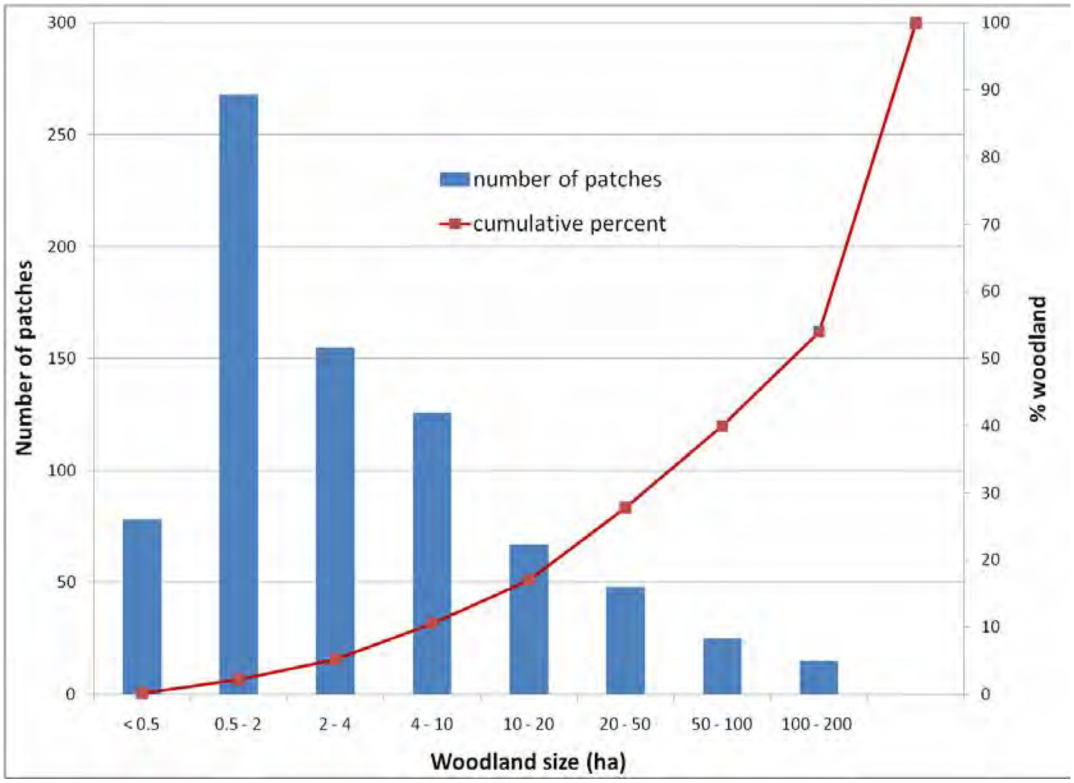


Figure 8-3: Woodland patch size distribution in the Pefferlaw River subwatershed.

8.3.2 Changes to hydrologic regime

Of all the natural heritage types identified in the subwatershed, changes to hydrologic regime will have the greatest impact on wetlands. Wetland types (fen, marsh, swamp, etc) 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 of wetlands and/or changes in wetland condition. Factors leading to changes in hydrology include increasing levels of impervious surfaces, extraction of water from rivers and streams, the removal of natural vegetation (e.g. deforestation, wetland removal), and municipal drains. Processes leading to changes in surface and ground water quantity are discussed in more detail within **Chapter 5 – Water Quantity**.

8.3.3 Invasive species

Invasive non-native species are a threat to biodiversity. While each species plays a specific role within its ecosystem, once out of its native setting and into a new ecosystems, these species can grow into enormous populations if unchecked by the evolved predatory/prey relationships of their native systems. Invasive species can dominate a habitat niche, preventing other species from surviving, thereby reducing biodiversity. The presence of invasive species can be an indicator of disturbance in an ecosystem as there are generally very few, if any, non-native species present in less disturbed features. Invasive species are usually highly effective at transporting themselves. For example, plants can disperse their seeds through such tactics as hitching a ride with an unsuspecting dog or person, through wind dispersal, or by a tenacious root system. Therefore, woodlands and wetlands that have been visited by very few people often have few to no invasive species and, therefore, higher biodiversity.

While there is very little information related to terrestrial invasive species in the Pefferlaw River subwatershed, the following invasive species have been recorded during LSRCA Conservation Area inventories.

Table 8-6: Invasive species identified in LSRCA Conservation Area inventories in the Pefferlaw River subwatershed.

European buckthorn (*Rhamnus cathartica*)	European starling (bird) (*Sturnus vulgaris*)	Coltsfoot (*Tussilago farfara*)
Dog-strangling vine (*Vincetoxicum rossicum*)	Giant hogweed (*Heradeum mantegazzianum*)	Purple loosestrife (marsh plant) (*Lythrum salicaria*)
Garlic mustard (*Allaria petiolata*)	European common reed (marsh plant) (*Phragmites australis*)	Helleborine (*Epipactis helleborine*)

Dog-strangling vine (*Vincetoxicum rossicum*) is a threatening upland species that has shown rapid increase recently. Its strong vine-like structure creates a thick blanket on the ground and can grow over small shrubs and trees leading to their death. This species is highly effective at crowding out other species; it is difficult even to walk through and blocks light from penetrating the ground.


Garlic Mustard (photo: Kentucky Division of Forestry)

In the past Garlic Mustard (*Allaria petiolata*) was used for medicinal purposes and as an herb in food. Now it is a persistent invasive species that threatens native groundcover in large areas and the species that depend on them. Garlic mustard has several properties that allow it to successfully replace large amounts of native groundcover in an area including the ability to self-pollinate, production of over 100 seeds per plant, and the production of phytotoxic chemicals that inhibit the growth of nearby vegetation. Because of the sticky nature of its seeds, it is easily transported by human activity and the passing wildlife. This plant prefers shady sites with fertile, low pH soils such as savannahs, upland and floodplain forests, and along roadsides.


Giant Hogweed (photo: Nottawasaga Valley Conservation Authority)

Giant Hogweed (*Heradeum mantegazzianum*) is an ornamental plant found in many gardens. As an individual plant can produce over 100,000 seeds that can stay viable up to seven years in the seed bank, it can easily spread over an area and replace the native species. While similar looking to the native Angelica and Cow parsnip, it is much larger, growing up to five metres in height. It also presents a health hazard to individuals that touch its clear sap. The sap contains toxins that cause photodermatitis and temporary or permanent blindness if it comes in contact with eyes (Pridham, 2009).

Capable of growing in a range of habitats, the Common Buckthorn (*Rhamnus cathartica*) has a rapid growth rate that allows it to create a thick cover, blocking shrubs and plants in the lower canopy and groundcover from sunlight. It has ‘allelopathic’ properties that inhibit the growth of nearby native plants, further allowing its own species to take over. Buckthorn is also a concern for the agricultural community as it is a host over the winter for soybean aphids and is an alternate host of oat rust.

In addition to those identified within Conservation Areas, another notable species recorded in the Lake Simcoe watershed that may also be present in the Pefferlaw River subwatershed is Japanese knotweed (*Polygonum cuspidatum*). Japanese knotweed is a highly invasive perennial that has escaped from gardens. This species will inhabit any type of habitat from roadsides, building sites and abandoned lands to meadows and woodland edges. It grows very aggressively, out-competing other species. It spreads rapidly by way of its thick and vigorous underground rhizomes, making it difficult to remove (OFAH 2006).

Japanese Knotweed (photo: Kentucky Division of Forestry)

It should be noted that the Lake Simcoe Protection Plan (2009) has developed a 'Watch List' of invasive species which are not yet in the Lake Simcoe watershed. However, if they do appear in the watershed, they are expected to have significant negative impacts on the terrestrial ecosystem. Those species include:

- Kudzu - *Pueraria lobata*
- Emerald ash borer – *Agrilus planipennis*
- Asian long-horned beetle – *Anoplophora glabripennis*
- Chronic wasting disease
- Oak wilt (caused by *Ceratocystis fagacearum*)
- White nose syndrome

The following section (Current Management Framework) summarizes the LSPP policies that address invasive species. Of these, the requirement to develop response plans for the Watch List species is a priority (Policy 7.4-SA).

8.3.4 Recreation

Natural areas such as woodlands and wetlands are popular locations for recreational activities such as hiking, cycling, dirt biking, boating, hunting, and snowmobiling. These activities, if not managed correctly and undertaken in a responsible manner, can reduce ecological condition of the natural heritage features. Impacts from recreational activities can include increased soil erosion, loss of habitat area (especially for species sensitive to human presence), introduction of invasive species, and pollution. Stresses on these sensitive areas are increasing as a result of increasing population and diminishing natural heritage lands.

8.3.5 Climate Change

Natural heritage features are going to be threatened by climate change. With predicted increases in air temperature and decreases in precipitation, water budgets will change and wetland species will be affected. Their vulnerability will increase and recent predictions suggest that 89% of the Lake Simcoe watershed wetlands will likely dry and ultimately shrink in size

(MOE, 2011). There will be losses in habitat diversity and species as well as the increased likelihood of invasive species expansion. Since the Pefferlaw River subwatershed is made up of 17% wetland, most of which are supported by groundwater inflows, the potential impacts from climate change are predicted to be somewhat moderated. However, the security of the sources of those groundwater inputs is extremely important to protect those wetland features and their associated functions in the long term.

Key Points – Factors Impacting Terrestrial Natural Heritage - stressors

- While there are multiple stressors to natural heritage systems, the greatest impact has been due to changes in land use. However in the case of the Pefferlaw River subwatershed, 43% of the area remains as a natural feature, which is above the LSPP target
- Invasive species, such a common buckthorn and dog strangling vine, can have a significant impact of natural heritage systems by out competing and displacing native species. The extent and impact of terrestrial invasive species in watershed is poorly defined, although it is known that numerous species are present.
- Recreational activities in natural heritage areas can lead to impacts such as erosion, species exclusion, and invasive species introduction.
- Changes in hydrologic regimes due to factors such as water extraction and may be stressing wetlands in the subwatershed, in particular during the summer months where a moderate surface water stress level has been identified at Tier 1 level (see **Chapter 5 – Water Quantity**).

8.4 Current Management Framework

8.4.1 Protection and Policy

Several acts, regulations, policies, and plans have shaped the identification and protection of the terrestrial natural heritage in the Pefferlaw River subwatershed. Those having most impact on natural heritage features are summarized in Table 8-7. This management framework relates to many different stressors that can potentially affect natural heritage ranging from the discharge of material to urban development. In Table 8-7 we categorize 8 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 this management framework broadly fall into one of two categories. The first broad category we define as those having little or no legal standing and are referred to as General or Have regard to Statements in Table 8-7 and are shown in blue. The second category includes those that have legal standing and must be conformed to; these are referred to as Regulated / Existing Targets in Table 8-7 and are shown in green. In many cases where an act, regulation, policy, or plan does not relate to the activity, these are shown in red.

Table 8-7: Summary of current the current management framework as it relates to the protection and restoration of terrestrial natural heritage.

Stressor affecting the protection and restoration of terrestrial natural heritage	Oak Ridges Moraine Plan (2002)	Greenbelt Plan (2005)	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)	Durham Regional Official Plan (2008)	York Region Official Plan (2008)
Growth/development/site alteration	🟩	🟩	🟩	🟦	🟦	🟦	🟩	🟩	🟩
Habitat fragmentation	🟥	🟩 1	🟩 2	🟥	🟥	🟩	🟥	🟦	🟥
Connectivity	🟩	🟩	🟩	🟥	🟦	🟥	🟥	🟦 8	🟥
Impervious areas	🟩	🟩	🟦	🟥	🟥	🟥	🟦	🟩 9	🟩 10
Introduction of invasive species	🟥	🟥	🟦 3	🟥	🟥	🟥	🟥	🟥	🟥
Impacts from recreation	🟩	🟦	🟦	🟥	🟥	🟦 4	🟩 6	🟦 8	🟥
Restoration	🟦	🟦	🟦	🟥	🟦	🟦 5	🟩 7	🟦	🟦
Climate change	🟥	🟥	🟦	🟥	🟥	🟥	🟥	🟦	🟥

🟦 General/Have regard to statement	🟩 Regulated/Existing targets	🟥 No applicable policies

[1] The only policy relates to lot creation within the Protected Countryside

[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] States that no person may damage or destroy the habitat of a species at risk, but does not specifically list any potential activities that may be permitted within habitat

[5] Person holding a permit to conduct an activity may be required to rehabilitate habitat damaged/destroyed in undertaking the activity; is also mentioned in policy pertaining to Species at Risk in Ontario Stewardship Program

[6] Along watercourses

[7] Required for valleyland applications, may be required in other cases (case-by-case basis)

[8] Related to paths and their potential impact on key natural heritage features and key hydrologic features

[9] Within Major Open Space Areas and Greenbelt Natural Heritage System

[10] Only within Oak Ridges Moraine planning area (as specified in the ORMCP)

In this section we provide a summary of the acts, regulations, policies, and plans as they pertain to the protection and restoration of terrestrial natural heritage. This summary is to give context to *future management considerations* and the *opportunities and recommendations to protect and improve natural heritage features in the subwatershed*. This summary is not intended to be comprehensive in terms of all the acts related to natural heritage, or the policies within these acts – the reader is directed to each piece of legislation for a full assessment of the legislation as it relates to natural heritage.

Oak Ridges Moraine Conservation Plan (2002)

This plan designates Natural Core and Natural Linkage Areas for the purpose of maintaining and improving the ecological integrity. Approximately 7,245 ha (or 16%) of the subwatershed is designated ORMCP Natural Core and Linkage areas. The policies that apply in the Natural Core and Linkage Areas include:

ORMCP Key Natural Heritage Features

- Wetlands
- Significant portions of the habitat of endangered, rare and threatened species
- Fish habitat
- ANSIs (Life Science)
- Significant valleylands
- Significant woodlands
- Significant wildlife habitat
- Sand barrens, savannahs, and tallgrass prairies

- Every application for development or site alteration which triggers Planning Act review shall identify planning, design and construction practices that ensure that buildings or site alterations do not impede the movement of plants and animals among key natural heritage features, hydrologically sensitive features and adjacent land.
- A minimum area of influence and minimum vegetation protection zone. An application for development or site alteration within the minimum area of influence that relates to a key natural heritage feature, but is outside of that feature and the minimum vegetation protection zone, are to be accompanied by a natural heritage evaluation. Factors natural heritage evaluation shall include:
    - Demonstrate that the development or site alteration will have no adverse affects on the key natural heritage feature or the related ecological functions
    - Identify planning, design and construction practices that will maintain and, where possible, improve or restore the health, diversity and size of the key natural heritage feature and its connectivity with other key natural heritage features
    - Demonstrate how connectivity within and between key natural heritage features will be maintained and, where possible, improved or restored before, during and after construction
    - Determine if the dimensions of the minimum vegetation protection zone as specified in the ORMCP are sufficient, and specify the dimensions necessary to provide for the maintenance and, where possible, improvement or restoration of natural self-sustaining vegetation within it
- Policies related to water conservation and the protection of water quantity and quality will have the added benefit of helping to maintain a great number of important natural heritage features, such as wetlands.

The Pefferlaw River subwatershed also contains Landform Conservation Areas (both Categories 1 and 2), for which there are a number of policies:

- Applications for development or site alteration with respect to land in a landform conservation area shall identify planning, design and construction practices that will keep disturbance to landform character to a minimum, including
    - Maintaining significant landform features such as steep slopes, kames, kettles, ravines and ridges in their natural undisturbed form
    - Limits on the portion of the developable area of the site that is disturbed and the area of the site that has impervious surfaces
- Applications for development in landform conservation areas are to be accompanied by a landform conservation plan, that details (through maps) elevation contours; analysis of the site by slope type; significant landform features such as kames, kettles, ravines and ridges; and all water bodies including intermittent streams and ponds.
- Landform conservation plans should also include a development strategy that identifies appropriate planning, design and construction practices to minimize disruption to landform character

The ORMCP also details a number of requirements for those uses that are permitted within Natural Core and Linkage Areas, such as gravel pits, agricultural uses, and low-intensity recreational uses to ensure that they have minimal impact on these important areas.

Lake Simcoe Protection Plan (2009)

The LSPP contains a number of policies aimed at protecting the natural features of the watershed. The Plan's natural heritage targets include:

- Achieving a greater proportion of natural vegetative cover in high quality patches
- Achieving a minimum 40 percent high quality natural vegetative cover in the watershed
- Protecting wetlands
- Naturalized riparian areas
- Restoration of natural areas or features
- Increased ecological health based on the status of indicator species and maintenance of natural biodiversity

The following are the policies set out by the plan that will help to meet these targets:

- Restricting the activities that can be undertaken in shoreline and riparian areas, and encouraging the re-naturalization of these areas
- The possible development of a shoreline regulation(s), which could address such issues as fertilizer use, activities contributing to the spread of invasive species, peat extraction, the filling and draining of existing wetlands, and vegetation removal
- The protection of key natural heritage and key hydrologic features (including wetlands, significant woodlands, significant valleylands and natural areas abutting Lake Simcoe) by prohibiting development and site alteration within these features and delineating a vegetation protection zone for each. A very limited number of land uses are permitted within this vegetation protection zone, these include forest, fish, and wildlife management; stewardship, conservation, restoration and remediation; flood or erosion

control projects; stormwater retrofits; and low intensity recreational uses. This applies only outside designated settlement areas.

- The minimum vegetation protection zone is the area within 30 metres of the key natural heritage or hydrologic feature, but this may be larger if determined appropriate through a natural heritage evaluation, which is required of all applications for development or site alteration within 120 metres of a key natural heritage feature or hydrologic feature.
- Within identified settlement areas, an application for development shall, where applicable:
  - Increase or improve fish habitat in streams, lakes and wetlands, and any adjacent riparian areas
  - Include landscaping and habitat restoration that increase the ability of native plants and animals to use valleylands or riparian areas as wildlife habitat and movement corridors
  - Seek to avoid, minimize and/or mitigate impacts associated with the quality and quantity of urban run-off into receiving streams, lakes, and wetlands

The LSPP also deals explicitly with issues around invasive species, with a target of preventing the introduction of new invasive species in the watershed. Terrestrial natural heritage policies aimed at meeting this target include:

- Preparation of watch list for priority species and for the identified species, rapid response plans
- The delivery of annual information and education programs for the general public and key stakeholders on how to prevent the spread of, and how to detect, invasive species
- The development of a community based social marketing project to identify effective methods to engage stakeholders for the purpose of modifying their behaviour to reduce the introduction and spread of invasive species

Greenbelt Plan (2005)

Almost 100%, of the Pefferlaw River subwatershed lies within the Greenbelt Act Area, with only two hectares falling outside of this area. The Greenbelt Act area also includes the ORMCP areas, but does not include designated urbanizing areas (known as the “White Belt”) that are not within the ORM. Within the Greenbelt Plan’s ‘Protected Countryside’ (which includes towns, hamlets and villages), there are a subset of lands that are identified as the Natural Heritage System. This Natural Heritage System includes the areas of the Protected Countryside with the highest concentration of the most sensitive and/or significant natural heritage features and functions. The Greenbelt Plan identifies a number of policies related to the protection of the features within this system. These include:

Greenbelt Plan: Key Natural Heritage Features

- Significant habitat of endangered species, threatened species, and special concern species
- Fish habitat
- Wetlands
- Life Science Areas of Natural and Scientific Interest
- Significant valleylands
- Significant woodlands
- Significant wildlife habitat
- Sand barrens, savannahs and tallgrass prairies
- Alvars

- New development or site alteration (as permitted by the policies of the Greenbelt Plan) are required to demonstrate that

  - There will be no negative effects on key natural heritage features or key hydrologic features
  - Connectivity is maintained or enhanced wherever possible
  - The removal of other natural features should be avoided
  - The disturbed area of any site does not exceed 25%, and the impervious surface does not exceed 10% of the total developable area of the site
- Where non-agricultural uses are contemplated, the applicants must demonstrate that
  - At least 30% of the total developable area will remain in or be returned to natural self sustaining vegetation
  - Connectivity along the system and between key natural heritage features and key hydrologic features located within 240 metres of each other is maintained or enhanced
  - Buildings or structures will occupy less than 25% of the total developable area
- Development of lands within wetlands, seepage areas and springs, fish habitat, permanent and intermittent streams, lakes, and significant woodlands is not permitted (there are several activities which are allowed within these areas including any associated vegetation protection zone.
- A proposal for development or site alteration within 120 metres of a key natural heritage feature within the Natural Heritage System requires a natural heritage evaluation and hydrological evaluation which will identify a vegetation protection zone which is sufficient to protect the feature from the impacts of the proposed change (including before, during, and after construction), and restore or enhance the feature and/or its function wherever possible.

Growth Plan for the Greater Golden Horseshoe (2006)

The policies of this plan are meant to direct growth in such a manner as to protect natural heritage features and other significant areas from the issues associated with urban sprawl. This plan builds on the natural systems of the Greenbelt Plan, with policies that strive for a healthy natural environment with clean air, land, and water.

There are several Natural Systems policies in the Growth Plan that will support the protection of the subwatershed’s natural areas. These include:

- The Ministry of Public Infrastructure Renewal will work with municipalities to identify natural systems for the Greater Golden Horseshoe, and where appropriate will develop additional policies for their protection
- The Greenbelt Policies apply throughout the natural system
- Planning authorities are encouraged to identify natural heritage features and areas that complement, link or enhance natural systems

Provincial Policy Statement (2005)

By focusing growth within settlement areas and away from significant or sensitive resources, the implementation of this piece of legislation will help to protect terrestrial natural heritage features within the Pefferlaw River subwatershed. The policies that support this can be found under Section 2.0 of the PPS and include:

- Policies stating that natural heritage features and areas shall be protected for the long term, and that the diversity and connectivity of natural features in an area, and the long term ecological function and biodiversity of natural heritage systems, should be maintained, restored or, where possible, improved.
- Policy 2.1.3 provides direction to regional and local municipalities regarding planning policies for the protection and management of natural heritage features and resources. The PPS defines seven natural heritage features (listed below) providing planning policies for each.
    - significant habitat of Species at Risk;
    - significant wetlands;
    - significant woodlands;
    - significant valleylands;
    - significant wildlife habitat;
    - Areas of Natural and Scientific Interest (ANSIs); and
    - fish habitat.
- The habitat of Species at Risk as well as provincially significant wetlands are designated and delineated by the Ontario Ministry of Natural Resources. These features and habitats are afforded provincial protection and are precluded from development under the *Planning Act*. Proposed development in non-provincially significant features, such as wetlands and woodlands, are subject to the demonstration of no negative impact on the ecological function.

Municipal and local planning authorities are responsible for the identification and designation of these features within their Official Plans (with the exception of provincially significant wetlands and the significant habitat of Species at Risk).

The Greenbelt Plan and Oak Ridges Moraine Conservation Plan (ORMCP) are provincially legislated areas that take precedence over the PPS.

Endangered Species Act (2008)

The purposes of the Endangered Species Act (ESA) are to protect species that are at risk and their habitats, as well as promoting the recovery of those species. Through the implementation of the policies of the ESA, protection will be afforded to the habitats of the Pefferlaw River subwatershed’s rarest species, thus helping to preserve the subwatershed’s biodiversity. These policies state that no person shall:

- Kill, harm, harass, capture or take a living member of a species that is listed on the Species at Risk Ontario (SARO) list as an extirpated, endangered, or threatened species
- Possess, transport, collect, buy, sell, lease, trade or offer to do the same with any specimen (living or dead) or part of a species that is listed on the SARO list as an extirpated, endangered, or threatened species
- damage or destroy the habitat of a species listed as endangered, threatened, or extirpated

The policies of the ESA also require that a recovery strategy be prepared for each of the species on the SARO list as an endangered or threatened species. These strategies are to include an identification of the habitat needs of the species, a description of the threats to the survival and recovery of the species. The ESA includes a policy that states that the precautionary principle should be used in the development of recovery plans – where there is a threat of significant reduction or loss of biological diversity, a lack of full scientific certainty should not be used as a reason for postponing measures to avoid or minimize such a threat.

LSRCA Watershed Development Policies (2008)

The LSRCA has a number of policies aimed at protecting natural heritage features. Wherever possible, the LSRCA directs development away from features such as Environmentally Significant Areas (ESAs), ANSIs, wetlands, significant valleylands, significant woodlands, sensitive or significant wildlife habitat, and the habitat of Species at Risk.

Depending on the location and scope of a plan of subdivision, the LSRCA may require the submission of a number of materials be included in the application, such as planting or vegetation plans, vegetation preservation plans, and environmental impact studies. The completion of these studies will help to protect features or minimize the impact of the development on the important features and functions within the subwatershed.

There are policies that deal specifically with maintaining valleylands by minimizing site alteration. Through these policies, the LSRCA may require a number of studies (such as Vegetation Plans, Tree Preservation Plans) and can place additional restrictions on development proposals within or in proximity to valleylands.

The Authority endeavours through its policies to encourage municipalities to identify ESAs and to work with them to develop appropriate environmental protection policies to incorporate into their Official Plans. The LSRCA does not support development in Group 1 biological ESAs, unless it can be shown (through an environmental impact study) that there will be no negative impacts on the ESAs. The LSRCA has other requirements for Group 2 and 3 ESAs that seek to minimize impacts of development.

Floodplains are also well protected through these policies, although development in this area may be permitted under some circumstances. However, the policies stipulate that within this area, cutting and filling will generally not be permitted in ESAs, wetlands, ANSIs, significant woodlands and valleylands, sensitive wildlife habitats, habitats of Species at Risk, and on steep slopes.

With respect to wetlands, the LSRCA’s policy statement is that new development and/or interference in any way shall be prohibited within all Provincially Significant Wetlands (PSW) regardless of existing uses, and that such activities will be prohibited within all other wetlands except under several circumstances. These include demonstrating the need to develop within the wetland, the absence of an alternate location for the proposed development, the design of the proposed development minimizes disturbance to the site, drainage patterns are maintained, and the completion of an appropriate Environmental Impact Study demonstrating that there will not be an effect on the control of flooding, or pollution or the conservation of land due to the development.

The policies also stipulate that some infrastructure projects may be permitted within wetlands. Where development is permitted, the LSRCA may also require compensation for feature and function loss.

The LSRCA requires a 120 metre setback from all PSWs and a 30 metre setback from all other wetlands, unless it can be demonstrated through submission of hydrological studies that there will be no negative impacts to the wetland.

Lake Simcoe Natural Heritage System

In 2007, LSRCA developed a Natural Heritage System for the Lake Simcoe watershed. The *Natural Heritage System for the Lake Simcoe Watershed Phase 1: Components and Policy Templates* is used by LSRCA staff to guide plan review, though the main intent is for adoption through municipal Official Plans. The foundation of the NHS is the *Provincial Policy Statement 2005* (PPS), the principal tool designed by the Province to incorporate natural heritage planning across the watershed. Science is the support structure of the NHS and supporting documentation (Beacon and LSRCA, 2007) provides comprehensive criteria based on recent scientific concepts in order to identify lands of ecological value within the watershed.

A four-tiered policy approach was developed to direct the protection of the natural features of the Natural Heritage System (Table 8-8). The first two levels of this policy approach are assigned a “provincially significant” designation and are considered to be those features that would be identified if following the guidelines and intent of the PPS. Level 3 of this approach represents significance at the watershed level, while Level 4-supporting features are those that are considered to be supporting the natural heritage system of the watershed. Finally, Big Woods Policy Areas are target areas for replacement, restoration and stewardship priorities (Beacon and LSRCA, 2007).

Table 8-8: Policy guidelines of the LSRCA Natural Heritage System Phase 1.

Significance	Policy Level	Guideline
Provincial	Level 1	Provincially significant, retention and protection
	Level 2	Provincially significant, retain and demonstrate no negative impact
Watershed	Level 3	Watershed significant, retain and avoid; demonstrate no net negative impact, replacement may be acceptable
Supporting	Level 4	Not necessarily a constraint to development but replacement encouraged
Big Woods Policy Areas	BWPA	Retain, no net loss of woodland

Approximately 20,127 ha (45%) of the Pefferlaw River subwatershed is within the four-tier LSRCA NHS, the breakdown is as follows (Table 8-9 and Figure 8-4).

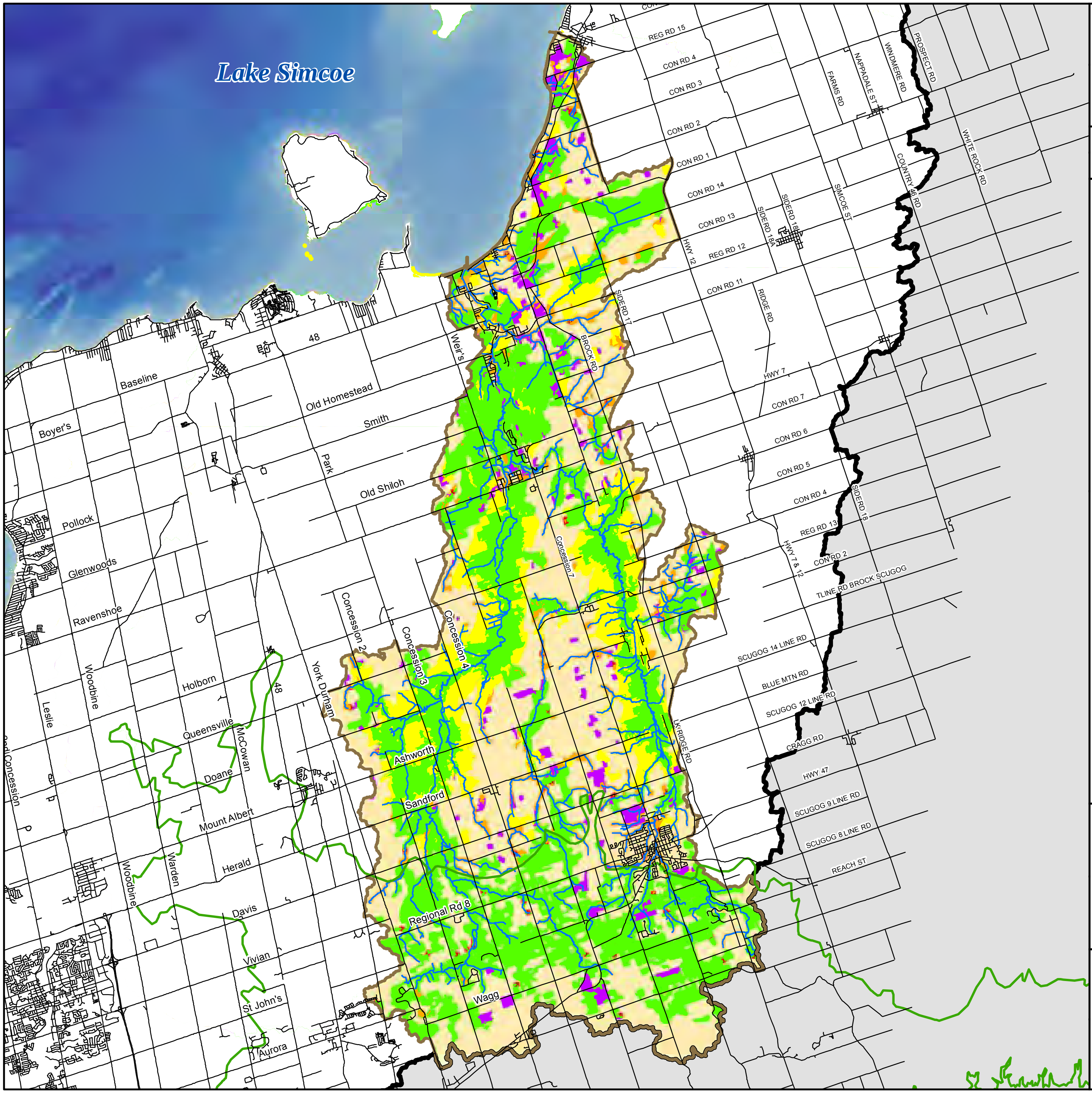
Table 8-9: LSRCA Natural Heritage System policy levels in the Pefferlaw River subwatershed.

Policy Level	Area in the Pefferlaw River subwatershed (ha)	Percentage of the Pefferlaw River subwatershed
Level 1	13,936.6	31.2
Level 2	4,002.2	9.0
Level 3	1,190.8	2.7
Level 4 - supporting	997.6	2.2
Total	**20,127.2**	**45.1**

Approximately 30% of the NHS of the Pefferlaw River subwatershed is comprised of Level 1 features, and close to 40% is comprised of Level 1 and Level 2 features, which, as mentioned above, are afforded the greatest level of protection.

LSRCA Natural Heritage System in the Pefferlaw River subwatershed

Figure 8-4



Legend

— Road

〰 Watercourse

LSRCA Watershed Boundary

Oak Ridges Moraine

Natural Heritage System Policy

🟩 Level 1

🟨 Level 2

🟧 Level 3

🟪 Level 4

● Proximity Linkage

Lake Simcoe Region conservation authority

0 1 2 4 6 8 10
Kilometres

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This map has been produced for illustrative purposes only.
LSRCA GIS Services DRAFT created July 2010.

Durham Regional Official Plan (2008)

Approximately 10,900 ha (25%) of the Pefferlaw River subwatershed is located on the Oak Ridges Moraine within the Regional Municipality of Durham. The Durham Regional Official Plan (2008) protects its natural environment through areas designated as Oak Ridges Moraine, Waterfronts, Major Open Space, and features such as environmentally sensitive areas, valley systems, water resources and plant and animal habitats.

Policies from the Durham Regional Official Plan include:

- Woodlands, wetlands and peat bogs be protected and managed to provide environmental, recreational benefits
- Encourages the development of a connected and functional natural system with appropriate linkages and corridors.
- Protection from development on lands identified containing key natural heritage and/or hydrologic features and their associated minimum vegetation zones.
- The requirement for an environmental impact study on development proposed within 120 metres of key natural heritage and/or hydrologic features.
- The protection of woodlands through cooperation with the area municipalities and conservation authorities to establish a tree inventory, establishing a target of 30% cover, and encouraging the expansion of woodlands to increase its function and linkages.
- The requirement to maintain at least 30% of the total developable area of a site be returned to natural self-sustaining vegetation and maintenance of the connectivity between key natural heritage or hydrologic features within 240 metres of each other for any proposed non-agricultural uses within Major Open Space Areas or the Greenbelt Natural Heritage System.
- Require development for Shoreline Residential Areas to integrate habitat restoration, and to establish a vegetation protection zone along shoreline of at least 30 metres.
- The identification that Prime Agricultural Area lands between the Oak Ridges Moraine Areas, Major Open Space Areas and Waterfront Areas shall function as open space linkages.
- Increasing woodland cover in York Region to 25% of the land area
- Prohibiting development and site alteration within significant woodlands and their associated vegetation protection zone (with some conditions). In circumstances where these activities are permitted, a woodland compensation plan must be completed
- Managing York Region forests sustainably in a manner that enhances ecological, educational, and recreational functions to ensure their health in perpetuity
- Supporting the goals and objectives of subwatershed plans

Acquisition of natural heritage features by public agencies

Several mechanisms exist for the acquisition of natural heritage features by the Lake Simcoe Region Conservation Authority and municipal governments.

The LSRCA has a land securement program which aims to acquire significant natural heritage features in the Lake Simcoe watershed, on a willing buyer – willing seller basis. LSRCA has developed a Natural Heritage System Land Securement Project, which focuses LSRCA’s securement efforts by identifying nine land securement priority areas (LSRCA, 2010) which will be actively pursued. One of the priority areas identified in that strategy is the Uxbridge wetlands, which includes the Pefferlaw-Udora Provincially Significant wetland complex, the Pefferlaw Brook Swamp ANSI, high quality waterfowl habitat, and large areas of interior forest habitat.The LSRCA may also consider receiving donations of relatively large parcels of land elsewhere in the subwatershed, if they meet the criteria of the Conservation Land Tax Incentive Program.

8.4.2 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 are funded by the LEAP program include managing manure and other agricultural wastes, decommissioning wells and septic systems, fencing and planting riparian areas, and increasing the amount of wildlife habitat in the watershed, among others. Since 1989, in addition to projects focused specifically on protecting water quality, LEAP has supported 19 riparian buffer and 28 upland tree planting projects in this 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 Pefferlaw River subwatershed, this program is implemented in partnership with the Durham Land Stewardship Council. To date, the Lake Simcoe Community Stewardship Program has supported five shoreline stabilization projects in the Pefferlaw River 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.

In 2008 and 2009, LSRCA field staff surveyed the majority of the watercourses in this subwatershed, documenting the range of potential stewardship projects that could be implemented to help improve water quality and fish habitat. This survey found nearly 400 places where additional riparian planting could be implemented in the tributaries in this subwatershed.

The forthcoming shoreline management strategy, and wetland and riparian area prioritization exercise, will identify and prioritize stewardship opportunities in this subwatershed, specific to the shoreline and inland riparian and headwater areas respectively.

These ongoing stewardship programs will soon be complemented by a forthcoming Voluntary Action Program. Initially, the Lake Simcoe Protection Plan proposed the development of a regulation to prohibit activities that would adversely affect the ecological health of the Lake Simcoe watershed (Policy 6.16). Feedback during the initial rounds of consultation in development of this regulation raised concerns about its enforceability, and the need to educate the public on best management practices before taking a regulatory approach. As a result, the MOE reframed the Shoreline Regulation as a Shoreline Voluntary Action Program.

The Shoreline Voluntary Action Program is intended to increase the extent of native vegetation along shorelines, and reduce the use of phosphate-containing fertilizer in the watershed, through a combination of surveys which are aimed at understanding the current range of public knowledge, attitudes, and practices, and outreach to summer camps, landowners, and garden centres.

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.

8.4.3 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. 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, both coordinated by Bird Studies Canada, provide information on long-term trends in wildlife populations throughout Ontario. There is one annual Breeding Bird Survey route in the Pefferlaw River subwatershed.

Climate change is generally not well addressed in the current management framework. The LSPP contains the most comprehensive policies related to this issue which could potentially cause shifts in the vegetative communities in the subwatershed, impact the hydrologic regimes that sustain wetlands, and make the subwatershed ecosystem more susceptible to stresses such as disease and insect infestation. The adaptation strategy that will be developed through the LSPP is a significant first step in addressing this issue, and some of the Official Plan policies are beginning to consider climate change as well. While it may not be appropriate for some of the existing legislation to address climate change issues, it will be important to incorporate climate change considerations wherever possible in making management decisions for the subwatershed, and implement policies requiring, at the very least, the incorporation of so called “no regrets” options into development and site alteration wherever possible.

It is important to recognize that on April 16, 2008, Durham Regional Council approved the Terms of Reference for the Durham Region Roundtable on Climate Change (DRRCC). The role of the DRRCC is to position the Region of Durham as a leader in addressing climate change issues. This will be achieved by preparing and recommending a comprehensive strategy with detailed actions that can be undertaken across the Region to address climate change.

This group will provide advice and recommendations to Regional Council on how the Region can assist in dealing with this global phenomenon. This committee will advise on strategies, both internal and external, to mitigate and adapt to the challenges caused by climate change, and in particular, global warming.

The DRRCC's mandate focuses on three areas:

- Committee Education: broadening members' knowledge of climate change issues;
- Corporate Response: reviewing measures identified by a Regional Staff Working Group that the Region, as a corporation and as community service provider, can take in its day to day business practices and operations to mitigate and adapt to climate change; and
- Outreach/Advocacy: encouraging Durham residents, the area municipalities, industries, corporations, businesses, institutions, and senior levels of government to address climate change in their respective practices and operations.

8.5 Management Gaps and Recommendations

As can be seen in the previous section, there are a number of programs in place to protect and enhance the natural heritage features in the Pefferlaw Brook 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.

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.

8.5.1 Gaps in Key Natural Heritage Protection Policies

The existing suite of natural heritage protection policies provided by the ORMCP, LSPP, Greenbelt, municipal official plans, and Provincial Regulations provide some level of protection from development for over the natural heritage features in the Pefferlaw River subwatersheds. However, there are inconsistencies between the protection offered under the policies. For example, all evaluated wetlands are protected in the ORMCP and Natural Heritage System of the Greenbelt, but only Provincially Significant Wetlands are protected outside the Natural Heritage System of the Greenbelt.

Features which aren’t protected include grasslands, small isolated woodlands, and non evaluated wetlands. Although small isolated forests are typically less ‘valuable’ than large complex natural areas, size alone is an incomplete measure of woodland value. Furthermore, the loss of these small isolated woodlands will hamper our ability to meet the Lake Simcoe Protection Plan target of 40% high quality natural vegetation in the Lake Simcoe watershed.

> **Recommendation #62 -** That the City of Kawartha Lakes and the Durham Regional Official Plans be amended at an appropriate time, to contain policies that would apply DP 6.23-6.29 (key natural heritage feature policies) of the Lake Simcoe Protection Plan for those lands beyond the Natural Heritage System within the Protected Countryside of the Greenbelt.
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> **Recommendation #63 -** That the subwatershed municipalities examine the feasibility of amending official plan policies to provide adequate mitigation and compensation on site alteration within natural features that are not defined as key natural heritage features.

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 yet no shared definition of what constitutes ‘quality’, when this data 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 #64 -** 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 of ‘high quality’ natural heritage features, and provide policy recommendations (as necessary) to ensure high quality natural heritage features are adequately protected upon the update of this subwatershed plan.

8.5.2 Grassland protection

Grassland habitats are an often overlooked natural heritage feature, and unprotected by natural heritage protection policies. For example, none of the Greenbelt, LSPP, or the Provincial Policy Statement accounts for "grasslands" as a type of natural heritage feature. However, they are disproportionately important for species of conservation concern. There are only five identified native grasslands (i.e. tallgrass prairies or alvars) in the Lake Simcoe watershed, and none of these are in the Pefferlaw Brook subwatershed. The identified native grasslands are each less than 25 ha in size, and together are less than 30 ha in total size. Features this small will be insufficient for the long-term persistence of grassland birds and insects. The protection of non-native grasslands is difficult however, as many of these are abandoned lots or vacant or non-intensive agricultural land, and as such they are often temporary in nature.

The concern in this subwatershed 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 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 #65 -** That the MNR, OMAFRA, 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
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> **Recommendation #66** - That subwatershed municipalities, with the support of the MNR and LSRCA, examine the feasibility of incorporating action plans, programs and amending official plans related to grassland protection, contingent on the studies being conducted on methods and policy to protect such grassland.

8.5.3 Land acquisition 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.

> **Recommendation #67 -** That the LSRCA, with input from municipalities continue to secure outstanding natural areas for environmental protection and public benefit, through tools such as land acquisition or conservation easement.
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> **Recommendation #68 -** That the Federal, Provincial and Municipal governments provide consistent and sustainable funding to ensure continued delivery of land securement programs.
>
> **Recommendation #69 -** That the LSRCA, MNR, and municipalities should continue to refine their land securement decision processes to ensure that they are securing natural areas that are critical to the health of the watershed (or securing and restoring areas which have the potential to become critical to the health of the watershed), but which are otherwise vulnerable to loss through incompatible land uses.

8.5.4 Stewardship implementation – increasing uptake

In addition to protecting existing terrestrial habitat, programs which support the stewardship, restoration, or enhancement of terrestrial 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. Despite this range of players, the uptake of proffered stewardship programs in these subwatersheds has been relatively limited.

> **Recommendation #70 -** That the MNR, MOE, OMAFRA, and LSRCA continue to implement stewardship projects in the Pefferlaw River subwatershed, and encourage other interested organizations in doing the same.
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> **Recommendation #71 -** That governmental and non-governmental organizations should improve coordination of programs to: (1) avoid inefficiencies and unnecessary competition for projects, and: (2) make it easier for landowner to know which organization they should be contacting for a potential project, using tools such as a simple web portal.
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> **Recommendation #72 -** That the Federal, Provincial and Municipal governments provide consistent and sustainable funding to ensure continued delivery of stewardship programs.
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> **Recommendation #73 -** That the MOE, MNR, OMAFRA, and LSRCA support research to determine barriers limiting uptake of stewardship programs in these subwatersheds, share these results with members of the Lake Simcoe Stewardship Network, and revise stewardship programs or stewardship outreach 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 #74 -** That the MNR, MOE, OMAFRA, and LSRCA investigate new and innovative ways of reaching target audiences in the local community and engage/involve 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. Results of these efforts should be shared with members of the Lake Simcoe Stewardship Network.

8.5.5 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 assessment of barriers to uptake as listed above, would allow improved targeting of programs to areas of relatively high need.

Recommendation #75 - That the MNR, in collaboration with MOE and LSRCA, should develop a spatially-explicit decision support tool to assist in targeting stewardship projects in the Lake Simcoe watershed. In the context of the Pefferlaw River subwatershed, this decision tool should take into account factors including:

- the need to increase riparian cover along the tributaries of the Pefferlaw River subwatershed
- protecting and restoring ecologically significant groundwater recharge areas, to help mitigate the expected impacts of climate change
- opportunities to increase connectivity across the subwatersheds for dispersing flora and fauna
- Potential impacts to grasslands such as cultural meadows
- Land securement as the most feasible approach to obtaining suitable land for priority restoration opportunities

8.5.6 Dealing with indirect impacts

Some of the greatest impacts to natural heritage values in the subwatershed in coming years may be indirect, rather than direct, in nature. For example, forests in urban areas are typically under more stress from invasive species, feral cats, unmanaged recreation, and indirect impacts associated with nearby roads.

Recommendation #76 - That the LSRCA and municipalities 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 #77 - That the MOE and its partners provide outreach to garden centres, landscapers and garden clubs regarding the danger of using invasive species in ornamental gardens and to promote the use of species native to the region that will be able to adapt to projected climate change.

Recommendation #78 - That the partner municipalities make information readily available to their residents on the importance of native plant landscaping, active transportation, and the impacts of uncontrolled house pets to natural areas.

8.5.7 Filling data gaps

Our understanding of the status and pressures related to natural heritage features and processes in the Lake Simcoe watershed is relatively limited. A monitoring program for natural heritage features and values in the Lake Simcoe watershed would contribute significantly to addressing this data gap. This monitoring program could be complemented by the following recommendations to more fully fill data gaps.

Recommendation #79 - That the LSRCA, MNR and MOE continue to maintain an up-to-date seamless Ecological Land Classification map for the watershed, managed in such a way as to allow change analysis (for example in 5 year increments for priority subwatersheds).

Recommendation #80 - 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.

8.5.8 Introduction of Invasive Species

Invasion of non-native terrestrial species reduces diversity, increases competition for existing habitat needs, and generally negatively impacts and simplifies the existing terrestrial community. The province has developed a Watch List under Lake Simcoe Protection Plan for terrestrial species not yet found in the watershed. The LSPP notes the importance of identifying funding sources for the implementation of invasive species response plans, but there is currently not a guaranteed fund for undertaking these activities.

Recommendation #81 - In reviewing any development proposal adjacent to a natural heritage features, the review agencies will promote that any vegetation being planted be native to the region, and will have be tolerant to climate change impacts, and further that planting of species native to the region is encouraged in property management programs.

Recommendation #82 - That the MNR ensure completion of early detection and rapid response plans for priority terrestrial species identified in the LSPP Watch List. In accordance with the LSPP these plans should be completed by 2015.

Recommendation #83 - That the MNR develops a communications plan to educate public and private constituents in the monitoring and eradication of invasive aquatic species.

9 Pefferlaw River Subwatershed's Natural Capital: The Value of the Subwatershed's Ecosystem Services

9.1 Introduction

In 2008, the Lake Simcoe Region Conservation Authority partnered with the David Suzuki Foundation and the Greenbelt Foundation to determine the value of the ecosystem goods and services provided by the features in the watershed. The value of the services provided by the entire Lake Simcoe watershed was estimated to be a minimum of $975 million dollars each year. As part of the subwatershed planning exercise, the conservation authority has completed a more specific analysis of the value of the services provided by the ecosystems of the Pefferlaw River subwatershed.

9.2 What is Natural Capital?

Natural capital refers to our natural assets, and the ecosystem goods and services that those assets provide. Natural assets and ecosystem services are the foundations of life – including human life. The benefits provided by natural capital include the storage of floodwaters by wetlands, water capture and filtration by forests, the absorption of air pollution by trees, and climate regulation.

Forests, wetlands, and rivers that make up watersheds are essentially giant utilities providing ecosystem services for local communities as well as 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, in Wilson, 2008). The goods and services provided by the Pefferlaw River subwatershed were estimated to be worth $170 million annually.

The most highly valued natural assets are the forests and wetlands, worth $320 and $463 million per year, respectively for the Lake Simcoe basin and $67 and $83 million, respectively for the Pefferlaw River subwatershed. The high value for wetlands reflects the many important services they provide, such as water regulation, water filtration, flood control, waste treatment, recreation, and wildlife habitat. Forests provide high value because of their importance for water filtration, carbon storage, habitat for pollinators, and recreation.

As the subwatershed plan is developed for the Pefferlaw River, this study reinforces the importance of ensuring meaningful protection of natural features, including through the implementation of the Natural Heritage System and policies through local official plans. The ecosystem values in this report can also be a useful tool for other regions to determine the hidden wealth of their respective ecological systems and plan more strategically for healthy and sustainable communities. By measuring or quantifying the value to communities of ecosystem services, we can more accurately account for land use changes which thereby help to inform land use and other decisions related to altering the landscape.

9.3 Valuing Ecosystems

Ecosystem goods and services are the benefits derived from ecosystems. 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, in Wilson, 2008). 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 Wilson, 2008).

There have been several techniques developed to determine economic values for non-market ecosystem services. The method used for this study uses avoided cost and replacement cost 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. All ecosystem service values are reported in 2005 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 without the earth’s ecosystems and resources, life would not be possible, so essentially the value of nature is priceless. It is also important to note that the value of natural capital and its services will increase over time, as services such as water supply become increasingly scarce due to population growth and the anticipated effects of climate change, for example. The valuations of ecosystem services, however, provide an opportunity to rigorously assess the current benefits and the potential costs of human impact.

1. Water Quality, Supply, and Regulation

Forests and wetlands can reduce non-point source water pollution because they filter, store, and absorb pollutants, such as nitrogen and phosphorus. Studies by the U.S. Environmental Protection Agency show that forests in rural areas improve water quality because trees divert rainwater into the soil where bacteria and microorganisms filter out pollutants. This filtering significantly reduces the sediment, pollutants, and organic matter that reach streams.

i. Water Filtration Services

Natural cover in watersheds is vital for a clean and regular supply of safe drinking water. While there are no drinking water intakes in the Pefferlaw River, the water does drain to the lake, where eight communities draw their drinking water supply – cleaner water from the rivers will result in reduced treatment requirements. Studies have shown that treatment costs increase as forest and wetland cover decreases in watersheds.

The value of the current forest/wetland cover for water filtration services, based on the estimated daily residential water use in the Lake Simcoe watershed, is $209.86 per hectare.

ii. Water Regulation and Flood Control

Forests and wetlands also regulate the flow of water, providing protection against flooding and erosion. The loss of forest affects stream flows leading to instability in drainage systems, reduced infiltration of water into soils, and increased peak flows. Wetlands act as natural retention reservoirs for water, slowing its release. Changes in stream flow, due to forest and wetland loss, results in lower water levels in dry seasons, higher than normal water levels in wet seasons or storms, greater amounts of sediment entering rivers, and increased water temperatures (Ribaudo, 1986, in Wilson, 2008).

The value of water regulation by forests is calculated as a replacement value, which represents the construction costs for water runoff control if the current forest cover was removed and converted for urban land use. The forest cover provides savings because it provides green infrastructure for the region. The total annual savings are $1,886 per hectare. For each five per cent of forest cover converted to urban land use, the incremental cost is an estimated $458 per hectare per year.

The annual value of flood control by wetlands is based on an average ($4,039 per hectare), a value which was derived from the review of four different studies.

iii. Waste Treatment

Wetlands are effective waste treatment systems – constructed wetlands are often used to treat human and agriculture wastes. Depending on the type, size, plants, and soils, wetlands can regulate, filter, and absorb a significant amount of nitrogen, phosphorus, and other contaminants. In the absence of wetlands, these nutrients would otherwise need to be removed by treatment plants. The combined annual total for waste treatment of nitrogen and phosphorus by wetlands is estimated at $2,148 per hectare (based on a range of $1,061 to $3,235/ha/year).

2. Clean Air

Trees are essential because they produce oxygen for our air. On average, one tree produces nearly 260 pounds of oxygen each year. Forests and trees also provide improvements in air quality. Trees remove air pollution such as carbon monoxide and sulphur dioxide by adsorption through their leaves and they also intercept airborne particles by retaining them on their leaves. These pollutants can have significant economic impacts in terms of health damage costs, economic losses due to agricultural crop damages, visibility reduction, and soil damage.

The amount of air pollutants removed by the tree canopy cover was calculated for the report using CITYgreen software. This software calculates the value of air cleansing by trees using average removal rates of various pollutants by trees. The annual value of the service of pollutant removal by tree canopy cover is estimated at $377 per hectare.

3. Carbon Services

Globally, forests and wetlands function as large terrestrial banks of carbon, preventing increases in the level of greenhouse gases in the atmosphere. Forests and wetlands play an integral role in the global carbon cycle by pulling carbon from the atmosphere. As a result, large amounts of carbon are stored in trees, plants, roots, and soils.

i. Forests

Carbon storage and annual carbon sequestration by forests are often misunderstood. Forest carbon storage refers to the total amount of carbon contained in an ecosystem at a given time. Carbon sequestration refers to the annual amount of carbon uptake by an ecosystem after subtracting the carbon released to the atmosphere due to respiration, disturbance, and decomposition.

The economic value of the carbon stored by forests was calculated using the avoided cost (i.e. the damages avoided by the carbon stored). The Intergovernmental Panel on Climate Change reported that the average cost of global damages due to the level of carbon dioxide in the atmosphere in 2005 was $52 per tonne of carbon (IPCC, 2007, in Wilson, 2008). Lake Simcoe's forests store 220 tonnes of carbon per hectare. Therefore, the annual value of the carbon stored was worth an estimated $919 per hectare) in 2005.

The annual uptake of carbon (i.e. net carbon sequestration) was calculated using CITYgreen software. The average annual value of the carbon sequestered (approximately 0.75 tonnes of carbon per hectare) is $39 per hectare based on the average cost of carbon emissions ($52 per tonne of carbon).

ii. Wetlands

Carbon storage by wetlands was determined using Canada's Soil Organic Carbon Database (Tarnocai and Lacelle, 1996 in Wilson, 2008). Using data extracted from this database, the annual value of the carbon stored based on the average damage cost of carbon emissions ($52/tonne of carbon) was determined. The value per hectare ranges from $524 to $1,302 per year depending on the type of wetland, and the soil carbon ranges from 125 to 312 tonnes per hectare.

Based on average global carbon sequestration rates for wetlands of 0.25 tonnes per hectare per year (http://www.aswm.org/science/carbon/quebec/sym43.html), the rate of carbon uptake in the Lake Simcoe watershed was estimated to be worth $13 per hectare. This is most likely a very conservative estimate because other studies have found higher rates of carbon uptake (Fluxnet Canada, http://www.trentu.ca/academic/bluelab/research_merbleue.html, in Wilson, 2008).

iii. Agricultural Land and Grasslands

Organic carbon stored in the agricultural soils of the Lake Simcoe watershed was extracted from the Canadian Soil Organic Carbon Database (Tarnocai and Lacell, 1996, in Wilson, 2008). The average annual value of the carbon stored by agricultural soils was calculated to be $547 per hectare. The average soil carbon content is 131 tonnes of carbon per hectare, ranging from 125 tonnes to 252 tonnes of carbon per hectare depending on the type of agricultural land cover.

Grasslands, a classification which in this report includes cultural meadow, alvar meadow, and tallgrass prairie land covers, store an average of 100 tonnes of carbon per hectare. The annualized value of carbon storage is worth an estimated $438 per hectare per year.

4. Biodiversity

i. Habitat

Wetlands are well known for the important habitat they provide for many species, especially birds, amphibians, and reptiles. The Lake Simcoe watershed is home to at least 32 of the 175 species at risk in southern Ontario.

The annual value for wetland habitat services is $5,830 per hectare based on the average annualized wetland habitat restoration costs for a group of relevant Great Lakes Sustainability Fund projects (IJC Study Board, 2006, in Wilson, 2008). The annualized value of restoring habitat represents the value of wetland habitat in terms of the avoided cost of damages to habitat.

The avoided cost of the loss or degradation of wetland habitat is also significant because of the importance of wetlands for many species, especially species at risk. In Canada, more than 200 bird species (including 45 species of waterfowl) and over 50 species of mammals depend on wetlands for food and habitat; many of these are species at risk.

ii. Pollination

Pollination is the transfer of pollen from one flower to another, which is critical for fruit and seed production in most plants. Approximately 80 per cent of all flowering plant species are specialized for pollination by animals, mainly insects. Without this service, many interconnected species and ecosystems functioning within an ecosystem would collapse (Commission on Genetic Resources for Food and Agriculture, 2007, in Wilson, 2008). Insect pollination is necessary for most fruits and vegetables including many annual crops grown in the watershed.

Several studies have documented the significance of the proximity of natural habitat to cropland for optimum yield and increased farm production. A Canadian study found that canola yield is correlated to the proximity of uncultivated areas. The researchers found that optimum yield and profit would be attained if 30 per cent of the field areas were set aside for wild pollinator habitat (Morandin and Winston, 2006, in Wilson, 2008).

The annual value of pollination services for the subwatershed was estimated based on 30 per cent of farm crop value (global average of crop production dependent on pollination). Given the significance of natural cover for pollinator biodiversity, nesting habitat, food, and nectar, the total value of pollination services was allocated proportionally to idle agricultural lands, grazing lands, hedgerows/cultural woodland, forest lands, and grasslands with an average annual value per hectare of $951.

5. Recreation and Tourism

The most important industries associated with Lake Simcoe are tourism and recreation. Approximately $200 million is spent annually on tourism and recreation on the watershed. The many recreation activities undertaken in and around Lake Simcoe depend largely on the health of the watershed and the lake itself. Based on the annual value of tourism, the natural cover (forests/wetland/grassland) in the subwatershed is worth $1,231 per hectare. This value assumes that without natural areas, tourism and recreation would not be viable in the region.

6. Other Ecosystem Services

There are a number of other ecosystem services provided by the subwatershed. These are listed below:

- Mitigation of air pollution by grasslands and urban recreational areas
- Water regulation services by grasslands and urban recreational areas
- Erosion control and sediment retention by grasslands, pasture lands, hedgerows, and cultural woodlands
- Soil formation by grasslands, forests, and soil building by earthworms for cropland, pasture, and hedgerows
- Seed dispersal (i.e. the natural regeneration by trees)
- Nutrient cycling by pasture land and hedgerows
- Recreation values for pervious urban recreational areas (estimated at 50 per cent of the value for natural cover)

A summary of the value of the various ecosystem services by land cover type in the Pefferlaw River as well as for the whole Lake Simcoe watershed is provided in Table 9-1.

Table 9-1: Summary of non-market ecosystem service values by land cover type.

Land Cover Type	Value per hectare ($/ha/yr)	Area (ha) in sub-watershed	Total sub-watershed value ($million/yr)	Area (ha) in Lake Simcoe basin	Total basin value ($million/yr)
Forests	4,798	13,922.8	66.8	66,835*	320.7
Grasslands	2,727	1,296.8	3.5	7,576	20.7
Wetlands	11,172	7,412.9	82.8	41,472*	463.3
Water	1,428	170.1	0.2	994	1.4
Cropland	529	15,293.1	8.1	94,986	50.2
Hedgerows/Cultural Woodland	1,453	763.3	1.1	3,995	5.8
Pasture	1,479	4,724.0	7.0	25,989	38.4
Urban Parks	824	652.1	0.5	3,543	2.9
Total		**44,235.1**	**170.0**	**218,421**	**903.50****

* The area of swamps were included in the calculations for both forests and wetlands for this exercise

** This does not include the value of Lake Simcoe

9.4 Conclusions

As has been demonstrated, the natural systems of the Pefferlaw River subwatershed provide a number of goods and services. These so-called “free” ecosystem services have, in fact, significant value. The analysis in this report provided a first approximation of the value of the non-market services provided – totalling at least $170 million each year. This results in a significant cost savings to the watershed residents and users.

It is critical that the true value and the costs of potentially damaging these ecosystem services be taken more directly into account in decision making by the municipal and provincial government, and also by the business community. We also have the opportunity to build on existing ecosystem services by enhancing the natural capital of the subwatershed through the restoration of woodlands, wetlands, and other forms of natural cover, as well as through stewardship activities.

The ecosystem values presented in this report can be a useful tool for determining the potential changes in ecosystem services due to policy and land use decisions. For example, land use planning at the subwatershed scale can utilize the physical supply of services (e.g. tonnes of carbon stored or nutrients absorbed) and the service values (e.g. dollars per hectare) to assess the loss of services and the cost due to changes in the natural cover of the watershed to an alternate use. It is important to note that ecosystem values should not be relied on solely, but considered in conjunction with other sources of information, such as biophysical and non-monetary ecological information

Measuring the value of, and monitoring, natural capital and the ecosystem services that it provides will become even more important as the climate changes. The IPCC’s latest report states that human pressures on natural ecosystems need to be reduced in order for our ecological systems to cope with the changing climate. Landscape scale protection of land and ecosystems will provide the additional benefit of our greater ability to cope and adapt in the face of climate change.

APPENDIX A:

Pefferlaw River Subwatershed Plan (2012) Consolidated Recommendations

Pefferlaw River Subwatershed Plan (2012)
Consolidated Recommendations

Overview

In an effort to organize the significant number of recommendations that have been prepared as part of the Pefferlaw River Subwatershed Plan, the recommendations have been divided into sections related to water quality, water quantity, aquatic habitat, fluvial geomorphology and terrestrial natural heritage. Those recommendations recognized as priority items will be the basis for the development of an Implementation Plan which will be undertaken over the next 5 years to protect or improve the health of the Pefferlaw River subwatershed.

It is recognized that many of the undertakings in the following set of recommendations are dependent on funding from all levels of government and may only be implemented if funding is available.

Water Quality

Groundwater (Hydrogeologic and Hydrologic)

Recommendation #1 - That the Pefferlaw River subwatershed municipalities promote Low Impact Development (LID) practices and the adoption of Smart Growth Urban Design Guidelines within the watershed for new developments to further mitigate the impacts of urban development.

Recommendation #2 - That the municipalities in the Pefferlaw River subwatershed in cooperation with LSRCA, work to protect those hydrologic functions that are currently supporting the Pefferlaw River high quality coldwater ecosystem e.g. groundwater quality and quantity, baseflow, instream habitat, streambank corridors and wetlands.

Recommendation #3 - That the LSRCA in cooperation with the subwatershed municipalities improve the characterization of the surface-groundwater interaction (including water quality) in Ecologically Significant Groundwater Areas and Highly Vulnerable Aquifers within the Pefferlaw River subwatershed.

Recommendation #4 - That the municipalities through LSRCA continue to promote and educate the public about private well maintenance and offer technical support for private well decommissioning within the Pefferlaw River subwatershed.

Surface Water

Urban - improving stormwater

Recommendation #5 - That the municipalities of the Pefferlaw River subwatershed are encouraged to work with the LSRCA and the development industry to promote the increased use of innovative solutions to address stormwater management such as soakaway pits, infiltration galleries, permeable pavement and other LID solutions. When new facilities are recommended, reduction of thermal impacts of those stormwater ponds will be considered in their design.

Recommendation #6 - That the municipalities of the Pefferlaw River subwatershed support the on-going inventory, installation and proper maintenance of oil grit/hydrodynamic separators combined with the use of technologies to enhance their effectiveness where this is appropriate; and where practical and feasible, enhance measures to control TSS.

Recommendation #7 - That the Province of Ontario, through the implementation of the Lake Simcoe Phosphorus Reduction Strategy, provide significant incentive funding to the related municipalities and/or the LSRCA to maintain, construct and /or retrofit stormwater facilities as identified by the LSRCA Stormwater Rehabilitation program.

Recommendation #8 - That the LSRCA strongly encourage routine maintenance of existing stormwater facilities by municipalities and continue to undertake the completion of stormwater retrofit projects in partnership with municipalities, subject to budget allocations. The criteria for maintenance should 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 undertaking retrofit projects throughout the watershed.

Recommendation #9 - That the federal and provincial governments provide financial incentives to allow municipalities to implement an enhanced street sweeping program targeted to uncontrolled urban areas.

Urban – reducing salt (chloride)

Recommendation #10 - That the LSRCA, municipalities and NGO's undertake a program to raise awareness and to educate property owners and property managers about salt management, and work with snow removal contractors to encourage their adoption of the salt applicator's license program, recognizing that public safety remains paramount.

Recommendation #11 - That the municipalities in conjunction with the LSRCA review the locations of their snow disposal sites and investigate innovative ways of reducing the impacts of excess chloride through the use of storage facilities such as wetland cells and/or stormwater treatment facilities.

Recommendation #12 - Recognizing that increasing concentrations of chloride in watercourses is an emerging issue shared by all municipalities in the Lake Simcoe watershed, that 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.

Urban – construction practices

Recommendation #13 - That the LSRCA and partner municipalities promote the adoption of sustainable site alteration and construction practices in the Lake Simcoe watershed through the preparation of a construction phase code of best management practices that is updated as necessary to ensure contemporary standards are maintained.

Recommendation #14 - That the partner municipalities and LSRCA improve current monitoring and enforcement of site alteration by-laws by undertaking a review of the current programs and developing a funding model that ensures adequate resources are available for improvements.

Agriculture

Recommendation #15 - That the watershed municipalities seek opportunities for input with existing Committees established through the LSPP for example, to encourage co-operative ways to implement phosphorus reduction measures within Lake Simcoe's watersheds and to develop 'action plans' for their implementation within the agricultural and rural communities.

Recommendation #16 -That a stewardship initiative is developed and implemented to offer incentives and work with landowners in the Pefferlaw River subwatershed.

Recommendation #17 - That in order to deal with the predicted increases in P loading (Pefferlaw R. @515kg), and to help address the high P concentrations in Lake Simcoe and as part of the Phosphorus Reduction Strategy in the LSPP, the LSRCA and its partners need to research innovative methods of P reductions and encourage MOE to explore water quality trading. The local agricultural community and landowners need to be engaged directly in this dialogue.

Recommendation #18 - That the LSRCA continue to offer, and where possible expand upon, stewardship incentives in the agricultural community of the Pefferlaw River subwatershed to deal with manure, management, milk house wastes, chemical and fuel storage, and water use and reuse.

Recommendation #19 - That the Federal, Provincial and Municipal governments provide consistent, long-term and sustainable funding to ensure continued delivery of stewardship programs.

Recommendation #20 - That the Province provide increased funding to support the current Environmental Farm Plan program and its 'on the ground' local improvements.

Recommendation #21 - That the OMAFRA, OFA, and landowner representatives in conjunction with LSRCA investigate changing trends in agricultural production within the Pefferlaw River subwatershed and to provide innovative BMP's for those new specialty crops such as Asian vegetables to the agricultural community.

Monitoring and Assessment

Recommendation #22 - That the LSRCA continue to maintain and/or enhance the existing monitoring network. This sampling should be continued into the future to assess the state of water quality in the Pefferlaw River subwatershed, and to determine/monitor any trends (including seasonal trends), emerging contaminants, or new substances of concern that may arise. At a minimum, the Toxic Pollutants Screening Study (LSRCA, 2004) should be repeated, but in a more targeted way to assess pesticides and pharmaceuticals based on land use.

Recommendation #23 - That expansion of the PWQMN or another more appropriate water sampling program should be considered in the Lake Simcoe watershed to capture proposed land use changes that could impact water quality. This enhanced monitoring would be used to capture data that is representative of the entire Pefferlaw River subwatershed e.g. from headwaters to mid reaches to the mouth at Lake Simcoe.

Recommendation #24 - That the current LSRCA monitoring network be reviewed annually to ensure it meets the surveillance/compliance goals of the monitoring strategy and as required, allow for special projects to be undertaken to address emerging trends.

Recommendation #25 - That water quality results are analyzed and reported annually and that the information be used to update the LSRCA Watershed Report Card. Further, stakeholders should be provided access to the water quality data collected via a web portal to increase distribution and communication links.

Water Quantity

Water Demand

Recommendation #26 - That the MOE be encouraged to continue to improve the WTRS (Water Taking Reporting System) by integrating the Permit To Take Water (PTTW) database with the Water Well Information System (WWIS) database, and connect those takings to wells/aquifers to facilitate impact assessment i.e. the PTTW database needs to be connected to the WWIS (Water Well Information System) database.

Recommendation #27 - That the MOE be encouraged to exercise their authority to restrict PTTW where emergency conditions dictate (e.g. low water response).

Recommendation #28 - That the Low Water Response program continue to ensure that water supply and ecosystem integrity can be protected and maintained in low water conditions; further that the Low Water Response system be used to reinforce communication and provide consistent messaging and better adoption of water restrictions during dry or drought periods.

Recommendation #29 - That the MOE be encouraged to consider sensitive hydrogeologic and hydrologic features (e.g. wetlands, SGRAs, coldwater reaches, losing and gaining reaches, ESRGAs in the future) identified in the Pefferlaw River subwatershed plan, in the review of PTTW applications.

Recommendation #30 - That the MOE be encouraged to routinely audit water takers to determine if they are in compliance with their PTTW, or to ensure permits are obtained when necessary.

Recommendation #31 - That the MOE through the PPTW process, investigate and implement innovative ways to reduce demand on surface waters during peak summer use. Options such as: promoting the taking of groundwater where appropriate; use of deeper wells; and if possible capturing spring stream flow or tile drainage in off-line storage facilities e.g. linear wetland for use during low flow periods, should be considered. The amount available for capture during spring flow should be determined through the development of ecological flow targets.

Recommendation #32 - That the LSRCA and the partner municipalities promote and support water conservation and reuse initiatives. These initiatives should have an emphasis on reducing water demand during the summer months and drought periods, and to incorporate low impact design (LID) solutions such as rainwater harvesting, and grey water reuse.

Recommendation #33 - That the LSRCA with the support of the municipalities and the Province improve the PRMS model outputs by maintaining and improving the surface water monitoring network through the strategic installation of more stream gauges.

Ecological Flows

Recommendation #34 - That the MOE and its local partners develop and implement more specific PTTW requirements in 'stressed' subwatersheds to meet, when defined, the instream flow regime for that system. In addition, that the MOE and its local partners will ensure all permits related to 'stressed' subwatersheds will receive a full review, such that MOE can determine if >10% baseflow is sufficient protection at least until the ecological flow regime has been determined.

Recommendation #35 - That the MNR and MOE in conjunction with LSRCA develop a more detailed surface water budget for the Pefferlaw River subwatershed that will provide basis of actions needed to determine instream flow targets.

Recommendation #36 - That the MOE and MNR with assistance from LSRCA determine ecological flow targets for the Pefferlaw River. These E-flow targets should be based on the Guidance Document framework (LSRCA 2010) which is being used for the Maskinonge River subwatershed.

Recommendation #37 - That based on long term monitoring of brook trout index spawning locations (refer to Recommendation # 56, Chapter 6 - Aquatic Habitat)**,** use that information as a field verification for groundwater-baseflow interaction (volume, location, temperature) and in future Ecologically Significant Groundwater Recharge Area work.

Reducing Impact of Land Use

Recommendation #38 - That the municipalities amend their Official Plans, if deemed necessary, to recognize recharge zones in maintaining the quantity and quality of groundwater required for a healthy watershed.

Recommendation #39 - That the LSRCA and its partners complete the ESGRA (Ecologically Significant Groundwater Recharge Areas) mapping as soon as possible.

Recommendation #40 - That the municipalities attempt to achieve a Post-development infiltration equals Pre-development infiltration policy within SGRAs and once developed, ESGRAs.

Recommendation #41 - That the municipalities adopt policies for the protection of ESGRA's under the LSPP Policy 6.38 into their Official Plans, once completed.

Climate Change

Recommendation #42 - That the MOE and MNR in cooperation with the LSRCA and input from municipal partners develop a transient and preferably a fully-integrated model with full river-routing capabilities to investigate the seasonal implications and ecological impacts of climate change, in terms of increase peak flows, reduced baseflows and increased water demand.

Recommendation #43 - That the MOE and MNR will develop a Risk Management Framework for climate change for the Pefferlaw River subwatershed.

Recommendation #44 - That the LSRCA seek input from 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 the Pefferlaw River subwatershed (vulnerable) through stream rehabilitation, streambank planting, barrier removal and other BMP implementation in conjunction with the protection of current hydrologic functions.

Aquatic Habitat

Stewardship Implementation – increasing uptake

Recommendation #45 - That the MNR, MOE, OMAFRA, and LSRCA continue to implement stewardship projects in the Pefferlaw River subwatershed, and encourage other interested organizations in doing the same.

Recommendation #46 - That governmental and non-governmental organizations should continue to improve coordination of programs to: (1) avoid inefficiencies and unnecessary competition for projects, and: (2) make it easier for landowner to know which organization they should be contacting for a potential project, using tools such as a simple web portal.

Recommendation #47 - That the Federal, Provincial and Municipal governments provide consistent, long term and sustainable funding to ensure continued delivery of stewardship programs.

Recommendation #48 - That the MOE, MNR, OMAFRA, and LSRCA support research to determine barriers limiting uptake of stewardship programs in these subwatersheds, share these results with members of the Lake Simcoe Stewardship Network, and revise stewardship programs or stewardship outreach 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 #49 - That the MOE, MNR, OMAFRA, and LSRCA investigate new and innovative ways of reaching target audiences in the local community and engage/involve 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. Results of these efforts should be shared with members of the Lake Simcoe Stewardship Network, municipal councils and agricultural groups.

Stewardship Implementation – prioritize projects

Recommendation #50 - That the LSRCA, in collaboration with MNR and MOE, should develop a spatially-explicit prioritization tool to assist in targeting stewardship aquatic habitat projects in the Lake Simcoe watershed. In the context of the Pefferlaw River subwatershed, this decision tool should take into account:

- The need to incorporate each major type of aquatic habitat stressor including bank hardening, barriers, riparian cover and on-line ponds;
- 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, increase connectivity for movement within and between tributaries, and shelter.

Recommendation #51 - That prioritized restoration areas be integrated into development of a stewardship plan that ensure prioritized restoration opportunities are undertaken in consultation with landowners as soon as feasible. This stewardship plan needs to incorporate outcomes of recommendations to improve uptake identified in Recommendations 45 through 48.

Recommendation #52 - In alignment with recommendation 50 and 51, LSRCA shall seek input from municipal partners to improve stream connectivity through a priority setting exercise specific to barrier/dam removal or retrofitting. It must be noted that priority setting exercise needs to include the recognition of the need to partition and/or restrict other competitive species of fish (e.g. brown trout, rainbow trout, round goby) from existing brook trout populations. Upon completion of the ‘reconnection’ program, LSRCA and partners will develop a communications plan for its implementation.

Impacts to Hydrologic Regime

Recommendation #53 - That the LSRCA with assistance from MNR and MOE establish ecological flows targets (also known and E-flows or in-stream targets) for the Pefferlaw River. These ecological flow targets should be based on the framework established for the Maskinonge River. Once established, E-flows should form the basis of strategy to achieve suitable E-flow within the Pefferlaw River. This strategy should also protect baseflow and location of upwellings in order to maintain thermal stability.

Recommendation #54 - That the LSRCA work with the municipalities and OMAF to promote innovative forms of cost effective municipal drain maintenance, or opportunities to create new drains using principles of natural channel design. Look for opportunities to decommission when the land use changes.

Monitoring and Assessment

Recommendation #55 - That the LSRCA with support and input from Municipalities, the Province, and private interests aim for improved spatial and temporal resolution in annual monitoring of aquatic habitat, including water quality, fish and benthic indicators.

Recommendation #56 - That the LSRCA, with support and input from Municipalities and the Province, undertake a baseline assessment of brook trout spawning areas within representative reaches of the Pefferlaw River, and from this, develop a routine monitoring program to continually assess natural reproduction and survival of aquatic communities.

Recommendation #57 - That the LSRCA and the Ministry of Natural Resources continue current cooperative fish community monitoring, assess information gaps and work together to quantify and assess the quality of critical fish habitats in the lake and its tributaries.

Recommendation #58 - In conformance with the LSPP, that the Ministry of Natural Resources lead the development of fish community goals and objectives for Lake Simcoe and its tributaries, in conjunction with the LSRCA and input from partner municipalities and to identify recommendations and develop an implementation plan containing priority enhancement opportunities for the Pefferlaw River.

Fluvial Geomorphology

Recommendation #59 - That the LSRCA and with input from municipal partners, in locations where channel stability is already considered to be 'low', assess those specific sites, develop priorities, assess the possibility of using 'new'/innovative solutions and then repair.

Recommendation #60 - That the LSRCA continue to work with owners of recently documented channelized reaches of stream (see BMP inventory) to develop priority list and implement solutions, such as Natural Channel Design.

Recommendation #61 - That the LSRCA with input from its municipal partners develop a complimentary fluvial geomorphic monitoring program to be used as a long term assessment tool in order to evaluate change (beyond the natural flow regime) in the channel geometry and/or sediment character of the Pefferlaw River and to identify potential causes of that change.

Terrestrial Natural Heritage

Gaps in Key Natural Heritage Protection Policies

Recommendation #62 - That the City of Kawartha Lakes and the Durham Regional Official Plans be amended at an appropriate time, to contain policies that would apply DP 6.23-6.29 (key natural heritage feature policies) of the Lake Simcoe Protection Plan for those lands beyond the Natural Heritage System within the Protected Countryside of the Greenbelt.

Recommendation #63 - That the subwatershed municipalities examine the feasibility of amending official plan policies to provide adequate mitigation and compensation on site alteration within natural features that are not defined as key natural heritage features.

Recommendation #64 - 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 of 'high quality' natural heritage features, and provide policy recommendations (as necessary) to ensure high quality natural heritage features are adequately protected upon the update of this subwatershed plan.

Grassland protection

Recommendation #65 - That the MNR, OMAFRA, 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 #66 - That subwatershed municipalities, with the support of the MNR and LSRCA, examine the feasibility of incorporating action plans, programs and amending official plans related to grassland protection, contingent on the studies being conducted on methods and policy to protect such grassland.

Land securement by public agencies

Recommendation #67 - That the LSRCA, with input from municipalities continue to secure outstanding natural areas for environmental protection and public benefit, through tools such as land acquisition or conservation easement.

Recommendation #68 - That the Federal, Provincial and Municipal governments provide consistent and sustainable funding to ensure continued delivery of land securement programs.

Recommendation #69 - That the LSRCA, MNR, and municipalities should continue to refine their land securement decision processes to ensure that they are securing natural areas that are critical to the health of the watershed (or securing and restoring areas which have the potential to become critical to the health of the watershed), but which are otherwise vulnerable to loss through incompatible land uses.

Stewardship Implementation – increasing uptake

Recommendation #70 - That the MNR, MOE, OMAFRA, and LSRCA continue to implement stewardship projects in the Pefferlaw River subwatershed, and encourage other interested organizations in doing the same.

Recommendation #71 - That governmental and non-governmental organizations should improve coordination of programs to: (1) avoid inefficiencies and unnecessary competition for projects, and: (2) make it easier for landowner to know which organization they should be contacting for a potential project, using tools such as a simple web portal.

Recommendation #72 - That the Federal, Provincial and Municipal governments provide consistent and sustainable funding to ensure continued delivery of stewardship programs.

Recommendation #73 - That the MOE, MNR, OMAFRA, and LSRCA support research to determine barriers limiting uptake of stewardship programs in these subwatersheds, share these results with members of the Lake Simcoe Stewardship Network, and revise stewardship programs or stewardship outreach 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 #74 - That the MNR, MOE, OMAFRA, and LSRCA investigate new and innovative ways of reaching target audiences in the local community and engage/involve 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. Results of these efforts should be shared with members of the Lake Simcoe Stewardship Network.

Stewardship Implementation – prioritize projects

Recommendation #75 - That the MNR, in collaboration with MOE and LSRCA, should develop a spatially-explicit decision support tool to assist in targeting stewardship projects in the Lake Simcoe watershed. In the context of the Pefferlaw River subwatershed, this decision tool should take into account factors including:

- the need to increase riparian cover along the tributaries of the Pefferlaw River subwatershed
- protecting and restoring ecologically significant groundwater recharge areas, to help mitigate the expected impacts of climate change
- opportunities to increase connectivity across the subwatersheds for dispersing flora and fauna
- Potential impacts to grasslands such as cultural meadows
- Land securement as the most feasible approach to obtaining suitable land for priority restoration opportunities

Dealing with indirect impacts

Recommendation #76 - That the LSRCA and municipalities 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 #77 - That the MOE and its partners provide outreach to garden centres, landscapers and garden clubs regarding the danger of using invasive species in ornamental gardens and to promote the use of species native to the region that will be able to adapt to projected climate change.

Recommendation #78 - That the partner municipalities make information readily available to their residents on the importance of native plant landscaping, active transportation, and the impacts of uncontrolled house pets to natural areas.

Filling data gaps

Recommendation #79 - That the LSRCA, MNR and MOE continue to maintain an up-to-date seamless Ecological Land Classification map for the watershed, managed in such a way as to allow change analysis (for example in 5 year increments for priority subwatersheds).

Recommendation #80 - 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.

Introduction of Invasive Species

Recommendation #81 - In reviewing any development proposal adjacent to a natural heritage features, the review agencies will promote that any vegetation being planted be native to the region, and will have be tolerant to climate change impacts, and further that planting of species native to the region is encouraged in property management programs.

Recommendation #82 - That the MNR ensure completion of early detection and rapid response plans for priority terrestrial species identified in the LSPP Watch List. In accordance with the LSPP these plans should be completed by 2015.

Recommendation #83 - That the MNR develops a communications plan to educate public and private constituents in the monitoring and eradication of invasive aquatic species.

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