

**TO:** Chair and Members of the Authority  
Meeting #9/08, November 28, 2008

**FROM:** Deborah Martin-Downs, Director, Ecology

**RE: CENTREVILLE CREEK SUBWATERSHED STUDY SYNTHESIS REPORT**

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**KEY ISSUE**

Approval of the final Centreville Creek Subwatershed Study Synthesis Report and ongoing implementation of the recommendations.

**RECOMMENDATION**

**THAT the Centreville Creek Subwatershed Study Synthesis Report, dated November 2008, be approved;**

**THAT copies of the report be sent to the Region of Peel, Town of Caledon, Humber Watershed Alliance and other appropriate partners for their reference and endorsement;**

**THAT the Region of Peel be commended for implementing a subwatershed based approach in their studies to evaluate options for municipal water supply servicing in the Village of Caledon East, Town of Caledon;**

**AND FURTHER THAT staff be directed to continue to work with municipalities and other partners to implement the recommendations of the report.**

**BACKGROUND**

As a headwater tributary of the Humber River, Centreville Creek flows from the Niagara Escarpment and Oak Ridges Moraine, through the Village of Caledon East in the Town of Caledon, and into the main branch of the Humber River at Albion Hills Conservation Area. Centreville Creek subwatershed contains a high concentration of good quality natural habitats including large forested areas, numerous and extensive wetlands and coldwater fish habitats. While the majority of Centreville Creek subwatershed is rural and protected from urban growth by the *Niagara Escarpment Plan, 1994*, *Oak Ridges Moraine Conservation Plan, 2002* and *Greenbelt Plan, 2005*, expansion of urban settlements in the Village of Caledon East is planned and requires additional municipal water supply infrastructure to service the new settlements.

In December 2002, Toronto and Region Conservation Authority (TRCA) initiated the Centreville Creek subwatershed study in partnership with the Region of Peel and Town of Caledon. The study was initiated to collect, integrate and summarize information on baseline conditions to inform Region of Peel studies that were evaluating options for servicing planned new developments in Caledon East with municipal water supply. At the time, studies were underway to evaluate the option of utilizing an existing artesian well in the area as a pumped municipal well. The subwatershed study also provided an opportunity to examine local watershed management issues and opportunities, and formulate recommendations for local actions that would contribute to achieving the objectives of the Humber River watershed strategy, *Legacy: A Strategy for a Healthy Humber*.

## Study Process and Products

The first phase of the study involved collecting field data to establish baseline conditions. New information collected through the study was provided to consultants working on Region of Peel studies to evaluate options for servicing new developments in Caledon East with municipal water supply. New information included:

- installation of a new permanent stream flow gauge on Centreville Creek at Albion Hills Conservation Area in 2002;
- field assessment of all terrestrial natural heritage patches in the study area (approximately 3,800 hectares) during 2002 and 2003 (only limited data had previously existed);
- full baseflow monitoring survey, which established an improved understanding of baseline low stream flow conditions and groundwater/surface water interactions;
- permeameter measurements to field verify groundwater infiltration rates, discharge rates and locations of groundwater discharge which was used to strengthen the York-Peel-Durham-Toronto groundwater database and groundwater modelling assumptions;
- assessments of channel form which characterized reaches and indicator sites and established criteria for use in designing stormwater management controls in new developments to help mitigate increases to channel erosion rates;
- assessment of natural riparian vegetation to identify opportunities for tree and shrub plantings;
- survey of agricultural land uses and practices, which was used to predict predominant source areas for agricultural non-point source water contaminants;
- inventory of on-line ponds which was used to identify opportunities to improve fish passage and mitigate thermal impacts on coldwater fish habitat;
- in-stream temperature monitoring to improve understanding of the extent of coldwater fish habitat in the study area and identify high priority areas for riparian plantings and thermal impact mitigation initiatives.

A study steering committee was established involving representatives of the planning and public works departments of the Region of Peel and Town of Caledon, TRCA, Humber Watershed Alliance and Niagara Escarpment Commission. Steering committee meetings were held to review the study work plan and drafts of study reports.

A stakeholder focus group was also formed to bring together elected officials, municipal staff and stakeholder groups and provide a forum for their review of study findings and input on recommendations. Two stakeholder focus group workshops were held in Caledon East on August 13th and September 30, 2003. Each meeting was attended by approximately 15 participants. Input was provided on local watershed management issues of concern and opportunities for stewardship and naturalization initiatives. They provided comments on the information presented to them regarding baseline conditions, and confirmed the management objectives established by *Legacy: A Strategy for a Healthy Humber* as being a suitable framework on which to base subwatershed study recommendations.

A draft *Characterization Report* providing a summary of baseline conditions, local watershed management issues and opportunities and draft management recommendations was completed in June 2003 and reviewed by the study steering committee. At the time, information regarding the groundwater system from the York-Peel-Durham-Toronto (YPDT) Groundwater Management Project was not available because the regional groundwater model did not yet include the study area. A groundwater modelling study had recently been completed for the Region of Peel that included the study area but the results required further evaluation and were considered preliminary at the time. It was decided that finalization of the *Characterization Report* should be delayed so that new information anticipated to come from the YPDT Groundwater Management Project could be integrated with other information on baseline conditions. It was felt that this new information would significantly improve the current understanding of subwatershed system function and groundwater/surface water interactions. While work on other aspects of the subwatershed study continued, information from the expanded YPDT regional groundwater flow model was not available until 2006.

In 2004 the Region of Peel's study evaluating options for water supply servicing of planned new developments in Caledon East concluded that utilizing the existing artesian well in the study area as a pumped municipal well was not feasible. Further evaluation of the option of increasing pumping rates from existing wells was undertaken. Baseline information collected through the subwatershed study was used to inform the monitoring and hydrogeological studies required to support an application for new permits to take water.

Work on the second phase of the Centreville Creek subwatershed study between 2003 and 2004 involved examining potential effects that anticipated future land uses could have on the health of the subwatershed and evaluating alternative scenarios of management action. Computer modelling techniques and expert analysis were used to predict the response of the subwatershed system with regard to surface water hydrology (using an HSPF water budget and continuous hydrologic simulation model), and surface water quality (using an Agricultural Non-point Source - AGNPS model). Three scenarios were examined:

- 1) baseline conditions (defined by 1999 land use);
- 2) anticipated new development to 2021 with a conventional management approach; and,
- 3) anticipated new development to 2021 with implementation of the TRCA target terrestrial natural heritage system.

Technical reports were completed documenting the results from the surface water hydrology and surface water quality scenario modelling studies. Steering committee meetings were held in November 2003 and April 2004 to review and discuss findings from scenario modelling studies and the format of the final study report.

Based on an integrated examination of information on baseline conditions, findings from scenario modelling and analysis work and input from Steering Committee members, recommendations for action were developed. It was recognized that the recommendations would need to be reviewed and confirmed or revised, once new information regarding the groundwater system and groundwater-surface water interactions was available from the YPDT groundwater model.

## **Key Study Recommendations**

Key findings and recommendations of the final Centreville Creek Subwatershed Study Synthesis Report are as follows:

### *Existing and Future Urban Areas*

- Region of Peel should continue to implement monitoring of groundwater levels to track effects of increased pumping from municipal wells and implement adaptive management measures if established thresholds are exceeded.
- Town of Caledon and TRCA should work together to implement improvements to stormwater management in existing portions of the Village of Caledon East with no stormwater treatment as part of future infrastructure improvements, redevelopment and infill development initiatives.
- Planning and design of new urban settlements should be based on design principles that minimize changes to pre-development water balance (i.e. pre-development rates of infiltration, run-off and evapotranspiration). Innovative urban designs that minimize impervious surfaces, maintain the function of small drainage features, incorporate stormwater controls that promote infiltration of run-off and utilize technologies such as green roofs and rainwater harvesting cisterns should be considered as part of the overall stormwater management strategy.
- Town of Caledon should require stormwater management plans associated with proposed new developments in the Village of Caledon East to include stormwater management facilities designed to control stream bank erosion through run off reduction. The design of new stormwater management facilities, including lot level and conveyance controls should be informed by continuous hydrologic simulation modelling using the HSPF model developed for Centreville Creek subwatershed, or another continuous simulation hydrologic model, and available information regarding the characteristics and sensitivity of stream channels.
- Planning and design of the natural heritage system and open space system within new urban settlements should take into consideration the lands within the subwatershed that have been targeted for securement and restoration of natural cover through the Terrestrial Natural Heritage System Strategy and consider ways to improve habitat quality and maintain or improve biodiversity.
- Region of Peel and Town of Caledon should consider alternatives to spreading of road de-icing salt as part of winter road maintenance programs within wellhead protection areas in the Village of Caledon East as a drinking water source protection strategy.
- Monitoring of the effectiveness of community design and management measures that will be put in place in new developments to mitigate potential negative environmental impacts should be undertaken as part of an adaptive management approach.

### *Natural and Cultural Heritage*

- Management of natural areas in existing and new urban settlements should include measures to avoid or mitigate negative influences on habitat quality associated with surrounding land uses, including enhancement of remaining habitat patches to improve size and shape, fencing to prevent uncontrolled access, provision of planned access points and trail infrastructure in public greenspace areas, enforcement of municipal by-laws restricting encroachments on public lands, and planned off-leash pet areas separate from sensitive natural features.



- Town of Caledon should develop interpretive signs, resources or programs highlighting local natural and cultural heritage features along local and inter-regional trails (i.e. Caledon Trailways portion of the Trans-Canada Trail).
- Town of Caledon should consider available information on the cultural heritage of the area when assigning place names associated with new urban settlements and utilized in programs at new public facilities to help new residents connect with the cultural heritage of the area.

#### *Rural Areas*

- TRCA should continue to promote rural and agricultural best management practices that reduce the risk of contamination of surface waters from land-based activities (e.g. vegetated riparian buffers, upgraded manure storage facilities, improved washwater management) and improve natural habitat. Rural Clean Water Program staff should contact landowners with land holdings in areas identified as predominant source areas for surface water contaminants to promote best practices and tree and shrub planting programs.
- TRCA should work with tenant farmers leasing lands adjacent to Albion Hills Conservation Area to improve manure storage facilities and spreading activities and undertake riparian tree and shrub plantings.
- TRCA should continue to work with landowners with land holdings in areas identified as high priority for naturalization to promote tree and shrub planting, wetland restoration and other rural best management practices.
- TRCA should work with landowners to mitigate high priority in-stream barriers to fish movement associated with on-line private ponds and adapt outlet structures to reduce downstream thermal impacts.

An electronic copy of the full report can be downloaded from the Humber River page in the watershed strategies section of the TRCA website ([www.trca.on.ca](http://www.trca.on.ca)). Contact TRCA staff to obtain a hard copy of the full report.

#### **Rationale for Study Hold**

In 2004, concurrent with work on the Centreville Creek subwatershed study, TRCA staff was also engaged in developing watershed plans for the Rouge and Humber rivers watersheds to assist the Region of Peel, Region of York and City of Toronto in fulfilling the requirements of the *Oak Ridges Moraine Conservation Plan*. It was decided that, because finalization of information on baseline conditions was awaiting input from the YPDT groundwater model and that timely input regarding available baseline information had been provided to the Region of Peel for their studies, that the subwatershed study would be put temporarily on hold so that TRCA staff efforts could be focused on meeting the legislated deadlines for Oak Ridges Moraine watershed plans. Key findings and management recommendations from the Centreville Creek subwatershed study were conveyed to TRCA staff working on the Centreville Creek Community Outreach and Environmental Stewardship Program. This information was also integrated into the Humber River watershed planning study. Upon completion of the Humber River watershed plan in June 2008, staff immediately resumed work on completion of the subwatershed study documentation.

### **Use of Study Products To Date**

As noted above, baseline information collected through the subwatershed study was used to inform the Region of Peel's studies to evaluate options for servicing new developments in Caledon East with municipal water supply. It also contributed to hydrogeologic studies and monitoring undertaken for the Region of Peel to support their applications for new permits to take water from existing wells.

Concurrent with preparation of the final study report, TRCA commenced the three year Centreville Creek Community Outreach and Environmental Stewardship Program in 2004 to increase awareness and educate the community about environmental issues impacting the subwatershed. This program included hands-on initiatives such as monitoring, habitat creation, watershed clean-ups and tree plantings that empowered and engaged the community. Information regarding priority areas for improved stewardship and opportunities for naturalization from the Centreville Creek subwatershed study was used to guide initiatives undertaken through this program. Program achievements included:

- engaged 3,500 individuals;
- 25 community planting events;
- 12 community clean-up events;
- worked with 57 school groups;
- planted 1,900 aquatic plants;
- planted 17,200 native trees and shrubs;
- installed 90 wildlife habitat structures;
- completed 9 monitoring programs;
- hosted 4 educational workshops;
- assisted 33 private landowners with stewardship initiatives.

### **Current Context and Role for the Subwatershed Study Synthesis Report**

Through the Humber River watershed planning study, updated information on baseline conditions in Centreville Creek subwatershed was included in the *Humber River State of the Watershed Reports*, and updated and more comprehensive management recommendations were put forward in the *Humber River Watershed Plan and Implementation Guide*. While the Humber River watershed reports are the most up-to-date sources of information on baseline conditions and management recommendations, the *Centreville Creek Subwatershed Study Synthesis Report* provides more detailed direction regarding local opportunities for improved stewardship and naturalization initiatives and should continue to be considered a primary source of information to guide work on community outreach and environmental stewardship initiatives in the area.

### **DETAILS OF WORK TO BE DONE**

TRCA staff will take the following steps to facilitate the transition from study recommendations to action:

- circulate copies of the *Centreville Creek Subwatershed Study Synthesis Report* to municipal partners to inform their environmental programs and planning processes for new urban settlements in the Village of Caledon East, and to the Humber Watershed Alliance to inform their community action site initiatives in Caledon East;
- work with Town of Caledon staff and development proponents to design an adaptive management monitoring program for the Caledon East community to evaluate the effectiveness of community design and management measures that will be put in place to mitigate potential negative environmental impacts of new developments;

- use findings to inform the ongoing implementation of the Rural Clean Water Program, Healthy Yards Program, Caring for the Moraine Landowner Contact Program and other environmental stewardship and outreach activities in the area.
- use findings to inform on-going drinking water source protection planning work.

#### **FINANCIAL DETAILS**

Funding was provided for the Centreville Creek Subwatershed Planning Study by the Regional Municipality of Peel through the Peel Water Management Project.

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**Date: November 7, 2008**



# Centreville Creek Subwatershed Study Synthesis Report

November 2008

Prepared by



In partnership with





# Preface

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In December 2002, Toronto and Region Conservation (TRCA) initiated the Centreville Creek subwatershed study in partnership with the Region of Peel and Town of Caledon. The study was initiated to collect, integrate and summarize information on baseline conditions to inform Region of Peel studies that were evaluating options for servicing planned new developments in Caledon East with municipal water supply. The subwatershed study also provided an opportunity to examine local watershed management issues and opportunities and formulate recommendations for local actions that would contribute to achieving the objectives of the Humber River watershed strategy, *Legacy: A Strategy for a Healthy Humber*.

This *Centreville Creek Subwatershed Study Synthesis Report* summarizes, integrates and documents the findings and recommendations from work on the subwatershed planning study conducted between January 2003 and December 2004. Work on the study was temporarily put on hold in 2005 in anticipation of additional information on the groundwater system becoming available from the York-Peel-Durham-Toronto (YPDT) groundwater model, and in order to focus resources on completing the Humber River watershed planning study to meet the requirements of the *Oak Ridges Moraine Conservation Plan, 2002*. While the *Centreville Creek Subwatershed Study Synthesis Report* was finalized in 2008, the information on baseline subwatershed conditions represents what was available between January 2003 and December 2004.

Updated and more comprehensive information on baseline conditions for the entire Humber River watershed has been integrated and reported in the TRCA's *Humber River Watershed Plan – Pathways to a Healthy Humber*, *Humber River Watershed Plan Implementation Guide*, and supporting State of the Watershed reports in 2008. The *Humber River Watershed Plan* and *Implementation Guide* also provide updated and more comprehensive management recommendations. These documents are the primary source of information on baseline conditions and management recommendations that should be used to inform planning and management initiatives and programs affecting Centreville Creek subwatershed.

While the Humber River watershed reports are the most up-to-date sources of information on baseline conditions and management recommendations, this *Centreville Creek Subwatershed Study Synthesis Report* provides more detailed direction regarding local opportunities for improved environmental stewardship and naturalization initiatives. The primary use of this report is to guide work on community outreach and stewardship programs and initiatives in the area. Direction regarding high priority areas for improved stewardship and naturalization provided through this study has already been used to guide numerous initiatives undertaken from 2004 to 2007 through the Centreville Creek Community Outreach and Environmental Stewardship Program.

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# PART 1 INTRODUCTION

## 1. Background

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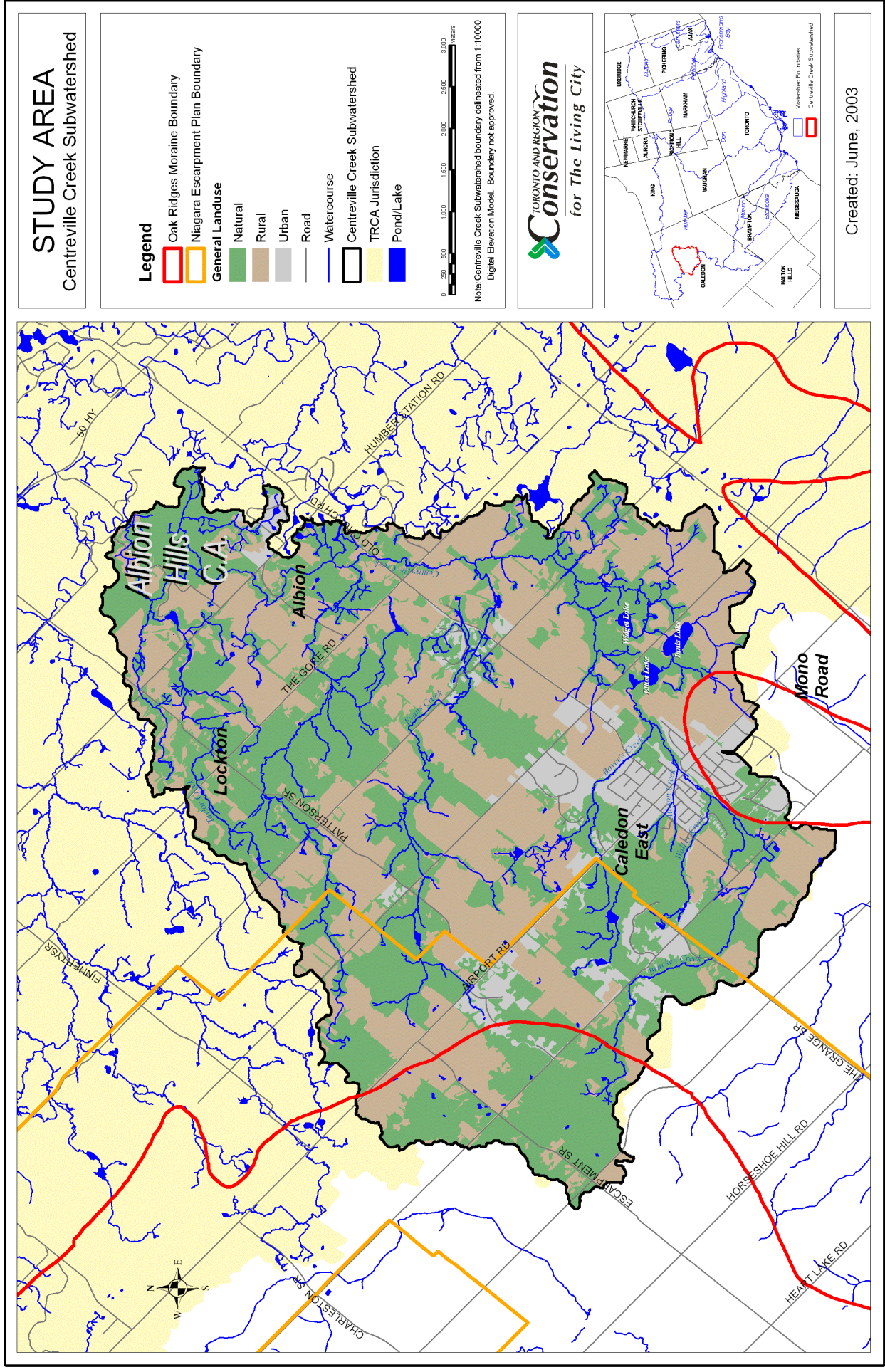
### 1.1 Subwatershed planning for Centreville Creek

Centreville Creek is a headwater tributary of the Humber River. The creek flows from the Niagara Escarpment and Oak Ridges Moraine, through the Rural Service Centre of Caledon East, and into the main branch of the Humber River at Albion Hills Conservation Area (**Figure 1.1**). In comparison with the urbanized southern portions of the Humber River, this subwatershed contains a high concentration of natural features, such as large forested areas, numerous and extensive wetlands, and good quality cold water aquatic habitat. While the majority of Centreville Creek subwatershed is rural and protected from urban growth by the *Niagara Escarpment Plan, 1994*, *Oak Ridges Moraine Conservation Plan, 2002*, and *Greenbelt Plan, 2005*, expansion of urban settlements in Caledon East is planned, which will require expansion of municipal water supply infrastructure to service the new settlements. New aggregate resource extraction pits may also be established in the area in the future.

In 2002, the Region of Peel initiated studies to evaluate options for servicing planned new developments in Caledon East with municipal water supply. At the time, studies were undertaken to evaluate the option of utilizing an existing artesian well in the area as a pumped municipal well, in order to provide the system capacity required to service planned new developments. To evaluate the feasibility of this option, information regarding baseline environmental conditions was needed.

Environmental planning studies in the Caledon East area had been completed for the Town of Caledon between 1995 and 1997 in support of the Caledon East Secondary Plan (Geomatics International *et al.*, 1997). Concurrently, the Humber River watershed strategy, *Legacy: A Strategy for a Healthy Humber* was completed which provided thirty objectives for a healthy, sustainable watershed, and a set of actions necessary to achieve them (MTRCA, 1997a). It also provided an overview of the state of the Humber River watershed at that time. However, these studies were based on information that was more than five years out of date in 2002. A comprehensive and integrated subwatershed scale study was needed that updated and added to available information on baseline environmental conditions in the Caledon East area to inform the Region of Peel's studies. Such a study also provided an opportunity to examine local watershed management issues and opportunities and put forward recommendations for action needed to achieve the objectives of *Legacy A Strategy for a Healthy Humber* (MTRCA, 1997a), in this area.

Figure 1.1: Study area



In December 2002, Toronto and Region Conservation (TRCA) initiated the Centreville Creek subwatershed planning study in partnership with the Region of Peel and Town of Caledon. Subwatershed planning is an integrated, ecosystem-based approach to land and water use planning using the boundary of a subwatershed to define the study area (OMOEE, 1993). A subwatershed can be defined as all lands draining to a creek, or other subsection of a watercourse or watershed. Subwatershed planning studies reflect the objectives of the watershed strategy or plan, but focus on addressing local watershed management issues and opportunities. They provide detailed technical analysis and guidance to local and regional governments with regard to environmental protection and restoration within the contexts of existing land and water use, and the planning of future development. Subwatershed planning studies also provide direction to non-governmental organizations and private landowners regarding best management and stewardship practices.

## **1.2 Study process**

A Steering Committee was established in 2002 to direct the organization and management of the Centreville Creek subwatershed study process. The Steering Committee was made up of representatives from the Public Works and Planning Departments of the Region of Peel and Town of Caledon, the Niagara Escarpment Commission and Toronto and Region Conservation (TRCA). Meetings were held to review the study work plan and drafts of study reports.

A Stakeholder Focus Group was also formed that brought together elected officials, municipal staff, local stewardship groups, trail associations and residents to review and comment on study findings and provide input on recommendations. Stakeholder Focus Group workshops were held in August and September 2003, during which participants provided input on local watershed management issues of concern and opportunities for stewardship and naturalization initiatives. They also confirmed the management objectives established by *Legacy: A Strategy for a Healthy Humber* as a suitable framework on which to base subwatershed study recommendations.

The subwatershed study process was divided into three main phases:

Phase 1 - Scoping and characterization;  
Phase 2 – Analysing and evaluating alternatives; and,  
Phase 3 - Developing recommendations

In the first phase of the study baseline environmental conditions were characterized through a review of available information and field studies to fill critical information gaps. The subwatershed system was conceptualized as being composed of the following components:

- Land and resource use.
- Groundwater system;
- Surface water quantity;
- Surface water quality;
- Fluvial geomorphology;
- Terrestrial system;
- Aquatic system;
- Cultural heritage; and,
- Recreational use



New information collected through field studies in 2002 and 2003 included:

- Installation of a new permanent stream flow gauge on Centreville Creek at Albion Hills Conservation Area in 2002 to establish baseline information on stream flow patterns;
- Field assessment of all natural cover (i.e., habitat) patches in the study area including inventories of vegetation community types and flora and fauna species, following the TRCA Terrestrial Natural Heritage Program protocols, to establish a consistent baseline of information;
- Full survey of summer stream flow during dry periods (i.e. baseflow), which established an improved understanding of baseline low stream flow conditions and groundwater-surface water interactions;
- Permeameter measurements to field verify groundwater infiltration rates and piezometer measurements to field verify groundwater discharge rates and locations, which were used to strengthen the York-Peel-Durham-Toronto (YPDT) groundwater database and groundwater modelling assumptions;
- Assessments of channel form which characterized reaches and indicator sites and established criteria for designing stormwater management controls in new developments to help mitigate increases to channel erosion rates;
- Assessment of natural riparian vegetation to help identify opportunities for tree and shrub plantings;
- Survey of agricultural land uses and practices, which was used to predict predominant source areas for agricultural non-point source water contaminants;
- Inventory of ponds, which was used to identify opportunities to improve fish passage and mitigate thermal impacts on cold water fish habitat;
- In-stream temperature monitoring to improve understanding of the extent of cold water fish habitat in the study area and identify high priority areas for riparian plantings and thermal impact mitigation initiatives.

Workshops involving Steering Committee and Stakeholder Focus Group participants and Toronto and Region Conservation (TRCA) staff were held at which information on baseline conditions and local watershed management issues was presented by TRCA technical staff and discussed as a group. Through this process a better understanding of interdependencies between the subwatershed system components was developed. A draft *Characterization Report* providing a summary of baseline conditions, local watershed management issues and preliminary recommendations was completed by TRCA in June 2003 and reviewed by the Steering Committee and Stakeholder Focus Group participants.

The second phase of the study involved examining potential effects that anticipated future land uses could have on the health of the subwatershed and evaluating alternative scenarios of management action. Computer modelling techniques and expert analysis were used to predict the response of the subwatershed system with regard to surface water hydrology (using an HSPF continuous hydrologic simulation model), and surface water quality (using an Agricultural Non-point Source - AGNPS model). Three scenarios were examined;

- 1) Baseline conditions (defined by 1999 land use);
- 2) Anticipated new development to 2021 with a conventional management approach; and,
- 3) Anticipated new development to 2021 with implementation of the TRCA target terrestrial natural heritage system.

Technical reports were completed documenting the results from the surface water hydrology and surface water quality scenario modelling studies. Steering Committee meetings were held to review and discuss findings from scenario modelling studies and the format of the final study report.

The third phase of the study involved integrated examination of information on baseline conditions, findings from scenario modelling and analysis work and input from Steering Committee and Stakeholder Focus Group participants. Recommendations for improved management and stewardship were developed and high priority areas for stewardship and naturalization initiatives were identified.

In 2004, concurrent with work on the Centreville Creek subwatershed study, TRCA staff were also engaged in developing watershed plans for the Rouge and Humber River watersheds to assist the Region of Peel, Region of York and City of Toronto in fulfilling the requirements of the Oak Ridges Moraine Conservation Plan. It was decided that, because finalization of information on baseline conditions was awaiting input from the YPDT groundwater model and that timely input regarding available baseline information had been provided to the Region of Peel for their studies, that the subwatershed study would be put temporarily on hold so that TRCA staff efforts could be focused on meeting the legislated deadlines for Oak Ridges Moraine watershed plans. Key findings and management recommendations from the Centreville Creek subwatershed study were conveyed to TRCA staff working on the Centreville Creek Community Outreach and Environmental Stewardship Program. This information was also integrated into the Humber River watershed planning study. Upon completion of the *Humber River Watershed Plan* in June 2008, staff immediately resumed work on completion of the subwatershed study documentation.



## 2. Study Area

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### 2.1 Overview

Centreville Creek subwatershed drains a 4662 hectare (46.6 km<sup>2</sup>) portion of land that lies entirely within the Town of Caledon and Region of Peel (**Figure 1.1**). This area exhibits a distinct rural character with land uses composed of a mixture of natural and managed forest, wetlands, croplands, pastures, dairy farms, horse ranches, estate properties, rural villages and major greenspace areas.

The majority of the subwatershed area is located on the Oak Ridges Moraine, which serves a vital groundwater recharge function for much of the Greater Toronto Area and beyond. A minor portion is located on the Niagara Escarpment, which has been designated as a World Biosphere Reserve by the United Nations. The Humber River is designated as a Canadian Heritage River because of its outstanding natural and cultural heritage features, recreational values and historical significance with respect to the development of Canada (Canadian Heritage Rivers System, 2003). The extensive natural areas that exist along these major landforms serve important hydrological functions as critical areas for groundwater recharge and discharge, and ecological functions as natural corridors that provide sources of food and refuge for diverse communities of wildlife and native plants, and thereby help to preserve the native biological diversity of the region.

Many kettle depressions, that are distinctive features of the Oak Ridges Moraine landscape, occur in the area, including several provincially significant wetland complexes and three small lakes located to the east of Caledon East: Elliot Lake (also referred to as Scott Lake or Belcon Pond), Innis Lake and Widget Lake. Other significant natural features in the area include large forested areas, wetlands and cold water streams providing high quality habitat for sensitive species including brook trout (*Salvelinus fontinalis*).

Water supplies for Caledon East are derived from three municipal groundwater wells located in the subwatershed, and proposals have been made by the Region of Peel to add a fourth well to provide the supply of potable water necessary to accommodate approved urban growth. A high concentration of cultural heritage sites has been identified along the upper main channel of the Humber River, making this an important area for heritage preservation, interpretation, and tourism. Major inter-regional trails traverse and converge in the Centreville Creek subwatershed, including the Caledon Trailways/Trans Canada Trail, Bruce Trail, Great Pine Ridge Equestrian Trail, and Humber Valley Heritage Trail. The subwatershed also includes a portion of Albion Hills Conservation Area.

### 2.2 Physiography

Centreville Creek subwatershed is characterized by varied terrain, with deeply incised valleys to the west, and more gently sloping terrain to the east. The regional topography slopes from a height of 447 metres above sea level (masl) on the Horseshoe Moraine at the western edge of the subwatershed to a low of 256 masl at the confluence of Centreville Creek and the main channel of the Humber River. The topography of the subwatershed is characteristic of moraine-type, hummocky terrain. Numerous kettle ponds and depressions are scattered across the area, along with several kame formations, which are generally concentrated in the southern and western portions.

Centreville Creek subwatershed occurs within four major physiographic regions of the southern Ontario landscape: 1) Oak Ridges Moraine; 2) The South Slope; 3) The Niagara Escarpment, and 4) Horseshoe Moraine (Chapman and Putnam, 1984). **Figure 2.1** illustrates the location of the subwatershed in relation to these major physiographic regions.

#### Oak Ridges Moraine

The Oak Ridges Moraine (ORM) is the prominent ridge of land separating the Lake Ontario drainage basin from the Georgian Bay and Trent River drainage basins and is the source area for many rivers and streams. The moraine sediments act as a conduit for vast quantities of groundwater which represents a vital source of potable water for many rural settlements in the region. The moraine forms a west-east trending belt of hummocky topography characterized by rolling hills interspersed with many kettle wetlands, ponds and lakes.

#### South Slope

The South Slope physiographic region is defined as the area along the southern slope of the Oak Ridges Moraine and extends along the moraine between Durham Region in the east to the Niagara Escarpment in the west. The South Slope is characterized by topography that gently slopes southward towards Lake Ontario and is composed of a plain of glacial till, overlain by a veneer of glaciolacustrine deposits from the ancient Lake Peel which are up to five metres in thickness in some locations.

The portion of Centreville Creek subwatershed that lies on the South Slope is limited to a small area in the immediate vicinity of Caledon East, at the southeastern edge of the subwatershed boundary.

#### Niagara Escarpment

The Niagara Escarpment is a prominent topographical feature that extends from the Lake Michigan basin and Niagara Region in the south to the Bruce Peninsula and onto Manitoulin Island in the north. The Niagara Escarpment Area is defined by a crest of resilient dolostone bedrock and encompasses a corridor of land where bedrock and boulders are present and the overburden is very thin or absent. In addition to its geological significance, the Escarpment is also a hydrologically important feature. The headwaters of several rivers flow from the slopes of the Escarpment and the geology of the area is such that it functions as a vast conduit for groundwater, helping to maintain water levels in underground aquifers.

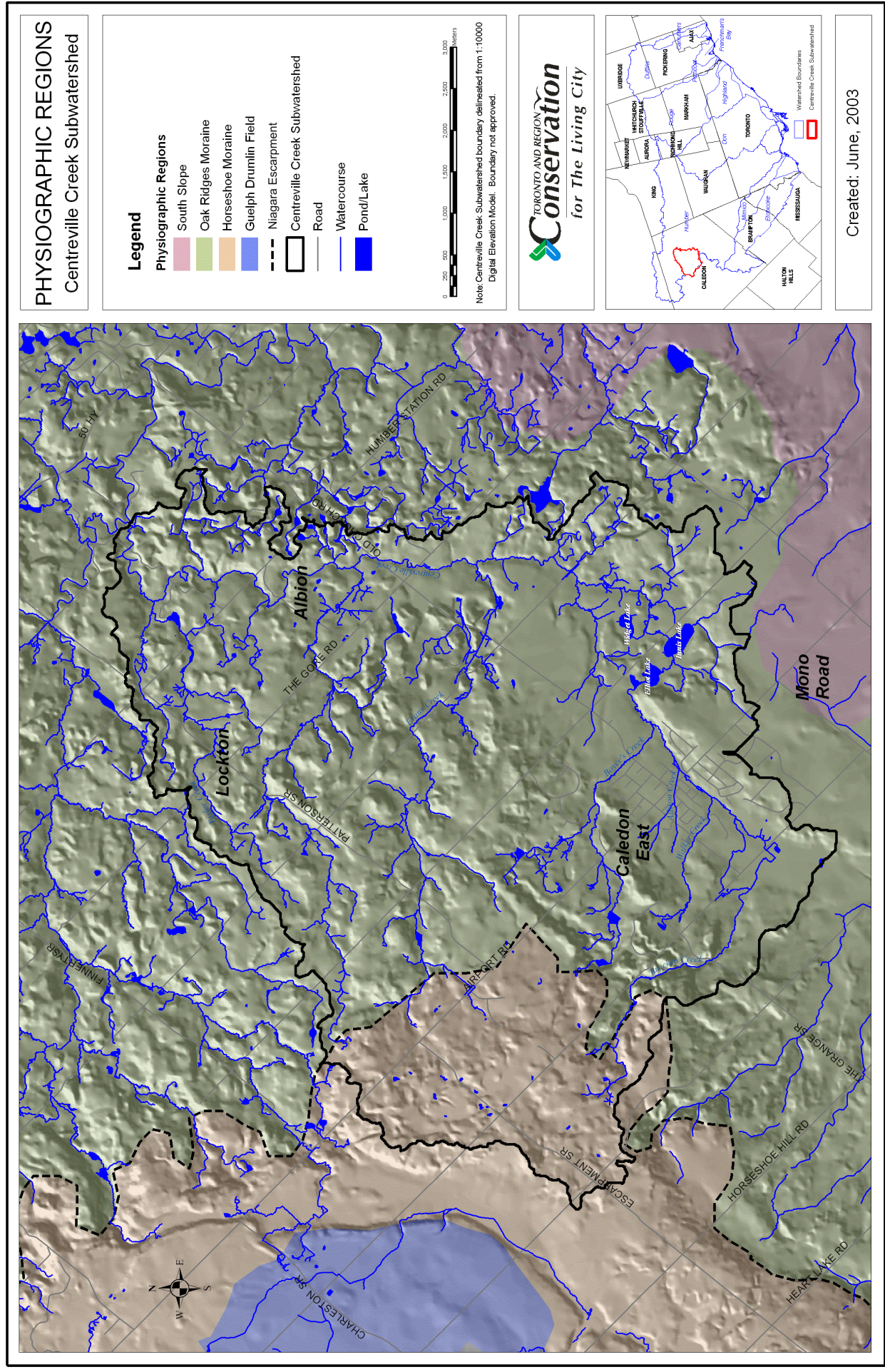
The Niagara Escarpment frames the western portion of the Centreville Creek subwatershed. Here, the vertical cliffs of exposed rock that are a dominant characteristic of the southern portions of the Escarpment are covered by Oak Ridges Moraine sediments, and appear as a steep topographic rise.

#### Horseshoe Moraine

The Horseshoe Moraine forms a horseshoe-shaped region above and west of the highest portions of the Niagara Escarpment. The two major landforms associated with this area are irregular stone knobs and ridges as well as pitted sand and gravel terraces and valley floors filled with swamps (Chapman and Putnam, 1984). In the Centreville Creek subwatershed, the Horseshoe Moraine region is limited to the extreme western portion above the Niagara Escarpment.



Figure 2.1 Physiographic regions



## 2.3 Geology

### Bedrock Geology

The Centreville Creek subwatershed is located where the Niagara Escarpment meets the Oak Ridges Moraine. Bedrock topography slopes steeply from a high of approximately 440 masl in the west to about 180 masl in the east. Because of the significant elevation change, north-south bands of various bedrock formations exist beneath the subwatershed. Bedrock outcrops are few because glacial deposits usually overlie these units. The bedrock formations comprise Paleozoic sedimentary rocks. Dolostone (Amabel Formation and Fossil Hill Formation) forms the crest of the escarpment in the west, underlain by thin beds of shale (Cabot Head Formation), dolostone (Manitoulin Formation), and sandstone (Whirlpool Formation). Beneath and to the east of these escarpment formations is a broad band of red shale (Queenston Shale Formation) centred on Caledon East (White, 1975; WHI, 2003).

Pre-glacial erosion and glaciation has formed an undulating bedrock surface that is incised by bedrock valleys. The valleys vary in width and depth and are infilled by a variety of unconsolidated sediments. A major bedrock valley system is interpreted to trend from Forks of the Credit (in the Credit River watershed to the west of the study area) to Bolton in the east (WHI, 2003). The valley trends east-northeast towards the interpreted location of the Laurentian Channel, east of the study area (Sharpe *et al.*, 2004).

### Quaternary Geology

Overburden deposits in the subwatershed are composed of silt, sand, gravel, clay and till units. The depositional structure and extent of these units is characterized by sharp boundaries between low energy (e.g., glaciolacustrine) and high energy (e.g., meltwater channel) environments. These sharp contacts and depositional complexities result from repeated advance, convergence and retreat of glacial ice lobes at the Niagara Escarpment during the Wisconsin glacialiation. This area may be the most geologically complex areas on the Oak Ridges Moraine, showing evidence of multiple periods of glaciofluvial, glaciolacustrine, and moraine deposition and erosion (WHI, 2003).

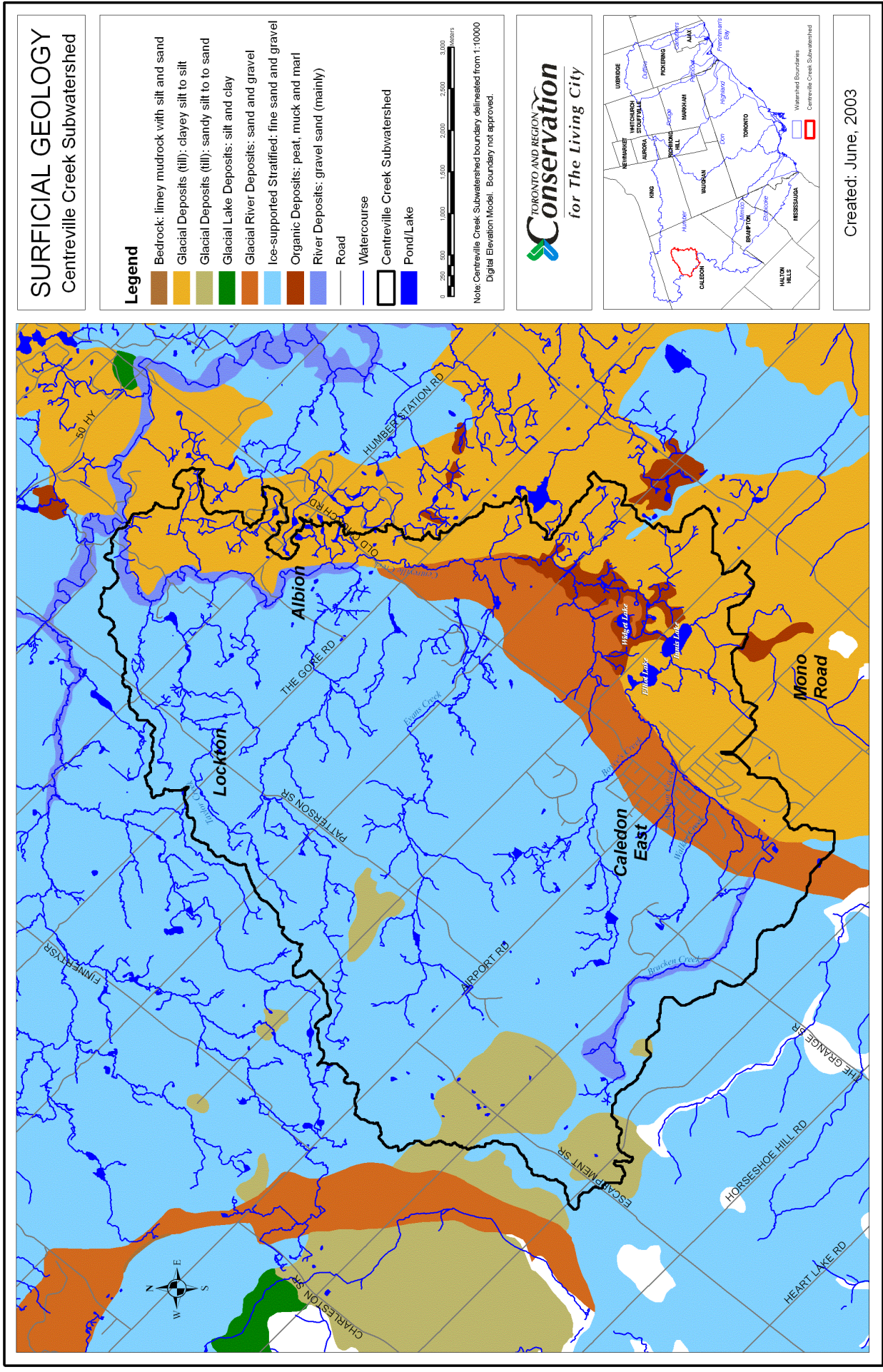
Overburden thickness is highly variable in the subwatershed. Overburden is thin in areas on the Niagara Escarpment but thick deposits are observed on its slope. North of Caledon East, overburden has a significant thickness of up to 100 metres in the vicinity of Granite Stones Road. Thickness is greatest in buried bedrock valleys.

Four main units characterize the quaternary geology in the study area, listed below from oldest to youngest (Sharpe *et al.*, 2004):

1. Lower Sediments – mostly fine to medium sand, with till remnants that are highly eroded;
2. Newmarket Till – silty sand till that is discontinuous within the study area;
3. Oak Ridges Moraine (ORM) Complex – composed of multiple sequences of fining upward deposits from outwash sands to glaciolacustrine silts and clays, capped by kame deposits, meltwater channel deposits, and ice-supported stratified drift; and,
4. Halton Till / Wentworth Till – silty clay till and sandy silt till deposits, both occurring at the surface.



Figure 2.2 Surficial geology



Glacial river deposits (i.e., a meltwater channel), oriented northeast-southwest, underlie Centreville Creek near Caledon East (**Figure 2.2**). The Caledon East Meltwater Channel extends from Inglewood (west of the subwatershed) to the Village of Albion where it is truncated by Halton Till (WHI, 2003). The channel follows the valley occupied by the East Credit River and Centreville Creek and ranges from 700 metres to 900 metres in width (White, 1975). The surface of the channel is underlain by fine to medium sand, recent river deposits and in some locations peat and wetland deposits. These deposits are underlain by ice supported stratified drift of the ORM coarse sediments which impart a high permeability and recharge capacity (WHI, 2003). The Caledon East Meltwater Channel is underlain by a much older and lower channel that cuts through the Newmarket Till (Sharpe *et. al.*, 2004). The lower channel has a significant effect on groundwater flow, in that it allows groundwater to move downward into the underlying aquifer in the lower sediments.

Surficial geology comprises a variety of glacial tills (Wentworth Till on the Horseshoe Moraine to the west, Halton Till to the east), stratified drift (sand and silt), glacial river deposits (sand and gravel), and organic deposits (peat). In addition, recent river deposits (sand and gravel) are found in the creek valleys (**Figure 2.2**).

#### *Recent River Deposits*

These deposits of sand and gravel are found along the existing channel of Centreville Creek and its tributaries. They are limited in extent, both vertically and laterally, and therefore are not significant in terms of their influence on regional hydrogeology.

#### *Organic Deposits*

Scattered deposits of peat and organic silts are present in some areas. These deposits are associated with kettle depressions that were created by blocks of ice that melted after the Late Wisconsinan glacier retreated. These depressions are believed to be significant recharge areas, since they lack surface drainage.

#### *Glacial Tills*

The tills that are interpreted to be present in this subwatershed comprise:

- Wentworth Till – sandy silt to sand with some gravel (White, 1975);
- Halton Till – clayey silt to silt with some gravel; and
- Newmarket Till - very dense clayey silt with some gravel.

Of these units, only the Wentworth and Halton Tills outcrop at surface (**Figure 2.2**). The Halton Till is of low permeability, and therefore limits recharge where it is present. It provide some protection to the underlying Oak Ridges Moraine coarse sediments, which form a regional aquifer. The Wentworth Till is coarse compared to the Halton Till, and therefore is expected to have higher recharge potential, and provide less protection to the underlying Oak Ridges Moraine sediments. The Newmarket Till does not outcrop in this subwatershed. It is a regional aquitard with a major northeast trending meltwater channel cut through it in the vicinity of Caledon East. Where this till is present, it provides protection to the regional aquifer in the lower sediments.

#### *Ice Supported Stratified Deposits - Oak Ridges Moraine Sediments*

This unit comprises stratified fine sand and gravel deposits that form a significant aquifer in this subwatershed. Where these sands and gravels outcrop, they allow high recharge into the groundwater system, particularly in areas with hummocky topography that limit overland flows.

## 2.4 Soils

Soils within the Centreville Creek subwatershed are dominated by sandy loams (78.5% of the total area), with minor areas of clay loam and loam (OAC & DDA, 1953). Sandy loam soils generally occur on the portions of the subwatershed that are north and west of the main channel of Centreville Creek, and the clay loam and loam soils occur south and east of the main channel (**Figure 2.3**). Isolated areas of organic soils occur in association with wetlands. The soils associated with the floodplain of Centreville Creek are variable with exposed gravels occurring at the surface along some sections of the stream.

Sandy loam soils are typically well-drained and exhibit rapid permeability. These soils have low moisture holding capacities and limited surface run off characteristics. They are generally rated Class 2 according to the Canada Land Inventory soil capability classification system (Agriculture and Agri-Food Canada, 1999) and are suitable for common field crops (e.g., forages, small grains and corn). Limitations to crop productivity that affect these soils relates to low natural fertility and low moisture holding capacity. Agricultural uses of these types of soils for crops other than forage (livestock feed) will often require supplemental irrigation and applications of fertilizer.

Clay loam soils are typically imperfectly drained and exhibit moderate to slow permeability. These soils have high moisture holding capacities and moderate to rapid surface run off characteristics. Their fine and medium textured surface materials make these soils susceptible to water erosion. Under good management, these soils are moderate to high in productivity for a wide range of common field crops (forages, small grains, and corn), special field crops (e.g., soybeans and canola) and fruit crops (e.g., strawberries, apples and pears).

The areas of clay loam soils represent the most productive farmland in the study area and are recognized as Prime Agricultural Areas by the Region of Peel (Regional Municipality of Peel, 2001). These areas are also where crop farming operations are located in the study area. Crops grown on these soils include wheat, oats, barley, corn and soybeans (see section 3.1 Rural and Urban Land Use).



This map illustrates the distribution of three fish species within the Caledon East watershed. The watershed boundary is defined by a thick black line. The background is color-coded to show the presence of different species: red for Yellow Perch, green for Rock Bass, and blue for White Sucker. The map also features a network of roads, including Highway 50, and various water bodies such as lakes and creeks. A north arrow is located in the bottom left corner.

**Species Distribution:**

- Yellow Perch (Red):** Primarily found in the northern and eastern portions of the watershed, particularly around the Albion and Caledon East areas.
- Rock Bass (Green):** Found in the central and southern portions of the watershed, with a notable concentration in the Caledon East area.
- White Sucker (Blue):** Distributed throughout the watershed, with a higher density in the northern and eastern regions.

**Geographic Features and Roads:**

- Roads:** Highway 50, Humber Station Rd, Old Church Rd, The Gore Rd, Patterson Sr, Airport Rd, Escarpment Sr, Horseshoe Hill Rd, Heart Lake Rd, and Finnerter Sr.
- Water Bodies:** Albion, Caledon East, and various creeks including Bracken Creek, Evans Creek, and the Caledon River.





## 2.5 Climate

Climate varies appreciably across southern Ontario both spatially and temporally with local variation created by such factors as topography, prevailing winds, and proximity to the Great Lakes. Human activities can also affect climate. Deforestation may increase stream and peak flood flows while decreasing evapotranspiration. Urbanization can increase cloudiness, precipitation and extreme winter temperatures while decreasing relative humidity, incident radiation, and wind speed (Phillips and McCulloch, 1972).

July is typically the warmest month of the year in the study area, with an average maximum temperature of 26.6 °C and average minimum temperature of 13.0 °C. January is typically the coldest month, with an average maximum temperature of -3.1 °C and an average minimum temperature of -12.3 °C (Environment Canada, 2003).

Mean annual precipitation in the Centreville Creek subwatershed has been estimated at 833 millimetres per year (mm/yr), based on climate data covering the period of 1979 to 1997 (Clarifica, 2003). Mean annual snowfall is approximately 153 mm/yr and mean annual rainfall is approximately 680 mm/yr. Climate normals established by historical data obtained from the Albion Field Centre (at Albion Hills Conservation Area) indicate that seasonal precipitation in the Centreville Creek subwatershed averages approximately 60 millimetres per month during the winter and approximately 74 millimetres per month in the summer, with August being the month when heaviest precipitation occurs (Environment Canada, 2003a). The difference in precipitation levels between seasons is likely a result of convective thunderstorms that occur during the summer. Despite the occurrence of thunderstorms in the summer and the corresponding stream flows that follow, historical stream flow data indicates that the periods of highest annual stream flow are associated with the spring snow melt which typically occurs in March or April (Environment Canada, 2003b).

## 2.6 Management considerations

The variable topography and physiographic location of the Centreville Creek subwatershed makes it a landscape of high scenic value. Many of the kettle and kame landforms in the study area may warrant protection under the Oak Ridges Moraine Conservation Plan as Landform Conservation Areas.

The highly permeable soils and surficial geology that occurs over the majority of the subwatershed, in combination with the hummocky, kettle and kame topography provide a high capacity for groundwater infiltration (also see **Section 4.2 – Hydrogeology**).

## 2.7 Local watershed management issues and opportunities

An important first step in the subwatershed planning process was developing a better understanding of local watershed management issues of concern in the study area and known opportunities to improve watershed health identified through previous initiatives. Consultation with municipal and agency staff, elected representatives, local residents, and other stakeholders was undertaken to identify watershed management issues and opportunities in the Humber River watershed during the preparation of the watershed strategy, *Legacy: A Strategy for a Healthy Humber* (MTRCA, 1997a) and the accompanying implementation guide, *A Call to Action* (MTRCA, 1997b). *A Call to Action*, identifies major issues that were affecting the Main Humber subwatershed at that time, which includes Centreville Creek, and outlines priority actions to address them. These issues and actions provided a good background for subwatershed planning work for Centreville Creek. Further consultation with agency staff, municipal staff and stakeholders regarding local watershed management issues was undertaken at the onset of the Centreville Creek subwatershed study. **Table 2.1** provides a summary of local watershed management issues in that were identified in *A Call to Action* that are relevant to Centreville Creek subwatershed.

**Table 2.1: Watershed management issues affecting Centreville Creek subwatershed**

| <b>Watershed Management Issue<sup>1</sup></b>   | <b>Relevance to Centreville Creek subwatershed</b>   |
|---|--|
| Protection of the resources and landforms of the Niagara Escarpment and Oak Ridges Moraine                                    | - The Niagara Escarpment and Oak Ridges Moraine are significant landforms in the subwatershed.   |
| Risk of damage from flooding and erosion to developments in the floodplain and on the valley slope                            | - Flood vulnerable areas exist within and downstream of the subwatershed.<br>- Future urban growth will increase the portion of the subwatershed with impervious cover which, without mitigation, could increase the potential for accelerated stream channel erosion.   |
| Protection of groundwater resources from deleterious land uses, activities and unsustainable use.                             | - Water supply for Caledon East is groundwater based and derived from municipal wells in and near the town.<br>- Water supply for residents and businesses in surrounding rural areas is also groundwater based and derived from private wells.<br>- Expansion of municipal water supply infrastructure is needed to service planned new developments in Caledon East.   |
| Protection of the quantity and quality of surface water resources   | - Future urban growth will increase the portion of the subwatershed with impervious cover which, without adequate mitigation, could change the existing pattern of groundwater and surface water flows.<br>- Portions of the subwatershed were developed without the level of stormwater treatment now required by current standards.<br>- Without adequate management, agricultural practices in the subwatershed have the potential to contribute to high levels of bacteria, sediment, phosphorus and nitrogen in surface waters. |
| Loss of small and ephemeral streams through drainage practices in rural and urban areas.                                      | - As a headwaters subwatershed, a majority of the area is drained by first, second and third order (i.e., small) streams.  |
| Impacts on cold water aquatic habitats from stormwater run off and human activities   | - Centreville Creek contains cold water aquatic habitat and supports brook trout populations, which are highly sensitive to increases in water temperature, siltation and chloride levels, which are changes that typically occur in urbanizing streams.   |
| In-stream dams, ponds and weirs are preventing fish passage and increasing summer water temperatures                          | - Several on-line private ponds (i.e., dams) exist along Centreville Creek and its tributaries.  |
| Quality of woodland terrestrial habitat is being degraded by forest fragmentation   | - Past clearing practices to establish farms and settlements have resulted in many isolated and irregular shaped forest patches which reduces the quality of habitat that they provide.  |
| Loss of wetlands due to changes in drainage associated with agricultural land use and urban development                       | - It is likely that many wetlands that once existed in the subwatershed were drained in the past to establish farms and settlements.   |
| Urbanization is diminishing the quality of terrestrial habitats through loss, encroachment, isolation, and over-use           | - Planned new developments in Caledon East will be near locally significant wetlands and other important natural areas which could result in impacts on habitat quality if encroachments are not adequately managed.   |
| Lack of natural riparian vegetation along stream banks and shorelines reduces the quality of aquatic and terrestrial habitats | - Some reaches of Centreville Creek do not receive benefits to channel stability, water quality and habitat that natural riparian vegetation provides.   |
| Use of natural areas for recreation needs to be balanced with maintaining healthy, self-sustaining ecosystems                 | - Albion Hills Conservation Area, the Caledon Trailways portion of the Trans-Canada Trail, and the Humber Valley Heritage Trail are popular destinations for nature-based recreation in the subwatershed.  |
| Mineral, aggregate and peat extraction activities need to be balanced with the protection of land and water resources         | - Portions of the subwatershed are designated as reserve areas for potential future extraction of aggregate resources.   |
| Loss of built heritage and archaeological resources   | - Several built heritage features are known to exist within the subwatershed that may warrant protection and integration into the new settlements in Caledon East.<br>- Archaeological surveys will need to be undertaken within the subwatershed prior to implementation of plans for urban growth.   |

<sup>1</sup> these general watershed management issues were identified in the Main Humber subwatershed, which includes Centreville Creek, in *A Call To Action* (MTRCA, 1997b).

## PART 2 BASELINE CONDITIONS

### 3. Land and resource use

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Prior to European settlement, forests and wetlands covered nearly all of the southern Ontario landscape. With the arrival of settlers in the 19<sup>th</sup> century, the forested hills of the Oak Ridges Moraine were cleared for timber and agriculture. However, unlike many other parts of southern Ontario, the sandy soils and rolling topography typical on much of the Moraine were not suitable for agriculture, and severe wind erosion was the result. In the early 20<sup>th</sup> century, agricultural land on the moraine was often abandoned. Large areas were reforested with conifer plantations.

#### 3.1 Rural and urban land use

Centreville Creek subwatershed is predominantly rural in character with the majority of land being used for agricultural and forest management purposes. The subwatershed contains approximately 2200 hectares of natural cover (47% of the total area) in the form of natural and managed forest, wetlands, meadows and successional land cover (shrub land and immature forest). In **Section 8.2, Table 8.1** provides a breakdown of the proportion of each natural cover class present in the study area.

Based on land use and land cover information that was interpreted from aerial photos taken in 1999, rural and agricultural land uses account for approximately 43% of the total subwatershed area (**Figure 3.1**). Urban areas, including Caledon East and estate residential subdivisions in the vicinity, cover about 9% of the subwatershed. The majority of urban land use is comprised of estate and low to medium density residential areas. **Table 3.1** provides a breakdown of land use in the subwatershed. The Town of Caledon Official Plan allows for expansion of the existing urban settlement area in the subwatershed to accommodate projected population growth to 2021 (Town of Caledon, 2002). The urban portion of Centreville Creek subwatershed will increase from 9% to approximately 15% with full implementation of the Caledon East Secondary Plan.

**Table 3.1 Land use in Centreville Creek subwatershed, 1999**

| Land Use Category                         | Area (hectares) | % of total area |
|---|-----------------|-----------------|
| Natural                                   | 2201            | 47              |
| Rural – Agriculture                       | 1633            | 35              |
| Rural - Residential                       | 369             | 8               |
| Urban - Estate Residential                | 206             | 4               |
| Urban - Low to Medium Density Residential | 126             | 3               |
| Urban – Parkland and Golf Course          | 64              | 1               |
| Urban - Institutional                     | 18              | <1              |
| Urban - Industrial/Commercial             | 11              | <1              |
| Open Water                                | 35              | <1              |
| <b>Total</b>                              | <b>4662</b>     | <b>100</b>      |

**EXISTING CONDITIONS**  
Centreville Creek Subwatershed

**Legend**

| Existing Landuse |                                |
|------------------|--------------------------------|
| [Dark Green]     | Natural                        |
| [Light Green]    | Golf Course/Parkland           |
| [Brown]          | Agriculture                    |
| [Red]            | Industrial/Commercial          |
| [Grey]           | Institutional                  |
| [Orange]         | Low-Medium Residential         |
| [Yellow]         | Rural Estate/Farm              |
| [Pink]           | Estate Residential             |
| [Blue Line]      | Road                           |
| [Blue Line]      | Watercourse                    |
| [Black Outline]  | Centreville Creek Subwatershed |
| [Solid Blue]     | Pond/Lake                      |

Note: Centreville Creek Subwatershed boundary delineated from 1:10,000 Digital Elevation Model. Boundary not approved.

**Landuse Types**

Existing Landuse Percentages By Area

| Landuse Type           | Percentage (%) |
|------------------------|----------------|
| Natural                | ~45%           |
| Agriculture            | ~35%           |
| Rural Estate/Farm      | ~10%           |
| Estate Residential     | ~5%            |
| Low-Medium Residential | ~2%            |
| Golf Course/Parkland   | ~1%            |
| Institutional          | ~1%            |
| Industrial/Commercial  | ~1%            |

**TORONTO AND REGION Conservation for The Living City**

**Watershed Boundaries**  
Centreville Creek Subwatershed

Created: June, 2003

## Agriculture

Agricultural land uses in the study area include both livestock operations, and field crop systems. Local livestock operations include dairy, beef cattle and several horse farms. Field crops grown in the area are predominantly grains (wheat, oats, and barley) and corn, with some soybean cultivation. The majority of agricultural land is used for growing livestock feed (hay), with many rural residential properties featuring large areas under hay. **Table 3.2** provides a breakdown of agricultural land uses in the study area based on a field inventory completed in 2003 (Cost Effective Cropping Inc., 2003). The spreading of manure on agricultural lands is done on a regular basis as a soil amendment and a means of managing livestock wastes.

**Table 3.2      Agricultural land use in the Centreville Creek subwatershed, 2002**

| Agricultural Land Use Category | Area (hectares) | % of total |
|--------------------------------|-----------------|------------|
| Corn                           | 181             | 11         |
| Hay                            | 405             | 25         |
| Idle (Fallow)                  | 490             | 30         |
| Pasture                        | 402             | 25         |
| Soybean                        | 100             | 6          |
| Wheat, oats, barley            | 55              | 3          |
| <b>Total</b>                   | <b>1633</b>     | <b>100</b> |

## Forest management

A 38 hectare resource management tract, owned and managed by the TRCA for forest management purposes, is located on Centreville Creek Road, south of Patterson Sideroad. This property is entirely forested with a plantation of coniferous species. There is no public access to the property. Many private property owners also maintain forested portions of their property, some of which have been periodically harvested for timber.

## Greenspace, golf courses and cemeteries

A prominent use of land within the study area is greenspace for nature-based recreation purposes. **Table 3.3** identifies the greenspace, golf courses and cemeteries within Centreville Creek subwatershed and provides a brief description of each area.

**Table 3.3 Greenspace, golf courses and cemeteries in Centreville Creek subwatershed**

| Area  | Description   |
|---|---|
| Albion Hills Conservation Area                  | This 496 hectare conservation area is the largest in the TRCA jurisdiction and the oldest in Ontario. Located at the confluence of Centreville Creek and the Humber River, this area features 26 kilometres of forested trails suitable for hiking, mountain biking, and horseback riding, in addition to facilities for fishing, boating, swimming, camping, picnicking, cross-country skiing, tobogganing and ice-skating.                |
| Trans-Canada Trail/Bruce Trail                  | A 13 km section of multi-use trail that traverses the Centreville Creek subwatershed is part of both the Caledon Trailways section of the Trans-Canada Trail and the Caledon Hills section of the Bruce Trail. The trail route follows along the right-of-way of the former Hamilton and Northwestern Railway. This is a "shared use" trail, designed to accommodate walking, cycling, fishing, horseback riding, and cross-country skiing. |
| Centreville Creek Wetland Boardwalk             | A 3.3 hectare portion of the Centreville Creek floodplain, located along the Trans-Canada Trail, just east of Airport Road in the community of Caledon East featuring a boardwalk over a wetland area and interpretive signs.   |
| Caledon East Public Cemetery                    | A 1.2 hectare property located on west side of Airport Road, at Patterson Sideroad.   |
| St. James Anglican Church Cemetery              | A 0.2 hectare property located on the west side of Innis Lake Road, just south of Old Church Road.  |
| St. John the Evangelist Roman Catholic Cemetery | A 2.0 hectare property located on the west side of The Gore Road, just north of Old Church Road.  |
| Devil's Paintbrush Golf Club                    | A 66 hectare private golf club located on the east side of St. Andrew's Road, south of Escarpment Sideroad. The 18 hole links-style course has been designed in a rustic style that reflects the hilly topography characteristic of the area.   |

### Aggregate resource extraction

No aggregate resource extraction operations are active within Centreville Creek subwatershed at present. However, a licensed extraction site is located just outside the subwatershed boundary, along The Gore Road, south of Old Church Road. A high potential aggregate resource area has been identified in the Town of Caledon's Caledon Community Resource Study (Planning and Engineering Initiatives, 1999). The area, identified as Resource Area #8d, is located south of Old Church Road and north of the Centreville Creek Wetland Area, between Innis Lake Road and The Gore Road. This 165 hectare area represents a secondary source of gravel resources that is associated with the Caledon East Meltwater Channel deposits. Based on an evaluation of the ten resource areas identified within the Town of Caledon, this area was judged to be a low priority in terms of extraction potential and a recommendation was made to conserve and protect this area for potential future use (Planning and Engineering Initiatives, 1999). The main constraints associated with extraction of this resource area that were identified are;

- considerable truck traffic using Old Church Road;
- proximity to hiking trail;
- proximity to Centreville Creek and tributaries;
- proximity to Centreville Creek Area ESA and wetland;
- deposits overlain by considerable woodlands;
- proximity to R.F. Hall High School.



In the study it was noted that, due to the secondary quality of the resource and the constraints indicated above, Resource Area #8 may only be feasible for nearby development, wayside pit use, or resource rescue-type extraction prior to planned new residential developments nearby.

### **Specific land use practices of concern**

A number of specific land use practices of concern were noted during 2002 natural heritage field surveys (TRCA, 2003). These include the excavation and filling of kettle wetlands and swamps, and livestock accessing watercourses and wetlands.

#### Excavation and filling of wetlands and swamps

Kettle wetlands (mostly marshes and thicket swamps) and headwater swamps (usually dominated by white cedar) have developed naturally over the millennia since the retreat of the glaciers. These areas usually have deep organic soil layers and support numerous flora and fauna species of conservation concern.

In recent years, kettle wetlands on private property have been excavated for the purpose of extracting the organic soil (peat) which is sold for horticultural use as a soil additive. Kettles have also been excavated and used to construct ornamental ponds for aesthetic purposes, or simply filled in with non-native soils. The fill material used often contains propagules of alien invasive species such as *phragmites* and garlic mustard, which contributes to their spread. Five incidences of such land use activities were noted in the study area in 2002.

Numerous ponds have been constructed on private property throughout the subwatershed area (see **Section 9.4**). These types of ponds tend to support wetland vegetation communities of low species diversity, such as reed canary grasses or cattails rather than the more diverse headwater swamp communities that may have existed previously. If they have substantial manicured turf grasses around them, they will tend to accumulate nutrients and have low water quality. By detaining water that was previously flowing, on-line ponds (i.e., dams) tend to increase the rate of evaporation upstream and the temperature of water downstream, potentially making downstream areas unsuitable for supporting cold water fish communities. On-line ponds also tend to accumulate sediments and require periodic dredging.

#### Livestock access to watercourses and wetlands

In several locations, livestock have access to watercourses, wetlands, and woodlots. Cattle or other livestock cause severe trampling and grazing of vegetation, soil erosion, and can contribute to high levels of bacteria in surface water. Allowing wetlands to be grazed also presents a risk to the health of the livestock because a number of highly poisonous plants can occur in them.

## **3.2 Major servicing**

### **Transportation**

Only three major (regional) roads cross the study area with the remainder of roads being two-lane rural or residential roads. Airport Road and Old Church Road are the main arteries for transportation to and from the study area. The Region of Peel Official Plan identifies a right-of-way requirement of 36 metres (equivalent to six lanes) for Airport Road, and 30 metres (equivalent to four lanes) for both Old Church Road and the Gore Road (Regional Municipality of Peel, 2001). Gravel roads within the study area include Escarpment Sideroad, Centreville



Creek Road, and Humber Station Road, with a portion of Mountainview Road being gravel-surfaced.

### **Water supply and wastewater**

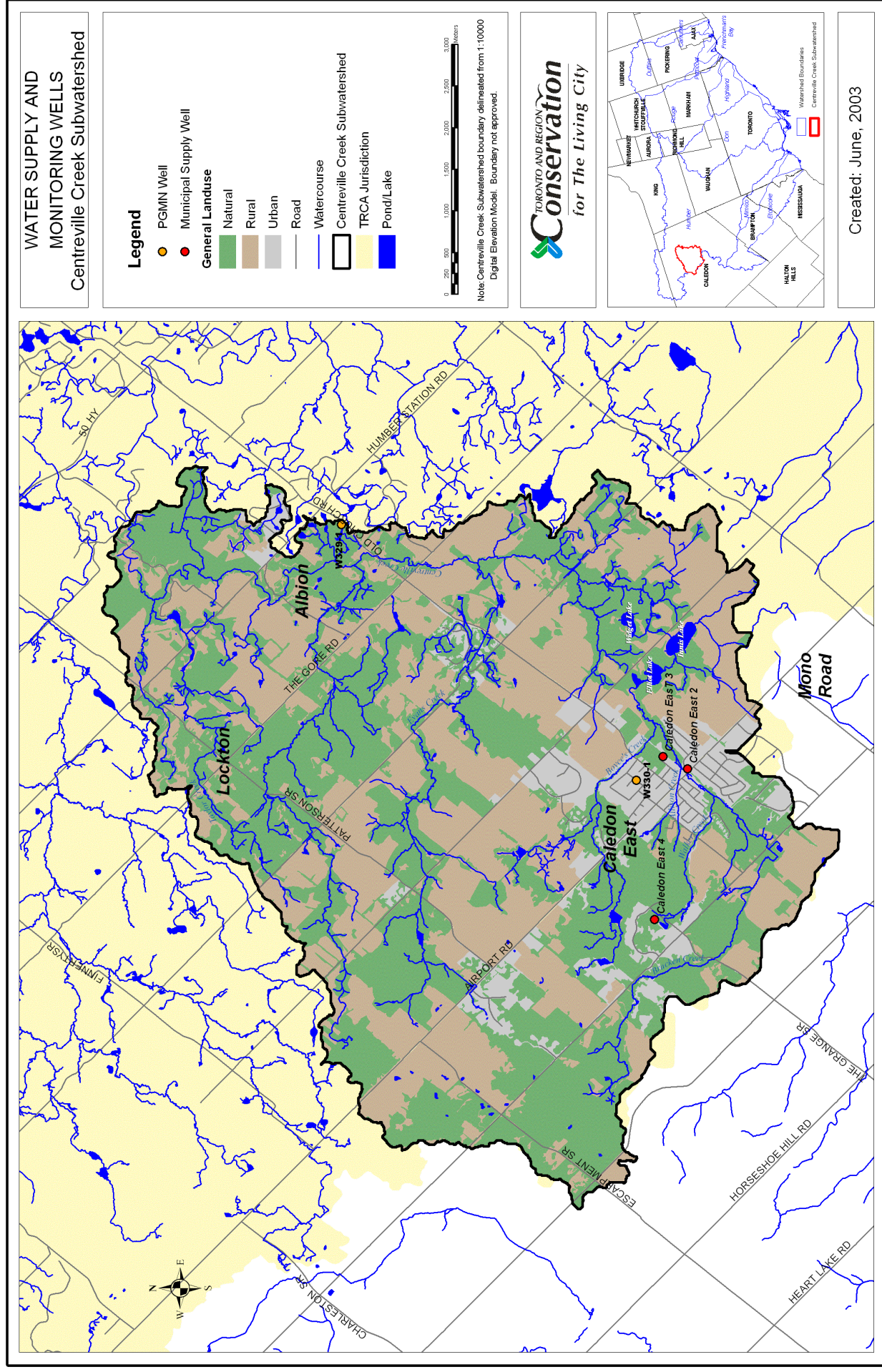
Centreville Creek subwatershed is located entirely within the portion of the Region of Peel where water supplies are derived from groundwater sources, and includes areas serviced by Region of Peel municipal wells (Caledon East and Palgrave), and areas serviced by private wells (Regional Municipality of Peel, 2001; WHI, 2003).

Caledon East is serviced by three groundwater wells which are located in Centreville Creek subwatershed (**Figure 3.3**). Caledon East wells No.2 (CE2) and 3 (CE3) obtain groundwater from the Oak Ridges Aquifer Complex via the semi-confined Caledon East Meltwater Channel (Stantec and WHI, 2004). Caledon East Well No.4 (CE4) pumps groundwater from the Lower Aquifer Complex (locally referred to as the Granite Stones Aquifer). Since being constructed in 1994, CE4 has been operated as the lead well for the majority of groundwater takings. Production wells CE2 and CE3 have been rotated into service in back-up positions and are used as the lead wells when CE4 is taken out of service for maintenance (Stantec and WHI, 2004).

Wastewater in Caledon East is collected in municipal sanitary sewers and is treated at the Lakeview Sewage Treatment Plant, in the City of Mississauga, before it is released to Lake Ontario.

Rural residents and businesses in the remaining portions of the subwatershed depend on private groundwater wells to provide water supplies for domestic, irrigation and livestock purposes and private septic systems for treatment of wastewater.

Figure 3.3 Water supply and monitoring wells



## Water use

Water use information within Centreville Creek subwatershed is currently available from the following sources:

- Ministry of the Environment, Central Region, Permit To Take Water Database;
- Peel Region Water Use Assessment (Beatty and Assoc., 2003).

The Ontario Ministry of the Environment (OMOE) is the agency responsible for the review and issue of permits to take water (PTTWs) for all water takings greater than 50,000 L/day, with a few exceptions. The OMOE database was provided to the TRCA in October 2002 and was revised by TRCA staff, removing records for redundant and non active users.

Based on revised OMOE records of permitted water takings (greater than 50,000 L per day) in the study area, there are 13 permitted water takings in Centreville Creek subwatershed, one of which is for surface water withdrawal (**Table 3.4**). Based on the Region of Peel Water Assessment Study, it is estimated that that 517 private wells exist in the study area (Beatty and Associates, 2003).

The largest water use category in the study area is public water supply, representing the Region of Peel groundwater wells supplying water to the Caledon East drinking water system. The second largest water use category is self supply, representing all the private wells in the study area providing domestic water supply to rural residences and businesses. Of particular note is the large difference between maximum permitted withdrawal volumes and actual withdrawal volumes.

**Table 3.4 Summary of water use in Centreville Creek subwatershed**

| Water use category   | Number of water takings |            |            | Max. permitted vol. (m <sup>3</sup> /yr) <sup>1</sup> |                  |                  | Average vol. (m <sup>3</sup> /yr) <sup>2</sup> |                |                |            |
|--|-------------------------|------------|------------|---|------------------|------------------|--|----------------|----------------|------------|
|  | surface                 | ground     | total      | surface   | ground           | total            | surface  | ground         | total          | % of total |
| Public supply  | 0                       | 7          | 7          |   | 3,927,677        | 3,927,677        |  | 369,499        | 369,499        | 71         |
| Self supply, irrigation                                    | 1                       | 5          | 6          | 2046  | 2,417,517        | 2,419,563        | 18   | 42,800         | 42,818         | 8          |
| Self supply, domestic (< 50,000 L/day, no permit required) | 0                       | 517        | 517        | 0   | Not applicable   | Not applicable   | 0  | 105,675        | 105,675        | 20         |
| <b>Total</b>   | <b>1</b>                | <b>529</b> | <b>530</b> | <b>2046</b>   | <b>6,345,195</b> | <b>6,347,240</b> | <b>18</b>                                      | <b>517,973</b> | <b>517,992</b> | <b>100</b> |

## Stormwater management

Stormwater management refers to the control of the quantity and quality of run off from urban areas. Measures to accomplish effective stormwater management are required for all new development and redevelopment projects. Stormwater management can be in the form of source controls (e.g., porous paving, rear yard soak away pits), conveyance controls (e.g., grassed swales, perforated pipe exfiltration systems), or end of pipe controls (e.g., wet detention ponds).

In the TRCA area of jurisdiction water quality control commensurate with Level 1 is required, as defined in the Ontario Ministry of Environment Stormwater Management Practices, Planning and Design Manual (OMOE, 2003).

<sup>1</sup> Based on OMOE permit to take water database records, 2002

<sup>2</sup> Based on Region of Peel Water Use Assessment Study (Beatty and Associates, 2003)

One dry pond stormwater management facility exists in the study area, which provides treatment to approximately 20% of Caledon East. Remaining urban areas were developed prior to requirements for stormwater management. Run off from these urban areas is discharged untreated to Centreville Creek.

### **3.3 Anticipated changes to land and resource use**

The major changes in land and resource use in Centreville Creek subwatershed anticipated in the near future are changes to groundwater withdrawals associated with Region of Peel wells servicing Caledon East, and growth of urban settlements associated with implementation of the Town of Caledon's Caledon East Secondary Plan. While potential remains for new aggregate extraction sites to be established in the subwatershed, these sites are considered to be low priority in terms of extraction potential and will likely remain in reserve for many years.

### **3.4 Links to other subwatershed system components**

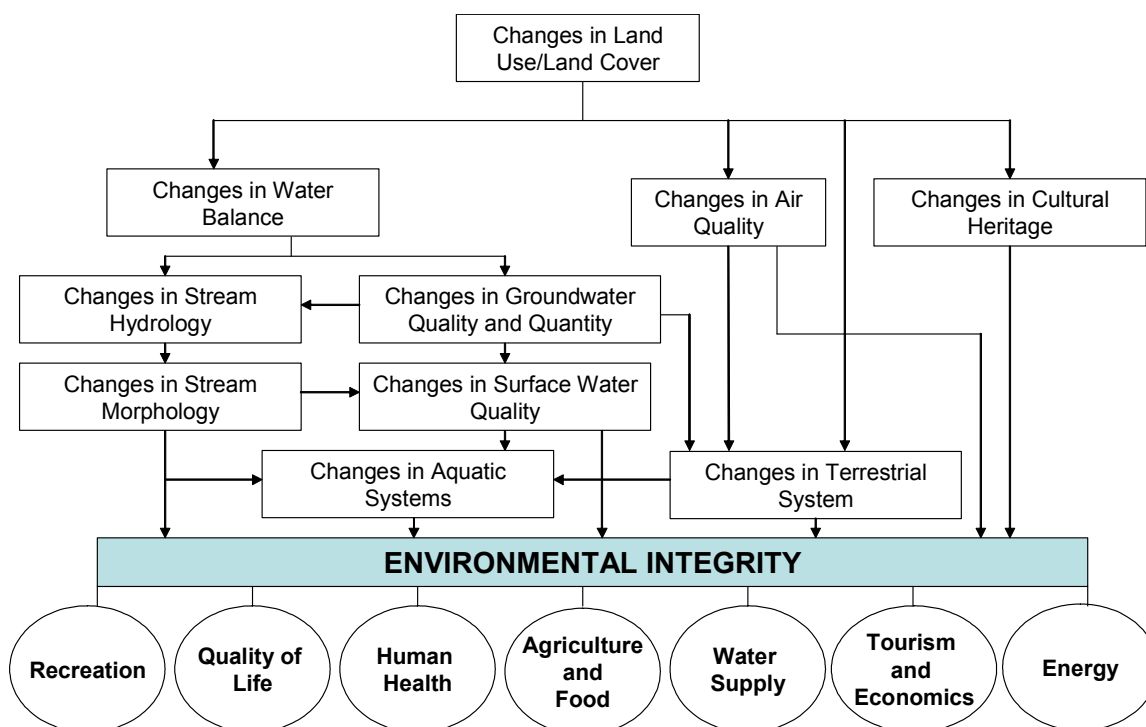
The potential impacts of changes to land use and land cover on the health of watersheds have been well-documented and include changes to groundwater infiltration, run off, stream flow regime, water quality, stream channel erosion, and wildlife habitat. The conceptual watershed response model outlined in **Figure 3.4** describes the ecological linkages that exist between different components of a watershed system and the sequential order of changes that can be anticipated to occur following a change in land use or land cover. In this conceptual model such changes could include:

- direct “footprint” effects, such as the loss of natural land cover or destruction of built heritage features;
- indirect “flow related” effects such as increased frequency of high stream flows, accelerated stream channel erosion and deterioration of water quality; and,
- cumulative effects such as changes in aquatic community composition that may arise from a combination of changes affecting upstream areas.

This model has been adapted from an initial model developed by Snodgrass (Snodgrass *et al.*, 1996), which focussed on impacts on aquatic ecosystems contained within streams and rivers, and on a later adaptation of that work by Credit Valley Conservation in a subwatershed study (CVC, 2001), which also focused on flow related impacts to the aquatic system. TRCA has expanded the model to include air quality, terrestrial system and cultural heritage components. The expanded model also identifies linkages between environmental integrity (or watershed health) and the beneficial uses that human derive from watershed resources (TRCA, 2003b).



**Figure 3.4: Watershed Response Model**



### 3.5 Management considerations

#### Existing rural and agricultural areas

Rural and agricultural land uses occur on the majority of this subwatershed. As a headwater stream, Centreville Creek is especially susceptible to changes in water quality as a result of influences from surrounding rural and agricultural land uses. Implementation of best management practices on rural and agricultural lands that reduce the risk of contamination of surface waters from land-based activities will be an important part of effective management for this subwatershed. Work to promote rural and agricultural best management practices (BMPs) in the rural portion of the subwatershed should continue through the Region of Peel and TRCA's Rural Clean Water Program. Rural Clean Water Program staff should use available information obtained through terrestrial natural heritage field inventories to focus work on promoting implementation of BMPs that reduce livestock access to natural areas where observations of severe livestock grazing or trampling have been made.

Residents rely on groundwater for domestic water supplies. A preliminary assessment of potential sources of groundwater contamination has been completed for the Region of Peel that identifies several properties in the subwatershed where a high level of risk for groundwater contamination may exist (AMEC, 2003). Further investigation of high potential risk areas should be undertaken, to assess actual risks and whether contaminant management plans are needed or already in place, on a site-by-site basis.

On-line ponds and dams on private property raise concern over the potential impacts that these structures have on fish movement, downstream water temperature and cold water fish communities. Similarly, should an on-line pond or dam structure fail during a storm event,

sediments that have accumulated behind the structure would be released, which raises concerns over potential impacts on downstream water quality and aquatic habitat.

Another management consideration with regard to rural land use in the study area pertains to lands that have been subjected to extractive resource uses (peat and aggregates) in the past. Plans for their rehabilitation and future use should be developed and implemented.

### **Existing urban areas**

Most of the existing urban areas in Caledon East were developed prior to the requirement for stormwater treatment. The Town of Caledon and TRCA should work together to implement improvements to stormwater management in portions of Caledon East with no stormwater treatment as part of future infrastructure improvements, redevelopment and infill development initiatives.

### **Future urban areas**

Growth of urban settlements can potentially affect the existing water balance in the watershed through changes to surface drainage patterns, and increases to impervious land cover. These changes affect the watershed's capacity to infiltrate precipitation and detain run off and thereby, to attenuate stream flows. Planning and design of new urban settlements and road infrastructure in this subwatershed should be based on design principles that minimize changes to predevelopment water balance. Innovative urban designs that minimize impervious surfaces, maintain the function of significant headwater drainage features, incorporate stormwater controls that promote infiltration of run off, utilize green roof technologies, and harvest and re-use rainwater should be considered as part of an overall stormwater management strategy.

Planning and design of the open space system within new urban settlements should take into consideration that lands within the subwatershed have been targeted for securement and restoration of natural land cover through the TRCA's terrestrial natural heritage system strategy (TRCA, 2004). Lands in the target terrestrial natural heritage system<sup>3</sup> should be considered by the Town of Caledon for designation as Environmental Policy Areas (EPA) and development should be directed to lands outside the targeted system to the greatest extent possible. Where this is not possible, a "net-gain" principle should be adhered to that recognizes the need to improve on existing conditions, and that any losses of existing or targeted natural land cover should be compensated elsewhere. Appropriately sized ecological buffers around important surface water and natural heritage features should be established for their protection. Planning and design of new public greenspace trails should consider available information on the sensitivities of the natural features (e.g., vegetation communities and flora and fauna species) and avoid features that are highly sensitive to human disturbance or particularly vulnerable to typical negative impacts associated with trail uses (see **Section 8**).

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<sup>3</sup> An updated target terrestrial natural heritage system has been defined for the Humber River watershed in the *Humber River Watershed Plan* (TRCA, 2008b) and *Implementation Guide* (TRCA, 2008a). The recommended target terrestrial natural heritage system shown in the *Humber River Watershed Plan* and *Implementation Guide* should be used to inform natural heritage system planning and management initiatives in Centreville Creek subwatershed.

## 4. Groundwater system

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Protecting the quality and quantity of groundwater flowing through the subwatershed is integral to the residents and businesses that rely on this resource for domestic and agricultural water supply, and critical to sustaining the health of local terrestrial and aquatic ecosystems.

### 4.1 Measuring groundwater quantity and quality

The quantity of water in any groundwater system is dependent on both recharge and discharge. Recharge rates measure the quantity of precipitation (i.e. rain and snowmelt) that infiltrates into the ground to recharge aquifers. Discharge rates measure the amount of groundwater that returns to the surface water system. Groundwater recharge can be affected by land use and especially by impervious land cover associated with urban settlements. The greater the impervious land cover, the less potential there is for infiltration, which has the potential to decrease groundwater recharge and discharge, which is a major component of baseflow in watercourses.

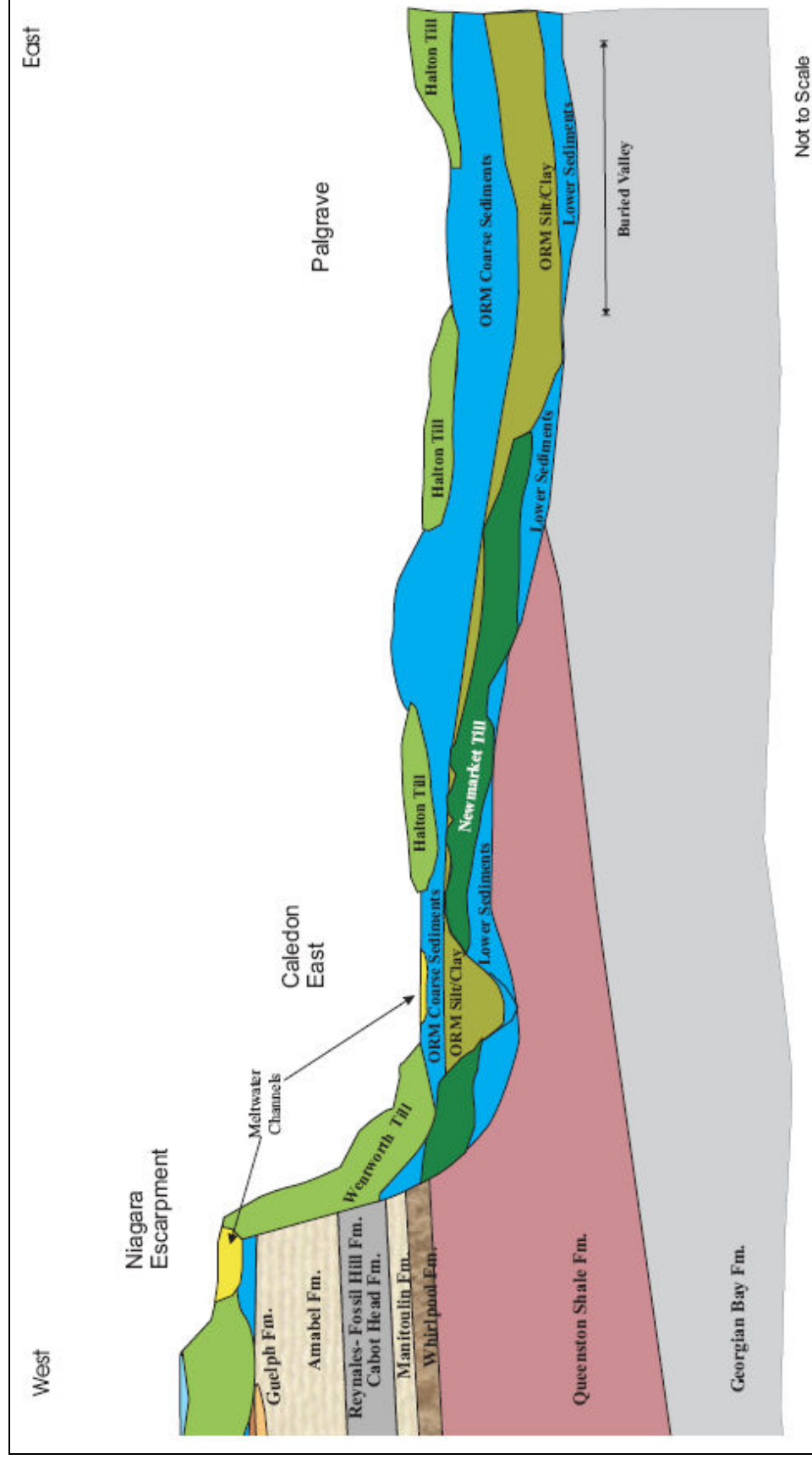
A common approach to developing a better understanding of groundwater systems is to develop conceptual and numerical models that simulate the subsurface geology and groundwater flow patterns within a certain study area. In support of their wellhead protection study for new municipal wells in Caledon East and Palgrave, a regional-scale geologic and groundwater flow model has been developed for the Region of Peel that covers the majority of the Town of Caledon and includes all of Centreville Creek subwatershed (WHI, 2003). Another regional-scale geologic model and numerical groundwater flow model is in the process of being developed for the geographic area encompassing the Regions of Peel, York, Durham and the City of Toronto (referred to as the YPDT groundwater model). This information is being compiled through a partnership between the regional municipalities of York, Peel and Durham, the City of Toronto and Conservation Authorities Moraine Coalition. These groundwater flow models utilize information from existing water wells and boreholes to construct a geologic model and predict groundwater movement through the subsurface and groundwater discharge to the surface water system. In 2004 the YPDT geologic model and groundwater flow model did not yet cover Centreville Creek subwatershed, but work was underway to extend the model boundary to include the entire Humber River watershed.

Groundwater levels and quality in the study area is monitored at municipal water supply wells by the Region of Peel and at Provincial Groundwater Monitoring Network (PGMN) wells by TRCA. Three municipal water supply wells and two PGMN wells are located in the subwatershed (**Section 3; Figure 3.3**). The Centreville Creek PGMN well (W 329-1) is located off Old Church Road, west of Humber Station Road. The Caledon East PGMN well (W 330-1) is located in Caledon East and was formerly a Region of Peel water supply well.

### 4.2 Hydrogeology

**Table 4.1** presents a summary of the hydrostratigraphic units in the study area based on the summary provided for the Region of Peel's wellhead protection study for new municipal wells in Caledon East and Palgrave (WHI, 2003). **Figure 4.1** illustrates the conceptual geologic model that guided development of the Region of Peel groundwater model (WHI, 2003). The figure shows the general configuration of each hydrostratigraphic unit that occurs in the study area. The hydrostratigraphic units consist of geologic units with similar hydrogeologic properties, which were grouped together for the purpose of analyzing regional groundwater flow.

Figure 4.1 Region of Peel conceptual geologic model (WHI, 2003)





**Table 4.1 Hydrostratigraphic units in the study area (from WHI, 2003)**

| <b>Hydrostratigraphic Unit</b>                 | <b>Geologic Unit</b>                          | <b>Description</b>  | <b>Zone</b>               | <b>Spatial Distribution</b>   |
|--|---|---|---------------------------|---|
| Upper Aquitard                                 | Halton Till/<br>Wentworth Till                | Silty to clay silt till/<br>sandy silt till                 | Overburden                | Continuous in Till<br>Plains and on<br>Escarpment; more<br>variable and<br>laterally<br>discontinuous<br>along moraine;<br>Unstratified |
| Oak Ridges<br>Moraine (ORM)<br>Aquifer Complex | ORM Coarse<br>Sediments                       | Glaciofluvial/ ice-<br>contact sands and<br>gravels         | Overburden                | Variable thickness<br>up to ~65 m;<br>thickest deposits<br>in kames and<br>meltwater<br>channels;<br>Stratified                         |
| Lower Aquitard                                 | Newmarket Till/<br>ORM Silt/Clay<br>Sediments | Silty sand till/<br>glaciolacustrine<br>silt and clay       | Overburden                | Regional but<br>discontinuous,<br>channeled   |
| Lower Aquifer<br>Complex                       | Lower Sediments                               | Fine to mediums<br>and, with till<br>remnants               | Overburden                | Thin to absent;<br>greatest thickness<br>in buried bedrock<br>valleys   |
| Bedrock Aquifer 1                              | Weathered<br>Bedrock                          | Upper 3-5 m of<br>fractured shale /<br>dolostone<br>bedrock | Bedrock (contact<br>zone) | Continuous,<br>fracturing varies<br>by layer but is<br>greatest in upper<br>3-5 m   |
| Bedrock Aquifer 2                              | Guelph/Amabel<br>Formation                    | Dolostone   | Bedrock                   | Niagara<br>Escarpment only,<br>small area of<br>study area  |
| Bedrock Aquitard                               | Queenston Shale/<br>Georgian Bay<br>Formation | Red shale/ blue<br>shale                                    | Bedrock                   | Continuous with<br>variable thickness   |

Topography exerts a controlling influence on the configuration of the groundwater table and consequently on the direction of groundwater flow. As a result, regional groundwater flow tends to move from topographically high areas to lower elevations throughout the study area, with local groundwater flow generally being controlled by smaller scale features such as hummocks and ridges (WHI, 2003).

Coarse-grained overburden deposits of the ORM, Lower Sediments, and fractured bedrock are the most transmissive units in the study area. Where ORM deposits are exposed at ground surface, groundwater recharge is generally greatest. Fine-grained overburden units such as tills represent both local and regional aquitards and limit the rate of recharge to aquifers and impede vertical groundwater flow.

Groundwater recharge is occurring throughout all areas of the subwatershed except where groundwater is directly discharging to surface water features. In areas of hummocky terrain, closed depressions capture precipitation that would otherwise become run off, which slowly infiltrates and provides a significant source of groundwater recharge to the regional aquifer systems. Across the till plains (i.e., Upper Aquitard), recharge is low and a larger proportion of precipitation becomes run off and flows to rivers and streams.

Based on 2002 summer baseflow measurements and confirmed through mini-piezometer measurements in 2003, major locations of groundwater discharge to Centreville Creek occur along the tributary streams, Bracken Creek, Boyce's Creek and Evans Creek (see **Section 5.3; Figure 5.1**). The source of this discharge is the Oak Ridges Aquifer Complex outcropping along the stream channel. As Centreville Creek passes through Caledon East, the stream channel encounters the highly permeable sediments of the Caledon East Meltwater Channel and the stream channel becomes a groundwater recharge area. A net decrease in summer baseflow was observed in Centreville Creek between Mountainview Road and Airport Road in 2002 (see **Section 5.3; Figure 5.1**). The stream channel continues to function as a recharge area to the Caledon East Meltwater Channel and underlying Oak Ridges Aquifer Complex until it enters the Innis Lake and Widget Lake wetland complex, where the channel is believed to resume functioning as a groundwater discharge area.

As mentioned previously in **Section 3.2**, Region of Peel production wells CE2 and CE3 obtain groundwater from the Oak Ridges Moraine Aquifer Complex, and specifically, from the Caledon East Meltwater Channel portion of this aquifer complex. The production wells are completed near the base of the meltwater channel into deposits of glaciofluvial sand and gravel (WHI, 2003). The upper portion of the meltwater channel is characterized by sand and gravel, which contains the shallow water table. Glaciofluvial sediments consisting of fine sand to discontinuous silt and clay layers separate these deep and shallow aquifer zones. Stantec confirmed the existence of a weak hydraulic connection between the deep and shallow zones of the Meltwater Channel Aquifer under pumping conditions, suggesting that the glaciofluvial sediments separating the water table from the deeper aquifer are leaky (Stantec, 2002).

Region of Peel production well CE4 is completed in a hydrostratigraphic unit referred to as the Lower Aquifer Complex or within local sand lenses embedded in the Lower Aquitard.

Geologically, the Lower Aquifer Complex consists of three distinct layers:

1. a sand and gravel layer,
2. till remnants, and
3. a deep sand and gravel unit that directly overlies bedrock, referred to as the Granite Stones Aquifer (Dames and Moore, 1996).

The Granite Stones Aquifer pinches out towards the east and is separated from the Caledon East Meltwater Channel by the Lower Aquitard (WHI, 2003). The water table in the area of CE4 is located within the upper ice supported stratified drift of the ORM Aquifer Complex, which is separated from the Lower Aquifer Complex by the till deposits of the Lower Aquitard.

Regional groundwater flow is southward through the ORM Aquifer Complex in the area of Caledon East. In the area of CE2 and CE3, the Caledon East Meltwater Channel exerts an influence on the direction of groundwater flow, with localized flow moving from west to east. In the area of CE4 groundwater flow through the Lower Aquifer Complex is to the south, which is consistent with regional groundwater flow patterns.

### 4.3 Potential sources of groundwater contamination

Potential sources of groundwater contamination in the subwatershed are nitrate and bacteria contamination from agricultural activities and private septic systems and de-icing salt from winter road maintenance practices. Nutrients from fertilizer and manure applications on agricultural lands can leach into the soil and contribute nitrates and bacteria to the groundwater system. Septic systems servicing rural residences also contribute nitrates and bacteria to the groundwater system. Winter road maintenance practices that involve the spreading of de-icing salt also can affect groundwater quality, as the spreading of these de-icing compounds often results in the salts being transported to nearby soils. The de-icing compounds rapidly dissolve in water and can be transported with the groundwater to shallow and deeper aquifers. Considering that private wells are often located near roads, the potential for winter road maintenance practices to affect the quality of water being derived from private wells is high.

Waterloo Hydrogeologic Inc. (WHI) completed a wellhead protection study for the Region of Peel for all municipal groundwater wells and proposed new wells, including a proposed Caledon East #5 well, located in the study area (WHI, 2003). Based on groundwater flow modelling work, delineations have been made of the capture zones for each municipal groundwater well. Capture zones have been delineated to show the surface of land where infiltrating groundwater would reach the municipal wellhead within 0 to 2 years, 2 to 5 years, 5 to 10 years, and 10 to 25 years. Certain land uses or human activities occurring within these zones have the potential to affect groundwater quality at the wellheads (e.g., spills from chemical or fuel storage areas, leachate from old landfills, septic systems, livestock waste, spreading of road de-icing salt, excessive fertilizer or pesticide use). An initial examination of land use within the wellhead capture zones for municipal wells in the Centreville Creek subwatershed indicates that potential sources of groundwater contamination exist related to agricultural and urban land uses in the vicinity of these wells.

In 2003, the Region of Peel also completed a land use and chemical occurrence inventory study that provided an assessment of potential groundwater contamination risks (AMEC, 2003). An aquifer vulnerability index was applied to identify areas where the shallow aquifer is more vulnerable to contamination based on hydrogeologic characteristics. Two main factors in determining aquifer vulnerability are the depth to the water table and the hydraulic conductivity of surficial deposits. Assessing groundwater contamination risk involved consideration of potential contaminant sources and their proximity to vulnerable aquifers. The vulnerability of a given area was rated on an Intrinsic Susceptibility Index (ISI) that ranked areas as high, medium or low vulnerability. Vulnerability of the shallow aquifer was ranked as medium or high over the majority of Centreville Creek subwatershed, due to the presence of highly permeable Oak Ridges Moraine sand and gravel deposits at or near surface.

Land use information was correlated with the assessment of aquifer vulnerability to assess potential groundwater contamination risks. Lands were ranked as either having a high, medium or low level of risk as potential sources of groundwater contamination. The majority of the subwatershed received ratings of low or medium in terms of groundwater contamination risk, with a few areas receiving high ratings (AMEC, 2003). These findings represent a preliminary assessment of potential risk. Further study and field investigations are required to assess actual level of risk and to determine whether or not contaminant management planning work is needed, or if plans are already in place.

#### **4.4 Management considerations**

Considering that discharge from the Oak Ridges Aquifer Complex is a major contributor of stream flow to Centreville Creek during extended dry periods, protecting the infiltration capacity of lands that contribute recharge to this aquifer is vitally important to protecting and enhancing the health of the creek and local aquatic ecosystems. Planning and design of new urban settlements in this subwatershed should strive to minimize changes to existing groundwater recharge rates through implementation of design principles that minimize impervious surfaces and incorporate stormwater management measures that infiltrate as much run off as possible.

Considering the high capacity for groundwater infiltration that exists in this subwatershed, and the lack of a low permeability cover over the Oak Ridges Aquifer Complex, the management of land use and human activities to prevent the contamination of groundwater resources and protect municipal and private sources of potable water supply is an important issue to consider. Planning of new urban settlement areas should consider the vulnerability of local shallow aquifers to contamination. Land uses that represent potentially high risk sources of groundwater contamination should either be directed away from wellhead capture zones and areas of high aquifer vulnerability, or should require contaminant management plans to be developed and implemented. Field investigations should be undertaken for areas identified as having high potential risk of groundwater contamination in the Region of Peel Land Use and Chemical Occurrence Inventory study, particularly in wellhead capture zones, to assess actual risk and whether or not contaminant management plans are needed.

The existence of a meltwater channel that cuts through the low permeability Newmarket Till layer separating the Oak Ridges Aquifer Complex and Lower Aquifer Complex suggests that groundwater flow between the two aquifers is occurring within the study area, but likely at a very slow rate.

Groundwater levels in wetlands and along stream channels down gradient of Caledon East wells and upward gradients in nearby groundwater discharge areas should be closely monitored to ensure that any future increases in groundwater takings do not negatively impact aquatic and terrestrial habitats.

Once predictions regarding the distribution of groundwater discharge areas and rates of discharge are made available for the entire Humber River watershed from the YPDT groundwater model, this information should be correlated with information from the Region of Peel groundwater model developed for their wellhead protection study. It should also be correlated with available baseflow measurements, aquatic system monitoring data and thermal regimes to gain a better understanding of how the groundwater system influences other components of the subwatershed system.

## **5. Surface water quantity**

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Centreville Creek is a spring-fed headwater tributary that flows through Caledon East, two online lakes and extensive riverine wetlands before flowing into the main branch of the Humber River at Albion Hills Conservation Area. The creek is composed of 151 kilometres of permanent and intermittent streams. Approximately 70 stream crossings exist along the length of the creek.

### **5.1 Measuring surface water quantity**

Stream flow can be measured in several ways. Permanent gauge installations provide the means to continuously monitor stream flow. Field measurements provide information on stream flow at a given location and time. Predictive modelling methods are also used to estimate stream flow conditions under various rainfall events and various land use scenarios at locations of interest.

#### **Permanent stream flow gauges**

Stream flow in Centreville Creek is measured continuously at a Toronto and Region Conservation stream gauge located in Albion Hills Conservation Area, near the Albion Hills Field Centre, upstream of the swimming area (see **Section 6; Figure 6.1**). This gauge was installed in June 2002. At the time of preparing this report, insufficient information was available from this gauge to properly characterize baseline stream flow conditions in Centreville Creek. Once at least five years of stream flow data has been collected, this information should be analyzed to establish baseline conditions regarding average annual and seasonal flow, baseflow and flow frequency.

#### **Field measurements**

Field measurements of stream flow during spring and summer low flow periods have been taken by TRCA at numerous locations throughout the subwatershed in order to gain a better understanding of groundwater-surface water interactions and to help identify natural and human influences on low stream flow conditions. TRCA applied Water Survey of Canada flow measurement standards and the Geological Survey of Canada (GSC) sampling protocol to ensure that measurements were taken under baseflow conditions. Given the geology and climate in the TRCA jurisdiction, a minimum 72-hour waiting time was established following any precipitation event before measuring. This would ensure that all surface run off had cleared the system and that the measured flow only reflected baseflow volumes. Measurements were made using electromagnetic current velocity meters.

#### **Hydrologic simulation models**

The existing hydrologic model of the Humber River watershed was last updated in 2002 (Aquafor Beech Ltd., 2002). The SWMHYMO computer model uses a unit hydrograph approach to simulate the response of the watershed to a precipitation event. To carry out the hydrologic analysis, the Humber River watershed was discretized into several hundred sub-catchments. A total of 19 sub-catchments make up the Centreville Creek subwatershed portion. Physical information regarding the size, shape and average slope of the sub-catchment areas, as well as soils and land use information was used to accurately represent the sub-catchments in the SWMHYMO model. The hydrologic model of the Humber River watershed was calibrated using data from 7 local precipitation gauges and 9 stream flow gauges. The calibrated model was then used to calculate peak flows associated with standard

rainfall distributions. The output from the updated SWMHYMO model has been used to develop updated floodplain mapping and an updated flood vulnerable areas and roads database. It has also been used to refine stormwater management criteria.

XCG Consultants Ltd. developed an HSPF continuous simulation hydrologic model and conducted an erosion analysis for the Centreville Creek subwatershed to determine suitable sizing criteria for end-of-pipe stormwater management facilities for erosion control (XCG, 2005). The HSPF model was developed to simulate the hydrology of Centreville Creek for baseline (1999) conditions and future conditions associated with full implementation of the Caledon East Secondary Plan. Comparisons were made between baseline and future conditions to determine what amount of stormwater detention is needed within new developments to minimize the increase in frequency of flows that exceed established erosion thresholds. **Section 15** provides a summary of the results of this scenario modelling work.

## **5.2 Stream flow**

Because the highly permeable soils and underlying surficial geology in this subwatershed area that favors infiltration over surface run off, the stream flow regime in Centreville Creek is influenced to a lesser degree by precipitation than streams draining from the less permeable soils and surficial geology of the South Slope and Peel Plain (e.g., West Humber to the south). During dry periods, many of the first, second and third order streams continue to exhibit flow due to groundwater discharge inputs from springs and outcrops of the Oak Ridges Aquifer Complex along the channel. This stream flow regime has a significant positive influence on surface water quality conditions, as low rates of surface run off and high rates of infiltration reduce the transport of pollutants from the land surface to the creek and groundwater discharge inputs help to keep surface water contaminant levels low and temperatures cool.

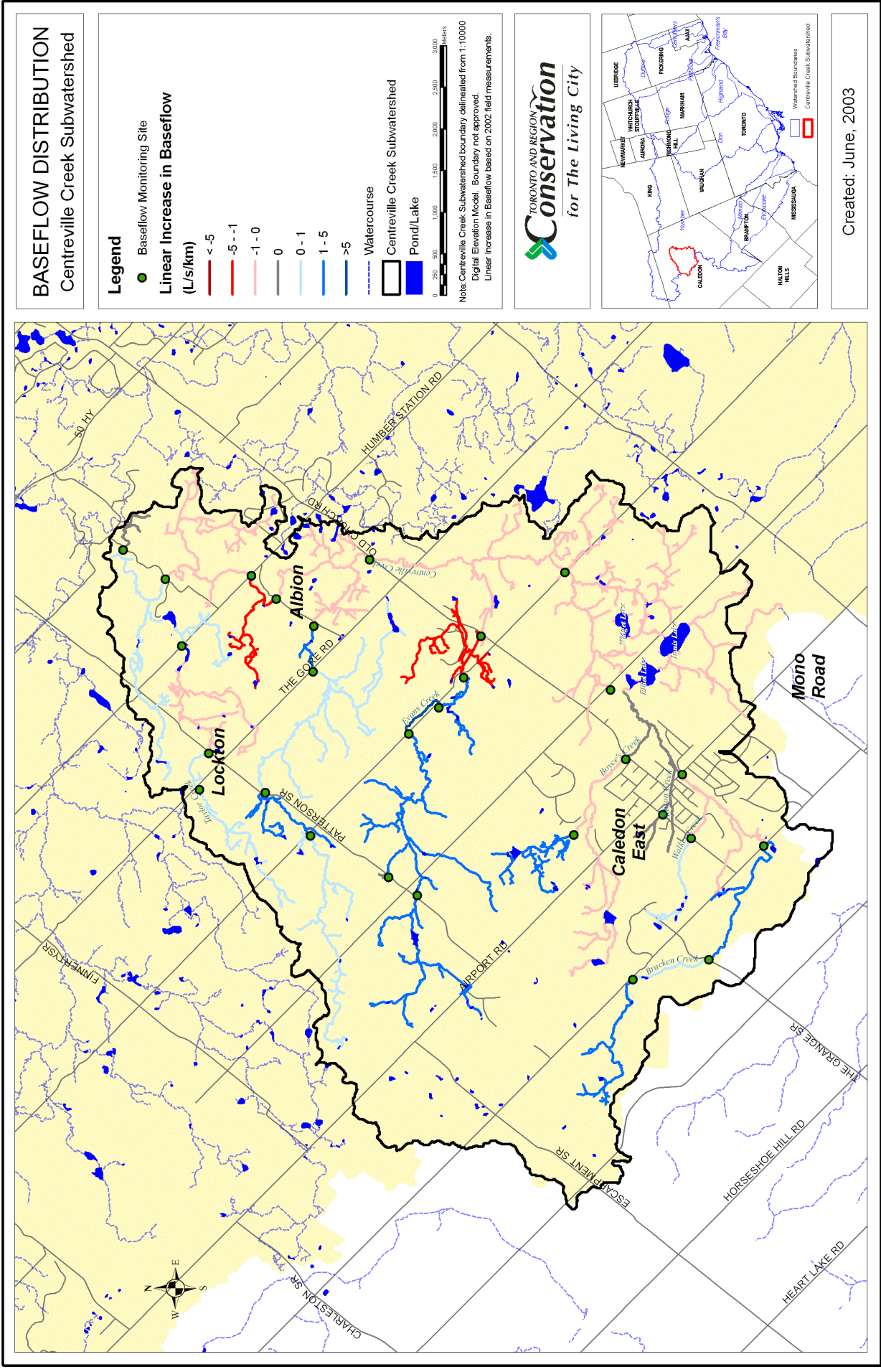
### **Baseflow**

Baseflow is defined as the amount of water flowing in a watercourse during periods of extended dry weather conditions. Baseflow conditions represent the lowest stream flow rates that typically occur in a given watercourse. Groundwater discharge is typically the main source of baseflow. In urban areas, contributions to baseflow from such sources as lawn watering and groundwater seepage into municipal storm sewer infrastructure can also contribute to baseflow. Any land use change that affects groundwater recharge and discharge rates, such as the growth of urban settlements, has the potential to change baseflow conditions in an affected watercourse.

A previous study of baseflow in Centreville Creek was undertaken in 1996 by the Geological Survey of Canada which involved measurements of stream flow at 28 sampling locations along the stream network (Hinton, 1997). More recent monitoring of low stream flow conditions by the TRCA was undertaken during the spring and summer of 2002, involving measurements of stream flow at 30 locations (**Figure 5.1**).



Figure 5.1 Baseflow measurements



In 2002 it was found that the main channel of Centreville Creek to the point where it crosses Centreville Creek Road, and Evans Creek together contribute close to 80% of the overall baseflow from the subwatershed, suggesting that significant groundwater discharge is occurring along these reaches. Similarly, results of the 1996 baseflow measurements indicated that these reaches contributed close to 70% of overall baseflow.

Interpretation of the results in terms of baseflow losses or gains along individual stream segments indicates that significant contributions occur along Bracken Creek (**Figure 5.1**). Along the reaches of the main channel of Centreville Creek downstream of Caledon East, subtle losses and gains were observed. These fluctuations are observed where Centreville Creek moves across the Caledon East Meltwater Channel deposits. Large contributions to baseflow occur along Evans Creek, particularly in the headwaters. As Centreville Creek passes through Caledon East, the stream encounters the highly permeable sediments of the Caledon East Meltwater Channel and the channel becomes a groundwater recharge area. A net decrease in summer baseflow was observed in Centreville Creek between Mountainview Road and Airport Road in 2002 (**Figure 5.1**). The stream channel continues to function as a recharge area to the Caledon East Meltwater Channel and underlying Oak Ridges Aquifer Complex until it enters the Innis Lake and Widget Lake wetland complex, where the channel is believed to resume functioning as a groundwater discharge area.

### **5.3 Flooding**

Greck and Associates Limited prepared updated floodplain mapping for the Humber River watershed in Peel Region, including the Centreville Creek subwatershed (Greck and Associates Ltd., 2003). The update involved a number of tasks. The existing base mapping was in analog form, and the HEC-2 computer model had been used to calculate floodlines. The existing maps were vectorized to digital form, and the HEC-2 model was converted to HEC-RAS, a more modern version of the hydraulic model. In addition to the basic model conversion, all bridge and culvert crossings were reviewed and refined in the model as necessary, and any other model irregularities, both those present in the previous model and those arising from the conversion, were corrected. Finally, regional floodline elevations were calculated with the updated HEC-RAS model, using the regional storm peak flow estimates from the updated hydrologic model (Aquafor Beech Ltd., 2002), and digital floodlines were prepared.

Floodplain mapping coverage of Centreville Creek extends up to Innis Lake Road. As part of the Caledon East Flood Study (Aquafor Beech Ltd., 2003), floodplain mapping coverage was extended upstream of Airport Road, and included two tributaries to Centreville Creek; Allison Creek and Boyce's Creek. As there was no previous coverage, new digital base mapping was prepared for the area and new cross sections were coded into a HEC-RAS model of the area.

TRCA maintains a database of flood vulnerable areas and roads, which is based on information from hydraulic model and floodplain mapping products. Aside from some flooding associated with overtopping of local road systems (at culvert crossings), the most significant flood risk that currently exists in the subwatershed is in Caledon East around the Airport Road crossing of Centreville Creek. The Town of Caledon and the TRCA initiated a Caledon East Flood Study to assess the extent of the affected area and to develop preliminary options for mitigative measures (Aquafor Beech Ltd., 2003). As part of the study, new digital floodplain mapping was prepared for Centreville Creek. In addition, regional storm floodline elevations were calculated for Allison Creek.

The study found that there are several buildings in the Centreville Creek floodplain, both upstream and downstream of Airport Road. The flooding was attributed to insufficient culvert capacities at the Airport Road crossing and the railway embankment / Caledon Trailways trail crossing immediately upstream of Airport Road, and historical filling and encroachment into the floodplain. Through Allison Creek, the regional storm flood flows exceed the capacity of the piped portions of the system, which results in flooding around several structures as regional storm run off spills eastward to Airport Road.

Finally, the study provided some preliminary options for flood control in Caledon East. These included further study of the trail and Airport Road stream crossings to determine if replacement was warranted, channel maintenance, and signage along the trail. Along Allison Creek, the recommended measures include reconstruction of the altered system through Caledon East to convey the 100 year return period storm peak flow rate through increased pipe capacity and channel improvements, provision of designated overland flow routes to Airport Road, flood proofing of buildings and channel maintenance.

#### **5.4 Water balance**

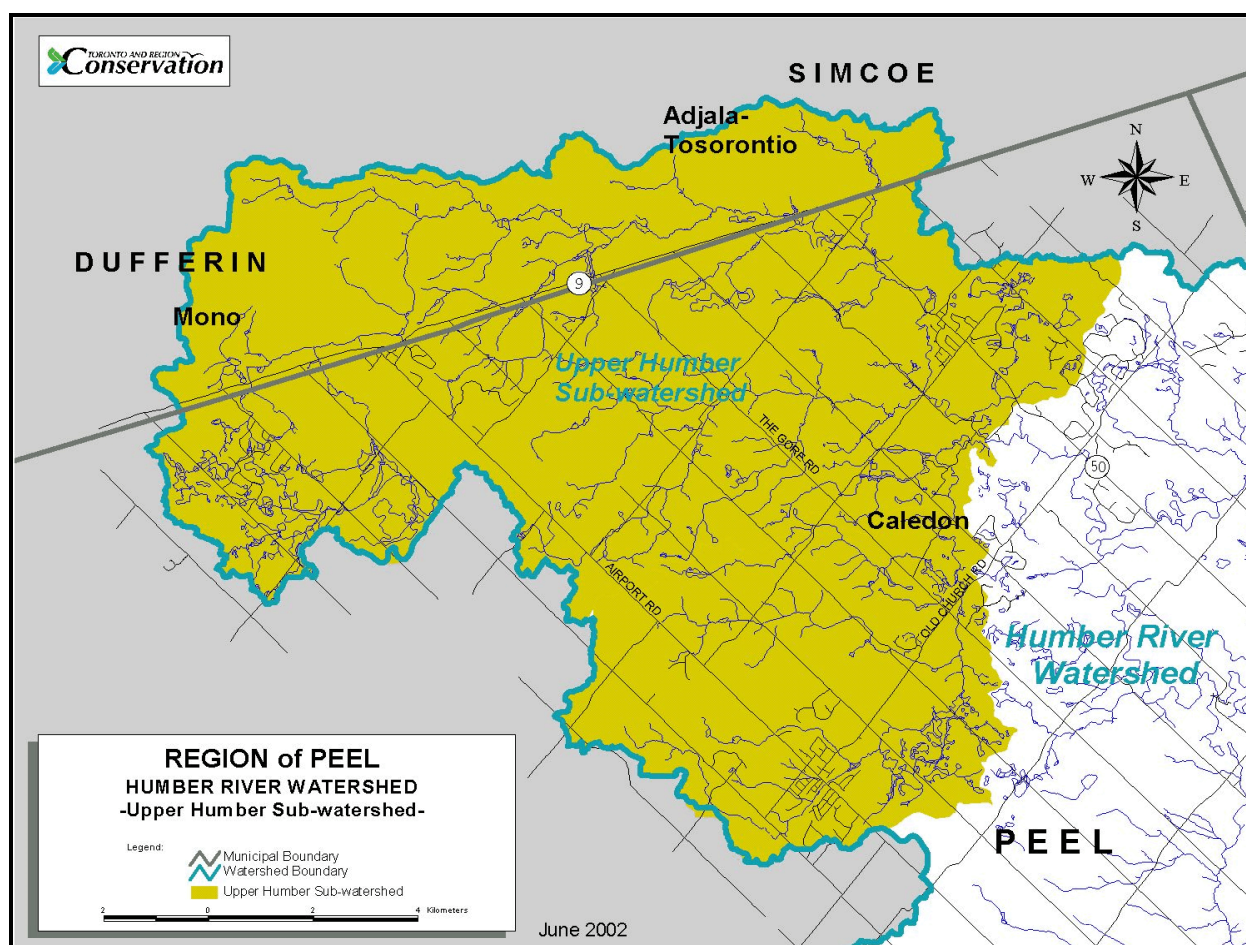
The accounting of the total quantity of water and its distribution within a watershed is known as the water balance. The main components that are accounted for in a water balance equation include: the total amount of precipitation input to the system, including both rain and snow; the percentage of precipitation which returns to the atmosphere through evaporation and transpiration (i.e., evapotranspiration); the percentage which enters the groundwater system through infiltration (i.e., recharge); the percentage which becomes run off and flows overland to collect in rivers and streams; and, the percentage which returns to the surface water system from the groundwater system (i.e., discharge). The processes by which these components move through the atmosphere, over land, and through the ground are collectively referred to as the hydrologic cycle. The physical properties of a watershed, such as drainage area, slope, soils, geology and land cover affect the distribution of water within the water balance and the processes that function within a watershed hydrologic cycle.

Clarifica Inc. was retained by Toronto and Region Conservation to complete a water balance analysis for the Upper Humber subwatershed. The Upper Humber subwatershed is defined by the area contributing drainage to the stream flow gauge on the Humber River near Palgrave, which includes the Centreville Creek subwatershed (**Figure 5.2**). The study characterized the surface water balance of the Upper Humber subwatershed for baseline conditions using 1999 land cover, and future conditions based on approved municipal official plan land use schedules (Clarifica, 2003).

In the study, the Water Balance Analysis System (WABAS) model was used to quantify the components of the water balance equation for the Upper Humber subwatershed. In addition to hydrometric data (measured flows) and physical basin parameters, the model requires climate time series input of daily precipitation, average or maximum-minimum daily temperature, and measured pan evaporation. Model outputs are time series information regarding run off, groundwater infiltration (recharge), evapotranspiration, and storage conditions.



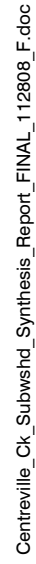
**Figure 5.2 Upper Humber subwatershed**



The WABAS model of the Upper Humber subwatershed was calibrated using measured flows from 1979 to 1998, and long-term water balance analyses were completed for both existing and future land use conditions. From the output of the water balance model, average annual groundwater infiltration rates for both existing and future land use conditions can be estimated and mapped. Under existing conditions, the model predicts considerable groundwater recharge throughout the majority of the Centreville Creek subwatershed<sup>4</sup> (**Figure 5.3**). Areas of lower groundwater infiltration include the impervious surfaces associated with existing urban development in Caledon East, and in the vicinity of the south and east edges of the subwatershed, where surficial soils and geology are less permeable.

<sup>4</sup> Updated estimates of average annual groundwater recharge, evapotranspiration and run off have been made using a watershed scale water budget model (PRMS), linked with the YPDT groundwater model, in developing the *Humber River Watershed Plan* (TRCA, 2008b) and *Implementation Guide* (TRCA, 2008a). Estimates of groundwater recharge and distribution reported in the *Humber River Watershed Plan* and *Implementation Guide* are the most up-to-date information available and should be used to inform planning and management initiatives in Centreville Creek subwatershed.

This map shows the Caledon region in Ontario, Canada. The Caledon East area is highlighted in red, and the Caledon West area is highlighted in yellow. The map includes a compass rose, a scale bar, and labels for various roads and water bodies. The Caledon East area is highlighted in red, and the Caledon West area is highlighted in yellow.





Initial analysis of the outputs of the water balance model for existing and future land use conditions shows that anticipated future development will not significantly impact groundwater recharge at a subwatershed scale, with only a minor increase in average annual run off volume (12 mm/yr) and a slight decrease in average annual groundwater infiltration rate (2 mm/yr). However, on a local scale, impacts from future development predicted by the model will be significant if predevelopment groundwater infiltration volumes are not met through innovative urban design and stormwater management measures. Without the implementation of lot level and conveyance stormwater management controls, average annual groundwater infiltration rates could be reduced by more than 75 mm/yr in some areas (Clarifica, 2003).

## **5.5 Management considerations**

Planning and design of new urban settlements and road infrastructure in this subwatershed should be based on design principles that minimize changes to predevelopment water balance. The results of the water balance analysis for the Upper Humber subwatershed establishes preliminary targets for groundwater infiltration, evapotranspiration and run off that should be maintained through urban design and stormwater management for new development in the subwatershed.<sup>5</sup>

Innovative urban designs that minimize impervious cover, maintain the function of significant small drainage features and incorporate porous paving materials and other stormwater controls that promote infiltration of run off, green roof technologies, and harvesting and re-use of rainwater should be considered as part of an overall stormwater management strategy. The design of stormwater management controls to service new urban settlements in this subwatershed should include capacity to provide quantity, quality and erosion control as per current standards (OMOE, 2003) and TRCA criteria. The updated hydrology model for the Humber River watershed establishes the predevelopment peak flow conditions which stormwater management controls associated with new areas of development will have to match as a part of the development approvals process.

The Town of Caledon and TRCA should work together to further evaluate options for remedial works to reduce risk of flooding in Caledon East, identified in the Caledon East Flood Study (Aquafor Beech Ltd., 2003).

The Town of Caledon and TRCA should also work together to implement known stormwater retrofit opportunities that will help to mitigate the negative impacts of untreated urban stormwater run off on the health of Centreville Creek (TRCA, 2001b).

Stream flow data that has been collected at the Centreville Creek stream gauge since installation should be analyzed to establish baseline conditions regarding average annual and seasonal flow, baseflow and flow frequency.

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<sup>5</sup>Updated estimates of average annual groundwater recharge, evapotranspiration and run off have been made using a watershed scale water budget model (PRMS), linked with the YPDT groundwater model, in developing the *Humber River Watershed Plan* (TRCA, 2008b) and *Implementation Guide* (TRCA, 2008a). Estimates of groundwater recharge and distribution reported in the *Humber River Watershed Plan* and *Implementation Guide* are the most up-to-date information available and should be used to inform planning and management initiatives in Centreville Creek subwatershed.



## 6. Surface water quality

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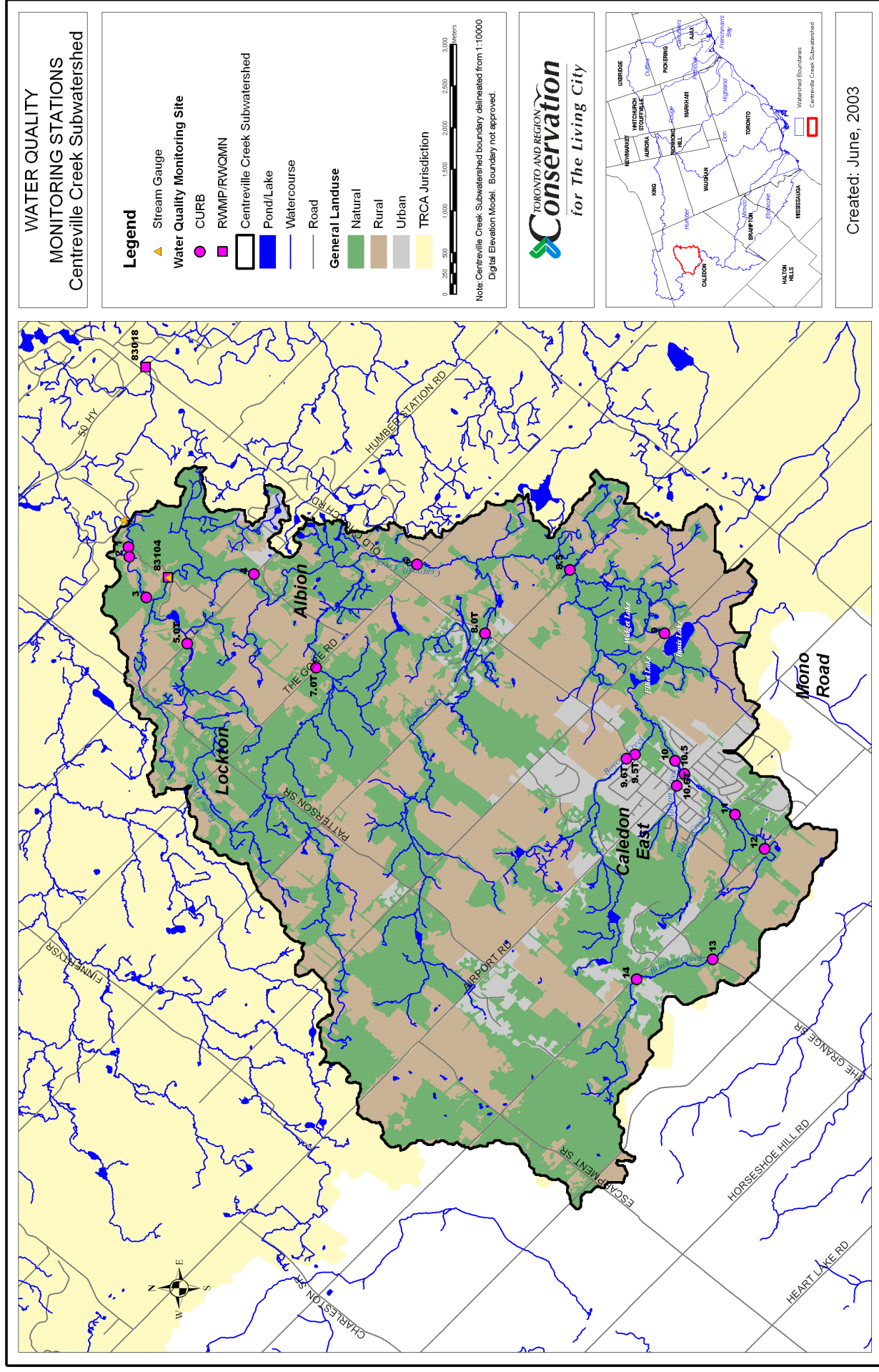
Numerous factors may be affecting surface water quality in Centreville Creek subwatershed. In the rural portions of the subwatershed, surface water quality is likely being influenced by the quality and quantity of groundwater that discharges to the stream and by run off from agricultural lands. In the urban portions of the subwatershed, contaminants from untreated urban run off also influence surface water quality. Surface water quality data has been collected in Centreville Creek as part of several monitoring programs and initiatives. Water quality data has been collected for such parameters as bacteria, nutrients, metals and other chemical parameters. In this section, available information regarding surface water quality in Centreville Creek and its major tributaries is assessed according to its suitability to support swimming and other body contact activities, and a healthy aquatic ecosystem. Concentrations of key water quality parameters are compared to Provincial Water Quality Objectives (PWQOs; OMOEE, 1999) or other guidelines established to protect particular uses or values.

### 6.1 Regional Watershed Monitoring Program sampling

Water quality samples are collected by TRCA as part of the Regional Watershed Monitoring Program (RWMP) at two stations that provide insight into conditions in Centreville Creek. One station (station 83104) is located on Centreville Creek, and receives drainage from Caledon East and run off from rural and agricultural land uses along the creek and its tributaries (**Figure 6.1**). This station was established in 2002 so data are available for only four months in that year (**Table 6.1**). The second station (station 83018) is downstream of the confluence of the Upper Main Humber and Centreville Creek, and includes drainage from the Centreville Creek subwatershed, and rural and agricultural lands and a few small settlement areas north of Albion Hills (**Figure 6.1**). Data from this station are summarized for the 1996 to 2002 period (**Table 6.2**). Samples at both stations were collected on a predetermined day of each month, and as such are biased towards dry weather conditions.

Most parameters at the Centreville Creek station (station 83104) met available guidelines, with the exception of phosphorus and lead (**Table 6.1**). Phosphorus failed to meet (or “exceeded”) the PWQO of 0.03 milligrams per litre (mg/L) in two of the four samples collected. Lead was analyzed only twice and exceeded the 5 micrograms per litre (ug/L) guideline on one of these occasions. Other metals analyzed (e.g., cadmium, chromium) met provincial objectives. Nitrogen compounds (nitrate, nitrite, unionized ammonia) were also within acceptable levels. Bacterial parameters were not analyzed at this station.

Figure 6.1 Surface water quality sampling stations



**Table 6.1 Summary of water quality data collected at Centreville Creek RWMP station**

| <b>Humber River, Centreville Creek</b><br><b>Station #: H 83104</b><br><b>(data collected from July 24, 2002 to October 29, 2002)</b> |                  |            |            |             |               |                  |                         |
|---|------------------|------------|------------|-------------|---------------|------------------|-------------------------|
|   | <b># of Obs.</b> | <b>Min</b> | <b>Max</b> | <b>Mean</b> | <b>Median</b> | <b>Guideline</b> | <b>% Meet Guideline</b> |
| <b>Suspended Solids (mg/L)</b>  | 4                | 3          | 19.3       | 7.6         | 3.8           | 25               | 100%                    |
| <b>Chloride (mg/L)</b>  | 4                | 32.8       | 37.6       | 35.6        | 36            | 250              | 100%                    |
| <b>Phosphorus (mg/L)</b>  | 4                | 0.02       | 0.06       | 0.04        | 0.04          | 0.03             | 50%                     |
| <b>Nitrate (mg/L)</b>   | 4                | 0.06       | 0.17       | 0.12        | 0.14          | 0.3              | 100%                    |
| <b>Copper (ug/L)</b>  | 4                | 0.28       | 0.47       | 0.39        | 0.4           | 5                | 100%                    |
| <b>Lead (ug/L)</b>  | 2                | 4.7        | 7.2        | 5.9         | 5.9           | 5                | 50%                     |
| <b>Zinc (ug/L)</b>  | 4                | 0.06       | 1.23       | 0.57        | 0.51          | 20               | 100%                    |

Source: TRCA, 2002.

Obs. = observations.

At the Albion Hills station (station 83018), below the confluence of Centreville Creek and the Upper Main Humber, concentrations of phosphorus and *E.coli* met provincial guidelines in 71% and 79% of samples, respectively. However, during the warm season from May to October, *E.coli* met the guideline in only 69% of samples collected, which is just below the target set for this constituent in the 2000 Humber River watershed report card (TRCA, 2000). Nitrate concentrations were higher than at the Centreville Creek station, often exceeding the lower limit of 0.3 mg/L identified in the Canadian Water Quality Guidelines (CCME, 1999) as the lower limit at which this nutrient may, under certain conditions, contribute to eutrophication of receiving waters. Metals were not analyzed at this station.

These data suggest that during dry weather, the major parameters of concern are phosphorus and bacteria. Not surprisingly, both of these are associated with run off from agricultural areas, the dominant land use in the subwatershed.

**Table 6.2 Summary of water quality data collected at Albion Hills' RWMP station.**

| <b>Humber River, Albion Hills</b><br><b>Station #: H 83018</b><br><b>(data collected from August 28, 1996 to May 30, 2002)<sup>1</sup></b> |                          |             |            |            |                         |               |                  |                         |
|--|--------------------------|-------------|------------|------------|-------------------------|---------------|------------------|-------------------------|
| <b>Parameter</b>   | <b>Monitoring Season</b> | <b>#Obs</b> | <b>Min</b> | <b>Max</b> | <b>Mean<sup>2</sup></b> | <b>Median</b> | <b>Guideline</b> | <b>% Meet Guideline</b> |
| <b>Suspended Solids (mg/L)</b>   | May - Oct                | 16          | 1          | 110        | 14.1                    | 6             | 25               | 88%                     |
|  | Nov - Apr                | 14          | 2          | 20         | 7                       | 4             |                  | 100%                    |
|  | all                      | 30          | 1          | 110        | 10.8                    | 5.5           |                  | 93%                     |
| <b>Chloride (mg/L)</b>   | May - Oct                | 16          | 6          | 296        | 52                      | 37            | 250              | 94%                     |
|  | Nov - Apr                | 14          | 36         | 103        | 52                      | 43            |                  | 100%                    |
|  | all                      | 30          | 6          | 296        | 52                      | 41            |                  | 97%                     |
| <b>E. Coli (counts/100 mL)</b>   | May -Oct                 | 13          | 5          | 230        | 31                      | 60            | 100              | 69%                     |
|  | Nov -Apr                 | 6           | 5          | 60         | 8                       | 5             |                  | 100%                    |
|  | all.                     | 19          | 5          | 230        | 20                      | 10            |                  | 79%                     |
| <b>Phosphorus (mg/L)</b>   | May - Oct                | 17          | 0.01       | 0.08       | 0.03                    | 0.02          | 0.03             | 82%                     |
|  | Nov - Apr                | 14          | 0.01       | 0.39       | 0.05                    | 0.02          |                  | 57%                     |
|  | all                      | 31          | 0.01       | 0.39       | 0.04                    | 0.02          |                  | 71%                     |
| <b>Unionized Ammonia (mg/L)</b>  | May - Oct                | 12          | 0          | 0.064      | 0.01                    | 0             | 0.02             | 92%                     |
|  | Nov - Apr                | 11          | 0          | 0          | 0                       | 0             |                  | 100%                    |
|  | all                      | 23          | 0          | 0.065      | 0.01                    | 0             |                  | 96%                     |
| <b>Nitrate (mg/L)</b>  | May - Oct                | 15          | 0.01       | 0.8        | 0.35                    | 0.33          | 0.3              | 47%                     |
|  | Nov - Apr                | 13          | 0.4        | 1          | 0.64                    | 0.6           |                  | 0%                      |
|  | all                      | 28          | 0.01       | 1          | 0.48                    | 0.5           |                  | 25%                     |

Source: TRCA, 2002

Obs. = observations

1. Prior to May 17, 1999, samples were not collected during the cold season (Nov.-Apr.)

2. Geometric mean used for *E. Coli*

## 6.2 Water quality modelling

Developed by the United States Department of Agriculture, the event-based Agricultural Non-Point Source (AGNPS) model is a useful tool for identifying sources and appropriate remedial actions for non-point source pollution (Young *et al.*, 1987). The model evaluates water quality based on a wide range of factors, including local hydrology, soils, nutrient and sediment loading, land use practices, land slope, precipitation, drainage, erosion and existing water quality. The model was successfully calibrated in the Duffins Creek watershed (Leon *et al.*, 2002), verified for the Humber River watershed (Stantec, 2003a) and applied in the Centreville Creek subwatershed (Stantec, 2003b).

Preliminary results of the modelled trace source contribution analysis module for adsorbed phosphorus and clay sediments are presented in **Figures 6.2 and 6.3**, respectively. Expressed as a percentage of total subwatershed load, the model predicts that the eastern portion of the subwatershed contributes a higher proportion of the total in-stream phosphorus and clay sediment loads than other areas do. These results are consistent with wet weather monitoring data collected in the late 1980s (see **Section 6.3** below). Areas predicted to contribute greater than 5% of total subwatershed loads are considered predominant source areas for phosphorus and sediment being transported to Centreville Creek. This information could be used to guide the work of Rural Clean Water Program staff to promote agricultural best management practices and tree and shrub planting programs that help prevent transport of nutrients and sediment to streams.

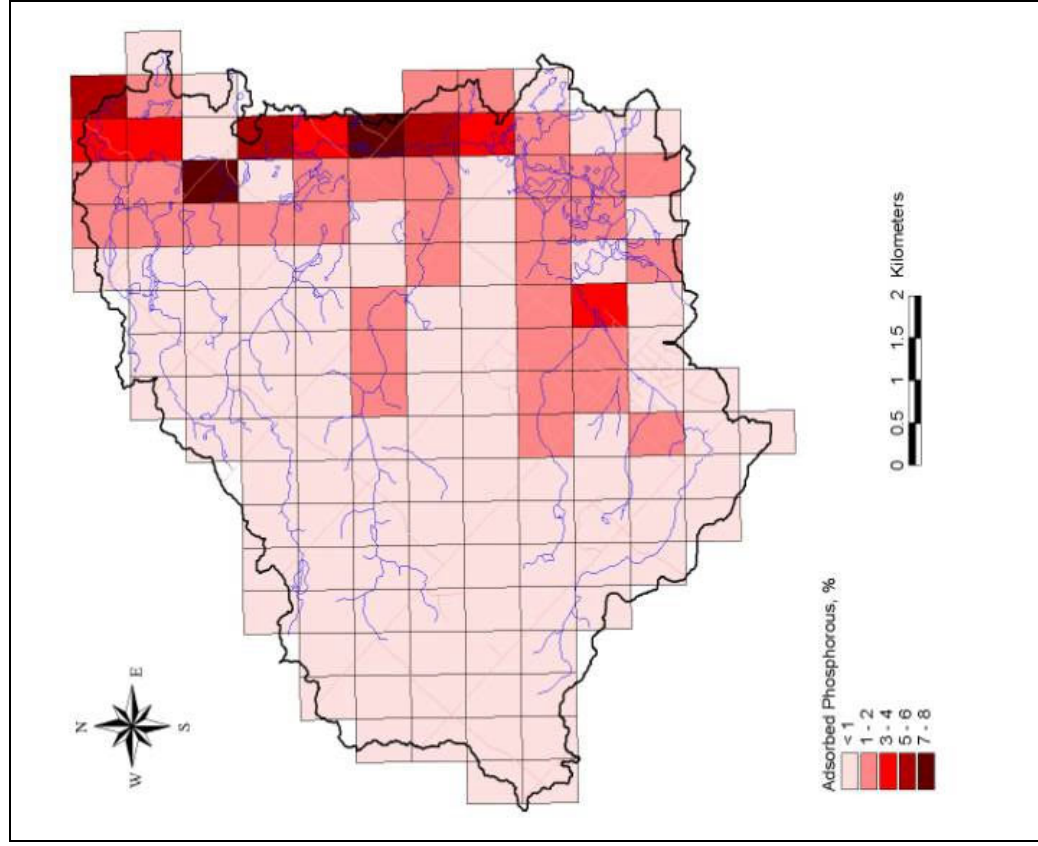
### **6.3 Historical trends in water quality**

Water quality sampling conducted between 1975 and 1996 by the Ontario Ministry of the Environment's Provincial Water Quality Monitoring Network at the Albion Hills station provided the basis for assessing historical trends in the Upper Main Humber and Centreville Creek for selected chemical constituents. A separate study of water quality in Centreville Creek that was part of the MTRCA Cleaning Up Rural Beaches (CURB) program, conducted from 1986 to 1988, offers a more detailed analysis of spatial trends in water quality parameters within the subwatershed during wet and dry weather conditions (Hubbard *et al.*, 1987 and Hubbard *et al.*, 1988). Trend analysis of the PWQMN data and major results of the CURB monitoring study on Centreville Creek are summarized below.

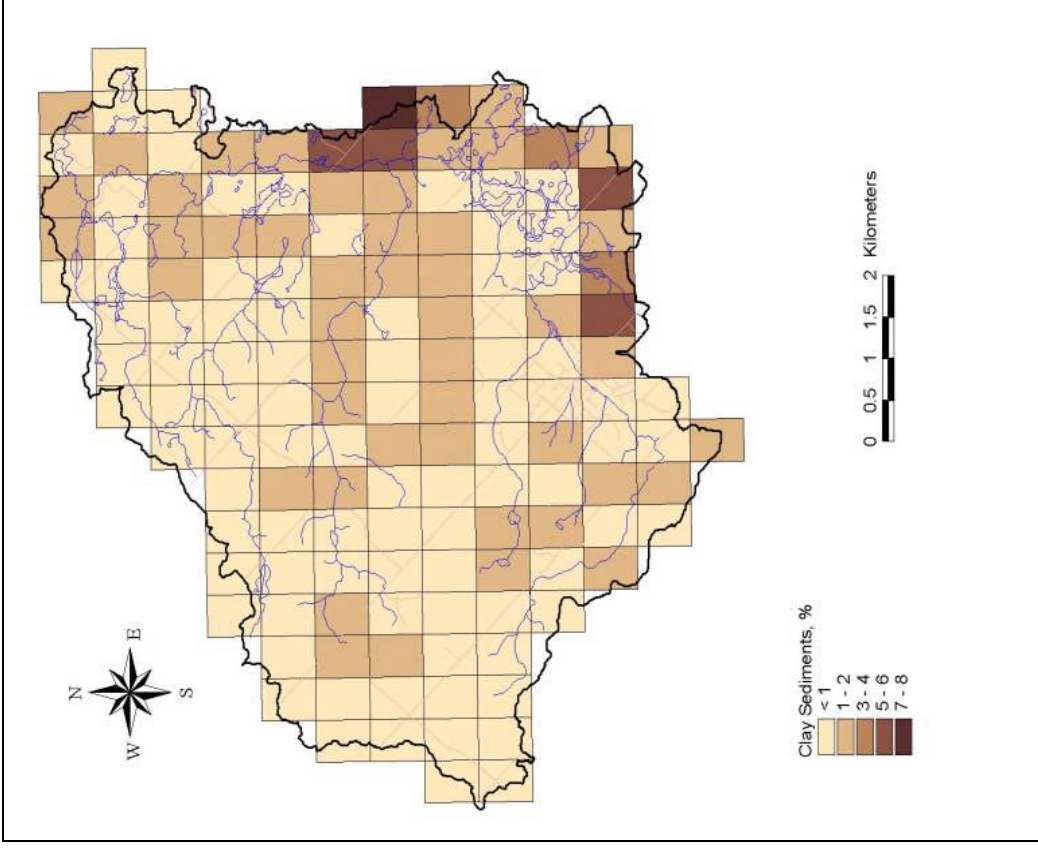
#### **Provincial Water Quality Monitoring Network sampling**

**Table 6.3** shows the results of the Kendall trend analysis of PWQMN data for selected water quality parameters at the Albion Hills station (station 83018). Samples were collected twice per month for the period indicated and represent predominantly dry weather conditions. An increasing trend was observed for chloride, faecal coliform and nitrite. The increases in chloride and faecal coliforms are attributed to urban growth, which increases run off of road salts and introduces new sources of bacteria from domestic animals and wild geese. The decrease in phosphorus is attributed to legislation which limited the use of phosphorus in detergents; and programs promoting the control of phosphorus discharges to watercourses. There were no statistically significant trends detected in suspended solids, total Kjeldahl nitrogen (TKN), ammonia or phenol levels.





**Figure 6.2** Source areas for adsorbed phosphorus in Centreville Creek (% of total annual load)



**Figure 6.3** Source areas for clay sediments in Centreville Creek (% of total annual load)



**Table 6.3 Trends in key water quality parameters at the Albion Hills PWQMN Station**

| Humber River, Albion Hills Conservation Area<br>Station #: H83018 |                   |  |            |       |        |
|---|-------------------|--|------------|-------|--------|
| Trend over entire period of observations                          |                   |  |            |       |        |
|   | # Obs             | Period of observations   | Trend      | Z     | Slope  |
| Phosphorus  | 185               | Jun 75-Dec 96  | decreasing | -2.77 | -0.095 |
| Suspended Sediment  | 175               | Jun 75-Sep 96  | --         | -1.47 | n/a    |
| Chlorides   | 61                | Jun 75-79; Sep 83; Nov 84; Jul 88; Mar 91; Oct 94-Dec 96                                     | increasing | 4.95  | 1.75   |
| Faecal Coliform   | 162               | Jun 75-Jun 94  | increasing | 1.96  | 2      |
| Phenol  | 108               | Feb 80-May 95  | no change  | -3.42 | n/a    |
| Total Ammonia (NH <sub>3</sub> +NH <sub>4</sub> )                 | 170               | Jun 75-Sep 94  | --         | 0.94  | n/a    |
| Nitrite (NO <sub>2</sub> )  | 49                | Jun 75-Dec 79; Jul 88  | increasing | 3.09  | 0.005  |
| Total Nitrates (NO <sub>2</sub> +NO <sub>3</sub> )                | insufficient data |  |            |       |        |
| Total Kjeldahl Nitrogen   | 66                | Jun 75-Dec 79; Mar 80; Sep 80; Feb 81; Oct 81; Sep 83; Nov 84; Jul 88; Mar 91; Oct 94-Dec 96 | --         | 0.84  | n/a    |
| Turbidity   | 179               | Jun 75-Dec 96  | –          | 0.44  | n/a    |

Source: Ontario Ministry of the Environment, 1996

# Obs = Number of Observations

-- = no statistically significant trend at 95% confidence interval

n/a = not applicable

### **Cleaning Up Rural Beaches (CURB) study (1986-1988)**

Between 1970 and the early 1980s, bacterial concentrations in the Humber and Rouge rivers often exceeded provincial guidelines, resulting in frequent closures of rural swimming beaches at the Boyd, Bruce's Mill, Claireville and Albion Hills Conservation Areas. Swimming beaches at Claireville and Boyd Conservation Areas were permanently closed in 1984, and chlorination units were installed at Bruce's Mill and Albion Hills to keep these beaches open. Concern over beach closures and loss of swimming opportunities in rural areas prompted the MTRCA to conduct a study of bacterial contamination and water pollution from September 1986 to March 1988 (Hubbard *et al.*, 1987 and Hubbard *et al.*, 1988). The study focused on three subwatersheds: Centreville Creek, East Humber and Bruce Creek. The following summary highlights study findings for Centreville Creek subwatershed.

#### Sampling program

In the Centreville Creek subwatershed, grab samples were collected at 11 and 18 stations on Centreville Creek and its tributaries in 1986 and 1987, respectively. The locations of monitoring stations are shown in **Figure 6.1**. The data set included 4 wet weather events and 14 dry weather periods. Water samples were analyzed by registered laboratories for microbiology and conventional parameters.

### Dry weather results

A large proportion of flow during dry weather originates primarily from relatively clean groundwater inputs. However, pollutants can enter the water during dry weather through poorly maintained septic systems, run off from field irrigation or lawn watering, vehicle washing, livestock and wildlife in streams, and contaminated sediments within the watercourse. Intensive sampling during dry weather showed faecal coliform densities above 1000 counts/100 mL in Caledon East, and at a storm sewer outfall at Airport Road. Faecal coliform densities were lower immediately downstream of Innis Lake (8 counts/100 mL), and near the Albion Hills swimming beach area. Mean dry weather faecal coliform densities exceeded the former provincial guideline of 100 counts/100 mL at 12 of the 18 sampling stations along Centreville Creek in 1987, and at 2 of the 11 stations sampled in 1986.

Concentrations of total phosphorus showed a pattern during dry weather similar to that of bacteria. Concentrations were highest within the Caledon East and at Airport Road, falling dramatically downstream of the two on-line lakes, Elliot Lake (also referred to as Scott Lake or Belcon Pond) and Innis Lake, then rising again towards Albion Hills Conservation Area. Phosphorus concentrations exceeded the provincial guideline of 0.03 mg/L in 44% of the 162 dry weather samples collected in 1987, and in 36% of 22 samples collected in 1986.

The concentrations of other pollutants were generally within acceptable limits. Chloride concentrations rarely exceeded 100 mg/L, unionized ammonia was consistently below 0.02 mg/L, and the highest dry weather total suspended solids (TSS) concentration was only 56 mg/L.

Non-routine sampling of bacterial parameters in sediment and the water column was conducted at the Elliot Lake and Innis Lake inlets and outlets and other stations in the subwatershed (**Figure 6.1**) to better understand the role these on-line lakes play in water quality. Results are presented in **Table 6.4**. Bacterial densities in both water column and sediment samples were elevated at the inlets to the two lakes, and were well above provincial guidelines. Faecal coliform densities were significantly lower at the outlets of the lakes, strongly suggesting that these natural features help to clean the water by acting as on-line settling basins. A large increase in bacteria levels occurred between Innis Lake and Centreville Creek Road. The cause was attributed to wildlife as opportunities for contamination from agriculture were few.

**Table 6.4 Non-routine bacterial sampling in the Centreville Creek subwatershed**

| Location                            | Sediment (c./gram) |                |             | Water Column ©./100 mL) |                |             |             |
|-------------------------------------|--------------------|----------------|-------------|-------------------------|----------------|-------------|-------------|
|                                     | <i>F. C.</i>       | <i>E. Coli</i> | <i>P.A.</i> | <i>F.C.</i>             | <i>E. Coli</i> | <i>F.S.</i> | <i>P.A.</i> |
| Caledon East                        | 92,000             | 92,000         | 930         | 112                     | 100            | 192         | 2           |
| Elliot Lake Inlet                   | 110,000            | 110,000        | 30          | 9,100                   | 7,900          | 44,000      | 420         |
| Elliot Lake Outlet                  | 4,300              | 1,500          | 3           | 10                      | 10             | 10          | 4           |
| Innis Lake Inlet                    | 24,000             | 24,000         | 3           | 1,700                   | 1,100          | 7,000       | 32          |
| Innis Lake Inlet (mouth)            | 46,000             | 46,000         | 3           |                         |                |             |             |
| Innis Lake Outlet                   | 930                | 930            | 3           | 10                      | 10             | 10          | 4           |
| Innis Lake Outlet at Innis Lake Rd. | 150                | 150            |             |                         |                |             |             |
| CC. at Centreville Ck. Rd.          | 92,000             | 92,000         | 3           | 160                     | 160            | 480         | 2           |
| CC. at Gore Rd.                     | 9,200              | 9,200          | 6           | 330                     | 300            | 460         | 4           |
| CC. at Humber Stn. Rd.              | 2,400              | 2,400          | 9           | 240                     | 300            | 460         | 4           |
| Bridge at Albion Hills Farm         | 9,300              | 9,300          | 23          |                         |                |             |             |

Source: Hubbard *et al.*, 1988

Note: CC = Centreville Creek

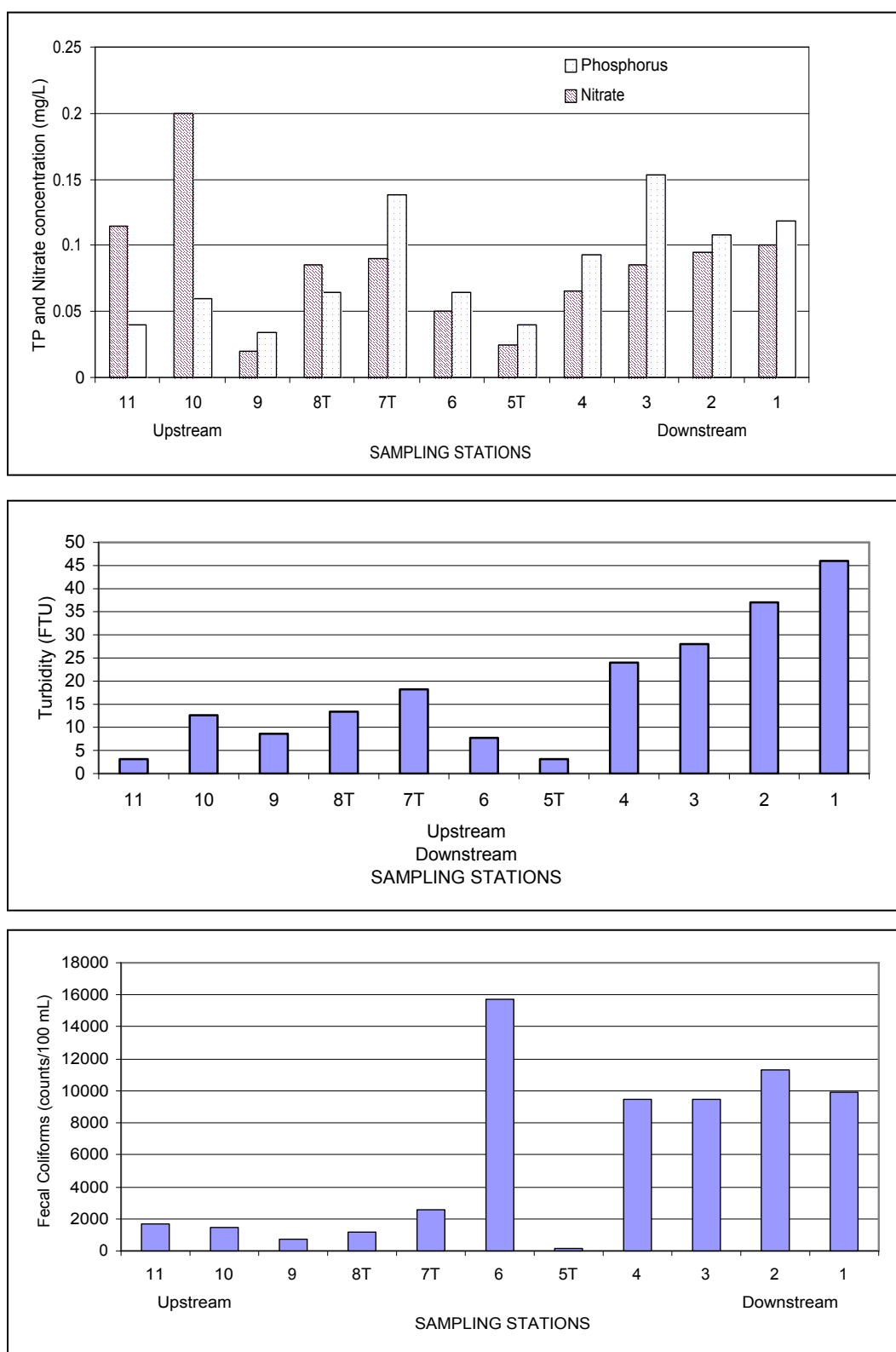
*F.C.* = faecal coliforms, *P.A.* = *Pseudomonas Aeruginosa*, *F.S.* = *Faecal Streptococci*.

#### Wet weather results

Stormwater run off picks up a wide range of pollutants as it flows across lawns, agricultural fields and hard surfaces. Fertilizers applied to lawns and agricultural areas, eroded sediment, and oil, grease, and metals from road run off are just a few of the many contaminants that are carried into lakes and rivers. In the Centreville Creek CURB study, samples during wet weather were collected at the same stations as during dry weather.

**Figure 6.4** shows the concentrations of selected pollutants at 11 stations on Centreville Creek for a large rain event in 1986. Station locations are shown on **Figure 6.1**. Tributaries of Centreville Creek are identified with a "T". The graphs show that pollutant concentrations were generally lowest at the Innis Lake outlet monitoring station (#9) and one of the tributary stations (#5T) upstream of Albion Hills. Elevated concentrations of most pollutants were observed near the Albion Hills Conservation Area. Nutrient concentrations were also relatively high at the tributary stations 7 and 8. In 1987, wet weather faecal coliform densities and phosphorus concentrations were highest within and upstream of Caledon East. Eighty percent of 36 wet weather samples collected in 1987 exceeded the phosphorus guideline of 0.03 mg/L.

**Figure 6.4 Concentrations of selected pollutants in Centreville Creek**



Note: Stations designated with "T" are tributaries of Centreville Creek.

Wet weather concentrations of chloride and nitrogen compounds were similar to dry weather, and generally within acceptable limits for the protection of aquatic life. Total suspended solids (TSS) concentrations were often above the recommended limit of 25 mg/L for the protection of aquatic life, although these levels persisted for relatively short durations. In 1987, average TSS concentrations during 3 wet weather events ranged from 2 to 282 mg/L among monitoring stations.

#### **6.4 Farmer survey**

In 2003, as input to the set up and validation of the Humber River watershed AGNPS water quality model, seven farmers in the Centreville Creek subwatershed were interviewed. These farmers represented a cross section of the type of farming operations that occur in the study area including four dairy farms, two horse farms, and one corn/grain/beef cattle farm. The main findings of the survey were as follows:

- A very small portion of all cropland in the subwatershed is actually owned by farmers (i.e., majority of farms are on leased land).
- No-till cropping is practiced on approximately 40% of croplands in the area.
- Tile drainage is uncommon due to the good drainage characteristics of the native soils.
- Manure storage facilities are still uncommon (was also noted in the 1987/88 CURB study) with some farmers indicating that they would like to build them but are hesitant to make such investments because the longevity of their livestock operations are uncertain.
- Horse farms are typically all hay and pasture with manure stored on the ground and hauled away for use as a soil amendment elsewhere.
- Dairy operations typically spread manure on feed crop grounds as a soil amendment but often do not test soils or manure for nutrient content and adjust fertilizer application practices accordingly.
- Farmers generally cannot afford excessive or unnecessary fertilizer use or tillage because profit margins are very slim in crop production.
- Where imbalances may be occurring between the quantity of nutrients applied to the land versus the quantity of nutrients removed in the form of crops, it is likely due to not properly accounting for nutrients applied through manure spreading.

These findings suggest that efforts to promote agricultural best management practices in the area should include promoting soil and manure nutrient testing so that fertilizer application rates can be adjusted to account for nutrients applied through manure spreading. They also indicate that financial incentives for investing in manure storage facilities are needed.

#### **6.5 Management considerations**

Based on recent and historical water quality sampling, the two primary contaminants of concern in the Centreville Creek subwatershed are faecal coliforms (i.e., bacteria) and phosphorus. These contaminants are often associated with one another and are prevalent in run off from both rural and urban areas. In general, wet weather concentrations of bacteria and most chemical parameters were much greater than during dry weather.

Water quality data collected in 1986 and 1987 indicated that, in general, elevated concentrations of bacteria and phosphorus were observed in and near the Caledon East, and downstream near the Albion Hills Conservation Area. The results of recent modelling of source areas for phosphorus and sediment are consistent with these results. The lowest

concentrations were observed at the outlets of two on-line lakes (Elliot Lake and Innis Lake), immediately downstream of the Caledon East. These lakes help to improve water quality in the stream by acting as settling basins for a range of contaminants. Human activities that disturb and re-suspend the sediment in Elliot Lake or Innis Lake could cause negative impacts on water quality downstream.

The outputs of the AGNPS water quality model combined with site-specific information could be used by Rural Clean Water Program staff to identify priority areas for developing nutrient management plans and promoting the implementation of on-farm best management practices and tree and shrub planting programs.

Wide-spread implementation of rural and agricultural best management practices that reduce the potential for transport of land-based contaminants to surface waters (e.g., conservation tillage, vegetated riparian buffer zones, improving manure storage or wash-water management) are important to protect surface water quality and the health of aquatic communities in this subwatershed. Routine maintenance of septic systems servicing rural residents should continue to be promoted through existing programs.

The Town of Caledon and TRCA should work together to implement known stormwater retrofit opportunities that will help to mitigate the negative impacts of untreated urban stormwater run off on the health of Centreville Creek.



## **7. Fluvial geomorphology**

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Fluvial geomorphology is the study of stream channel form and the processes controlling it, which include stream flow regime and the erodibility of the channel. Land use changes, particularly urbanization, affect run off characteristics of the land which, if unmitigated, changes the stream flow regime. In most instances change in stream flow regime typically involves an increased frequency of elevated stream flows, which result in increased rates of stream channel erosion. If the change in stream flow regime exceeds certain thresholds, the stream channel will adjust to accommodate the altered flow regime. Stream channel adjustments involve changes to the form of the stream channel, such as widening, lowering or both, and often lead to the deterioration of aquatic habitat and surface water quality.

To mitigate this impact in urban development situations, various agencies have started implementing stormwater management practices. A recent advance in the field of urban stormwater management has been the inclusion of erosion criteria in the design of stormwater controls. Specifically, innovative stormwater management approaches take into consideration threshold values for stream flow that control channel erosion processes. New stormwater controls are being designed to match predevelopment exceedance of these erosion thresholds in order to ensure that channel erosion is not exacerbated by land use changes.

In addition to appropriately designed stormwater management controls, the enhancement and restoration of natural land cover along riparian zones and on tablelands and restoration of wetlands helps to mitigate negative impacts of land use change on the stream channel.

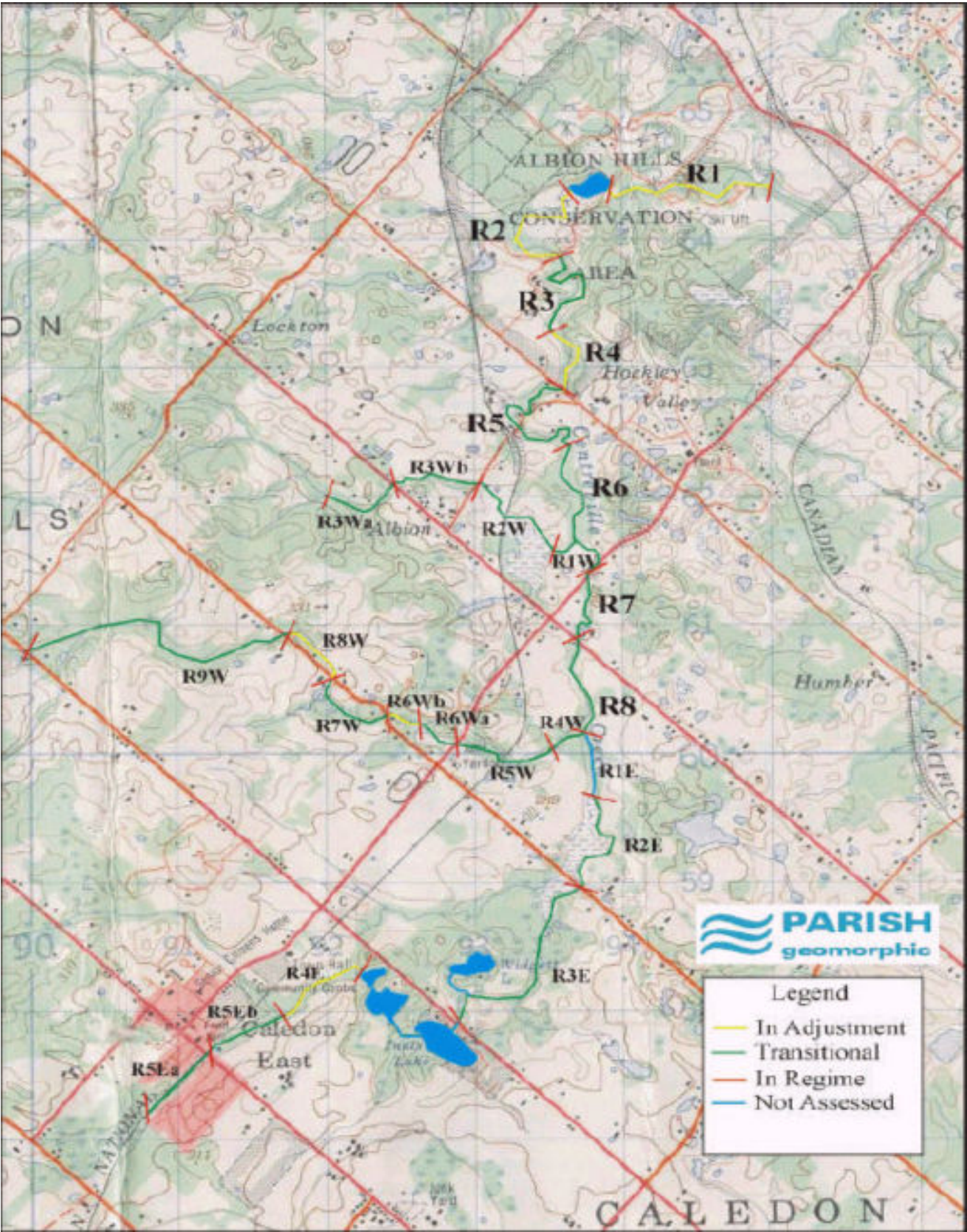
### **7.1 Measuring fluvial geomorphology**

In 2003, Parish Geomorphic completed a fluvial geomorphology study and erosion assessment report for Centreville Creek subwatershed (Parish Geomorphic Ltd, 2003). As part of the study, topographic and geologic mapping and aerial photography were used to delineate Centreville Creek into a set of similar reaches. Several factors were considered in the delineation of reaches including sinuosity, gradient, hydrology, geology, degree of valley confinement and vegetation coverage.

### **7.2 Reach assessments**

Each reach was visited in order to complete rapid assessments. The two assessment techniques used for the study were Rapid Geomorphic Assessment, which examines indicators of channel instability, and Rapid Stream Assessment, which considers the ecological functioning of the stream to provide a broader view of the system. Based on these assessments, the identified reaches were classified as being either in regime (stable), in transition, or in adjustment (**Figure 7.1**).

Figure 7.1: Fluvial geomorphology assessment reaches



In addition to the reach-by-reach characterization, three sensitive reaches (R1, R4E, and R8W) were selected for detailed fieldwork (**Figure 7.1**). At these sites, measurements of channel geometry and bed and bank materials were recorded. With the detailed field information, analyses based on critical shear stress and permissible velocities were performed to establish erosion thresholds. A baseline channel profile was established and erosion pins were installed at these detailed study sites to permit the monitoring of changes over time.

### Erosion thresholds

As mentioned previously, the erosion thresholds were calculated for the three detailed sites (**Table 7.1**). These threshold values describe the minimum stream flow conditions necessary to initiate sediment entrainment and transport (Parish Geomorphic Ltd., 2003). Generally, critical flow values were estimated to be well below estimated bank full flow values. This implies that channel sediments can be entrained during stream flows well below bank full conditions.

**Table 7.1: Erosion threshold values at selected sensitive reaches**

| Parameters                         | R1           | R4E         | R8W          |
|------------------------------------|--------------|-------------|--------------|
| Critical Flow (m <sup>3</sup> /s)  | 0.59         | 0.08        | 0.20         |
| Critical Depth (m)                 | 0.25         | 0.10        | 0.12         |
| Analytical Method Used             | Komar (1987) | Chow (1959) | Komar (1987) |
| Bank Full Flow (m <sup>3</sup> /s) | 5.68         | 1.61        | 4.83         |

### Channel stability

Surface deposits in Centreville Creek subwatershed are predominantly comprised of Oak Ridges Moraine sand and gravel deposits with some areas of Halton Till. In areas along the channel where sands and silt are exposed there is a propensity for stream bank erosion and lateral migration. Along reaches where beaver dams or wood debris jams have occurred, the stream channel also tends to be unstable. All reaches assessed were classified as being "in adjustment" or "transitional". The implication is that the channel reaches are undergoing erosion and/or sediment deposition processes as the channel adjusts or reacts to the existing stream flow regime. The erosion and sediment deposition processes may be resulting in channel downcutting, channel widening, channel aggradation and alignment adjustments.

## 7.3 Management considerations

Stormwater controls in new urban settlements in this subwatershed should be designed to match predevelopment frequency and duration of flow that exceeds established critical flow values in order to ensure that existing levels of channel instability at sensitive sites downstream are not increased.

Maintenance of naturally vegetated stream corridors that allow channels to move across the floodplain, and enhancement of riparian vegetation should be promoted wherever possible.

Planning and design of stream crossings associated with new road and footpath infrastructure should be based on available information on the form and sensitivity of the stream channel, and include assessment and consideration of meander belt widths to determine the most appropriate type and size of crossing structure and location of the crossing.

## 8. Terrestrial system

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The terrestrial system includes forests, wetlands, meadows and successional (shrub land or immature forest) types of natural land cover and the species of flora and fauna that they support. Increased urbanization replaces natural cover, displacing native flora and fauna, fracturing the connectivity of the remaining habitats and often bringing with it other negative pressures on remaining natural features, habitats and wildlife communities (e.g., trampling of native vegetation, introduction of alien invasive species, predation of wildlife by pets, litter and illegal dumping of wastes, etc.).

Urban expansion in the Greater Toronto Area (GTA) has led to continuous incremental loss of natural cover and species. Despite good intentions, policies that focus on protecting only the most significant features, habitats and rare species ultimately contribute to this overall loss of biodiversity and ecosystem function. In a landscape that supported over 90 percent forest cover prior to European settlement, current mapping shows that only about 17 percent forest and wetland cover remains within the watersheds of the GTA. This represents a substantial loss of ecological integrity.

### 8.1 Measuring the terrestrial system

At a landscape level, the region is made up of thousands of habitat patches. Each patch consists of one type of habitat. Habitat patches are mapped through interpretation of digital ortho-rectified aerial photography and classified according to the broad categories of forest, wetland, meadow and successional (shrub land or immature forest). The extent of habitat patches are quantified using a geographic information system (GIS). Using this landscape scale mapping, predictions regarding the overall quality of habitat that individual patches are likely capable of supporting are made by assigning scores to each patch for each of the following criteria:

- **Size:** area of the patch (hectares);
- **Shape:** ratio of edge length to area; and,
- **Matrix influence:** the degree to which nearby land uses are likely influencing (positive or negative) the quality of habitat the patch provides (i.e., urban land uses are assumed to exert a high negative influence, while agricultural land uses exert a moderate to low negative influence, and natural land cover exerts a positive influence).

Scores for each of these criteria are added together to calculate an overall quality score for each habitat patch, ranging from 3 to 13+ , where a higher score indicates a higher quality of habitat. Higher scoring habitat patches will likely support species of conservation concern. Examining scores for individual criteria can provide insight into the specific factors that are likely contributing to predictions of low habitat quality. By examining quality of habitat ratings for all patches across the TRCA jurisdiction, an assessment of the overall quality of habitat in the regional terrestrial system can be made.

The TRCA Terrestrial Natural Heritage Program establishes a number of objectives to prevent further deterioration of the quality of the regional terrestrial natural heritage system. The objectives are based on six indicators, which include the aforementioned “quality” criteria (size, shape and matrix influence). The remaining indicators are not used for predicting the quality of habitat for individual patches but are useful in assessments carried out at a jurisdictional or regional scale. The remaining indicators are as follows:

- **Quantity:** total amount of natural cover in the landscape across the jurisdiction
- **Distribution:** measure of distance between the centre of the jurisdiction and the centre of the system of habitat patches
- **Connectivity:** qualitative measure referring to the connection between or isolation of habitat patches
- **Biodiversity:** representation of the variety of vegetation types and flora and fauna species

While the TRCA Terrestrial Natural Heritage Program focuses on analysis at the landscape scale to establish objectives for the TRCA jurisdiction, detailed field inventories and surveys are also undertaken as they provide important information and can be used in conjunction with the landscape level objectives, for decision-making at the site level.

A component of the site scale work undertaken through this program is the inventory and mapping of vegetation communities and flora and fauna species, and the scoring and ranking of the communities and species observed according to the level of concern they represent in the TRCA jurisdiction. These local rankings (or L-ranks) are assigned on a scale of L1 to L5 with L1 representing vegetation communities or species of greatest conservation concern and L5 representing those of lower concern. Vegetation community scores and ranks are based on two criteria: local distribution and the number of geophysical factors on which they depend. Flora species are scored using four criteria: local occurrence, population trend, habitat dependence, and sensitivity to impacts associated with development. Fauna species have seven criteria that make up their score: local occurrence local population trend, continent-wide population trend, habitat dependence, sensitivity to development, area sensitivity, and mobility restriction. Using this scale, communities or species ranking L1, L2 or L3 are considered species of conservation concern, rather than the previous concept of being considered a rare community or species. This proactive approach allows pre-emptive steps to be taken before the species actually become rare.

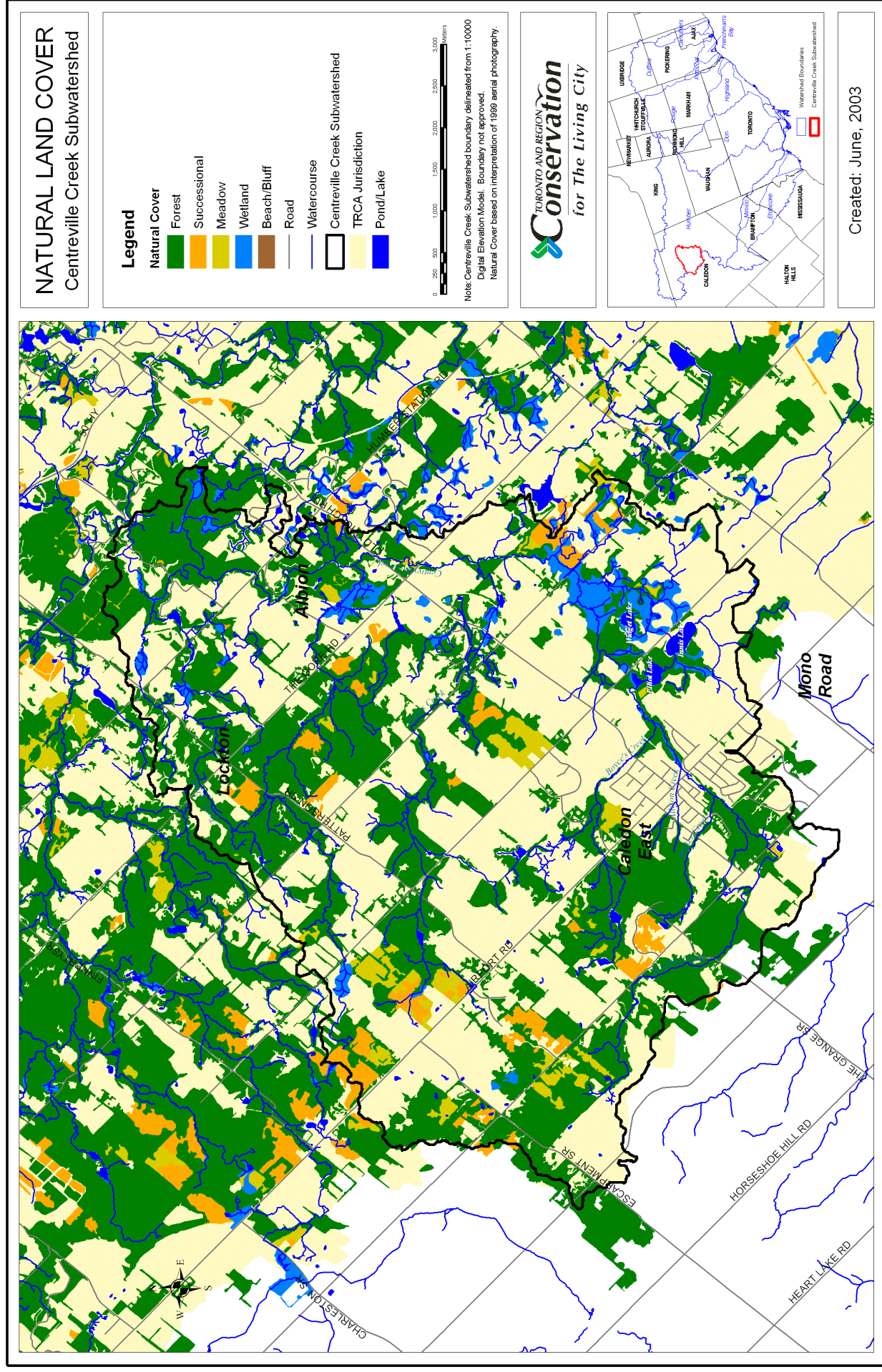
The landscape scale mapping of natural cover is based on 1999 aerial photography (TRCA, 2003a). Inventories of vegetation communities and flora and fauna species in Centreville Creek subwatershed were completed in 2002 and 2003 (TRCA, 2003a). Vegetation community categories were based on the Ecological Land Classification (ELC) system (Lee *et al.*, 1998) and determined to the Vegetation Type level of detail. Locations of flora species of concern (species ranked L1-L3) were mapped as point data.

## 8.2 Quantity

The health of the natural system in any region is directly dependent on the total quantity of land that has natural cover. As the amount of natural cover in the landscape diminishes through conversion to agricultural and urban land uses, the ability of the land to support biodiversity and to maintain or enhance the quality of human life diminishes.



Figure 8.1: Natural cover in the Centreville Creek subwatershed





The 4662 hectare Centreville Creek subwatershed makes a substantial contribution to regional natural cover with a total of 2207 hectares, or 47% of the total subwatershed area (**Figure 8.1**). This high proportion of natural cover is rivaled in the TRCA jurisdiction only by other parts of the Humber River headwaters, upstream of the confluence with Centreville Creek, and by parts of the upper Duffins Creek around Glen Major Resource Management Tract. **Table 8.1** provides a breakdown of the proportion of each general type of natural cover that occurs within the subwatershed.

**Table 8.1      Natural cover in the Centreville Creek subwatershed, 1999**

| Natural cover class | Area (hectares) | % of total subwatershed area |
|---------------------|-----------------|------------------------------|
| Forest              | 1798.4          | 38                           |
| Meadow              | 115.0           | 2                            |
| Successional        | 135.2           | 3                            |
| Wetland             | 158.4           | 4                            |
| <b>Total</b>        | <b>2207.1</b>   | <b>47</b>                    |

### 8.3      Quality

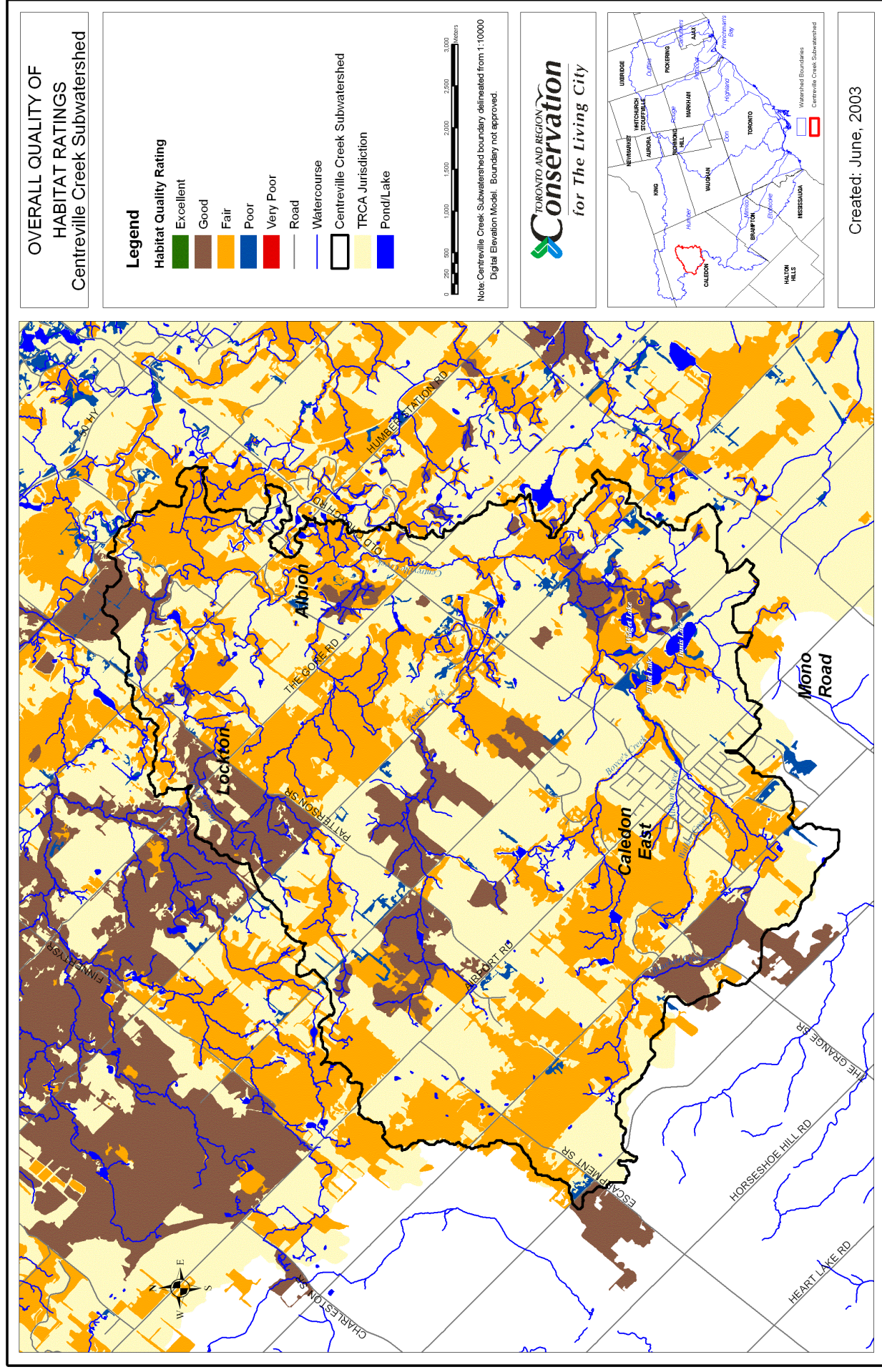
Ratings of overall quality of habitat were assigned to all natural cover patches in the TRCA jurisdiction based on combining scores for the criteria of size, shape and matrix influence. These ratings predict the overall quality of the habitat patch at a landscape level. The average overall quality of habitat rating for all patches in the TRCA jurisdiction is “fair”, while the TRCA Terrestrial Natural Heritage Program aims to raise this average rating to “good”, primarily through securement of a targeted land base and restoration of natural land cover (TRCA, 2004).

From a natural heritage perspective the Centreville Creek subwatershed ranks as one of the most functional areas within the entire TRCA jurisdiction. This is amply illustrated by the diverse vegetation communities and flora and fauna species documented in field surveys. **Figure 8.2** shows the overall quality of habitat ratings for natural cover patches within or partially within the subwatershed.

The principal factor that detracts from the total scores for habitat patches in Centreville Creek subwatershed is habitat patch shape (ratio of edge length to area). If the shapes of habitat patches were improved throughout the subwatershed by restoring natural cover at the edges of the existing patches to make them rounder and better connected, the overall patch scores would improve. This would contribute to improving the overall terrestrial system and complement the already high quality habitats to the north of the study area (e.g. Glen Haffy and Palgrave areas).

Although natural cover is somewhat fragmented in the study area, the full effect of such fragmentation on the function of the terrestrial system seems not to have been fully realized yet. It is likely that this delay in effect is due to the fact that the majority of surrounding land use is agricultural which does not exert such a highly negative influence on habitat quality as urban land use. Additionally, with only three major roads (medium capacity regional roads) intersecting the study area, the highly disruptive influences that busy roads and highways exert on the terrestrial system are limited.

Figure 8.2 Overall quality of habitat ratings



Planning and design of new urban settlements should include management measures to minimize encroachments into natural areas (e.g., fencing, designated public greenspace areas and trails, planned greenspace access points, pet off-leash areas, etc.). This will be especially important in planned new developments in Caledon East that will be close to the good quality forest and wetland habitats around Centreville Creek and the Elliot Lake and Innis Lake areas, where flora and fauna species of conservation concern have been observed.

## **8.4 Biodiversity**

Biological diversity, or as it is commonly referred to, biodiversity, is the variety of life, in all its forms, and includes ecosystem diversity, species diversity, and genetic diversity (IUCN, UNEP, and WWF, 1991; UNEP, 1992). In the TRCA Terrestrial Natural Heritage Program, biodiversity is assessed through inventories of vegetation communities and flora and fauna species.

### **Vegetation communities**

#### Forest vegetation communities

The greatest amount of forest is in the northern and western parts of the subwatershed, where the rolling topography and sandy soils are less favorable for agriculture. These areas include mature forests, younger stands that have regenerated on abandoned farmland and managed forest plantations. Treed swamps function dually as forest and wetland. Deciduous and mixed forests dominated by sugar maple, white ash, beech, white cedar, and eastern hemlock account for most of the natural forest, with trembling and largetooth aspens, and paper birch prominent in younger stands. Plantations of conifers make up a significant share of the forest cover in the subwatershed.

#### Wetland and aquatic vegetation communities

Centreville Creek subwatershed is outstanding for its wetlands. The southern part of the subwatershed supports a diverse array of wetlands of varying size embedded in a largely agricultural land use matrix. Scattered wetlands also occur throughout the northern portion.

Aquatic vegetation communities occur in Elliot, Innis and Widget Lake, as well as in large kettle ponds, beaver ponds and constructed ponds on private property. Aquatic species of concern (both flora and fauna) are not restricted to natural ponds, although marsh and swamp wetland communities are more diverse than those found in man-made ponds. Stonewort or pondweed submerged shallow aquatic communities are the most commonly encountered. Communities with floating-leaved aquatic plants include those dominated by duckweeds and water-meal, certain pondweeds, and water-lilies (Innis Lake and Widget Lake).

Marshes (shallow and meadow) are associated with kettle wetlands and riparian areas. Kettle marshes in the subwatershed typically have a deep organic horizon (often >1 metre), and are mostly dominated by broad-leaved cattail, northern or eastern manna grass, bur-reed, or sedges. Other extensive marshes are created by periodic flooding along watercourses. These range from forb dominated meadow marshes with such species as swamp aster and Joe Pye weed to extensive tracts of Canada bluejoint that occur along Centreville Creek. Old dams of beaver or human origin have given rise to large marshes often dominated by narrow-leaved or hybrid cattail. The largest of such marshes is found on the east side of The Gore Road north of Old Church Road and around Elliot Lake (also referred to as Scott Lake or Belcon Pond).

Thicket swamps dominate the majority of kettle wetlands and also occur along stream banks, at the perimeter of marshes, and occasionally in seepage zones. Willow organic thicket swamps are encountered most frequently and typically contain dogwood, speckled alder, and winterberry holly. A series of kettles in the west, near Mountainview Road and Escarpment Sideroad, include unusual buttonbush organic thicket swamps. These often impenetrable, seasonally inundated thicket swamps are excellent habitat for breeding wetland birds, wood frogs, grey tree frogs, and spring peepers.

Forested swamps are widespread in seepage areas that line many of the stream valleys, as well as in some of the low lying sites on less permeable soils in the southern part of the subwatershed. Swamps associated with the headwaters of streams typically have a strong coniferous component. Cedar swamps may occur as pure stands or mixed with other conifers such as hemlock, balsam fir, and tamarack, or with deciduous trees such as trembling aspen, red maple, and yellow birch. The ground layer is often rich with mosses, ferns, and boreal herbs.

Deciduous swamps are more typical of the less permeable soils in the southern part of the subwatershed. These areas are characterized by seasonal saturation and vernal pooling followed by drying later in the summer. Normally, the soils are mineral but may be organic if the site is a kettle. Poplar, swamp or silver maple, and black or red ash mineral deciduous swamps all occur within the study area.

True peatlands are rare in the subwatershed. No kettle bogs were encountered in the TRCA field work. It is possible that many of the thicket swamps and marshes have gone through a bog phase in the past and changed through natural succession or human disturbance. However, one leatherleaf shrub fen was found in a kettle in the northern part of the study area, and two fens with small cedars and tamarack were also found in seepage areas. Recently disturbed or excavated areas with abundant seepage support mineral fen meadow marshes with such species as variegated scouring-rush.

#### Barrens and other open dynamic vegetation communities

Sand barrens are rare in the western part of the Oak Ridges Moraine, being much more characteristic of the eastern portion. However, sand barrens occur to a limited extent on upland sites, particularly in the north and west of the study area. Sand barrens are characterized by scattered, stunted trees and shrubs, grasses such as flat-stemmed bluegrass and sand dropseed, and a mix of characteristic native and exotic forbs such as grey goldenrod and hawkweeds.

#### Meadow and successional vegetation communities

Large areas of abandoned agricultural land occur within the subwatershed. These include expanses of old field which may still be lightly grazed, and various cultural woodlands, thickets, and savannahs. The most extensive areas of such communities occur in the west and central parts of the subwatershed. Most prevalent of the various communities are meadows dominated by goldenrod, and thickets, savannahs, and woodlands with young forest tree regeneration (especially white ash) mixed with apple. In some cases, regeneration of cedar and pine (especially Scots pine) give the successional areas a stronger coniferous component. A higher proportion of alien species occur in these successional communities than in most forests and wetlands. If allowed to regenerate naturally, these communities would eventually



evolve into forest. It is important to note that some of the meadow and successional areas support flora and fauna species of conservation concern.

Vegetation communities of conservation concern that occur in the Centreville Creek subwatershed include wetlands, and dry sand barrens. The most notable wetland communities of conservation concern include several fens located in seepage zones. In one case, a fen wetland community associated with a kettle peatland was observed. Wetland vegetation communities of conservation concern (all ranked L1) that were observed in the study area include: Leatherleaf - Forb Shrub Fen; Low White Cedar Shrub Fen; and Tamarack - White Cedar Treed Fen. Many other wetland communities of conservation concern were found to occur in the subwatershed, including deciduous swamp and rare aquatic communities. Upland communities of conservation concern include sand barren (treed, shrub, and open), and various forests ranging along the moisture spectrum.

### **Flora species of conservation concern**

The current estimate of the number of flora species of conservation concern in the Centreville Creek subwatershed is approximately 200 species. **Figure 8.3** shows the locations where flora species of conservation concern have been observed in the subwatershed, with each location classified by the species rank in terms of level of concern. Most species are not necessarily rare plants. In many cases factors such as sensitivity to development or restricted habitat requirements are determining factors.

Round-leaved sundew (*Drosera rotundifolia*), which receives the highest rank of L1, is an excellent example of a highly vulnerable plant in the TRCA jurisdiction that is found to occur in the study area. This plant occurred in bogs and fens around Toronto in the past, but is now found in only a handful of fens and kettle peatlands that remain on the Oak Ridges Moraine. Most of its habitat has been eliminated, and it is vulnerable to indirect impacts from nearby land uses.

### **Fauna species of conservation concern**

**Figure 8.4** shows the locations of observations fauna species of conservation concern in the subwatershed, with each location classified by the species rank in terms of level of conservation concern. A total of 54 L1-L3 bird species were recorded consisting of one L1 species (hooded warbler) holding two potential breeding territories, 13 L2 species and 40 L3 species. In addition, nine non-avian species of concern were recorded in the Centreville Creek study area, consisting of two L1 species (red-spotted newt and yellow-spotted salamander), five L2 species and two L3 species. Surveys done in previous years also reported two more bird species of concern, bringing the total species of fauna ranked L1-L3 to 65.

Almost all of the 65 L1-L3 species that occur in the Centreville Creek subwatershed have a regional distribution very much weighted to the north, outside of the southern, more urbanized portion of the TRCA jurisdiction. Species such as veery, scarlet tanager and field sparrow have nearly been extirpated from the southern portion of the Greater Toronto Area and are now only observed in northern rural portions and some ravine systems.

This map displays the Culebra River Watershed, characterized by a complex network of roads and water bodies. Land use is categorized into green (forest/vegetation), yellow (open land/agriculture), and orange (developed areas). Numerous orange dots are scattered across the watershed, indicating sampling locations. Key roads labeled include MONROE RD, PATTERSON RD, ESCARPMENT SR, HEART LAKE RD, HORSESHOE HILL RD, and THE GRANGE BR. A north arrow is located in the bottom left corner.

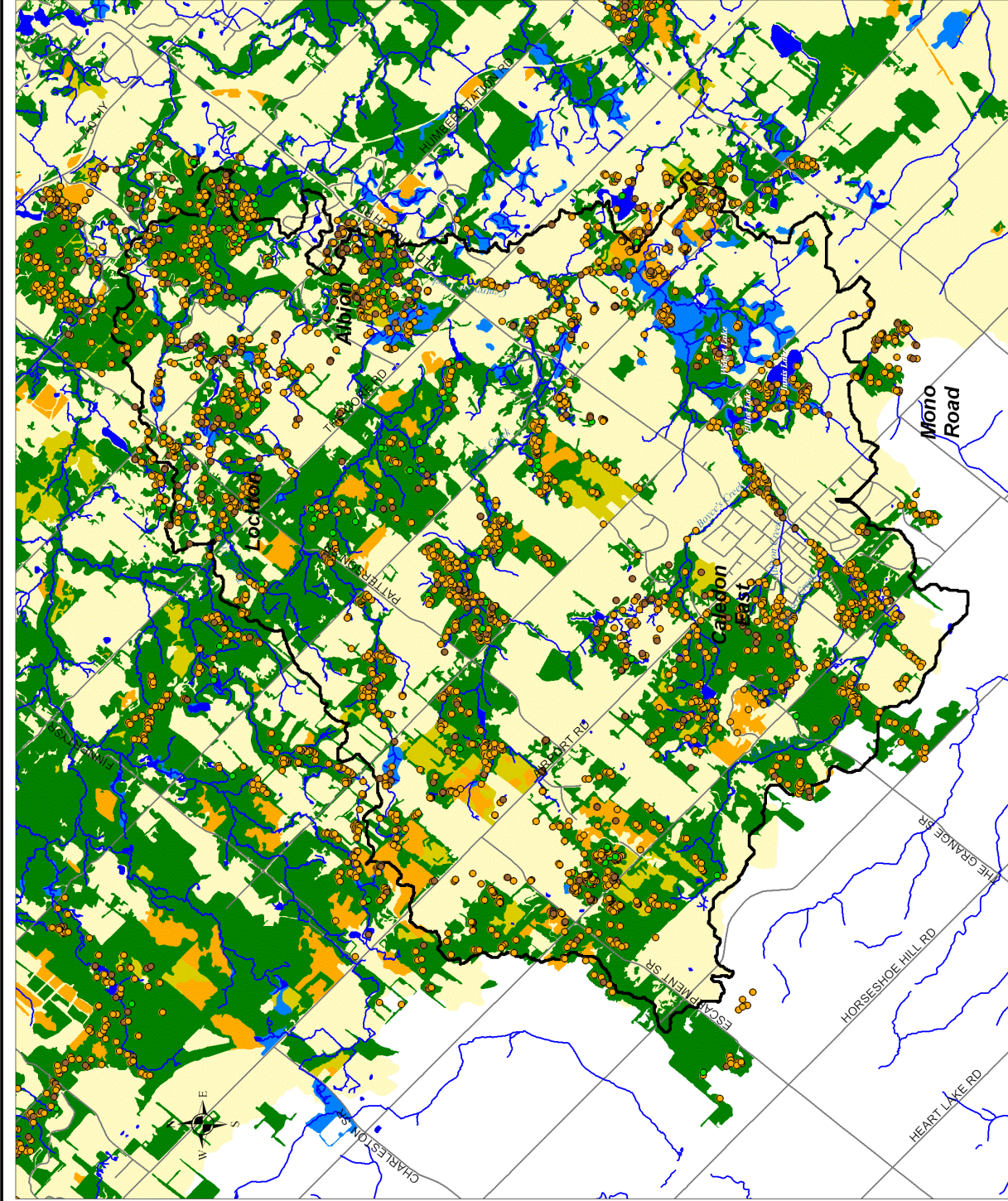
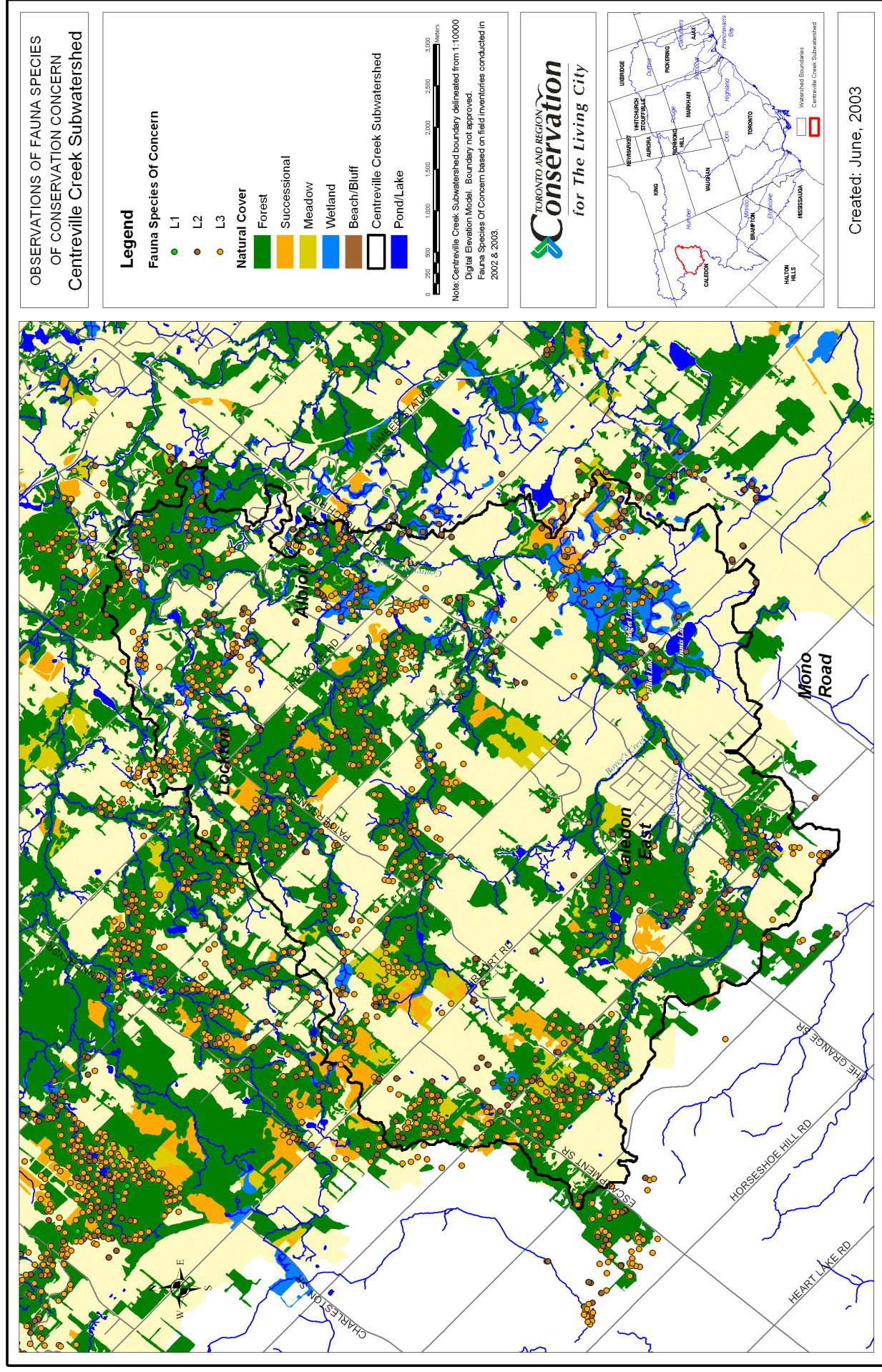




Figure 8.4 Observations of fauna species of conservation concern



## 8.5 Management considerations

Planning of land use changes in this area should consider the TRCA target terrestrial natural heritage system (TRCA, 2004) and strive to protect the land base needed to both protect existing natural habitats, and regenerate or improve their function and quality. The TRCA target terrestrial natural heritage system that has been identified at the regional scale of analysis (TRCA, 2004) needs to be further examined and refined at the watershed scale based on available knowledge of constraints and opportunities. The refined target terrestrial natural heritage system will establish targets for both quantity and distribution of natural land cover necessary to maintain and improve the overall health of the terrestrial systems in the Humber River watershed.<sup>6</sup>

Planning and design of the open space system within new urban settlements in this subwatershed should take into consideration that lands within the subwatershed have been targeted for securement and restoration of natural land cover, based on the TRCA terrestrial natural heritage system strategy methodology. Lands in the target terrestrial natural heritage system should be considered by the Town of Caledon for designation as Environmental Policy Areas and development should be directed to lands outside the targeted system to the greatest extent possible. Where this is not possible, a net-gain principle should be adhered to that recognizes the need to improve on existing conditions, and that any losses to existing or targeted natural land cover should be compensated elsewhere.

Appropriately sized ecological buffers around important surface water and natural heritage features should be established for their protection. Planning and design of new public greenspace trails should consider available information on the sensitivities of the natural features (e.g., vegetation communities and flora and fauna species) and avoid features that are highly sensitive to human disturbance or particularly vulnerable to typical negative impacts associated with trail uses.

Management of remaining natural areas in existing and future urban settlements should include measures to avoid or mitigate negative influences associated with surrounding urban land uses, including enhancement of remaining habitat patches to improve patch shape and size, fencing to prevent uncontrolled access, provision of planned access points and trail infrastructure in public greenspace areas, enforcement of municipal by-laws restricting encroachments on public lands, routine garbage collection, and planned off-leash pet areas that prevent access to sensitive natural features.

Planning and design of new urban settlements should be designed to maintain the existing water balance within areas contributing surface drainage or groundwater flow to hydrologically sensitive vegetation communities (e.g., wetland and wet forest communities). This may require seasonal water balance assessments to be completed as part of study requirements in support of proposals for new urban growth.

Landscape analysis indicates that the overall habitat patch scores show a high proportion of patches are rated as “fair” and “good”. The principle factor detracting from habitat quality scores is shape (ratio of edge length to area). This finding suggests that the focus of terrestrial

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<sup>6</sup> A target terrestrial natural heritage system has been defined for the Humber River watershed in the *Humber River Watershed Plan* (TRCA, 2008b) and *Implementation Guide* (TRCA, 2008a). The recommended target terrestrial natural heritage system shown in the *Humber River Watershed Plan* and *Implementation Guide* should be used to inform natural heritage system planning and management initiatives in Centreville Creek subwatershed.

habitat restoration initiatives in the study area should be on making natural cover patches less irregularly shaped, in order to maximize the amount of interior area.

Some meadow and shrub land areas were found to support flora and fauna species of conservation concern, which suggests that active reforestation initiatives should be planned in such a way that retains high quality meadow and shrub land habitats and allows them to evolve naturally.

## 9. Aquatic system

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Rivers serve the vital function of conveying water in a watershed, but also act as important ecosystems in their own right, contributing greatly to biodiversity and forming a critical component of a natural heritage system. Aquatic species have adapted to historic patterns in flow and channel structure, water quality and temperature. Aquatic ecosystems are influenced by factors such as surface water and groundwater quantity and quality, stream channel characteristics, and the terrestrial ecosystem. These dependencies make aquatic life a good indicator of overall watershed health.

### 9.1 Measuring the aquatic system

The health of an aquatic system can be inferred by examining the diversity of aquatic species and their distribution in a given area. However, pinpointing thresholds at which ecological integrity is put at risk is difficult owing to the synergistic effects of changes to water quality, quantity, riparian vegetation, temperature, human use, and a host of other factors. Historically, knowledge of the natural physiographic setting, indices, biomass and other measures have been used to assess the aquatic system.

Fish community monitoring data provides one measure for assessing the health of the aquatic system as fish are relatively easy to sample and identify and are relatively well understood in terms of ecological requirements. Information on fish communities in Centreville Creek subwatershed was obtained by electrofishing and seine netting at established Regional Watershed Monitoring Program locations (**Figure 9.1**). This information has been used to assess the health of the fish community by calculating the Index of Biotic Integrity (IBI). The IBI uses nine measures that are grouped into four general categories; namely, species richness, local indicator species, trophic composition, and fish abundance (Steedman, 1988). The measurements are scored against values observed or expected in less disturbed, similarly sized streams in southern Ontario. The composite score using the nine measurements results in a quality rating from 9 (poor) to 45 (very good), with corresponding ranges as follows: poor (9-20), fair (21-27), good (28-37), very good (38-45).

Benthic invertebrates are small animals with no backbone that live on stream and lake bottoms. They may be worms, leeches, snails, crayfish and insect larvae. They are good indicators of water quality and aquatic habitat conditions for numerous reasons, including the following:

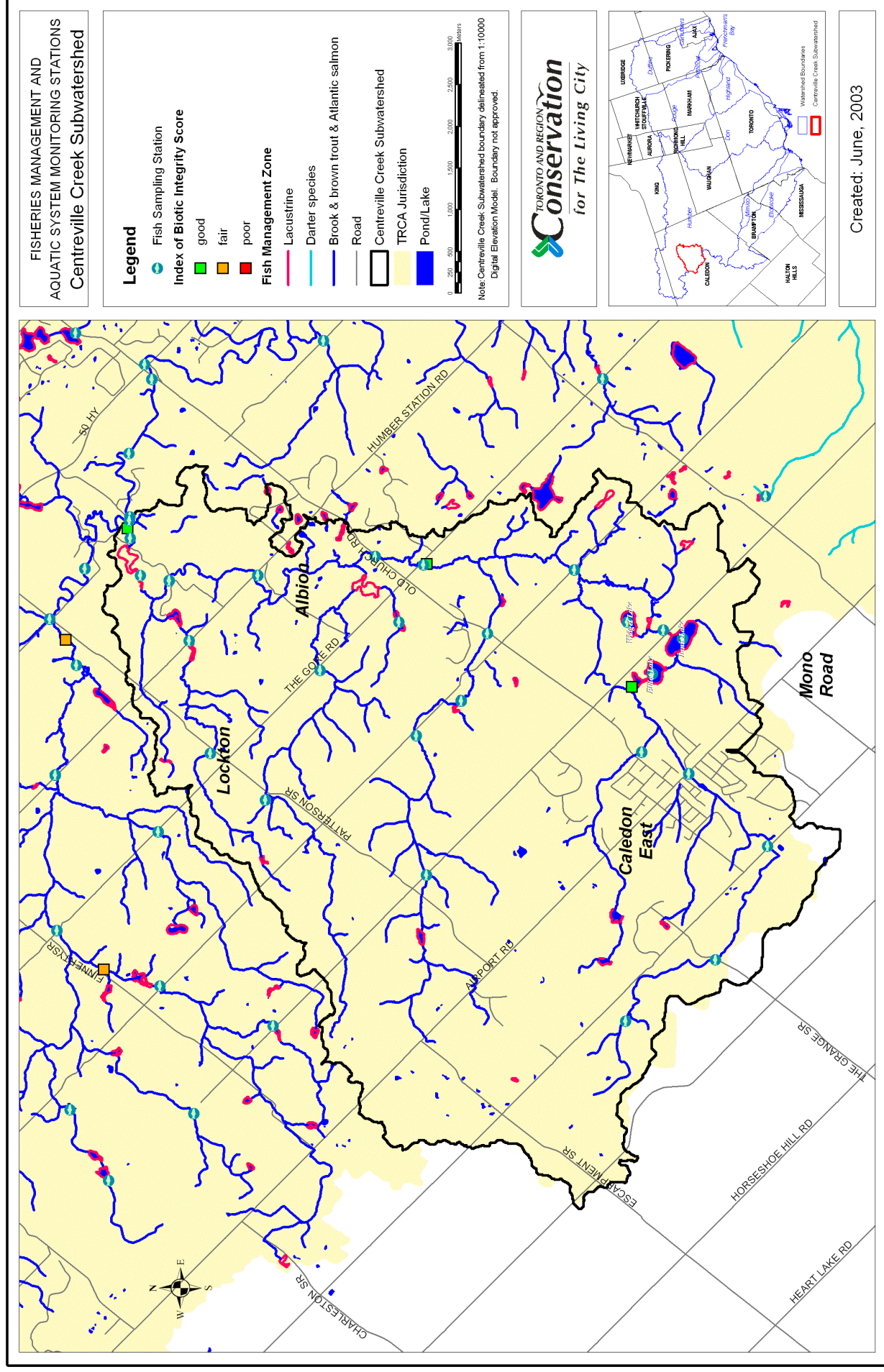
- Relatively easy and inexpensive to collect;
- Sensitive to changes in their environment;
- Tend to remain in small geographic ranges throughout their lives;
- Accumulate effects of multiple stresses;
- Exhibit varying tolerances to environmental impacts.

Indices are applied to benthic invertebrate data. The scoring is based on the composition of the sample collected, such as percentage of various invertebrates like worms, midges, and sowbugs.

There are three Regional Watershed Monitoring Program stations within the subwatershed where fish and benthic invertebrates sampling is performed on a three year cycle (**Figure 9.1**), with the first sampling completed in 2001.



**Figure 9.1: Fisheries management zones and aquatic system monitoring stations**



## 9.2 Fish

Fisheries data for Centreville Creek spans more than 50 years to the most recent sampling in 2001 (**Figure 9.1, Table 9.1**). Over this time a total of 31 species have been observed, including brown trout and white perch, which are both introduced species. Though not found in the collection records, it is also highly likely that Atlantic salmon once spawned in the tributaries of the subwatershed. They were once very common in the Humber River but a number of factors led to their extirpation from the Lake Ontario drainage area in the late 1800s.

In 2001, 19 species were observed including brown trout and white perch (**Table 9.1**). The fewer number of stations, narrower spatial distribution and single season collection period all likely contributed to the fewer species found in the 2001 survey compared to historical data. Found for the first time in 2001, spottail shiner and white perch are typically lake species and unexpected records in this part of the Humber River. Their presence may be the result of misidentification or intentional or accidental release. Some of the more sensitive species historically recorded but not found in 2001 include American brook lamprey, rainbow darter, Iowa darter and mottled sculpin.

The TRCA performed an IBI analysis on 2001 fish sampling data, using the methodology outlined by Steedman (Steedman, 1988). The IBI scores calculated for the stations in Centreville Creek reflect healthy stream conditions (**Table 9.2**). Although the 1999 data shows all stations in the study as having scores of “fair”, two stations had scores of 27, which is at the high end of the “fair” range.

**Table 9.2 IBI scores in the Centreville Creek subwatershed**

| IBI score           | Number of stations |       |      |      |
|---------------------|--------------------|-------|------|------|
|                     | 1984*              | 1985* | 1999 | 2001 |
| 9 - 20 (poor)       | 0                  | 0     | 0    | 0    |
| 21 - 27 (fair)      | 0                  | 1     | 3    | 0    |
| 28 - 35 (good)      | 2                  | 1     | 0    | 3    |
| 36 - 45 (very good) | 0                  | 1     | 0    | 0    |
| TOTAL               | 2                  | 3     | 3    | 3    |



**Table 9.1 Fish species identified in the Centreville Creek subwatershed.**

| Common name               | ODPD (1948) | Wainio & Hester (1973) | OMNR-MTRCA (1974 - 1995) | Steedman (1984 - 1985) | Wichert (1991) | TRCA (1999) | Ontario Streams (2001) | TRCA (2001) |
|---------------------------|-------------|------------------------|--------------------------|------------------------|----------------|-------------|------------------------|-------------|
| American brook lamprey    |             |                        | X                        | X                      |                |             |                        |             |
| brown trout <sup>1</sup>  |             |                        |                          |                        |                |             |                        | X           |
| brook trout               | X           | X                      | X                        | X                      |                | X           | X                      | X           |
| central mudminnow         |             |                        | X                        |                        |                |             |                        |             |
| white sucker              | X           | X                      | X                        | X                      | X              | X           | X                      | X           |
| northern hog sucker       |             | X                      |                          |                        |                |             |                        | X           |
| northern redbelly dace    | X           | X                      | X                        | X                      |                |             | X                      | X           |
| brassy minnow             |             |                        | X                        | X                      |                |             | X                      | X           |
| golden shiner             | X           | X                      |                          |                        |                |             |                        | X           |
| common shiner             | X           | X                      | X                        | X                      | X              | X           | X                      | X           |
| spottail shiner           |             |                        |                          |                        |                |             |                        | X           |
| blackchin shiner          |             | X                      |                          |                        |                |             |                        |             |
| bluntnose minnow          |             | X                      | X                        | X                      |                | X           | X                      |             |
| fathead minnow            |             | X                      | X                        | X                      |                | X           |                        |             |
| blacknose dace            | X           | X                      | X                        | X                      | X              | X           | X                      | X           |
| longnose dace             |             |                        |                          |                        |                | X           |                        |             |
| creek chub                | X           | X                      | X                        | X                      | X              | X           | X                      | X           |
| brown bullhead            | X           | X                      | X                        |                        |                | X           | X                      |             |
| brook stickleback         |             |                        | X                        | X                      | X              |             |                        | X           |
| white perch <sup>1</sup>  |             |                        |                          |                        |                |             |                        | X           |
| rock bass                 |             | X                      | X                        |                        |                |             | X                      | X           |
| pumpkinseed               | X           | X                      | X                        | X                      |                |             |                        |             |
| bluegill                  | X           |                        |                          |                        |                |             |                        |             |
| smallmouth bass           |             | X                      |                          |                        |                |             |                        |             |
| largemouth bass           | X           |                        | X                        |                        |                | X           |                        |             |
| yellow perch              | X           | X                      | X                        |                        |                |             |                        |             |
| rainbow darter            |             |                        | X                        |                        |                |             |                        |             |
| iowa darter               |             |                        | X                        | X                      |                |             |                        |             |
| fantail darter            |             |                        | X                        | X                      |                | X           | X                      | X           |
| johnny darter             | X           | X                      | X                        | X                      |                | X           | X                      | X           |
| mottled sculpin           | X           |                        | X                        | X                      |                |             | X                      |             |
| <b>Number of stations</b> | <b>12</b>   | <b>10</b>              | <b>11</b>                | <b>3</b>               | <b>2</b>       | <b>4</b>    | <b>2</b>               | <b>3</b>    |
| <b>Number of species</b>  | <b>14</b>   | <b>17</b>              | <b>22</b>                | <b>16</b>              | <b>5</b>       | <b>12</b>   | <b>13</b>              | <b>16</b>   |

Notes: 1 – introduced

### 9.3 Benthic invertebrates

Benthic invertebrates include all the organisms without a backbone that are found dwelling in the bottom substrate of a watercourse or waterbody. Invertebrates are an important part of the food chain in stream ecosystems. Examples of benthic invertebrates include crayfish, aquatic worms, snails, clams, and larval stages of blackflies, mosquitoes, mayflies, dragonflies and damselflies.

Three Regional Watershed Monitoring Program stations in the subwatershed were sampled in 2001 (**Figure 9.1**). A summary of the results of the analysis for these stations are shown in **Table 9.3**. The results suggest relatively healthy aquatic habitats, however high levels of nutrients (e.g., phosphorus) in surface waters may be present, which is supported by water quality sampling data (see **Section 6**).

**Table 9.3 Summary of indices of benthic community composition - Centreville Creek 2001**

| Indices                 | Centreville Creek at the<br>Gore Road<br>(HU031WM) | Centreville Creek<br>upstream of Elliot Lake<br>(HU032WM) | Centreville Creek at<br>Albion Hills C.A.<br>(HU033WM) |
|-------------------------|--|---|--|
| Number of Individuals   | 1229   | 1051  | 4404   |
| Taxa Richness           | 27   | 50  | 41   |
| EPT Taxa                | 3  | 4   | 9  |
| % Oligochaeta           | 2  | 3   | 0  |
| % Chironomidae          | 84   | 42  | 58   |
| % Insecta               | 98   | 78  | 95   |
| % Gastropoda            | 0  | 2   | 0  |
| % Bivalvia              | 0  | 2   | 1  |
| % Crustacea             | 0  | 15  | 0  |
| % Isopoda               | 0  | 15  | 0  |
| Shannon Weaver Index    | 3.28   | 4.32  | 4.21   |
| Hilsenhoff Biotic Index | 7.30 (very poor)                                   | 6.12 (fairly poor)  | 6.46 (fairly poor)                                     |

### 9.4 Aquatic habitat

The type and quality of habitat that an aquatic ecosystem can support depends on a number of factors including stream size (or stream order), water temperature, in-stream barriers and riparian vegetation.

#### **Stream order**

Stream order is a method of describing a drainage system based on stream size and function. First order streams have only one unbranched tributary, whereas a second order stream occurs when two first order streams meet. Within this headwaters subwatershed, streams are predominantly first, second, or third order. In low order streams aquatic communities are more dependent on riparian vegetation for moderating stream temperature, as well as for providing organic matter.

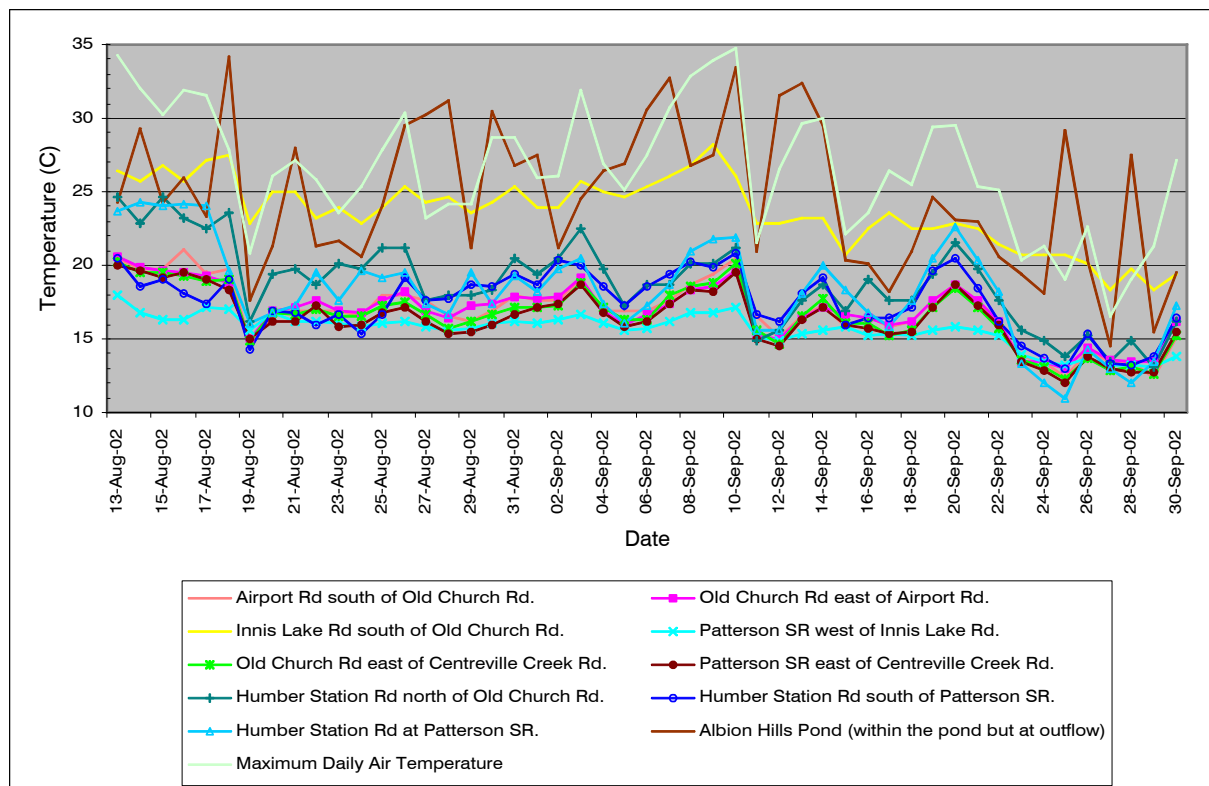
## Temperature

Stream temperature is one of the main factors that determine the type of aquatic community that is present in a watercourse. Temperatures that do not reach more than 21°C may be suitable for cold water species such as trout or sculpin, while warmer waters generally support a different range of species. The presence of cold water conditions also suggests areas of groundwater discharge, since groundwater input is one of the factors limiting trout distribution (Bowlby and Roff, 1986a; Bowlby and Roff, 1986b).

From August 13 to October 2, 2002 stream temperatures were sampled at ten locations within Centreville Creek, with temperatures recorded every 10 minutes. An additional station at the outlet of the swimming area pond in Albion Hills Conservation Area was also monitored from May 14 to November 1, 2002, however data from this location are considered unreliable, as recorded temperatures exceeded maximum air temperature at times.

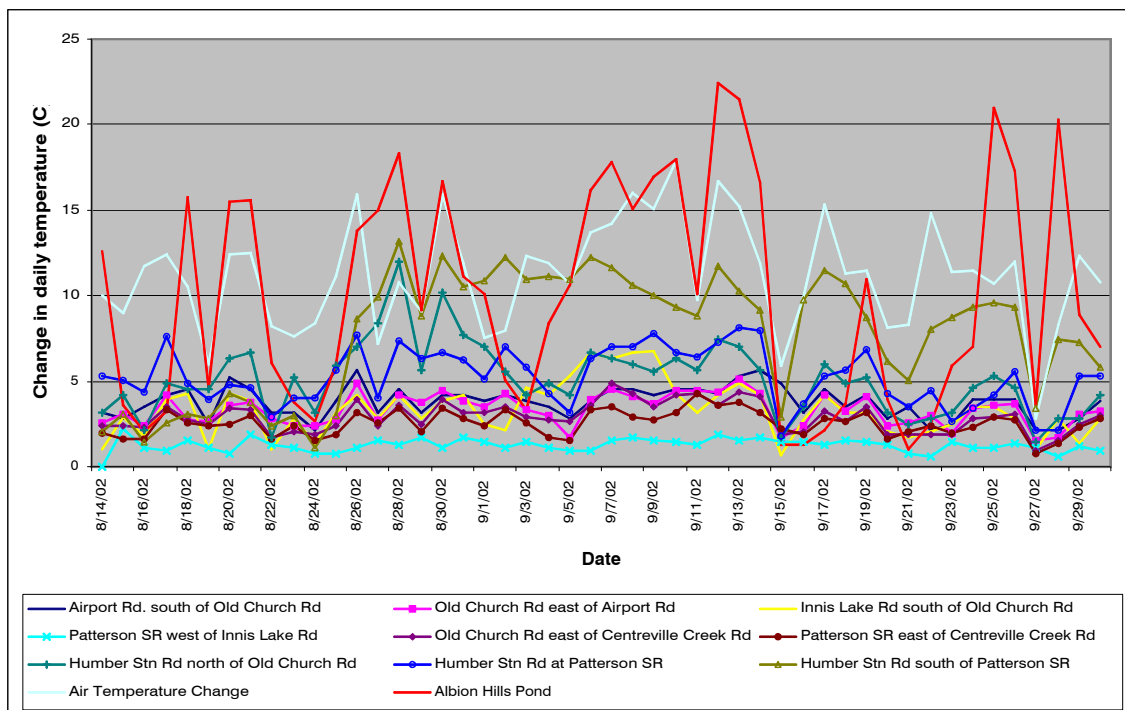
**Figure 9.2** shows stream temperatures measured at each location at 4:00 PM of each day monitored, which generally reflects peak water temperatures over the period of the day. This information shows that even during hot summer days, when air temperatures reached or exceeded 30°C, water temperature in several locations along Centreville Creek rarely exceeded 21°C. These locations include Boyce's Creek (Old Church Road, east of Airport Road), the main channel of Centreville Creek as it passes through Caledon East (Airport Road south of Old Church Road), Evans Creek (Old Church Road east of Centreville Creek Road; Patterson Sideroad west of Innis Lake Road), and Taylor Creek (Humber Station Road south of Patterson Sideroad).

**Figure 9.2 Centreville Creek stream temperature at 4 PM (Aug. 13 - Sept. 30, 2002)**



**Figure 9.3** shows daily change in stream temperature for each day monitored. Locations where temperature fluctuations were large include the main channel of Centreville Creek downstream of Innis Lake (Innis Lake Road south of Old Church Road), the main channel as it crosses Humber Station Road (north of Old Church Road, and Taylor Creek at Humber Station Road (south of Patterson Sideroad). The most stable temperatures were recorded at the station on Evans Creek (Patterson Sideroad west of Innis Lake Road; and Old Church Road east of Centreville Creek Road), suggesting that this tributary receives a significant amount of cool groundwater discharge and likely has riparian vegetation providing shade to the stream.

**Figure 9.3 Daily change in water temperature (Aug. 14 - Sept. 30, 2002)**



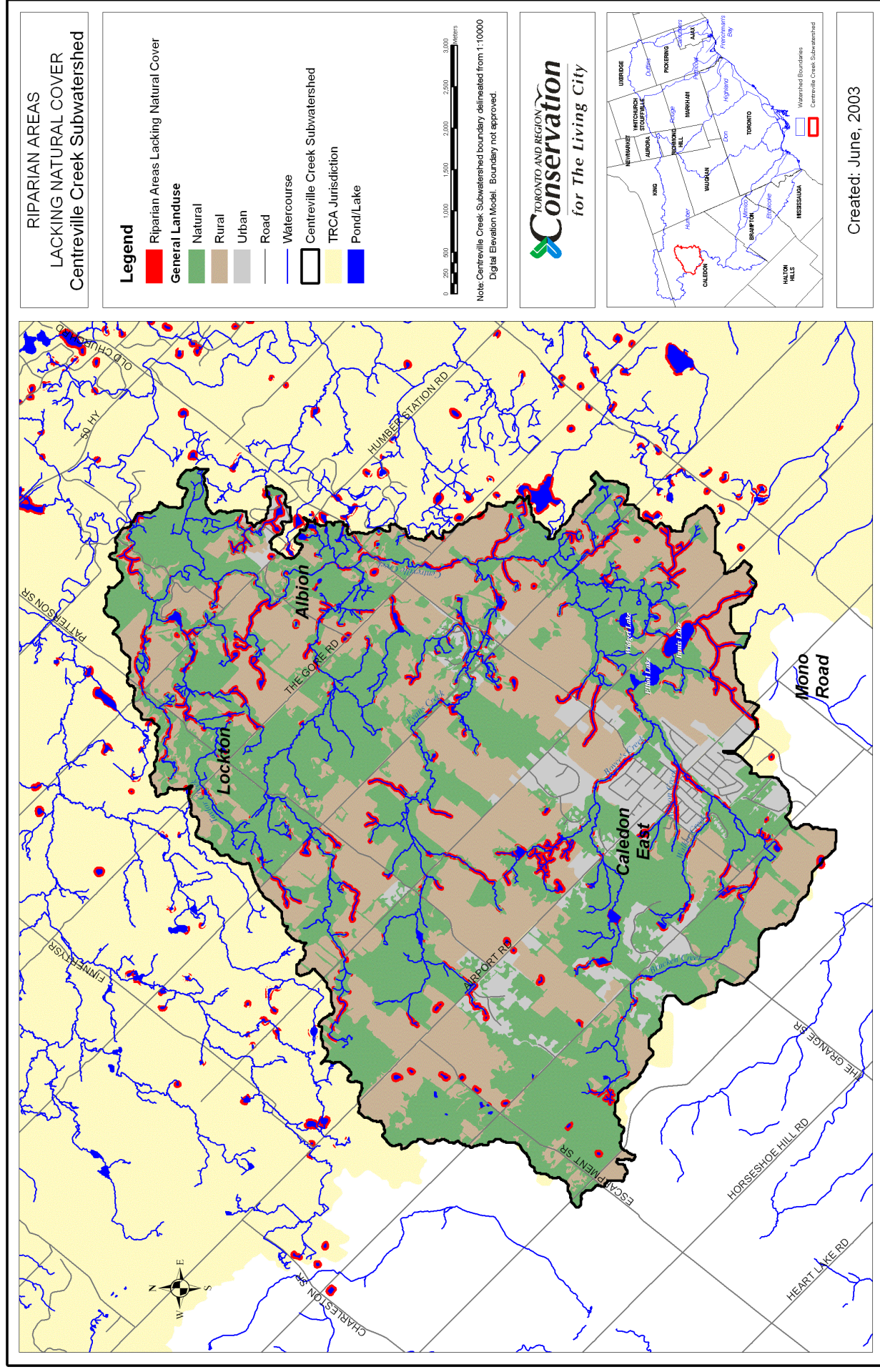
Water temperature data for Taylor Creek at Humber Station Road south of Patterson Sideroad shows a high daily change but had fairly cool temperatures at 4:00 PM, suggesting that this location may be impacted by sun exposure (i.e., lacking riparian vegetation cover). This site is also directly downstream of an on-line pond on private property. To a lesser extent, the same trend in temperature was observed along Centreville Creek at Humber Station Road north of Old Church Road.

### Riparian vegetation

Riparian vegetation also plays an integral role in the health of the aquatic system. Riparian vegetation consists of plant communities adjacent to water bodies, such as rivers, streams, lakes, ponds or drainage ways. Riparian vegetation provides sources of organic materials to aquatic ecosystems. The plants also help to regulate temperature by providing shade, stabilize stream banks, and benefit water quality by filtering overland run off.



Figure 9.4 Riparian areas lacking natural cover, 1999



Lack of natural vegetation along riparian areas is an issue along several reaches in this subwatershed (**Figure 9.4**). In 1999 approximately 77% of riparian areas<sup>7</sup> in the subwatershed had natural riparian vegetation cover. This is considered a good quantity of natural riparian vegetation, in comparison with other Humber River headwater subwatersheds (e.g., in nearby Cold Creek subwatershed, 58% of riparian areas had natural vegetation cover). Natural riparian vegetation has been lost along some reaches of Centreville Creek through agricultural and urban land use encroachments. A lack of riparian vegetation can lead to increased water temperature and stream bank erosion, decreased food supply for the aquatic ecosystem, and greater vulnerability of surface waters to contamination from land based sources of pollutants (e.g., run off from agricultural lands).

## **9.5 Pond inventory**

In 2002 and 2003 TRCA conducted an inventory of ponds located in the subwatershed, utilizing 1999 aerial photography to locate ponds. A total of 36 ponds were identified from aerial photos. Site visits were conducted at 23 ponds to collect information regarding whether the pond was natural, created through an on-line hydraulic structure (i.e., dam), or whether it was an off-line pond fed by a spring or surface drainage. Information was also collected regarding whether the outlet structure draws water from the surface or bottom of the pond (i.e., top draw or bottom draw outlet structure). Other information regarding surrounding vegetation and use of the pond was also collected.

A total of 17 on-line ponds were identified, 12 of which had top draw outlet structures. Several of these on-line ponds represent in-stream barriers to fish movement. Additionally, the ponds with top draw outlet structures represent opportunities to convert the outlets to bottom draw structures which would help to reduce downstream thermal impacts on cold water aquatic habitat. **Figure 9.5** illustrates the results of the pond inventory work.

## **9.6 Fisheries Management Plan**

The *Humber River Fisheries Management Plan* is a resource document that establishes overall management direction for aquatic habitat and species in the Humber River (OMNR and TRCA, 2004). It is used to develop and implement regeneration projects and to inform planning applications during the development approvals process. The plan compares the past and present physical, biological and chemical conditions in the watershed to assess change in the aquatic communities within the watershed over time. By taking into account the impacts of human activities in the watershed, the plan sets species management targets for the future.

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<sup>7</sup> Riparian areas are defined as lands within 30 metres of the stream bank. Riparian areas were delineated based on TRCA watercourse mapping information using a geographic information system.



**POND INVENTORY**  
Centreville Creek Subwatershed

**Legend**

**Pond Inventory**

- Online Pond, Top Draw
- Online Pond
- Offline Pond

**General Landuse**

- Natural
- Rural
- Urban

**Watercourse**

- Centreville Creek Subwatershed
- TRCA Jurisdiction
- Pond/Lake

Note: Centreville Creek Subwatershed boundary delineated from 1:10000 Digital Elevation Model. Boundary not approved.

Scale: 0 to 3,000 Meters

Map Labels: Lockton, Albion, Caledon East, Airport Rd, The Grange Rd, Horseshoe Hill Rd, Heart Lake Rd, Mono Road, Humber Station Rd, Patterson Sr, Escarpment Sr, Charleson Sr, Finnerback Sr, The Grange Rd, Horseshoe Hill Rd, Heart Lake Rd, Mono Road, Humber Station Rd, Patterson Sr, Escarpment Sr, Charleson Sr, Finnerback Sr.

Conservation for The Living City

Created: June, 2003

One of the main factors that determine the type of fish community in a stream is soil type and surficial geology. Simply put, the higher percentage of coarse materials such as gravels found in the soil, the easier it is for water to infiltrate into the ground and discharge at another location. In Centreville Creek, the underlying sands and gravels of the Oak Ridges Moraine allow for significant amounts of water to infiltrate through the soils, and discharge year-round at a temperature of approximately 8 - 10°C. This creates cold water conditions throughout most of the subwatershed, which is confirmed by the presence of brook trout and mottled sculpin in many of the streams and tributaries. Based on an assessment of the suitability of Centreville Creek to support cold water species, the target species for this subwatershed, as identified in the *Humber River Fisheries Management Plan*, are brook and brown trout and Atlantic salmon (**Figure 9.1**).

## **9.7 Management considerations**

The aquatic community in Centreville Creek includes brook trout, a species of fish that is highly sensitive to changes in groundwater discharge, water temperature, stream channel substrates and water quality, all of which are types of changes that typically occur in urbanizing streams. The planning and design of new urban developments in the subwatershed should include stormwater management measures that minimize changes to predevelopment infiltration rates and patterns of stream flow. Due to the high sensitivity of the aquatic ecosystem to changes in water temperature, stormwater management ponds in new developments should be designed to provide level 1 quality control (OMOE, 2003) while maximizing the area of open water that is shaded by vegetation and include subsurface outlets to help prevent stormwater from heating up during treatment.

Results from 2001 aquatic system monitoring indicate healthy aquatic habitats, however high levels of nutrients (e.g., phosphorus) in surface waters are likely occurring, based on benthic invertebrate sampling information. This is supported by surface water quality sampling data (see **Section 6**). Information regarding predominant sources of phosphorus and sediment from water quality modelling should be used to guide the work of Rural Clean Water Program staff to promote agricultural best management practices that reduce transport of nutrients to streams.

While many reaches of Centreville Creek likely support cold water aquatic habitat conditions year round, in-stream water temperature monitoring suggests that some reaches are likely being impacted by sun exposure and the presence of natural or man-made ponds upstream. Several opportunities exist to convert top draw pond outlets to bottom draw structures which would help to reduce downstream thermal impacts on cold water aquatic habitat. Opportunities also exist to convert ponds created by on-line hydraulic structures (i.e., dams) to off-line ponds, which would also contribute to reducing downstream thermal impacts.

While riparian areas along Centreville Creek have good natural riparian vegetation cover, tree and shrub planting opportunities exist that would help prevent warming of the stream from sun exposure, improve food supply for the aquatic ecosystem and reduce the vulnerability of surface waters to contamination from land based sources of pollutants.

Several opportunities exist to mitigate in-stream barriers to fish movement associated with on-line ponds (i.e., dams), which would help to improve the health of fish communities by providing a greater range of accessible habitat.

## **10. Cultural heritage**

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In the past, cultural heritage in Ontario was largely overlooked as development occurred. As such, a lot of the archaeological evidence that revealed the history of a given land was lost or destroyed. Scientific archaeological investigations began only 50 years ago. As a result of these investigations, as well as through oral traditions and historical records, part of the history surrounding the Humber River watershed has been recorded and a number of cultural heritage sites are now recognized and preserved.

### **10.1 Historical context**

The Centreville Creek subwatershed has a diverse cultural history which may extend back to the last ice-age. It is well established that human activity has always centred on a region's rivers and lakes in order to fill the need for a stable water supply, to utilize associated resources and to take advantage of the potential for transportation. For more than 10,000 years Centreville Creek has served as a stage upon which the drama of human history has unfolded: Aboriginal hunters and farmers, European explorers, traders, soldiers, surveyors and settlers. All of these people benefited from the use of the creek in some way, and some decided to make this area their home.

To place the human history of the Centreville Creek subwatershed into the proper context, the following descriptions briefly encapsulate the Aboriginal and historic Euro-Canadian cultural periods for the archaeological record of southern Ontario (O'Brien, 1980).

#### Palaeo-Indian, 10,000 to 7,000 BC

As the glaciers retreated from southern Ontario, nomadic peoples gradually moved into the areas recently vacated by the massive ice sheets. These Palaeo-Indians lived in small family groups and it is presumed that they hunted caribou and other fauna associated with the cooler environment associated with this time period. It should be remembered that as the glaciers melted at the end of the last ice age 12,000 years ago, the landscape of southern Ontario was very much like the tundra of the present day eastern sub-arctic. During this time, the water levels and shorelines of Lake Huron and Lake Ontario were fluctuating due to run off from the melting glaciers. Traditionally, the Palaeo-Indian occupation of southern Ontario has been associated with these glacial lake shorelines. However, recent investigations in the vicinity of Toronto indicate that these peoples also utilized interior locations away from the glacial lakes (OMC, 2002).

#### Archaic, 7,000 to 1,000 BC

As the climate in southern Ontario warmed, the Aboriginal populations adapted to these new environments and associated fauna. Thus, many new technologies and subsistence strategies were introduced and developed by the Archaic peoples of this time period. To harvest the new riches of the warming climate, the Archaic bands of southern Ontario followed an annual cycle which utilized seasonably available resources in differing geographic locales within watersheds. For example, from the spring through to the fall, bands would have joined together and inhabited sites along lakeshore environments, where abundant sources of food such as fish, waterfowl and wild rice enabled the establishment of larger multi-season encampments. As the seasons changed, and aquatic resources became scarce, these bands split into smaller groups and moved inland to utilize other resources which were available during the fall and winter.

### Initial (Early and Middle) Woodland, 1,000 BC to AD 700

Early in the Initial Woodland period (1,000 B.C.- A.D. 0), band sizes and subsistence activities were generally consistent with the groups of the preceding Archaic. Associated with the earliest components of this cultural period is the introduction of clay pots. Ceramic vessels provide a means for longer term storage of foodstuffs. With the ability to store foodstuffs during times of plenty, the stress of harder times was greatly reduced as it would have been possible to take advantage of the accumulated goods. Additionally, at around A.D. 0, a revolutionary new technology, the bow and arrow, was brought into southern Ontario and radically changed approaches to hunting. These two technological innovations allowed for major changes in subsistence and settlement patterns. As populations became larger, camps and villages with more permanent structures were occupied longer and more consistently. Generally, these larger sites are associated with the gathering of two or more band groups into what are referred to as macrobands. Often these larger groups would reside in favourable locations to cooperatively take advantage of readily accessible resources such as fish.

### Late Woodland (Ontario Iroquoians), AD 700 to 1651

Around A.D. 700 corn was introduced into southern Ontario from the south. With the development of horticulture as the predominant subsistence base, the Late Woodland period gave rise to a tremendous population increase and to the establishment of permanent villages. These villages consisted of numerous longhouses, made from wooden posts placed in the ground and tied together at the top in an arch-like fashion. Although these windowless structures were only 20 feet (6 metres) wide (and the same in height) they extended anywhere from 30 to 150 feet (9 to 46 metres) in length providing shelter for up to 50 people. Quite often these villages, some of which were 3 to 10 acres (1 to 4 hectares) in size, were surrounded by multiple rows of palisades suggesting that defence was a community concern during this period.

### Contact, AD 1650-1800

Following the dispersal of the Petun and Huron by the Iroquois in 1650, southern Ontario lay vacant for fifteen years. Then, during the mid-to-late 1600s, in an attempt to expand their fur hunting grounds to the north, Iroquois groups established a number of villages along the north shore of Lake Ontario. Two of these, called Ganatsekiagon and Teiaiagon, were built by the Seneca upstream from the mouths of the Rouge and Humber Rivers, respectively. Current research shows that no villages of this size were built in the Centreville Creek subwatershed. After the Seneca abandoned the north shore of Lake Ontario in the last half of the seventeenth century, the Algonkian-speaking Mississauga moved in to the Greater Toronto area, particularly in the western reaches, where they were flourishing when the French, and later the British, arrived.

## **10.2 Measuring cultural heritage**

Information on the cultural heritage of an area can come from a variety of sources.

Archaeological records are one source, which include such evidence as found artifacts, human remains, and other traces of past civilizations and settlements. Another source of information is from material culture, which includes artifacts, teachings and stories that have been passed down through generations. Oral traditions of First Nations peoples are a source of information, as are the historical records of European explorers, traders and settlers. Historical records in North America only date back to the early 1600s.



### Archaeological sites

Archaeological sites are registered with the Government of Ontario. **Table 10.1** summarizes the archaeological sites found in the subwatershed (OMC, 2002). Although to date, few archaeological sites have been found in the Centreville Creek subwatershed, without doubt native peoples during the Late Woodland period utilized the natural resources in this area. There is ample evidence of this from numerous archaeological sites in other nearby areas in the Humber River watershed.

**Table 10.1 Known archaeological sites in Centreville Creek subwatershed**

| Culture                 | Time period            | Number of known sites |
|-------------------------|------------------------|-----------------------|
| Palaeo-Indian           | 10,000 to 7,000 B.C.   | 1                     |
| Archaic                 | 7,000 to 1,000 B.C.    | 0                     |
| Woodland                | 1,000 B.C. to A.D. 700 | 2                     |
| Undetermined Precontact | undetermined           | 3                     |
| Historic Euro-Canadian  | A.D. 1650 to 1800      | 1                     |
| <b>Total</b>            |                        | <b>7</b>              |

### Assessment of archaeological site potential

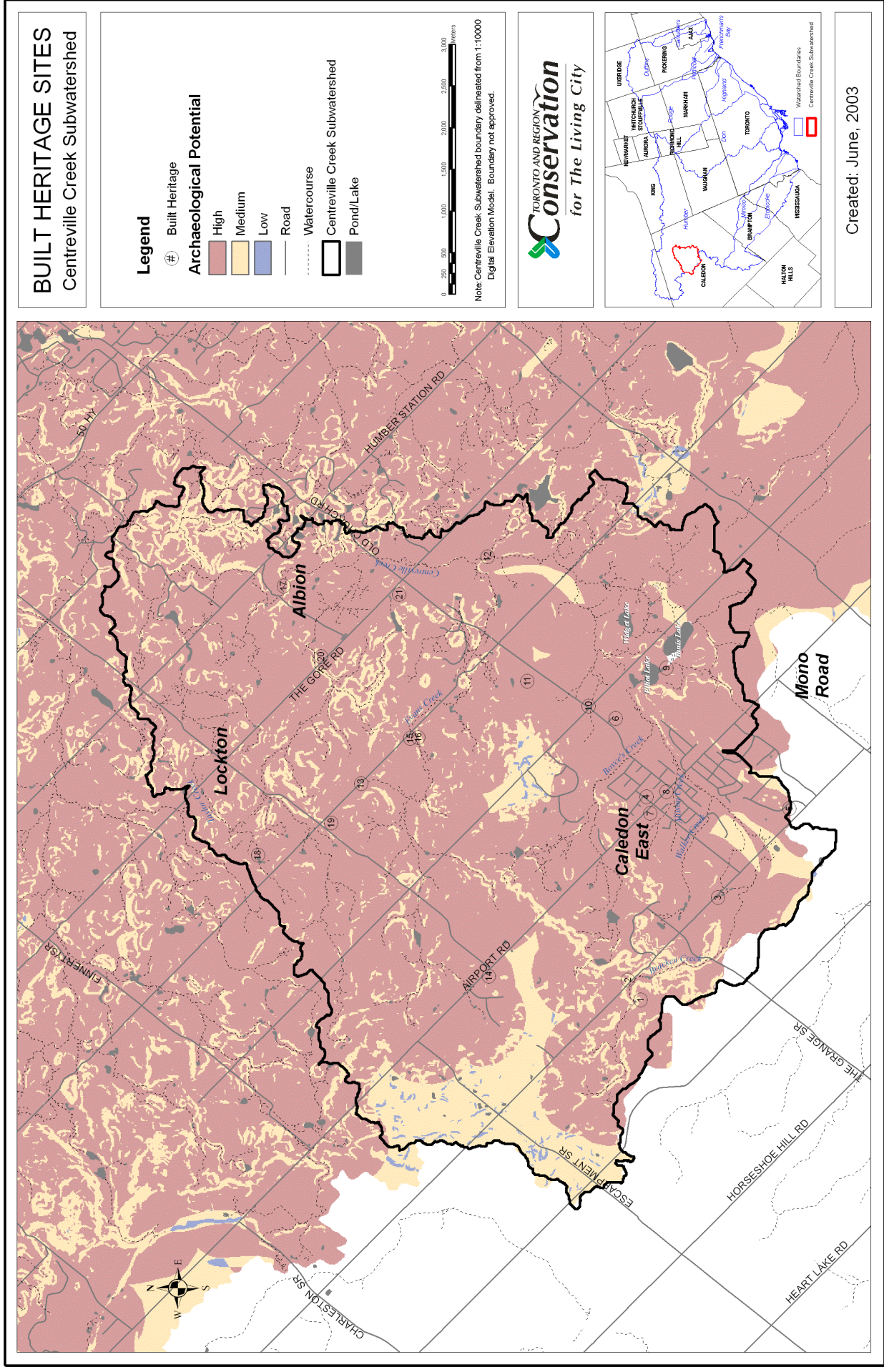
The lack of known sites in the subwatershed is not necessarily a reflection of sparse occupation during the past rather it is likely due to a lack of investigations conducted in the area. In order to predict whether or not a given area within the landscape may have been occupied during the past, an archaeological site predictive model has been developed for the Greater Toronto Area (MTRCA, 1990). The archaeological site predictive model provides an indication of the likelihood of finding archaeological sites within a given area. The model does not predict precise site location, rather it represents a generalized view of the current understanding of prehistoric settlement patterns and applies this knowledge to the area under study.

The model classifies land in terms of high, medium and low potential for containing archaeological sites according to a set of physical parameters. The model is based on the concept that settlement of a site in the past is more likely to have occurred on lands where the basic human needs of water, shelter and food are readily attainable. The three physical parameters utilized in the model are: distance to water source; slope; and soil drainage. Ranks for individual parameters are combined using a Geographic Information System to produce the final model output which assigns ranks for archaeological site potential for the area under study. **Figure 10.1** shows the output of the archaeological site predictive model for the Centreville Creek subwatershed.

The strong sustained flow of cool clean water in Centreville Creek, and the many kettle ponds and wetlands in the study area would have provided an abundant supply of freshwater and other natural resources to would-be inhabitants in the past. The output of the model supports the suggestion that the number of known archaeological sites in the study area does not reflect a lack of occupation during the past but rather a lack of investigations that have been conducted.



Figure 10.1: Built heritages sites and archaeological site potential



### 10.3 Built heritage

Many buildings and other built structures within the Town of Caledon have been designated as cultural heritage sites through the *Ontario Heritage Act* or through designation by the Heritage Board. The Town of Caledon, through their Heritage Board, has prepared an inventory of buildings of architectural and historic importance. Examination of these inventories identified a total of 21 built heritage features and their original uses which fall within the study area, eight of which are Designated properties (TRCA, 2002b). **Table 10.2** describes the built heritage sites that have been identified and designated in the subwatershed and **Figure 10.1** illustrates the locations of each feature. The sophistication and complexity of Euro-Canadian settlements in the subwatershed is demonstrated in the variety of architectural styles found in the heritage structures defined in this project. The variety of different architectural styles lends a unique identity to the Centreville Creek landscape and sets them apart from 19th century sites elsewhere in the Greater Toronto Area. **Table 10.2** provides a description of the heritage value of each site and **Figure 10.1** provides an indication of their respective locations.

**Table 10.2 Identified and Designated built heritage sites in Centreville Creek subwatershed**

| Site # | Feature                     | Level of significance | Description   |
|--------|-----------------------------|-----------------------|---|
| 1      | Pitton-Millichamp Log House | Local                 | This a Designated one and half storey log house. The wall height is equalled to ten squared logs with dovetailed keying. There have been compatible modern additions made to the rear of the building   |
| 2      | Day Log House               | Local                 | This log residence, built circa 1825, was renovated by Joseph Day. It is listed for its historical significance by the Town of Caledon LACAC.   |
| 3      | Blackburn Farm Complex      | Local                 | The Designated buildings include a farmhouse and an octagonal barn. The house dates circa 1850 and the barn was built in 1894. The farmhouse is a small one and a half storey rectangular building, with additions that were all in keeping with the style of the original structure. The barn is the last remaining octagonal barn in the Town of Caledon and has been restored. Previously known as the Cunningham-Osborne Complex. |
| 4      | Johnston-Wallis House       | Provincial            | This Designated structure is a two storey ell-shaped residence built in the Ontario Gothic architectural style. The yellow brick construction is characteristic of the Caledon East area. It was built between 1885 and 1888. The original owner was Robert Johnston, a Member of Parliament in 1900. In 1888, the structure was sold to the Presbyterian Church for use as a manse.  |
| 5      | Garden Hill Villa           | Local                 | Built in 1881, this Designated stone house was likely built around an existing log house. The property includes the house and drive shed, plus most of the original tree and shrub plantings. The two-storey house is ell-shaped with wing additions and a bell tower. Later, a one storey "Doody house" was added. The Coach House/Drive Shed is a board and batten frame building which likely predates the house.                  |
| 6      | Cranston-Freeborn House     | Local                 | Built in 1871, this Designated residence is a two storey building constructed in a modified Italianate style. This original architectural style has been preserved, despite later additions.  |

| Site # | Feature   | Level of significance | Description   |
|--------|---|-----------------------|---|
| 7      | Allison's Grove                                 | Provincial            | The original owner of this Designated historical residence was Samuel Allison, who graduated from the University of Toronto in 1860, and served as a surgeon in the American Civil War from 1863 to 1865. He was later the Medical Officer of Health for Peel County. His large ell-shaped house was built in 1888. The present owner is the great-granddaughter of the original owner.                     |
| 8      | Cranston-Moses-Graham House                     | Local                 | This Designated residence was built circa 1880 for Thomas Cranston, owner and proprietor of the adjacent general store to the south. The ell-shaped, two storey, Ontario style house is in the yellow brick which is characteristic of the Caledon East area. Modern additions have been made. The original drive shed was renovated and made into a workshop.  |
| 9      | Alexander Cransten Mill                         | Local                 | In Caledon East, the mill at this unregistered historical archaeological site was established in 1870. It has since been demolished   |
| 10     | St. James Anglican Cemetery                     | Local                 | This is an historic cemetery  |
| 11     | Wilson Family Plot                              | Local                 | This is an historic cemetery  |
| 12     | Historic Mill                                   | Local                 | This unregistered historical archaeological site was, before being demolished, a mill.  |
| 13     | Daley-Waldie House                              | Local                 | This Designated two storey log house, built in 1878, consists of eight courses of squared timbers. The house has a three-bay facade and a hip roof in addition to a brick veneer and wood pillared front porch. A large addition in the early twentieth century have given the house a Victorian appearance. In the mid-1980s, the underlying squared logs of the pioneer home were uncovered and revealed. |
| 14     | Historic Mill                                   | Local                 | Now an unregistered historical archaeological site, the mill that once stood here has now been demolished.  |
| 15     | Allendale Mills                                 | Local                 | Established in 1846, the structure has been demolished. It is now an unregistered historical archaeological site.   |
| 16     | Allendale Mill                                  | Local                 | This unregistered historical archaeological site is the former location of a mill, now demolished.  |
| 17     | Centreville Mill                                | Local                 | This is the former location of a mill that was established in 1865. Now an unregistered historical archaeological site.   |
| 18     | Historic Mill                                   | Local                 | This is the former location of a mill, now an unregistered historical archaeological site.  |
| 19     | Kearn's Anglican Cemetery                       | Local                 | This is a historic cemetery.  |
| 20     | Centreville Primitive Methodist Cemetery        | Local                 | This is a historic cemetery.  |
| 21     | St. John the Evangelist Roman Catholic Cemetery | Local                 | This is a historic cemetery.  |

#### **10.4 Management considerations**

There has been a general lack of archaeological investigations located in the Oak Ridges Moraine Area, and understanding of the cultural history of this region remains quite poor. Archaeological evidence of the sources of food and building materials that inhabitants utilized in the past provides indications of the types of flora and fauna communities that once thrived in this area.

In the context of the surrounding area, Centreville Creek subwatershed contains a fairly high concentration of built heritage sites which contribute to the unique character of the landscape and community. Preserving and reflecting this character as Caledon East develops in the future has been identified by local residents as an important issue.

Awareness and appreciation of the cultural heritage of the area could be improved by identifying heritage sites located in close proximity to the inter-regional trails and providing interpretive information resources. For example, the site of the former Centreville Mill, which is located on the main channel of Centreville Creek, upstream of the crossing at Mill Lane, is in very close proximity to the Trans-Canada Trail, where it crosses Mill Lane. Although the mill building has been demolished, the marsh wetland that exists today is likely a remnant of the mill pond that once existed there.

The provincial government and Town of Caledon Heritage Board, have designated a number of heritage sites within the subwatershed for preservation. The official plan of the Town of Caledon contains policies that promote the preservation and protection of any designated built heritage feature (Town of Caledon, 2002).

If development is proposed in an area that has not had an archaeological assessment, an assessment must be conducted as part of studies in support of development proposals.

Available information on the cultural heritage of this area should be considered when assigning place names associated with new urban settlements. Consideration should also be given to utilizing available cultural heritage information in programming at new public facilities (e.g., community centres, libraries, schools, etc.) to help new residents connect with the cultural heritage of this area.

## 11. Recreational use

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Recreational uses within the study area include four inter-regional trails, a major conservation area, a wetland boardwalk, and a private golf course (**Figure 11.1**). The following sections provide descriptions of each recreational feature.

### 11.1 Inter-regional trails

#### Trans-Canada Trail/Bruce Trail

A 13 km long section of multi-use trail that traverses the Centreville Creek subwatershed is part of both the Caledon Trailways section of the Trans-Canada Trail and the Caledon Hills section of the Bruce Trail. The trail route follows along the right-of-way of the former Hamilton and Northwestern Railway. This is a shared use trail, designed to accommodate walking, cycling, fishing, horseback riding, and cross-country skiing. A Trans-Canada Trail pavilion is located along the trail as it passes through Caledon East, and features panels displaying the names and messages from donors and trail supporters. No motorized vehicles are allowed on the Caledon Trailways portion of the Trans-Canada Trail/Bruce Trail, nor are hunting activities permitted. Pets must be kept on a leash while using the trail and off-trail travel is not permitted unless recognized by signage.

The Caledon Trailways Committee is a group of interested citizens, users' organizations, elected officials and town staff, formed to identify goals and objectives relating to short term and long term operation and management of the trail. Committee members organize and participate in fundraising and stewardship initiatives to maintain and improve the trail infrastructure and adjacent lands.

#### Humber Valley Heritage Trail

The Humber Valley Heritage Trail is a hiking trail along the Humber River valley, north of Bolton, which connects with the Trans-Canada Trail and Bruce Trail. The majority of the Humber Valley Heritage Trail traverses lands owned by Toronto and Region Conservation, including the Bolton Resource Management Tract and Albion Hills Conservation Area. The portion of the trail that is within the Centreville Creek subwatershed is within Albion Hills Conservation Area.

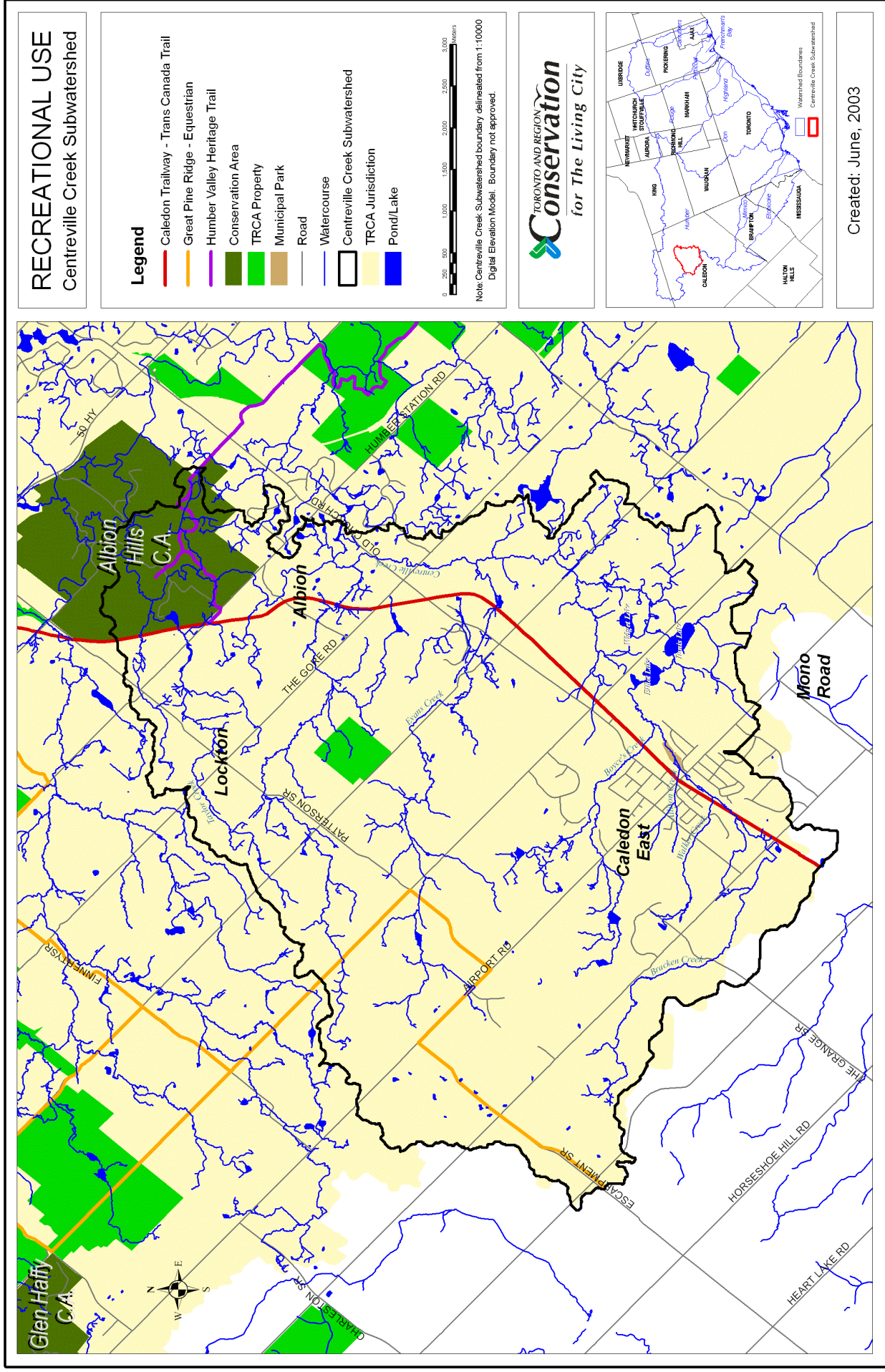
The Humber Valley Heritage Trail Association (HVHTA) is a group of interested citizens, and trail users whose goals are to promote and create recreational trails and to promote public education about the natural environment. The HVHTA is actively involved in trail monitoring and maintenance and in providing interpretive information about the natural and cultural heritage features in the area. Both the HVHTA and TRCA envision a future where a continuous system of inter-regional trails link the headwaters of the Humber River and the Oak Ridges Moraine with the Lake Ontario waterfront.

#### Great Pine Ridge Equestrian Trail

The 320 kilometre Great Pine Ridge Equestrian Trail was established by the Ontario Trail Riders Association (OTRA) in 1973. The OTRA is a non-profit organization with the mission to identify, develop and preserve multi-use trails throughout Ontario. The portion of the Great Pine Ridge Equestrian Trail that runs through Centreville Creek subwatershed follows along sections of Escarpment Sideroad, Airport Road, Patterson Sideroad and Innis Lake Road.



Figure 11.1 Recreational use areas



## **11.2 Albion Hills Conservation Area**

Albion Hills was established in 1954 as Ontario's first conservation area in response to a high demand for public recreation areas generated by the rapidly growing urban centres in and around the City of Toronto. The park was named after the rural township of Albion that is located nearby. Located at the confluence of Centreville Creek and the Humber River, in the hilly terrain between Bolton and Palgrave, the 496 hectare conservation area contains extensive areas of both natural and managed forest and kettle wetland ponds and depressions which provide habitat for many flora and fauna species of conservation concern. A portion of Albion Hills is recognized as an Area of Natural and Scientific Interest (ANSI) by the Ministry of Natural Resources. Albion Hills typically receives between 80,000 to 90,000 visitors annually. Canada Day celebrations held in the park in July have drawn crowds of over 9000 visitors in a single day in recent years. Albion Hills closes for only a short period in the late fall and re-opens for wintertime recreation activities.

The park offers opportunities for camping, swimming, boating, picnicking, fishing, biking, hiking, cross-country skiing, tobogganing and ice-skating activities. The park offers 26 kilometres of mountain biking trails and separate hiking trails. In response to the increase in popularity of mountain biking, more shared use of the hiking trails with mountain bikers is being allowed. Two annual 24 hour mountain bike race events are held at Albion Hills every summer. In cooperation with race organizers, mountain biking trails are being designed to provide a challenging and more fulfilling experience for riders. In addition to the trails within the park, Albion Hills provides a link with the inter-regional trail system which includes the Caledon Trailway section of the Trans-Canada Trail, the Caledon Hills section of the Bruce Trail, and the Humber Valley Heritage Trail.

The park also offers opportunities for swimming at a designated beach area. In order to ensure safe swimming conditions in the reservoir created along the main channel of Centreville Creek, a chlorination system is used in combination with a filter curtain which is intended to prevent adverse effects of elevated bacterial levels that occur periodically in this natural watercourse.

A campground is operated within the park, featuring serviced and unserviced campsites, laundry facilities, showers and a campground store. The campground offers pull-through sites for recreational vehicles and a dumping station for septic system wastes. Two picnic shelters and 11 picnic sites are available for booking during the mid-spring to late fall season.

In addition to serving conservation and recreation purposes, Albion Hills also provides excellent outdoor education opportunities. In 1962, a residential field centre was opened, where thousands of students come every year to explore and learn first-hand about the importance of forests, rivers and wildlife.

## **11.3 Municipal parkland**

Municipal parkland in the study area is located in Caledon East, along the Trans-Canada Trail, south of Old Church Road and east of Airport Road. The property is a 3 hectare portion of the floodplain of Centreville Creek and features a boardwalk over a wetland area and commemorative signs.

#### **11.4 Golf courses**

Devil's Paintbrush Golf Club is a 66 hectare private golf course located on the east side of St. Andrew's Road, south of Escarpment Sideroad. The 18 hole course, which opened in 1992, has been designed in a rustic style that reflects the hilly topography characteristic of the area. Fescue grasses have been planted in certain areas rather than the turfgrass species that are more commonly used in golf course design. A major portion of Devil's Paintbrush Golf Club drains to Bracken Creek, a tributary to Centreville Creek. Groundwater wells on the property are utilized on a seasonal basis to supply water for irrigation.

#### **11.5 Management considerations**

Local trail organizations have a strong interest in trail management issues. A great opportunity exists for the Town of Caledon and the TRCA to partner with these organizations to participate in stewardship and monitoring initiatives and interpretive programs or activities that promote public awareness of local natural and cultural heritage.

To help ensure safe swimming conditions at the Albion Hills Conservation Area public beach, agricultural best management practices that reduce the potential for transport of sediment and bacterial contaminants to surface waters (e.g., conservation tillage, vegetated riparian buffer zones, improving manure storage and spreading practices, improved wash-water management) should continue to be promoted to farmers and landowners in upstream areas through the Rural Clean Water Program. In particular, improvements to manure storage and spreading practices on leased farmland adjacent to Albion Hills Conservation Area, which is located a short distance upstream of the swimming beach, should be implemented as a priority. Routine maintenance of septic systems servicing rural residents should also continue to be promoted through this program.

## 12. Policy framework

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Understanding the roles and responsibilities of different levels of government in land use planning and water management, as well as the existing policies and plans relevant to the study area, is important to understanding how recommendations of the subwatershed study could be implemented through policy.

### 12.1 Land use planning in Ontario

In the Province of Ontario, the federal, provincial and municipal governments are all involved in land use planning. The federal role in land use planning is generally indirect, however as the highest level of government in Canada, federal legislation supercedes all other levels of government. At the federal level, ownership of land and control of transportation and telecommunications often has implications on municipal land use planning decisions. Development proposals that affect fish habitat must satisfy the regulations under the federal *Fisheries Act*.

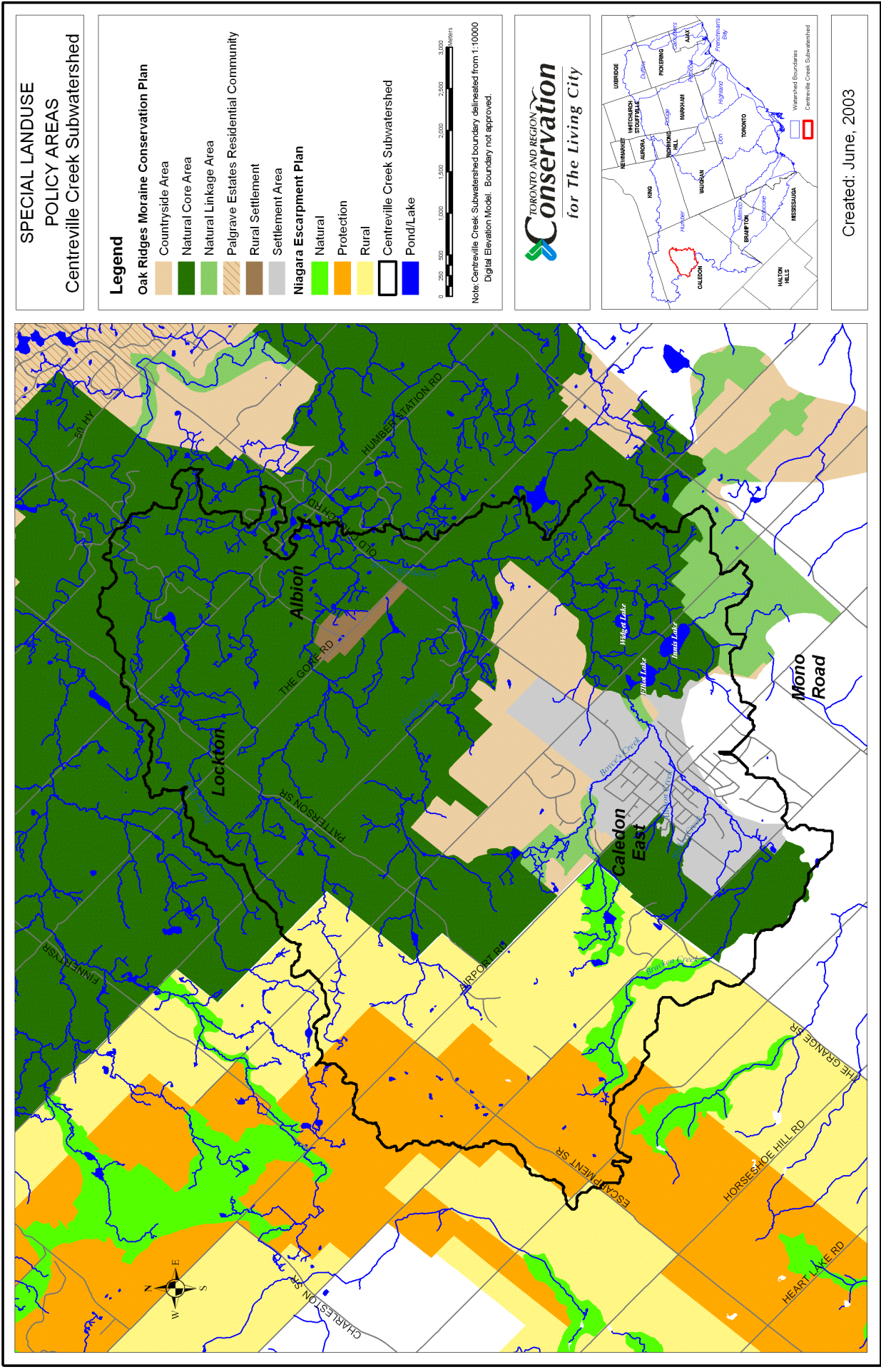
The provincial role in land use planning is governed indirectly through various pieces of provincial legislation, and directly through the *Planning Act*, the establishment of municipal governments, ownership of land, and control over utility corridors and public highways. The *Planning Act* sets out the policies by which a municipality must implement land use planning decisions. The Provincial Policy Statement articulates provincial policies set out under the *Planning Act* which influences land use planning.

The Provincial Policy Statement provides policy direction for land use planning and development on matters of provincial interest. A healthy economy and managed growth of communities, wise use and protection of resources, and the long term health and safety of Ontario's population are the key components of the Provincial Policy Statement. With regard to natural heritage protection, the PPS defines key provincial interests through designated Areas of Natural and Scientific Interest (ANSI) and Provincially Significant Wetlands (PSW). ANSIs are areas identified by the Ontario Ministry of Natural Resources that have significant natural heritage, scientific study or educational values that warrant their protection. There are two types of ANSIs: Life Science (for the protection of provincially or regionally significant ecological features); and, Earth Science (for the protection of significant geological features). Provincially Significant Wetlands are wetlands that have been evaluated by the Ontario Ministry of Natural Resources and protected for their biological, hydrological, and other special features.

Numerous other pieces of provincial legislation and associated regulations address environmental considerations that may be applicable to specific land use planning situations, including the *Environmental Assessment Act*, *Lakes and Rivers Improvement Act*, *Conservation Authorities Act*, *Drainage Act*, *Public Lands Act*, *Aggregate Resources Act*, and *Environmental Protection Act*. The *Niagara Escarpment Plan, 1994*, and the *Oak Ridges Moraine Conservation Plan, 2002*, outline policies for land use planning specific to the Niagara Escarpment and Oak Ridges Moraine planning areas, which the *Planning Act* shall conform to. **Figure 12.1** illustrates the portions of Centreville Creek subwatershed that are subject to the policies and regulations of the *Niagara Escarpment Plan (NEC, 1994)* and *Oak Ridges Moraine Conservation Plan (OMMAH, 2002)*.



Figure 12.1 Special land use policy areas in Centreville Creek subwatershed





## 12.2 Niagara Escarpment Plan

The southern Ontario portion of the Niagara Escarpment stretches 725 kilometres from Queenston, near Niagara Falls, to Tobermory on the Bruce Peninsula. Public concern about protecting the natural heritage values of the Niagara Escarpment began to emerge in the early 1960s, primarily in response to mineral resource extraction activities in the area. The provincial government responded with the enactment of the *Niagara Escarpment Protection Act, 1970* and the *Pits and Quarries Control Act, 1971*, which served to restrict aggregate extraction activities along the escarpment. In 1973, the Niagara Escarpment Planning and Development Act was enacted to “provide for the maintenance of the Niagara Escarpment and land in its vicinity substantially as a continuous natural environment, and to ensure that only such development occurs as is compatible with the natural environment”. The Act established the Niagara Escarpment Commission and required it to develop a land use plan which would achieve several important objectives for the escarpment including protecting unique ecological and historic areas, and providing adequate opportunities for outdoor recreation and public access.

The *Niagara Escarpment Plan* (NEC, 1994) outlines the land use policies, development criteria and a system of open space areas designated under the *Niagara Escarpment Protection Act*. The Niagara Escarpment Plan Area (183,311 hectares) is located within portions of 21 local municipalities, two cities, and seven counties or regions. All of the lands within the Niagara Escarpment Plan Area have been placed into one of seven land use designations: Natural; Protection; Recreation; Rural; Mineral Extraction; Minor Urban; and Urban. **Table 12.1** provides a summary of the objectives for each land use designation.

With the introduction of the *Niagara Escarpment Protection Act* in 1973, the Niagara Escarpment Commission was established to oversee implementation of the objectives of the Act. The Niagara Escarpment Commission is responsible for interpreting and promoting the objectives of the Plan, reviewing, commenting and making decisions on development permit applications, processing proposed Plan amendments, and commenting on official plans, municipal by-laws, environmental assessments and other policy-related initiatives to ensure conformity with the Niagara Escarpment Plan.

**Figure 12.1** illustrates the portions of Centreville Creek subwatershed that are subject to the policies and regulations of the *Niagara Escarpment Plan*.

**Table 12.1 Niagara Escarpment Plan land use designations and objectives (NEC, 1994)**

| <b>Designation</b>               | <b>Objective</b>  |
|----------------------------------|---|
| Escarpment Natural               | <ul style="list-style-type: none"> <li>• To maintain the natural features, stream valleys, wetlands and cultural heritage features;</li> <li>• To encourage compatible recreation, conservation and educational activities;</li> <li>• To maintain and enhance the landscape quality of Escarpment features.</li> </ul>   |
| Escarpment Protection            | <ul style="list-style-type: none"> <li>• To maintain and enhance the open landscape character of the Escarpment features;</li> <li>• To provide a buffer to prominent Escarpment features;</li> <li>• To maintain natural areas of regional significance and cultural heritage features;</li> <li>• To encourage agriculture, forestry and recreation</li> </ul>  |
| Escarpment Rural                 | <ul style="list-style-type: none"> <li>• To maintain the scenic value of lands in the vicinity of the Escarpment;</li> <li>• To maintain the open character of the landscape by encouraging the conservation of the traditional cultural landscape and cultural heritage features;</li> <li>• To encourage agriculture and forestry and provide for compatible rural land uses;</li> <li>• To provide a buffer for the more ecologically sensitive areas;</li> <li>• To provide for the designation of new Mineral Resource Extraction Areas.</li> </ul>  |
| Minor Urban                      | <ul style="list-style-type: none"> <li>• To recognize, maintain and enhance existing rural settlements, or provide concentration points for development in rural areas;</li> <li>• To ensure the existing Minor Urban Centres and any new development can be accommodated and serviced in an environmentally sustainable manner;</li> <li>• To maintain and enhance the cultural heritage features of these settlement areas;</li> <li>• To ensure that new development is compatible with the identity and traditional character of the existing Minor Urban Centres;</li> <li>• To generally direct the growth of villages, hamlets and settlement areas away from Natural Areas and Protection Areas, and into Rural Areas;</li> <li>• To ensure that any growth will be in accordance with a municipal official plan and/or secondary plan</li> </ul> |
| Urban                            | <ul style="list-style-type: none"> <li>• To minimize the impact and further encroachment of urban growth on the Escarpment environment</li> </ul>   |
| Escarpment Recreation Area       | <ul style="list-style-type: none"> <li>• To minimize any adverse effects of recreational activities on the Escarpment environment;</li> <li>• To provide areas where new recreational development can be concentrated around established, identified, or approved lakeshore cottage areas;</li> <li>• To recognize the importance of recreation areas to the Ontario economy;</li> <li>• To provide for the development of new ski centres or other recreational areas;</li> <li>• To ensure that future recreational development is compatible with cultural and natural heritage values in the area;</li> </ul>   |
| Mineral Resource Extraction Area | <ul style="list-style-type: none"> <li>• To designate licensed Mineral Resource Extraction Areas;</li> <li>• To minimize the impact of mineral extraction operations on the Escarpment environment;</li> <li>• To provide for areas where new pits and quarries may be established;</li> <li>• To ensure that after uses and rehabilitation are compatible with the applicable Plan designation, the surrounding environment and existing uses;</li> <li>• To encourage the rehabilitated after uses of pits and quarries to be integrated into the Niagara Escarpment Parks and Open Space System.</li> </ul>  |

### 12.3 Oak Ridges Moraine Conservation Plan

The Oak Ridges Moraine (ORM) is an ecologically and hydrologically sensitive landform that stretches from the Trent River in the east to the Niagara Escarpment in the west. Located north of and parallel to Lake Ontario, the Moraine divides the watersheds draining south into western Lake Ontario from those draining north to Georgian Bay, Lake Simcoe and the Trent River system. The Moraine shapes the present and future form of the Greater Toronto region, and its ecological functions are critical to the region's continuing health (OMMAH, 2002).

The Oak Ridges Moraine is under increasing pressure for new residential, commercial, industrial and recreational uses which compete with the present natural environment. Given the on-going pressure for development on the Moraine, a tri-regional initiative (consisting of Peel, York and Durham Regions) published a paper in 1999 recommending the establishment of a long term strategy for the ORM.

In response to the regional initiative and efforts by local interest groups the province announced a comprehensive strategy for the Oak Ridges Moraine in November 2001. The strategy included introducing the *Oak Ridges Moraine Conservation Act, 2001*, a land exchange settlement, and the formation of an Oak Ridges Moraine Foundation.

The *Oak Ridges Moraine Conservation Plan, 2002* (OMMAH, 2002) is a regulation established under the *Oak Ridges Moraine Conservation Act*. The Plan divides the Moraine into four land use designations with identified permitted uses. **Table 12.2** provides a summary of the ORM Conservation Plan land use designations. Municipalities in the ORM planning area are required to update their official plans to conform to the *Oak Ridges Moraine Conservation Plan*, which will guide land use planning on the moraine.

The Plan identifies Key Natural Heritage Features (such as wetlands and woodlands) and Hydrologically Sensitive Features (such as kettle lakes and springs). Development is generally prohibited within these features. Development near these types of features will only be allowed if it will not adversely affect these features. Site-specific environmental impact studies will be required for proposed developments that are within the "minimum area of influence" of these terrestrial and hydrological features. The Plan also provides for a 30 metre "minimum vegetation protection zone" to be established as a buffer around key natural features.

In areas with significant landscape character (referred to as Landform Conservation Areas), development will have to meet particularly stringent review and approval standards to ensure that the Moraine landscape is protected.

The water resource policies of the Plan require municipalities to prepare watershed plans, water budgets and water conservation plans which are to be incorporated into their official plans within a specified time period. Development in wellhead protection areas and areas that are highly vulnerable to groundwater contamination is limited. Limitations are also set on impervious surfaces in areas outside Settlement Areas.

Other key requirements of the *Oak Ridges Moraine Conservation Plan* include:

- prohibiting the reduction of Natural Core Areas and Natural Linkage Areas in future reviews of the Plan;

- prohibiting the expansion of Settlement Area boundaries until a ten year review is completed, and then, only into Countryside Areas;
- prohibiting new aggregate extraction operations in Natural Core Areas, but allowing this restriction to be revisited during the ten year review.

**Figure 12.1** illustrates the portions of Centreville Creek subwatershed that are subject to the policies and regulations of the *Oak Ridges Moraine Conservation Plan, 2002*.

**Table 12.2 Oak Ridges Moraine Conservation Plan land use designations (OMMAH, 2002)**

| Land Use Designation  | Objective  | Permitted Uses  |
|-----------------------|--|---|
| Natural Core Areas    | To protect those lands with the greatest concentrations of key natural heritage features which are critical to maintaining the integrity of the Moraine as a whole.  | Only existing uses and very restricted new resource management, agricultural, low intensity recreational, home businesses, transportation and utility uses are allowed in these areas.  |
| Natural Linkage Areas | To protect critical natural and open space linkages between the Natural Core Areas and along rivers and streams.   | Only those uses permitted in Natural Core Areas, plus some mineral and aggregate resource operations are allowed in these areas.  |
| Countryside Areas     | To provide a transition zone of agricultural and rural land use that acts as a buffer between the Natural Core Areas/Natural Linkage Areas and the Settlement Areas. Prime agricultural areas and natural features within these areas are to be protected. | Uses typically allowed in agricultural and rural areas are permitted in these areas, including major recreational uses. Existing rural settlements are contained within these areas. Policies on creating and developing new lots are very restrictive. |
| Settlement Areas      | To provide opportunities for limited growth of existing communities planned by municipalities to reflect community needs and values.   | Urban uses and development, as set out in municipal official plans, are allowed.  |

## 12.4 Water use policy framework

In Canada, the governance of the use or development of water resources generally falls within the jurisdiction of the provinces, with the exception of issues pertaining to boundary waters, which are handled by the federal government.

In the Province of Ontario, policies and guidelines have been formulated and legislation has been implemented to guide, permit, and regulate water taking and water use in a manner that supports broader social, economic, and environmental objectives. The water resources of the province are considered to be a public good, to be used and managed through the application of policies, laws, regulations and both corporate and individual stewardship. The key pieces of provincial legislation that govern water use allocation and water use management are:

- the *Ontario Water Resources Act* (governs water takings);
- the *Lakes and Rivers Improvement Act* (governs construction and operation of dams and diversions);
- the *Public Lands Act* (provides authority for the Ontario Ministry of Natural Resources to construct and operate dams); and,

- the *Conservation Authorities Act* (regulation of floodplains and watercourse alterations, authority for Conservation Authorities to construct and operate flood protection works, programs to manage natural resources excluding coal, oil and gas, and development of watershed management programs).

Water takings in Ontario are governed by the *Ontario Water Resources Act* and the Water Taking and Transfer Regulation (O. Reg. 285/99). Section 34 of the Act requires anyone taking more than a total of 50,000 litres in a day, with some exceptions, to obtain a Permit To Take Water. The permit-to-take-water provisions of the Act support the efficient development and beneficial use of the province's surface and groundwater resources through application of a permit system involving the regulation of withdrawals and the settlement of interference complaints. The Water Taking and Transfer Regulation establishes the scope of considerations that may be taken into account by the Ontario Ministry of the Environment (OMOE) in the issuance of water-taking permits, which include: protection of natural functions of the ecosystem; groundwater that may affect or be affected by a proposed surface water taking; and, surface water that may affect or be affected by a proposed groundwater taking.

Additionally, the Provincial Policy Statement under the *Planning Act* provides direction to municipalities with respect to long range and inter-municipal planning of water services. It also provides important protection for wetlands, groundwater recharge and discharge functions and headwaters.

## **12.4 Regional municipalities**

The provincial government established regional municipalities as upper-tier municipal corporations. Regional municipalities generally set out a regional level of strategic land use policies to guide economic, environmental and community-building decisions of a larger context. This allows for the implementation of planning and servicing initiatives on a regional scale, based on directions given in the Provincial Policy Statement. Regional official plans set broad, long-term policy directions on matters related to the environment, resources, regional growth, regional structure, and regional services. Local municipal official plans must conform to regional official plans.

### **Region of Peel Official Plan**

The Region of Peel Official Plan (ROP) is strategic in nature, providing a framework for growth and development in Peel to the year 2021 (Regional Municipality of Peel, 2001). The ROP defines the Regional Structure in Peel Region as being composed of the Greenlands System and Peel's renewable and non-renewable resources, the Urban and Rural System (as defined by the 2021 Regional Urban Boundary), the Rural Service Centres, the Palgrave Estate Residential Community, and the Lester B. Pearson International Airport.

Centreville Creek subwatershed falls entirely within the Rural System and includes portions of the Greenlands system, the Prime Agricultural Areas, High Potential Mineral Aggregate Resource Areas, and a major portion of the Caledon East Rural Centre. Caledon East is serviced with potable water from the Region's Caledon East wells. The Region of Peel has applied to the Ministry of the Environment to renew Permits to Take Water for the Caledon East wells in order to meet the future demand for potable water supply in the area.



## **12.5 Local or area municipalities**

Local municipal official plans contain policies for the specified area relating to land use planning and development control. The local official plan examines growth management within the municipality while having regard to the larger, regional context. Many municipal official plans include secondary plans or neighbourhood plans, which are detailed policy documents governing specific areas within a municipality. Municipal official plans also identify natural areas such as valley and stream corridors, and set policies for the protection of significant natural features. Zoning by-laws are provided to implement official plan policies and are used to establish land use permissions and restrictions and development standards.

Local and regional municipalities may also implement special municipal by-laws, such as tree preservation by-laws, or fill by-laws to address land use under unique conditions or local environmental concerns. Such by-laws are important to watershed management for a number of reasons:

- They prohibit and regulate activities that may have detrimental effects on natural resources;
- They increase public awareness;
- They impose legally enforceable standards by which to manage natural resources; and,
- They provide a localized base from which to address specific environmental and/or risk management issues.

### **Town of Caledon Official Plan**

The Town of Caledon Official Plan provides a statement of principles, goals, objectives and policies intended to guide future land use, physical development and change, and the effects on the social, economic, and natural environment within the Town of Caledon (Town of Caledon, 2002). The Official Plan contains a set of principles, strategic directions, and goals that provide overall guidance to the Town of Caledon in exercising its responsibility for land use regulation, provision of infrastructure and delivery of services. The Plan acknowledges that sustaining the integrity of the natural environment in Caledon is essential to the continued social and economic well-being of the Town. The Ecosystem Objectives, Ecosystem Planning Strategy, General Policies, and Performance Measures described in the Official Plan establish a broad framework for ecosystem planning and management in Caledon, and are supplemented by detailed environmental and open space/recreational land use policies and designations.

In support of the Town of Caledon Official Plan, Secondary Plans are also prepared for the Town's Rural Service Centres in order to guide and manage growth within these communities to the year 2021 by providing more detailed planning objectives and policies pertaining to development activities. Secondary Plans have been prepared for the communities of Bolton South Hill, Bolton Core Area, West Bolton, Caledon East, and Palgrave Estate Residential Community.

The major changes in land use that are anticipated to occur within Centreville Creek subwatershed over the next twenty years are associated with implementation of the Caledon East Secondary Plan. The 2021 settlement boundary of Caledon East established by the Secondary Plan falls almost entirely within the Centreville Creek subwatershed boundary. A high concentration of the Town of Caledon's Environmental Policy Areas (EPAs), which are comprised of Natural Core Areas and Natural Corridors, occur within the study area.

### Caledon East Secondary Plan

The Caledon East Secondary Plan provides a detailed framework for guiding the evolution of the Caledon East community to the year 2021 (Town of Caledon, 2002). It is the outcome of a study undertaken to examine the function of the Caledon East Rural Service Centre including land uses, community facilities, and municipal services. The Secondary Plan Study examined Caledon East in terms of its broad environmental and land use context (Geomatics International *et al.*, 1997), resulting in amendments to Environmental Policy Area designations and the confirmation of the existing Agricultural and Rural designations and policies in the surrounding area. The Secondary Plan envisions a compact Caledon East Settlement Area, centred on the existing commercial core, surrounded by rural countryside containing agricultural uses, the estate residential lots that currently exist, and the hamlet of Mono Road. The settlement area boundary for Caledon East has been established based on a rounding out of the settlement recognizing the natural boundaries created by the Environmental Policy Area designations and the existing road network. The intent is to create a well defined edge to the settlement by containing it within a green belt. This will preserve the rural landscape surrounding Caledon East, protect prime agricultural land to the south, and maintain Mono Road as a separate rural community. The EPA designations currently form a green belt along the north-west and south-east boundaries of the settlement. Opportunities to complete the green belt will be pursued through the creation of open space corridors and trail links as part of new development, environmental rehabilitation initiatives, and the regulation of land uses outside the settlement boundary, in accordance with the Agricultural and Rural Area policies of the Official Plan.

During the public consultation process that was undertaken as part of the Secondary Plan Study, residents of Caledon East expressed their strong interest in community design as a means of retaining the aspects of Caledon East that they value. Some of the values expressed included maintaining the historic character of the community, preserving and enhancing natural features, integrating open space within the community, linking neighborhoods, facilities and open space with a trail system, and maintaining views of valued landscape features and the night sky. A set of community design principles were developed and included as part of the Secondary Plan to ensure that new development and redevelopment in Caledon East is compatible with the values expressed by the community.

## **12.6 Watershed planning**

Watershed planning applies the ecosystem approach to land use planning within the boundaries of a watershed (OMOEE, 1993). Watershed planning involves the identification of natural features and functions, the assessment of interactions and natural processes on a broader scale than within municipal boundaries, and the assessment of linkages between natural processes and social and economic demands. A watershed plan usually contains objectives and targets for the protection of the natural system, water resource management, enhancement or rehabilitation of natural features, and establishment of best management practices for the design of subdivisions and open space areas. Watershed plans may also outline directions for stormwater management. Planning recommendations contained in watershed plans should be incorporated into municipal official plans through official plan amendments (OMOEE, 1993).

## **The Humber River Watershed Strategy**

In 1995, the Humber Watershed Task Force was formed and given a mandate to develop a Watershed Strategy to achieve a sustainable, healthy watershed for the Humber River using an ecosystem-based approach which considers the environment, society and economy as being linked. The Humber Watershed Task Force was guided by the vision of a healthy Humber watershed, which was expressed as the Humber Challenge and Guiding Principles:

### *THE HUMBER CHALLENGE*

*Our challenge is to protect and enhance the Humber River watershed as a vital and healthy ecosystem where we live, work, and play in harmony with the natural environment.*

### *GUIDING PRINCIPLES*

- *To achieve a healthy watershed, we should:*
- *Increase awareness of the watershed's resources;*
- *Protect the Humber River watershed as a continuing source of clean water;*
- *Celebrate, regenerate, and preserve our natural, historical, and cultural heritage;*
- *Increase community stewardship and take individual responsibility for the health of the Humber River;*
- *Establish linkages and promote partnerships among communities;*
- *Build a strong watershed economy based on ecological health; and,*
- *Promote the watershed as a destination of choice for recreation and tourism.*

In carrying out its mandate, the Task Force identified the environmental, social, and economic issues facing the Humber as well as opportunities for regeneration. Based on input from Task Force members, municipalities, agencies, organized groups, institutions, businesses and members of the public, a set of recommendations on how to achieve a healthy Humber River watershed were developed and expressed as a set of thirty objectives with associated actions. These recommendations were woven together to form *Legacy: A Strategy for a Healthy Humber* (MTRCA, 1997a), and its companion volume, *A Call to Action - Implementing Legacy: A Strategy for a Healthy Humber* (MTRCA, 1997b). The thirty objective statements can be summarized as follows:

- Protect significant landforms
- Protect water resources (water quantity and water quality)
- Improve air quality
- Protect wildlife habitats
- Protect and promote the Humber's culture and heritage
- Improve recreational opportunities
- Use land wisely
- Use resources wisely

## PART 3 POTENTIAL FUTURE CONDITIONS

### 13. Scenario analysis

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The second phase of the study involved modelling potential future conditions in the subwatershed in order to predict how surface water components of the subwatershed system will respond to anticipated changes to land use and alternative management practices. Through this scenario modelling and analysis work, a better understanding of sensitivities in the subwatershed system to land use changes were identified. Based on predictions of the effectiveness of different management practices, recommendations were developed regarding what management practices should be implemented to maintain or improve the health of the subwatershed system.

Computer modelling techniques and expert analysis were used to predict the response of the subwatershed system with regard to surface water quality (using an Agricultural Non-point Source - AGNPS model), and surface water hydrology and channel form (using an HSPF continuous hydrologic simulation model).

#### 13.1 Study questions

The study design was guided by the following questions, which arose from a review of local watershed management issues of concern (see **Section 2.0; Table 2.1**):

- **Urban growth:** How will planned growth of urban settlements in Caledon East affect surface water quality, stream flow and channel erosion downstream?
- **Agricultural best management practices:** How would implementation of agricultural best management practices in strategic locations affect surface water quality?
- **Natural cover:** How would an expanded terrestrial natural heritage system (i.e., increased quantity of natural cover) affect surface water quality?
- **Urban stormwater management:** How will different stormwater management pond designs affect channel erosion downstream of planned urban growth areas?

#### 13.2 Land use and management scenarios

To answer the study questions noted above, a set of three scenarios of potential future land use and management were defined and input to the predictive computer models.

##### Scenario 1 - Baseline conditions

Baseline conditions were defined according to land use and land cover information derived from 1999 aerial photography (see **Section 3; Figure 3.1**).

##### Scenario 2 - Anticipated new development to 2021 with a conventional management approach

This scenario was defined according to 1999 land use and land cover with changes made according to the Town of Caledon Official Plan land use designations contained in the Caledon East Secondary Plan (**Figure 13.1**). In this scenario it was assumed that a conventional management approach to urban stormwater management would be implemented whereby new developments would include end-of-pipe stormwater management ponds, sized to provide

flood, quality and erosion control.

Scenario 3 - Anticipated new development to 2021 with an expanded natural heritage system

This scenario was defined according to 1999 land use and land cover with changes made according to the Town of Caledon Official Plan land use designations contained in the Caledon East Secondary Plan. In this scenario it was assumed that a conventional management approach would be implemented as in Scenario 2, along with increasing natural land cover in the subwatershed from the 1999 level of 47% of the total area, to 60% of the total area (**Figure 13.2**). Areas where additional natural cover was assumed to be restored were agricultural and rural lands in the TRCA draft target terrestrial natural heritage system (TRCA, 2004).

The following sections summarize the key findings from this scenario analysis work.









## 14. Surface water quality modelling

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### 14.1 Introduction

The quality of water in the Centreville Creek subwatershed is one of several environmental variables that could be affected by future changes in land use (see **Section 3; Figure 3.4**). Expansion of the road network, for instance, may result in larger quantities of automobile pollutants such as oil, grease, road salts and heavy metals entering the watercourse. Similarly, an increase in residential land uses can result in a rise in bacteria from domestic pets and urban wildlife (e.g., geese, gulls, racoons) and higher nutrient levels from lawn care and gardening activities. On the other hand, enhancement of vegetation adjacent to streams, and conversion of agricultural land to meadow or forest can help to improve water quality by stabilizing stream banks, uptake of nutrients from shallow groundwater, and eliminating agricultural sources of nutrients and bacteria.

The Agricultural Non-Point Source (AGNPS) model was used to predict the effect of land use and land cover changes on water quality and provide guidance on how potential impacts can be managed. The AGNPS model is an event model, simulating conditions based on a single precipitation event distributed uniformly across the subwatershed. Model simulations incorporate a wide range of variables affecting water quality, including soils, topography, nutrient application rates, local hydrology, land use practices, precipitation, and drainage. Outputs include run off volume, peak flow, sediment yield and phosphorus load and concentration. In this model, the presence of other pollutants, such as heavy metals and bacteria, may be inferred from changes in sediment yield because these pollutants are often strongly associated with suspended solids.

### 14.2 Model calibration

Leon *et al.* (2002) performed a detailed calibration and sensitivity analysis of the AGNPS model in the Duffins Creek watershed, approximately 40 kilometres east of the Humber River watershed. This calibration was validated in the Humber River watershed using stream flow data for six storm events at five stream gauge stations to ensure model simulations were representative of the Humber River. As part of the validation exercise, default values and hydrologic curve numbers were modified within a narrow range to achieve an improved match between observed and simulated data (Stantec, 2003a). This validation exercise was repeated in the Centreville Creek subwatershed (Stantec, 2003b) using stream flow data from the nearest stream gauge station on the Humber River near Palgrave, 1999 land use and land cover data and information regarding fertilizer use and tillage practices obtained through the surveys conducted in the study area in 2003 (Cost Effective Cropping Inc., 2003).

### 14.3 Scenario analysis results

**Table 14.1** presents model simulations of total sediment yield, ortho-phosphate load and total phosphorus concentrations for each of the three scenarios evaluated.

**Table 14.1 Total sediment yield, ortho-phosphate load and total phosphorus concentrations predicted at the subwatershed outlet under potential future scenarios**

| <b>Water Quality Variable</b>                | <b>Storm Event</b> | <b>Scenario 1 - Baseline Conditions</b> | <b>Scenario 2 - OP Build-out with SWM Ponds</b> | <b>Scenario 3 - OP Build-out with Expanded Natural Cover</b> | <b>Scenario 4 - Opportunistic Approach</b> |
|--|--------------------|---|---|--|--|
| <b>Total Sediment Yield (kg)</b>             | 47 mm, 18 hrs      | 104,580                                 | 102,420 (↓2.1%)                                 | 83,997 (↓19.7%)  | --   |
|  | 54 mm, 10 hrs      | 147,440                                 | 142,110 (↓3.6%)                                 | 119,682 (↓18.8%)   | 143,784 (↓2.5%)                            |
|  | 55 mm, 24 hrs      | 142,100                                 | 136,557 (↓3.9%)                                 | 114,912 (↓19.1%)   | --   |
| <b>Total Ortho-phosphate Load (kg)</b>       | 47 mm, 18 hrs      | 11.2                                    | 12.4 (↑11.0%)                                   | 4.35 (↓61%)  | --   |
|  | 54 mm, 10 hrs      | 14.8                                    | 15.9 (↑7.5%)                                    | 4.85 (↓67.2%)  | 12.7 (↓14.3%)                              |
|  | 55 mm, 24 hrs      | 15.7                                    | 13.9 (↓11.0%)                                   | 4.85 (↓69.0%)  | --   |
| <b>Total Phosphorus Concentration (mg/L)</b> | 47 mm, 18 hrs      | 0.35                                    | 0.39 (↑11.4%)                                   | 0.20 (↓42.8%)  | --   |
|  | 54 mm, 10 hrs      | 0.27                                    | 0.31 (↑14.8%)                                   | 0.12 (↓55.6%)  | 0.24 (↓11.1%)                              |
|  | 55 mm, 24 hrs      | 0.27                                    | 0.27 (0%)                                       | 0.12 (↓55.6%)  | --   |

**Note:** 1. Numbers in brackets represent the percent change from baseline conditions (Scenario 1).

2. Storm events occurred Aug 15, Aug 26 and September 10<sup>th</sup>, 1986, respectively.

3. There is more confidence in the relative difference among scenarios (i.e. percent change) than in the actual concentrations or loads predicted by the model.

### **Scenario 1 - Baseline conditions**

Model predictions regarding water quality in the subwatershed suggest that under baseline conditions, surface water is relatively clean during storm events. Elliot Lake and Innis Lake, both located a short distance downstream of Caledon East are predicted to function like large on-line settling basins that remove much of the suspended sediments and associated contaminants in the stream that have been contributed from upstream urban and rural areas. Concentrations of only two pollutants, phosphorus and *E.coli*, were predicted to exceed Provincial Water Quality Objectives during the storm events examined (Stantec, 2003b). The model indicated that major source areas for phosphorus and clay sediments were clustered on the eastern border of the subwatershed where more erodible clay and silty clay soils predominate (**Figures 6.2 and 6.3**). Land use contributed to phosphorus and sediment loadings to the stream in some areas, particularly for soluble phosphorus, but appeared to be less important in determining overall loading contributions than soil texture and slope (Stantec, 2003b).

### **Scenario 2 - Anticipated new development to 2021 with a conventional management approach**

This scenario represents an increase in urban land uses from 9% to 15% of the total subwatershed area. Model simulations of this scenario indicate a 2 to 4% decrease in total sediment yield (TRCA, 2003c). Results for phosphorus were ambiguous. Two of the three storm event simulations showed an increase in ortho-phosphate load and total phosphorus concentration. The third storm, however, registered a decrease in ortho-phosphate loading and no change in total phosphorus concentration.

These results reflect differences in source areas and transport mechanisms for sediment and phosphorus under agricultural and urban land uses. Overland run off from agricultural fields and drainage ditches can transport significant quantities of eroded sediment, especially when there is limited crop cover. Bare, erodible soils are generally less prevalent in urban areas, but roads and other impervious areas act as efficient traps for grit and dust, which is readily washed off these surfaces during rain events. Implementation of stormwater management measures help to reduce the discharge of sediment and other pollutants from urban areas into watercourses. These same measures also reduce peak flows, although in-stream erosion rates may still be higher than under agricultural land use because of the larger run off volumes associated with increased impervious cover. It is reasonable to expect, therefore, that the net effect of these various considerations is a moderate decrease in sediment yield, as predicted by the model (TRCA, 2003c).

Phosphorus enters the watercourse largely through the application of synthetic and organic fertilizers to crops and urban lawns. Since phosphorus has a strong affinity for solid particles, a decrease in sediment load often corresponds to a decline in particulate phosphorus loads. The increase in soluble phosphorus load during two storm events simulated by the model may reflect increased areas covered by manicured lawns and gardens associated with new residential and institutional land uses, which are associated with high fertilizer application rates (JDE Ventures, 1998).



### **Scenario 3 - Anticipated new development to 2021 with an expanded natural heritage system**

The third scenario simulates the effect on water quality if selected idle lands and farm fields were to be converted to forest, leaving intact the additional urban cover modelled in scenario 2. Relative to existing conditions, model results under this scenario indicate a 19 to 20% decrease in sediment yield, a 61 to 69% decrease in soluble phosphorus load, and a 42 to 56% decrease in the total phosphorus concentration (TRCA, 2003c).

These substantial reductions reflect the effect of enhanced forest cover both in reducing run off (i.e. increasing infiltration and evapotranspiration) and decreasing the land area over which nutrients are applied. Trees are very effective at retaining water where it lands by creating a thick organic layer of partly decomposed leaf litter and debris under their canopies, and providing channels for infiltration of water through their large root networks.

### **Scenario 4 - Opportunistic management approach**

In addition to these two scenarios, an opportunistic management approach scenario was also evaluated (TRCA, 2003c). In this scenario, a forested area equivalent to a 30 metre buffer strip on either side of the stream was added to four 500 metre by 500 metre grid cells identified by the AGNPS model under the baseline conditions scenario as priority source areas of sediment and phosphorus. This scenario evaluates the relative benefit of focusing water quality improvement efforts on key areas immediately adjacent to the stream, as compared to the approach assumed in Scenario 3 of widespread restoration of natural cover. It also provides a general assessment of water quality improvements associated with riparian buffers, which is one of the most commonly employed agricultural best management practices.

The four grid cells represent only 6% of the subwatershed area. Model simulations showed total reductions in sediment yield, ortho-phosphorus and total phosphorus concentration at the subwatershed outlet of 2.5%, 14% and 11%, respectively (TRCA, 2003c).

The total sediment yield consisted mostly of clay sized particles. Fine clay sized sediments contain more adsorbed phosphorus relative to coarse sized particles because of their larger surface to volume ratio. Thus a small decrease in sediment yield (in this case 2.5%) can result in a relatively large decrease in phosphorus loads (TRCA, 2003c). The decline in loading also reflects improved infiltration in riparian areas, which reduces loads by decreasing the volume of run off that enters streams.

## **14.4 Conclusions**

Model simulations of water quality under four scenarios indicated that build out of the Caledon East Secondary Plan will likely result in marginally lower sediment yields, but a moderate increase in phosphorus loading to the stream. Combining the Official Plan build-out with increased natural cover more than offsets the adverse impacts of urban growth on water quality, at least with respect to sediment and phosphorus. Under this scenario, sediment yields decrease by 19% over the existing conditions scenario, and stream phosphorus concentrations fall by between 43 and 56%. Simulation of riparian buffers in strategic areas showed a significant reduction in phosphorus. The sediment load reduction was much lower, suggesting that while there may be considerable local benefit to water quality from improved riparian buffers, a more broad based program of natural cover enhancement is required to effect significant improvements on sediment load at a subwatershed scale.

This evaluation is based on model simulations of only two water quality variables: phosphorus and sediment. Other common urban contaminants, such as copper, zinc and lead bind preferentially to solids and would, therefore, be expected to show a similar change to that simulated for sediment under the various scenarios. The actual impact of urban growth on stream quality will ultimately depend on the level of stormwater management that is provided in new developments.

## **15. Surface water hydrology modelling**

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### **15.1 Introduction**

Surface water hydrology could also be affected by future changes in land use in this subwatershed. Growth of urban settlements will result in an increase in the quantity of land covered by impervious surfaces (e.g., roads, roofs, parking areas). Without stormwater management controls to reduce or mitigate impacts, the growth of urban settlements will change predevelopment water balance by reducing the amount of precipitation that infiltrates into the ground (groundwater infiltration or recharge) and that returns to the atmosphere (evapotranspiration) and increasing the amount that runs off the land (run off). As illustrated in **Section 3, Figure 3.4**, this would result in changes in surface water hydrology and the potential for accelerated stream channel erosion. With implementation of stormwater management controls such as ponds, permeable pavement, infiltration trenches, soakaway pits, grassed swales, etc.) impacts of increased impervious cover on some aspects of surface water hydrology and channel erosion can be partially mitigated.

The Hydrologic Simulation Program – Fortran (HSPF) model was used to conduct an erosion analysis for Centreville Creek subwatershed to determine suitable sizing criteria for end-of-pipe stormwater management ponds for stream channel erosion control (XCG, 2005). The HSPF model was developed to simulate the hydrology of Centreville Creek for baseline (1999) conditions (Scenario 1) and future conditions associated with implementation of the Caledon East Secondary Plan (Scenario 2). Comparisons were made between baseline and future conditions in an attempt to determine what amount of stormwater detention is needed within new developments to minimize the increase in duration of flow that exceeds established erosion threshold flow.

The HSPF model is a continuous simulation hydrologic model that utilizes information regarding topography, surface drainage, soils, land use, watercourses, lakes and ponds to predict stream flow at selected locations within a watershed or subwatershed for a given period of simulation. The model requires time series information inputs for temperature and precipitation over the period of simulation and generates time series information regarding predicted stream flow rates at selected locations. Output of the HSPF model can be used to predict the effects of changes to land use on a wide range of indicators of stream flow. This information can be related to information regarding channel form and sensitivity to predict the effect of changes in stream flow on the potential for changes in channel form to occur.

### **15.2 Model set up and calibration**

XCG Consultants Limited (XCG) was retained by Toronto and Region Conservation (TRCA) to undertake HSPF model development and an erosion analysis for Centreville Creek subwatershed. The Centreville Creek model was developed using the unit-response function (URF) methodology to simulate the hydrology of the watershed which allows the modeller to estimate the total hydrologic response of a sub-catchment by summing, in proportion, the contributing unit responses. The model was calibrated using measured stream flow data from the TRCA gauge installed in Centreville Creek at Albion Hills Conservation Area for the period of May to September 2003, and precipitation data from the gauge located at the Caledon East Pumping Station. The calibration focused on achieving an overall acceptable water balance and matching monthly and total stream flow volumes to within 10% of observed values. For

details regarding model set-up and calibration refer to the report, *Centreville Creek HSPF Model Development and Erosion Analysis* (XCG, 2005).

### **15.3 Erosion control analysis**

#### **Erosion thresholds**

As discussed in **Section 7.2**, erosion thresholds for selected sites in the study area were established by Parish Geomorphic through field assessments (Parish Geomorphic, 2003). Parish found that all reaches assessed were either "in adjustment" or "transitional", meaning that the channels are undergoing erosion and/or sediment deposition processes as they adjust to the existing stream flow regime. The erosion and sediment deposition processes may be resulting in channel downcutting, channel widening, channel aggradation and alignment adjustment at various locations. Four reaches were selected for detailed site descriptions and assessments of erosion thresholds; R4E, R8W, GHU-34, and R1 (**Section 7.2; Table 7.1**). These sites were selected because they were the most sensitive reaches assessed downstream of planned new urban growth areas (**Figure 15.1**).

#### **Overview of analytical approach**

Urban development will increase the amount of surface run off from the developed area if stormwater management measures are not implemented. There will be increases in stream flow following rainfall or snowmelt events. These flow increases can cause channel erosion and sedimentation, or can aggravate existing erosion/deposition processes and accelerate the rate of change of channel morphology and channel alignment. Accelerated rates of erosion, sedimentation and morphological adjustment can have negative impacts on terrestrial and aquatic habitat through loss of riparian vegetation and collapse of undercut banks. It can also put public infrastructure (e.g., bridges, pipes, pathways) or private property that is located near the stream at greater risk of damage from channel erosion. It also negatively impacts the aesthetics of stream corridors.

The focus of this modelling study was on determining the level or extent of stormwater management needed in new urban development areas to mitigate impacts on downstream channel erosion. The modelling analysis was based on the assumption that a conventional approach to stormwater management would be implemented that consists of detention of surface run off from new urban developments in stormwater management ponds. In this approach, ponds are designed to provide gradual release of treated stormwater to the creek at rates that maintain the frequency and duration of critical flow (i.e., erosion threshold flow) to predevelopment levels at sensitive downstream locations.

## 15.4 Scenario analysis results

### Scenario 1 – Baseline conditions

#### Simulated stream flow regime versus erosion thresholds

The model was used to simulate stream flow for baseline (1999) conditions using hourly measured precipitation and temperature data for the 12 year period of 1991 to 2002. Using model outputs at selected locations, stream flow duration curves were generated to illustrate the portion of time during this period that flows exceeded certain values. The output locations corresponded with sites where assessments of erosion thresholds were completed by Parish in 2003 (**Figure 15.1**). These flow duration curves were compared with established critical flow values to determine the duration of flow that exceeds the erosion threshold value under 1999 land use conditions. This provided insight into the feasibility of controlling future frequency and duration using stormwater management ponds alone.

The figures below (**Figures 15.2 to 15.5**) present the flow duration curves for the simulated flow regime (baseline conditions) at each of the four sites assessed by Parish. **Table 15.1** indicates the percentage of time that the critical flow value is exceeded at each site.

**Table 15.1 Existing flow regime versus erosion threshold for selected sites in Centreville Creek**

| Site   | Drainage area (hectares) | Critical flow (m <sup>3</sup> /s) | Percentage of time critical flow is exceeded. |
|--------|--------------------------|-----------------------------------|---|
| R4E    | 1,320                    | 0.08                              | 63.0%   |
| R8W    | 807                      | 0.20                              | 3.2%  |
| GHU-34 | 4,195                    | 0.07                              | 100%  |
| R1     | 4,674                    | 0.59                              | 16.6%   |

It is predicted that critical flows at R4E and GHU-34 are at, or very near baseflow levels, supporting Parish's prediction that these reaches are currently adjusting to the existing stream flow regime and moderately unstable (Parish Geomorphic, 2003). In terms of controlling the impact of new development, the main implication of the low critical flow values at R4E and GHU-34 is that it will be difficult or impossible to control the magnitude and duration of critical flow exceedance to predevelopment levels using run off detention (stormwater management ponds) alone. If the new development is designed with conventional catchbasin-to-sewer drainage systems there will be an increase in direct surface run off and an increase in flow volume reaching the creek downstream. At site GHU-34, any amount of increase in flow volume will invariably increase the magnitude of exceedance of the critical flow and thereby increase the potential for channel erosion and result in greater morphological instability than what currently exists. No amount or design of stormwater detention within new development areas can maintain the baseline level of critical flow exceedance at site GHU-34. Similarly, at site R4E it will be difficult for run off detention alone to eliminate any increase in either the magnitude or duration of predevelopment critical flow exceedance because critical flow is at or very near baseflow (**Figure 15.6**).



Figure 15.1 Centreville Creek HSPF erosion analysis locations

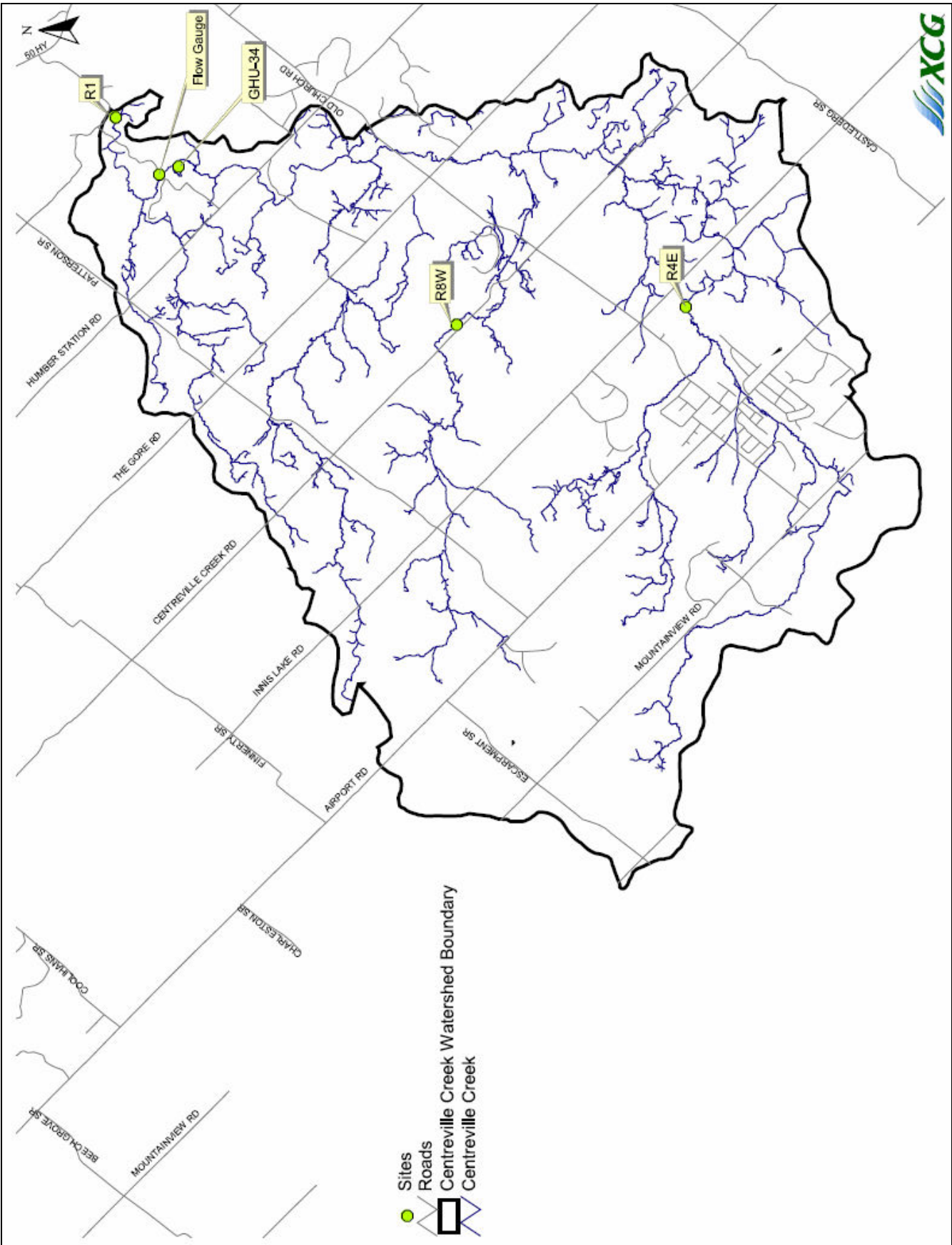


Figure 15.2 Flow duration curve at site R4E, baseline conditions

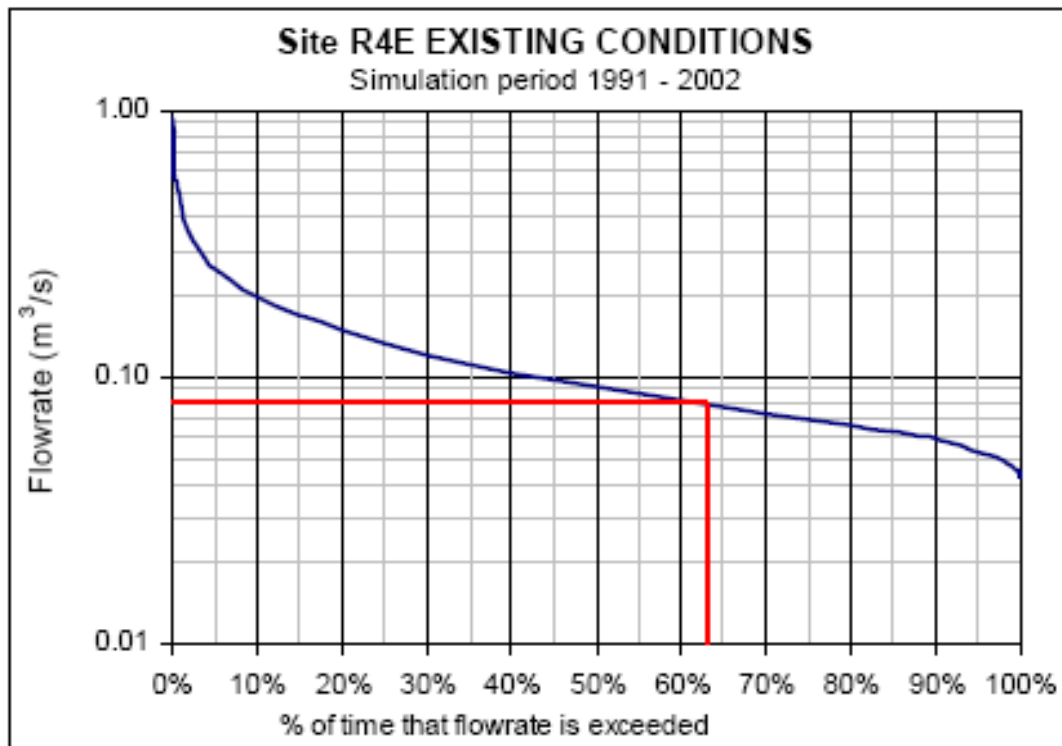


Figure 15.3 Flow duration curve at site R8W, baseline conditions

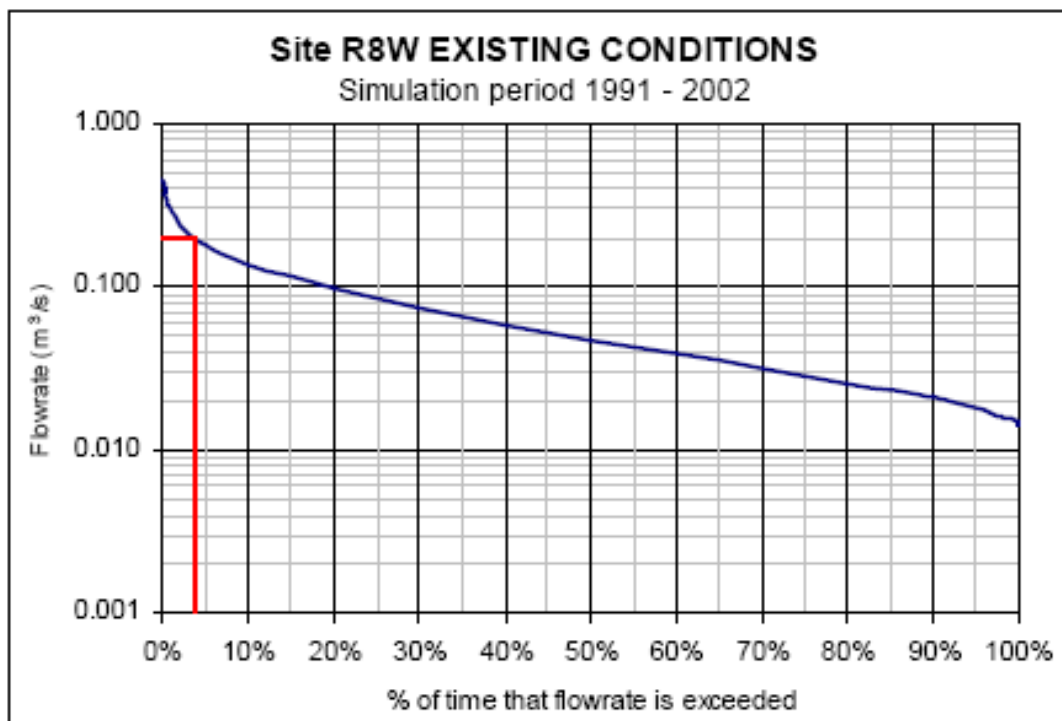


Figure 15.4 Flow duration curve at site GHU-34, baseline conditions

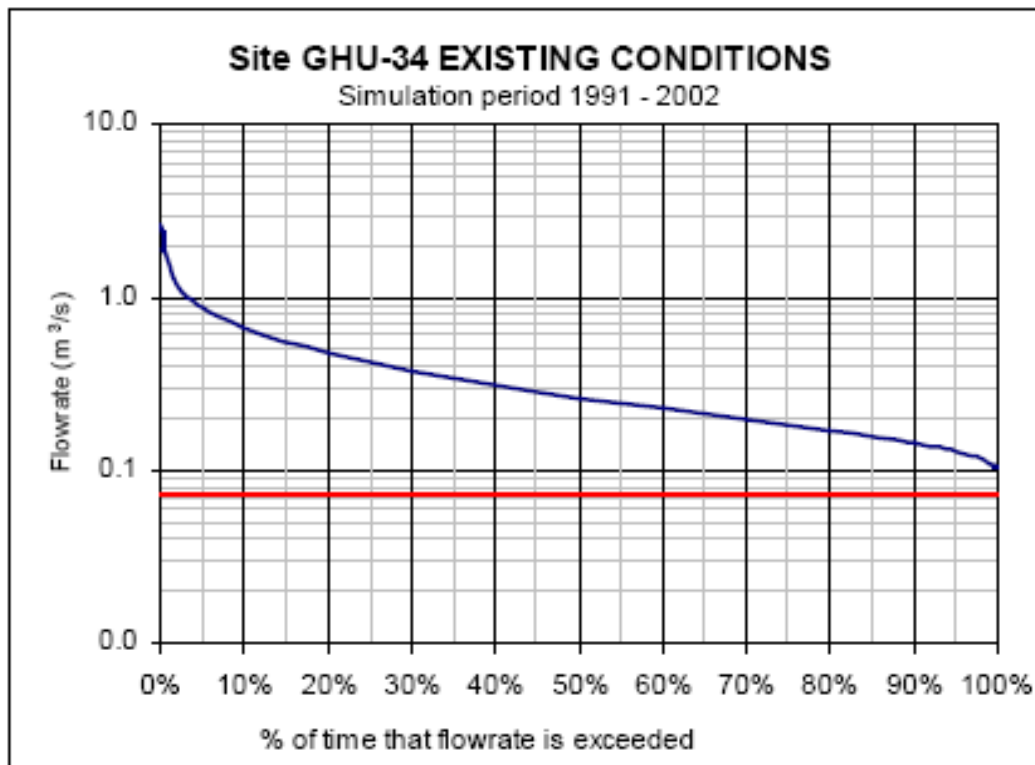
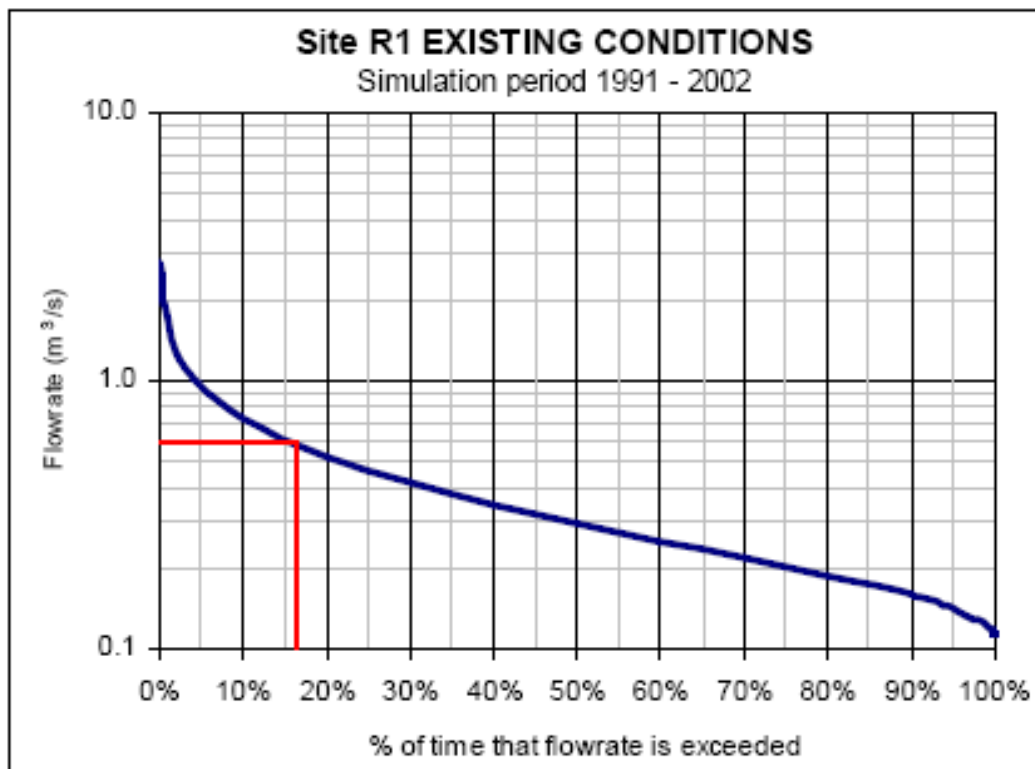
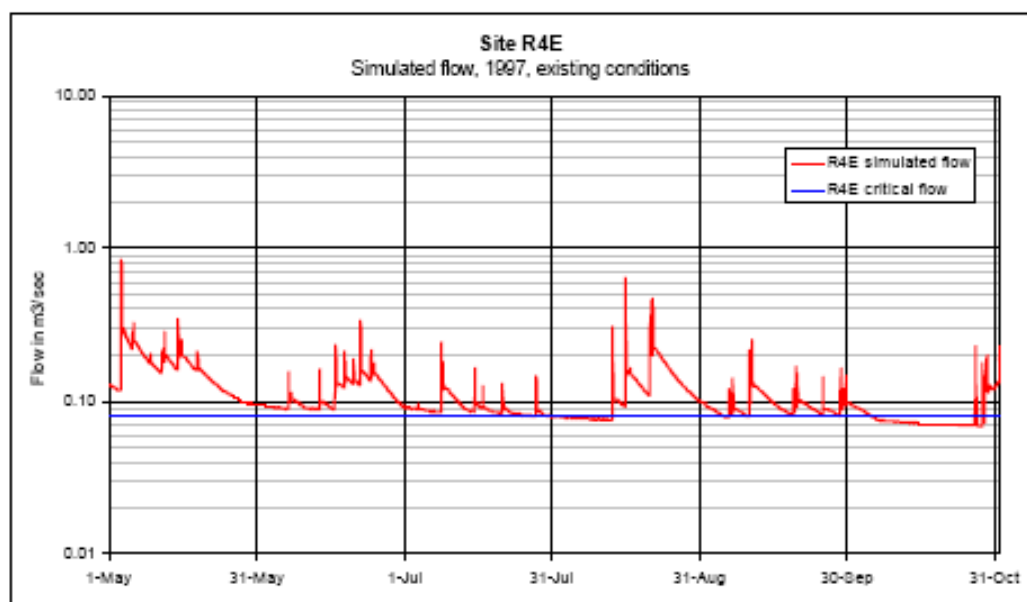


Figure 15.5 Flow duration curve at site R1, baseline conditions



**Figure 15.6 Simulated flow regime at Site R4E, May to October 1997**



### **Scenario 2 - Anticipated new development to 2021 with a conventional management approach**

With the above considerations in mind, a modelling analysis was carried out to examine whether run off detention using stormwater management ponds within new development areas draining to site R4E, which includes the majority of planned new development in Caledon East, could substantially mitigate impact on channel morphology at this site. In this scenario it was assumed that new development areas would be designed with conventional catchbasin-to-sewer drainage systems and that stormwater management ponds for run off detention would be the only controls put in place (i.e., no lot level or conveyance stormwater controls).

In order to compare future conditions with baseline conditions, erosion index values were calculated using model outputs for the period of simulation that allows a quantitative estimate to be made of change in magnitude and duration of critical flow exceedance. The basis for this erosion index is the relationship between flow rate in an open channel and resulting tractive stress on the channel boundary (i.e., wetted perimeter) as implied by the Manning equation of open channel flow. The erosion index is calculated as follows:

$$\text{Index} = \sum (Q_{\text{simulated}}^{3/5} - Q_{\text{critical}}^{3/5}) \Delta t$$

where:  $Q_{\text{simulated}}$  = simulated flow

$Q_{\text{critical}}$  = critical flow

$\Delta t$  = length of time the critical flow is exceeded

Erosion index values were calculated using simulated stream flow for the May to October period (6 months) of each of the 12 years (1991 to 2002). Since the model was calibrated based on data for the May to September period, the model is considered to be valid for that part of the year.

Model outputs were generated for this scenario using a range of different pond design parameters in order to examine the effect of different storage and outflow characteristics on critical flow exceedance. However, all modelling runs confirmed that the erosion index cannot be maintained at existing levels through the use of detention alone, simply because of the critical flow (erosion threshold) is at or near baseflow. Stormwater detention facilities cause increases in baseflow by prolonging elevated flow as the ponds drain down following a storm event. At sites R4E and GHU-32 this would result in an increase in erosion index, regardless of the size or design of the detention facility.

### **Scenario 3 - Scenario 3 - Anticipated new development to 2021 with an expanded natural heritage system**

This scenario was not examined using the HSPF model.

## **15.5 Conclusions**

The key conclusion from this modelling analysis is that to maintain baseline levels of channel instability at the most sensitive sites (as exemplified by sites R4E and GHU-34), new urban development must be designed to not increase total flow volume at those sites. This implies that new urban development in Centreville Creek subwatershed must be designed to not increase the amount of direct surface run off entering the creek.

Various techniques can be used to achieve substantial reductions in direct surface run off within new development sites. The amount of run off reduction and the feasibility of keeping run off volumes to predevelopment levels will depend on a number of factors including:

1. The total impervious area of the proposed development, and how much pervious area will be left to provide opportunities for infiltration;
2. The amount of impervious area that is attributable to vehicle traffic surfaces including roads, driveways and parking areas;
3. Road maintenance practices, especially the extent to which winter road maintenance relies on application of de-icing salt;
4. Native soil characteristics (i.e., infiltration capacity); and,
5. Depth to water table.

To achieve substantial reduction or zero increase in surface run off, drainage from impervious surfaces will have to be infiltrated into the native soil profile and groundwater system, detained and evapotranspired by green roof technologies, or harvested by rainwater cisterns or rain barrels. This will require highly innovative approaches to development design that include green roof and rainwater harvesting technologies and where site layout, grading and surface drainage pathways direct surface run off to pervious (landscaped) areas where temporary ponding and infiltration can take place. Stormwater detention ponds will likely still be needed in addition to these innovative development design features to control peak stream flows and treat the quality of urban run off.



There are potential drawbacks to allowing run off to pond in pervious areas for infiltration purposes. If infiltration areas take too long to drain down following a storm event, standing water could become a public health concern by causing conditions favorable for mosquito breeding. Temporary ponding may also be regarded as aesthetically undesirable by some property owners. Within high density urban developments (e.g., industrial and commercial developments), a primary challenge will be to find ways to safely and efficiently infiltrate run off from roads and parking areas. These paved areas can easily account for over 50% of all impervious area. As well, the run off from such surfaces tends to contain higher levels of contaminants, sediments and debris. Treatment of run off from some paved areas may be needed before being directed to pervious areas to avoid contamination of the groundwater system. Alternatives to the spreading of de-icing salt as part of winter road and parking area maintenance practices will need to be considered.

To achieve significant reduction in surface run off, alternatives to conventional urban road drainage design will need to be considered. Conventional curb-and-catchbasin design may not be the best approach, as such systems may have to include engineered infiltration devices (e.g., piped exfiltration galleries) at strategically selected locations. Instead, roads with grassed swale drainage may be a more practical way of minimizing run off from the road system. In either case, contamination of road run off by de-icing salt during winter will need to be controlled through changes to road maintenance practices.

The design of planned new urban developments in Centreville Creek subwatershed by development proponents, should be informed by water balance modelling analysis to determine the size and configuration of lot level and conveyance stormwater controls needed to maintain predevelopment run off volume. This design approach should identify locations and sizing criteria for run off reduction and infiltration measures that are feasible based on native soil characteristics, depth to water table, and the type and density of development that is planned.

## PART 4 CONCLUSIONS

### 16. Management framework

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A multi-stakeholder Humber Watershed Task Force was established in 1994 to develop an ecosystem-based strategy to achieve a sustainable, healthy watershed for the Humber River. In 1997 the Task Force published *Legacy: A Strategy for a Healthy Humber* (MTRCA, 1997a) and *A Call to Action* (MTRCA, 1997b). These documents provided thirty objectives for a healthy, livable, sustainable and prosperous watershed and recommended actions to achieve them. In 2000, the Humber Watershed Alliance produced a report card that identified indicators that describe the types of information that are needed to evaluate progress towards achieving the watershed strategy objectives. The report card summarized and evaluated watershed health and set targets for conditions to be achieved (TRCA, 2000).

The Humber River watershed strategy establishes the overall guiding principles and framework of objectives, indicators and targets on which the recommendations of the Centreville Creek Subwatershed Study are based. The Centreville Creek Subwatershed Study builds upon the watershed strategy framework by providing recommendations for actions necessary to achieve the objectives of the watershed strategy within the subwatershed.

**Appendix A** summarizes the framework of objectives, indicators and targets for management of the Humber River watershed.

## 17. Management recommendations

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Considering the objectives and targets described in **Appendix A**, and based on analysis and integration of available information on baseline conditions, the following management recommendations have been prepared.<sup>8</sup> These management recommendations may be refined through further studies at more detailed scales that are required to support proposed new developments, and at the watershed scale as part of the Humber River watershed planning study, initiated in 2004. The recommendations are organized according to three general management zones: Existing and Future Urban Areas; Natural and Cultural Heritage; and Rural and Agricultural Areas.

### Existing and future urban areas

1. Region of Peel should continue to implement monitoring of groundwater levels to track effects of increased pumping from municipal wells and implement adaptive management measures if established thresholds are exceeded.
2. Region of Peel and Town of Caledon should consider alternatives to spreading of road de-icing salt as part of winter road maintenance programs within wellhead capture zones in Caledon East as a drinking water source protection strategy.
3. Town of Caledon and TRCA should work together to implement improvements to stormwater management in existing portions of Caledon East with no stormwater treatment as part of future infrastructure improvements, redevelopment and infill development initiatives.
4. Planning and design of new urban settlements should consider areas regulated by the TRCA and direct development outside of areas vulnerable to periodic flooding.
5. Planning and design of new urban settlements should be based on design principles that minimize changes to predevelopment water balance (i.e., predevelopment rates of infiltration, run off and evapotranspiration). Innovative urban designs that minimize impervious surfaces, maintain the function of small drainage features, incorporate stormwater controls that promote infiltration of run off and utilize technologies such as green roofs and rainwater harvesting cisterns should be considered as part of the overall stormwater management strategy.
6. Town of Caledon should require new developments in Caledon East to include stormwater management systems designed to control stream bank erosion through run off reduction. The design of new stormwater management facilities, including lot level and conveyance controls should be informed by water balance modelling analysis, and be located and sized to maintain predevelopment run off volume.
7. Due to the high sensitivity of the aquatic ecosystem to changes in water quality and temperature, stormwater management ponds in new developments should be designed to provide level 1 quality control (OMOE, 2003) while maximizing the area of open water

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<sup>8</sup> Updated and more comprehensive management recommendations for the entire Humber River watershed are found in the TRCA's 2008 *Humber River Watershed Plan – Pathways to a Healthy Humber* and *Humber River Watershed Plan Implementation Guide*. These documents are the primary source of management recommendations that should be used to inform planning and management initiatives and programs affecting Centreville Creek subwatershed. While the Humber River watershed reports are the most up-to-date and comprehensive sources of management recommendations, this *Centreville Creek Subwatershed Study Synthesis Report* provides more detailed direction regarding local opportunities for improved environmental stewardship and naturalization initiatives.

that is shaded by vegetation and include subsurface outlets to help prevent stormwater from heating up during treatment.

8. Planning and design of the natural heritage system and open space system within new urban settlements should take into consideration the lands within the subwatershed that have been targeted for securement and restoration of natural cover through the terrestrial natural heritage system strategy (**Figure 17.1**)<sup>9</sup> and consider ways to improve habitat quality and maintain or improve biodiversity.
9. Maintenance of naturally vegetated stream corridors that allow stream channels to move across the floodplain, and enhancement of riparian and tableland vegetation should be promoted wherever possible.
10. Planning and design of stream crossings associated with new road and footpath infrastructure should be based on available information on the form and sensitivity of the stream channel to determine the most appropriate type and size of crossing structure and location of the crossing.
11. A phased approach to the construction of new urban settlements should be required in order to minimize the total area of disturbed land during the period of construction.
12. Monitoring of the effectiveness of community design and management measures that will be put in place in new developments to mitigate potential negative environmental impacts should be undertaken as part of an adaptive management approach.

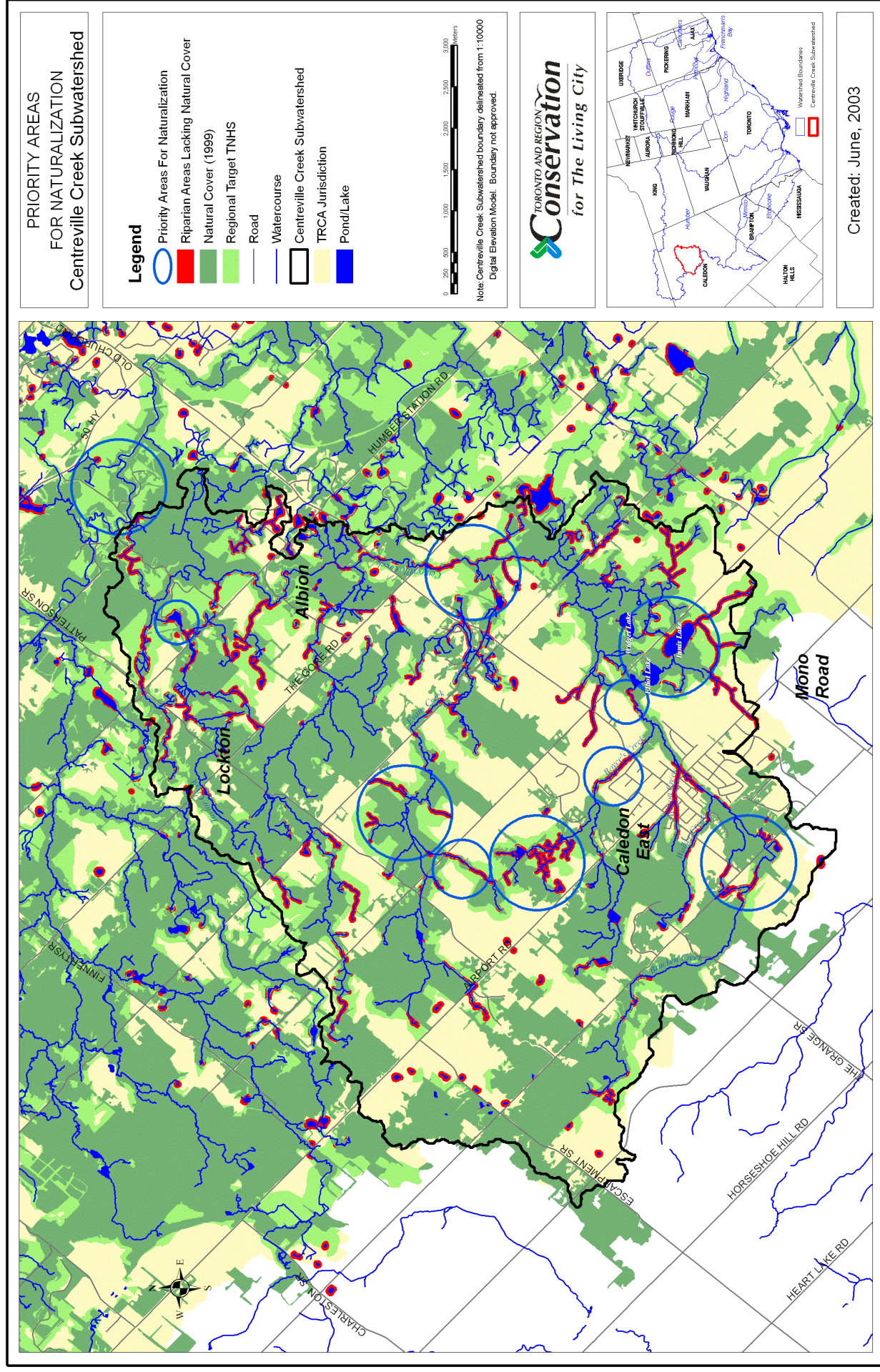
#### **Natural and cultural heritage**

13. Management of natural areas in existing and new urban settlements should include measures to avoid or mitigate negative influences on habitat quality associated with surrounding land uses, including enhancement of remaining habitat patches to improve size and shape, fencing to prevent uncontrolled access, provision of planned access points and trail infrastructure in public greenspace areas, enforcement of municipal by-laws restricting encroachments on public lands, and planned off-leash pet areas separate from sensitive natural features.
14. Town of Caledon should develop interpretive signs, resources or programs highlighting local natural and cultural heritage features along local and inter-regional trails (e.g., registered built heritage sites, watercourse names, habitat regeneration sites, heritage farms/trees/hedgerows).

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<sup>9</sup> The 2004 draft target terrestrial natural heritage system shown on Figure 17.1, has been revised in developing the final *Toronto and Region Terrestrial Natural Heritage System Strategy* (TRCA, 2007), and further refined at the watershed scale in developing the *Humber River Watershed Plan* (TRCA, 2008b) and *Implementation Guide* (TRCA, 2008a). The recommended target terrestrial natural heritage system that appears in the *Humber River Watershed Plan* and *Implementation Guide* is the most up-to-date and should be the one used to inform natural heritage system planning and design in Centreville Creek subwatershed.

Figure 17.1 High priority areas for naturalization





15. Town of Caledon should consider available information on the cultural heritage of the area when assigning place names associated with new urban settlements and utilized in programs at new public facilities to help new residents connect with the cultural heritage of the area.
16. TRCA should work with landowners to promote tree and shrub planting programs for private lands within high priority areas for naturalization (**Figure 17.1**).
17. Town of Caledon should replace culverts that are in-stream barriers to fish movement on Grange Sideroad and Walker Road (**Figure 17.2**).
18. TRCA should mitigate the in-stream barrier to fish movement associated with Taylor Pond at Albion Hills Conservation Area, and restore a natural meandering channel and wetlands, and incorporate a viewing area for educational benefits (**Figure 17.2**).
19. TRCA should work with landowners to mitigate high priority in-stream barriers to fish movement (convert online ponds to offline ponds where possible) and thermal impacts from private ponds (convert outlet structures from top draw to bottom-draw) where benefits to water temperature and aquatic habitat are expected (**Figure 17.2**).
20. TRCA should work with landowners to develop and implement tree and shrub planting plans to restore natural riparian vegetation and improve connectivity between forest habitat patches (**Figure 17.1**):
  - along Bracken Creek, west of Mountainview Road, across from Walker Road;
  - along Boyce's Creek, north of Old Church Road; and,
  - along the tributary of Evans Creek, from Innis Lake Road west to the Caledon East ESA Complex.
21. TRCA should work with landowners to develop and implement wetland restoration plans in high priority areas for naturalization (**Figure 17.1**):
  - Former peat extraction site draining to Boyce's Creek, on east side of Airport Road, north of Old Church Road;
  - Taylor Pond at Albion Hills Conservation Area;
  - East and west sides of Innis Lake Road, south of Old Church Road (Centreville Creek Area, ESA 35);
  - Wet area at the southeast corner of Humber Station Road and Patterson Road;
22. TRCA should involve Albion Hills Field Centre and Etobicoke Field School outdoor environmental education program participants and local school and community groups in habitat regeneration and pre/post-project monitoring activities at Albion Hills Conservation Area (e.g., Taylor Pond mitigation and tree/shrub plantings).

### **Rural and agricultural areas**

23. TRCA should continue to promote rural and agricultural best management practices that reduce the risk of contamination of surface waters from land-based activities (e.g., vegetated riparian buffers, upgraded manure storage facilities, improved washwater management) and improve natural habitat. Rural Clean Water Program staff should contact landowners with land holdings in areas identified as predominant source areas for surface water contaminants to promote best practices and tree and shrub planting programs (**Figure 17.3**).

Figure 17.2 High priority in-stream barriers and thermal impact mitigation opportunities

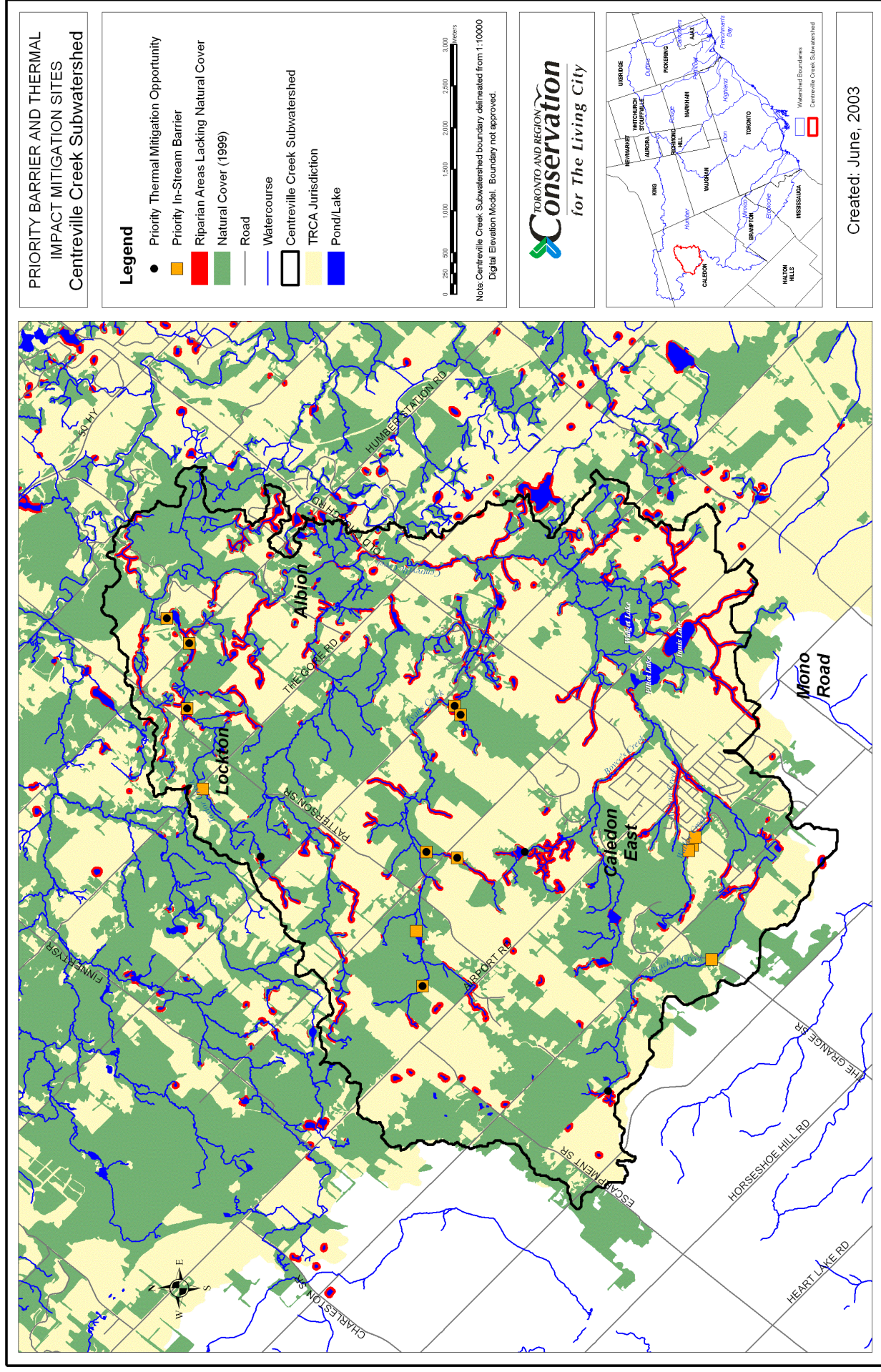
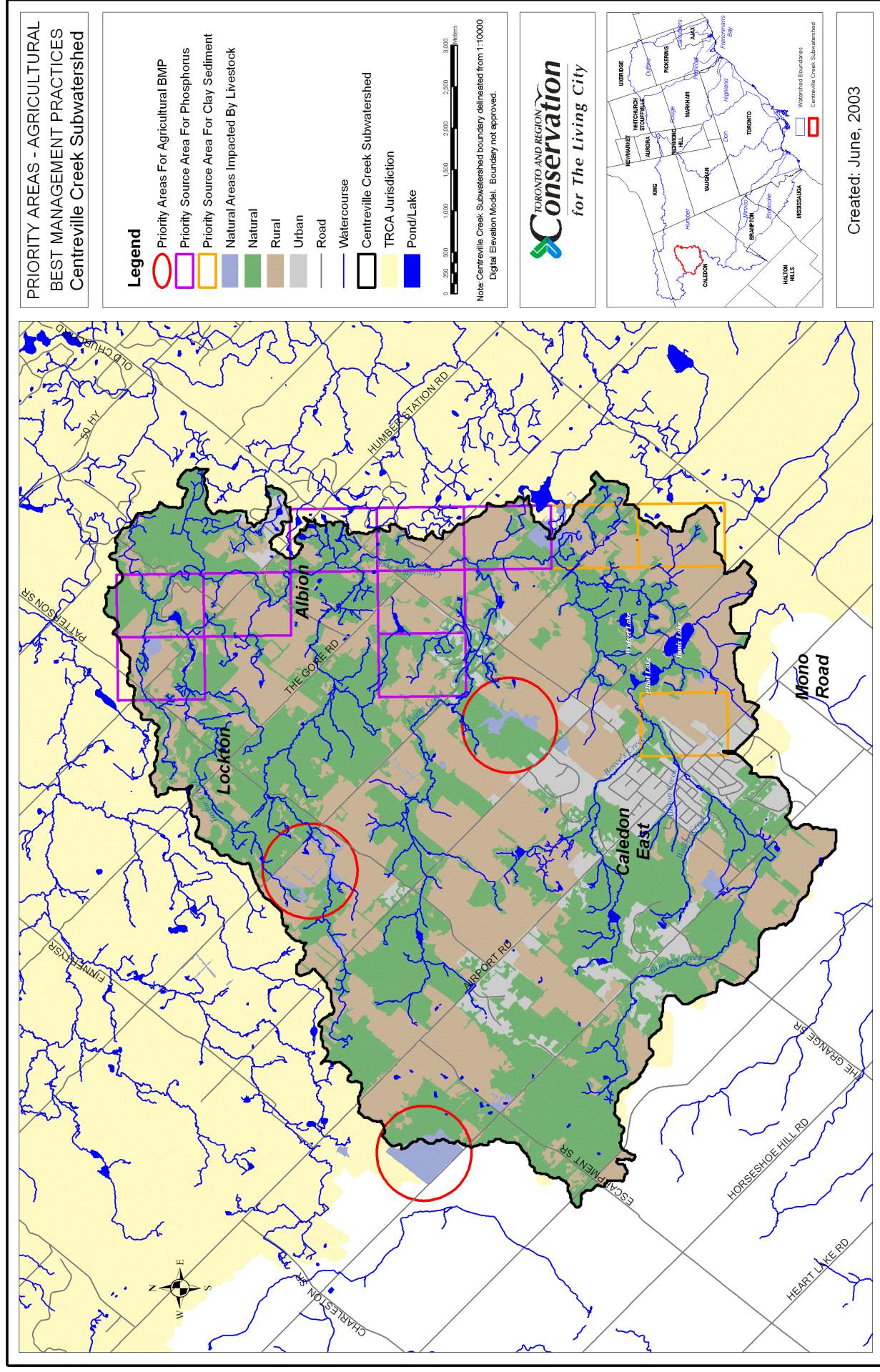




Figure 17.3 High priority areas for agricultural best management practices



24. TRCA should work with tenant farmers leasing lands adjacent to Albion Hills Conservation Area to improve manure storage facilities and spreading activities and undertake riparian tree and shrub plantings.
25. TRCA should utilize subwatershed knowledge to undertake a strategic landowner contact program to promote good environmental stewardship practices (e.g., limiting livestock access to natural areas, private pond maintenance and enhancement, exotic/invasive species control, woodlot management practices, well and septic system maintenance) and available incentives (**Figure 17.3**).

## 18. Recommendations for further study

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*Note: Recommendations in italics had already been acted upon, or were in the process of being implemented when this report was finalized in 2008.*

### **Groundwater system**

1. *Predictions regarding the distribution of groundwater discharge areas, and rates of discharge are still needed for Centreville Creek subwatershed from YPDT groundwater flow modelling work. When this information becomes available, it should be correlated with information from the Region of Peel groundwater flow model, available baseflow measurements, aquatic system monitoring data and fisheries management targets to gain a better understanding of how the local and regional groundwater system influences other components of the subwatershed system.*<sup>10</sup>
2. *A regional-scale groundwater flow model should be used to identify locally significant recharge areas that are contributing to the flow of groundwater to significant groundwater discharge areas in the subwatershed.*<sup>10</sup>
3. Monthly monitoring of surface and groundwater levels should be undertaken as soon as possible in hydrologically sensitive natural features that may be affected by planned urban growth.
4. Field investigations should be undertaken for areas identified as having high potential risk of groundwater contamination in the Region of Peel Land Use and Chemical Occurrence Inventory study to assess actual risk and whether or not contaminant management plans are needed.

### **Surface water hydrology**

5. Stream flow data that has been collected at the Centreville Creek stream gauge should be analyzed to establish baseline conditions regarding average annual and seasonal flow, baseflow and flow frequency and duration.
6. *The Town of Caledon and TRCA should work together to further evaluate options for remedial works to reduce risk of flooding in Caledon East identified in the Caledon East Flood Study.*
7. *The Humber River watershed hydrology and hydraulic models should continue to be updated regularly to incorporate land use changes as planned urban growth proceeds in this area.*

### **Terrestrial system**

8. *Further analysis at the watershed scale of available information regarding vegetation communities, flora and fauna species of conservation concern, and approved municipal official plan land use designations is needed to refine the TRCA target terrestrial natural heritage system for the Humber River watershed.*<sup>10</sup>

### **Planning and design of new urban developments**

9. Seasonal water balance assessments for wetland or wet forest communities that will be affected by planned new urban settlement areas will need to be completed to ensure that

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<sup>10</sup> This work has been completed through developing the *Humber River Watershed Plan* (TRCA, 2008b) and *Implementation Guide* (TRCA, 2008a).



proposed land use changes will not negatively impact these hydrologically sensitive vegetation communities.

10. An assessment of headwater drainage features should be undertaken within planned new urban development areas. Headwater drainage features should be mapped and described according to their form and function and appropriate management strategies should be prescribed to maintain the function of significant features.

### **Monitoring**

11. *Region of Peel should continue to implement monitoring of groundwater levels to track effects of increased pumping from municipal wells and implement adaptive management measures if established thresholds are exceeded.*
12. *TRCA should continue measurements of baseflow at indicator sites on a monthly basis throughout the spring and summer months each year.*
13. Long-term monitoring in this subwatershed should include tracking vegetation communities and flora and fauna species of conservation concern in order to evaluate the effectiveness of the natural heritage system design and management measures to be put in place to control encroachments in natural areas.
14. Monthly monitoring of surface and groundwater levels in hydrologically sensitive natural features that may be affected by planned new urban development should be undertaken as soon as possible to establish baseline conditions.

## 19. Next steps

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The following outline describes next steps that should be undertaken to implement key recommendations from this study. This outline is intended to serve as a basis for discussions with subwatershed study partners and proponents of new developments in the study area with regard to implementing the recommendations of the study.

*Note: Recommendations in italics had already been acted upon, or were in the process of being implemented when this report was finalized in 2008*

1. Proponents of new urban developments should undertake water balance modelling analysis on a subwatershed scale to design the drainage system and stormwater management controls needed to maintain predevelopment run off volume. This design approach should identify locations and sizing criteria for run off reduction and infiltration measures that are feasible based on native soil characteristics, depth to water table, and the type and density of development that is planned.
2. TRCA should work with Town of Caledon staff and development proponents to design an adaptive management monitoring program for planned new communities in Caledon East to evaluate the effectiveness of community design and management measures that will be put in place to mitigate potential negative environmental impacts of new developments;
3. *TRCA should refine the target terrestrial natural heritage system at the watershed scale for the Humber River watershed based on available information regarding constraints and opportunities as part of the Humber River watershed planning study.*
4. *TRCA should integrate new information from regional-scale groundwater flow modelling work with available baseflow measurements, aquatic system monitoring data and fisheries management plan targets to gain a better understanding of how the local groundwater system influences other components of the subwatershed system.*
5. *Use findings to inform the ongoing implementation of the Rural Clean Water Program, Healthy Yards Program, Caring for the Moraine Landowner Contact Program and other environmental stewardship and outreach activities in the area.*
6. Region of Peel should undertake field investigations for areas identified as having high potential risk of groundwater contamination in the Region of Peel Land Use and Chemical Occurrence Inventory study to assess actual risk and whether or not contaminant management plans are needed or already in place.

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**Appendix A – Framework of objectives, indicators and targets for management of the Humber River watershed (MTRCA, 1997a; TRCA, 2000)**

| <b>OBJECTIVES - Legacy: A Strategy For A Healthy Humber, 1997</b>   | <b>INDICATORS - Humber Report Card, 2000</b> | <b>TARGETS - Humber Report Card, 2000</b>   |
|---|--|---|
| <b>Environment</b>  |  |   |
| 1. Protect the form and function of landforms such as the Niagara Escarpment, Oak Ridges Moraine, and South Slope | Significant landforms                        | 2005:<br>- Quantity of developed land within ORMCP and NEP areas is limited to that approved as of 1999 (~6200 ha.);<br>- Best management practices are used in all development to protect the landform and its functions   |
| 2. Protect the form and function of the Humber River and its tributaries  | Significant landforms                        | 2005:<br>- Best management practices are used in all development to protect the landform and its functions  |
| 3. Use ground and surface water at sustainable rates  | Groundwater quantity                         | 2005:<br>- Rate of groundwater extraction is restricted according to targets set by a Groundwater Management Strategy   |
| 4. Protect groundwater sources  | Groundwater quantity                         | 2005:<br>- New development maintains predevelopment groundwater recharge rates  |
| 5. Manage stormwater to protect people and the health of streams and rivers                                       | Stormwater management<br><br>River flow      | 2005:<br>- Watershed resident awareness of stormwater management issues has risen to 80%;<br>- Targets for improving water quality and reducing erosion confirmed through Humber Watershed Stormwater Retrofit Study and Toronto's Wet Weather Flow Management Master Plan;<br>- Total annual flow is unchanged or decreasing based on 1999 values;<br>- In subwatersheds where the trend for total annual flow is increasing, agencies work towards reversing the trend<br>2015:<br>- Agencies and landowners continue to work towards reversing increasing trends in total annual flow<br>2025:<br>- Total annual flow at all gauge stations is stable or decreasing to predevelopment levels |

| OBJECTIVES - Legacy: A Strategy For A Healthy Humber, 1997                          | INDICATORS - Humber Report Card, 2000   | TARGETS - Humber Report Card, 2000  |
|---|---|---|
| 6. Prevent groundwater contamination  | Groundwater quality   | <p>2005:</p> <ul style="list-style-type: none"> <li>- A Groundwater Management Strategy is in place;</li> <li>- No increase in concentrations of contaminants observed in monitoring well water samples;</li> <li>- No new development allowed within Peel's Wellhead Protection Areas;</li> <li>- Wellhead Protection Area policies initiated by all regional municipalities.</li> </ul> <p>2015:</p> <ul style="list-style-type: none"> <li>- Chloride and nitrate concentrations observed in monitoring well water samples have decreased to safe levels, as determined by the Groundwater Management Strategy</li> </ul>  |
| 7. Reduce the amount of sediment that enters surface waters;                        | Conventional pollutants   | <p>2005:</p> <ul style="list-style-type: none"> <li>- In upper reaches of the watershed concentrations of conventional pollutants have not increased beyond 1990-95 levels;</li> </ul> <p>2015:</p> <ul style="list-style-type: none"> <li>- Concentrations of conventional pollutants in the Main, East, and West Humber subwatersheds meet PWQO or other specified criteria for at least 75% of water samples;</li> <li>- In the Lower Humber and Black Creek subwatersheds concentrations of conventional pollutants meet PWQO or other specified criteria for at least 50% of water samples.</li> </ul>   |
| 8. Reduce the amount of nutrients and bacteria that enter ground and surface waters | <p>Bacteria</p> <p>Swimming beach closures</p> <p>Conventional pollutants</p> | <p>2005:</p> <ul style="list-style-type: none"> <li>- Bacteria levels in monitoring station samples are lower than 1990-96 levels;</li> <li>- Lake Ontario swimming beaches are open more than 70% of the season.</li> </ul> <p>2015:</p> <ul style="list-style-type: none"> <li>- Bacteria levels in the Main, East and West Humber subwatersheds meet Provincial Water Quality Objectives (PWQO) more than 75% of the time;</li> <li>- Bacteria levels in the Lower Humber and Black Creek meet PWQO more than 50% of the time;</li> </ul> <p>2025:</p> <ul style="list-style-type: none"> <li>- Bacteria levels meet PWQO more than 75% of the time in the entire Humber watershed.</li> </ul> |

| OBJECTIVES - Legacy: A Strategy For A Healthy Humber, 1997  | INDICATORS - Humber Report Card, 2000                                | TARGETS - Humber Report Card, 2000  |
|---|--|---|
| 9. Reduce the amount of pesticides, chemical fertilizers, oil, grease, metals, road salt, and other contaminants that enter ground and surface waters | Conventional pollutants<br><br>Heavy metals and organic contaminants | (also see Obj. #7)<br>2005:<br>- Priority toxics are detected in 25% less samples than in the 1991-92 survey;<br>- Concentrations of persistent organic contaminants and toxic metals meet PWQOs;<br>- Concentrations of organic contaminants in young-of-the-year fish meet IJC Aquatic Life Guidelines;<br>- Restrictions on sport fish consumption have not increased from 1999 levels;<br>2015:<br>- There are no restrictions on consuming fish<br>2025:<br>- Persistent organic contaminants have been virtually eliminated (present in less than 10% of samples) |
| 10. Protect ground and surface waters from spills and illegal discharges of hazardous materials   | Heavy metals and organic contaminants                                | 2005:<br>- Priority toxics are detected in 25% less samples than in the 1991-92 survey;<br>- Concentrations of persistent organic contaminants and toxic metals meet PWQO<br>- Concentrations of organic contaminants in young-of-the-year fish meet IJC Aquatic Life Guidelines;<br>- Restrictions on sport fish consumption have not increased from 1999 levels;<br>2015:<br>- There are no restrictions on consuming fish<br>2025:<br>- Persistent organic contaminants have been virtually eliminated (present in less than 10% of samples)                         |
| 11. Reduce air pollution in the Humber watershed  | Air quality  | 2005:<br>- 25% reduction in number of days AQI exceeds 50<br>2015:<br>- Nitrogen oxide and organic compound emissions reduced by 45% as per Ontario's 1998 Smog Plan;<br>- 75% reduction in number of days AQI exceeds 50<br>2025:<br>- No days when AQI exceeds 50   |



| OBJECTIVES - Legacy: A Strategy For A Healthy Humber, 1997 | INDICATORS - Humber Report Card, 2000   | TARGETS - Humber Report Card, 2000   |
|--|---|--|
| 12. Protect and regenerate aquatic habitats                | <p>Benthic invertebrates</p> <p>Fish communities</p> <p>Riparian vegetation</p> | <p>2005:</p> <ul style="list-style-type: none"> <li>- Protect the existing condition of benthic invertebrate communities;</li> <li>- In the East Humber, target fish species are present and the median IBI score is "good" with 30% of stations scoring "very good";</li> <li>- An additional 80 km of stream bank has woody riparian vegetation</li> </ul> <p>2015:</p> <ul style="list-style-type: none"> <li>- All stations in the East, West and Main Humber subwatersheds score "good" or better;</li> <li>- In the Main Humber, target species are present and the median IBI score is "good" with 30% of stations scoring "very good";</li> <li>- An additional 160 km of stream bank has woody riparian vegetation</li> </ul> <p>2025:</p> <ul style="list-style-type: none"> <li>- All stations in the East, West, Main and Lower Humber subwatersheds score "good" or better;</li> <li>- In stream barriers in the Lower Humber have been removed or mitigated;</li> <li>- In the West Humber, target species are present and the median IBI score is "good" with 30% of stations scoring "very good";</li> <li>- In Lower Humber target species are present and median IBI score is "good"</li> <li>- An additional 160 km of stream bank has woody riparian vegetation</li> <li>- 75% of total stream length has woody riparian vegetation</li> </ul> |

| OBJECTIVES - Legacy: A Strategy For A Healthy Humber, 1997 | INDICATORS - Humber Report Card, 2000   | TARGETS - Humber Report Card, 2000  |
|--|---|---|
| 13. Protect and regenerate terrestrial habitats            | <p>Forest cover</p> <p>Wetlands</p> <p>Vegetation communities</p> <p>Wildlife</p> | <p>2005:</p> <ul style="list-style-type: none"> <li>- No loss of forest cover;</li> <li>- increase forest cover to 30% of watershed area;</li> <li>- urban tree canopy is identified as part of the watershed forest cover;</li> <li>- reforestation of 60 ha.;</li> <li>- increase quantity of wetlands to 10% of watershed area;</li> <li>- restore 15 ha. of wetlands including one <math>\geq</math> 1 ha. within Toronto;</li> <li>- revised natural cover targets established upon completion of TNHS;</li> <li>- quantity and distribution of different vegetation communities has been confirmed (i.e., ELC mapping available for entire watershed?);</li> <li>- Priorities have been established for protecting and restoring diverse native vegetation communities (i.e., TNHS target system has been defined?);</li> <li>- All indicator wildlife species present in 1999 are still present (subwatershed);</li> </ul> <p>2015:</p> <ul style="list-style-type: none"> <li>- quantity and distribution of native vegetation communities has increased;</li> <li>- All 25 indicator species are present in Main and East Humber;</li> <li>- 18 of 25 indicator species are present in West Humber;</li> <li>- 12 of 25 species are present in Lower Humber and Black Creek;</li> <li>- A self-sustaining population of river otter successfully re-introduced.</li> </ul> |
| <b>Society</b>   |   |   |
| 14. Identify and document cultural and heritage resources  | Heritage resources  | <p>2005:</p> <ul style="list-style-type: none"> <li>- All mill sites have been identified;</li> <li>- Municipalities maintain inventories of historical plaques in the watershed;</li> <li>- Ministry of Culture makes all reports from archaeological consultants available to public agencies</li> </ul>  |
| 15. Protect and conserve heritage resources                | Heritage resources  | <p>2005:</p> <ul style="list-style-type: none"> <li>- All known archaeological sites in the watershed are protected;</li> <li>- At least five (5) built heritage sites per municipality proceed each year from Listed to Designated status under the Ontario Heritage Act;</li> </ul>   |

| OBJECTIVES - Legacy: A Strategy For A Healthy Humber, 1997  | INDICATORS - Humber Report Card, 2000 | TARGETS - Humber Report Card, 2000   |
|---|---------------------------------------|--|
| 16. Celebrate the diverse culture and heritage resources of the Humber watershed  | Heritage events                       | 2005:<br>- 50% of surveyed watershed residents can name a Humber heritage event;<br>- Municipalities and heritage groups offer at least one annual heritage event;<br>2015:<br>- 75% of surveyed watershed residents can name a Humber heritage event;<br>2025:<br>- All surveyed watershed residents can name at least one Humber heritage event  |
| 17. Identify and promote the economic value of cultural and heritage resources  | n/a                                   | n/a  |
| 18. Create an accessible and connected greenspace system  | Public greenspace                     | 2005:<br>- An additional 200 ha. of greenspace has been acquired by TRCA;<br>- An additional 200 ha. of greenspace has been acquired by municipalities<br>2015:<br>- An additional 400 ha. of greenspace is in public ownership and accessible   |
| 19. Develop a system of inter-regional trails through the greenspace system   | Trails                                | 2005:<br>- An additional 17 km of inter-regional trails are completed;<br>- Priority trail sections are linked in the Main, East, West and Lower Humber subwatersheds;<br>- Planning for priority linkages in the Black Creek subwatershed are underway<br>2015:<br>- An additional 32 km of trails are completed<br>2025:<br>- An additional 32 km of trails are complete;<br>- All trail gaps identified in 1999 have been addressed |
| 20. Identify and develop local- and regional-scale recreation, education, and tourism destinations within the greenspace system | Outdoor recreation                    | 2005:<br>- Angling and fish viewing opportunities are increasing;<br>- Membership at TRCA facilities and conservation areas is up;<br>- A greater variety of programs are offered at TRCA locations, including horseback riding and nature interpretation  |

| OBJECTIVES - Legacy: A Strategy<br>For A Healthy Humber, 1997  | INDICATORS - Humber<br>Report Card, 2000 | TARGETS - Humber Report Card, 2000   |
|--|--|--|
| <b>Economy</b>   |  |  |
| 21. Balance economic development with protection of the environment and society                      | Sustainable use of resources             | 2005:<br>- Measure(s) for sustainability have been developed;<br>- Environmental awareness and commitment to take action to conserve has increased   |
| 22. Incorporate greenspace in all urban and rural developments                                       | n/a                                      | n/a  |
| 23. Protect the integrity and the economic viability of agricultural areas                           | Agricultural land                        | 2005:<br>- No new urban development has taken place on Prime Agricultural Lands as identified in the Peel and York Region Official Plans (as of 1999);<br>- No new urban development has taken place on other prime agricultural lands<br>2015:<br>- The existence of a healthy agricultural industry that ensures the permanent protection of prime agricultural land for agricultural uses |
| 24. Conserve the natural resources of the Humber watershed   | Sustainable use of resources             | 2005:<br>- Measure(s) for sustainability have been developed;<br>- Environmental awareness and commitment to take action to conserve has increased   |
| <b>Getting It Done</b>   |  |  |
| 25. Create a Humber Watershed Alliance to facilitate implementation of the Humber Watershed Strategy | n/a                                      | n/a  |

| OBJECTIVES - Legacy: A Strategy For A Healthy Humber, 1997  | INDICATORS - Humber Report Card, 2000   | TARGETS - Humber Report Card, 2000  |
|---|---|---|
| 26. Cultivate partnerships between individuals, community groups, businesses, and public agencies in order to implement the Humber Watershed Strategy | <p>Community stewardship</p> <p>Business stewardship</p> <p>Municipal stewardship</p> | <p>2005:</p> <ul style="list-style-type: none"> <li>- Awareness, understanding and participation in stewardship activities are increasing among watershed residents;</li> <li>- 100% of surveyed watershed residents can name at least one activity that they are doing to improve the Humber watershed;</li> <li>- 100 businesses have signed the Humber Pledge and have been involved in at least one watershed management project;</li> <li>- Policies and by-laws that protect significant landforms and groundwater are in place;</li> <li>- All municipalities assess the environmental impact of their policies and practices;</li> <li>- Participation in community clean-up programs continues to increase;</li> </ul> <p>2015:</p> <ul style="list-style-type: none"> <li>- 100% of surveyed watershed residents can name at least two activities they are doing to improve the Humber</li> <li>- 250 additional businesses have signed the Humber Pledge and have been involved in at least one watershed management project;;</li> <li>- All municipalities have the necessary by-laws and policies necessary to protect the Humber River watershed and commit the appropriate resources for education, monitoring and enforcement;</li> </ul> <p>2025:</p> <ul style="list-style-type: none"> <li>- 100% of surveyed watershed residents can name at least three activities they are doing to improve the Humber</li> <li>- 250 additional businesses have signed the Humber Pledge and have been involved in at least one watershed management project</li> </ul> |
| 27. Market the Humber watershed as a destination of choice for healthy living, working, and playing   | n/a   | n/a   |



| OBJECTIVES - Legacy: A Strategy For A Healthy Humber, 1997                                    | INDICATORS - Humber Report Card, 2000 | TARGETS - Humber Report Card, 2000   |
|---|---------------------------------------|--|
| 28. Develop educational programs that focus on the Humber watershed                           | Outdoor environmental education       | 2005:<br>- 25% of students in the watershed take part in outdoor environmental education<br>2015:<br>- All students in the watershed take part in outdoor environmental education<br>2025:<br>- Outdoor environmental education is fully integrated into school curriculum |
| 29. Fund the implementation of the Humber Watershed Strategy through existing and new sources | n/a                                   | n/a  |
| 30. Develop the Humber Report Card to monitor health of the ecosystem                         | n/a                                   | n/a  |

Note: n/a = not applicable