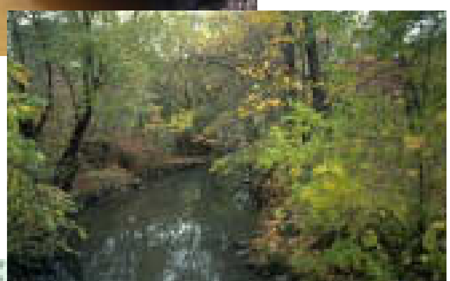
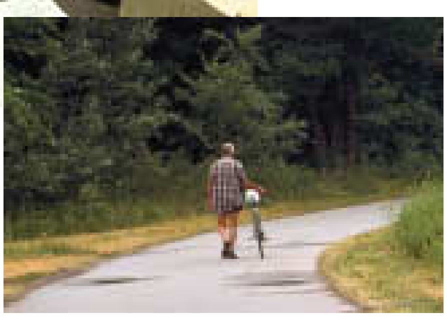


STATE OF THE WATERSHED REPORT:

HIGHLAND CREEK WATERSHED



THE TORONTO AND REGION CONSERVATION AUTHORITY

TORONTO

STATE OF THE WATERSHED REPORT: HIGHLAND CREEK WATERSHED

AUGUST, 1999

THE TORONTO AND REGION CONSERVATION AUTHORITY

TORONTO

For more information about the Highland Creek watershed, please contact:

The Toronto and Region Conservation Authority
5 Shoreham Drive
Downsview, Ontario
M3N 1S4

http://www.trca.on.ca
Tel. (416) 661-6600
Fax. (416) 661-6898

City of Toronto
Water & Waste Water Division
Works & Emergency Services Department
300 Consilium Place, Suite 1000
Scarborough, Ontario
M1H 3G6

http://www.city.toronto.on.ca/sewers
Tel. (416) 396-7156
Fax. (416) 396-5681

ISBN 0-9684992-1-X

Table of Contents

MAPS OF THE HIGHLAND CREEK WATERSHED

FIGURES

TABLES

BOXES

The *Highland Creek State of the Watershed Report* has been produced by staff of The Toronto and Region Conservation Authority (TRCA) in partnership with the City of Toronto. The focus is to provide information that will help with the development of a management strategy for the regeneration of the Highland Creek watershed. This is in response to the recognized problems of poor water quality, loss and fragmentation of wildlife habitat, fluctuating stormwater levels, erosion, and loss of aquatic habitat and aquatic life.

An ecosystem approach was used to guide the development of the *Highland Creek State of the Watershed Report*, recognizing how closely human life is connected to the natural environment. This approach will be critical for the development of a more detailed, community based watershed strategy that will provide recommendations about how to improve the health of Highland Creek's natural environment.

This State of the Watershed Report discusses in detail historical and contemporary human use of the Highland watershed, and the condition of the land, air, water, and natural habitats within it. A discussion of current regeneration opportunities and projects is also provided in this report, highlighting the efforts of the City of Toronto, Friends of Highland Creek, and the TRCA.

INTRODUCTION

BACKGROUND

CHAPTER 1

The Toronto and Region Conservation Authority (TRCA) is a provincial/municipal partnership established in 1957, under the Conservation Authorities Act, to manage the renewable natural resources of the region's watersheds.

The TRCA, with one-third of Ontario's population within its area of jurisdiction, acts in the community's interest through advocating and implementing watershed management programs that:

- maintain and improve the quality of the region's lands and waters
- contribute to public safety from flooding and erosion
- provide for the acquisition of conservation and hazard lands
- enhance the quality and variety of life in the community by using its lands for inter-regional outdoor recreation, heritage preservation, and conservation education

In 1989, The Metropolitan Toronto and Region Conservation Authority[1] completed the *Greenspace Strategy for the Greater Toronto Region*, a strategic planning exercise to establish long-term management goals. This provided direction for the conservation of the Lake Ontario waterfront, the river valleys, and the Oak Ridges Moraine, and identified the need for greater cooperation to achieve more integrated natural resource planning and management. It proposed that the TRCA establish planning task forces for each major watershed within the TRCA's jurisdiction.

A watershed is the total area of land drained by a watercourse and its tributaries. Watershed management strategies are developed to provide direction to natural systems protection, restoration, public education, recreation, and cultural and heritage planning activities within a watershed. To date, the TRCA has established planning task forces and completed watershed management strategies for three of the nine watersheds within its jurisdiction. In 1990, the TRCA

[1] In January 1998, the name of The Metropolitan Toronto and Region Conservation Authority changed to The Toronto and Region Conservation Authority.

adopted the *Comprehensive Basin Management Strategy for the Rouge River Watershed*, the first watershed management strategy. The second watershed management strategy, *Forty Steps to a New Don*, was published by the Don Watershed Task Force in 1994. In 1997, *Legacy: A Strategy for a Healthy Humber* and *A Call To Action* were published as an integrated watershed management strategy for the Humber River.

For The Toronto and Region Conservation Authority, the development and implementation of a watershed management strategy is typically a three phase process (TRCA, 1998f):

Phase 1 Production of a State of the Watershed Report or its equivalent that describes and assesses key environmental and related social and economic conditions, and identifies issues in the watershed.

Phase 2 Establishment of a multi-stakeholder watershed task force to oversee development of a watershed management strategy. The State of the Watershed Report and community consultation provide a knowledge base for the task force to develop the strategy. The strategy recommends actions necessary to protect, regenerate, and celebrate the watershed.

Phase 3 Implementation of the watershed management strategy and monitoring of the progress toward regeneration is guided by a committee of watershed stakeholders.

Publication of the *Highland Creek State of the Watershed Report* will complete Phase 1 of the watershed management strategy development process for the Highland Creek watershed. The TRCA will be working in partnership with the City of Toronto, and other watershed stakeholders and members of the public, to develop the Highland Creek watershed strategy.

The City of Scarborough began undertaking subwatershed studies within the Highland Creek watershed in 1992. One of the first studies was the Centennial Creek Subwatershed Study, completed in 1996. The subwatershed implementation plan recommended a variety of projects and management strategies. The William Alexander Dempsey EcoPark, a series of three wetlands and retrofit ponds, was completed in 1996 as the first large project to be completed under this subwatershed study.

1.1 PURPOSE OF THE REPORT

The *Highland Creek State of the Watershed Report* will contribute to the development of a management strategy for the watershed using an ecosystem based approach. The purpose of the report is to provide sufficient background information on the watershed so that planning, management, consultation, regeneration, and monitoring efforts can be prioritized and coordinated.

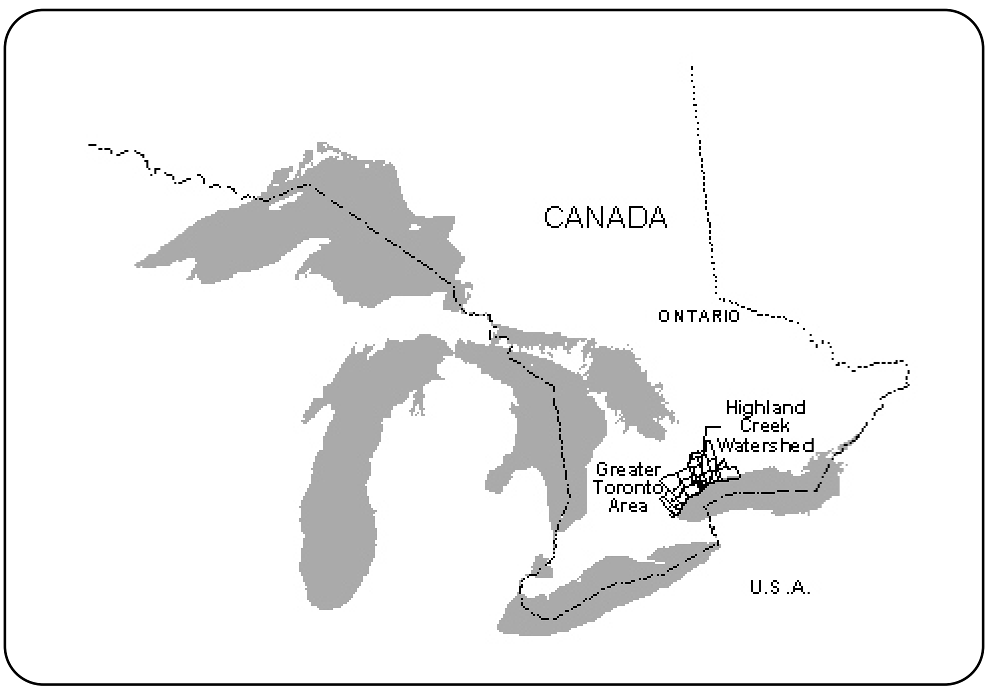
To fulfill this purpose, the report documents the natural and cultural heritage of the Highland Creek watershed and provides an assessment of current environmental and related social and economic conditions. The report also provides some direction for the future management of the watershed.

1.2 STUDY AREA

The study area is the Highland Creek watershed, located in the eastern section of the City of Toronto (see Figure 1). The Highland Creek watershed is an urban watershed lying within a fully urbanized landscape. Approximately 85 percent of the total area of the watershed is covered by urban uses, making it the most developed in The Toronto and Region Conservation Authority's jurisdiction. The remaining 15 percent of the watershed is identified as open space, which includes parks, vacant land, cemeteries, golf courses, and other green space.

The watershed drains an area of 102 km^2, and lies almost entirely within the boundaries of the new City of Toronto. A small portion extends north into the Town
Markham (see Map 1: Highland Creek Watershed). The approximate total length

FIGURE 1: Highland Creek Watershed in the Great Lakes Basin Ecosystem

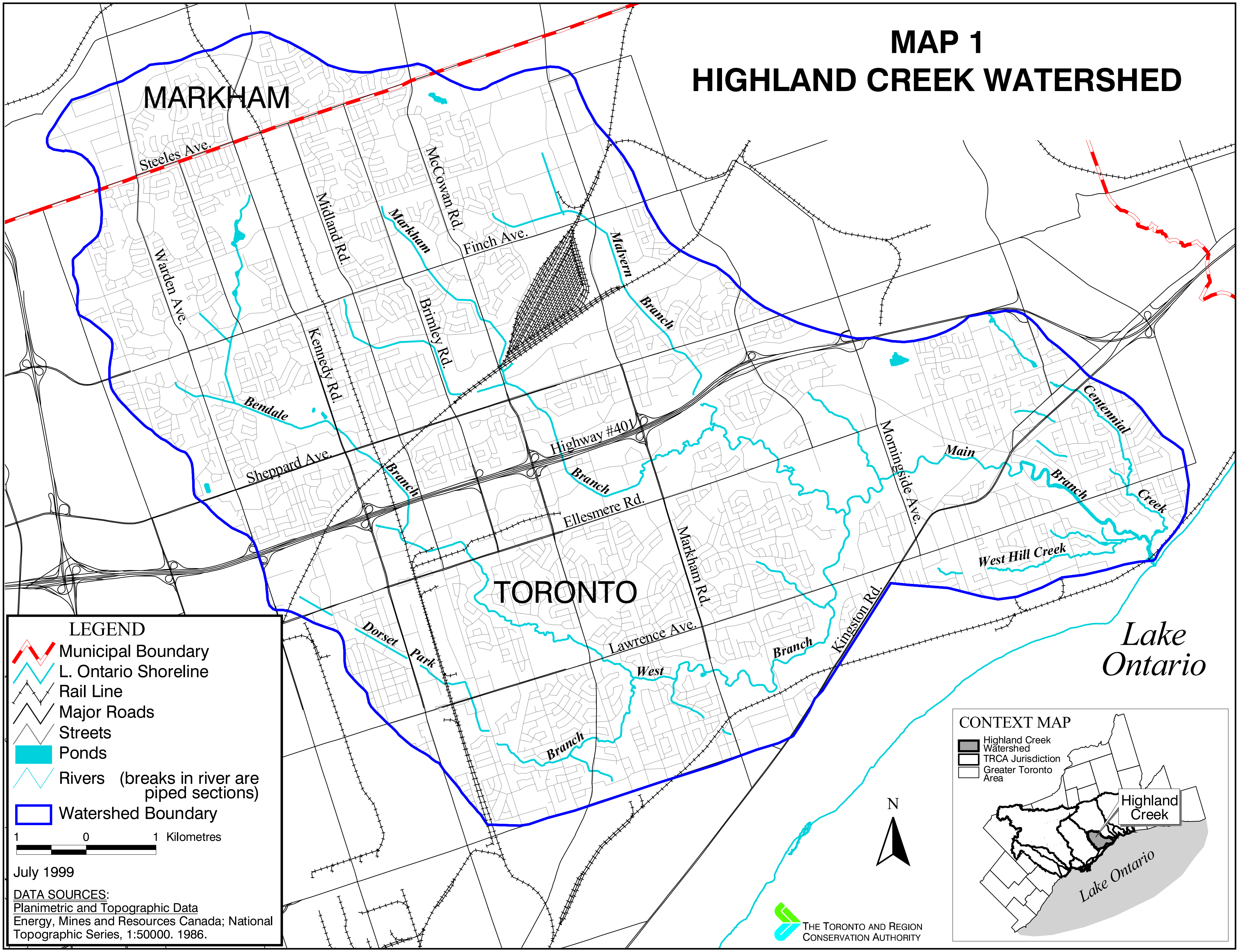


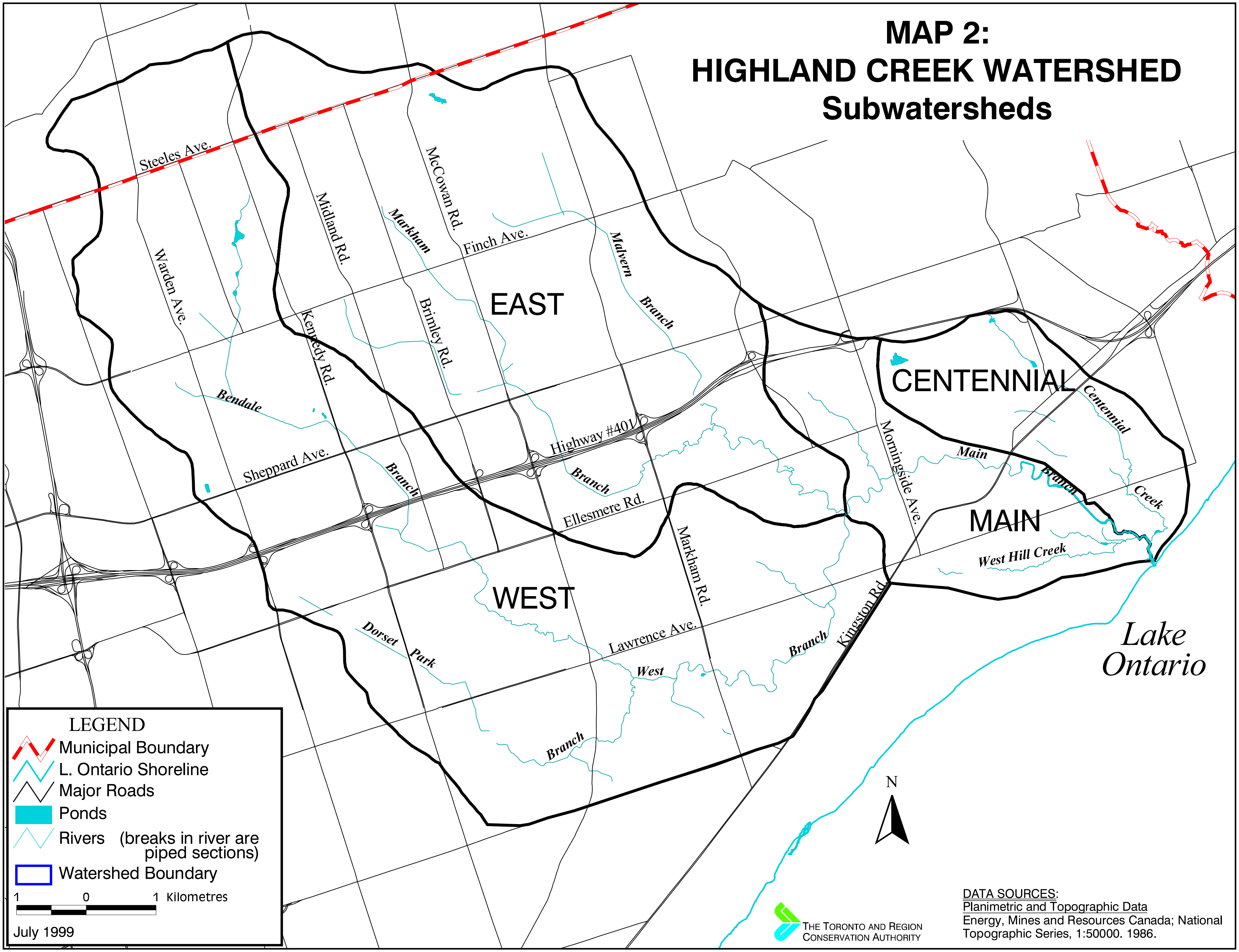
of the watercourse is 74 km. Highland Creek has four distinct branches: the Main (which also includes West Hill Creek [also called the Danzig or Thornton Creek), Centennial Creek, the East Highland, and the West Highland. The East Branch is further subdivided into the Malvern and Markham Branches, and the West Branch is formed by the Bendale and Dorset Park Branches (see Map 2: Subwatersheds).

1.3 REPORT STRUCTURE

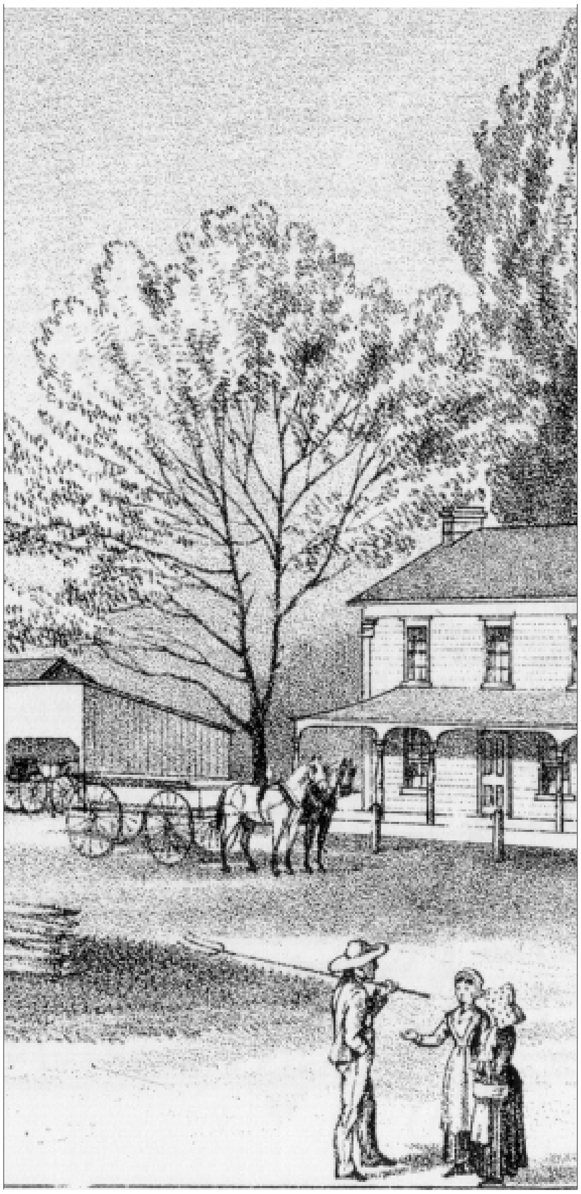
A sustainable ecosystem approach was used to guide the development of the *Highland Creek State of the Watershed Report*. In taking this approach, the ecosystem was broadly defined as including the components of natural environment, society, and economics, and their respective interactions. A sustainable ecosystem would be one where current environmental, social, and economic needs are met through the integrated management of these ecosystem components, leaving sufficient resources to meet the needs of the future. This report is a description and analysis of the watershed conditions, and is based primarily on an extensive literature and data search. Provincial, regional, municipal, and other sources of information about the Highland Creek watershed were compiled and analysed. Recognizing that it was not possible to study everything within the watershed, this document focuses on the ecosystem components of land, air, water, and life.

There are four parts to this document. Part 1, *Introduction,* provides an introduction to the report. Part 2, *Human Use of the Watershed*, provides an overview of cultural heritage, inventories heritage sites and archaeological resources, and documents human occupation up to the present as it has been affected by and affects the natural heritage system of the Highland Creek watershed. Part *3, Natural Heritage*, describes the current conditions of air, land, water, and natural habitats within the watershed. It also describes the interactions among these components of the natural heritage system. Part 4, *Directions for Management*, summarizes some key issues and current regeneration initiatives to be considered in the development of a watershed management strategy.


MAP 1
HIGHLAND CREEK WATERSHED
MARKHAM
TORONTO
Lake Ontario
Steeles Ave.
Finch Ave.
Sheppard Ave.
Highway #401
Ellesmere Rd.
Lawrence Ave.
Kingston Rd.
Warden Ave.
Midland Rd.
Kennedy Rd.
Brimley Rd.
McCowan Rd.
Markham Rd.
Morningside Ave.
Markham Branch
Malvern Branch
Bendale Branch
Dorset Park Branch
West Branch
Main Branch
Centennial Creek
West Hill Creek
LEGEND
Municipal Boundary
L. Ontario Shoreline
Rail Line
Major Roads
Streets
Ponds
Rivers (breaks in river are piped sections)
Watershed Boundary
1 0 1 Kilometres
July 1999
DATA SOURCES:
Planimetric and Topographic Data
Energy, Mines and Resources Canada; National Topographic Series, 1:50000. 1986.
N
THE TORONTO AND REGION CONSERVATION AUTHORITY
CONTEXT MAP
Highland Creek Watershed
TRCA Jurisdiction
Greater Toronto Area
Highland Creek
Lake Ontario



MAP 2:
HIGHLAND CREEK WATERSHED
Subwatersheds
EAST
CENTENNIAL
MAIN
WEST
Steeles Ave.
Finch Ave.
Sheppard Ave.
Highway #401
Ellesmere Rd.
Lawrence Ave.
Kingston Rd.
Warden Ave.
Midland Rd.
Kennedy Rd.
Brimley Rd.
McCowan Rd.
Markham Rd.
Morningside Ave.
Markham
Malvern
Branch
Bendale
Branch
Branch
Centennial
Creek
Main
Branch
West Hill Creek
Dorset
Park
Branch
West
Branch
Lake
Ontario
N
LEGEND
Municipal Boundary
L. Ontario Shoreline
Major Roads
Ponds
Rivers (breaks in river are piped sections)
Watershed Boundary
1 0 1 Kilometres
July 1999
THE TORONTO AND REGION CONSERVATION AUTHORITY
DATA SOURCES:
Planimetric and Topographic Data
Energy, Mines and Resources Canada; National Topographic Series, 1:50000. 1986.



Traditionally, a key determinant of the location of human settlements has been water. Lakes, rivers, and streams provided a stable water supply, transportation corridors, food, and other resources to humans. The Highland Creek was no exception, and thus many cultural and heritage resources have been found within the watershed. These cultural heritage resources are integral to the development and implementation of a watershed management strategy as they demonstrate the importance of past peoples and their environments relative to the condition of the watershed today.

To place the cultural history of the Highland Creek into context, chapters 2 and 3 describe the Aboriginal and Euro-Canadian historical periods. These chapters are summarized from the *Highland Creek Watershed Heritage Study* (TRCA, 1998b).

HUMAN USE OF THE WATERSHED

PREHISTORIC SETTLEMENT

CHAPTER 2

This chapter provides an overview of prehistoric settlement in the Highland Creek watershed. Included is information about the aboriginal groups that once inhabited the watershed, the impact of their settlement on the watershed, and a summary of known heritage sites.

Prehistoric settlement refers to the aboriginal populations who inhabited the Highland Creek watershed prior to the arrival of Europeans. Humans began to migrate into the area following the last ice age about 12,500 years ago. There is a long history of aboriginal use of the watersheds along the north shore of Lake Ontario, including in the Highland Creek area. Archaeological evidence indicates that the first inhabitants were the Paleo Indians who moved into the Toronto area after the glaciers retreated from the region. They resided in the area from 10,000 B.C.E. to 7,000 B.C.E. (the term B.C.E. is defined as “Before the Common Era” which is equivalent to “B.C.” or “Before Christ”). Following this came the Archaic period lasting from 7,000 B.C.E. to 1,000 B.C.E. The last period was the Woodland period, which lasted from 1,000 B.C.E. to 1651.

2.1 PALEO INDIAN 10,000 TO 7,000 B.C.E.

Paleo Indians were the first aboriginal group to inhabit southern Ontario after the glaciers began to retreat about 12,500 years ago. These nomadic people lived in small family groups and spent their lives following the herds of caribou and other large mammals that wandered through the tundra-like landscape that existed during this period (Archaeological Services Inc. et al., 1994). Their lives were closely connected to the migratory patterns of their chief sources of food, and they acted as an important and functional element of the ecosystem.

No physical evidence of Paleo Indians has been discovered in the Highland Creek watershed. However, sites have been found to the west in the Humber River watershed and to the east in the Rouge River watershed, suggesting that Paleo Indian settlements may have existed within the Highland Creek watershed.

2.2 ARCHAIC 7,000 TO 1,000 B.C.E.

Following the Paleo Indian period, the Archaic peoples settled in the area, utilizing new technologies and subsistence strategies. The technological prowess of the Archaic peoples can be seen in the weapons and tools they produced. These included exquisite spear points, wood working tools such as axes, and specialized objects such as net-sinkers and copper tools. Native copper that was used to make special objects was mined from deposits along Lake Superior, suggesting the establishment of long range trading networks among the Archaic peoples. New subsistence strategies focused on the seasonal abundance of food resources. In the spring and fall, bands would join together at strategic locations along the Lake Ontario shoreline to exploit abundant food resources such as fish, shell fish and waterfowl. For the rest of the year they would split into smaller groups and move inland within loosely defined hunting camps (probably based on watersheds) to hunt game and gather wild berries, nuts, and other resources.

Tools of the Archaic people

Three archaeological sites attributed to the Archaic peoples have been discovered in the Highland Creek watershed. These sites, located inland from the Lake Ontario shoreline, are typical of the interior campsites established during the fall and winter months. The sites have been identified through collections of stone tools and flakes, indicative of butchering and hide processing practices. Unfortunately, all three of these sites have since been destroyed. Larger and more extensive spring and summer sites, where several bands would have gathered together to exploit the abundant aquatic resources, would have occurred along the Lake Ontario shoreline. At that time, however, Lake Ontario was much lower than present day levels, so any surviving archaeological sites would now be under water.

Though we are aware that the Archaic peoples inhabited the Highland Creek watershed, there is very little information available. No detailed excavation of the three discovered sites was undertaken prior to their destruction, and any existing spring and summer shoreline sites would now be under water.

2.3 INITIAL WOODLAND 1,000 B.C.E. TO 700

Following the Archaic period, the Woodland period is distinguished by the introduction of clay pots. This technology provided great advantages, allowing for the long term storage of food. These food stores were used during the winter, when food was scarce. The introduction of the bow and arrow also occurred at this time. This new technology radically changed the approach to hunting, and led to greater success in the acquisition of game. Greater success in the acquisition of food led to an increase in population and the subsequent formation of larger and more permanent sites of habitation. The Woodland peoples are also distinguished by cultural sophistication. Elaborate burial rituals were practised, and there was a marked increase in the number and variety of goods acquired through a more extensive trade network that stretched to the east coast of North America and as far south as the Ohio Valley.

Initial Woodland sites have been discovered in adjacent watersheds, and therefore would be expected to be found in the Highland Creek watershed; however, none have been discovered to date.

2.4 ONTARIO IROQUOIAN (LATE WOODLAND) 700 TO 1651

A number of distinctive cultural attributes distinguish the Late Woodland people. These include the use of agriculture, introduced into southern Ontario around the year 700, and the further development of pottery technology.

With the development of agriculture as the primary source of food, the Late Woodland period saw a tremendous increase in population and the establishment of permanent villages. Villages were made up of a number of longhouses, some of which were up to 46 metres in length. These large structures provided shelter for up to 50 people. Villages were often 1.2 to 4.1 hectares in size and were surrounded by wooden walls or palisades.

Two Late Woodland sites have been found in the Highland Creek watershed (gravesites are not included). These include a permanent village site called Thomson village, and a temporary campsite called the Macklin campsite. A grave site (ossuary) has also been discovered.

The Thomson village site is located on a plateau overlooking a tributary of the Highland Creek. Excavations have recovered a number of artifacts including pottery fragments, smoking pipes, stone tools and items for personal adornment. Food remains discovered on the site have included corn, and the bones of animals including deer, bear, beaver, racoon, passenger pigeon, and fish.

The Macklin campsite was a special purpose site set up for the temporary exploitation of a particular resource (e.g., fish, deer). Many more sites probably exist within the watershed, but due to their temporary nature and the small number of artifacts usually found in them, they tend to be overlooked.

The most striking sites, however, are the large communal grave sites known as ossuaries. Ossuaries are large circular pits (approximately three to five metres in diameter) that contain the skeletal remains of hundreds of individuals. The digging and filling of an ossuary was an immensely powerful religious ceremony occurring about every ten years. At that time the inhabitants of a village would exhume the bones of their ancestors, clean and wrap them in fur robes, and then re-bury them in a prepared pit. The ceremony would last up to ten days, after which it was believed the souls of the dead were finally at rest and united with one another in the spirit world. One site, the Tabor Hill Ossuary, was discovered in the Highland Creek watershed and is thought to be associated with the Thomson village site that lies a short distance away to the west.

Late in this period, European traders introduced the fur trade to the aboriginal people. Early French explorers ventured to the area in about 1615, and trading began to grow in importance. As trade in furs increased and these resources took on a commercial value, the local aboriginal economies became linked to the much larger European economies. The aboriginal nations' dependence on European goods increased, and a period of disease and warfare developed leading to the decimation and ultimate dispersal of the Huron and Petun by the Iroquois of upper New York state.

2.5 IMPACTS ON THE NATURAL HERITAGE SYSTEM

The history of the aboriginal communities in the Highland Creek area is one of increasing sophistication and social development. With greater societal organization came an increasing ability to influence and impact the environment. The earliest Paleo Indians inhabiting the area were organized in small bands that followed the migration patterns of their prey. They were closely linked to the natural rhythms of the environment, and acted as an important and functional element within it. Their impact on the environment was minimal.

This began to change during the Archaic period and intensified during the Initial Woodland period due to the development of new food storage technologies (pottery) and new hunting technologies (bow and arrow). With these new technologies and the resultant increase in population, aboriginal communities were able to utilize more effectively the available environmental resources.

Agriculture and the further development of other technologies in the Late Woodland period increased the impact of the aboriginal communities on the environment. For example, fields for crops were cleared in the flood plains. However, despite these developments, their impact on the environment was still negligible compared to the impact of the European settlers that followed.

2.6 HERITAGE RESOURCES

There are fourteen known archaeological sites in the Highland Creek watershed (see Map 3: Cultural Heritage) (TRCA, 1998b). Table 1 provides a summary of these archaeological sites, which are registered with the Ontario Ministry of Citizenship, Culture and Recreation.

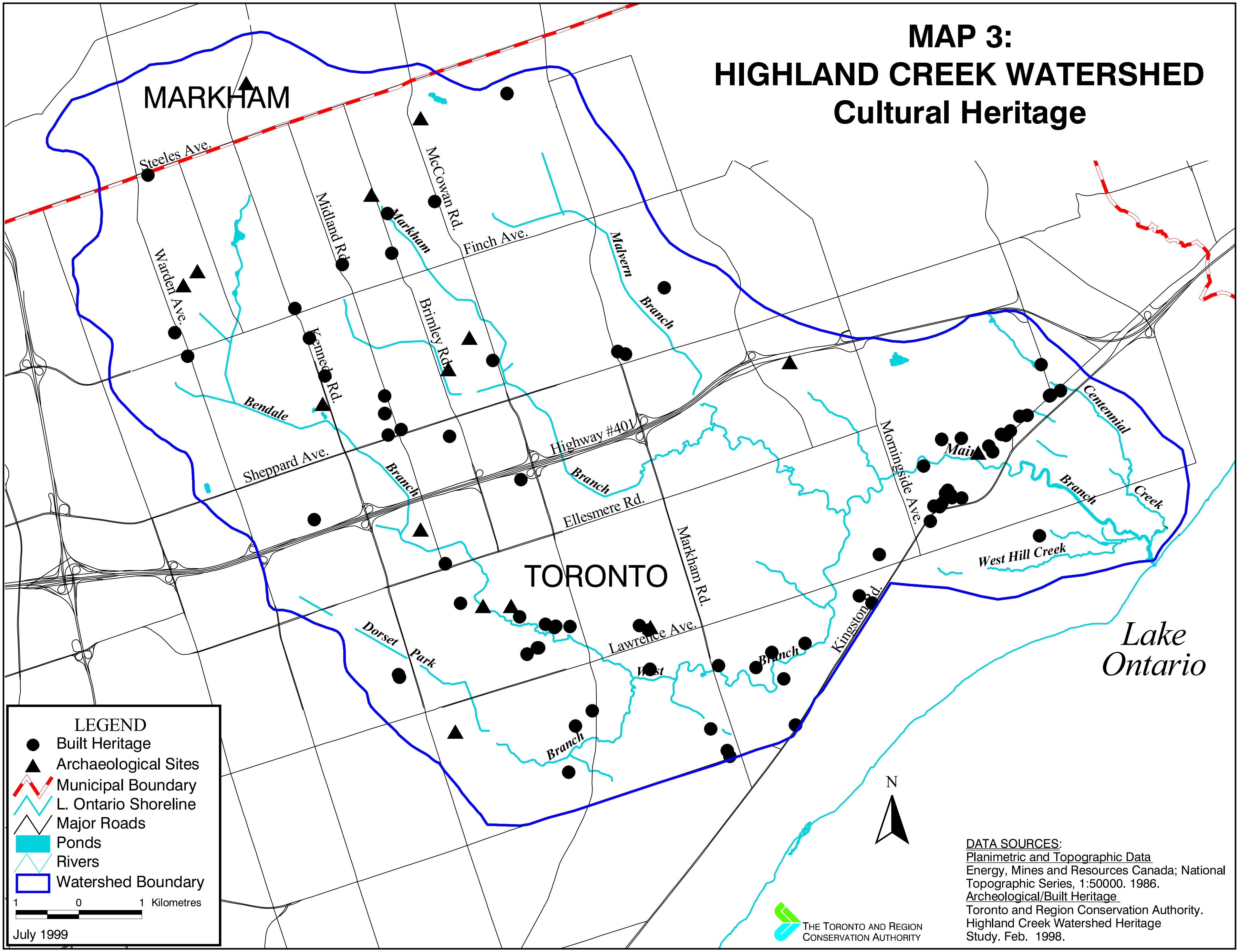

MAP 3:
HIGHLAND CREEK WATERSHED
Cultural Heritage
MARKHAM
TORONTO
Lake Ontario
Steeles Ave.
Finch Ave.
Sheppard Ave.
Highway #401
Ellesmere Rd.
Lawrence Ave.
Kingston Rd.
Warden Ave.
Midland Rd.
Kennedy Rd.
Brimley Rd.
McCowan Rd.
Markham Rd.
Morningside Ave.
Markham Branch
Malvern Branch
Bendale Branch
Dorset Park Branch
West Branch
Main Branch
Centennial Creek
West Hill Creek
LEGEND
Built Heritage
Archaeological Sites
Municipal Boundary
L. Ontario Shoreline
Major Roads
Ponds
Rivers
Watershed Boundary
1 0 1 Kilometres
July 1999
N
THE TORONTO AND REGION CONSERVATION AUTHORITY
DATA SOURCES:
Planimetric and Topographic Data
Energy, Mines and Resources Canada; National Topographic Series, 1:50000. 1986.
Archeological/Built Heritage
Toronto and Region Conservation Authority. Highland Creek Watershed Heritage Study. Feb. 1998.

TABLE 1: Highland Creek Watershed Archaeological Sites

Cultural Affiliation	TOTAL SITES
Archaic	
Late	**2**
Woodland	
Middle Woodland	**2**
Late Woodland	**2**
Historical	
Mississauga	**2**
Undetermined	**6**
Total	**14**

These sites cover almost all of the occupations in the area including representations from Late Archaic, through the Initial and Late Woodland (Iroquoian) to the historic Mississauga's. All of the sites except one are located within the boundaries of the City of Toronto (Scarborough District). The majority of these sites lie close to the valley and stream corridors. This is not surprising considering human activity has traditionally centred around rivers and lakes in order to fill the need for a stable water supply, to use its associated resources, and to take advantage of the waterway's transportation potential. The valley and stream corridors of Highland Creek, from their origins on the South Slope of the Oak Ridges Moraine to Lake Ontario, provided ample opportunity for the use of aquatic and other resources that these early people would have needed to survive.

SUMMARY

There is a long history of human aboriginal occupation in the Highland Creek watershed. Fourteen known archaeological sites have been found and documented to date, in the watershed. Many others have probably been destroyed by development, or still exist within the valley and stream corridors waiting to be discovered.

HISTORICAL SETTLEMENT

CHAPTER 3

The period of historical settlement in the Highland Creek watershed began in about 1650 when aboriginal populations first made contact with European explorers and settlers. A major landmark on the north shore of Lake Ontario, the Scarborough Highlands lent their name to the creek immediately below them from the beginning. Its Mississauga name of "Yat.qui.I.be.no.nick", recorded in 1796, and all subsequent names reflect its geographical position as the first creek below the high land. Travellers going westward on the lake would often camp at the mouth of the Highland Creek rather than attempt a passage along the base of the Bluffs in darkness or bad weather.

The following sections provide an overview of the historical period including contact between aboriginal and Euro-Canadian peoples, key characteristics of the successive periods of settlement, the impact of this settlement on the environment, and a summary of heritage resources found in the watershed.

3.1 CONTACT 1650 TO 1800

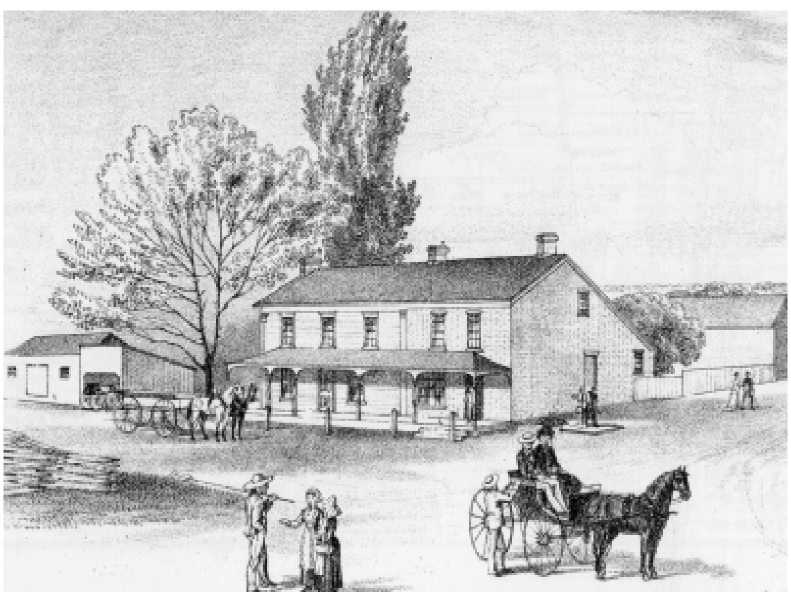
Following the decimation and ultimate dispersal of the Petun and Huron by the Iroquois in 1650, southern Ontario was uninhabited for a few years before the Iroquois moved into the area to establish a number of large villages along the north shore of Lake Ontario for the exploitation of the local fur resources. One such village was Ganatsekiagon, located on the Rouge River. No villages of this size and importance have been found in the Highland Creek watershed, but evidence shows that the resources of Highland Creek were used by the native peoples of these villages.

By about 1700, the Iroquois had left their Rouge River village and were replaced by the Mississauga Indians. This new community continued to trade furs with the French, travelling to the trading posts near the mouth of the Humber River. Although there were reportedly two main Mississauga villages along the Lake Ontario shoreline in the 1780s, a number of small seasonal encampments elsewhere indicate that they maintained their traditional subsistence strategies of fishing, hunting, and the trading of furs in exchange for European goods that they incorporated into their way of life. Within the Highland Creek watershed, two sites are thought to represent such seasonally exploited sites. These are the Tam O'Shanter and the Kwe Village sites.

3.2 SETTLEMENT PHASE

Although the English defeated New France after the Battle of the Plains of Abraham at Quebec City in 1759, permanent settlement did not begin in the Toronto area until after 1793. This is when Governor Simcoe moved the capital there and laid out a 10 block military grid adjacent to the mouth of the Don River. Among the many who followed Simcoe to the new capital was David Thomson, a stone mason employed in the construction of the new government buildings in York. In late 1796 he set out to find a homestead for his family in the Township of Scarborough.

In choosing a homestead location, settlers avoided areas of low or marshy ground, or land covered in pine, an indication of poor sandy soils. As such, they avoided the extensive marsh at the mouth of the Highland where they feared fever-spreading mosquitoes, and the "pine plains" of the Lake Iroquois Sand Plain near the lakeshore. Early settlement was therefore largely confined to the middle and upper reaches of the watershed.



Store and residence of John Tingle,
Lot 35, Con. D Scarboro Township, Wexford

Thomson established his family homestead in the upper reaches of the Highland Creek watershed. Following an aboriginal path, he chose a location near a clear flowing spring, close to the present day area west of McGowan Road, between Ellesmere Road and Lawrence Avenue. This was close to where St. Andrew's Church would later be built in 1819. It was here that he began clearing land for his homestead, becoming the first Euro-Canadian settler in the watershed (Bonis, 1982).

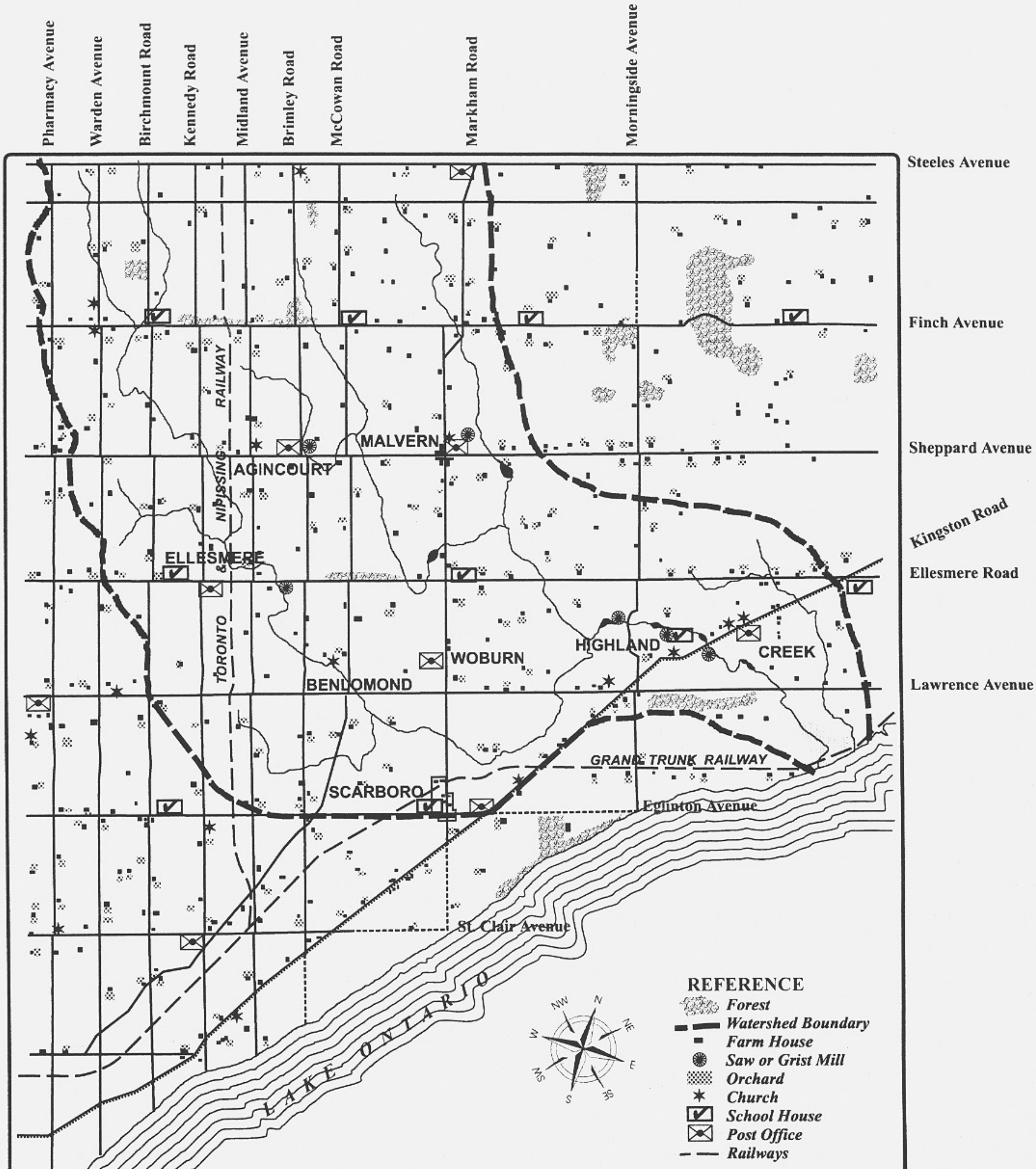
The first transportation link constructed through the watershed was Danforth Road. Originally an aboriginal trail, it was widened and opened as a road in 1799 (Bonis, 1982). This was soon followed by Kingston Road which was originally built in 1801, and later straightened and improved in 1815 (Bonis, 1982). Despite these new transportation routes, settlement was slow. The Scarborough Bluffs prevented ships from finding suitable locations to dock (ODPD, 1956) and the mouth of Highland Creek contained a vast wetland. As such, the flat land at the foot of Port Union Road was the only suitable location for ships to dock in the area.

The number of settlers in Scarborough Township was a mere 89 in 1802, increasing to 102 in 1805, and 140 by 1809 (ODPD, 1956). During this pioneer stage of development, the main activities of the settlers were to open up the area by clearing land, erecting a log cabin, and putting in their first crop of potatoes, corn, and squash. The impact of settlement on the environment was negligible at first. In fact, the creation of cleared areas increased productive wildlife habitat along the forest edges. The quail is an example of a species that benefited from the cutting of the forests, as they "...were unknown in the dense forests of Upper Canada before they were cleared" (ODPD, 1947, pg. 398 and 402). As the population increased and more land was cleared for agricultural uses, mills were constructed along Highland Creek. These mills provided timber for construction purposes, and ground wheat into flour. The first of these was the Cornell Saw and Grist Mill, constructed in 1804 at Kingston Road near the growing community of Highland Creek-West Hill. By 1861, there were eleven sawmills, one grist mill, one woollen mill and two steam sawmills. By 1878 this had been reduced to four sawmills and two grist mills as a result of the continued deforestation and subsequent lowering of the water table. The stream flows were reduced, many of them dried up completely or only flowed intermittently, and the larger ones began to experience fluctuations in flow. The following (Map 4) illustrates land use in the Highland watershed in 1878.

Alterations to the fisheries resources occurred in the early settlement years. Many settlers had remarked on the abundance of fish, especially the salmon that was found in the many streams flowing into Lake Ontario. However, the mill dams began to prevent many fish from reaching their spawning grounds up stream, and many of those that did were suffocated by saw dust from the numerous saw mills.

3.3 AGRICULTURAL PHASE

By the mid 1850s development in Scarborough began to move from the initial pioneering phase into an era of settled agriculture. Deforestation had occurred on over 50 percent of the township, and the population was more than 4,244 (ODPD, 1956). Between 1851 and 1861 forest cover in Scarborough township experienced
its greatest decrease. In 1851, 73.2 percent of the township was covered in forest, this was reduced to 33.6 percent by 1861 (ODPD, 1956). In 1861 the local Census enumerator commented that many of the sawmills on the Highland were idle, while others were "rotting down, the supply of timber having entirely failed" and been "used up" (Reeves, 1992, pg. 159).



MAP 4:

SCARBORO. 1878

SCALE, 60 CHAINS TO ONE INCH.

Adapted from the
Illustrated Atlas of York 1878

Disruptions to the hydrologic cycle (refer to Chapter 7: Water, for further details) were a result of continued deforestation in the late 1800s. This caused the Highland Creek to flood, damaging mills and other properties. The unpredictable water fluctuations in the creek made mill activities difficult and many of them were closed or converted to more reliable steam power.

During this period of settled agriculture, a number of small hamlets were developed to provide services for the surrounding farmers. These included: Agincourt, Armadale, Benlomond (Bendale), Ellesmere, Highland Creek, Malvern, Milliken, Scarborough Village, West Hill, and Woburn where the Scarborough Township Offices were located upon incorporation in 1850. Development within the watershed was accelerated in the 1850s due to improvements in transportation which included the construction of the Grand Trunk Railway along the southern part of the watershed, the establishment of a railway station at nearby Port Union, and the planking of Markham Road in 1857. Later improvements included the construction of the Toronto and Nipissing Railway through the western portion of the watershed in 1871 which spurred further development in Agincourt. Not only did the development of this transportation infrastructure facilitate additional urban development, it had a direct impact on the landform of the area as well. The Grand Trunk rail lines were built across the sandspit at the mouths of Highland and Centennial Creeks, placing an immovable urban grid on what had been a shifting and dynamic sand dune system. Further construction along the railway line resulted in Centennial Creek being diverted into the Highland Creek, just north of Lake Ontario.

By 1900, the population of Scarborough township had reached 3,711. The township was predominately agricultural, but there were a number of hamlets situated throughout the watershed. Two of these - Agincourt and Highland Creek/West Hill - were experiencing continued growth. With the growth of the nearby City of Toronto, urban development crept into the south-western part of Scarborough township along Kingston Road and into areas adjacent to existing concentrations of development, especially Agincourt and Highland Creek/West Hill. Further growth was facilitated by additional transportation improvements such as the construction of the Toronto and Scarboro Electric Railway along Kingston Road, which reached West Hill in 1906 (Stamp, 1989). This was followed by the paving of Kingston Road in the early 1920s.

By the 1940s, urbanization of the area along both sides of Kingston Road was well underway, as was the expansion of the existing communities of Highland Creek-West Hill and Agincourt.

3.4 URBAN PHASE

The watershed, which had been predominantly agricultural from the mid 19th to the mid 20th century, changed radically in the post World War II period with the growth of the City of Toronto. Beginning in the 1950s and continuing for forty years, urban subdivisions and industrial development replaced the agricultural fields, especially after the opening of Highway 401 in 1956 (Bonis, 1982).

Urban growth generally progressed from the southerly part of the watershed toward the north (see Map 5: Historical Urban Development). The exception was Agincourt, which experienced continued growth throughout the late 19th and early 20th centuries. By 1960 urban development had progressed northerly to Ellesmere Road, reaching just north of Highway 401 by 1970, and covered the rest of the watershed by 1990.

3.5 HISTORICAL RESOURCE USE

Historical land uses which relied on natural resources warrant specific discussion in this *State of the Watershed Report* because their activities resulted in the character of the watershed that we see today. Resource-based industries have historically been the most important sector of the Canadian economy and they are still considered important for economic prosperity, but within the Highland Creek watershed they have been replaced by urban land uses.

3.5.1 Forestry

Forestry was the first significant resource use and economic activity within the Highland Creek watershed. European settlers found the watershed almost 100 percent forested in the late 1790s and early 1800s. The removal of the forest to facilitate the growth of agriculture would have been the most significant economic activity in the watershed during the early part of the 19th century. The importance of forestry began to decline in 1851 and was replaced with agriculture by 1861, when the total amount of forest cover in Scarborough township was reduced to 33.6 percent (ODPD, 1956). In 1861, the local Census enumerator commented that many of the sawmills on the Highland had closed due to the lack of available timber (Reeves, 1992).

3.5.2 Agriculture

As land was cleared and forestry went into decline, agriculture became the main economic activity within the Highland Creek watershed. This occurred sometime in the 1850s and extended into the mid 20th century. The watershed was predominately agricultural until the 1950s. Then, the area began to be urbanized as part of the post World War II building boom associated with the growth of the City of Toronto. Today the watershed is entirely urbanized, with remnant agricultural operations accounting for less than 1 percent of land use.

3.5.3 Aggregate Extraction

Aggregate extraction operations in the Highland Creek watershed were limited to the sand and gravel shoreline of the former Lake Iroquois. Large operations were present in the early part of the 20th century, but now there are no active operations within the watershed. Some of the gravel pits have filled in with ground water to create large ponds (e.g., on Conlins Road south of Highway 401), others upon closure were used as landfill sites for municipal waste.

3.5.4 Fisheries

The Highland Creek watershed historically supported a diverse fish community. The high percentage of forest which originally covered the watershed before European settlement, and the high percentage of baseflow of cold water from underground aquifers, meant that the Highland offered a pristine environment for the most sensitive fish species including Atlantic salmon and brook trout. These resources would have provided food for local settlers and a ready source of income.

As the environmental characteristics of the watershed began to change and the forests were cut down, the diversity of the fish community began to change and the more sensitive species disappeared. Today, the sport fishery in Ontario is worth millions of dollars a year. Unfortunately, the degraded condition of the Highland Creek means that few of these dollars are spent within the watershed.

3.6 IMPACT ON THE NATURAL HERITAGE SYSTEM

A Natural Heritage System refers to the interactions between the physical, chemical, and biological elements of a natural system. The impact of Euro-Canadian settlement on the natural heritage system of the Highland Creek watershed has been severe. Forests were replaced with agricultural crops, and wildlife was replaced with domestic animals. This resulted in impacts on both ground and surface water resources. The loss of forest cover resulted in a lower water table, which caused many of the tributaries of the Highland Creek to disappear and an increase in runoff and erosion from the land. The fisheries resources were devastated by changes in flow pattern, barriers within the stream, and the loss of habitats.

The headwaters of Highland Creek which had previously meandered through the landscape, were channelized in order to permit new residential and industrial development. Though this was the practice at the time it is now understood that these actions have resulted in many detrimental impacts on the environment. Current planning practices protect some valley and stream corridors, and promote the regeneration of degraded streams.

3.7 HERITAGE RESOURCES

Due to the shape of the Highland Creek watershed, which narrows to a point at Lake Ontario, areas outside of the watershed were included in the *Highland Creek Watershed Heritage Study* (TRCA, 1998b) to provide a context for the built heritage resources within the watershed. These areas include land to the south towards Lake Ontario, and the historical area of Port Union to the east.

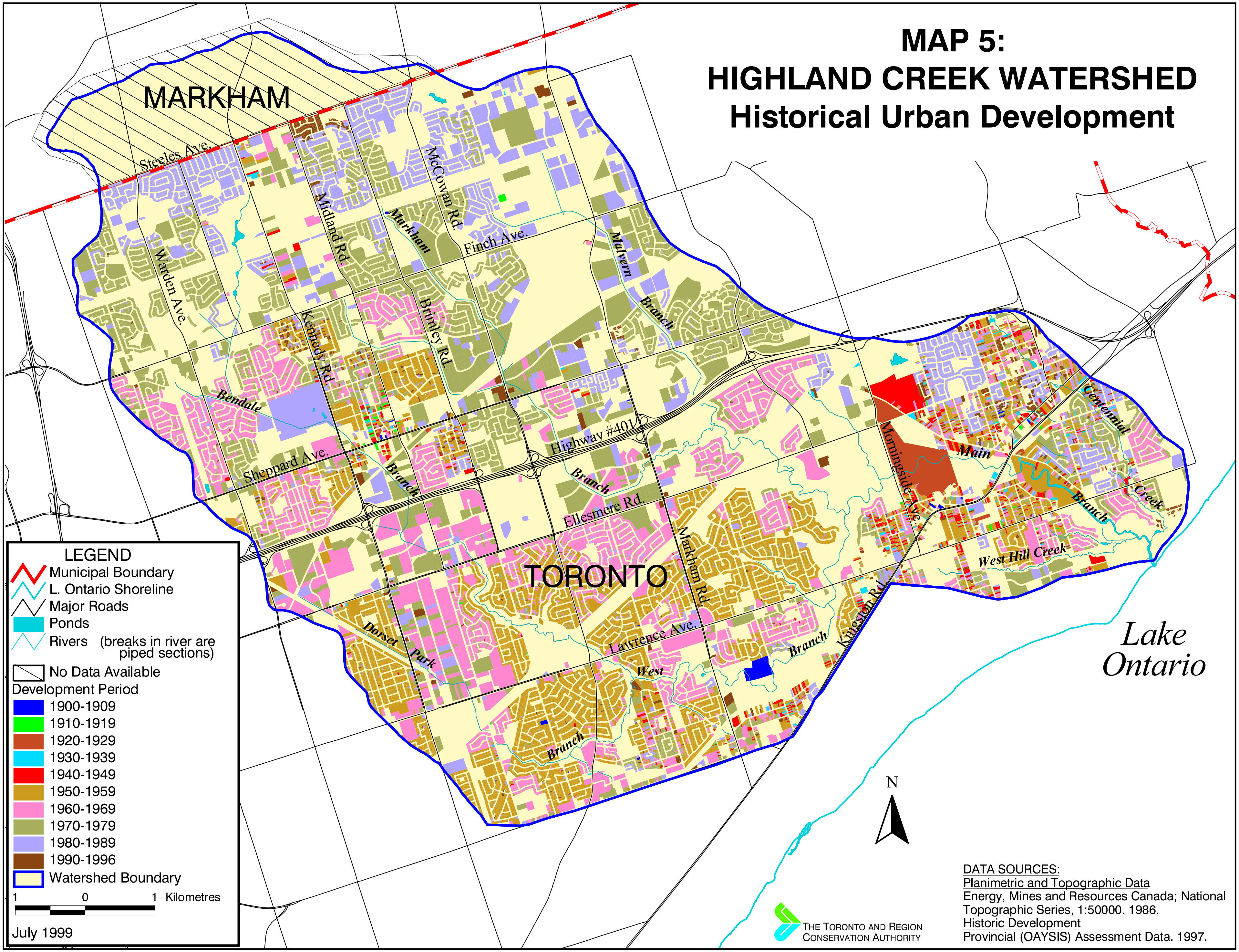
An inventory of buildings of architectural and historical importance has been prepared by Local Architectural Conservation Advisory Committees (LACAC), or Historic Boards, in each of the former municipalities of the City of Toronto. An examination of these inventories located a total of 91 heritage features and their original uses, of which 35 properties that have been classified as 'Designated' as heritage properties under the Ontario Heritage Act fall within the watershed (see Table 2). It should be noted that this list is not definitive.

If an individual structure was not classified as "Designated" or "Listed" by a municipality, it was not included in the local inventory and consequently is not included in this study.

The sophistication and complexity of the Euro-Canadian settlement of the Highland Creek watershed is demonstrated by the vast array of architectural styles found in the heritage structures defined in the study. Over 15 different architectural styles lend a unique identity to the 19th century Highland Creek landscape which sets it apart from other communities in the Toronto area.

W.J. Morrish Store (1891) - a Highland heritage building

MAP 5: HIGHLAND CREEK WATERSHED
Historical Urban Development



LEGEND
Municipal Boundary
L. Ontario Shoreline
Major Roads
Ponds
Rivers (breaks in river are piped sections)
No Data Available
Development Period
1900-1909
1910-1919
1920-1929
1930-1939
1940-1949
1950-1959
1960-1969
1970-1979
1980-1989
1990-1996
Watershed Boundary
1 0 1 Kilometres

July 1999

THE TORONTO AND REGION CONSERVATION AUTHORITY

DATA SOURCES:
Planimetric and Topographic Data
Energy, Mines and Resources Canada; National Topographic Series, 1:50000. 1986.
Historic Development
Provincial (OAYSIS) Assessment Data. 1997.

TABLE 2: Highland Creek Watershed Built Heritage Structures: Original Use

TYPE	Total
Residential	**58**
Religious	**6**
Trees	**1**
Educational	**4**
Institutional	**1**
Commercial	**8**
Arch	**1**
Cemetery	**11**
Cairn	**1**
TOTAL	**91**

SUMMARY

The Highland Creek watershed has been transformed by the settlement of people from Europe since the late 18th century. Development of the watershed has mirrored that of other areas of southern Ontario, progressing from the initial settlement phase, through the agricultural phase and into the urban phase. This legacy of human occupation has resulted in a rich assortment of 19th and early 20th century cultural resources. Ninety-one heritage structures have been identified and documented. No doubt, many more will be recognized in the future.

CONTEMPORARY CONDITIONS

CHAPTER 4

The watershed today continues to be a home for a diversity of people, who occupy it for residential, business, and recreational purposes. In turn, these people have affected the form and function of the natural heritage system. This chapter will provide an overview of the cultural communities currently living, working, and enjoying outdoor recreation opportunities in the watershed. Current land use, resource use, and urban infrastructure located in the watershed will also be discussed as they influence the natural heritage system.

4.1 CHARACTERISTICS OF CURRENT WATERSHED COMMUNITY

As discussed in chapters two and three, people have lived in the Highland Creek watershed for the last 12,000 years. Euro-Canadian settlement began in a number of distinct communities such as Highland Creek, West Hill, Agincourt, Malvern, Bendale, and others. Some of these communities are still found today, but all are more populous, diverse, and integrated into the larger municipalities of the City of Toronto and Markham. The differences in the size and composition of these distinct cultural communities, as well as of the business communities within the Highland Creek watershed, place different demands on the natural heritage system.

4.1.1 Population

The Highland Creek watershed falls almost entirely within the City of Toronto, with a small section located in the Town of Markham. Updated information from the 1996 Census indicates that there are 341,018 people living within the City of Toronto portion of the watershed. The 1996 census data for the Town of Markham indicates that there are 16,655 living within the Markham portion of the watershed. The current total population in the Highland Creek watershed is therefore approximately 357,673.

4.1.2 Cultural Diversity

The current population of the Highland Creek watershed is more culturally and ethnically diverse than it has been at any other time. Knowledge of this diversity is important for watershed management for a number of reasons. For example, some cultural communities may have little or no participation in watershed regeneration activities because of cultural or language barriers. Indeed, environmental restoration activities will only be successful if they reflect and are supported by such a diverse cultural community.

The latest census information (1996) for the Highland Creek watershed identifies 268,160 individuals who indicated that they were from a single ethnic origin. A total of 61,725 (23.0 percent) were Chinese, 55,315 (20.6 percent) were English, 21,785 (8.1 percent) were Canadian, 20,140 (7.5 percent) were East Indian, 17,790 (6.6 percent) were Black, 10,960 (4.1 percent) were Italian, 9,140 (3.4 percent) were Filipino, 8,640 (3.2 percent) were Greek, 5,270 (1.9 percent) were German, and 3,490 (1.3 percent) were French. Individuals who indicated that they were from a single ethnic community other than those above accounted for 53,905 (20.1 percent) of the 268,160 total. It should be noted that an additional 63,785 individuals indicated that they were from more than one ethnic origin.

4.2 RECREATION, MAJOR GREENSPACE AND TRAIL SYSTEMS

Major opportunities for outdoor public recreation in the Highland Creek watershed are typically found within or near valley and stream corridors. These corridors often contain greenspaces that are the foundation on which a linked, publicly accessible, and diverse open space and trail system has been and can continue to be acquired, protected, or enhanced.

Significant lifestyle trends indicate (RCFTW, 1992):

- leisure time being spent closer to home
- a heightened interest in the environment and out-of-doors for physical and emotional health, and spontaneous recreation activities
- an ageing population which may lead to a rise in the demand for golf, bicycling, walking, and similar outdoor activities related to natural areas
- strong public and community support for linked parks and trails, and the preservation of natural areas

These trends combine to explain the rising demand for a publicly accessible and linked greenspace system consisting of natural areas which have been protected and enhanced to provide passive outdoor recreational opportunities. Through documenting and describing existing opportunities in the watershed, this section emphasizes the potential for increasing the size of, and linkages within, the greenspace system, based on the valley and stream corridors of the (see Map 6: Recreation, Major Greenspace, Trails and Destinations).

4.2.1 Greenspace System: Opportunities and Linkages

Morningside Park

Publicly owned lands and to a lesser degree private businesses have traditionally provided outdoor recreation opportunities for the general public. In the Highland Creek watershed TRCA lands, municipal parklands, trails, and other open space areas provide the basis for a publicly accessible regional and local greenspace system, primarily in the valley and stream corridors. There are two significant west-east hydro corridors bisecting the watershed, which act as extensive informal trail systems. Potential constraints or barriers to a linked greenspace system include Highway 401, private golf courses, and private property.

4.2.1.1 Lands Owned by The Toronto and Region Conservation Authority

The TRCA, in cooperation with the Province, the City of Toronto, and other municipalities, has pursued various objectives of providing for outdoor, regional scale, recreation on lands it has acquired for watershed management purposes. In total, the TRCA owns 406.32 hectares of land in the Highland Creek watershed. Lands acquired by the TRCA in the Highland Creek watershed were primarily for flood control and regional scale recreational purposes. These include the 32.58 hectare Colonel Danforth Park, the 165.22 hectare Morningside Park, and the 61.56 hectare Tam O'Shanter Golf Course. Most of these lands were managed under agreement by the former Municipality of Metropolitan Toronto and are now managed by the City of Toronto.

4.2.1.2 Municipal Parks

The overall open space system provided by municipalities is guided by municipal official plans, parks and open space plans, and trail plans, as well as policies related to urban development. Map 6: Recreation, Major Greenspace, Trails and Destinations provides a summary of the existing outdoor recreational opportunities in the Highland Creek watershed, including those owned by the municipality (City of Toronto). The City of Toronto owns a total of 694.09 hectares within the Highland Creek watershed, representing almost half of the land designated for open space and recreational purposes.

The City of Toronto operates regional scale parks such as Morningside and Colonel Danforth Parks, as recreational destinations. Since its inception in 1955, the regional parks system has evolved to accommodate a wide array of active and passive regional scale leisure facilities and programs on a year round basis.

4.2.1.3 Greenspace Lands for City of Toronto Works Initiatives

The City of Toronto (and previously the City of Scarborough) acquired watercourses and lands in valleys for stormwater management and renaturalization. While a portion of these lands serve a stormwater management purpose, the remainder of the lands provide passive greenspace, natural areas, and opportunities for trails. An example of this initiative is the William Alexander Dempsey EcoPark, located in the headwaters of Centennial Creek subwatershed.

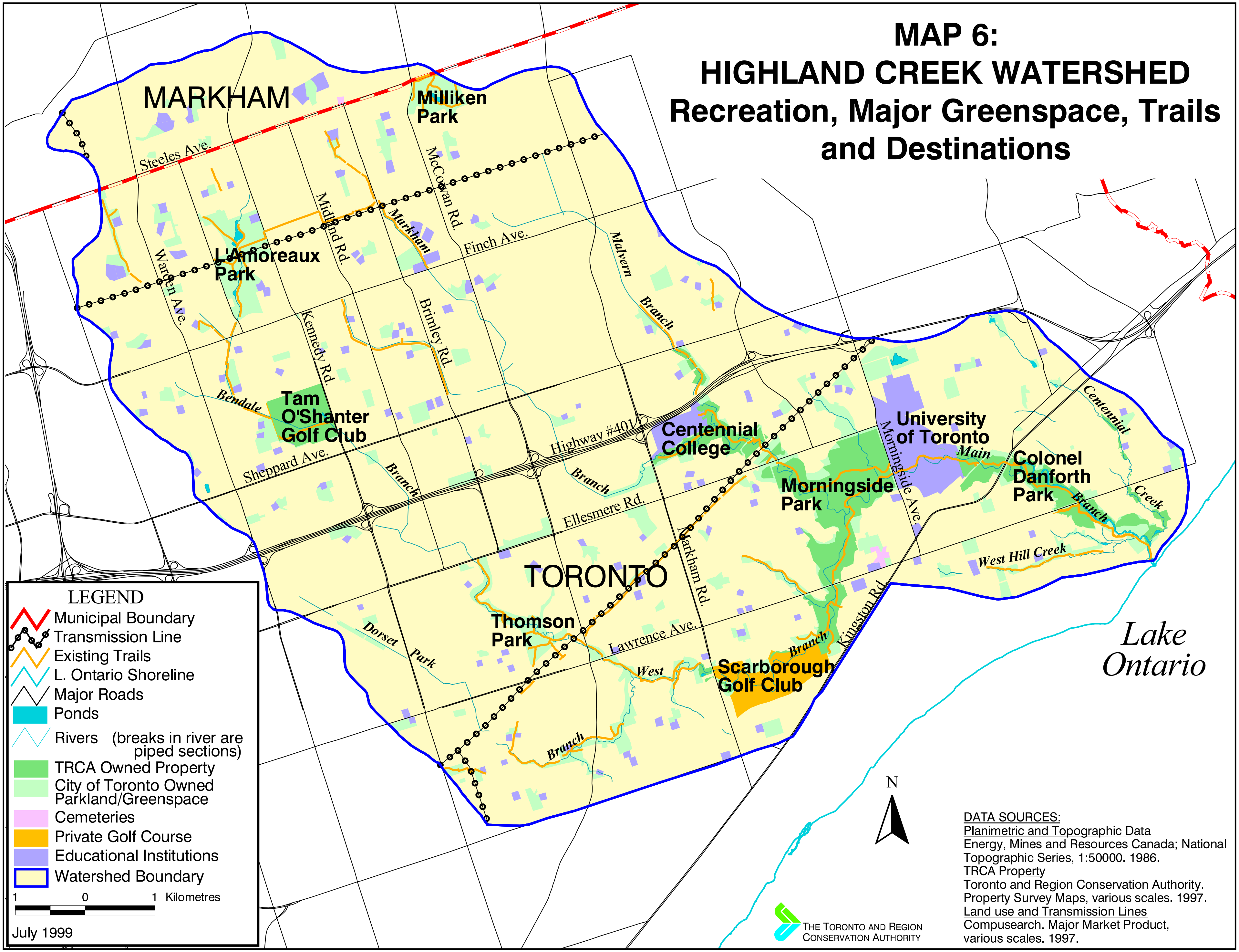
4.2.1.4 Other Recreational Lands

In addition to lands traditionally considered to be public greenspace, public golf courses, cemeteries, and utility corridors are, or can potentially be, used by the public for recreational activities.

Golf Courses
As shown on Map 6: Recreation, Major Greenspace, Trails and Destinations, there are two golf courses located in the valley and stream corridors of the Highland Creek watershed. One is the private Scarborough Golf & Country Club. The other is the publicly owned Tam O'Shanter Golf Course, managed by the City of Toronto.

Utility Corridors
Public utility corridors represent opportunities for public uses such as sports fields and open spaces, and for trail linkages. The Recreation, Major Greenspace, Trails and Destinations Map 6, as well as the Land Use Map 7, identifies two main Ontario Hydro utility (hydro) corridors traversing the watershed in an east/west direction. Portions of a former north/south hydro corridor west of Warden Avenue (between McNicoll Avenue and Lawrence Avenue) have recently been sold by Ontario Hydro and are now re-zoned for a variety of different land uses, including residential and open space (refer to section 10.4.1 for a more detailed description). The more northerly of the east/west corridor runs along the south side of McNicoll Avenue. The more southerly one runs diagonally, beginning south of Lawrence Avenue and ending near Morningside Avenue. These corridors offer the potential to link greenspace within the

Greenspace opportunities



MAP 6:
HIGHLAND CREEK WATERSHED
Recreation, Major Greenspace, Trails and Destinations
MARKHAM
TORONTO
Lake Ontario
Milliken Park
L'Amoreaux Park
Tam O'Shanter Golf Club
Centennial College
University of Toronto
Morningside Park
Colonel Danforth Park
Thomson Park
Scarborough Golf Club
Steeles Ave.
Finch Ave.
Sheppard Ave.
Highway #401
Ellesmere Rd.
Lawrence Ave.
Kingston Rd.
Warden Ave.
Midland Rd.
Kennedy Rd.
Brimley Rd.
McCowan Rd.
Markham Rd.
Morningside Ave.
Markham Branch
Malvern Branch
Bendale Branch
Dorset Park Branch
West Branch
Main Branch
Centennial Creek
West Hill Creek
N
LEGEND
Municipal Boundary
Transmission Line
Existing Trails
L. Ontario Shoreline
Major Roads
Ponds
Rivers (breaks in river are piped sections)
TRCA Owned Property
City of Toronto Owned Parkland/Greenspace
Cemeteries
Private Golf Course
Educational Institutions
Watershed Boundary
1 0 1 Kilometres
July 1999
DATA SOURCES:
Planimetric and Topographic Data
Energy, Mines and Resources Canada; National Topographic Series, 1:50000. 1986.
TRCA Property
Toronto and Region Conservation Authority. Property Survey Maps, various scales. 1997.
Land use and Transmission Lines
Compusearch. Major Market Product, various scales. 1997.
THE TORONTO AND REGION CONSERVATION AUTHORITY

watershed with the adjacent Don and Rouge River watershed greenspaces, and is under consideration as a route for the Trans Canada Trail (a proposed multi-use trail that will link communities across Canada by the end of the Year 2000).

Cemeteries

Due to their landscape character, cemeteries constitute open space and are used for walking, and for linking parks and other greenspaces. Most of the cemeteries in the Highland Creek watershed are quite small in size and are not linked to other open space areas. Of these, St. Margaret's Cemetery north of Lawrence Avenue East, east of Galloway Road is the largest within the watershed.

Educational Institutions

School sites are typically clustered with other public facilities such as parks, and are located adjacent to valley and stream corridors. Several elementary and secondary schools within the watershed have outdoor sports facilities, fields, playgrounds, and open spaces that the public can use, and function as links to other greenspace areas.

Two educational institutions hold major parcels of land within the watershed. These are the University of Toronto (Scarborough College) and Centennial College. The University of Toronto owns a large parcel between Ellesmere Road, Military Trail, Old Kingston Road and Morningside Avenue. This parcel includes the entire Highland Creek valley between Colonel Danforth and Morningside Parks. Centennial College sits on table land south of Highway 401 and east of Progress Avenue, overlooking the confluence of the Malvern and Markham Branch of Highland Creek.

4.2.1.5 Trail System

There are approximately 54 kilometres of trails in the Highland Creek watershed, which include multi-use routes intended to service pedestrians, cyclists, and roller-bladers. The existing formal and proposed off-road trails in the watersheds are indicated on Map 6: Recreation, Major Greenspace, Trails and Destinations. Trail development in the Highland Creek watershed is directed toward meeting the recreational needs of both the regional and local populations.

Highland Creek Trail

4.2.1.5.1 Local and Regional Trail Systems

Many of the trails throughout the watershed are isolated, unconnected, and not part of the valley and stream corridor, as seen on Map 6: Recreation, Major Greenspace, Trails and Destinations. The greatest barriers to a linked trail system in the Highland Creek watershed are Highway 401 and privately owned lands.

A continuous trail system is available throughout a large part of the main valley of Highland Creek from the mouth to above the confluence on the West branch. From there, almost to Markham Road, the valley is occupied by the privately owned Scarborough Golf & Country Club. The trail continues farther upstream along sections of the Bendale and Dorset Park branches. Trails also exist north of Highway 401 along reaches of the Markham, Bendale and Malvern branches, but these are not fully connected to each other nor do they cross the Highway. Undesignated informal trails through hydro corridors are also used by the community.

The development of additional links between existing segments of trails, between various parts of the watershed (north and south), and to neighbouring watersheds, would provide a greater range of recreational opportunities for the community. To make this a reality, it would be necessary to link existing trails with future trails in parks, open space and private property, hydro and rail corridors, and cycling routes on roads (Victor Ford and Associates Inc., 1998).

4.2.1.5.2 Inter-Regional Trails

The regional Waterfront Trail, established along much of the north shore of Lake Ontario between Burlington and Trenton, connects from the west to the Highland Creek Trail System at the mouth of Highland Creek, along the southerly limit of the watershed. It is discontinued between the mouth of Highland Creek and the mouth of the Rouge River, but continues farther east from the Rouge.

A second regional trail called the Trans Canada Trail is proposed to pass through Toronto, following along part of the existing Waterfront Trail. The proposed Highland Creek section is aligned along the Waterfront Trail from East Point Park in the west, and would c mouth of the creek at the proposed Port Union Waterfront Improvement Project bridge, linking u Union Waterfront Improvement Project. The Port Union Waterfront Improvement Project is a community driven initiative that has the mandate of providing safe community access to the Lake Ontario shoreline.

The implementation of the proposed Port Union Waterfront Improvement Project would establish a trail between the mouth of the Highland Creek to the Rouge River, creating a trail link between the Don and Rouge River watersheds.

4.3 LAND USE

From the 1850s to the 1950s, the Highland Creek watershed was predominately agricultural. Urban development was sparse, concentrated primarily in the hamlets of Agincourt and Highland Creek-West Hill (see Map 5: Historical Urban Development). One limiting factor to urban growth was the lack of adequate transportation links between the watershed and the City of Toronto. The main transportation link was via Highway #2 (Kingston Road) which traverses the lower portion of the Highland Creek watershed. This restricted most urban development to the southerly extremes of the watershed.

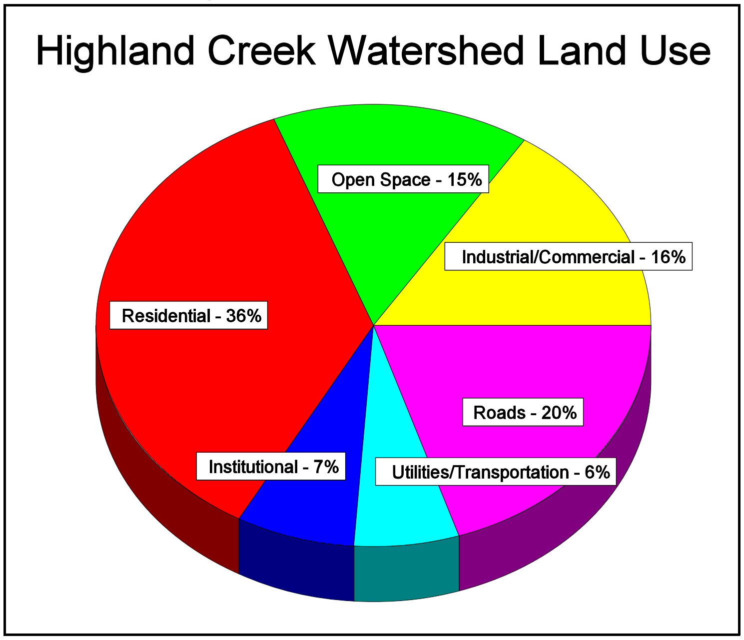
The prospects for additional urban development changed dramatically upon the completion of Highway 401 through Scarborough in the mid 1950s. Quick and easy access to the Metropolitan Toronto area became available upon the opening of this new Highway in 1956. This access, coupled with the post World War II baby boom and a shift of the population to the suburbs, resulted in the rapid development of the watershed. Agricultural fields were soon replaced by residential subdivisions, commercial shopping malls, and industrial factories. This urban development would continue for the next forty years.

The progression of urban development in the watershed began in the south and continued in a northerly direction toward the headwaters. By 1976, approximately 61 percent of the Highland Creek watershed was covered by urban development (Kilborn, 1977). Development within the watershed has continued since, and it is now characterized by large areas of land devoted to low density uses, whether they be residential, commercial/office, industrial, or educational institutions such as the Scarborough Campus of the University of Toronto.

Based on 1997 Provincial Assessment data, 85 percent of the watershed is covered by urban uses comprised of: 16 percent Industrial/Commercial; 36 percent Residential; 7 percent Institutional; 6 percent Utilities/Transportation; and 20 percent Roads. The remaining 15 percent of the watershed is covered by Open Space (Agriculture, Cemetery, Golf Courses, Greenspace and Park/Recreational Areas) (Province of Ontario -OAYSIS-, 1997). As such, the Highland Creek watershed is now the most urbanized of all the watersheds within the TRCA’s jurisdiction.

For the *State of the Watershed Report*, the above six categories have been used to broadly define land use patterns in the Highland Creek watershed (detailed information on land use patterns and policies can be found in the Official Plans of the City of Scarborough and the Town of Markham).

FIGURE 2: Highland Creek Watershed Land Use - 1997



- *Open Space*: Includes TRCA lands, parklands, cemeteries, golf courses, private parks, undeveloped lands adjacent to highway corridors, vacant lands, agriculture, and undeveloped valley and stream corridors. For a more detailed map that differentiates between some of these types of open space, see Map 6 located in section 4.2: Recreation, Major Greenspace, Trails and Destinations.

- *Residential:* Although there are some pockets of high density development, the vast majority of residential development in the watershed is low to medium density and thus is not differentiated in any mapping or analysis.

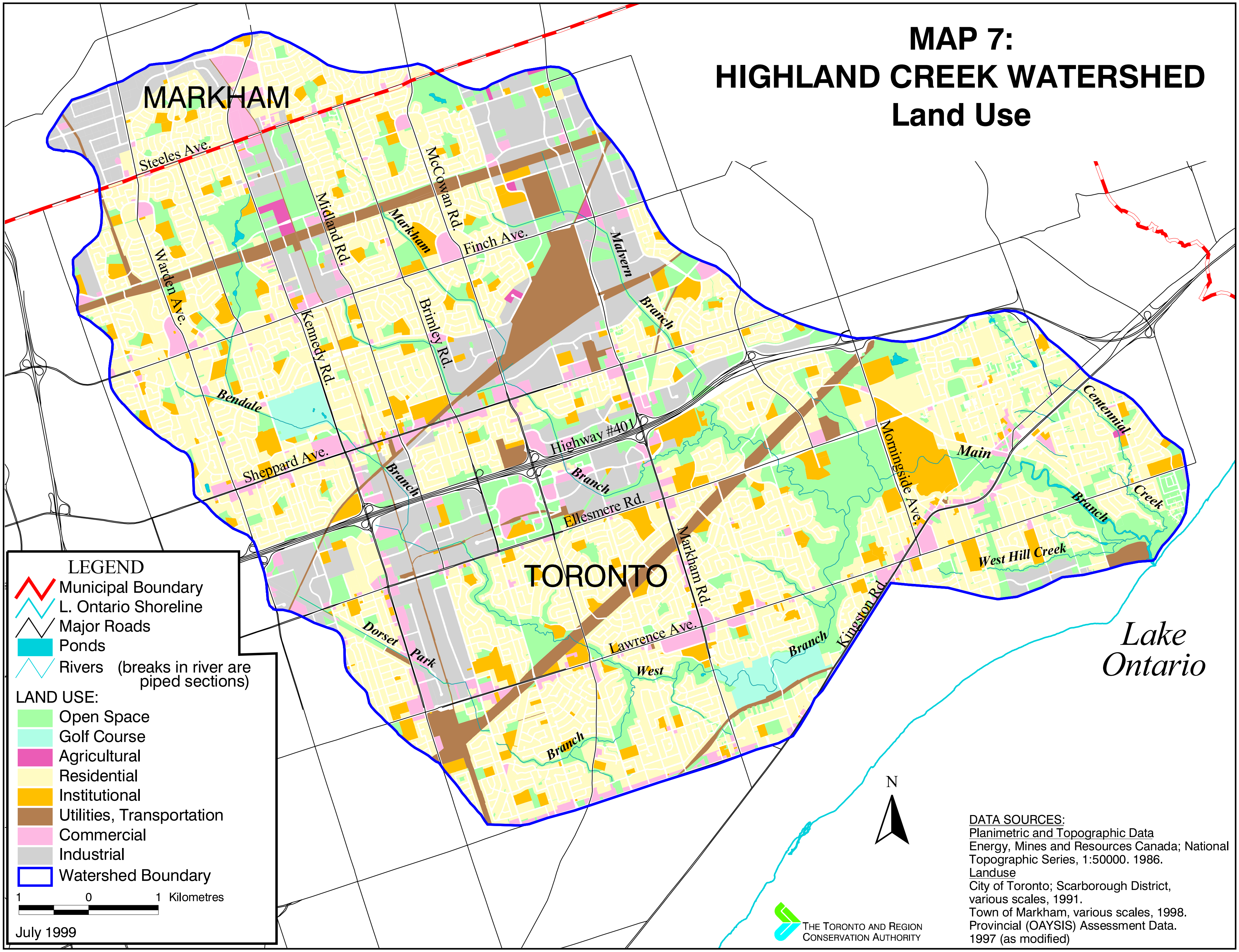
- *Institutional:* This includes lands upon which government institutions are located. For example, schools, hospitals, churches, fire and police stations.

- *Industrial/Commercial*: Lands used for manufacturing and industrial purposes, including both light and heavy industrial, retail, commercial, and office purposes.

- *Roads:* Includes all streets, road allowances, and parking lots.

- *Utilities, Transportation:* Railways, hydro corridors, pipelines, and unopened transportation corridors.

A more detailed representation of these categories can be seen on Map 6: Land Use following this section. Changes in land use are constant and ongoing, and present opportunities for environmental improvements. Opportunities such as these are discussed in more detail in Section 10.4.2.


MAP 7:
HIGHLAND CREEK WATERSHED
Land Use
MARKHAM
TORONTO
Lake Ontario
Steeles Ave.
Finch Ave.
Sheppard Ave.
Highway #401
Ellesmere Rd.
Lawrence Ave.
Kingston Rd.
Warden Ave.
Kennedy Rd.
Midland Rd.
Brimley Rd.
McCowan Rd.
Markham Rd.
Morningside Ave.
Markham
Malvern
Branch
Bendale
Branch
Branch
Dorset
Park
West
Branch
Branch
Main
Branch
Centennial
Creek
West Hill Creek
N
LEGEND
Municipal Boundary
L. Ontario Shoreline
Major Roads
Ponds
Rivers (breaks in river are piped sections)
LAND USE:
Open Space
Golf Course
Agricultural
Residential
Institutional
Utilities, Transportation
Commercial
Industrial
Watershed Boundary
1 0 1 Kilometres
July 1999
DATA SOURCES:
Planimetric and Topographic Data
Energy, Mines and Resources Canada; National Topographic Series, 1:50000. 1986.
Landuse
City of Toronto; Scarborough District, various scales, 1991.
Town of Markham, various scales, 1998.
Provincial (OAYSIS) Assessment Data. 1997 (as modified)
THE TORONTO AND REGION CONSERVATION AUTHORITY

4.4 URBAN INFRASTRUCTURE

Urban development is built on infrastructure. For watershed management, and for describing current conditions within the Highland Creek watershed, infrastructure to treat water is important for discussion. The effects of transportation infrastructure and utilities are also relevant because in addition to their importance in servicing economic development, they affect the natural heritage system.

In addition to the minor conveyance system of sanitary sewers, storm sewers and water mains, City infrastructure also includes the major drainage system comprised of overland flow routes, natural streams and valleys, and the man-made channels, ponds and all other storm runoff conveyance mediums accommodating the residual flows in excess of the minor system capacity. During peak flows streets also serve as part of the major drainage system (City of Toronto Drainage Policy, 1998). The City of Toronto Works and Emergency Services Department views watercourses as an integral part of their infrastructure system not only from a storm drainage point of view, but also from a water quality and greenspace perspective.

4.4.1 Water and Sewage

Drinking water for inhabitants of the Highland Creek watershed is supplied from Lake Ontario via the R.C. Harris Filtration Plant located at the foot of Victoria Park Avenue, and the F.J. Horgan Filtration Plan located at the foot of Manse Road (Fenco MacLaren et al., 1996). Wastewater in the Highland Creek watershed is treated by the Highland Creek Water Pollution Control Plant (WPCP), located at the mouth of Highland Creek. Construction on the plant began in 1954 and the initial phase was completed in 1956. Expansion has continued since that time to keep pace with development (Fenco MacLaren et al., 1996). Water pollution control plants are designed to remove human waste sewage, and limited quantities of industrial and other sewage. These plants were not designed to treat pollutants such as heavy metals and toxic organic compounds (ie. pesticides). Despite these limitations, the WPCP's receive a number of chemicals through the dumping of paints, solvents, cleaners, and other substances commonly used by households and industry, into the sewage system. Although some of these other pollutants are removed through the sewage treatment process, many remain in the effluent discharged into Lake Ontario. When water is drawn from the lake for purposes such as drinking, it may contain trace amounts of these same pollutants.

4.4.2 Transportation

The transportation systems within the Highland Creek watershed consist of roads and highways, rail, and public transit.

Highway 401 corridor through the Highland Creek watershed

Roads and Highways
The increased use of the automobile on the city's roads and highways impacts local air quality, contributing to the health hazards associated with smog, and overall global warming or climate change. In addition, many roads and highways cross natural areas reducing the amount of habitat available and creating barriers to the movement of fish and wildlife. Roads and highways can also affect the water quality of local watercourses through stormwater runoff and spills.

Approximately 20% of the Highland Creek watershed is covered in roads, which includes all of the travelled portions, as well as other road allowances and parking lots. Highway 401 traverses the watershed, dividing it into two sections. It is the most travelled highway in Canada, resulting in congestion along its route through the Greater Toronto Area.

Rail
Canadian National (CN) and Canadian Pacific (CP) rail lines are located within the Highland Creek watershed. These rail lines are used mainly to service industry. The CN rail line traverses across the southern portion of the watershed and additionally provides for GO Transit (Government of Ontario Transit - soon to be called Greater Toronto Transit) commuter rail service along the north shore of Lake Ontario. The CP rail line traverses across the watershed in a north-east/south-west direction, and the CP major east end marshalling yards are located within the watershed in the area bounded by Finch Avenue East on the north, Markham Road on the east, Nugget Avenue on the south, and McCowan Road/Middlefield Road on the west.

Public Transit
The transit system within the Highland Creek watershed consists of a combination of buses, subways, and trains. The Scarborough Rapid Transit Line runs through the Highland Creek watershed, from McCowan Road/Ellesmere Road, west to Kennedy Road/Eglinton Road, where it meets with the eastern

terminus of the Toronto Bloor-Danforth subway line. The Scarborough Rapid Transit line extension to Markham Road and Sheppard Avenue is planned and approved but unfunded. Also, as identified above, GO Transit commuter train services traverse the southern boundary of the watershed. Public transit facilities such as these alleviate traffic congestion, as well as consume less fuel and land, and emit fewer pollutants than automobiles.

4.4.3 Utilities

Several public utility corridors cross the Highland Creek, including hydro corridors, gas pipelines, and unopened transportation corridors. Such corridors present opportunities for public use, and links to adjacent watersheds.

SUMMARY

The Highland Creek watershed is very diverse, from a cultural perspective. During the preparation of a Highland Creek watershed management strategy it will be important to adjust community consultation to assist persons from different cultural backgrounds to become aware and involved, as different cultural traditions may provide a more diverse set of issues and outcomes.

Historical development has resulted in the watershed being dominated by low density residential land uses, with extensive transportation and utility corridors. Although 85 percent of the land is covered by urban uses, there are still many opportunities for the development of a linked, comprehensive trail and greenspace system that takes advantage of existing open space features. The transportation corridors traversing the watershed present a challenge to linking the southern part of the watershed to the northern part, with a greenspace system.

Natural Heritage includes the physical, chemical, and biological elements of the environment -- what is often termed *Nature* or the *Environment*. A Natural Heritage System refers to the interactions and dependencies between and among the physical, chemical, and biological elements of natural heritage. It is these interactions that control the hydrologic cycle and the quality of habitat for plants, animals, birds, and fish.

The concept of natural heritage has frequently been used with initiatives to conserve natural areas, species, and ecosystems at risk (Riley and Mohr, 1994). However, this approach to natural heritage is narrow since it focuses on *landscape features* (such as woodlots and wetlands) and neglects the many interactions that occur within the entire *landscape system*. A broader approach, such as the one taken in this report, recognizes that the features and functions of the natural heritage system are present throughout the Highland Creek watershed, in a continuum from the nature dominated (e.g., woodlots and wetlands) to the human dominated (i.e. urban) landscapes. Urbanized ecosystems consist of natural features and built structures, that function differently from more natural (and often rural) landscapes in the way that they cycle water, air, and nutrients.

In this report, natural heritage has been defined as the basic fabric of the landscape and thus is synonymous with the environment. This discussion of natural heritage and the natural heritage system is based largely on work of the Natural Heritage subcommittee of the Humber

NATURAL HERITAGE

Watershed Task Force and documented in *Natural Heritage of the Humber River Watershed: Strategies for the Protection and Enhancement of the Natural Heritage System* (1996). From this perspective, natural processes and nature are present everywhere. Specific locations differ only in the way they function within the overall system. Viewing the landscape in this way allows management activities to focus on the important interactions within and between landscape features.

The natural heritage system can be described in terms of four components:

- *land* including landforms, soils and geology
- *air* including climate and air quality
- *water* including surface and ground
- *life* including plants, animals and humans

Characterizing natural heritage in terms of these four components provides a framework for describing natural features. More importantly, it allows for description and analysis of the many interactions and interrelationships between components of the natural heritage system. Climate, land form, and composition are the driving forces that, in combination with society's influence, have determined the features and functions found within the watershed today. Individual features include such things as woodlands, wetlands, watercourses, valleys, and aquifers. It is the interaction between these features in the watershed that begins to define the functions that are performed.

The functions performed in the watershed vary from simple to complex interactions. For example, a woodlot can function as a habitat for many birds, mammals, and amphibians, but it also performs more complex functions by influencing the characteristics of surface runoff. The runoff characteristics in turn affect the characteristics of local watercourses and thus fish habitat. Thus the simple woodlot not only functions by directly providing habitat for specific species, but indirectly influences the characteristics of aquatic habitats.

There are far more interrelationships within the natural heritage system than can be described in this section of the *Highland Creek State of the Watershed Report*. However, through knowledge of the interactions within the natural heritage system, an understanding of how the system functions can be gained, and thus direction can be developed as to what might be achieved through regeneration activities. This part of the report provides a framework for developing an understanding of how the natural heritage system operates in the watershed. In the four chapters that follow, the condition of the Highland Creek watershed is described in terms of the four components of the natural heritage system: land, air, water, life.

LAND

CHAPTER 5

The Highland Creek watershed is approximately 102 km^2 in size, which is small compared to the other watersheds within the Greater Toronto Area. The creek flows through two physiographic regions on its way to Lake Ontario: the South Slope, and the Lake Iroquois sand plain (see Map 8: Physiographic Regions). The surficial deposits and soil characteristics of these regions play an important part in the natural heritage system of the watershed.

5.1 GEOLOGIC HISTORY

Over the last 120,000 years, numerous ice ages have affected the lands that eventually became North America (Theberge, 1989). About 13,000 years ago the last glacier flowed along the St. Lawrence valley into present day Lake Ontario. As this thick lobe of ice moved over the landscape, it scoured the surface and carried billions of metric tons of rocks and soil bound up within it. North of Toronto it collided with another glacier moving south from northern Ontario, depositing tons of soil and rock that had been scraped off of many kilometres of land by both glaciers. This created the Oak Ridges Moraine. The moraine sets the northerly limit of the Greater Toronto Bioregion, and forms the headwaters of many Greater Toronto Area rivers (RCFTW,1992).

The last glaciers covering southern Ontario began to melt about 12,500 years ago, but a remaining ice jam blocked the St. Lawrence valley, forcing the water to flow over higher ground across present day New York State and down the Hudson River valley. The backup of water created a lake larger than present day Lake Ontario, called Lake Iroquois (Archaeological Services Inc. et al., 1994).

The ice jam in the St. Lawrence River valley melted away approximately 11,500 years ago, Water which had previously flowed down the Hudson River valley took a new, lower route along the St. Lawrence to the Atlantic Ocean, resulting in dramatically lower levels in Lake Ontario (Archaeological Services Inc. et al., 1994). By about 11,400 years ago, the lake hit its lowest level and was about 80 metres lower than today (Anderson et al.). Over the next several thousand years the water levels of the lake slowly began to increase as the St. Lawrence Valley, no longer covered by a heavy ice sheet several miles thick, began to rebound and increased in elevation. By about 4,000 years ago, present day lake levels were reached (Archaeological Services Inc. et al., 1994).

5.2 PHYSIOGRAPHY OF HIGHLAND CREEK

The following describes the different physiographic regions found within the Highland Creek watershed. Figure 3: Conceptual Groundwater Flow Model for the Rouge River-Highland Creek Watershed, depicts these regions diagrammatically.

South Slope

The headwaters of Highland Creek begin in the area defined as the South Slope (see Map 8: Physiographic Regions). The South Slope lies to the south of the Oak Ridges Moraine and to the north of the Lake Iroquois sand plain. In the Highland Creek watershed, the South Slope is actually made up of a number of layers of material laid down by successive glaciers over the last 150,000 years (Karrow, 1967).

The oldest layer is the sands, silt and clays of the Scarborough and Don Formations, which were deposited between 135,000 and 60,000 years ago. This deposit has been designated as the 'Lower Aquifer' under the Highland Creek watershed, and lies on top of weathered shale bedrock (Eyles et al., 1998).

Above the Scarborough Formation lies the Sunnybrook Formation, which was laid down about 50,000 years ago. This layer is less permeable and acts as a barrier to the movement of ground water (Eyles et al., 1998).

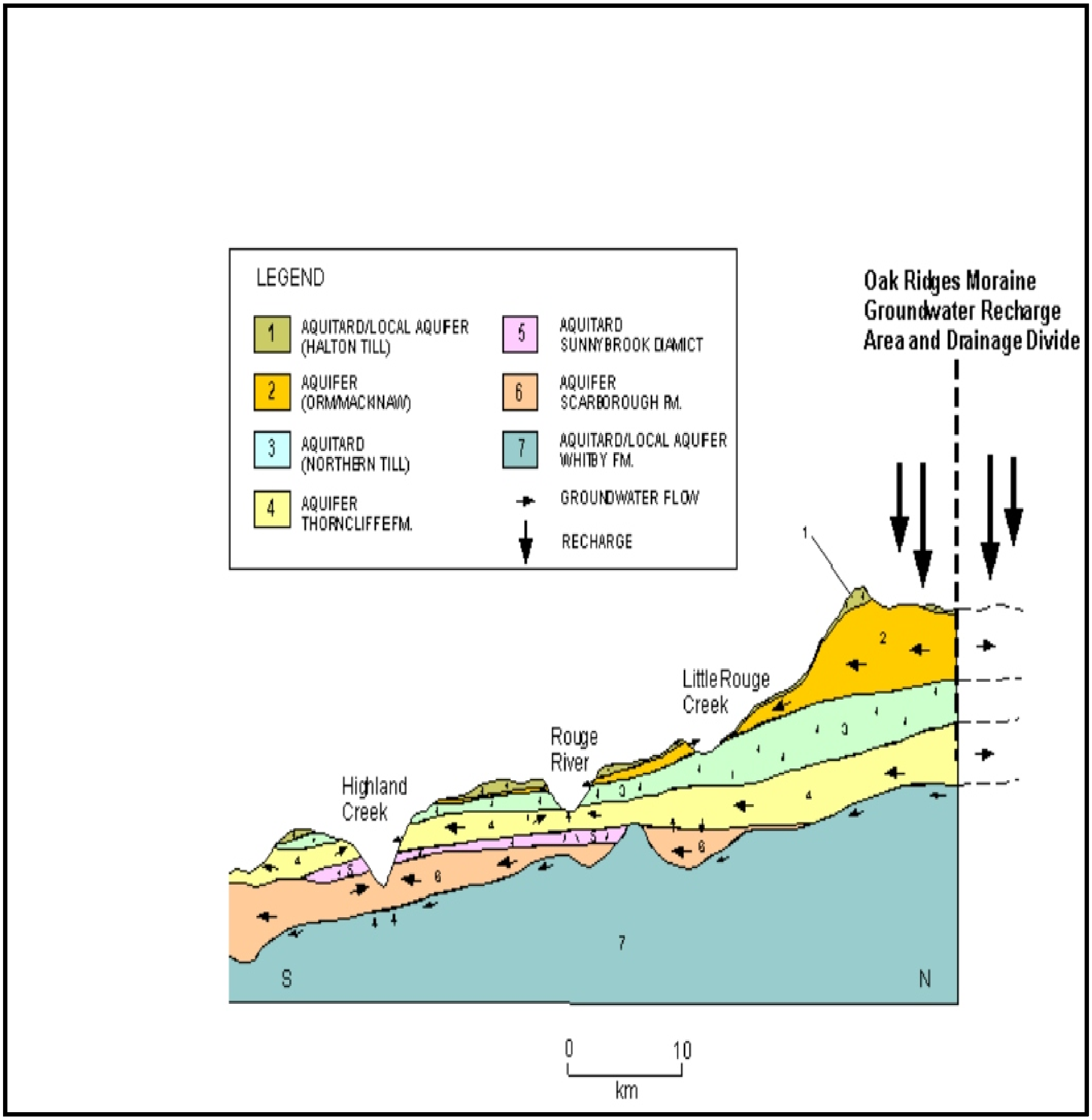
The layer above this, known as the Thorncliffe Formation, is comprised of layers of sands, silt and clays laid down about 45,000 years ago. This is known as the 'Middle Aquifer' (Eyles et al., 1998).

Over the Thorncliffe Formation lies the Northern Till, another less permeable layer, laid down between 20,000 and 45,000 years ago that acts as a barrier to the movement of ground water (Eyles et al., 1998).

Above this layer lies patches of the Halton Till/Mackinaw Interstadial Formations (sand and gravel). These were laid down approximately 13,300 years ago. For the most part these soils are relatively impermeable. However, some areas are comprised of more permeable sands and gravel, while other areas are extensively weathered allowing water to percolate beneath the surface. These soils act as the 'Upper Aquifer' in this region of the Highland Creek watershed (Eyles et al., 1998).

Some interesting features created by the glaciers are a series of little hills called drumlins. These features are usually found in groups and "point in the direction of movement of the glacier" (Chapman & Putnam, 1984, pg. 16). In the watershed, groups of drumlins are found in the Wexford and Malvern areas, as well as northwest of Agincourt (Chapman & Putnam, 1984). The soils of the South Slope are relatively impermeable so any precipitation that falls here quickly runs off to the local watercourses.

FIGURE 3: Conceptual Groundwater Flow Model for the Rouge River - Highland Watershed



Source: M. Meriano, 1999

Lake Iroquois Plain

Comprised mostly of permeable sands, the Lake Iroquois Plain was created about 12,500 years ago along the shores of glacial Lake Iroquois. This gravel and sand shoreline forms the southern boundary of the South Slope, cutting across the bottom of the Highland Creek watershed (see Map 9: Surficial Geology). This ancient shoreline, itself a distinctive ridge feature, ran roughly along present day Kingston Road, east of Markham Road, before turning in a north-east direction toward the Rouge River. It is comprised largely of sand and gravel, and was used by many sand and gravel companies (see Map 9: Surficial Geology). The area south of the Lake Iroquois beaches is made from sediments that were carried down from the South Slope by the ancient Highland Creek thousands of years ago and deposited offshore (Chapman & Putnam, 1984). When the ice dam in the St. Lawrence melted and the waters of Lake Iroquois fell to much lower levels, these beaches were left high and dry.

Known as the Iroquois sand plain, this area is composed of permeable sandy soils which act as the shallow, or 'Upper Aquifer' in this section of the Highland Creek watershed (Eyles et al., 1998). They allow precipitation to readily infiltrate the ground, resulting in ground water discharge to the creek. Groundwater discharge plays an important role in the hydrology of the creek and thus will play a prominent role in any future restoration plans for the creek.

Valley and Stream Corridors

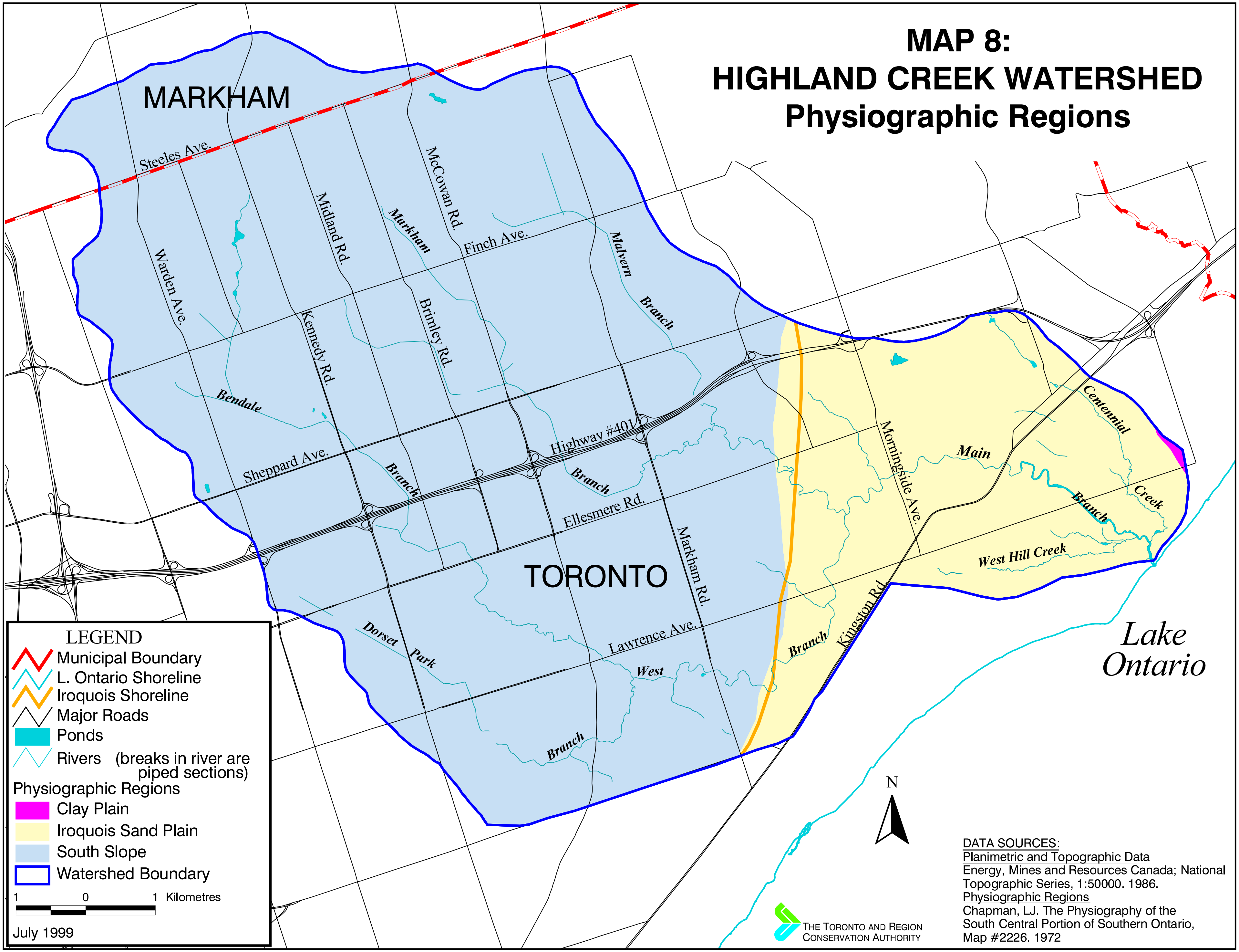
Valley and stream corridors are formed by natural processes which continue to influence the landforms, features, and functions, today. These corridors are the conduits for the collection and movement of water through the landscape. They are dynamic systems that perform important ecological functions such as the:

- transport of nutrients and sediments
- provision of habitat and routes for the movement of fish and wildlife
- improvement of air quality (forest cover)
- attenuation of noise
- creation of microclimates
- maintenance of a genetic pool for native flora and fauna
- hydrologic regulation

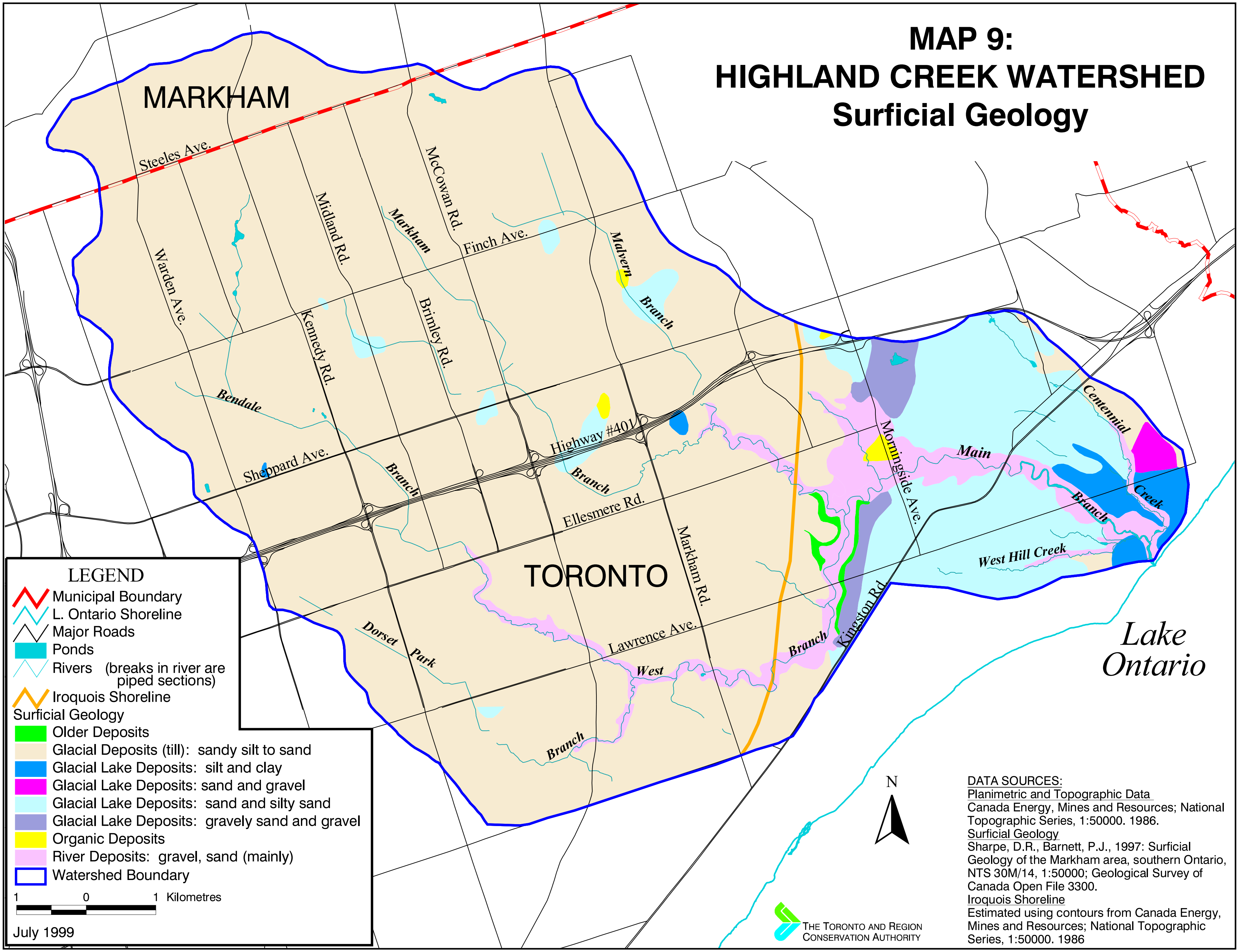
Valley and stream corridors are important biological and physical linkages which both contain and link many of the provincially, regionally, and locally designated significant natural areas. They are valued landscape features providing diversity and contributing to environmental quality and the provision of open space and recreational opportunities, and contain rich archaeological resources.

In many ways, the network of valley and stream corridors in a watershed can be viewed as a tree, with the main branch of the watercourse seen as the trunk and the radiating tributaries acting as the branches. Valley corridors are distinctive features which have been carved in the landscape by the movement of water over

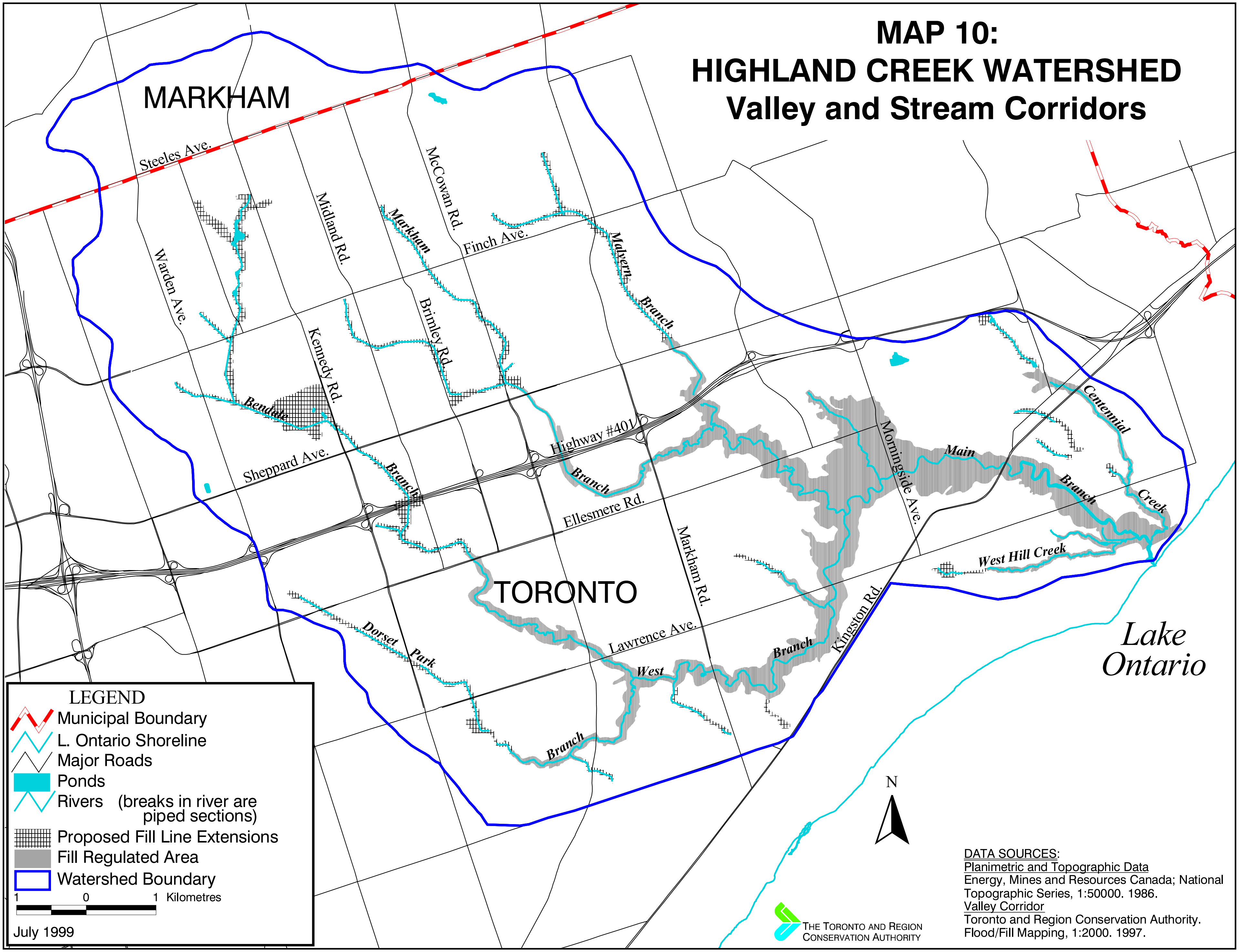
MAP 8: HIGHLAND CREEK WATERSHED Physiographic Regions



MAP 9:
HIGHLAND CREEK WATERSHED
Surficial Geology



MAP 10: HIGHLAND CREEK WATERSHED
Valley and Stream Corridors



time. Such distinct valley features are most apparent in the lower portions of the Highland Creek watershed south of Highway 401 (see Map 10: Valley and Stream Corridors). Stream corridors, on the other hand, are less distinct than valley features, and generally consist of a watercourse and associated floodplain. In the Highland Creek watershed this includes most of the watercourses above Highway 401.

The function and form of valley and stream corridors are influenced by a number of factors including natural processes such as precipitation and land use practices in the watershed.

SUMMARY

The landform features discussed in this chapter (the south slope, the Lake Iroquois sand plain, and the valley and stream corridors) are important components of the natural heritage system. Of particular interest is the impact of these features on the hydrologic cycle, or movement of water, within the watershed. The valley and stream corridors provide wonderful opportunities for outdoor recreation. However, settlement and, more recently, extensive urban development, has impacted the functioning of these landform features. For example, filling, burying, piping and other watercourse alterations have resulted in a loss of these corridors and along with it a reduction in terrestrial, riparian, and aquatic habitat.

AIR

CHAPTER 6

For watershed planning and management, climate and air quality are important factors as they affect and are affected by land use and human activities. Changes in climate can affect the quantity and quality (temperature, dissolved oxygen, assimilative capacity, etc.) of water in river systems. Changes in air quality can affect water quality, vegetation, and the health of humans and wildlife.

6.1 CLIMATE

Climate is a major force shaping the natural heritage system of the Highland Creek watershed. Defined as the "long range, average pattern of quantity and seasonal distribution of temperature, precipitation and humidity" of a particular region (Miller & Armstrong, 1982, pg. 47), climate provides the basis for the types of habitat communities present in the watershed and in turn the species of wildlife that inhabit them.

The Highland Creek watershed lies in the transition area between two climatic zones: the Moderate Temperate zone, and the Cool Temperate zone (Environment Canada, 1997c). Each of these zones has a particular vegetation and habitat community associated with it. These differences are more fully described in Section 8.1.1.

In the Moderate Temperate zone, climatic conditions lean toward humid and warm to hot summers with mild and snowy winters. Temperatures remain above 0 degrees C for eight to nine months of the year (April to November). Further north in the Cool Temperate zone conditions are cooler. Summers are warm while winters are mild. Temperatures remain above 0 degrees C for eight to nine months of the year (Environment Canada, 1989). See Figure 4 for a summary of temperatures in the Highland Creek watershed (1961 and 1990).

In the Highland Creek watershed, precipitation is fairly evenly distributed throughout the year (see Figure 5)(data for January and February is not available for the Ellesmere Station). Precipitation rates vary from a low of 56 millimetres in March to a high of 83.5 millimetres in August (Environment Canada, 1991).

Within the watershed, Lake Ontario's impact on air temperature and precipitation exhibits the greatest influence on micro-climates. Generally, Lake Ontario has a moderating effect on temperature. Landform features can also

FIGURE 4: Highland Creek Watershed Monthly Mean Temperatures, 1961-1990

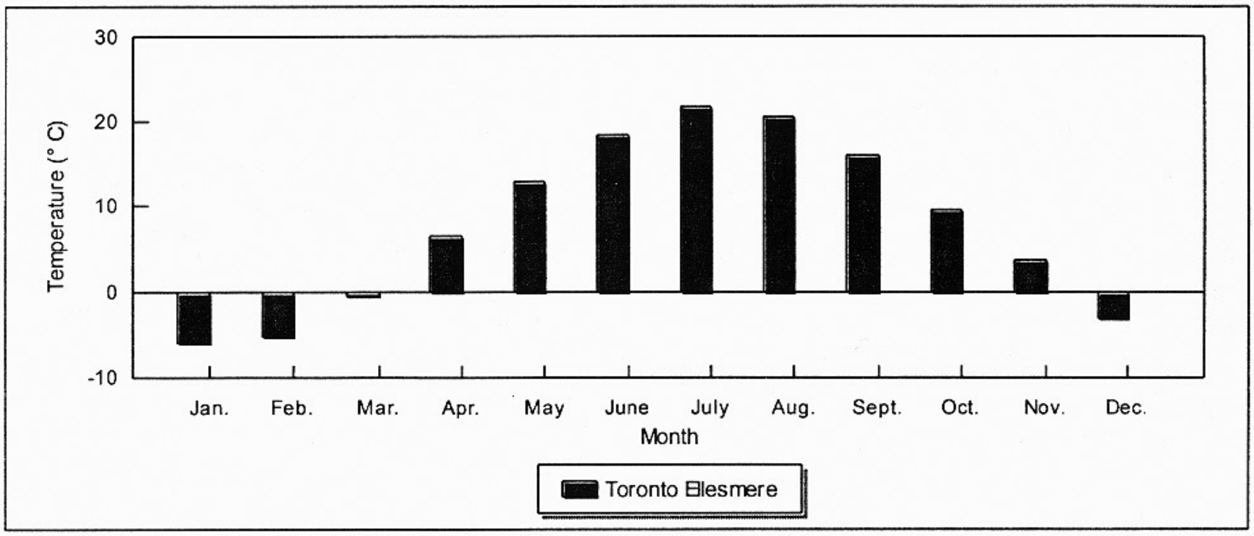
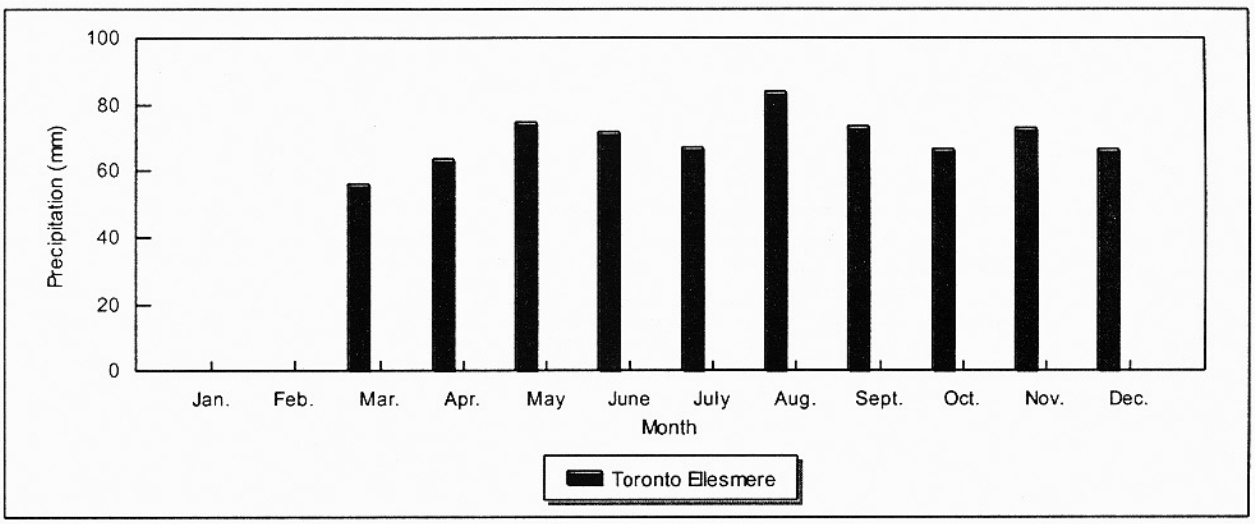


FIGURE 5: Highland Creek Watershed Monthly Mean Precipitation, 1961-1990



Source: Environment Canada, 1993.
Note: Precipitation data is not available for the Ellesmere Station for January or February.

Figures 4 and 5 provide a summary of the temperature and precipitation patterns in the Highland Creek watershed. Measurements were taken by Environment Canada at the Monitoring Station located at Lawrence Avenue East and Kennedy Rd.

affect micro-climates. For example, south facing valley slopes are drier, less shaded, and warmer than north facing slopes. Since the Highland Creek watershed is located at the northern extreme of the Carolinian Forest Region, south facing slopes and flat lands tend to support more Carolinian vegetation. Carolinian vegetation is not likely to be found on cooler, more moist, north facing slopes. In these ways, landscape features influence local climate which in turn influences other components of the natural heritage system.

Land use can also affect climate at the local level. Urbanization alters the earth's surface and its ability to absorb and reflect sunlight as well as release heat. Due to large amounts of impervious surfaces, urban development can influence local climate in a number of ways. For example, overall evaporation can be reduced if rainfall is quickly drained away. Extensive urban development creates an *urban heat island* which is thought to be caused by heat given off by buildings and vehicles combined with increased heat retention by paved, stone, and concrete surfaces. Within the watershed this results in warmer summer and winter temperatures. This can affect vegetation communities and the hydrologic cycle, by causing more precipitation in winter to occur as rainfall.

In general, the climate in urban areas can greatly impact human health. For example, in the summer, heat stress is typically more pronounced due to higher than average temperatures combined with increased pollutant levels. This can severely affect the health of the elderly, very young, and those with respiratory problems, making outdoor activity difficult and potentially hazardous.

6.2 CLIMATE CHANGE

The greenhouse effect is a natural process, without which global average temperatures would be too low to sustain life. Greenhouse gases (e.g., water vapour, carbon dioxide, nitrous oxide, and methane) trap heat in the atmosphere and warm the earth. The problem is that greenhouse gases are increasing in the atmosphere largely because of human activities. These increases are enhancing the greenhouse effect and trapping more heat (Scheraga, 1998).

Change in global climate due to human activities is a controversial and intriguing issue. Current research indicates that atmospheric concentrations of carbon dioxide (CO_2) are expected to double by the year 2060. This doubling is relative to levels prior to the Industrial Revolution, before the beginning of major fossil fuel use (Scheraga, 1998).

Much of the controversy surrounding climate change is related to our ability to reduce or eliminate the impacts of increasing levels of carbon dioxide in the atmosphere. It is argued that even with the best efforts to reduce CO_2 loadings by Canada, the United States, and other major emitters of greenhouse gases, the doubling of concentrations in the atmosphere will occur regardless. This is a result of an increasing share of emissions coming from developing countries

(Scheraga, 1998). Efforts to reduce loadings must continue to ensure CO_2 is not increased beyond the anticipated levels (i.e., greater than a doubling of CO_2). A doubling of the amount of CO_2 and increases in other greenhouse gases will result in the atmosphere trapping a higher percentage of the sun's incoming solar radiation within the earth's atmosphere. This will increase the earth's overall mean temperature and allow for a greater amount of water vapour to remain in a gaseous state. The ability of the atmosphere to contain higher amounts of water vapour will affect the functioning of the hydrologic cycle and directly affect the Great Lakes and the rivers within the Toronto region. The anticipated impacts include lower baseflows, lower lake levels, longer and more severe drought periods, milder winters, and a change in precipitation patterns resulting in more intense rainfalls. All these anticipated changes could have implications for managing water and associated natural heritage resources.

Within the City of Toronto, the potential implications of climate change on watershed management activities could include the following:

- Fisheries management may be affected due to temperature changes and lower baseflows within rivers and streams.
- More intense rainfalls may result in more frequent flooding events of rivers. This will have an impact on urban infrastructure by increasing street and basement flooding incidences.
- Milder winters may result in more mid-winter melts. This has the potential to trigger more frequent flooding and greater amounts of erosion.
- The potential for a significant reduction in the levels of the Great Lakes may impact erosion and flooding along shorelines and, in turn, will affect wetlands, fisheries, and human usage of the shoreline.
- Forest ecosystems are expected to shift northward. In a changing climate, species currently threatened with extinction would have the greatest risk of extinction while opportunities for successful establishment of exotic species would be enhanced.

While we may not be in a position to reverse the trend and potential impacts of reaching a doubling of CO_2 in the atmosphere, we can adapt to some of its impacts. We are in a unique position to recognize and incorporate techniques into the watershed management strategy process that would allow for adaptive management whenever possible, for example by planting species of trees and shrubs that will more likely be able to adapt to climate change.

Global warming is a problem requiring actions at many levels: global for international agreements; national for national and provincial gas reduction targets and different regional adaption strategies; local for land use planning and conservation efforts; and individual for lifestyle choices.

Actions taken at a local level, such as tree planting, can play a role in the overall solution. There are many benefits to trees. Trees absorb CO_2 from the atmosphere, lower cooling costs in the summer by providing shade, and saving energy in the winter by providing windbreaks. Estimates of the amount of CO_2 extracted from the atmosphere by trees vary with the projected size, species, and life span. Small trees such as red ash, cherry and dogwood, live for approximately 40 years and absorb 2.22 tonnes of CO_2 each. Medium size trees such as black ash, hickory, and oak, live for about 60 years and extract 4.04 tonnes of CO_2 each. Finally, large trees such as maple, pine, and spruce, live for about 120 years and each removes 24.44 tonnes of CO_2 from the air (TAF, 1997). In comparison, a normal car burning gasoline creates approximately 0.000306 tonnes (0.306 Kg) of CO_2 for every kilometre travelled or roughly 0.306 tonnes (306 Kg) of CO_2 for every 1000 kilometres (TAF, 1997). Therefore, one medium size tree is needed for every 13,202 km that we drive.

In addition to reducing CO_2 levels in the earth's atmosphere, trees also provide habitat for wildlife, and absorb rainwater which assists with stormwater control.

6.3 AIR QUALITY

Air quality in the Highland Creek watershed is affected by international, regional, and local sources of pollution. Scientific research over the last decade has shown that a great number of toxic chemicals can be transported in the air for many thousands of kilometres (Environment Canada, 1994). It is estimated that up to 50 percent of the toxic chemicals found in Lake Ontario are the result of deposition from the air (Ashworth, 1986).

Generally, over the last 25 years air quality in Ontario has improved, despite the large increase in population and the number of cars and other vehicles on the roads and highways. Many of the commonly tested pollutants such as sulphur dioxide, carbon monoxide, and total suspended particulates, have "declined significantly" over this time period (Ministry of the Environment, 1997, pg. 1). However, these gains have been offset by increasing problems related to ground level ozone, smog, and inhalable and respirable particulates.

Smog "is a distinct form of poor air quality. It occurs on warm summer days when a combination of toxic gases and fine particles forms through a series of chemical reactions triggered by sunlight and heat" (City of Toronto, April 1998, pg. 4).

These include nitrogen oxides, volatile organic compounds, carbon monoxide, sulphur dioxide, ozone, and suspended particulates (Ministry of the Environment, 1998). This most frequently occurs in the summer months of the year, during spells of hot and humid weather. Local sources of pollutants contribute to the severity of these occurrences, but "more than half [of] the province's ground-level ozone can be attributed to trans-boundary pollution" from the United States (Ministry of the Environment, 1997, pg. 7).

Ground level ozone is of particular concern (see Table 3) as it can cause problems for individuals suffering from heart and respiratory problems, as well as cause damage to vegetation and buildings (Ministry of the Environment, 1997). Due to these effects, this particular pollutant continues to be a concern for the Ontario Ministry of Environment.

Another pollutant of concern is particulates, created through many industrial processes and present in motor vehicle exhaust, in the form of total suspended particulates (TSP) and suspended particulates (SP) (see Table 3). Of most concern are the smallest particulates (less than 10 microns in diameter) which can be inhaled deep into the lungs. These particulates can "aggravate bronchitis, asthma and other respiratory diseases", and are "linked to increased hospital admissions and premature death" (Ministry of the Environment, 1997, pg. 21).

In order to assess the impact of the combination of pollutants on human health, the Ministry of Environment has created the Air Quality Index (AQI) (see Box 1: Ambient Air Monitoring). The AQI measures six common air pollutants (sulphur dioxide, ozone, nitrogen dioxide, total reduced sulphur compounds, carbon monoxide, and suspended particles), and is based on 24 hour averages taken at over 200 continuous monitoring sites (Ministry of the Environment, 1995). Scoring is on an incremental basis on a scale from 0 to 100, with 0 being the best air quality and 100 + indicating very poor air quality (though anything over 32 is considered unacceptable)(Ministry of the Environment, 1997).

Ozone was the pollutant most responsible for AQI scores over 31 indicating moderate to poor air quality (Ministry of the Environment, 1997). Coupled with the AQI, the Ministry also periodically issues Air Quality Advisories for periods of high ground level ozone levels. Between January, 1993 and June 25, 1999, there were 21 Air Quality Advisories issued for the province, covering 41 days; and 18 Air Quality Advisories lasting 33 days issued for the Toronto area (includes Scarborough) (Kieley, 1999).

Overall, data from the Ontario Ministry of the Environment's AQI indicate that for the majority of the time, air quality within the Highland Creek watershed ranges between "very good" and "good".

BOX 1: AMBIENT AIR MONITORING

The Ontario Ministry of the Environment's Air Quality Information System (AQUIS) is a large database containing air pollution measurements. The AQUIS data is used to monitor pollutant concentrations all over Ontario. Data is divided into two major groupings: continuous (1-hour) and daily (24-hour) measurements.

The measurements gathered for AQUIS are used to calculate the Air Quality Index (AQI). Operating since 1988, the AQI measures six common air pollutants which are considered to have adverse effects on human health and the environment: sulphur dioxide (SO_2); ozone (O_3); nitrogen dioxide (NO_2); total reduced sulphur compounds (TRS); carbon monoxide (CO); and suspended particles (SP). The Air Quality Index is measured at 29 sites in 24 of Ontario's urban centres. The AQI is categorized into five levels:

AQI Index Categories
0-15 Very Good
16-31 Good
32-49 Moderate
50-99 Poor
100+ Very Poor

Since 1993, Environment Canada and the Ontario Ministry of the Environment have been issuing Air Quality Advisories to the public in Ontario when elevated air pollution levels due to ground-level ozone were forecast. This program helps to increase public awareness of air quality and human health issues, while encouraging people to contribute to pollution prevention.

The Air Pollution Index (API) is a sub-index of the AQI. The Air Pollution Index is calculated from 24 hour running averages of sulphur dioxide (SO_2) and suspended particles (SP), and is released in combination with the eight hour average concentration of carbon monoxide (CO). API advisories were introduced to southern Ontario in 1993. The API is used as the basis of an alert and control system to warn of deteriorating air quality. When air pollution levels reach a value of 32 and are expected to persist for at least six hours, an Air Pollution Advisory is issued. Regulation 346 under the *Ontario Environmental Protection Act* (1971) authorizes the Minister of the Environment for Ontario to order any point source of air pollution that is not essential to public health or safety to curtail or cease its operation. During an advisory, the public is encouraged to limit activities that contribute to air pollution such as unnecessary trips in the car and using gas-powered lawn mowers. People with respiratory problems are encouraged to limit outdoor activities.

Source: Environment Canada. Air Quality in Ontario 1995: 25 Years of Environmental Achievement, Queens Printer of Ontario, 1997.

TABLE 3: Pollutants that Frequently Exceed the Ontario Ambient Air Quality Criteria

POLLUTANT	SOURCES	EFFECTS
OZONE (O_3)	Ozone is a colourless gas produced by photochemical reactions between nitrogen oxides, volatile organic compounds (typically emitted from internal combustion engines), and air, in the presence of sunlight. Ozone is not directly emitted into the atmosphere in significant amounts. Ozone is formed downwind of these sources and is capable of travelling long distances. A large portion (over 50 percent or greater) of the ground-level ozone concentrations found in Ontario can be attributed to long range transport of ozone and its precursors from industrialized states south of the Great Lakes. Warm temperatures are critical and elevated concentrations generally occur from May to September between noon and early evening. In Ontario, the highest concentrations of ozone are recorded on hot sunny summer days. Ground-level ozone pollution is a primary component of smog.	Human: Ozone is a pulmonary irritant that affects the respiratory mucus membranes, other lung tissues, and respiratory functions. Studies have demonstrated that ozone impairs the normal function of the lungs, causing alterations in respiration rates, the most characteristic being shallow, rapid breathing. People with respiratory and heart problems are at higher risk. Exposure to ozone may result in chest tightness, coughing, and wheezing. Vegetation: Injury to vegetation is one of the earliest signs of photochemical air pollution. Ozone will generally cause a plant to grow 10 to 40 percent more slowly, age prematurely, lose its leaves during the growing season, and produce pollen with a shorter life span (Region of Peel, 1995). Sensitive plants are useful biological indicators of this type of air pollution. Visible signs of injury due to ozone are flecking and leaf discolouration.
TOTAL SUSPENDED PARTICLES (TSP) **SUSPENDED PARTICLES (SP)**	TSP is a generic term for airborne particles including aerosols, smoke, fumes, dust, fly ash, and pollen. The composition varies with place and season but normally includes soil, organic matter, sulphur and nitrogen compounds, metals such as lead, carbon, or higher hydrocarbons formed by incomplete combustion of hydrocarbon fuels. Size range varies from 0.1 to 100 microns. SP is a relative measure of suspended particulate matter in the atmosphere most likely to reach the lungs (diameter generally less than 10 microns, PM_{10}). These have the greatest effect on health. Major sources of particulate emissions are industrial processes including combustion, incineration, construction, mining, metal smelting and processing, motor vehicle exhaust, residential wood combustion, and road dust. Natural sources of particulate matter include windblown soil, forest fires, ocean spray, and volcanic activities.	Human: The greatest impact on health is from particles less than 10 microns in diameter which can penetrate deep into the lungs and can aggravate bronchitis, asthma, and other respiratory diseases. More serious health effects may be associated with suspended particulate matter which contains a toxic particulate component or which has adsorbed a gaseous pollutant on the surface of the particles. Corrosion, soiling of materials, and visibility reduction are additional effects. Vegetation: Damage to vegetation can also occur.

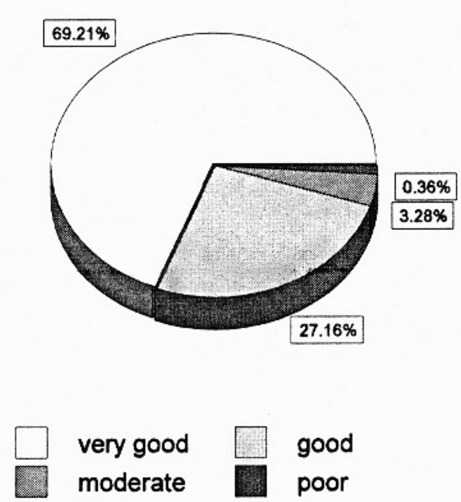
In 1997, the air quality monitoring station at Lawrence Avenue East and Kennedy Road reported "very good" conditions 69 percent of the time; "good" conditions 27 percent of the time; "moderate" conditions 3.3 percent of the time; and "poor" conditions 0.36 percent of the time (see Figure 6)(Kiely, 1999). As such, air quality within the Highland Creek watershed was "very good" to "good" 96 percent of the time. The pollutant that was responsible for all air quality indicies above 31 in 1997 was ozone.

The Air Pollution Index (API) measures 24 running averages of sulphur dioxide and suspended particulates and is used as the basis for the issuance of Air Pollution Index Alerts by the Ministry of Environment. Table 4 illustrates the number of occasions between 1988 and 1996 in which the Scarborough Air Pollution Index exceeded 31, meaning the air quality deteriorated from good to moderate or poor. One incident occurred in 1989 and another in 1994. During these years the highest API recorded at the Ellesmere station was 42, in 1994. If the index reaches 50, the Ministry of Environment has the power to order major sources of emissions to curtail operations. If the levels climb even higher, the Ministry has the power to order further curtailment and shutdown.

TABLE 4: Number of Instances of Air Pollution Index Alerts being issued at Ellesmere Station (1988-1996)

STATION	1988	1989	1990	1991	1992	1993	1994	1995	1996
Ellesmere	0	1	0	0	0	0	1	0	0

FIGURE 6: 1997 Air Quality - Scarborough Station



Source: Kiely, 1999.

The City of Toronto has developed a 'Smog Alert Response Plan' that is implemented on days when Air Quality Advisories are issued by the Ministry of Environment. The objectives of this plan are to:

- Implement Divisional Smog Alert Response Plans that will see a short-term reduction or suspension of activities that contribute to poor air quality on Smog Alert days.
- Provide information to Divisions and staff serving at-risk groups, such as children and seniors, to support informed programming and service delivery decisions on Smog Alert days.
- Provide education materials for distribution by Divisional staff serving at-risk populations, such as children and seniors, so that these client groups learn about smog, its effects on health, and the precautions they should take on Smog Alert days.

Examples of the actions that will be undertaken by City departments and divisions include the suspension of use of all non-essential vehicles, a reduction of vehicle idling, and encouraging staff to use public transit or walk instead of using cars.

Similar programs have been established other organizations, such as the TRCA, to reduce the amount of ground level ozone being produced during days of Air Quality Advisories.

SUMMARY

Key issues related to air in the Highland Creek watershed include both climate and air quality. The climate of the Highland Creek watershed affects vegetation communities, wildlife, the hydrologic cycle, and other components of the natural heritage system. The large degree of urban development in the watershed may be affecting the local climate through contributing to the "urban heat island" effect. In turn, these changes may influence air quality as well as the health of humans, vegetation communities, and wildlife.

Air quality within the Highland Creek watershed is usually very good. However, ground level ozone and particulate pollutants have exceeded provincial air quality standards on a number of occasions, especially during the summer months. Impaired air quality is largely a consequence of vehicle, industrial, and residential emissions, with a large amount of ground level ozone and its precursors originating from outside of the watershed.

WATER

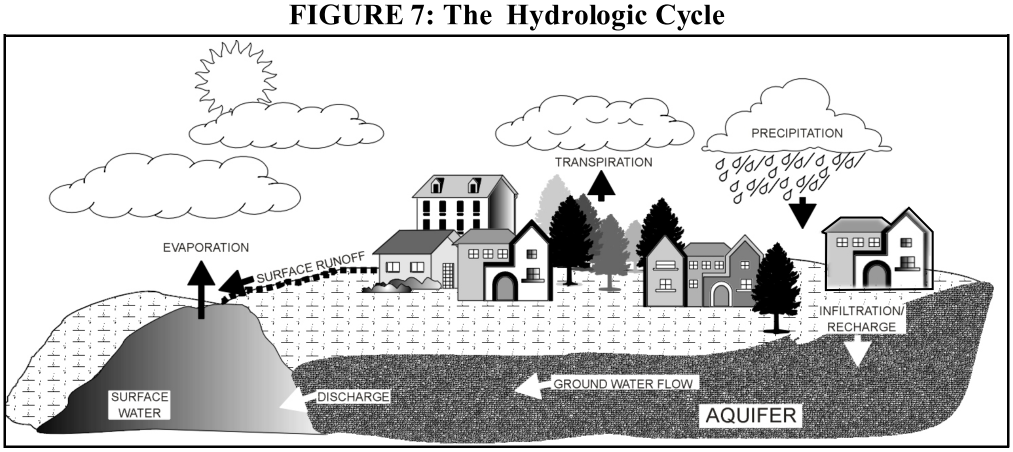
CHAPTER 7

One of the fundamental components of the natural heritage system is water. All life depends upon it. Water is constantly moving or cycling through the environment. This movement of water as atmospheric moisture, groundwater, and surface water is known as the hydrologic cycle (see Figure 7). The quality and quantity of these resources are important factors in the determination of watershed health.

7.1 GROUNDWATER

Groundwater is an essential component of the hydrologic cycle, and hence of the natural heritage system. As groundwater moves through one or more geologic layers, it can eventually discharge, or seep out, into valleys, streams, lakes or wetlands. In this way, groundwater provides the baseflow of many streams and can regulate factors such as water quantity, quality, and temperature.

FIGURE 7: The Hydrologic Cycle



7.1.1 Groundwater Quantity

It is important to note that similar to surface water, groundwater typically flows downhill following the slope of the water table. Groundwater also flows toward and eventually drains into watercourses and lakes.

The Highland Creek watershed is underlain by layers of soil deposited over many thousands of years. Some of these layers are permeable and allow water to flow through them. These are known as aquifers. Others are less permeable and slow down the movement of water. These are known as aquitards. The Highland Creek watershed is underlain by three major aquifers, known as the Upper, Middle, and Lower Aquifers (Eyles et al., 1998).

The Upper Aquifer is intermittent across the watershed. It is confined to a thin layer of soil on the South Slope less than five metres in thickness, and to the Lake Iroquois sand plain situated south of the Lake Iroquois shoreline (Eyles et al., 1998). It is through these layers that surface waters infiltrate to recharge local groundwater.

The Middle Aquifer is confined to the layer of sands, silt and clays of the Thorncliffe Formation, which were deposited in the area about 30-45,000 years ago. North of the Highland Creek watershed, up to the Oak Ridges Moraine, the Middle Aquifer is recharged by the Upper Aquifer as ground water leaks through the Northern Till which separates them (Eyles et al., 1998). Within the Highland Creek watershed, recharge to the Middle Aquifer occurs through the overlying Northern Till and from the Lower Aquifer below it. Groundwater flow in this aquifer within the watershed is generally in an easterly direction. Discharge areas from the Middle Aquifer into Highland Creek exist in a number of locations, especially in the deeply defined valley system of the lower reaches of the creek where the aquifer is exposed. These discharges are a natural asset, contributing a baseflow of cold water to the creek throughout the year.

The Lower Aquifer is made up of the sands, silt and clays of the Scarborough and Don Formations, which were deposited between 135,000 and 60,000 years ago. Flow within this aquifer follows the contours of the bedrock, running in a southerly direction from the north. The designated Rouge River bedrock channel runs through the Rouge River watershed and into the lower portion of the Highland Creek watershed in the vicinity of Centennial Creek, exiting in the area of the current mouth at Lake Ontario (Eyles et al., 1998). This aquifer also discharges directly into Highland Creek (contributing to baseflow), as well as directly into Lake Ontario. Evidence shows that in many locations the Lower Aquifer is linked to the Middle Aquifer through sand lenses in the intervening Middle Aquitard, permitting flow between the two aquifers (Eyles et al., 1998).

7.1.2 Groundwater Quality

Contamination of groundwater resources is considered to be more serious than of surface waters (Howard, 1997). In surface waters, contamination from spills is usually discovered relatively quickly, while contamination of the groundwater can often take years to be detected. By that time, the contamination can be serious and irreversible. Groundwater quality can be contaminated by a number of factors including point sources such as landfill sites, underground storage tanks and septic systems, and non point sources such as road salt.

"As a general rule, point sources can cause severe pollution of groundwater on a very localized scale, whereas distributed and line sources of contamination generally cause widespread contamination at relatively low levels" (Howard, 1997, pg. 96).

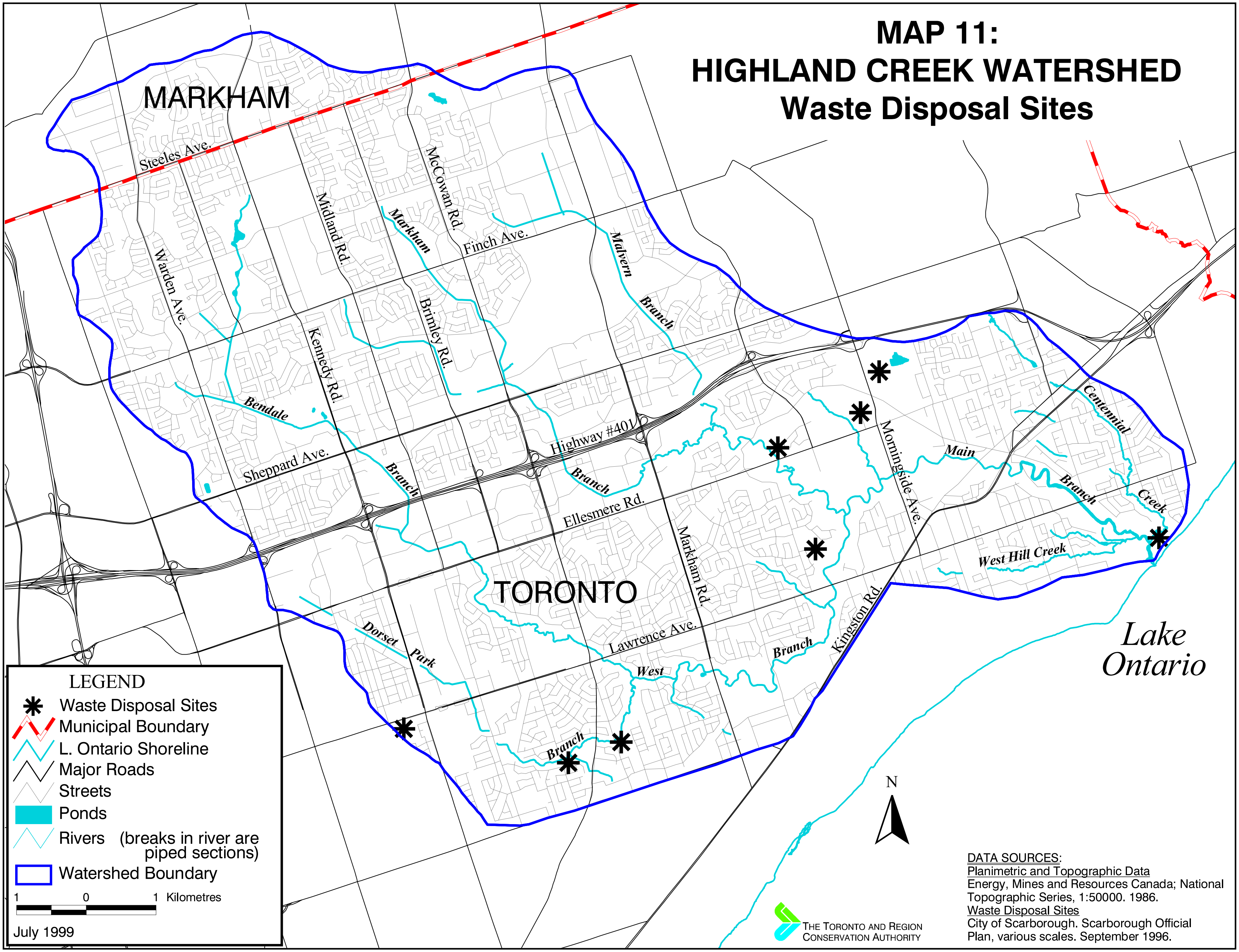
There are eight known landfill sites within the Highland Creek watershed (see Map 11: Waste Disposal Sites). The former City of Scarborough began a program to remediate old landfill sites in 1992. Most known sites have been studied to assess methane gas and groundwater conditions. Remediation of four sites has been initiated; further remediation is planned for 1999.

These former waste disposal sites have the potential to contaminate local ground and surface waters. The amount of contamination originating from a landfill site is determined by the quality of the landfill material and the amount of water that percolates through the site as a result of precipitation and/or groundwater movement. Studies of closed landfill sites have indicated that contamination from municipal waste has "relatively high concentrations of inorganic chemicals, dissolved organics and metals" and that these concentrations vary over time. The majority of the contaminants are released within the first ten years of the life of the landfill site, decreasing over time (Birks and Eyles, 1997).

Many of these sites are located in the valley corridor or in old gravel pits. One substantial, privately owned landfill site is the asbestos disposal site of the former John's Manville Plant, that was constructed at the foot of Port Union Road in 1946. The company built a dike system into the adjacent large wetland at the mouth of Highland Creek where it meets Centennial Creek, and then proceeded to use the area as a disposal site for their asbestos. The plant was recently closed and a new residential community is being constructed adjacent to the disposal site, where the plant was located. As part of the decommissioning process approved by the Ministry of Environment, all the asbestos waste from the property was placed in the former settling ponds and capped with clay to prevent rainwater infiltration. This portion of the site has now been designated as a waste disposal site.

Another landfill site, the Morningside landfill site, was operated by the Township of Scarborough between 1960 and 1967 in an old gravel pit on the east side of Morningside Avenue, just south of Hwy. 401. In 1996 the City of Scarborough began implementation of a remediation plan to prevent the migration of gas and leachate from the site. At that time, an underground barrier was constructed from Military Trail almost to Hwy. 401. Construction of a barrier along the east and part of the south side of the landfill site will be completed in fall of 1999. Natural physical features restrict gas and leachate from migrating both north and south (City of Toronto Works Department Scarborough District, June 3, 4, 5, 1998).

Another major source of groundwater contamination is from leaking underground storage tanks, associated with the storage of gasoline and other


MAP 11:
HIGHLAND CREEK WATERSHED
Waste Disposal Sites
MARKHAM
TORONTO
Lake Ontario
Steeles Ave.
Finch Ave.
Sheppard Ave.
Highway #401
Ellesmere Rd.
Lawrence Ave.
Kingston Rd.
Warden Ave.
Midland Rd.
Kennedy Rd.
Brimley Rd.
McCowan Rd.
Markham Rd.
Morningside Ave.
Markham Branch
Malvern Branch
Bendale Branch
Dorset Park Branch
West Branch
Main Branch
Centennial Creek
West Hill Creek
N
LEGEND
Waste Disposal Sites
Municipal Boundary
L. Ontario Shoreline
Major Roads
Streets
Ponds
Rivers (breaks in river are piped sections)
Watershed Boundary
1 0 1 Kilometres
July 1999
THE TORONTO AND REGION CONSERVATION AUTHORITY
DATA SOURCES:
Planimetric and Topographic Data
Energy, Mines and Resources Canada; National Topographic Series, 1:50000. 1986.
Waste Disposal Sites
City of Scarborough. Scarborough Official Plan, various scales. September 1996.

petroleum products. Gasoline is made up of a number of components, some of which are soluble and easily dissolved in water. These include benzene, toluene, ethylbenzene, and xylene. These chemicals are highly toxic, so relatively small amounts can contaminate large quantities of groundwater. For example, one litre of gasoline will render one million litres of water undrinkable (Howard, 1997).

Septic systems are still being used in many of the older communities in the watershed. These areas were developed before the extension of sanitary sewer services into Scarborough, with private septic systems adjacent to the homes. The typical life of a septic system is ten to fifteen years, after which they can fail (Howard & Livingstone, 1997). If these systems fail, they have the potential to introduce contaminants into the groundwater system such as chlorides, nitrates, sodium, calcium and potassium, as well as cleaning agents and other chemicals commonly used by individuals in their homes. Contaminant plumes of over 100 metres in length have been observed in areas of sandy soils (Howard, 1997). A province wide study conducted by the Ministry of the Environment in 1990 found that approximately 34 percent of the 9,067 septic systems inspected were malfunctioning (Commission on Planning and Development Reform in Ontario, 1993). Although previous studies have shown that older areas with septic tanks cause problems, further investigation is required to determine the effect that septic systems have on the quality of groundwater in the Highland Creek watershed.

Of the non-point sources perhaps the one with the greatest potential for long-term damage is the use of road de-icing chemicals by the City of Toronto, which are applied to ensure public safety. A study conducted on the Highland Creek watershed between 1989 and 1991 indicated that of the approximate 10,000 tonnes of chloride applied to Highland roads on an annual basis, only 45 percent is flushed out of the watershed via runoff. The rest infiltrates into the ground and contaminates the groundwater of the Upper Aquifer (Howard & Haynes, 1997). However, due to the interconnectedness of the aquifer system it is only a matter of time before the salt contamination moves into the other aquifers (Howard, 1998). The City of Toronto has been proactively looking into the use of alternatives to salt and the use of salt reduction strategies, such as using computerized salt spreaders and state of the art salt application control equipment, and better training for winter maintenance staff. The implementation of these methods has resulted in a reduction in the use of road salt by 60% since 1968, measured in centimeters of snow per lane kilometer (Albanese, 1999).

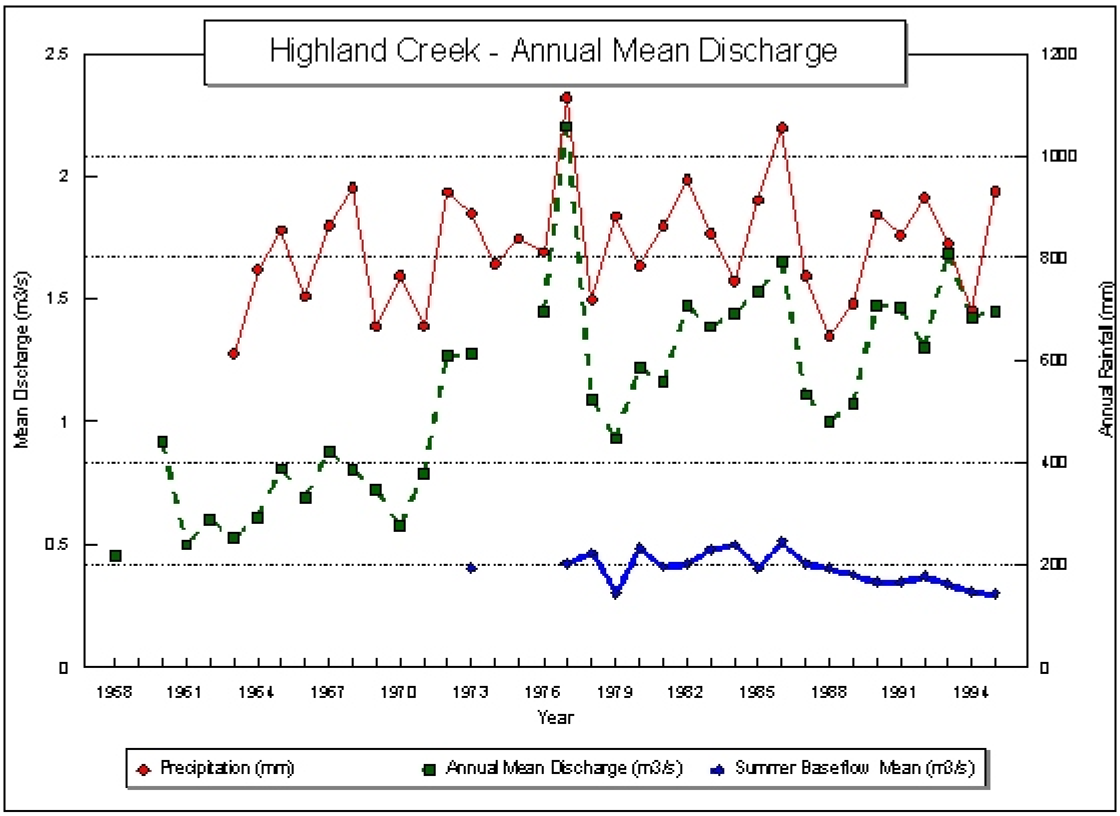
7.2 SURFACE WATER

Surface waters include those portions of the hydrologic cycle that flow above ground, including the groundwater that seeps into the watercourse from aquifers. This flow forms what we know as Highland Creek. Surface flow is variable throughout the year, and is dependent on local conditions such as precipitation, surficial soils, geology, vegetation, topography, and land use.

7.2.1 Surface Water Quantity

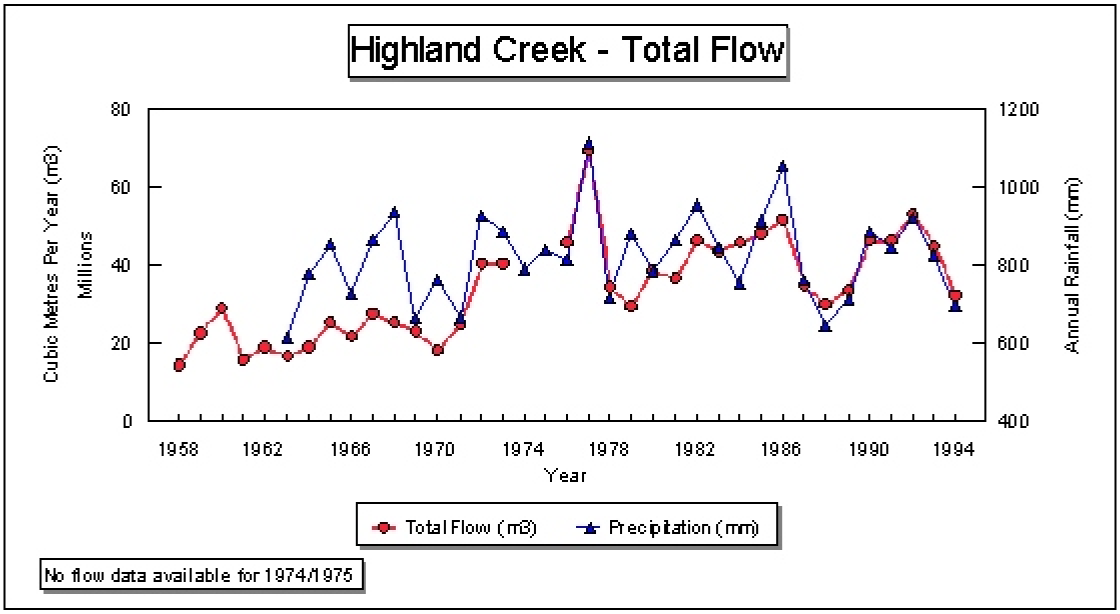
As indicated in Figures eight and nine, the overall volume of total surface water flow has more than doubled in the Highland Creek since 1958, while the amount of total annual precipitation has remained relatively constant (information provided by the Ministry of Environment West Hill Flow Gauge Station). This trend reflects a marked change in the hydrologic regime of the Highland Creek due to the change in land use from agricultural to an urban form.

FIGURE 8: Highland Creek Annual Mean Discharge - 1958 to 1995



The most dramatic increase in mean annual discharge and total flow can be observed after 1970 when development began to accelerate in the watershed. This change in land use tends to result in a reduction of infiltration, surface depression storage, and evapotranspiration. The consequence of which is higher amounts of surface runoff. The urban infrastructure of channels, roads and sewers, contain and transport the runoff more efficiently to the receiving streams, resulting in a shift in the response of urban stream systems to runoff events. As a result, there is a more rapid hydrologic response to storm events, typified by large, rapid flows during these events. The linkage between precipitation rates, the annual mean discharge, and total flow is most particularly evident in the years after urban land uses began to dominate the watershed particularly in the 1980s and 1990s.

FIGURE 9: Highland Creek Yearly Total Flow - 1958-1995



The change in the hydrologic flow regime experienced through urbanization results in changes within the watercourses as they expand and deepen to accommodate the increase in the flow rates that they must carry. While the expansion of the low flow channels occurs throughout the system, the speed and degree of change is dependent largely upon the material through which the channel must flow. In the lower portions of the Highland Creek, below the Lake Iroquois shoreline, the sandy soils are experiencing a much more rapid adjustment. The widening and deepening which has, and is occurring, also results in a disconnection of the low flow channel from its floodplain.

The increase in flows also impacts aquatic life in the creek. The amount of cool groundwater that seeps into the creek, known as baseflow, has remained relatively constant over the years. However, due to the increase in the total amount of water flowing through the system, the amount of baseflow relative to the larger flows has decreased to the point where it now accounts for only 18 percent of the average annual flow. In the 1960s and 1970s this ratio would have been between 35 and 40 percent. This change in flow condition has resulted in an increase in the size of the watercourse, greater stream erosion and sedimentation, and an increase in water temperature. These changes make the watercourse unable to support sensitive coldwater fish species such as Atlantic salmon which once lived in Highland Creek.

There could be several reasons for the reported reduction in base flow after 1989. The location of the flow station was moved upstream in 1989 from just south of Old Kingston Road to just west of Morningside Avenue. Moving the station further upstream, away from the pervious sandy soils of the Lake Iroquois plain and closer to the impervious soils of the South Slope, could have reduced the amount of baseflow passing through the flow gauge for two reasons. Firstly, there was less baseflow available because of a reduction of infiltration and surface storage. Secondly, the amount of baseflow contributed from the lands further downstream were no longer being included in the calculations. If base flow is gradually falling, then this will significantly affect fish habitat and water takers in drought periods. Every effort should be made to encourage recharge, from the disconnection of roof downspouts to dry wells, etc.

7.2.1.1 Flooding History

The Highland Creek watershed has had a long history of flooding. The first recorded events occurred as early as 1800, and were noticed as part of the site inspections on the then-recently completed Danforth Road. A Mr. Lewis Grant noted in his report that the bridge on the west branch of Highland Creek had previously been washed away due to flooding (Ontario Department of Planning and Development, 1956). The *Rouge Duffins Highland Petticoat Conservation Report* (Ontario Department of Planning and Development, 1956) documents 35 flooding events between 1850 and 1956. Of these the worst was Hurricane Hazel which passed through the Toronto area on October 15th and 16th, 1954**.**

Hurricane Hazel caused an enormous amount of damage in the Toronto area. In the Highland it was estimated that the creek rose by 16 feet, and 17 homes were washed away, not to mention the destruction of ten bridges and severe damage to six others. All together, there was an estimated $500,000 in damages within the Highland Creek watershed (MTRCA, 1959). It was the destruction caused by Hurricane Hazel that precipitated the formation of The Metropolitan Toronto and Region Conservation Authority (now The Toronto and Region Conservation Authority), and the acquisition and preservation of much of the valley lands in the lower Highland Creek.

Another major flooding event occurred on subsequent days in August, 1976. During these two days (August 27th and 28th), two major storms passed over the watershed, dropping up to 75 mm of rain. The resultant flooding caused over $1.3 million worth of damage, including the destruction of 14 bridges crossing the Highland Creek on the Scarborough Golf and Country Club property (Kilborn Limited, 1977).

The most recent major flooding event occurred during another major storm on August 27, 1986. During this storm event the highest discharge rate on record was recorded for the Highland Creek at 161 cubic metres per second. As occurred during the storm events in 1976, there was flood and erosion damage to areas along the watercourse, particularly at the Scarborough Golf & Country Club (Maclaren, 1987).

7.2.1.2 Flood Vulnerable Areas

There are a number of flood vulnerable areas and roads within the Highland Creek watershed (see Map 12: Flood Vulnerable Areas). Some of these indicate areas where structures were historically developed in the flood plain. The majority of the sites however, are flooded due to undersized culverts (the design criteria resulted in undersized culverts), or piped sections of the watercourse which are not large enough to handle the volume of water expected from a Regional-scale storm. In that case, the water backs up, flooding adjacent areas. Portions of the Dorset Park Branch and the Bendale Branch are particularly susceptible to this type of flooding.

7.2.1.3 Erosion Sites

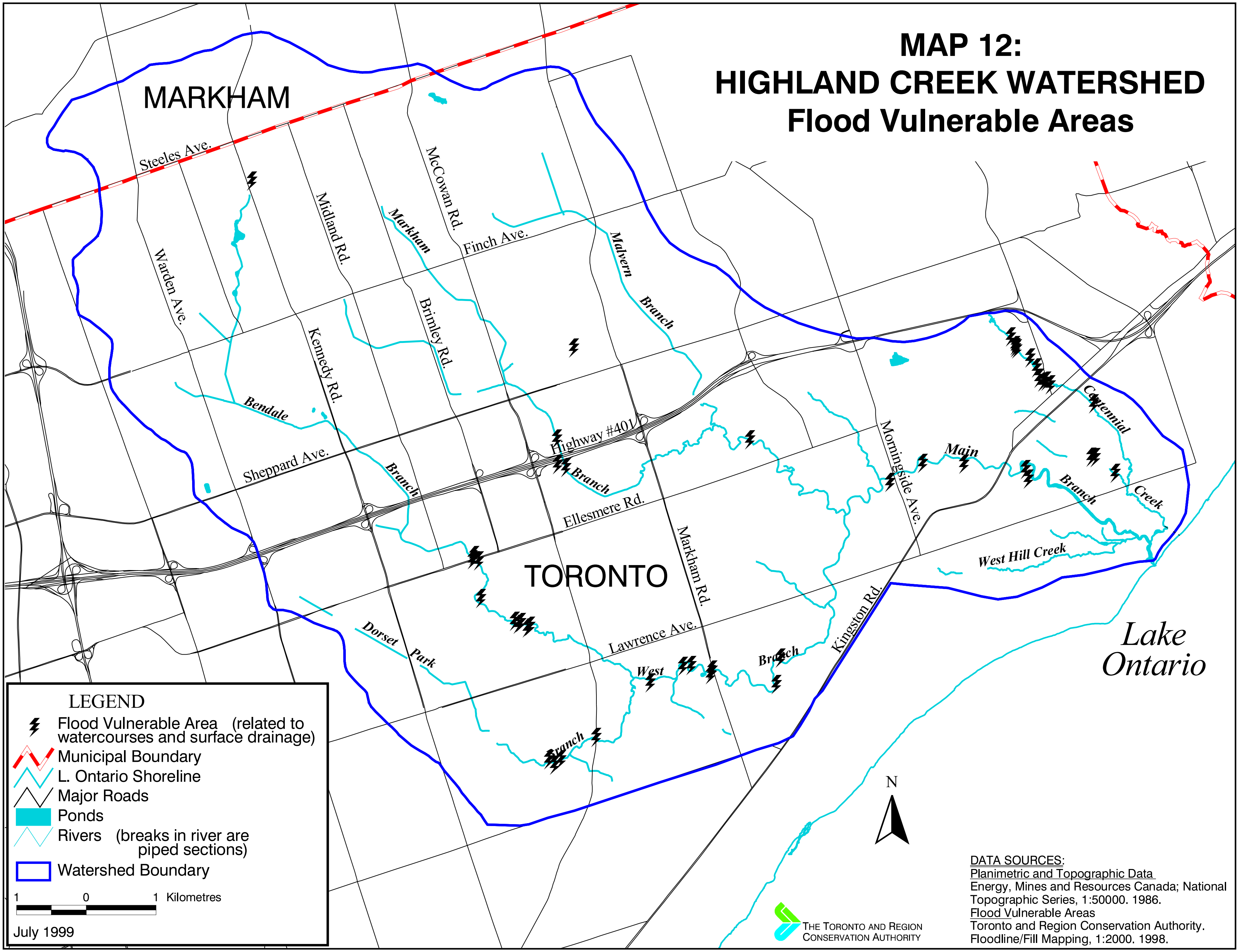
In a healthy, undeveloped watershed, water flows are relatively constant and even. Erosion is gradual, kept in check by healthy riparian vegetation. Watercourses move slowly across the flood plain, which minimizes the amount of sediment entering the stream. The maintenance of a constant, stable, and natural hydrologic cycle is extremely important to the health of the watershed (MacViro, 1995).

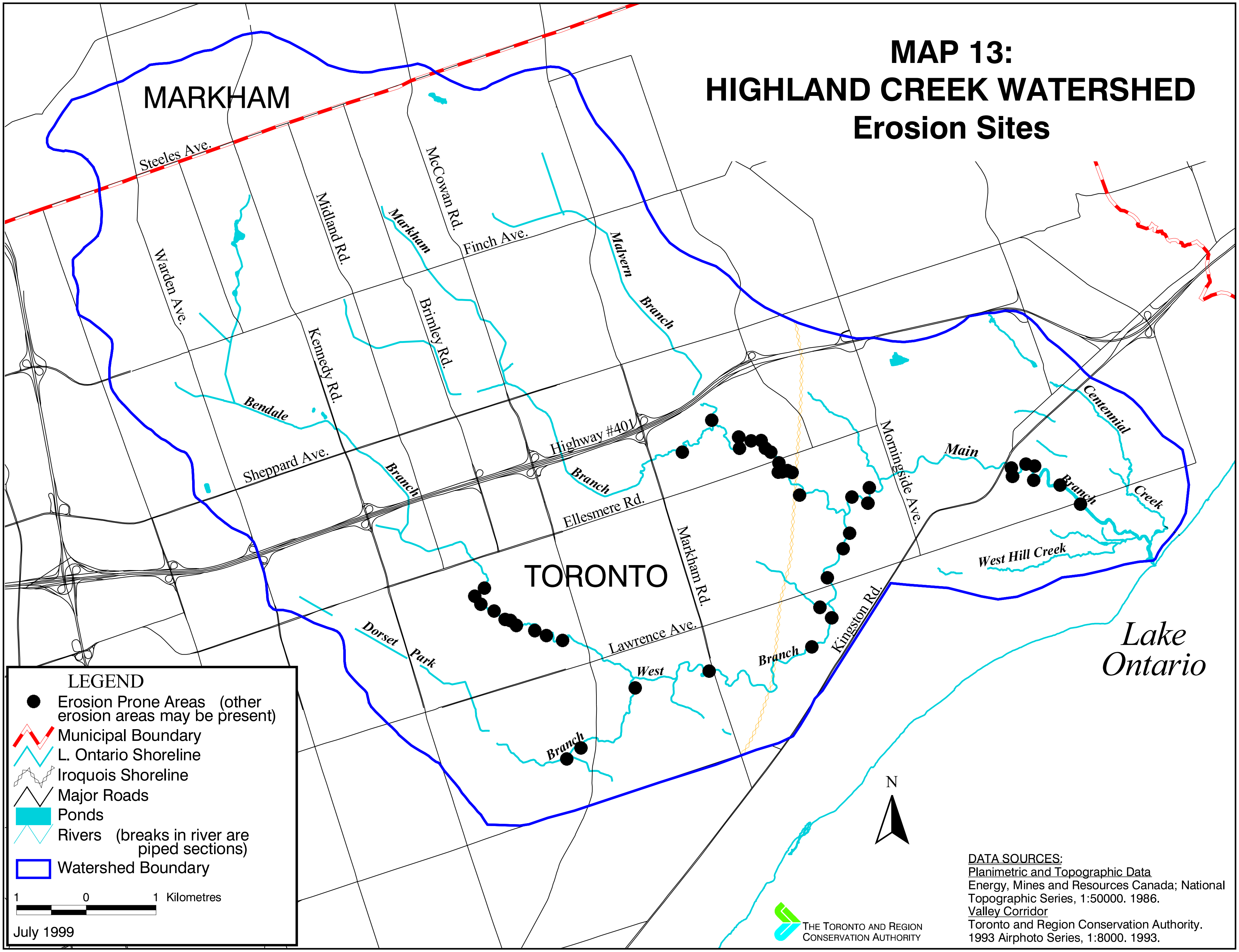
When a watershed is developed, however, high streamflow events become much more frequent due to an increase in impervious surfaces and in the corresponding stormwater runoff. This throws the system out of balance and may result in excessive stream bank erosion, loss of vegetation, and more frequent and severe flooding. In this situation the response has often been to channelize sections of the watercourse to prevent bank erosion and to allow water to pass through the system more quickly.

As urbanization spread into the upper portions of the Highland Creek watershed in the late 1960s and 1970s, the headwaters of the creek were channelized to facilitate development and to carry away stormwater as efficiently as possible.

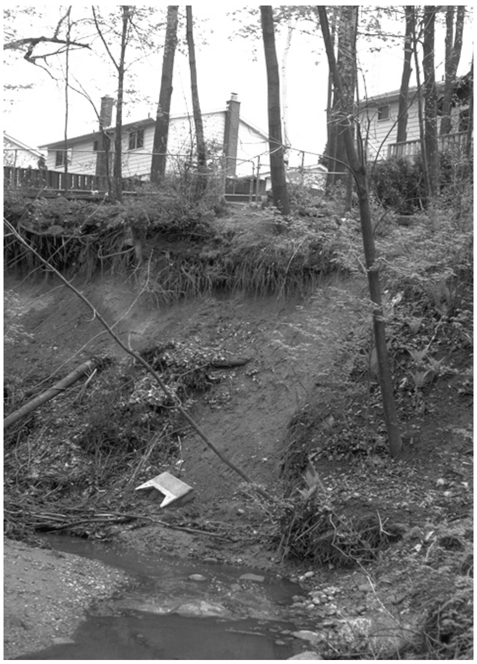
As development proceeded, the flow of water in the creek became more uneven, ranging from high flows during wet weather events to low flows during the dry summer months. The unnatural higher flows of water were quickly funnelled through the system via concrete channels. This has resulted in severe erosion downstream, especially along the sandy banks of the lower Highland on the Lake Iroquois plain (see Map 13: Erosion Sites). Here, the large volumes of water have resulted in an unnaturally wide channel which causes the watercourse to flow as a thin sheet over a broad area. This allows the water to heat up in the sun. Higher water temperatures prevent the more sensitive fish species from living in the Highland Creek.

Thus, Highland Creek is currently characterized by highly variable streamflows, bank erosion, some risk of flooding, and extensive areas of artificial stream


MAP 12:
HIGHLAND CREEK WATERSHED
Flood Vulnerable Areas
MARKHAM
TORONTO
Steeles Ave.
Finch Ave.
Sheppard Ave.
Highway #401
Ellesmere Rd.
Lawrence Ave.
Kingston Rd.
Warden Ave.
Midland Rd.
Kennedy Rd.
Brimley Rd.
McCowan Rd.
Markham Rd.
Morningside Ave.
Markham Branch
Malvern Branch
Bendale Branch
Branch
Main Branch
Centennial Creek
West Hill Creek
West Branch
Dorset Park Branch
Lake Ontario
N
LEGEND
Flood Vulnerable Area (related to watercourses and surface drainage)
Municipal Boundary
L. Ontario Shoreline
Major Roads
Ponds
Rivers (breaks in river are piped sections)
Watershed Boundary
1 0 1 Kilometres
July 1999
The Toronto and Region Conservation Authority
DATA SOURCES:
Planimetric and Topographic Data
Energy, Mines and Resources Canada; National Topographic Series, 1:50000. 1986.
Flood Vulnerable Areas
Toronto and Region Conservation Authority. Floodline/Fill Mapping, 1:2000. 1998.


MAP 13:
HIGHLAND CREEK WATERSHED
Erosion Sites
MARKHAM
TORONTO
Lake Ontario
Steeles Ave.
Finch Ave.
Sheppard Ave.
Highway #401
Ellesmere Rd.
Lawrence Ave.
Kingston Rd.
Warden Ave.
Kennedy Rd.
Midland Rd.
Brimley Rd.
McCowan Rd.
Markham Rd.
Morningside Ave.
Markham Branch
Malvern Branch
Bendale Branch
Dorset Park Branch
West Branch
Main Branch
Centennial Creek
West Hill Creek
N
LEGEND
Erosion Prone Areas (other erosion areas may be present)
Municipal Boundary
L. Ontario Shoreline
Iroquois Shoreline
Major Roads
Ponds
Rivers (breaks in river are piped sections)
Watershed Boundary
1 0 1 Kilometres
July 1999
THE TORONTO AND REGION CONSERVATION AUTHORITY
DATA SOURCES:
Planimetric and Topographic Data
Energy, Mines and Resources Canada; National Topographic Series, 1:50000. 1986.
Valley Corridor
Toronto and Region Conservation Authority. 1993 Airphoto Series, 1:8000. 1993.

channel. Erosion is occurring throughout the watercourse. As part of the background research for the *State of the Watershed Report*, the TRCA undertook a study to identify specific erosion sites that endanger infrastructure and private property. The sites were first identified through the interpretation of aerial photography, and then were confirmed in the field. The study identified forty-six erosion sites within the Highland Creek watershed that currently endanger infrastructure and private property (see Map 13: Erosion Sites). The majority of these are concentrated within three general areas: Birkdale Ravine/Thomson Memorial Park; Morningside Park; and Colonel Danforth Park (TRCA, 1998c).



Erosion along Highland Creek

The majority of the erosion sites with Birkdale Ravine/Thomson Memorial Park consist of minor bank erosion caused by undercutting of the banks due to the wide variations in stream flow. In several locations, gabion baskets that were installed years ago, have failed and are now lying on the stream bed. For the most part these erosion sites are not causing any damage to property, but within Thomson Memorial Park the foundation of a footbridge is being undermined.

Areas within Morningside Park largely consist of the sandy soils of the old Lake Iroquois shoreline, making them highly susceptible to erosion. Most of the outside creek bends within this area have been undercut by the water, and the slopes are failing. Private property adjacent to two of the failed slopes appear to be at risk should the erosion continue.

The largest erosion sites in the Highland Creek watershed are found along the sandy banks of Colonel Danforth Park. Evidence of past slumping and slope failures can be found there. Several sections along the bank have been eroded as a result of undercutting. These erosion scars extend up the valley wall, measuring from 30 to 70 metres in height.

7.2.2 Surface Water Quality

Surface water quality is heavily influenced by the conditions of the watershed. The Highland Creek watershed is totally urbanized, and it's water quality reflects this. The quality of water in Highland Creek can be described through addressing the following questions:

BOX 2: CONTAMINANTS IN FORAGE FISH

The presence of organic contaminants such as PCBs and pesticides, is better studied by fish tissue analysis than water quality sampling. In general, current PCB concentrations in forage fish in Toronto streams are lower than in fish collected in the early 1980s. However, 92 percent of all sites sampled in 1992 had fish with PCB concentrations above the Aquatic Life Guidelines of the International Joint Commission. Of the 20 organic contaminants tested for in young-of-the-year fish collected in 1992 from Highland Creek, only DDT was detected.
Contaminants such as PCB, Mirex, heptachlor, octachlorostyrene, aldrin, and toxaphene were not found. A significant decrease in PCB and DDT residues was observed in young-of-the-year spottail shiners over the period 1981-1989. This trend indicates that ambient levels of organic contaminants in the creeks, and thus inputs to Lake Ontario, have decreased over the years.
Source: Suns and Hitchin,1994.

- What is the current water quality in the creek; and how does it compare with other streams?
- Is water quality getting better or worse? Is there a trend?
- Is the water safe enough for use? Does it meet provincial objectives?
- Where does the pollution come from?

Water quality data from Ontario's Provincial Water Quality Monitoring Network provides a basis for the Highland Creek watershed water quality assessment undertaken by the TRCA in 1998. The station at West Hill on the lower Highland Creek has been in operation since 1972. Data from the period of 1985 to 1995 were considered to reflect current conditions. This assessment was augmented with data for the same period from the City of Toronto's six sampling stations in this watershed (see Map 14: Provincial Water Quality Monitoring Stations and Toronto Lake and Stream Stations). This source represents only the summer months and focussed on five selected water quality parameters: phosphorus, suspended sediments, chlorides, faecal coliform bacteria, and phenols. These parameters were selected for analysis due to their relevance to common water use concerns (see Table 5: Key Water Quality Parameters). While heavy metals and persistent organic pollutants (e.g., pesticides) are also of interest, an accurate assessment of these parameters is not possible with data provided by the above-noted monitoring programs due to limitations associated with sampling and analytical techniques. Results of other specialized studies of these contaminants are included in Box 2.

Sections 7.2.2.1 to 7.2.2.5 summarize the results of this water quality assessment, which is described in more detail in *Highland Creek Surface Water Quality Background Technical Report* (TRCA, 1998d). Findings of related studies are also presented to describe the pollutant sources that impact upon Highland Creek.

7.2.2.1 Current Conditions

High levels of phosphorus, suspended sediment, chloride, bacteria, and phenols degrade water quality in the Highland Creek. Pollutant concentrations are at similar levels throughout the Creek, and poorer conditions are most closely associated with periods of wet weather. However, for many parameters, the Highland is comparable to or less degraded than other Toronto watersheds. Maps 15 to 18 show mean concentrations of these parameters in the Highland Creek relative to those in four other watersheds of the Toronto and Region Remedial Action Plan (RAP). Section 10.2.1 discusses the Toronto RAP in further detail.

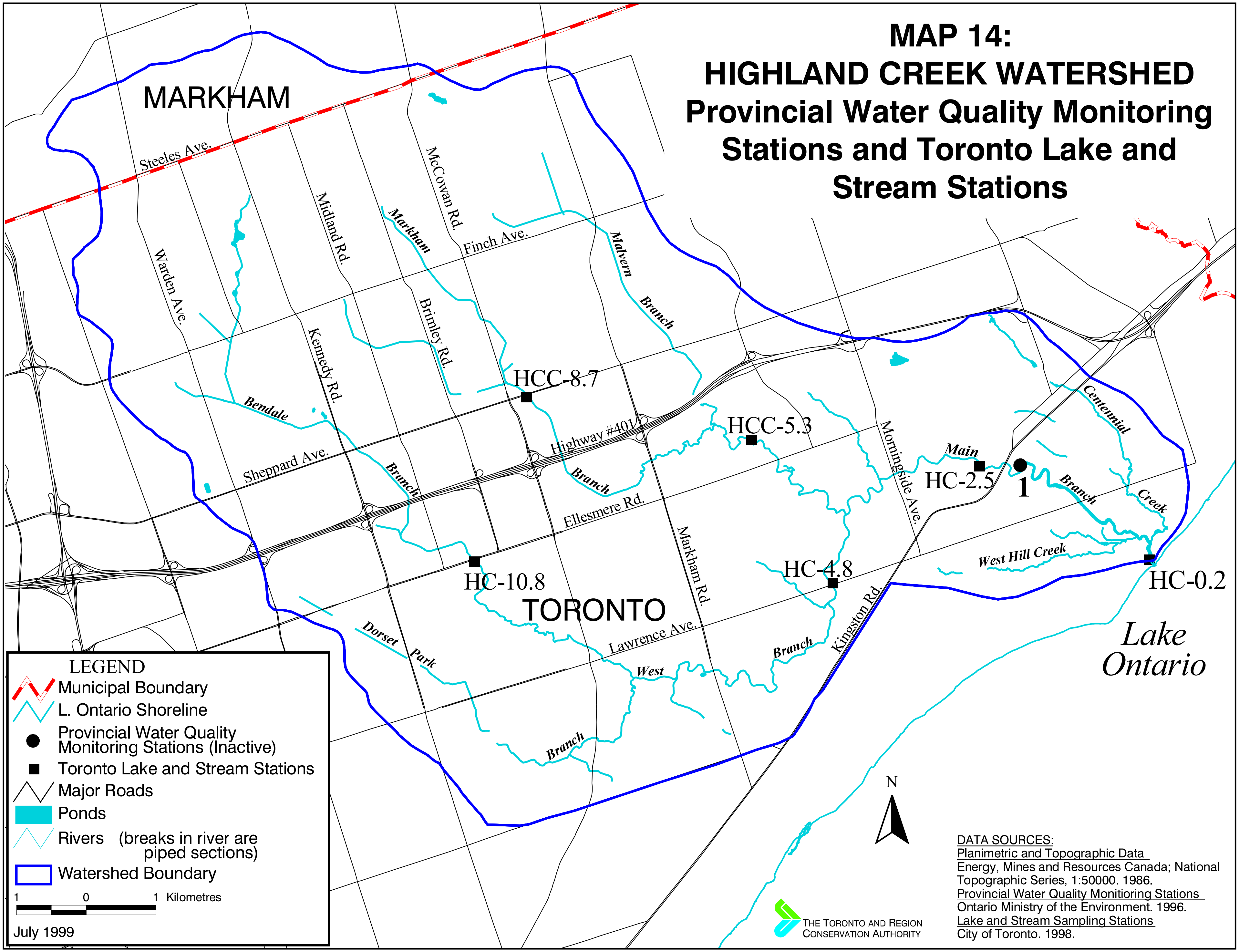

MAP 14:
HIGHLAND CREEK WATERSHED
Provincial Water Quality Monitoring Stations and Toronto Lake and Stream Stations
MARKHAM
TORONTO
Lake Ontario
Steeles Ave.
Finch Ave.
Sheppard Ave.
Ellesmere Rd.
Lawrence Ave.
Highway #401
Warden Ave.
Midland Rd.
Kennedy Rd.
Brimley Rd.
McCowan Rd.
Markham Rd.
Morningside Ave.
Kingston Rd.
Markham Branch
Malvern Branch
Bendale Branch
Dorset Park Branch
West Branch
Main Branch
Centennial Creek
West Hill Creek
HCC-8.7
HCC-5.3
HC-2.5
1
HC-10.8
HC-4.8
HC-0.2
N
LEGEND
Municipal Boundary
L. Ontario Shoreline
Provincial Water Quality Monitoring Stations (Inactive)
Toronto Lake and Stream Stations
Major Roads
Ponds
Rivers (breaks in river are piped sections)
Watershed Boundary
1 0 1 Kilometres
July 1999
THE TORONTO AND REGION CONSERVATION AUTHORITY
DATA SOURCES:
Planimetric and Topographic Data
Energy, Mines and Resources Canada; National Topographic Series, 1:50000. 1986.
Provincial Water Quality Monitoring Stations
Ontario Ministry of the Environment. 1996.
Lake and Stream Sampling Stations
City of Toronto. 1998.

TABLE 5: Key Water Quality Parameters

Selected Water Quality Parameters	Significance and Sources
Phosphorus	• Phosphorus and other nutrients generally do not have a direct impact on aquatic fauna. However, they do fuel plant and algal growth which may alter stream and lake habitats. As these plants die, they decay and this process consumes oxygen which, in turn, reduces the amount of oxygen available for aquatic life. Excessive plant growth also reduces water clarity and can be aesthetically undesirable. Phosphorus is a nutrient actively taken up by plants and, therefore, is not found in significant concentrations, except in waters receiving abnormally high inputs. The Ministry of the Environment has set a Provincial Water Quality Objective of 0.03 mg/L as the maximum concentration of phosphorus to protect aquatic life and assist in meeting requirements for recreation. • Sources include lawn and garden fertilizers, eroded soil particles from construction sites, stream banks, agricultural fields, and sanitary sewage.
Suspended Solids	• Suspended sediments are the small solid particles carried in water. For fish that rely on sight for feeding, turbidity may pose a problem. Where concentrations of suspended solids are too high, the particles may cause abrasion on the gills and affect the health of the fish. Particularly high suspended sediment concentrations are aesthetically undesirable. They also indicate that the bottom waters are choked with fine material as this sediment eventually settles over the bottom of the stream or lake when slower water velocities occur. Total suspended sediments also provide an indication of the presence of other contaminants such as oils, metals, and bacteria that tend to adhere to sediment particles. Less than 25-80 mg/L total suspended solids are recommended to maintain a good fishery. • Suspended sediments originate from many sources such as areas of soil disturbance (e.g., construction sites or farm fields), eroding streambanks and streambeds, and grit accumulated on urban streets.
Chloride	• Chlorides are usually present in most waters since they may be of natural mineral origin. The North American mean background concentration of chlorides is 8 mg/L. However, the largest contributions of chlorides can be linked to human activities such as road and parking lot salting, industrial wastes, and domestic sewage discharge. The Canadian Water Quality Guidelines identify 250 mg/L as the maximum concentration to protect the aesthetics and taste of drinking water. Chloride levels of 200-500 mg/L may have a limited impact on aquatic life. • Although chlorides are not critical to aquatic or human life at levels commonly observed, they are an important indicator of other sources of contamination. For example, an increase in chloride concentrations often acts as a "signature" for runoff from salted roads and other "urban" surfaces, or leachate from landfills.
Faecal Coliform Bacteria	• Although not of particular concern to aquatic life, bacteria densities impact on human health and the recreation potential of a water body. High bacteria levels in a water body are indicative of loadings of faecal matter of either animal or human origin. Acceptable limits for the bacteria *Escherichia coli* are 100 per 100 mL to protect for recreational water quality. Formerly, however, faecal coliform bacteria were measured as an indicator of health risk with a respective health limit of 100 counts per 100 mL. Therefore, in order to evaluate trends in bacteria levels over time, this former measure must be considered. • Bacterial loadings during dry weather can be attributed to illegal connections between storm and sanitary sewers and inputs from wildlife and domestic animals. During wet weather conditions, stormwater runoff carries bacteria from pet, livestock, and wildlife faeces and bacteria in association with eroded sediment particles to the watercourse.
Phenols	• Phenols are produced from many industrial processes and may also be released from aquatic plants and decaying vegetation. At certain levels phenols can be toxic to fish and may taint fish flesh producing unpalatable tastes and odours. MOE has set a Provincial water Quality Objectives of 1 ug/L to protect aquatic life and recreation.

Phosphorus

The mean phosphorus concentration of 0.1 mg/L at the West Hill station in Highland Creek is comparable to levels observed in other local urban streams. It is slightly lower than, but within the same order of magnitude as, mean concentrations in the Don River during dry and wet weather conditions. Concentrations are highest in the spring, and may correspond with elevated suspended sediment levels also observed at this time. Spring runoff tends to carry more soil particles, eroded from areas of exposed soils. Spring phosphorus sources may be associated with lawn and garden fertilizer applications.

Suspended Sediments

Sediment concentrations appear to be very consistent throughout the watershed, with mean concentrations ranging from 7 to 47 mg/L. Mean suspended sediment concentrations observed at the West Hill station are an order of magnitude lower than those observed in the Etobicoke and Mimico Creeks. This may be due to the fact that those watersheds are still experiencing urbanization and have maintained rural lands, while the Highland Creek watershed has been in a stable urban condition for most of the past 10 years. Mean sediment concentrations are also an order of magnitude lower than those observed in the Don River during wet weather, and comparable to those observed during dry weather.

Chloride

A mean chloride concentration of 328 mg/L in Highland Creek is typical of mean values found in other urban watercourses. Chloride concentrations exhibit a very strong seasonal correlation, with higher levels observed during the December to March period. January mean concentrations are in the order of 700 mg/L, directly relating to winter salt use on roads, driveways, parking lots, and sidewalks.

Faecal Coliform Bacteria

There appears to be progressively lower mean levels of bacteria toward the mouth on both branches of Highland Creek. Mean densities range from 36,592 counts/100 mL at Ellesmere Avenue on the West Branch; 51,731 counts/100 mL at Sheppard Avenue on the East Branch; to 9,320 counts/100 mL above the Highland Creek Sewage Treatment Plant. This pattern is opposite to that observed in most other Toronto watercourses. The mean values in the upper reaches appear to be elevated due to a few extremely high recordings, as the median values are relatively consistent throughout the watershed. Mean and median faecal coliform densities of 4,917 counts/100 mL and 1,060 counts/100 mL, respectively, found at the Ministry of Environment's West Hill station, are within the same order of magnitude but are slightly higher than levels observed in the lower reaches of other local urban watercourses.

Phenols

A mean of 2.1 ug/L and median phenol concentration of 1.0 ug/L are similar to concentrations observed in other local urbanized watercourses. No distinctive seasonal trends in phenol values are observed.

7.2.2.2 Surface Water Quality Trends

Water quality in Highland Creek has been improving over the last 30 years, as evidenced by decreasing concentrations of phosphorus and suspended sediments. This trend is likely due, in part, to the success of management programs such as those introduced in the early 1970s to reduce phosphorus use in detergents. The decreasing trend in suspended sediment may also reflect more stable watershed conditions that have followed a period of soil disturbing activity associated with urban growth during the 1960s. Increasing levels of faecal coliform bacteria and chloride have been observed. Given that the watershed has been largely urbanized since water quality monitoring began in 1972, urban growth represents only a small source of the increase of bacteria. Further investigation into other possible sources may be warranted. Chlorides are primarily associated with winter salt applications on roads, parking lots and other paved surfaces. While there are social expectations that pavement be clear 24 hours a day and in all kinds of weather, municipalities try to reduce usage of road salt through lighter applications and better timing. It is possible that the creek is still responding to past impacts. A University of Toronto study has projected that groundwater contaminated by past road salt use will become an increasingly significant source of chlorides where groundwater contributes to baseflow in Highland Creek. These trends are consistent with those observed in other local watersheds.

7.2.2.3 Violations of Water Quality Criteria

Water quality is generally measured by its ability to sustain human uses such as swimming or drinking, or to support a healthy aquatic community. As shown in Table 5, guidelines have been set for key water quality parameters in order to protect a particular use. The percentage of water quality samples that fail to meet the specified guideline can provide an understanding of present water quality conditions and concerns. In Highland Creek, water quality conditions fail to meet Provincial Water Quality Objectives and other guidelines less than 50 percent of the time for most parameters with the exception of bacteria.

- Phosphorus still fails to meet the PWQO of 0.03mg/L in 37 percent of the samples, despite significant reductions in concentrations. Even though this level of exceedance is low in comparison to other local watersheds, it is still contributing to the excessive growth of aquatic plants in the creek and represents a phosphorus load to Lake Ontario.
- Suspended sediment levels exceed the 25 mg/L guideline for a good fishery 18 percent of the time. Some elevation is natural during wet weather, but these conditions do not pose a problem for aquatic life if they do not persist for long periods, or if benthic organisms and sensitive habitats (ie. spawning beds) are not affected by sedimentation.
- Chloride levels exceed 250 mg/L 40 percent of the time at the West Hill station. The highest, potentially toxic, chloride levels are observed during the winter months.

- Bacteria levels are such that body contact recreation (i.e., swimming) is unsafe over 98 percent of the time.
- Phenol levels fail to meet the PWQO of 1 ug/L 49 percent of the time, posing potential toxicity to fish.

7.2.2.4 Sources of Pollution

Although water quality is measured in the river system, it is influenced by the natural conditions and land use in the watershed. The relatively flat topography and impermeable soils characteristic of the headwater reaches would have resulted in high volumes of runoff and limited groundwater contribution to stream baseflow, even in a natural watershed state. Water temperature would have tended to be warmer in these upper reaches, especially in summer without the cool groundwater inputs. South of Highway 401, below the old Lake Iroquois shoreline, there are substantial groundwater inputs from a deeper regional aquifer. These have a moderating effect on water temperature and provide a greater capacity to reduce the effects of pollutants carried in runoff through dilution.

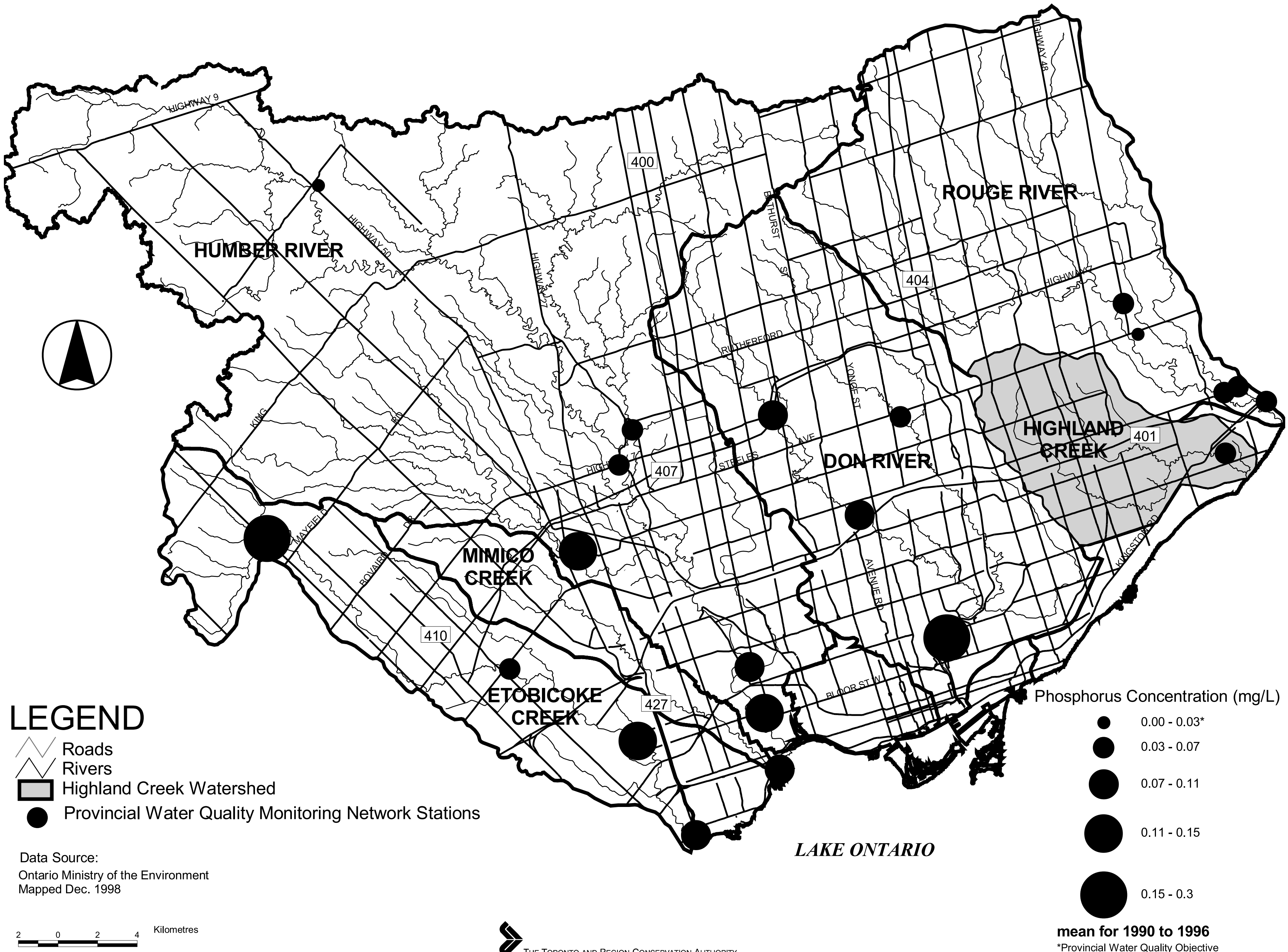
Historically, the watershed was forested with stream conditions capable of supporting a diverse fish community (e.g., migratory Atlantic salmon, resident brook trout, and pike). However, as forests and wetlands were cleared for agriculture and dams were built for grist and sawmills, the hydrological conditions in the watershed were altered. In the late 1960s and early 1970s, urban areas expanded rapidly and further impacted flows and water quality in the Creek. Since 1969, mean annual flows in Highland Creek have more than doubled, while the relative contribution of baseflow has declined. This trend is a typical result of urbanization, as the large areas of impervious surface and efficient drainage systems promote greater volume and velocities of stormwater runoff.

The Highland Creek watershed is entirely urbanized, and the water quality exhibits the impacts of this land use. The following discussion focuses on those pollutant sources deemed to be of prime significance in the Highland Creek watershed.

Stormwater

Stormwater runoff transports sediment, nutrients, bacteria, metals, and synthetic organic chemicals. These pollutants arise from a variety of sources in the urban landscape including: pet and wildlife faeces, soil erosion, pesticides and fertilizers, road salt, vehicle use (oil, grease, and exhaust containing metals), and particulate matter from atmospheric deposition. There are a number of conveyance and end-of-pipe stormwater management methods that may be used to convey and remove pollutants from stormwater. These include pervious pipe systems, filter strips, and oil/grit separators, among others. The use of constructed ponds to treat stormwater is discussed in Box 3, and various approaches to stormwater management are briefly described in Box 4.

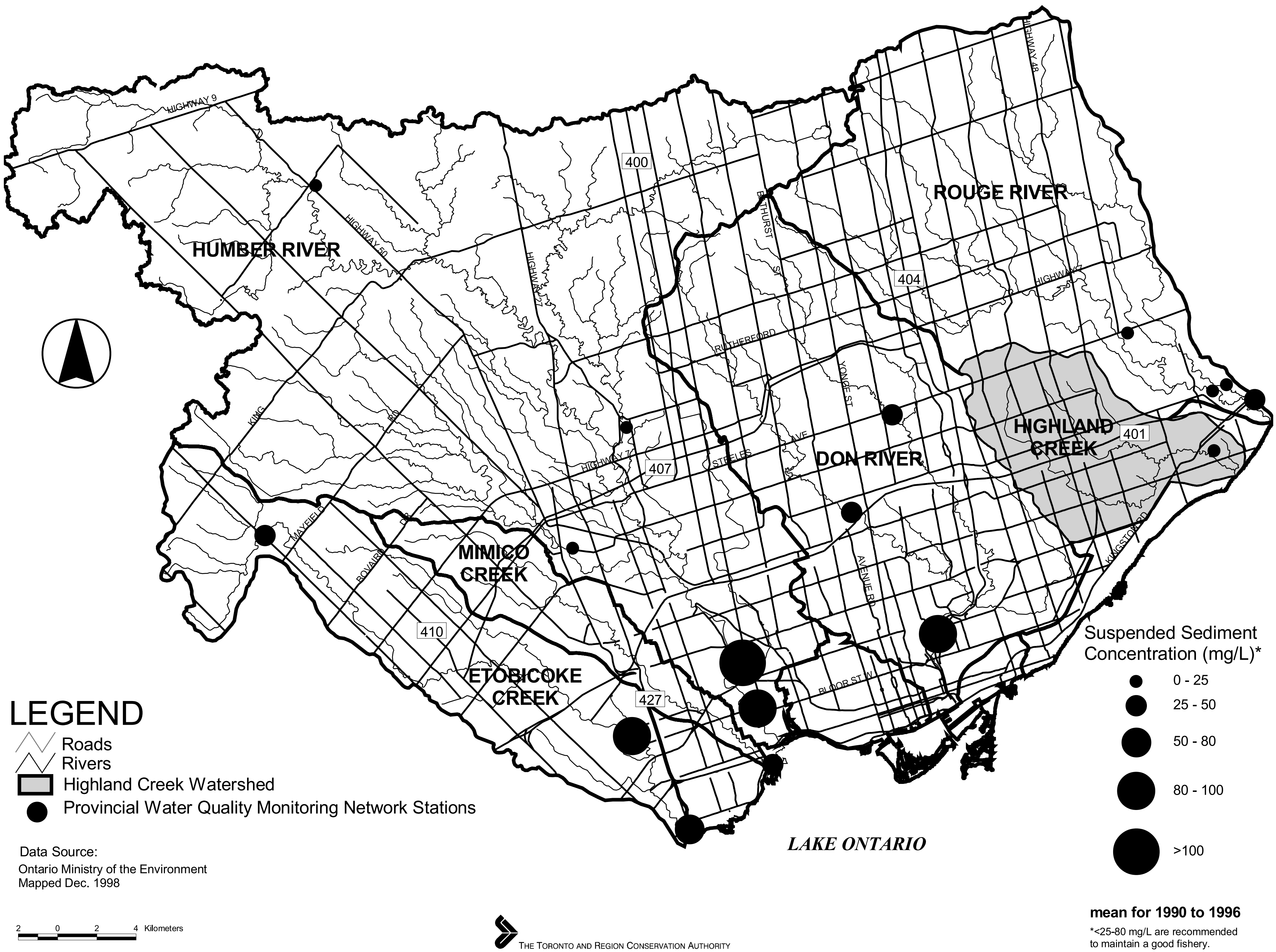
MAP 15: TORONTO REMEDIAL ACTION PLAN STREAM WATER QUALITY PHOSPHORUS CONCENTRATION



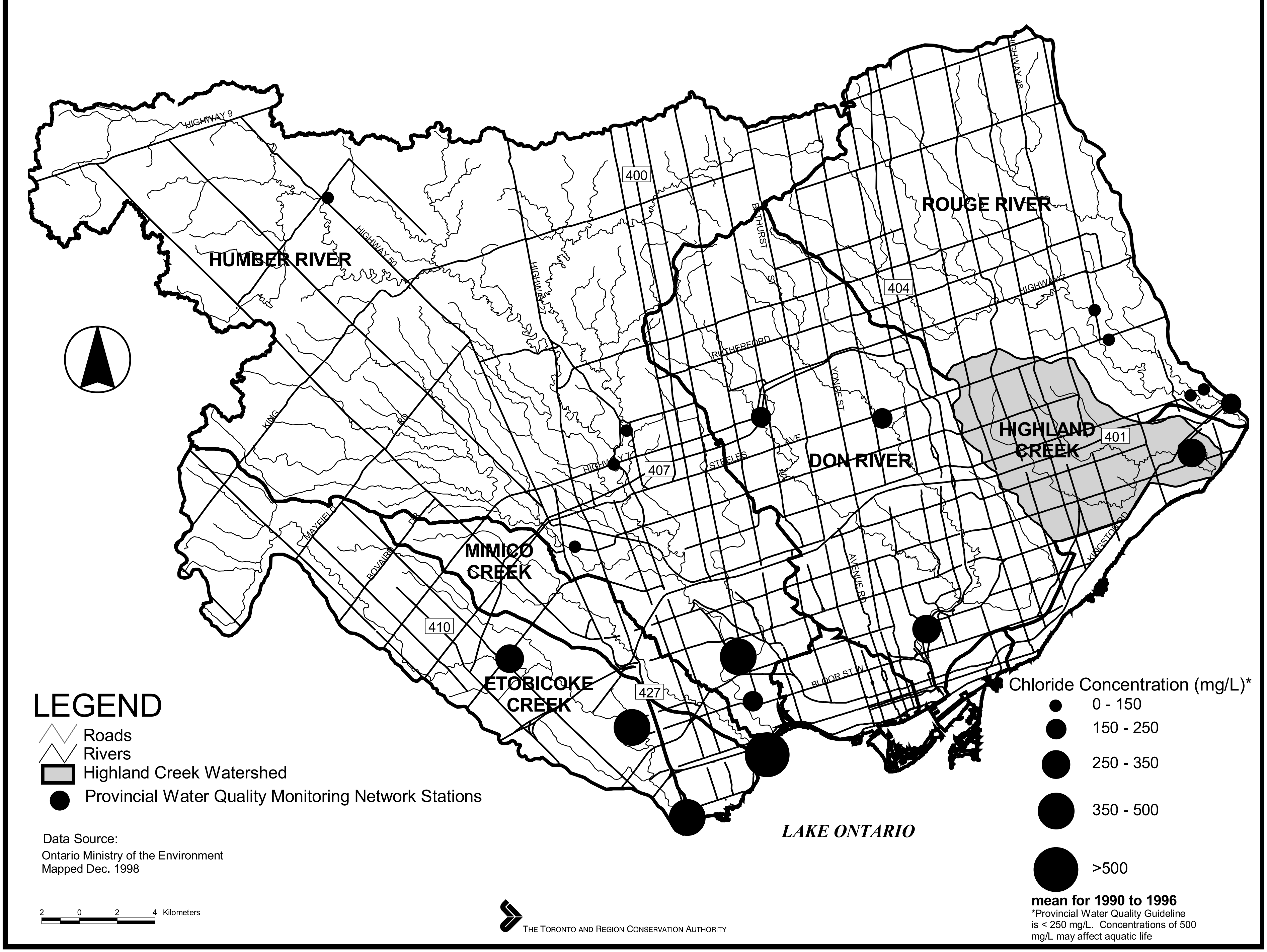
Data Source:
Ontario Ministry of the Environment
Mapped Dec. 1998

THE TORONTO AND REGION CONSERVATION AUTHORITY

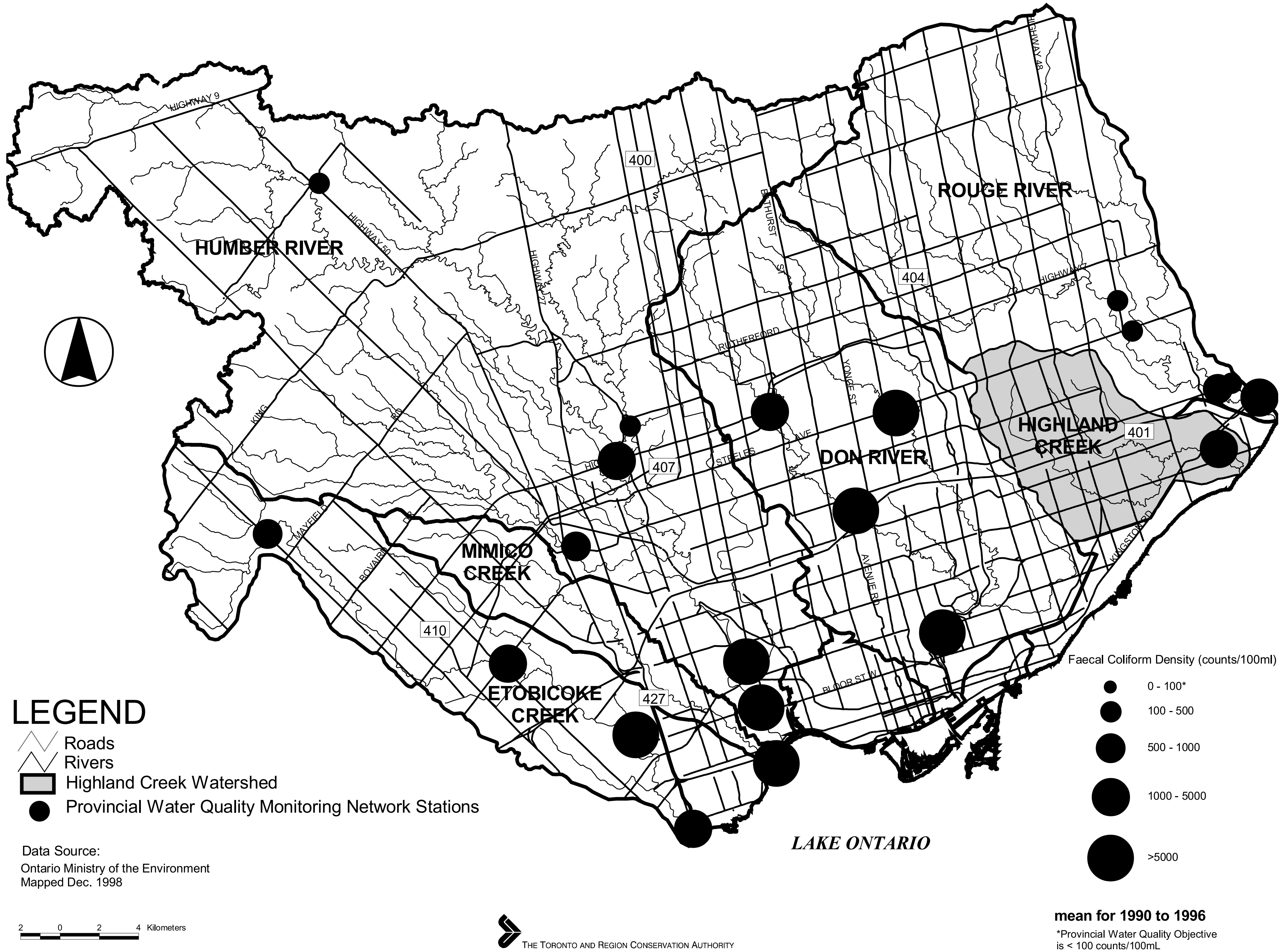
MAP 16: TORONTO REMEDIAL ACTION PLAN STREAM WATER QUALITY SUSPENDED SEDIMENT CONCENTRATION



MAP 17: TORONTO REMEDIAL ACTION PLAN STREAM WATER QUALITY CHLORIDE CONCENTRATION



MAP 18: TORONTO REMEDIAL ACTION PLAN STREAM WATER QUALITY FAECAL COLIFORM DENSITY



BOX 3: CONSTRUCTING OR "RETROFITTING" PONDS TO TREAT THE QUALITY OF STORMWATER

For new developments, stormwater management facilities are designed to mitigate any or all of the following impacts of urbanization: increased quantity of runoff, lowered water quality, and greater potential for streambank erosion.

There are a number of stormwater ponds within the Highland Creek watershed that control water quantity, quantity, or both quantity and quality. Stormwater quality ponds mitigate the degraded quality of urban runoff by promoting the settling of suspended solids or particles, and, where wetland vegetation is present, some nutrient removal may be provided. Water quality ponds may take various forms including wet ponds, dry ponds, and constructed wetlands. Wet ponds and wetlands provide a permanent pool of water which acts to dilute the poor quality inflow, promote settling, and prevent resuspension of previously settled particles. Wetlands are typically of shallower depths so they have a larger portion of their surface area covered by emergent vegetation.

Methods for the prevention of streambank erosion resulting from urbanization are typically incorporated into water quality facilities by allowing for the slow release of runoff volumes from relatively frequent rainfall events, for example of one inch of rainfall or less. In other words, the runoff from such a storm is stored and released over a period of one to two days with the intent of reducing the outflow to the point where the existing streambanks will not experience increased erosion.

Although all three components of quantity, quality, and erosion control are now typically incorporated in a single pond, the design of earlier water quantity ponds did not address the issues of water quality and erosion impacts because the ponds were generally dry facilities and they released the runoff relatively quickly (typically over a few hours). Without sufficient detention time for those events more frequent than the two year storm, little or no erosion control was afforded by these facilities. Likewise, lacking a permanent pool of water, these facilities provided limited water quality improvement. Nevertheless, traditional water quantity ponds can provide 'retrofit' opportunities in existing, built-up areas. Subject to maintaining their original flood control function, these facilities can, in many instances, be retrofitted to achieve both improved water quality and erosion control where none previously existed. This is typically undertaken by excavating the pond bottom to create a permanent pool and promote emergent plant growth, and by adjusting the outlet structure to increase the storage time (thereby choking back the outflow) for frequent rainfall events.

BOX 4: WATER QUANTITY/QUALITY MANAGEMENT: SOLUTIONS

Attitudes towards urbanization and the environment have been changing over the past two decades. An important element of this change is the development of a more natural approach to stormwater management, one that attempts to mimic the natural functioning of the hydrologic cycle in terms of flow controls, while at the same time removing pollutants. Stormwater management is achieved using a combination of four approaches:

1. Pollution Prevention

- Elimination or reduction of the use of pesticides, fertilizers, or other pollutants.
- Municipal maintenance activities such as street cleaning.

2. Stormwater Lot Level (Source) Controls

These and related measures are implemented on-site:

- *Reduced Lot Grading* to encourage ponding, natural infiltration, and evaporation of runoff.
- *Roof Leaders* to discharge to ponding areas, soakaway pits, or rain barrels.
- *Sump Pumping of Foundation* draining to either the surface or to soakaway pits.
- Lot Level *Best Management Practices.*

3. Stormwater Conveyance Controls

Conveyance systems are used to transport stormwater runoff from lots to receiving waters:

- *Pervious Pipe Systems* allow exfiltration of water through the pipe wall into a deep gravel bed and then the surrounding soil as it is conveyed downstream. The City of Toronto is one of the few municipalities which has attempted to implement this.
- *Pervious Catch-Basins* are oversized catch-basins connected to exfiltration trenches. They are intended to infiltrate road drainage which has high levels of suspended sediment.
- *Grassed Swales or Roadside Ditches* encourage infiltration and reduce flow velocities.

4. End-of-Pipe Stormwater Management Facilities

These are used to service numerous lots or whole subdivisions. These facilities receive stormwater from a conveyance system and then discharge it to receiving waters:

- *Wet and Dry Ponds* temporarily store stormwater to allow settling of sediments. Wet ponds retain a permanent pool of water which allows sediment and other pollutants to settle to the bottom. Dry ponds have no permanent pool of water and are only used for quantity control.
- *Constructed/Artificial Wetlands* improve water quality as well as provide ancillary benefits in terms of habitat, although concerns have been raised because of the potential availability of pollutants to wildlife.
- *Infiltration Systems* include infiltration trenches and basins.
- *Filter Strips* spread stormwater across a strip of vegetated land to promote filtering of pollutants and infiltration of stormwater.
- *Oil/Grit Separators* combine storage chambers for sediment trapping and oil separation with a drainage inlet, or inflow sewer, for intercepting stormwater runoff.
- *Buffer Strips* are natural areas (e.g., vegetated set backs) existing between development and receiving waters.

Stormwater passes through storm sewers or drainage ditches, and ends up being discharged directly into the creek. Only since 1990 have land developments incorporated stormwater management facilities with a quality control component to treat the runoff. In the Highland Creek watershed, only about 4% (about 300 ha) of the existing urban portion of the watershed has stormwater quality management measures that meet current requirements (see Map 19: Areas Controlled by Major Stormwater Management Facilities). The City of Toronto is preparing a Wet Weather Flow Management Master Plan which will recommend approaches for improving stormwater management in existing urban areas throughout the City.

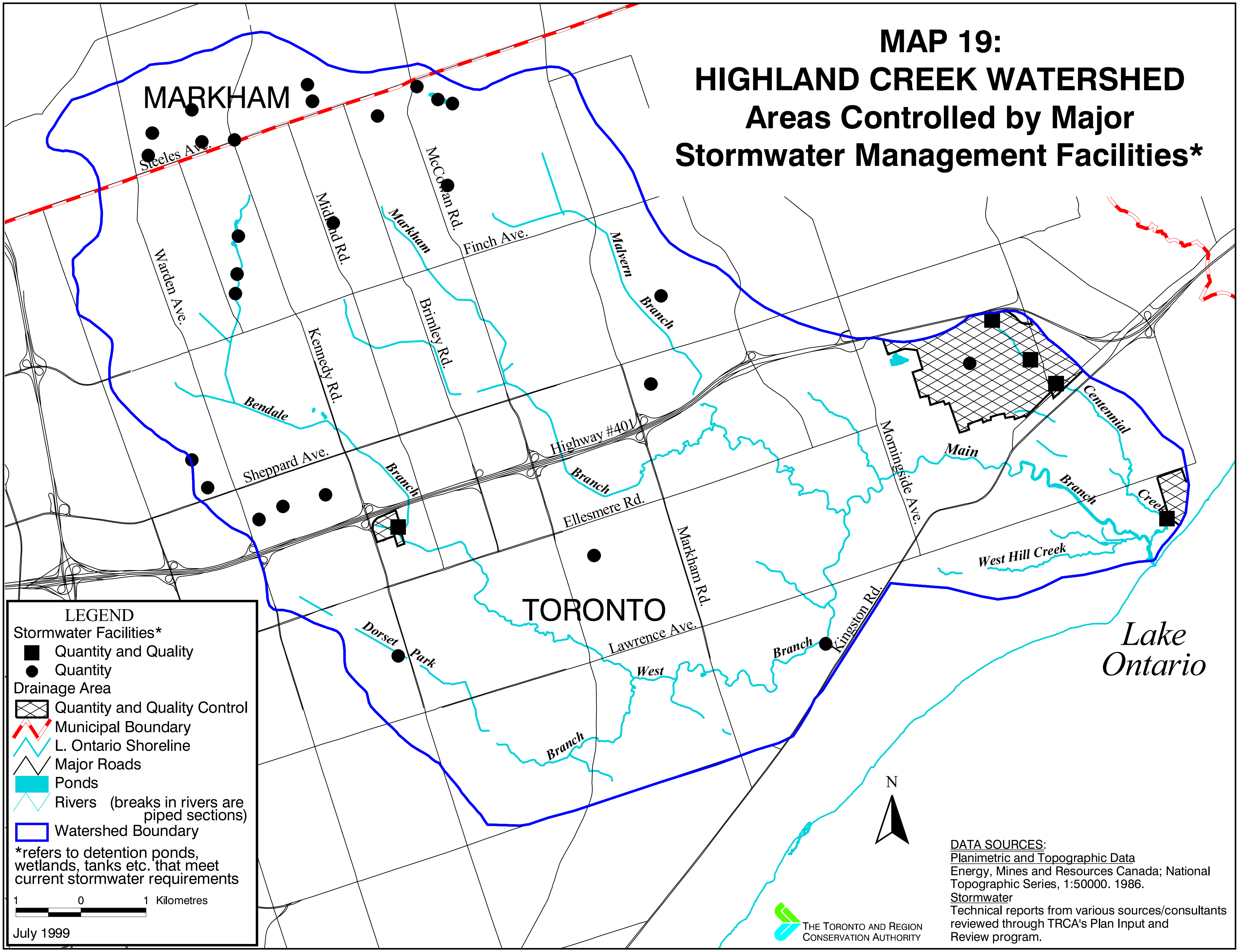
In addition to stormwater runoff, storm sewer infrastructure may carry pollutants released through illicit discharges or accidental spills. Municipalities and agencies recognize this concern and monitor storm sewer outfalls during dry weather to identify any with high levels of contaminants. Such outfalls are often termed 'priority outfalls'. The contaminants may be traced back to their sources (e.g., spills, dumping, or improper connections) so that offenders can be warned to change their practices, or be prosecuted. Map 20: Storm Outfalls depicts the 334 stormwater outfalls discharging to Highland Creek (Gartner Lee, 1987). The City of Toronto (formerly through Metro Works and the City of Scarborough) undertakes monitoring programs for the outfalls.

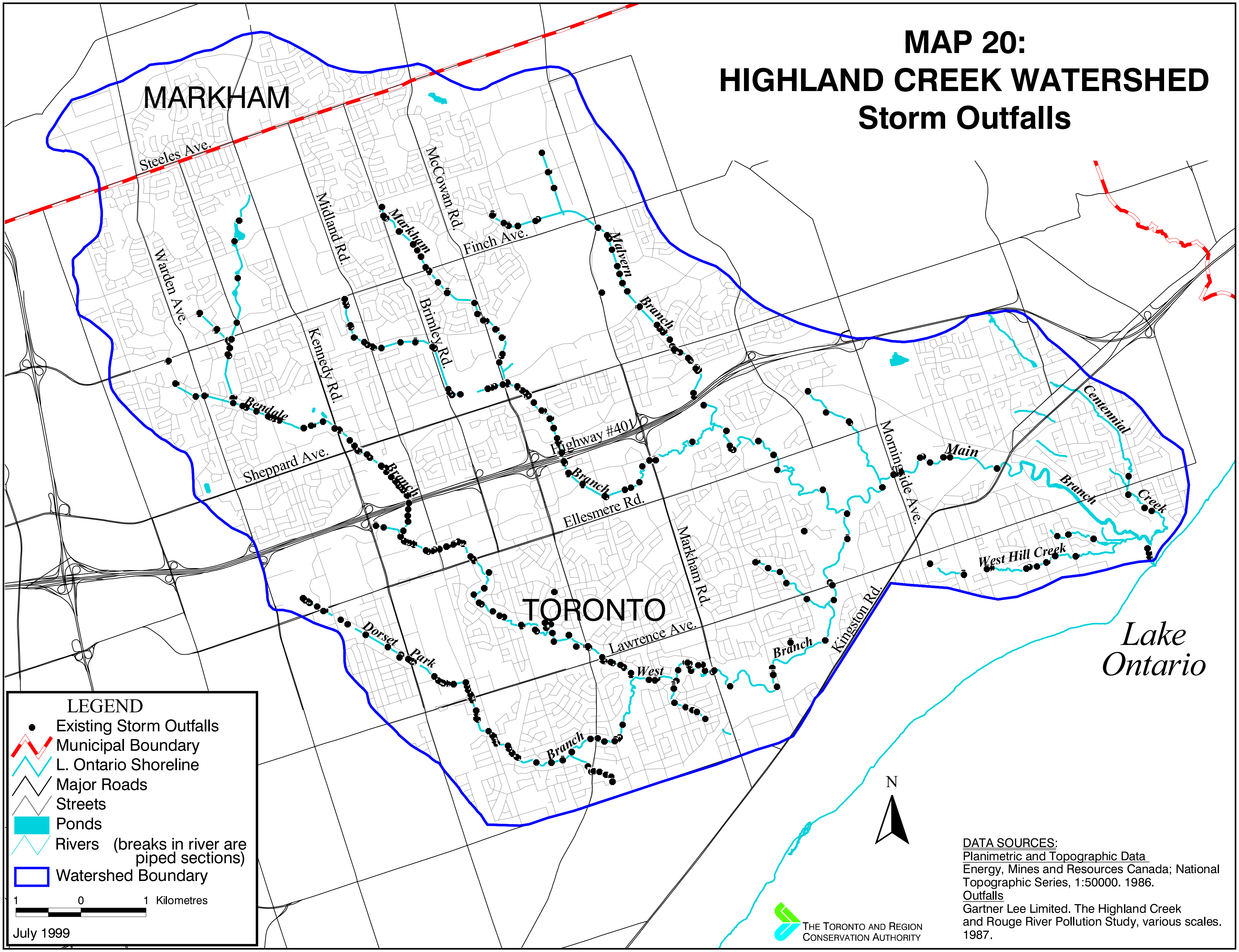
According to a report from Metro Works, the greatest proportion of major problem outfalls during 1992-1995 were in the industrial sector (TRCA, 1998d). During 1992-1993, the sources of these problems were found to be associated with two major incidences of poor housekeeping and one major spill incident. During 1994-1995 (the most recent report), Highland Creek had three major incidents of cross connection, seven incidents of spills, and four incidents of dumping. Based on these investigations, it was deemed that no outfalls in the Highland Creek watershed warranted "priority status" for extensive efforts to trace pollutants to source.

Stormsewer outfall discharging into the Highland

The City of Scarborough conducted a study of outfalls, pollutant sources, and pollutant loadings in 1986 (Gartner Lee, 1987). Since then, Scarborough continues to sample its outfalls for bacterial analysis on a rotating five year cycle. Priority outfalls are then investigated and the problems corrected (Minor, 1995). Benthic invertebrate sampling has been conducted jointly by Scarborough and TRCA in order to help characterize the health of the watershed and help to identify sources of impairment.

MAP 19: HIGHLAND CREEK WATERSHED
Areas Controlled by Major Stormwater Management Facilities*




MAP 20:
HIGHLAND CREEK WATERSHED
Storm Outfalls
MARKHAM
TORONTO
Lake Ontario
Steeles Ave.
Finch Ave.
Sheppard Ave.
Highway #401
Ellesmere Rd.
Lawrence Ave.
Kingston Rd.
Warden Ave.
Midland Rd.
Kennedy Rd.
Brimley Rd.
McCowan Rd.
Markham Rd.
Morningside Ave.
Markham Branch
Malvern Branch
Bendale Branch
Dorset Park Branch
West Branch
Main Branch
Centennial Creek
West Hill Creek
LEGEND
Existing Storm Outfalls
Municipal Boundary
L. Ontario Shoreline
Major Roads
Streets
Ponds
Rivers (breaks in river are piped sections)
Watershed Boundary
1 0 1 Kilometres
July 1999
N
THE TORONTO AND REGION CONSERVATION AUTHORITY
DATA SOURCES:
Planimetric and Topographic Data
Energy, Mines and Resources Canada; National Topographic Series, 1:50000. 1986.
Outfalls
Gartner Lee Limited. The Highland Creek and Rouge River Pollution Study, various scales. 1987.

Spills

Deliberate discharges or accidental spills are especially prone to occur in densely urbanized areas, particularly in industrial areas and transportation corridors. During the period 1988-1996, a total of 39 spills that reached Highland Creek were reported to the Spills Action Centre at the Ministry of the Environment (see Map 21: Spill Locations 1988-1996). Approximately 31 percent of these 39 reported spills were oil, petroleum, or diesel fuel. The large proportion of these types of spills is attributable to the fact that petroleum is one of the most common liquids used in urban areas and as a liquid, can move easily over and through land. Industrial land uses and roads represent the primary source areas of such spills.

Analyses undertaken in the Toronto Area Watershed Management Studies suggest that a petroleum spill of 100 L may be as toxic to aquatic biota as combined sewer overflows or stormwater runoff associated with a rainfall event in the order of 10 mm. Also, the frequency of occurrence may be of more concern than the magnitude of a spill (Ministry of Environment, 1991). For spills with known volumes, the average volume of a spill in the Highland Creek watershed was 615 L. It should be noted that not all spills are reported and that sources for spills may be unknown. Most spills have occurred in the following industrial areas:

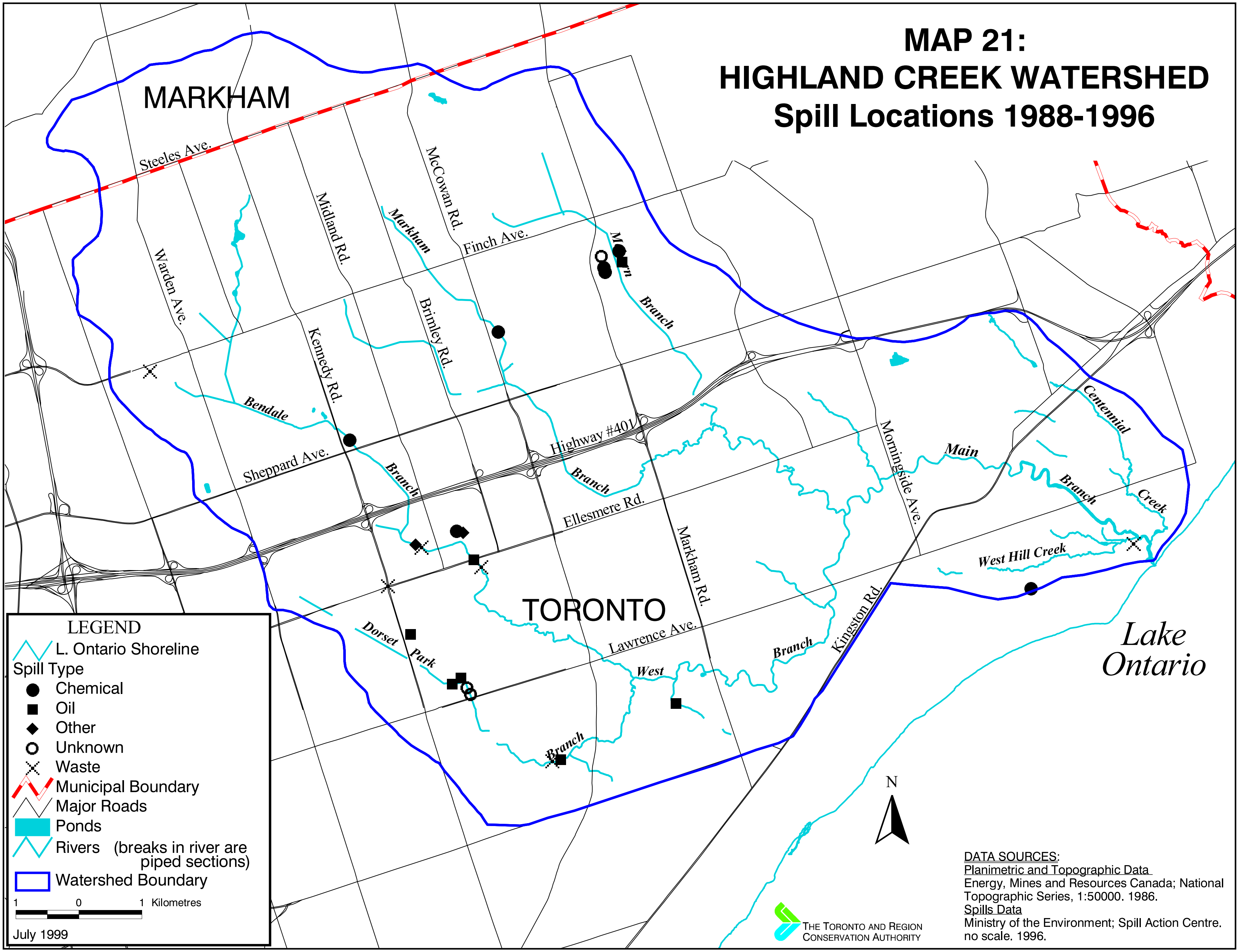
- east of Markham Road, north of the CP rail line, south of Finch Avenue
- east of Kennedy Road, north of Ellesmere Road, south of Highway 401
- north of Lawrence Avenue, between Kennedy Road and Midland Avenue

Pet and Wildlife Faeces

Pet and wildlife faeces can represent a significant source of bacteria to urban waters. Based on 1996 dog licensing data from the City of Scarborough, there are approximately 6,900 dogs living in the Highland Creek watershed (Mitton, 1997). These dogs generate about 2.07 tonnes of faecal matter per day, which is equivalent to the daily faecal output of 2,300 humans (Melbourne Water etc., 1993). It is interesting to recognize that, under current regulations, the Ministry of the Environment would require a developing community of that size to provide some form of communal treatment system for this volume of human sewage.

Stoop and scoop by-laws protecting Highland waters

It should be noted that on average about 70 percent of dog owners participate in 'stoop and scoop' practices, which help to manage


MAP 21:
HIGHLAND CREEK WATERSHED
Spill Locations 1988-1996
MARKHAM
TORONTO
Lake Ontario
Steeles Ave.
Finch Ave.
Sheppard Ave.
Highway #401
Ellesmere Rd.
Lawrence Ave.
Kingston Rd.
Warden Ave.
Midland Rd.
Kennedy Rd.
McCowan Rd.
Brimley Rd.
Markham Rd.
Morningside Ave.
Markham Branch
Bendale Branch
Dorset Park Branch
West Branch
Main Branch
Centennial Creek
West Hill Creek
N
LEGEND
L. Ontario Shoreline
Spill Type
Chemical
Oil
Other
Unknown
Waste
Municipal Boundary
Major Roads
Ponds
Rivers (breaks in river are piped sections)
Watershed Boundary
1 0 1 Kilometres
July 1999
THE TORONTO AND REGION CONSERVATION AUTHORITY
DATA SOURCES:
Planimetric and Topographic Data
Energy, Mines and Resources Canada; National Topographic Series, 1:50000. 1986.
Spills Data
Ministry of the Environment; Spill Action Centre. no scale. 1996.

this pollutant at source (Mitton, 1997). Taking this reduction factor into account, the remaining 2,075 dogs still generate about 0.62 tonnes of faecal matter daily, which compares to the output from about 692 humans (Melbourne Water etc., 1993). This analogy helps to underscore the need to promote pet management, especially considering that there is likely a much larger population of geese and other wildlife whose impacts must also be absorbed by the natural environment.

Streambank Erosion

Stormwater runoff not only has a direct impact on river water quality, but also affects quality indirectly through accelerated stream bank erosion and associated release of sediment. Soil erosion also releases phosphorus and nitrogen to the creek, as these nutrients are naturally associated with soil particles. Although bank erosion is a natural phenomenon, urban development increases the volume of runoff and the frequency of erosive flows. Erosion rates for Highland Creek and other predominantly urban watercourses were listed among the highest of major tributaries in the Toronto area (RCFTW, 1991). While erosion rates in Highland Creek may have lessened now that watershed development has stabilized, it is apparent that erosion is still active, and should be studied further to determine the extent of stormwater management retrofit work needed to address the problem.

Construction Activity

Newly developing urban areas, infill developments, redevelopment, and instream works represent a potential source of sediment loadings to the watercourse, if proper erosion and sediment controls are not used. Some areas, such as the Cities of Toronto, Mississauga, and Brampton, have enacted Erosion and Sediment Control Bylaws. These Bylaws have been shown to be the most effective tool in promoting and enforcing the use of proper controls.

Landfills

Historical records of former landfill sites vary considerably in the amount of information available about the site, its operation, and its on-going care and maintenance. Scarborough’s remediation program for 'old landfills' has been adopted by the new City of Toronto, and will continue to investigate and remediate sites throughout 1999 (see Section 7.1.2).

Atmospheric Fallout

Atmospheric sources of various pollutants can be relatively more significant in urban areas than in predominantly rural watersheds. This is due to the large area of impervious surface and the stormwater conveyance systems that collect and convey pollutants to watercourses, often without treatment. A local Toronto outfall monitoring study (D’Andrea et al., 1993) found no significant difference in stormwater quality between drainage areas of different urban land use types (e.g., industrial, residential) for most atmospheric parameters. This finding may be explained by a common atmospheric source of pollutants.

Vehicle emissions may be a relatively significant source of certain pollutants, because pollutants in vehicle emissions are deposited directly onto roads. Stormwater runoff conveys pollutants directly into drainage systems, without opportunity for filtration which might occur with particles deposited on vegetated surfaces or percolated into soil. A study characterizing the sources of polycyclic aromatic hydrocarbons (PAHs) in street and creek sediments noted the significance of vehicle emissions relative to other industrial sources, because most of the PAHs in vehicle emissions are deposited on the street/road grid itself or within 40 metres either side of the road (Sharma et al., 1997).

Air quality in the Highland Creek watershed is a result of local, national and international sources. Generally, air quality has improved in Ontario over the past 25 years, however there are increasing problems with ground level ozone, smog, and suspended particulates. Of these pollutants, particulates are of most concern to water quality. Particulates are created by industrial processes and are present in motor vehicle exhaust. Air quality in the Highland Creek watershed is considered to be good, with respect to human health effects, 95 percent of the time (see Section 6.3). However, it is not known to what extent the Air Quality Index for Human Health is as a good indicator of potential for water quality impacts.

SUMMARY

Water quality in Highland Creek is degraded with high levels of phosphorus, suspended sediment, chloride, bacteria, and phenols. Pollutant concentrations are at similar levels throughout the creek. Poorer conditions are most closely associated with periods of wet weather. However, for many parameters, Highland Creek is comparable to or less degraded than other Toronto area watersheds. In the Highland Creek, water quality conditions exceed Provincial Water Quality Objectives and other guidelines less than 50 percent of the time for most parameters with the exception of bacteria. Water quality has been improving over the last 30 years, as evidenced by decreasing concentrations of phosphorus and suspended sediments. However, increasing levels of faecal coliform bacteria and chloride have been observed. Similar to other local urban watersheds, water quality in Highland Creek exhibits the impacts of land use in its watershed.

NATURAL HABITATS

CHAPTER 8

This section describes the living components of the natural heritage system (plants and animals). The discussion will follow the natural delineation between the two broad habitat categories: terrestrial and aquatic. These, in turn, are further subdivided into a number of distinct habitat types.

8.1 TERRESTRIAL HABITAT

The Highland Creek watershed covers a total area of 102 km^2, all of which is now within an urban context. Most of the creek tributaries north of Highway 401 have been channelized in the residential and industrial areas. What remains of the natural terrestrial habitat is now restricted to a few small forest blocks and hedgerows, although some meadow (old field) and early successional habitat is found along the banks of some of the creek channels and in undeveloped areas. The largest remaining blocks of terrestrial habitat are found south of Highway 401 (see Map 22: Existing Terrestrial Habitat).

As part of the work program for the *Highland Creek State of the Watershed Report*, the TRCA undertook a reconnaissance study and assessment of the terrestrial habitat within the watershed. The analysis of terrestrial habitat conditions was guided by a set of principles based on the objectives of biodiversity conservation and the maintenance of ecosystem health and integrity. These principles are particularly relevant for urbanized watersheds, such as Highland Creek, where natural habitats are fragmented and isolated by surrounding land uses. A number of these principles are summarized in Table 6**.** The *Terrestrial Habitat Analysis Of The Highland Creek Watershed* report (TRCA, 1998e), forms the basis of this section of the *Highland Creek State of the Watershed Report*.

Canada can be divided into nine floristic regions, each based on a dominant vegetation community type. Transition zones between these regions are subtle, and contain representative species or patches of habitat typical of each overlapping region. The Highland Creek watershed is located in a transition zone between the Carolinian (deciduous forest) and Great Lakes-St. Lawrence (mixed forest) regions, but features species and communities more typical of the latter.

TABLE 6: Principles for Habitat Evaluation

Principle	Description
Habitat Type and Representation	All open areas provide habitat that is of use for some species. Natural habitats are of greatest concern since these and their associated species are rapidly disappearing as humans modify the landscape. While a natural heritage system typically attempts to maintain representation of all indigenous habitat types and species within a given region, in a heavily settled landscape it may not be possible to maintain a natural ratio of habitat types.
Naturalness/ Disturbance	The concept of 'natural' is problematic because it often assumes a lack of human influence, and few such areas exist in a settled landscape. A more appropriate approach may be to consider the degree to which an area has remained unaltered or unmanaged over a period of time. Generally, the more pristine and less disturbed a natural area is, the better will be its capacity for representation and maintenance of biodiversity. Undisturbed areas can also act as historical baselines for ecological restoration, and can be important for scientific study. However, regenerating habitats such as old field that support many native species of plants and animals, can also be considered as natural -- especially in agricultural and urban landscapes.
Habitat Size	Large patches of habitat are typically of greater value than small patches. Larger areas are more likely to sustain ecological functions such as nutrient recycling. Some species are 'area sensitive' and need large blocks of a particular habitat type. Large blocks also help to maintain species richness (total number of species in a given landscape). However, in areas where small patches of habitat are all that remains, they perform many useful functions, for example, being stopover habitat for migratory birds and butterflies. Forest interior is used to describe parts of a forest block that are 100 metres or further from the forest edge. Negative edge effects will penetrate a forest block to a minimum of 100 metres.
Habitat Shape	In part, habitat shape determines the degree to which a forest is exposed to edge effects. These are negative external influences that affect the structure and species composition of a forest fragment. They include wind damage, increased predation by opportunistic edge species, brood parasitism of native songbirds by the brown-headed cowbird, and exotic plant invasions. The amount of edge compared to the amount of interior habitat in a forest fragment is measured as the edge-to-interior (or edge-to-area) ratio. Long, thin, or irregularly shaped forest fragments tend to have a great deal of edge and no interior. In contrast, compact blocks have a greater capacity to support interior habitat, and will have less edge. A circle has the lowest edge-to-interior ratio (Payne and Bryant, 1994; Forman, 1995).

Principle	Description
Fragmentation/ Connectedness	The long term viability of wildlife populations is largely based on the ability of individuals to find adequate resources and to maintain fitness through genetic exchange. These are enhanced by dispersal capacity of a species, meaning the capacity of a species to move freely. The dispersal capacity of wildlife can be restricted according to the degree to which a species is a habitat specialist and the measure of isolation of its habitat in the landscape. Forest patches that are close together will be easier to reach than those which are far apart. A natural connection between habitats that provides cover can act as a corridor that helps to allow movement. In settled landscapes, valley and stream corridors are often the best candidates for maintaining connectivity between natural habitats.
Arrangement/ Proximity	Closely clustered habitat patches are better than those which are far apart (Noss, 1995). The ability of wildlife to move, or for seeds to be dispersed, between suitable habitats is in part dependent on how close together the habitats are. Hydrological and biochemical functions are also more likely to be maintained if patches are in close proximity (MNR, 1997). At the landscape level, arrangement and proximity involve the concept of interspersion, meaning the interface between natural habitat types (Forman, 1995). Zones of interspersion are high in biodiversity because several habitat types are represented in one small area. They therefore have the capacity for maintaining a high representation of species.
Habitat Diversity/ Complexity	Vertical structure is a fundamental feature of forest ecosystems. A healthy forest typically has several vegetation layers, including the canopy of mature trees, an understorey of young trees or shrubs, and the herbaceous ground layer made up of wildflowers, ferns, and other plants. Woody debris on the forest floor can also be considered a structural feature. The presence of these layers helps to explain why forests tend to have a higher degree of biodiversity than other ecosystems, since each layer provides habitat (a niche) for different species (Hunter, 1990; Adams, 1994). Horizontal structure also affects biodiversity. For example, an untouched forest is typically a shifting mosaic of different age classes and regenerating areas that provide a variety of habitats for wildlife (Sauer, 1998).
Species Diversity	Sites that have a high species diversity could have the capacity to maintain representation of more species and habitat types. To a large degree this capacity depends on habitat size, shape, and relationship to other natural areas in the landscape.
Species Rarity	Special attention should be given to rare species and their habitats since these are most at risk of disappearing. Many species have been officially designated as significant because they are vulnerable or endangered, although many rare species have yet to be officially recognized. At the watershed level, National, Provincial, regional, and local significance should be considered.

Vegetation patterns are further affected by geological features and soil types. The headwater region of Highland Creek is found on the South Slope formation, which is made up of relatively impermeable soils. This type of soil typically supports hardwood forests composed of maple and beech on upland areas, and a mixture of hardwood and cedar swamp in low, poorly drained areas. Further south is the Iroquois Plain, which is made up of permeable sand and gravel left behind as part of the original shoreline of glacial Lake Iroquois. These soils provide ideal growing conditions for pine and oak.

A summary of the condition of each of the major natural habitat types found in the watershed is provided below.

8.1.1 Forested Lands

Historically, forests in southern Ontario were likely to have an average canopy height of around 24 metres (80 feet) with towering white pines reaching heights of 46-55 metres (150 to 180 feet) or more (Whitney, 1994).

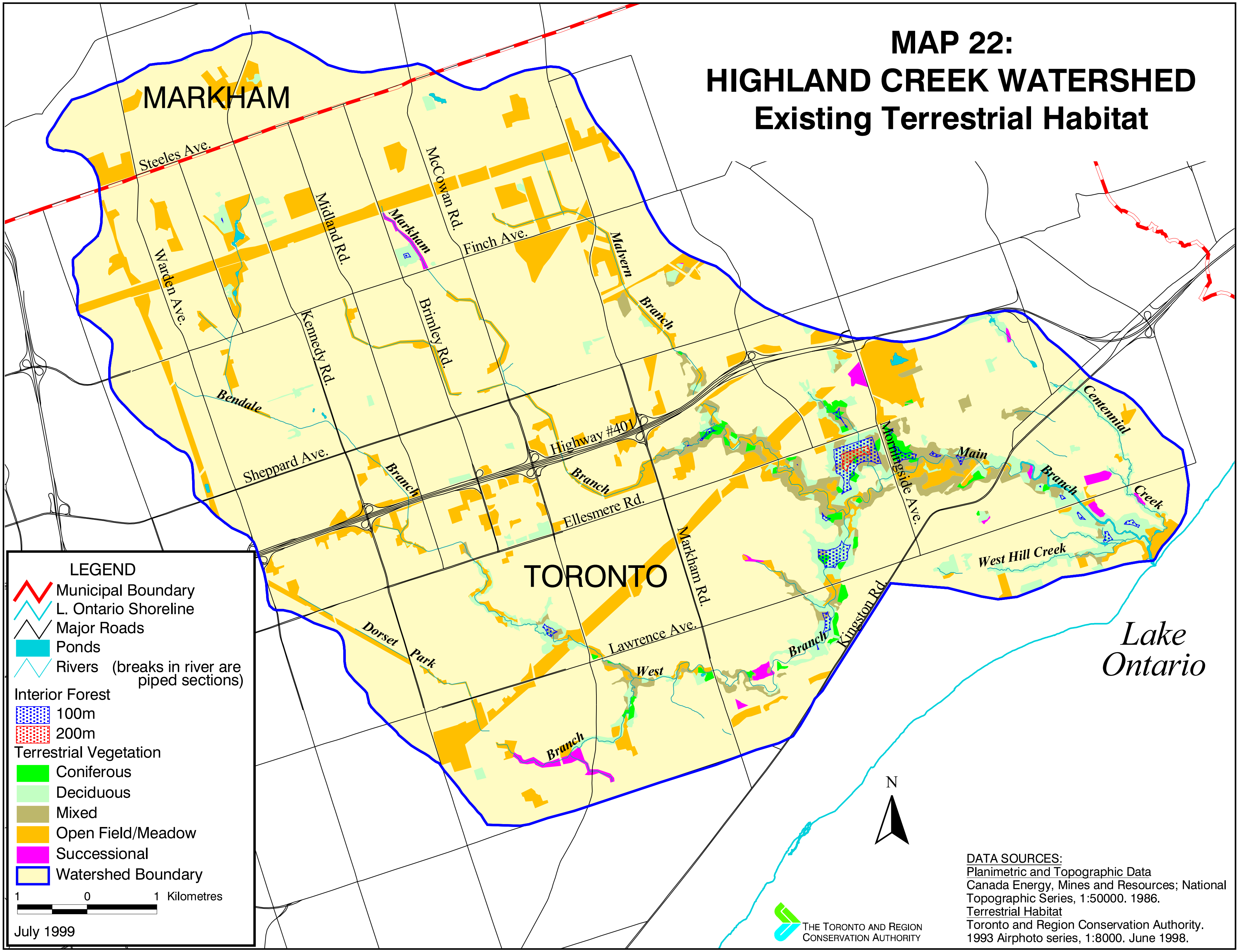
The first Europeans to venture into the Highland Creek watershed would have found a landscape blanketed in forests, as was typical for much of what is now the Greater Toronto Area. Surveyor's notes for southern Ontario (including the Scarborough area) indicate that uplands typically supported maple, elm, beech and basswood, with oak and pines being found on areas with sandy soils, while hemlock was typically found on valley slopes (ODPD, 1956).

In addition to what is found today, wildlife present in the region at the time of European settlement would have included such large mammals as gray wolf, cougar, lynx, black bear, elk, and possibly bison (Kurta, 1995). All of these are now extirpated, presumably as a result of habitat loss, hunting pressure, and the fur trade.

The first homestead in the Highland Creek watershed was established in 1796. Three years later the Danforth Road reached the watershed, followed shortly thereafter by the Kingston Road (Bonis, 1982). From this point many settlers began arriving and clearing forests in the watershed for agriculture.

The process of settlement later included the establishment of numerous saw mills to take advantage of the abundance of commercially valuable trees. By 1861 there were eleven saw mills, one grist mill, one woolen mill, and two steam sawmills in the watershed. By 1878 however, only two sawmills remained, clearly indicating the speed at which the supply of valuable timber had diminished. Indeed, forest cover in Scarborough Township dropped from 73.2 percent to 33.6 percent in the decade between 1851 and 1861 alone (ODPD, 1956).

Continuous agricultural use left a fragmented landscape in which mere remnants of the original habitat types and their component species were found in isolated



MAP 22: HIGHLAND CREEK WATERSHED
Existing Terrestrial Habitat

patches. These areas survived because they were unsuitable for crop production, or were set aside for other values such as supply of firewood, recreational use, or water retention.

By the 1950s the dominant remaining forest cover type by area in the watersheds of Scarborough and Pickering was white cedar swamp (ODPD, 1956). On upland areas the dominant remaining forest cover type was a mix of sugar maple and American beech. Only three percent of the trees in these remaining forests had a diameter at breast height of 18 inches (46 cm) or more. This suggests that most of what remained at that time was second growth that had appeared after the original clearing.

For the past few decades the major trend in the Highland Creek watershed has been the process of rapid urbanization. Indeed, at present virtually the entire watershed is urbanized. The consequences of this process for terrestrial habitat are numerous and complex. While urbanization can result in direct loss of habitat remnants, the greatest concern may be the indirect impacts of such intensive land use on the remaining natural areas and wildlife that inhabit them.

The Highland Creek watershed covers a total of 10,158 hectares. In 1954, 785.94 hectares or 7.7 percent of the watershed were forested (see Map 23: 1954 Forest Cover). Today, 625.1 hectares is currently forested (see Map 24: 1993 Forest Cover). This represents 6.2 percent of the total watershed. The various types of forest cover are outlined in Table 7.

TABLE 7: Highland Creek Watershed Forest Cover

Forest Cover Type	**Highland Creek**
Deciduous	357.5 hectares
Mixed	216.6 hectares
Coniferous	51.0 hectares
Total	625.1 hectares

The most common forest type in the Highland Creek watershed is deciduous, with a coverage of 357. 5 hectares. Mixed deciduous and coniferous forest covers a total of 216.6 hectares. True coniferous forest covers only 51.0 hectares, and is made up primarily of white pine stands on the Iroquois Plain formation. An extensive riparian deciduous forest dominated by crack willows is found in the flood plain between Lawrence Avenue and the mouth of the creek.

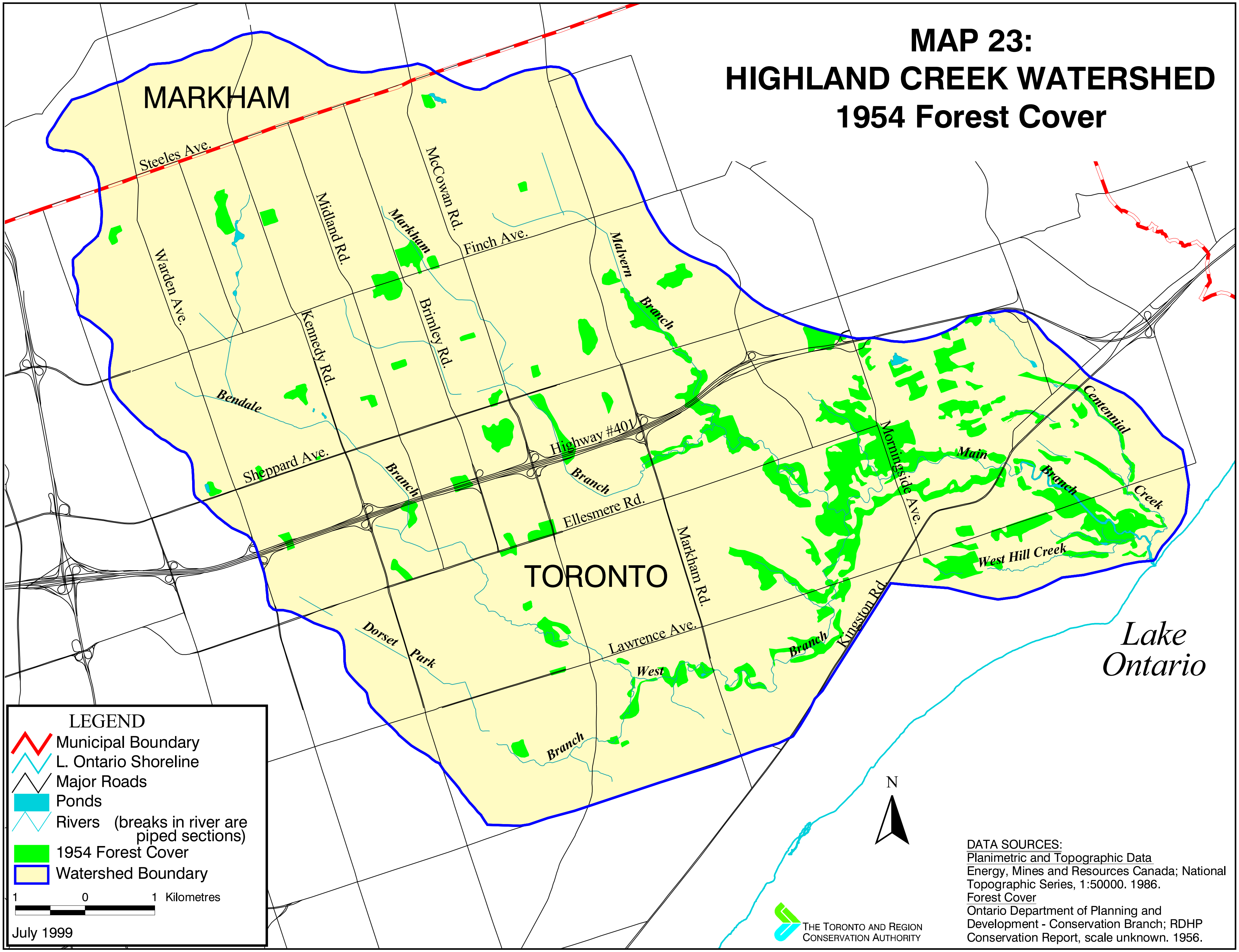
Forests in the Highland Creek watershed can be loosely divided into two categories: small woodlots in table land areas, and forest blocks associated with valley and stream corridors. A number of small table land woodlots are scattered throughout the Highland Creek watershed. Some of the most outstanding examples of these are the Milliken Woods, the Passmore Forest in L'Amoreaux Park North, and the Brimley Woods, all north of Highway 401. Until recent decades these were forest remnants in agricultural fields. They are now completely surrounded by residential or commercial/industrial development. Other small woodlots include the Scarborough Civic Centre woodlot, and the Conlins woodlot, both of which are south of Highway 401.

L'Amoreaux Park woodlot

Table land woodlots in the watershed range in size from 7.35 hectares to 0.34 hectares, averaging 2.2 hectares in size. It has been demonstrated that woodlots of less than 2.3 hectares tend to be dominated by edge species (Levenson, 1976). These include specialists, such as white-tailed deer and indigo bunting, that rely on edge habitat as well as habitat generalists (such as raccoon, striped skunk, red fox) that freely make use of the habitat types on either side of the edge. Of these table land forests, only the Brimley woods is large enough to provide forest interior habitat. However, the presence of many trails throughout the site may result in edge effects throughout.

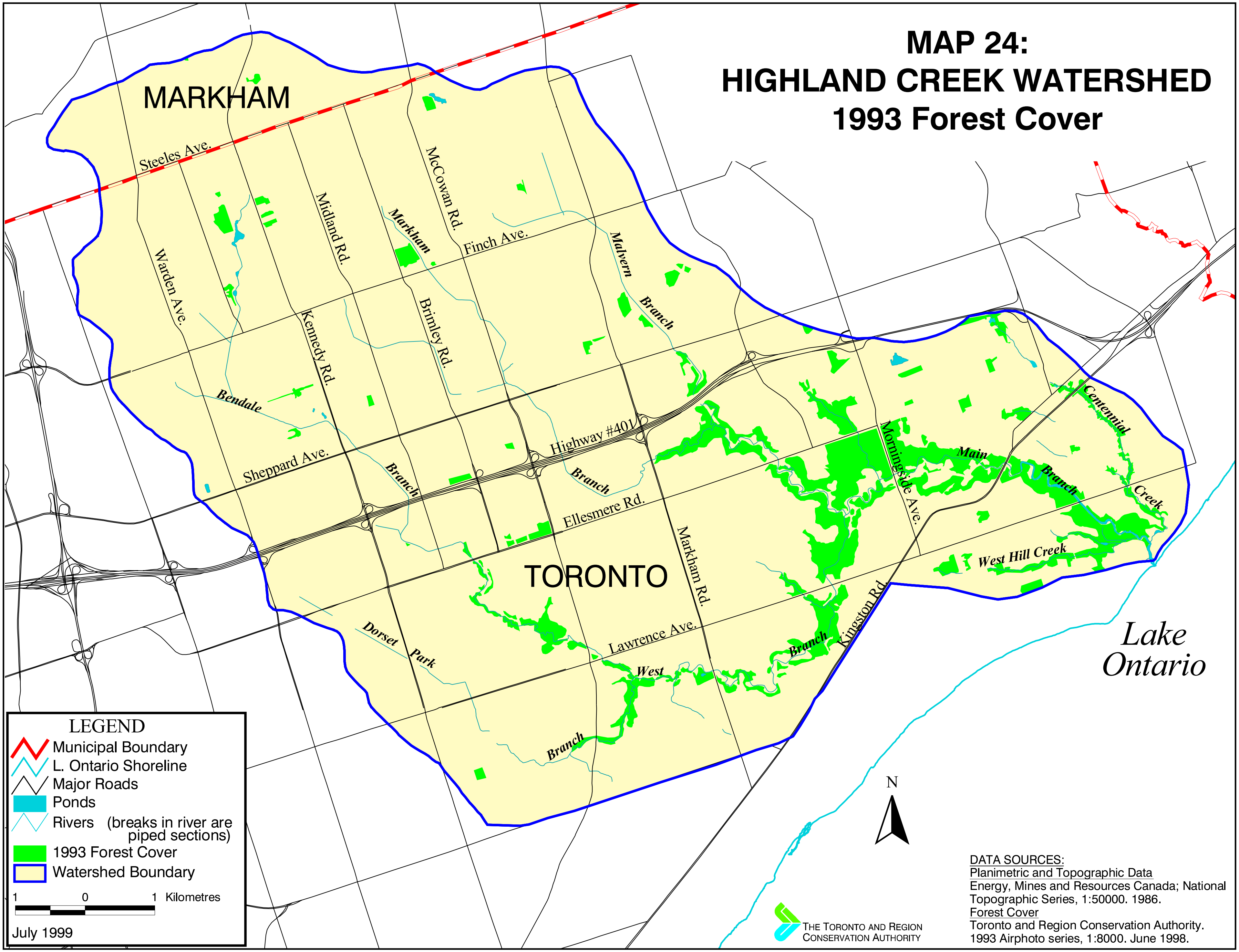
As is typical of publicly owned forests in the urban setting, most of these small woodlots are heavily used for recreation. Designated trails have helped to minimize damage, however some have been severely impacted by over use and trampling. Dog walking, cycling, and use of remote areas for illicit purposes all contribute to such degradation. Wildflowers and small vertebrates are subject to collection, and the latter also suffer increased predation by domestic cats and dogs.

Despite these impacts, the woodlots mentioned above appear to be in remarkably good condition considering the intensity of surrounding land use. This assessment is based on several indicators. One is the presence of many woodland wildflowers such as trout lily, white and red trilliums, and spring beauty, which have a preference for undisturbed areas and intact soils. Another



MAP 23:
HIGHLAND CREEK WATERSHED
1954 Forest Cover
MARKHAM
TORONTO
Lake Ontario
Steeles Ave.
Finch Ave.
Sheppard Ave.
Highway #401
Ellesmere Rd.
Lawrence Ave.
Warden Ave.
Kennedy Rd.
Midland Rd.
Brimley Rd.
McCowan Rd.
Markham Rd.
Morningside Ave.
Kingston Rd.
Markham Branch
Malvern Branch
Bendale Branch
Highland Creek Main Branch
Centennial Creek
West Hill Creek
Dorset Park Branch
West Branch
Branch
N
LEGEND
Municipal Boundary
L. Ontario Shoreline
Major Roads
Ponds
Rivers (breaks in river are piped sections)
1954 Forest Cover
Watershed Boundary
1 0 1 Kilometres
July 1999
THE TORONTO AND REGION CONSERVATION AUTHORITY
DATA SOURCES:
Planimetric and Topographic Data
Energy, Mines and Resources Canada; National Topographic Series, 1:50000. 1986.
Forest Cover
Ontario Department of Planning and Development - Conservation Branch; RDHP Conservation Report, scale unknown. 1956.

MAP 24:
HIGHLAND CREEK WATERSHED
1993 Forest Cover



DATA SOURCES:
Planimetric and Topographic Data
Energy, Mines and Resources Canada; National Topographic Series, 1:50000. 1986.
Forest Cover
Toronto and Region Conservation Authority. 1993 Airphoto series, 1:8000. June 1998.

indication is structural features of the forests such as a healthy understorey of native trees and shrubs, woody debris on the forest floor, and the presence of standing dead trees or snags. Some management through wood cutting has helped to preserve these features. Finally, the regeneration of many of the native trees can be a good indicator of health. Sugar maple is doing particularly well in this respect, while the presence of young American beech is also a positive sign. Nevertheless, white pine, red oak, and some of the less common tree species may not be achieving the same rate of success. These should be monitored closely if species diversity is to be maintained.

Small woodlots in the watershed have been fragmented and isolated in the landscape for decades, hence faunal species diversity is considerably lower than large blocks of the same forest type. In part this is because of limited dispersal capacity of many species and the resulting inability to move from one forest fragment to another in search of resources or a mate. Furthermore, species such as migratory songbirds that attempt to breed in such areas may suffer from negative edge effects. Predators of bird nests, including foxes, racoons, skunks, squirrels, crows, and blue jays, all frequent these habitats, as does the parasitic brown-headed cowbird.

Urbanization can have a profound effect on a forest fragment. For example, a study of forest birds in the Region of Waterloo, Ontario (Friesen et al., 1995) indicated that northern oriole, rose-breasted grosbeak, scarlet tanager, and in particular the wood thrush were all negatively impacted by residential development.

Morningside Park Environmentally Significant Area

The largest remaining blocks of forest are found in the lower part of the Highland Creek watershed. Of these, the site which features the largest contiguous forest is Morningside Park. Two Environmentally Significant Areas (ESAs) have been designated in this park, and will be discussed in more detail in the Special Features section of this report. Relatively large blocks of forest are found in Colonel Danforth Park and Hague Park, two more designated ESA sites that will also be discussed in detail in the Significant Features section. Many of the ravine slopes outside of these parks also feature smaller expanses of deciduous and mixed forest habitat.

In addition to being representative of native tree associations and the presence of many locally uncommon species, these large forest blocks are notable for their condition and structure. Areas that are relatively inaccessible have suffered minimal damage from overuse. Much of the original soil is therefore intact, and this supports a healthy herbaceous ground layer of wildflowers and ferns. Woody debris such as stumps, logs, and bark is also present in areas of minimal use. This acts as valuable cover for amphibians such as the red-backed salamander, and helps to maintain fungal diversity, an important component of ecosystem health. Isolated, undisturbed areas also maintain a good understorey of young trees and shrubs, boosting overall plant diversity, while providing habitat for breeding birds. Although mature trees dominate these forests, little true old growth of native tree species is represented. Nevertheless, the presence of breeding pileated woodpeckers indicates that some trees are mature enough to provide habitat for this old-growth dependent species.

These structural features, coupled with the fact that few invasive exotic plants have penetrated the more remote areas, makes them good candidates for baseline sites. As such they can help maintain representation of a high diversity of flora and fauna, and can aid in ecological restoration work for other parts of the watershed by providing a record of what local forest cover should look like, and possibly acting as seed sources for plant material.

Most of the forested land in the southern portion of the watershed is directly associated with valley and stream corridors, and therefore appears as long, narrow strips of habitat from a landscape perspective. In addition to their importance for recreation, these perform a valuable function as green corridors for wildlife movement and dispersal. This function has been lost throughout much of the upper watershed due to stream channelization and lack of forest cover.

Unfortunately, the long, narrow shape of these habitats also means that there is a high edge-to-area ratio, and therefore considerable exposure to negative edge effects. Much of the valley and stream corridor forest will be affected by these. Nevertheless, isolated pockets of forest interior habitat do exist in some parts of the lower watershed (see Map 22: Existing Terrestrial Habitat), including a total area of 47.9 hectares of forest interior that is more than 100 metres from an edge. The actual amount for the watershed is probably lower because the mapping does not take into account that a stream bed wide enough to break canopy cover essentially bisects a forest, creating edge habitat.

Small pockets of forest interior conditions exist in Colonel Danforth Park on either side of the watercourse south of Lawrence Avenue. Although this is riparian forest, which is seldom considered in the context of edge versus interior conservation concerns, several birds that are considered to be forest interior species, including hairy woodpecker and wood thrush, are thought to breed here.

Considering that it contains the largest expanse of forest in the watershed, it is not surprising that the most extensive area of forest interior habitat is also found in Morningside Park. This 74.4 hectares block supports 24.5 hectares of interior greater than 100 metres from an edge. More significantly, this is the only site in the watershed that supports forest that is more than 200 metres from an edge, in this case an area of some 5.7 hectares. Because this site is comprised of high quality mixed forest on bottom land and slope, it has the capacity to support a diversity of forest interior species.

Despite the quality of individual habitats, the total of forest interior in the watershed falls well below Remedial Action Plan guidelines (see Table 8). The amount suggested for total area greater than 100 metres from an edge per watershed is 10 percent. The actual amount appears to be less than one half of one percent. For interior forest that is 200 metres or more from an edge the guideline suggests five percent of the watershed. In this case the actual amount comes to less than one tenth of one percent. Because of the way the information was collected these values may not be precise. However, they are an accurate representation of current conditions.

TABLE 8: Summary of Remedial Action Plan Guidelines for Forest Habitat

Parameter	Guideline
Percent Forest Cover	30 percent of watershed should be in forest cover.
Size of Largest Forest Patch	At least one 200 hectares forest patch which is a minimum 500 metres wide.
Percent of Watershed that is Forest Cover 100 metres and 200 metres from Forest Edge	Greater that 10 percent forest cover 100 metres from edge; greater than 5 percent forest cover 200 metres from edge.
Forest Shape and Proximity to other Forested Patches	Forest patches should be circular or square in shape and in close proximity (e.g., 2 kilometres) to adjacent patches.
Fragmented Landscapes and the Role of Corridors	Corridors designed to facilitate species movement should be a minimum of 100 metres wide and corridors designed for specialist species should be a minimum of 500 metres wide.
Forest Quality - Species Composition and Age Structure	Watershed forest cover should be representative of the full diversity of species composition and age structure found in that ecoregion.

Source: Environment Canada, Ontario Ministry of Natural Resources and Ontario Ministry of the Environment, 1998.

The fact that much of the remaining forest in the Highland Creek watershed is made up of small fragments does not imply that they are no longer significant. According to the *Draft Natural Heritage Reference Manual* (MNR, 1998) "woodland size should be evaluated in the context of the percent forest cover in the planning area and/or regional landscape." This document suggests that "in planning areas where woodland cover is less than five percent of the land base, even the smallest woodlands may be important to biological diversity of the local area since they provide the only habitat for woodland dependent species." That the Highland Creek watershed supports only six percent indicates that virtually all remaining forest is of some significance.

Woodlands in urban and agricultural landscapes are vital stopover areas for many species of Neotropical migratory birds. When close to large bodies of water such as Lake Ontario these habitats can be especially important as staging or resting areas (Towle, 1994). During the peak of spring and autumn migrations even small patches of natural forest habitat can be crowded with individuals of many species. Running parallel to the migration route, the north-south direction of valley corridors in the Toronto Region helps to 'channel' the birds through the urban landscape. Most of these birds feed on insects which are specific to indigenous trees. The birds also have foraging strategies that are based on natural vegetation structure. Natural woodland is more capable of providing these needs than manicured parks or yards.

That there was probably close to 100 percent forest cover prior to European settlement suggests that about 94 percent has been lost, the majority of which was cut down prior to 1861. This large loss of forest cover has had a great impact on the watershed and continues to be an issue of concern. Although some substantial individual forest blocks remain in the watershed, the total area coverage of 6.2 percent falls well short of the 30 percent forest cover guideline suggested as a minimum ecological requirement for watershed health or rehabilitation (Environment Canada, Ontario Ministry of Natural Resources, and Ontario Ministry of the Environment, 1998).

The relationship between forests and biodiversity is an especially important consideration with respect to forest values. Forests are highly complex systems comprised of thousands of individual species, which have evolved together over time. The health of the entire system and the other ecosystems that interact with it is dependent upon the sustaining of these species and their interactions. All human values of forests are ultimately based on maintenance of this ecological web.

The role of forests in production of oxygen is well recognized, as is their value in climate control. Both local and global climates are moderated by the presence of trees which absorb heat energy and provide shade. Forests are also widely appreciated for aesthetic qualities. A trip to a forested park or conservation area on an autumn or spring day will indicate how popular these ecosystems are for recreation.

There are many other benefits gained from forest cover. Forests are known to act as sponges, absorbing and retaining rainfall before releasing it slowly to continuously replenish streams and rivers. In so doing they maintain water quality by reducing erosion and resulting siltation. By providing shade, forests keep waters cool and clear, reducing algal growth and associated eutrophication. In short, removal of forest cover can lead to rapid runoff, soil erosion, siltation of streams and loss of water quality. The Highland Creek watershed suffers from all of these problems.

Although forest cover in the Highland Creek watershed is well below the 30 percent suggested by the Remedial Action Plan guidelines, much of what does remain is of high quality. Considering the pace of development and the negative impacts which this typically has on urban watersheds, this is a very positive situation. Nevertheless, it is worth considering that in many cases small forest fragments in developed landscapes throughout eastern North America are going through a process of "progressive simplification" (Sauer, 1998), a problem related to what has been called 'Ecosystem Distress Syndrome' (Yazavenko and Rapport, 1996). Essentially this involves the gradual reduction in biodiversity of a forest fragment as disturbance makes the habitat less hospitable for native species and more hospitable for the weedy and exotic species that replace them. Invasive exotic plants such as common buckthorn, garlic mustard, and dog strangling vine are present in the Highland Creek watershed, and are invading woodland areas in both upland and valley sites. Direct management of these may become necessary where they are known to be reducing native biodiversity. Since disturbance and overuse create the conditions for such invasions, management of these problems will help protect against exotic species as well.

Negative edge effects have undoubtedly had an impact on species diversity in remaining forest patches within the watershed. The presence of roads and an increase in collecting may also be contributing to a reduction of amphibian and reptile diversity. For example, wood frog, spring peeper, and milk snake are all common in rural forest blocks, yet only a few records exist for Highland Creek (Johnson, 1998), despite the presence of suitable habitat. Collecting is also having a negative impact on plant diversity. Despite signs warning against doing so, wildflowers and ferns (fiddleheads in particular) continue to be taken from the parks for consumption, decoration, or home gardens.

Careful management will be required to deal with all of these issues. Ecological restoration can be applied to improve and expand what forest habitat remains. However, restoration to a near pristine natural system may be impossible. Notwithstanding, urgency exists to ensure the protection of as many of the least disturbed sites in the Highland Creek watershed as possible.

8.1.2 Meadow and Old Field

Historically, open meadows were probably rare, with these and successional forest growth being limited to areas that had been subjected to natural fires, or areas where soil or moisture conditions were unsuitable for tree growth.

The process of urbanization can create a temporary profusion of meadow and early successional habitats as land is taken out of agricultural production and put under speculation as real estate. Whether or not this habitat type and the species populations it supports can be considered natural is open to debate.

A number of essentially different habitat types are often grouped under the general heading of grassland, including prairie, savannah, meadow, and old field. Tall grass prairie is a very specific and rare habitat type that is found sporadically in southern Ontario where local soil and climate conditions result in regular fires. Savannah is a mixture of prairie with fire resistant trees. Oak savannah is known to occur at only a few sites in southern Ontario, one of them being High Park in Toronto. The term meadow is so widely applied that it is difficult to define. Generally this habitat is created by natural disturbance such as fire or windthrow. An old field, by contrast, is essentially an area that is regenerating following an anthropogenic use such as agriculture or pasture (Geomatics International, 1995).

The above definitions suggest that meadow is a natural habitat as opposed to old field which is unnatural. However, within the context of the Greater Toronto Area, meadow and old field can be considered together since the landscape has such a long history of human use that it is often difficult to distinguish between the two.

Disturbance by humans has also altered the composition of such open habitats through the accidental or deliberate introduction of many exotic species. Some of the most common and typical wildflowers of old fields and meadow, including Queen Anne's lace, chicory, burdock, ox-eye daisy, teasel, bull thistle, and common mullein, are in fact exotic. Many grass species are also exotic (reed canary grass is highly invasive and now dominates many floodplain meadow areas throughout the Greater Toronto Area).

It is difficult to define the point of ecological succession at which meadow or old field can be considered shrub land, because an old field often contains numerous shrubs. For practical reasons the stage at which woody vegetation covers more ground than herbaceous plants is probably a good indicator of transition between the two habitat types.

Site conditions for meadows and old fields can vary dramatically from rich flood plain soils to poor, contaminated fill in industrial areas. The diversity of native vegetation and wildlife present at individual sites is largely determined by these soil quality conditions, as well as the degree of local disturbance. Sites with poor soil may be in a permanent condition of old field since drainage conditions, the presence of contaminants, or the lack of vital nutrients may retard ecological succession. Once again, it is useful to draw a rough line between the urbanized and rural landscape contexts. The most altered or contaminated sites tend to be those that are surrounded by industry, since these open spaces often provide a convenient dumping ground for land fill or other wastes.

Meadows and old fields can support a high diversity of herbaceous plants and are the exclusive habitat of many species of wildlife. Higher quality meadows feature numerous grassland birds, including savanna sparrow, field sparrow, vesper sparrow, bobolink and eastern meadowlark - all of which have been experiencing population declines in eastern North America (DeGraaf and Rappole, 1995). These habitats also support a high diversity of butterflies, and provide the milkweed food source of the Monarch, a nationally vulnerable species according to the federal Committee on the Status of Endangered Wildlife in Canada.

Meadow and old field habitats cover approximately 938.9 hectares or 9.2 percent of the Highland Creek watershed. Some of what is included in this figure is un-mowed grass, as is the case with some of the hydro corridors. Also included are open areas committed for industrial or residential development. Because meadow was probably quite rare during pre-settlement times, this habitat type can be considered over-represented. Some measure of good quality upland and lowland meadow is desirable to maintain local representation of species associated with these habitats, as well as to provide interpretation opportunities. However, given that this habitat is far more abundant than forest habitat, its potential for reforestation should be considered carefully. Indeed, from a conservation perspective, much of the value of meadow or old field habitat in the Greater Toronto Area may be based on it's potential to become forest.

That 33 percent (326.7 hectares) of the existing meadow and old field habitats are located within hydro corridors suggests two things: First, that with some management these areas alone may be more than adequate to maintain representation of this naturally uncommon habitat type within the watershed. Secondly, these areas could conceivably have a high potential for connectivity and movement of species between habitats of various types. Unfortunately, the presence of many roadways disrupts this connectivity. As such, improvement in habitat for species other than birds or butterflies (i.e., small mammals) could lead to an increase in road kills. Tunnels would alleviate this situation, but could only be built at considerable expense.

Many meadow and old field habitats are represented as isolated fragments, and these can serve as valuable stepping stones for species on the move. Fragments of meadow and old field habitat in the urban landscape have a high value as stopover or staging areas for migratory grassland birds and Monarch butterflies. This is especially the case where these habitats occur in proximity to Lake Ontario, which these wildlife species must cross during migration.

8.1.3 Successional Habitats

The idea of ecological succession - a process involving a series of predictable habitat stages leading to a more complex "climax" habitat that characterizes a region - has been challenged by some ecologists (Botkin 1990). Nevertheless, while the causes and consequences of change may be unpredictable due to the complexity of natural systems, the stages of ecological succession themselves often are predictable. For example, because they tend to be fast growing, shade-intolerant, and short-lived, "pioneer" tree species such as aspen are typically the first to colonize a disturbed site. If soil and moisture conditions are adequate, shade tolerant tree species such as maple and beech will probably grow in underneath these over time, eventually forming a so-called "climax" maple-beech forest that is typical of the GTA region.

In a forest-dominated landscape, all upland habitats can be considered successional in so much as each represents a particular ecological stage between disturbance and old growth forest of the type that is considered the climax ecosystem. However, the term successional is usually used to refer to a habitat stage that lies between meadow and the mature trees typical of climax forest. This should not be confused with a forest of mature pioneer tree species.

In a primary (unmanaged) forest, areas comprising successional growth of varying ages are typically scattered throughout the landscape (Sauer 1998). These are the result of previous disturbances such as fire, windthrow, disease, etc. This varied makeup contributes to overall biodiversity of the forest. The actual amount of successional habitat that is typical for a given area is impossible to define because of the unpredictability of disturbance.

Earlier stages of succession, including shrubland and young, even-aged deciduous forest is found in isolated patches throughout the Highland Creek watershed. Generally this occurs in areas that were once agricultural land, and are now under speculation for industrial or residential developments. In short, successional habitat as considered here is old field that has regenerated to the point of domination by woody vegetation such as shrubs or young trees of pioneer species such as poplar and aspen. Depending on the soil quality and degree of outside disturbance, some of these areas have the potential to become quality forest habitat if left alone for several decades.

The total amount of successional habitat in the Highland Creek watershed is 42.2 hectares. This represents only 0.42 percent of the entire area. In a landscape that was originally forest-dominated, successional growth of various stages would have contributed to the overall diversity of habitat within the watershed. Shrubland was probably only found in isolated patches. Therefore, as with meadow habitat, the extent to which this small amount of the successional habitat is of a local conservation concern is open to debate. The issue is really one of species and habitat representation. Still, since shrub land habitat may be on the decline in southern Ontario, it is worthwhile to consider its conservation value in this regional context.

Depending on the size and density of shrubs or trees, this habitat can support a variety of vertebrate species associated with open areas or edge habitat. For example, white-tailed deer regularly make use of recently cleared or early successional habitats (Kurta, 1995). If the successional growth is found in proximity to large forest blocks it may be able to support locally uncommon species such as ruffed grouse, which has an affinity for aspen groves (Ehrlich et al., 1988), while ultimately contributing to an increase in forest block size.

In a heavily settled landscape successional habitat can provide important places of refuge for wildlife and greatly benefit migratory birds in passage. Where it occurs in natural stream and river valley corridors or unnatural corridors such as rail or hydro lines it can be of high value for species dispersal because of the cover it provides.

The amount of successional habitat that is associated with valley and stream corridors in the Highland Creek watershed is 35.1 hectares, or 83 percent of the total. Considering the value of this habitat for wildlife and the dispersal cover that shrub-land can provide for species that are more typical of forests, this degree of connectivity can help to sustain populations of many species. As with meadow habitat, however, the value of isolated fragments of successional growth as stepping stones or stopover habitat should not be underestimated.

The need to maintain a percentage of successional habitats within a watershed is debatable, in part because their natural presence in the landscape would be based on irregular occurrence of disturbance factors such as fire and storm damage. Furthermore, an attempt to maintain such representation might involve either intensive management of individual sites, or a complex system involving deliberate disturbance of late successional or forested sites on a rotational basis. It would be more efficient to let existing successional sites revert back to forest, while simultaneously allowing overly represented meadow or field habitat to become successional and eventually forest.

The ecological potential of successional habitats as future forest should be an important consideration within a natural heritage protection framework. Because they are essentially a step ahead of human created naturalization efforts, their protection can substitute for time and energy in meeting long-term forest representation goals. Furthermore, because many restoration projects are undertaken haphazardly, or are fast-tracked by planting trees (later stage of succession), shrub lands may have better potential to prepare soils and set the stage for a more natural ecosystem with higher representation of indigenous biodiversity. If connected via corridors they can be continuously colonized by the full range of plant and animal species typical of each successive stage of vegetation growth. This should be considered in long term planning.

8.1.4 Wetlands

There are five main wetland types: bog, fen, swamp, marsh, and shallow open water (National Wetlands Working Group, 1988). Wetlands have a number of important hydrological and ecological values, including:

- controlling run-off following precipitation, thus reducing flood potential and erosion
- acting as reservoirs, thus helping to regulate stream flow
- filtering or trapping sediments to reduce downstream sedimentation
- acting as sources for ground water recharge
- providing opportunities for nutrient exchange between aquatic and terrestrial ecosystems
- acting as nutrient sinks by accumulating organic soils
- acting as filters by storing excess nutrients or toxins
- acting as sinks for methane gas
- providing habitat for a high diversity of species

In addition to these important ecological functions, wetlands have considerable aesthetic, recreational, educational, and economic value. They are often appreciated for their beauty, can provide opportunities for nature interpretation on the part of students or the general public, are excellent sites for bird watching, and can provide hunting and fishing opportunities. Once considered wastelands, wetlands are now widely recognized as important habitats that should be conserved wherever possible.

Historically, the most common wetland type prior to European settlement was probably forest swamp. A large coastal marsh existed at the mouth of Highland creek, part of which remains today as Stephenson's Swamp.

Wetlands should be a high priority for conservation and restoration in the Highland Creek watershed, both for the values cited above, and because next to forest they may well have been the most abundant natural habitat type. The Canada-Ontario Remedial Action Plan has developed a series of guidelines for wetlands within watersheds (see Table 9). It must be noted that the total area of wetlands desired within a watershed may be more or less than the guideline's suggested minimum of 10 percent, and should be based on historical records if possible.

TABLE 9: Summary of Remedial Action Plan Guidelines for Wetland Habitat

Parameter	Guideline
Percent Wetlands in Watershed and Subwatersheds	Greater than 10 percent of each major watershed in wetland habitat; greater than 6 percent of each subwatershed in wetland habitat; or restore to original percentage of wetlands in the watershed.
Amount of Natural Vegetation Adjacent to the Wetland	Greater than 240 metres width of adjacent habitat that may be herbaceous or woody vegetation.
Wetland Type	The only two wetland types suitable for widespread rehabilitation are marshes and swamps.
Wetland Location	Headwater areas of ground water recharge, flood plains for flood attenuation, and coastal wetlands for fish production.
Wetland Size	Swamps should be as large as possible to maximize interior forest habitat. Marshes of various sizes attract different species and a range of sizes is beneficial across a landscape.
Wetland Shape	Swamps should be regularly shaped with minimum edge and maximum interior habitat. Marshes thrive on interspersion, a term describing the irregular shape of functional marsh habitats.

Source: Environment Canada, Ontario Ministry of Natural Resources, and Ontario Ministry of the Environment, 1998

Based on geographical features and soil types, Snell (1989) has suggested that over 80 percent of the wetlands in the Greater Toronto Area have disappeared since pre-settlement times. The original extent of cover for the Highland Creek watershed was estimated to be 149 hectares, or only about 1.5 percent of the total area (Snell, 1989). However, since this study did not include riverine or estuarine wetlands, this figure is probably underestimated.

Currently, approximately 23.5 hectares of wetland remain in the Highland Creek watershed. This represents less than one half of one percent of the total area, and a possible loss of 84.3 percent based on historic studies (Snell, 1989). Of the five principle wetland types, marsh, swamp and shallow open water habitats are represented.

The Ontario Ministry of Natural Resources wetland evaluation system is based on biological hydrological, social, and special feature values. Evaluated wetlands are scored and ranked according to their degree of significance. One wetland site within the Highland Creek watershed, the Stephenson's Swamp complex, has been evaluated and classified using this system (under the name of 'Highland Creek Wetlands'), and is considered to be provincially significant.

The Highland Creek Wetland Complex (Stephenson's Swamp) is located at the confluence of the Highland and Centennial Creeks just north of Lake Ontario. The complex is composed of four individual wetlands with a combined area of 7.6 hectares. Of these, the cattail marsh associated with the lower Centennial Creek is the largest at 5.6 hectares. Such coastal marshland is now rare on Lake Ontario, as are many of the species typically associated with it, including American bittern, least bittern, black tern, map turtle, and northern water snake. None of these are reported from the site. This may in part be a result of the limited availability of open water within the marsh. This site has been altered by land filling, railway construction, and encroaching urbanization. Problems include an inconsistent water flow from Centennial Creek, and the presence of exotic species such as purple loosestrife and carp (Heaton and Forder, 1998).

Also featured in the Highland Creek complex are several swamp areas, one of which is associated with Centennial Creek, and two other sites on the Highland Creek floodplain. These wetlands are relatively isolated from trails, and are well sheltered by trees and shrubs. Attesting to this isolation and protection is the presence of wood ducks, a shy, swamp dependent species that is uncommon around urban areas. These ducks are on record as breeders in the past, and were observed at the site again in 1998. Also indicative of the wildlife values of this wetland complex is the presence of beaver, and at least three breeding amphibian species.

Another substantial wetland in the watershed has been referred to as the Highland Creek Swamp (Brownell, 1993). This site, which covers a total area of approximately 16.4 hectares, is located on both sides of Morningside Drive between Morningside Park and the University of Toronto's Scarborough Campus. Vegetation communities at this site include mature deciduous forest swamp, coniferous forest swamp, and open and closed thicket swamp. The swamp is notable for its vegetative diversity, as well as the presence of locally rare balsam fir. The forested part of the site in Morningside Park contains some very isolated areas that appear to be in exceptionally good condition, although the invasive common reed is rapidly colonizing some of the more exposed areas.

In addition to numerous small wet meadow and swampy areas in the flood plain, the Highland Creek Watershed also contains a number of shallow open water wetlands. For the most part these are constructed ponds that feature areas dominated by cattail. Such sites can provide breeding areas for more common wetland birds such as red-winged blackbird, Canada goose, and mallard, as well as amphibians such as green frog, leopard frog, and American toad. The latter two species are breeding in the pond at Milliken Park, suggesting that even highly manicured ponds can benefit some wildlife species provided that cover such as cattails is present.

Wetland conservation will be important for maintaining local and regional representation of many species. Amphibians in particular use wetlands for breeding, and often require a close association between wetland and terrestrial habitat such as forest or shrub land. This association is difficult to maintain in a fragmented landscape, but does occur in Morningside Park and the Highland Creek wetland complex.

Common yellowthroat warbler

A number of wetland birds are considered to be area-sensitive, and require marsh habitat that is a least several hectares in size to provide enough food resources, or to support a population large enough to maintain required social behaviour. These include American and least bitterns, black tern, and marsh wren. It is not inconceivable that these species could breed in the marsh near the mouth of the creek should their resource requirements be met. Others such as common yellowthroat and swamp sparrow are possible breeders in the larger more pristine sites, and could be encouraged to breed in other urban areas if enough cover were provided and sites were left relatively undisturbed. The current practice of manicuring the landscape up to the water's edge will ensure that such species remain absent, while problem species such as Canada goose will remain abundant.

While size or connectivity between wetland and upland habitats is important for many wildlife species, as with other habitat types, isolated islands of wetland within the developed landscape do provide important refuges for wildlife, and are especially valuable as stopover areas for those migratory birds that prefer this kind of habitat.

In summary, wetland habitats are under-represented in the Highland Creek watershed. Although some high quality sites exist, much of what remains suffers from water pollution, loss of associated habitat, disturbance by humans, and invasions by exotic species such as purple loosestrife and the common reed.

8.1.5 Designated Special Features

In addition to classified wetlands (see above), two other measures of habitat significance are recognized by the TRCA. These are the TRCA's own Environmentally Significant Area (ESA) system, and the system for identifying Areas of Natural and Scientific Interest (ANSI) developed by the Ontario Ministry of Natural Resources (see Map 25: Special Features).

The ESA program was developed to identify and protect the regionally significant lands and waters (which are vital to the health of the ecosystem) in the TRCA region. Criteria used in the selection of areas include:

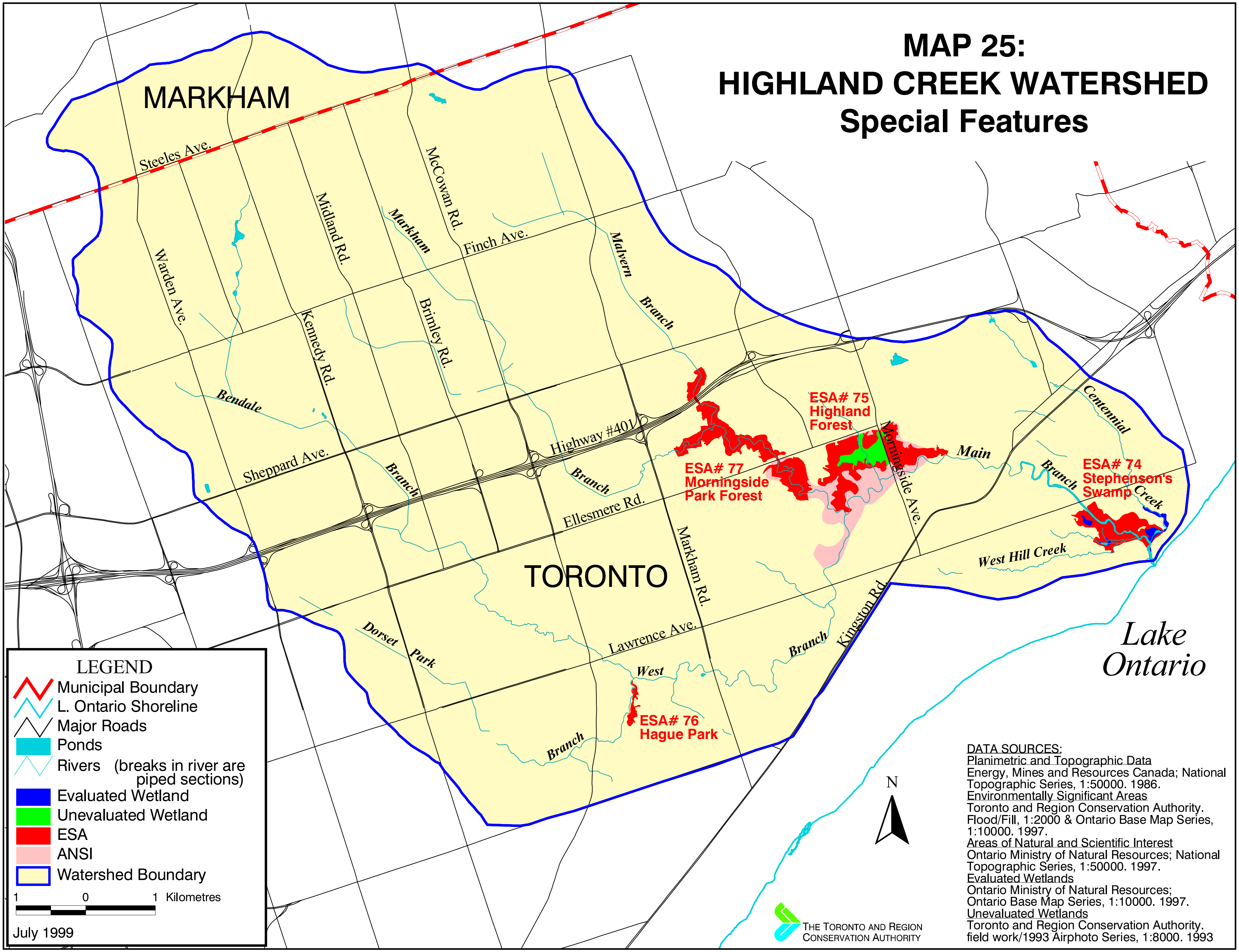
- distinctive and unusual landform or geological feature
- significant water storage function and/or a ground water recharge/discharge function
- linkages and corridors between significant habitats
- essential habitats for significant species and populations
- rare, vulnerable, threatened or endangered species
- high quality habitats (including size and diversity)
- habitats of limited representation
- habitats of considerable size
- habitats previously classified as an Area of Natural and Scientific Interest, or as a Provincially Significant Wetland

Stephenson's Swamp

Four ESA sites have been designated in the Highland Creek Watershed (see Map 25: Special Features). These include Stephenson's Swamp (ESA #74), Highland Forest (ESA #75), Hague Park (ESA #76), and the Morningside Park Forest (ESA #77).

The Stephenson's Swamp ESA (#74) covers the entire floodplain and some of the valley walls of Highland Creek south of Lawrence Avenue, encompassing the Highland Creek Wetland Complex and Lower Highland Creek Park.

Much of this ESA is riparian floodplain forest with crack willow as the dominant tree species. Despite the fact that this tree is an exotic species from Europe, it has considerable wildlife value since it provides cover in the form of well sheltered areas, food in the form of insect pests such as caterpillars, and nesting cavities for birds such as downy woodpecker, and white-breasted nuthatch. The wood ducks at this site may also be nesting in these tree cavities. Unfortunately, the European starling also makes regular use of these, and may evict native birds that are less aggressive. This crack willow forest also supports breeding pairs of the locally uncommon blue-gray gnatcatcher.



MAP 25:
HIGHLAND CREEK WATERSHED
Special Features
MARKHAM
TORONTO
Lake Ontario
Steeles Ave.
Finch Ave.
Sheppard Ave.
Highway #401
Ellesmere Rd.
Lawrence Ave.
Warden Ave.
Midland Rd.
Kennedy Rd.
McCowan Rd.
Brimley Rd.
Markham Rd.
Morningside Ave.
Kingston Rd.
Markham Branch
Malvern Branch
Bendale Branch
Dorset Park Branch
West Branch
Main Branch
Centennial Creek
West Hill Creek
ESA# 74 Stephenson's Swamp
ESA# 75 Highland Forest
ESA# 76 Hague Park
ESA# 77 Morningside Park Forest
LEGEND
Municipal Boundary
L. Ontario Shoreline
Major Roads
Ponds
Rivers (breaks in river are piped sections)
Evaluated Wetland
Unevaluated Wetland
ESA
ANSI
Watershed Boundary
1 0 1 Kilometres
July 1999
N
THE TORONTO AND REGION CONSERVATION AUTHORITY
DATA SOURCES:
Planimetric and Topographic Data
Energy, Mines and Resources Canada; National Topographic Series, 1:50000. 1986.
Environmentally Significant Areas
Toronto and Region Conservation Authority. Flood/Fill, 1:2000 & Ontario Base Map Series, 1:10000. 1997.
Areas of Natural and Scientific Interest
Ontario Ministry of Natural Resources; National Topographic Series, 1:50000. 1997.
Evaluated Wetlands
Ontario Ministry of Natural Resources; Ontario Base Map Series, 1:10000. 1997.
Unevaluated Wetlands
Toronto and Region Conservation Authority. field work/1993 Airphoto Series, 1:8000. 1993

Mature upland coniferous, deciduous, and mixed forest is also featured in the ESA. The quality of these habitats is indicated by the presence of typical native forest wildflowers such as white and red trillium, trout lily, etc., as well as many ferns and mosses and the rare radiate sedge. Regenerating American beech and eastern hemlock trees also indicate quality habitat since these species often do not reproduce well in the Toronto area. Also present are locally uncommon red pine and sycamore.

Three species are of particular note for this ESA. One is the dotted wolffia, a nationally rare plant that is found in wetland areas. Another is the pileated woodpecker, an old-growth dependent bird which breeds in the mature forest of Colonel Danforth Park. The third is the yellow-spotted salamander, a sensitive forest species that is rare in urban areas. Unfortunately, according to Johnson (1983), this salamander population was seriously impacted when parts of this ESA were contaminated by a nearby asbestos manufacturer. Even if any individuals still survive at the site, the population may be too small to be viable.

The Highland Forest ESA (#75) is located on both sides of Morningside Avenue south of Ellesmere Road. This site encompasses an extensive mature mixed forest on the valley slope, as well as the Highland Creek Swamp in the lowland area. Dominant trees include sugar maple, American beech, white ash, and red oak. The site also features the uncommon black maple and large specimens of red maple.

Although a small amount of trampling and erosion has occurred in the slope forest, the herbaceous ground layer features a high diversity of native wildflowers, including white trillium, trout lily, jack in the pulpit, red baneberry, and two species of toothwort. The presence of red-backed salamanders is a further indication of forest quality. The nationally and provincially rare rough-leaved goldenrod is also known to occur at this site. The swamp portion of the site supports such regionally uncommon plants as balsam fir, water avens, water pennywort and the two sedges. Unfortunately, a severe infestation of dog strangling vine is encroaching on the south end of that portion of the forest found on the east side of Morningside Avenue.

The Hague Park ESA (#76) is located south of Lawrence Avenue East between McCowan Road and Bellamy Road North. The ESA at this site includes mature mixed forest on the ravine slopes that features sugar maple, American beech, eastern hemlock, eastern white cedar, white birch, and basswood. Especially relevant is a healthy stand of trees dominated by black cherry, a typical Carolinian species. Also present is the regionally rare American hazelnut.

The Morningside Park Forest ESA (#77) encompasses a large area on the east branch of Highland Creek stretching from just north of Highway 401 almost to the confluence of the creek south of Ellesmere Road. Eastern white cedar dominates much of the forest area, although mixed forest of sugar maple, white birch, and eastern hemlock is scattered throughout the valley. The ESA designation is based on the maturity and health of these forests, and the degree of tree regeneration. This site directly connects with the Highland Forest ESA to form the largest remaining forest block within the Highland Creek watershed.

The Ontario Ministry of Natural Resources' ANSI system identifies sites that have valuable features in terms of protection, natural heritage, scientific study, or education. There are two categories of ANSI: Life Science, and Earth Science. The single ANSI in the Highland Creek watershed encompasses the entire area of the Morningside Park ESA as well as adjacent lands, and is based on life science features, including the forested slope and the cedar-tamarack swamp located adjacent to Morningside Drive.

8.1.6 Overview of Terrestrial Habitat Conditions

Only remnants of the terrestrial habitats of the pre-settlement period remain in the Highland Creek watershed. The upper portion of the watershed (particularly the area north of Highway 401) has been drastically altered by residential and industrial development. The tributaries in this area would originally have been ill defined stream corridors meandering through the landscape. However, most of the creek tributaries have been channelized through this section. Riparian vegetation has been essentially lost and the original stream corridors have been reduced to manicured flood control ditches. Terrestrial habitat in this part of the watershed is dominated by old field, located primarily in hydro corridors and along channelized streams. Nevertheless, several upland woodlots have survived, although these are subject to intense pressure from recreational use. These woodlots help to maintain representation of species and vegetation communities while acting as refuges and stepping stone habitats for wildlife. No natural wetlands of any significance are currently found north of Highway 401.

Much of the terrestrial habitat in the lower portion of the watershed is also comprised of isolated fragments, again, primarily of old field. Fortunately, several large, high quality blocks of forest have survived in the valley and stream corridors. These not only help to maintain water quality and indigenous biodiversity, but their continuity over large areas makes them extremely valuable as wildlife corridors. Two large wetlands, Stephenson's Swamp and the Highland Creek Swamp, have also survived. These are important not only for their many significant features, but because they are the only substantial wetlands remaining in the watershed.

With the exception of the larger forest blocks in the lower part of the creek, remaining natural areas in the watershed are highly fragmented and for the most part relatively small. Connectivity between tableland sites is poor. The fragmented nature of natural habitats within the landscape suggests that many of the problems with which conservation biologists are concerned are present here. These include the difficulty of maintaining wildlife metapopulations (the total of interacting small populations in a region) because of the limitations on dispersal which isolated habitat fragments present. In essence, many of the disconnected habitat sites may be acting as population sinks in which species that are specific to that habitat site, and which have limited dispersal capacity, are at risk of disappearing. The size and shape of remaining forest fragments and blocks also suggests that negative edge effects are probably having a serious impact at most sites.

Over the past few decades the Highland Creek watershed has almost become completely urbanized. The pressures associated with this intensive form of land use will continue to have a profound effect on remaining terrestrial habitats. Forests and wetlands are of particular concern. Indirect impacts of development related to recreational use, as well as road kills and pollution will likely continue. Careful management based on protection and ecological restoration will be required if sensitive species are to survive, and the health of natural areas within these watersheds is to be maintained.

8.2 AQUATIC HABITAT

The health of the aquatic environment and the condition of the Highland Creek watershed are interconnected. The aquatic environment is directly affected by the quality and quantity of water that flows over or through the land. And, as such, aquatic habitats provide a good indication of the condition of a watershed.

The aquatic ecosystem is most often recognized or described as different types of fish habitat, since fish communities have had a long history of being used as indicators of the health of aquatic habitats. The following sections provide an overview of the three broad categories of aquatic habitat found in the Highland Creek watershed: riverine, lacustrine, and estuarine. For each category of habitat found in the Highland Creek watershed, its significance, condition, and changes in condition over time are described. Activities that have affected the condition of habitats are also identified. For a more comprehensive description and analysis of these habitats, as well as the physical, biological, and chemical conditions in the Highland Creek watershed the reader is referred to the *Draft Highland Creek Watershed Fisheries Management Plan* (TRCA, 1998a).

8.2.1 Riverine Habitat

Riverine habitat, that is the habitat within rivers creeks and streams, includes two basic habitats: coldwater and warmwater. The determination of which habitat exists in any particular location is a result of conditions in the watershed. Determining factors include such things as surficial geology (see Map 9: Surficial Geology), the characteristics of flow, and land use within the watershed (see Map 7: Land Use). These influences determine which type of habitat will dominate in areas of the watercourse; and it is these habitats that determine the makeup of the fish community present.

Historically, Highland Creek supported a diverse fish community. The high percentage of forest cover which originally covered the watershed before European settlement, and the high percentage of baseflow of cold water from underground aquifers, meant that the Highland offered a pristine environment for the most sensitive fish species including Atlantic salmon and brook trout. The large wetland at the mouth of the Highland would have added to the diversity of the watershed by providing habitat for warm water species such as northern pike. As with many watersheds in the Greater Toronto Area, the fish communities in the Highland Creek watershed began to change gradually as land was cleared for agriculture, dams were built for sawmills, and fishing pressure and harvesting increased. By the 1950s, while there were still many sensitive species found in the watershed, there were signs that the watershed was becoming degraded.

A cumulative historic species list indicates that there have been a total of 40 fish species documented in the watershed over the past fifty years. Of these 40 species, 32 are native and 6 have been introduced. It is highly likely that many more species were present in the Highland Creek at one time. For example, in the Rouge River watershed, including the lower marsh, more than 50 species of fish can be found. This is 30 percent more than the cumulative historic list for Highland Creek. (TRCA, 1998a)

Recent field surveys in Highland Creek have found 23 species of fish, of which 4 are introduced. While this appears to be only a slight decrease in overall numbers from the 1950s, in fact this represents a significant degradation in the structure of the fish community in Highland Creek. While the survey undertaken in the 1950s found many top predator fish such as bass and perch, and sensitive species such as redside dace, the most recent survey indicates that many of the top predator fish are missing, along with most of the more sensitive species.

It is interesting to note that there has been a change in the location of healthy sites in Highland Creek over the past fifty years. The sites that contained more species than expected in a healthy ecosystem were historically located in the headwaters of Highland Creek. Over the past fifty years, there has been a shift towards the mid reaches of Highland Creek. In the 1950s, the fish communities in the lower reaches of Highland Creek responded quickly to degraded water quality. The reverse situation is presently occurring. The headwaters are highly altered with concrete channelization and piping, however, the fish communities in the downstream reaches have not responded to the same degree. In particular, while the fish communities in the lower reaches had previously undergone significant changes, and stabilized at a new threshold, the headwater fish communities have changed significantly; and not for the better (TRCA, 1998a).

The Index of Biotic Integrity (IBI) is a measure of fish community structure. It is used to identify the health of the aquatic ecosystem. This measure was originally developed in the United States but has been adapted to assess streams in southern Ontario. This method assesses the health of fish communities on the basis of five categories: species richness, local indicator species, trophic composition, fish abundance and fish condition. These categories are then measured on a scale of 9 (poor) to 45 (very good). To assess the health of the aquatic ecosystem in the Highland Creek, a sampling program was undertaken by the TRCA between 1994 and 1996. The results were assessed using the IBI. IBI scores for the Highland Creek watershed were generally low (see Map 26: Index of Biotic Integrity Scores). Scores ranged from 13 to 25, with a median score of 19 indicating poor biotic integrity. Approximately 22 percent of all stations were not scored because no fish was collected. Of the stations that contained fish, 68 percent were rated as having "poor" biotic integrity. The remaining 32 percent of the stations sampled were rated as having "fair" biotic integrity. None of the stations were rated as having a "good" or "very good" biotic integrity (TRCA, 1998a).

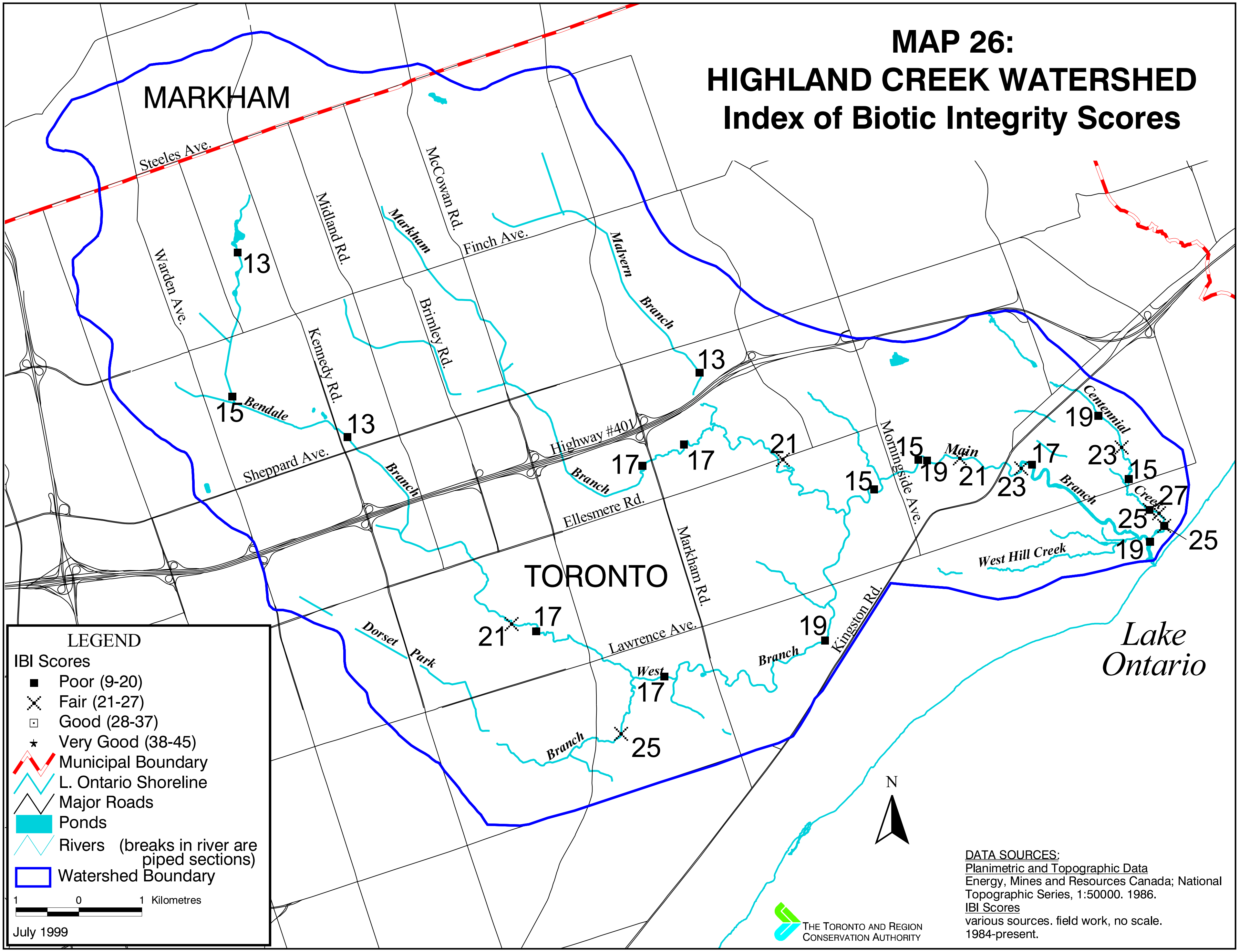
This degradation has occurred for a variety of reasons including problems with water quality/quantity, loss of woody riparian vegetation, and the construction of instream barriers which prevent the free movement of fish.

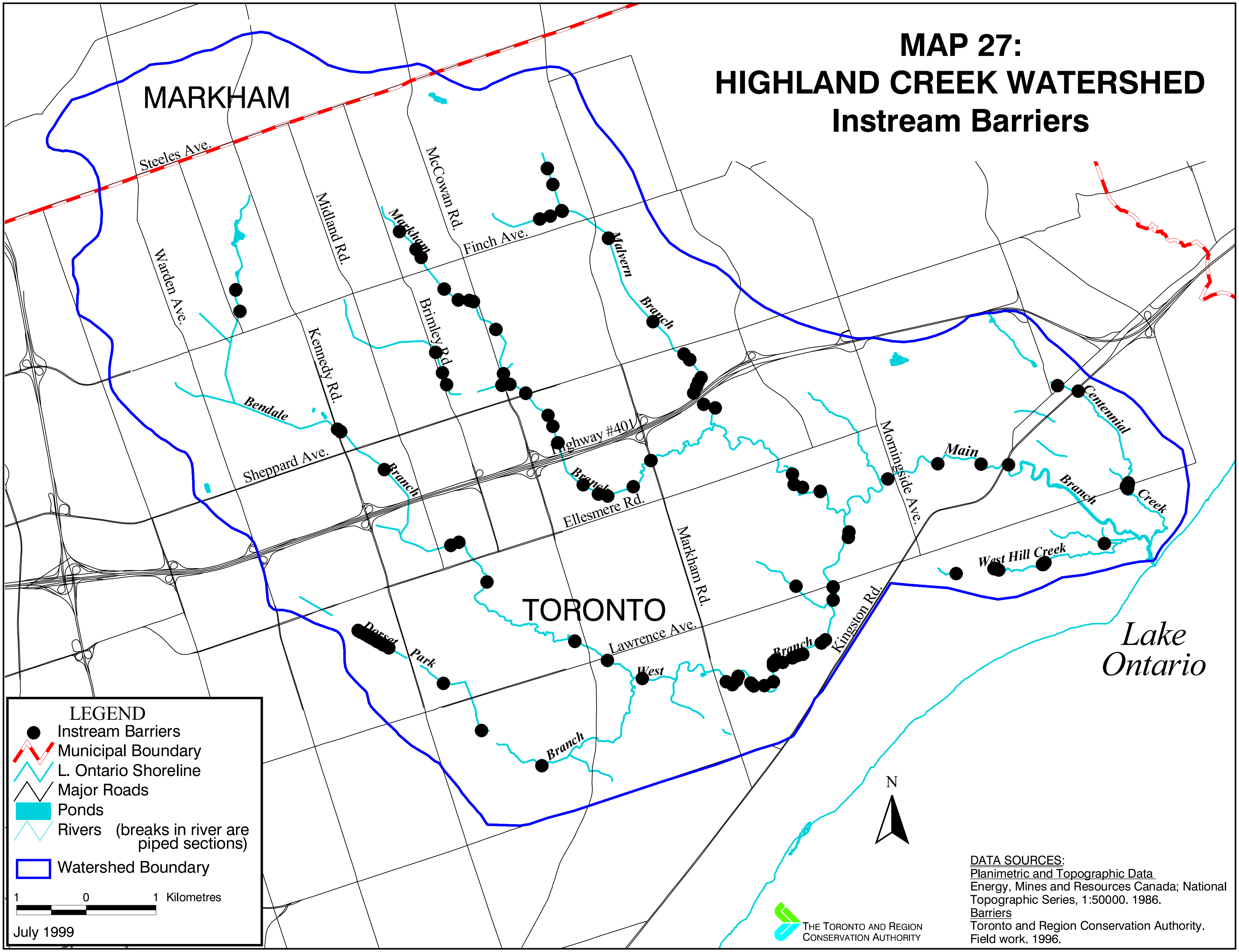
The current degraded condition of the water quality in the Highland Creek watershed has been described in section 7.2.2 above, and therefore will not be repeated here other than to say that the degraded condition of the water is a direct result of urbanization in the watershed and the lack of virtually any stormwater controls for either quality or quantity. The vast increases in the quantity of water flowing through the watercourse is also a significant problem. As detailed in section 7.2.1, there has been a great increase in water flow since the 1970s when significant urban development began in the watershed. This has resulted in unstable and uneven flows, and diluted the flow of cold water contributed from underground aquifers thereby increasing the temperature of the waters and causing the more sensitive trout species to leave. In addition, the overall percentage of riparian woody vegetation along the banks of the Highland, which is an essential component of fish habitat, has been reduced to 32.2 percent overall (ranging from 62.9 percent in lower Highland Creek to a low of 12.8 percent on the East Branch of the Highland including the Malvern and Markham Branches). As described previously, there is virtually no forest cover north of Highway 401. Further complicating this problem is the fragmentation of the fish habitat within the creek. Over 90 instream barriers have been identified, which prevent the free movement of fish throughout the watercourse (see Map 27: Instream Barriers)(TRCA, 1998a). All of this has caused considerable stress to fish communities and resulted in the pollution tolerant species found in Highland Creek today.

8.2.2 Lacustrine Habitat

The term 'lacustrine' refers to lakes or ponds, which are defined as a standing body of a relatively fluid substance (water). Lacustrine habitat is found in ponds or lakes. Currently, there are two existing on-line ponds and three off-line ponds in the Highland Creek watershed. All of these ponds are located north of Highway 401 along the Bendale branch of the Highland Creek watershed except

MAP 26: HIGHLAND CREEK WATERSHED
Index of Biotic Integrity Scores




MAP 27:
HIGHLAND CREEK WATERSHED
Instream Barriers
MARKHAM
TORONTO
Lake Ontario
Steeles Ave.
Finch Ave.
Sheppard Ave.
Highway #401
Ellesmere Rd.
Lawrence Ave.
Kingston Rd.
Warden Ave.
Midland Rd.
Kennedy Rd.
McCowan Rd.
Brimley Rd.
Markham Rd.
Morningside Ave.
Markham Branch
Malvern Branch
Bendale Branch
Dorset Park Branch
West Branch
Main Branch
Centennial Creek
West Hill Creek
N
LEGEND
Instream Barriers
Municipal Boundary
L. Ontario Shoreline
Major Roads
Ponds
Rivers (breaks in river are piped sections)
Watershed Boundary
1 0 1 Kilometres
July 1999
The Toronto and Region Conservation Authority
DATA SOURCES:
Planimetric and Topographic Data
Energy, Mines and Resources Canada; National Topographic Series, 1:50000. 1986.
Barriers
Toronto and Region Conservation Authority. Field work. 1996.

for one pond which is located south of Highway 401 in the Lower Highland Creek watershed (TRCA, 1998a).

In general, these waterbodies can be characterized as` low slope, low velocity, zones of sediment deposition. Many are eutrophic and anoxic (oxygen deficient) near the bottom during the summer months. Some, like the Lower Highland Creek pond, are quite turbid. Due to the detention time and exposure to the sun's rays, these waterbodies experience high summer temperatures which may negatively impact downstream cold or cool water aquatic communities.

Ponds such as these can provide habitat for amphibian and reptiles. The large pond located in an old gravel pit on Conlins Rd. just south of Highway 401 is an excellent example. Here can be found a number of turtle species including Blanding's Turtle, Stinkpot Turtle, and Midland Painted Turtle (Johnson, 1998).

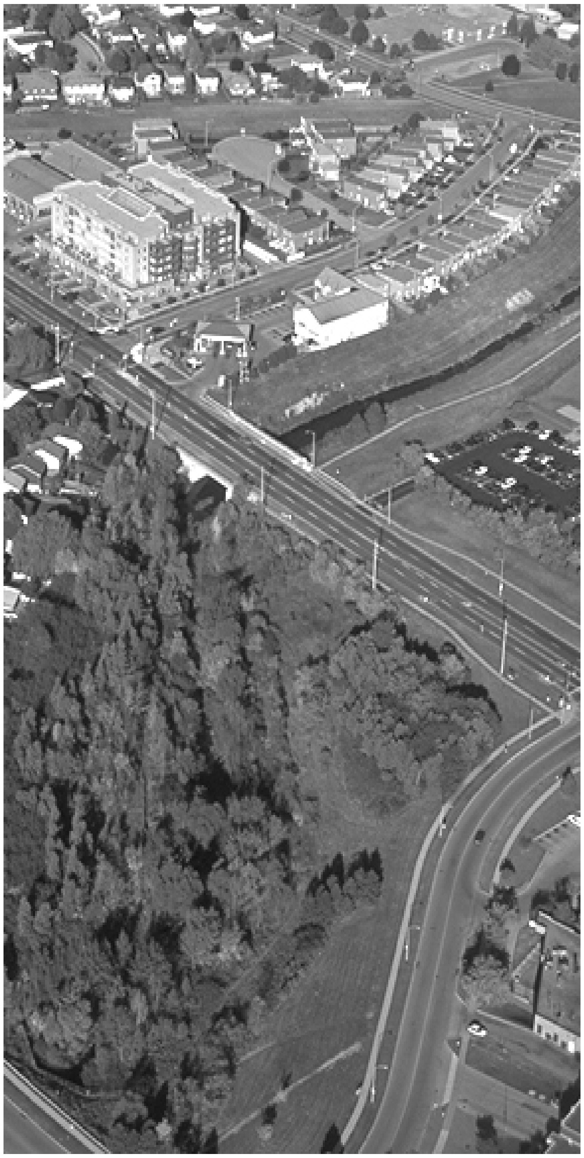
8.2.3 Estuarine Habitat

Estuarine habitat occurs in the area of transition at the mouth of Highland Creek where it meets Lake Ontario. As such, these habitats are directly influenced by the water levels in Lake Ontario and provide a key link between the creek and the lake. Although usually small in size, estuaries are of critical importance to the maintenance of local fisheries resources and healthy ecosystems (Stephenson, 1988). Estuaries provide aquatic habitat sheltered from open lake conditions, and tend to favour warm water fish species such as largemouth and smallmouth bass, and northern pike. Despite their significance, estuarine environments represent some of the most depleted aquatic habitats along the shores of Lake Ontario (Whillans, 1982) and their loss represents a significant impairment of the ability of these areas to support aquatic life.

Estuarine habitat within Highland Creek is used by many lake resident species for spawning, feeding, and refuge. The unique position of this habitat as the link between the watershed and Lake Ontario allows it to be utilized by a great many more species than would normally be found in a watercourse of this size.

SUMMARY

Both aquatic and terrestrial habitat in the Highland Creek watershed have been significantly altered and degraded as a result of development. Settlement and subsequent urbanization have resulted in the loss of most of the historical terrestrial habitats; and has caused many watercourses to be filled, piped, channelized, or otherwise altered. There are over 90 instream barriers to fish movement, poor water quality, unstable flows, and only 32.2 percent of the watercourse has woody riparian vegetation. As a result, the resident fish community is dominated by pollution tolerant species. The loss of these habitats is typical of urban water courses, but there are opportunities that exist for regeneration.



Part Four is divided into two chapters. Chapter nine is designed to identify watershed management issues that should be addressed as part of the development of a watershed strategy. A summary is provided of the key environmental, social, and economic issues identified in the *State of the Watershed Report*. Included is a brief overview of current monitoring initiatives considered to be a critical component of watershed management. Finally, because dividing the watershed into subwatersheds or reaches may assist management efforts, a brief explanation of subwatershed and reach planning is provided.

Chapter 10 highlights some of the initiatives that are currently taking place to regenerate the Highland Creek watershed. As water quality is a key issue, the Great Lakes Water Quality Agreement and the Toronto and Region Remedial Action Plan are briefly described. A number of site specific regeneration projects that are underway within the watershed are identified in section 10.1.

DIRECTIONS FOR MANAGEMENT

DIRECTIONS FOR STRATEGY DEVELOPMENT

CHAPTER 9

This chapter is designed to identify issues which may be considered during the development of a watershed strategy. In the previous Don, Humber, and Rouge watershed strategies undertaken by the TRCA, the task forces have addressed a number of issues including the following:

- developing a realistic vision for a healthy watershed
- discussing, refining, and prioritizing key watershed issues
- setting goals to achieve the vision
- setting measurable, definable objectives which work toward achieving goals and provide benchmarks for success
- establishing specific actions that are needed to achieve objectives
- setting priorities for regeneration

Section 9.1 summarizes key environmental, social, and economic issues that have been discussed in the *State of the Watershed Report*. As monitoring is an integral part of watershed management, a brief overview of some monitoring initiatives is also provided. Finally, since dividing the watershed into subwatersheds or reaches can assist in management efforts, a brief explanation of subwatershed and reach planning is provided.

9.1 WATERSHED HEALTH: SUMMARY OF KEY ISSUES

Watershed health is a complex concept. It is a relative term, relevant only within a specific context. For example, the number of fish species present in a *healthy* river environment can be expected to be lower in an urbanized watershed than the number which constitutes a *healthy* river environment in an undeveloped watershed. As the Highland Creek watershed is highly developed, this will need to be considered in the strategy development process. Also, some contextual factors change over time and can alter a definition of health. These factors include changes in community values or scientific knowledge.

A management strategy for the Highland Creek watershed will guide efforts to define and achieve watershed health. The strategy will identify key issues in the watershed which will need to be addressed in order to restore the watershed. As well, appropriate indicators will need to be selected which can be used to monitor progress toward restoring the health of the Highland Creek watershed.

The following summarizes key environmental, social, and economic issues that have been discussed in the *State of the Watershed Report*. It is anticipated that as strategy development progresses, the list will become more refined and new issues will be added. As the whole of the watershed is urbanized, the key environmental and social issues are related to impacts from land use.

Environmental Issues

Air:

- *Issue: Urban development contributing to 'urban heat island' effect.* The climate of the Highland Creek watershed affects vegetation communities, wildlife, the hydrologic cycle, and other components of the natural heritage system. Further, the large amounts of urban development in the watershed may be affecting the local climate through contributing to the 'urban heat island' effect. In turn, these changes may influence air quality as well as the health of humans, vegetation communities and wildlife.

- *Issue: Impaired air quality.* Air quality within the Highland Creek watershed is very good the majority of the time. However, ground level ozone and particulate pollutants exceed provincial air quality standards on a number of occasions, especially during the summer months. Impaired air quality is largely a consequence of vehicle, industrial, and residential emissions, with a large amount of ground level ozone and its precursors originating from outside of the watershed.

Water:

- *Issue: Unregulated flow in Highland Creek.* The natural flow of water in the Highland Creek was greatly affected by the loss of the original forest cover. More recently, the flow regime has been affected by extensive urban development in the watershed. Grading the land, altering watercourses, and the increase in impermeable surfaces with urban development have caused an increase in the frequency of higher flows in the watershed. As urban development covered the watershed over time, the annual mean flows in Highland Creek have more than doubled. This increased flow is not regulated, nor is there an adequate stormwater management plan in place at the present time.

- *Issue: Reduction of aquifer recharge.*
  Groundwater is a key component of the hydrologic cycle of the Highland Creek watershed. The urbanization of the watershed, and the proliferation of paved and covered surfaces, may reduce the recharge of underground aquifers. In turn, this can reduce or eliminate baseflow to streams, as most of the rainfall quickly runs off with little opportunity to infiltrate into the ground.

- *Issue: Contamination of groundwater.*
  Groundwater quality can be affected by a number of factors including landfill sites (of which eight are known in the watershed), underground storage tanks, septic systems, and road salt. A study into the potential impact of the use of road salt has estimated that if conditions in the watershed remain the same, the average concentration of salt in ground water will reach 426 mg/L. This level is almost twice the current drinking water objective of 250 mg/L.

- *Issue: Uncontrolled stormwater quality.*
  The impairment of surface water quality within the watershed is to a large degree a result of uncontrolled stormwater runoff and spills. Water quality within Highland Creek is degraded by phosphorous, suspended sediments, chlorides, bacteria, and phenols. In terms of trends, overall water quality has been improving over the last 30 years. Levels of phosphorous and suspended sediments have decreased. However, despite these improvements levels of chlorides and bacteria have increased (faecal coliform bacteria exceeds the provincial guidelines of 100 ml/L 98 percent of the time). Concentrations of phenols have remained unchanged. These levels are typical of other urban watersheds.

- *Issue: Transportation spills in watershed.*
  There were 39 reported spills in the Highland Creek watershed between 1988 and 1996. Most spills occurred in industrial areas along Markham Road north of Highway 401, in the Kennedy Road/Ellesmere area, and north of Lawrence between Kennedy Road and Midland Avenue. These identified areas could be targeted for specific controls and actions. Approximately 31percent of these spills released petroleum products. The average spill volume was 615 litres.

- *Issue: Increased bank erosion.*
  To accommodate development, large sections of the Highland Creek have been channelized. Increased runoff due to the proliferation of impervious surfaces and a general lack of stormwater management are attributed to increased erosion downstream. A recent study identified 46 erosion sites on the Highland Creek south of Highway 401 concentrated in three general areas: Birkdale Ravine/Thompson Memorial Parks, Morningside Park, and Colonel Danforth Park.

***Life*:**

- *Issue: Loss of natural habitat cover.*
  Only 6.2 percent of the Highland Creek watershed is covered in forest. Considering that there was probably close to 100 percent forest cover prior to European settlement suggests that up to 93 percent has been lost, the majority of which was cut down prior to 1861. Meadow and old field habitats account for 9.2 percent of the Highland Creek watershed. Such habitats would have been uncommon prior to European settlement. However, they can serve as valuable 'stepping stones' for species on the move such as migrating grassland birds and butterflies, and may support uncommon grassland species. It has been estimated that approximately 1.5 percent of the Highland Creek watershed was historically covered by wetlands. Today, wetlands represent less than 0.5 percent of the watershed. Nevertheless, the watershed does contain two substantial wetlands. The Highland Creek Wetland Complex (Stephenson's Swamp) is located at the confluence of the Highland and Centennial Creeks just north of Lake Ontario. This wetland has been designated by the Ministry of Natural Resources as being Provincially Significant. The second is the Highland Creek Swamp, located on both sides of Morningside Avenue in Morningside Park and the University of Toronto's Scarborough Campus. This wetland is currently unclassified.

- *Issue: Fragmentation of natural habitat areas.*
  Terrestrial habitats in the watershed are largely fragmented and often degraded as a result of current and historical land uses. In many cases, wildlife are restricted to small isolated pockets of habitat which may result in populations collapsing. Most of the large 'core' natural areas occur in the southern portion of the watershed south of Highway 401. North of Highway 401, vegetation is more sparse with only a few forested areas. The habitat which remains scattered throughout the watershed no longer supports all of the species that would have been historically present. Despite these facts, some core natural areas in the watershed have been designated for their exceptional character. These include one Provincially Significant wetland, four Environmentally Sensitive Areas (ESA), and one Area of Natural and Scientific Interest (ANSI).

- *Issue: Lack of healthy aquatic habitat.*
  Aquatic habitats in the Highland Creek watershed have been significantly altered and degraded as a result of development. Settlement and later urbanization caused many watercourses to be filled, piped, channelized, or otherwise altered. The creek contains over 90 instream barriers to fish movement, and suffers from poor water quality and unstable flows. Currently, only 32.2 percent of the watercourses have woody riparian vegetation. As a result, the resident fish community is dominated by pollution tolerant species.

Social Issues

Cultural Heritage:

- *Issue: Lack of documentation of archaeological sites.*
  Fourteen archaeological sites have been found and documented in the Highland Creek watershed. Many others have probably been destroyed by development, while other sites probably exist within the stream and valley corridors still to be discovered.

Diversity:

- *Issue: Need to recognize and work with watershed ethnic diversity.*
  The watershed is populated by an ethnically diverse population. Of the approximately 360,000 people living in the watershed, 23.0 percent are Chinese, 20.6 percent are English, 8.1 percent are Canadian, 7.5 percent are East Indian, 6.6 percent are Black, 4.1 percent are Italian, 3.4 percent are Filipino, 3.2 percent are Greek, 1.9 percent are German, and 1.3 percent are French.

***Outdoor Recreation*:**

- *Issue: A need for connected trails and greenspaces.*
  Large areas of the valley and stream corridors are used for outdoor recreation and education. The main issue surrounding outdoor recreation is the missing links in the greenspace and trail system due to the extensive transportation corridors crossing the watershed, and to private land ownership. The greatest barrier in the watershed continues to be Highway 401. A continuous formal trail system is available throughout a large part of the main valley of Highland Creek from the mouth (connected to the Waterfront Trail) to above the confluence on the West branch, where it is interrupted by the privately owned Scarborough Golf Club. Further upstream, the trail continues along sections of the Bendale and Dorset Park branches of the Creek. Unofficial trails through hydro corridors are used by the community. The major natural areas are located south of Highway 401, and while these communities have abundant recreational opportunities, those communities north of Highway 401 (where natural areas are scarce) have less of an opportunity to enjoy these natural features.

Economic Issues

- *Issue: High costs associated with maintaining existing hardened watercourses.*
  Much of the Highland Creek watercourse has been channelized or hardened in order to deal with the large amount of water that flows through the system. Ongoing maintenance and replacement of these structures can result in large outlays of capital dollars.

- *Issue: Loss of outdoor recreational opportunities.*
  Wildlife viewing, angling, and other outdoor recreational opportunities have been lost because of the destruction of aquatic and terrestrial habitats, and subsequent loss of species.

- *Issue: Perceived high costs associated with regenerating the watershed.*
  There are issues relating to the costs of natural regeneration due to urbanization of the entire Highland Creek watershed. This is especially true in the upper reaches of the Highland where the majority of the Creek has been channelized or piped, stormwater management issues are paramount, and tableland and riparian vegetation is minimal. The cost of regenerating these areas may be viewed as a limiting factor rather than as a necessary cost of ensuring a healthy watershed.

9.2 MONITORING

As our understanding of ecosystem health is incomplete, one challenge is to develop an acceptable definition of ecosystem health, and then develop indicators so that it will be possible to determine whether management, policy, or other initiatives are making progress toward identified goals. Monitoring, therefore, is an integral part of watershed management as it provides a base for determining progress toward ecological health, and can track how the watershed is improving as a result of watershed regeneration and enhancement initiatives.

A watershed monitoring program should encourage the participation of residents, schools, and other individuals and groups to assist with data collection and interpretation. This participation can help to build community environmental stewardship and is a cost-effective way to gather data throughout the watershed.

Establishing targets and indicators is essential for monitoring and evaluating progress toward regeneration goals. Analysing and communicating/publishing this information may also help to celebrate progress and regeneration actions, stimulate further action, and educate communities about watershed health.

9.2.1 Targets and Indicators

A watershed indicator can be considered a signal: a specific measurement which points to watershed health. Indicators measure progress toward goals and objectives.

A target is a specific aim that will be achieved in the future. Targets may be set for the short, medium, or long term (DWRC and MTRCA, 1997). For example, in *Turning the Corner, The Don Watershed Report Card (1997)*, targets were set for each indicator using the years 2000, 2010, and 2030.

Indicators and targets can be developed in tandem with the watershed strategy or they can be developed through a separate process. While many of these will be integrative indicators, meaning they will measure progress toward the achievement of more than one objective, they will likely be based on the components set out in the ecosystem model:

Environment - land, water, air, and life
Social - culture, heritage, recreation, and public education
Economy - urban development and resource use

There are some key points that should be considered when selecting indicators. Knowing what makes a 'good' indicator can also assist in the development of goals and objectives. In general, an indicator should be:

- sensitive to change over time - not an 'all or nothing' response
- measurable
- cost effective
- consistent with other societal objectives
- understandable to target audiences

Other criteria might include the ability of the indicator to be measured and analysed by community groups. Direct community involvement in data collection and analysis can reinforce stewardship and foster community action.

9.2.2 Ensuring Compatibility with Other Monitoring Initiatives

Other relevant monitoring initiatives need to be reviewed before developing a monitoring program for the Highland Creek watershed. In addition to it being a potentially cost effective approach, it may help to ensure consistency between indicators for the Highland Creek watershed and other watershed monitoring programs. Consistency is important as it provides the basis for making comparisons.

A number of initiatives will need to be considered at the outset of a monitoring program for the Highland Creek watershed:

- *Turning the Corner, The Don Watershed Report Card (1997)*. Produced by The Don Watershed Regeneration Council and The Metropolitan Toronto and Region Conservation Authority in 1997;
- *The Humber River Watershed Report Card* (in process);
- City of Toronto *State of the Environment Report*;
- Scarborough *State of the City Report*; and
- The Metro Toronto and Region Remedial Action Plan Stage 2 document, *Clean Water, Clear Choices; Recommendations for Action* (1994) which contains indicators and specific targets (delisting criteria) for Areas of Concern.

Currently, a watershed monitoring program for the Toronto and Region Remedial Action Plan is being developed. The program will allow for reporting on the status of each beneficial use impairment in Areas of Concern, and for the identification of changes in condition through time. It will also provide direction for selecting the remedial actions necessary for restoring impaired beneficial uses and thus eventually delisting an Area of Concern.

9.3 SUBWATERSHED AND REACH PLANNING

Studying, planning, and managing on the basis of watersheds is critical for establishing overall watershed condition. It is also important to create a realistic vision for the future state of the watershed based on existing conditions, and then set the context for actions to work toward that vision. It is for these reasons that the *State of the Watershed Report* describes the Highland Creek watershed as a whole. However, dividing the watersheds conceptually can assist with management efforts. For this *State of the Watershed Report*, subwatersheds were delineated in anticipation of the establishment of subwatershed strategies and reach plans (see Map 2: Subwatersheds).

9.3.1 Subwatershed Plans

To facilitate more detailed study, planning, and implementation of watershed management strategy objectives and actions, the watershed was divided into smaller, more manageable units based on subwatershed boundaries. Highland Creek can be separated into four subwatersheds:

- the Main Highland which includes the Creek downstream of the confluence, and the West Hill/Danzig/Thornton Creek;
- Centennial Creek;
- the East Highland, which includes both the Malvern and Markham Branches, and the portion of the creek downstream to the confluence; and
- the West Highland, which includes the Bendale and Dorset Park Branches, and the portion of the creek which flows downstream to the confluence.

9.3.2 Reach Planning

The majority of regeneration actions will likely occur at the level of specific reaches, smaller tributaries, or neighbourhood sized sections of watercourses. The development of reach plans can present conditions and opportunities to regenerate valley and stream corridors in greater detail. For the Don River watershed, reach plans were developed to assist management efforts and provide, at a glance, information showing which areas in each subwatershed require the greatest or least amount of regeneration. These 'reach plans' were based upon technical information, input from agencies, and information from task force members, individuals and local community groups.

In *Forty Steps To A New Don*, reach plans show opportunities for regeneration, outlined under eight categories:

- water quality
- water quantity
- aquatic habitat
- terrestrial habitat
- management practices
- recreation opportunities and improvements
- education and interpretation
- special areas (such as ESAs or areas of cultural significance)

Specific regeneration actions were suggested for each reach and actions were assigned a 'level of effort', ranked as limited, moderate, or extensive. The ranking was based upon constraints involved in completing an action and included cost, simplicity, and methods of undertaking the action. Capital works were mostly considered an extensive level of effort due to their high costs.

Although many reach plans focus on the watercourse and the associated valley and stream corridors, drainage area characteristics also need to be considered, particularly so that water quality and quantity issues are adequately addressed.

Implementation of reach plans can be through a number of means but always involve the local community in plan development, implementation, and monitoring progress toward regeneration goals. Reach plans may include both structural and non-structural works, be implemented in partnership with government agencies and other groups, and provide adequate and meaningful opportunities for community involvement.

SUMMARY

Through the development of a watershed strategy, issues of watershed health will be identified and a plan to address these issues formulated. This would include the development of targets and indicators, which will be used as monitoring tools to determine the success of the strategy. This can be undertaken in a subwatershed context, which would allow a finer level of detail such as reach specific actions.

WHAT'S HAPPENING NOW

CHAPTER 10

Impaired water quality is a key issue for the Great Lakes, Lake Ontario, and all river systems within the Toronto region. As future recommendations for management of the Highland Creek watershed will likely include water quality, a brief description follows of two initiatives relevant for water quality in the Highland Creek watershed: the Great Lakes Water Quality Agreement, and the Toronto and Region Remedial Action Plan. A listing of regeneration projects and programs that have been initiated by a variety of watershed stakeholders are included in section 10.3.

10.1 THE CANADA-UNITED STATES GREAT LAKES WATER QUALITY AGREEMENT

The Great Lakes Water Quality Agreement is a joint commitment between Canada and the United States. It was signed by the two federal governments in 1972, in response to concerns about water quality degradation in the Great Lakes. The purpose of the Agreement is "...to restore and maintain the chemical, physical and biological integrity of the waters of the Great Lakes Basin Ecosystem." Both governments are responsible for meeting their obligations under the Agreement.

In response to Canada's obligations under the Agreement, the Federal and Ontario governments signed the Canada-Ontario Agreement (COA) respecting the Great Lakes Basin Ecosystem. The Canada-Ontario Agreement describes shared responsibilities and establishes targets for Great Lakes restoration and protection, including the development and implementation of Remedial Action Plans.

10.2 REMEDIAL ACTION PLANS

The Canada-United States Great Lakes Water Quality Agreement was amended in 1987 to include the Remedial Action Plan Program. Remedial Action Plans (RAPs) are underway in 42 Areas of Concern (AOC), which are some of the most severely degraded areas of the Great Lakes. Currently, there are 16[1] Areas of Concern located in Canada including the Toronto and Region AOC, which contains the Highland Creek watershed. The restoration of beneficial uses in Areas of Concern is the primary mission of RAPs. Included in the Agreement is an Annex on Remedial Action Plans which lists impaired beneficial uses (see Box 5).

BOX 5: FROM ANNEX 2 OF THE GREAT LAKES WATER QUALITY AGREEMENT

"Impairment of beneficial use(s)" means a change in the chemical, physical or biological integrity of the Great Lakes System sufficient to cause any of the following:

i. restrictions on fish and wildlife consumption
ii. tainting of fish and wildlife flavour
iii. degradation of fish wildlife populations
iv. fish tumors or other deformities
v. bird or animal deformities or reproduction problems
vi. degradation of benthos
vii. restrictions on dredging activities
viii. eutrophication or undesirable algae
ix. restrictions on drinking water consumption, or taste and odour problems
x. beach closings
xi. degradation of aesthetics
xii. added costs to agriculture and industry
xiii. degradation of phytoplankton and zooplankton populations
xiv. loss of fish and wildlife habitat

Remedial Action Plans (RAPs) are an iterative, action-planning process which identify the responsibility and time frame for implementing remedial and preventative actions necessary to restore beneficial uses in Areas of Concern. Presently, documents are developed at each stage of the RAP process and forwarded to the International Joint Commission (IJC)[2] for review and comment. The following description of the RAP process is summarized from the *Canadian Great Lakes Remedial Action Plan Update* (October 1997).

The RAP process is carried out in three stages. **Stage 1** includes the collection of information by agency experts to define and identify environmental problems and the probable sources and causes. This information is discussed with the community. A Public Advisory

[1]Originally, there were 17 Canadian Areas of Concern. Collingwood Harbour was considered restored and removed from the list in 1996.

[2]The International Joint Commission (IJC) is an independent international organization established under the Boundary Waters Treaty of 1909. The Commission advises the United States and Canadian governments on boundary water issues. The Commission has three members appointed from each federal government.

Committee (PAC) is also formed during this stage.

In **Stage 2,** the PAC develops a common vision for their Area of Concern**,** sets goals, and determines the uses the area should support. Subsequently, a strategy is developed that recommends remedial actions to restore and protect these goals and uses.

Upon completion of implementation, **Stage 3** confirms the effectiveness of those measures in the restoration of the beneficial uses and attainment of clean-up targets.

Experience has shown that implementing clean-up and protection measures often occurs during the completion of Stage 2. Further, real progress in RAPs occurs in a step-wise fashion, with incremental improvements in environmental quality throughout the evolution of the RAP.

10.2.1 Toronto and Region Remedial Action Plan[3]

The Toronto and Region Remedial Action Plan was conceived as a strategy for cleaning up the waterfront between Etobicoke Creek and the Rouge River. As it became clear that restoring the waterfront would be impossible without cleaning up the rivers that drain into the area, the Toronto and Region Remedial Action Plan's geographic area expanded to include the Etobicoke, Mimico, Humber, Don, Highland, and Rouge watersheds, and the entire waterfront.

The Toronto and Region RAP Stage 1 document, *Environmental Conditions and Problem Definition*, was released in September 1988. The Stage 2 plan, *Clean Waters, Clear Choices,* sets goals, and identifies remedial actions, responsible agencies, costs, timetables, and establishes monitoring programs to track progress. Stages 1 and 2 of the Toronto and Region RAP were developed through the work of the Metro Toronto and Region RAP Team and supported by Public, Scientific, and Technical Advisory Committees.

The Toronto and Region RAP is currently in Stage 3, the implementation stage. Fifty-three recommended actions work toward addressing the twelve goals of the Toronto and Region Remedial Action Plan. Most of the RAP goals have established specific targets (delisting criteria). When these targets are met, the ecosystem is considered restored (Metro Toronto RAP, 1994). As outlined in *Clean Waters, Clear Choices*, these goals are concerned with the following issues:

[3]Formerly The Metro Toronto and Region Remedial Action Plan.

- ecosystem health
- fishable, swimmable, drinkable waters and nearshore zones
- discharges to waterbodies
- costs of clean-up; cost-effectiveness
- public access
- sediments
- lakefilling
- atmospheric deposition
- coordination with other programs
- navigation and recreation
- public awareness and consultation
- monitoring and review

Currently, the TRCA and the Waterfront Regeneration Trust are the local coordinating agencies for the Toronto and Region RAP's implementation. Under the terms of a Memorandum of Understanding signed in October 1997, the two agencies are taking on the coordination and public involvement responsibilities to help implement the Toronto and Region Remedial Action Plan. Both Environment Canada and the Ministry of the Environment will remain the responsible agencies throughout Stage 3. Local community participation through involvement in watershed advisory committees and volunteer efforts are also important for the successful implementation of the Toronto and Region RAP.

10.3 REGENERATION PROJECTS

There are a number of current initiatives being undertaken in the watershed working toward its restoration. These include the Markham Branch Restoration project, the Centennial Creek Subwatershed Plan, and the Integrated Shoreline Management Plan. Appendix 1 summarizes the current regeneration initiatives that influence the Highland Creek watershed.

10.3.1 Markham Branch Restoration Project

The Markham Branch Restoration Project, developed to rehabilitate a portion of the Markham Branch of Highland Creek, was undertaken by the former City of Scarborough Works Department (CCL, 1994). The restoration work was carried out on the section of the creek between Highway 401 and Markham Road. Originally, this branch of the creek extended south of Ellesmere Ave in a large meander, but this was modified in the late 1960s to facilitate the construction of industrial development in the area. The creek was straightened and channelized through the area. After this work was carried out, the creek was largely devoid of any habitat with virtually no forest cover, other than an old apple orchard located near Markham Road. The channel was mostly confined with limited access to the floodplain. The water is degraded, mostly as a result of stormwater, and during site visits before the project was begun no fish were

Markham Branch Regeneration Project, June 1999

discovered in the creek. The restoration project on this portion of the Highland Creek has recreated a natural valley design (CCL, 1995). The confined and artificial valley corridor was re-graded and contoured so that it now more closely emulates the profile of a natural valley. The channel has been removed and the creek now flows through a naturalizing valley corridor. A pool and riffle system was created to provide natural habitat for fish and other wildlife. In addition, the stormwater outfalls have been redesigned to flow through small wetlands which will slow down and treat the stormwater. Finally, forest cover will be reestablished through the planting of native shrub and tree material. A trail system with interpretive displays is also planned.

All of the structural work has been completed. Additional plantings of native shrub and tree material will take place over the coming years by Friends of Highland Creek, a local community group.

10.3.2 Centennial Creek Subwatershed Plan

Centennial Creek is a watercourse draining a small portion of the south-east corner of the former City of Scarborough. Originally a pristine watercourse which issued from springs along the Lake Iroquois shoreline, Centennial Creek was once abundant in fish and wildlife, and may have once been 'a cold water stream' (MacViro, 1995). Over the years, and especially since the 1960s, the creek has been degraded by urban development. The headwaters have been severed by Highway 401 and the open watercourse has been cumulatively piped and buried to allow for additional urban development. Consequently the system is starved of water, and what is left has been degraded by urban runoff. Most of the natural vegetation has been removed and there are no remaining core natural areas on the tablelands. In short, the subwatershed is degraded (MacViro, 1993).

In 1993 the City of Scarborough initiated a study to examine ways in which to protect the subwatershed and prevent further damage to the Centennial Creek ecological corridor. The recommendations adopted range from policy initiatives, to the protection of existing environmental assets such as the provincially significant wetlands at the mouth of Highland Creek, to initiatives aimed at the improvement of water quality (stormwater management ponds), ecological restoration, enhancement of the existing watercourse, and the removal of instream barriers to fish (MacViro, 1996). Work has already been undertaken to remove some of the fish barriers below Lawrence Avenue East, and the removal of fill from north of Ellesmere Road in 1997.

Additional work was undertaken in 1998 at three sites within the Centennial Creek Eco Park. The three sites include the Willowlea, Ellesmere, and Meadowvale Wetlands (Landscape Planning Limited et al., 1998). In 1998 work was undertaken to construct the hills and depressions necessary to provide for water retention areas. This was followed up with the planting of native wetland, shrub and tree material. This work will result in the creation of a diversity of habitat at each site including wetland, meadow, and forested areas.

All three sites now incorporate increased areas for water storage and facilities to treat stormwater using natural methods. These measures will decrease the quantity of runoff, improve its quality, and promote infiltration into the sandy soils of the area. The design allows the Willowlea and Ellesmere Wetlands, located just south of Highway 401 and just north of Ellesmere Road respectively, to be subject to intermittent flows of surface water during the spring snowmelt, and rain events. The Meadowvale Wetland, located just north of Kingston Road, will be subject to year round flows of cool ground water, which will benefit local fish resources. Recreational trails have been constructed in all three sites, and Conservation Easements will be sought to link the Willowlea and Ellesmere Wetland sites. A monitoring program will be instituted to evaluate the performance of the project.

Willowlea Wetland, June 1999

10.3.3 Integrated Shoreline Management Plan

Prepared for the MTRCA, the Integrated Shoreline Management Plan examines the shoreline between Tommy Thompson Park and Frenchman's Bay. Highland Creek lies between these two points and is discussed throughout the report. Descriptions of physical features and processes as well as natural heritage and cultural features are included in the report. The report identifies the Highland Creek watershed as an important core habitat system linked to other systems. The report proposes a Natural Heritage Strategy for the shoreline and the nearshore area which will promote the protection, enhancement, and restoration of the natural environment. Cultural heritage and recreation issues are also discussed.

Implementation of the recommendations related to the proposed Natural Heritage Strategy, and Public Use Strategy (recreation) will provide benefits to the Highland Creek watershed. Specifically, the report recommends the restoration and enhancement of Stephenson's Swamp, the removal of fish barriers, and the "support of all measures designed to improve water quality in [the] watershed". Already accomplished is the extension of the Highland Creek trail system to the Waterfront Trail (Fenco MacLaren Inc., 1996, pg. 9-13 to 9-14).

One recommendation of the ISMP that is progressing is the proposed Port Union Waterfront Improvement Project. Community driven, the goal of the project is to provide safe community access across the CN rail lines which parallel Lake Ontario, to the waterfront. This would affect the mouth and associated dynamic coastal beaches of the Highland due to the potential construction of a pedestrian bridge over the mouth of the creek. An added benefit to the completion of this project would be the extension of the Waterfront Trail along Scarborough's shoreline.

10.4 OPPORTUNITIES

Since the Highland Creek watershed is fully urbanized, additional opportunities to restore the watershed may present themselves through action directed specifically at restoration activities, or through potential redevelopment.

10.4.1 Hydro Lands

In March 1996, Ontario Hydro declared surplus approximately 150 acres of corridor lands in Scarborough. In April, 1996 the City of Scarborough initiated a planning study to determine the appropriate use of the land in the corridors. The lands are thin corridors extending north and south between Pharmacy Ave. and Warden Ave. above and below Highway. 401, and south easterly from Highway 401 across Warden Ave., through Birchmount Rd. to Kennedy Rd.

As a result of the process initiated by the City, the former City of Scarborough Council in September 1997 approved Official Plan Amendment 1001 to add an Open Space designation to the existing Ontario Hydro designation on the corridor. Ontario Hydro appealed that amendment to the Ontario Municipal Board. During this same period, Hydro was negotiating with potential purchasers of the land who ultimately submitted their own planning applications, primarily to allow low density residential infill development along the corridor. In time, these applications too were appealed to the Board, and the various appeals were consolidated into separate hearings for the corridor north and south of Highway 401.

The Board in December 1998 and May 1999 issued decisions largely approving the various applications north and south of the 401 respectively. In the latter case the approval only applies to the portion of the corridor between the 401 and

Warden Avenue. The hearing on the southern portion of the corridor between Birchmount Road and Kennedy Road is in abeyance pending the City's purchase of this stretch.

During the preparation for the Ontario Municipal Board hearing on the Hydro Lands the City directed a study to determine if lands were desirable or required to implement stormwater quality and quantity improvements as well as renaturalization. The resulting report prepared by XCG Consultants Ltd. in association with two other consultants, was called "Ontario Hydro Corridor (West Highland Creek) Investigation of Stormwater Management, Naturalization and Open Space Opportunities". Part of the conclusions of the report suggested priority ranking for acquisition and prepared conceptual plans for all reaches of the corridor.

The City has authorized negotiations to purchase two portions of the Hydro corridor labelled as priority 1 (Finch Avenue to south of Pine Meadow Boulevard and Birchmount Road to Kennedy Road). There is an agreement of purchase and sale on most of the land from Birchmount Road to Wye Valley which is expected to close in June 1999. The City is currently considering whether to purchase portions of priority 2 and 3 lands for additional parkland and trails.

10.4.2 Regeneration/Redevelopment

Now that the Highland Creek watershed has been fully urbanized, most new development will have to be accommodated through the redevelopment of existing sites. Such redevelopment and/or regeneration projects provide opportunities for the regeneration of the Highland Creek watershed and the protection of existing resources. Properties adjacent to the watercourses provide the greatest opportunities for regeneration. However, opportunities can exist on any property within the watershed. When redevelopment opportunities present themselves a number of regeneration principles should be considered which could help to improve the watershed. These include:

- *Stormwater management*

One of the main problems in the watershed is the amount of stormwater flowing largely unregulated through the system. This has led to problems with water quality, erosion, and other degradation. Stormwater management controls should take place in each new development in the watershed, with special attention paid to sites adjacent to the existing watercourse. On-site measures that reduce overall runoff from the site should be the first priority. This includes measures such as roof top storage, infiltration trenches, and the use of rain barrels. Once opportunities have been exhausted on-site, off-site controls should be considered. This could include controls within the conveyance system itself, or treatments at the end-of -pipe such as natural wetland stormwater management ponds which can treat both quantity and quality. The majority of the watershed is made up of soils of the South Slope which are relatively impermeable, allowing precipitation to quickly run off to the local watercourse. However, there are local pockets of more permeable sandy soils on which infiltration and stormwater management initiatives could focus (see Map 8: Surficial Geology). Many of these occur either adjacent to or within the stream corridor and hence could be used not only to reduce peak flows but to promote infiltration. Such actions may contribute toward additional baseflow in the watershed.

- *Optimize corridor width*

Many of the original stream and valley corridors in the watershed have been altered through urban development. This is especially true north of Highway 401 where the creek has been placed in concrete lined channels. Acquisition of lands adjacent to existing corridors provides the landbase for opportunities such as stormwater management, renaturalization, and natural channel design. Strict acquisition of lands through dedication or outright purchase is one option, however stewardship agreements or conservation easements may also be a viable option.

- *Channel improvements*

Large sections of Highland Creek are within concrete lined channels. Redevelopment may provide opportunities to renaturalize portions of these artificial channels. Examples such as the Markham Branch Restoration Project, where natural channel design has replaced a previous artificial concrete channel, have demonstrated that natural channel design can assist in stormwater management while providing opportunities for improvements in water quality, wildlife habitat, outdoor recreation, and other benefits.

- *Remove fish barriers*

There are a number of barriers within the watercourse which prevent the free movement of fish. Redevelopment may provide additional opportunities to remove such barriers provided energy levels are not increased. Priority barriers will be identified in the *Highland Creek Fisheries Management Plan* and remediated as funds are available.

- *Provide for additional trail linkages*

There are many trail systems within the Highland Creek. However, sections of these trails are isolated from one another due to barriers such as private property and transportation corridors (ie. Highway 401). Redevelopment can provide opportunities to fill in these missing links, and over time a more integrated and connected trail system can be achieved in the watershed.

- *Naturalization*

Many areas of the watershed are devoid of natural areas and forest cover. Any opportunity for additional plantings of native material should be taken no matter where they are located. However, sites adjacent to the existing watercourse provide special opportunities to enhance existing riparian vegetation. Remnant wetlands should be regenerated. They offer rare habitat for marsh species, that could readily re-establish. Artificial wetlands could be created to expand upon the amount of available wetland habitat.

SUMMARY

There are many current and future regeneration opportunities available in the Highland Creek watershed, primarily through land redevelopment. Such opportunities will require partnerships between all levels of government and with the Highland community in order to be successfully implemented.

APPENDIX 1: Regeneration Projects in the Highland Creek Watershed

WATERSHED	MUNICIPALITY	LOCATION	PROJECT TITLE	LEAD AGENCY AND PARTNERS	CONTACT	STATUS	BRIEF DESCRIPTION
Highland Creek	City of Toronto	Markham Branch between Markham Rd. and McCowan	Markham Branch Restoration Project	Toronto Works (Scarborough District) and Friends of Highland Creek The Cooperators, TRCA, MNR	Grant Taylor, Toronto Works (Scarborough District) Karen Boniface, Friends of Highland Creek	Natural Channel Design completed. Pedestrian Trail and additional plantings still to be done.	Replacement of channelized portion of Highland Creek with natural channel design, wetlands, plantings of native species, pedestrian trail.
Highland Creek	City of Toronto	Centennial Creek Corridor bounded by Hwy. 401, Meadowvale Rd., Centennial Rd. Lake Ontario	Centennial Creek Subwatershed Plan	Toronto Works (Scarborough District), TRCA	Sandra Ormonde, Toronto Works (Scarborough District)	Ongoing	Initiated in 1993, the Subwatershed Plan proposed a number of projects to improve water quality, create wetland habitat, remove fish barriers, and enhance the existing watercourse
Highland Creek	City of Toronto	Mouth of Highland Creek	Integrated Shoreline Management Plan	TRCA	Larry Field, TRCA	Ongoing	Plan identifies Highland Creek watershed as important core habitat system. Plan recommends the restoration and enhancement of Stephenson's Swamp, the extension of the Highland Creek trail system to the Waterfront Trail, the removal of fish barriers, and all measures designed to improve water quality in the watershed.
Highland Creek	City of Toronto	Cedarbrook Park		Toronto Works (Scarborough District)	Doug Kerr, Toronto Works (Scarborough District 4)	completed 1996	Implemented natural channel design to address erosion problems
Highland Creek	City of Toronto	Highland Creek Wetlands Complex	Metro Toronto Coastal Wetlands Rehabilitation Plan	MNR, Ontario Streams, Ontario Federation of Anglers & Hunter, Great Lakes 2000 Cleanup Fund, City of Toronto	Mark Heaton, MNR	Proposed	Recommendations include habitat improvements within the wetland complex, tree plantings on asbestos dump, support for the Centennial Creek Subwatershed Plan, and other watershed initiatives aimed at reducing peak flows, increasing base flow and water quality

REFERENCES

Adams, L.W. Urban Wildlife Habitats: A Landscape Perspective. University of Minnesota Press, 1994.

Adams, L.W. and L.E. Dove. Wildlife Reserves And Corridors In The Urban Environment: A Guide To Ecological Landscape Planning And Resource Conservation. Shepherdstown, West Virginia: National Institute for Urban Wildlife, 1989.

Agee, J.K. "Management of greenbelts and forest remnants in urban forest landscapes." Urban Forest Landscapes. Ed. Bradley, G.A. Washington: University of Washington Press, 1995.

Albanese, Paul. Personal interview. July 23, 1999.

Anderson, T.W. and C.F.M. Lewis. "Postglacial Water-Level History of the Lake Ontario Basin." Quaternary Evolution Of The Great Lakes. Ed. P.F. Karrow and P.E. Calkin. Geological Association of Canada Special Paper 30.

Archaeological Services Inc.& Unterman McPhail Cuming Associates (ASI et al.). Settling The North Shore. Toronto: Waterfront Regeneration Trust, July 1994.

Ashworth, William. The Late, Great Lakes: An Environmental History. Toronto: Collins Publishers, 1986.

Barrett, Suzanne and Joanna Kidd. East Bayfront And Port Industrial Area: Pathways: Toward An Ecosystem Approach. Toronto: Royal Commission On The Future Of The Toronto Waterfront, April 1991.

Birks, Jean & Carolyn H. Eyles. "Leachate From Landfills Along the Niagara Escarpment." Environmental Geology Of Urban Areas. Ed. Nicholas Eyles. Geological Association of Canada, 1997.

Bonis, Robert R., ed. A History Of Scarborough. Scarborough: Scarborough Public Library, 1965 [1982].

Botkin, D.B.. Discordant Harmonies: A New Ecology For The Twenty-First Century. New York: Oxford University Press, 1990.

Bradley, G.A., ed. Urban Forest Landscapes: Integrating Multidisciplinary Perspectives. Seattle: University of Washington Press, 1995.

Bricker, B. and R. Reader. "The effect of woodlot size on woody species composition and richness." Conserving Carolinian Canada. Ed. G. Allen, P.F. Eagles and S.D. Price. Waterloo: University of Waterloo Press, 1980.

Brownell, V.R.. Waterfront Natural Areas - Part 1: An Overview Of Natural Areas Along The Lake Ontario Waterfront From Burlington To Trenton. Toronto: Waterfront Regeneration Trust, 1993.

Budd, W.W., P.L. Cohen, P.R. Saunders, and F.R. Steiner. "Stream corridor management in the Pacific Northwest: 1. Determination of stream corridor widths." Environmental Management 11 (1987): 587-597.

Chapman, L.J. and D.F. Putnam. The Physiography Of Southern Ontario (Third Edition). Toronto: Ontario Ministry of Natural Resources, 1984.

City of Scarborough. Official Plan. Scarborough, 1995.

City of Toronto. City of Toronto Drainage Policy. Toronto, 1998.

City of Toronto Healthy City Office. Smog: Make It Or Break It. Toronto: City of Toronto, April 1998.

City of Toronto Public Health Department. City of Toronto Smog Alert Response Plan (Fact Sheet). Toronto, 1998.

City of Toronto Works Department, Scarborough District. Acquisition Of Former Landfill Site Owned By Ministry Of Transportation. February 20, 1998, to Corporate Services Committee, March 30, 1998.

City of Toronto Works Department, Scarborough District. Old Landfill Site Survey and Remediation Programs. Adopted by Toronto Council June 3,4,5, 1998.

Commission On Planning And Development Reform in Ontario. New Planning For Ontario: Final Report. Queen's Printer for Ontario, June 1993.

Cumming Cockburn Limited. City of Scarborough Phase 1 Progress Report: Baseline Audit And System Characterization, Highland Creek (Markham Branch) Rehabilitation Study. July 1994.

Cumming Cockburn Limited. Highland Creek Rehabilitation Study: Markham Branch (Draft). April 1995.

Cumming Cockburn Limited (CCL). City Of Scarborough, Highland Creek Rehabilitation Study, Markham Branch. April 1995.

D'Andrea, M., D. Maunder, W. Snodgrass. Characterization of Stormwater and CSO in Metropolitan Toronto. 1993.

DeGraaf, R.M. and R.I. Miller, eds. Conservation Of Faunal Diversity In Forested Landscapes. London: Chapman and Hall, 1996.

DeGraaf, R.M. and J.H. Rappole. Neotropical Migratory Birds: Natural History Distribution And Population Change. Ithaca, New York: Cornell University Press, 1995.

Department of Planning and Development, Ontario. The Rouge, Duffins, Highland, Petticoat Valley Conservation Report. Toronto, 1956.

Dickason, Olive Patricia. Canada's First Nations: A History Of Founding Peoples From Earliest Times. Toronto: McClelland & Stewart Inc., 1992.

Dodd, Christine F., et al. "The Middle Ontario Iroquoian Stage." The Archaeology Of Southern Ontario To A.D. 1650. Ed. Chris J. Ellis and Neal Ferris. London, Ontario: Occasional Publication of the London Chapter, OAS Number 5, 1990. 321-359.

Don Watershed Regeneration Council and The Metropolitan Toronto and Region Conservation Authority (DWRC, MTRCA). Turning The Corner: The Don Watershed Report Card. MTRCA, 1997.

Ehrenfeld, D., ed. A Landscape Perspective: Readings In Conservation Biology. Cambridge, Massachusetts: Society for Conservation Biology and Blackwell Science, 1990.

Ehrlich, P.R., D.S. Dobkin and D. Wheye. The Birder's Handbook: A Field Guide To The Natural History Of North American Birds. New York: Simon and Schuster Inc. 1988.

Ellis, Chris J., Ian T. Kenyon and Michael W. Spence. "The Archaic." The Archaeology Of Southern Ontario To A.D. 1650. Ed. Chris J. Ellis and Neal Ferris. London, Ontario: Occasional Publication of the London Chapter, OAS Number 5, 1990. 65-124.

Environment Canada. Ecoclimatic Regions Of Canada: Ecological Land Classification Series, No. 23. 1989.

Environment Canada. Canadian Climate Normals. Atmospheric Environment Service, 1991.

Environment Canada. Canadian Climate Normals, 1961 - 1990. Ottawa: Minister of Supply and Services Canada, 1993.

Environment Canada. Mystery on the Great Lakes. Atmospheric Environment Service, Minister of Supply and Services Canada, 1994.

Environment Canada. The Canada Country Study: Climate Impacts And Adaptation, Highlights For Canadians. Environment Canada, 1997a.

Environment Canada. The Canada Country Study: Climate Impacts And Adaptation: Ontario Region Executive Summary. Environment Canada, 1997b.

Environment Canada. The Canada Country Study: Climate Impacts And Adaptation: National Summary For Policy Makers. Environment Canada, 1997c.

Environment Canada. Adapting To Climate Variability And Change In Ontario. Volume IV of the Canada Country Study: Climate Impacts and Adaptation, March 1998.

Environment Canada, Ontario Ministry of Natural Resources, and Ontario Ministry of Environment. A Framework For Guiding Habitat Rehabilitation In Great Lakes Areas Of Concern. Minister of Public Works and Government Services Canada, 1998.

Eyles, N. & W.F. Howard. "A hydrochemical study of urban landslides caused by heavy rains: Scarborough Bluffs, Ontario, Canada." Canadian Geotechnical Journal 25 (1988).

Elyes, N., M. Meriano, J. Boyce. Ground water Modelling And Urban Planning: A Joint University Of Toronto/City Of Scarborough Initiative, Phase 1 Report: Hydrogeology Of The City Of Scarborough And The Surrounding Rouge River-Highland Creek Watershed Area. Draft, January 1998.

Fahrig, L. And G. Merriam. "Conservation of fragmented populations." A Landscape Perspective: Readings In Conservation Biology. Ed. Ehrenfeld, D. Cambridge: Society for Conservation Biology and Blackwell Science, 1990.

Fenco MacLaren Inc. et al. Integrated Shoreline Management Plan, Tommy Thompson Park To Frenchman's Bay. Toronto: December 1996.

Forman, R.T.T. Land Mosaics: The Ecology Of Landscapes And Regions. Cambridge University Press, 1995.

Forman, R.T.T. and S.K. Collinge. "The 'spatial solution' to conserving biodiversity in landscapes and regions." Conservation Of Faunal Diversity In Forested Landscapes. Ed. DeGraaf, R.M. and R.I. Miller. London: Chapman and Hall, 1996.

Friesen, L.E., P.F.J. Eagles, and R.J. MacKay. "Effects of residential development on forest-dwelling neotropical migrant songbirds." Conservation Biology 9 (1995): 1408-1414.

Frombetti, O. and K.W. Cox. Land, Law, And Wildlife Conservation: The Role Of Conservation Easements And Covenants In Canada. Reference Paper No. 3. Ottawa: Wildlife Habitat Canada, 1990.

Gartner Lee Limited. Highland Creek and Rouge River Pollution Study. For the City of Scarborough, 1987.

Gartner Lee Limited. Highland Creek Trail Study. August 1995.

Geomatics International Inc. Management Options For Old Field Sites In Southern Ontario. Guidelines And Literature Review. Southern Region Science and Technology Transfer Unit Technical Report TR-009. Ontario Ministry of Natural Resources, 1995.

Government of Ontario. Conservation Authorities Act, R.S.O. 1990. Queen's Printer for Ontario, 1990.

Hammond, H. Seeing The Forest Among The Trees: The Case For Holistic Forestry. Vancouver: Polestar Press, 1991.

Hanna, R. Life Science Areas Of Natural And Scientific Interest In Site District 7-4: A Review And Assessment Of Significant Natural Areas In District 7-4. Ontario Ministry of Natural Resources, September 1984.

Heaton, M.G, and D.R. Forder. Metro Toronto Coastal Wetlands Rehabilitation Plan. Draft Report. Aurora: Ontario Ministry of Natural Resources, 1998.

Hilts, S. And R. Reid. Creative Conservation: A Handbook For Ontario Land Trusts. Toronto: Federation of Ontario Naturalists, 1993.

Hosie, R.C. Native Trees Of Canada. Eighth Edition. Minister of Supply and Services Canada, 1979.

Hough Stansbury Woodland Naylor Dance Limited, Gore & Storrie. Ecological Restoration Opportunities For The Lake Ontario Greenway. Toronto: Waterfront Regeneration Trust, June 1994.

Howard, Ken. Personal interview. 1998.

Howard, Ken W.F. "Impacts of Urban Development on Ground Water." Environmental Geology Of Urban Areas. Ed. Nicholas Eyles. Geological Association of Canada, 1997.

Howard, Ken W.F. & Janet Haynes. "Contamination of Urban Ground Water by Road De-icing Chemicals." Environmental Geology Of Urban Areas. Ed. Nicholas Eyles. Geological Association of Canada, 1997.

Howard, Ken. W.F. & Stephen Livingstone. "Contaminant Source Audits and Ground-water Quality Assessment." Environmental Geology Of Urban Areas. Ed. Nicholas Eyles. Geological Association of Canada, 1997.

Humber Watershed Task Force. Natural Heritage of the Humber River Watershed: Strategies for the Protection and Enhancement of the Natural Heritage System. Toronto: TRCA, 1996.

Hunter, M. L. Jr. Wildlife, Forests, And Forestry: Principles Of Managing Forests For Biological Diversity. Englewood Cliffs, New Jersey: Prentice-Hall, 1990.

Johnson, Bob. Amphibians And Reptiles In Metropolitan Toronto: 1982 Inventory and Guide. Toronto Field Naturalists, 1983.

Johnson, Bob. Metropolitan Toronto Herpetofaunal Inventory And Guide. 1998.

Jonathan Kauffman Planning Consultant Ltd., et al. Metro Waterfront Environmental Study. Toronto: Metropolitan Toronto Planning Department, April 1992.

Karrow, P.F. Pleistocene Geology Of The Scarborough Area. Geological Report 46. Toronto: Ontario Department of Mines, 1967.

Kieley, Phil. Personal interview. July 8, 1999.

Kilborn Limited. Report On The Storms Of August 27th And 28th, 1976 And Subsequent Flooding On Highland Creek. For The Metropolitan Toronto And Region Conservation Authority, January 1977.

Kurta, A. Mammals Of The Great Lakes Region. Toronto: Fitzhenry and Whiteside, 1995.

Landscape Planning Limited, et al. Upper Centennial Creek Eco-design. February 23, 1998.

Lang, Reg and Audrey Armour. Environmental Planning Resourcebook. Environment Canada Lands Directorate, 1980.

Levenson, J.P. Forested Woodlots As Biogeographic Islands In An Urban-Agricultural Matrix. Diss. University of Wisconsin, Milwaukee, 1976.

MacArther, R.H. "Population ecology of some warblers of northeastern coniferous forests." Ecology 39 (1958): 599-619.

MarLaren Plansearch/Lavalin. Review and Documentation of the August and September 1986 Flood Events: Report to the Metropolitan Toronto and Region Conservation Authority. February 1987.

MacViro/Ecological Services for Planning. Centennial Creek Subwatershed Study, Assessment Of Existing And Potential Conditions, Phase 1 Interim Report (Draft). City of Scarborough, November 1993.

MacViro/Ecological Services for Planning. Centennial Creek Subwatershed Study. City of Scarborough, October 1995.

MacViro/Ecological Services for Planning. Centennial Creek Subwatershed Plan: Phase Three Executive Summary. November 1996.

Melbourne Water & Melbourne Parks and Waterways. Backyard to Bay - Catchment Impacts: The Urban Waterway Challenge. 1993.

Metropolitan Toronto and Region Conservation Authority (MTRCA). Plan for Flood Control and Water Conservation. Downsview: MTRCA., 1959.

Metropolitan Toronto and Region Conservation Authority (MTRCA). Environmentally Significant Areas Study. 1982 (updated 1996).

Metropolitan Toronto and Region Conservation Authority (MTRCA). Greenspace Strategy for the Greater Toronto Region. Downsview: TRCA, 1989.

Metropolitan Toronto and Region Conservation Authority (MTRCA). Valley and Stream Corridor Management Program. Downsview: MTRCA., 1994.

Metropolitan Toronto and Region Conservation Authority (MTRCA). MTRCA Fill Line Extension Project: Executive Summary. Downsview: MTRCA., 1995.

Metropolitan Toronto and Region Conservation Authority and Ministry of Natural Resources (MTRCA and MNR). The Rouge River Fisheries Management Plan: Part 1- Management Strategy. Downsview: MTRCA., 1992.

Metropolitan Toronto and Region Remedial Action Plan (MTRRAP). Clean Waters, Clear Choices: Recommendations For Action. Toronto: Metropolitan Toronto and Region Remedial Action Plan, 1994.

Metropolitan Toronto and Region Remedial Action Plan (MTRRAP). Environmental Conditions and Problem Definition. Toronto: Metropolitan Toronto and Region Remedial Action Plan, 1998.

Miller, G. Tyler, Jr., & Patrick Armstrong. Living In the Environment: International Edition. Belmont California: Wadsworth International Group, 1982.

Milligan Raedeke, D.A. and K.J. Raedeke. "Wildlife habitat design in urban forest landscapes." Urban Forest Landscapes. Ed. Bradley, G.A. Seattle: University of Washington Press, 1995.

Milus Bollenberghe Topps Watchorn. Woodlot Management Plan: City Centre Woodlot, City of Scarborough, Volume 1. March 1989 (revised September 1989 & February 1990).

Ministry of Energy and Resources Management. Ontario Regulation 253/64. July 1, 1965.

Ministry of the Environment. Methodology for Evaulating Impacts of Spills Remediation and other Remedial Options upon Don River Water Quality - Supporting Document #3, Strategy for Improvement of Don River Water Quality. 1991.

Ministry of the Environment. Air Quality in Ontario: 1992. Queen's Printer for Ontario, 1993.

Ministry of the Environment. Air Quality in Ontario: 1994 Comprehensive Report. Queen's Printer for Ontario, 1995.

Ministry of the Environment. Provincial Water Quality Monitoring Stations. 1996.

Ministry of the Environment. Spill Action Centre. 1996.

Ministry of the Environment. Air Quality In Ontario 1995: 25 Years Of Environmental Achievement. Queen's Printer for Ontario, 1997.

Ministry of the Environment. Air Quality in Ontario: 1996. Queen's Printer for Ontario, 1998.

Ministry of Environment and Energy. Stormwater Management Practices Planning and Design Manual. Queen's Printer for Ontario, 1994.

Ministry of Natural Resources. Natural Heritage Training Manual. Version 1.0. Ontario: Ministry of Natural Resources, 1997.

Ministry of Natural Resources. Draft Natural Heritage Reference Manual. Version 1.0. OMNR,, February 1998.

Ministry of Natural Resources. Draft Coastal Wetlands Rehabilitation Plan. March 1998.

Ministry of Natural Resources, Southern Region, ANSI Working Group. Questions And Answers Concerning "Areas Of Natural And Scientific Interest" On Private Lands. Ontario Ministry of Natural Resources, April 1992.

Minor, J.D. "Finding Illicit Connections and Discharges with P2IL." Stormwater NPDES Related Monitoring Needs. Proceedings of the American Society of Civil Engineers, 1995.

Mitton, Don. Personal interview. April 1, 1997.

Myrvold, Barbara et al. The People Of Scarborough: A History. The City of Scarborough Public Library Board, 1997.

National Wetlands Working Group. Wetlands Of Canada. Ecological Land Classification Series, No. 24, Sustainable Development Branch, Environment Canada, Ottawa, 1988.

Noss, R. "Corridors in real landscapes: a reply to Simberloff and Cox." Conservation Biology 1 (1987): 159-164.

Noss, R. Maintaining Ecological Integrity In Representative Reserve Networks. Discussion Paper, World Wildlife Fund Canada/World Wildlife Fund-United States, 1995.

Noss, R.F. and A.Y. Cooperrider. Saving Nature's Legacy: Protecting And Restoring Biodiversity. Washington D.C.: Island Press, 1994.

Ontario Department of Planning and Development (ODPD). Humber Valley Conservation Report. Toronto: 1947.

Ontario Department of Planning and Development (ODPD). Rouge Duffin Highland Petticoat Conservation Report. Toronto: 1956.

Payne, N.F. and F.C. Bryant. Techniques For Wildlife Habitat Management of Uplands. New York: McGraw-Hill Inc., 1994.

Peter Martin Associates ltd. Illustrated Atlas of York 1878. 1968.

Reeves, Wayne. Regional Heritage Features On The Metropolitan Toronto Waterfront. Toronto: Metropolitan Toronto Planning Department, June 1992.

Region of Peel. State of the Environment: Atmosphere Report. Brampton, Ontario: Region of Peel Planning Department, 1995.

Reznicek, A.A. "Are small reserves worthwhile for plants?" Endangered Species Update 5(2) (1987): 1-3.

Riley, J.L. and P. Mohr. The Natural Heritage Of Southern Ontario's Settled Landscapes. A Review Of Conservation And Restoration Ecology For Land-Use And Landscape Planning. Ontario Ministry of Natural Resources, Southern Region, Aurora, Science and Technology Transfer, Technical Report TR-001, 1994.

Robinson, S.K., et al. "Management implications of cowbird parasitism on Neotropical migrant song birds." Status And Management Of Neotropical Migratory Birds. Ed. Finch, D.M. and P.W. Stangel. USDA Forest Service General Technical Report RM-229, 1992.

Royal Commission on the Future of the Toronto Waterfront (RCFTW). Shoreline Regeneration for the Greater Toronto Bioregion. Minister of Supply and Services Canada, Queen's Printer of Ontario, 1991.

Royal Commission on the Future of the Toronto Waterfront (RCFTW). Regeneration: Toronto's Waterfront And The Sustainable City: Final Report. Minister of Supply and Services Canada & Queen's Printer of Ontario, 1992.

Sauer, L.J. The Once And Future Forest: A Guide To Forest Restoration Strategies. Washington D.C.: Island Press, 1998.

Scarborough Local Architectural Conservation Advisory Committee (LACAC). Home Sweet Scarborough. Scarborough: Scarborough LACAC, 1996.

Scarborough Works Department. An Assessment Of Natural Areas In Scarborough. June 1983: 47-49.

Scarborough Works Department. An Assessment Of Natural Areas In Scarborough: Part 2. June 1983.

Scheraga, Joel. D. "What is the Future?" Adapting to Climate Change and Variability in the Great Lakes - St. Lawrence Basin: Proceedings of a Binational Symposium, May 13-15, 1997. Toronto: Environment Canada, Environmental Adaptation Research Group (EARG), 1998.

Sharma, M., E.A. McBean, J. Marsalek. "Source Characterization of Polycyclie Aromatic Hydrocarbons in Street and Creek Sediments." Water Quality Resources Journal. 32.1 (1997): 23-35.

Simberloff, D. And J. Cox. "Consequences and costs of conservation corridors." Conservation Biology 1 (1987): 63-71.

Simberloff, D., J.A. Farr, J. Cox, and D.W. Mehlman. "Movement corridors: Conservation bargains or poor investments?" Conservation Biology 6(4) (1992): 493-505.

Smith, We. H. Smith's Canadian Gazetteer. 1846. Coles Publishing Co., 1972.

Snell, E.A. "Recent wetland loss trends in Southern Ontario." Wetlands, Inertia Or Momentum. Ed. Bardecki, M.J. and N. Patterson. Toronto: Federation of Ontario Naturalists, 1989.

Spence, Michael, et al. "Cultural Complexes of the Early and Middle Woodland Periods." The Archaeology Of Southern Ontario To A.D. 1650. Ed. Chris Ellis and Neal Ferris. London, Ontario: Occasional Publication of the London Chapter, OAS Number 5, 1990.

Stamp, Robert M. Riding The Radials: Toronto's Suburban Electric Streetcar Lines. The Boston Mills Press, 1989.

Statistics Canada. 1991 Census. 1991.

Statistics Canada. 1996 Census. 1996.

Stephenson, T.D. Significance of Toronto area coastal marshes for fish. In M.J. Bardecki and N. Patterson, eds., Wetlands: Inertia or Momentum. Proceedings of a Conference held in Toronto, Ontario, pp. 415-423. 1988.

Strus, R.H., I.D. Buchanan, and C.T. Rance. Metro Toronto Aquatic Habitat Rehabilitation. Maple: Ontario Ministry of Natural Resources, 1993.

Suns, K. and G. Hitchin. Young-of-the-Year Data: Organic Contaminants in Forage Fish From Toronto Area Streams. Toronto: Ministry of Environment and Energy Biomonitoring Section, 1994.

Terborgh, J. Where Have All the Birds Gone? Princeton, New Jersey: Princeton University Press, 1989.

Theberge, John, (Ed.). Legacy: The Natural History Of Ontario. McClelland & Stewart Inc., 1989.

Toronto Atmospheric Fund (T.A.F.). Greenhouse Gas Emission Reductions -- Quantification Guidelines for TAF Applicants. Toronto: Toronto Atmospheric Fund, July 1997.

Toronto and Region Conservation Authority (TRCA). Draft Highland Creek Watershed Fisheries Management Plan. Toronto: TRCA, 1998a

Toronto and Region Conservation Authority (TRCA). Highland Creek Watershed Heritage Study. Toronto: TRCA, 1998b.

Toronto and Region Conservation Authority (TRCA). Highland Creek Watershed: Identifying Erosion Sites. Toronto: TRCA, September 4, 1998c.

Toronto and Region Conservation Authority (TRCA). Highland Creek Watershed Surface Water Quality Background Technical Report. Toronto: TRCA, 1998d.

Toronto and Region Conservation Authority (TRCA). Terrestrial Habitat Analysis Of The Highland Creek Watershed. Toronto: TRCA, 1998e.

Toronto and Region Conservation Authority (TRCA). The Toronto and Region Conservation Authority 1998-2000 Business Plan. Toronto: TRCA, 1998f.

Towle, K. Bring Back The Birds: A Community Action Guide To Migratory Songbird Conservation. Toronto: Conservation International - Canada, 1994.

Towle, K. "Public naturalization projects: Some growing concerns for wild life and biodiversity." Wild Earth. Spring 1996a.

Towle, K. The Role of Ecological Restoration in Biodiversity Conservation: Basic Issues And Guidelines. Toronto: Evergreen Foundation, 1996b.

Town of Markham. Official Plan. Markham, 1987, revised 1993.

Victor Ford and Associates Inc. Inventory of Cycling Trail Opportunities in Rail and Hydro Corridors. Prepared for the Toronto Cycling Committee. Toronto: City of Toronto, 1998.

Wackernagel, M. How Big is Our Ecological Footprint? Using the Concept of Appropriated Caring Capacity for Measuring Sustainability. Vancouver: University of British Columbia, 1994.

Wackernagel, M. and W. Rees. Our Ecological Footprint: Reducing Human Impact on the Earth. British Columbia: New Society Publishers, 1996.

Whillans, T.H. Changes in marsh area along the Canadian shore of Lake Ontario. Journal of Great Lakes Research. 8 (1982): 570-577.

Whitney, G.G. From Coastal Wilderness to Fruited Plain: A History Of Environmental Change In Temperate North America From 1500 To The Present. Cambridge: Cambridge University Press, 1994.

Miles and Co. Illustrated Historical Atlas of York County Ontario. 1878. Wilson's Publishing Company and APMIST Enterprises Ltd., 1996.

Yazavenko, S.B. and D.J. Rapport. "A framework for assessing forest ecosystem health." Ecosystem Health 2.1 (1996): 40-51.

Maps

Chapman, L.J. The Physiography of the South Central Portion of Southern Ontario. Map# 2226. 1972.

City of Toronto. Toronto Lake and Stream Sampling Stations. 1998.

Energy, Mines and Resources Canada: National Topographic Series, 1:50 000. 1986.

Ministry of Natural Resources. National Topographic Series 1:50 000. 1997.

Ontario Base Map Series 1:10 000. 1997.

Province of Ontario (OAYSIS) Assessment Data. 1997.

Sharpe, D. R. and P. J. Barnett. Geology of the Markham Area, Southern Ontario. NTS 30m/14. 1:50 000. Geologic Survey of Canada Open File 33.

The Toronto and Region Conservation Authority. 1993 Air Photo Series. 1:8 000. 1993.

The Toronto and Region Conservation Authority. Flood/Fill Mapping. 1:20 000. 1997.