State of the Watershed Report

BACKGROUND REPORT ON THE HEALTH OF THE GRAND RIVER WATERSHED 1996-97

Prepared for
The Grand Strategy Co-ordinating Committee
By The Grand River Conservation Authority
August, 1998

PREFACE

The Grand River watershed, located in the heart of southwestern Ontario, includes all of the land drained by the Grand River and its tributaries, the Nith, Conestogo, Speed and Eramosa Rivers. The Grand River originates near the Village of Dundalk and winds its way over 300 kilometres southeast to Lake Erie. It is a large watershed, almost 7 000 square kilometres, and contributes 10 percent of the drainage to Lake Erie. The watershed's contribution to Canada's gross domestic product is comparable to that of Nova Scotia.

The Grand River watershed is one of the most studied areas in Canada. One conservation authority, forty-eight municipalities, First Nations, four post-secondary institutions, hundreds of primary and secondary schools, non-government and community groups, and industry have all examined various aspects of the river and its associated resources over the past century. Yet, this information has not been fully consolidated to give us a complete picture of the watershed, the way it responds to land use changes, its overall health, or the increased demands and stresses on it in the face of anticipated high growth over the next twenty years.

Our continued growth and prosperity depend on a healthy watershed. The more we understand about the watershed and the way it functions, the better able we are to ensure that our actions keep it healthy .

This *"State of the Watershed Report Background Report on the Health of the Grand River Watershed"* represents the collective knowledge of the many who have studied the Grand River watershed and was compiled by the Grand River Conservation Authority with their assistance. As such, it is a reference guide for watershed managers, educators, community groups, and others. This information, however, is only a "snapshot" in time. There are several information gaps which are identified in the report. It is anticipated that over time, with the efforts of all who are involved in *The Grand Strategy*, our information base will broaden as more research is undertaken and shared. From this information base, we will be able to develop indicators of watershed health and create an annual "Report Card" which measures both the positive and negative impacts of our actions. This will allow us to collectively adjust our activities to reduce or remediate negative impacts and to celebrate our successes.

This report is a companion document to *"State of the Watershed Focus on Watershed Issues 1996-97"*, a clear and concise summary of the current situation in the watershed. Topics cover population growth, business development, water supply, wastewater disposal, flooding, water quality, fisheries, natural areas and biodiversity, outdoor recreation, and human heritage.

If you have any comments or wish to contribute additional information for future editions, please contact:

Barbara Veale, Coordinator of Strategic Planning and Partnerships
Grand River Conservation Authority
400 Clyde Road, Cambridge, Ontario N1R 5W6
Phone: (519) 621-2761 ext. 274
Fax: (519) 621-4844
E-mail: bveale@grandriver.on.ca

Reflections of the Grand

The Source:

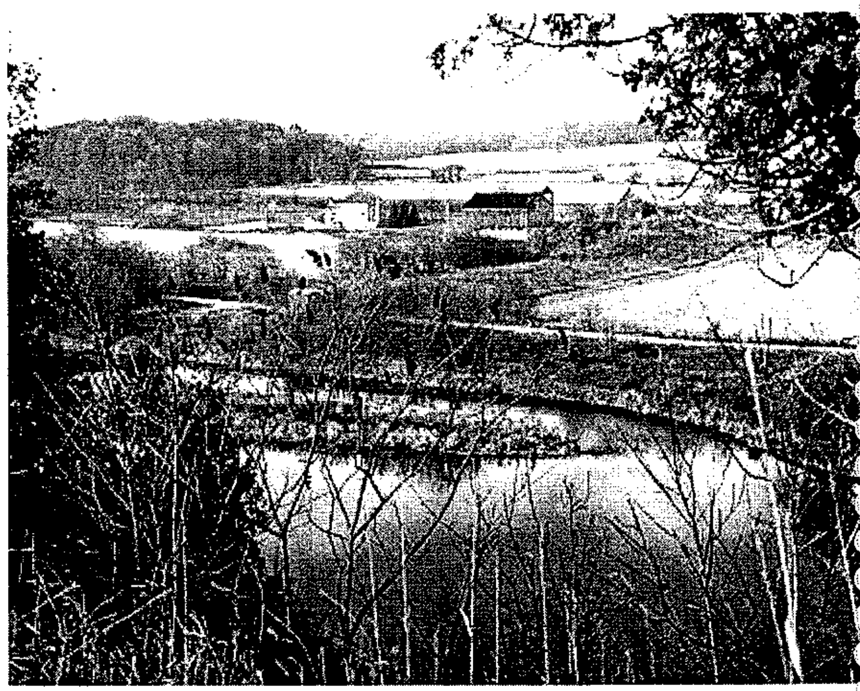
From its humble beginnings north of Dundalk, our "Grand" River flows 298 kilometres south to Lake Erie, picking up four major tributaries the Nith, Conestogo, Speed and Eramosa along the way.

Photo: Elizabeth Bourque

The Rural Character:

The river meanders through picturesque rural countryside as shown by the photograph taken in the Township of Woolwich. The thriving cities of Kitchener and Waterloo lie only a short distance downstream.

Photo: Elizabeth Bourque

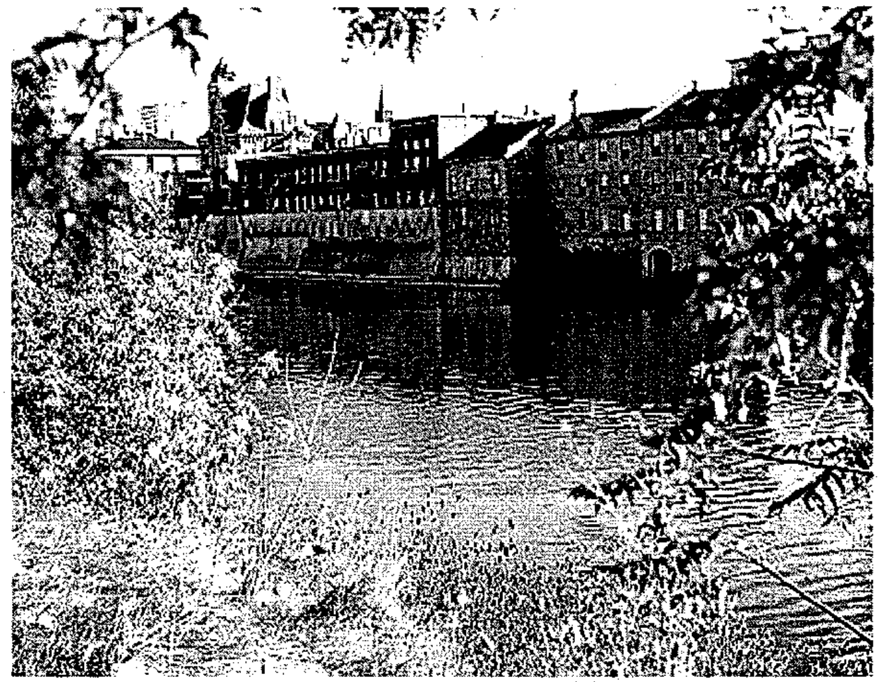


And Its Changing Character

The Urban Character:

Flowing through downtown Galt (Cambridge), the river transforms into an integral partner of the urban environment, providing economic and aesthetic benefits.

Photo: Elizabeth Bourque



The Mouth:

At the mouth of the river, the provincially significant Dunnville marshes play host to migratory birds and several species of fish before the river empties into Lake Erie.

Photo: Elizabeth Bourque

The Challenge:

The Grand River is the life blood of watershed communities, as illustrated in this photograph of Cambridge. The prospects for growth are making decisions about the watershed's quality of life an enormous challenge and an urgent responsibility. Tackling resource issues and securing a healthy future depends on our ability to work together to find creative solutions and to stretch limited dollars.

Photo: GRCA

STATE OF THE WATERSHED REPORT

A BACKGROUND REPORT ON THE HEALTH OF THE GRAND RIVER WATERSHED

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1. INTRODUCTION

This report is a "snapshot in time". It outlines the state of resources in 1996/97 in the Grand River watershed, and represents the collective knowledge of government agencies, municipalities, organizations, community groups, educational institutions, Six Nations, and the Grand River Conservation Authority. It is intended to provide information and a reference guide for a diverse range of watershed managers in topics other than their own area of expertise. The report also identifies where information in some fields is scattered and incomplete, and where more knowledge is needed.

1.1 The special heritage of the Grand River

The Grand River, and its major tributaries, the Nith, Conestogo, Speed and Eramosa Rivers were officially proclaimed a Canadian Heritage River in 1994. It is the only highly settled river in Canada to achieve this coveted status. The designation is based on the abundance of nationally significant human heritage features and excellent recreational opportunities which are associated with the river.

1.2 The challenge for the future

The growth and economic viability of the Grand River watershed relates directly to the availability of a sustainable source of clean, potable water and the cost of treating wastewater. Waterloo Region and Guelph depend heavily on water supplies taken or recharged from the river system. Brantford and the Six Nations rely exclusively on the river for water supply. Treated wastewater from over 525,000 people is discharged into the Grand River and its tributaries. The cost of polishing wastewater to acceptable water quality levels is escalating.

Over the next 15 years, 200,000 additional people will live in the watershed. Despite these pressures, the Grand River is one of the healthiest river systems in North America flowing through a densely populated area. Our challenge is to continue to accommodate growth and economic development without compromising the health of the watershed resources on which we rely.

1.3 The watershed perspective

Problems associated with resource use typically stem from activities that cause unexpected or cumulative impacts downstream. Solving these problems requires sound information about the consequences of actions.

Since the turn of the century, watershed-scale issues such as flooding, water quality and water supply have been studied. Little consideration was given to the relationship between the solution and its impact on other land and water resources. Costly remedial measures often solved the immediate problem, but created new problems downstream.

Today, concerns are expressed about the ability of the Grand River to stay healthy in the face of expected population growth, land use change and increasing demands on surface and ground water. A watershed approach is necessary if we are to effectively and economically resolve recurring and new watershed-scale problems.

1.4 Sharing responsibility

Responsibility for resource management in the Grand River watershed is shared. Formally, the primary responsibility for resource management rested with municipalities, provincial agencies, the Grand River Conservation Authority and the First Nations. A growing number of non-government organizations, businesses, educational institutions, and landowners are actively participating in researching, monitoring, rehabilitating and enhancing watershed resources. It is expected that, as government funding for resource management is scaled-back, more emphasis will be placed on "grass-roots" or community involvement.

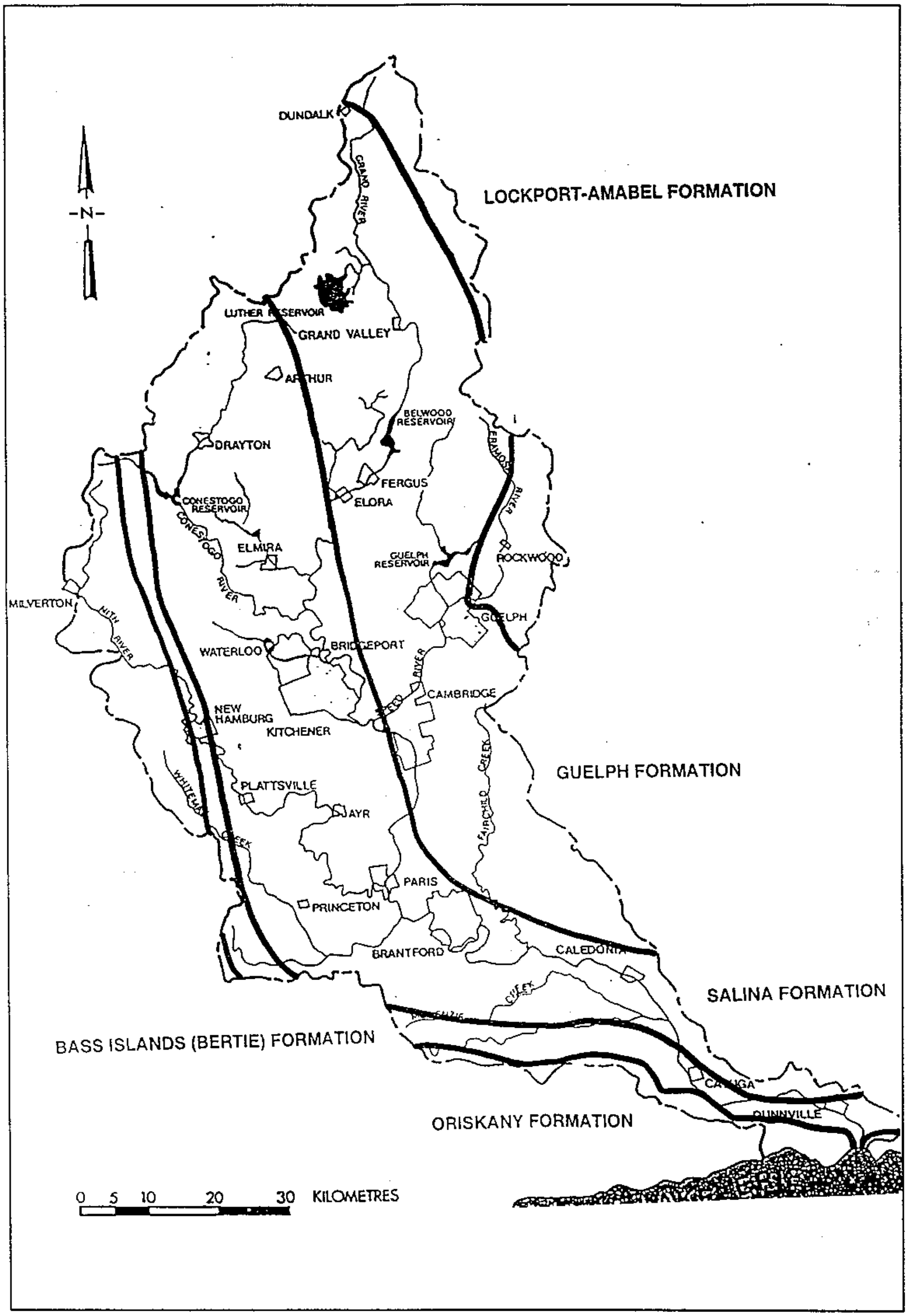
Addressing watershed-scale issues requires participation from all sectors. It is particularly important for municipalities to continue their long tradition of cooperative river management so that future municipal water requirements and the health of the watershed are not jeopardized.

1.5 A forum for partnerships

A forum for partnerships for dealing with watershed-scale issues already exists. The watershed municipalities have managed natural resources on a watershed-scale basis through the Grand River Conservation Authority for over fifty years. GRCA has also partnered with government agencies and others to carry out a wide range of watershed conservation programs and activities.

In 1996, to deal with the pressing issues at a time of falling budgets, the GRCA invited watershed partners to set priorities for action and pool their efforts for the biggest benefit to watershed health. The process is called *The Grand Strategy*. The partnership includes representatives of provincial and municipal governments, agencies, First Nations, educational institutions, community interest groups and the public and private sectors. There are now about 300 people involved in the process. *The Grand Strategy* sets the stage for long-term shared management, integrating not only water supply and quality issues, but recreational, economic and heritage considerations.

FIGURE 1-1: BEDROCK FORMATIONS IN THE GRAND RIVER WATERSHED



2. NATURAL HISTORY OF THE GRAND RIVER WATERSHED

2.1 Bedrock formations and glacial history

Three major bedrock formations of soft sedimentary limestones, shales, and sandstones overlie the Pre-Cambrian bedrock under the surface of the Grand River drainage basin. The Salina bedrock formation runs down the length of the watershed on the eastern side of the main branch of the Grand River. Its composition of limestone, dolomite, shales and gypsum and salts allows some solids to dissolve easily into water moving through the rock pores. The Guelph bedrock formation, of less easily dissolved limestone and dolomites, runs down the west side of the basin, meeting a small area of the similar Amabel-Lockport formation on the far west border of the watershed. See Figure 1-1, page 1-4.

Over 15,000 years ago, ice lobes of the Wisconsinan glacier scoured and eroded the ground, carrying along soil, boulders and rock, and leaving scars and ridges in the harder bedrock. The enormous weight of the continental ice changed the normal drainage pattern of rivers flowing to the Great Lakes, and tilted the shores of the glacial lakes upwards to the northeast. Lowlands were uncovered, and the present Great Lakes drainage system was formed.

Receding ice left behind glacial debris (till) of poorly sorted boulders, sand, clay and other materials to become the varied landforms of moraines, eskers, and drumlin fields that characterize and influence the natural history of the Grand River watershed. During long periods of thawing, meltwater flowed into many successions of glacial lakes in extensive low-lying areas near Lake Erie. Plumes of sand and clay particles carried by meltwaters settled on the ancient lakebeds to become the clay plains of the lower Grand River valley.

2.1.1 The shape of the Grand River valley

Ontario Island, a high flat area of hard bedrock south of the present Georgian Bay, was the first area of land to appear after the last glacier. This included the Dundalk Uplands Plain, source of the headwaters of the Grand, Saugeen and Maitland Rivers. From here, the land sloped south to Lake Erie, and west to Lake Huron, with the long spine of the Niagara Escarpment forming a natural drainage barrier to the east. After the recession of the glacial ice, an efficient tree-like drainage pattern developed to form the present Grand River drainage system.

The moving ice scored a network of channels into the hard bedrock of the Dundalk Upland Plain. Meltwater or rain ran from the plain in these channels, or collected in poorly drained depressions to become the bogs and swamps of Luther and Melancthon Townships.

The Grand River flows south, through the physiographic regions of the Dundalk and Stratford Till Plains, carving a valley through the bedrock of the upper watershed, and the gravel terraces left by meltwater 'spillways'. In the Elora Gorge area, the river cuts deep into the dolostone, producing canyon-like walls and rugged beauty.

In the central part of the basin, the Grand River creates a wide, winding valley through gravel glacial deposits. Here, the Grand River is joined by the Conestogo River, a major tributary draining the upper, west side of the watershed . Much of the central part of the watershed is a region of moraines, drumlins and sandy hills. These include the Waterloo Sand Hills, the Guelph Drumlin field, the Waterloo Moraine, and parts of the Galt and Paris Moraines.

In the moraines, rainwater and snowmelt, seeping down through porous higher ground, is contained by an impervious layer of clay over bedrock to form subterranean water reservoirs or 'aquifers'. Groundwater reservoirs found in the central Grand River valley include the large Waterloo-Mannheim aquifer. Other post-glacial features of the central region include the Baden kames, the Rockwood potholes, and the Wrigley-Bannister Lake complex.

The Speed and Eramosa Rivers drain the lands in the upper eastern part of the watershed and join the Grand River in the middle basin.

Further south, the Nith River flows from the central and western side of the watershed to join the Grand River as it moves over the delta of the former Lake Warren. The soft silts and clay of the Norfolk Sand Plain allow the Grand River to meander freely, eroding and depositing bank soil with its movement. To the south, a mixture of settled till and clay layers in the old lake beds created the Haldimand Clay Plain, a flat, wide area with poor drainage and many wet sloughs. Small glacial ridges provide drainage channels for lower watershed streams flowing into the river. In total, there are 11 physiographic regions in the Grand River watershed which are described in more detail in Chapter 10.

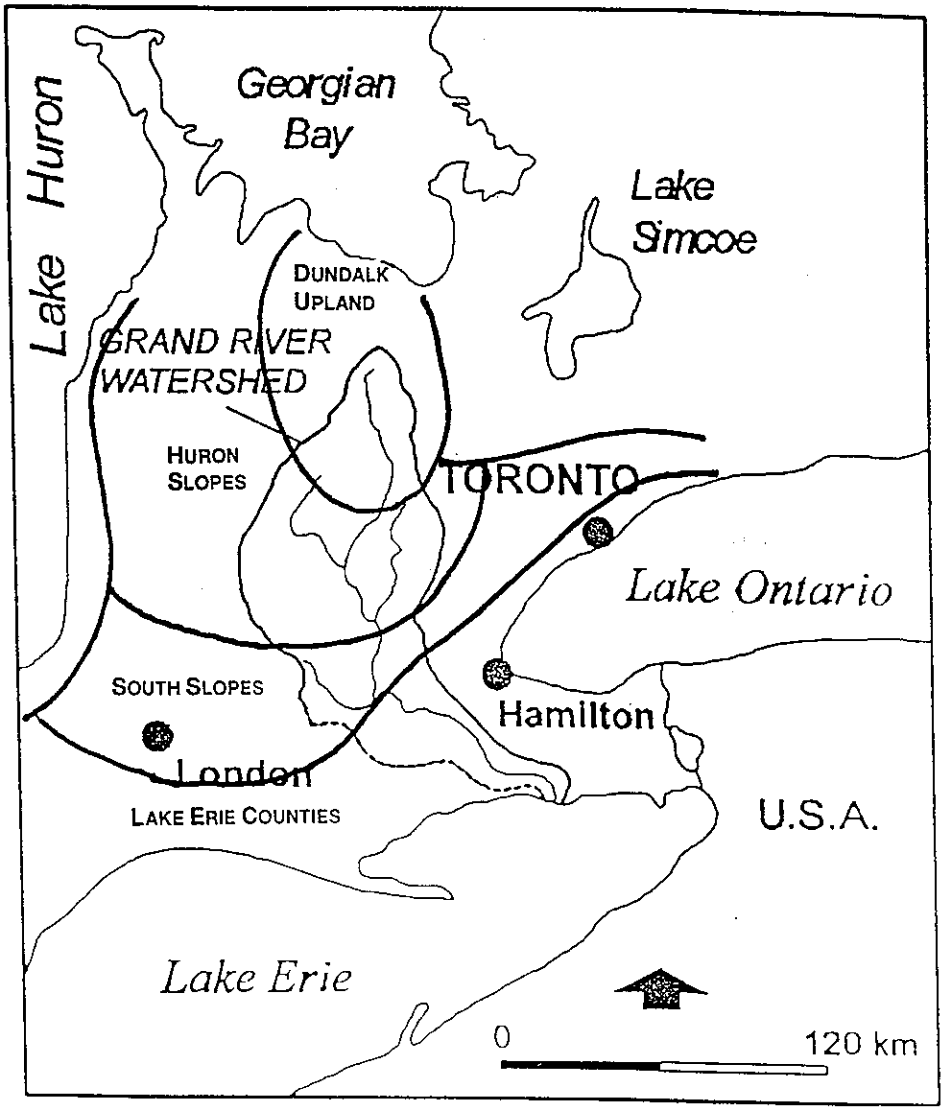
2.2 Climate zones of the Grand River watershed

On average, there is no "wet season" in Southern Ontario and precipitation is even distributed throughout the year. However, in any given month the amount of rain and snow varies greatly. A dry month will cause noticeably lower flows in the Grand and its tributaries. A month of rainy weather will saturate the soil, fill the swamps, and raise the river levels. Little snow accumulation in a warm or dry winter will lead to moderated spring flows like those of recent years. Cold winters with heavy snow accumulation usually lead to heavy spring runoff and floods like those of the 1970's. The Grand River watershed straddles four climate zones. These are the Dundalk Uplands, the Huron and South Slopes and the Lake Erie Counties zones. See Figure 2-1, page 2-3.

2.3 Ecoregions of the Grand River watershed

There are 29 ecoregions in the Grand River watershed. These are broad land units characterized by a distinguishing pattern of terrain, soils, vegetation, waterbodies and flora. They range from the scenic Hillsburg Sand Hills to Luther Marsh, and the urbanized central Grand River corridor to the extensively forested Six Nations Reserve. The ecoregions are described more completely in Chapter 10.

FIGURE 2-1: CLIMATE ZONES OF THE GRAND RIVER



DUNDALK UPLANDS

Here, the higher altitude produces a cooler climate. Winters are colder and the snow stays longer in the spring. Any moisture left in winds after they pass over the Huron Slopes is dropped on this tableland as snow or rain.

HURON AND SOUTH SLOPES

The Slopes rise from the plains bordering Lakes Erie and Huron. Moisture, picked up by winds blowing over Lake Huron, condenses as snow or rain on the slopes. This creates a "snowbelt" area on the west side of the Grand River watershed, between the towns of Arthur and Stratford, with a higher than average rainfall and snow accumulation.

THE LAKE ERIE COUNTIES

In the Lake Erie Counties zone, close to the Lake Erie shore, winds passing over the lake are warmed in winter and cooled in summer. This produces a warmer climate with a long, frost-free growing season in the lowland plains from the mouth of the Grand River northwards to Brantford.

3. SETTLEMENT IN THE GRAND RIVER VALLEY

3.1 Native people of the Grand River valley

During the last ice age, because of low sea levels, Asia and North America were connected near the Bering Sea by a 1609 km (1,000 mile) wide grassy plain. Primitive hunters followed the herds of large game animals across this land bridge, to spread over North America during the next ten centuries. These people were named 'Clovis Point People' by archeologists because their distinctive stone tools were first found in Clovis, New Mexico.

Descendants of the Clovis People moved south and east of the Bering Strait in search of food, eventually reaching the land of the Grand River and Lake Erie. Archeologists gave the name of 'Mound Builders' to what is believed to have been the earliest inhabitants of this part of North America. Many remains of Pre-historic native settlements, dating back to 9,000 years, were found in the Grand River valley, including nine sites in the Rockwood area. The Mound Builders were extinct by the time the first European explorers reached the Grand valley, and in their place were the Eastern Woodlands tribes, known as the Iroquoian-speaking people.

From the Grand River, eastward across the Niagara River, Southern Ontario was home to the Iroquoian people of the Neutral Nation, or Attiwandaron ('people who speak a slightly different language'). The Neutrals were an agricultural people, growing corn, beans, squash and tobacco, and supplementing their diet with wild game and fish. Their palisaded riverside villages were moved as the soil became exhausted. The term Neutral was used by French explorers because of their nation's refusal to become involved in warfare between the Huron Nation to the north and the Iroquois Nation to the east. The Hurons and Iroquois visited and traded with the Neutrals, and at times would wage war in Neutral territory if they were not accompanied by members of the Neutral tribe. The term Neutral should not imply a pacifist people, for the Neutrals were themselves fiercely at war with the Assistaronon (Fire Nation) people of Michigan and Ohio.

In 1650, several disputes with the Senecas of the Iroquois Nation resulted in the Neutrals being embroiled in a war on two fronts. In the summer of 1651, a large scale attack by the Senecas drove the Neutrals from the Grand River valley. For the next hundred years the valley remained unpopulated, used only by occasional hunting parties of Iroquois. Later, the land came into the possession of the Mississaugas, who named the river the O-es-shin-ne-gun-ing, ('the one that washes the timber down and carries away the grass and the weeds').

During these troubled times, the Grand River valley was visited sporadically by parties of French explorers, missionaries and fur traders. René De Galinée, a geographer priest, mapped the area in 1669 to 1670, and gave the name of La Rapide to the Grand River.

Jacques-Nicholas Bellin (1703-1772) was the first cartographer to use the name 'Grand River' He referred to the river as 'R. d'Urse ou la Grand Rivière' on a famous map of the Great Lakes published in 1744.

After the defeat of the French by the British forces in 1760, the country became known as Upper Canada and La Rapide was renamed the Ouse, after an English river. In the spring of 1775, open rebellion of the American colonists forced more changes in the Grand River valley.

British Loyalists were driven from their lands in the new republic and resettled along the east end of Lake Erie and the lower Grand River valley. Among the loyalists fleeing to British protection were descendants of six thousand German refugees, who had earlier been allowed to make their New World home on lands owned by the Six Nations.

3.1.1 The Six Nations settlement

During the revolution, the Six Nations People from the Finger Lakes area of New York State fought for the British under the command of Chief Joseph Brant. They were left homeless after the defeat and Joseph Brant appealed successfully to the British Crown for a new home for his people.

Land in the Grand River valley was chosen and purchased from the Mississaugas in 1784. The land grant encompassed six miles each side of the river, from source to mouth. The total extent of the river was unknown at that time, and government surveys placed the grant's northern boundary near Fergus, with a total area of 674,910 acres. Brant chose a site for his new Mohawk village at the side of the Grand River in the place known as Brant's Ford (Brantford).

3.2 European settlement

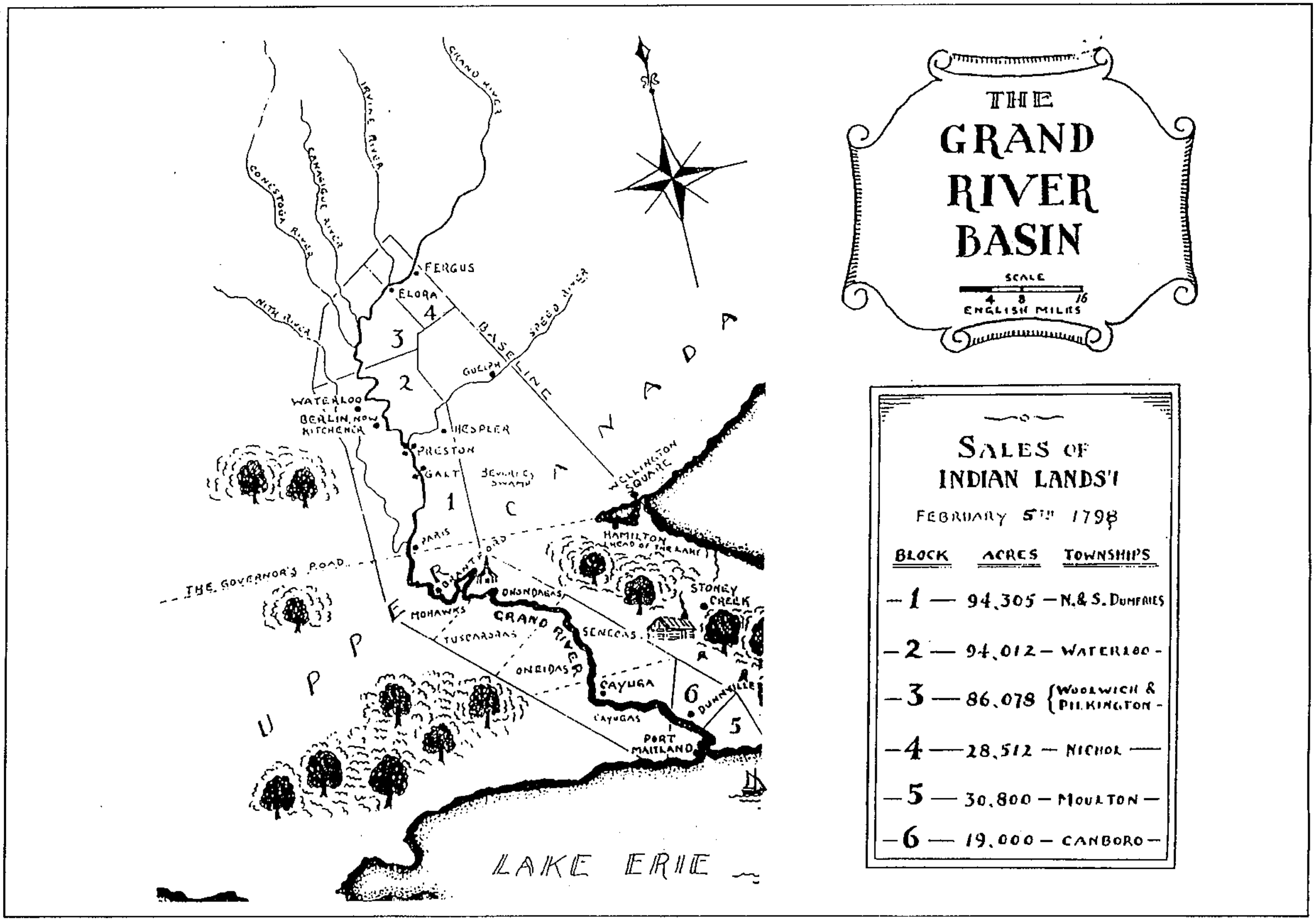
In the 1790's, an established means of colonizing the interior of Upper Canada was through the granting of large tracts of land. Land owners then sold lots or parcels to prospective settlers and developers. Joseph Brant negotiated this right for himself and the Six Nations, selling six major blocks of land, totalling 352,707 acres, in 1798. See Figure 3-1, page 3-3. These became the settlements of the major cities in the Grand River watershed, and included much of the valley's prime agricultural land. The disposition of these lands set the stage for the development of the rich cultural heritage of the valley.

Block 1, bought by William Dickson and settled with hardy Scots immigrants, became Cambridge and the Dumfries Townships. Scottish immigrants also settled on the banks of the Irvine and the Grand Rivers in Block 4, creating the communities of Fergus and Elora in Nichol Township. The strong Mennonite heritage of the Waterloo region can be traced to the sale of Block 2, originally known as the Beasley Tract. Mennonites from Pennsylvania purchased 60,000 acres through the agency of the German Company. Later Mennonite settlers acquired most of the adjacent Block 3 to create Waterloo and Woolwich Townships.

The first settlers in the fertile lands in the south and middle of the watershed were farmers. They cleared the forest, and tilled the newly opened lands to grow wheat and other grains, and graze livestock. The cleared trees were used or sold as lumber, or burnt on the land to produce potash for export. The fast-flowing Grand River and its tributaries provided transportation routes, and a reliable source of power for the grist and saw mills that sprang up in response to the needs of the early settlers. The Grand River also provided drinking water and a waste disposal system for the river communities. Mill ponds, created in some areas like Waterloo, provided a constant power source for local mills. As a focal point in the development of the community, these ponds often became treasured scenic parks and recreation areas for the townspeople.

Patterns of settlement developed early. The well-drained fertile soils of the middle valley were prime agricultural lands, especially in the valleys of the Conestogo and Nith Rivers. In the lower basin, the sand and silt soils in the Brantford, Whiteman's Creek areas were used for crops, although irrigation of the land was needed for good productivity. The clay soils of the lower basin and the extensive marshes along the river banks were a poor agricultural prospect, and of less interest to most settlers. Few early settlers reached the swamps and high land of the upper reaches of the Grand River.

FIGURE 3-1: SALE OF THE SIX NATIONS LANDS
(from *The Grand River*, by Mabel Dunham (1945) Toronto, McClelland and Stewart.



3.3 Industrial development

The middle basin became the focus for growth and development because of the advantages of water power from the fast flowing river, and the proximity of easily cultivated valley land. Communities such Guelph, Galt, Preston, Hespeler, Paris, and Brantford grew around mills and the valley flats.

Thousands of German and other European immigrants brought better tools and technology like the 'rollers' that replaced mill stones in the St. Jacobs flour mill in 1875. Stores and factories were built to provide commodities for the growing population. Streets were laid out in new communities, and older wooden mills and homes were replaced by handsome stone structures. The introduction of steam power in the late 19^{th} century revolutionized transportation and manufacturing. Cities like Berlin (now Kitchener) were created away from the river and became centres of industry, producing beverages, food, and clothing. Riverside textile mills in Paris, Galt, Preston and Hespeler were converted to steam, and provided employment for the steadily increasing numbers of people moving into the towns.

In 1829, the first Welland Canal was built to link Lakes Ontario and Erie for commercial navigation. Water was diverted from the lower Grand River at Dunnville to provide flow for the canal, and the feeder canal became part of the navigable waterway of the Grand River. The Grand River Navigation Company was created in 1832 and introduced a new era of prosperity to the Grand River valley. Five dams, five locks and two canals were built to enable horse-drawn barges to travel upriver as far as Brantford. Teams of horses plied the towpaths, and rights of way were established that are still mentioned in local deeds. Riverside communities, such as York, Indiana and Middleport, evolved to serve the needs of boatmen and travelers. Dams provided industrial water power and some prosperity to communities like Dunnville and Caledonia.

In the 1850's, the coming of the railway was the impetus for dramatic changes in the industrial settlement of the Grand River valley, and ultimately resulted in the failure of the Grand River Navigation Company in 1861. Rail freight charges were low, and railroads did not freeze over in the winter, or run dry with insufficient flow in the summer. By the 1850's, the trip from Brantford to Toronto could be accomplished by rail in a matter of hours as opposed to days required by river barge and lake steamer. The canals fell into disrepair, and all but a few remnants disappeared.

3.4 Land use and river problems

As the middle basin of the watershed became more populated, settlers moved north in their quest for agricultural land and arrived in the area of the headwaters of the Grand River around 1831. They found an enormous bog covered with tamarack and cedar trees. The area was named Luther and Melancthon by an early surveyor, who described the area as 'all swamp', and declared it the meanest land he ever saw. A devout Roman Catholic, he named the land after the meanest men he could think of, the leaders of the Protestant reformation, Martin Luther and Phillipp Melancthon!

Seed rotted in the heavy, poorly-drained clay soil of the Dundalk Till Plain. The short growing season and difficult conditions proved daunting for even the most determined farmers and many turned to lumbering to provide a livelihood. Massive timber cutting took place in Luther and Melancthon in the 1860's. Pine, cedar and tamarack logs were cut in the winter and floated downstream in the spring to Galt, to be shipped by train to Toronto.

Thousands of logs were also taken from swamp lands near the Irvine and Conestogo Rivers. By 1894, the forests of Luther were almost completely cleared. Deforestation did not increase the agricultural potential of the swamps, but it did change the way the Grand River was able to deal with heavy spring rains and snowmelt. Surplus flows, previously restrained in woody swamps, now rushed downriver, flooding river side lands, destroying property and livestock, and sometimes claiming human lives. Drainage channels, built to create agricultural land, also provided avenues for the spring rains to flush from the high land into the already swollen rivers.

As Luther Marsh and other swamps in the upper watershed were drained, summer flows in the river were no longer augmented by a steady seepage from these wetlands. Settlers downriver contended not only with heavy spring floods, but at other times had insufficient water to power their mills and remove their waste. Increased population meant increased sewage to be dealt with by a river that became sluggish and polluted. By the late 1800's there was growing public concern and recognition of serious community problems resulting from the environmental crisis occurring in the Grand River.

4. EVOLUTION OF RESOURCE MANAGEMENT

In the early 1900's, a series of heavy floods caused severe hardship, damage and expense in the Grand River valley. Some legislation, such as the Public Health Act (1880), and the Municipal Waterworks Act (1882) was in place to deal with some water quality problems, but there was no unified approach to dealing with water problems.

The Ontario Hydro-Electric Power Commission was created in 1907 to deal with the supply of hydro-electric power to the municipalities. It was also regarded by the provincial government as the primary water management agency, responsible for hydrologic and land use surveys.

After a particularly damaging period of floods, and litigation suits against valley municipalities, the Grand River Improvement Association of representatives of flood-prone municipalities was formed in 1912. Their spokesman and advisor was William H. Breithaupt, a civil engineer from Berlin (now Kitchener). Breithaupt advocated the construction of dams in the upper watershed to provide flood protection and to augment river flow to reduce mill power problems in the summer. Provincial assistance was requested, and the proposal was referred to the Ontario Hydro-Electric Power Commission for study. The six year study took place during a period of stable, and often low flows and, as the scheme was reported to be impractical, the interest of the Improvement Association members waned.

4.1 The Finlayson Report

In 1929, the largest flood in living memory inundated the business areas of Brantford, Paris and Galt. In 1931, the Grand River Valley Boards of Trade, an amalgamation of local Boards, petitioned the provincial government to investigate the provision of flood control and water conservation in the valley. A government inquiry was ordered into the recurring problems of the river. The collaborative governmental and municipal Finlayson Report was completed in 1932.

The Finlayson Report, broader in perspective than previous studies, recognized low flow as a health hazard for valley residents. It considered problems of water supply, and sewage disposal, as well as flood control and provision of hydro-electric power. The Report recommended the construction of four reservoirs, at Luther, Waldemar, and Elora on the Grand River, and at Hollen on the Conestogo River. Also recommended was the establishment of an artificial lake at Luther.

4.2 Grand River Conservation Commission

The Grand River Conservation Commission Act was passed in 1932, allowing any five municipalities in the Grand River valley to complete the financial, legal and administrative arrangements to implement the recommendations of the Finlayson Report. In 1934, a charter was granted to representatives from Brantford, Kitchener, Galt, Fergus and Caledonia to form the Grand River Conservation Commission. Further studies by H. G. Acres, Chief Engineer of the River Commission in 1939 resulted in changes to the recommendations and priorities for construction.

In spite of legal, governmental, and community differences and difficulties, the Shand Dam was built on the Grand River just north of Fergus. Completed in 1942, it was the first dam to be built in Canada for the prevention of flooding and low flow problems. Seventy-five percent of the cost of the dam was shared by the Federal and Provincial governments, and the participating municipalities shared the remaining twenty-five percent.

The dam created Belwood Lake, a 12 kilometre-long reservoir, with a storage capacity of more than 14 million gallons. In 1952, a smaller impoundment was built on Black Creek at Luther Marsh, creating once more a vast wetland at the headwaters of the Grand River. Conestogo Reservoir was constructed in 1957 to complete the plan.

With the Shand and Luther Dams built, and Conestogo in the final design stages, the Ontario Department of Planning carried out a review of the major tributaries. A series of reports between 1957 and 1962 (Grand River Hydraulics Report), recommended the construction of a series of reservoirs including Montrose, Guelph, Hespeler, Everton, Nithburg, and Ayr. Of these, only Guelph Dam was built on the Speed River in 1976.

During the creation of the River Commission, and the construction of the Shand Dam, many environmental and recreational groups were concerned with all aspects of conservation in Ontario. Recognizing that land and water resources should have permanent management and protection, representatives of these organizations met at the Guelph Conference in 1941. As a result of the conference, a joint federal and provincial survey of the Ganaraska River watershed was initiated. This pilot project looked at many issues of land and water conservation, including forest rehabilitation and soil preservation.

4.3 Conservation Authorities in Ontario

As a result of the recommendations of the Ganaraska Survey, the Conservation Authorities Act of 1946 was created. This legislation gave municipalities in a river valley the structure to initiate conservation measures within the framework of their watershed boundaries, with technical and financial help from the provincial government. Certain conditions determined the establishment and membership of each Conservation Authority. They were developed as semi-autonomous, corporate bodies, with members representing each of the participating watershed municipalities and the Province.

The Grand Valley Conservation Authority was established in 1948, and two separate conservation agencies now operated in the Grand River valley. The activities of the Authority were focused on river valley development, reforestation, land use problems and recreational areas. The Grand River Commission maintained its responsibility for the construction and operation of multi-purpose reservoirs.

After a sometimes cooperative, and sometimes turbulent co-existence, the two conservation agencies amalgamated in 1966 to form the Grand River Conservation Authority, with the provincial mandate to manage the water and related land resources of the Grand River valley.

From 1966 to the present day, the Grand River Conservation Authority has worked in partnership with other government agencies and municipalities to solve flood damage, water quality and water shortage problems. Mitigative actions included tree planting, dyking, channelization, and erosion control works carried out by the Grand River Conservation Authority and benefiting municipalities. Regulation of development and land use changes in floodplain areas is a shared responsibility with the planning departments of watershed municipalities and the GRCA.

4.4 Grand River Basin Water Management Study

With the responsibility of managing water resources in the Grand River valley divided among several government bodies, the need for a more comprehensive approach was becoming evident. In 1971, the *Ontario Treasury Board Review of Planning for the Grand River Watershed* recommended that an inter-agency, basin wide study be implemented.

An unusually severe flood in May 1974 caused $6,736,730 worth of property damage in the Grand River watershed with the brunt of damage in Cambridge and middle basin municipalities. A Royal Commission Inquiry into the circumstances of the flood was instituted and headed by Judge W. W. Leach. In 1975, the *Report of the Royal Commission Inquiry into the Grand River Flood, 1974*, was released. Recommendations from the Commission included the development of a comprehensive water management plan and, in 1977, the Grand River Basin Water Management Study was approved.

The study was directed by the Grand River Implementation Committee with representatives from provincial ministries, and the Grand River Conservation Authority. Public consultations were held throughout the process. The purpose of the Study was to define water management problems in the Grand River Basin, and to develop alternative water management plans to reduce flood damage, provide adequate water supply and maintain adequate water quality.

4.4.1 Recommendations of the Basin Study

The 1982 Recommended Plan included:

- channelization and dyke construction at major flood damage centres;
- continuation of flood plain regulations and development restrictions, and incorporation of these policies into municipal official plans and bylaws;
- continuance of fill control and dumping in defined areas, and expansion of the registered fill line along river valleys;
- protection of some wetland areas by planning controls and acquisition;
- development of new groundwater sources and supplementation of Kitchener-Waterloo water supplies by withdrawal from the Grand River;
- installation of improved sewage treatment facilities in some areas; and maintenance of water quality monitoring stations;
- adoption of urban storm water management practices;
- identification of rural non-point sources of water pollution, and evaluation of the effectiveness of improved management practices;
- The final recommendation of the plan was that a co-ordinating committee be formed to carry out a periodic re-evaluation of the plan, coordinate activities and investigations, and recommend new or modified alternatives to achieve the water management objectives of the Grand River Basin.

It was recommended that the components of the water management plan be implemented by existing government agencies in accordance with their traditional responsibilities, as shown in Figure 4-1, page 4-4.

FIGURE 4-1: RESPONSIBILITIES FOR WATER RESOURCES MANAGEMENT:

Responsibility	Agencies
Flood control, flood warning, dyking and channelization	Grand River Conservation Authority (GRCA) Municipalities Ministry of Natural Resources (MNR)
Flood proofing	Individual landowners.
Water supply projects and sewage treatment plants	Municipalities Ministry of Environment and Energy (MOEE).
Acquisition of hazard and reservoir lands	Grand River Conservation Authority.
Control of non-point source pollution	Landowners, municipalities, GRCA, Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA), MOEE, MNR
Planning controls	Municipalities, GRCA, Ministry of Municipal Affairs and Housing (MMAH), MNR.

4.4.2 Implementation of the Basin Study recommendations

Since 1982, the major components of the Plan, dealing with flood control, water supply and water quality, have been largely completed by the existing government agencies. The formation of a Coordinating Committee was not formally implemented until 1994, when the need for a more holistic approach to watershed management was evident.

During the designation of the Grand River as a Canadian Heritage River in 1994, a management plan for heritage and recreational resources was developed. The process of building *The Grand Strategy for Managing the Grand River as a Canadian Heritage River* was facilitated by the Grand River Conservation Authority on behalf of the Province of Ontario. Participants stressed that pressing resource issues must also be addressed collectively on a watershed basis.

The Grand River Conservation Authority coordinated the development of *The Grand Strategy for Shared Watershed Management,* setting the stage for long-term shared management, integrating not only water supply and quality issues, but recreational, economic and heritage considerations.

4.5 The Grand Strategy for Shared Watershed Management

With provincial downsizing, responsibility for day-to-day delivery of land use planning, urban infrastructure and resource management will rest with the municipalities. It will fall to a partnership of municipalities and watershed residents to meet the challenges and deal with the issues. More must be done with less, and resource management efforts must be put where they will have the most effect.

The Grand Strategy partnership includes representatives of provincial and municipal governments, agencies, First Nations, educational institutions, community interest groups and the public and private sectors. There are now about 300 people involved in the process.

The purpose of The Grand Strategy is to tackle the most pressing cross-boundary watershed management issues facing communities in the Grand River watershed. This will be accomplished by setting priorities, building partnerships, linking programs and pooling resources.

4.6 Products of The Grand Strategy

Products of *The Grand Strategy* include:

- A Joint Work Plan identifying specific tasks and priority actions for 1997 and 1998.
- Expanded forums for dealing with issues, sharing expertise and information;
- An annual report card;
- A maintained and accessible data base;

To ensure that the future resource management in the Grand River watershed is undertaken with broad-based participation on a continuing basis, the Grand River Conservation Authority will:

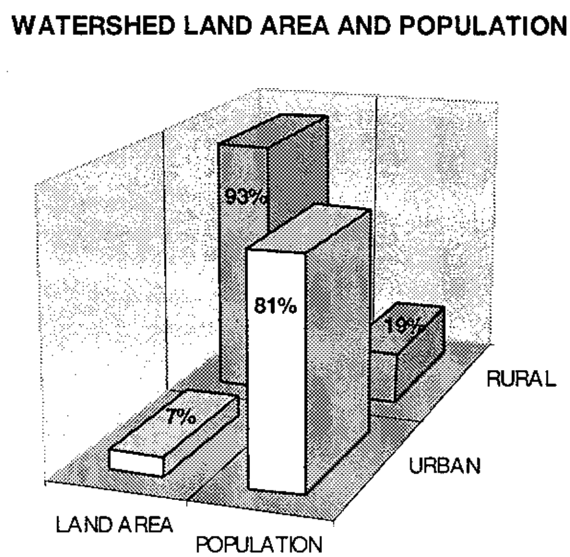
- provide opportunities for watershed stakeholders to actively participate in a shared approach towards solving watershed problems which build on *The Grand Strategy* process;
- coordinate the preparation of an annual state of the watershed report which will describe the existing health of watershed resources; report on the effectiveness of the year's activities; and, identify priorities for action;
- provide administrative and technical support required to ensure ongoing participation and interest;
- organize and maintain, with other partners, an accessible and current information base;
- carry out priority actions for which the Grand River Conservation Authority is deemed responsible.

5. URBAN AND RURAL LAND USE

5.1 Watershed population growth

- Most of the 730,000 Grand River watershed residents live in Brantford, Cambridge, Guelph, Kitchener and Waterloo. At present 81% of the population is living on 7% of the watershed land area. The average urban population density is estimated at 1157 persons per square kilometre. (1991 figures)
- Ninety three percent of the watershed is considered rural (less than 400 persons per square kilometre) and supports 19% of the population.

FIGURE 5-1: WATERSHED POPULATION AND LAND AREA



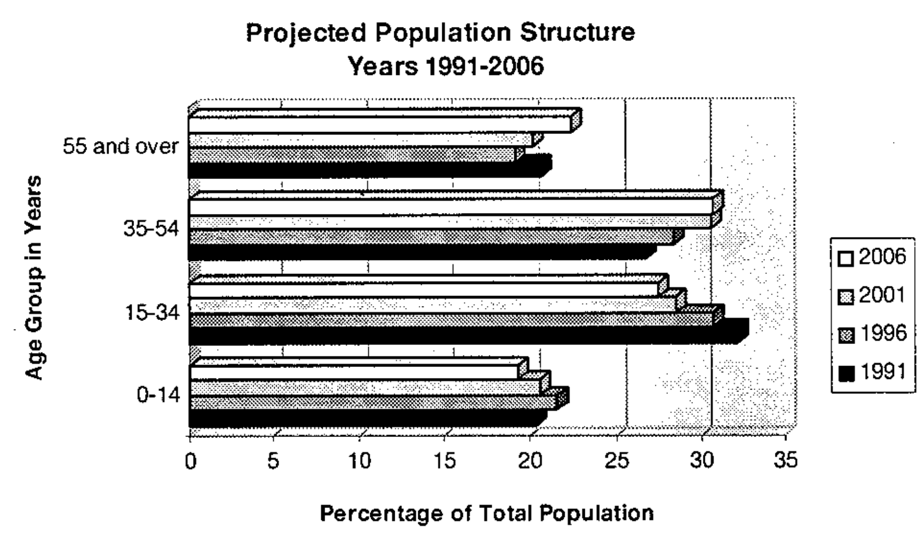
- The population of the watershed is expected to increase by 35% by 2011, and 50% by 2021. Fifty seven percent of the expected population growth will be the result of migration into the watershed.
- Most of the growth (90%) will take place in the central portion of the watershed, in and around the five major cities, and along the Highway 401 and 403 corridors. Each of the five cities projects that this growth can be accommodated within the current city boundaries.
- The remainder will be clustered around serviced towns and urban settlement areas, since many municipalities in the higher growth area have policies restricting rural severances and directing development to serviced settlement areas.

- In rural areas, most of the predicted growth will occur in existing unincorporated hamlets and villages. Infilling is expected to be the major source of residential growth. Expansion or creation of new settlements is subject to servicing constraints and planning to avoid creating "ribbons" of development. Constraints also include the preservation of prime agricultural land, environmentally sensitive land and aggregate resource areas.

5.1.1 Population demographics

- The total experienced labour force living in the watershed is 364,790. Over 73% are employed within three sectors of the economy (service, manufacturing and trade).
- The service sector includes health and social services, business service industries, accommodations, and food and beverages and is the most dominant in the watershed economy (32%).
- The proportion of the labour force working in manufacturing (25%) is significantly higher in this watershed than in Ontario and Canada as a whole. (*1991 Statistics Canada*)
- The population is aging. From 1991 to 2021, people aged 55 and older will shift from 17% to 31% of the population. The population aged from 15 to 64 will shift from 63% to 53% of the population.
- In many areas of Canada, the population will grow although the potential labour force will not. In the Grand River watershed, the labour force will grow significantly despite the shift to an older population. The potential labour force aged 15 to 64 will increase by 47% between 1991 and 2021, an increase of 229,000 people.
- Population growth and age structure changes will have implications for future municipal services including water supply, wastewater treatment, housing, recreation and transportation. Industrial or business area expansion may be needed to meet employment needs. However, changes in the drainage patterns of the land, such as those associated with subdivision and industrial development, can lead to long term impacts on water flow, groundwater recharge and surface water quality.

FIGURE 5-2: WATERSHED POPULATION STRUCTURES



5.1.2 Population economics

- Total income for the watershed in 1991 was over $12.3 billion. Income per capita is estimated at $17,894, compared to the average for Ontario of just over $14,000.
- Average income for the experienced watershed labour force is $33,734, and average income per household is estimated at $50,635.
- The contribution of the Grand River watershed to Canada's gross domestic product is larger than that of several provinces, and is comparable to that of Nova Scotia.

FIGURE 5-3: GRAND RIVER WATERSHED URBAN AREAS - 1991

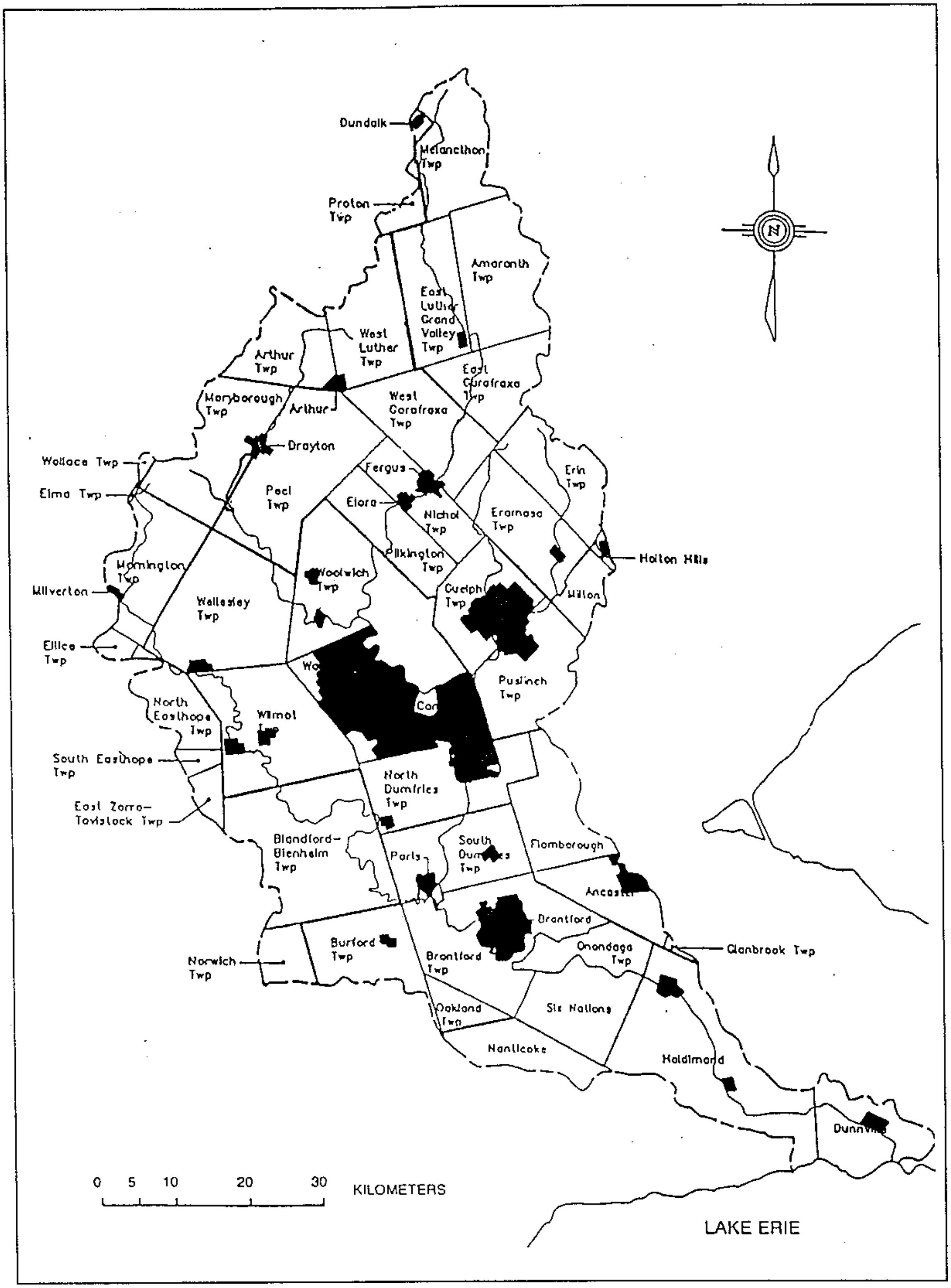
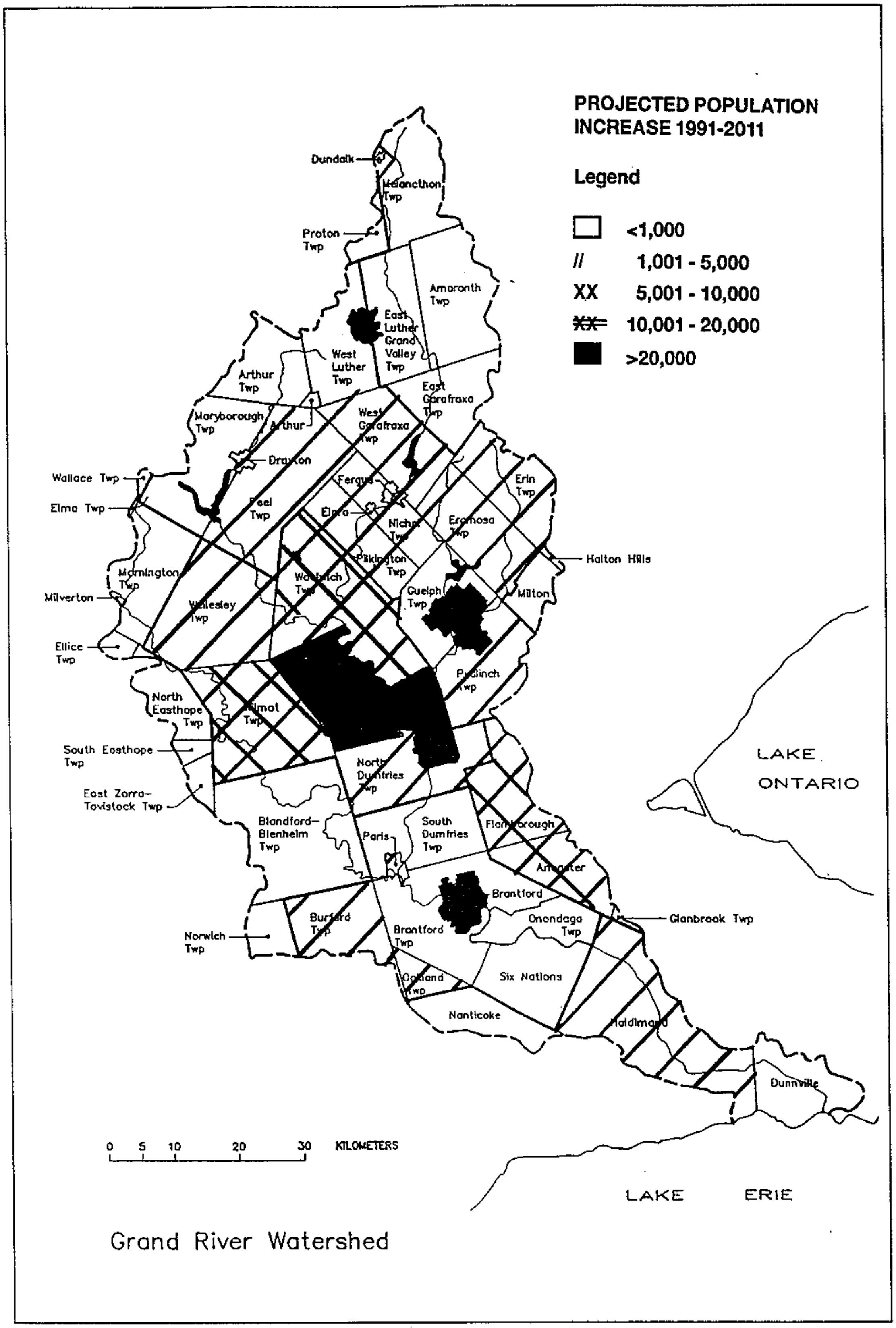


FIGURE 5-4: PROJECTED POPULATION INCREASE, 1991 - 2011



5.2 Major urban centres

5.2.1 City of Guelph

Guelph is located at the confluence of the Speed and Eramosa Rivers in the southern part of Wellington County. Since 1986 the population has increased by approximately 19 percent to the present population of 97,000. The city is projecting a moderate rate of growth which will represent an average annual increase of 1.5 percent. To accommodate future growth, Guelph recently annexed lands to the south from the Township of Puslinch and lands to the north from the Township of Guelph.

Guelph has adopted extensive policies to protect the natural environment, including water quality and quantity. By prohibiting new development on private septic systems, these policies discourage urban sprawl, premature construction of infrastructure and servicing and negative environmental impacts. Development and redevelopment are directed to (in order of priority):

- areas with existing municipal services
- areas designated as a priority for municipal trunk services
- unserviced areas where a secondary plan is adopted

Extensive growth in the city is limited by the assimilative capacity of the Speed and Grand Rivers. Studies are underway to examine this issue.

5.2.2 Cities of Kitchener, Waterloo and Cambridge

Over 427,000 people live along the Grand River in the Cities of Kitchener, Waterloo and Cambridge in Waterloo Region. This figure represents 88 percent of the total population within the Region. Along with Guelph, these three urban centres form the "Technological Triangle", one of Canada's leading growth areas.

Factors accounting for the growth include the presence of three universities, proximity to major markets in Ontario and the United States, as well as a cost of living lower than that of the Greater Toronto Area. Highway 401 bisects the Region between the Cities of Kitchener and Cambridge and provides easy access for the increasing number of commuters.

The 1985 Regional Official Policies Plan predicted that population would grow by 15 percent to 367,300 in 1991 based on 1981 census data. In fact, the population grew by 23 percent to 392,081. According to the Regional Official Policies Plan approved in October 1995, the population is expected to reach 558,000 by 2016. This represents an increase of 42 percent based on the 1991 census data. There is sufficient land within the settlement boundaries of urban areas to accommodate the majority of anticipated growth to the year 2016.

5.2.3 City of Brantford

Brantford anticipates that growth to 2016 will be accommodated within the existing City boundaries. Towards 2016, residential growth is expected into extend into the south west sector of the City. The potential for intensification elsewhere, while considered high, is not quantified and may be under-projected. It is noted that environmental clean-up costs for older abandoned industrial sites around the City's core make redevelopment costs prohibitive.

Industrial growth is an issue. New industrial areas on the fringe of the City have been established to the east and northwest. The City is looking hard at infrastructure in order to assess infrastructure expansions based only on very realistic population projections.

5.3 Rural settlement

5.3.1 Dufferin, Grey and North Wellington Counties

Dufferin, Grey and north Wellington Counties encompass a significant portion of the headwaters of the Grand River. Between 1986 and 1994, the population of Grand Valley, and the Townships of Melancthon, East Luther, Amaranth and East Garafraxa in Dufferin County increased by 13 percent. A large portion of the residential growth has occurred in the settled areas of Grand Valley and Waldemar and on rural retirement lots. There has also been an increase in smaller farm units and hobby farms. This area will most likely continue to experience moderate growth by providing rural residential opportunities for commuters to the Greater Toronto Area.
A very small portion of Grey County lies within the headwaters of the Grand River watershed. Land use is predominantly rural. Most of this growth has occurred in the Village of Dundalk. It is expected that future growth will be limited due to servicing constraints in the village.

5.3.2 Central Wellington County

Between 1981-1991, the population of Wellington County increased by 23 percent - the same rate experienced by the City of Guelph. The bulk of the growth occurred in the central portions of the county. Reasons why the south-central portion of the county is expected to continue to attract new residents include:

- the unique location between two large urban complexes (Toronto and Kitchener/Waterloo);
- high capacity transportation connections (Hwy. 401, GO transit);
- lower housing and industrial land costs than the Greater Toronto Area;
- the perceived quality of life in a 'rural' environment and
- the diverse economic and institutional base.

According to a Ministry of Municipal Affairs study, "*Perspectives, Beyond the Greater Toronto Area" (May, 1990)*, the south-central population is expected to increase by 36 per cent between 1986 to 2011. This growth rate matches that projected for the Greater Toronto Area. The expected growth pressures will produce difficult issues for both urban and rural municipalities where new development can significantly alter the form and human composition of the landscape.

5.3.3 Halton Region

Halton Region encompasses a small but significant portion of the Eramosa River - Blue Springs Creek drainage area. This area historically experienced limited growth. The Region and its area municipalities have adopted polices to identify, protect and enhance the natural environment, and restrict new estate residential development on private septic systems. Any additional development will be directed to existing urban areas, the majority of which lie outside of the Grand River watershed.

5.3.4 Regional Municipality of Waterloo

The Regional Municipality of Waterloo, located in the centre of the watershed, is home to 55 percent of the watershed residents. The population within the four rural townships is projected to remain at 12 percent of the total population for the Region. Strong policies limit major expansion and encourage development in established settlement areas. Environmental constraints to sanitary servicing, particularly along portions of the Nith River are also recognized.

New growth is being directed to Elmira and St. Jacob's in the Township of Woolwich, Wellesley in the Township of Wellesley, Baden and New Hamburg in the Township of Wilmot, and Ayr in the Township of North Dumfries. Of these six settlement areas, Elmira and New Hamburg have the most opportunity for commercial and industrial growth but are limited by servicing constraints.

High priority is given to the protection of the Region's agricultural, natural environment and water resources. This will be accomplished by restricting non-farm development in the rural areas, encouraging the development of compact urban areas, and requiring appropriate environmental studies and community planning to be completed prior to the approval of greenfield development.

5.3.5 Perth and Oxford Counties

Perth County is predominantly an agricultural area occupying a small rural part of the Grand River watershed. Milverton and Nithburg have experienced new residential growth. The main pressure for growth extends from the need for retirement lots for the farming community, and the desire for rural residential lots within commuting distance to local urban centres.

5.3.6 Brant County

Municipal restructuring will be a major issue in many watershed communities over the next few years, and will influence the make up of these areas. The following comments however, reflect issues associated with the current municipal structure.

5.3.6.1 *Onondaga Township, Brantford Township (East)*

Growth in Onondaga Township and the east side of Brantford Township is influenced by the proximity to neighbouring urban centres. An increase in population is expected due to the expansion of neighbouring municipalities, especially Hamilton-Wentworth Region. Limitations to services and financial capabilities may mean that growth will be accommodated through infilling and settlement area expansion and some rural non-farm related residential severances.

The main employment sector in the past has been agriculture and primary manufacturing. Agricultural uses will continue to dominate. Brantford Township is directing non-farm industrial development to the Brantford Airport Area and the east side of Brantford. Onondaga Township is looking at the potential for expansion through the tourism industry.

5.3.6.2 *Brantford Township (West), Burford Township, Oakland Township*

Population increases in Burford Township, Oakland Township and the west side of Brantford Township are influenced by the proximity to Brantford, Paris, and Highway 403. Growth is expected to occur through infilling and minor expansions to existing settlement areas.

5.3.6.3 *Town of Paris*

Annexations have occurred which have opened additional area for development on the south west sector of the Town, although much of the area is open space associated with the Nith and Grand Rivers. The town's water supply comes from well fields to the north of the municipality. While this supply seems reasonably secure, the Town of Paris is exploring methods of protecting the existing wells and is searching for additional groundwater sources.

5.3.7 Hamilton-Wentworth Region

While 22 per cent of the land base of Hamilton-Wentworth is situated within the Grand River watershed, only 12.5 % of the population of the Region resides here. It is expected that the Region as a whole will experience a 25 per cent increase in population between 1992 and 2021. The highest growth is projected for the urban centres outside of the Grand River watershed.

The Region has accepted key responsibility in planning for growth. A report, *"Vision 2020 - The Sustainable Region"* describes the character of Hamilton-Wentworth Region by the year 2020. It includes principles to create a Region that will fulfill human needs while maintaining a healthy social, economic and physical environment. To achieve this, and to ensure wise use of resources, growth management is seen as vital. Regional Council has stated a preference for a compact urban form within firmly set urban boundaries, for which most of the major infrastructure already exists.

5.3.8 Haldimand-Norfolk Region

Since 1976, over 40 percent of the growth in Haldimand Norfolk Region has been in the major settlement areas of Caledonia, and Cayuga in the Town of Haldimand. Caledonia has captured a significant portion of this growth. It is seen as an attractive bedroom community accommodating the growth in the labour market of Hamilton-Wentworth. There has also been an increase in the number of retirees moving into the area. These trends are expected to continue into the future.

In the 1996-2021 period, new job opportunities are expected to be mostly in the business and personal services sector. The single largest source of employment in the Region is agriculture, followed by trade. Manufacturing is becoming more important. Tourism is seen to be an area where there is significant potential for growth and expansion.

The population of Dunnville has remained relatively stable with only modest increases expected over the next 20 years. The urban area of Dunnville is situated central to the municipality along the Grand River, and is the only area within the Town serviced with water and sewer. Approximately half of the municipality's population resides here. The current population of Dunnville is just over 12, 000, with 5,000 persons making up the labour force. While there are diversified employment opportunities in the Town of Dunnville, 21% of the labour force commutes to other centres for employment.

The Lake Erie shoreline is experiencing an increase in residential development and redevelopment, albeit for the most part in a seasonal form.

5.4 Rural land use

Although only 19 percent of the population of the Grand River Watershed is rural, it controls over 93% percent of the land base. The majority of the land is used for agricultural production. The land use decisions made by rural residents and farmers have a significant impact on the water quality and landscape features of the Grand River watershed.

Rural land use is not expected to alter dramatically in the future. Since 1976, population in the rural areas has increased by approximately 23 percent. However, several general trends have been discerned which may change the impact of rural land use on the health of the ecosystem.

The 1991 Census of Agriculture defines a 'census farm' as an agricultural holding which produces at least one of the following products for sale: crops, livestock, poultry, animal products, greenhouse or nursery products, mushrooms, sod, honey or maple syrup products. The sales level of $250 is used as the lower limit in the definition of a census farm. Figure 5-5, page 5-10, illustrates the changes in the number of census farms by county.

FIGURE 5-5: CHANGES IN NUMBER OF CENSUS FARMS BY COUNTY

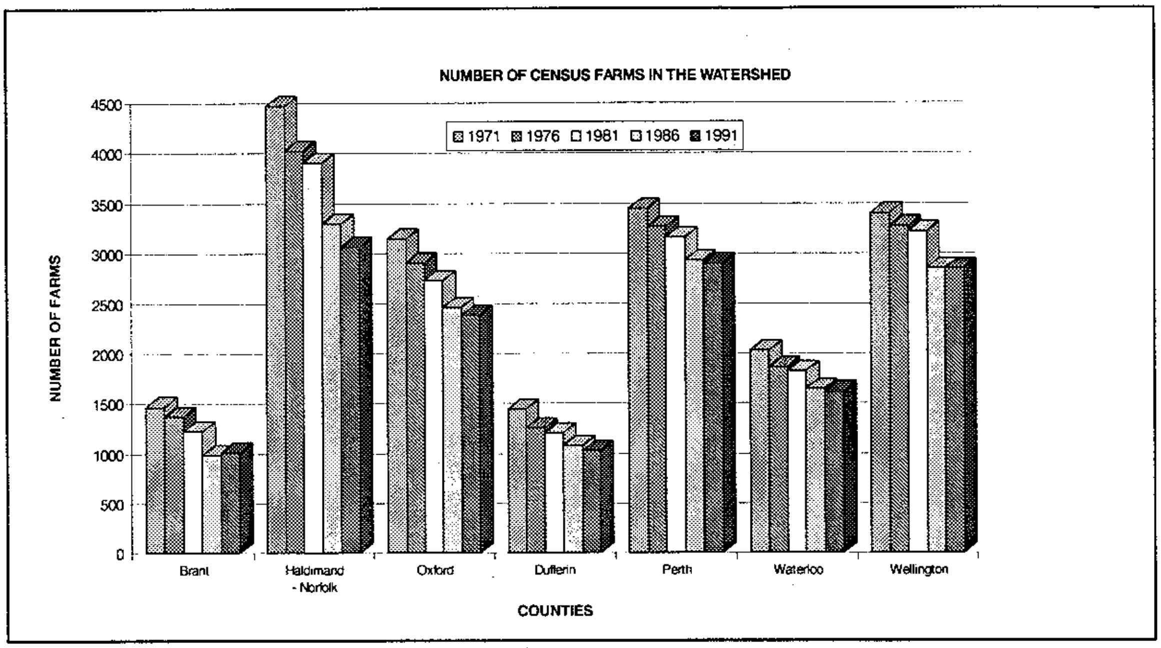
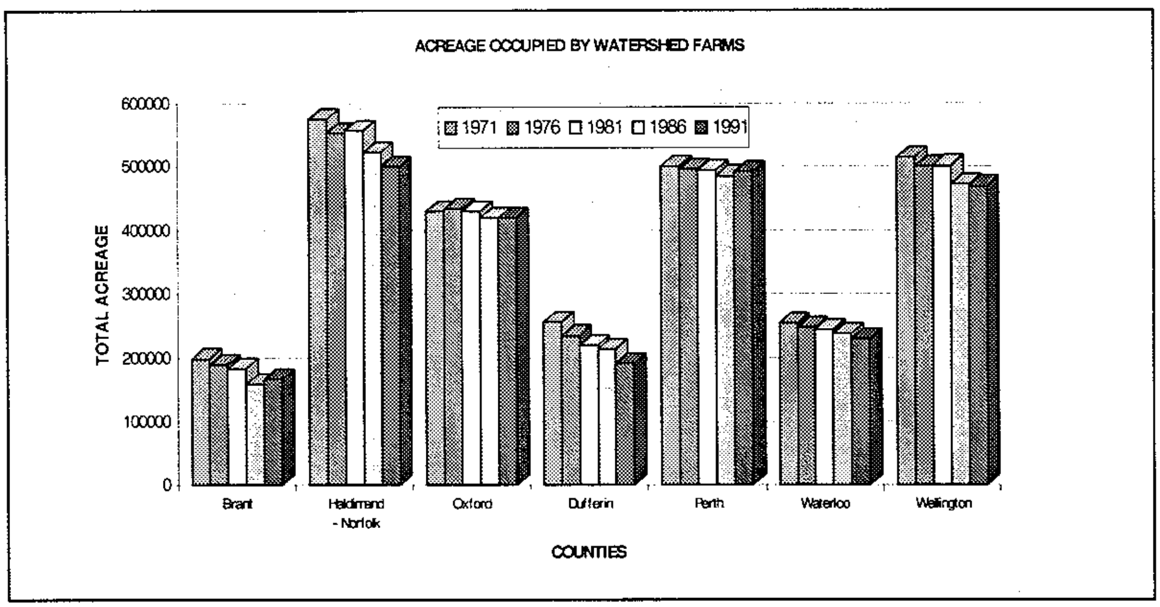


FIGURE 5-6: CHANGES IN THE ACREAGE OCCUPIED BY WATERSHED FARMS



5.4.1 Rural population trends and issues

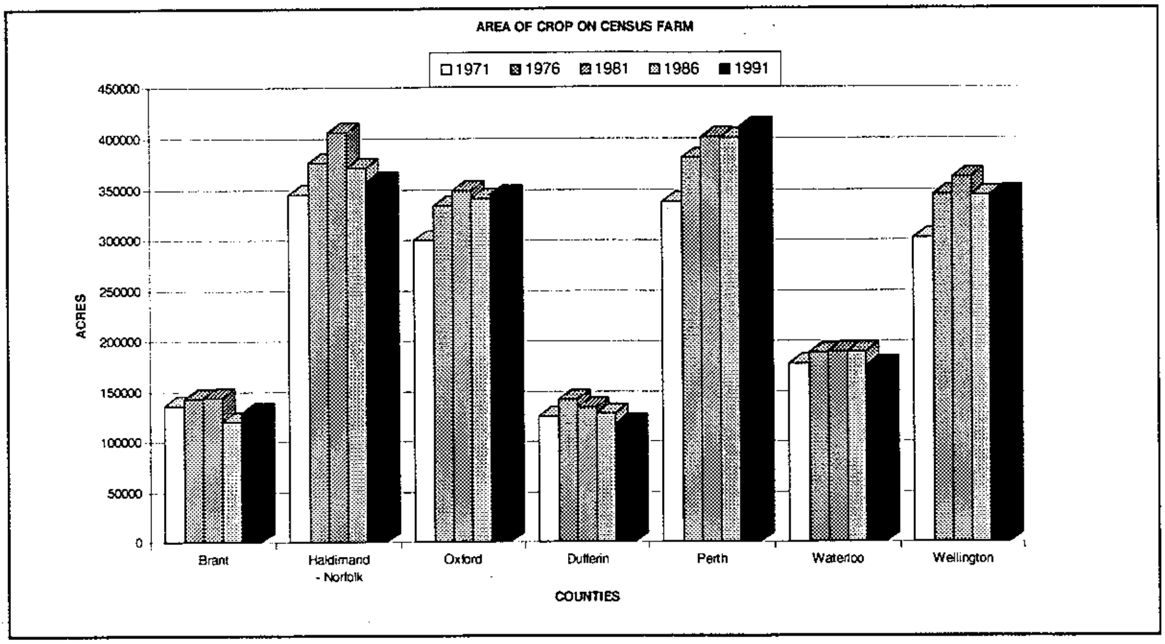
- The increase in the number of non-farming residents produces a corresponding increase in the number of household septic systems. This creates a higher potential for contamination of watercourses and groundwater by drainage from poorly maintained systems.
- There is increased potential for impacts on wetlands and other environmental features with more rural development. The creation of "bedroom communities" can be associated with problems such as a low residential tax base and relatively high servicing expectations.
- In some areas there is a loss of prime agricultural land to development. The number of farms in the watershed decreased by approximately 25% from 1971 to 1991. This decrease was accompanied by changes in the size of watershed farms. The number of smaller farms (less than 600 acres) decreased by approximately 25%, from 1971 to 1991, while the number of farms larger than 600 acres increased by 62% across the watershed.
- Many farm lands are rented and there may be a diminished long-term stewardship commitment for farms where the owners may be non-resident or a conglomerate.
- Costs of implementing best management practices may be prohibitive or unwelcome to a farmer. Some best management practices benefit downstream residents, without producing a monetary benefit to the farmer.
- There is a lack of financial incentive to maintain farm woodlots and wetlands for their environmental value.

5.4.2 Cropping trends and issues

- The proportion of agricultural land used for crop production has increased compared to land used for other agricultural uses. Row crop production is associated with the potential for soil erosion, chemical runoff (pesticides and herbicides) and nutrient enrichment to watercourses. Excess nutrients can move from fields to watercourses, usually through surface runoff during rainstorms but some loss occurs through tile drains.
- The total area of corn production in the watershed decreased by 10% to 30%. Although fodder corn production decreased because of changes in livestock feeding regimes, grain corn production increased and continues to be an important cash crop in the watershed.
- The practice of monoculture declined dramatically and has been replaced by crop rotation. This trend reflects changing markets and the recognition of the importance of rotations in maintaining production and environmental quality. Forages and legumes (beans) are an important part of a rotation, lowering costs by fixing their own nitrogen. In many areas beans are planted on land formerly used for corn production.
- Crop variety has increased across the watershed. Beans, soybeans and coloured beans crops increased in the watershed. Spring wheat, rye, buckwheat, canola, sunflowers, triticale, coloured beans and millet were grown to varying extents in different areas of the watershed in 1991.
- Tobacco acreage decreased by 10% in watershed counties with a potential economic impact in some counties.

- Ginseng gardens became a visible part of the Brant and Haldimand-Norfolk Counties agricultural scene over the last ten years. OMAFRA figures (1996) show over 300 ginseng producers with an estimated 4,000 acres in production located mainly in the watershed. Production has been somewhat reduced during the past two years because of market uncertainties.

FIGURE 5-7: AREA OF CROPLAND ON CENSUS FARMS IN THE WATERSHED



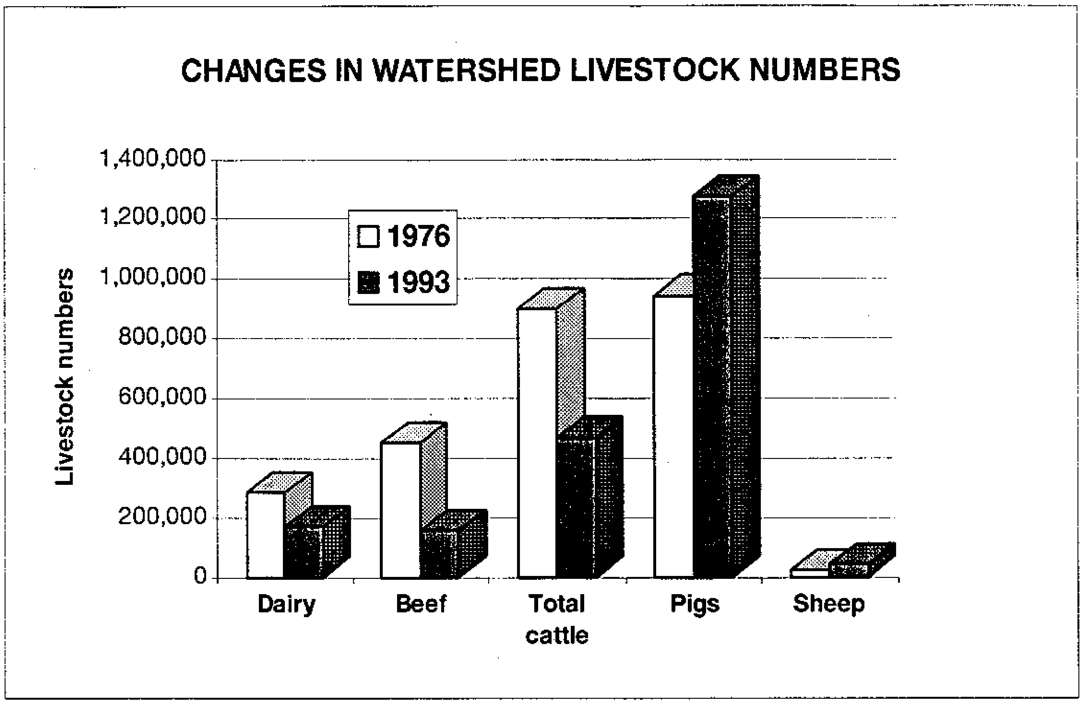
5.4.3 Livestock trends and issues

- Livestock producers are moving to larger concentrations of animals, and a change in manure handling systems from solid to liquid. Farm land acreage may be insufficient in some areas to utilize the complete waste output of farm livestock. Inadequate waste management increases the potential for bacterial contamination of water wells and municipal drains. Tile drains can carry contaminants from fields to waterways. *See Water Quality, pages 8-41 and 8-49.*

- Livestock production is concentrated in the middle and upper Grand area. In the upper Grand area, livestock density is greater than 2 animal units per acres (0.8 AU/ha). In the lower Grand area, the density ranges from 1 to 1.5 animal units per acre (0.41 - 0.60 AU/ha). The Environmental Farm Plan assigns a poor environmental rating to areas with more than 2 animal units per acre of crop land available for manure application.

- Livestock can break down stream banks, and introduce silt and bacteria into waterways. This results in degraded water quality for downstream users.

FIGURE 5-8: CHANGES IN WATERSHED LIVESTOCK NUMBER, 1976 - 1993



5.5 Agricultural management practices

Management practices such as conservation tillage and grassed waterways help to control erosion and chemical runoff. In the mid portion of the Grand River watershed, conservation tillage is practiced on more than 25% of the crop land. In the lower section, 15-20% of the crop land is under a conservation tillage system. Grassed waterways are used by 15-20% of the farmers in the middle and upper Grand River watershed to control soil erosion.

Waterways can be fenced to exclude cattle and, where necessary, crossing areas and watering devices can be installed to meet livestock needs.

Watershed programs to assist farmers and rural landowners in implementing best management practices include:

- The Environmental Farm Plan Program (EFP) sponsored by the Ontario Farm Environmental Coalition. Farmers completing a self-assessment workbook are eligible for up to $1,500 to help them make positive environmental changes on their land. The EFP program was started by farmers in 1993, through a coalition of Farm Associations with funding from the federal Green Plan. Funding was also recently received from CanAdapt to extend the program from 1997 to 2000.

- A Water Quality Management Program administered by the Regional Municipality of Waterloo and the Grand River Conservation Authority. The objectives of the program are to improve regional water quality by addressing sources of surface water degradation, primarily focusing on the Conestogo and Nith Rivers and Canagagigue Creek within the Region of Waterloo. Funding is provided to help farmers find practical solutions to contamination of local streams by farm runoff.

- The Wetland Habitat Fund provides advice and 50% of project costs to landowners to conserve their wetlands as wildlife habitat. The program is funded by Wildlife Habitat Canada and the Ontario Ministry of Natural Resources and delivered through the Easter Habitat Joint Venture.

6. WATER RESOURCES

6.1. Overview

Despite its seeming abundance, water is a finite resource in the Grand River Valley. It rains or snows. Water runs overland into the streams or soaks into the ground to be stored in underground reservoirs called aquifers. The stored water moves underground toward an outlet back to the streams or rivers. Heavy rains and snowmelt running into the streams cause the noticeable flow variations and floods that we typically see in the spring and fall. The water moving to the streams from underground storage is called base flow and represents the steadier but lower flows we see in the dry summer and winter months.

The natural flow regime of the Grand River is highly variable. In August 1936, the recorded flow at Cambridge (Galt) was 1.1 cubic metres per second (m^3/s), a little more than a trickle. Conversely, a flow of 1,642 m^3/s would have occurred at Cambridge(Galt) during April, 1975 resulting in major flooding in the community. Significant flood damage was avoided because reservoir operations reduced the flow by fifty per cent.

Five multi-purpose dams have been constructed: Shand (1942), Luther (1952), Conestogo (1958), Woolwich (1974), and Guelph (1976). These dams are operated to reduce peak flows, particularly during the spring freshet. During summer months, stored water is released to augment low summer flows.

6.2. The hydrologic cycle

The hydrologic (water) cycle is a continuous process. Water is transported from the oceans, to the atmosphere, to the land, and back to the oceans. The hydrologic cycle is global in nature but can also be viewed on a watershed scale.

At the watershed scale, water comes from the atmosphere in the form of rain or snow. Precipitation is captured by vegetation (interception) and evaporates back into the atmosphere. Precipitation that reaches the ground fills depressions (depression storage), soaks into the ground to replenish soil moisture and groundwater reservoirs (infiltration), or flows to a watercourse (surface runoff).

Water stored in land depressions evaporates or infiltrates into the ground. Large depression areas form wetlands or bogs with no surface water outlet. Small depression areas capture water temporarily in lawns or fields before evaporation or infiltration.

Water entering the ground takes several paths. Some may evaporate directly from the soil (evaporation). Water absorbed by vegetation through its roots is released to the atmosphere through its leaves (transpiration). Infiltrated water is held by the soil or moves through the soil to reach the aquifer (percolation). The water table represents the upper level of an aquifer. Water stored in an aquifer is transported underground, sometimes for considerable distances and over a period of time (for days, years, or hundreds of years), before it is discharged to a wetland or stream.

Water that is not temporarily stored in depressions or infiltrated, runs off the land to minor channels (gullies, swales, rivulets, and the like), eventually reaching the streams and rivers that define a watershed.

Streams are formed by the flows they receive. The range of flows that a stream receives during the course of a year determines its size and shape. The characteristics of the watershed contributing to the stream such as land cover, geology and drainage network determines how water reaches the stream.

The long term average annual precipitation across the Grand River Watershed ranges between 850 to 1000 (mm). The long term average potential evapotranspiration across the Grand River Watershed ranges from 550 to 600 (mm) per year. After evapotranspiration loss approximately 250 to 450 (mm) of water is available for recharge to the groundwater aquifer or runoff to streams and rivers. Typically this surplus water is available during the months of January, February, March, April and December. During the remaining months of the year more water is generally consumed by evapotranspiration and then falls. During the drier months baseflows in streams are supplied from water added by reservoirs, sewage treatment plants, wetlands and the groundwater aquifers throughout the watershed.

6.3. Factors which influence the flow of water

6.3.1. Geology and land form

The quantity of water trapped in depressions depends on the irregularity of ground surface. In hummocky terrain, such as that found in moraines and drumlin fields, large amounts of water are trapped in bogs and kettle depressions. Surface runoff to the streams is restricted and causes much of the precipitation to either infiltrate or evaporate. In gently rolling terrain, such as that found in the Dundalk and Stratford Till Plains, much less water is trapped in depressions and more water tends to runoff to the streams, especially where municipal drainage has been implemented.

The amount of water soaking into the ground depends on the surficial geology, whether the water can sit long enough to soak into the ground, whether the ground is frozen, and, how wet or dry the soil is. Infiltration is very high in sandy and sandy till soils such as those found in the Hillsburg and Norfolk Sand Plains, the Waterloo and Horseshoe Moraines, and the Guelph Drumlin Fields. Infiltration is low in areas such as the Dundalk and Stratford Till Plain and Haldimand Clay Plain. Areas with low infiltration tend to have a well developed surface drainage network whereas areas with high infiltration do not.

The slope of the land influences how fast water runs off. In flat areas, surface water may pond and move slowly off the land to the creeks and streams. In steep areas, water moves off the land quickly. If large volumes of surface runoff move too quickly to streams, flooding results.

6.3.2. Land cover

Land cover affects the path and the length of time water takes to enter a stream, lake, or wetland, or to infiltrate into the ground.

In areas of dense forest, the leaves intercept as much as half of the precipitation, allowing it to evaporate back to the atmosphere. Forest soils are more absorbent than agricultural soils because of higher organic matter content. Infiltration into the ground is increased because the ground surface is less regular and the soil is looser and more fractured. Where the canopy is dense, the snow that falls to the forest floor is sheltered from the sun resulting in slow snow melt and gradual runoff in the spring.

Wetlands are nature's reservoirs, storing water and allowing it to infiltrate, evaporate or be released slowly to local watercourses.

Where agricultural crops are grown, the ability of water to infiltrate is lessened, often resulting in large volumes of runoff. The drainage network is usually well-defined. The volume and rate of runoff from row crops is usually higher than from unimproved pasture and forage crops. No-till and conservation tillage practices leave vegetative stubble and waste vegetation on the fields, reducing potential for soil erosion and improving potential for infiltration.

6.3.3. The drainage network

The natural form of a stream channel is the result of factors such as the geology, vegetation and land cover of the area and climate. Streams convey water and also provide temporary storage of water and sediment.

A stream system consists of a stream channel and a floodplain. These components carry the flow extremes from low summer flow to major floods. The floodplain provides a relief zone where water can spill over during floods. This takes the pressure off the channel banks and assists in maintaining stability during these extreme flow conditions. Deep rooted vegetation along the stream corridor will contribute to the stability of the stream banks.

Stream channels also meander within their valleys. This sinuous alignment assists in dissipating the energy in the water flow, as well as transporting sediment as bedload along the stream system. This movement often results in a series of deeper pools connected by shallower riffle areas. With stream meandering, banks are worn away on the outward curve. On the inside curve, where the current is slower, sediment is dropped to create shallow areas and point bars.

Streams are dynamic in nature. Their form can slowly change over time depending on climate and changes in the way the land is used and the stream management. These changes can be caused by agricultural and urban development, drainage modification and management of protective vegetation (buffer) areas along the stream. Extreme floods can also cause rapid changes to the stream form.

FIGURE 6-1: THE WATER CYCLE

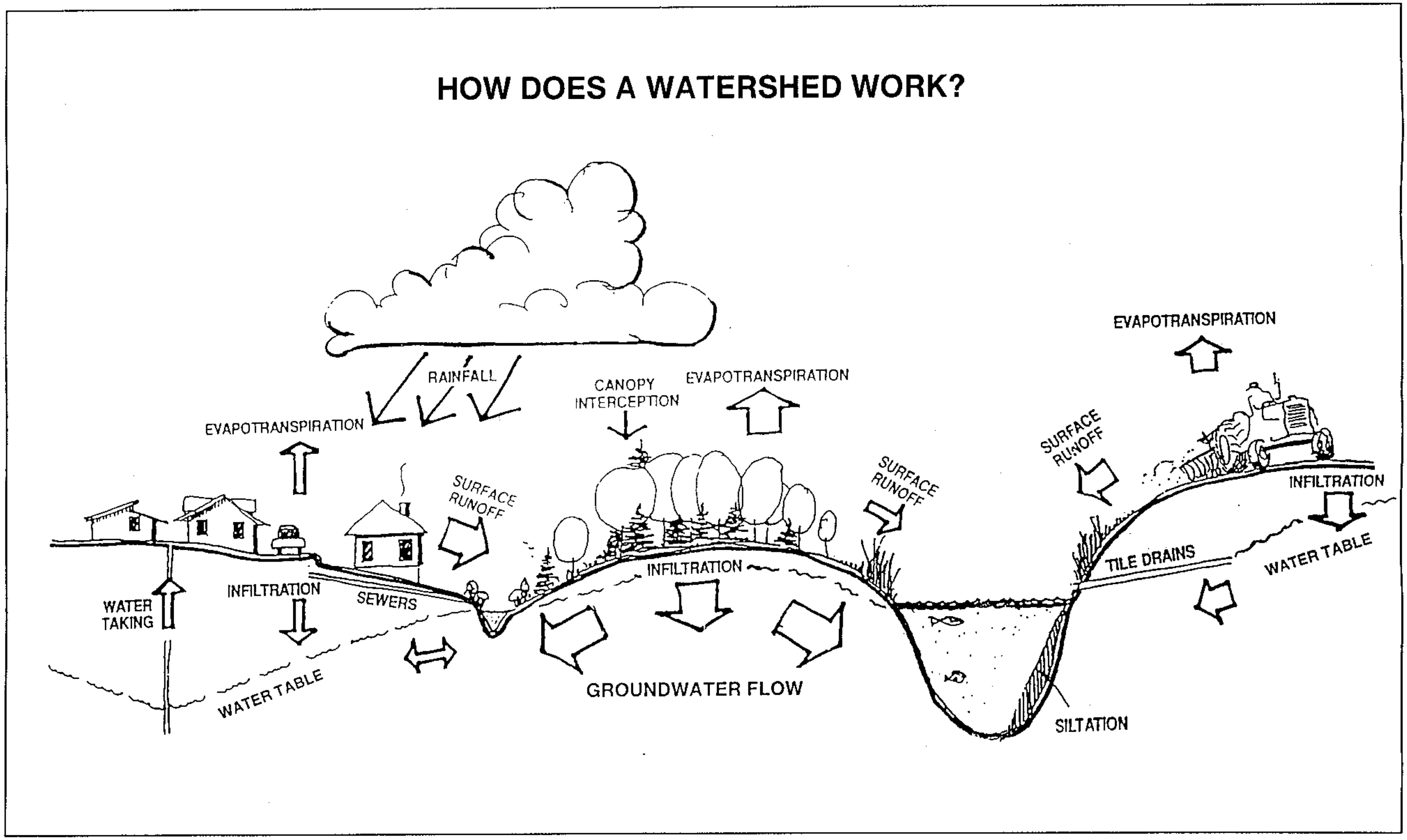


FIGURE 6-2: HOW HUMAN ACTIVITIES AFFECT THE WATER CYCLE

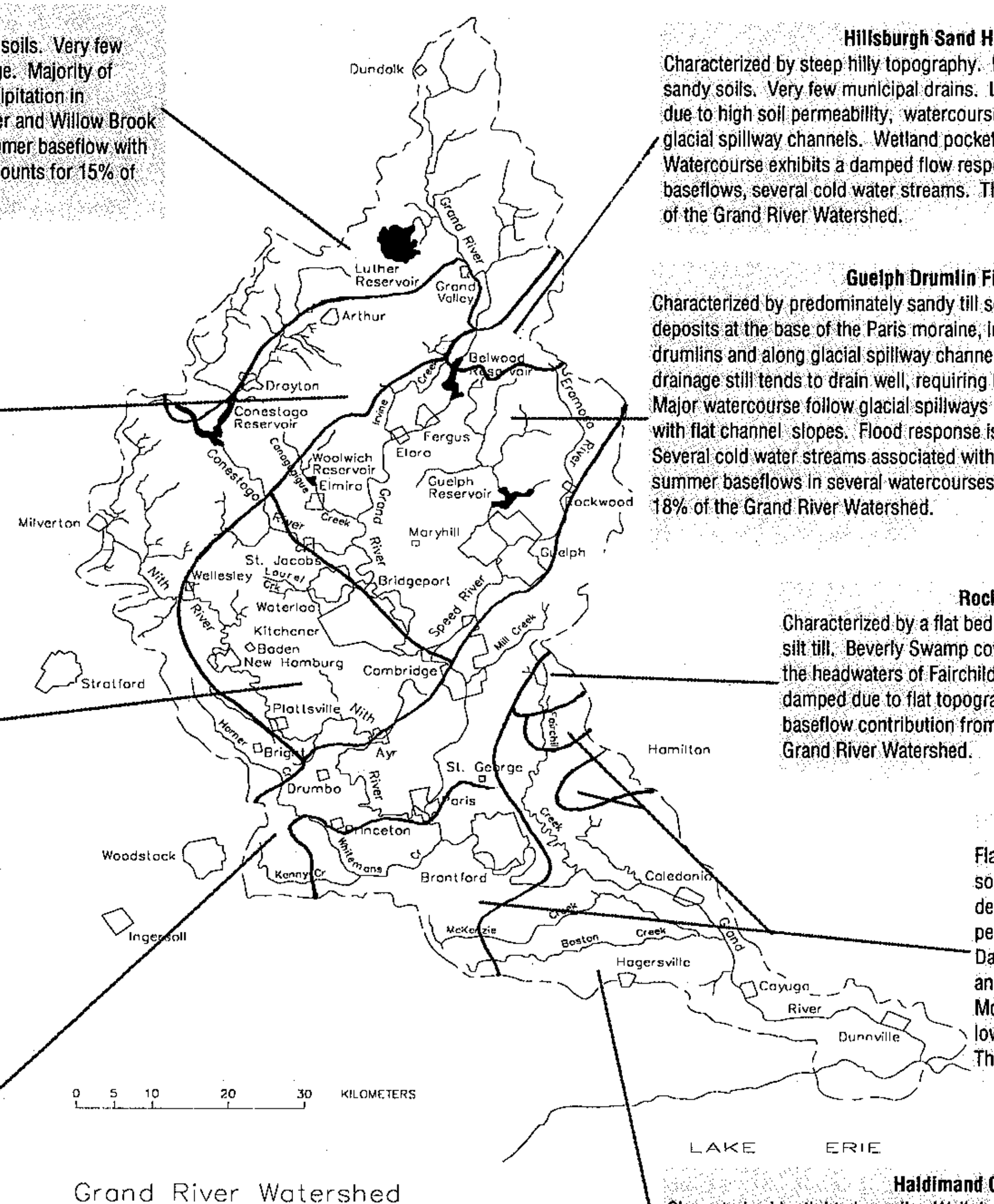
Hydrologic Cycle Component	Depends On	Affected By	Effects	Consequences
Interception Depression Storage (water stored on the surface)	• Vegetation density • Topography • Poor drainage	• Vegetation clearing • Filling depressions, wetlands • Drainage improvements • Tillage	• More frequent surface runoff. • More volume to surface runoff.	• More frequent streamflow fluctuations. Erosion. • More extreme streamflow fluctuations. Flooding.
Infiltration (water soaking into the ground)	• Coarse soils • Opportunity (i.e. depression storage)	• Pavement • Drainage improvements • Soil compaction	• More volume to surface runoff. • Less volume to groundwater.	• More extreme streamflow fluctuations. Flooding, streambank erosion. • Lower groundwater tables.
Transpiration (water given off by plants)	• Vegetation	• Vegetation clearing	• Less evapotranspiration. • Higher local air termperatures. • Lower humidity.	• Changes in local microclimate, effects on sensitive wildlife and people.
Percolation (water moving down through the ground to an aquifer)	• Coarse soils	• Groundwater interference allowing horizontal discharge movement. • Tile drainage • Extraction	• Redirected groundwater. • Changes in water regime. • Less water to deep groundwater. • Less groundwater stored.	• Changes to aquatic habitat and wetlands. • Reduced well capacity.
Groundwater Discharge to Streams	• Amount of groundwater. • Soil stratigraphy. • Topography	• Infiltration • Percolation	• Increase in groundwater to stream may increase quality.	• Higher quality, more diverse species.
Surface Runoff (water running the ground surface to a stream)	• Amount of water not trapped or infiltrated. • Topography • Fine soils Vegetation density	• Filling of depressions, wetlands • Pavement • Soil compaction Tree clearing • Improved drainage, municipal drains, storm sewers	• More frequent surface runoff. • More surface runoff volume, faster surface runoff. • Increased soil erosion.	• More sedimentation in channels. • More extreme streamflow fluctuations. Flooding, stream bank and bed erosion. • Changes in channel form. • Aquatic habitat disruption, reduced habitat diversity.
Channel Flow (water flowing in a stream)	• Channel density • Channel size and shape (depth, velocity) • Floodplain relief • Floodplain storage	• Municipal drains, channel works that deepen channels • Increase surface runoff causing stream bank and bed erosion. • Filling or construction in floodplain	• Channels are removed from their floodplains.	• Increased channel velocity, stream bank and stream bed erosion. • Increase flows and erosion downstream.

Dundalk Till Plain
Characterized by poorly drained sandy silt clay soils. Very few granular deposits. Extensive municipal drainage. Majority of original wetlands drained. Highest annual precipitation in watershed. Upper Conestogo River, Irvine River and Willow Brook exhibit a flash flood response. Little or no summer baseflow with the exceptional discharge from reservoirs. Accounts for 15% of the Grand River Watershed area.

Stratford Till Plain
Characterized by gently rolling topography. Primarily clay till soils. Extensive municipal and tile drainage. Very few wetlands or depressional areas. Higher than average precipitation. Headwaters of the Nith, Irvine and lower Conestogo River located at this plain. These watercourses exhibit a flash flood response. Little or no summer baseflow from till plain. This plain accounts for 18% of Grand River watershed.

Waterloo Moraine
Characterized by sandy till and granular soils. Municipal drainage common on tighter till soils, less extensive than on till plains to the north. Several depressional areas with no outlet. Several isolated wetlands often associated with depressional areas. Flood response tends to be damped except where extensive municipal drainage exists. Several cold water streams. This area contributes to baseflow in major river and streams during the summer low flow periods. Accounts for 11% of Grand River watershed.

Paris Moraine
Characterized by sandy tills and granular deposits. Extremely hummocky topography with extensive closed depressional areas. Wetlands associated with depressional areas. Limited municipal drainage, often no feasible outlet. Damped flood response due to extensive depressional areas and pervious soils. Supports several cold water streams. Contributes large volumes of baseflow to the Eramosa, lower Speed, middle Grand and lower Nith Rivers. This area accounts for 12% of the Grand River Watershed.



Hillsburgh Sand Hills
Characterized by steep hilly topography. Primarily well drained sandy soils. Very few municipal drains. Limited drainage network due to high soil permeability, watercourse generally follows broad glacial spillway channels. Wetland pockets in valley floors. Watercourse exhibits a damped flow response. Good summer baseflows, several cold water streams. This area accounts for 2% of the Grand River Watershed.

Guelph Drumlin Field
Characterized by predominately sandy till soils, many granular deposits at the base of the Paris moraine, in the valleys between drumlins and along glacial spillway channels. Some municipal drainage still tends to drain well, requiring less agricultural drainage. Major watercourse follow glacial spillways having broad floodplains with flat channel slopes. Flood response is generally damped. Several cold water streams associated with granular deposits. Strong summer baseflows in several watercourses. This area accounts for 18% of the Grand River Watershed.

Rockton Bedrock Plain
Characterized by a flat bedrock plain overlaid by thin layer of sandy silt till. Beverly Swamp covers a large portion of this plain. Forms the headwaters of Fairchild Creek. Response from this area is damped due to flat topography and swamp storage. Little or no baseflow contribution from this area. Accounts for 1% of the Grand River Watershed.

Norfolk Sand Plain
Flat plain composed of mainly sandy to sandy silt soils, depth of sands range up to 23 metres in depth. Sparse drainage network due to highly permeable soils. Minimal municipal drainage. Damped flood response due to permeable soils and flat topography. Forms headwaters of McKenzie Creek. Provides significant baseflow to lower Whiteman's and upper McKenzie Creek. This area accounts for 8% of the watershed.

Haldimand Clay Plain
Characterized by tight clay soils. Well developed drainage network due to low soil permeability. Several municipal drains. Few wetland areas due to well developed drainage network. Flash flood response due to tight soils, limited depressional storage and well developed drainage network. Little or no baseflow during summer low flow period. This area accounts for 16% of the watershed.

FIGURE 6-3:
SURFACE WATER CHARACTERISTICS OF THE GRAND RIVER WATERSHED

6.4. Groundwater characteristics

The shape and composition of the land controls to a great degree the groundwater flow system. Receding glaciers left behind drifts of clay, sand, gravel and boulders in varying depths over much of the watershed. Unsorted glacial deposits of clay, sand, gravel and boulders are known as glacial till. The quality and quantity of groundwater available to us is determined by the characteristics of this surface deposit (overburden), the shape of the land, and the composition and porosity of the underlying bedrock. A general description of groundwater characteristics by physiographic region is given in Figure 6-4, page 6-9.

The surface geology of the Grand River watershed can be grouped into three categories: till plains; clay plains; and outwash deposits, which are areas of sands and gravel sorted and left behind by glacial meltwaters. The bedrock of the Grand River watershed is composed of three main limestone formations, the Salina, the Guelph and the Amabel-Lockport.

Areas with low surface permeability

A large part of the watershed is covered by an overburden with low permeability. This includes the silt and clay tills found in the Stratford and Dundalk till plains and, to a lesser degree, some parts of the central moraine region. In these areas, precipitation seeps slowly downwards through the soil to the bedrock. Where the bedrock is fractured, water will move into and flow through the bedrock. Although the amount of water flowing into the bedrock from the surface is low, the cumulative effect of seepage from the vast till plains produces large areas of groundwater. These groundwater accumulations (aquifers) are an important source of municipal water supply. In the clay or till areas, water wells not only draw water from the bedrock but may also draw water from sand and gravel pockets lying within the till.

Water flowing beneath the ground emerges at the surface in some valley areas through sand and gravel deposits under, or adjacent to streams. Where the water table is high, and the overburden is thin and broken, (e.g., Haldimand Clay Plain and the boundary of the Rockton Bedrock Plain), water lies at the surface in low swampy areas.

Areas with high surface permeability

Surface water moves easily from the surface into the glacially deposited sands and gravels found in the Waterloo Moraine, Hillsburgh Sand Hills, Guelph Drumlin Field and the Norfolk Sand Plain. This movement can replenish both bedrock and overburden aquifers, and allow a steady flow to discharge into local streams to provide large quantities of base flow in the dryer months.

Aquifers in these areas can lie at several different levels in the overburden. Flow in these aquifers is controlled by the shape of the land, and localized layers of impermeable rock or clay which influence groundwater movement. Areas of permeability or "windows' in these constraining layers allow groundwater to move to the surface in some low lying areas or stream valleys, or recharge deeper aquifers.

Groundwater movement

The topography, or shape, of the bedrock also influences the way groundwater moves through the overburden and the bedrock. The flow is generally from north to south along the axis of the Grand River basin, but it may be influenced by local bedrock conditions. This is evident in the groundwater flow directions near the Speed and Eramosa Rivers, the Conestogo River near Conestogo Lake, and the Grand River from Belwood Lake through Elora, Fergus, and in the Cambridge area.

In some areas the bedrock topography directs the flow right out of the Grand River basin. These include the northerly part of the Dundalk Till Plain, northwest of Arthur, the northern part of the Hillsburgh Sand Plains, and the Norfolk Sand Plain in the vicinity of Dundas valley.

Groundwater quality and quantity

Groundwater quality and quantity is generally high in aquifers in the thicker overburden and upper bedrock. Groundwater throughout the Grand River watershed is generally hard because it contains minerals dissolved into water moving through the limestone bedrock.

Water drawn from the Salina formation in the western and southern parts of the Grand River watershed generally contains high levels of sulphates and chlorides. These dissolved solids come from minerals contained in the bedrock and exceed the permissible levels for drinking water. In these areas water may have a sulphurous smell, and residents often rely on wells in the overburden to avoid the sulphurous bedrock water.

Lower, moderate levels of dissolved solids are present in water drawn from the Guelph and Amabel-Lockport bedrock formation. This formation provides some of the highest quality drinking water found on the north eastern parts of the Grand River watershed.

Major water taking or interference or changes in the surface permeability can influence the movement of groundwater and reduce the amount available for wells or for year-round flow to streams. Groundwater aquifers can become contaminated where industrial or septic system wastes, or agricultural fertilizers can move easily into the ground.

Stratford Till Plain

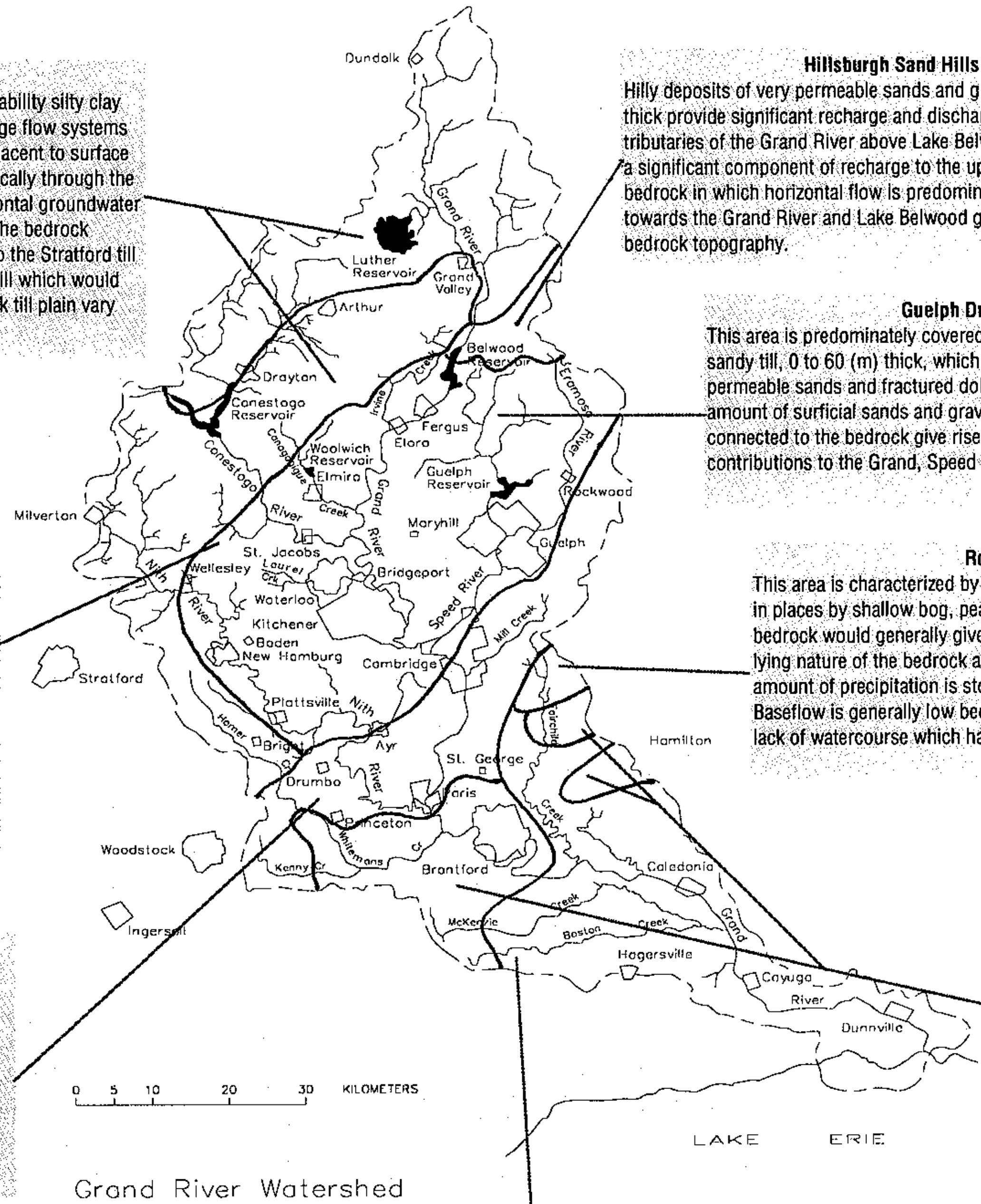
The Stratford till plain is dominated by low permeability silty clay tills, 30-60 (m) thick. Local recharge and discharge flow systems occur where sands and gravels underlie or are adjacent to surface water bodies. Groundwater generally moves vertically through the tills to the upper fractured dolostone where horizontal groundwater flow is the main component and is controlled by the bedrock topography. The Dundalk till plain is analogous to the Stratford till plain except the till is more permeable sandy silt till which would permit slightly more recharge. Tills in the Dundalk till plain vary from 0 to 30 (m) in depth.

Waterloo Moraine

This area consists of the thickest overburden deposits in the watershed up to 120 (m) thick. The Moraine is capped by permeable sands and gravels and is underlain by various layers of lower permeability tills and high permeability sands and gravels. This setting gives rise to high rates of recharge in the upper, permeable sands and gravels and a significant horizontal component of groundwater flow which provides substantial baseflows to Laurel Creek, the Nith River and its tributaries. A component of the recharge water moves to lower aquifers through gaps or windows in the buried till units. Flow in the lower aquifers is more regional and is not controlled by the surface water features. The groundwater flows are generally to the south, in the same direction of flow as the groundwater in the upper dolostone of the Salina and Guelph Amabel formations.

Paris Moraine

This area is generally characterized by low to moderate permeability, very hummocky, sandy silt tills from Rockton to south of Paris and a lower permeability till plain to the southwest. These units provide limited recharge to the upper dolostone bedrock aquifer. A majority of the northern flank, adjacent to the moraine, is comprised of highly permeable sands and gravels. These units provide significant baseflows to the Eramosa, Speed, Grand and lower Nith Rivers and tributaries.



Hillsburgh Sand Hills

Hilly deposits of very permeable sands and gravels up to 55 (m) thick provide significant recharge and discharge to the eastern tributaries of the Grand River above Lake Belwood. There is likely a significant component of recharge to the upper dolostone bedrock in which horizontal flow is predominant and directed towards the Grand River and Lake Belwood generally following the bedrock topography.

Guelph Drumlin Field

This area is predominately covered by low to moderate permeability sandy till, 0 to 60 (m) thick, which generally recharges underlying permeable sands and fractured dolostone bedrock. A significant amount of surficial sands and gravels adjacent to watercourse and/or connected to the bedrock give rise to significant baseflow contributions to the Grand, Speed and Eramosa Rivers and tributaries.

Rockton Bedrock Plain

This area is characterized by flat lying, fractured dolostone bedrock, overlain in places by shallow bog, peat or sandy till deposits. The exposed fractured bedrock would generally give rise to high recharge but because of the flat lying nature of the bedrock and generally high water table, a substantial amount of precipitation is stored within the low lying areas and swamps. Baseflow is generally low because of the flat bedrock topography and the lack of watercourse which have cut into the rock below the watertable.

Norfolk Sand Plain

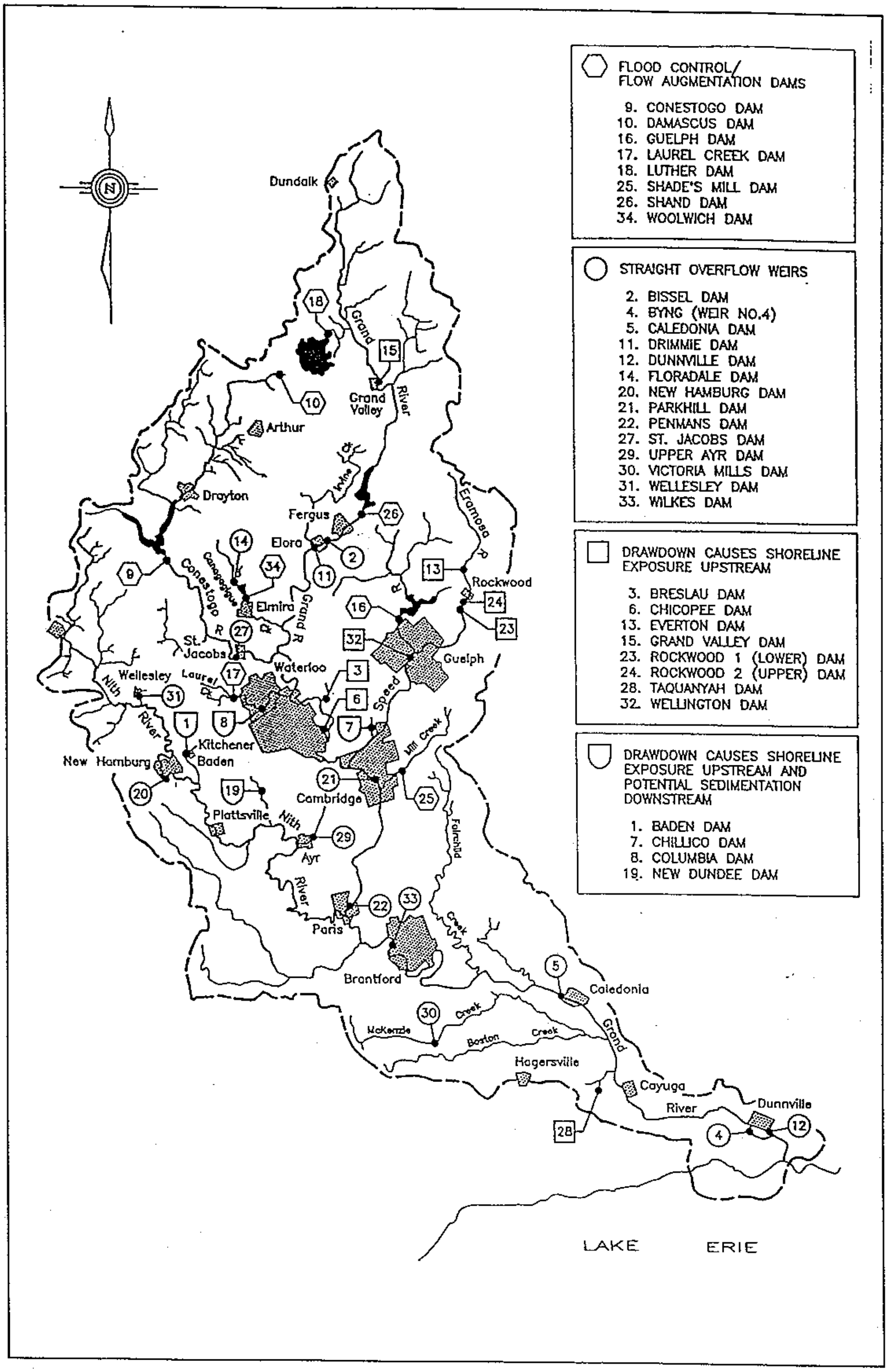
This area consists of highly permeable sands, generally in the order of 10 (m) thick, with thinner deposits to the north and east and thicker deposits to the southwest. The sand plain provides significant baseflows to upper McKenzie, lower Whiteman's and Horner Creeks. The sand plains act as a significant unconfined aquifer which provides little recharge through the underlying clays and silt clay till to the Salina dolostone in the southwest. In the Northeast, the sands are generally in contact with the bedrock. The sand and upper bedrock in this area would tend to act as one shallow unconfined aquifer.

Haldimand Clay Plain

This area is covered almost entirely by low permeability clay and silt clay deposits. The deposits are generally thicker to the extreme west, but are commonly in the order of 10 (m) thick. In areas such as the northeast where the clay deposits are less than 3-5 (m) thick, the fractured nature of the clay can provide hydraulic connection to the underlying unit which usually bedrock and as such can deliver significant recharge. The clay will not contribute significantly to baseflows in streams. Discharge to surface watercourse generally occurs where bedrock is near ground surface (e.g. less than 5 (m) thick)

FIGURE 6-4: GROUNDWATER CHARACTERISTICS OF THE GRAND RIVER WATERSHED

FIGURE 6-5: WATER CONTROL STRUCTURES IN THE GRAND RIVER WATERSHED



6.5. Reservoirs

There are thirty-four water control structures operated by the Grand River Conservation Authority throughout the watershed. These structures range from simple overflow weirs to large multi-purpose dams and reservoirs. Figure 6-5, page 6-10, shows the location of control structures throughout the watershed. Small mill ponds and overflow weirs are remnants of the valley's early industrial heritage. These structures are often a community focal point and recreational area. While they back up water and deepen the river channel locally, they do not provide flood control or improve river flow.

Eight water control structures perform dual or multi-purpose functions. Figure 6-6 lists the major water control structures in the Grand River watershed and the primary functions for which they were designed.

Luther, Shand, Conestogo, and Guelph provide flow augmentation and flood control for the main Grand River. The others influence the local tributary on which they are situated.

FIGURE 6-6: MULTI-PURPOSE DAMS AND RESERVOIRS

Reservoir Name	Primary Reservoir Function	Year Built	Dam Height (metres)	Storage Capacity (cubic metres)
Shand Dam	Flood Control, Flow Augmentation	1942	22.5	63,874,000
Conestogo Dam	Flood Control, Flow Augmentation	1958	23.1	59,457,000
Guelph Dam	Flood Control, Flow Augmentation, Recreation	1976	14.3	22,387,000
Luther Dam	Flood Control, Flow Augmentation, Wildlife Management	1952	5.0	28,075,000
Woolwich Dam	Flood Control, Flow Augmentation	1974	11.7	5,491,000
Shade's Mill	Flood Control, Induced Infiltration, Recreation	1973	9.8	3,240,000
Laurel Creek	Flood Control, Recreation	1968	5.6	2,450,000
Damascus Dam	Flood Control, Flow Augmentation	1978	6.8	1,540,000

6.5.1.1. Luther Dam

Luther Dam provides low flow augmentation and some flood control to the Upper Grand River above Lake Belwood. When operated in combination with the Shand Dam, Luther Dam also provides low flow augmentation on the main Grand River downstream of Shand Dam. Luther Dam is operated to maintain a minimum summer flow of 0.4 m^3/s through Grand Valley to improve the river's capacity to receive wastewater from the Grand Valley Water Pollution Control Plant.

6.5.1.2. Shand and Conestogo Dams

Shand Dam, in combination with Conestogo Dam, provides flood control and flow augmentation for communities downstream of the confluence of the Grand and Conestogo Rivers. Major flood damage centres downstream of this confluence include Kitchener (Bridgeport), Cambridge (Galt), Paris, Brantford, Caledonia, Cayuga, and Dunnville.

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These dams are operated to maintain minimum summer flows at Kitchener (Doon) of 9.9 m^3/s and Brantford of 17 m^3/s. These minimum flows are critical to ensure adequate water supply and dilution of wastewater effluent along the main Grand River. Shand Dam also provides flood control and low flow augmentation to West Montrose, and to Elora and Fergus where a thriving tailwater trout fishery has developed. Conestogo Dam provides flood control and flow augmentation to St. Jacobs and Hawkesville on the lower Conestogo River.

Dam operations present a challenge. Flood storage requirements are critical during periods of high precipitation and runoff. Yet there is a need to ensure adequate water storage in late spring to augment low summer flows. During May to July, flood control storage in the two largest reservoirs is limited. During this period, dam operations is monitored closely. While all reservoirs provide some recreational opportunities, not all are operated to accommodate recreation as a primary function (e.g., Belwood Lake, Conestogo Lake).

6.5.1.3. Guelph Dam

Guelph Dam provides flood control and flow augmentation to Guelph and Cambridge (Hespeler and Preston) on the Speed River. This dam is operated to maintain a minimum summer low flow in Guelph of 1.7 m^3/s, which increases the capacity of the Speed River to receive the City of Guelph treated wastewater discharge and enhances water quality in the Speed River. Guelph Lake, formed behind the dam, provides recreational opportunities.

6.5.1.4. Woolwich Dam

The Woolwich Dam, on Canagagigue Creek, is located upstream of Elmira. A minimum summer low flow of 0.3 m^3/s is maintained during the operating season to increase the capacity of Canagagigue Creek to receive Elmira's treated wastewater. This dam also helps reduce flooding along the Canagagigue Creek downstream of the through the village of Elmira.

6.5.1.5. Shade's Mills Dam

The Shade's Mills Dam works in tandem with the channel works downstream to provide flood control for Mill Creek as it passes through Cambridge (Galt). The Shade's Mills reservoir serves a water supply function by recharging water to municipal wells located nearby.

6.5.1.6. Laurel Creek Dam

The Laurel Creek Dam provides flood control for Laurel Creek through Waterloo as well as recreational opportunities.

6.5.1.7. Damascus Dam

Damascus Dam, located on the Conestogo River above Arthur, provides flood control and flow augmentation to the upper reaches of the Conestogo River. Damascus Reservoir also provides some limited recreational opportunities.

6.5.2. Operating rules for multipurpose reservoirs

The operation of multipurpose reservoirs follow a yearly filling and drawdown cycle. This cycle is guided by a "rule curve". A rule curve is an operating procedure developed for each dam to deal with competing needs for downstream flood control and low flow augmentation. This curve reflects physical operating constraints related to the dam structure, location and seasonal weather factors.

FIGURE 6-7: OPERATING RULE CURVES

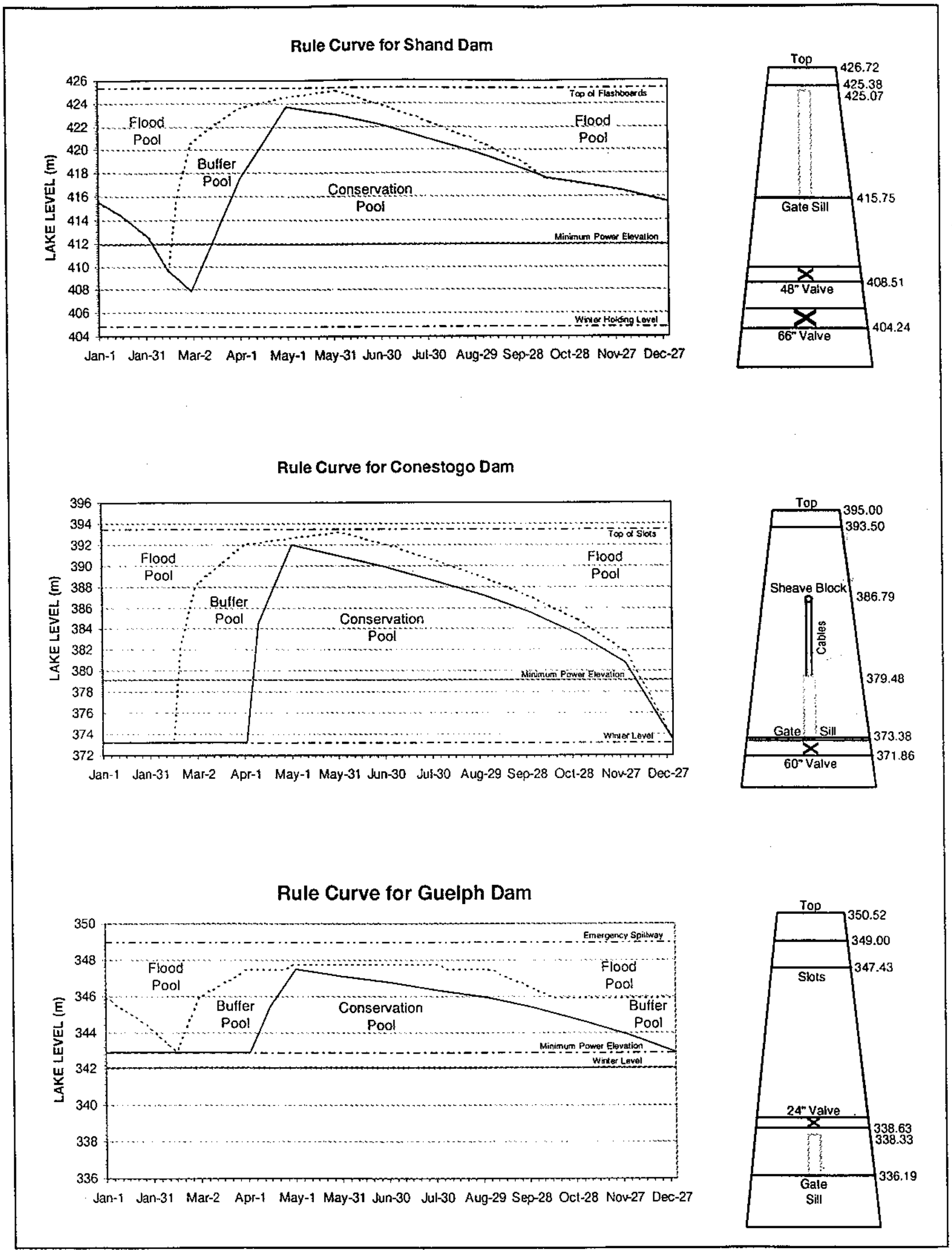
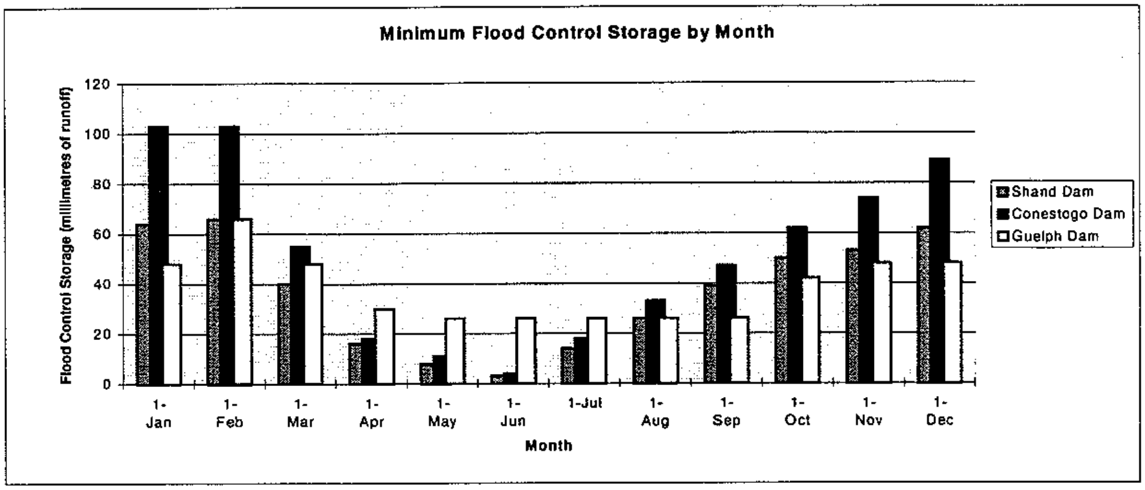


Figure 6-7, page 6-13, illustrates how the operating range of the three largest dams varies throughout the year. Normally, reservoirs levels are drawn down or held constant throughout the January and early February. During late February to early June, reservoirs are filled to their summer operating level. Between June and December, water is released slowly to provide flow augmentation.

FIGURE 6-8: MINIMUM FLOOD CONTROL STORAGE BY MONTH



6.5.2.1. Reservoir storage components

The different storage components of a reservoir are referred to as pools. There are three storage pools associated with large multi-purpose reservoirs: 1) Flood Pool, 2) Buffer Pool, and 3) Conservation Pool.

1. The Flood Pool is the storage available to provide flood control. This pool varies throughout the year. It is largest in the early spring and late fall when the reservoirs are drawn down.
2. The Buffer Pool is the storage available between the Flood Pool and Conservation Pool levels. It represents the degree of flexibility available for dam operations such as filling the reservoir if snow pack melts early or storing water in excess of the minimum required for flow augmentation.
3. The Conservation Pool is the storage available to provide summer flow augmentation. This pool represents the minimum storage reserved at a given time of the year to meet future downstream flow augmentation targets. Runoff from spring snowmelt and rainfall is used to fill the Conservation Pool.

It is important to note that during dry years there may be just enough water from spring snowmelt and rains to fill the conservation pool in the three major reservoirs. Therefore when early winter melts occur a portion of the runoff from the melts has to be held in the reservoir to ensure filling of the conservation pool can be achieve. During the months of April and May the reservoirs are monitored closely and adjusted as required to meet operating targets which are guided by the rule curve.

6.5.3. *Physical operating constraints*

The design of dams, particularly the Shand and Conestogo Dams, can constrain operations at specific times of the year. These physical operating constraints affect the ability to modify operations to meet changing needs and multiple uses.

6.5.3.1. Shand and Conestogo Dams

Summer operation

All of the water stored at Shand and Conestogo Dams is in heavy demand to meet water supply and water quality needs downstream. Only during unusually wet periods is there excess storage. In most years, the lakes are drawn down steadily to meet downstream flow augmentation requirements.

Shand and Conestogo Dams were not designed with designated flood storage separate from conservation storage, as was the case for the Guelph Dam. The same space that is reserved for flood control in the spring and fall is used to store water in the late spring and early summer for flow augmentation. As a result, the lakes at Shand and Conestogo Dam are drawn down throughout the summer to create flood control space for the fall tropical storm season, whether the storage is needed to augment flows or not.

Summer recreation

Belwood and Conestogo Lakes are used extensively for recreation. Cottages lots have leased around these lakes since their construction decades ago. The reservoirs are used for motor boating, skiing, swimming and fishing. Although it would be beneficial to hold the lake levels steady for these recreational activities, the dams are not designed to accommodate steady recreational lake levels, as described above. Periodically, lake levels are lowered below acceptable levels for recreation to ensure that downstream water quality, water supply, and flood control needs are met.

Winter operation

Shand Dam is illustrated conceptually in Figure 6-7, page 6-13. Note that the gate sills are 7 metres above the 48" low flow valve. During the winter, reservoir levels are lowered below the gate sill to avoid freezing in the gates. The storage between the gate sills and the valve is used for winter flow augmentation. Note that the 48" low flow valve is several metres above the lake bottom. This higher winter holding level benefits fisheries.

Conestogo Dam provides less operating flexibility than the Shand Dam. In contrast, the gate sills are situated immediately above the low flow valve. Water levels are kept above the gate over the winter period on alternate years. Every second year, water levels are lowered to the gate sill for gate maintenance. Higher winter holding levels allow for winter flow augmentation only in alternate years.

Hydro turbine

The Hydro turbine also affects low flow operations at Conestogo Dam. The turbine is housed in the single valve. During summer months there may be insufficient flow through the turbine to augment downstream flows and the additional flow must be provided through a gate.

During winter operation, the Hydro turbine shuts down once the water in the reservoir reaches the elevation of the gate sill. Once the turbine shuts down, a gate is opened to discharge low flows. This results in icing of the gate sill. Options must be examined in the future to allow more operating flexibility during low flow periods.

6.5.3.2. *Luther Dam*

The Luther Dam stores water from a limited upstream drainage area. The reservoir and associated marshlands makeup one third of this drainage area. If the reservoir was drained, it would take approximately two years to refill it to a normal spring operating level. Draining and rejuvenating the marsh, as recently proposed, would result in a decreased ability to augment flows on the Grand River downstream.

The construction of a valve at Luther Dam in 1990 has permitted more precise low flow discharges. The rule curve for Luther Dam was reviewed recently as part of the Luther Marsh Management Plan. This plan acknowledges the importance of the area for wildlife and recommends that dam operations be modified to accommodate habitat considerations.

6.6. Effect of the dams on river flows

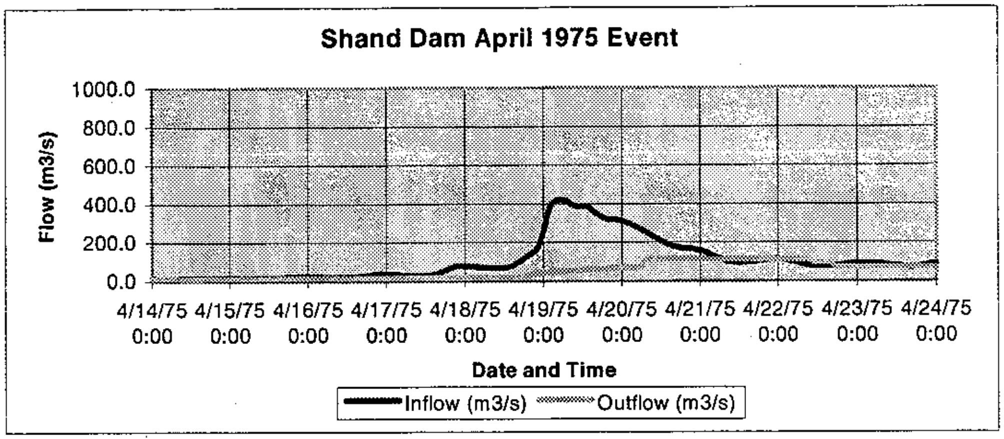
The variation in flood and drought flows is moderated by the multi-purpose reservoirs. The reservoirs are operated as a system to reduced peak flows during floods and augment flows during periods of summer low flows.

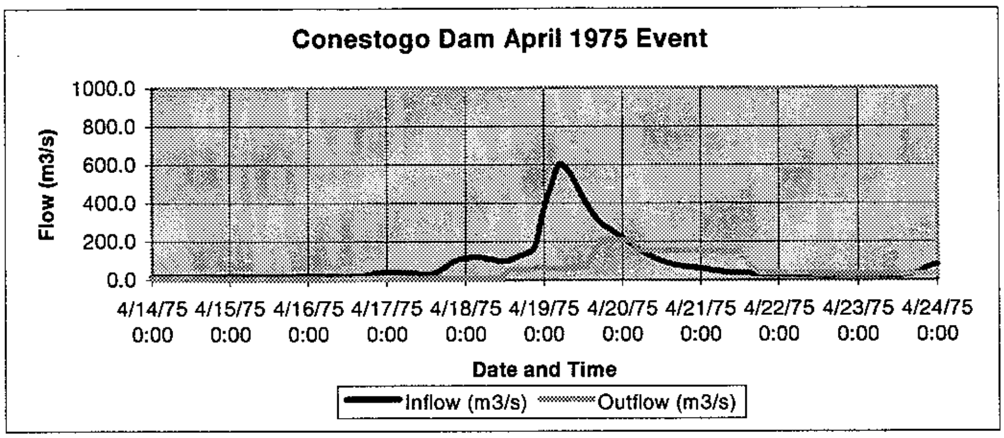
6.6.1. *Flood control*

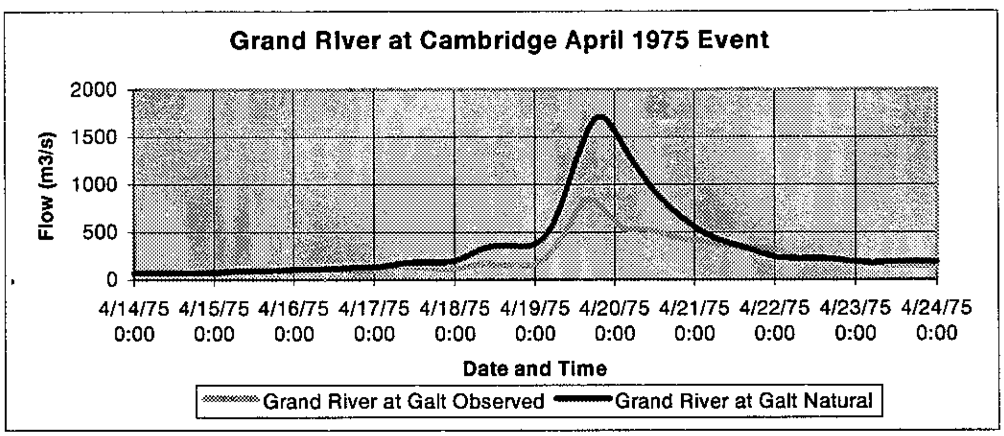
Regulation of flood flows on the main Grand River are influenced primarily by the Shand and Conestogo dams, and to a lesser extent by the Guelph Dam. The other reservoirs provide flood control primarily to the local tributary on which they are situated. The three large reservoirs are multi-purpose reservoirs, providing both flood control and flow augmentation. These competing needs reduce the amount of storage available for flood control during May, June and July.

During the winter, reservoir levels are drawn down to make room for the spring melt. Their effectiveness is diminished if major storms occur following the spring melt when the reservoirs have been filled, or if multiple spring storms occur back to back, leaving little opportunity to replenish flood control between storms. Flood control capability is regained in the late summer and fall as the reservoirs are drawn down. Figure 6-9, page 6-17, illustrates the April 1975, snowmelt/rainfall event. Reservoir regulation was used to reduce flooding in areas downstream of the reservoirs. In Cambridge (Galt) the flood peak was reduced by 50% and major flooding was avoided. Without regulation provided by upstream reservoirs, the peak flow from the 1975 event would have exceeded the 1974 peak flow and widespread flooding would have occurred.

FIGURE 6-9: EFFECT OF DAMS ON APRIL 1975 FLOOD EVENT







6.6.2. Low flow augmentation

The current minimum flow targets for the Grand River, Speed River and the three multipurpose reservoirs were established as part of the 1982 Grand River Basin Water Management Study. The recommended targets from the basin study were implemented in 1983. Figure 6-10 summarizes the current minimum flow targets.

FIGURE 6-10: RELIABILITY OF MEETING MINIMUM FLOW TARGETS AT DOON AND BRANTFORD

	Grand River Minimum Summer (May 1 to Oct 31) Targets at:		Grand River Minimum Fall (Nov 1 to Dec 31) Targets at:		Grand River Minimum Winter (Jan 1 to Apr 30) Targets at:	
	Doon (m^3/s)	Brantford (m^3/s)	Doon (m^3/s)	Brantford (m^3/s)	Doon[4] (m^3/s)	Brantford (m^3/s)
Minimum Flow Target[1]	9.9	17.0	7.1		2.8%	
Reliability (occurrence)[2]	82.4%	88.2%	88.2%		100%	
Reliability (time)[3]	98.9%	99.6%	94.5%		100%	
Actual Minimum Weekly Flow	8.5	144.8	5.5	10.1	3.9	7.2
Actual Minimum Daily Flow	8.3 (Oct)	14.4(Oct)	5.1	9.5	3.8	6.6

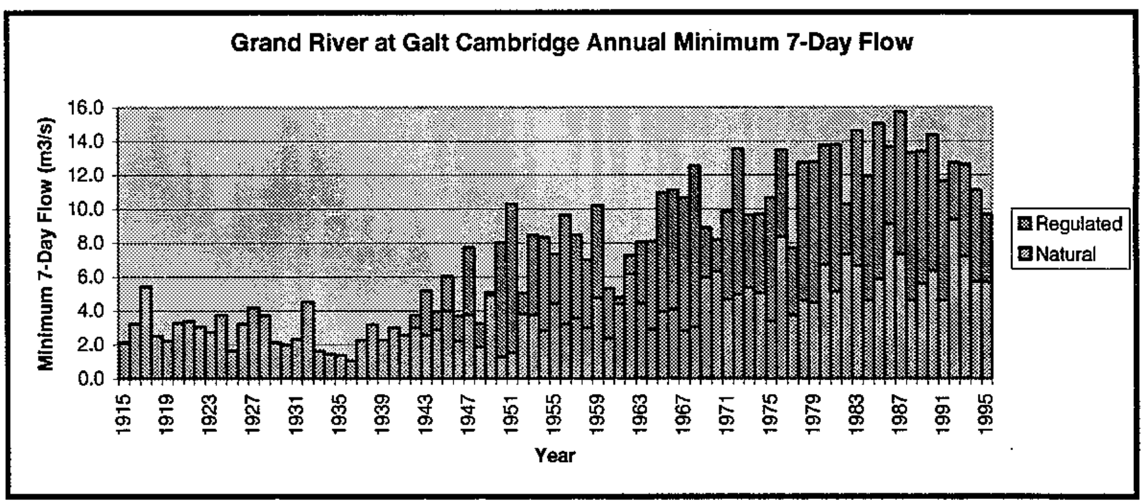
1) Because of the 30 hour travel time from the reservoirs to Doon, the daily flows can vary approximately +/- 0.9 m3/s from the target/ The travel time from the reservoirs to Brantford is 48 hours. The daily flows can vary +/- 1.4 m3/s from the target.

2) Reliability (occurrence) refers to the percentage of days target was met in 17 years of flow records.

3) Reliability (time) refers to the percentage of days target was met within operating period for 17 years of flow records.

4) During November to December, flows can be measured at Doon and Brantford, but, due to ice conditions during January to April, flows can not be accurately measured at these stations. Therefore, from January to April, equivalent target flows are set at Shand Dam where winter flows can be estimated.

FIGURE 6-11: MINIMUM 7-DAY FLOW, GRAND RIVER AT GALT, CAMBRIDGE



The difference in summer flows under existing reservoir operations and under natural conditions at Kitchener (Doon) and Brantford on the Grand River and at Guelph on the Speed River is shown in Figure 6-12, page 6-20. This figure illustrates the strong influence on summer low flows. The river would virtually dry up at some locations if it were not for augmentation provided by the reservoirs.

The portion of summer low flows provided by the reservoirs a specific locations along the river is illustrated by Figure 6-13, page 6-21. This is the average augmentation over the summer low flow season July to August . Percentage augmentation during dry weeks is much higher and can reach 85% throughout the City of Kitchener.

The Region Municipality of Waterloo's recently updated Master Water Supply Strategy (1994) confirmed the reliability of the Grand River to support a withdrawal up to 16 million imperial gallons per day (MIGD) without affecting water quality in the Grand River. This withdrawal along with groundwater supplies would satisfy the Region's water supply needs to 2025. Currently Waterloo Region withdraws 4 MIGD.

FIGURE 6-12: FREQUENCY OF SUMMER FLOWS AT DOON, GUELPH AND BRANTFORD (MINIMUM 7-DAY MEAN FLOW)

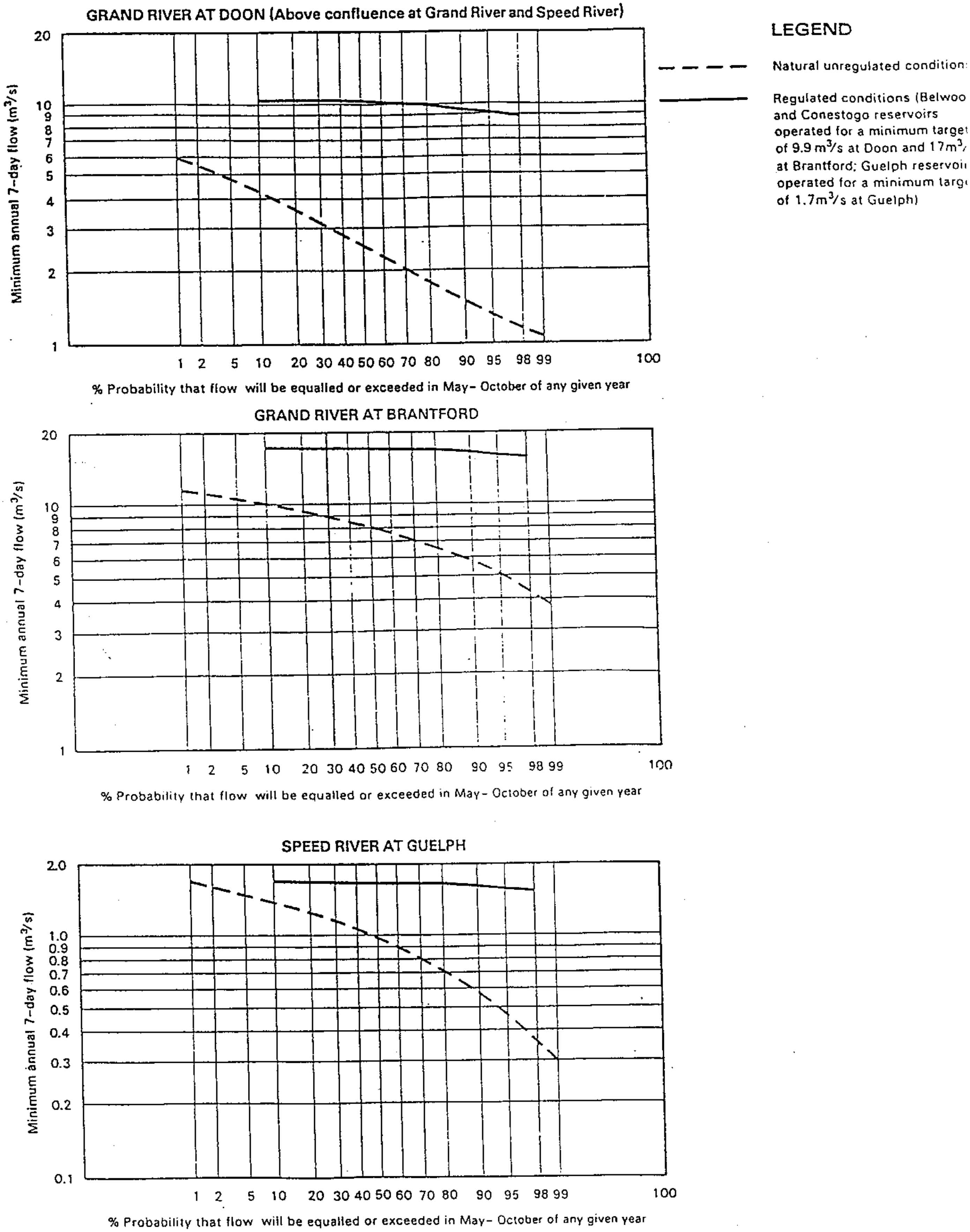
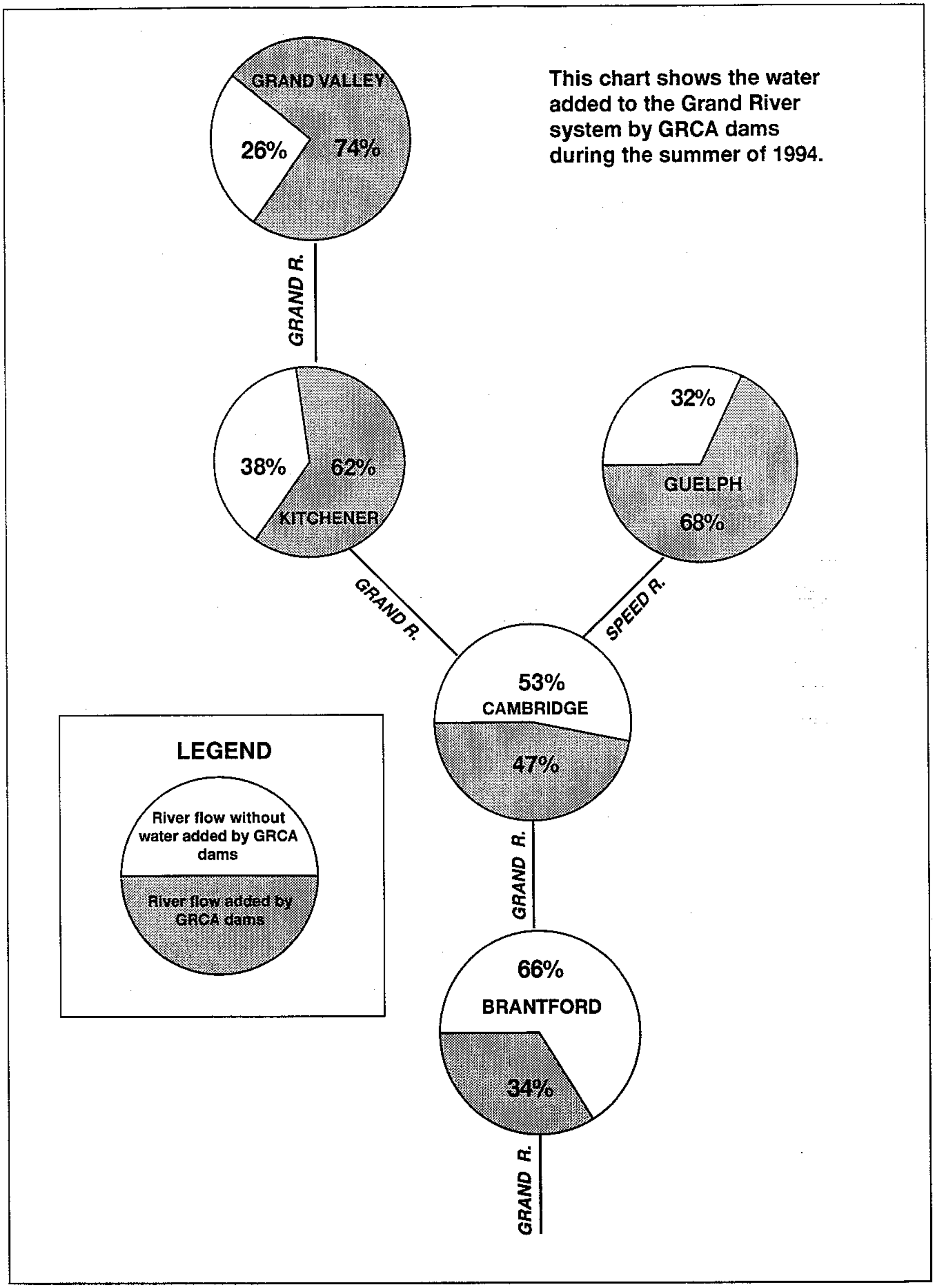


FIGURE 6-13: RIVER FLOW AUGMENTATION



6.7. Flooding

Flooding in the Grand River watershed is cyclic. Several years may pass between major floods but the threat of flooding is ever present. The Grand River Basin Water Management Study found that, next to water supply, flooding and water quality were perceived as the second most important water management issues in the Grand River Basin. This perception was undoubtedly affected by major floods that occurred during the 1970's.

The problem of flooding in the Grand River watershed began with early settlement. Settlers located close to rivers to harness water power for industry and to transport goods by barge. Development adjacent to the river bank reduced channel capacity, leaving little room for the rivers to spill their banks without causing property damage. Flooding problems became persistently worse after the turn of this century with clearing and drainage in the headwaters.

In addition to land use practices which promote rapid runoff, ice jams also increase flooding. During spring breakup or fall freeze up, ice jams can form a dam that backs up water and ice moving down the river. With the clearing of vegetation and drainage of wetlands, water reaches the river faster, leaving less time for the ice to soften prior to breakup. The ice and water spill over the river banks causing flooding. Ice jams are difficult to predict. They can occur with little warning and result in major flooding. Flooding problems resulting from ice jams in the Grand River are documented in an unpublished report by Paul Frigon entitled *"Ice Jams in the Grand River Basin, 1981"*

A history of major flood events in the watershed is summarized in Figure 6-14, page 6-23. Flooding during the past two decades has not been as severe in the major urban centres as that experienced in the past. Floods of record have more recently occurred on the Nith River above Nithburg 1986, Conestogo River at Glen Allen 1985, and Whiteman's Creek 1992. A chronology of ice jam flooding is presented in Figure 6-16, page 6-28. Major ice jam floods have occurred in Brantford and Cayuga in the past two years. The recent major ice jam floods were largely caused by early winter melts which move the ice out of the upper reaches of the river. This ice collects and is jammed in the lower reaches of the main river.

6.7.1. Existing flood damage centres

An extensive investigation of flood damages was carried out as part of the Grand River Basin Water Management Study and recommendations regarding mitigative measures needed *(Technical Report 39).* The flood damage centres in the Grand River watershed are shown in Figure 6-15, page 6-26, and the extent of the flooding problems in each community is summarized.

Although several communities are protected by dykes, flood events will occur over the long term that could cause overtopping of these dykes. An example is February 1996, water backed up as a result of the ice jam came within a foot over topping the flood control dyke. Given the risks to those living in the floodplain and behind dykes throughout the watershed flood warning and monitoring is extremely important.

Flood Forecasting and Warning

The Conservation Authority is responsible for flood forecasting and flood warning in the Grand River Watershed. This responsibility includes monitoring river conditions, operating reservoirs and relaying timely flood warning information to the Municipal Flood Coordinators through the flood warning system.

FIGURE 6-14: CHRONOLOGY OF MAJOR FLOODS

DATE	COMMUNITY	RESULTANT DAMAGE Note: Damages in dollars are referenced to the time losses were reported
1912 April	Cambridge (Galt) Guelph	Cellars were flooded; loss set at minimum of $100,000. A conservative estimate for flood losses was $76,000.
1913 March	Elora New Hamburg Dunnville	Damage estimated at $5,000. Damage estimated at $5,000. Damage exceeded $5,000.
1918 February	Cambridge (Galt)	Broken gas mains: "thousands of dollars damage to goods stored in the cellars of stores owned by local merchants."
1922 March	Cambridge (Galt)	Thousands of dollars damage.
1928 March	Cambridge (Galt)	Thousands of dollars damage. Some inhabitants of south Water Street showed the usual reluctance to leave their homes when first warned by local authorities.
1929 March-April	Cambridge (Galt)	Two bridges were damaged at $15,000. A mile of Water Street was flooded. The April flood caused an estimated damage of $250,000. Fifty-seven victims reported a total loss of $120,000.
	Guelph	The loss in manufacturing plants from flooding was reasonably believed to amount to "hundreds of thousands of dollars", without taking account of the damage in the houses.
	Paris	Penman's Manufacturing plants were flooded. The Nith River rampaged. Several houses were badly flooded and one was demolished, half of it going downstream. It was the most destructive flood the Nith River has staged in years.
	Brantford	The Grand River left its bed above the city and rushed across the northern flats scattering huge ice floes through the suburbs. There was ice damage at the waterworks, the canal overflowed, fill was washed away, car tracks were flooded and factories threatened.
1932 February	Cambridge (Galt)	Eighteen inches of water inundated Water Street.
	New Hamburg Paris	Cellars were flooded resulting in "extensive damage."
	Brantford	The low ground between Birkett's Lane and Cockshutt bridge was flooded.
1947 April	New Hamburg Cambridge (Galt) Paris Brantford	Heavy losses: "Worst flood in thirty-two years." Nineteen businesses reported damage of $20,300. Spent $2,239 to repair the dykes and $1,858 for cleaning. Damage exceeded $100,000.
1948 March	Kitchener (Bridgeport)	At least forty dwellings were inundated: damage in the "many thousands of dollars."
	New Hamburg	Thirty-seven homes inundated, water being six inches or more deep on the ground floors. Eleven streets were under water and two approaches to the village were impassable: "largest flood since 1883".

<table>
<tr><th>DATE</th><th>COMMUNITY</th><th colspan="4">RESULTANT DAMAGE
Note: Damages in dollars are referenced to the time losses were reported</th></tr>
<tr><td>1948 March</td><td>Cambridge (Galt)
Brantford
Cambridge (Hespeler)</td><td colspan="4">Damage estimated at $750,000.
Damage exceeded $100,000.
Damage estimated at $140,526.</td></tr>
<tr><td>1950 April</td><td>New Hamburg
Brantford
Waterloo</td><td colspan="4">Forty homes were evacuated.
Damage exceeded $100,000.
Heavy losses: “thousands of dollars” damage.</td></tr>
<tr><td rowspan="3">1954, October Hurricane Hazel</td><td>Kitchener (Bridgeport)</td><td colspan="4">Over sixty homes inundated: two hundred people evacuated; total damage $40,000.</td></tr>
<tr><td>New Hamburg</td><td colspan="4">At least fifty homes isolated.</td></tr>
<tr><td>Cambridge (Galt)</td><td colspan="4">Severe flooding: hundreds of basements flooded.</td></tr>
<tr><td>1965 February</td><td>Cambridge (Galt)</td><td colspan="4">Hundreds of basements flooded.</td></tr>
<tr><td rowspan="7">1974 May</td><td></td><td colspan="2">Flood damage claimed</td><td colspan="2">Flood damage appraised</td></tr>
<tr><td></td><td># of Claims Processed</td><td>($)Value claimed</td><td># of Claims Approved</td><td>($) Value Appraised</td></tr>
<tr><td>Brantford
Residential
Non-Residential
Total</td><td>
256
47
303</td><td>
285,351
144,608
429,959</td><td>
233
38
271</td><td>
206.341
79,326
285,667</td></tr>
<tr><td>Cambridge
Residential
Non-Residential
Total</td><td>
348
278
626</td><td>
861,917
3,451,141
4,313,058</td><td>
303
245
548</td><td>
357,186
1,682,712
2,039,898</td></tr>
<tr><td>Kitchener
Residential
Non-Residential
Total</td><td>
100
18
118</td><td>
357,266
151,723
509,989</td><td>
93
16
109</td><td>
163,330
71,247
234,577</td></tr>
<tr><td>Paris
Residential
Non-Residential
Total</td><td>
59
36
95</td><td>
59,587
190,996
250,583</td><td>
52
33
85</td><td>
37,359
69,811
107,170</td></tr>
<tr><td>All Other
Residential
Non-Residential
Total</td><td>
39
19
58</td><td>
84,609
131,236
215,845</td><td>
29
15
44</td><td>
61,940
50,841
112,781</td></tr>
<tr><td>1975 April</td><td>Paris</td><td colspan="4">Cost of emergency flood prevention $50,000; estimate damage on Elm Street was $900.</td></tr>
<tr><td>1976 June</td><td>Conestogo</td><td colspan="4">Damage was $15,000 to $18,000.</td></tr>
</table>

DATE	COMMUNITY	RESULTANT DAMAGE **Note: Damages in dollars are referenced to the time losses were reported**
1979 March	Paris	Flooding caused by ice jam: "thousands of dollars" damage.
1982	Grand Valley New Hamburg Ayr Brantford	
1985	Galt	Flooding of Highway 24 through Cambridge-Galt. Minor flooding of low lying areas.
1986	New Hamburg	Flooding of several homes along Jacob, Asmus, Grace, Shade and Milton Streets. 33 buildings were estimated to be flooded.
	Ayr	Flooding of several buildings along Northumberland and Swan Streets
1990	Grand Valley	Minor flooding of building fronting on the river as a result of a rapid spring melt, air temperatures rose to almost 20 degrees.
1996	Brantford	Major ice Jam flood in February resulted in water levels within 0.3 (m) of over topping the dykes in Brantford. Emergency measures were taken to prepare 5000 residences for evacuation. Dykes held.
1997	New Hamburg	Flooding of several homes along Jacob, Asmus, Grace, Shade and Milton Streets. Similar to flooding that occurred in 1986.
	Ayr	Flooding of an estimated 14 building along Northumberland and Swan Streets. Similar to flooding experienced in September 1986.
	Cayuga	Severe flooding, extensive damage to trailer park and several homes. Flooding resulted from an ice jam downstream of Cayuga that resulted in levels through Cayuga similar to those experience during the May 1974.

TABLE 6-15: EXISTING FLOOD DAMAGE CENTRES

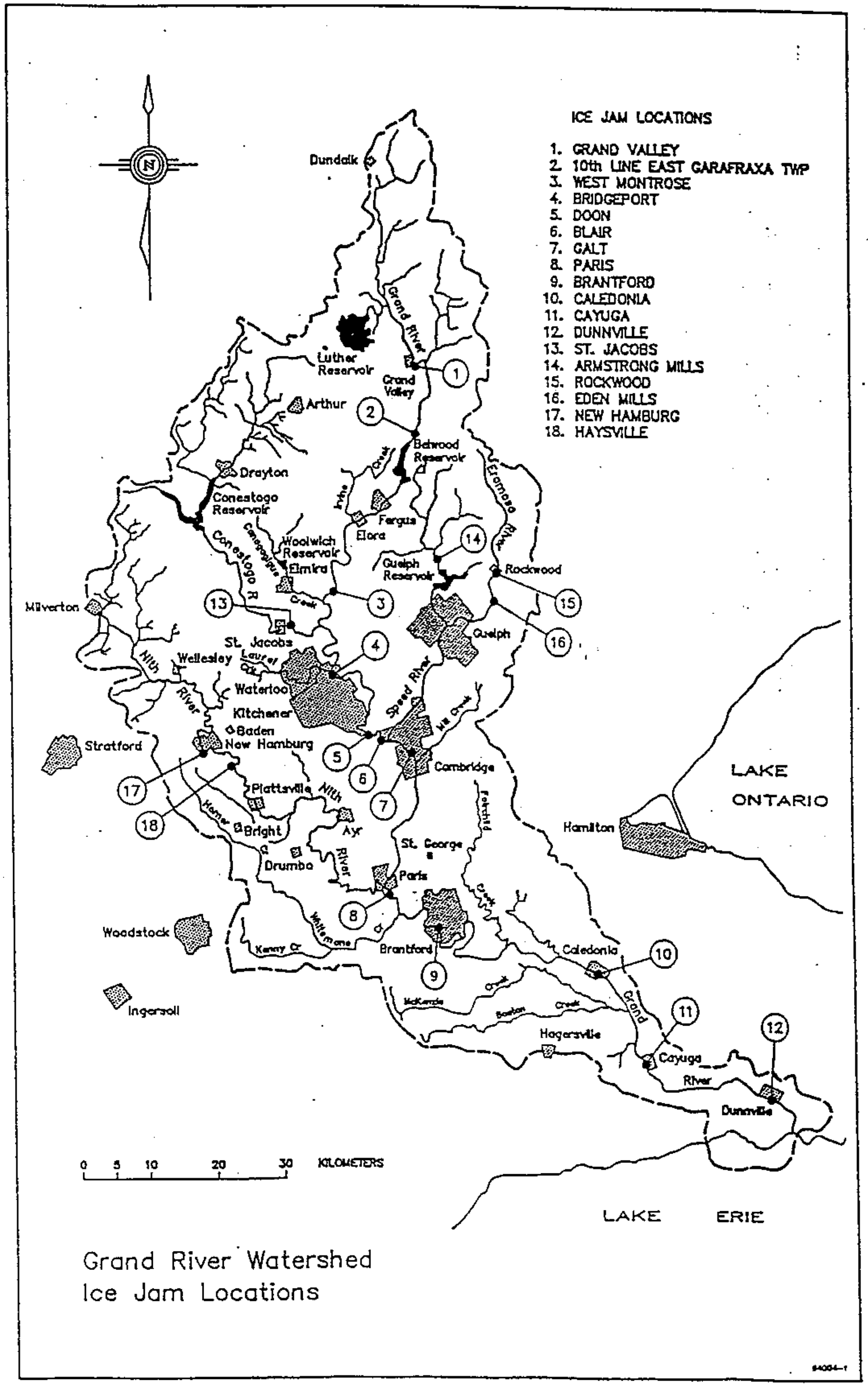
Location	Major Causes	Structures in the Floodplain	Average Annual Damages (based on dollar value in year indicated)	Major Flood Events	Probability of Flooding in any given year	Mitigative Action Taken to Date
Grand River						
Grand Valley	ice jams high flows	155	*1979* $28,000	1947, 1954, 1972, 1975, 1982	Hwy. 25 - 50% Homes - 5%	• downstream silt bar removed 1982 • improved warning
Waldemar	high flows	27		1947, 1954, 1972, 1975	Homes - 20%	• flood warning
Fergus	high flows	37			Extreme events only	• flood warning
Elora	high flows	15		1972, 1979	Boardwalk shops - 95% Other - extreme events only	• flood warning
West Montrose	high flows ice jams	17			Homes - 20%	• downstream island removed in 1981, flood warning
Conestogo	high flows	11		1974, 1976		• flood warning
Kitchener (Bridgeport)	high flows	95	Less than *1979* $1000	1974	less than 1%	• dyke system built in 1978
Cambridge (Galt)	high flows	503	Less than *79* $1000	1929, 1947, 1948, 1954 1974, 1979	less than 1%	• dyke system completed in 1995
Glen Morris	high flows			1948, 1954, 1974	2% homes	
Paris	high flows ice jams	217	*'79* $65,000	1972, 1974, 1975, 1979	4% commercial core.	• dyke system on east bank
Brantford	high flows ice jams	2700	less than *79* $1000	1947, 1948, 1954, 1972, 1974, 1975, 1979	less than 1% homes	• dyke system completed in 1995
Six Nations	ice jams high flows					
Caledonia	high flows	120	*79* $8000	1948, 1954, 1974, 1979	20% commercial core	• dyking u/s of Hwy. 6
Cayuga	ice jams high flows	116		1948, 1954, 1974, 1981	50% flooding of trailer park 20% flooding of homes	• New mapping
Dunnville	ice jams high flows	700	*85* $92,000		4% flooding of core	• New Mapping
Port Maitland	ice jams wave setup on Lake Erie	36		1975, 1976, 1979, 1980	10% homes along lake.	• Shoreline Mgm plan. • New mapping in 1995

Location	Major Causes	Structures in the Floodplain	Average Annual Damages (based on dollar value in year indicated)	Major Flood Events	Probability of Flooding in any given year	Mitigative Action Taken to Date
Canagagigue Ck.						
Elmira	high flows	15		1974, 1975		
Conestogo River						
Drayton	high flows, ice jams	74		72, 74, 75	4% homes upstream of Wellington street.	• extended dyking in 1987
St. Jacobs	high flows	3		48, 54		
Laurel Creek						
Waterloo	urban flash flooding	63 (uptown)	*1989* $221,000	1965, 1975	10% commercial core	• channelization late 80's • floodline mapping mid 80's • watershed study 1992
Schneider Creek						•
Kitchener	urban flash flooding	hundreds		1975, 1988, 1992		• New mapping 1994 • culvert upgrade proposed
Eramosa River						•
Rockwood	high flows/ice jams	22		1948, 1950, 1954, 1975	2% homes, commercial core	• new mapping 1989
Eden Mills	high flows/ice jams	41		1948, 1950, 1954, 1975		• new mapping 1989
Speed River						•
Guelph	high flows	600	*79* $30,000	1948, 1950, 1954, 1974		• new mapping 1989
Cambridge (Preston)	high flows ice jams	103	*79* $15,000	1948, 1950, 1974		• new mapping 1989
Mill Creek						•
Aberfoyle	high flows	18			2% homes	•
Cambridge (Galt)	urban flask flooding	30				• channelization mid to late 80's
Nith River						•
Wellesley	high flows	40				•
New Hamburg	high flows ice jams	120	*79* $25,000	1954, 1967, 1975, 1977, 1979,1986	10% homes 5% major flooding of commercial core	• New Mapping 1985.
Plattsville	high flows ice jams	90	*79* $2,000	same as New Hamburg	5% homes	• New mapping 1985
Ayr	high flows	21	*79* $10,000	same as N. Hamburg	5% businesses	• New mapping 1985
Wolverton	high flows	25		same as N. Hamburg	5% homes	•

FIGURE 6-16: CHRONOLOGY OF MAJOR ICE JAMS

YEAR	LOCATIONS
1852	Galt, Brantford (March 14)
1857	Galt, Cayuga (February 14)
1860	Galt, Brantford (March 4)
1861	Brantford (March 2)
1865	Galt (March 21)
1866	Galt
1867	Galt
1870	Bridgeport (April 7)
1893	Brantford (March 6)
1898	Blair, Bridgeport (March 12
1899	Brantford (March 16), Salem (April 11)
1900	Galt (February 8), Brantford (April 1)
1902	Elora, Fergus
1903	Elora, Fergus
1904	Galt, Brantford (March 26)
1905	Fergus (March 24), Hespeler (March 25)
1913	Galt, Brantford, Freeport (March 13), Dunnville (March 15)
1918	Galt, Brantford (February 20)
1922	Galt (March 7)
1928	Blair (March 25)
1929	Salem, Freeport, Cayuga (March 15)
1930	Dunnville
1934	Bridgeport, Galt, Brantford, Cayuga (March 3)
1939	Grand Valley (March 29)
1942	New Hamburg (March 10)
1948	Grand Valley, Caledonia (March 10), Dunnville (March 17)
1950	Caledonia
1951	Caledonia
1952	Freeport
1954	Caledonia
1965	Caledonia
1971	West Montrose
1972	Grand Valley (April 14)
1974	Grand Valley (March 5), West Montrose
1975	West Montrose
1976	West Montrose
1977	Caledonia, Dunnville, West Montrose
1979	Paris (March 5)
1980	West Montrose
1981	Paris (February 19), Dunnville (February 22), West Montrose (February 23)

FIGURE 6-17: AREAS PRONE TO DAMAGING ICE JAMS



7. WATER USE

The water resources of the Grand River Watershed are used for a wide variety of purposes including water supply, wastewater disposal, recreation, and fish and wildlife habitat. Increasing population will place an ever increasing demand on these finite resources.

7.1 Water supply

Extraction of surface and ground water for consumption purpose within the Grand River Watershed can be classified into five general categories: irrigation and recreation; municipal; industrial; rural domestic; livestock.

A municipal water supply usually services residential, industrial, institutional, and commercial water users within an urban or built up area. While most industries are connected to the municipal water supply system, there is a significant number of major industries that obtain large quantities of water from private sources. Similarly, a significant amount of water is extracted from private sources for rural domestic use and consumption.

Water uses which do not fall in the categories described above are considered under other. This would include a limited number of commercial and recreational establishments which consume small quantities of water from private sources, usually on a seasonal basis.

The sum total of all these water uses provides an estimate of the total water demand in the Grand River watershed. The total estimated withdrawals in the basin range from a yearly average of 520,000 cubic metres per day (114 million gallons), or 6 cubic metres per second, to a daily maximum of 1,015,000 cubic metres per day (223 million gallons) or 12 cubic metres per second during the summer months assuming maximum simultaneous withdrawal for irrigation and recreational uses. Annual and daily water use is shown in Figure 7-1 and Figure 7-2, on page 7-2.

FIGURE 7-1: WATER USE, DAILY DEMAND

Water use by general type	Daily demand 1979 (m^3per day)	Daily demand 1979 %	Daily demand 1995 (m^3per day)	Daily demand 1995 %
Irrigation & Recreation	459,000	50%	****459,000***	45%
Municipal	238,680	26%	323,598	32%
Industrial Commercial	156,060	17%	***†156,060***	15%
Rural Domestic	27,540	3%	48,154	5%
Livestock (1993)	36,720	4%	28,139	3%
Total	**918,000**	**100%**	**1,014,951**	**100%**
*Estimated irrigation and recreational demand for 1995 used 1979 estimates				
†Estimated industrial and commercial demand for 1995 used 1979 estimates				

FIGURE 7-2: WATER USE, ANNUAL DEMAND

Water use by general type	Annual demand 1979 (m^3per year)	Annual demand 1979 %	Annual demand 1995 (m^3per day)	Annual demand 1995 %
Irrigation & Recreation	4,640,131	3%	****4,640,131***	2%
Municipal	87,118,200	57%	118,113,270	62%
Industrial & Commercial	38,667,758	25%	***†38,667,758***	20%
Rural Domestic	10,052,100	7%	17,576,210	9%
Livestock (1993)	13,402,800	9%	10,270,808	5%
Total	**153,880,989**	**100%**	**189,268,177**	**100%**
*Estimated irrigation and recreational demand for 1995 used 1979 estimates				
†Estimated industrial and commercial demand for 1995 used 1979 estimates				

FIGURE 7-3: DAILY WATER DEMAND IN THE GRAND RIVER WATERSHED

*Data columns are unshaded where no current information is available

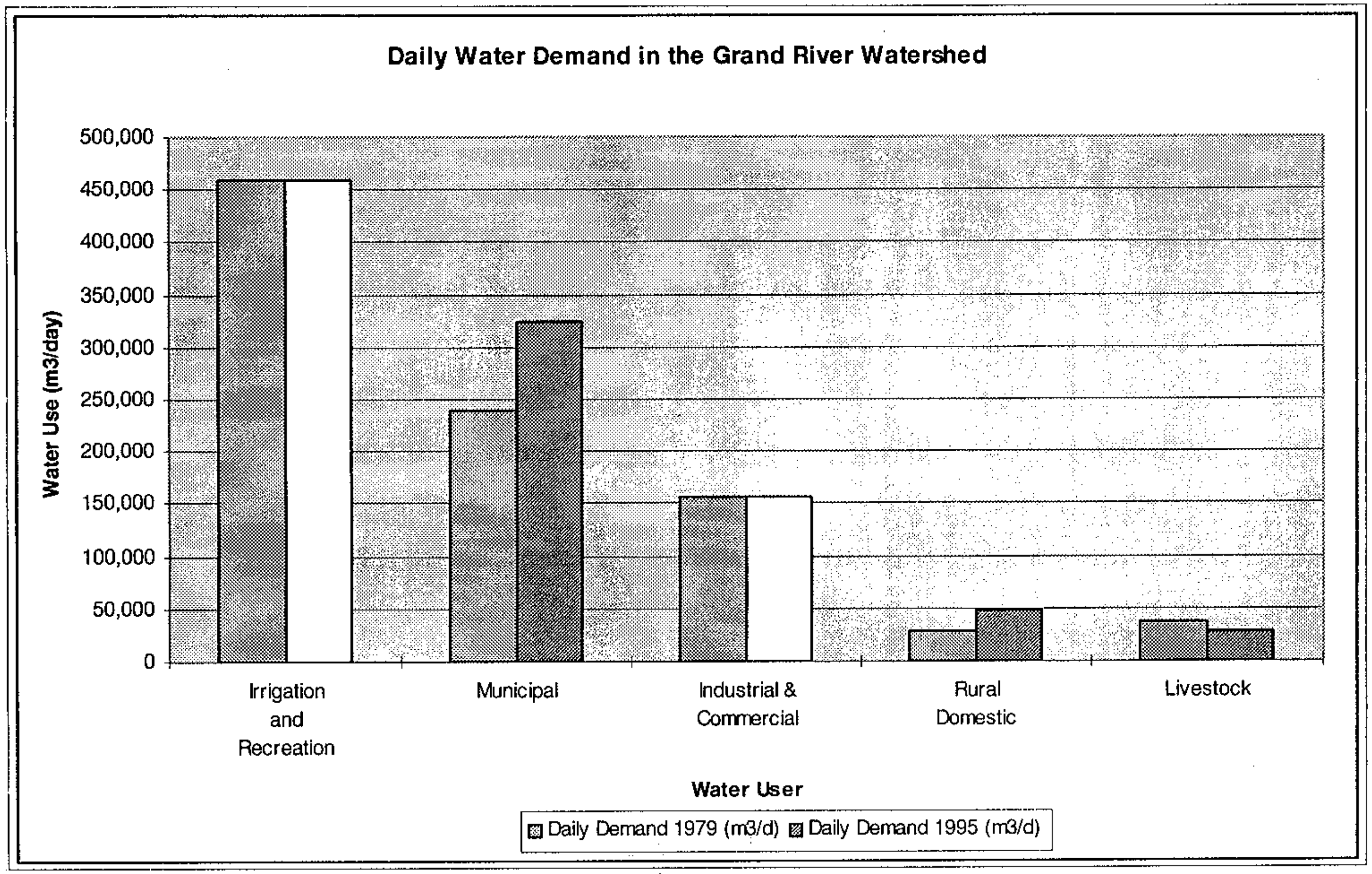
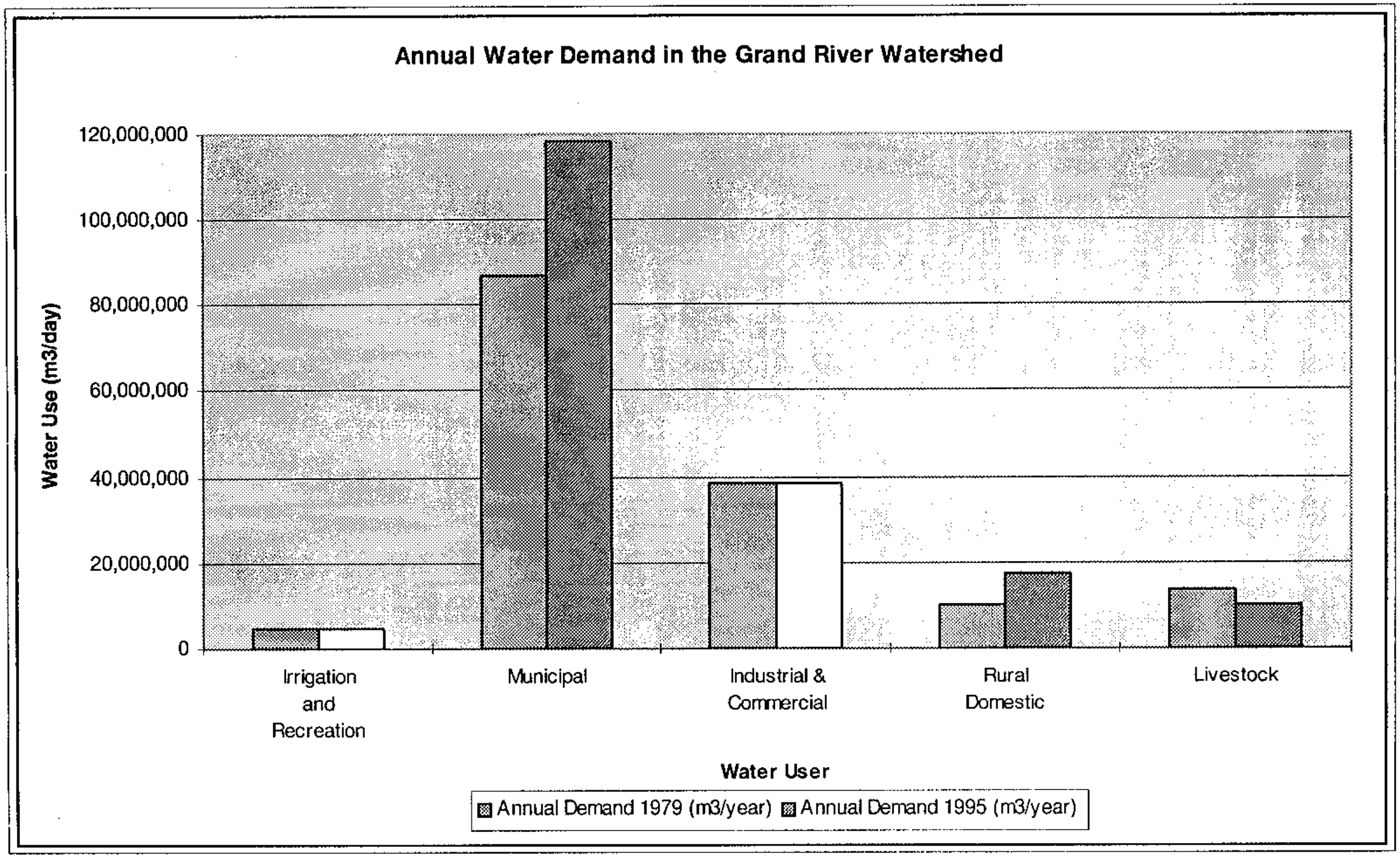


FIGURE 7-4: ANNUAL WATER DEMAND IN THE GRAND RIVER WATERSHED

***Data columns are unshaded where no current information is available**



Figures 7-3 and 7-4 illustrate how municipal demand is dominant when considered on an annual basis. Irrigation and recreation can be dominant on a daily basis particularly during summer dry periods. These charts show that rural domestic and municipal water demand have increased since 1979 while livestock water use has decreased. Livestock water user demand has decreased as a result of the decline in the number of beef cattle in the watershed.

During peak demand periods of the year it is estimated water is being withdrawn at the rate of 12 m^3/s. This is equal to the normal summer lowflow in the Grand River through Kitchener. It is also equal to six times the normal summer lowflow in the Speed River below the confluence through Guelph, or two thirds of the normal summer lowflow in the Grand River through Brantford.

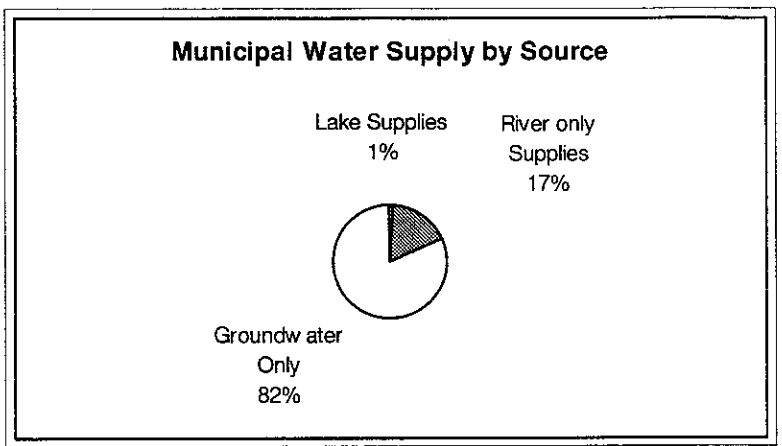
To put another perspective on water demand, the total volume of water use in the watershed during peak periods represents the volume of 12,000 litre bags of milk per second.

7.1.1 Municipal

Municipal water use is the greatest consumptive use of water for urban and rural domestic purposes. An average of 324,000 cubic metres per day (m^3/d), or 71 million gallons per day, is required to meet the municipal water supply needs of the urban population. Of this amount, 17% is supplied from surface water, 82% from groundwater and 1% from the Great Lakes. The remainder of the unserviced watershed population uses approximately 48,154 m^3/d (10.5 million gallons per day) comes from groundwater sources for rural domestic purposes.

In the Grand River watershed the dominant use of groundwater as the source for municipal water supply is illustrated below in Figure 7-5.

FIGURE 7-5: MUNICIPAL WATER SUPPLY BY SOURCE



Only Dunnville, Caledonia and Cayuga are currently served by supplies from the Great Lakes. Most other areas in the Province of Ontario have a much greater reliance on surface water supplies. In the Grand River Watershed there is a higher reliance on groundwater for municipal water supply making this area unique from other heavily populated areas in the Province.

Almost 85% of the municipal water demand occurs in the urban centres of Kitchener, Waterloo, Cambridge, Guelph and Brantford. The tri-city area including Cambridge, Kitchener, Waterloo, St. Jacobs and Elmira had an average day demand of 200,000 cubic metres per day (44 million gallons) in 1995 according to the Region of Waterloo Water and Waste Water Monitoring Report. Of this total approximately 20% of the water used in the Tri-city was supplied by the Grand River in 1995 and the remaining 80% was from groundwater sources.

Figure 7-6, page 7-7, provides a break down of water use by municipality. The sources of this information in this table include: the Municipal Water Use Database for Ontario maintained by Environment Canada with data up to 1994, Municipal Water and Waste Water Monitoring report and personal contact with the operators in the various municipalities.

FIGURE 7-6: WATER USE BY MUNICIPALITY

**1995 figures are used unless otherwise indicated.*

Location	Present population	Municipal population served	Rural population served	Per capita average daily demand (l/day)	Average daily demand (m^3/day)
Dundalk	1,550	1,450		438	635
Grand Valley	1,517	1,517		253	384
Fergus	9,000	9,000		503	4,523
Elora	3,200	3,200	100	448	1,477
Arthur	2,033	2,030	3	503	1,023
Drayton	1,333	1,260		377	475
Woolwich	17,500	9,500		633	6,011
Waterloo	80,100	80,000		501	40,093
Kitchener	168,282	168,282		549	92,387
Eramosa Twp (Rockwood)	57,000	2,800		219	613
Guelph Township	3,045	485		474	230
Guelph City	91,000	90,000		489	44,000
Cambridge	97,000	79,000		773	61,057
St. George *(1993)*	1,842	1,842		740	1,364
Paris	8,500	8,500	100	553	4,755
Wellesley	1,327	1,327		384	509
Milverton	1,680	1,680		203	341
Baden/New Hamburg *(1994)*	6,640	2,487		1,287	3,200
Bright	245	245		500	122
Plattsville	890	890		374	558
Drumbo		500		295	148
N. Dumfries (Ayr)	6,821	2,000		750	1,500
Brantford Twp.	6,509	1,800		596	1,073
Brantford City	82,000	82,000		518	42,500
Ohsweken		350		350	123
Haldimand	19,880			611	5,014
(Caledonia)		7,004			4,161
(Cayuga)		1,589			575
Dunnville	11,766	5,364		885	4,747
Total	680,660	574,307	203	526	323,598

FIGURE 7-7: PERCENTAGE OF POPULATION SERVED BY MUNICIPAL WATER SUPPLY

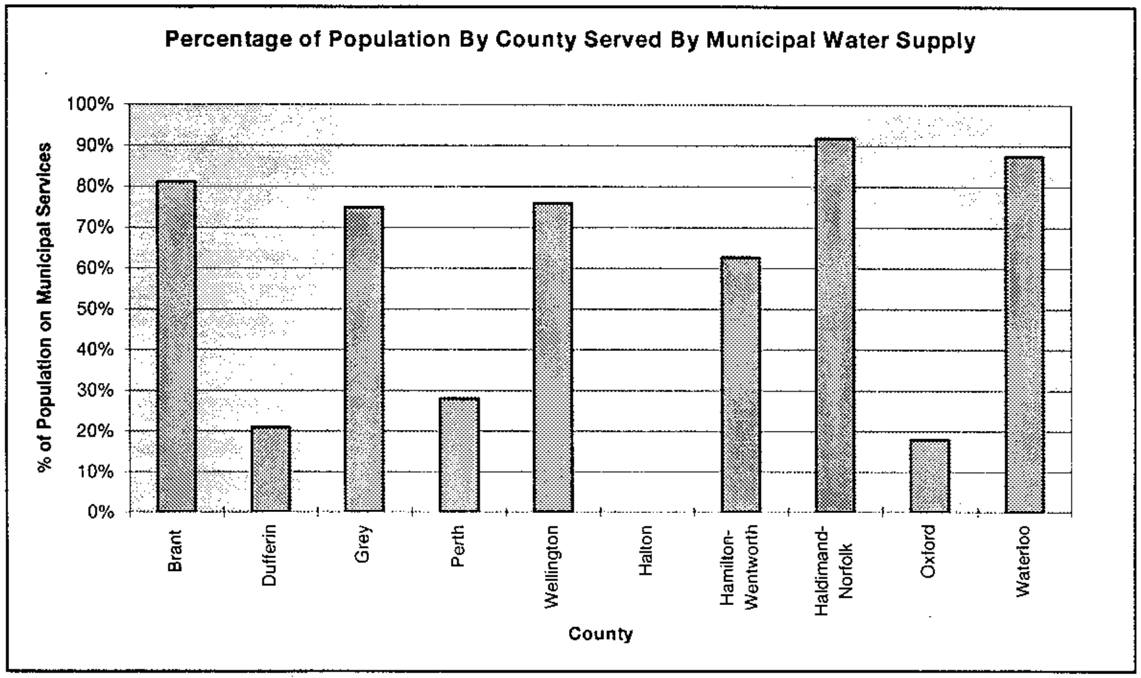
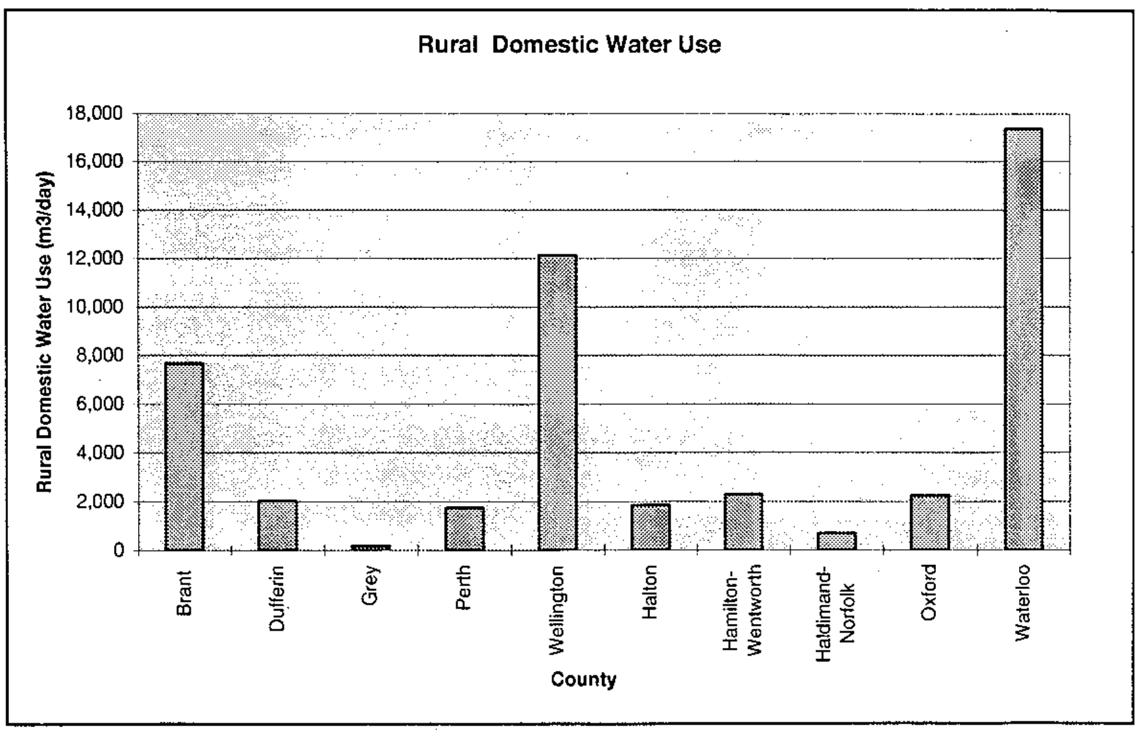


FIGURE 7-8: RURAL DOMESTIC WATER USE



Rural domestic water use is based on the estimated rural population figures and a per capita use of 350 litres daily. *(1995 figures).*

7.1.2 Industrial

Although water consumption data for industries obtaining water from municipal sources have not been compiled separately in this report, it was estimated that in 1979, an average of 30 percent of municipal water consumption in the major urban centres was for industrial service. In addition, industries not connected to a municipal water supply system withdrew about 156, 000 cubic metres per day (34 million gallons) which is estimated to represent 15% to 20% of the total watershed water withdrawals. Most of the industrial water needs provided by non-municipal sources occur in the middle and lower parts of the watershed.

In 1979 over 60 percent of the water withdrawn directly for industrial use was obtained from groundwater sources including wells and dugout ponds. Uses, in order of decreasing amounts of water withdrawn, include washing aggregates and de-watering gravel pits, industrial cooling, food processing and industrial processing, pollution control, and miscellaneous purposes. Water used in aggregate processing is generally discharged to settling ponds and eventually returned to the groundwater system through natural seepage or to streams. Water used for industrial cooling and processing by manufacturers is generally discharged to existing municipal sewer systems.

The remaining industrial supply is obtained from surface water and is used mainly for mineral extraction and processing (sand, gravel, limestone). The waste is usually discharged to settling ponds and returned to the surface water source. On the average, approximate one percent of the total volume of water used is lost through evaporation during an eight month operation period between April and November.

To update industrial and commercial water use to present date would require organizing the Ministry of Environment water taking permits on a watershed basis. Water takings were last updated for the Grand River Watershed in 1982.

7.1.3 Agricultural

Within the Grand River watershed, water is used for two main agricultural purposes: watering livestock and irrigating crops.

7.1.3.1 Livestock watering

Based on the number of livestock in the basin, the amount of water used in 1976 for livestock consumption was estimated to be about 35,000 m^3/d (7.7 million gallons per day). Water supplies for feedlot and poultry farm operations are primarily obtained from wells. Pastured cattle and mixed herds on small farms are watered from a variety of sources, including streams, ponds, springs, and drilled or dug wells. The largest livestock demands occur in the basins of the middle Grand and Nith Rivers.

FIGURE 7-9: 1976 WATERSHED LIVESTOCK POPULATION

Livestock population by County - 1976	Dairy Cattle	Other Cattle	Pigs	Sheep	Horses	Goats	Chickens	Turkeys
Brant	11,143	12,146	30,061	909	964	668	278,403	90,015
Waterloo	24,763	55,724	144,320	2,171	3,389	1,260	1,660,080	315,718
Wellington	35,299	70,233	143,906	6,567	3,322	2,561	2,144,358	66,331
Haldimand-Norfolk	5,344	5,453	12,506	619	368	347	371,326	63,394
Perth	5,562	6,940	20,193	177	194	125	178,726	15,254
Oxford	4,287	4,570	11,047	123	164	84	87,620	41,958
Dufferin	1,534	7,980	5,598	408	247	233	23,545	
Halton	69	272	255	47	49	24	10098	
Hamilton-Wentworth	291	739	1443	76	61	17	65453	1718
Grey	476	3585	1595	285	72	66	22241	1021
Totals	88,768	167,642	370,925	11,383	8,829	5,384	4,841,850	595,410

FIGURE 7-10: 1993 - WATERSHED LIVESTOCK POPULATION

Livestock population by County - 1993	Dairy Cattle	Other Cattle	Pigs	Sheep	Horses	Goats	Chickens	Turkeys
Brant	6,834	4,784	40,516	2,343	1,189	403	375,181	22,236
Waterloo	21,300	34,000	229,500	2,200	3,470	1,210	1,739,597	161,966
Wellington	31,115	36,315	217,108	14,127	3,664	1,753	2,065,096	134,256
Haldimand-Norfolk	3,527	2,774	15,211	1,199	413	202	440,895	67,378
Perth	4,152	3,012	39,140	608	207	89	181,607	10,267
Oxford	3,522	1,064	20,472	467	155	90	84,089	28,873
Dufferin	1,021	3,749	3,837	1,056	259	126	27,907	119
Halton	55	203	235	41	52	17	11243	
Hamilton-Wentworth	244	551	1196	169	66	10	67088	1263
Grey	428	2845	647	74	47	24526	883	883
Totals	72,197	89,296	567,863	22,284	9,521	28,426	4,993,588	427,242

FIGURE 7-11: 1976 - LIVESTOCK WATER USE

Water use by County - 1976	Dairy Cattle (m^3/d)	Other Cattle (m^3/d)	Pigs (m^3/d)	Sheep (m^3/d)	Horses (m^3/d)	Goats (m^3/d)	Chickens (m^3/d)	Turkeys (m^3/d)
Brant	2,017	828	273	8	66	6	139	45
Waterloo	4,482	3,800	1,312	20	231	11	830	158
Wellington	6,389	4,789	1,308	60	227	23	1,072	33
Haldimand-Norfolk	976	372	114	6	25	3	186	32
Perth	1,007	473	184	2	13	1	89	8
Oxford	776	312	100	1	11	1	44	21
Dufferin	278	544	51	4	17	2	12	0
Halton	12	19	2	0	3	0	5	0
Hamilton-Wentworth	53	50	13	1	4	0	33	1
Grey	86	244	14	3	5	1	11	1
Total	16,076	11,431	3,371	105	602	48	2,421	299

FIGURE 7-12: 1993 - LIVESTOCK WATER USE

Water use by County - 1993	Dairy Cattle (m^3/d))	Other Cattle (m^3/d)	Pigs (m^3/d)	Sheep (m^3/d)	Horses (m^3/d)	Goats (m^3/d)	Chickens (m^3/d)	Turkeys (m^3/d)
Average # litres per day estimated used by each animal.	181	68	9	9	68	9	0.5	0.5
Brant	1,237	326	368	21	81	4	188	11
Waterloo	3,855	2,318	2,086	20	237	11	870	81
Wellington	5,632	2,476	1,974	128	250	16	1,033	67
Haldimand-Norfolk	638	189	138	11	28	2	220	34
Perth	751	205	356	6	14	1	91	5
Oxford	638	73	186	4	11	1	42	14
Dufferin	185	256	35	10	18	1	14	0
Halton	10	14	2	0	4	0	6	0
Hamilton-Wentworth	44	38	11	2	4	0	34	1
Grey	77	194	6	1	3	223	0	0
Totals	13,067	6,089	5,162	203	650	259	2,498	213

Agricultural livestock watering demands declined between 1976 and 1993. This decline can be attributed to a reduction in beef cattle in the watershed.

7.1.3.2 Irrigation Water Demand

Water use for farm crop irrigation occurs between the months of June and August. Considerable areas of tobacco and market garden crops requiring irrigation are grown on the sandy soils in the watersheds of Whiteman's, Mt. Pleasant, and McKenzie Creeks, in Brant and Oxford Counties. As of 1979, the Ontario Ministry of the Environment authorized a maximum water withdrawal rate for irrigation of about 442,400 m^3/d (97 million gallons) with 88% of this amount from surface water sources. Actual water withdrawals are generally much less than those permitted by the Ministry. Studies indicate that, on average, approximately 25 percent of the authorized withdrawals for irrigation occur simultaneously. The most intensive irrigation occurs in a relatively short time period when the crops are nearing maturity. At present, tobacco is the crop most commonly irrigated.

Irrigation water demands tend to coincide with the period of lowest water availability in streams and therefore represent a significant potential impact on stream flows and aquatic resources.

To update industrial and commercial water use to present date would require organizing the Ministry of Environment water taking permits on a watershed basis. Water takings were last updated for the Grand River Watershed in 1982.

7.2 Waste assimilation

Water bodies such as the Grand River have the ability to accept and assimilate a certain amount of oxygen-demanding wastes and other biodegradable wastes. However, if too much organic material is discharged, oxygen resources may become severely depleted leaving insufficient oxygen for fish and other organisms. Thus there is need for a balance between waste discharged into a river and the river's ability to safely absorb these wastes.

7.2.1 Municipal Sewage Treatment

There are currently 26 municipal sewage treatment plant operating in the Grand River Watershed. These plants generally discharge treated sewage to the Grand River or to one of its tributaries on a continuous basis. Some plants like Drayton, Dundalk and Arthur utilize lagoon discharge on a seasonal basis. The individual plant discharges by month for 1993 are provided in Figure 7-13, page 7-13.

During dry periods of the year, sewage effluent can make up a substantial portion of the flow in the Grand River or its tributaries at specific locations. The portion of minimum daily flows constituted by treated effluent by month for selected locations is presented in Figure 7-3, page 7-13. Depending on the location, the percentage of the minimum daily flow constituted by treated effluent varied from 1% to 22 %. Percentages were highest on the Speed River due to discharges from the Guelph and Cambridge-Hespeler plants.

FIGURE 7-13: SEWAGE TREATMENT EFFLUENT VOLUME BY PLANT, 1993

1993 Effluent discharges by plant in thousands of cubic metres per day (1000m^3)													
Plant location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
	1000m^3	1000m^3	11000m^3	1000m^3	1000m^3	1000m^3	1000m^3	1000m^3	1000m^3	1000m^3	1000m^3	1000m^3	1000m^3
Arthur	1.66	1.09	1.41	2.96	1.15	1.25	0.88	1.02	1.06	1.15	1.07	1.05	1.31
Ayr	0.72	0.63	0.65	0.67	0.62	0.60	0.56	0.56	0.60	0.62	0.61	0.62	0.62
Baden	0.81	0.59	0.77	0.84	0.64	0.62	0.62	0.56	0.61	0.65	0.68	0.68	0.67
Brantford	59.04	45.56	51.40	56.32	52.17	51.31	48.03	47.72	45.72	46.00	44.10	42.61	49.16
Cainsville	0.00	0.00	0.00	0.62	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.05
Caledonia	5.14	3.53	4.88	4.67	3.99	3.67	2.90	2.86	2.79	3.03	3.19	3.10	3.65
Cayuga	1.09	0.53	1.19	0.95	0.58	0.67	0.49	0.49	0.51	0.56	0.60	0.54	0.68
Drayton	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.08	0.00	0.51
Dundalk	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91
Dunnville	4.79	3.46	5.27	3.41	2.67	3.02	3.43	3.64	4.13	4.18	4.74	4.94	3.97
Elmira	4.28	1.85	3.86	4.59	3.30	3.90	3.21	2.14	2.86	3.04	3.81	3.45	3.36
Elora	1.95	1.44	1.59	1.99	1.65	1.76	1.57	1.42	1.46	1.50	1.50	1.53	1.61
Fergus	5.62	3.46	4.52	6.23	4.27	4.66	4.11	3.57	3.68	3.85	4.04	3.97	4.33
Galt	35.83	31.70	32.51	36.50	33.65	34.61	32.25	33.49	35.27	35.53	32.37	31.15	33.57
Grand Valley	0.81	0.49	0.56	0.94	0.45	0.46	0.35	0.33	0.35	0.36	0.36	0.36	0.48
Guelph	53.43	43.32	45.66	53.34	45.40	44.10	41.25	39.94	42.85	46.24	47.64	45.90	45.76
Hespeler	6.14	4.56	5.05	5.58	4.65	4.59	4.16	4.58	4.57	4.64	4.72	4.66	4.83
Kitchener	78.90	65.80	70.90	79.60	68.40	65.80	60.70	60.70	62.30	62.20	62.90	62.00	66.68
New Hamburg	0.00	0.00	0.21	2.51	1.99	1.42	0.85	0.71	0.55	2.27	2.15	0.94	1.13
Oswego Park													
Paris	2.66	2.63	3.52	3.42	2.82	2.54	2.51	2.53	2.46	2.17	2.18	2.35	2.65
Plattsville	0.76	0.66	0.76	0.81	0.68	0.66	0.54	0.59	0.64	0.77	0.62	0.52	0.67
Preston	11.99	9.15	10.42	11.32	10.74	10.14	9.67	9.22	9.32	9.27	9.04	9.29	9.96
St. George	0.58	0.50	0.52	0.55	0.54	0.57	0.49	0.49	0.50	0.50	0.50	0.51	0.52
St. Jacobs	1.37	0.69	0.85	1.34	0.91	0.97	0.74	0.60	0.64	0.64	0.66	0.77	0.85
Waterloo	41.18	30.54	37.34	40.15	32.64	31.90	29.83	30.54	33.69	34.39	32.65	32.55	33.95
Wellesley	0.62	0.32	0.56	0.65	0.40	0.46	0.33	0.31	0.37	0.39	0.40	0.45	0.44
Total	320.28	253.41	285.31	320.88	275.22	270.59	250.38	248.92	257.84	264.86	267.54	254.85	272.32

FIGURE 7-14: SEWAGE EFFLUENT AS A PERCENTAGE OF MINIMUM DAILY STREAMFLOW BY MONTH IN 1993

1993	Sewage Effluent Discharges Expressed in (m^3/s) at Specific Gauge Locations in the Grand River Watershed.											
Location of gauges	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
The measurements below are expressed in cubic metres per second (m^3/s)													
Marsville	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.02
West Montrose	0.11	0.07	0.09	0.12	0.08	0.09	0.08	0.07	0.07	0.08	0.08	0.08	0.08
Below Elmira	0.05	0.02	0.04	0.05	0.04	0.05	0.04	0.02	0.03	0.04	0.04	0.04	0.04
St. Jacobs	0.04	0.02	0.03	0.05	0.02	0.03	0.02	0.02	0.02	0.02	0.09	0.02	0.03
Bridgeport	0.19	0.11	0.16	0.22	0.15	0.16	0.14	0.12	0.13	0.13	0.21	0.14	0.15
Downstream of Kitchener STP	1.58	1.23	1.41	1.61	1.32	1.29	1.18	1.17	1.24	1.25	1.32	1.23	1.32
Hanlon	0.62	0.50	0.53	0.62	0.53	0.51	0.48	0.46	0.50	0.54	0.55	0.53	0.53
Beaverdale	0.69	0.55	0.59	0.68	0.58	0.56	0.53	0.52	0.55	0.59	0.61	0.59	0.59
Galt	3.32	2.65	2.94	3.34	2.81	2.73	2.52	2.50	2.62	2.67	2.76	2.64	2.79
Canning	0.03	0.03	0.03	0.06	0.05	0.04	0.03	0.03	0.03	0.05	0.05	0.04	0.04
Brantford	3.80	3.07	3.39	3.87	3.28	3.21	2.96	2.94	3.08	3.16	3.21	3.07	3.25
York	4.55	3.65	4.05	4.58	3.94	3.85	3.56	3.54	3.65	3.73	3.76	3.60	3.87
Port Maitland	4.62	3.69	4.12	4.64	3.98	3.89	3.60	3.58	3.71	3.79	3.82	3.67	3.93

In 1993, the population served by sewage treatment plants was estimated to be 550,000. Several of these sewage treatment plants use advanced tertiary treatment. Implementation of advanced treatment at several plants over the past 25 years is one of the main factors that has contributed to improved water quality in the Grand River today.

7.2.2 Rural Non Point Source Pollution

Treated effluent is one contributing factor that affects the quality of water in the Grand River. The other dominate factor is rural non-point source pollution. Rural non-point source pollution can results from sources such as water running of agricultural field, manure storage facilities tile drained field and farm lot operations. During rainstorms or spring snowmelt fertilizers and manure waste may be washed into tributaries carried into the Grand River or its major tributaries. The nutrient contained in this waste can affect the river's water quality.

Until recently programs such as the Ministry of Environment Clean Up Rural Beaches assisted rural land owners to implement measures to reduce diffuse sources pollution. This program has since been discontinued. Initiatives are now underway to find alternate funding sources to deliver a similar sort of program.

7.2.3 Flow Augmentation

Flow added to the river by major reservoirs, especially during the dry periods of the year, plays an important factor in maintaining river water quality. Flow added to the river system from the Shand, Conestogo, Guelph, Luther and Woolwich reservoirs helps to dilute treated effluent and diffuse source pollution entering the system downstream of the reservoirs.

Figure 6-13, page 6-21, illustrates the portion of river flow provided by adding water to the river system from reservoir storage at key locations throughout the watershed.

7.3 Water-based recreation

Water-based recreation covers a wide variety of activities undertaken by people in or on the water as well as on land adjacent to water bodies. Water-based recreation opportunities are available in the Grand River watershed both on public and privately owned lands. Data collected in 1982 show that opportunities for these activities in the watershed were 3,059,000 for picnicking, 2,029,000 for camping and 2,410,000 for swimming.

The Grand River Conservation Authority is a major provider of water-based recreation facilities at reservoir sites such as Conestogo, Belwood, Elora, Laurel Creek, Shade's Mills, Guelph Lake and Byng Island. Most of these recreation facilities are clustered in the central part of the watershed, although swimming and boating are popular river and lakeshore activities in the lower Grand River.

During 1997, 1.1 million visitors used the Grand River Conservation Authority's conservation areas, and 800,000 people enjoyed the camping facilities. An estimated 7 million dollars of tourist revenue was generated for the local economy by visitors to these areas. Water skiing and boating are popular in the lower Grand River, and fishing opportunities vary from a world-class cold water fishery in the upper reaches of the Grand River and some tributary headwaters, to warm water sport fishing (i.e., bass) in stretches of the main Grand River.

Canoeing and kayaking are becoming more popular, with several canoe livery companies now established, mainly in the central and lower part of the watershed. More information is needed on the number of recreational users of the river, including anglers and boaters, and the issues associated with increased use. These issues include water quality and quantity, access facilities, riverside landowner concerns, and potential conflicts between some different forms of river recreation.

7.4 Fish and wildlife

7.4.1 Surface water quantity

The protection of water quantity is a key component of Ontario's water management strategy. Management of water quantity is needed to avoid conflicts among various users. Water quantity and quality are closely related, as the amount and physical characteristics of water available are an important aspect of water quality. Groundwater quantity management is essential for the added reason that groundwater is often an important component of streamflow.

Water quantity management in Ontario involves a combination of common law, land patent, and federal and provincial statutes. The main involvement of the Ministry of Environment and Energy in this field is through the water taking permit system under the Ontario Water Resources (OWR) Act. Specific details are contained in *"Permit To Take Water Program Guidelines and Procedures Manual"*, MOEE, 1984.

Recognizing the many and varied uses of water, the MOEE policy for the management of water quantity is: *"To ensure the fair sharing, conservation and sustainable use of the surface and ground waters of the province"*.

8. WATER QUALITY IN THE GRAND RIVER WATERSHED

8.1 The importance of water quality

Surface water quality directly affects all the major water uses of the Grand River and its tributaries. Fish survival, diversity and growth, recreational activities such as swimming and boating, municipal, industrial and private water supplies, agricultural uses such as irrigation and livestock watering, waste disposal, and general aesthetics are all affected by the physical, chemical, biological and microbiological conditions that exist in the watercourse.

Water quality is influenced by natural conditions such as basin geology. This is observed in the turbid lower Grand River, which flows through large clay plains and receives sediment eroded from them. Biological processes such as plant growth also affect water quality, for instance where algae growth impairs the appearance of the water or affects instream dissolved oxygen concentrations.

Water quality is usually characterized by a series of indicator parameters. Different uses, such as agricultural, industrial, and potable, require different levels of these indicators. Use impairments result when existing water quality is not adequate for the desired use. It is therefore important to identify beneficial water uses in the basin so that appropriate water quality objectives can be determined.

8.1.1 Grand River water quality is improving

In general, water quality conditions throughout the Grand River are substantially improved over those of the late 1960s and early 1970s. All water quality monitoring stations now exhibit 'satisfactory' conditions, and a few upstream stations are considered 'good', but there is also evidence that the improving trend may have slowed or even stopped, probably as a result of rapid urbanization in the basin.

Where water quality impairment currently exists within the basin, it is generally localized and does not affect normal water uses. Upstream reaches have always showed, and continue to show, the best water quality, with quality declining progressively with distance downstream. This deterioration reflects the inputs from point and non-point sources, including sewage treatment plants, industrial activity, urban development, and agriculture throughout the basin. The key water pollutants arising from these sources are oxygen-consuming materials, nutrients (which encourage nuisance aquatic plant growth), bacteria, suspended sediments, trace contaminants and toxic substances. In parts of the basin, particularly urban areas, the causes of water quality impairment are complex. One of the greatest challenges in basin management is therefore to understand the relative contributions of various pollution sources to overall water quality, and to find the most cost-effective combination of measures to restore impaired uses.

8.1.2 Continued improvement is necessary

Nutrient enrichment causing nuisance plant growth continues to affect many of the watercourses, and adversely affects the river's oxygen regime. Phosphorus and (to a lesser extent) nitrogen loads from a variety of sources encourage this nuisance plant growth and therefore the dissolved oxygen problem. Yet phosphorus loads from point sources (like municipal sewage treatment plant effluents) have been greatly reduced in recent years. It is now believed that control of non-point sources (like agricultural drainage) may be an important element in further phosphorus reduction efforts.

Heavy metals, pesticides and industrial organic chemicals have been studied extensively in the Grand River but are rarely found above guideline levels. Spills to watercourses cause water quality problems for water treatment plants, recreationalists and aquatic biota. A reporting system and contingency planning process currently exist; however, spills still occur. No fish species collected from the river is currently unsuitable for human consumption, although pollutant concentrations in some of the larger fish of predatory species such as walleye, northern pike, smallmouth bass and coho salmon are elevated to the point where consumption should be restricted to a few meals per week.

Micorganisms (with the possible exception of *Cryptosporidium*) and heavy metals do not appear to be a serious problem in the Grand River, except in localized areas. *Crytosporidium*, which may originate in areas where poor animal waste management practices occur, is a concern for those that take their water supply from the river.

The following sections examine the watershed uses that affect, or are affected by, water quality, appropriate water quality targets for those uses, and the current "state of the watershed" in terms of water quality. This information then leads to a discussion of the most pressing water quality issues in the basin - areas where existing water quality is inadequate to support desired uses, either now or in the future.

8.2 Water uses affected by water quality

The surface water resources of the Grand River Basin support a rich diversity of water uses, many of which are discussed elsewhere in this report. The following are the uses that are most directly affected by, or themselves affect, surface water quality.

8.2.1 Aquatic life

Aquatic plants and animals are often very sensitive to water quality. Physical parameters such as temperature and suspended solids can affect growth rates and reproductive success. Chemical conditions such as excess phosphorus or oxygen-demanding wastes can create conditions that are toxic to plants and animals. Cold water fisheries, in particular, require pristine water quality including cool temperatures and abundant dissolved oxygen. Many water quality objectives for the protection of aquatic life are based on the needs of sensitive cold water fish species like salmon and trout.

8.2.2 Drinking water supply

People in the Grand River Basin draw their drinking water either from municipally treated supplies or from groundwater (wells). This water use has two important aspects, both of which are related to water quality. First, water for human consumption must meet certain minimum standards to be healthy and safe. And second, the quality of "raw" (untreated) water can have implications for the nature, and therefore the cost, of required treatment.

8.2.3 Recreation

Many recreational activities occur within the Grand River Basin. The most basic of these is probably simple enjoyment of the river's beauty, or aesthetics. Sport fishing is also a popular activity, usually associated with consumption of the fish that are caught. Body contact with river water can occur accidentally or intentionally, for instance through swimming and bathing, wading, or capsizing of small water craft. Here again, the desired water quality will depend on the nature of the use: salmon fishing demands the pristine water quality required by cold water species; swimming requires water with low densities of bacteria and viruses; and occasional ("incidental") water contact can probably occur without adverse consequences in water of poorer quality than either of these. Ideally, water in the basin should be "swimmable" and "fishable", but the water quality interpretation of these terms will likely be different.

8.2.4 Agriculture

Agriculture is a major water user in the Grand River Basin. Typical agricultural water uses include livestock watering, livestock housing wash water, milk house wash water, and water used for irrigation. Some of these uses, such as the wash waters, are also important sources of pollutants. Others, like livestock watering and irrigation water, demand a certain minimum water quality to be safe and effective.

8.2.5 Industry

Industries use water in manufacturing processes, for washing floors and equipment, and for cooling. The quality of water required by an industry will depend on its ultimate use. In some cases, for example food processing or brewing, it is essential to have influent water of the very highest quality, equal to or better than the most stringent criteria. For other purposes, such as cooling waters, quality concerns may be related more to the protection of equipment (for instance against corrosion or build-up) than to the protection of human health or aquatic biota.

8.3 Major contributions to the Great Lakes

Ontario borders on inter-provincial and international waters, and the implications of the Province's activities must be considered in that context. For example, the Province has agreed that the Specific Water Quality Objectives contained in the Great Lakes Water Quality Agreement or more stringent Provincial objectives shall be used in environmental programs to achieve and maintain Great Lakes water quality. Ontario also enforces its own provincial discharge limits and effluent requirements developed by the Federal Government for specific industrial sectors and for specific pollutants.

The following section describes some of the water quality guidelines and objectives that have been developed by the Ontario Government and other jurisdictions.

8.4 Water quality objectives in the Grand River basin

8.4.1 Established water quality objectives

Ideally, we would have provincial objectives for all water quality parameters, and all surface waters in the basin would meet the most stringent of those objectives. In fact, we have only a limited number of criteria to work with (primarily Ontario's Provincial Water Quality Objectives), and although they cover most of the categories listed above, they do not cover all the individual parameters.

Some basin water uses - for instance, aesthetics - do not have established guidelines. In these cases, we can turn to the experience of other jurisdictions with similar uses, or simply rely on community consensus to formulate water management goals.

The following sections describe some objectives already established for water uses in the Grand River and elsewhere in Ontario.

8.4.2 Provincial Water Quality Objectives

Provincial Water Quality Objectives (PWQO) are numerical and narrative criteria which serve as chemical and physical indicators representing a satisfactory level for surface waters (i.e. lakes and rivers) and, where it discharges to the surface, the groundwater of the Province. The PWQO are set at a level of water quality which is protective of all forms of aquatic life and all aspects of the aquatic life cycles during indefinite exposure to the water. The Objectives for protection of recreational water uses are based on public health and aesthetic considerations. Separate Objectives have been established for livestock watering and irrigation waters.

Provincial Water Quality Objectives are intended to provide guidance in making water quality management decisions such as the designation of the surface waters which should not be further degraded. They are often used as the starting point in deriving waste effluent requirements included in Certificates of Approval and other instruments issued to regulate effluent discharges. They are used to assess ambient water quality conditions, infer use impairments, assist in assessing spills and monitoring the effectiveness of remedial actions.

The Ontario Ministry of Environment and Energy has established a comprehensive process for setting Provincial Water Quality Objectives as described in the 1992 MOEE publication *"Ontario's Water Quality Objective Development Process"*. Reference documents providing details on the development of each PWQO are also available from MOEE. The PWQO listing is routinely updated to reflect new or revised Objectives.

Provincial Water Quality Objectives are useful indicators, but not direct measurements, of aquatic ecosystem health. Non-chemical factors such as the loss of habitat, sedimentation, water quantity regulation and the introduction of non-indigenous species often have profound and overriding influences on aquatic ecosystems.

Table 8-1, page 8-5, illustrates the difference in Provincial Water Quality Objectives and/or minimum acceptable water quality for each of the major basin water uses and several key water quality parameters.

TABLE 8-1: COMPARISION OF PROVINCIAL WATER QUALITY OBJECTIVES FOR MAJOR WATER USES.

Comparison of Provincial Water Quality Objectives for Major Water Uses							
Use	**Turbidity (FTU)**	**TP (mg/L)**	**Dissolved Oxygen**	**Copper (ug/L)**	**Zinc (ug/L)**	**Total DDT (ug/L)**	**Fecal Coliforms**
Aquatic Life	<10%Secchi Disk change	0.03	47-58% saturation	5	16	0.00.3	-
Swimming	-	-	-	-	-	-	100/100mL
Drinking	1.0	-	-	1,000	5,000	0.03-	0/100mL
Livestock	-	-	-	500	25,000	50	-
Irrigation	-	-	-	200	2,000	-	-

8.4.3 Candidate substances for bans and phaseouts

Some hazardous substances have been banned from use in Ontario. Candidate substances for bans, phase-outs or reductions are included in Tables 1.7 and 1.8 in the MOEE publication entitled *"Candidate Substances For Bans, Phase-Outs Or Reductions - MultiMedia Revision" (October 1993)*. Because of their inherently hazardous nature, every effort should be made to prevent these substances from gaining access to the environment. From an environmental protection perspective, the application of pollution prevention principles - that is, avoiding the creation of the pollutants in the first place - is far more desirable than reliance on waste treatment.

The MOEE policies for the management of hazardous substances in surface waters are to ***"Prevent the release, in any concentration, of hazardous substances that have been banned."***

Provincial Water Quality Objectives have been developed for many of the banned hazardous substances. The Objectives are not to be used for the development of new waste loadings for these substances. Rather, they provide a benchmark available to assess the environmental implications of past releases or accidental losses and remediation work.

8.4.4 Other water quality guidelines and objectives

The Ontario Drinking Water Objectives, published by the Ministry of Environment and Energy, contains a comprehensive list of treated drinking water objectives primarily employed for the protection of public health. The Canadian Water Quality Guidelines, published for the Canadian Council of the Ministers of the Environment, contain a wide range of specific-use objectives including agricultural uses and industrial water supplies.

The United States and Canada jointly agreed on a range of water quality objectives under the Great Lakes Water Quality Agreement, most recently ratified in 1987[1]. Although these objectives have no weight under the law, they reflect a fundamental agreement between the two signatory parties on acceptable water quality. The Ontario PWQO are closely modelled on this list.

Health and Welfare Canada sets guidelines for various parameters that have the potential to affect human health. These include guidelines for water quality where the water is intended for recreational water use, and also drinking water guidelines. These targets are usually, but not always, similar to those set by provincial agencies, and sometimes address parameters not included in provincial guidelines.

Although not strictly speaking concentration guidelines, the MOEE-MNR *"Guide to Eating Ontario Sport Fish - Southern Ontario"* provides guidance on which fish species and sizes may pose a human health concern. This guide is published annually by the two ministries and distributed widely in Ontario, notably in Brewer's Retail outlets, free of charge. The fish consumption advisories rely on measurements of a range of contaminants including mercury, mirex, and DDT but do not make explicit reference to tissue concentrations in the published text. A wide variety of fish have been collected in the lower Grand River (Caledonia to Dunnville) and the Speed River near Preston. Over the past decade, close to 50,000 fish from throughout Ontario have been analyzed for trace contaminants. In light of this background, the fish collected from the Grand River are typical of an urbanized watercourse.

8.5 Current water quality conditions

8.5.1 Using water quality data as a decision-making tool

Water quality monitoring programs should be designed to answer certain specific questions, particularly questions about whether the water is suitable for drinking, swimming, and other beneficial uses. This means that we must make decisions about which parameters to examine, and how frequently to monitor them. Ideally, this should yield a data set that can be readily interpreted and compared with other data from past programs or other systems, or with established water quality guidelines. If water quality is found to be below guideline levels, there is, in theory, a clear indication of where water quality is impaired and remedial action may be required.

[1] International Joint Commission. 1988. Revised Great Lakes Water Quality Agreement of 1978, as Amended by Protocol Signed October 7, 1987. IJC, Ottawa and Washington.

The comparison of existing with ideal conditions is not, however, as simple as it sounds. The high cost of sample collection and analysis means that we can only afford to take a few samples at each location each year, and must estimate ambient conditions from those few samples. One of the problems we face in interpreting these data is that conditions in the river are sometimes highly variable, because it is continually responding to changes in inputs, meteorological conditions (e.g. rainfall and snowmelt), and other factors like lake effects. Special studies by MOEE in the early to mid-1980s examined the magnitude of variation in total phosphorus concentrations in the Grand River at Dunnville. That station is clearly influenced by lake conditions, both flow and quality, yet even so the daily variability of this parameter is surprising.

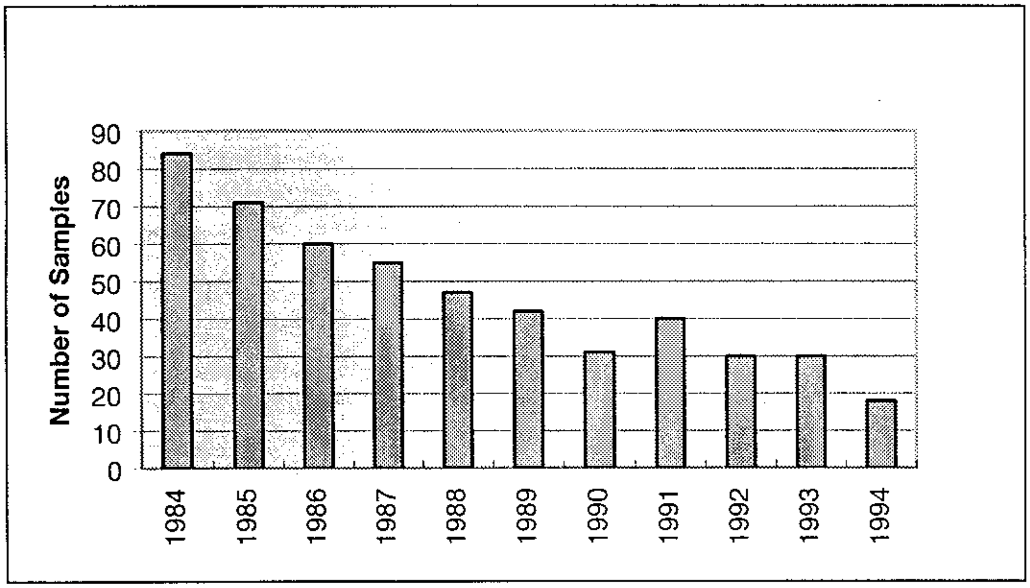
Even at calm, low-flow conditions in late summer, phosphorus concentrations were observed to change by 25 to 30% within an hour. At high flow conditions in the spring melt, fluctuations as high as 120% were seen over an hour period. In fact, phosphorus concentrations were never the same in two subsequent samples, almost always differing by 15 to 30%. Depending on when samples were collected, the "average" value calculated could differ by as much as an order of magnitude. (An example from March, 1993, illustrates this point. In that month, three measurements of total phosphorus were taken at Dunnville, showing concentrations of 0.4000 mg/L, 0.240 mg/L, and 0.0380 mg/L respectively. Although we can calculate an average of these three values, that average - which is 0.226 mg/L - may or may not reflect conditions that were truly typical - 'average' - through that month.)

It is particularly difficult to evaluate trends over time when we have only small sample sizes to work with, because it's difficult to determine whether the changes we see are a result of real changes in the river or simply random variability. In recent years, fewer and fewer samples have been collected in the Grand River, even for routine parameters like total phosphorus, simply because of progressive cuts in available operating funds.

Figure 8-1, on page 8-8, shows this decline graphically for total phosphorus at Dunnville. Declining sampling frequency has made it increasingly difficult to determine whether a downward (improving) trend actually exists in important parameters such as total phosphorus. For some parameters like trace contaminants, which are measured only occasionally, it may only be possible to determine that the substance is present or absent, but not to estimate its concentration.

A further challenge in understanding water quality is simply finding all the available data. In the Grand River, several levels of government and a variety of agencies (e.g. Ministry of Environment and Energy, Regional Municipality of Waterloo, local municipalities such as Guelph and Brantford, the Grand River Conservation Authority, and members of the Six Nations at Brantford) conduct monitoring of water quality. University researchers and consultants collect additional data for specific projects. The data are held in several locations and in various formats, significantly complicating not only data analysis but even data retrieval. With time, we hope to compile a complete inventory of past and current monitoring stations, sampling dates, and results.

Figure 8-1: NUMBER OF TOTAL PHOSPHORUS SAMPLES COLLECTED AT DUNNVILLE, 1983-1994



Some monitoring is necessary to meet legislative requirements, for instance, for the provision of safe drinking water. Although groundwater is the primary source for domestic water supply in the Grand River watershed, there are areas where surface water is taken and treated for domestic needs. There are a number of groundwater infiltration areas in the basin using detention storage or streamflow as input. For this reason, continued knowledge of ambient conditions of the surface water is necessary to protect drinking water supplies and other beneficial uses.

Water quality monitoring is also required in support of other monitoring programs. For example, water quality monitoring is an important adjunct to fisheries assessment, because it can help explain the presence or absence of certain sport, prey, or nuisance species. Fisheries and wildlife habitats are primary concerns within the Grand River watershed. The Grand River at Dunnville provides and sustains a major spawning habitat for walleye, and is a designated fisheries rehabilitation area of MNR. There are other areas of fisheries concerns, including as Elora, Fergus, West Montrose, Whiteman's Creek, and Mill Creek (primary habitat areas for brown trout).

The following sections give an overview of water quality conditions in the Grand River, based on current and historic studies.

FIGURE 8-2: WATER QUALITY PARAMETERS CURRENTLY MONITORED IN THE GRAND RIVER BASIN

Conventional Parameters

Alkalinity, Total
Alkalinity, Inflection Point
Chloride, Unfil.Reac
Conductivity, Ambient
Conductivity, 25c
Dissolved Oxygen
Carbon, Dissolved Organic
pH Field
pH (-Log H+ Concn)
Stream Condition
Temperature, Water,
Hardness, Total
Residue, Filtered (Dissolved Solids)
Residue,Particulate (Suspended Solids)
Residue,Total (Total Solids)

Heavy Metals

Aluminum, Unfiltered Total
Arsenic, Unfiltered Total
Cadmium, Unfiltered Total
Chromium, Unfiltered Total
Copper, Unfiltered Total
Lead, Unfiltered Total
Mercury, Unfiltered Total
Nickel, Unfiltered Total
Zinc, Unfiltered Total

Nutrients

Ammonium, Total Filter.Reac
Nitrates Total, Filter.Reac
Nitrite, Filtered Reactive
Nitrate, Filtered Reactive
Nitrogen,Tot,Kjeldahl
Phosphorus, Unf.Reactive
Phosphate,Filtered Reactive
Phosphorus,Unfiltered Total
Endrin Aldehyde
Endrin
Endosulfan,Sulphate

Microbiological Parameters

Escherichia coli Mf
Fecal Coliform Mf
Fecal Streptococcus Mf

Trace Organic Compounds

Alachlor
Metalachlor
Aldrin
Hexaclorocyclohexane, Alpha-BHC
Hexaclorocyclohexane,Beta- BHC
Hexaclorocyclohexane,Delta- BHC
Hexaclorocyclohexane,Gamma BHC
Chlordane,Alpha
Chlordane,Gamma
DDT Total
Dieldrin
DMDT Methoxychlor
Endosulfan,Total (Calculated)
Endosulfan I
Endosulfan II
Heptachlorepoxide
Heptachlor
Mirex
Oxychlordane
Octachlorostyrene
OP-DDT
PCB Total
PP-DDD
PP-DDE
PP-DDT
Atrazine
Cyanazine
Cyprazine
Atrazine,Deethylated
Prometone
Propazine
Prometryne
Sencor
Simazine
Dicamba
MCPA
MCPB
Mecoprop
Picloram
Silvex
2,4 Dichlorophenoxyacetic Acid
2,4 Dichlorophenoxybutyric Acid
2,4 DP
2,4,5 Trichlorophenoxyacetic Acid
Chlorofenvinphos
Demeton
Diazinon
Dimethoak
Dursban
Ethion
Guthion
Leptophos
Malathion
Phosalone
Parathion
Phosmet
Carbofuran
Carbaryl
Cycloate
Eptam
Molinate
Pebulate
Propoxur
Sutan
Trichlorobenzene 1,3,5
Vernolate
Hexachlorobutadiene
Hexachlorocyclopentadiene
Hexachloroethane
Hexachlorobenzene
Hexachlorocyclobutadiene
Hexachloroethane
Octachlorostyrene
Pentachlorobenzene
Trichlorotoluene 2,3,6
Trichlorotoluene 2,4,5
Trichlorotoluene 2,6,A
Trichlorobenzene 1,2,3
Tetrachlorobenzene 1,2,3,4
Tetrachlorobenzene 1,2,3,5
Trichlorobenzene 1,2,4
Tetrachlorobenzene 1,2,4,5

8.6 Indicators of water quality

The guidelines described above cover a range of parameters. Space does not permit a full listing of these, but the following sections give an overview of the major types of water quality indicators.

8.6.1 GRCA's Water Quality Index

8.6.1.1 *Description*

The foregoing discussion illustrates the complexity of assessing water quality conditions in the Grand River: a location may exhibit good quality for certain parameters but poor quality for others. One useful approach to overcoming this problem is to use a composite index, and considerable research has been conducted on what can and should form part of such an index.

In the early 1970s, the Quebec Ministry of Natural Resources developed a water quality index to assess waters intended for aquatic life with a low tolerance level (for instance, salmon and trout). GRCA has used this index as a measure of overall water quality since the early 1980s, when it was first used as part of the Grand River Basin Water Management Study[2]. The index incorporates information about oxygen, pH, suspended solids, water temperature, and turbidity. It does not include nutrients, alkalinity, metals, phenols, PCBs, or pesticides, and thus is more useful for a general evaluation of potential impacts on aquatic biota than for impacts on the health of humans or other organisms.

The index is based on statistical relationships between the concentrations of individual parameters and overall water quality, generally expressed as linear equations with the parameter rating as the dependent variable. The ratings, or scores, for each parameter - values from 0 to 100 - are then multiplied together, with each parameter weighted to reflect its overall contribution to water quality. The annual water quality index value is computed as the average of all monthly index values.

The index is calculated as follows:
(DO = dissolved oxygen; SS = suspended solids, Turb = Turbidity):

Water Quality Sub-ratings:

Qi DO $= 8.824x - 2.044$
Qi pH $= 75x - 431.25$ if $pH \leq 7.1$
$= -26.83x + 289.64$ if $pH \geq 7.1$
Qi SS $= -1.60x + 101.0$
Qi Temp $= -5.86x + 130.21$
Qi Turb $= -3.96x + 99.0$
Where x is the value of the parameter at a given location.

[2] See: Baker, M. 1987. Grand River Valley water quality index and surface water quality trends 1970s-1980s. Cambridge. Grand River Conservation Authority.
Annett. T. 1996. The Grand River Water Quality Index and Surface Water Quality Trends 1970s-1990s. Cambridge. Grand River Conservation Authority.

Baker (1987) explains the Water Quality Sub-Ratings as follows:

Water Quality Sub-Rating	Water Quality Evaluation
100	Excellent
≥ 85	Very Good (for given use)
≥ 75	Good (for given use)
≥ 60	Satisfactory (quality not good but water still considered usable)
< 60	Poor (water not usable as is, requires treatment to improve its quality)
1	Very poor (water usable only on short-term basis with normal treatment; long-term treatment would be complex and costly.

The Water Quality Index is then calculated from the individual water quality sub-ratings as follows:

Water Quality Index:

$WQI = (Q_1)^P \times (Q_2)^P \times (Q_3)^P \times (Q_4)^P \times \ldots \times (Q_n)^P$

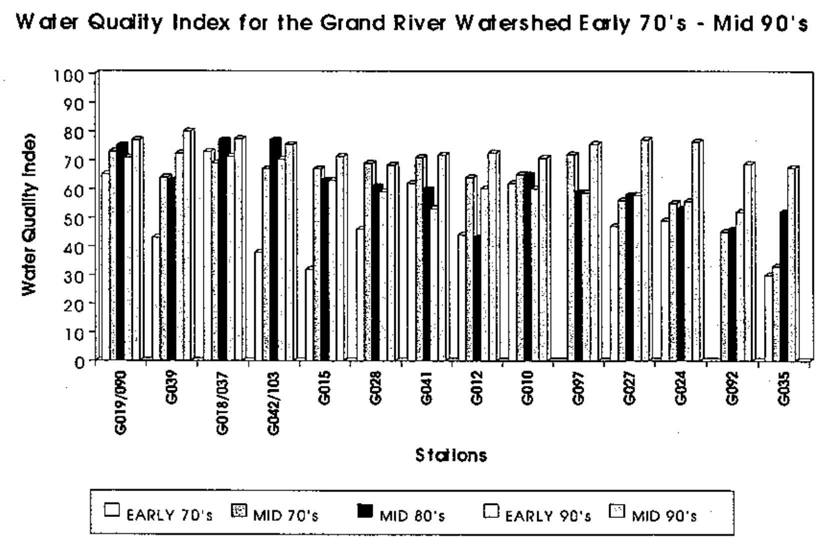
Where: Q_i = water quality sub-rating for parameter I (values between 1 and 100)

P_i = weighting of the i^{th} parameter, a number between 0 and 1 chosen such that the sum of all weights = 1.0)

8.6.1.2 Recent findings: Water Quality Index trends 1970-1996

Generally speaking, water quality is better in upstream reaches of the Grand River than in the middle and lower reaches. This spatial trend, which has probably existed for many decades, is clearly illustrated in Figure 8-4, page 8-13 (the horizontal axis shows station locations from upstream, on the left, to downstream, on the right).

FIGURE 8-3: ANNUAL WATER QUALITY INDEX VALUES FROM EARLY 1970'S TO MID 1990'S



Upstream stations reflect relatively low loadings (inputs) of suspended solids, phosphorus and Kjeldahl nitrogen, although loadings of these pollutants increase steadily with downstream distance. Between Fergus/Elora and the West Montrose area, intense agricultural activities contribute significant additional pollutant loads. The tributaries to the Grand River are smaller streams, often with intense agricultural activity within their basins. The combination of modest flows and heavy pollutant loads sometimes makes the water quality in these tributaries significantly worse than in the main stem of the Grand River. Tributaries are, therefore, often important pollutant sources in their own right to the Grand River.

Examination of historic records reveals that water quality in the late 1960s and early 1970s was poor through much of the watershed (see Figure 8-4, page 8-11), although only a few years later much of the river had recovered to satisfactory levels (Figure 8-6, page 8-14). Data for the Speed River show degraded water quality in the early 1970s, with some recovery (to satisfactory) by the mid 1970s, except downstream of the Guelph sewage treatment plant, where conditions remained poor. On the Nith River, all stations were poor in the early 1970s, with slight improvement to satisfactory at Paris by the mid 1970s. Water quality in Alder Creek was reasonably good from the early 1970s to the early 1980s but by the mid 1980s had begun to deteriorate slightly. Water quality in the Conestogo River was similarly “poor” from Conestogo Dam to St. Jacobs in the early 1970s and through the mid 1970s.

FIGURE 8-4: WATER QUALITY INDEX IN THE EARLY 1970'S

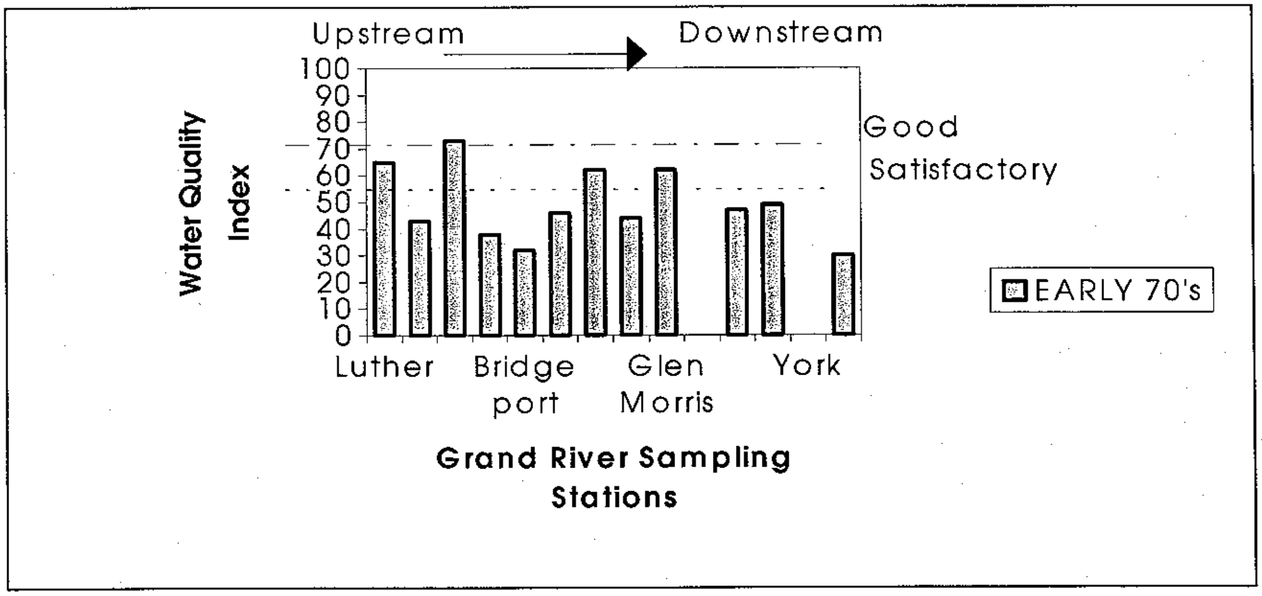
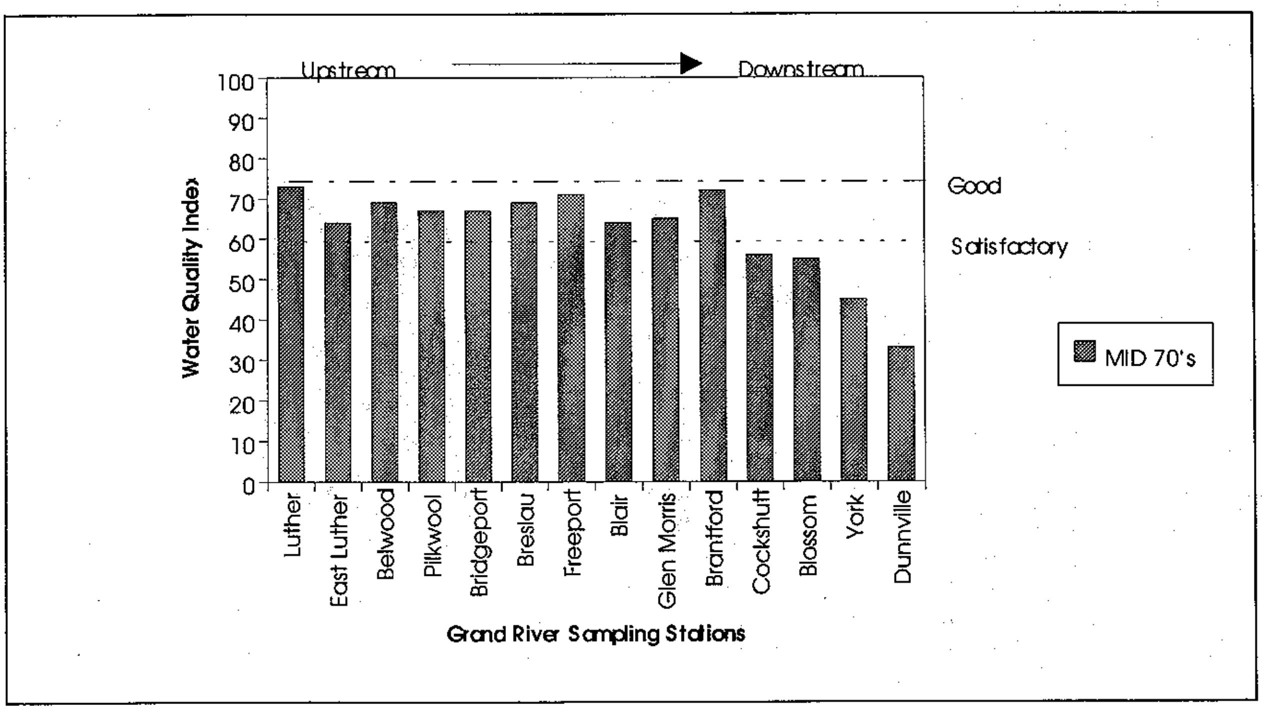
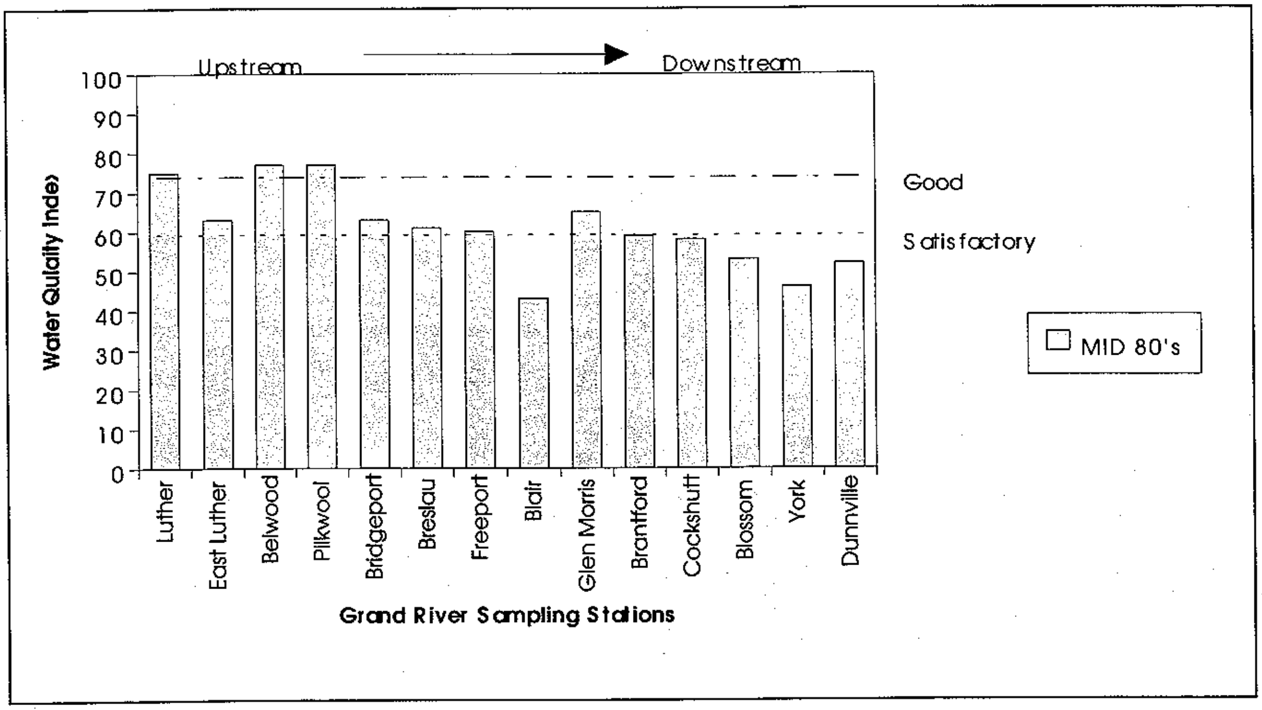


FIGURE 8-5: WATER QUALITY INDEX IN THE MID 1970'S



Despite the improvements observed by the mid 1970s, overall quality in the river had deteriorated once again by the mid 1980s, perhaps in response to the basin's growing population and associated pollutant inputs (Figure 8-6). In the Speed River, the good water quality of the early 1980s showed some deterioration, especially downstream of the Guelph Sewage Treatment Plant, in the mid-1980s. (The lack of data for the Eramosa River prevented a parallel analysis being conducted for that river). In the Nith River, all stations showed satisfactory quality by the early 1980s, but again this quality deteriorated slightly through the mid 1980s. Water quality in the Conestogo River in the early 1980s had improved to the point that two stations showed satisfactory status, although quality was generally lower from County Road #7 downstream to St. Jacobs. The overall quality of the Conestogo River remained generally "satisfactory" into the mid 1980s.

FIGURE 8-6: WATER QUALITY INDEX IN THE MID 1980'S



By the early 1990s, some improvement was observed at most stations, with satisfactory or good conditions at most stations. This improvement has continued to the present time when conditions are seen to be satisfactory or good throughout the basin, and excellent in the most upstream locations. See Figures 8-7, and 8-8, page 8-15.

FIGURE 8-7: WATER QUALITY INDEX IN THE EARLY 1990'S

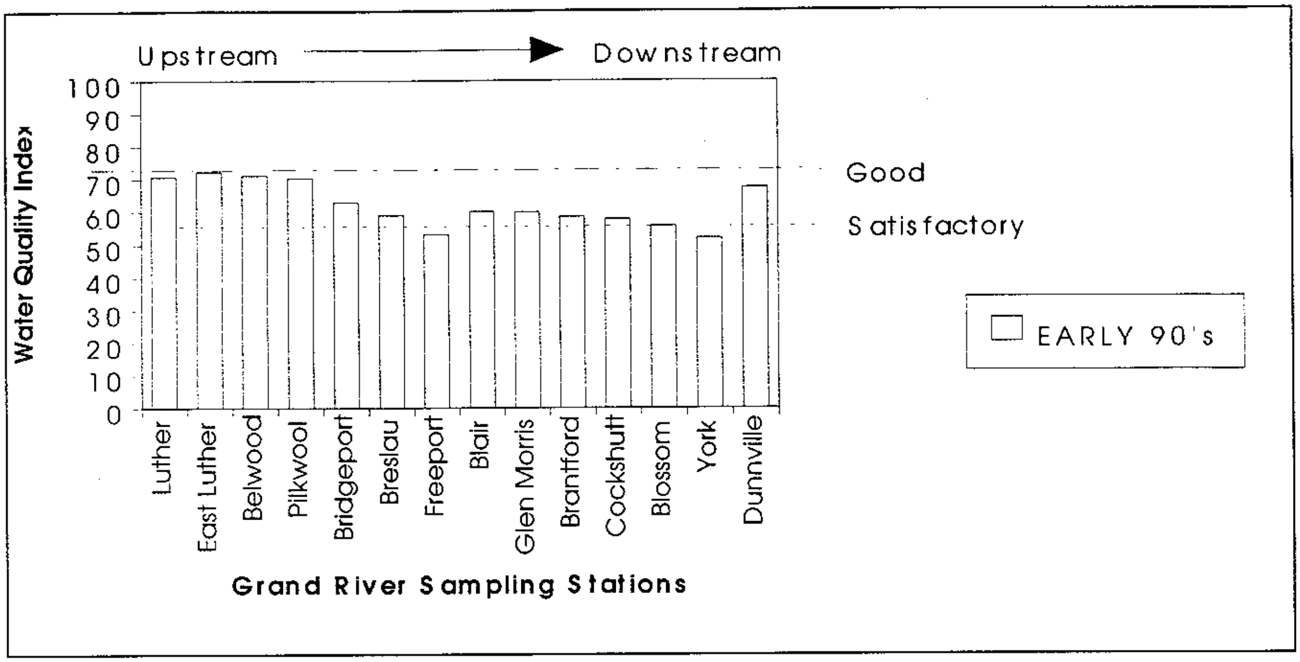
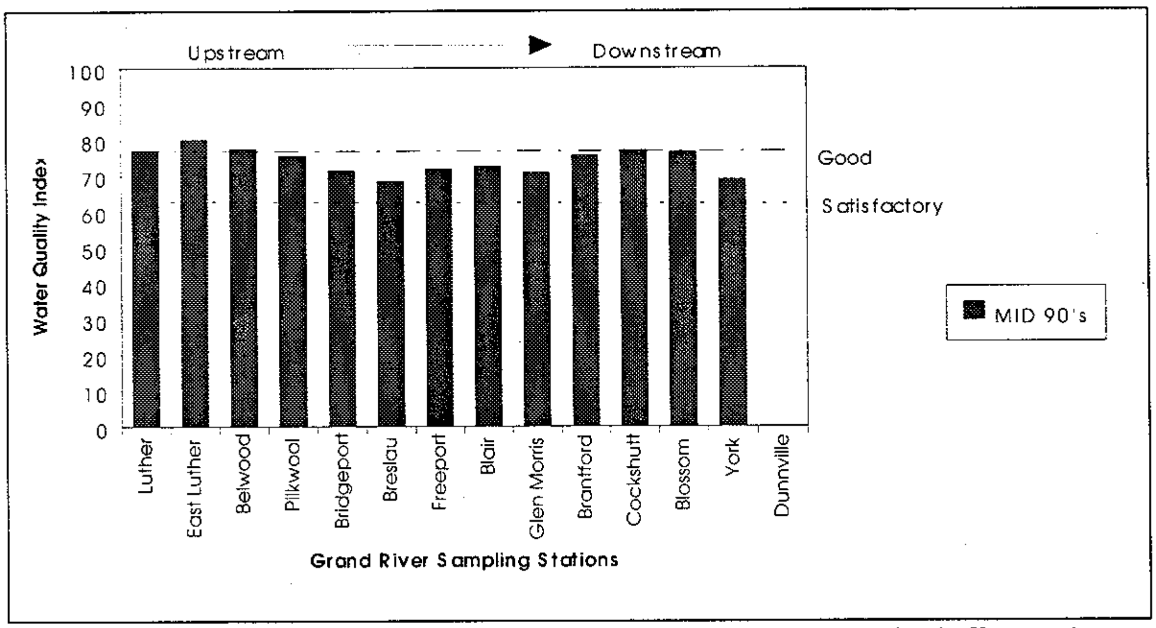


FIGURE 8-8: WATER QUALITY INDEX IN THE MID 1990'S



These results give us much to be proud of, because they represent the combined efforts and financial resources of many people working together to improve water quality in the Grand River - and succeeding at that task.

Yet a close examination of individual water quality parameters shows that some areas are still under stress. The task that lies ahead of us is to continue improving water quality even though development in the basin is certain to increase. More development means more land clearance, more impervious surfaces, more industrial growth, and more point and non-point source discharges. Our challenge is to plan now for pollution control actions that will allow this growth to continue while protecting valued water resources in the basin. The following sections discuss the status of individual water quality indicators throughout the basin.

8.7 Chemical indicators of water quality

8.7.1 Dissolved oxygen

8.7.1.1 Description

Dissolved oxygen is one of the most important parameters in water quality management. Adequate dissolved oxygen levels have to be maintained in surface waters for the healthy functioning of aquatic ecosystems and for the biological assimilation of organic and nitrogenous wastes. Normally, it is not a surplus of dissolved oxygen that is of concern, but rather a deficiency or complete absence thereof and excessive variation.

The Provincial Water Quality Objective for dissolved oxygen (DO) is a function of temperature. For warm water biota, concentrations of dissolved oxygen should stay above concentrations ranging between 4 mg/L (summer months) to 7 mg/L (winter months). Adequate dissolved oxygen concentration to support aquatic life depends on the species being considered. The Ministry of Environment and Energy sets a higher criterion of 5 mg/L at 20 deg. C for cold water fish species and a criterion of 4 mg/L at 20 deg. C for warm water fish. The latter generally applies to the monitored region of the central Grand River. Higher DO is generally required during spawning seasons in the spring and fall periods.

Dissolved oxygen levels can fluctuate widely, especially when abundant plant growth is present. This is because plants have two dominant oxygen-related processes: respiration and photosynthesis. Photosynthesis is the process by which plants produce oxygen (and carbohydrates) in the presence of light. Respiration is a process of cell maintenance that is a net oxygen consumer. Where plant growth is abundant, dissolved oxygen (DO) levels are typically very high during the day (from photosynthetic production of oxygen) but much lower at night (as a result of respiration). During the May-July maximum aquatic plant growth season, the diurnal DO cycle is most pronounced and the amplitude of this fluctuation is a reflection of the density of aquatic weed growth.

8.7.1.2 Recent findings

Minimum daily DO for both Blair and Bridgeport for 1989-1994 indicate occasional violations of a 4 mg/L criterion (the warm water fishery target). This represents little improvement over conditions that existed during the Grand River Basin Water Management Study (1982), when DO would typically violate this criterion at Bridgeport about 5% of the time.

Currently, summer daily minimum DO levels at Bridgeport are, however, low enough to be of concern, and maximum daily DO at Bridgeport does show a fairly clear increasing trend over the last five years, particularly in the May-June peak plant growth period. This observation is of concern because it suggests that attached algae and rooted macrophytes (e.g. Eurasian milfoil) and other plants have increased in density in the monitored river sections.

Higher maximum DO indicates that there is a risk of lower minimum DO occurring, which may be sufficiently low to be a risk to aquatic life.

Further analysis appears to be warranted. If the loads of oxygen demanding materials (BOD) increase, or if additional nutrient enrichment results in increased plant growth, these already-marginal DO levels will certainly deteriorate further. Analysis of data from the last five years shows that minimum DO concentrations do not appear to worsen between Bridgeport and Blair stations, even though additional nutrients probably enter the river through that reach. This suggests that additional plant growth may be discouraged by factors other than nutrient limitation, perhaps shading or inappropriate substrate. Nutrient loadings through this zone, mainly from the Kitchener sewage treatment plant, do however result in major increases in plant growth further downstream. Maximum daily DO concentrations for the Blair Station do not show any clear trend over the last five years

Exceedances of dissolved oxygen targets in the lower Grand River are consistently more frequent than in upstream reaches and appear to be directly related to plant growth and phosphorus. Phosphorus sources to this area may therefore be possible targets for future remedial action.

8.7.2 Suspended sediments (particulates)

8.7.2.1 Description

In natural watercourses, suspended solids consist normally of erosion silts and clays, organic detritus and plankton (algae). The impact of human activities, however, alter and augment the suspended solids in surface waters by the discharge of municipal and industrial wastes, increased erosion from deforested and cultivated areas, urban storm drainage, commercial gravel washing operations, and various other activities.

Some suspended solids particularly clays are colloidal, that is they virtually always remain in suspension, whereas much of the particulate matter will settle to the bottom of a river, lake or reservoir if the velocity or currents are slow. At high velocities, previously settled solids will be scoured from the bottom, resuspended and carried downstream.

Suspended sediment concentrations vary significantly from river reach to reach, and from season to season in the Grand River. Aside from giving the river a turbid or muddy appearance, the elevated concentrations measured in some areas do not seem to have a significant impact on uses such as municipal water supply and aquatic life.

Probably the most significant aquatic environmental factor concerning suspended sediments in the Grand River is the fact that clays and silts can adsorb and transport other pollutants such as phosphorus, heavy metals and organic compounds such as pesticides.

There is currently no PWQO for suspended solids; rather, existing policy recommend that ambient levels of turbidity not increase by more than 10%.

8.7.2.2 Recent findings

1993 data for the Grand River show a clear increasing trend from low suspended solids concentrations in headwater regions (usually less than 5 mg/L) to higher levels downstream of urbanized areas (typically 10-30 mg/L at Blair, Glen Morris, and Brantford), and with highest levels at locations farthest downstream (e.g. often over 30 mg/L at York and Dunnville).

The Conestogo, Nith and Speed Rivers are significant contributors of suspended solids to the river because of the extensive agricultural activities in their basins and, in some cases, because of local geological conditions.

Suspended solids is one of the parameters most dramatically affected by meteorological conditions, because it reflects solids transported by rainfall and runoff from urban and agricultural areas. As a result, it is usually highly variable over the year, and even over a single day. These factors make it difficult to separate the effects of weather conditions from those of altered inputs, and thus to detect trends that may have resulted from management actions. Nevertheless, there is some evidence from available data that 1993 conditions are somewhat improved over those measured in 1988, when concentrations of this parameters were regularly higher at most stations. This is consistent with trends observed in the Water Quality Index, which includes suspended solids as one of its component parameters.

8.7.3 Phosphorus

8.7.3.1 Description

Phosphorus is an element that is commonly found in nature in the form of phosphates. There are many sources of phosphorus compounds including drainage from undisturbed land and the atmosphere but in the Grand River Basin, phosphorus contributed by municipal and industrial waste discharges and agricultural activities are by far the most significant.

Phosphorus compounds take many forms. Total phosphorus represent all of the phosphorus in the water sample (orthophosphate, polyphosphates and organic phosphorus compounds). Several forms of phosphorus associate with suspended particulate matter and thus distribution patterns (i.e. high spring concentrations) parallel the suspended sediment patterns.

The filtered reactive components of total phosphorus, being dissolved in water, does not generally follow the spatial and temporal suspended sediment patterns.

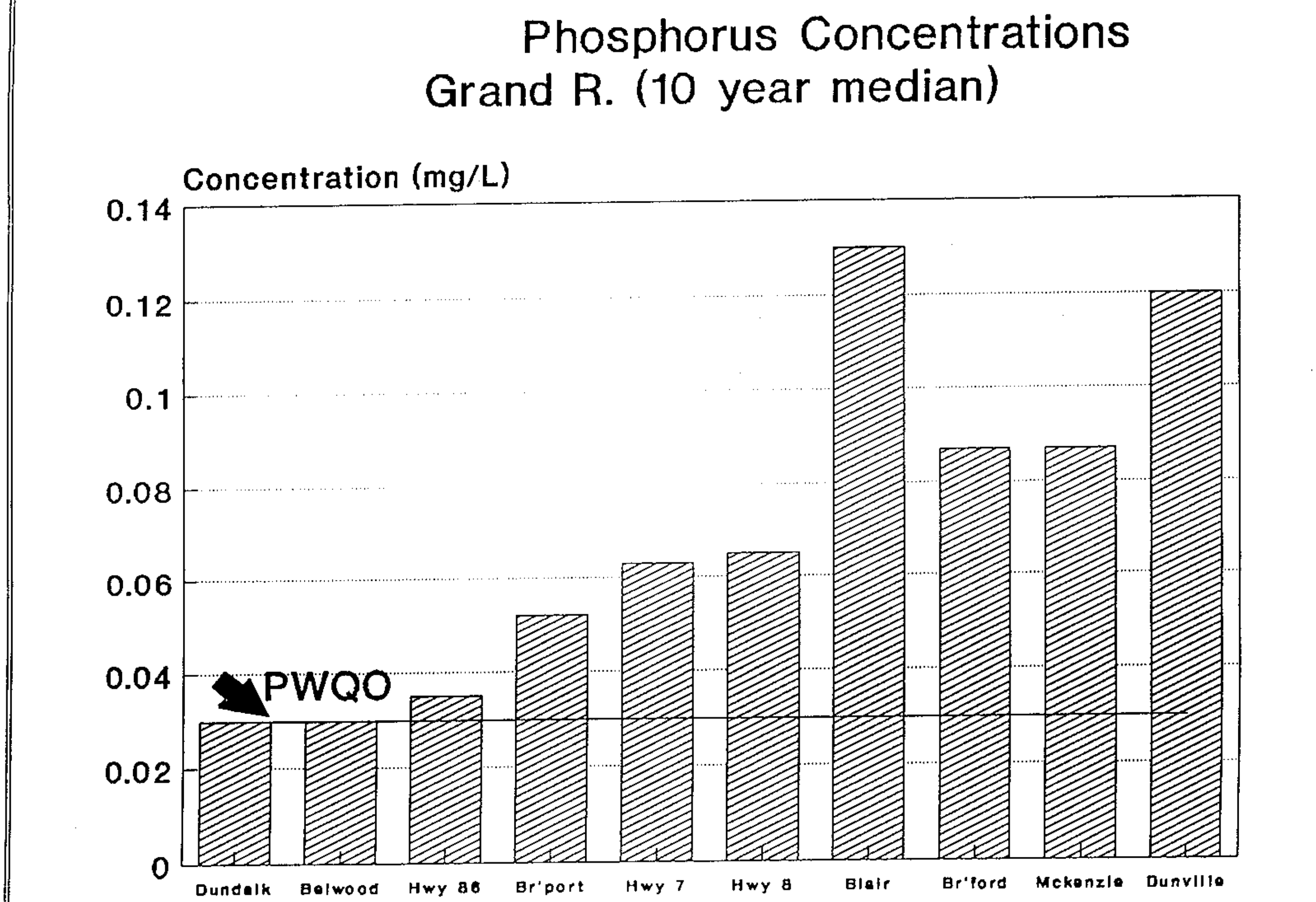
Phosphorus is a primary nutrient for plant and animal life. While the soluble or filtered reactive phosphorus is the preferred form for uptake by algae, it is generally considered that most of the phosphorus may sooner or later be available to algae and, therefore, a general guideline of 0.030 milligrams per litre (mg/L) of total phosphorous has been established by the MOEE to prevent excessive plant growth in rivers and streams.

8.7.3.2 Recent findings

The Pollution from Land Use Activities Reference Group (PLUARG) studies in 1976 revealed that agricultural loads of phosphorus come from runoff from cropland, leachate from faulty septic systems, runoff from manured areas, milkhouse waste water discharge, tile drainage and livestock access to watercourses. Soil erosion from cropland is the largest source of sediment and phosphorus delivered to watercourses, in terms of annual loading. A review of surface water quality in the Regional Municipality of Waterloo (1995) indicates that phosphorus from agricultural sources accounts for 41% of the load observed at Galt.

Routine monitoring by MOEE reveals that phosphorus levels at Dundalk and Belwood are the lowest in the basin and are usually in compliance with the PWQO of 0.30 mg/L, but rise steadily with downstream distance. Recent monitoring by the RMOW showed that phosphorus increases from low levels upstream of Bridgeport to average concentrations around 0.06 mg/L at Bridgeport and Highway 8, to much higher levels (0.1 to 0.3 mg/L) at Dunnville. At Dunnville, total phosphorus levels virtually always exceed the guideline, sometimes by a factor of 10 or more. "Average" concentrations are on the order of 0.13 mg/L, but there is considerable variability around this value. Although a slight decreasing trend is apparent from 1993 to 1994, the high daily, seasonal, and annual variability of results at this site makes it difficult to determine whether this trend is real or an artifact of sampling frequency. Like suspended solids, to which phosphorus often attaches, this parameter is strongly affected by rainfall/runoff conditions, and tends to exhibit the highest concentrations at periods of spring snowmelt and runoff. Also like suspended solids, phosphorus loads from the Conestogo, Nith and Speed Rivers are often high as a result of intensive agriculture in those basins.

FIGURE 8-7: PHOSPHORUS CONCENTRATIONS IN THE GRAND RIVER (10 YEAR MEDIAN)
(from Review of Surface Water Quality Protection Measures, July 25, 1995, Regional Municipality of Waterloo Report)



PWQO=Provincial Water Quality Objective

8.7.4 Nitrogen

8.7.4.1 Description

Nitrogen occurs abundantly in nature and is an essential nutrient for all living organisms. Aside from natural sources, municipal wastewater discharges and agricultural activities are prime nitrogen contributors in the Grand River basin.

As well as being a nutrient, nitrogen has other aquatic environmental significance. The organic compounds of nitrogen place significant demands on a waterbody's dissolved oxygen resources while they are being oxidized to the stable nitrate form.

A fraction of the filtered ammonia component of total Kjeldahl nitrogen can be toxic to aquatic life. This component, un-ionized free ammonia, varies significantly with water temperature and pH. Since warm water and alkaline conditions result in elevated un-ionized free ammonia concentrations, summer conditions are most critical for this parameter. The provincial objective for un-ionized free ammonia is 0.02 mg/L. It occurs naturally in low concentrations (0.002 mg/L) and is present in higher concentrations in wastes discharged from sewage treatment plants (in the order of 0.5 mg/L) or direct runoff from livestock operations. It can occur at levels approaching the provincial objective in the deep water areas of reservoirs during the summer stratification period.

The nitrite and nitrate components of total nitrogen can be of concern to human health (particularly infants) if water supplies contain high concentrations of these substances. MOEE drinking water quality criteria suggest that nitrate (N) should not exceed 10 mg/L. Concentrations in the Grand River fall well below this.

8.7.4.2 Recent findings

The main sources of nitrogen in the basin are municipal sewage treatment plant effluents, runoff from lands treated with nitrogen fertilizers or manures, and drainage from feedlots and manure storage facilities. In our watershed, this parameter is of less concern than phosphorus in terms of its tendency to promote nuisance plant growth. A more serious concern with nitrogen compounds is their impact on the river's oxygen regime. Evidence from recent studies in the RMOW indicates that the nitrogenous oxygen demand of sewage treatment plant effluents far exceeds the carbonaceous oxygen demand (that is, the oxygen used in breaking down carbon-containing wastes). Although there is little information available to demonstrate this, estimates of the proportion of un-ionized free ammonia in some sewage treatment plant effluents suggest that levels may sometimes be high enough to be toxic to aquatic life. The MOEE does not currently impose specific limits on nitrogen compounds in sewage treatment plant effluents.

A significant quantity of nitrogen is also released from non-point sources in the basin. As with suspended solids, these loads tend to be small in upstream reaches but increase significantly in areas of intense agriculture and near urban centres like Guelph and Waterloo. Typical runoff concentrations are on the order of 3.5 mg/L Total Kjeldahl Nitrogen. Consultant reports commissioned by the RMOW suggest that agricultural sources of nitrogen may be at least as important as sewage treatment plant effluents in the Region, comprising more than a third of total nitrogen loads to the river.

Below Brantford, the impact of the Nith River loading and inputs from the WWTP and urban stormwater drainage from Brantford are clearly seen. From this point through Caledonia to the mouth, loadings remain high, although total Kjeldahl nitrogen (and suspended solids) levels show slight reductions over this reach, probably because of reduced agricultural intensity and reduced river velocities encouraging particulate settling.

8.7.5 Trace contaminants

8.7.5.1 Description

Trace contaminants are substances such as heavy metals, pesticides and industrial organic compounds which may occur in water in the parts per billion range or less. These substances, acting individually or in combination with other substances, can cause death, disease including cancer, behaviour abnormalities, genetic mutations, physiological malfunctions, malfunctions in reproduction or physical deformities in organisms (plants and animals, including humans) or their offspring. The consequences of contaminating the environment with hazardous substances may also include a loss of valuable species, restrictions on important socio-economic activities or a variety of irreversible ecological changes that threaten future use and enjoyment of the environment. Substances such as mercury, in its organic or methylmercury form, and some organic compounds such as mirex and polychlorinated biphenyls (PCBs) can bioaccumulate in fish, sometimes to the point where consumption by humans should be restricted or stopped. Elevated levels of trace contaminants can also affect the suitability of water for municipal water supply or agricultural uses such as livestock watering and irrigation.

Metals are elements of the earth's crust and can be found naturally in low concentrations virtually everywhere. They are also found in sewage treatment plant discharges, industrial wastes, urban stormwater drainage and rural land drainage. Domestic and industrial effluents from municipal sewage treatment plants and urban land drainage, including atmospheric fallout of pollutants such as lead from automobile exhaust, appear to be the most significant sources of metals in the Grand River Basin.

The Ministry of Environment and Energy has established objectives for the protection of aquatic life and drinking water criteria for metals. The aquatic life objectives are more recently developed and much more stringent than the drinking water criteria.

TABLE 8-2: MOEE OBJECTIVES FOR METAL

	Aquatic Life Objective (PWQO)	Drinking Water Criterion
Total Aluminum	0.075 mg/L	no Provincial objective
Total Lead	0.005 mg/L	0.05 mg/L
Total Cadmium	0.00045 mg/L	0.005 mg/L
Total Zinc	0.016 mg/L	5 mg/L
Total Copper	0.005 mg/L	1 mg/L

The Provincial Water Quality Objective for lead was recently revised downward from 25μ/L to 5 μg/L. (Lead concentrations are strongly dependent on alkalinity and hardness. The quoted PWQO values are those corresponding to observed hardness/alkalinity conditions in the Grand River basin).

Pesticides and many industrial organic compounds do not occur naturally and their presence is attributable to human activities. Pesticides, including herbicides, fungicides, and insecticides are used for insect and weed control in both rural and urban areas and are found in runoff from both types of areas and in sewage treatment plant discharges. Industrial organic compounds are usually virtually everywhere. Electrical equipment, paints, solvents, caulking compounds, printing ink, plastics, cosmetics and pharmaceuticals are only a few of the products in which industrial organics have been used. Because of their widespread use, these compounds are sometimes present in sewage treatment plant discharges and land drainage, most notably from urban areas.

The dioxin compound 2,3,7,8-TCDD is an extremely toxic organic chemical found as unwanted by-product in the herbicide 2,4,5,-T. During the 1960's large quantities of 2,4,5,-T were processed at Uniroyal Ltd. in Elmira. Small traces of this compound have been found in the groundwater aquifer beneath the Uniroyal property.

The Ministry of the Environment and Energy presently conducts one of the most extensive monitoring trace contaminant programs in the province on the Grand River, examining a wide range of compounds at five locations on the Grand four times a year. This program has been in place since 1986.

Provincial Water Quality Objectives exist for a range of pesticides and industrial organic compounds, although many others currently lack guidelines. In the Grand River, measured amounts of these materials virtually never exceed existing objectives, and those individual objectives will not be listed here. The full range of PWQO may be found in MOEE's publication *"Water Management Goals, Policies, Objectives and Implementation Procedures of the Ministry of the Environment"* (1994).

8.7.5.2 Recent findings

Levels of metals recently reported by the Regional Municipality of Waterloo (RMOW) (1995) reveal low concentrations of most parameters. Concentrations are highest at times of high flow, probably because metal compounds are often adsorbed to and transported with fine sediments like clays.

Lead levels in most areas are usually around the new, lower objective but also show occasional high exceedances, particularly at periods of high flow. Concentrations are, however, well below drinking water objectives. The highest lead levels appear to occur downstream from major urban areas and transportation corridors.

Data for zinc show that measured concentrations at West Montrose, Bridgeport, Doon and Galt were always below 0.02 mg/L and often below 0.005 mg/L. Copper concentrations reported in the RMOW range from less than 0.002 mg/L at Bridgeport to almost 0.006 mg/L at Doon and Galt.

Levels of heavy metals are highest in downstream reaches, probably reflecting accumulated inputs from upstream areas. Based on MOEE monitoring data, lead concentrations at Dunnville appear to show a slight increasing trend over the past twelve years, from an average of about 0.003 mg/L to about 0.005 mg/L. However, it is difficult to determine whether this trends is real or an artifact of reduced sampling effort in recent years (down from a high of 81 samples in 1984 to 16 samples in 1994). Total aluminum values at Dunnville average around 1.00 mg/L, with observed minimum values around 0.04 mg/L and observed maxima around 6.0 mg/L. Aluminum compounds are commonly added to drinking water as a means of clarification, so the observed levels may be related to this source. Zinc concentrations at Dunnville are also somewhat higher than in the middle reaches of the river but still low relative to the guidelines. This suggests that zinc is unlikely to have a significant impact on either aquatic life or drinking water supplies. Copper levels are also slightly higher at Dunnville than at upstream stations, averaging around 0.003 mg/L but ranging to a maximum of about 0.05 mg/L. This suggests that copper levels are probably of little concern with respect to drinking water supply but may be placing some stress on the aquatic communities. Cadmium concentrations in the Grand River generally fall below PWQO and drinking water objectives. Cadmium objectives are, however, exceeded in the Nith River and lower Grand River and in reaches of the Conestogo River.

The most frequently detected pesticides at the boundary of the RMOW on the Grand at Bridgeport are atrazine, lindane and its related isomer alpha-BHC. The concentrations of these compounds are consistently below the Provincial Water Quality Objectives (PWQO). Of the 187 chemicals analyzed by the RMOW and MOEE at Bridgeport, only 20 were detected between 1986 and 1993. The levels were at trace concentrations and did not exceed PWQOs. Monitoring upstream of Waterloo has not shown any significant chemical presence from historical and regulated industrial sources in Elmira.

Pesticides data collected at the mouth of the Grand River for the PLUARG studies (1977) showed that DDT, dieldrin, chlordane, heptachlor expoxide, endosulphan, endrin, lindane and atrazine were present but well within the Ministry of the Environment's objectives for the protection of aquatic biota and livestock watering. Concentrations observed at that time also met Health and Welfare Canada's guidelines for drinking water. In general, concentrations of these trace substances have declined over the intervening twenty years, and most are now at or near detection limits. The greatest concern about these materials may now be from accidental or intentional spills to the river.

Samples collected from Canagagigue Creek and the Speed River for the Grand River Basin Water Management Study (1980) showed the presence of a wide variety of organic compounds at very low concentrations. While there have been few objectives or guidelines established for these compounds, a review of available literature indicates that concentrations of substances measured to date from the Grand River should pose no threat to aquatic life or use of the river for water supply.

8.7.6 Acutely toxic substances

8.7.6.1 Description

Chlorine and un-ionized free ammonia are two toxic substances which can stress or kill fish and other aquatic life forms at relatively low concentrations. Un-ionized free ammonia was discussed above under "Nitrogen".

Chlorine is used as a disinfectant at most conventional sewage treatment plants in the basin to eliminate bacteria and other disease causing micro-organisms before the treated wastewater is discharged to the river. (In some Region plants, such as Galt, ultraviolet light is used instead of chlorine to disinfect the treated effluent). In order to ensure disinfection, common practice is to achieve a total chlorine residual of about 0.5 mg/L after treatment.

The provincial objective for chlorine for the protection of fish is 0.002 mg/L or about 1/250th of sewage treatment plant residual level. The toxic forms of chlorine, free chlorine and chloramines (chlorine and nitrogen compounds), are relatively short lived in the receiving waterbodies but can severely affect the aquatic community downstream of an outfall. Data from a range of systems in North America suggests that this impact can extend from a few metres to several kilometres below a sewage treatment plant outfall.

Chlorine, ammonia and many other wastewater components cannot usually be reduced to the provincial water quality objectives in the treated effluent without large expenditures and the use of very sophisticated technology. To accommodate practical treatment limitations the mixing zone or limited-use zone concept is applied. A designated area immediately adjacent to the outfall is identified as a zone where concentrations may exceed the objectives, but on the other hand, will not be rapidly lethal to important aquatic organisms. A mixing zone should not extend across the entire stream presenting a barrier to the migration of fish and other aquatic organisms; rather, a substantial zone of passage with pollutant concentrations below the objectives is needed. Acceptable mixing zones are determined on a case by case basis, and are not used as an alternative to treatment.

8.7.6.2 Recent findings

We do not currently have detailed information about the extent of impacts from un-ionized free ammonia and residual chlorine downstream of sewage treatment plant discharges in the Grand River. Chlorine and ammonia compounds are known to be present downstream from most conventional sewage treatment facilities in the basin. Wastewater discharges from lagoons are not usually chlorinated so chlorine toxicity is not usually a problem below these facilities. The most serious conditions are likely to exist downstream from the large sewage treatment plants serving the major urban centres. Further research is needed to investigate the potential for chlorine and ammonia toxicity in the basin.

8.7.7 Microbiological indicators of water quality

8.7.7.1 Description: Indicator organisms

A number of organisms have been considered as indicators of health risk for swimming areas. Fecal coliform bacteria have been used as a fecal pollution indicator for many years because of ease of measurement. This group, however, contains a number of organisms that are not known to cause disease in humans, so fecal coliform counts do not correlate well with the incidence of gastrointestinal illness. As a result, use of this group is being phased out. Recent improvements in detection and measurement techniques enable the use of organisms that give a more reliable indication of health risk.

The Provincial Drinking Water Guidelines state that waters intended for drinking should essentially be free of micro-organisms.

The PWQO for recreational water use states that a potential human health hazard exists when any or all of the following conditions exist:

- pathogenic organisms, such as *Pseudomonas aeruginosa*, *Salmonella typhii*, and polio virus, can be enumerated and frequently isolated from the water
- the geometric mean density of a series of fecal coliform bacteria samples exceeds 100 organisms per 100 mL of water
- the geometric mean density of a series of total coliform bacteria samples exceeds 1000 organisms per 100 mL of water

Some Canadian provinces, the International Joint Commission, the U.S. Environmental Protection Agency and some U.S. states have recommended or are in the process of recommending the use of one or more of the following microorganisms -- *Escherischia coli*, enterococcus bacteria, and *Pseudomonas aeruginosa* -- as indicator organisms for health risk assessment at swimming beaches. E. coli is the most widely known member of the fecal coliform group and is a normal inhabitant of the intestine of warm-blooded animals. It is a clear indicator of the presence of fecal material and therefore of the possible presence of pathogenic organisms.

The term enterococci refers to species of the fecal streptococcal group, which includes *Streptococcus faecium* and *S. faecalis*. They occur in significant quantities in both human and animal feces. *Streptococcus avium* and *S. gallinarium* are found principally in bird feces. Recent experience indicates that the identification of enterococcal isolates is more useful in the determination of the type, source and degree of fecal contamination. The PWQO for indicator bacteria do not give an objective for enterococci or fecal streptococci. Instead, the PWQO notes that measures of fecal streptococci are best used in conjunction with fecal coliforms to indicate the source of contamination. A ratio of geometric mean densities of fecal coliforms to fecal streptocci of greater than 4 is considered to indicate a source that is human in origin. If the ratio is less than 0.7, the source is likely to be non-human. (The use of this ratio has arisen from observations of fecal coliform and fecal streptococci bacteria in human and non-human species, but it is now believed to be an unreliable predictor of source because of the considerable variability in natural fecal composition.)

Pseudomonas aeruginosa is a pathogenic organism and is discussed below.

8.7.7.2 Description: Coliphages

Coliphage is the term given to virus-like entities that infect and replicate in fecal coliforms, coliforms and *E. coli*. Because coliphages replicate only in these organisms, the presence of coliphage also indicates the probable presence of these indicators.

Coliphages are shed at high levels by humans and other warm-blooded animals, and their presence indicates that fecal material, possibly containing surviving pathogenic enteroviruses, is present. Some coliphages are more resistant to environmental conditions and chlorination than are most enteroviruses, so that the elimination of the latter can be assumed to have occurred if these coliphages cannot be found. However, there are circumstances under which coliphage detection may not accurately indicate the presence of enteroviruses (U.S. EPA 1984).

8.7.7.3 Description: Pathogens

No maximum limits were proposed in the 1990 Guidelines for Canadian Recreational Water Quality (Health and Welfare Canada 1990) for the following microbiological organisms: *Pseudomonas aeruginosa*; *Salmonella*; *Shigella*; *Staphylococcus aureus*; *Campylobacter jejuni*; *Legionella spp.*; and viruses, nor are these organisms listed in the current Ontario Provincial Water Quality Objectives. Monitoring for some or all of these organisms should, however, be undertaken when it is deemed necessary to obtain a more complete assessment of the quality of specific water-contact recreational areas (Health and Welfare Canada 1990).

Pseudomonas aeruginosa is a potential pathogen; it causes a variety of infections, including skin rashes, and is the main etiological agent for external ear infections (otitis externa) in swimmers. *Staphylococcus aureus* should be measured when there is epidemiological or other evidence of its presence in recreational water in order to assess the hazards of excessive use of the water and person-to-person transfer of pathogens. All *Salmonella* species (enterobacteriaceae) are pathogenic, and a health hazard exists when this organism is consistently isolated from a bathing area. Symptoms of salmonellosis include gastroenteritis, enteric fever and septicemia. Eleven percent of samples from unpolluted streams and 35% from minimally polluted streams were positive for Salmonella. A relationship between the presence of Salmonella and the levels of fecal coliforms in water has been noted, and the bacterium can be consistently isolated from surface waters in which the fecal coliform levels are above 200 per 100 mL. Sources of *Salmonella* are various and include sewage plant effluents, food processing plant effluents, and storm water (Health and Welfare Canada 1990). *Salmonella typhimurium* can be used as a support parameter to aid regulatory agencies in determining the health risk involved in using a water body for recreation.

8.7.7.4 Description: Viruses

Viruses are submicroscopic microorganisms that are unable to replicate outside their normal host. Among the more than 100 enteric viruses that are excreted in feces and could possibly be found in recreational waters, some can remain ineffective for several months in water and sediments. The infectious dose for viruses is at least one order of magnitude lower than that of bacteria (Health and Welfare Canada 1990).

Sources of viruses include animal wastes, municipal sewage and other sources of human waste. The level of viruses in water can vary widely over short periods of time, so ratios of virus to fecal coliforms (levels of which are more stable) cannot be used to assess risk of infection; viruses have been found in water when fecal coliforms could not be detected (Health and Welfare Canada 1990).

8.7.7.5 *Description: Giardia lamblia*

Authorities in recreational areas are becoming more aware of the risk of *Giardia lamblia* (Protozoa) infection. Waterborne giardiasis has received much attention lately, as outbreaks have been traced to pristine waters, as well as to sewage-contaminated potable water (lin 1985). The beaver is one of the more common of the animal reservoirs of the parasite. *Giardia* is more resistant to chlorination than are indicator organisms, pathogenic bacteria and viruses; thus, fecal coliform counts cannot be used as indicators of protozoan contamination of recreational waters.

8.7.7.6 *Description: Cryptosporidium*

Cryptosporidium is a newly recognized pathogenic protozoan and may be as important as *Giardia*, causing a diarrheal illness known as cryptosporidiosis, which has occurred in Canada. Outbreaks are associated primarily with drinking inadequately treated drinking water (Health and Welfare Canada 1990). *Cryptosporidium* forms protective cysts and are relatively resistant to environmental degradation and treatment. *C. parvum* is the only species documented as disease-causing in mammals. This organism is of concern to Waterloo Region, but good enumeration techniques are not firmly established. *Cryptosporidium* occur in high numbers where cattle have free access to surface waters or where poor animal waste management practices result in contaminated runoff from manured areas.

There are very few data on the presence and densities of oocysts in the watershed, partly because analytical procedures are still under development and debate. According to literature sources, *Cryptosporidium* occurs in up to 60 wild and domestic animals, including cows, horses, goats, sheep, poultry and house pets. Its occurrence is sometimes associated with the presence of other pathogens such as *Salmonella*, *E. coli*, or rotavirus or coronavirus infections. High levels (1000 - 6000 cysts/100L) are reported for rivers draining areas with numerous dairy farms, but faulty septic systems have also been implicated in the spread of the organism.

In addition to animal sources, very high concentrations of *Cryptosporidium* and *Giardia* cysts have been reported in raw sewage. *Giardia* occurs at a frequency of between 1% and 24% of the human population, depending on the community, socioeconomic class, lifestyle and age. Sewage Treatment Plants using Conventional Activated Sludge treatment are thought to remove only 79% of raw sewage *Cryptosporidium* cysts, resulting in an average of 1300 cysts/L in effluent; however, effluent from CAS plants with sand filtration contains only about 10 cysts/L. Urban runoff may also be a source of oocysts, due to the reservoir of *Cryptosporidium* in pets. No literature data has been found for this source in Ontario.

Recent research shows that 70 to 100% of U.S. raw water supplies contained some *Cryptosporidium* cysts, compared to only 11% of the 113 Canadian samples collected in a recent study. In Ontario, 17% of samples were positive. The difference may be attributable to the degree of water use and re-use in U.S. surface water supplies, and possibly due to climatologic factors. However, it is important to note that at the time these studies were done, no standard method had been established for oocyst enumeration, and Canadian and U.S. study results may not be directly comparable. Some researchers believe that there is a much higher likelihood (10 time normal) of finding oocysts in water contaminated by urban sources. Watersheds with both urban and agricultural inputs were found to have higher occurrence still.

8.7.7.7 Recent findings: Indicator organisms

Analyses of microbiological data collected from routine monitoring and intensive studies indicate the existence of bacterial pollution at a number of agricultural and urban sites in the Grand River; in general, this bacterial pollution is localized and site specific. High levels of fecal pollution indicator bacteria (Total Coliform, Fecal Coliform and Fecal Streptococcus) are being discharged in agricultural and urban runoff from a variety of land use activities. Pathogens (disease-causing bacteria) were also detected at selected sites examined in detail. These results indicate that health hazards exist at problem sites, particularly if water is used for recreational activities.

Diurnal and seasonal variation in populations of indicator bacteria were observed at all sites examined. The maximum contribution of bacterial pollutants occurred during the summer and fall periods. In contrast, bacterial input during winter and spring months was generally low. Low levels of indicator organisms during spring may be due to significant dilution by relatively large volumes of water in spring runoff. Dry-weather flow conditions can be expected to reflect normal baseline inputs, while runoff resulting from moderate to heavy rainfall typically contributes high densities of indicator bacteria to receiving waters, particularly in small watersheds.

In general, the number of indicator microorganisms was lower in the water samples than in the sediment samples taken at selected sites. Any disturbance and relocation of bottom sediments (e.g. by dredging) could contribute substantially large numbers of bacteria to downstream surface waters. There is also some evidence that bacteria can over-winter and reproduce in sediments.

Data from the mid-1970s showed that bacteriological conditions in Canagagigue Creek were extremely poor, with fecal contamination arising from a mixture of human and non-human wastes. In the RMOW's 1994-95 studies, it was noted that by far the highest loadings of fecal coliform bacteria within the Region currently come from the Conestogo River (no data were available from Canagagigue Creek). Fecal coliform levels are consistently low at Bridgeport and Mannheim and in compliance with the PWQOs, but increase significantly as the river flows through the Region. The highest counts occur during the major runoff periods of spring and winter. Natural die-off of organisms between the Conestogo (where counts were much higher) and Mannheim probably accounts for the lower and acceptable values observed at Mannheim.

Moderate to high density livestock operations, manure-laden fields, contaminated soil and wild animals appear to be the main source of bacterial contamination at sites designated as problem areas in the agricultural watersheds and at other sites where agriculture is the predominant land use. In addition, it is probable that certain point sources (e.g. septic tank effluent from rural dwellings) intermittently contribute large numbers of indicator bacteria to the nearby watershed.

Urban runoff is mainly responsible for non-point source pollution in urban and smaller residential areas. Bacterial pollution in urban land runoff is predominantly of non-human origin and is mainly derived from fecal material from animals (e.g. pets, birds, rodents) and to a lesser extent from vegetation and soil contaminated with animal wastes. In addition, a substantial portion of bacterial contamination originates from combined and/or sanitary sewer bypass during periods of rainfall.

It is difficult to ascertain the percent contribution and relative significance of non-point versus point sources of bacterial pollution to receiving waters. (Even effluent from a well-operated sewage treatment plant is not usually bacteria-free even when it is disinfected.) Although no accurate estimates are available, it is possible that 50 to 70% of the bacteria observed in urbanized stream reaches arises from non-point sources such as urban and agricultural runoff.

From the limited data collected from other land use activities, it appears that extractive industry, transportation and sanitary landfills do not pose a serious pollution problem in terms of bacterial water quality and their overall contribution to microbial pollution is minimal.

8.7.7.8 Recent findings: Cryptosporidium

On April 21, 1993, the Regional Medical Officer of Health advised that an outbreak of cryptosporidiosis had occurred with 25 confirmed cases reported. The following day, the number of cases had risen to 42. The Mannheim WTP and infiltration wells were shut down as a precautionary measure, and an investigation was begun as to the presence and location of *Cryptosporidium* and *Giardia* in the treatment and distribution system and in the river water.

Following the April 21, 1993 outbreak in RMOW, regional and provincial authorities conducted detailed investigations of the potential sources of the oocysts. Operating policies were established to minimize any risk of introduction of these microorganisms into the distribution system. A key technical change was the reduction of the turbidity levels in treated water to consistently maintain a maximum of 0.1 NTU, thus reducing the likelihood of cysts entering the treated water.

During and following the cryptosporidiosis outbreak, monitoring was done for *Cryptosporidium* and *Giardia* in several locations. Data from the Hidden Valley Low Lift Station on the Grand River showed *Giardia* ranging from 80 - 200 counts/100L, and *Cryptosporidium* ranging from 10 - 190 counts/100L, based on results from a number of laboratories.

Cryptosporidium samples were taken from the Grand River above the Conestogo River confluence, and the Conestogo River above the Grand River confluence, following the April 21, 1993, outbreak of cryptosporidiosis. Although sample sizes are small, there is a rough indication from these data that counts were higher in the Conestogo River than the Grand River. Counts of *Cryptosporidium* at the Mannheim intakes are higher than the Grand River above Conestogo River confluence, and may show the effect of loadings from the Conestogo River. However, the influence of urban runoff and sewage discharge from Waterloo is unknown, as is the source of any *Cryptosporidium* loadings to the Conestogo River from agricultural non-point or other sources.

8.7.8 Macroinvertebrates (benthos)

8.7.8.1 Description

Macroinvertebrates are small, invertebrate animals that live in and on the sediments of lakes and streams. Because they are always in close contact with the sediment, they are excellent indicators of benthic (deep) water and sediment quality. Macroinvertebrate communities integrate the effects of different pollutant stressors and thus provide a holistic measure of their aggregate impact. They also integrate stresses over time and provide an ecological measure of fluctuating environmental conditions.

Biosurveys have many advantages, including low costs (relative to assessment of individual chemical parameters) and direct interest to the public (and intuitively well understood by lay people). Where criteria for specific ambient impacts do not exist (e.g., non-point source impacts that degrade habitat), biological communities may be the only practical means of evaluation. Biosurveys have value in a planning and management framework to prioritize water quality problems for more stringent assessments and to document environmental recovery following control action. This is a particularly useful approach for monitoring non-point source impacts and the effectiveness of certain Best Management Practices.

8.7.9 Aquatic plants and algae

8.7.9.1 Description

An overabundance of aquatic plants can contribute to a river's deterioration by reducing oxygen concentrations to below critical levels required by sport fish species such as brown trout. In addition, dense plant growths are unsightly and can reduce a river's aesthetic and recreational value.

Where community drinking water is obtained from the river, problems can arise with some species of aquatic plants. Algae, small enough to pass through the intake screens, may clog and bind the filters. Some blue-green algae species release a toxin when chlorinated, and some species also produce an unpleasant taste and odour. These conditions increase the chemical requirements at water treatment plants with attendant rise in costs of water treatment.

Shallow, fast flowing reaches provide ideal habitats for submerged plants. When there is a continuous supply of nutrients, low turbidity and a good combination of sunlight and warm temperatures rooted macrophytes and attached filamentous algae will thrive.

Three species of aquatic macrophytes currently cause problems in specific locations of the Grand River - *Cladophora glomerata* (Cladophora), *Potamogeton pectinatus* (Potamogeton) and *Myriophyllum spicatum* (Milfoil).

In the Grand River, the most prolific and therefore troublesome of these species is Cladophora, an attached filamentous green algae which grows well on rocky substrates in cooler temperatures. Cladophora typically reaches nuisance levels in May and June and again in September when the water temperatures are less than 25 °C. Cladophora requires rocky substrates for anchorage and is therefore usually found in shallow areas where the flow reduces silt buildup. The alkaline waters of the Grand River are well suited to this species, which prefers a pH above 7.0. Cladophora growth becomes a nuisance when the filament length is greater than 0.25 metres.

Potamogeton is a rooted aquatic macrophyte which grows in gravel or silt substrates during warmer months. Regrowth each year is from tubers buried in the sediment. The leaves of this species do not accumulate silot or epiphytes (parasitic plants), allowing it to survive better than many species in polluted or silted rivers. Potamogeton's absence from cleaner reaches is less easy to explain, but may be related to a requirement for high phosphorus flux. Slow flowing and deep areas of the Grand River may not have a sufficient phosphorus flux to support rapid growth.

Myriophyllum spicatum (Eurasian water milfoil) is a rooted aquatic plant which infests many lakes in Ontario. It was first observed in the Grand River above Waterloo in 1976 and currently occupies large areas of the Luther Reservoir with fragments being spread downstream. Milfoil prefers organic substrates and therefore grows best in the deeper areas of the river. In shallow riffle areas, the flow trims the milfoil stems short, causing the plant to form small dense clumps. The present distribution of milfoil is limited but the nuisance potential of this species is well known and the infested area is expanding every year. Mapping is currently underway to determine the range of this species in the Grand River.

The dominant life processes of aquatic plants results in the production and release of oxygen during the daylight hours (photosynthesis) and the consumption of oxygen during the entire day (respiration). As the density of plants increases over the growing season, oxygen concentrations at night are driven lower. In certain river sections this situation results in daily minimum dissolved oxygen concentrations of near zero for periods of several weeks. This is one of the factors that has led to a loss of game fish in these sections, leaving the coarser fish species, such as carp, to become dominant.

There are currently no guidelines available for aquatic plant growth, but violation of the PWQO for dissolved oxygen provides a good indicator of when problem levels of plant growth exist.

8.7.9.2 Recent findings

The portion of the Grand River from Fergus to the confluence with the Conestogo River exhibits conditions suitable for the proliferation of nuisance plant and algae growth. These conditions, combined with the availability of phosphorus and nitrogen from agricultural activities, make this an area of prime concern for the growth of species like Cladophora and Potamogeton, and a possible target for remedial measures targeted at reducing nutrient loads. From West Montrose to Paris, the river consistently shows dense growth of Potamogeton, and Eurasian water milfoil is known to be present in nuisance quantities in the Grand River at Grand Valley, the Grand River below Breslau, and the Grand River at Cambridge, and the Luther Lake outflow.

Conditions favourable for nuisance weed and algae growth are also found in the Speed River between Guelph and the confluence with the Grand River, in Canagagigue Creek above Elmira, in the Conestogo River above the Conestogo Dam and around St. Jacobs, and in Boston Creek. The Speed River from Guelph to the confluence with the Grand River is an area of dense Potamogeton growth.

8.7.10 Health of the fishery

8.7.10.1 Description

Fish are good indicators of long-term (several years) effects and broad habitat conditions because they are relatively long-lived and mobile. Fish communities generally include a range of species that represent a variety of trophic levels (omnivores, herbivores, insectivores, planktivores, piscivores). They tend to integrate effects of lower trophic levels; thus, fish community structure is reflective of integrated environmental health.

Fish are at the top of the aquatic food chain and are consumed by humans, making them important subjects in assessing contamination. Aquatic life uses (water quality standards) are typically characterized in terms of fisheries (coldwater, coolwater, warmwater, sport, forage). Monitoring fish communities provides a direct evaluation of the value of the fisheries resource to anglers and commercial fishermen.

Fish are relatively easy to collect and identify to the species level. Most specimens can be sorted and identified in the field and released unharmed. Environmental requirements of common fish are comparatively well known. Life history information is extensive for most species and information is also readily available on fish distributions. As discussed above, the MOEE and MNR jointly conduct an annual monitoring program for contaminants in fish, and report their findings in their *"Guide to Eating Ontario Sport Fish"*.

8.7.10.2 Recent findings

Fisheries and wildlife habitats are primary concerns within the Grand River watershed. The Grand River at Dunnville provides and sustains a major spawning habitat for Walleye, and is a designated fisheries rehabilitation area of MNR. These fisheries are important as an environmental indicator of ecosystem integrity and as an important recreational resource. There are other areas of fisheries concerns, such as Elora, Fergus, West Montrose, Whiteman's Creek, and Mill Creek (primary habitat areas for brown trout). Because of fisheries habitat it is necessary that ambient water quality monitoring programs are in place to ensure adequate water quality.

To measure the levels of trace contaminants in sport fish under the MOEE-MNR sport fish monitoring program, specimens were collected from the lower Grand River from Caledonia to Lake Erie; the Grand River near Kitchener and the Speed River in Cambridge. Mercury concentrations in most fish are low. However, concentrations in some of the larger fish of predatory species such as walleye, northern pike, smallmouth bass and coho salmon are elevated to the point where consumption should be restricted to eight meals per month. In the case of some of the larger fish of these species, a limit of four meals per month is recommended.

Only the very large walleye, over 65 centimetres (2 ft.) in length, from the lower Grand River are not suitable for any consumption. Mirex was not detected in any of the fish tested. Fish from Canagagigue Creek, upstream and downstream from Elmira have been tested for the dioxin - 2,3,7,8-TCDD (1981). This substance was not detected in any fish from the creek. Detailed information on contaminants in sport fish from the Grand River as well as consumption advice is contained in the Ministry of the Environment publication *"Guide to Eating Ontario Sport Fish - Southern Ontario"*.

8.7.11 Biodiversity

8.7.11.1 Description

At The U.N. Conference On Environment and Development, held in Rio De Janeiro In June 1992, 156 nations signed a global convention on biodiversity, with the goal of protecting biodiversity and restoring damaged ecosystems. Since that time, protection of biodiversity has been of increasing concern to many nations including Canada. Protection of biodiversity implies the protection of plant and animal species, usually with their natural habitat, and is therefore much more than preservation of seeds and genetic material. Ontario's environmental legislation largely ignores the issue of biodiversity, and certainly guidelines like the Provincial Water Quality Objectives were not developed with biodiversity protection in mind. Canadian federal and provincial governments are currently developing guidelines for the preservation of biodiversity.

8.7.11.2 Recent findings

We do not currently collect data on biodiversity in aquatic or terrestrial habitats within the Grand River basin. Further research is needed to define biodiversity conditions in the basin and to monitor changes in those conditions over time and space.

8.7.12 Aesthetics

8.7.12.1 Description

The PWQO for aesthetics simply states that "water used for swimming, bathing, and other recreational activities should be aesthetically pleasing...[and] devoid of debris, oil, scum, and any substance which would produce an objectionable deposit, colour, odour, taste or turbidity".

Other water quality parameters that are used to measure aesthetics directly are clarity (light penetration), turbidity, colour and oil and grease (visible film or odour). The PWQO for water clarity states that, if the bottom of waters used for swimming is not visible, then the water should have a Secchi disk transparency of at least 1.2 m. (A Secchi disk is a bicoloured black and white disk which is lowered on a line until it is no longer visible. The depth of disappearance is recorded, then the disk is raised until it can be seen once again, and the depth recorded once more. The average of the two depths is the Secchi disk depth.)

8.7.12.2 Recent findings

Consistent with data for suspended solids, which is directly related to water clarity, 1993 turbidity levels in upstream reaches are typically low at less than 2 FTU (Formazin Turbidity Units) and gradually increase with distance downstream. At Belwood, levels are more usually in the range of 2 to 5 FTU. Between Bridgeport and Brantford, average turbidity is still less than 10 FTU, but occasional high values of 15 to 20 FTU are not uncommon. Downstream of York, average turbidity levels approach 10 FTU and can approach 30 FTU.

Water clarity, as measured here by turbidity levels, is closely linked to suspended solids and thus responds quickly to changes in meteorological conditions. Highest turbidity is usually observed following major rainfall events and during periods of snowmelt and associated runoff.

8.8 Pollution sources in the Grand River basin

Pollution sources in the Grand River basin are of two types: point sources, such as industrial and municipal wastewater discharges, and non-point sources, such as urban and rural drainage. Point sources are relatively easy to find and those responsible for them are usually easy to identify. Remedial measures for point sources usually involve addition of pollution-control technology, often at high cost. Over the past twenty years, we have made excellent advances in reducing pollution from point sources in the Grand River watershed.

By contrast, non-point sources aren't owned by any particular individual or group. Rather, they are diffuse, arising - and entering surface and groundwaters - not at a single point but over a wide area. Control of non-point sources usually involves asking people to change their behaviour, for instance to plough their land in a different way, or to "stoop and scoop" after domestic pets. Although these measures are often much lower in cost than those employed in point sources, they can be much harder to implement, because of resistance to change. Successful implementation may require financial incentives such as grants and subsidies for farmers, public education programs, and similar initiatives. We have been much less successful in developing an understanding of the role of, and controls for, non-point sources in the Grand River watershed.

The following sections describe major pollution sources as they are currently understood.

8.8.1 Point sources

8.8.1.1 Municipal sewage treatment plants

Industrial and domestic waste contributed by more than 650 water-using industries and approximately 74% of the basin population are transmitted via sanitary sewer systems for treatment at one of the 26 sewage treatment plants serving the urban areas in the Grand River watershed. Cooling, process and general purpose waters from 95 commercial, industrial and institutional sources are discharged after any required treatment to storm-sewer systems or directly to the receiving streams. Estimates of all these point-source discharges were prepared using the routine monitoring data collected by the Ontario Ministry of the Environment and supplemented by PLUARG monitoring at some locations for parameters nor normally sampled by the Ministry in the late 1970s.

In 1976, ninety-three million cubic metres of municipal waste were treated by the 22 sewage treatment plants then in the watershed. Nine sewage treatment plants located in the urban areas of greatest population (Cambridge, Kitchener, Waterloo, Brantford, Guelph, Elmira and Dunnville) and industrial activity treated 94% of this water volume. Only a few industries are located in outlying rural districts and smaller urban centres. The types of industries common to the Grand River watershed are textile and rubber manufacturing, metal processing, chemical industries and food processing operations including large abattoirs and meat packing plants. These municipal and industrial point-source discharges contribute a total flow of about 4 m3/s - a significant proportion of the low flow or baseflow in the Grand River (approximately 5 to 15 m3/s).

Separate sewer systems exist throughout almost all of the communities serviced by the 26 sewage treatment plants. A few combined sewer systems are found in relatively small areas of the older urban centres (e.g. Kitchener). Phosphorus removal was instituted in 1974 by all of the sewage treatment plants in the Grand River basin.

The PLUARG monitoring data (1976), obtained from sampling the outfalls of the nine major sewage treatment plants in the basin, suggest that the major pollutant inputs from point sources are phosphorus, nitrogen, metals and chloride. Trace amounts of PCBs (10-2 to 10-5 kg/d) were detected at all nine of the sewage treatment plants where supplementary sampling was undertaken for the PLUARG program. Traces of various pesticides (Lindane and DDT derivatives) have also been detected.

Figure 8-10, page 8-37, shows the 26 wastewater treatment plants in the basin in 1994. Table 8-3, 8-38, outlines the treatment method, design capacity, percentage of plant used, the loadings to the river and the population served. The data clearly reveal that a number of plants in the basin are approaching their design capacity. This situation is important both because stressed treatment works may not perform as well as those with abundant capacity, and also because adequate capacity is necessary to support future growth in the basin.

Table 8-3, page 8-38, also illustrates the magnitude of pollutant loadings from these plants, especially Brantford at 724.4 kg/day BOD, 697.1 kg/day suspended solids, and 27.7 kg/day total phosphorus. Other plants with significant loadings to the river are Galt, Guelph, Kitchener, and Waterloo, the first of which was upgraded in 1996, and the second of which is now nearing capacity. Even the best-operated sewage treatment plants are important sources of BOD, suspended solids, phosphorus, nitrogen compounds, and heavy metals.

FIGURE 8-10: LOCATION OF MUNICIPAL WASTEWATER TREATMENT PLANTS

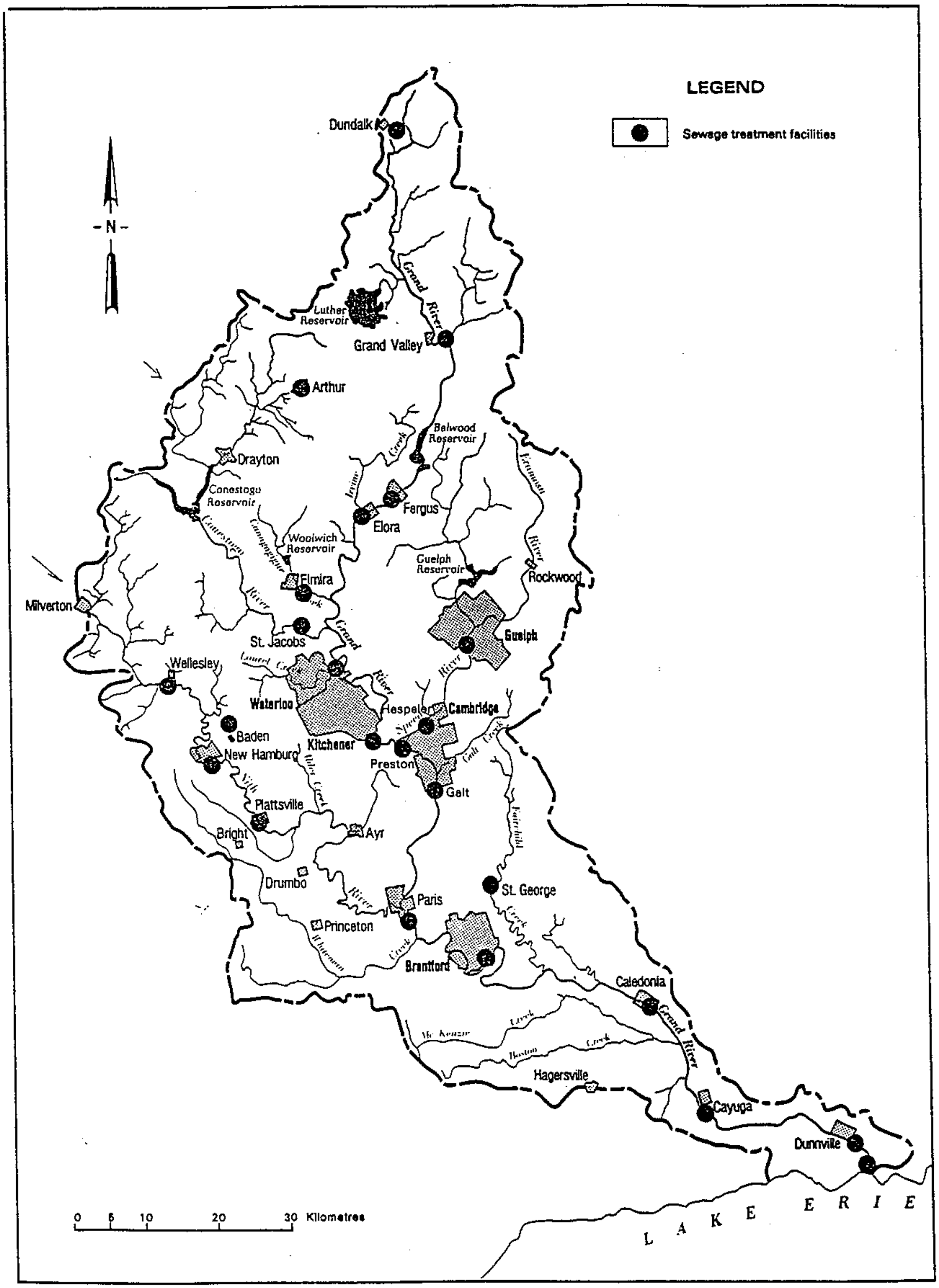


TABLE 8-3: WASTEWATER TREATMENT PLANTS IN THE GRAND RIVER WATERSHED

Plant Name	Treatment	Design Capacity 1000 m^3/d	Existing ADF 1000 m^3/d	Sewage Flow % of Capacity	Loadings (kg/d) BOD$_5$	SS	TP	Population Served
Arthur	Ext. Aer.	1.465	1.19	81.2	2.8	6.0	0.4	1736
Ayr	Ext. Aer.	1.182	0.66	55.8	2.6	3.2	0.3	2050
Baden	Ext. Aer.	0.923	0.69	74.8	6.5	11.5	0.6	1152
Brantford	CAS	81.818	52.25	63.9	724.4	697.1	27.7	73000
Cainsville	Seasonal	0.168						65
Caledonia		4.950	3.66	73.9	5.9	35.3	1.7	5655
Cayuga	CAS	0.909	0.64	70.4	1.9	4.2	0.3	1258
Drayton	Oxid.	0.559	0.48	85.9	1.7	3.2	0.2	1156
Dundalk	Ditch	1.059	1.00	94.4				
Dunnville	Lagoon	7.728	5.35	69.2	24.1	37.8	6.2	5182
Elmira		4.546	3.76	82.7	13.5	18.8	2.2	7090
Elora	Ext. Aer.	3.064	1.65	53.9	6.0	12.7	0.5	3583
Fergus	CAS	6.400	4.43	69.2	10.7	19.8	2.1	6050
Galt	Ext. Aer.	38.641	34.44	89.1	377.0	605.0	16.8	60000
Grand	CAS	0.660	0.41	68.3	2.3	5.1	0.2	1489
Valley	CAS	54.552	46.43	85.1	250.7	297.1	35.3	82000
Guelph	Oxid.	9.319	4.92	52.8	33.8	66.2	3.8	11392
Hespeler	Ditch	122.742	65.19	53.1	281.3	652.1	37.8	164000
Kitchener	CAS/EP	2.728	1.73	63.4	5.0	8.5	1.0	3978
New	High Rate	7.046	2.53	35.9	6.1	8.9	1.2	7700
Hamburg	CAS	0.596	0.53	88.9				
Paris	Aer. Cell,	16.866	9.59	56.9	59.9	74.8	7.5	18727
Plattsvill	EP	1.064	0.51	47.9	0.9	1.0	0.3	1300
e	Ext. Aer.	0.955	0.78	81.7	4.6	13.9	0.5	1266
Preston		72.730	32.82	45.1	354.6	579.8	27.9	66627
St. George	CAS	0.500	0.44	88.	1.2	1.9	0.1	950
St. Jacobs	Ext. Aer.,							
Waterloo	EP							
Wellesley	Oxid.							
	Ditch							
	CAS							
	Ext. Aer.							

EP = Effluent polishing CAS = Conventional Activated Sludge

8.8.1.2 Industrial direct dischargers

Although most industries in the Grand River watershed discharge their wastes to municipal sewer systems, there are a few so-called "direct dischargers" that discharge process or cooling waters directly to the river. These direct dischargers are required to monitor the effluent and submit the information to the MOEE; many are also bound by the Municipal-Industrial Strategy for Abatement effluent limits regulations under Ontario's Environmental Protection Act. Direct industrial discharges may be treated process wastewaters, wash waters, or cooling waters. The MISA program also requires that industrial facilities develop stormwater management plans acceptable to MOEE. Major industrial sources in RMOW include American Standard, Stanley Hardware, Uniroyal Chemical, Canada Alloy, and Sulco Chemicals.

8.8.1.3 Private waste disposal

In the Grand River basin, approximately 13% (56,000) of the urban population use private waste-disposal systems (i.e., are unsewered) throughout the year. A total (both urban and rural) population of 135,000 people use approximately 36,000 private waste-disposal systems throughout the basin. An additional 7,000 systems are used in seasonal dwellings and their pollutant input to the watershed is minimal in relation to the permanent systems.

Monitoring studies suggest that the primary pollutants of concern from private waste-disposal systems are phosphorus and to a lesser extent nitrogen. Bacterial contamination may occur as a result of runoff from faulty private-waste disposal systems (seepage of septic-tank effluent) and create localized problems in the receiving waters.

8.8.1.4 Spills

Unintentional discharges of pollutants (spills) are required by law to be reported to the Spills Action Centre (MOEE) and the regional and local municipality, as well as downstream water takers. Spills have a major impact on water intakes and depending on the nature of the material could have a severe impact on stream biota.

8.8.2 Non-point sources of pollution

8.8.2.1 Urban storm runoff

Approximately 3% of the Grand River Basin is urbanized. The major urban concentration in the watershed occurs in the central portion of the basin commonly referred to as the industrial triangle (Kitchener/Waterloo/Cambridge complex). This urban/industrial triangle represents the highest density of population (53% of the basin's urban population of 435,000) and industrial activity (more than 650 water-using industries) in the basin. Other urban centres in the basin are Guelph, which is located at the confluence of the Speed and Eramosa Rivers, and Brantford, on the main stem of the Grand River approximately 65 km upstream from Lake Erie.

Urban runoff results when rainfall or snowmelt occurs on urban areas. Runoff water washes the impervious surfaces of accumulated sediments, bacteria, and soluble chemicals which are discharged through storm sewers or open ditches to watercourses. Urban storm runoff therefore carries a variety of pollutants, including heat, solids, nutrients, bacteria, pesticides, metals and toxic organic pollutants.

Monitoring data suggest that urban land drainage may be an important source of lead, copper, zinc and some trace organic compounds such as pesticides. These pollutants are generated as a result of industrial, commercial, residential and automobile emissions, point-source discharges and spills, street litter and construction activities. The major pollutant inputs to receiving streams from urban drainage occur during storm events. The particulate build-up on the impervious surfaces in an urban area occurs as a normal accumulation phenomenon from the concentration of industry, population, traffic, etc. The particulate accumulation is then washed off by surface runoff during storm events.

Bacteriological pollution (high levels of fecal pollution indicator bacteria derived from pets, rodents, and birds) may also be a problem in urban runoff. Pathogens (*Pseudomonas aeruginosa* and *Salmonella*) were detected at the downstream outlet of an urban subwatershed under study in the basin and have also been found in combined and sanitary-sewer overflows during heavy rainfall events. These kinds of bacterial pollution, if not treated, can constitute a potential health hazard, particularly if the receiving water is to be used for recreational activities or public water supplies.

Urban runoff in the Grand River watershed does not appear to be a significant factor in the degradation of Great Lakes water quality. The majority of urban land in the basin is situated approximately 100 km from the lake, offering abundant opportunity for instream settling of particulates and their attached pollutants. This situation differs considerably from that of large urban areas such as Detroit, Cleveland, Hamilton, and Toronto, which are all located on the Great Lakes shoreline and thus discharge runoff directly into the lakes. Available evidence shows that pollutants originating in Grand River basin urban runoff likely move down the river gradually, settling and resuspending and eventually making their way to the lake. During periods of high flow, this sequence of events may occur more quickly, but in general it appears that some sediments is retained in the system each year. More than 3% of the total basin load of pollutants (up to 20% of the metals load) comes from urban runoff. This suggests that urban runoff has a greater impact on the water quality of the Grand River than on Great Lakes water quality.

8.8.2.2 Agricultural runoff

Agriculture affects the land and, through the land's erodibility, the water, in many different ways. To begin with, agricultural activities typically result in widespread land clearance, exposing the land surface to the energy of falling rain. Tillage and land management practices can have a tremendous impact on the amount of soil and water that is lost from cropland. Similarly, livestock operations can concentrate wastes and wastewaters in a small area, unlike the natural condition. Manure storage and spreading activities can be an important source of bacteria to receiving waters.

Figure 8-11, page 8-43, shows the major sub-basins contributing to agricultural non-point source pollution.

The most obvious impact of agriculture on the environment is often increased sediment loads resulting from land disturbance. This sediment can carry with it attached phosphorus, heavy metals, and pesticides. Approximately 75% of the Grand River watershed is in agriculture of varying intensity. The following are some major agricultural activities in the basin.

The influence of agriculture and urbanization in the upper Grand River basin has led to an overabundance of phosphorus and associated nuisance plant growth in the middle Grand River area. This in turn has caused dissolved oxygen problems. Studies completed for the RMOW indicate that soil erosion from cropland is the largest source of sediment and phosphorus delivered to the watercourse in terms of annual loading, with most of the load released in the fall, winter and spring when soil is left unprotected by cover crops.

8.8.2.3 Cropland

Any agricultural practice that exposes soil to natural erosive forces represents a pollution hazard. The thrust of good agricultural practices is to protect the land and to hold rainfall in the soil where it cannot contribute to floods, erosion and sedimentation problems. In general, the greater the ground cover and canopy, the lower the pollution potential. Agricultural activities have been demonstrated to be important sources of suspended solids, phosphorus, nitrogen, and pesticide residues. As discussed earlier, suspended solids often carry adsorbed phosphorus, metals, and organic compounds, so the combination of eroded sediment plus available pollutants makes agricultural runoff potentially a potent pollution source. In areas with poor manure management or unrestricted cattle access to streams, microbiological pollution, including bacteria, *Giardia*, and *Cryptosporidium*, may also be a problem.

The nature and timing of tillage methods is one of the most important agricultural practices that affect non-point source pollution. Conventional tillage methods rely on fall ploughing to leave a clean seed bed for spring planting. Conservation tillage methods leave varying amounts of crop residue on the field, reducing erosion rates by up to 80% in no-till fields. Conservation tillage, contour ploughing, strip cropping, cover crops, crop rotation, and residue management are among the non-structural best management practices that can reduce erosion and subsequent phosphorus loadings by more than 60%.

8.8.2.4 Livestock production

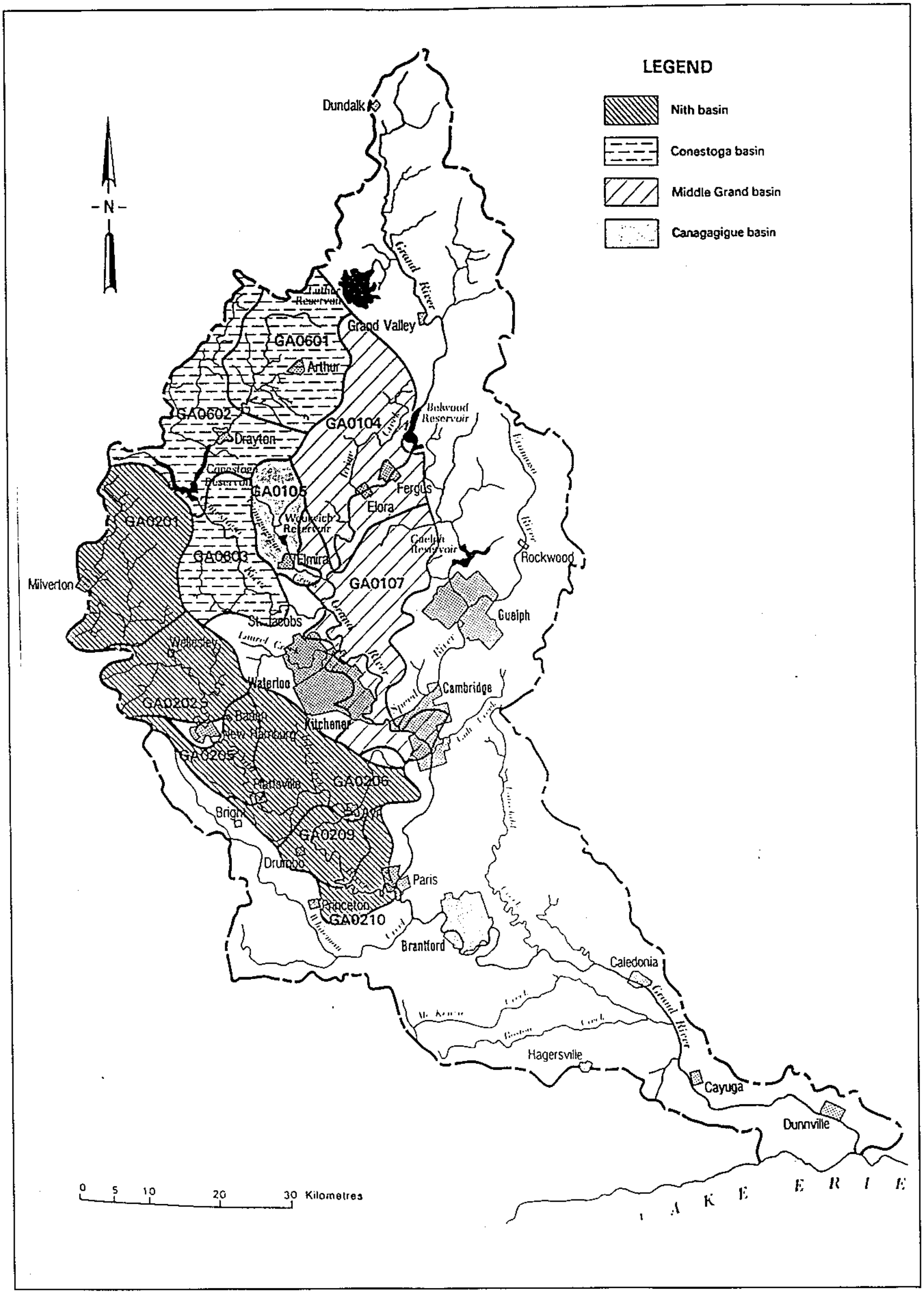
Since 1976 total livestock numbers in the Grand River watershed have decreased by about 30%. The largest decrease is in cattle numbers. Production of pigs and sheep on the other hand have increased by almost 50%. Despite the changes in numbers, livestock production has become more concentrated and specialized, resulting in more animals being kept per unit area. The concentration of manure and livestock wastes creates environmental and practical problems in terms of storage and utilization of the manure. For instance, a 100 cow dairy herd produces approximately 165 metric tons (dry weight) of manure per year and 600,000 litres of milkhouse washwater.

Manure can gain entry to watercourses and groundwater from a number of sources. Runoff from barnyards, feedlots and manure piles can be a significant source of pollution, depending on the distance to the watercourse and site characteristics. Inventories of the upper Conestogo River and upper Nith River Watersheds revealed that approximately 500 farms require improved manure storage facilities to reduce contaminated runoff. In these watersheds, over 200 dairy farms require improved milkhouse wash water storage and treatment. To reduce the impact of these sources, the volume of liquids should be minimized by diverting precipitation and surface water from yards and feedlots and into appropriate storage and treatment facilities. Livestock facilities should also be located well away from watercourses and wells.

Land application of manure must be managed to reduce environmental impacts and to maximize benefits to crop production. Sites suitable for manure application should have low erosion potential, be situated away from streams or slopes leading to stream and drainage pathways.

About 170 sites in the upper Conestogo and upper Nith River Watersheds currently give livestock unlimited access to a watercourse. Restricting livestock from watercourses with fencing and providing protected stream crossings and alternate water sources can result in significant local improvements to stream quality and health. Concentrations of phosphorus and bacteria decreased by over 75% after livestock were restricted from a tributary of the Speed River.

FIGURE 8-11: MAJOR SUB-BASINS CONTRIBUTING TO AGRICULTURAL NON-POINT POLLUTION



8.8.2.5 Transportation corridors

Provincial, County and Township highways occupy approximately 1.7% of the land (11,300 ha) in the Grand River watershed. The major pollutants produced as a result of the maintenance of these transportation corridors are chloride and sodium from highway de-icing operations. Literature studies report that other pollutants such as oil and grease, pesticides and heavy metals may be produced as a result of routine maintenance operations. Suspended solids are also common in highway runoff, as they are in urban runoff. Various factors affect the volume and quality of highway runoff, including traffic density, setting (urban/rural), de-icing and spills.

Monitoring data from a 1.3 km length of 4-lane highway in the basin confirms increased chloride loads as a result of de-icing operations. Preliminary results from soil sampling suggest that lead has been accumulating downwind of the highway in the soil. All other water quality parameters that were monitored in a small stream draining the area alongside the highway, with the exception of filtered nitrite plus nitrate-nitrogen, did not exhibit increased concentrations downstream of the highway. Similarly, levels of heavy metals and pesticides were unchanged downstream of the highway in both suspended sediment and bed sediment samples.

8.8.2.6 Solid and liquid waste disposal

Waste-disposal practices such as sanitary landfills, processed organic waste, and spray irrigation have had minimal impacts on stream-water quality in the Grand River watershed, probably because of their limited areal extent. Increased land usage by practices like these could impair stream water quality, especially with respect to nutrients and chlorides. If the waste is enriched with heavy metals and organic chemicals, accumulations in the soil could ultimately create an environmental health hazard if proper design and management procedures are not observed.

8.8.2.7 Undisturbed land

Monitoring data suggest that subwatersheds which are in relatively undisturbed states (woodlots and idle land) have a minimal impact on the receiving streams. Approximately 19% of the Grand River watershed is wooded or idle land. Runoff from these areas of perennial vegetation cover is considered to represent natural (undisturbed) conditions. Water quality monitoring downstream of such areas suggests that natural chemical and physical weathering of carbonate rocks can be an important influence on stream water quality. These carbonate rocks are naturally high in lead, cadmium and zinc, so as weathering occurs, the heavy metals contained in the rocks are gradually released to the water flowing over them. Rock weathering also affects soil chemistry, which in turn influences water quality. This is particularly true for phosphorus, which is a component of rocks such as apatite and collophane, and thus can enter soils derived from those parent materials.

8.9 Water quality issues

8.9.1 Surface water quality issues

Comparison of water quality targets for desired uses with actual water quality conditions in the Grand River reveals a number of areas where further improvement is required now, or where water resources should be protected to guard against deterioration under future growth. This is consistent with Provincial Water Management Policy 2, which states that:

> ***"Water quality which presently does not meet the Provincial Water Quality Objectives shall not be degraded further and all practical measures shall be taken to upgrade the water quality to the Objectives."***

As described in earlier sections, water quality in the Grand River basin, although generally improved over conditions of twenty years ago, still requires further action in many areas. A vision for water quality in the basin can be stated as follows:

> ***Clean, potable water supply for both urban and rural residents. Water quality such that the cost of water treatment for municipal use is minimized. We can boat and swim in the river throughout the entire system without health concerns. We can safely eat the fish. Water quality supports the recreational use of the river system. Watershed residents value water and the quality of water.***

Several concerns are currently preventing, or will soon prevent, realization of this vision. It is becoming increasingly clear that water resources in the Grand River basin must be managed in an integrated fashion. Point source controls alone will not be sufficient to achieve the vision of basin water quality. Instead, we must examine all pollutant sources in the basin, and their cumulative impact on the river system. The most cost-effective combination of solutions may involve point- and non-point source controls, instream management measures, and other actions.

The key issues - challenges - in water quality management are described in Table 8-4, page 8-46.

TABLE 8-4: WATER QUALITY MANAGEMENT ISSUES IN THE GRAND RIVER BASIN

Issue	Description	Major Sources	Management Options
#1: Phosphorus	Phosphorus in the Grand River and the major tributaries exceeds the provincial water quality objectives almost everywhere. The high levels are encouraging the growth of rooted aquatic plants and algae, which in turn deplete the river of the dissolved oxygen necessary to support a range of aquatic animals including fish.	• sewage treatment plants effluents • urban storm water runoff • rural runoff carrying soil, livestock manure, milk house wash water, and fertilizers.	• Implement additional phosphorus removal at selected sewage treatment plants. • Install buffer strips to protect urban streams from the impacts of runoff; retrofit storm water management controls into existing urban areas. • Undertake studies to determine which types of urban storm water control are most effective for removing phosphorus. • Work with the farm community on conservation tillage, manure management, nutrient management, and stream buffering.
#2: Microorganisms (Bacteria, Viruses, *Cryptosporidium*, *Giardia*)	Microorganisms such as bacteria, viruses and parasites can make water unsafe for consumption by humans and livestock; body contact recreation may be limited if bacterial contamination is too high.	• urban storm water runoff carrying pet feces • rural runoff from manure yards and manured fields • livestock access to watercourses • inadequate or faulty septic systems • sewage treatment plant bypass.	• Reduce the incidence of sewage treatment plant bypass by upgrading overloaded plants and by reducing entry of storm water into sanitary sewer systems • Provide additional treatment for drinking water sources that are affected by oocysts like *Cryptosporidium.* • Install buffer strips to protect urban streams from the impacts of runoff; retrofit storm water management controls into existing urban areas. • Undertake studies to determine which types of urban storm water control are most effective for removing bacteria. • Work with the agricultural community on nutrient management, manure management, stream buffering, control of milk house wash water. • Implement controls, guidelines, and/or alternatives for septic systems.
#3: Suspended Solids	Particles of silt, clays, algae and other organic matter give the water a turbid or muddy appearance and can absorb and transport other pollutants such as phosphorus, heavy metals, and pesticides. Suspended solids smother spawning beds and interfere with respiration of some fish such as trout, thus affecting the river's appearance and recreational value. Solids are costly to remove from municipal water supplies.	• natural stream processes • soil-baring human activities such as agriculture, construction, and stream clean-outs.	• Install buffer strips to protect urban streams from the impacts of runoff; retrofit storm water management controls into existing urban areas. • Undertake studies to determine which types of urban storm water control are most effective for removing sediment. • Work with the farm community on conservation tillage, erosion control, and stream buffering; reduce the impact of drain maintenance by implementing techniques such as natural channel design, buffer strips, and sediment traps. • Retire fragile lands to permanent vegetation.

TABLE 8-4: WATER QUALITY MANAGEMENT ISSUES IN THE GRAND RIVER BASIN

Issue	Description	Major Sources	Management Options
#4: Ammonia and Chlorine Toxicity	Localized ammonia and chlorine toxicity downstream of sewage treatment plants can kill aquatic life or cause a barrier to fish movement across the river.	• Most sewage treatment plants discharge ammonia and chlorine as byproducts of the treatment process and thus may be sources of this problem (insufficient data to determine site-specific effects).	• Install additional treatment (e.g. nitrification, dechlorination, alternative disinfection) at affected sewage treatment plants (only warranted if field surveys determine that effluent toxicity is currently causing an impact on the downstream aquatic community).
#5: Spills	Accidental or intentional spillage can occur wherever chemicals are in use or in transport, causing downstream water intakes to be shut down and recreational users of the river to be affected.	• Spills warning is not consistent at present, resulting in occasional impacts on downstream uses and delays in implementation of remedial measures.	• Enforce spills reporting and response requirements under Ontario's Environmental Protection Act; improve consistency of spills reporting through education and technical support. • Enhance our capability to predict the travel time and impacts of spills, and to respond appropriately to spill situations.
#6: Overall Water Quality Management	Overall water quality management means taking action where it will make the biggest improvement in water quality for the smallest effort or cost.	Even if the sewage treatment plants were able to discharge distilled water, most of the Grand River and its major tributaries would still not meet the provincial water quality objectives for phosphorus, bacteria, and suspended solids. Work must also be done on the other sources, urban and rural, if the vision is to be reached.	• Most effort in the last fifty years has been put into better treatment for municipal and industrial sewage. There is still work to be done in municipal and industrial waste water treatment, but there are big costs for small gains now. • More cost-effective solutions may be found in control of non-point sources such as urban and agricultural runoff; these should be integrated with point source controls • A shift to overall water quality management will optimize capital expenditure for water quality improvements.

8.10 Priorities for action — Surface water quality

It is clear from the foregoing discussion that several water quality issues have their roots in the same human activities, or sources. The following management actions are considered priorities because they target these key sources.

8.10.1.1 Monitoring and reporting

1. Focus urban stream quality monitoring in the Cities of Guelph, Waterloo, and Kitchener. Determine:
    - which urban streams are contributing the biggest phosphorus and sediment loads and
    - which types of stormwater control measures are most effective for removing phosphorus, bacteria, and sediment
2. Focus work with the farm community on reducing phosphorus, bacteria, and soil entering streams in the Nith River watershed upstream of New Hamburg, and in the Conestogo River watershed above Hawkesville, and the Canagagigue Creek watershed above Elmira. Investigate the degree to which Boston and MacKenzie Creeks are contributing to the phosphorus problems in the lower Grand River.
3. Continue and extend whole effluent toxicity testing at sewage treatment plants; scan receiving streams downstream of sewage treatment plant discharges for ammonia or chlorine toxicity.
4. Implement overall water quality management:
    - Report current conditions and confirm priority water quality problems by updating analysis of water quality data.
    - Determine sources contributing to priority water quality problems by updating analysis of water quality data. Update projections on the combined impact of waste water treatment plant discharges by updating, extending, and applying the Grand River dissolved oxygen simulation model.
    - Where point sources are the major contributors, update local waste water management strategies and incorporate upgrades into municipal / industrial capital plans
    - Where non-point sources are major contributors, locate areas/operations that are major contributors by updating diffuse source information and analysis of water quality data.
5. Update the Grand River Simulation Model.

8.10.2 *Wastewater treatment plants*

1. Upgrade sewage treatment plants which are not in compliance with their approved discharge targets. Required upgrades may include:
    - effluent polishing (e.g. nitrification)
    - increased phosphorus removal
    - replacement of chlorine as a disinfectant
    - other special measures for instance relating to control of trace contaminants.
2. Monitor implemented practices to ensure that effluent quality and instream water quality responds as expected.
3. Reduce risk of watercourse contamination by ensuring that any sewage sludge application to land complies with MOEE-OMAFRA guidelines.

8.10.3 *Urban areas*

1. Reduce impact of stormwater runoff from urban areas by implementing stormwater quality guidelines for new development. Retrofit older areas where possible.
2. Monitor the implementation of stormwater management measures to ensure that instream water quality is protected.
3. Identify areas susceptible to groundwater contamination.
4. Promote understanding of appropriate pesticide/herbicide use through education programs.
5. Implement awareness programs such as Yellow Fish Road (painting fish shapes on storm sewer access covers to increase public awareness that fish may be affected by discharges to sewers).

8.10.4 *Rural non-point sources*

1. Using the information obtained in monitoring programs, identify the highest priority sources of non-point source pollution; make cost sharing arrangements for cost-effective control projects; and initiate highest priority projects. These may include:
    - soil erosion control techniques
    - good manure storage and spreading practices
    - milkhouse wash water controls
    - restricted access of cattle to watercourses
    - land management techniques such as retirement of fragile lands, cropping and tillage practices, and related measures
2. Investigate emissions trading (e.g. point source dischargers buy reductions from non-point source dischargers) as a mechanism for reducing nutrient loads to the river.

3. Encourage proper storage, handling, and application of pesticides, herbicides, and fertilizers through operator certification programs, education and technical support.

8.10.5 Spills

1. Improve ability to predict downstream impacts of spills through development or augmentation of appropriate computer simulation techniques for spill forecasting, to assist water treatment plant operators and others in responding to spill events.
2. Reduce the risk of spills from point sources by implementing Best Management Practices at problem areas.
3. Enforce spills reporting and response requirements under Ontario's Environmental Protection Act.

9. FISHERIES IN THE GRAND RIVER WATERSHED

9.1 Historical background

The Grand River is Lake Erie's largest tributary and provides important warm water and nutrients to the lake ecosystem. Many migratory species also rely on the Grand River for critical spawning habitat.

The pristine environment of the Grand River watershed found 300 years ago has been described as 'an angler's heaven'. Rivers and streams ran cool, clear and full, and were home to large populations of trout and walleye. The only witnesses and beneficiaries of this abundance were wild animals and native hunting parties.

When European settlers first moved into the valley, they used the river to drive their mills, remove their waste and as a 'water highway' to transport people and goods. The giant forests were cleared, first to create farms and homesteads, and then to provide expansion room for communities growing around the mills.

Removal of the forests resulted in huge changes to the flow patterns, and the capacity and resiliency of the rivers and streams to deal with large rainstorms and snowmelt. Tree roots and natural vegetation no longer protected the stream banks from erosion. Fish spawning and feeding areas were covered in silt from eroded banks and runoff. Lack of shade warmed the water to a degree that could not be tolerated by sensitive fish such as the native brook trout. Other impacts of human settlement included contamination of watercourses by human effluent, waste from sawmills and industries, and by runoff from agricultural and developed lands.

Water quality deteriorated dramatically in the Grand River from the late 1800's to the 1930's, when low flows, flash floods, draining of wetlands, erosion and poor water quality reached a peak. The construction of several large dams which augmented flows, improved municipal and industrial wastewater treatment and the clean up of point sources of nutrients and industrial contaminants, helped to improve the river and its aquatic resources. Since 1966, regulations have improved water quality and fish habitat despite increased human settlement in the watershed. As evidence of this improvement, a 1966 Ministry of the Environment survey found no Smallmouth Bass or Pike upstream of Brantford; in 1995 both species were found to be thriving throughout the watershed.

9.1.1 Flow management in the watershed

Any management planning for environmental resources, such as fish, must consider the 'ecosystem' within which the resource resides. In this case, the watershed is the fundamental ecosystem unit, and the management of zones or reaches within the watershed must be considered in the context of the whole watershed.

The Grand River is a regulated river. Flows in the Grand, the Conestogo and the Speed are regulated by a series of large upstream reservoirs. The Shand Dam, near Fergus, was built in 1942 to provide flood control and flow augmentation. The Conestogo Dam near Drayton was constructed in 1957 for flood control, and the Guelph Reservoir was built in 1976, primarily to augment summer flows in the Speed River as it passed through Guelph.

Much of the improved river habitat conditions in the past 15 years can be attributed to more stable flows that are provided by a change in reservoir operations with increased attention to the health of the aquatic community. Flow augmentation allows the dispersal and flushing through of waste water and sediment, and the provision of stable water depths in the shallow section of the river. This facilitates fish population movement and reproduction, and the maintenance of food supplies such as aquatic invertebrates.

Provision of fishways at some dams and weirs has allowed fish to reach upstream habitat. Several dams on the Grand River may play a role in preventing the invasion of exotic species.

9.1.2 Water quality and fisheries

Scientists use the types of invertebrates and fish found in a water body as a measure of water quality. A healthy functioning system will have a wide diversity of plants and animals. The absence or decline of fish populations in a watercourse can act as a warning signal that all is not well in the system, much as the canary in the coal mine warned miners of impending danger.

Water quality is a key factor in determining the types of fish species which can be supported in a stream or river. Healthy aquatic ecosystems benefit humans directly though their water supplies and fish consumption, and indirectly through recreation opportunities and aesthetics.

Parameters that are used to evaluate water quality and fish habitat include water temperature, the amount of dissolved oxygen in the water, turbidity and bacterial and pollutant levels.

9.1.3 Fish habitat requirements

The natural limits of the productive potential of any waterbody are imposed by the geology, topography, climate and chemistry of the landscape. These limits control the habitat characteristics necessary for different fish communities. These limitations can be further altered by human impacts that impair or damage the natural system.

Fish, like all living organisms, have basic needs for shelter, food and reproduction in order to carry out their life cycle. Fish species such as brook trout, require very specific conditions, while others are more tolerant of a wide range of conditions. Brook trout are usually found in the upper groundwater-fed, well-vegetated reaches of streams where cold, fast flowing water picks up more oxygen and transfers more carbon dioxide. Groundwater active areas are usually associated with a surface geology of gravel and sand outwash areas or moraines.

Streams that have a balance between cool deep sections and fast flowing shallow rapids (riffles) provide a diversity of habitats. Fast water flows move fine sediments downstream allowing the gravel substrate to remain clean. The gravel and small rocks provide important substrate for stream insect production and trout spawning. Shelter and resting places for trout are provided by streambanks that are undercut by fast water flow.

Till plains and till moraines containing clays and silts do not have a strong groundwater flow to local streams and so do not have the critical characteristics to maintain a coldwater fish habitat. Still or slow moving waters offer a different habitat used by fish species such as bass and perch. Here, the surface water is warmer, with a lower dissolved oxygen content. Cool refuges may be found in deep pools or at spring sources. Submergent and emergent vegetation near the shoreline provide critical spawning and nursery areas.

9.1.4 Human impacts on water quality

Changes in land use over the last century have changed the aquatic ecosystem of the Grand River. Rural and urban land use practices contributing to degraded water quality and fish habitat include:

- removal of bankside vegetation
- channelization of streams
- alterations in drainage patterns
- unrestricted livestock access to streams, paving of large areas, and
- construction of ponds in streams
- introduction of excess nutrients and chemicals from field runoff.

Negative effects on the aquatic environment include silting of feeding and spawning areas, flashy flows, warmer stream temperatures, loss of baseflow from springs and groundwater seepage, contaminated runoff and reduced diversity of aquatic plants and wildlife.

TABLE 9-1: HABITAT CONDITIONS OF SELECTED FISH AS DETERMINED BY SURFICIAL GEOLOGY AND WATER CHEMISTRY

Species	Surface Geology	Groundwater Activity	Temperature (sustainable range)	Channel Size (Stream Order)	Chemistry (TDS/D.O.)
Brook Trout (*Salvelinus fontinalis*)	Gravel/sand moraines /gravel and sand tills; sand plains (deep overburden)	High Found in active discharge areas.	10 - 20°C	1-3 Historically used larger rivers for over-wintering.	High Water Quality (e.g. D.O.>7 mg/l)
Brown Trout (*Salmo trutta*)	Gravel moraines; gravel spillways; sand and gravel tills (moderate to deep overburden)	Mod. - High require groundwater for thermal refuge and temperature moderation	15 - 23°C	2-5 Will occasionally use 1st order stream for reproduction.	Mod. - High Water Quality (e.g. D.O. >6 mg/l)
Rainbow Trout (*Oncorhynchus mykiss*)	Gravel spillways; gravel tills and moraines (shallow to moderate overburden)	Mod. - High require groundwater for thermal refuge and temperature moderation.	15 - 24°C	1-7 Most successful spawning in 1-4.	Mod. - High Water Quality (e.g. D.O.>6 mg/l)
Smallmouth Bass (*Micropterus dolomieui*)	Gravel spillways; gravel tills; some gravel moraines, some clay tills	Moderate - Low (shallow to deep overburden)	18 - 28°C	3-8 Require dampened hydrograph for spawning success.	Mod. - High Water Quality (e.g. D.O.>4 mg/l)
Walleye (*Stizostedion vitreum*)	Gravel outwash; gravel/cobble tills	Low	16 - 24°C	3-8 Require high flows over riffles for 2 weeks.	Mod. Water Quality (e.g. D.O.>4 mg/l and mod. to high turbidity)
Pike (*Esox lucius*)	Gravel outwash; gravel/clay tills	Low	14 - 22°C	1-8 Spawn in floodplains with 2-3 week connection to the main river.	Mod. - Low Water Quality (e.g. D.O.>4 mg/l)
Channel Catfish (*Ictalurus punctatus*)	Gravel outwash; gravel/clay tills	Low	18 - 30°C	4-8	Mod. Water Quality (e.g. D.O.>4 mg/l)
Mooneye (*Hiodon tergisus*)	Gravel outwash; gravel/cobble tills	Low	18 - 30°C	4-8	Mod. Water quality (e.g. D.O.>4 mg/l), non-turbid water
Yellow Perch (*Perca flavescens*)	Gravel outwash; gravel/cobble tills	Low	21 - 24°C	4-8	Mod. - High Water Quality (e.g. D.O.>6 mg/l), non-turbid water

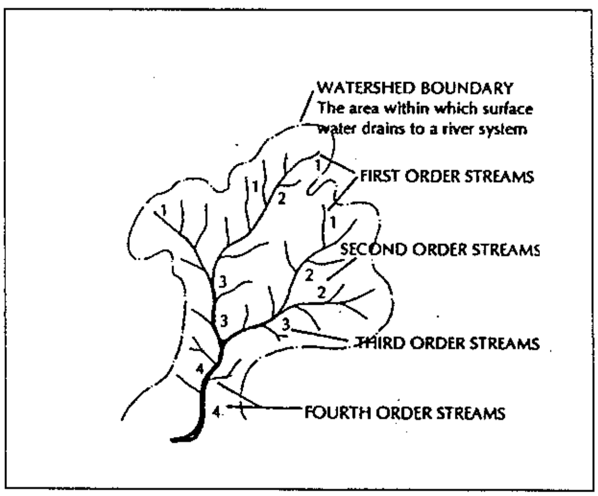
9.1.5 Classification of rivers and streams

Rivers and streams in Ontario are classified by the Ontario Ministry of Natural Resources according to the type of fish community supported by the conditions in the watercourse.

FIGURE 9-1 CLASSIFICATION OF STREAMS BY TYPE

Type 1 Coldwater streams	These streams contain self sustaining populations of sensitive trout species with limited tolerance for changes in chemical and physical characteristics.
Type 2. Potential Coldwater	These streams are Type 1 in their headwaters, but adjacent land use or flows from warm water tributaries have reduced or eliminated coldwater fish communities.
Type 3. Warmwater Sportfish	These streams contain any combination of fish that are more tolerant of warm water conditions, such as smallmouth bass, northern pike, walleye, yellow perch, or panfish. The streams are generally large, with the exception of some spawning and nursery streams.
Type 4. Warmwater Baitfish	These streams do not contain warmwater sportfish, but support any combination of minnow species, or other fish species classified as 'baitfish' by the Ministry of Natural Resources.
Type 5. Altered Streams	These streams have historically suffered from extensive streambank or streambed alteration, and/or unmitigated inputs of stormwater. These watercourses may or may not contain fish.

FIGURE 9-2: CLASSIFICATION OF STREAMS BY ORDER



Stream order classification describes the organization of a stream system or network. Small streams join larger streams, and small valleys join larger valleys in the drainage basin.

In the method of stream ordering, first-order streams are the smallest in the system, and two of them must join to form a second-order stream. Two second-order streams must join to form a third-order stream and so on.

FIGURE 9-3: FISH HABITAT DISTRIBUTION

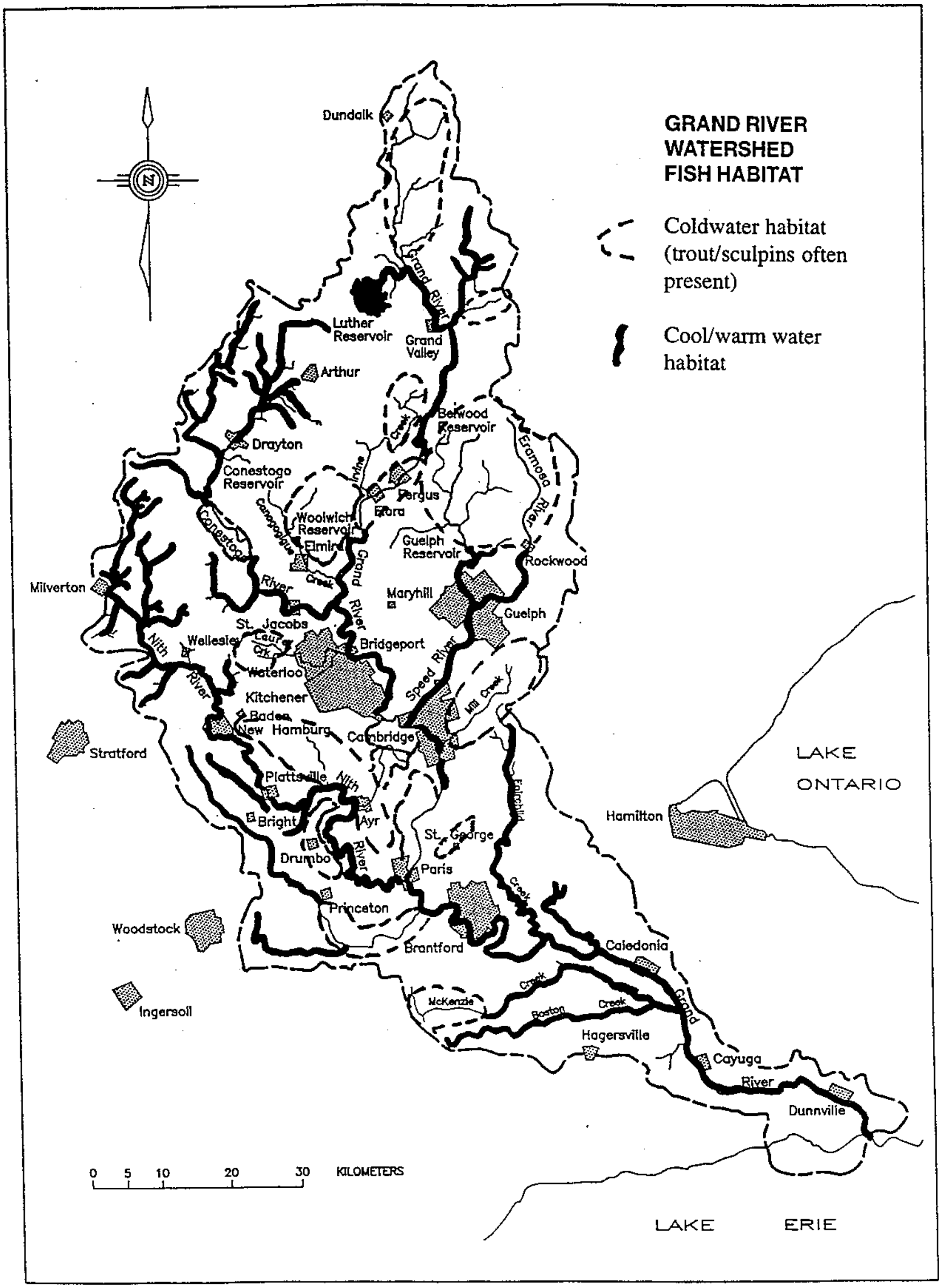


TABLE 9-2: SPORTFISH DISTRIBUTION IN THE GRAND RIVER WATERSHED

Fish species	Location found
Pike	• Throughout the Grand River from Grand Valley to the Belwood Reservoir • Conestogo River • Grand River from Fergus to Cambridge • Guelph Reservoir and some areas of the lower Speed and Eramosa Rivers • Grand River from Caledonia to Lake Erie • Nith River
Smallmouth Bass	• Main stem of the Grand River from top to bottom. • Speed, Conestogo and Nith Rivers • Guelph Lake, Belwood Lake, Shades' Mills Reservoir
Largemouth Bass	• Common in many sections of the watershed • Grand River downstream from Waterloo • Guelph Lake, Shades' Mills Reservoir, Damascus Lake, Pinehurst Lake • Nith, Conestogo and lower Speed Rivers
Walleye	• Grand River from Lake Erie to Dunnville with resident populations at Caledonia, Brantford, New Hamburg (Nith River) • Stocked in Conestogo River
Brown Trout	• Whitemans Creek, Brantford area • Grand River below Shand Dam • Mill Creek, Alder Creek, D'Aubigny Creek • Eramosa River system
Rainbow Trout (Migratory)	• Upper Grand River • Most of the tributaries of the Nith River between Paris and New Hamburg. • Whitemans Creek, Brantford area • Grand River from Lake Erie to Paris
Brook Trout	• Upper Speed and Eramosa Rivers • Cedar, Mill, Landon's, McKenzie, Strasburg, D'Aubigny, Blair, Bechtel, Canagagigue, Washington, Alder, Hanlon Creeks • Other coldwater tributaries
Chinook Salmon and Pink Salmon	• Grand River, Lake Erie to Paris

9.2 Existing fishery conditions in the Grand River

9.2.1 Game and recreational fish species

The fisheries resources in the Grand River watershed are 'diverse'. The Grand River supports a warmwater fish community from West Montrose down to the mouth at Port Maitland. Northern Pike are found throughout the watershed, and bass in general are also very prevalent. Upstream tributaries and headwaters are more suitable for coldwater fish species. Table 7-4 outlines sportfish distribution in the Grand River watershed.

In southern Ontario, 80% percent of all coldwater streams have been lost due to changes in land use. Many tributaries in the Grand River watershed, such as the upper Speed and Eramosa Rivers, are still high quality brook trout streams. Strasburg, Laurel, Blair, D'Aubigny, Hanlon, and Devil's Creeks are examples of coldwater streams supporting remnant trout populations within urban boundaries.

Stream rehabilitation over the last 12 years and improvements in land use practices have improved habitat for coldwater species. Several trout streams in the Brantford area now support populations that have increased up to 800% from 1960 population levels.

Stocked trout are also found in the upper Grand below the Shand Dam. The bottom draw dam supplies a consistent flow of cold water downstream during the summer months. This is a good example of a 'tailwater' fishery.

The Dunnville fishway constructed in 1994 in the Dunnville dam allows both jumping and non-jumping fish species to access habitat upstream to Caledonia. The Caledonia dam contains two fishways that have not been successful in passing fish farther upstream. The dam is not a barrier to migratory rainbow and salmon which are known to move during high flows in the fall from Lake Erie, up the Grand River past Caledonia to the dam in Paris.

Rainbow trout are now found in the Nith River as far upstream as New Hamburg. There is increasing evidence that these fish are using most of the tributaries of the Nith between Paris and New Hamburg for spawning and rearing. Population estimates recently conducted in Whiteman's Creek near Brantford, have found up to 2,000 young-of-the-year rainbow trout in 500 metres of the stream.

9.2.2 Rare, Threatened and Endangered fish species

More information is needed on the population distribution and health of fish species listed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). The following information is given in the MNR Fact Sheet, October 1994, Nationally and Provincially Rare, Threatened and Endangered Species of Cambridge District.

Threatened: Black Redhorse *(Moxostoma duquesnei)*

Vulnerable
Greenside Darter *(Etheostoma blennioides)*
Northern Brook Lamprey *(Ichthyomyzon fossor)*
Redside Dace *(Clinostomus elongatus)*
Silver Shiner *(Notropis photogenis)*
Central Stoneroller *(Campostoma anomalum)*

9.2.3 Extirpated (extinct) fish species

Muskellunge and Sturgeon were once found in the Grand River. There have been recent unconfirmed report of muskie in both the Nith River system and Grand River downstream of Brantford. Sturgeon were last reported in the lower river near Dunnville in the 1950's.

9.2.4 Non-game fish species

Other species of fish that are often overlooked for their value in the system are the many varieties of minnows, panfish and bottom dwellers. All play an important role in a healthy aquatic ecosystem. Many game fish are dependent on these species for survival. Examples of non-game fish found only in the lower Grand River include, Mooneye, Quillback and Channel Catfish, Common White Sucker, Brown Bullhead, Longnose Gar, Black and White crappie, Pumpkinseed Sunfish, Freshwater Drum and Yellow Perch have a wider distribution.

9.2.5 Economic benefits of fisheries

9.2.5.1 Recreational use and consumption

Many local residents and visitors from outside the area use the Grand River for recreational fishing. In recent years the Grand has been considered a world class fishery. There is a need to evaluate both the economic and recreational value of this fishery. The present and predicted angling pressure and harvest is not known.

Results of the 1990 Provincial Angling Survey have not yet been evaluated and applied to the area of the Grand River watershed. However, from an informal review of fishing licenses sold in the area in the past year, it appears that there is a large increase in the number of 'tourist' anglers from the United States coming to fish the Grand River. This may be the result of high profile articles in sports magazines during 1995. There are also reputed to be four or five professional fishing guides now working in the upper watershed.

The Ministry of Environment and Energy Guide to Consumption of Fish indicates that it is safe to eat up to eight meals per month, and probably more, of fish in the Grand River systems, except for a 'no consumption' advisory on large walleye (65 to 75 cm) caught below Dunnville. There are some restriction (four meals per month) on largemouth bass (35 to 45 cm) caught in Guelph Lake, and larger walleye caught above Dunnville.

9.2.5.2 Commercial use

More information is needed on the status of the baitfish industry. Baitfish licenses are issued by the Ontario Ministry of Natural Resources to regulate the activity. However a monitoring program should be developed to determine impacts of bait fishing on sensitive minnow species, the food chain, and the degree of incidental catch on young of the year sportfish.

9.2.6 Past and current rehabilitation/restoration programs

The Grand River Conservation Authority has been carrying out stream rehabilitation in conjunction with the Ontario Ministry of Natural Resources, special interest groups and landowners since the early 1980's. Many of these rehabilitation projects are considered provincial models.

Upper Grand River (Dundalk to West Montrose)

Annual stocking program of hatchery yearling brown trout (12,000 to 20,000 per year), ongoing and supported by a large volunteer effort. The long-term goal is to establish a self-sustaining trout population. The fish are distributed throughout the stretch of Grand River from Shand Dam downstream to the Waterloo-Wellington boundary. These fish, which are 6 to 7 inches when stocked, will grow to 11 to 14 inches in length in one year, and in less than 3 years will be considered 'trophy' fish.

Wild brood stock transfer of brown trout from local streams distributed in the Grand River below Shand Dam. This is part of a long term plan to improve the genetics and sustainability of the trout populations

Implementation of 'catch and release' program in 13 kilometres of the 28 kilometer stretch of regulated river in the Upper Grand region.

Carroll Creek enhancement projects supported by MNR and volunteer efforts of research scientists, landowners, and local groups.

Swan Creek enhancement project with landowners and Wellington District High School volunteers.

Middle Grand (West Montrose to Brantford)

Snyders Flats floodplain pool, pond, and riparian wetland creation project. Innovative habitat improvement project in conjunction with the gravel industry.

Construction of New Hamburg Fishway (1991) by Grand River Conservation Authority and the Ministry of Natural Resources. This project was undertaken to provide walleye access to underutilized upstream spawning areas.

Development of a partitioned coldwater fishery in Whiteman's Creek and implementation of experimental special regulations by the Ministry of Natural Resources and Grand River Conservation Authority in 1989.

The Yellow Fish Road / Storm Drain Marking program in Kitchener, Waterloo, Cambridge, Paris and Brantford, instituted in Ontario as a pilot project for the Federal Department of Fisheries and Oceans, Central Region by the Grand River Conservation Authority.

Local habitat improvement initiatives on Mill Creek (Puslinch Township), Strasburg Creek (Kitchener), Laurel Creek (Waterloo), Hanlon Creek (Guelph), D'Aubigny Creek (Brantford), Kenny Creek (Burford Township and Devil's Creek (Cambridge).

Beaver Creek project to demonstrate stewardship practices that mutually benefit agriculture and fish and wildlife. Major funding assistance for the Wetlands/ Woodlands / Wildlife program provided by the Canada/ Ontario Agriculture Green Plan.

Lower Grand (Brantford to Lake Erie)

Adult walleye transfer program from the Thames River to the Grand River, downstream of Caledonia. This program was undertaken over a three year period from 1989 to 1991 by volunteers and the Ministry of Natural Resources, Fonthill and Cambridge Districts.

Spawning habitat enhancement projects, e.g. boulder/rubble placement below Weir 4 at Dunnville.

Construction of the Dunnville fishway in 1994 in partnership with the Dunnville District Hunters & Anglers, Six Nations of the Grand River, the Ontario Ministry of Natural Resources and the Grand River Conservation Authority. This project was undertaken to allow walleye and other non-jumping fish species to access spawning habitat from Dunnville to Caledonia.

Dunnville fishway research into walleye genetics, migratory patterns, spawning activities and success, and relationship to the eastern basin walleye population of Lake Erie. This is an ongoing project of the Grand River Conservation Authority with the Lake Erie Management Unit of the Ministry of Natural Resources, Department of Fisheries and Oceans and the University of Waterloo.

9.3 Information requirements

A strong emphasis on cooperation has developed between the GRCA, the Ministry of Natural Resources offices, Six Nations of the Grand River, special interest groups and landowners within the basin. Productive partnerships along with subwatershed planning and management have enabled residents of the watershed to enjoy a diverse and extremely productive fish community.

Nevertheless, there is evidence that fish habitat is cumulatively being degraded. Urban land use, agricultural practices, reservoir operations, sewage treatment facilities, and water extraction have all contributed to shifts in the aquatic community as a reflection of these changes.

As part of the 'shared management plan for the Grand River', it is imperative that fisheries, stream benthos (invertebrates), and water quality information be collected to update the resource database on a watershed scale. This information is the critical linkage between implementing the overall watershed strategy and monitoring the 'health' of the watershed over the long-term.

9.4 Summary of issues and opportunities

The presence of a diverse human settlement and occupation pattern, historically and at present has resulted in a variety of land uses that have directly and indirectly affected the aquatic ecosystems of the Grand River. Some of the ongoing problems and issues resulting from human activities include:

Water quality impairment

Water quality in some areas of the watershed has deteriorated due to contaminant impacts of from non-point sources, such as fertilizers, soil erosion, septic systems, sewage sludge disposal and urban stormwater introduction. Specific concerns such as: mixing zones downstream of sewage treatment plants resulting in residual chlorine levels that limit fish and benthic invertebrate production, excess nitrogen which causes excessive aquatic plant growth which results in dissolved oxygen sags particularly at night; rural land use across the upper part of the watershed contributes milkhouse wastes and household septic systems which leach directly into streams and add tremendous amounts of nutrients and bacteria; unrestricted cattle access to watercourses releasing nutrient-bound sediment and bank trampling adding substantially to instream sediment, bacteria and associated nutrient levels.

There are huge opportunities to improve instream water quality by adopting a strategic land and water stewardship program targeted at specific subwatersheds that have been identified through a data assessment process. Continued efforts to rehabilitate streams and cooperative projects with rural landowners will show long-term results.

Habitat impairment

In the tributaries and the main stem of the Grand River, habitat has been impaired due to sediment loading from both urban and rural sources. Changes in flow regimes and channelization of tributaries and the main river have caused erosion and changes in the channel structure and function. The majority of the aquatic impacts are related to the loss of living space, spawning habitat destruction, groundwater interruption, thermal increases and reduction in food (invertebrate) production and the simplification of the aquatic ecosystem.

Land use planning in most areas fails to consider landscape ecology and cumulative impacts to aquatic ecosystems. The agencies and public must be vigilant in their approach to the protection of fish habitat and water quality through the municipal plan review process.

Opportunities for rehabilitation and creation of new habitat must be recognized. Community stream rehabilitation efforts must also be acknowledged and technical advice provided where possible. There is tremendous evidence in the Grand River watershed that stream rehabilitation has improved habitat particularly for degraded coldwater streams. A strategic partnership approach to stream rehabilitation. A strategic and cooperative stream restoration program should be developed, funded and implemented throughout the watershed.

Water taking

There are virtually no controls in effect or enforced on groundwater or surface water taking for commercial and private interests (less than 50,000 L/day). Cumulative impacts are not assessed in many areas, and urban demands for municipal water supplies continue to increase on the main stem of the Grand River.

It is important to note that under Ministry of Environment and Energy water taking permits, entire streams can be literally dried up by users that have been given approval. This is particularly prevalent in rural areas where irrigation routinely occurs, i.e., the subwatersheds of Whiteman's Creek, Mt. Pleasant Creek etc.

Commercial water-bottling companies are another unquantified issue that actually exports water out of the watershed. There has been no assessment of the impact of this activity.

Aquaculture/fish stocking programs

Issues of disruption of native stock genetics and food chain imbalance must be considered with any fish stocking program. Escape from existing hatchery facilities is also an issue since there could be serious impacts to the genetic integrity of native populations. As an example, hatchery brook trout could cause disease or genetic disruption through reproduction with a self-sustaining native stream brook trout population.

The industry and 'special' stocking programs under the revised MNR regulations will require a clear administrative process and biological review (risk analysis) to allow for the protection of existing stocks, while allowing for enhancements, restoration and creation of fisheries.

Need for revision of angling regulations

In some cases, current regulations result in a loss of angling opportunities, but there is a need to ensure that liberalizing certain regulations does not result in over-exploitation of the fishery resource. As an example, there are large numbers of migratory rainbow trout that are being stalled below the Caledonia dam especially after fall rain events.

At the present time, anglers are unable to fish for these migratory fish between September 30 and the last Saturday in April. However they can fish for pike and walleye. This leads to the conflict of catching rainbow trout under the guise of angling for walleye or pike.

Overharvest and out-of-season angling (poaching) may be preventing some fish populations from reaching their potential. However, fisheries related enforcement and compliance are restricted in part due to insufficient resource information and limited support funding. The public recognizes the need for more enforcement and the dilemma of associated funding cuts. Increased enforcement officers in the field is a priority that has been identified from recent public meetings.

There is also interest in creating sanctuaries in some of the more sensitive coldwater streams to protect resident trout populations from casual angling where again trout are caught under the guise of fishing for suckers or panfish. In addition, the public is suggesting minimum size limits and reduced catch limits for popular species such as smallmouth and largemouth bass, northern pike, walleye, and trout.

Reservoir and flow management

There is a need to optimize the balance between flow targets and reservoir targets. Objectives within and downstream of each reservoir should also be established.

Encouraging examples of integrating downstream flow needs with operations now exist. The successful brown trout program in the Elora-Fergus area is totally dependent on the cold bottom draw discharge from the Belwood reservoir.

The installation of a valve in the Luther dam (1989) has allowed for predictable and consistent flows through Grand Valley to Belwood reservoir. This in turn has resulted in improved water quality and an increase in the smallmouth bass population in this section of the Grand River and in Belwood reservoir.

Vulnerable, Rare, Threatened and Endangered fish species

The distribution and status of these species are poorly documented. There is an initiative presently underway, funded in part by the World Wildlife Fund, to inventory sections of the Grand and its tributaries and prepare recovery plans for all VTE fish species found in the watershed.

Introduction of exotic species

There is reason for concern particularly in the lower river in regard to the invasion of exotic species such as the zebra mussel, goby, river ruffe, sea lamprey, exotic zooplankton, etc. These organisms may have harmful impacts on native species and functions of aquatic ecosystems.

Zebra mussels clog water intakes and outlets found for example at sewage treatment and water supply plants. 'Build-up' or infestations of this species make it difficult to operate dam structures, turbines and fishways. They also substantially reduce the amount of available phytoplankton and nutrients which could lead to the collapse of the existing aquatic ecosystems (especially in lake and reservoir environments).

Ruffe and gobies are extremely prolific and aggressive fish, likely outcompeting native species. A loss of native fish populations would ultimately simplify the aquatic ecosystem. Sea lamprey have been reduced by 90% in Lake Erie, however, large quantities of suitable spawning habitat exist upstream of the Dunnville dam. Substantial efforts have been taken through the design of the Dunnville fishway to prevent lamprey from accessing the upper river.

10. NATURAL HERITAGE

"Natural heritage includes geological features and landforms; associated terrestrial and aquatic ecosystems; their plant species, populations and communities; and all native animal species, their habitats and sustaining environment." (*A Natural Heritage Areas Strategy*, OMNR, 1992).

10.1 Landscape history

The shaping of the Grand River watershed by the natural processes of glacial action, climate, and revegetation produced the primarily forested landscape found by the early European settlers. Significant areas in the central part of the watershed, such as the Paris sand plains, were covered by scattered trees and prairie grasses, or in some cases, only prairie. The upper and lower reaches of the watershed, however, were for the most part densely forested.

With settlement by Loyalists in the 1700's and later European immigrants, the wilderness frontier was pushed back. By the late 1800's, the upper reaches of the watershed were settled, and the Grand River watershed was largely deforested. By the time the wilderness frontier had been pushed up onto the Dundalk plateau, some areas that had been re-settled earlier were already suffering from environmental degradation because of the drastic forest removal. The area of forest cover reached its lowest point around 1920.

In 1905, the first provincial tree nursery was established in Guelph at the Ontario Agricultural College, and was soon moved to St. Williams. Shortly thereafter, E. J. Zavitz, the newly appointed provincial forester, began touring the province to evaluate the state of the land base. In many areas he found that farms were already being abandoned because of soil erosion. In many cases these farms reverted to the municipal government because taxes were not paid, and reforestation of these farms was begun. These efforts were concentrated in areas of sandy soil such as Simcoe, Norfolk, and Northumberland Counties. These were the first targets of reforestation efforts in Ontario.

After the large areas of 'blowsand' and abandoned farms had been planted, attention turned to marginal lands which could be found in varying amounts on all farms. Farmers were encouraged to plant trees on marginal and fragile land so that the land could grow a 'crop' more suited to the site, and to prevent further degradation of the land base. This effort continues today, emphasizing fragile land, which, by definition, will degrade if it is cultivated annually.

In 1891 there were 802 tanneries in Ontario using hemlock bark in the processing of hides. The appetite of the tanning industry for hemlock reduced this species to a minor and even rare tree in some areas. Even though by the early 1900's the devastating effects of forest clearing were being felt in Ontario, and action to restore forests was being taken, the example of the tanneries is important. Despite the efforts to re-establish forests, it remained a resource to be plundered at will. Other species such as rock elm were also sought out and over-harvested. These species are now under-represented in the southern Ontario landscape as a result.

Human impacts on the forest were not always so direct, but sometimes even more devastating. Two imported diseases changed the Grand's forests dramatically. In the 1920's and 1930's chestnut blight decimated the American chestnut trees in Ontario. Today, there are only a few hundred known in Ontario, the largest and healthiest of which is in the Grand watershed near Burford. The native elms, a dominant forest tree in many moist and wet areas, were practically scrubbed from the landscape in the late 1960's and early 1970's by the Dutch Elm disease. Today the native butternut tree is fighting Butternut Canker, a fungal disease which threatens to exterminate butternuts from the forests of eastern North America.

As some of the indigenous forest species cling to survival, new introductions became important elements of the landscape. The Europeans brought with them many seeds, purposely for food or decoration and sometimes inadvertently. These trans-Atlantic hitchhikers were often the unwelcome weeds of agricultural fields in Europe. Some introduced species, such as Norway spruce and European larch have tended to be innocuous. Other species, such as Norway maple, Scots pine, crack willow, buckthorn, autumn and Russian olive, garlic mustard, purple loosestrife, many cultivated grasses, and others, are suspected of posing a significant threat to the integrity of indigenous plant communities in some situations.

Introduced wildlife species such as starlings, house sparrows, pigeons, and other species may have contributed to shifts in the balance of the ecosystem. Feral dogs or a coyote - dog cross have become problematic in rural and urban fringe areas as they run in packs and attack livestock. In the past rabies further complicated this problem as raccoon, skunk, feral dogs and coyote were all potentially infected. However, provincial programs to address the spread of rabies have been very successful and cases of occurrence are now scarce. Perhaps the greatest impact has come from another imported group of animals: livestock.

Livestock was at first an integral part of every farm operation. Livestock was naturally relegated to the areas of the farm where cropping was difficult: the river and stream floodplains, steep slopes, rocky or thin soil, and in the forests. By the turn of the century, virtually every acre of the average farm in the Grand River watershed was either cropped or pastured, including the forest.

Evidence that indiscriminate grazing was harmful to forests, coupled with improvements in grass pastures, convinced many farmers to reduce or eliminate livestock in woodlands. The economic pressure to move away from the traditional general farm to the specialized farm has been a far more effective 'motivator' in reducing livestock impact on the environment. Livestock production is now concentrated on a fraction of the farms that it formerly occupied, and these operations tend to use feed lots, rather than free range pasturing. The current exception to this trend in the Grand watershed is the traditional Mennonite farming community, which continues to practice farming based on the 'general farm' model. Livestock access to streams in the remaining floodplain pastures has been discouraged by government programs providing financial incentives to farmers to fence off their streams.

10.2 Current status of forests and wildlife

About 18 % of the watershed is forested today. Latest guidelines distributed by ecologists state that a healthy watershed is 30% forested. Less than 3% of the watershed's land base is publicly owned forest land. The amount of natural area that is protected to some degree from development by municipal designations (e.g. Environmentally Sensitive Policy Areas) may be as high as 10%, but exact figures are not compiled. The effectiveness of these designations in preventing degradation of the sensitive areas varies considerably, but can certainly not be considered absolute protection. Most areas of the watershed are protected under municipal tree cutting by-laws. These are designed to prevent degradation of the forest from an extraction/productivity perspective, and have been somewhat effective in this regard.

In the Grand River watershed there are no known examples of large areas untouched by human activities. There are, however, many areas where the trees are older than 100 years (a commonly used threshold age in defining old growth). The recent discovery that the gnarled eastern white cedars along the Niagara Escarpment are one of the most significant old growth forests in eastern North America, draws to mind the possible parallels with the limestone cliffs at Elora, Rockwood, and Everton.

There are many woodlands that exhibit old growth characteristics in the watershed, but with the possible exception of the cliffs, there are probably no 'virgin' forests. Some areas already supporting very old trees should be allowed to move towards a realistic facsimile of what old growth in this region would look like. The strategy should include core and buffer areas, and provide a representative sample of old growth forests types for the Grand.

The vast majority of the forested sites or woodlots in the watershed are less than 400 hectares in area and are surrounded by agricultural or urban lands. Throughout the watershed many stands of trees, wetlands and other natural landscape features have been converted to land use areas for housing, industry, agriculture and recreation. Remaining woodlots have been impacted by summer logging, grading, and artificial land drainage. Breeding and rearing of wildlife have been heavily impacted.

Migratory songbirds are perhaps the best indicators of the state of wildlife habitat. While naturalists and environmentalists raised concerns and awareness in the 1970's and 1980's of the substantial losses of the rainforests our birds migrate to in winter, residents of the watershed have continued their incompatible forest management practices. Now, we have several species on the rare, threatened, and endangered lists and continuing declines of more than a dozen neotropical songbirds since 1966. There is a need for the creation of several large woodlands greater than 400 hectares in extent to function as source areas and refuges to compensate for the population sinks in the smaller ones which are vulnerable to disturbance and predation.

Many forests today have a very simple structure: one or two ages of trees with nothing in between. This is not necessarily bad, and having some forests like this is undoubtedly good. It may require some conscious decisions to ensure that a good sample of more complex forests occurs in the watershed. The complexity would involve species composition and an all-aged structure, including a healthy shrub layer. Some species will prefer these conditions, and the struggling interior forest-dwellers will be among them.

Today in the Grand watershed, pasturing in woodlands is virtually non-existent, and during the past three decades many floodplain pastures have been abandoned. Many of the abandoned pastures have been reforested, or now offer opportunities for forest restoration. This general trend away from livestock grazing in forests and floodplains, may in fact be one of the two most profound and far-reaching influences on the current state of the Grand landscape.

Urbanization is the other. With the growth of the cities and development of transportation systems, it became more and more common for many of their residents to live in the surrounding countryside. The ownership and management of the landscape is no longer the exclusive domain of the farm community.

An urban forest grew in the cities sometimes by default at first, but increasingly by design. The urban forest today often has a canopy coverage greater than the surrounding agricultural landscape, although the urban forest does not have the same structure and composition as rural forests. This does not mean that the urban forest is in a healthy state as it is mostly planted and has many buildings and roads throughout. The urban forest now is only beginning to be managed in an holistic, ecosystem-based approach.

The current state of urban forests in the Grand watershed is not entirely encouraging, despite the significant achievements of municipal urban forestry departments. Much progress has been made in protecting remnant forests, yet development continues to erode that resource as cities spread outward.

The contribution of the urban forest to the health, vitality, sustainability, livability, and even economic success of communities is poorly understood. It is often overlooked in decision-making processes, and often ranked low on the list of priorities when conflict arises between various uses or potential uses of urban land.

The problem of native plants being displaced by opportunistic non-native plants is certainly most acute in urban areas. The majority of street trees are selected from a very few street-hardy species, such as Norway and silver maple, green and white ash, linden, and honey locust, and therefore our 'streetscapes' lack the diversity in species composition that might protect them from disease and insect epidemics.

Community involvement in urban forest establishment and care is now at a very high level. The trend in parks is away from manicured situations toward a balance of these areas with 'naturalized' areas. There is a general trend in municipal projects and also in a growing segment of the general population, toward planting indigenous species. Forests are probably given a higher priority than ever before for protection from development pressure. As cities grow, significant natural areas are incorporated into, and protected within, development plans as never before.

Comprehensive inventories are not available for all urban areas in the watershed, and it is difficult to quantify the state of urban forests in the Grand watershed. However, it is reasonably safe to say that awareness of the urban forest's importance is growing, protection from development has improved, and that political and financial support are inadequate or unreliable to make significant improvements. Opportunities and challenges exist in the management of naturalized areas, maintaining or enhancing the integrity of existing natural areas, and maintaining the 'streetscapes'. Education programs are needed to help the public and politicians understand the urban forest.

The 'suburbanization' of the countryside continues to have, an incredible influence on the landscape. Naturally, there are more houses in the country. Many of them have been built into existing forests, and thereby converted what may have been healthy forest habitat to 'edge' habitat. Although all types of habitat have their value for some creature, prairie, savannah, wetland, and interior forest habitats appear to be the types of habitat most in need of protection and restoration. Edge habitat and the species that depend upon it are both plentiful in the Grand watershed.

Many urbanites living in the country plant trees or retire marginal and fragile farm land at a rate that in parts of the watershed exceeds marginal land retirement by farmers. In many cases, only the land that it best suited to agricultural production is farmed. Where there is a financial imperative to eke a living from the land, this situation is sometimes considered a luxury that must be foregone. It may be that the urban influence in the countryside has been, on balance, a mixed blessing.

On balance, there is (probably) more land going into forests than coming out of forests. It may be that the quality of the ecosystems are not of comparable 'value' to society.

10.2.1 Ecosystem diversity

The valley of the Grand has a diversity of landscapes (ecosystems) based on the variety of geological features and soil types, and differences in climate and elevation. The climatic and elevation variation in the watershed accounts for two major life zones, the Great Lakes — St. Lawrence Region (Alleghenian Zone) and the Carolinian Zone.

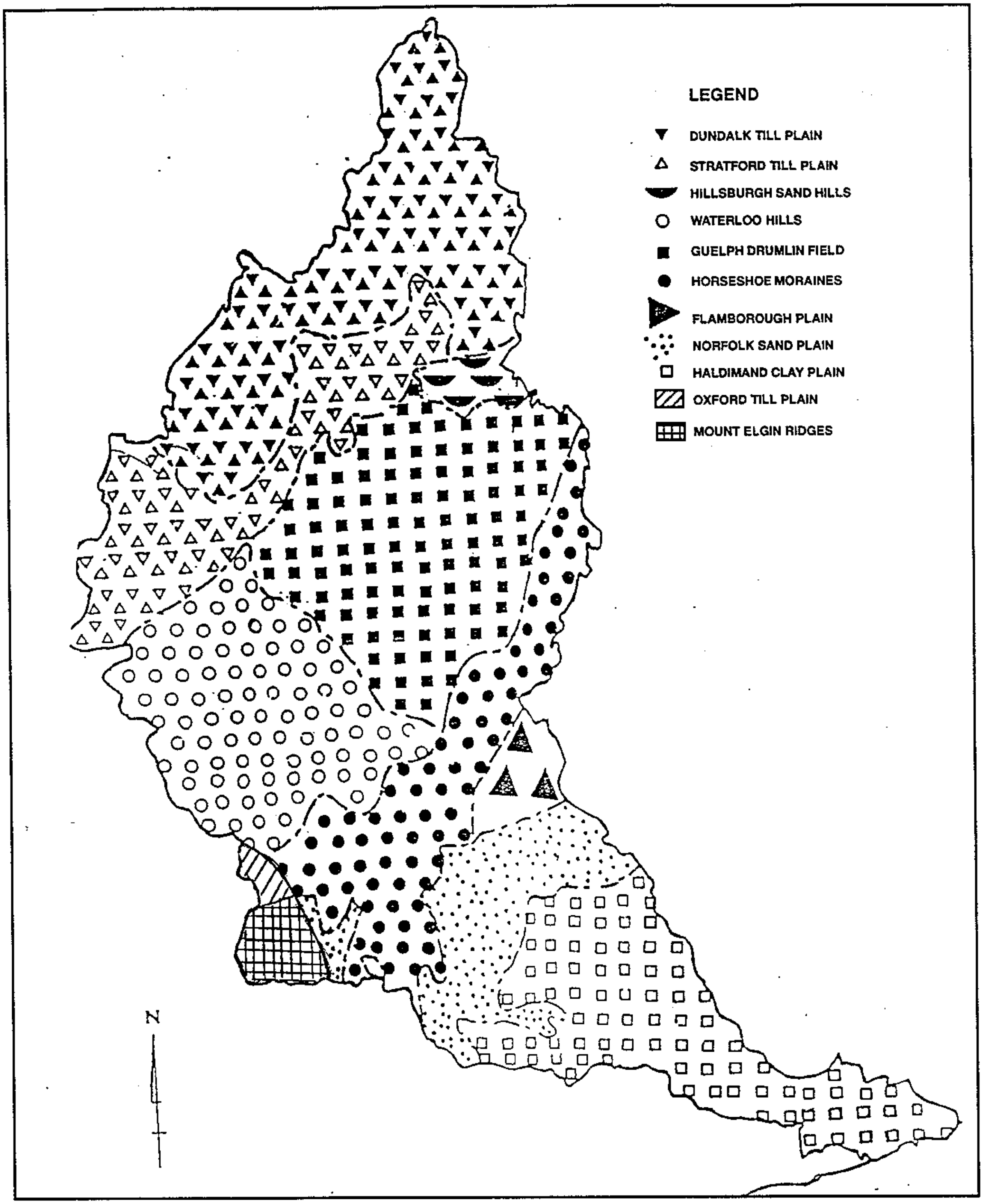
The Great Lakes - St. Lawrence forest is a transition zone between the deciduous forests of the south and the boreal forests of the north. Parts of the Grand watershed north of Cambridge are in the southern section of this zone where the forests still look more deciduous than boreal. This life zone in Ontario is not as heavily urbanized nor as intensively farmed as the Carolinian zone. There is a lack of glamorous species to attract attention to it, and yet it also is under pressure.

The northern limit of the Carolinian zone is at about Cambridge. The extended growing season allows many species more characteristic of southern climates to enrich the diversity of this life zone. It accounts for only 1% of Canada's land area, yet a quarter of all Canadians live within it. As a consequence of so small an area housing so many people, the pressures on this life zone are intense. A hugely disproportionate fraction of Canada's rare, threatened, and endangered species are from the Carolinian zone

10.2.2 Ecoregions of the Grand River Watershed

Within these two broad life zones, the underlying geological features, surficial soils, and climate create 29 ecoregions in the watershed. These ecoregions and their characteristics are described in the Atlas to the Ecoregions of the Grand River Watershed. Rather than describe the resources of each of the ecoregions in this report, we have focused on the 11 physiographic regions as shown in Figure 10-1, page 10-6. In many sectors of the watershed the boundaries of physiographic regions and ecoregions are coincidental. However, subtle differences in the terrain, climate and historical land use have created subregions with differing ecological characteristics.

FIGURE 10-1: PHYSIOGRAPHIC REGIONS OF THE GRAND RIVER WATERSHED



10.2.3 Physiographic Regions of the Grand River Watershed

There are 11 regions in the watershed which are described as "minor physiographic regions" by L. J. Chapman and D. F. Putnam in *"The Physiography of Southern Ontario"*. As stated above, ecosystem diversity is affected dramatically by the presence of the two major climatic or plant growth zones, the Alleghenian and Carolinian. The physiographic regions of the watershed are described below, in order from north to south.

10.2.3.1 The Great Lakes - St. Lawrence Region (Alleghenian zone)

10.2.3.1.1 The Dundalk Till Plain

The Dundalk Till Plain and headwaters ecoregion, located mainly above Highway 9, is a major headwater area for the Grand, Nith and Conestogo Rivers. It has extensive wetland complexes, wet meadows, and agricultural land in 4 major source areas. They are the Dundalk , Melancthon, Amaranth, and Keldon source areas.

The till plain is drained by an extensive network of agricultural drains and small watercourses which link the numerous wetlands. Two large eskers and a series of small drumlins, which are located at the northwest boundary of the Watershed, add considerable diversity to the habitat of the till plain. The western most esker runs through the Keldon swamp southeasterly to the north bog at Luther Marsh Wildlife Management Area. This is a 5,679 hectare complex of bog, marsh, mixed deciduous-coniferous swamp, upland deciduous forest ,plantation, meadow and agricultural fields. There are 504 hectares of bog in the Luther Marsh complex. The well vegetated Horseshoe Moraine and Niagara Escarpment physiographic regions border the till plain on its east side. There is a noticeable transition from scarce natural vegetative cover along the west side of the till plain to extensive cover in the east.

Data from the *Ontario Breeding Bird Atlas* (Cadman et. al. 1987) show that diversity of bird species is lowest in the Watershed in this northwest sector. Diversity ranges from 71 to 97 species. In sharp contrast, there are 134 species of birds at Luther Marsh. Sub-boreal vegetation and the extent of the marsh and forest make this area attractive to birds usually found much further north. It is important to migratory birds and significant breeding birds such as Black-crowned Night Heron, Red-necked Grebe, Wilson's Phalarope, Osprey, Common Loon, Great Blue Heron and Hooded Merganser.

10.2.3.1.2 The Stratford Till Plain

The Stratford Till Plain lies south of the Dundalk Plain and comprises the Listowel and Stratford ecoregions. This flat clay plain is wedge shaped with its broadest sector in the west, between New Hamburg, Millbank and Highway 9. The point is in the east, between Belwood and Highway 9. As on the plain to the north, natural vegetative cover is more extensive in the east. The valleys of the Conestogo, Irvine and Grand Rivers are more deeply cut through this area and wildlife corridors in a north-south orientation are somewhat developed. The headwater area of the Nith River, in the western sector is very open and there is little wildlife habitat. The most northerly source area for the Speed River in the east has slightly better covered drainage ditches and small watercourses.

Lake Conestogo and valley lands in the Drayton area have the most extensive habitat on this till plain between Glen Allen and Wallenstein, on the Conestogo River, there is a diverse valley forest accompanied by floodplain meadows. This area has several species of birds and plants which are rare or uncommon in Wellington County.

Another area of relatively high quality habitat is the Rich Tract, a Wellington County Agreement Forest located between Fergus and Arthur along Highway 6. It has sub-boreal plant communities and bird species uncommonly observed in the Watershed.

10.2.3.1.3 The Hillsburg Sand Hills

Prominent sand hills and a transitional area adjacent to the Horseshoe moraine and Stratford Till plain characterize the Hillsburg Sand Hills physiographic region and Orangeville ecoregion. This is a very scenic area of the watershed with hills slightly higher than those of the Waterloo Hills region. Agricultural use is limited due to topographical and drainage factors. The region is approximately 30% forested and much of the forest is composed of provincially significant swamps located in the valleys between the hills.

10.2.3.1.4 The Guelph Drumlin Field

The watersheds of the Speed and Eramosa Rivers lie within Guelph Drumlin field physiographic region and Guelph ecoregion. This region has the most extensive network of forest habitat in the watershed. Valleys between the numerous hills and drumlins are typically covered by large forests and the areas of lowest elevation are swamp and flood plain.

At the toe of the slope there is often a seepage line or numerous springs which support rich cedar swamps and communities of ash, birch, hemlock, balsam fir and hard and soft maple. The cedar swamps form a large network of valley habitat with several large core areas which are linked by streams. Beaver have built dams on the majority of the streams, affecting fish habitat and creating marshes. The beaver activity is supported by extensive areas of aspen and balsam poplar which are located in transitional areas on the slopes adjacent to swamps and marshes. The drumlin field provides several thousand hectares of the best habitat in the watershed for furbearers such as beaver, muskrat, deer, mink, raccoon, flying squirrel, red and black squirrel.

Seven well known areas of importance in this sector of the watershed are the Elora Gorge, Grand River Valley from Inverhaugh to Winterbourne, Swan Creek valley and swamp, Salem Forest, Speedside Forest, Eramosa River Valley, Ariss Woods. Most of these were documented in the South Wellington Environmentally Sensitive Areas Study (Eagles et. al., 1976).They provide over 1500 hectares of significant/sensitive habitat.

The limestone walls of the Elora and Salem Gorges and the floodplain meadows and swamps of the downstream river valley are inhabited by several species of plants which are rare in the Watershed. They include Cut-leaved Grape Fern, Slender Cliff-brake, Smooth Cliff-brake, Maidenhair Spleenwort, Green Spleenwort, Butterwort, White Camas, Grass of Parnassus, and Twin Leaf. This same area supports a trout fishery. A headwater swamp at Highway 6 in the Swan Creek valley has a number of uncommon plant species and uncommon birds, including Red-breasted Nuthatch and Red-headed Woodpecker.

At the northwest corner of the drumlin field, in the Lutteral Creek watershed there is swamp/upland forest known as the Speedside Forest. This diverse area supports five species of ferns which are rare in the Watershed. The Ariss woods are located on a significant esker and have importance due to size and botanical features. The Eramosa River Valley follows a lengthy glacial spillway from Brisbane to Guelph. The Brisbane Swamp, which is a major headwater area for the river, and the upper river valley, above Ospringe, are within the drumlin field. From Ospringe, the Eramosa River flows through the Horseshoe Moraine physiographic region to its confluence with the Speed River.

10.2.3.1.5 Horseshoe Moraine

The Horseshoe Moraine region is very a dynamic area and provides extensive habitat, including 5000 hectares of wetlands. The southern arm of the region extends from Erin to Puslinch Lake in the Alleghenian habitat and plant growth zone then southerly through the centre of Brant County to Simcoe in the Carolinian Zone. Approximately 30% of the moraine region is forested, field sizes are slightly smaller, and fencerow vegetation is often very well developed.

Within the Alleghenian zone the moraine comprises the Campbellville and Puslinch ecoregions.

The Eramosa River cuts deeply through limestone bedrock from Everton to Guelph, all types of wetlands are represented, and Puslinch Lake, the largest natural lake between Toronto and Windsor is present. The watersheds of Hanlon, Irish, Mill, Aberfoyle, and Torrance Creeks and the corridor of the lower Speed River are within this physiographic region.

Stretches of these creeks and the Eramosa River are classified as cold water. Karst-like topography is found in the Rockwood area. There are several swamps and upland forests which have interior breeding habitat for birds requiring seclusion. The main ones are either source areas for or are located adjacent to the above stated creeks and are named after them. The Eramosa River-Blue Springs Creek wetland complex with a total area of 1045 hectares is home to significant species including Northern Flying Squirrel, Mourning Warbler, and Eastern Goshawk.

The wetlands and valleylands once supported Canada Lynx, Bobcat, Eastern Cougar and River Otter. Puslinch Lake and associated wetlands form a complex with an area of 350 hectares and the fens, bogs and swamps along its south shore make it one of the most diverse and dynamic areas of habitat in the Watershed. The lake is a fishery and stop-over for migrating waterfowl. Eastern Ribbon Snake is found in the southern half of the complex.

In the late 1950's, Highway 401 was constructed through the middle of the Watershed, from Morriston to Woodstock. To preserve high quality agricultural land the highway was routed through wetlands and woodlands at the backs of farms.

As a result the highway split the 1400 hectare Mill Creek wetland complex in half and severed the 113 hectare Irish Creek swamp from its source area in the Puslinch Lake complex. Drainage and wildlife movement patterns were severely disrupted. Mill Creek wetlands support several species of orchids and 3 rare species of ferns and the creek itself is a regionally significant trout stream. There are 7 regionally rare species of ferns and several regionally rare herbs in the Irish Creek swamp. The swamp and its adjacent maple, beech, hemlock upland woodlands provided habitat for Red Shouldered Hawk in the 1970's.

From the Eramosa and Puslinch areas of southern Wellington County the Galt moraine component of the Horseshoe Moraine region extends south-westerly through the Townships of North and South Dumfries, Brantford and Oakland. The Grand River cut through the moraine south of Cambridge creating a deep, richly vegetated valley. Adjacent to the valley are patches of prairie, kettle bogs, and headwater swamps of small tributary streams. Water from precipitation infiltrates to the water table in areas of sand and gravel deposits in the moraine and the local groundwater flow is toward the rivers and streams.

The groundwater discharge in the forms of springs, seepage lines, and upwelling, supports very important habitat. The discharge supports small cold water streams which flow year round; it affects soil formation thereby creating special plant and herpetofaunal habitat; it causes wetland development on steep slopes; and it creates upwelling of water in the river which is cooler than air temperature in summer and warmer than air temperature in winter. Due to the influx of warmer water, sections of the Grand River in this physiographic region do not freeze over in the winter and as a result Canada geese and other waterfowl can overwinter on the river.

Wildlife habitat in the Horseshoe Moraine physiographic region is further enhanced in the area south of Puslinch Lake because of the climatic influence of the Carolinian Zone. This plant growth and habitat zone is characterized by growing seasons and relatively mild winters which are typical of parts of the Carolinas. This area of Ontario, which is located south of a line from Grand Bend to Toronto, is the most southerly portion of Canada. Special attention is given to the Carolinian Zone-the banana belt of the Watershed, later in this report.

10.2.3.1.6 Waterloo Hills

Much of the core of the Watershed and the most of the Regional Municipality of Waterloo is located within the Waterloo Hills physiographic region. This area has the greater portion of the watershed population and urban development. Wildlife habitat is threatened here.

The Grand River has cut its valley in a north-south direction through the eastern half of the region and two of its major tributaries-the Conestogo and Speed, converge on the Grand in this area. These were the major water based wildlife corridors in the past but functions have been limited by all of the urban land uses in the vicinity. Water was used for transport and power at the time of settlement and towns and villages grew up along the rivers at the expense of riverine wildlife corridors. Urban development has extended outwardly from these nodes engulfing whole tributary watersheds.

The Grand River corridor and the Cities of Waterloo, Kitchener, and Cambridge comprise the central Grand River ecoregion. This is the eastern half of the Waterloo Hills physiographic region.

The Waterloo Hills region has a higher percentage of easily managed land for agriculture than the till plains to the north and the Horseshoe Moraine to the east. As a result, wildlife habitat has been reduced to 'islands of green' which have been invaded by several non-native plant species introduced for agricultural and urban landscaping purposes.

The invasions of aggressive exotics coupled with management and harvesting practices have reduced the level of natural integrity of these remnants of our natural heritage. Due to the competition for the use of land in urban growth and extensive agriculture, new nonagricultural development has frequently been pushed into the naturally vegetated lands with less capable soils. There are approximately 100 areas in the region with high levels of diversity and integrity of habitat and there is widespread interest in sustaining them.

The western sector of the Waterloo Hills region drains to the Nith River and, as on the Stratford and Dundalk Till Plains, there is less forest cover in the west than in the east. Large woodlots in the Amulree, Wellesley, Crosshill, St. Clements, Bamberg, Josephsberg, St. Agatha, and Phillipsburg areas provide a range of habitat for significant wildlife species. Most are dominated by Sugar Maple, Beech, and Hemlock in rich stands on hummocky ground. This is the Wilmot ecoregion; named after its largest municipality, the Township of Wilmot.

Small low lying kettle depressions occurring in the generally upland woodlands are usually covered by Soft (Red or Silver) Maple. Larger kettles at St. Clements and Bamberg are bog like with numerous plant species which are found on acidic soils including Black Spruce, Labrador Tea, and many orchids. The woodland at Josephsberg is primarily swamp, dominated by Soft Maple and White Cedar. Some of the significant species found in these areas include Red-backed Vole ,Snowshoe Hare, Dwarf Mistletoe, Pale Laurel, Clubspur Orchid, Ragged Fringed Orchid, and White Water-crowfoot.

The central and eastern sectors of this region lie within the watersheds of the main Grand and Conestogo Rivers and creeks of medium size including Laurel, Boomer, Martin, Schneider and upper Alder Creeks. Water from precipitation infiltrates in the sand hills and discharges as groundwater to the headwater wetlands and source areas of the streams, creating fens, bogs, kettle lakes, swamps, marshes and sufficient baseflow in streams to support trout fisheries. There is a great concentration of these areas in the Erbsville area in the Laurel Creek watershed. Over 625 hectares of wetlands and a trout stream amidst a series of hills, plus groundwater recharge and discharge areas make the area very dynamic. The kettle lakes in this sector are Paradise, Sunfish, and Spongy Lakes. Significant species in these areas include Early Coral-root, Pink Pyrola, Leconte's Sparrow, Barred Owl, and Red-shouldered Hawk. Wildlife is enhanced somewhat in this area by the Laurel Creek reservoir as numerous migratory bird species stop over there in spring and fall, including Double-crested Cormorant, Osprey, Snow Goose, Common Loon, American Golden Plover, and Terns.

Northeast of Elmira there are 2 landforms of recognized significance. They are the Woolwich sand hills and the Woolwich swamp. The prominent sandy hills were reforested approximately 65 years ago. The plantations provide habitat which is unique in the region as the hills are surrounded by heavy soils characteristic of till plains. Pinesap and Red-breasted Nuthatch, which are more common in northern Ontario, are found in the plantations. At the bottom of the hilly area or its southeast side, there is a large swamp which is a headwater area for a branch of Canagagigue Creek. Coniferous species including Black Spruce, White Spruce, Balsam fir, and White Cedar make up a large percentage of the swamp canopy.

The valleys of the Conestogo and Grand Rivers in the Waterloo Hills region have been utilized as pasture land for generations and natural vegetation has been suppressed in many bottomland areas. Narrow ribbons of forest on steep slopes and in flood plain seepage areas provide some fragmented woodland habitat. These areas have potential to become broad corridors with diverse core habitat and routes for daily and seasonal wildlife movement.

10.2.3.2 The Carolinian zone

10.2.3.2.1 Flamborough Plain

The western side of the former Township of Beverly, now the Town of Flamborough, lies within the Flamborough plain physiographic region and Beverly ecoregion. Shallow soils over bedrock in the Sheffield-Rockton area provide interesting habitat which is characterized by swamps, marshes and bedrock outcrops. The west end of the Beverly Swamp and the headwater area of Fairchild Creek are located in this region.

The 2000 hectare Beverly Swamp is the third largest remaining interior wetland in Southern Ontario and it is home to several species which are at the southern limits of their ranges in Canada. They are Black Spruce, Porcupine, Northern Flying Squirrel, Snowshoe Hare, Woodland Deer Mouse, and Water Shrew (Ecologistics, 1976).

There are relatively flat exposed bedrock plains in the Kirkwall, Rockton area with alvar-like vegetation. Eastern Red Cedar or Juniper is one of the species which is often found in patches in such areas. Extensive areas of meadow in this vicinity supported large populations of sparrows. Reforestation and agricultural practices have drastically reduced the quality and extent of the meadow habitat.

10.2.3.2.2 Horseshoe Moraine - Carolinian Sector

The Carolinian Zone is the land of the Flowering Dogwood, Sassafras, Hickory and Tulip trees, and recognized as a nationally significant resource.

The southern arm of the Horseshoe Moraine physiographic region stretches into the Carolinian Zone and splits the Norfolk Sand Plain physiographic region into west and east halves in the Watershed. This southern arm comprises the core of the Dumfries ecoregion, named after the Townships of North and South Dumfries. East and west fringes of the ecoregion are on the Norfolk sand plain. The combination of the till moraine and the climatic factors of this plant growth zone creates high diversity in habitat. The diversity is further enhanced by the deeply cut valley of the Grand River in the middle of the region and by the sand plains on the flanks.

Some of Ontario's most significant and most sensitive habitat is located in this lower sector of the moraine region. There are 35 recognized natural areas of provincial interest, including all types of wetlands, prairie, upland forest, riparian corridors, islands and meadows. They cover over 2550 hectares. Species of wildlife which are rarely found in this part of the Watershed are also rare in the rest of Canada.

Because this is the most southerly part of Canada, many species are at the northern extent of their range here. One species, American Chestnut, is threatened by Chestnut Blight. One relatively large Chestnut tree located between Cambridge and Glen Morris recently died of the disease. In addition to Chestnut, 3 other species, Bird's Foot Violet, American Ginseng, and Common Barn Owl are also present in this moraine region, but, threatened in Ontario. There are approximately 10 species classified as vulnerable and approximately 100 which are regionally rare and provincially significant. Several are provincially rare.

There are 2 noteworthy areas which were recently discovered in Brantford. These are indicative of the status of our inventory of natural heritage areas in the Watershed. In 1990 the Brantford perched fen and adjacent savannah site and the Brantford Golf Course prairie and adjacent savannah were discovered and documented by botanists. Several rare grasses, sedges, herbs shrubs and one rare tree, Dwarf Chinquapin Oak were found in these areas. More work by botanists and other natural heritage specialists, who work throughout the province, may uncover other significant resource areas.

10.2.3.2.3 Norfolk Sand Plain

The area of the watershed which has the greatest capability for agriculture and plant growth, in general is the Norfolk Sand Plain physiographic region. Lands here are rated above prime and are used for specialty crops grown in few regions in Canada. Wildlife habitat is threatened here because there is little marginal land left for wildlife. Land uses which are not agricultural have traditionally been allocated to the marginal lands, leaving habitat highly fragmented. Few core areas other than large swamps exist. Examples are Falkland Swamp (240 ha), Oakland Swamp (800 ha),and Burford Swamp (820 ha.)

There are two parts in this plain region, one being west of the southern Horseshoe Moraine region, the other east. The western portion covers the watershed from a line extending from Ayr to Princeton and southerly to the watershed boundary in the vicinity of Scotland and Oakland. The Waterford ecoregion is within this part of the physiographic region. The lower half of the Whiteman's Creek watershed, all of Charlie Creek watershed, and source areas for McKenzie Creek and Boston Creek are located in this physiographic region.

Whiteman's Creek has a large watershed extending form its source area in the Oxford Till Plain region, through the Norfolk Sand Plain region to the Horseshoe Moraine region where it has cut a deep valley to the confluence with the Grand River. In the sand plain the gradient of the creek lessens and it is linked to a large complex of small wetlands, most of which are swamps and marshes.

Within and adjacent to these wetlands are many irrigation ponds, usually ringed with willow tree and shrubs. Few significant species have been found in this region and natural heritage inventory work is in progress. Whiteman's Creek is a very significant trout fishery in the moraine region and its headwater area in the Princeton - Innerkip area has a variety of significant species and habitats.

The eastern portion of the Norfolk Sand plain region, in the Peter's Corners, Ancaster, Cainsville area, is drained by Fairchild Creek and Big Creek. This portion is the St. George ecoregion. Wetlands in the Fairchild Creek watershed complex (205 ha.) are important to this region. Again most natural areas are small, fragmented and narrowly sinuous along streams and steep slopes.

The Norfolk Sand Plains region has been significantly affected by the development of Highway 403. As was the case with Highway 401, 40 years ago, planners tried to minimize land severances and agricultural impacts. The road therefore was routed through the middle of many wetlands and woodlots from Woodstock to Ancaster across this physiographic region.

10.2.3.2.4 Oxford Till Plain

The Oxford Till Plain physiographic region is located in the Plattsville, Drumbo, Princeton, Woodstock area and it is a source area for Black Creek and Whiteman's and Homer Creeks. The eastern fringe of the Woodstock ecoregion and the western half of the Blenheim ecoregion are within this physiographic region. All of the blocks of natural habitat of any significant size are wetlands in this region. There are 2 main complexes. The Black Creek complex drains to the Nith River and has an area of 890 hectares. This complex supports deer and waterfowl and 4 provincially significant species and has over 30 regionally significant species.

The upper Whiteman's Creek complex has a number of wetlands within it which are provincially significant on their own merits. They include Chesney Bog, Pine Pond, Lockart Pond, Buchanan Lake, and Benwall Swamp. The complex totals 2486 hectares. One endangered species, Small Whorled Pogonia is present in the central portion of the complex adjacent to Highway 401. There are 6 provincially significant and 29 regionally significant species in these wetlands. Upland woodlands are small and highly fragmented while riparian vegetation corridors are well developed in many areas.

10.2.3.2.5 Mount Elgin Ridges

The Kenny Creek watershed and the Norwich ecoregion are located in this northeastern tip of the Mount Elgin Ridges physiographic region. The landscape is dominated by a succession of ridges composed of imperfectly drained clay or silty clay and hollows having alluvial swamps, and deposits of sand and silt. Colles Lake and adjacent wetlands, which are centrally located in the ecoregion are typical features of the physiographic region. The wetlands of the Kenny Creek watershed, which are mainly riparian swamps are provincially significant and the creek supports a warm water fishery.

Dairy farming is the primary land use in this area, in contrast to the sandy lands to the east which are tobacco and specialty crop lands.

10.2.3.2.6 Haldimand Clay Plain

The lower Grand River Watershed, southeast of a line through Alberton, Onondaga, and Bealton is within the Haldimand Clay Plain region. The core of the watershed from Caledonia south to Lake Erie lies within the Cayuga ecoregion. The Grand River corridor is well developed in this ecoregion with extensive marshes, floodplain meadows, oak savannahs, woodlands, and willow lined river banks, between the roads which parallel the river.

There are several areas of significance in the region, some for their size and others for their high quality habitat. The Six Nations and New Credit Indian Reserves comprise the Tuscarora ecoregion within this physiographic region and they are almost 50% forested. An ecological study was carried out in the area in the early 1980's and observations of a few regionally rare species have been reported. The most important observation, however, is that the large mid-concession blocks of forest have several large core areas which are separated from the forest edges by 200 to 400 metres. The potential nesting habitat for interior nesting species and the potential habitat for Carolinian species requiring large amounts of forest in daily and seasonal ranges is phenomenal.

Other large areas of forest of importance are the North Cayuga slough forest (1214 ha.), the Oriskany Sandstone woodland and Dry Lake wetland complex (306 ha.), the Taquanyah wetland complex (142 ha.), the lower Grand River marshes (1106 ha.), the Dunnville northwest woodland and wetland complex (230 ha.), and the Mount Healy woods (81 ha.). These areas are worthy of special attention.

The North Cayuga slough forest is a diverse forest dotted with vernal pools and sloughs which are ringed by swamp communities. Upland areas are dominated by Sugar Maple, White Ash, and Red Oak. Low wet basins are dominated by Red Maple, Swamp White Oak and Black Ash. There are transitional areas having a broad range of species. The area is drained by 2 creeks; Oswego Creek to the east and tributaries to the Grand River to the west. One creek extends westerly through a woodland and ravine system at Ruthven.

This is a valuable area and Macdonald (1980) noted 460 plant species, of which 14 are considered nationally, provincially, and or regionally rare, including Black gum, Flowering Dogwood, Southern Arrow-wood ,and a sedge (Carex seorsa). Of 73 bird species recorded, 4 are rare in Canada, Ontario and regionally. They are Red-bellied Woodpecker, Acadian Flycatcher, Tufted Titmouse, and Prothonotary Warbler. There is also a heronry in the forest.

The Grand River and Dunnville marshes are 2 of the best examples of riverine marshes in Southern Ontario and are significant stop-over areas for migratory birds. Comprehensive studies of these areas are now underway. Significant bird species are King Rail, which is nationally and provincially rare, and Black Tern.

The Oriskany Sandstone woodlands and Dry Lake wetland complex is a very dynamic and significant area of the Watershed. This the only outcrop of Oriskany Sandstone in the province and it is the western end of the Onondaga Escarpment, which extends into the Niagara Peninsula. The area has several mysterious clay knolls scattered throughout and examples of karst features. Of 627 species of plants found, 12 are provincially and nationally rare and 27 are regionally rare. This area is the only known home of the nationally and provincially rare Black Rat Snake in the watershed. Red-bellied Woodpecker, Orchard Oriole, and Yellow Breasted Chat, all of which are provincially rare, were also found here. Two nationally and provincially rare mammals, the Woodland Vole and the Southern Flying Squirrel are on record for this area.

10.2.4 Edge habitat

There is currently a high edge to interior ratio in forests of the Grand watershed. Conditions are far from ideal in most parts of the landscape for species that require forest interior habitat. Edge habitat favours generalists, while forest interior favours specialist species such as thrushes, warblers, and vireos. The microclimate, and exposure to predation and disturbance, are two edge factors that work against the specialists.

Edge habitat was long ago recognized as being favourable for sport hunting, and because of this, many land management programs of the past encouraged the creation of edge habitat. Currently, the emphasis is on increasing the core interior forest areas somewhat to bring edge and interior habitat into a better balance.

Some wildlife species increased in relative abundance because the landscape changes (e.g. more edge) favoured them: white-tailed deer, red fox, and raccoon. Others moved into the area when conditions suited them after the landscape change: coyote and brown-headed cowbird. More recently the opossum has moved north from its traditional range to now cover most of the Grand watershed.

10.2.5 Species diversity

The massive changes that the landscape of the Grand has experienced have favoured some species at the expense of others. There may be more species in the watershed now than before European contact, but this kind of unnatural diversity is not a true indicator of ecosystem health. It has become evident in the past decade that the interior forest-dwelling and some wetland organisms are suffering; they are the species at whose expense the others have flourished. In order for species diversity to give an accurate indication of ecosystem health, this context must be remembered.

During the drastic landscape changes of the 1800's, many wildlife species requiring large expanses of forest disappeared from the list of Grand valley inhabitants. These include the timber wolf, black bear, passenger pigeon, cougar, bobcat, and lynx. Other species survive, but just barely. These include southern flying squirrel, eastern mole, Blanding's turtle, red-headed woodpecker, butterfly weed, pickerel frog, and a whole suite of interior forest birds such as warblers and thrushes. Species such as the cucumber tree, Kentucky coffee-tree, and prickly pear cactus have never been common here, and are even less so today: Other species, like the bald eagle, and wild turkey, have been re-introduced.

European settlers introduced many plants and animals purposely and accidentally. Some of these species, such as purple loosestrife, capitalize on opportunities so aggressively that they potentially displace indigenous plants.

Trees such as Norway spruce, European larch, and Scots pine have traditionally been planted in reforestation areas. The Scots pine has recently fallen out of favour, but the larch and spruce are still widely planted.

Of these three species, the Scots pine is of concern because of its prolific off-site regeneration capability. A long list of 'wildlife' shrubs has shown this 'invasive' ability: cardinal autumn olive, Russian olive, Tatarian honeysuckle, Rosa rugosa, multiflora rose, and others.

Many 'natural' areas are now comprised of a strong component of non-indigenous plants and animals. Norway maple and buckthorn are potentially a serious threat to natural areas in every urban area of the watershed. Garlic mustard is a non-woody invader of the forest floor. Among other species, European starlings and house sparrows, which are themselves non-indigenous, spread the seeds of non-indigenous species far from any place they were planted.

10.2.6 Biodiversity

There are significant bands of vegetation, landscape units and ecosystems which extend across large portions of the watershed often at right angles to the overall drainage pattern. They are extremely important to the maintenance of biodiversity in the watershed.

On the Till Plains the remnant woodlands found on farms are usually found at the mid-concession farm lot lines and they resemble green ribbons across the largely cultivated landscape. These ribbons are often the main wildlife corridors and they often run across the watercourses and valley lands, extending into the watersheds of the Maitland, Thames and Saugeen Rivers. Links have been established with the Bruce Peninsula.

Another area of significant vegetation is found in a triangular patch having points at Acton, Brisbane, and North Woolwich Swamp near Elmira. Although it is patchy on its west side the forested areas in the east are extensive. One of the dominant tree species in the 'patch' is white spruce. This is the farthest extension of the range of white spruce into South central Ontario and it supports forests having both unique and representative habitats in three or more physiographic regions in the watershed.

A broad complex of "natural areas" extends from Brisbane southwesterly to Ayr and westerly from Ayr to Woodstock, in the general direction of the groundwater flow across the watershed. The majority of the natural areas are wetlands and there are contiguous deposits of sand and gravel which are forested. Some contiguous areas are prairie, as outlined in Section 9.2.3.2. Land use and development pressure is high and will become higher in this area.

Parallel to the above complex of tremendous natural heritage resources is a band of existing and potential prairie sites. It extends southwesterly from Clyde and Brantford to Woodstock and Scotland. There are many south facing sandy slopes with patches of oak savannah and some prairie elements. Again, the orientation of this band is somewhat cross-watershed.

The areas described above have contributed vastly to the biodiversity of the Grand River Watershed. They are large and connect ecological communities here with those in other watersheds, the Niagara Escarpment and the remainder of the Great Lakes Basin. The maintenance of the ecosystem diversity, species diversity and genetic diversity of the watershed and parts of the Great Lakes Basin is somewhat dependent upon our ability to sustain and protect the habitats in these areas.

10.2.7 Genetic diversity

Ecologists and foresters now recognize that matching the destination of a transplanted organism with its genetic make-up is more important than previously realized. Often when plants are moved there is little or no regard for matching destination to seed source. The horticulture industry operates mainly on maximum hardiness, so that, theoretically, there are minimal restrictions on where the plant can be moved to successfully.

However, in many species the genetic traits are important beyond the concept of maximum hardiness. Seed sources for nursery stock from the Ministry of Natural Resources have routinely, although not exclusively, been matched to their ultimate destinations. Consequently, the majority of stock used in reforestation in the Grand watershed could be considered genetically appropriate for its site, because much of GRCA's reforestation has been done with Ministry trees.

The role of the Grand River Conservation Authority's nursery in this issue is very important. By enhancing the ability of landowners in the watershed to plant genetically appropriate indigenous plants, the GRCA is contributing to the health of the indigenous gene pool. The nursery continues its research into strategies for the resurrection of the sweet chestnut to its former prominence.

Also within the Grand watershed is the University of Guelph Arboretum. Their collection of various genetic strains of unusual Carolinian species is the largest of its kind in Ontario.

GRCA and the Arboretum are both members of the newly formed Forest Gene Conservation Association, whose mandate is to address issues such as these.

Genetic diversity in the natural forests may be in a downward trend because of the isolation of forest patches from each other. Too little is known about the genetic variability for a given species, and therefore this is only informed speculation. Natural regeneration is playing a greater role in reforestation - by design and by default. This signals an improved genetic matching of the 'new' forests to their sites than might previously have been the case with artificial regeneration only.

The conservative estimates of global climate change indicate that the climate will change more quickly than trees can genetically adapt or shift their ranges (through regeneration). It will probably also prove futile to try to anticipate the climatic conditions at a site and plant a tree now that will be genetically adapted to the conditions at maturity. The tree might have to survive and grow for decades in unsuitable circumstances before the climate changed to what was suitable for it. Therefore, all the genetic variability that is available will be needed to protect against the potential impact of climate change.

10.2.8 Disturbance and stress

The pattern of arrangement of natural areas across the landscape can be a major contributor to various disturbance and stress mechanisms. As an example, hedgerows joining forest patches are suspected of sometimes facilitating the introduction of invasive exotic organisms.

In the central part of the Grand watershed are the cities of Brantford, Kitchener-Waterloo, Cambridge and Guelph. Tremendous development pressure is put on adjacent lands. Some woodlots are destroyed, some are built into, and some are 'preserved'. Saving a woodlot from having houses built within it is worthwhile, but certainly does not prevent stress and disturbance impacts. Additional or new traffic (walkers, bikers, etc.) can pummel the forest floor plants and soil. Even if not a single person walks into the woodlot, recent studies at the University of Waterloo show that interior forest-dwelling birds may not inhabit woodlots with nearby development.

The amount of forest land affected is significant. Although it is almost certain that gains in forest cover in rural parts of the valley exceed losses in urban areas, the loss of function of these woodlands is still very important. The woodlots being affected near cities are often high quality forests, while the new forest cover is probably decades away from providing similar calibre of habitat.

Climate change is predicted to be a global phenomenon within our lifetimes. This area is expected to become warmer and drier. Before that happens, the frequency of extreme weather events may increase. Hail storms, ice storms, drastic freeze-thaw cycles in mid-winter, late spring frosts and early fall frosts, and extreme cold without snow cover on the ground, are all harmful to trees. If the frequency increases, or the extremes become more extreme, the cumulative impact could put forest trees into a decline spiral. Some theorize that that the decline of sugar maples in this valley and elsewhere around 1988, and commonly blamed on acid rain, was actually caused by a series of such events. It could be that global climate change is already harming the forests, but it cannot be proven beyond a doubt.

Around 1990, the gypsy moth invasion became an issue in this watershed for the first time. These voracious imported caterpillars strip the leaves of most tree species, but show a marked preference for oak, poplar, and birch. Their preference for oak makes them a devastating insect in forests of the Carolinian zone. All of the Grand's section of the Carolinian zone was affected, and the insects have been spotted as far north as Belwood Lake.

Two of the worst-hit spots were the lands of the Six Nations, and Byng Island Conservation Area. At Byng, the combination of soil compaction from recreational use and gypsy moth defoliation has put many of the magnificent oaks there into decline. Pinehurst, Byng, Lafortune, and Taquanyah properties of GRCA were sprayed with Bt (bacterial insecticide) in 1992. Gypsy moth populations have declined throughout the infestation area, probably because of unfavourably cold winters. This insect is expected to cause more problems in the near future.

Acid rain and other pollutants are not an obvious stress on local forests at this time, and yet they are certainly having harmful impacts. The Grand River Valley lies in the path of airborne acid coming from the Ohio valley industrial areas. Although this is a zone of very high acid deposition, it is also an area where the calcareous soils and underlying geology buffer the system; the lime in local soils balances the acid rain, and pH remains tolerable for vegetation.

Road de-icing salts are a major problem for urban street trees and trees and forests near major highways. The dieback on branch tips caused by salt can be seen very easily along Highway #401. This stress does not threaten to overwhelm rural forests, as it is a localized problem near the major roads. In the urban forest, however, the possibility of having a relatively continuous and healthy tree canopy is seriously jeopardized along major roads.

Excess low level ozone may be the most important pollutant impacting on the trees of this basin. Background (natural) concentrations of ground level ozone are increased as a by-product of chemical reactions between various fossil fuel combustion pollutants. Unnaturally high concentrations of ground level ozone are known to impair the productivity of agricultural crops such as beans, and it is certain that increased stress is being put on forest ecosystems, but information regarding the extent of the stress is still emerging. Like the acid precipitation situation, ozone is a pervasive stress agent throughout the Grand watershed. Unlike acid precipitation, there is no known natural 'buffer' against excess ozone.

The level of forest products harvest has not increased dramatically in the Grand watershed over recent years. Harvesting generally takes the form of 'improvement' thinnings in hardwood forests, and row thinnings in plantations. The work is often done by small equipment at appropriate seasons (i.e. when soils are not saturated and thawed) so that damage to the forest is minimal. There are unscrupulous logging outfits operating in the watershed, but their impact is limited to a relatively small number of woodlands. Improvement thinnings were often cut according to the marking of the Ministry of Natural Resources. Private consultants have recently replaced the Ministry of Natural Resources in the provision of tree marking services and forest management on private land.

Many tree species such as the oaks that are prized both economically and ecologically, are intolerant of heavy shade. This means that they cannot thrive in heavy shade, and therefore require some form of disturbance to regenerate in the forest. Natural disturbances include fire and wind storms that remove parts of forests and allow shade-intolerant species to regenerate on the sunlit forest floor. Fire has occurred less frequently in the past few decades than what would historically have been the case. Many of the current forests have sprung up after severe harvesting operations that would probably be considered unethical and unacceptable today. Both severity and/or frequency of disturbances has declined, and this situation suggests that care must be taken if these 'shade intolerant' species are to remain an important part of our forests.

In the natural progression of succession, shade intolerants are in time replaced by shade tolerant species such as beech and maple. Changes in the pattern of disturbances can therefore be seen as a pushing or pulling forests this way and that along the succession continuum. The composition of our forests could become far less diverse if all forests become dominated by shade tolerant species. To avoid this possibility, various types of disturbances are being experimented with, especially prescribed burns coupled with thinning.

10.2.9 Ecosystem resilience

Resilience in industrial (e.g. boreal) forest situations is a measure of the speed and integrity with which a forest regenerates after harvest. Almost all cutting operations in Grand watershed forests are selective, and usually in the positive sense of improvement thinnings. A forest canopy normally remains, although it is somewhat less dense, after a harvest operation. The disturbance is quite different from the large scale industrial harvests in the boreal forest. In local harvests, seed trees are always close at hand and microclimate is not drastically altered. Consequently it is not that difficult for the forest to regenerate in most circumstances.

That is not to say that there is no chance of harmful impact from improvement thinnings. Seeds of disruptive non-indigenous plants may be brought in on equipment from other woodlots, or soils and remaining trees can be severely damaged by poorly designed and implemented operations. If a thinning is so severe as to effectively extend the 'edge' effect into what had been forest interior, then the system may not rebound to the same level of integrity even though there is ample regeneration.

Abandoned farmlands are regenerating to forest naturally. This is a good sign of resilience. However, the time taken to regenerate varies quite a bit, depending on ground cover, seed source and other factors. The value of these meadows and shrubland stages prior to full regeneration should not be overlooked. Whether a field takes five years or thirty to regenerate, it provides habitat to a certain community at every stage. Non-indigenous species such as Scots pine and buckthorn often become established in regenerating fields, which is not as desirable as indigenous species such as cedar and hawthorn performing that function.

10.3 Multiple benefits of forests

10.3.1 Conservation of soil and water

10.3.1.1 Water quality

A combination of factors has improved water quality in the Grand's rivers and streams over the past three decades. Two of them are related to forestry:

- increased application of agricultural and agroforestry Best Management Practices (e.g. Environmental Farm Plans),
- improved waste water treatment,
- improved storm water management, and
- increased forest cover and riparian buffers.

Forest cover has increased in the moraines , and this is precisely where forestry cover can dramatically increase (up to tenfold) the rate of groundwater recharge.

10.3.1.2 Hydrology and stream flow

Drastic deforestation during the European settlement era is one reason that river flow became less moderated. Stream flow is not as exaggerated in forested areas as it is in agricultural or urban areas of similar topography and soils. Forest soils are more absorbent than agricultural soils because of higher organic matter content; tree trunks, branches and leaves intercept as much as half of the precipitation falling on mature forest.

Infiltration of precipitation into the ground is increased because the ground surface is less regular and because the soil is looser and more fractured. Evapotranspiration rates are higher for forests than other vegetation cover types; and both snow accumulation and snowmelt delay are higher in forests than in fields or cities. On balance, as a result of all these effects of forests on the hydrology cycle, both floods and 'low flow' become less extreme as forest cover increases.

The negative impacts of deforestation became evident in the Grand valley soon after European settlement had covered the watershed. Two solutions have been pursued since then: reservoirs and reforestation. Some areas of the watershed have increased in forest cover, but much opportunity still exists especially in the north and northwest parts of the watershed, to improve streamflow with additional forest cover.

10.3.1.3 Soil Quality

Soil quality has been improved through the application of agricultural and agroforestry Best Management Practices. Especially important in this regard are windbreaks, conservation tillage, and retirement and subsequent reforestation of seriously eroding farmland. Unfortunately, it is probably accurate to say that the windbreak establishment movement of the last two decades has not been as successful as the hedgerow removal trend of the 1960's and 1970's; that is, the damage done by hedgerow/fencerow removal has not yet been fully repaired.

10.3.2 Biological productivity

The Carolinian and Great Lakes - St. Lawrence forest regions are some of the most diverse and productive in Canada. In the Carolinian zone, the relatively long growing season and the mixing of major forest types leads to a great deal of biological productivity (as mentioned in Species diversity, on page 10-15). Despite this relatively high productivity, the potential is even higher. By strategically addressing the edge:core ratio, the productivity could be improved.

The conversion of conifer plantations to hardwood could be done more quickly with concerted effort. Diverse plantings are becoming the norm, and this may 'jump start' the process, but there is a backlog of fairly homogenous conifer plantations, which, depending on objectives, could be diversified through strategic thinning and/or seeding.

10.3.3 Extraction of forest products

A very small percentage of forests in the watershed are professionally managed. Many others are being managed in an ethical fashion, but could yield more of the desired product by greater application of scientific management techniques. The local forests are capable of yielding, on a sustainable basis, far greater volumes and higher quality of products. The Ministry of Natural Resources programs to encourage the adoption of forestry Best Management Practices are being retracted, and there may be a crisis in forest management if this is an important issue. Lumber mills and veneer mills import from the United States logs that could be grown here.

The general economic argument in favour of forest products may be persuasive, but a more far-reaching issue is in the value that landowners place on their natural areas. If all natural areas are considered a financial burden to landowners who need to make a living from the land, then maintaining these elements of the landscape may become more difficult. If, however, landowners come to think of natural areas as an integrated part of their revenue-generating system, then perhaps more people will be interested in natural areas.

10.3.4 Social and recreational benefits

Demand for forest-based recreation exceeds the capacity of public open space to satisfy the need. Popular highlights of the Grand valley such as Elora Gorge Conservation Area, Rockwood Conservation Area, and others, are being used beyond their carrying capacity. One bright spot in this regard is the advent of Rails to Trails program, which provides walking and cycling trails on abandoned rail lines.

Recreational opportunities are being sought by urbanites on private rural lands. There is significant conflict at this interface. Mechanisms for fostering symbiotic owner and 'recreationist' relationships are needed.

10.4 Wildlife management programs

Management of wildlife resources in the Watershed has been advanced in the last 10 years by a number of projects and programs. Some of the success stories are summarized below.

Christmas Bird Count

The Christmas Bird Count is an effective way to analyze and monitor long term changes in the distribution, abundance and population trends of birds which over-winter in the Watershed. Since 1900, birdwatchers have been going out in 'parties' to conduct counts in the established 15 mile (24 km.) diameter circles in various parts of North America.

Local naturalist clubs organize the activity and send the data to the National Audubon Society in the U.S. The 1993-94 Christmas Bird Count in Ontario included 2,715 participants and a total of 172 species observed. The record high was 183 species in 1991. when a total of 1,047,299 birds were counted. The birdwatchers spent 6,414 'party hours' (the highest ever was 6,519) (L. Burr and D. Rupert, Feb., 1995). This data collection activity will benefit wildlife and wildlife management.

Breeding Bird Survey

The Breeding Bird Survey was initiated in the United States and Canada in 1966. It is a standardized roadside survey which is implemented by volunteers each June. The volunteers are assigned a 40 kilometre route and 50 stops are made at 0.8 kilometre intervals.

All birds seen or heard during each 3 minute stop are recorded. Participation is increasing in these surveys. Ontario participation increased by 37% between 1993 and 1994. Over the 92 routes a total of 184 species was recorded with an average count of 64 species per route (C. Downes, 1995). The Breeding Bird Survey is examining ways in which habitat data can be obtained as part of the survey.

Ontario Herpetofaunal Summary

The abundance, distribution and ecology of Ontario's amphibians and reptiles has been documented since 1984 in the Ontario Herpetofaunal Summary.

By 1986, the volunteers who participated in the project had submitted 13,402 records of 51 species and subspecies. The volunteers numbered 586 in 1986, and 1003 in the period 1984 to 1986.

In the 1986 report, records were summarized on the basis of the Breeding Bird Atlas squares. These are the 10 km by 10 km squares based upon the Universal Transverse Mercator (UTM) grid system. From the summary map produced it is apparent that the southern half of the watershed and Luther Marsh in the upper half, have received a lot of attention. But, a great deal of work is required in the upper half. This was originally intended to be a seven year project, which would hopefully be adopted by other teams after 1990.

Wetland Evaluation

The majority of wetlands in the Watershed have been evaluated in a Provincial program which was initiated in 1984. Wetlands across Ontario have been compared through evaluations carried out in accordance with the Ministry of Natural Resources and Environment Canada Wetland Evaluation Manual and wetlands have been given priorities for protection through classification and designation. Most of the wetlands in the Grand River Watershed have been given a 'provincially significant' designation.

Carolinian Canada

The Carolinian Zone of Canada covers less than 0.25% of its land but has a large percentage of the number of the nationally rare species. In 1985 a program called Carolinian Canada was initiated to select a number of critical unprotected sites in the Carolinian Zone and facilitate protection of those sites through a variety of innovative means. Member agencies and organizations of Ontario's Natural Heritage League formed partnerships in projects to secure the 38 Carolinian Canada Sites. The Cambridge District office of the Ministry of Natural Resources and the Grand River Conservation Authority share the lead agency role in addressing the needs of 5 sites in the Watershed. They are: Beverly Swamp, Grand River Forests and Spottiswood Lakes, Sudden Bog, Oriskany Sandstone, and Six Nations Reserve.

The Conservation Authority has promoted private stewardship, acquired land and passed regulations in the first 4 sites and has assisted staff at Six Nations in their work. The projects have been well received by landowners.

Luther Marsh Management Area

The 5,679 hectare Luther Marsh Management complex is now operating under its second management plan. The complex has been under management by a steering committee of stakeholders for 35 years of its 44 year history. Waterfowl sanctuaries are set in place from March 15 to November 14. Limited waterfowl and small game hunting is permitted from September to February, during the hunting season.

A number of research papers have been written on the resources and management aspects involved and a number of students have received training there.

Puslinch Lake Research Area

Research at the Puslinch Lake-Irish Creek Wetlands has been facilitated by an informal agreement between the Wetlands Research Institute at the University of Waterloo and the Grand River Conservation Authority. Land which the Authority owns on the south and west sides of Puslinch Lake has been set aside for 20 years or as long as possible for research. A number of theses and research papers have published on the basis of work carried out in the research area.

Dunnville Wetlands property

The Nature Conservancy of Canada acquired over 900 acres of land between Dunnville and Lake Erie on the east side of the Grand River and turned it over to the Conservation Authority for management. A steering committee has been set up to guide resource inventories, research, management planning and habitat restoration. Most of the property is provincially significant marsh of the lower Grand River complex.

North American Waterfowl Management Plan
Eastern Habitat Joint Venture

An agreement between the Ministry of Natural Resources, Ducks Unlimited, Wildlife Habitat Canada, and Environment Canada - Canadian Wildlife Service has facilitated work in the Watershed. Under the Eastern Habitat Joint Venture owners of provincially significant wetlands have been contacted and private stewardship has been promoted. Land owners in the Horseshoe Moraine, Waterloo Hills, Norfolk Sand Plain, Flamborough Plain and Haldimand Clay Plain regions have been contacted and many have entered into voluntary handshake agreements to maintain the natural heritage resources of their lands.

Prescribed burns

Prescribed burns have been carried out by fire staff of the Ministry of Natural Resources at Luther Marsh, the Drynan Tract of the Regional Municipality of Waterloo, the Taylor farm, the F. W. R. Dickson Wilderness Area, and the Brantford Golf Course Prairie. These prescribed burns are economically feasible methods of managing vegetation to maintain biodiversity.

10.5 Summary of natural heritage issues in the Grand River watershed

Need for understanding of 'natural heritage' and complexity

There is a need for a comprehensive definition and understanding of 'natural heritage' among resource managers and watershed stakeholders. This should recognize the complexity, interconnections and finite capacities of ecosystems, so that an ecosystem approach to resource management can be adopted.

Many species of vegetative and animal wildlife are in decline due to habitat loss and fragmentation, increases in edge habitat, cowbird parasitism, urbanization, shoreline development and alteration, and agricultural practices.

Opportunities:

Develop a natural heritage system endorsed by watershed 'stakeholders' and partners as a framework for priority settling and resource management with a 'holistic' ecosystem approach. The establishment of a natural heritage system, which has design and strategic planning components, creates opportunities for restorative and management projects. The 'living Watershed Plan', data sharing agreements, and a resource monitoring framework will support the ecosystem approach.

Identify large patches of natural area that will be key building blocks of natural heritage framework; and connecting linkages between key patches and protect as possible. Habitat which is unique or scarce in an area should be identified because of its limited representation and vulnerability. Identify circumstances where investment in restoring/improving patch or corridor function will be optimized and promote or undertake these projects. Sufficient study must be carried out to recognize these areas.

Undertake operational activities and support practical research that help refine our understanding of the linkages, such as that between vegetation and hydrology at a local level. GRCA has resources that it can apply in support of research such as expertise and data sets in hydrology and watershed vegetation patterns, and land on which to undertake studies.

As linkages become better understood, stewardship programs can be better targeted to improve hydrologic attributes.

Areas in which more research is needed include: the inadequacy of present species protective measures which focus on rarity rather than diversity; the response of bird and other wildlife populations to habitat management, and protection of bird species which at present have no effective conservation or habitat protection.

Need for information integration and exchange

A large body of scientific information on natural heritage exists. This includes forestry, habitat and wildlife species information, but little has been acted upon or integrated into a conservation or management process. A natural heritage data and information system is required which is compatible and integrated with provincial and federal systems and natural heritage frameworks.

Options:

Resource information can be shared, and networking between all levels of participants facilitated, by workshops, newsletters and cooperatives.

Many agencies, both government and non-government are working together on frameworks for data collection monitoring and ecological land classification. All watershed stakeholders must plug into the system, and communicate and use this information more effectively.

Education opportunities and technical information services should be identified or created to assist stakeholders in developing stewardship roles.

Need for a long-term monitoring program of natural heritage resources

An on-going ecosystem health monitoring program is needed to understand the status and health of the Grand River watershed's natural heritage. This is essential to allow us to adapt our stewardship and resource management approaches to current circumstances.

Need for more landowner stewardship and resource management

It is imperative that landowner contact be continued throughout the watershed in pursuit of greater commitments by landowners to natural heritage protection, management and restoration. Without this work the biodiversity of the watershed is at risk.

Opportunities

Field naturalists, interest groups and schools of all levels can be encouraged and helped to undertake a monitoring program. Monitoring should be coordinated within the watershed, and tied into current monitoring activities (such as on-going hydrologic monitoring), with safeguards to ensure data quality and conformity of collection methods.

Education and technical support should be available to monitoring activity participants.

A 'Watershed Report Card' would be used to keep monitoring groups informed on the 'trends' of natural resource systems, and the effectiveness of rehabilitation programs.

A need to understand the role of vegetation in the watershed hydrology

The relative abundance, pattern of distribution, and composition of vegetative communities plays a crucial role in the hydrology of the Grand River watershed. To optimize the positive contribution of vegetation to the hydrology of the valley requires enhanced understanding of this issue in both the public and resource managers.

Opportunity

Undertake operational activities in-house and/or support practical research that help refine our understanding of the link between vegetation and hydrology at a local level. The Groundwater Institute and the three watershed universities will have an interest in this work.

GRCA has resources that it can apply in support of research such as expertise and data sets in hydrology and watershed vegetation patterns, and land on which to undertake studies. As linkages become better understood, stewardship programs can be better targeted to improve hydrologic attributes.

Forest stewardship programs need improvement

Forest stewardship programs are not targeted as tightly as desirable in order to improve watershed health.

Opportunity

Work in cooperation with watershed landowners and the greater community to optimize forest-related benefits to watershed hydrology, ecology, biodiversity, recreation, economics, etc.

Natural succession is not used effectively as reforesting agent

Landowner preferences for, or bias against certain landscape characteristics works against efficiently utilizing natural succession as a deliberate and desirable agent of reforestation.

Opportunity

Provide information that will help landowners perceive various stages of succession in a more favourable light (e.g. hawthorn shrub forest on old pasture).

Unreliable timber markets

Unreliable market for small dimension and lower quality timber products works against landowners, including GRCA, undertaking beneficial thinnings in plantations and natural woodlots. Productivity is therefore not optimized, and in the case of plantations, conversion to natural hardwoods is potentially delayed. The prospect of generating reasonable revenues from forest lands is an important incentive to have available for those landowners that do not consider ecological arguments alone to be persuasive enough.

Opportunities

As the largest forest land owner in the watershed, GRCA should be able to wield considerable influence in market development. In conjunction with MNR and Stewardship Councils, and the Ontario Woodlot & Sawmill Operators Association,

GRCA should pursue any market development opportunities that would benefit GRCA revenue-generating potential, and/or benefit cooperating landowners. The role of GRCA may be to swing the weight of our raw material flow in support of promising market developments. One mechanism to do this might be a watershed-wide woodlot owners' marketing and stewardship cooperative.

Time lag issues

Forest and natural area management are the most easily and frequently deferred activities both politically and economically because they require such long-term planning and operational scales.

There is a political misconception that forestry issues can be largely ignored during a term of office without causing political repercussions.

Landowners are faced with investment (time, and money) decisions that polarize activities into two areas: 1) must do this year, and 2) can wait until next year. For these reasons, improvements to forests, agroforestry, and natural areas are commonly and repeatedly deferred.

The benefits of natural areas/trees in the landscape may not be appreciated, or conversely, missed, for some time after changes occur. This time lag may be on the order of decades, and the impact of one action may be hard to distinguish, but effects add up over time and across a watershed to produce a significant cumulative effect.

Opportunities:

The key to all of these situations is to increase the level of understanding of the general public about forestry issues. Neither the landowner or the politician may have sufficient incentive to act positively on forest issues without the support of the more general public.

Education opportunities to strengthen general support for forest protection and stewardship activities should be investigated and applied to augment existing educational activities. One such opportunity may be the development of demonstration forest/natural areas management sites.

Impacts of pollution on forests

Pollution of various sorts is having harmful impacts on watershed forests. Acid rain, road salt, and ozone are the most significant problems for trees.

Opportunity

Monitor the impacts of these forces in conjunction with research communities and others, so that information about impacts can be used by government and industry to make timely and beneficial decisions and persuasive arguments.

Inadequate forest cover

Forest cover is inadequate in most parts of watershed for healthy, sustainable watershed. Estimates of the percentage of a watershed that must be natural for the watershed to be healthy in the long term vary, but they range between one quarter and one third. The average percent forest cover in the Grand's watershed is about eighteen, but many parts of the watershed are less than ten percent forested.

Opportunity

Continue promoting and assisting private landowners with reforestation. Diversify reforestation formula to include forest restoration (establishment of facsimile of historical forest) where feasible. Increase promotion of, and assistance with, natural regeneration as a form of forest expansion.

Low representation of old growth forest

Old growth forest is an under-represented succession stage in the Grand River forest.

Opportunity

Identify opportunities to manage forests on GRCA lands, or on private land in cooperation with landowners, to increase the old growth attributes for hydrology and habitat benefits.

Lack of understanding value of 'urban' forests

Urban forests are not understood as urban infrastructure and the value of services rendered (measured in dollars) is not known — a status they may need to achieve to receive consideration on equal footing with other infrastructure (roads, sewers, etc.).

Opportunity

Work with member municipalities and others in quantifying the benefits of the urban forest as municipal infrastructure.

11. HUMAN HERITAGE

11.1 What are human heritage resources?

The Grand River valley boasts a wide diversity of heritage resources. Flowing through the heartland of Southern Ontario, it provides the common thread that links a harmonious blend of natural and cultural landscapes. Today, valley residents enjoy a rich legacy of history, reflected through well-preserved evidence of the Aboriginal and European cultures that were drawn to the fertile valley of the Grand. Many of the valley's features and landscapes reflect the attitudes, values and effect of a wide variety of people. They tell the story of our past and are an integral part of the valley's social fabric.

During the process of designating the Grand River as a Canadian Heritage River, participants defined heritage resources as "the human and natural components in the living context, which provide people with a sense of place and community". Human heritage was defined as the "tangible and intangible elements of society including artifacts; historical and archaeological structures and sites; architecture; transportation and settlement patterns; works of art; recorded folk tales; festivals; customs; traditions; and values. Natural heritage was defined as "geological features and landforms; associated terrestrial and aquatic ecosystems; their plant species, populations and communities; and all native animal species, their habitats and sustaining environment." The combination of natural and human heritage elements comprises the heritage landscape (Grand River Conservation Authority, *The Grand Strategy for Managing the Grand River as a Canadian Heritage River*, 1994).

11.2 Human heritage resources

In 1988-89, extensive research was carried out to determine whether or not there were sufficient features and values associated with the Grand River system which would warrant giving the Grand River special status as a Canadian Heritage River. An abundance of features and values of national significance were found. These were classified under five cultural themes which define the valley's history and development (Heritage Resources Centre, *The Grand as a Canadian Heritage River, 1989; Nominating the Grand as a Canadian Heritage River, 1990).*

11.2.1 Native people

There has been a strong association of Native Peoples with the watershed for thousands of years. Paleo-Indian tools and other artifacts from the big game hunting days, some 7,000 to 11,000 years ago have been found. The archaeology of the valley also yields evidence of later Archaic hunting peoples (5000 B.C. to 1000 B.C.) and the Woodland peoples who were originally hunters. The later Woodland people evolved a more sedentary lifestyle where agriculture played an important role. Such crops as corn, beans and squash were developed and grown along the banks of the Grand.

In 1784, the Six Nations people, led by Joseph Brant (Thayendenaga) were granted land in the Grand River valley encompassing six miles on each side of the river from source to mouth. The extent of the river was unknown at this time. A subsequent government survey formally identified the source at a point near Fergus. This is reportedly the first grant of Crown land in the history of Ontario. The land was granted in recognition of the loyalty and bravery shown by the Iroquois who fought for the British during the American Revolution.

The Six Nations people were comprised of the Mohawk, Oneida, Onondaga, Cayuga, Seneca and later, Tuscarora tribes. Several nationally significant historical landmarks near Brantford reflect the rich native history of the valley. Examples include Chiefswood, the family home of E. Pauline Johnson, famous Canadian poet; St. Paul's Her Majesty's Chapel of the Mohawks, the first Protestant church in Ontario and only Royal Chapel in North America; and, the home of Rev. Peter Jones, a highly regarded Ojibway missionary who translated hymns and scriptures into Ojibwa.

11.2.2 Cultural mosaic

The Grand River valley is outstanding for its ethnic or cultural mosaic which encompasses an unique array of cultural groups including native people as well as Europeans who traveled or lived along its banks and more recently, post-World War II migrants who settled within the watershed. Some examples of these cultural influences include:

- French explorers and missionaries, who in the early seventeenth century, lived with the Huron Indians south of Georgian Bay and journeyed down the Grand. Fathers Brébeuf and D'Allion were purported to be the first recorded white persons to paddle down the Grand in 1626. French priest and geographer René de Galinée named it "La Rapide" in 1669. Jacques-Nicholas Bellin, a French cartographer is thought to have published the first map of the area in 1744, naming the Grand River as "R. d'Urse ou la Grand Rivière." Governor John Graves Simcoe christened it the 'Ouse' in the 1790s, a name still commemorated by street signs on the riverfront road in Cayuga.

- Europeans who were loyal to the Crown (United Empire Loyalists) and migrated to Ontario after the American Revolution, settled along the lower Grand on lands obtained from Joseph Brant. The Nelles family, Loyalists from the Mohawk valley, were the first settlers at York. By 1828, about 30 families lived in the area. A provincial plaque commemorates this settlement. Descendants of the Nelles family still reside in the area. Today, the Grand River Branch of the United Empire Loyalist is active throughout the watershed.

- Mennonites, of German descent, who traveled from Pennsylvania in search of religious freedom. They followed "The Trail of the Black Walnut" north along the fertile floodplain of the Grand River valley, to establish new agricultural communities in present-day Waterloo Region. The Pioneer Memorial Tower, a National Historic Site, was erected along the Grand River near Doon in 1925 to commemorate the settlement of the first two farms in Waterloo County, the Schoerg and Betzner farms. The plaque acknowledges that, in 1805, a company formed in Pennsylvania called the German Company Tract purchased 60,000 acres. This constituted the first larger settlement in the then far interior of Upper Canada. Old order Mennonites and Amish still flourish in the rural areas of Waterloo Region near Elmira, St. Jacobs, and Hawkesville continuing their traditions. At West Montrose, the only remaining covered bridge in Ontario spans the Grand River and is commemorated by a provincial historic plaque. The Joseph Schneider Haus, a restored 1820 Mennonite home in Kitchener, illustrates the life and times of these early settlers.

- Scots, Irish and English immigrants who settled in the north of the valley. This includes many Scots in communities such as Guelph, Galt (Cambridge), Fergus and Elora. The Canada Company, a land company who administered the development and sale of the million- acre Huron Tract, was responsible for attracting many settlers to Upper Canada.

- John Galt, a Scotsman and the first superintendent of the Canada Company designed the layout of Guelph. His plan included public parks and broad streets. The Scottish heritage in these settlements is most prominently displayed in the local architecture and stone buildings and festivals such as the Fergus Highland Games, an event that attracts over 35,000 visitors yearly.
- Americans who settled in Paris in the 1820s and brought with them a unique architectural style. Levi Boughton, who immigrated from New York in 1838, was responsible for the eleven houses and two churches of distinctive cobblestone, the largest assemblage in Canada.

11.2.3 Industrial history

The Grand River valley contains an outstanding concentration of nineteenth century factories, mills, foundries, dams, canal and other industrial structures. In addition, a number of major technological innovations were made at historic sites along the river. Outstanding examples are the invention by E.W.B. Snider of a rolling mill for grinding grain at St. Jacobs; Alexander Graham Bell's invention of the telephone in Brantford; and Joseph Emm Seagram's distillery in Waterloo.

Other examples of industrial history include the development of a canal system built between 1830 and the 1860s from Dunnville to Brantford. Paddlewheelers and other craft used the system to transport passengers, wheat and other goods to and from United States and other Canadian ports. Access to other cities was facilitated by the construction of a feeder canal between the lower Grand and the Welland Canal. Remains of the Grand River locks and the Welland feeder canal are quite visible today. William Hamilton Merritt, builder of the first Welland Canal, was one of the early entrepreneurs associated with these canals and commercial ventures. The Elora Mill, first constructed as a flour mill in 1833, has been converted into a restaurant and inn and is the only five-storey mill remaining in Canada.

11.2.4 Human adaptation to the river

An important historic theme is the tradition of cooperative management to adapt to the floods and other fluctuating flow conditions throughout the river system. To prevent floods, augment low summer flows and reduce pollution, the Grand River Conservation Authority (1966) and its predecessors, the Grand River Conservation Commission (1938) and the Grand Valley Conservation Authority (1948) were established by the watershed municipalities to act on their behalf. The formation of Conservation Authorities as delivery agencies working in partnership with watershed municipalities and the Province is unique to Ontario.

A combination of structural and non-structural solutions such as dams and weirs, dykes, purchase of floodplain valley lands, reforestation, and regulatory and planning mechanisms was used to combat the damage and health problems arising from fluctuating flows. This range of solutions illustrates human adaptation to periodic flooding and drought. The Shand Dam, a multi-purpose dam, was built in 1942 to reduce flooding and augment low summer flows and was the first of its kind in Canada. Communities such as Brantford, Paris and Cambridge still have earthen dykes, stone and concrete breakwalls, and buildings whose construction incorporates floodproofing measures. The "Living Levee" is an outstanding example of flood protection that incorporates heritage and recreational aspects and attracts constant use by the community.

11.2.5 Famous people

Many famous people have been associated with or inspired by the Grand River. Those recognized through the erection of a national historic plaque include:

Tom Longboat, Etienne Brulé, Fathers Dollier and Galinée, Joseph Brant (Thayendenaga), E. Pauline Johnson, Rev. Peter Jones, William Hamilton Merritt, Alexander Graham Bell, Arthur Sturgis Hardy, Lieutenant-Colonel John McCrae, Edward Johnson, Homer Watson, E.W.B. Snider, Joseph Emm Seagram, William Lyon MacKenzie King, and Adelaide Hunter Hoodless.

FIGURE 11-1: NATIONAL HISTORIC SITES AND FEATURES IN THE WATERSHED

LOCATION	PLAQUE *denotes a related historic source
Baden	Castle Kilbride
Brantford	Invention of the Telephone* Arthur Sturgis Hardy St. Pauls. Her Majesty's Chapel of the Mohawks
Cambridge	Otto Julius Klotz
Cayuga	Ruthven Park
Fergus/Elora	Wellington County Museum and Archives
Guelph	Col. John McCrae *
Kitchener	Pioneer Memorial Tower William Wilfred Campbell Archibald McKellar MacMechan William Lyon McKenzie King Homer Ransford Watson*
Ohsweken	The Six Nations Tom Longboat Pauline Johnson* Thayendaenaga (Joseph Brant)
New Credit Reserve	Kahkewaquonaby (The Reverend Peter Jones)
Rockwood	James Jerome Hill
St. George	Adelaide Hunter Hoodless*
Waterloo	Joseph Emm Seagram*

FIGURE 11-2: PROVINCIAL HISTORIC SITES AND FEATURES IN THE WATERSHED

LOCATION	PROVINCIAL HISTORIC PLAQUES *denotes a related historic resource.
Arthur	The Founding of Arthur James Morrison, 1861-1936
Ayr	The Goldie Family and the Village of Greenfield.
Baden	Sir Adam Beck's Birthplace
Brantford	St. Pauls, H. M. Chapel of the Mohawks* The Founding of Brantford Brant County Court House* Augustus Jones Rev. Peter Jones 1802-1856 Sara Jeanette Duncan 1861-1922 Honorable Arthur S. Hardy 1837-1901 'Mohawk Village' Lawren Harris 1885-1970 Canada's First Telephone Business Office* The Mohawk Institute 1831* William Charles Good 1876-1967 The Grand River Mission* Honorable George Brown 1818-1880 The Ontario School for the Blind* Royal Canadian College of Organists
Cambridge	Tassie's School (Galt Collegiate Institute) Galt City Hall* Sergeant Frederick Hobson, VC. 1837-1917. The Founder of Preston
Cayuga	The Haldimand Grant 1784
Dunnville	The Founding of Dunnville.
Elora	David Boyle, 1842-1911 The Founder of Elora
Fergus	The Founders of Fergus The Fergus Curling Club* St. Andrew's Presbyterian Church*
Guelph	Edward Johnson 1881-1959 John McLean 1799-1890* John Galt 1779-1839 The La Guayra Settlers Ontario Veterinary College Ontario Agricultural College Guelph City Hall 1856* Joseph Connelly 1840 - 1904* The Founding of Guelph Guelph Public Library Henry Langley 1836- 1907* Wellington County Court House*

LOCATION	PROVINCIAL HISTORIC PLAQUES *denotes a related historic resource.
Kitchener	The Huron Road* Bishop Benjamin Eby 1785-1853 Wm. Lyon McKenzie King 1874-1950* The Joseph Schneider House 1820*
Milverton	The Founding of Milverton
Mount Pleasant	Dr. August Stowe-Gullen 1857-1943
New Credit Reserve	New Credit Indian Reserve and Mission
New Dundee	William J. Wintemberg 1876-1941
New Hamburg	The Founding of New Hamburg The First Amish Settlement
Oakland	Battle of Malcolm's Hills 1814
Ohsweken	Captain John Brant 1794-1832 Tom Longboat 1886-1949 E. Pauline Johnson 1861-1913*
Paris	"King" Capron 1796-1872* The Asa Wolverton House*
Port Maitland	The Grand River Naval Depot 1815
Princeton	Colonel Thomas Hornor 1767-1834 The Honorable Harry Nixon 1891-1961
Puslinch Twp.	The Settlement of Puslinch*
Rockwood	Rockwood Academy*
Scotland	Duncombe's Uprising 1837
Waterloo	Abraham Erb 1772-1830 The University of Waterloo* Waterloo Lutheran University* St. Jerome's College Evangelical United Brethren
West Montrose	West Montrose Covered Bridge 1881
Wolverton	Wolverton Hall*
York	The Nelles Settlement 1785

11.3 Status of information on heritage resources

While the background studies for the designation of the Grand River as a Canadian Heritage River identified abundant heritage resources of national significance, they did not produce an exhaustive inventory of all heritage resources within the watershed. Intangible heritage resources such as customs, traditions and values associated with the cultural mosaic have not been well defined in the research carried out to date.

Various local agencies such as the Local Architectural Conservation Advisory Committees, Architectural Conservancies, Arts Councils, Historical Societies and other groups have identified values and features that have some special heritage significance from the perspective of: the agency; a part of the community; the whole community; and the Province. Inventories are at different stages of development. For the heritage resources that have been identified, there is no agreement on the standard level of 'baseline' information to be collected or of monitoring information to be collected which reports the status and changes in the condition of the resource.

11.4 Condition of heritage resources

The background research that was carried out to identify outstanding or significant features and values that warranted national stature did not provide a comprehensive inventory of the condition of the various resources. Many of the heritage structures are privately owned and are maintained as a business or private residence. Other sites and features have been protected and are well maintained by local, provincial and federal government agencies. Sites such as Woodside National Park, Pioneer Memorial Tower, Homer Watson Gallery, Bell Homestead, West Montrose Covered Bridge, and the Shand Dam are examples.

Many of the significant built heritage resources were photographed in 1994 and 1995 to provide a visual account of the site at the time that the Grand River was designated. However, there has been no comprehensive, detailed assessment of the condition of these resources throughout the watershed.

It is acknowledged that the twenty-four Local Architectural Conservation Advisory Committees (LACACs) and other heritage groups within the watershed may have information regarding the condition of some of the heritage resources in their municipality or community. Similarly, researchers have investigated the traditions and customs of various cultural groups within the watershed but this information has not been consolidated.

11.5 What is happening to heritage resources?

Improvements to several significant heritage features have been made since 1994. Sites being renovated and improved include Chiefswood, Myrtleville Museum in Brantford, Bell Homestead Museum, Ruthven, and the Button Factory in Waterloo. Doon Heritage Crossroads has been enhanced with the addition of a new curatorial centre. Victoria Park in Kitchener has been graced with the renovated Clock Tower from the old City Hall. Abandoned rail lines (Cambridge-to - Paris; Elora Cataract Trailway, and Hamilton-to-Brantford) have been developed into rail-trails and are now part of the Trans Canada Trail, providing interpretative heritage opportunities in addition to recreation.

Four features in the watershed are new national historic sites. In 1994, Castle Kilbride, built in 1877 by James Livingstone was declared a national historic site. Ruthven Park, near Cayuga on the banks of the Grand River, was designated a national historic site in 1995. The estate was built by David Thompson who was closely associated with the Grand River Navigation Company.

During 1996, the Wellington County Museum and Archives, located between Fergus and Elora attained status as a National Historic Site. Built of locally quarried limestone in 1877 as a House of Industry and Refuge, this landmark structure provided shelter for the "deserving poor," the aged and the homeless for almost a century. In 1997, Rev. Peter Jones, a Mississauga Chief and Methodist minister was commemorated by the Historic Sites and Monuments Board.

Unfortunately, some heritage landscapes and sites are currently stressed and may be lost. Development pressures adjacent to the Pioneer Memorial Tower in Kitchener and in the Mennonite communities north of Waterloo threaten the existing cultural landscape. Historic features such as Eden Mills Bridge, a provincially listed historic bridge, have degraded and need to be refurbished or replaced. Several old mills including the Caledonia Mill, App's Mill and Hortop Mill are in danger of falling into irrevocable ruin. Parts of Huron Road are being fragmented through infrastructure improvements and urbanization in the tri-city area.

Some features that have recently been lost include the Seagram Distillery and Museum, Waterloo; Labatts Brewery, Waterloo; and the Hydro Building in Dunnville (first in Ontario).

Many heritage resources are supported by government grants and subsidies. The current fiscal realities indicate that funding for administration, operation, education, and displays and events will have to be financed more from the community.

11.6 Awareness and use of heritage resources

Many of the significant historical features within the watershed have been converted to other uses such as museums, country inns, restaurants, specialty stores, and government or business offices. Many of the sites attract visitors world-wide. Events and festivals such as the Fergus Highland Games, Cambridge Highland Games, Kitchener-Waterloo's Oktoberfest, Cambridge Riverfest, Brantford Riverfest, Wellesley Apple Butter Festival, and the Elmira Maple Syrup Festival are examples of events that collectively attract hundreds of thousands of visitors to the watershed. Recent research carried out under the auspices of the Ontario Ministry of Citizenship, Culture and Recreation indicates that growth is happening in the cultural tourism sector (Ministry of Culture, Tourism and Recreation, The Cultural Tourism Handbook, 1993). Tourists, particularly European tourists are very interested in Canada's Native culture (see Tourism references, page 13-21).

Awareness and use of heritage resources throughout the watershed and the existing and potential interpretive, educational, economic and promotional linkages between various cultural attractions have not been fully explored. Information regarding levels of use, visitor profiles, dollars spent, spin-off effects to the local economy and awareness of features and sites within the watershed is incomplete and scattered at best.

11.7 Challenges of conserving and interpreting heritage resources

Several challenges related to heritage resources within the watershed are:

- the national significance of the valley's heritage resources must be better communicated to watershed residents and visitors;
- the levels of awareness, appreciation and understanding of different cultures within the watershed, including Native Peoples and how these cultures shaped the valley's environmental, social and economic fabric should be increased;

- new approaches to conserving and interpreting important heritage resources, including heritage landscapes, which are being degraded or lost through urbanization, lack of funds for upkeep, disinterest, or lack of awareness must be found;
- additional research is needed to identify important heritage resources and landscapes within the watershed and to determine their existing condition and use;
- new funding sources or ways to maintain, operate and interpret significant heritage resources need to be found, particularly for those significant sites and features which are at risk;
- new processes must be found to assist municipalities and heritage organizations in strengthening their abilities to plan, manage and make decisions about heritage;
- the tourism potential of the heritage resources within the watershed should be explored.

11.7.1 Opportunities for conserving and interpreting heritage resources

While the challenges for conserving and interpreting outstanding heritage resources seem overwhelming at times, the potential benefits or opportunities that arise can have significant impact on the health and well-being of watershed residents. Some of the opportunities include:

- greater awareness and interest in heritage resources will create a greater "sense of place" for watershed residents;
- cultural tourism and economic development can increase dramatically in the future given the diversity of interesting and significant cultural features and values within the watershed and the river's special status as a Canadian Heritage River.

11.8 Priorities for action

In 1997-98, it is important to focus on actions that encourage communities throughout the Grand River watershed to take ownership for increased heritage conservation activities. This would promote greater community and government awareness and trigger the application of appropriate assistance measures and controls to strengthen the stewardship, enjoyment ad responsible use of valued heritage resources. Actions in 1997-98 will be planned to meet the following objectives:

- to clarify the process and information aspects of identification, listing, monitoring and reporting on the status of significant heritage resources of the Grand River, a Canadian Heritage River;
- to encourage individual communities, through a process of widespread resident involvement to define/identify the qualities of significant places and their component parts and the current state/condition of these valued resources;
- to determine the capacity of municipalities, agencies and other groups to plan, manage and make decisions about heritage resources in the Grand River valley;
- to increase community involvement in the monitoring of resources which the community values.

Rather than trying to meet the objectives in all of the communities in the watershed at once, activities should be undertaken in pilot communities. In 1997-98 it is important that:

- a draft checklist, in keeping with the monitoring requirements of the Canadian Heritage Rivers Board, that enables communities to list and monitor their heritage resources in a straightforward, consistent and useful manner be developed. This action would provide the basis for expanding the existing information base to include an assessment of the condition of outstanding human heritage resources in the watershed. An up-to-date information base is essential to provide a benchmark from which to measure change.
- the draft checklist be tested and revised in 3-4 pilot communities. Those communities that have a range of locally, provincially and nationally significant heritage resources would be eligible to be a pilot community. These communities should be representative of the upper, middle and lower watershed areas. Participants in the pilot should represent a variety of stakeholders and be willing to complete a final checklist for resources already inventoried and additional resources that are valued in their community.
- monitoring reports (using the model checklist) for all nationally significant heritage resources be updated.
- an assessment of municipal and regional capacity to plan, manage and make decisions about heritage resources be carried out.
- the State of the Watershed Report and the annual status report to the Canadian Heritage Rivers Board be updated based on the new information gathered.

12. RECREATION RESOURCES

12.1 What are recreation resources?

The Grand River watershed offers a various array of high-quality recreational opportunities. The meaning of recreation in the context of the river as defined by participants in The Grand Strategy is 'the diversity of opportunities that are provided through the appreciation, stewardship and accessibility of watershed resources' (Grand River Conservation Authority, *The Grand Strategy for Managing the Grand River as a Canadian Heritage River, 1994*).

12.2 Recreation resources

The Grand River Valley is renowned for its natural beauty, cultural diversity and quality recreational opportunities (in a natural setting). For these reasons, the Grand River and its major tributaries were declared a Canadian Heritage River in 1994. The Canadian Heritage River designation brings recognition, status and the opportunity to promote the river at all levels (international, national, provincial, local). However, there is a need to ensure that the recreational and natural values which contribute to the diversity and range of quality recreational experiences are not undermined or degraded due to exploitation, overuse or loss of attributes such as water quality.

An initial overview of the location, types and quality of recreational experiences within the watershed was undertaken in 1989 to assess whether or not the watershed complied with the eligibility requirements for heritage river designation under the category of recreation. Recreational uses and opportunities associated with Grand River watershed resources were characterized and described by theme (Heritage Resources Centre, *The Grand as a Canadian Heritage River, 1989; Heritage Resources Centre, Nominating the Grand as a Canadian Heritage River, 1990*). Little research was carried out regarding level of use, existing and potential conflicts, economic implications, tourism opportunities, etc. In the past three years, there has been a renewed interest among non-profit and profit groups to use and promote the river and its abundant assets.

Recreational uses and opportunities associated with Grand River watershed resources are characterized and described by the following themes.

12.2.1 Water sports

Water sports includes such activities as canoeing, kayaking, sailing, power boating, water skiing and swimming. The Grand River provides excellent river touring for day trips by canoe or kayak. The many historic attractions and diversity of landscape offer vistas of scenery, nature and human heritage that are impossible to obtain by other means. Canoeing and kayaking are popular in the reaches of the Grand below Grand Valley. The most popular stretch of the river for canoeing is on the main Grand River south of Elora where the river flow is most consistent. Tributaries including the Conestogo, Speed, Eramosa, and Nith rivers are navigable over limited stretches. No major water control dams are found on the central and south stretches of the Grand, although refurbished mill dams and canal weirs must be portaged at Cambridge, Paris, Brantford, Caledonia and Dunnville.

The Grand River is navigable for power boats below Brantford. However, the river is obstructed by the dams at Caledonia and Dunnville. Water skiing occurs mainly in the two sections above Dunnville. Excursion and dinner boat tours are operated above the Caledonia Dam.

Power boats are permitted on the reservoirs at Belwood and Conestogo where water skiing is popular. In recent years, these reservoirs have attracted an increasing number of jet skiers.

Small sailboats and sailboards are accommodated on the river south of Brantford but use is limited because of the number of power boats which use the river. Sailing and wind surfing is widespread on all reservoirs including Belwood, Conestogo, Guelph, Laurel Creek, Shade's Mills and Pinehurst Lake.

Swimming opportunities occur in the Grand River and its tributaries wherever there is convenient access to the water. The Grand River Conservation Authority currently operates eleven conservation areas which provide access for swimming in reservoirs, small lakes and quarries with sand beaches. Large outdoor pools attract swimmers at Brant and Byng Island Conservation Areas. Rock Point Provincial Park has 600 metres of beach on Lake Erie, a short distance from the mouth of the Grand River. In addition, there are many municipal and private/commercial parks which provide swimming opportunities.

12.2.2 Nature/scenic appreciation

The Grand River watershed provides numerous opportunities for appreciating the beauty and tranquillity of the valley's heritage. Activities such as birdwatching, photography, naturalist activities, picnicking and camping abound. The natural areas which offer the best opportunities for viewing flora and fauna are Luther Marsh, Elora Gorge, Grand River Forest between Cambridge and Paris, and Dunnville Marsh. Outstanding scenic vistas can be found at Fergus, Elora, Cambridge (downtown Galt), Homer Watson Park (Kitchener), Glen Morris, Caledonia, and Dunnville. Several naturalist clubs organize outings on a regular basis.

The Grand River Conservation Authority provides camping facilities at eight Conservation Areas (Elora Gorge, Guelph Lake, Conestogo Lake, Laurel Creek, Rockwood, Pinehurst, Brant Park, Byng Island). These areas provide 2,700 campsites, a third of which are serviced with hydro and water. Next to Parks Ontario, the Grand River Conservation Authority is the second largest provider of camping opportunities in the Province. The Conservation Authority also provides group camping facilities at the Conservation Areas. Some areas such as Guelph Lake can host large camping events such as those held by the Boy Scouts, Girl Guides and the National Campers and Hikers Association.

Picnicking opportunities are available at the eleven Conservation Areas. The provincial, regional, and municipal governments as well as the private sector have also established picnic areas and campgrounds in the valley. In 1982, it was estimated that opportunities for picnicking in the watershed were 3,059,000.

12.2.3 Fishing and hunting

Recreational fishing is popular in the Grand River and its tributaries. In general, the diversity of species increases from the upper river to the lower river. Among the fish caught for recreation in the river are: northern pike, smallmouth bass, largemouth bass, walleye, brown trout, brook trout, rainbow trout, salmon, channel catfish, crappie and panfish. Excellent fishing opportunities exist above and below the dams at Conestogo, Belwood and Guelph.

The Grand River draws more and more visitors each year. A weekly fishing report introduced in 1996 and sponsored by the Grand River Conservation Authority, became popular with local and visiting anglers. It is estimated that fly-fishing now adds well over $1 million to the local economy in the Fergus-Elora area.

Opportunities to hunt waterfowl, small game and deer are found in many of the natural areas throughout the watershed. Luther Marsh and the Dunnville Marshes are highly valued for hunting waterfowl and some small game. The Grand River Conservation Authority provides safe, high-quality hunting opportunities through its controlled hunting programs at Luther Marsh and Conestogo Lake. Hunting for white-tailed deer is permitted in the off season, between Cambridge and Paris, on lands managed by the Ontario Ministry of Natural Resources.

12.2.4 Trails and corridors

Trails and corridors can be classified into various types such as non-motorized or passive trails, scenic drives and/or cycling routes, and equestrian and snowmobiling trails.

The Grand River watershed boasts the greatest concentration of passive single and shared-use recreational trails in Ontario. These trails provide opportunities for a network of continuous, linked greenway corridors. They include single use hiking trails such as the Grand Valley Trail; Avon Trail; Guelph-Speed Trail; and the Guelph Radial Line.

Several abandoned rail lines have been purchased by the Grand River Conservation Authority including the Cambridge-to-Paris Rail-trail; Elora Cataract Trailway, and the Brantford-to-Hamilton Rail-trail as shared recreational trails. In 1996, the official openings of the Elora-Cataract Trailway and the Brantford-to-Hamilton Trail were held. These trails, which pass through floodplains and wetlands, Carolinian forests, and rural pastoral countryside added 87 km to the trail system in the watershed. In 1996, these two rail trails and the Cambridge-to-Paris Rail Trail became part of the Trans Canada Trail. In 1997, the linkage between the Cambridge-to-Paris Rail-trail to the Brantford-to-Hamilton Rail-trail was secured by a number of agencies working together including the Conservation Authority, the Town of Paris, The Grand River Foundation, the provincial Ministry of Transportation, the Township of Brantford and the City of Brantford.

A section of another abandoned rails lines from Caledonia-to-Hamilton rail line has been purchased by the Hamilton Region Conservation Authority. The Province of Ontario has purchased the abandoned rail line which runs between Guelph and Goderich. Several other abandoned rail lines are currently under discussion for purchase by the Province of Ontario. These include the Brantford-to-Simcoe line and the Caledonia-Dunnville-Fort Erie line.

Cross-county ski trails are maintained by the Grand River Conservation Authority at Laurel Creek, Elora Gorge and Pinehurst Conservation Areas, weather permitting.

Numerous scenic drives have been informally identified in open space concept plans relating to open space development along river corridors. An extensive system of snowmobiling trails, secured and maintained by the local snowmobile clubs in each county or region also exist.

12.2.5 Human heritage appreciation

The many fine heritage features and resources within the watershed provide varied opportunities for recreational pursuits linked to heritage appreciation and enjoyment. Several heritage organizations and LACACs organize historic walking tours and brochures for self-guided tours. Events and festivals draw thousands of visitors yearly.

12.3 What is the state of the recreation resource?

The state of recreational resources and opportunities link directly with the health of watershed resources (i.e. surface water quality, fish, wildlife, and vegetation; heritage sites and their condition; natural and cultural landscapes; and scenic vistas).

The water quality in the river and its tributaries is monitored on a regular basis throughout the summer months to ensure that the water is safe for body contact. The water quality is generally good enough to permit swimming in all areas where public access is allowed. Occasionally, during hot dry spells particularly toward the end of summer, some beaches and swimming areas are required to close for health and safety reasons.

The Grand River currently meets all five water quality characteristics of importance to recreational use for non-contact recreation as endorsed by CCREM (Canadian Council of Resource and Environment Ministers). These include under the nuisance category; vector and nuisance organisms, and phytoplankton, and under the physical and chemical category; aesthetics, oil and debris. In certain short sections, aquatic vascular plants may pose problems to some kinds of boating but not canoeing.

Many areas of scenic beauty are protected and maintained as publicly-owned lands. Some historical landscapes are preserved as Heritage Conservation Districts (e.g. Doon in Kitchener). A few scenic vistas are under pressure from development on lands adjacent to the river corridor in urban areas. Signs of overuse are apparent at the lookout at Homer Watson Park and at Elora Gorge and Rockwood Conservation Areas.

Existing single and shared-use trails and corridors are well maintained by user groups and agencies. Facilities such as canoe access points and camping and picnicking facilities within Conservation Area parks have been upgraded in recent years. A new canoe portage was constructed in Paris in 1997.

Fishing opportunities for both warm and cold-water species are excellent in the Grand River watershed. *The Guide to Consumption of Fish (OMNR)* indicates that it is safe to eat fish caught from the Grand River system up to eight meals per month, except for a "no consumption" advisory on large walleye (65 to 75 cm) caught below Dunnville. There is some restriction on largemouth bass (35 to 45 cm) caught in Guelph Lake (up to four meals a month), and larger walleye caught above Dunnville.

Hunting is controlled by licenses and permits. Controlled hunts take place at Luther Marsh and Conestogo Lake to ensure safety and to limit the numbers of waterfowl and game birds that are taken.

Heritage appreciation is directly dependent on quality of the heritage resource and the awareness watershed residents and visitors have regarding the significance of the resource.

12.4 Awareness and use of recreation resources

Use of recreational resources within the watershed has increased in recent years. Approximately 1,100,000 people visit the GRCA Conservation Areas annually. Usage at other private campgrounds and day use areas is unknown.

River touring is on the rise, particularly from the Elora Gorge downstream to Paris. In recent years, five entrepreneurs have established businesses related to canoe tripping which provide canoe/kayak rentals, shuttle service and guided trips. Two of these businesses also provide bicycle rentals. One even provides tourist packages for heritage tours and overnight accommodation at various Bed and Breakfast establishments and local historic inns. A 48 minute video about canoeing the Grand River was produced by the CKCO-TV in collaboration with the Grand River Conservation Authority in 1995 and is shown periodically by the TV station.

Local tackle shops and outfitters report an increase in sales and fishing licenses for the Grand River watershed. In fact, an influx of "tourist" anglers has occurred over the past year, in part, due to a number of articles written about fishing along the Grand in high profile national and international sports magazines. CKCO-TV in Kitchener recently highlighted fly fishing in the Grand River in its August 1, 1997 edition of "Province Wide". Other television shows have highlighted fishing opportunities on the Grand River including Bob Izumi's "Real Fishing" show and Jim and Kelli Watt's show aired to U.S. audiences on ESPN 2 in December 1997.

The rail-trails are being used extensively. While no official usage statistics are available, it has become a popular hiking and biking trail, particularly on weekends, not only for local residents but for visitors as well. It is expected that usage of trails and corridors will continue to increase as they become developed for public use and are interconnected into a continuous open space network through the Trans Canada Trail system.

Festivals and events are well attended throughout the watershed. The annual Kitchener-Waterloo Oktoberfest attracts over 600,000 participants over nine days of activities. The Fergus Highland Games is famous across North America and draws over 35,000 for the weekend festival. The cultural ambiance of St. Jacob's and Fergus-Elora has both enhanced existing business opportunities and attracted new businesses to the area.

Increased recreational use in the watershed has led to some conflicts between adjacent land uses and between competing recreational uses. For example, residents who live beside trails are concerned about the loss of privacy and the possibility of vandalism and break-ins. Increased urban development has affected scenic vistas, cut off access to the river corridor and reduced the quality of the outdoor recreational experience. In some cases, the development or enhancement of recreational opportunities affects the natural resource base or may raise safety issues. For instance, in Dunnville, fragmentation of sensitive wetlands and floodplain management issues conflict with proposed waterfront recreational development.

Increasingly, different recreational uses compete for the same stretch of river. For instance, fly fishing which is very popular in the river reach below the Shand Dam, competes with kayaking, particularly in the Elora Gorge. Other recreational pursuits are so popular that the recreational experience is affected. Some canoeists and hikers have complained that increased use of the river and the hiking trails has reduced the quality of the experience because of the number of people using the resource at the same time. Increased use has also led to physical degradation such as erosion, soil compaction, loss of vegetation, and disturbance of wildlife habitat.

Municipalities like Grand Valley, New Hamburg, Guelph, Cambridge, Brantford and Dunnville are looking to the river system and the opportunities it provides to develop a focal point for community activities and civic pride. Discussions are currently taking place to determine how waterfronts should be redeveloped to take best advantage of river assets. Conflicting views are apparent because of the variety of experiences which could be fostered along the river and because of environmental or safety issues associated with development.

The nature and extent of outdoor recreational use in the valley and the existing and potential conflicts need to be further investigated.

12.5 Challenges associated with managing recreation resources

Some of the challenges associated with managing recreational resources include:

- the diversity and excellence of the valley's recreational activities, opportunities and experiences need to be promoted more with watershed residents and visitors;

- additional research is necessary to determine the existing demographics, levels and patterns of recreational resource use, and trends for the future;
- those attributes that support quality recreational experiences need to be identified (i.e. water quality, number of participants, nature appreciation opportunities, etc.);
- existing and potential conflicts between different recreational pursuits within the watershed and between recreation and other land uses need to be identified and addressed;
- indicators of overuse or degradation need to be established in order to determine the carrying capacity or threshold for certain recreational activities and experiences;
- the economic trade-off and benefits accrued to communities from recreational use of the watershed's heritage and natural resources need to be calculated;
- opportunities for linking various activities together to create a wide variety of recreational experiences should be pursued;
- new partnerships among profit and non-profit groups and organizations must be forged to ensure development, maintenance and enhancement of existing recreational opportunities.
- a process, either formal or informal needs to be created to deal with river-related recreation issues on a watershed basis.

12.6 Opportunities associated with managing recreation resources

Managing recreational resources in a sustainable manner has a number of benefits. Some opportunities include:

- enjoyment of the watershed's human and natural heritage resources will foster greater awareness and stewardship;
- closer ties can be established between urban and rural communities;
- economic development and tourism can increase dramatically for local communities and for the watershed as a whole;

12.7 Priorities for action

In terms of addressing challenges related to recreation within the watershed, the following actions need to be carried out:

- Investigate:
    - the existing demographics, levels, kinds and patterns of outdoor recreational use (in a natural setting), and current trends;
    - attributes that support quality outdoor recreational experiences (i.e. water quality, scenic vistas, nature appreciation opportunities, levels of use, etc.);
    - existing and potential conflicts between different outdoor recreational pursuits within the watershed and between recreation and other land uses;
    - indicators of overuse, degradation, and quality recreational activities and experiences;
    - carrying capacity or thresholds for recreational activities and experiences;

- the economic trade-offs, benefits, and spin-offs accrued to the Grand River Conservation Authority, watershed communities and private businesses from recreational use of the watershed's heritage and natural resources;
- the existing and potential management arrangements associated with outdoor recreation; and,
- additional facilities or linkages that are needed to improve existing recreational opportunities and quality of experiences throughout the watershed.

- Create a process, formal or informal, to deal with river-related recreation issues on a watershed basis.
- Promote municipal policies/plans to guide riverfront development. These policies and plans should be designed to resolve conflicting resource issues, to maintain/improve the quality of the experience, and to provide for infrastructure to accommodate increasing interest. Priority areas include Dunnville, Haldimand, Brantford, New Hamburg, West Montrose, Fergus, Elora and Grand Valley. (Cambridge and Guelph have completed plans.).
- Develop a code of ethics for recreational use in the Grand River watershed.
- Build partnerships for creating, linking, maintaining and using of outdoor recreation resources and facilities. In particular to expand:
  - the extent and variety of a sustainable world-class fishery in the Grand River and its tributaries
  - link trail systems within and outside of the watershed.
  - Establish mechanisms to resolve/neutralize conflicts among land uses and among users.
- Develop a broad conceptual plan for recreation in the watershed which identifies where specific activities are most suited.

In 1997/98 action is required to undertake the following:

- develop a preliminary joint work plan around these needs;
- formulate policies to guide appropriate riverfront development and activities in Grand Valley, New Hamburg, Cambridge, Brantford, and Dunnville.

13. TOURISM IN THE GRAND RIVER WATERSHED

13.1 What are the tourism opportunities?

The heritage resources of the watershed combined with the excellent recreational opportunities that are available provide the basis for a strong cultural and eco-tourism industry. A strong cultural and eco-tourism industry would serve to increase resident and non-resident appreciation for, and enjoyment of Grand River watershed experiences, resulting in enhanced economic benefits to both profit and non-profit partners.

The Grand River watershed has been underutilized as a cultural, recreational and educational asset. Greater public awareness of the multiplicity of experiences offered on, in, and around the Grand is required to increase use and build a strong industry.

With the designation of the Grand River as a Canadian Heritage River in 1994, a number of positive results occurred:

- During the Canadian Heritage River designation process, groups and communities collectively provided input and direction. Many of these people viewed the Grand as a economic asset for the first time.
- Because of the designation of the Grand River as a Canadian Heritage River, publicity has been afforded the Grand and the experiences it offers, greatly enhancing public awareness and destination recognition.
- A number of recreational, cultural and educational opportunities have been inventoried and/or identified. Many of these have the potential to generate greater, or new economic returns to watershed partners.
- Due to increased awareness of the Grand as an asset, a number of profit and non-profit interests have already taken initiatives to increase the profile of the Grand, in their own promotional efforts.

The economic benefits of usage, in particular by non-residents, will accrue to businesses, organizations and communities throughout the watershed. Those who benefit should also be the ones to direct and help fund tourism marketing programs and initiatives.

13.2 The challenge

The challenge is to create a thriving cultural and eco-tourism industry without negatively impacting on the quality of the experiences or the resources on which the industry is based.

13.3 Principles for tourism marketing

The promotion and use of the watershed's natural and cultural resources requires a coordinated effort. A number of tourism operators, recreation providers, festival organizers, businesses, and cultural attractions promote experiences in the Grand River watershed independently. Opportunities are missed to link experiences throughout the watershed and to cost-effectively market the Grand as a tourism destination. The secret for success (generating maximum exposure and use at acceptable costs) would appear to be the utilization of existing organizations and their respective resources working together as a team with a common goal. In setting up an effective tourism marketing strategy, the following principles have been established:

- The greatest exposure of the Grand as a leisure activity destination or destination support element will occur when partners throughout the Grand include the leisure offerings of the Grand in their existing promotion vehicles and programs;
- Tourism marketing initiatives should address both promotion strategies (paid for advertising and promotions) and communication strategies (use of the media for publicity, free advertising);
- Development and execution of a Tourism Marketing Strategy should be directed by as association of committed partners working as a Tourism Marketing Committee;
- The Tourism Marketing Committee should communicate on a regular basis with those who are monitoring the heritage and natural resources of the watershed to ensure that inappropriate promotion of overused, abused or conflicting resource use does not occur.

13.4 Tourism initiatives 1994-97

Since the designation of the Grand River as a Canadian Heritage River, the Grand River has drawn increasing numbers of visitors each year. Several marketing, promotion and education initiatives have occurred which promote the Grand River and the superb recreational and heritage experiences it has to offer. A sampling of these initiatives includes:

- Several brochures promoting features and activities throughout the watershed including: "*Your Map & Guide to the Southern Grand River Valley*", 1996, featuring scenic tours by car, bicycle, canoe and foot, places to eat and stay, shopping and entertainment, and parks and recreation; *"Your Guide to Grand River Country"* , 1997, featuring the Grand River and its tributaries, a detailed regional map highlighting major attractions. historical features, natural wonders, recreation sites and much more; *"Journey the Grand.. Travel Routes Along the Grand River - A Canadian Heritage River", 1997*, and *"Spectacular by Nature"*, 1997, a guide to the conservation lands;
- Establishment of the Conservation Lands of Ontario, an alliance of five conservation authorities including the Grand River Conservation Authority to become a model for cooperative marketing and sustainable tourism;
- Several articles highlighting the Grand River as a Canadian Heritage River written in national magazines including *Explore, Canadian Geographic, and Fly Fisherman. Ontario Out-of-Doors* published a feature article on fishing the Grand River in February 1995. *The Grand Valley Heritage Magazine* with the theme "Connecting Communities and Cultures" was published in 1996 and distributed throughout the watershed.
- Tamarack, a folk singing group, in collaboration with CBC, produced a television documentary *entitled "On the Grand, The Story of a River"*. Tamarack also produced a CD of original songs about the heritage of the Grand River and has performed them throughout Ontario. The group is also developing a *"Tamarack on the Grand School Program"* to be presented to over 250 schools in the Grand River watershed.

- An ongoing awareness campaign by the Grand River Conservation Authority to inform 1,100,000 park users and 730,000 watershed residents about the Heritage River designation and the recreational opportunities offered at the Conservation Areas. Supported by local businesses, the Conservation Authority was able to widely distribute park tabloids which linked activities at the Conservation Areas with local community activities. An additional publication called *"Focus on Conservation"* is distributed twice a year to 176,00 household through the daily newspapers.

- The production of a forty-five minute video by the Grand River Conservation Authority in collaboration with CKCO-TV. The video, entitled *"The Grand Adventure"* was produced as a companion piece to the Grand River Conservation Authority publication *"Canoeing on the Grand"* which is currently in its seventh pressing, representing over 15,000 copies sold. The video is aired from time to time on CKCO-TV, Kitchener and is available to the public.

- A book entitled *"Fly Fishing the Grand River"* by Ian D. Martin and Jane E. Rutherford was published. In 1996, a weekly fishing report, sponsored by the Grand River Conservation Authority, became popular with local and visiting anglers. This report is featured in local newspapers and on the Internet through the Grand River Conservation Authority website. In May 1997, the site was receiving over 800 "hits" per week for fishing information.

- A partnership of Bed and Breakfast establishments in Brant County called the Grand River Heritage Bed & Breakfast Association. The name depicts their interest in heritage structures and their historical merits, as well as the conservation of the Grand River.

- Brantford Riverfest '95 erected the first community plaque commemorating the Grand River as a Canadian Heritage River at a kick-off ceremony for Riverfest on April 21, 1995. The original Canadian Heritage Rivers Plaque was erected in September 1994 and resides in Mill Race Park in downtown Cambridge.

- In collaboration with the Grand River Conservation Authority, local public and separate school boards are incorporating the Canadian Heritage River theme into their teaching curriculums. A curriculum guide, *"The Grand: A Canadian Heritage River"* for grades 7-9 was produced by the Waterloo County Board of Education in 1995 and is currently being updated.

- Participation in the SchoolNet Digital Collections Program which features information about the Grand River. Students can gain easy access to information about the heritage and recreational resources of the watershed. This site is linked to the Grand River Conservation Authority's website.

- The production of a CD-ROM by Harcourt Brace and Company, Canada Ltd., Canadian Geographic and Medium Cool (1997) featuring 11 Canadian rivers including the Grand River. This interactive CD is geared to students and uses maps, images, videos, and text to explore natural systems, settlement and culture and resource use and economy of each river.

- The publication of a coffee-table book entitled *"Voyages: Canada's Heritage Rivers"*. A section of the book is dedicated to the Grand River. The Ontario launching of the book was part of the first anniversary celebration of the Grand River as a Canadian Heritage River in 1995. It received the prestigious Natural Resources Council of America Award for best environmental publication in 1996 and is available at bookstores across North America.

- The development of a destination marketing brand called "Grand River Country" by watershed communities. This brand enables partners to integrate existing marketing vehicles and initiatives and the development of new materials and/or initiatives in order to attract visitors to the Grand River watershed.

13.5 Priorities for Action

Priority actions for 1997/98 include:

- developing a consensus among tourism stakeholders that the core strategy will be, but not limited to, integration of quality Grand experience messages into existing programs and promotions;
- promoting "Grand River Country" as a destination marketing brand;
- putting together an inventory of existing and potential marketable Grand experience products, services and packages that have destination marketing value;
- undertaking an inventory of existing facilities, programs, publications and promotions that promote leisure experiences and/or travel within the watershed;
- developing committee-approved Grand experience messages and collateral marketing materials to be used by profit and non-profit partners throughout the watershed. Identify and obtain funding sources for material costs;
- formulating an internal communications strategy to share information and obtain input from key stakeholders on a timely basis;
- determining practical program success evaluation criteria.

13.6 Tourism references

1. *The Cultural Tourism Handbook, Lord Cultural Resources, 1993*, states that tourists, particularly European tourists, are very interested in Canada's native culture.
2. *Discover the Opportunity, Industry Canada and the Department of Canadian Heritage, 1996*, indicates:
    - "A 1993 National Tour Foundation Study found that the majority of group tour consumers prefer trips which will teach them something new - historical, cultural or environmental."
    - "In 1991, the Stanford Research Institute projected 10-15% growth in adventure/cultural tourism and a 25-30% growth in nature tourism."
    - "The World Tourism Organization estimates that 37% of all trips have a cultural component and that this type of tourism will grow 15% annually until the end of the century."
    - "Heritage Tourism draws: 33% of Canadian travellers, 37% of U.S. travellers, 40% of overseas travellers."

3. *Canadian Provincial Analysis, The Canadian Tourism Commission, 1996.* This study of the travel habits of U. S. travellers provides the following statistics regarding the primary activities of stay for overnight leisure travellers.

Culture (net)	46%
Nature (net)	37%
Attractions (net)	18%
Touring (net)	18%
Outdoor sports (net)	16%

* the total exceeds 100% as respondents were able to check more than one activity per person trip.