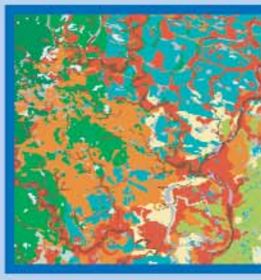
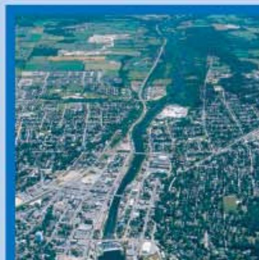
EXECUTIVE SUMMARY





Grand River Watershed

Characterization Report ▪ January 2008

DRINKING WATER SOURCE PROTECTION

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Ontario

This report is made possible through the support of the Government of Ontario

Kettle Creek Conservation Authority (KCCA)

Catfish Creek Conservation Authority (CCCA)

Long Point Region Conservation Authority (LPRCA)

Grand River Conservation Authority (GRCA)

The Watershed Characterization Reports were prepared by the drinking water source protection project staff of the four conservation authorities in the Lake Erie Source Protection Region.

1. Introduction

The Clean Water Act

The Clean Water Act was passed by the Ontario legislature in October 2006 to implement many of the recommendations of the provincial inquiry into the Walkerton tainted water tragedy.

The Act, its regulations and other provincial guidance documents outline a process to develop a source protection plan for the Grand River watershed. This work will be guided by the Lake Erie Region Source Protection Committee.

A source water protection plan is an agreement among the people and the communities of a watershed about the ways to protect water quality and quantity for drinking water systems.

The source protection planning process will:

- identify existing water supply and water quality issues;
- identify sources of drinking water and vulnerable areas in a watershed;
- identify the threats to source water quality and quantity;
- establish the risk posed by threats in vulnerable areas; and
- outline policies and programs to eliminate existing significant threats and to ensure no future drinking water threats become significant threats.

Documents

In order to accomplish this goal, several documents will be prepared:

- a watershed characterization report;
- a terms of reference for the source protection committee;
- a technical assessment report; and
- a source protection plan.

The first document – the watershed characterization report – is an overview of the current state of the watershed. It includes information on the natural system (bedrock geology, surface geology, forests, wetlands, etc.) and the human system (urban areas, population growth, land use, water systems, etc.). The report describes the links between the natural and human systems.

This executive summary provides an overview of the material in the full Grand River Watershed Characterization Report.

A note to readers

Both the full characterization report and this summary are draft documents. They will both be updated as more information becomes available.

2. Watershed overview

Watershed characteristics

The Grand River watershed is the largest in Southern Ontario, with an area of approximately 6,800 square kilometers. The Grand River is 300 km long and the watershed has an average width of about 36 km. The Grand's headwaters are in Dufferin and Grey counties and it flows south to Lake Erie where it enters at Port Maitland.

The major tributaries of the Grand River include the Conestogo and Nith rivers, draining the western half of the watershed; and the Speed and Eramosa rivers, which drain the north-east. Other notable tributaries include Whitemans and McKenzie creeks in the southwest, and Fairchild and Big creeks in the southeast.

The flow in the Grand River is augmented from four major multi-purpose reservoirs: Luther, Belwood, Conestogo, and Guelph. The Grand River Conservation Authority operates these reservoirs as a system to control floods and to maintain the river capacity to both supply water and assimilate wastewater.

Population

According to the 2001 census, the watershed had 821,000 residents living in 13 upper tier municipalities (counties, regions and separated cities), and 26 lower tier municipalities (cities and townships). In addition, there are two First Nations communities southeast of Brantford: Six Nations of the Grand River and Mississauguas of the New Credit.

About 93 per cent of the land in the watershed is rural with 75 per cent of the watershed actively farmed on 6,400 farms. The 2001 census also showed there were 290,000 head of cattle, about 500,000 head of swine and almost 8.8 million heads of poultry.

River quality

Water quality in the Grand River system is generally good in the headwaters areas of the Grand and its tributaries. However, as the rivers flow through the intensively farmed rural areas and the growing urban areas of the central watershed, water quality declines.

In particular, high levels of nutrients (phosphorus and nitrogen) from urban and rural areas encourage aquatic plant growth which, in turn, results in lower dissolved oxygen levels.

Not only do high nutrient levels make the rivers less hospitable to aquatic creatures, they can also affect the use of surface water as a source of municipal drinking water.

On the other hand, the influx of groundwater from springs and cold-water tributary streams, particularly in the central portion of the watershed where the moraines are located, helps to buffer the impact of upstream land use activities.

Groundwater discharge to the Grand River between Cambridge and Paris and along the Nith River between New Hamburg and Paris helps to improve water quality of the rivers, to the benefit of downstream communities that take water from the river, such as Brantford and Ohsweken (Six Nations).

Uses of the river

The Grand River and its tributaries go through many changes as they flow from north to south. It's not a surprise, therefore, that the view that watershed residents have of the river changes from north to south, as well.

In the first half of the 20th century, many people considered the Grand River an "open sewer," as it was called by one newspaper.

However, there has been a significant improvement in overall quality of the Grand River and most of its tributaries in the past 50 years. Improvements in sewage treatment, controls on discharge of industrial pollutants into water courses and changes on the landscape (e.g. beneficial management practices on the farm, stormwater management in cities) have all had a positive impact on water quality.

The result has been not only better water quality, it has led to a revival of the Grand system as a focal point of outdoor recreation and tourism.

The brown trout fishery in the Fergus-Elora area, which draws anglers from across the continent, is one example. Another is the stretch of the Grand between Paris and Brantford, which has been designated an Exceptional Waters reach and is popular with anglers, paddlers and hikers.

North

The residents of the largely rural communities in the northern headwater areas are looking for sustainable resource management, including agricultural land, wetlands, wildlife and water. They are being asked to do many things to improve water quality downstream. They are con-


Grand River Conservation Authority
Grand River Watershed
Grand River
Conestogo River
Speed River
Eramosa River
Guelph
Nith River
Waterloo
Kitchener
Cambridge
Grand River
Brantford
Whitemans Creek
5 0 5 10 15 Kilometers
Lake/River
Stream
Road
Municipal Boundary
Grand River Watershed
N

2. Watershed overview (cont'd)

cerned that the downstream communities that benefit should also share the cost.

Central

The central portion of the watershed is experiencing rapid population growth, in the urban centres of Guelph, Brantford and Waterloo Region. This is the area of moraines and the Norfolk Sand Plain which are home to some of the most complex groundwater systems and most specialized wildlife habitats.

The communities of the central Grand are concerned about protecting the groundwater that supplies most of their community's drinking water supply.

They are also concerned about the health of the river and its capacity to handle increasing amounts of wastewater. At the same time, the river has become a focus for downtown renewal and development of outdoor recreation.

South

The people of the southern Grand – where most municipal water supplies come from the Great Lakes – are looking to develop a viable tourism industry focused on the river. They are looking upstream for water quality improvements that will let them do that.

Sources of drinking water

Approximately 80 per cent of the residents of the Grand River watershed – about 650,000 people – get their drinking water from municipal water systems. The remainder get their water from private wells.

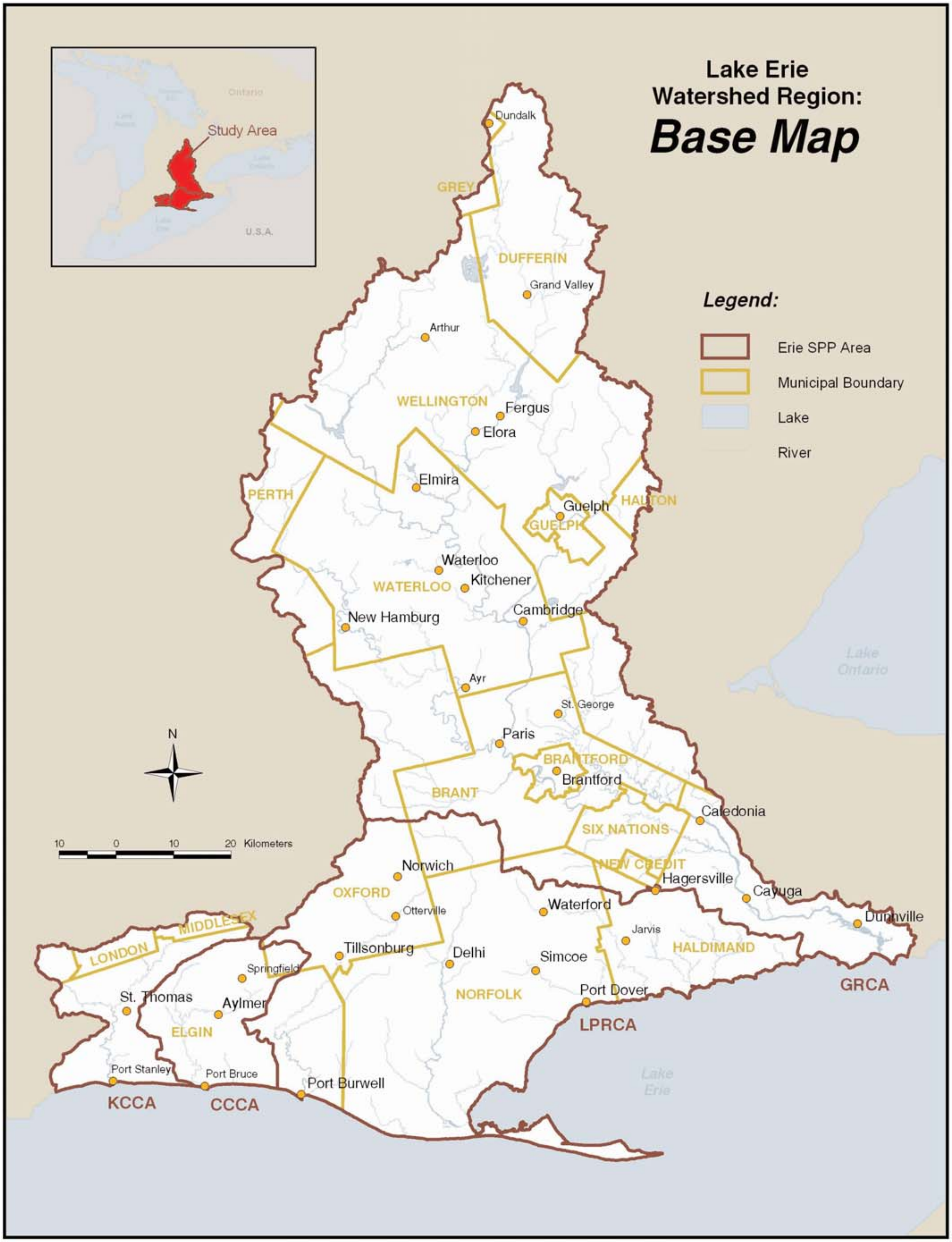
The municipalities get their water from three sources: groundwater wells (69 per cent), rivers (29 per cent) or the Great Lakes (3 per cent).

3. Lake Erie Source Protection Region

Under the Clean Water Act, Conservation Authorities have been grouped together into Source Protection Regions for the purpose of sharing resources and expertise. The Grand River watershed is part of the Lake Erie Region which also includes the Long Point Region, Catfish Creek and Kettle Creek watershed areas.

There are several reasons why these four conservation authorities have come together to form the Lake Erie Region:

- all of the watersheds drain into Lake Erie;
- they share some geographic attributes;
- some of the urban areas within Catfish, Kettle and Long Point share one Lake Erie intake; and
- they share some political ties. Several municipalities have territory in two or three of these watersheds, so having one source protection region simplifies municipal involvement in the planning process.


Lake Erie
Watershed Region:
Base Map
Study Area
Ontario
U.S.A.
Legend:
Erie SPP Area
Municipal Boundary
Lake
River
N
10 0 10 20 Kilometers
Dundalk
GREY
DUFFERIN
Grand Valley
Arthur
WELLINGTON
Fergus
Elora
Elmira
PERTH
Guelph
GUELPH
HALTON
Waterloo
Kitchener
WATERLOO
New Hamburg
Cambridge
Ayr
St. George
Paris
BRANTFORD
Brantford
BRANT
Caledonia
SIX NATIONS
NEW CREDIT
Hagersville
Cayuga
Dunnville
Norwich
OXFORD
Otterville
Waterford
Jarvis
HALDIMAND
MIDDLESEX
LONDON
Springfield
Tillsonburg
Delhi
Simcoe
St. Thomas
Aylmer
ELGIN
NORFOLK
Port Dover
GRCA
LPRCA
Port Stanley
Port Bruce
Port Burwell
KCCA
CCCA
Lake Ontario
Lake Erie

4. Geology and groundwater

Bedrock geology

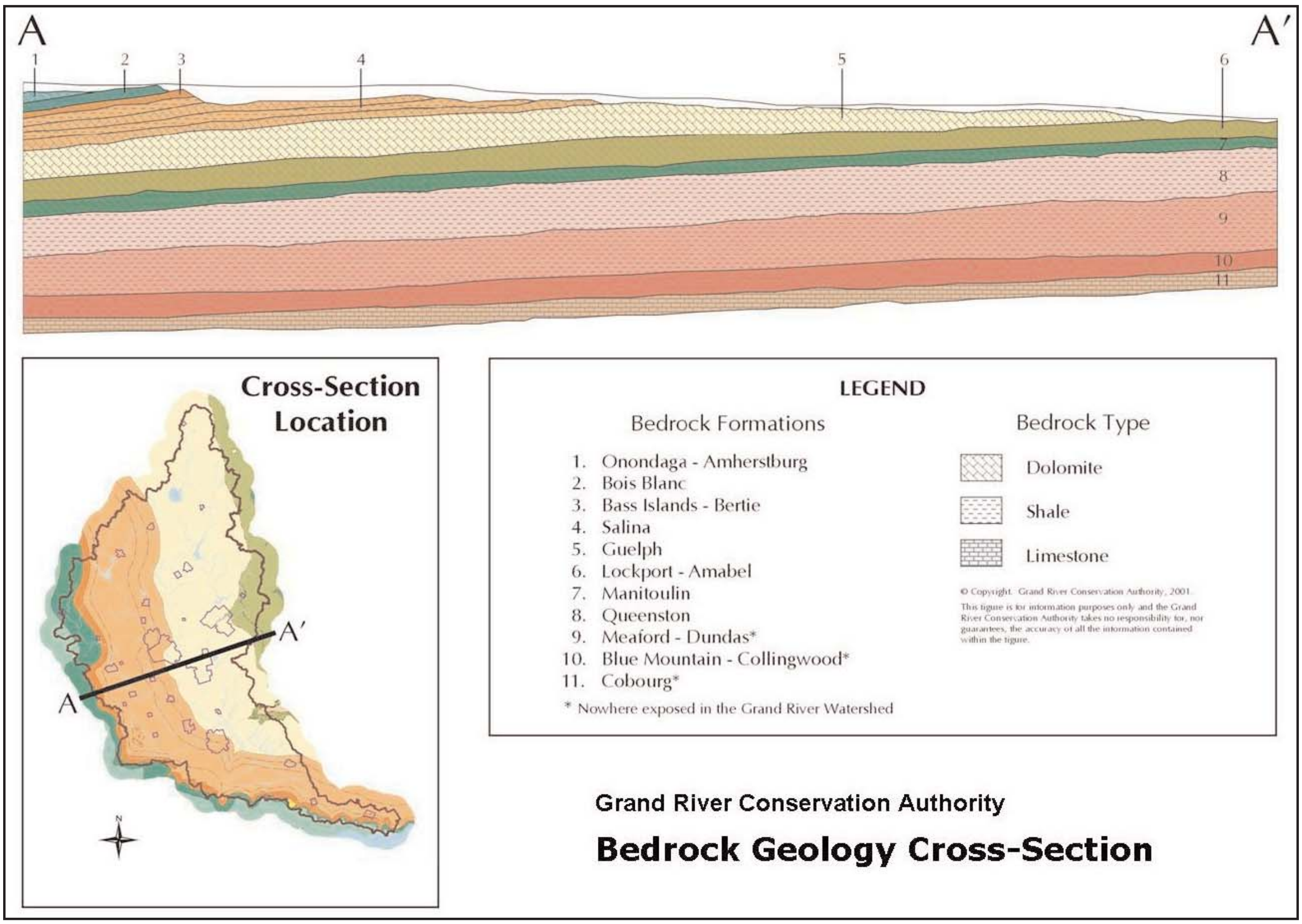
Deep below the watershed are layers of ancient bedrock – some of it 370 million years old. Eleven different bedrock formations have been identified in the watershed.

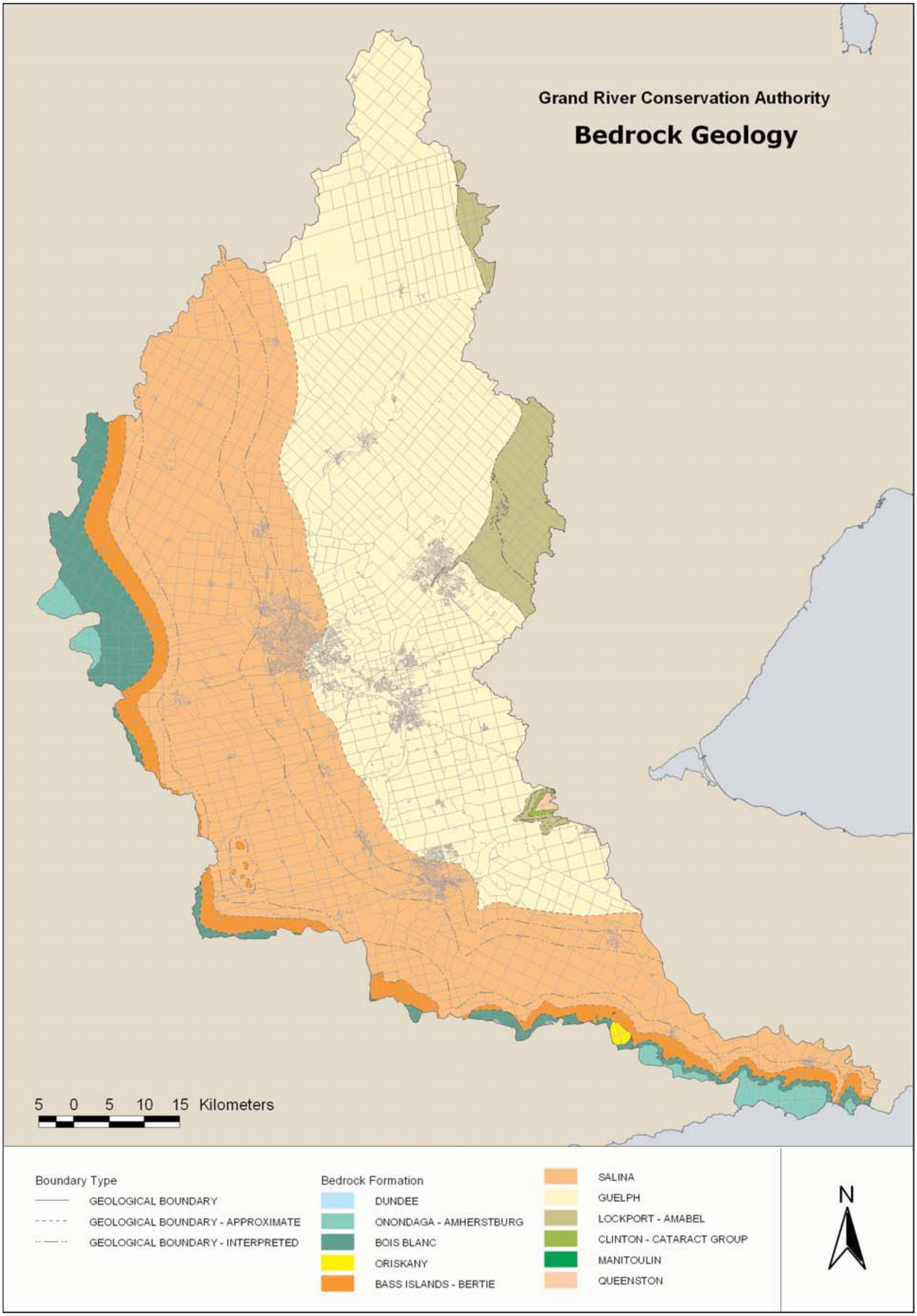
There is a slight dip – about two degrees to the west – in the bedrock layers, which means that the eastern parts of each layer are a little higher than the western parts. As a result of the dipping layers, beneath the overburden cover, the bedrock appears to form long, parallel bands of varying widths, running from the northwest to the southeast.

Three bedrock formations dominate in the Grand River watershed: the Guelph and Amabel formations in the east and the Salina Formation in the west. These porous, fractured limestone units have the ability to yield significant quantities of groundwater, making them important sources of water for municipal and private use. The water in these bedrock aquifers may be hundreds, or even thousands of years old. As a result, the water has picked up minerals from the surrounding bedrock, which sometimes results in increased hardness, sulphur or salt content in the water.

The Guelph and Amabel formations in the eastern side of the watershed have proven to be particularly abundant and good quality sources of drinking water.

The Salina, Bois Blanc and Onondaga-Amherstburg formations on the western side of the watershed have naturally occurring higher concentrations of sulphur, salts and other minerals, which can affect the taste and odour of the water supply. However, these problems can often be dealt with during treatment after the water is pumped out of the ground. Many private drinking water wells on the western side of the watershed avoid the bedrock aquifer and instead use the groundwater resources in the lower-yielding overburden aquifers.





Grand River Conservation Authority
Bedrock Geology
5 0 5 10 15 Kilometers
Boundary Type
GEOLOGICAL BOUNDARY
GEOLOGICAL BOUNDARY - APPROXIMATE
GEOLOGICAL BOUNDARY - INTERPRETED
Bedrock Formation
DUNDEE
ONONDAGA - AMHERSTBURG
BOIS BLANC
ORISKANY
BASS ISLANDS - BERTIE
SALINA
GUELPH
LOCKPORT - AMABEL
CLINTON - CATARACT GROUP
MANITOULIN
QUEENSTON
N

4. Geology and groundwater (cont'd)

Surface (Quaternary) geology

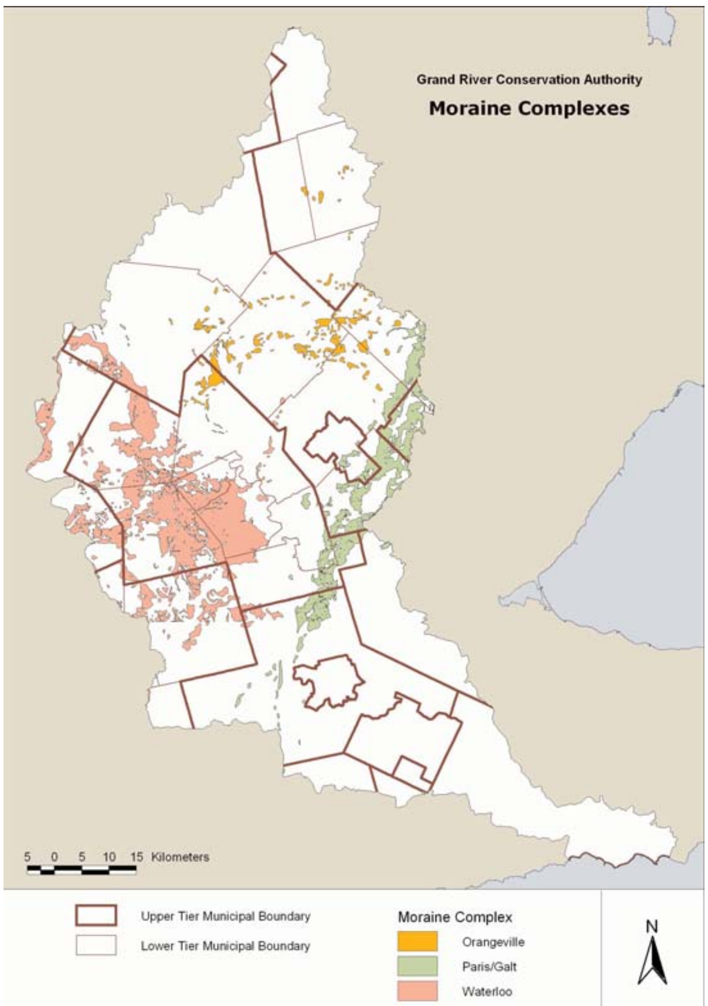
The shape and nature of the surface materials of the Grand River watershed is largely a product of the glaciers that covered the area 10,000 years ago. As the glaciers retreated from the Grand River watershed, today's surface materials were left in place. In the physiography map, the silt and clay tills are shown in green. Coarse-grained gravel and sand materials are shown in red, orange, and yellow. Clay is shown as blue.

By and large, the watershed can be divided into three zones:

North

The northern portion of the watershed is notable for its till plains – large, gently rolling areas covered by dense, fine-grained clay and silt-rich materials. The largest regions are the Dundalk Till Plain in the headwaters area of the Grand and Conestogo rivers and the Stratford Till Plain to its south and west. The density of the surface materials makes it difficult for water to soak into the ground. As a result, a high percentage of precipitation runs off the surface to feed creeks and rivers. The till plains are excellent farm land thus they have been extensively tile-drained and have few wooded areas. Because of the fine textured soil, extensive cultivation, rapid runoff of surface water and lack of vegetated buffers along water courses, soil erosion is prevalent in this area. Vegetated buffers have been developed along many kilometres of stream over the last 10 years under the Rural Water Quality Program.

Most wells in this area draw from the bedrock or sand seam aquifers found between the layers of heavier till.



Central

When the glaciers melted, the central portion of the watershed was an active drainage channel, located at the intersection of three major ice lobes. Notable features in this portion of the watershed include:

- the Waterloo, Orangeville and Galt-Paris moraines;
- the Guelph Drumlin Field;
- the gravel terraces (outwash spillways for glacial runoff) along the Eramosa, Speed and Grand River valleys; and
- the Norfolk Sand Plain.

The cities of Waterloo, Kitchener, Cambridge, Guelph and Brantford, which hold the majority of the watershed's population, are located in this central zone.

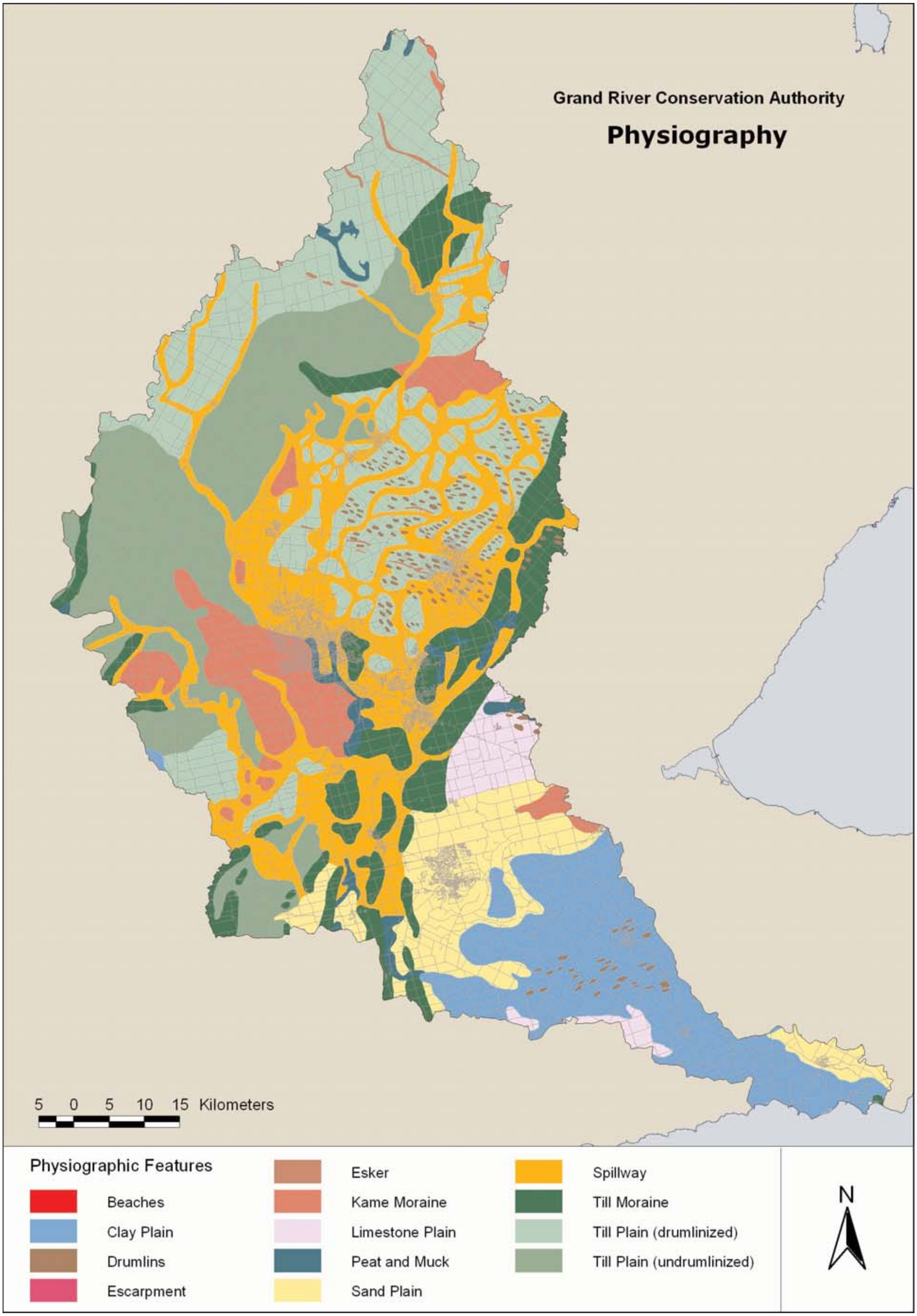
The moraines, particularly the kame moraines (such as the Waterloo Moraine), are notable for coarser soils and closed drainage areas which allow more water to infiltrate into the groundwater system and recharge the area's aquifers. These aquifers are rich sources of water for both municipal and private water systems.

The kame moraines and the gravel terraces are primary sources of aggregate (sand and gravel).

Groundwater also discharges in large quantities at the foot of the moraines, creating wetlands and cold water streams that support rich and diverse ecosystems.

Where wetlands and steeply sloping hills dominate, 20 to 30 per cent of the landscape is forested. The more gently rolling areas are extensively cultivated.

The Norfolk Sand Plain, in the southwestern part of the central zone, is also rich in water which is intensively used for both mixed farming and cash crops. However, the fact


Grand River Conservation Authority
Physiography
5 0 5 10 15 Kilometers
Physiographic Features
Beaches
Clay Plain
Drumlins
Escarpment
Esker
Kame Moraine
Limestone Plain
Peat and Muck
Sand Plain
Spillway
Till Moraine
Till Plain (drumlinized)
Till Plain (undrumlinized)
N

4. Geology and groundwater (cont'd)

that the soils are more permeable also means that it is easier for contaminants to enter the ground and reach wells.

South

The prominent feature in the southern part of the watershed, from Brantford to Lake Erie, is the Haldimand Clay Plain. It is characterized by heavy clay soils which are relatively impermeable, resulting in a high level of runoff and little groundwater recharge. Much of the land is poorly drained and is used predominantly as livestock pasture. Private wells often draw from the shallow sand seams layered in the clay, since the underlying Salina Formation has naturally poor water quality.

Areas susceptible to groundwater contamination

Where surface materials are coarse-grained or shallow, and the water table is high, groundwater can often be affected by waste or chemicals applied to or spilled on the ground.

Some areas that are particularly susceptible to groundwater contamination include:

- the Dundalk Highlands in Dufferin County because of the shallow overburden;
- the Flamborough Bedrock Plain in the City of Hamilton, which breaks through the surface in several areas and has only shallow cover in others;
- the loose surface material of the gravel terraces (outwash plains) running through Wellington, Waterloo and Brant alongside the Galt-Paris Moraines; and
- the Norfolk Sand Plain in Oxford and western Brant counties where shallow aquifers have little protection.

In these areas, most municipal wells and some private wells use deeper aquifers that may be protected from surface influences by thick layers of denser till or clay materials.

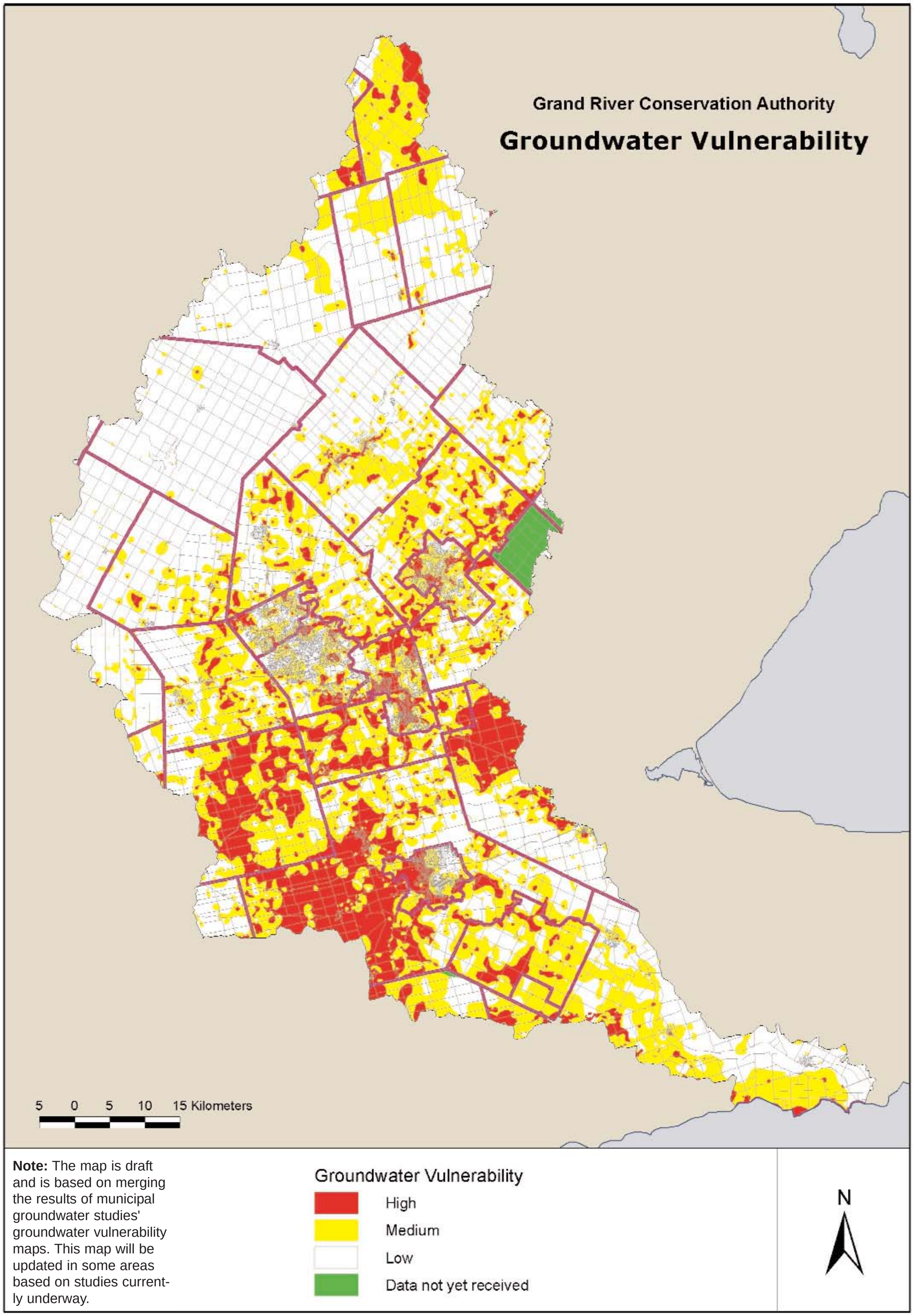
The groundwater vulnerability map shows the relative susceptibility of groundwater contamination for the aquifers that are most commonly used for municipal and private drinking water.

In the north end of the watershed, the Dundalk Highlands, the bedrock aquifer is the primary source of drinking water. Overburden cover in this area tends to be generally thin, which results in a medium-to-high susceptibility rating.

Further south, there is a broad area of low vulnerability. Similar to the northern parts of the watershed, this area also uses the bedrock aquifer as the primary source of drinking water. This area, however, is covered by large thicknesses of Tavistock Till and Mornington Till; fine-grained, silt and clay-rich till units which provide a larger degree of protection to the underlying bedrock aquifers. Throughout the central portion of the watershed, areas of high vulnerability are generally related to outwash, glaciofluvial and ice-contact deposits. Each deposit is primarily composed of coarse-grained sand and gravel units which are often located at or near ground surface. Therefore, aquifer units in these deposits have a relatively higher susceptibility to contamination.

In the southwestern portion of the watershed, overburden aquifers are within the sandy material of the Norfolk Sand Plain. These sand-rich deposits are located near ground level and have little-to-no overlying protection, thus this area has a moderate to high relative vulnerability to contamination.

In the southeastern part of the watershed in Haldimand County, primary groundwater resources are located within the Salina Formation. This bedrock aquifer is covered by a layer of clay-rich deposits — the Haldimand Clay Plain — which provide some protection to the underlying aquifer. Areas of moderate vulnerability in this area are a result of thin overburden cover, whereas areas with thicker overburden cover have a lower relative vulnerability.



Note: The map is draft and is based on merging the results of municipal groundwater studies' groundwater vulnerability maps. This map will be updated in some areas based on studies currently underway.

5. Hydrology and surface water

Overview

The Grand River drains approximately 6,800 square kilometres from its headwaters in the Dundalk Highlands to its mouth in Port Maitland on Lake Erie. Along its 300 kilometres, the elevation drops approximately 180 metres.

The major tributaries of the Grand River include the Conestogo and Nith rivers which drain the western half of the watershed; the Speed and Eramosa rivers drain the north-east. Several smaller tributaries drain the southern half of the watershed including Fairchild, Whitemans and McKenzie creeks. Portions of the Grand River and some of its tributaries are regulated for flood control and low flow augmentation using four major and three smaller reservoirs and an extensive stream gauge network.

The geology differs across the watershed, creating different hydrologic conditions. The till plains of the northern portion of the watershed are characterized by a fairly dense network of watercourses, high surface runoff and very little ground infiltration. Watercourses in this area respond quickly to precipitation, with little to no flow during sustained dry periods. The topography is relatively flat, which has driven the need for extensive agricultural drainage works.

The central portion contains the majority of the watershed's moraines and sand/gravel deposits left by glaciation. Because of the significant amount of pervious material, and the lack of a well-defined drainage network, this area is characterized by extremely high infiltration and relatively low surface runoff. High infiltration sustains the area's rich groundwater aquifers that support the high concentration of cold water fisheries found in this area. Urbanization in this part of the watershed has led to an increase in surface runoff from impervious areas and localized flooding issues.

The Haldimand Clay Plain in the southern portion of the watershed produces a dense network of watercourses with extremely high surface runoff and little to no infiltration. Much like the northern till plain area, the southern portion of the watershed responds very quickly to precipitation events, with very little flow during dry periods.

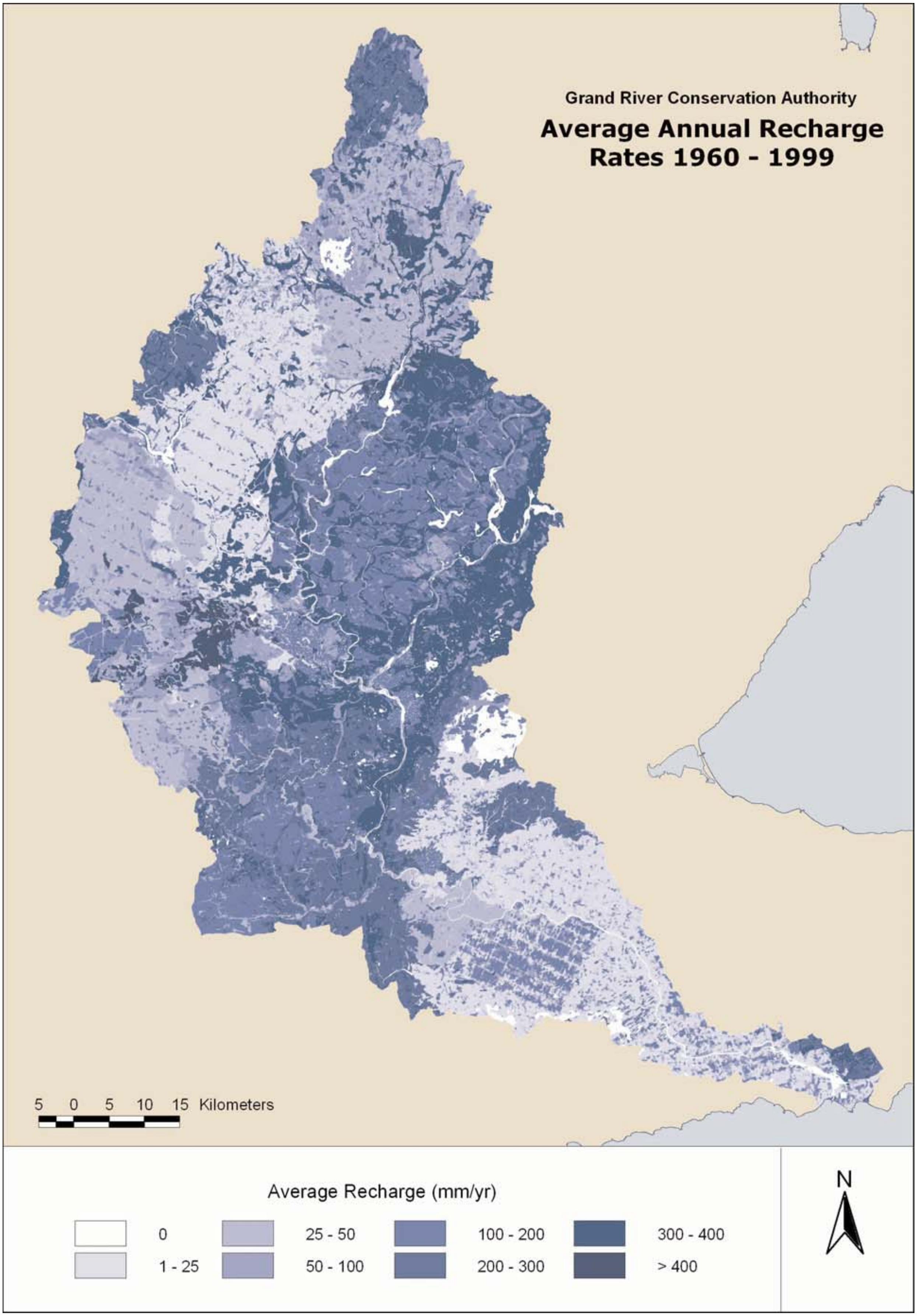
Major groundwater recharge areas

Groundwater recharge occurs throughout the Grand River watershed. The rate of recharge depends on the slope of the ground surface, soil moisture, grain size and stratification.

The areas of highest recharge tend to coincide with the moraine features. The moraine areas represent very significant recharge zones for the watershed's major aquifers.

Recharge in the areas of the Galt, Paris and Waterloo moraines contributes to the groundwater system in the overburden deposits. The Orangeville Moraine is a major recharge area that contributes to the bedrock aquifers in the region. In addition to the moraine features, areas within the Upper Grand area contain isolated, interspersed pockets of coarse-grained material which allow for high recharge rates.

To the southwest, the Norfolk Sand Plain is an area characterized by thick deposits of highly permeable, coarse-grained sands. High recharge supports extensive unconfined overburden aquifers throughout the Norfolk Sand Plain. Potentially a large quantity of recharge from this area leaves the watershed as subsurface flow across the watershed boundary.


Grand River Conservation Authority
Average Annual Recharge
Rates 1960 - 1999
5 0 5 10 15 Kilometers
Average Recharge (mm/yr)
0
1 - 25
25 - 50
50 - 100
100 - 200
200 - 300
300 - 400
> 400
N

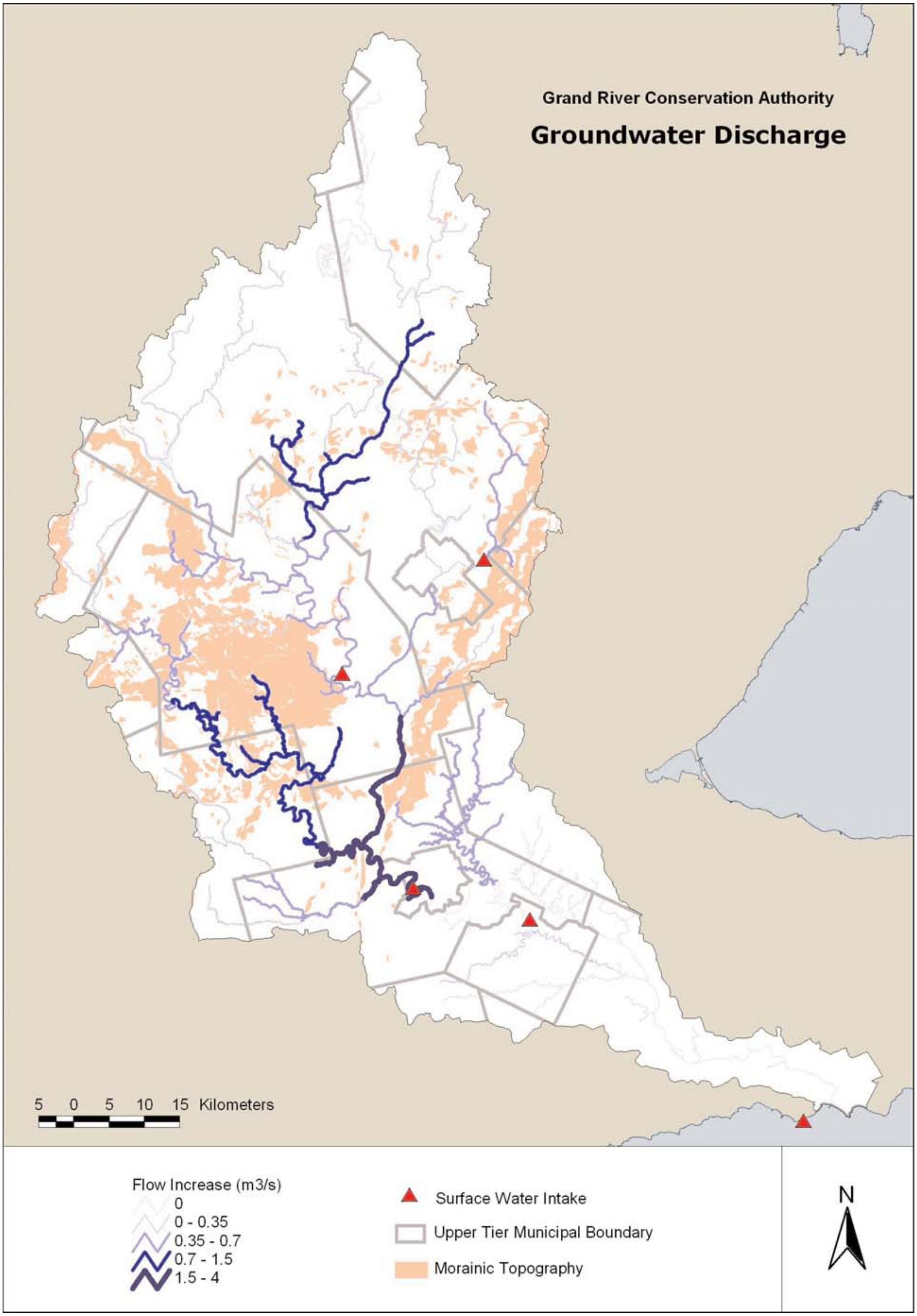
5. Hydrology and surface water (cont'd)

Major groundwater discharge areas

Groundwater flows to the surface water system, or discharges, in many places throughout the watershed, including at the toe of moraines, where river valleys cut through moraines, and in wetland areas.

Major discharge areas within the Grand River watershed are associated with the major river corridors, as shown on the map, especially along the lower Nith River and the Grand River south of Cambridge. In addition, the Luther Marsh and Amaranth Swamp (upper Grand River), Blue Springs Creek (Eramosa River), Roseville Swamp (middle Grand River), Black Creek Swamp (Nith River), Beverly Swamp (Fairchild Creek) and Oakland Swamp (McKenzie Creek) are significant wetland areas that are regional-scale groundwater discharge areas.

Numerous coldwater streams supporting native brook trout originate in the moraine-wetland complexes. In addition, groundwater discharge areas within the watershed have created and maintained a significant habitat for cold water aquatic species, such as rainbow trout. In the larger river systems, such as the Grand near Brantford, groundwater discharge from further upstream has spurred a resurgence in trout populations over the last 20 years as water quality has improved.


Grand River Conservation Authority
Groundwater Discharge
5 0 5 10 15 Kilometers
Flow Increase (m3/s)
0
0 - 0.35
0.35 - 0.7
0.7 - 1.5
1.5 - 4
Surface Water Intake
Upper Tier Municipal Boundary
Morainic Topography
N

6. Reservoirs and reservoir operations

The Grand River is a managed river system where reservoir operations, water supply, and wastewater management were designed as an integrated system on a watershed basis.

The system is managed through the operation of seven dams and reservoirs owned by the GRCA.

The most recent water management plan, called the Grand River Basin Water Management Plan, was completed in 1982 with a 50 year planning horizon to 2031.

It established objectives and targets for reducing flood damage, providing water supply, and improving water quality, and recommended actions for achieving these objectives.

The reservoir system is operated to reduce flooding and to add water to the river during low flow periods in order to provide municipal water supply and improve wastewater assimilation and river water quality.

The four major GRCA dams – Shand and Luther on the Grand River, Conestogo on the Conestogo River and Guelph on the Speed River — provide flow augmentation and flood control for these rivers.

The other three GRCA dams perform similar functions on smaller tributary streams – Laurel Creek (Waterloo), Canagagigue Creek (Elmira) and Mill Creek (Cambridge).

The reservoirs are filled during the spring snowmelt, the most active flooding season, and then gradually drawn down over the summer and early fall, thereby supplying more flow in the river than would normally be.

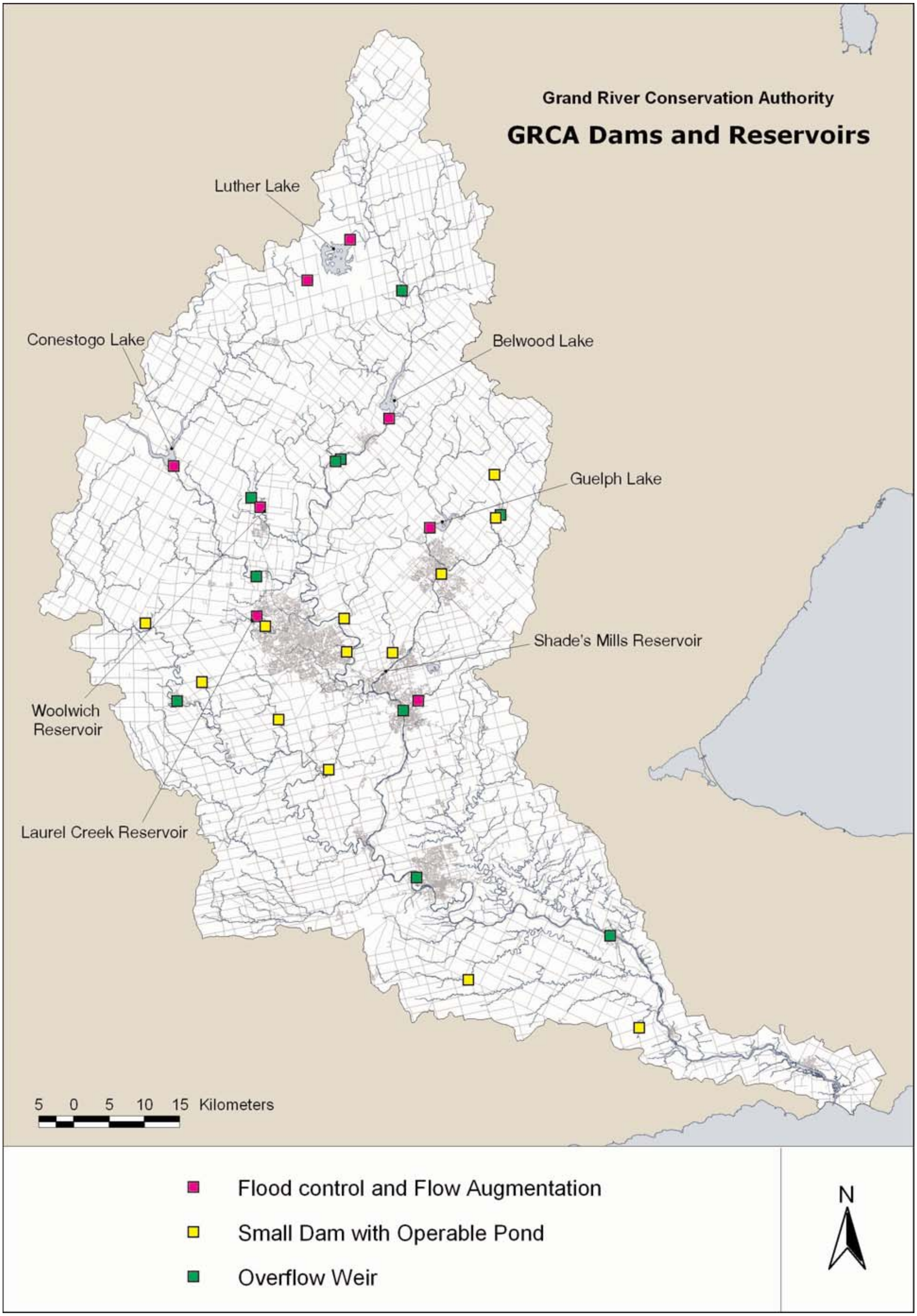
For example, there were days during the very dry summer of 2007 when more than 95 per cent of the water in the Grand River at Doon (Kitchener) was water from reservoir storage.

Management of these dams is supported by an extensive network of low monitoring gauges stationed around the watershed. There are close to 40 of these stations which report their data hourly to the GRCA head office in Cambridge where it can be monitored by GRCA staff. The information is also posted on the GRCA website.

There are about 142 dams in the Grand River watershed, including those built by early pioneers to power as wells as newer dams built to enable crop irrigation.

The historical dams often provide a landmark or heritage feature for their communities. Many of the ponds above the dams provide outdoor recreation. On the other hand, on-stream dams tend to impair river water quality by slowing water movement and collecting nutrient-rich sediment. As these old dams deteriorate and require investment, communities must weigh the balance between heritage and recreation values versus water quality improvement.

Ownership of the dams is diverse. Many are privately owned and a few are owned by municipalities. The GRCA owns 32 dams (see map) and in recent years has decommissioned three dams. Some dams are orphaned, with no acknowledged owner.


Grand River Conservation Authority
GRCA Dams and Reservoirs
Luther Lake
Conestogo Lake
Belwood Lake
Guelph Lake
Shade's Mills Reservoir
Woolwich Reservoir
Laurel Creek Reservoir
5 0 5 10 15 Kilometers
Flood control and Flow Augmentation
Small Dam with Operable Pond
Overflow Weir
N

7. Population

Overview

At the time of the 2001 census, the Grand River watershed had a total population of more than 821,000 people. The watershed is characterized by dense urban centres surrounded by lightly populated rural areas. Approximately 73 per cent of the population (or 600,000) live in the five cities: Kitchener, Waterloo, Cambridge, Guelph and Brantford. However, these cities occupy only about seven percent of the total land area of the watershed.

All five of the cities are experiencing growth and intensification. The population in rural areas has remained relatively stable, although it has grown in several larger, serviced towns and villages including Fergus, Elora, Rockwood, New Hamburg and Paris.

Population trends and projections

Recent population forecasts for the municipalities in the Grand River watershed indicate that the total population will increase to 1.2 million in 2031 from 821,000 in 2001.

Most of this growth will occur in the five cities over the next 25 years, due, in part, to the strength and diversity of their economies and the proximity to the Greater Golden Horseshoe cities of Toronto and Hamilton.

Recent provincial initiatives, such as the creation of the Greenbelt around the Greater Toronto Area, and the passing of the Places to Grow legislation, have caused many municipalities in the watershed to re-evaluate population projections.

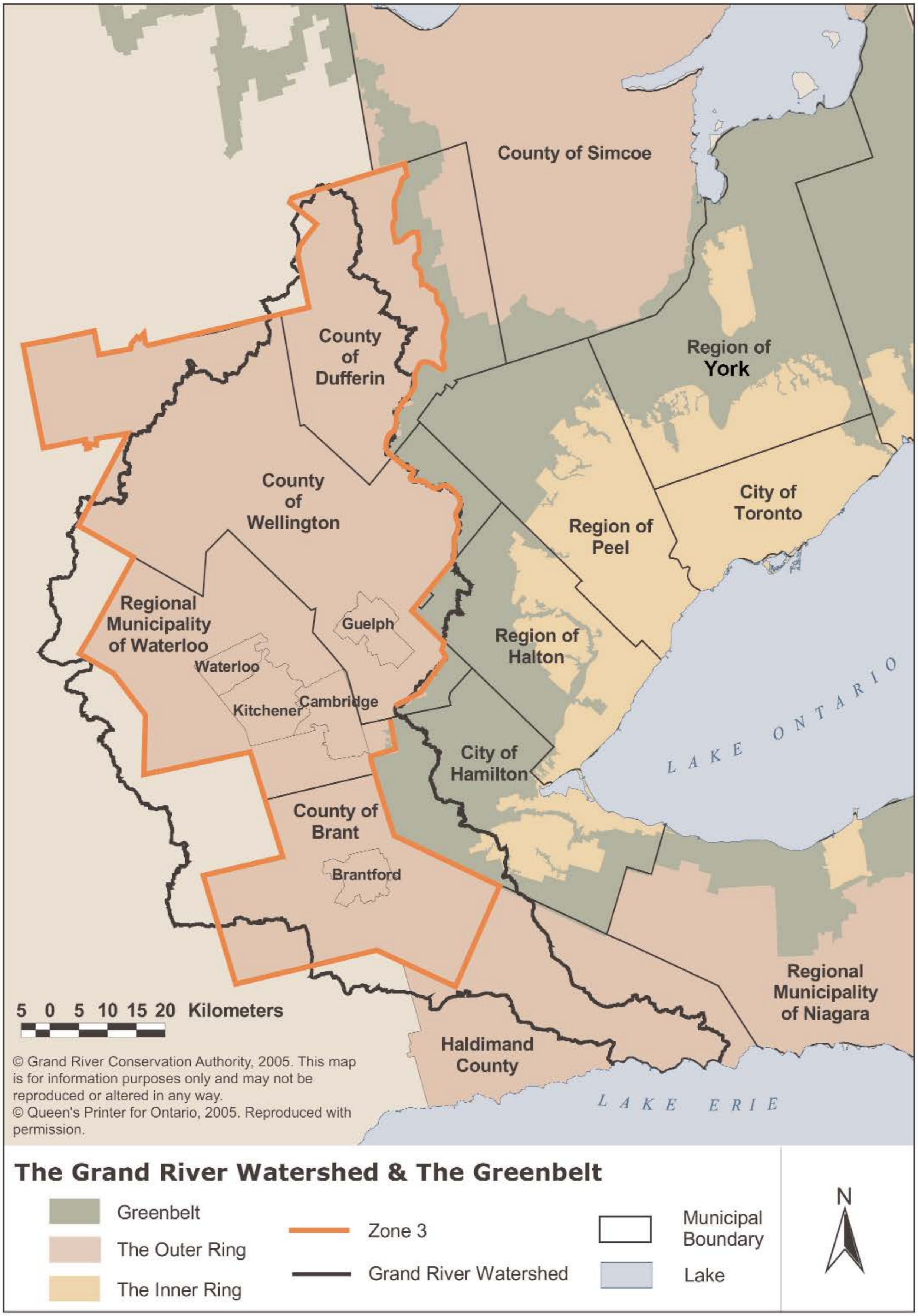
The Greenbelt Act imposed rigid planning policies limiting growth in communities surrounding the GTA. The greenbelt area runs almost entirely along the eastern boundary of the Grand River watershed, and includes portions of the watershed in the City of Hamilton and Halton Region. (A tiny finger of the Greenbelt juts into Waterloo Region to include a wetland in North Dumfries Township along the Hamilton border.)

The planning restrictions in the greenbelt area may cause leapfrogging, in which urban growth “jumps over” the greenbelt from the Toronto-Hamilton region into the Grand River watershed.

In addition, the province’s Places to Grow Act designates the five cities of the Grand River watershed as “urban growth centres.” The Act provides population projections for these cities that are significantly higher than recent growth rates used by the municipalities. In many cases, the new, higher growth rates will require significant changes to municipal growth, infrastructure and servicing strategies to ensure that existing services can accommodate the population intensification expected by the Act.

Growth rate of Grand River cities

Community	2001 population	2031 population	Growth rate
Waterloo Region	456,000	729,000	60%
Guelph	109,450	166,750	52%
Brantford	86,417	132,018	53%


County of Simcoe
County of Dufferin
Region of York
County of Wellington
City of Toronto
Region of Peel
Regional Municipality of Waterloo
Guelph
Region of Halton
Waterloo
Kitchener
Cambridge
LAKE ONTARIO
City of Hamilton
County of Brant
Brantford
Regional Municipality of Niagara
5 0 5 10 15 20 Kilometers
Haldimand County
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LAKE ERIE
The Grand River Watershed & The Greenbelt
Greenbelt
The Outer Ring
The Inner Ring
Zone 3
Grand River Watershed
Municipal Boundary
Lake
N

8. Land cover and land use

Settlement history

The Grand River watershed has been inhabited by humans since the last ice age, over 10,000 years ago. By the time Europeans explored the area in the 1600s the area was occupied by Iroquoian-speaking tribes.

In 1784, members of the Six Nations Confederacy, who then lived primarily in New York State, moved to the Grand River watershed to settle in the Haldimand Tract, a parcel of land six miles either side of the Grand River that had been granted to them to replace lands they lost as a result of the Revolutionary War.

In the early 1800s an influx of Mennonites (from Pennsylvania) and Scottish settlers marked the opening of the Grand River watershed to large-scale settlement. Early farmers cleared the land in the south and middle of the watershed, using the Grand as a means of transportation and a source of power for the grist and saw mills that sprang up. The river also provided drinking water and a waste disposal system.

The middle section of the basin became the centre of development because of the advantage of water power from the fast flowing river and the proximity of easily cultivated valley land. Communities such as Fergus, Guelph, Galt, Preston, Hespeler, Paris and Brantford grew around mills and the valley flats.

Settlers moved to the northern areas of the watershed in the mid-1800s, however the poorly-drained soils and shorter growing season led many to turn to lumbering as an alternative to farming.

Deforestation changed the way the Grand River was able to deal with heavy spring rains and snowmelt, leading to higher spring floods. As wetlands were drained, summer flows were no longer augmented by a steady seepage, with the result that summer flows declined. Increased population meant increased sewage to be dealt with by a river that had become sluggish and polluted.

To address the problems, the municipalities of the Grand River watershed banded together to create the Grand River Conservation Commission, a predecessor of today's GRCA. Legislation creating the commission was passed in 1932 and it came into existence in 1934. Its first project was construction of the Shand Dam on the Grand near Fergus in 1942.

Municipal structure

The Grand River watershed includes 13 upper tier municipalities (counties, regions and separate cities) and 26 lower tier municipalities (cities and townships.)

Single tier municipalities are the cities of Guelph, Hamilton and Brantford, and the counties of Brant, Norfolk and Haldimand.

Two tier systems (with number of lower tier municipalities in the watershed in brackets) are: Grey County (one), Dufferin County (four), Wellington County (six), Perth County (two), Halton Region (two), Waterloo Region (seven) and Oxford County (four)

Urban areas

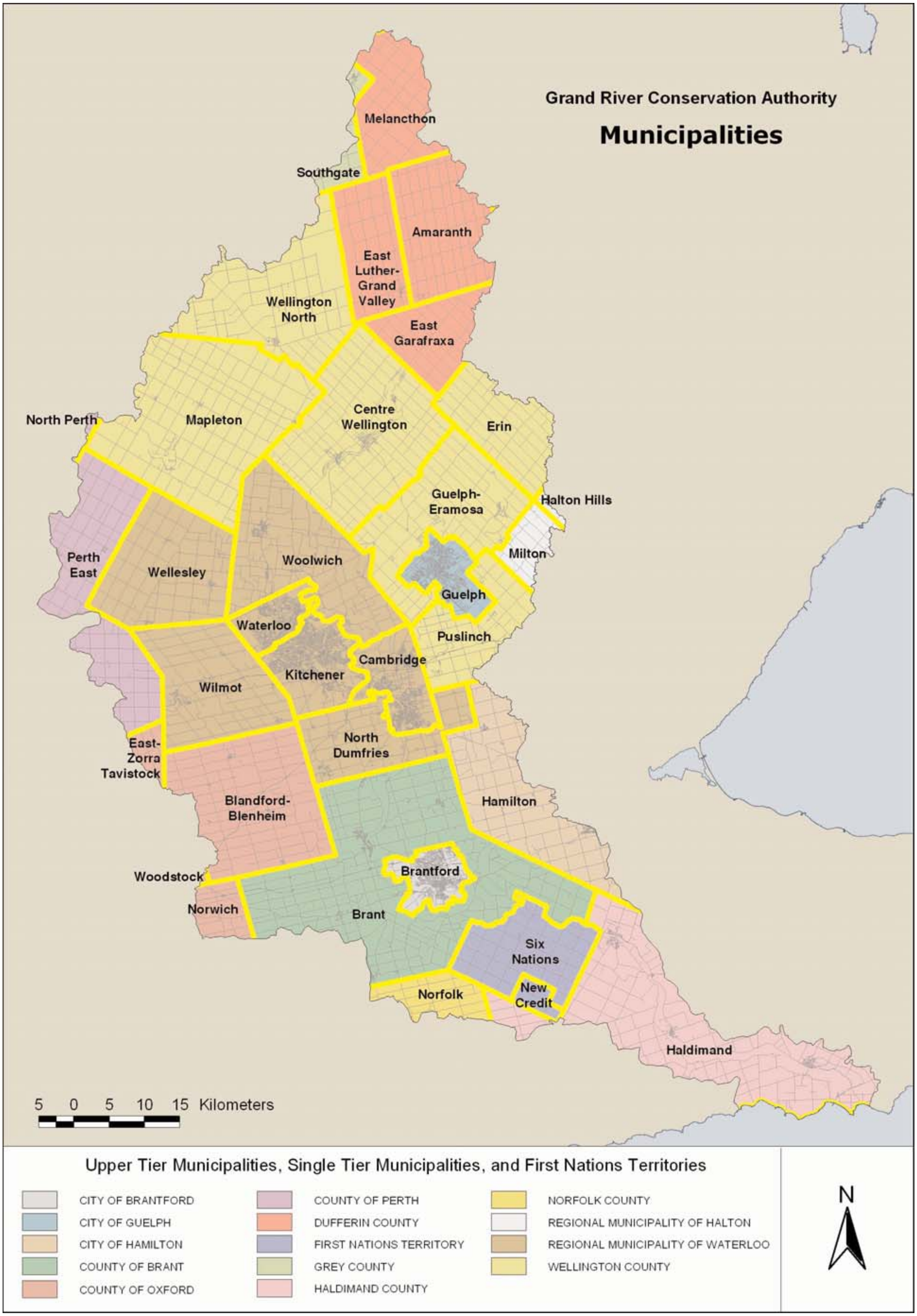
Over time, the mill towns of the Grand River watershed grew into thriving manufacturing communities during the mid-19th century, which brought about a whole new series of environmental issues. By the late 20th century, a switch to service-based and high tech economic activities was well under way.

As of 1991, the service sector was the dominant sector of the watershed economy (32 percent), followed by manufacturing (25 per cent) and trade (17 percent). The proportion of the labour force working in manufacturing is significantly higher in this watershed than in the rest of Ontario and Canada. To maintain employment growth and business development, industry needs an abundant, qualified workforce, ready transportation of goods, and predictable development costs and regulatory framework. The abundant well-trained workforce is attracted by the quality of life and the promising standard of living in the area.

Industrial and commercial sector operations are primarily located in urban, serviced areas. Industrial sectors include chemical manufacturing, automotive parts and assembly manufacturing, high-tech industries, textiles and many other.

Industrial pollution has been an important issue in the history of the Grand River watershed. The discharge of industrial chemicals and waste into waterways was a significant cause of deteriorating water quality in the 20th century. However, the implementation of provincial regulations on discharges has played a significant role in the overall improvement of water quality in the Grand system.

Still, the numerous brownfield sites in the watershed's


Grand River Conservation Authority
Municipalities
Melancthon
Southgate
Amaranth
East Luther-Grand Valley
Wellington North
East Garafraxa
Mapleton
North Perth
Centre Wellington
Erin
Guelph-Eramosa
Halton Hills
Milton
Perth East
Wellesley
Woolwich
Guelph
Waterloo
Puslinch
Cambridge
Kitchener
Wilmot
East-Zorra Tavistock
North Dumfries
Hamilton
Blandford-Blenheim
Woodstock
Brantford
Norwich
Brant
Six Nations
New Credit
Norfolk
Haldimand
5 0 5 10 15 Kilometers
Upper Tier Municipalities, Single Tier Municipalities, and First Nations Territories
CITY OF BRANTFORD
CITY OF GUELPH
CITY OF HAMILTON
COUNTY OF BRANT
COUNTY OF OXFORD
COUNTY OF PERTH
DUFFERIN COUNTY
FIRST NATIONS TERRITORY
GREY COUNTY
HALDIMAND COUNTY
NORFOLK COUNTY
REGIONAL MUNICIPALITY OF HALTON
REGIONAL MUNICIPALITY OF WATERLOO
WELLINGTON COUNTY
N

8. Land cover and land use (cont'd)

cities remain a legacy of those earlier days. Brownfields have the potential to contaminate both surface water and groundwater resources. However, identification of brownfields is often a difficult task, as contamination can remain undetected in soil and groundwater for many years.

Agriculture: crops and pasture

Agriculture remains the dominant land use in the watershed. The land is noted as some of the best farmland in the country, with the favorable climate and proximity to markets ensuring that farming remains a critical part of the economy. About 75 per cent of the total land of the watershed is actively farmed on 6,400 farms.

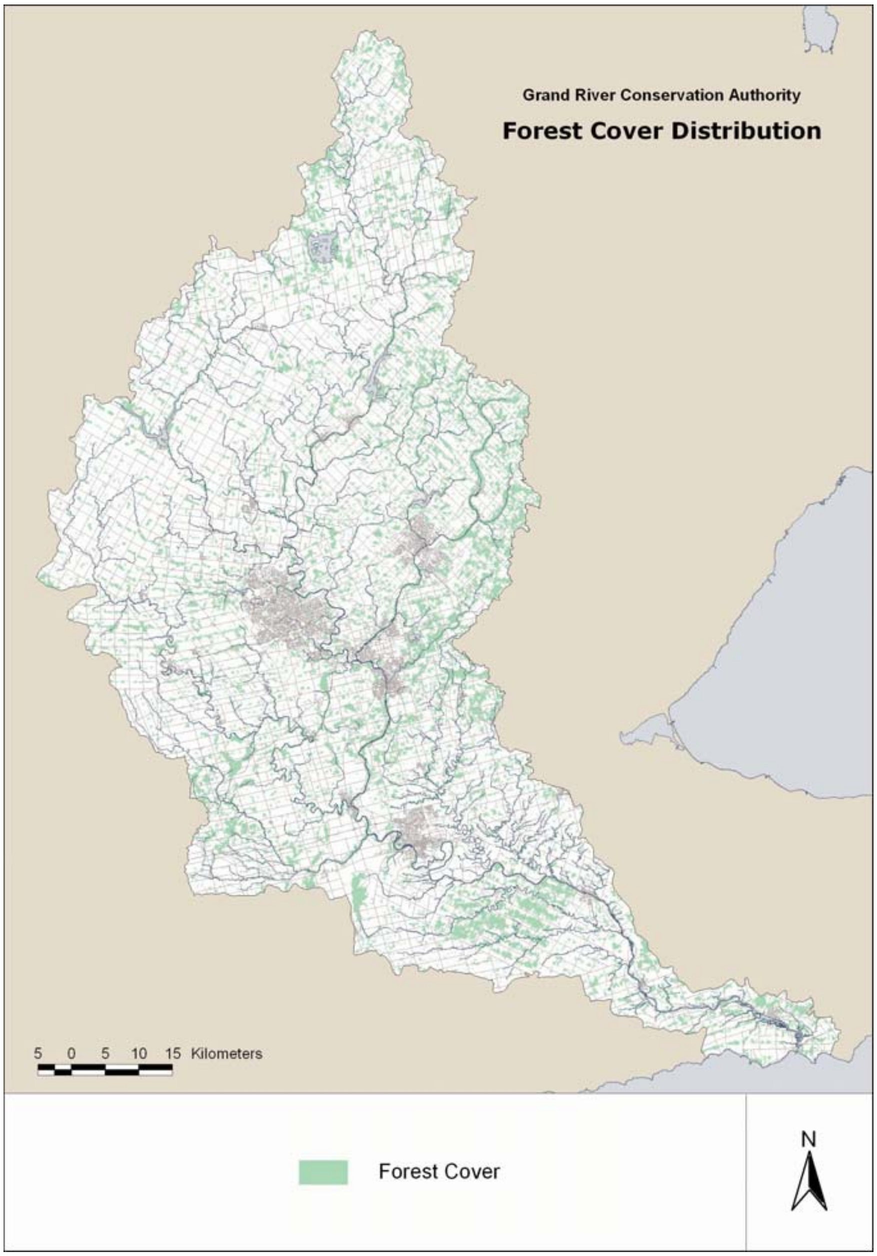
Both livestock and agricultural crops are prominent. About 53 per cent of the land supports crops. There are a total of 290,000 head of cattle, 500,000 head of swine and almost 8.8 million heads of poultry across the watershed. Corn (29 per cent), hay for fodder and forage (25 per cent) and soybeans (21 per cent) are the most common crops.

In some parts of the watershed, notably the northwest in Waterloo Region and Wellington County, more than 90 per cent of the land is used for agriculture. These rural regions are located in till plains with rich soils. The tight soils result in higher runoff rates, which can result in soil erosion and allows contaminants (e.g. manure or fertilizers) to enter the surface water system more quickly.

In addition, woodlots are small and many farmers work the land right down to the river's edge meaning there is less vegetation along watercourses to capture contaminants as they run off the land.

Areas with a high proportion of livestock farming often have higher nutrient loads.

In the southwestern part of the watershed, the sandy soils of the Norfolk Sand Plain are an ideal area for a variety of crops, notably tobacco, fruits and vegetables. This is an area where a high level of crop irrigation can have an impact on both ground and surface water supplies.



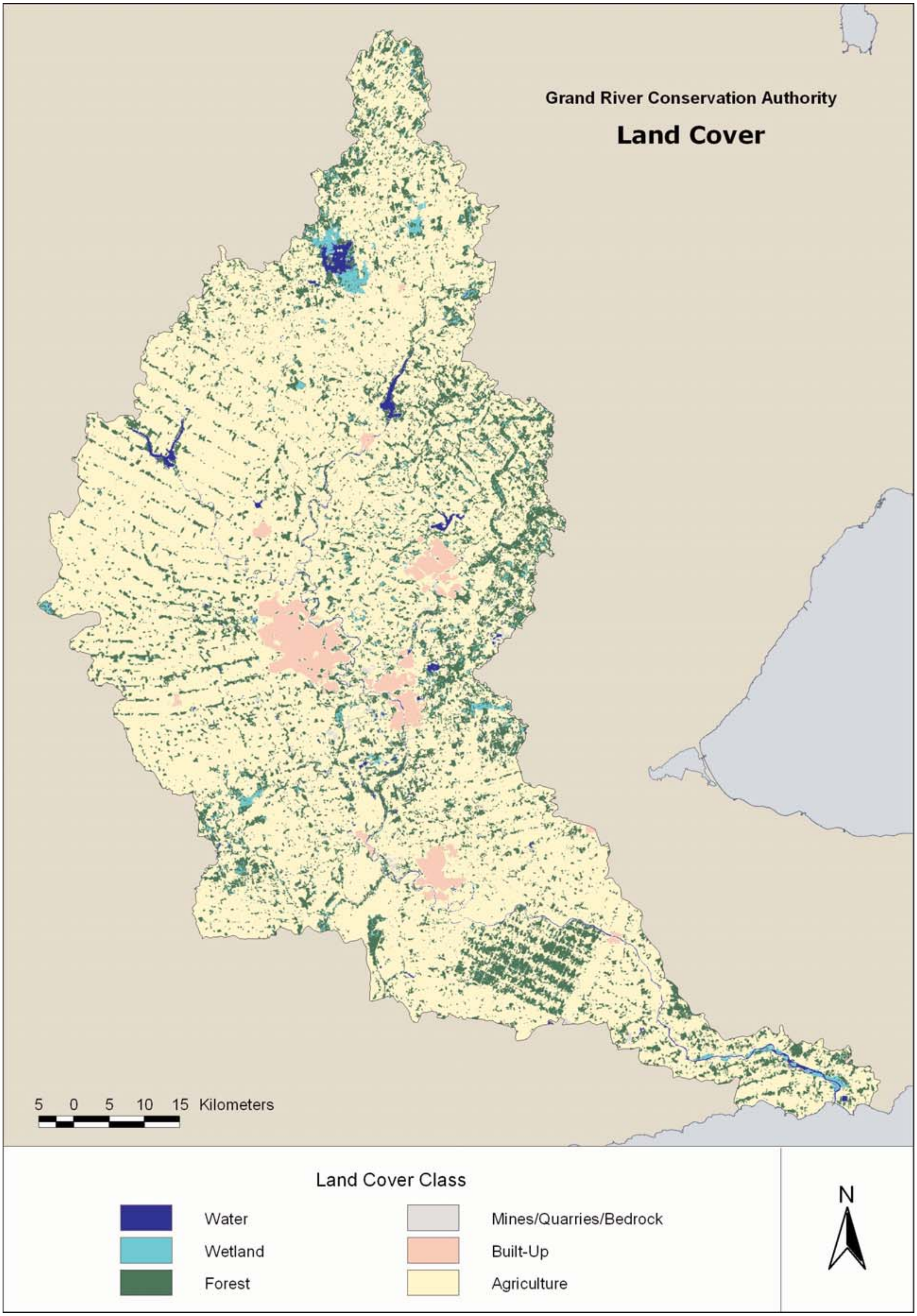
Aggregate extraction

Many parts of the Grand River watershed are rich in aggregate materials, notably the Waterloo Moraine, the gravel terraces along the Galt-Paris Moraine and the Norfolk Sand Plain.

They provide high quality aggregate products for construction and building materials.

Forest and vegetation cover

Forest and vegetation cover are important factors in overall watershed health. Trees and other vegetation reduce soil erosion and runoff, which are often significant


Grand River Conservation Authority
Land Cover
5 0 5 10 15 Kilometers
Land Cover Class
Water
Wetland
Forest
Mines/Quarries/Bedrock
Built-Up
Agriculture
N

8. Land cover and land use (cont'd)

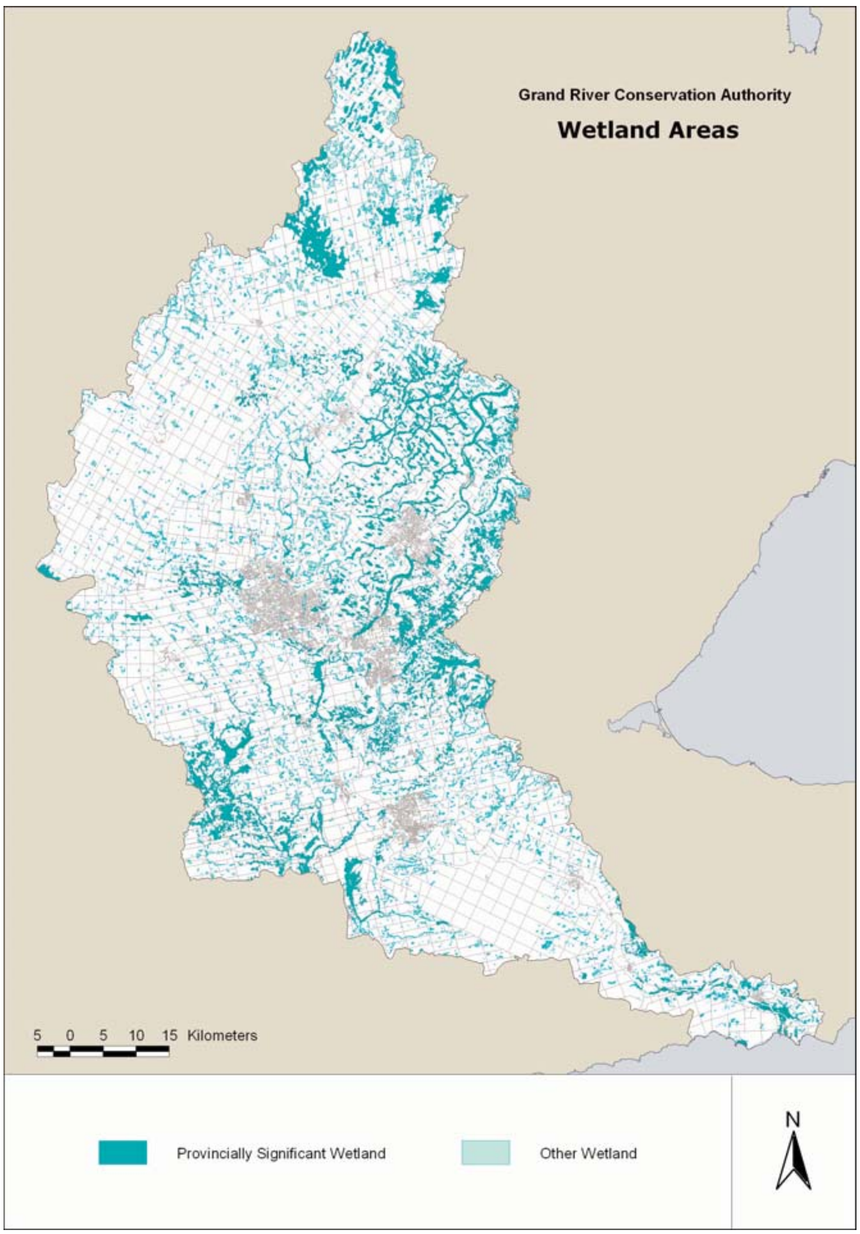
sources of contamination in surface water. Forested areas help improve groundwater by promoting infiltration and uptake of nutrients and other contaminants.

Forested areas make up approximately 19 percent of the total land cover, a significant increase from the five per cent of 100 years ago. However, Environment Canada recommends a minimum forest cover of 30 per cent to sustain the health of a watershed.

The amount of forest cover differs across the watershed. The best agricultural land in the west and northwest averages only five per cent forest cover. The hilly areas of the east, such as the Eramosa River subwatershed, have an average forest cover of 30 per cent.

The southern half of the watershed is notable for its Carolinian forests, which are home to species normally found much further south in the Carolinas. This forest type is dominated by sugar maple and beech along with basswood, silver maple, and several species of oak.

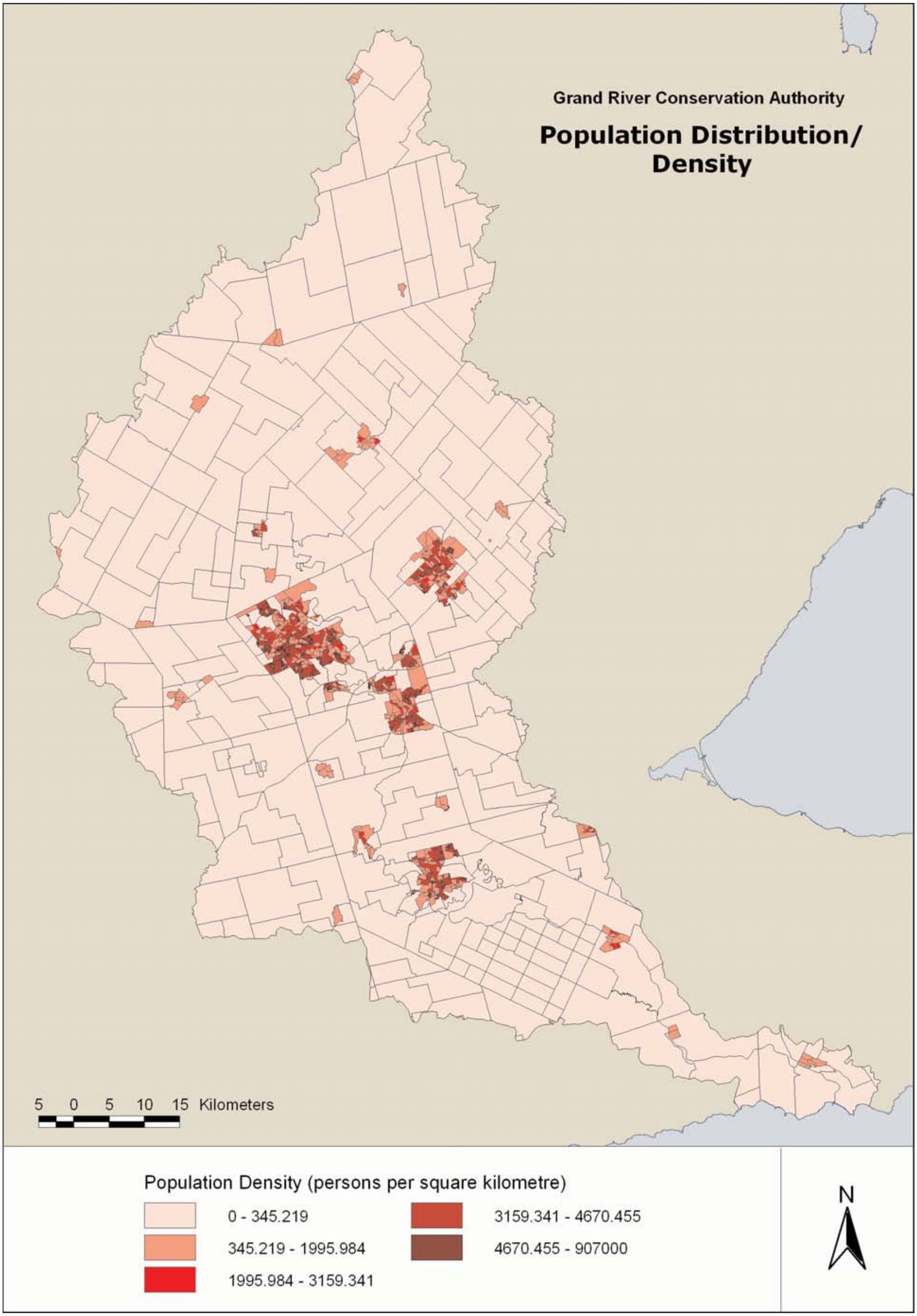
In the northern half of the watershed, the Great Lakes-St. Lawrence Forest predominates, containing eastern hemlock, white pine and eastern white cedar. In addition, balsam fir, white spruce and white birches reach their southern limit in this zone. In some of the upper reaches of the watershed, cool hollows of wetland vegetation similar to the muskeg of the boreal forest of the far north can be found.



Wetlands

Wetlands absorb surface water runoff and release it slowly. As a result, wetlands act as a filter and can reduce the level of some contaminants (nutrients, sediment, etc.) in the water before it enters the ground or flows downstream. Wetlands often contribute seasonally to groundwater recharge, especially in areas of permeable soils such as gravel, sand or loam. Some types of wetlands are fed by groundwater as it comes to the surface through a seep or spring.

Within the Grand River watershed, over 65 per cent of historical wetlands have been lost, while in some areas as much as 85 per cent have been lost. A minimum of ten per cent wetland coverage is thought to be required to indicate a healthy watershed. While the watershed as a whole meets this target, there is considerable variation across the watershed.


Grand River Conservation Authority
Population Distribution/ Density
5 0 5 10 15 Kilometers
Population Density (persons per square kilometre)
0 - 345.219
345.219 - 1995.984
1995.984 - 3159.341
3159.341 - 4670.455
4670.455 - 907000
N

9. Water use

Overview

Calculating water use involves compiling information from a wide variety of sources. Some water users, such as municipalities, report their annual consumption. In other cases it is necessary to extrapolate total water consumption from information about typical use patterns for categories of consumers, such as rural residents.

Estimates were determined using the best available data, including Census of Population, Census of Agriculture, municipalities, and the Permit to Take Water (PTTW) database, as well as expert opinion of water managers.

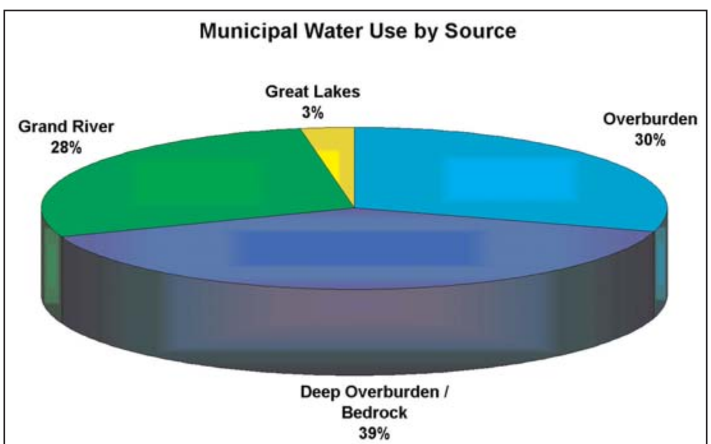
Large water users – those taking more than 50,000 litres a day – must have a permit from the Ontario Ministry of the Environment. However, this only establishes the maximum allowable taking and does not necessarily reflect the actual amount of water taken.

Municipal use and sources

Municipal water use is the supply of water provided through a central distribution system operated by a municipality. It includes urban domestic use, whether indoor or outdoor, as well as industrial, commercial, institutional and other uses.

There were 51 separate municipal systems in 11 municipalities across the watershed and one system on the Six Nations Reserve. The sources of water include deep bedrock groundwater wells, shallower overburden groundwater wells, the Grand River system and the Great Lakes.

More than 80 per cent of the residents of the Grand River watershed – about 650,000 people — get their drinking water from municipal water systems. The rest get their water from private wells.



The municipalities get their water from three sources: groundwater wells, the river and the Great Lakes.

Groundwater – 69 per cent

There are about 194 wells serving 47 municipal water systems, primarily in the central and northern parts of the watershed. They provide water to the urban areas of the Region of Waterloo, the City of Guelph and most other towns and villages.

Many of the municipal wells tap into aquifers that are in deep bedrock, notably the Lockport-Amabel Formation, the Guelph Formation and the Salina Formation.

Some municipal wells, notably in the Region of Waterloo and the counties of Brant and Oxford, draw their water from the overburden. The aquifers of the Waterloo and Orangeville moraines and the Norfolk Sand Plain are rich sources of groundwater.

Grand and Eramosa Rivers – 28 per cent

Two communities — Brantford and the village of Ohsweken of the Six Nations Territory — get all of their drinking water from the Grand River.

The Waterloo Region Integrated Urban System serving Kitchener, Waterloo and Cambridge as well as several towns, draws about 20 per cent of its water from the Grand River.

The City of Guelph uses water from the Eramosa River to recharge its groundwater collection system at Arkell during the summer.

The flow in the Grand River is augmented from four major reservoirs — Luther, Belwood, Conestogo and Guelph — that are operated by the Grand River Conservation Authority to maintain minimum flows in the river to supply water and assimilate wastewater.

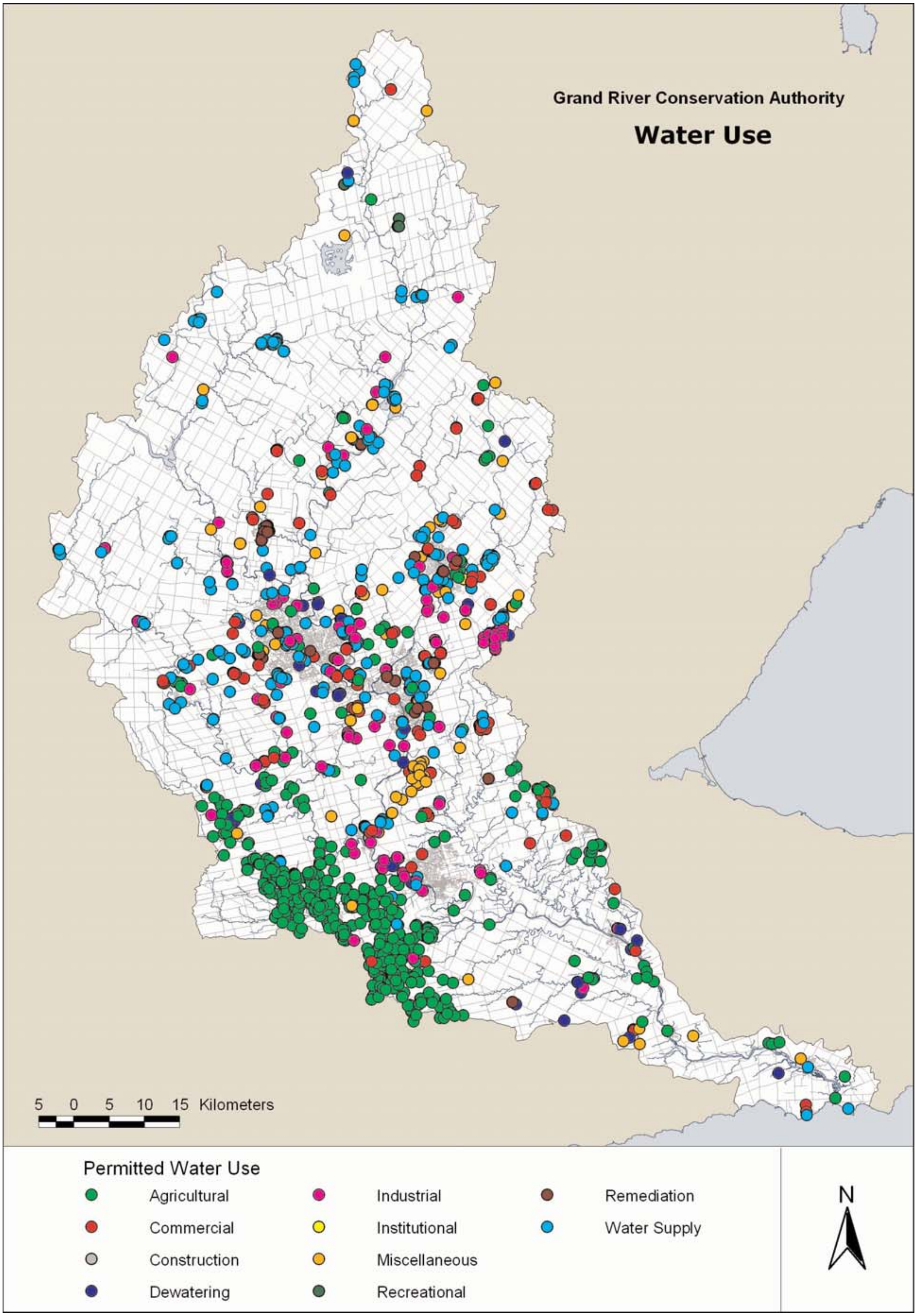
Great Lakes – 3 per cent

Dunnville in Haldimand County is served by an intake in Lake Erie.

Other communities in Haldimand County – Cayuga, Caledonia and York – are served by water piped from the City of Hamilton which draws its water from Lake Ontario. (The Hamilton intake is the subject of study by the Hamilton-Halton Source Protection Committee.)

Rural domestic

Un-serviced domestic water use is all water uses for domestic use (indoor and outdoor residential water use) that are not on a municipal distribution system and


Grand River Conservation Authority
Water Use
5 0 5 10 15 Kilometers
Permitted Water Use
Agricultural
Commercial
Construction
Dewatering
Industrial
Institutional
Miscellaneous
Recreational
Remediation
Water Supply
N

9. Water use (cont'd)

served by private or communal systems. The estimate for un-serviced domestic water use has been based on population estimates and per capita water use rates for rural residents.

Rural domestic per capita water use has traditionally been much lower than urban domestic use. While the actual rate varies depending on a large number of factors, 160 litres per day was assumed to be the rural domestic per capita water use rate. A large percentage of this water is likely returned to the shallow groundwater system via septic systems.

The rural population in the Grand River watershed is estimated to be 115,000, drawing 6.7 million cubic metres of water per year, representing 2.4 per cent of total water use in the watershed.

Agriculture

Agricultural water use falls into two categories:

- livestock and farming operations
- crop irrigation

Water for livestock and other farming operations is generally year-round, as opposed to crop irrigation, which only occurs during the summer growing season. Permits to Take Water are not required for livestock and associated uses.

The volume of livestock and other year-round agricultural water requirements, excluding irrigation water, is estimated to be 9.6 million cubic metres per year.

Crop irrigation is the application of supplemental water onto cropped fields when natural precipitation is insufficient.

Crop irrigation is not widespread and mostly involves specialty crops such as vegetables, sod, fruit, tobacco, potatoes and ginseng. It is most common in the Norfolk Sand Plain area in Brant and Norfolk counties. Irrigation is concentrated in June through September, with some exceptions earlier or later in the growing season. The concentration of these large water takings during warmer and often drier months places stress on both groundwater and surface water sources.

Permits to Take Water are required for irrigation. However, use is generally not metered so the information on the quantity of water taken for irrigation is estimated based on the typical number and duration of irrigation events and irrigation practices.

Industrial water use

Most industries in the watershed are connected to municipal water systems and their water use is reflected in the municipal total. Industrial uses on private supplies account for 14.3 percent of the total volume of water taking in the watershed. These industries include aggregate washing (9.0 per cent) and cooling water and other non-specified industrial uses (4.8 percent). Most of the water taken for industrial use is recycled and returned to the watershed.

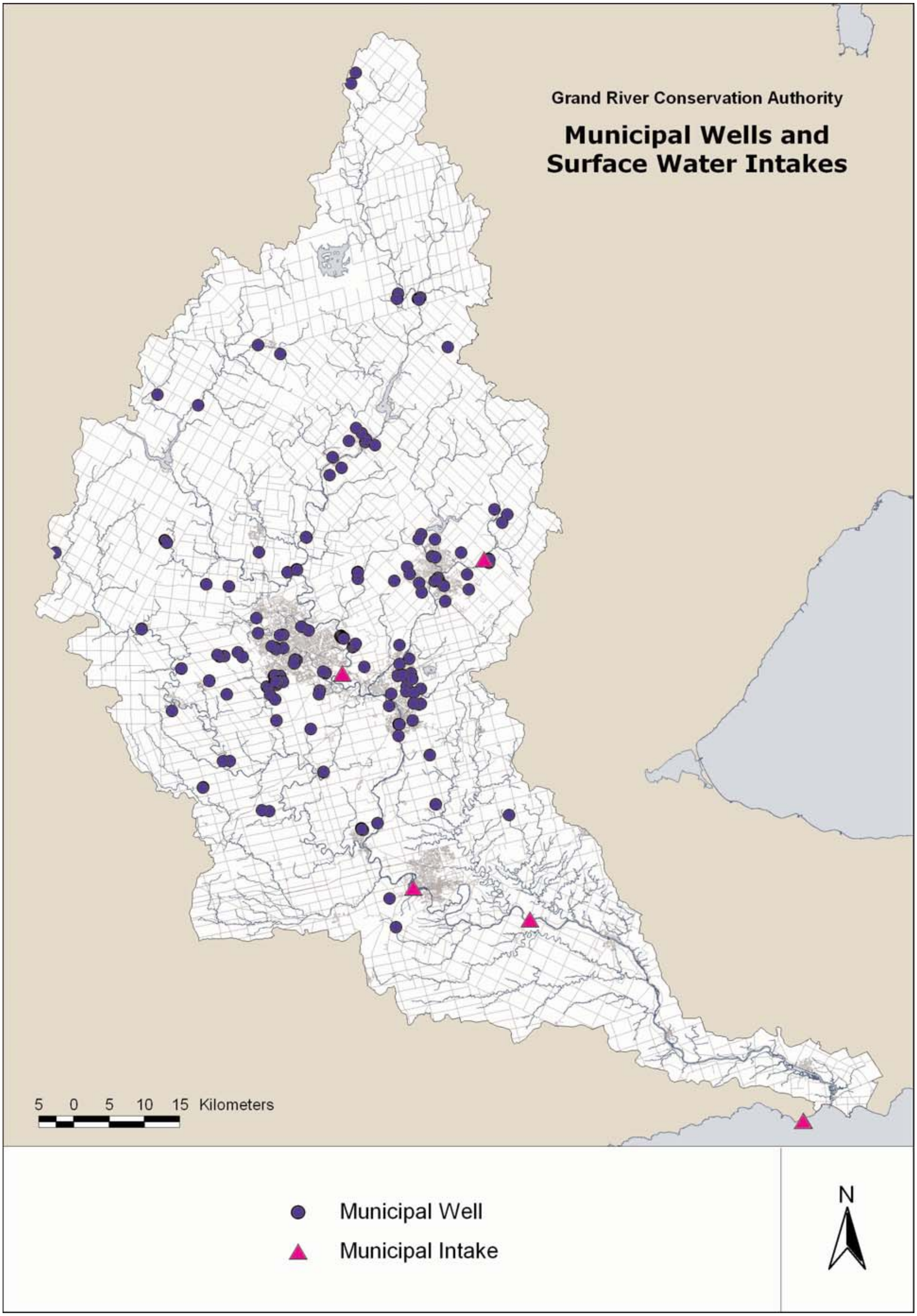
Aggregate producers require water on a daily and seasonal basis for washing gravel and sand products; the water is usually re-circulate through a series of settling ponds. Some pits and quarries with extraction below the water table are dewatered to facilitate extraction. The water in this case is discharged to a surface water stream. Dewatering is no longer common in the Grand River watershed where most pits are now excavated by drag-line. However, dewatering of pits, quarries, mines, and construction sites still accounts for 17.4 percent of the total water use volume in the Grand River watershed.

Commercial

The majority of private commercial supplies are for golf course irrigation, aquaculture and water bottling. Permits have also been issued for commercial businesses such as malls, as well as ski hills for snowmaking. Golf courses, similar to agricultural irrigation, take most of their water in the summer. More than 75 golf courses make up 2.1 percent of water used in the Grand River watershed.

Aquaculture or fish farms generally use permits to divert water from the source (a well or stream) to fish tanks or ponds. In many cases, aquaculture operations return most of the water back into the environment. Larger aquaculture operations may treat the water leaving their farm to remove excess nutrients before it is discharged back to a surface water body.

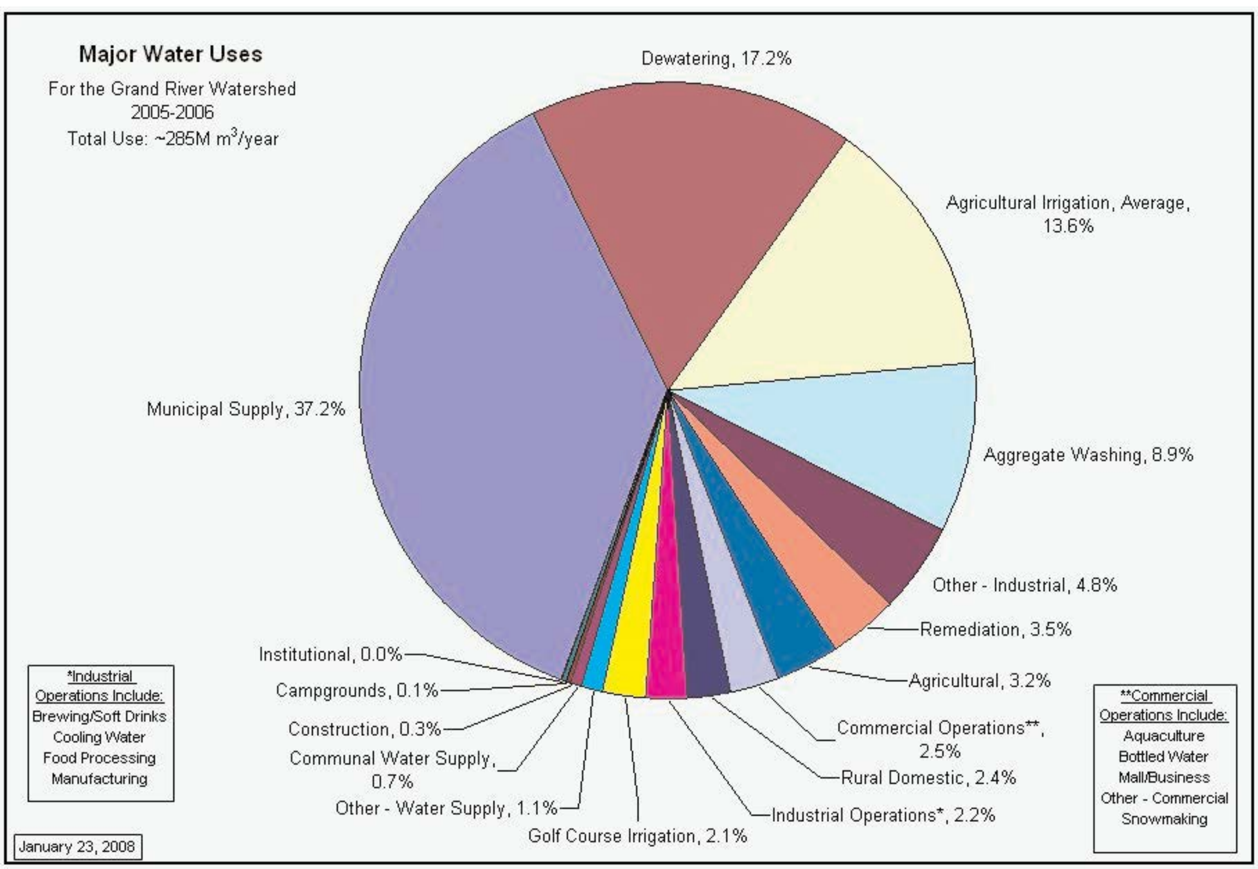
Water bottling for commercial sale accounts for only a small portion of water taking in the Grand River watershed, at 0.35 percent.


Grand River Conservation Authority
Municipal Wells and Surface Water Intakes
5 0 5 10 15 Kilometers
Municipal Well
Municipal Intake
N

9. Water use: municipal water systems

Municipality	Community	Source	Customers
Grey County			
Southgate	Dundalk	2 wells	1,691
Dufferin County			
Amaranth.	Waldemar	2 wells.	380
East Luther-Grand Valley	Grand Valley	4 wells	1,600
East Garafraxa	Marsville	1 well	100
Wellington County			
Wellington North	Arthur	3 wells	2,500
Mapleton	Moorefield	1 well	550
Mapleton	Drayton	1 well	1,500
Centre Wellington	Fergus & Elora	8 wells	14,200
Guelph-Eramosa	Hamilton Drive	2 wells	1,000
Guelph-Eramosa	Rockwood	2 wells	3,000
Guelph			
		23 wells and Eramosa River intake	125,000
Region of Waterloo			
Integrated Urban System (IUS)	Kitchener, Waterloo, Cambridge, parts of Wilmot & Wellesley	67 wells (80%) and Grand River intake (20%)	325,000
Kitchener		*See IUS*	
Waterloo		*See IUS*	
Cambridge		*See IUS*	
North Dumfries	Ayr	3 wells	4,055
North Dumfries	Branchton Meadows	2 wells.	122
North Dumfries	Roseville	2 wells.	290
Wellesley	Linwood	2 wells.	800
Wellesley	St. Clements	2 wells.	1394
Wellesley	Wellesley	2 wells.	2299
Wilmot	Erb Street	*See IUS*	
Wilmot	Foxboro	3 wells.	398
Wilmot	Mannheim	*See IUS*	
Wilmot	New Dundee	2 wells	1132
Wilmot	Baden-New Hamburg	1 well	9370
Wilmot	St. Agatha	2 wells.	83
Wilmot	Wilmot Centre	*See IUS*	
Woolwich	Conestogo Golf	2 wells	411
Woolwich	Conestogo Plains	2 wells.	367
Woolwich	Elmira	*See IUS*	
Woolwich	Heidelberg	2 wells	1,059
Woolwich	Maryhill	2 wells.	160
Woolwich	Maryhill Village Heights	2 wells.	134
Woolwich	West Montrose	1 well	182

Municipality	Community	Source	Customers
Perth County			
Perth East	Milverton	3 wells	1,750
Oxford County			
Blandford-Blenheim	Bright	2 wells	366
Blandford-Blenheim	Drumbo	1 well	500
Blandford-Blenheim	Plattsville	2 wells	1,150
Brant County			
	Paris	4 wells - Gilbert well field	12,247
	Paris	3 wells - Telfer well field	from both fields
	St. George	3 wells	3,000
	Airport	1 well	500 and 20 businesses
	Mount Pleasant	2 wells	1,500
Hamilton			
	Lynden	1 well	400
Brantford			
	Brantford and Cainsville (Brant)	Grand river intake	93,000
Haldimand County			
	Dunnville	Lake Erie intake	5,575

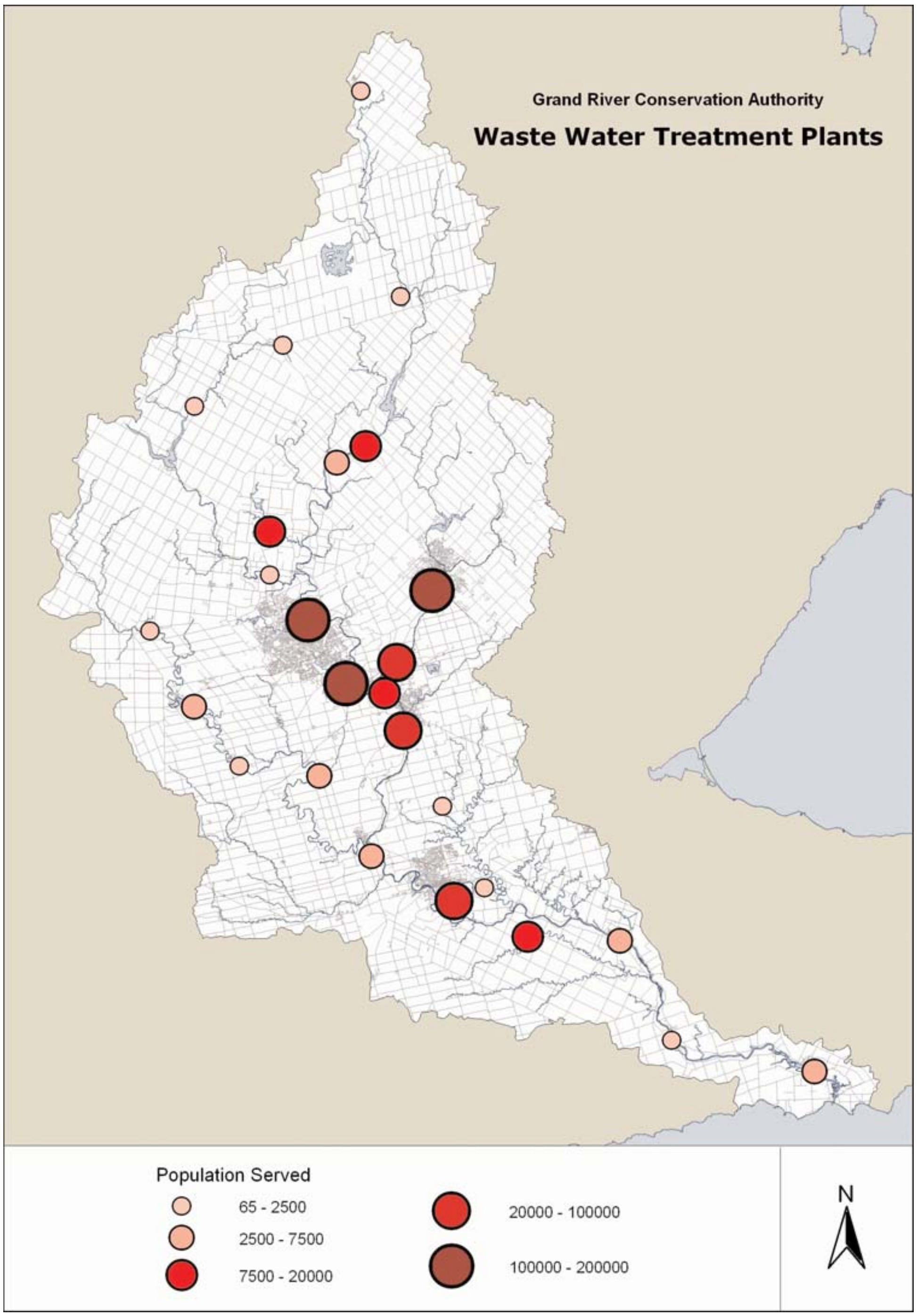


10. Waste treatment and disposal

Sewage treatment

There are 29 municipal wastewater treatment plants discharging to the Grand River and its tributaries. Treatment level varies, and includes lagoon systems, as well as secondary and tertiary treatment systems. Secondary treatment refers to biological and chemical removal of organic matter from sewage. In tertiary wastewater treatment plants, advanced treatment processes are used to remove other constituents such as ammonia and phosphorus.

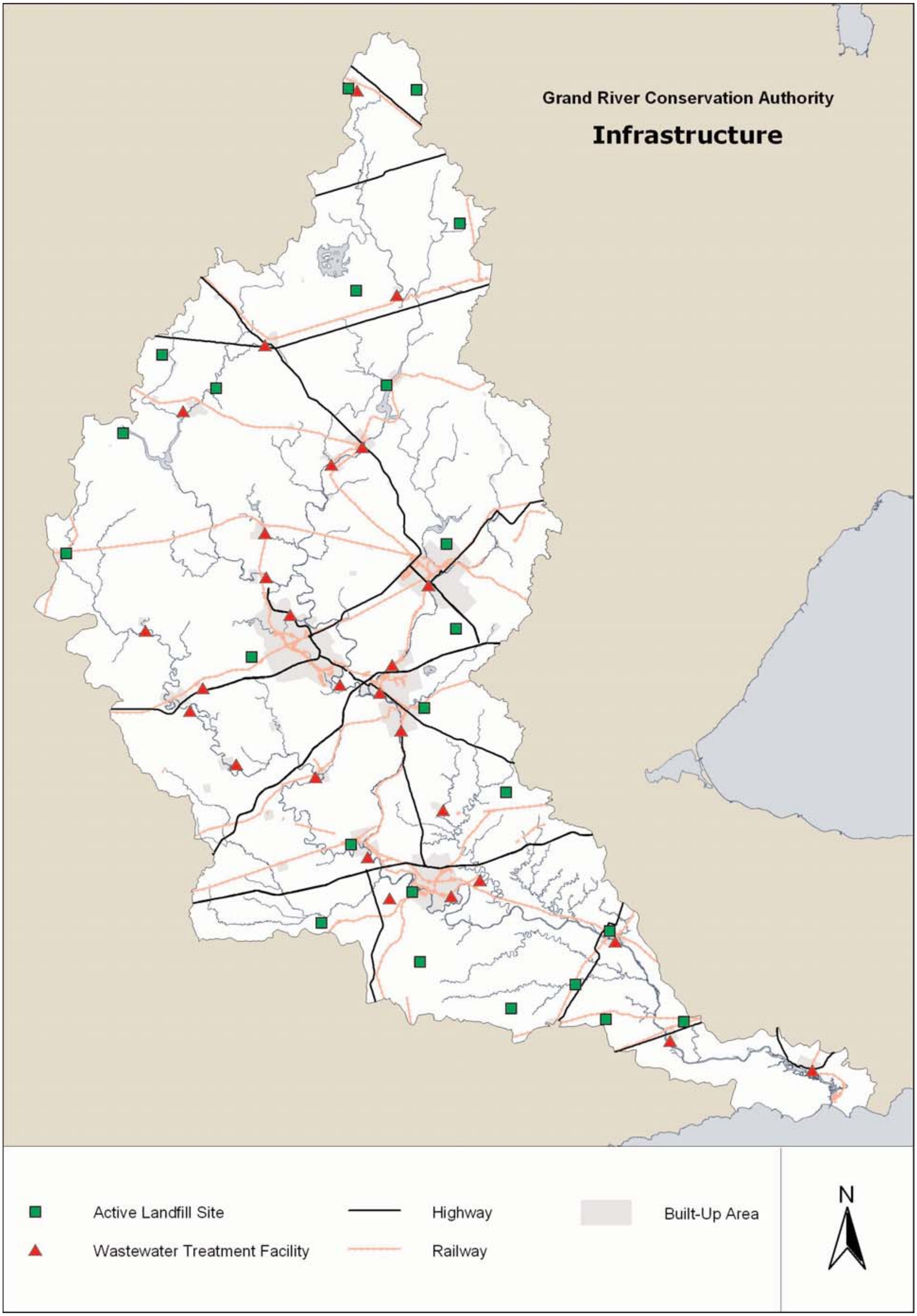
In most cases, the municipal wastewater treatment plants discharge continuously throughout the year, although there are four lagoon systems that are only permitted to discharge seasonally in spring and fall. There are no primary treatment systems or combined sewer overflows in the watershed.



Approximately 85 per cent of the total population of the watershed is served through municipal wastewater treatment plants. The remaining people have on-site septic or sewage systems. About two thirds of the serviced population is serviced by secondary treatment, while the remaining third have tertiary treatment, which includes advanced wastewater treatment such as the reduction of ammonia.

Landfills

There are 23 active municipal landfills in the watershed and many more closed and inactive sites.


Grand River Conservation Authority
Infrastructure
Active Landfill Site
Wastewater Treatment Facility
Highway
Railway
Built-Up Area
N

11. Water quality: surface

Surface water monitoring

The Grand River Conservation Authority, in partnership with the Ontario Ministry of the Environment, takes regular water samples from 36 sites throughout the watershed as part of the Provincial Water Quality Monitoring network (PWQMN). The GRCA also collects water quality information for issue-specific studies including subwatershed plans, basin assessments, and pesticide surveys in partnership with academia as well as the provincial and federal governments.

The samples collected under the PWQMN are examined for routine chemistry including nutrients, suspended solids, major ions and anions (such as chloride and sodium), pH and metals (such as lead and manganese). Temperature is routinely collected through the remote deployment of dataloggers in priority river reaches.

The monitoring site at Dunnville, near the mouth of the Grand, is sampled more frequently and for additional contaminants such as pesticides. This site is part of the Enhanced Tributary Monitoring Network co-ordinated by the Ministry of Environment.

In addition, the Grand River Conservation Authority has been working with the Ministry of Environment and Environment Canada since 2003 to collect river samples for pesticide analysis at approximately 12 to18 sites throughout the watershed.

Real-time data collection

The GRCA operates seven automatic monitoring stations which collect data continuously and is posted to its website in real time. Information is collected on temperature, dissolved oxygen, pH and conductivity. This network is important for gathering information to model the water quality of the river, watch the water quality in real time, to provide early warning to downstream drinking water intakes, collect information to evaluate the state of the river for aquatic life and assist with dam operations.

Many academic institutions in the watershed also undertake scientific studies and sampling programs that help to characterize the water quality of the river and its tributaries. Some recent studies include determining the occurrence and variability of pathogens in the river including E.coli, campylobacter, clostridium perfringens, cryptosporidium and giardia. Others have looked at the identification and prevalence of human or veterinary pharmaceuticals in the Grand River and its tributaries.

Surface water conditions and trends

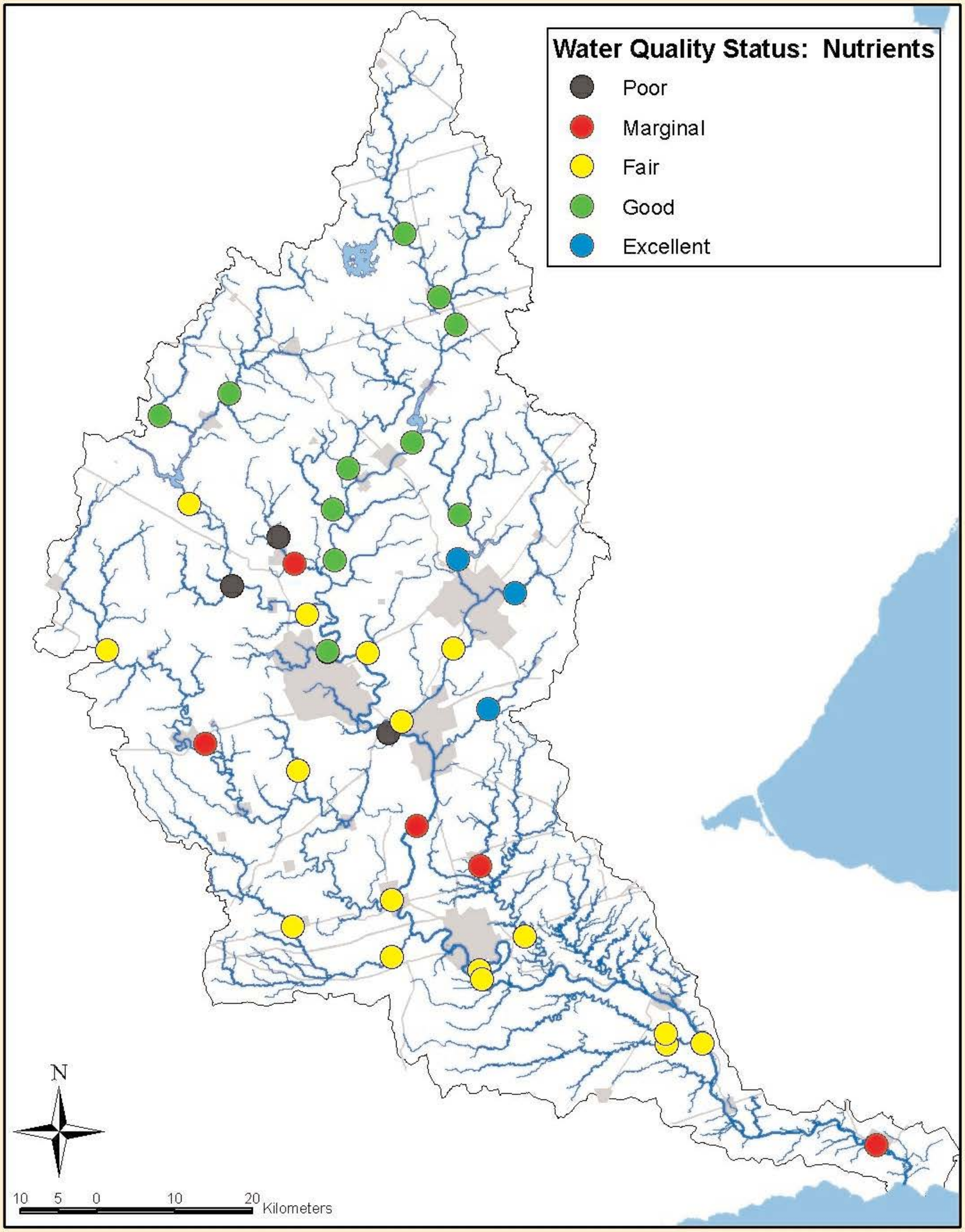
Water quality issues in the Grand River watershed include high nutrient (e.g. phosphorus and nitrogen) and suspended sediment levels that contribute to prolific aquatic plant growth (i.e. high primary productivity). The nutrient enrichment and prolific aquatic weed growth in the river contribute to significant fluctuations in dissolved oxygen during the summer months. Dissolved oxygen levels in the central region of the watershed can frequently be below provincial objectives to protect aquatic life.

The cumulative impact of runoff from agricultural areas, urban stormwater and discharges from 29 wastewater treatment plants contribute to the overall marginal condition of the river in Dunnville. The Grand River is a significant influence on the nearshore area of Lake Erie and likely promotes the growth of Cladophora in this area. The Grand is also a significant source of nutrients to the eastern basin of the lake.

High concentrations of ammonia-nitrogen in freshwater can be toxic to aquatic life under certain conditions (e.g. the temperature and acidity of the water). On occasion, high levels of ammonia in the Grand River have been found to be toxic to aquatic life and have also interfered with the treatment process at drinking water treatment plants during the winter.

Chloride levels tend to be low in the upper watershed and gradually increase as the river flows through the central urban area. Levels in the river during spring runoff can be two to three times greater than average concentrations, likely due to road salt being washed off roads. Chloride levels have significantly increased over time, especially downstream of the urban centres of Guelph and Kitchener-Waterloo. Similarly, sodium levels tend to be low in the headwaters and increase as the river flows through the urban areas. By the time the river reaches the intake for Brantford's drinking water supply, sodium levels in the river are generally above 50 mg/L.

Although pesticides and pathogens are not routinely monitored in the Grand River, studies by local universities have indicated that most pathogens associated with animal and human waste can be found in the river (Dorner et al 2006). Furthermore, human and livestock pharmaceuticals such as naproxen, ibuprofen, carbamazepine and lin-



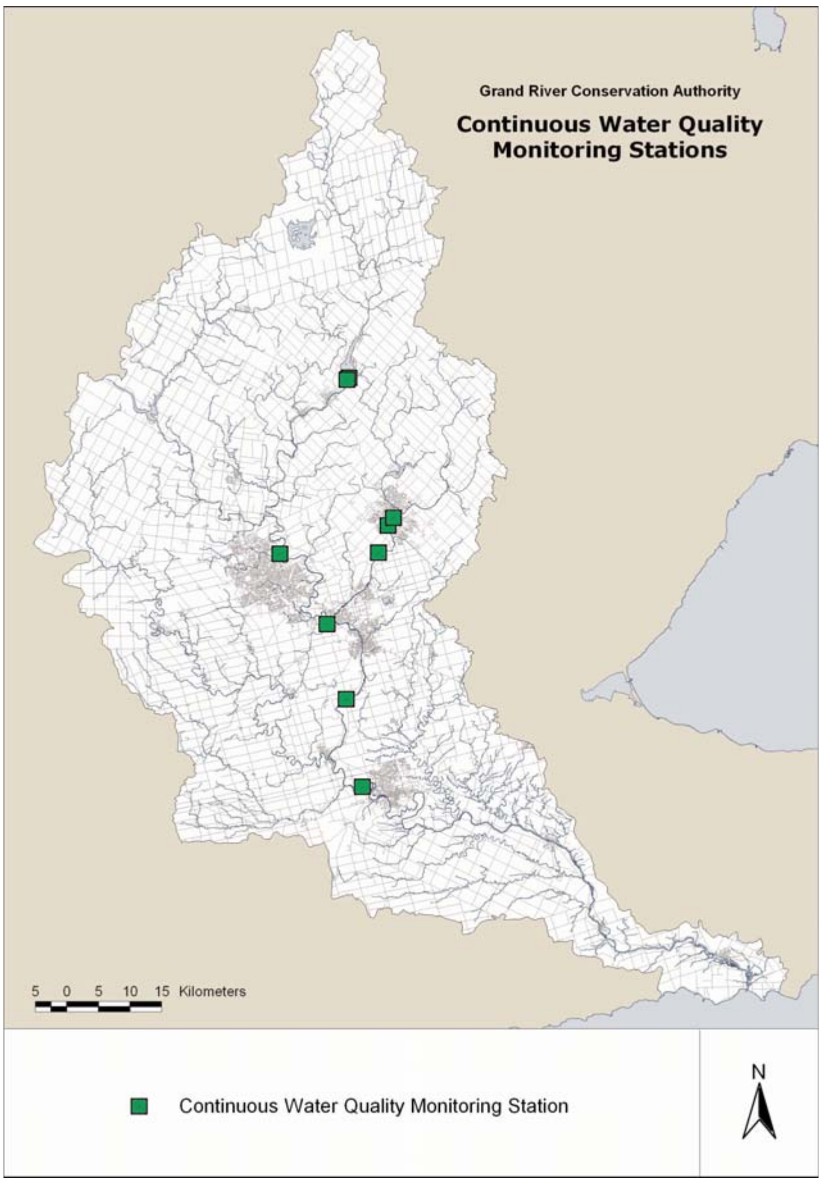
Status of Water Quality in the Grand River Watershed
Indicator: Nutrient Levels
2002 to 2006

11. Water quality: surface (cont'd)

comycin have also been detected in the river, although at extremely low levels (Servos, et al 2007; Lissmore et al 2006). The risk associated with these chemicals in surface waters are not known. Studies are underway to determine the significance of this. Some pesticides such as atrazine and 2,4-D have frequently been detected at various sampling locations throughout the watershed, but at very low levels and generally below provincial or federal objectives.

In summary, the underlying geology and land use in the watershed contribute to the water quality issues in the watershed. Runoff generated from the northern till plain (upper Conestogo/Nith Rivers) and southern clay plain (Grand River below Brantford) contribute a significant amount of nutrients and suspended sediment to the river as this area drains some of the most intensive agricultural production in the province. Conversely, groundwater discharge to small tributaries in the central region of the watershed contribute to the elevated nitrate concentrations found in these streams.

Nitrate levels are routinely above the federal objective throughout the watershed. Although runoff from agricultural areas can be a significant contribution to the overall nutrient or suspended sediment loading of the river, wastewater treatment plants contribute a significant amount of nutrients during the summer and winter when there is little runoff.



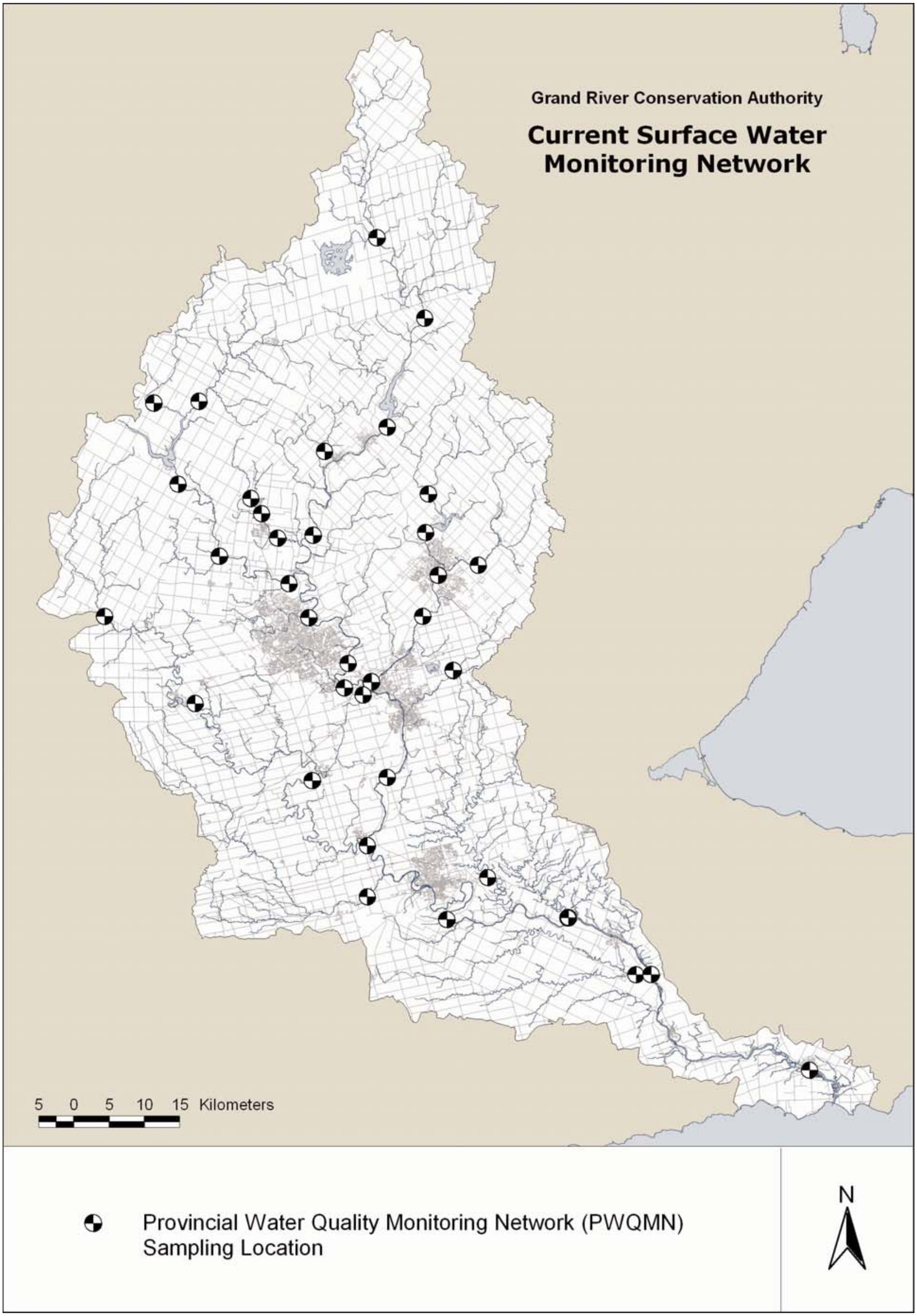
Spills

Some spills and wastewater treatment plant bypasses can be a risk to downstream water users. Of greatest concern are incidents involving industrial chemicals, such as gasoline or diesel and untreated (raw) sewage, since these can contribute chemicals or high levels of pathogens to the river. Typically, raw sewage spills occur at sewage system pumping stations which lose their power or otherwise fail. Incidents of raw manure spills into water courses are also a concern.

A summary of three years of incidents (2003-05) showed that about 22 spills or bypasses out of a total of 134 (16 per cent) involved raw sewage. (Report on Spills and Bypasses in Grand River Watershed 2003-2005)

Tertiary or secondary bypasses at wastewater treatment plants are likely not a risk to downstream users as the effluent has received some level of treatment such as nutrient removal and chlorination that kills pathogens before the effluent reaches the river.

In the event of a spill or wastewater treatment bypass, downstream water users, including the GRCA, are notified by the provincial Spills Action Centre (SAC). The Grand River Conservation Authority works with downstream users and provides necessary information on the time it would take a spill at a particular location to reach downstream drinking water intakes.


Grand River Conservation Authority
Current Surface Water Monitoring Network
5 0 5 10 15 Kilometers
Provincial Water Quality Monitoring Network (PWQMN) Sampling Location
N

11. Water quality: groundwater

Groundwater monitoring

Since 2001 groundwater has been monitored through the Provincial Groundwater Monitoring Network, a network of wells distributed throughout the watershed that provide insight on ambient conditions and long-term trends.

There are 24 monitoring wells at 18 locations within the watershed. At this time, the wells are primarily used to monitor changes in water levels. However in 2006 an annual water quality sampling program was initiated in which collected samples are analyzed for a suite of chemical parameters.

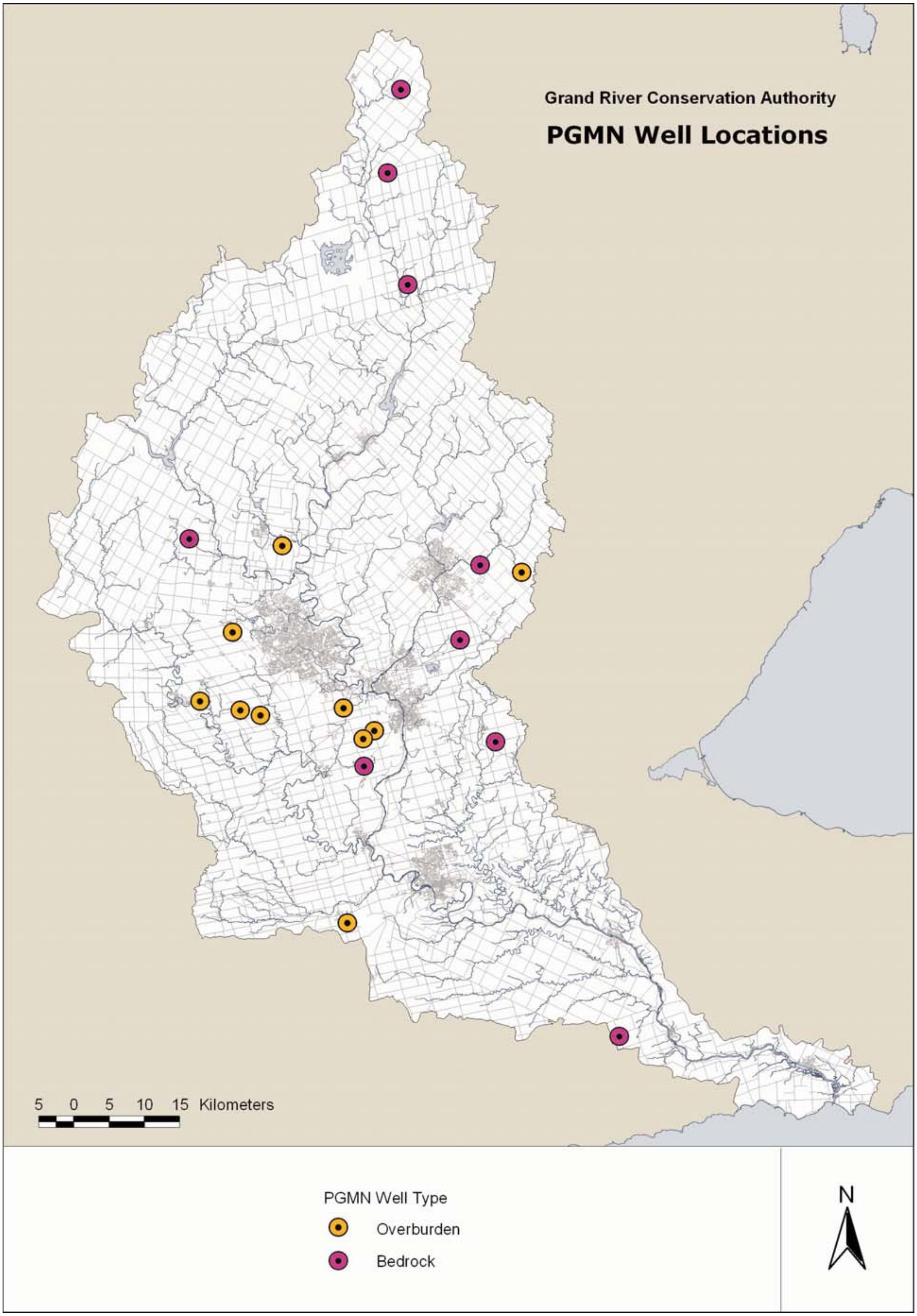
In addition, under Ontario Regulation 170/03, each municipality is required to take samples from each of its wells on a regular basis to test for bacteria (E. coli), organic chemicals such as pesticides, manufacturing chemicals and inorganic materials such as sodium, chloride and nitrate. Results are compiled into an annual report and publicly posted, usually on each municipality's website. Where results exceed the Ontario Drinking Water Standards (MOE, 2006), corrective action is taken by the municipality.

Groundwater conditions and trends

Although there is no long-term groundwater quality data for the watershed, several trends have become apparent through programs such as municipal well sampling under the Drinking Water Systems Regulation (O. Reg. 170/03).

Increasing concentrations of sodium and chloride, stemming from the application of road salt, are a common problem in many municipal wells. A number of Ontario municipal wells have also been affected by chemicals such as those used in manufacturing, farming and industrial applications. In response, some municipalities have had to institute treatment or remediation processes. In some cases the municipalities have simply abandoned the use of the well.

Since groundwater is derived from the downward migration of surface water, the quality of groundwater is dependent on the quality of the recharge water. Clean, safe drinking water is generally hundreds of years old, having often entered the groundwater system prior to the introduction of heavy chemical use and waste production at ground surface. As the quality of surface water becomes increasingly affected by chemicals and waste by-products such as road salt, manure, manufacturing chemicals, and pesticides it is likely that the presence of chemicals in the groundwater system will rise unless better land use and chemical handling processes are put in place.


Grand River Conservation Authority
PGMN Well Locations
5 0 5 10 15 Kilometers
PGMN Well Type
Overburden
Bedrock
N

12. Drinking water issues

Potential groundwater issues

Groundwater takes on the characteristics of its surroundings. If it is trapped in an aquifer, it will take on chemicals from the surrounding rock, such as sulphur or iron.

And, of course, human activities can have an effect on the quality of groundwater. Chemicals used in factories, manure and fertilizers used on farms, organic material from septic tanks, salt applied to roads - these can all show up in groundwater.

Since 1998 the Ontario government and municipalities in the Grand River watershed have been conducting groundwater studies, to determine the quantity and quality of groundwater supplies.

The studies identified the characteristics of the aquifers, defined protection zones for the areas around municipal wells, catalogued potential threats to groundwater quality and analysed water use.

The studies also identified the varieties of contaminants that show up in groundwater sources, including some in the Grand River watershed.

Bacteria and viruses

These pathogens can come from human and animal waste from sewage sludge, septic tanks and manure. The best known bacteria, E.coli, is found in both human and animal waste and can sometimes make its way into a well from these sources.

However, most die off and decompose within 100 to 250 days. This means that for groundwater-based systems, the area of greatest concern is the area closest to the well, especially for wells in the shallow overburden. Pathogens are unlikely to survive long enough to show up in groundwater from bedrock aquifers or deep wells in overburden aquifers.

Municipal water treatment systems are designed to kill pathogens in groundwater.

Nitrates

Nitrates are a form of nitrogen and are found in human and animal waste, as well as many commercial fertilizers. They are highly soluble, stable and capable of migrating considerable distances if they are leached into a groundwater source. They cannot be removed by commonly used treatment methods.

The Ontario Drinking Water Standards say that nitrate levels should be no higher than 10 milligrams per litre.

In the Grand River watershed, high or rising nitrate levels have been detected in aquifers in the Guelph area and in Brant County (Paris and Burford).

Chloride

The most common source of chloride is road salt, which is highly soluble and can readily build up in an aquifer. They cannot be removed by commonly used treatment methods. Chlorides have been identified as a potential issue in wells serving Guelph and Brant County.

Petroleum products

These products can be harmful in drinking water at only a few parts per billion. While petroleum products seldom travel more than several hundred metres from their source, they can persist in the environment for years. Gasoline storage tanks, especially from the 1950s and 1960s, are one source.

Chlorinated solvents

Chemicals such as paint removers, dry cleaning fluids and metal degreasers are highly toxic, very persistent and highly mobile in groundwater. Heavier than water, they tend to pool at the bottom of an aquifer and can be very difficult to detect or remove. One that has been detected in several communities is TCE or trichloroethylene.

While these products can be removed by treatment, in some cases, such as Guelph and the Region of Waterloo, wells affected by chlorinated solvents have been taken out of production permanently or for remediation. In Centre Wellington (Fergus) water from one well is treated for TCE.

Pesticides

Many pesticides are biodegradable, although they can be toxic at low concentrations. Some of their breakdown products are also dangerous.

12. Drinking water issues (cont'd)

Potential surface water quality issues

In the Grand River watershed, four communities get all or some of their water from the river system: Guelph, Region of Waterloo, Brantford and Ohsweken. In addition, Dunnville is served by an intake on Lake Erie.

Surface water quality is highly variable as a result of strong climatic influences such as runoff from snowmelt or rain events, ice cover during the winter, or prolific aquatic plant growth during the summer months. Therefore, water quality concerns for drinking water treatment should be considered in the context of the variability of the source water, the concentration of the parameter, and the ability of the treatment plant to remove the contaminants.

Non-treatable contaminants

General water quality parameters in the Grand River that can become potential issues in raw surface waters are those parameters that can not be removed through the conventional treatment process and include:

- nitrate;
- chloride and sodium;
- pesticides; and
- taste and odour causing compounds (e.g. geosmin)

Preliminary trend analysis indicates that levels of nitrate and chloride are increasing in the Grand River. However, current levels are not above drinking water objectives.

Sodium levels in the Grand River at Brantford are above the 20 mg/L guideline for patients on sodium-reduced diets.

Contaminants that affect plant operation

There are some water quality parameters which, at very high levels, can interfere with the operation of water treatment process. That disruption can cause potential drinking water issues.

Some conditions include:

- highly variable turbidity levels that exceed treatment design;
- seasonally high ammonia levels that interfere with the chlorination process that can cause disinfection byproducts;
- high organic nitrogen and carbon levels that can interfere with the chlorination process; and
- high bromide levels that can interfere with ozonation to produce disinfection byproducts.

Emerging contaminants

Some emerging contaminants, including pharmaceuticals, personal care products and some pesticides should be considered as potential drinking water issues.

However, more research is needed to fully understand the implications of the presence of these compounds in raw source waters and whether conventional treatment can remove them.

Spills

Spills and wastewater treatment bypasses of raw sewage are likely the greatest concern to downstream drinking water intakes. Incidents involving industrial chemicals, gasoline, diesel or untreated (raw) sewage have the potential to result in high levels of chemicals or pathogens that may impact downstream water users. In the event of a spill, timely notification is required to implement suitable response protocols (i.e. closing the intake).

13. Glossary

Aquifer

A saturated, permeable geologic unit that can transmit significant quantities of water under ordinary hydraulic gradients.

A *confined aquife*r is one completely filled with pressurized water and separated from the land surface by a relatively impermeable confining bed, such as shale.

An *unconfined aquifer* is one where the water-table marks its upper limit.

Aquitard

A water-saturated sediment or rock whose permeability is so low it cannot transmit any useful amount of water. It may function as a confining bed.

Bedrock

The solid rock that underlies loose material, such as soil, sand, clay, or gravel. Most bedrock layers are hundreds of millions of years old.

Brownfield

Brownfields are abandoned or underused industrial or commercial properties where redevelopment is complicated by actual or perceived environmental contamination.

Carolinian Zone

The southernmost part of Ontario, generally south of a line drawn between Toronto and Grand Bend. The climate, moderated by the Great Lakes, is able to support animal and plant species normally found in the Carolinas in the U.S. Many of the species are rare or non-existent in the rest of Canada.

Moraine

An accumulation of till either carried on a glacier or left behind after the glacier has receded.

An *end moraine is* a ridge of till deposited along the front edge of a glacier.

A *kame moraine* is an irregularly shaped hill or mound composed of sorted or stratified sand and gravel that is deposited in contact with glacial ice.

The *Horseshoe Moraines* are a series of moraines encircling most of southwestern Ontario, with the ‘top’ of the horseshoe near Georgian Bay and the tips of the ‘legs’ at the south, near Lake Erie.

Overburden

Unconsolidated soil and other materials such as silt, sand, clay, gravel and stones which lie above bedrock.

Till

Unstratified, unsorted glacial sediment deposited directly by a glacier.