FIGURES

TABLES

2.0 WATERSHED CHARACTERIZATION

The Watershed Characterization provides an overview of the watershed in the Central Lake Ontario Source Protection Area (CLOSPA). It is noted that the source protection jurisdiction covers the area that is managed by the Central Lake Ontario Conservation Authority (CLOCA) where the Authority manages the conservation lands and conducts the monitoring programs. Many agencies have been involved in the collection and assessment of data that supports the analyses presented in this Assessment Report. See **Appendix A** (**Table A.1**) for details on these sources of data.

Groundwater: Water located beneath the ground surface in soil pore spaces and in fractured rock.

Hydrologic cycle: The continuous movement of water on, above and below the surface of the earth.

Surface water: Water occurring in lakes, rivers, streams that may be used as a source of drinking water. As water moves in a cycle (hydrologic cycle), the two sources of drinking water (groundwater and surface water) interact; this may cause contaminants to move between the groundwater and surface water systems.

Watershed: An area where many sources of surface water drain into the same place.

This chapter is organized into the following categories:

- **Local Watershed Description:** Information on natural characteristics of the study area;
- **Ecology:** Information on natural cover, aquatic habitats, and species at risk;
- **Water Systems and Water Use:** Information on how water is used by drinking water systems, and how much is drawn from water sources;
- **Water Quality and Trends:** Information on water quality (*groundwater* and *surface water*) and trends in the watershed to determine if the water quality is getting better, getting worse, or staying the same; and
- **Land Use:** Information on where people live and how they utilize the landscape.

This description provides a framework to assist in answering two important questions about the drinking water in this area:

- What is its condition?
- What impact do land and water activities have on the sources of drinking water?

To understand the risk to drinking water sources in any one area, the system must be reviewed as a whole. All sources that support drinking water systems must be assessed, including municipal and privately owned ones. Therefore, the CLOSPA study area covers both groundwater and Lake Ontario sources, even where there are no groundwater sources for municipal drinking water. About 95% of the population in the CLOSPA receives its drinking water from treatment plants that source water from Lake Ontario.

2.1 LOCAL WATERSHED DESCRIPTION

The characterization of the CLOSPA has been detailed in the report entitled *Interim Watershed Characterization*, herein called the Characterization Report, which referenced a variety of data sets, and background studies completed through collaboration with various private and public organizations. A summary of the data sources used is provided in Appendix A.

The Characterization Report was peer-reviewed by municipal and provincial representatives as well as private consultants, but this was undertaken prior to the finalization of the *Technical Rules.* Additional work was undertaken in 2008/2009 on the data so that the Assessment Report could present a more updated characterization of the Source Protection Area.

The Characterization Report contains the foundation technical data and information upon which the summary below has been based. The findings of the Characterization Report were based on data sets, and studies undertaken at the CLOSPA, and by those made available through collaboration with various private and public organizations. Where possible, the data and information have been updated in an attempt to bridge the time gap to 2009.

The area managed by CLOCA:

- Is located to the east of the Greater Toronto Area (GTA);
- Covers an area of 638.6 km^2 that is fully contained within the Regional Municipality of Durham; and
- Includes all or part of the:
    - Cities of Pickering and Oshawa;
    - Towns of Ajax and Whitby;
    - Municipality of Clarington; and
    - Townships of Scugog and Uxbridge.

CLOCA owns or manages a number of conservation areas within the study area. From west to east, they are as follows:

- Lynde Shores
- Heber Down
- Crow's Pass
- Cane Tract
- Simcoe Hall Valley Lands
- Toad Hollow Valley Lands
- Audley Road Woods
- Oshawa Valley Lands
- Purple Woods
- Stephen's Gulch
- Long Sault
- Rahmani
- Hampton
- Enniskillen
- Bowmanville Valley Lands South
- Bowmanville Valley Lands North
- Bowmanville-Westside Marshes

CLOSPA has 15 watersheds within its boundaries (as shown in **Figure 2.1**). These boundaries have been historically used under our watershed management program. They follow the Province's technical standards that relate to drainage patterns, geology, and slope.

Within CLOSPA's boundaries, the following five major watersheds start from the Oak Ridges Moraine:

- Lynde
- Oshawa
- Farewell
- Bowmanville
- Soper

Many smaller watersheds originate from the Lake Iroquois shoreline. Several small streams that drain directly into Lake Ontario have been grouped into the “Lake Ontario Catchments” category in **Table 2.1**. **Table 2.1** contains a list of all watersheds, their total drainage area, and the total stream length.

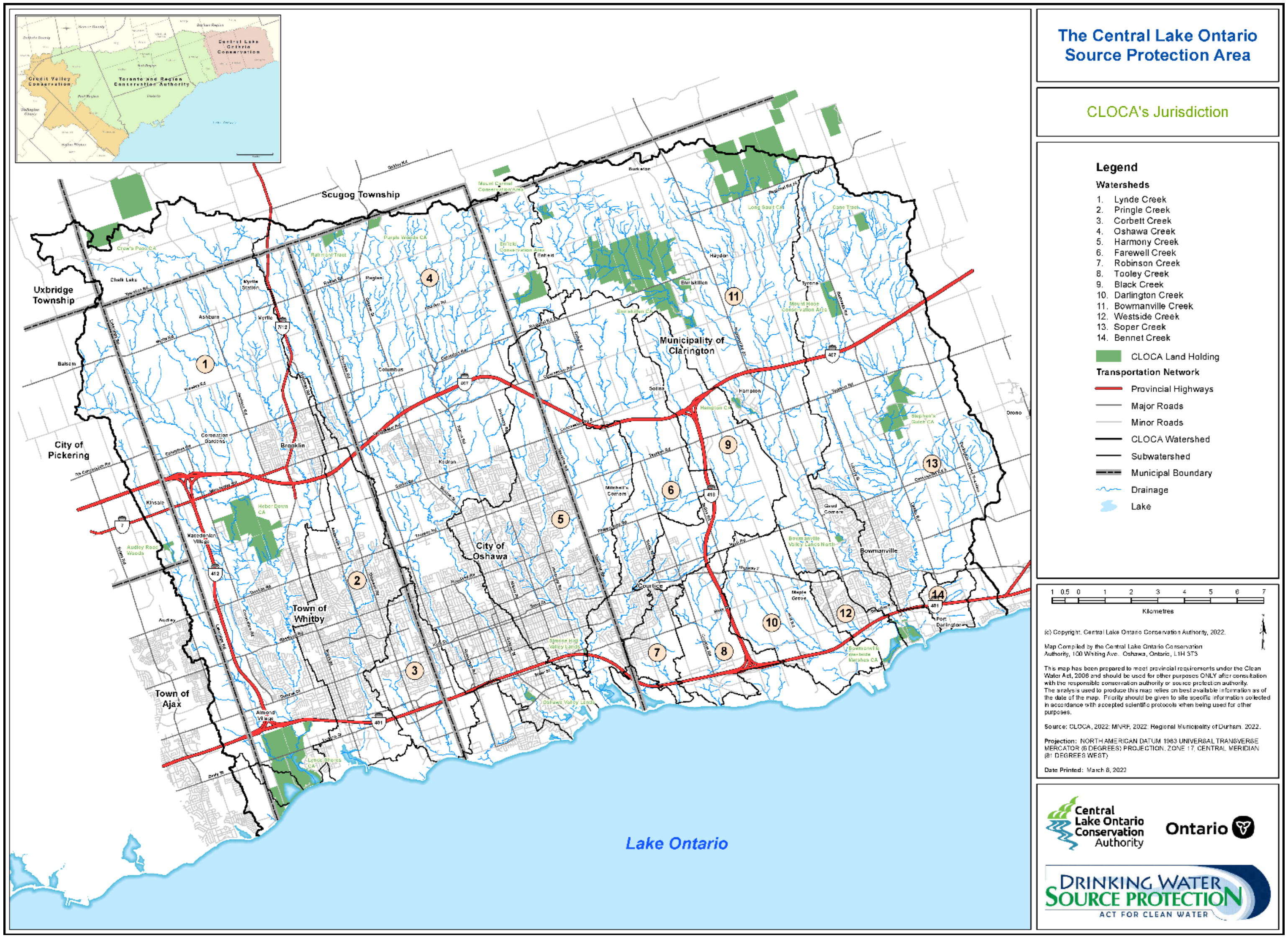

Figure 2.1: Watersheds in CLOSPA's Jurisdiction

Name	Drainage Area (km^2)	Total Stream Length (m)	Watershed Description
Lynde Creek Watershed	132.2	247200	Originates in the Oak Ridges Moraine, with the northern part protected under the *Oak Ridges Moraine Conservation Act*, and drains into Lake Ontario through Lynde Creek Marsh, a provincially significant wetland (PSW). **Location** • Is entirely within the Regional Municipality of Durham and crosses five local municipalities: the Township of Uxbridge, Township of Scugog, City of Pickering, Town of Ajax, and Town of Whitby. • Includes six hamlets: Ashburn, Macedonian Village, Almond Village, Kinsale, Myrtle, and Myrtle Station. • Includes the large Heber Down conservation area in the middle. • Is also covered in some parts by the Greenbelt. • Includes the Lake Iroquois Beach, another major landform that crosses through the centre going east-west. **Culture and development** • Is mostly farmland south of the Oak Ridges Moraine. • Has most of its south portion covered by the Town of Whitby urban area. • Has its main open space, Lynde Shores Conservation Area, on the Lake Ontario waterfront. • Has seen huge growth during the last ten years in the Village of Brooklin within the central portion. We expect that this watershed will become more developed as Whitby grows, especially the areas surrounding Brooklin, Kinsale, and Almond Village. • Impacts expected on its middle and western portion from the extension of Highway 407 East and its western link.

Name	Drainage Area (km^2)	Total Stream Length (m)	Watershed Description
Pringle Creek Watershed	28.5	27000	Originates in the Lake Iroquois Beach and northern surrounding lands, and drains into Lake Ontario through the Whitby Harbour PSW. **Location** • Is located mainly within the urban boundary of the Town of Whitby. Its northeastern boundary straddles the municipal border of the Town of Whitby and the City of Oshawa. **Culture and development** • Contains the urban area of the Town of Whitby, most of which is developed. • Has natural areas and agricultural lands concentrated within the northern portion, including a portion of the Whitby-Oshawa Iroquois PSW located on the Lake Iroquois Beach. • Will likely be further developed in northern portions as the Town of Whitby grows along with the extension of Highway 407 East.
Corbett Creek Watershed	14.6	17800	Originates just south of the Lake Iroquois Beach, and drains into Lake Ontario via the Corbett Creek Coastal Marsh PSW. **Location** • Crosses two local municipalities in Durham Region: the Town of Whitby and the City of Oshawa. **Culture and development** • Has been fully developed over the years, with mostly residential and industrial areas in east Whitby and west Oshawa. Includes remaining natural areas that generally follow the flood plain.
Oshawa Creek Watershed	110.2	221200	Originates from the Oak Ridges Moraine, and drains into Lake Ontario through the Oshawa Creek Coastal Wetland and the Oshawa Harbour. **Location** • Is mainly in the City of Oshawa, but also extends into the Municipality of Clarington, the Town of Whitby, and the Township of Scugog. • Contains four hamlets: Raglan, Columbus, Myrtle (partially), and Myrtle Station (partially). • Is crossed at its lower half by the Lake Iroquois Beach.

<table>
<tr><th>Name</th><th>Drainage Area (km^2)</th><th>Total Stream Length (m)</th><th>Watershed Description</th></tr>
<tr><td></td><td></td><td></td><td>Contains the Purple Woods Conservation Area in the north part, which CLOSPA manages. CLOSPA also owns other lands there, including the Oshawa Valley Lands in the south part (maintained by the City of Oshawa) and the Rahmani Tract just west of Purple Woods. The Oshawa Valley Lands support an urban trail system, while the Rahmani Tract does not have any trails.
Is protected in its northern part under the Oak Ridges Moraine Conservation Act.
Culture and development
Is fully developed in its southern half, containing much of Oshawa's residential area and the industrial areas located south of Highway 401.
Contains agricultural areas and larger portions of natural areas in the watershed's northern half. Major growth is expected within the City of Oshawa in the lower part of its northern half along with the extension of Highway 407 East.</td></tr>
<tr><td>Goodman Creek Watershed</td><td>10.3</td><td>13000</td><td>Originates in the Lake Iroquois Beach, and drains into the main branch of the Oshawa Creek.
Location
Is entirely within the City of Oshawa, with its northwestern boundary straddling the Oshawa and Whitby border.
Culture and development
Is mainly residential land in Oshawa's west end, with a large portion of the Oshawa airport.
Contains a mix of agricultural and natural areas in its northern tip.</td></tr>
<tr><td>Harmony Creek Watershed</td><td>46.7</td><td>73800</td><td>Originates in the south-slope till plain of the Oak Ridges Moraine, and drains into the main branch of Farewell Creek.
Location
Is within the City of Oshawa and the Municipality of Clarington.
Includes the hamlet of Mitchell Corners.
Contains one small holding of conservation land, Simcoe Hall, in its southern tip.
Culture and development
The Lake Iroquois Beach runs through the middle, and contains a portion of the Harmony-Farewell Iroquois Beach Wetland.</td></tr>
</table>

Name	Drainage Area (km^2)	Total Stream Length (m)	Watershed Description
			• Is mostly developed, and mainly contains the residential areas of East Oshawa and a small northwest portion of the Courtice urban area. • Contains a mix of agricultural and natural areas in the northern end. • Is expected to see more development as the City of Oshawa grows. Will also see further growth with the extension of Highway 407 East in its northern end.
Farewell Creek Watershed	36.3	67400	Originates in the south-slope till plain of the Oak Ridges Moraine, and drains into Lake Ontario via the Oshawa Second Marsh PSW. **Location** • Mostly covers the Municipality of Clarington, while its southern end extends into the City of Oshawa. • Includes the hamlet of Solina. • Contains the Lake Iroquois Beach throughout its middle, and contains a significant portion of the Harmony-Farewell Iroquois Beach Wetland PSW. • Notably, includes the Oshawa Second Marsh Wildlife Reserve, the main open space on the Lake Ontario waterfront. This space is publicly owned. **Culture and development** • Is well developed in its southern half, composed of the residential part of the Courtice urban area and the homes, industry, and businesses of East Oshawa. • Comprises a mix of agricultural and natural areas in its northern half. • Is expected to see more development in certain portions, since land within the Courtice urban area continues to be developed. Will also see further growth with the extension of Highway 407 East in its northern end.

<table>
<tr><th>Name</th><th>Drainage Area (km²)</th><th>Total Stream Length (m)</th><th>Watershed Description</th></tr>
<tr><td>Black Creek Watershed</td><td>24.2</td><td>39200</td><td>Originates in the south-slope till plain of the Oak Ridges Moraine, and drains into the main branch of the Farewell Creek.
Location
• Is entirely within the Municipality of Clarington.
• Includes a small portion of the hamlet of Hampton.
• Contains Lake Iroquois Beach deposits across its southern half, along with a large portion of the Harmony-Farewell Iroquois Wetland Complex.
Culture and development
• Mainly contains agricultural and natural areas.
• Contains homes in the eastern end of the Courtice urban area in its southern tip.
Will also see further growth with the extension of Highway 407 East and its eastern link.</td></tr>
<tr><td>Robinson Creek Watershed</td><td>5.7</td><td>8600</td><td>Originates in the Lake Iroquois Beach, and drains into Lake Ontario through the McLaughlin Bay Wetland PSW.
Location
• Is entirely within the Municipality of Clarington.
• Includes Darlington Provincial Park at its southern tip.
Culture and development
• Is mainly used for agriculture. Homes are focused along the northwestern border, comprising the existing edge of Courtice's developed areas.
Will likely experience more development as the Courtice urban area continues to grow.</td></tr>
</table>

<table>
<tr><th>Name</th><th>Drainage Area (km²)</th><th>Total Stream Length (m)</th><th>Watershed Description</th></tr>
<tr><td>Tooley Creek Watershed</td><td>10.5</td><td>15300</td><td>Originates in the Lake Iroquois Beach, and drains directly into Lake Ontario through a locally significant coastal wetland.
Location
Is entirely within the Municipality of Clarington.
Includes a portion of the Maple Grove Wetland Complex PSW in its northern tip.
Culture and development
Almost entirely composed of agricultural areas, with a few scattered clusters of homes and industrial areas surrounding Highway 401.
Will likely see future development over time.
Expected impacts in its eastern end from the Highway 407 eastern link.</td></tr>
<tr><td>Darlington Creek Watershed</td><td>16.4</td><td>22100</td><td>Originates in the Lake Iroquois Beach, and drains into Lake Ontario through a diversion channel next to a local wetland.
Location
Is entirely within the Municipality of Clarington.
Contains only one hamlet, Maple Grove.
Culture and development
Contains mainly agricultural areas because a large portion of the watershed lies outside the municipal urban boundaries.
Includes a large grouping of natural areas in the portion that lies within the Lake Iroquois Beach.</td></tr>
</table>

Name	Drainage Area (km^2)	Total Stream Length (m)	Watershed Description
Westside Creek Watershed	5.7	9700	Originates south of Highway 2 (in the Lake Iroquois Plain), and drains into Lake Ontario through the Bowmanville West Side Marshes. **Location** • Is entirely within the Municipality of Clarington. • Includes a small portion of the hamlet of Maple Grove. **Culture and development** • Is mostly developed, mainly as homes north of Highway 401 and a mix of business and industry south of Highway 401. Includes one conservation area, Bowmanville Westside Marshes, in its southern end.
Bowmanville Creek Watershed	90.5	187700	Originates in the Oak Ridges Moraine, and drains into Lake Ontario through the Bowmanville Creek Coastal Wetland PSW. **Location** • Is mostly within the Municipality of Clarington, while a small portion of its northern tip extends to the Town of Scugog. • Contains four hamlets: Haydon, Enniskillen, Hampton, and a portion of Tyrone. • Besides the hamlets, has only one major residential area, Bowmanville, which takes up its southern portion. • Has the Lake Iroquois Beach cutting across its upper southern half. • Includes four conservation areas: ○ Enniskillen Long Sault in the north; ○ Hampton in the central portion; ○ Bowmanville West Side Marshes in the south; and **Culture and development** • Contains mostly a mix of natural and agricultural areas. • Will likely see further development in its southern portion as growth within the Bowmanville urban area continues. • May also see growth in its upper middle portion with the extension of Highway 407 East.

<table>
<tr><th>Name</th><th>Drainage Area (km²)</th><th>Total Stream Length (m)</th><th>Watershed Description</th></tr>
<tr><td></td><td></td><td></td><td>Notably, is protected under both the Oak Ridges Moraine Conservation Act and Greenbelt legislation that restrict growth in sensitive areas.</td></tr>
<tr><td>Soper Creek Watershed</td><td>75.4</td><td>158000</td><td>Originates in the Oak Ridges Moraine, and drains into Lake Ontario through the Bowmanville Creek Coastal Wetland PSW.
Location
• Is located entirely within the Municipality of Clarington.
• Contains the Lake Iroquois Beach, which cuts across its upper southern half.
• Contains only one hamlet, Tyrone.
• Includes two conservation areas: Stephen’s Gulch and part of the Bowmanville Westside Marshes.
• CLOSPA very recently received a dedication of land in its northern part, referred to as the Cane Tract. Currently, there are no formal trails on these lands.
Culture and development
• Similar to its western neighbour (Bowmanville Creek watershed), is mainly a mix of natural and agricultural areas.
• Besides the hamlet of Tyrone, includes only one major residential area, Bowmanville, on its southern portion.
• Will likely see further development in its southern portion as growth within the Bowmanville urban area continues.
• May see growth along through its upper middle portion with the extension of Highway 407 East.
Like the Bowmanville watershed, is notably protected under both the Oak Ridges Moraine Conservation Act and Greenbelt legislation, which restrict growth in sensitive areas.</td></tr>
</table>

Name	Drainage Area (km^2)	Total Stream Length (m)	Watershed Description
Bennett Creek Watershed	7.4	17500	Originates in the surrounding area of Highway 401, and drains directly into Lake Ontario. **Location** • Is entirely within the Municipality of Clarington. **Culture and development** • Is mainly agricultural, with small amounts of natural areas. Will likely experience further development south of Highway 401 as growth occurs within the urban boundary of Bowmanville.
Lake Ontario Catchments	24.0	70800	Several small, unnamed catchments (5 m^2 or less) along the Lake Ontario Shoreline that drain directly into Lake Ontario. They bear little weight on the water systems, or on the ecosystem as a whole. However, ecological conditions are considered under local planning initiatives.

Table 2.1: CLOSPA's Watersheds

2.2 ECOLOGY

2.2.1 Natural Land Cover

Natural land cover within CLOSPA can be broadly classified into three categories: forest, wetland, and meadow. Treed swamps are listed under wetlands in this report.

Within the CLOSPA boundary, nearly 27% of the land cover is naturally occurring, either as forest, wetland, or meadow. This breaks down as follows:

- Forest—11%, or nearly 7,200 hectares (ha);
- Wetland—8%, or 5,600 ha; and
- Meadow or successional, including thicket and savannah—8%, or 5,600 ha.

Fen: Low, flat, swampy land, such as a bog or marsh.

Riparian areas: The vegetated areas close or within a water body that directly contribute to fish habitat by providing a variety of functions such as shade, cover, and food production areas.

Successional areas: Ecosystems that are undergoing the gradual process of change that results from one community gradually replacing another.

Wetland: Land that is seasonally or permanently covered by shallow water, as well as land where the water table is close to or at the surface. In either case, the presence of abundant water has caused the formation of hydric soils and has favoured the dominance of either hydrophytic plants or water tolerant

Natural land cover in the area that the conservation authority manages follows a few different patterns. The most obvious is the valley corridors, which run north-south. Larger forests run east-west along the Oak Ridges Moraine. Here, the landscape has not been amenable to farming in the past.

The remnant Lake Iroquois Shoreline, running east-west, contains a very distinct band of wetlands, mainly treed swamps. These areas were also not farmed because the soils in this region drain poorly. The Ministry of Natural Resources considers much of the wetland cover across the Lake Iroquois Shoreline to be provincially significant.

Ecological Land Classification (ELC)

The Province of Ontario uses ELC to survey and classify these land resources. Its goal is to identify ecological patterns that recur on the landscape, so that fewer units of ecosystem will need to be noted that fall outside of these patterns (Bailey *et al*., 1978). The Province has adopted this approach to make it easier to manage natural resources and the information about them.

CLOCA has used ELC to map vegetation communities in the area. The level of detail extends to the community series level (which, for example, notes the difference between a coniferous swamp and a deciduous swamp). For a vegetation community to be mapped, it has to be at least 0.5 ha. The information goes into a database, and boundaries of independent vegetation communities are mapped digitally. **Figure 2.2** shows the vegetation communities that have been mapped for the CLOSPA area using ELC. They were captured using colour digital air photos from 2008, with some areas confirmed through visits to these sites. We have rolled numerous vegetation communities into the main groupings for this map. The map also shows wetlands, including marsh, aquatic, and swamp.

CLOSPA **Table 2.2** and **Table 2.3** list the vegetated areas (both dry land and wetland). They are also based on the ELC mapping shown in **Figure 2.2**.

ELC Code	Name	Area (m^2)	% of CLOSPA (WRIP) Boundary
BBO	Open Beach/Bar	118,347	<0.1
BBS	Shrub Beach/Bar	9,595	<0.1
BBT	Treed Beach/Bar	94,441	<0.1
BLO	Open Bluff	157,104	<0.1
BLS	Shrub Bluff	23,324	<0.1
BLT	Treed Bluff	5,105	<0.1
CUM	Cultural Meadow	26,325,286	4.1
CUP	Cultural Plantation	11,936,412	1.9
CUS	Cultural Savannah	245,078	<0.1
CUT	Cultural Thicket	21,276,342	3.3
CUW	Cultural Woodland	10,746,665	1.7
FOC	Coniferous Forest	10,247,018	1.6
FOD	Deciduous Forest	15,604,322	2.4
FOM	Mixed Forest	23,072,983	3.6

Table 2.2: Vegetated Areas (Dry Land) by Percentage of the CLOSPA Study Area

ELC Code	Name	Area (m^2)	% of CLOSPA (WRIP) Boundary
MAM	Meadow Marsh	5,035,535	0. 8
MAS	Shallow Marsh	2,835,832	0.4
FEO	Open *Fen*	19,303	<0.1
OAO	Open Water Aquatic	2,200,192	0.3
SAF	Floating-Leaved Shallow Aquatic	49,856	<0.1
SAM	Mixed Shallow Aquatic	36,765	<0.1
SAS	Submerged Shallow Aquatic	252,813	<0.1
SWD	Deciduous Swamp	9,456,716	1.5
SWC	Coniferous Swamp	4,689,951	0.7
SWM	Mixed Swamp	21,118,469	3.3
SWT	Thicket Swamp	10,124,950	1.6

Table 2.3: Wetland Areas by Percentage of the CLOSPA Study Area

Treed Riparian Habitat

CLOSPA staff based the mapping of treed, or riparian, habitat on the conservation authority ELC data from 2005, and included the following habitats (which also appear in **Table 2.4**):

- Forested habitats—coniferous, deciduous, and mixed;
- Treed swamps—coniferous, deciduous, and mixed; and
- Cultural forests—plantations and woodlands.

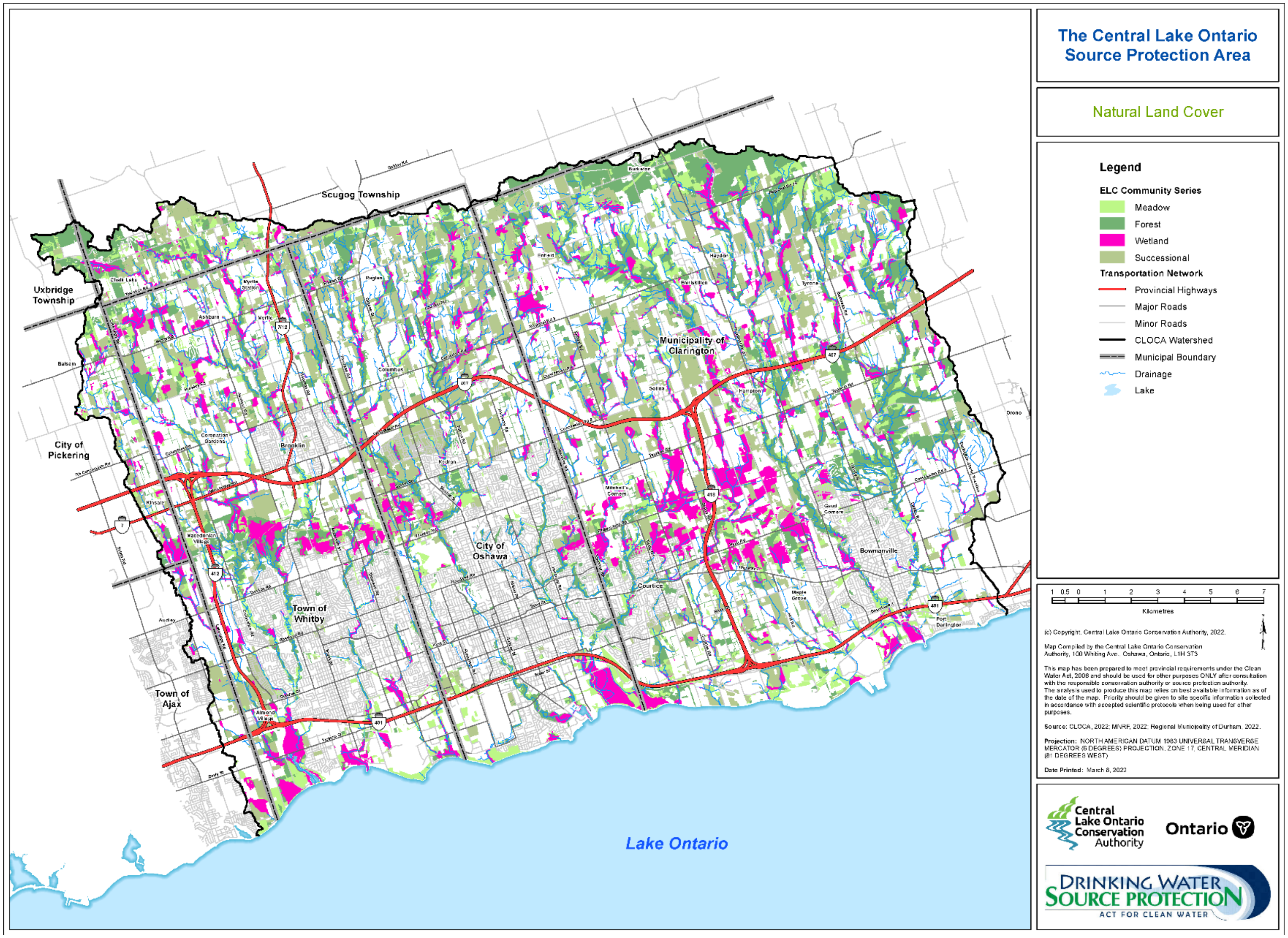

Figure 2.2: Natural Land Cover

The mapping includes riparian permanent, intermittent, and *ephemeral watercourses.* It does not take into account thicketed habitats or other riparian vegetation that may provide sufficient cover and benefit aquatic habitat. This is especially true in less notable streams or Redside dace habitats. It also does not include the smaller watersheds within CLOSPA's jurisdiction. We expect that a similar analysis will be conducted this year.

Ephemeral Watercourses: Streams or creeks where the flow is short lived.

CLOSPA Watershed	Total Stream Length (km)	Stream Length with Treed Riparian Habitat (km)	Percent of Stream Length with Treed Riparian Habitat (%)
Lynde	326	112	34
Oshawa	360	105	30
Black/Harmony/Farewell	224	89	40
Bowmanville/Soper	440	200	45

Table 2.4: Treed Riparian Cover by Stream Length within the Major CLOSPA Watersheds
(Data source: 2005 CLOCA Ecological Land Classification and 2000 drainage based on the interpretation of air photos.)

2.2.2 Aquatic Habitats and Species

Since the late 1990s, the conservation authority has done extensive surveys of our local creeks and coastal wetlands. These surveys are part of an inventory across the CLOSPA area to:

- Learn about the aquatic species and their habitats; and
- Assess and monitor their condition.

(More about how we conduct surveys appears in *CLOCA Aquatic Monitoring Program, 2009 to 2013* (CLOCA, 2009)).

This monitoring has helped the conservation authority develop Aquatic Resource Management Plans (ARMPs) and Fisheries Management Plans (FMPs). These documents contain summaries of the data the conservation authority has collected. They also make recommendations to help the conservation authority conserve, manage, and protect aquatic resources.

Since developing these plans, CLOCA has continued to monitor the watershed each year. Staff have collected additional information that helps to assess the aquatic health in the watershed.

This chapter summarizes the most recent aquatic information that has been collected. This information includes the types of aquatic habitats and species, including fish and invertebrates, contained within CLOSPA.

The information here adds to previous documents, including:

- *Watershed Characterization Report* (CLOCA, 2007);
- *Aquatic Resource Management Plans* (CLOCA, 2000, 2002, 2006, and 2008); and
- *Fisheries Management Plans* (CLOCA/MNR, 2007).

Aquatic Habitat

Water temperature is one of many criteria used to assess water quality in a stream and the health of aquatic habitat. Many organisms rely on their own warmth requirements and may not tolerate large changes in water temperature. Healthy riparian areas along water bodies help regulate temperature. Water temperature can provide information on how fish species are distributed, and what land uses are in the surrounding watershed. Measuring temperature also provides information on where groundwater-surface water interaction occurs.

In this report, the thermal preferences of fish species were used to classify stream temperature. Coldwater habitats have stream temperatures of less than 19°C, cool water habitats have temperature between 19°C and 25°C, and warm water is classified as over 25°C (Coker *et al*., 2001).

Data was gathered using in-stream temperature loggers (CLOCA, 2009). Past watershed characterization reports have used point-in-time measurements, but this approach has limits and does not always accurately reflect thermal conditions.

Aquatic invertebrate: These are water-dwelling animals that do not have a spine or backbone. Examples are flatworms and other worms, molluscs and other crustaceans, sponges and jellyfish.

Benthic invertebrate: These are invertebrates that live at the bottom of a body of water.

Headwaters: Area of a watershed where a major river system originates.

Fish Species

CLOCA's streams and wetlands provide habitat for more than 50 species of fish. These are mainly cold and cool water species living in the mid to upper reaches of large watersheds. Warm water species are found in the lower reaches where there is lake influence, or in areas with warming waters caused by land use, such as urbanization. The most notable fish species include:

- Coldwater migratory salmonids like rainbow trout (*Oncorhynchus mykiss*), which are present in almost all subwatersheds;
- Brown trout (*Salmo trutta*);
- Chinook salmon (*Oncorhynchus tshawytscha*); and
- Coho salmon (*Oncorhynchus kisutch*) in the larger subwatersheds.

There are a few sensitive species of note in the CLOSPA watersheds. We can use these species to get an idea of how healthy the streams are. These species include:

- Brook trout (*Salvelinus fontinalis*) is mainly confined to coldwater fish habitat within the northern limits of the watershed. Optimum Brook Trout habitat is mainly in coldwater streams, such as those originating from the Oak Ridges Moraine. One small population of brook trout are at Iroquois Beach in the Black Creek watershed, which is the most southerly population of Brook trout within CLOSPA's jurisdiction.
- Slimy sculpin *(Cottus cognatus)* is a *benthic* fish known to live near the *headwaters* of some CLOSPA watersheds, mainly near the Oak Ridges Moraine. This coldwater species is especially sensitive to thermal degradation, so will not live where the land has been disturbed (Jenkins and Burkhead 1993). A similar species, the Mottled sculpin (*Cottus bairdii*) is more sensitive, but is more widespread than *Cottus cognatus*. Thus we can also examine the Mottled sculpin to identify suitable trout habitats.

- Redside dace (*Clinostomus elongatus*) is a sensitive minnow, known to live in Lynde Creek, which is a federally and provincially designated species at risk with an endangered status. See **Section 2.2.3** for more information on the Redside dace.

Biological Water Quality

Three programs within the conservation authority collect information on biological water quality. Each program has sampling that supports projects and biannual samples occurs in May and October. Methods used to gather data include:

- Biological Monitoring and Assessment Protocol *(BioMAP):* invertebrates were collected from each site and identified to the species level (Griffiths 1999). Samples were collected from 31 sites between 2001 and 2004. Certain *aquatic invertebrates* are known to tolerate poor water quality conditions, while other more sensitive ones will not. Thus, we only found the more sensitive aquatic invertebrates in areas where water quality was good. Further, we used the number of tolerant and intolerant individuals in our sample for each site to assess water quality.
- Hilsenhoff Scores: measure the tolerance of *benthic invertebrates* to organic pollution to assess water quality. The conservation authority calculated Hilsenhoff scores for 282 benthic invertebrate samples taken between 1998 and 2003.
- Ontario Benthos Biomonitoring Network (OBBN): the OBBN protocol (Jones *et al.,* 2005) involves sampling and identifying benthic invertebrates to understand water quality. CLOCA has participated in the OBBN since 2005. The program measures whether the environment is degraded by comparing test sites to other “reference” sites that are in good condition. Data was collected from 59 sites through the eastern portion of the conservation authority jurisdiction between 2005 and 2008. OBBN samples were also collected at 13 sites throughout the Lynde Creek watershed in 2009. However, the field data had not yet been summarized at the time of writing this report.

Results

All three of the methods described above show similar trends throughout the area CLOSPA manages.

- There tends to be the highest percent of individuals from sensitive taxa within undisturbed headwater areas or areas with mainly natural cover and well-vegetated valleys. Where new, urban areas had a higher percent of sensitive taxa, these areas still had intact, well-vegetated valleys.
- Natural features that help to maintain the health of these streams are typically protected areas (e.g., areas within the Harmony-Farewell or Whitby-Oshawa Iroquois Beach Provincially Significant Wetlands).
- Areas with high urban development and little riparian cover all contained much lower numbers of sensitive taxa.
- The greatest taxa richness typically occurred within larger stream orders or within areas with mainly natural land cover.

For a summary of (1996-2004) BioMAP sampling and Hilsenhoff results, see:

- *Aquatic Resource Management Plans* (CLOCA 2000, 2002, 2006 and 2008).

- *Fisheries Management Plans* (CLOCA/MNR 2007).

Wetlands Habitat

As areas where land and water come together, wetlands provide unique and specialized habitat for a variety of species. Wetlands help regulate the flow of water, and reduce the effects of flooding downstream. They also act as a natural water filter. By removing toxins and all other impurities, they improve overall water quality. If wetlands are destroyed or degraded species that depend on the habitat will be negatively impacted. These species include rare and endangered flora and fauna that depend on wetland areas.

The main type of wetland along the Lake Ontario shoreline is the drowned river mouth wetland. These wetlands provide specialized habitat for rare species, and are a key stopover for migrating birds. For example, the Lake Iroquois Shoreline has a rich diversity of large wooded swamps, which often support sensitive breeding birds and plant species that are rare in this region.

The conservation authority assesses its wetlands on biological, social, hydrological and special features criteria.

2.2.3 Species at Risk

The CLOSPA area is home to seven species at risk protected under the *Endangered Species Act, 2007* (see **Table** 2.5). Of these, the Redside dace (*Clinostomus elongatus*) is the only protected species that is known to be linked with groundwater discharge areas or headwater streams.

The *Endangered Species Act, 2007* protects all endangered, threatened, and extirpated species. It also protects the habitat of endangered and threatened species. An extirpated species is one that is no longer found in a certain region, although it may still exist in other regions.

Type of Species	Name of Species	Provincial Status
Bird	King Rail	Endangered
Plant	Butternut	Endangered
Fish	Redside dace	Endangered
Reptile	Blanding's Turtle	Threatened
Bird	Least Bittern	Threatened
Fish	Atlantic Salmon	Extirpated
Plant	Dense Blazing Star	Threatened

Table 2.5: Species at risk within the CLOSPA area

Redside Dace

Of the species at risk listed above, only the Redside dace is directly linked to the assessment of source water that is used for drinking water purposes. The Redside dace requires clear flowing water, riffle-pool sequences and vegetation overhanging the sides of streams. This species eats a fairly specific diet of land-dwelling insects. The Redside dace's general habitat is protected under the *Endangered Species Act, 2007*. This protection includes all streams where we know the species exists (based on records of catch within the last 20 years) and includes a riparian zone of 30 m around the bank.

Within CLOSPA, Redside dace are found in:

- The Heber Down subwatershed upstream of Taunton Road;
- The Main Branch subwatershed in the Brooklin area; and
- The Ashburn subwatershed from Brooklin to Chalk Lake.

Historically, they have also lived in the lower Myrtle Station subwatershed.

Urban development poses the largest threat to Redside dace in Ontario. Intensive agriculture is another threat. These threats contribute to the following negative impacts on this sensitive species:

- Siltation, where the watershed becomes blocked or choked with mud;
- Changes in stream channel structure and water clarity;
- Base flow alterations;
- Higher stream temperatures;
- Loss of riparian vegetation; and
- Pollutants entering the watershed.

Redside dace once lived in the Lynde Creek and Pringle Creek watersheds. However, as habitats are destroyed or degraded in downstream urban areas, Redside dace are now largely only in the less-disturbed headwaters of Lynde Creek north of Whitby and Brooklin. They are now extirpated from the Pringle Creek watershed, which is almost entirely developed.

By February 2011, the Ministry of Natural Resources is required under the *Endangered Species Act, 2007* to develop a habitat regulation specific to the Redside dace. The *Redside Dace Recovery Strategy* recommends that this regulation expand on the general habitat requirements to include a riparian zone of the stream meander belt, plus 30 metres. The intention is to provide protection over the long term as the stream migrates. It is also recommended that the regulation include certain areas where the Redside dace have lived over the past 20 years. These are areas where restoration is planned and where it is highly likely that the habitat can be rehabilitated successfully.

2.3 WATER SYSTEMS AND WATER USE

There are no municipal wells within the study area. The municipal drinking water for the CLOSPA jurisdiction comes from Lake Ontario. Lake Ontario provides source water for Water Treatment Plants (WTPs) in major settlements such as Whitby, Brooklin, Oshawa, Bowmanville, and Courtice. Outside of the serviced areas, drinking water supplies come from privately owned wells and/or privately owned communal wells.

The Assessment Report must also map and describe:

- Municipal drinking water systems that serve residences;
- Regulation 170 systems, including those that provide drinking water or that serve designated or public facilities (such as community centres, camp grounds, churches, schools, etc.) Provincial data indicates that a total of 94 Regulation 170/03 water systems exist in the CLOSPA; and
- Private water wells (7964 in the CLOSPA study area).

Most people in CLOSPA live in the south, along the Lake Ontario shoreline. The population within the urban fringe (lands near but outside urban centres), receive drinking water by pipelines from Lake Ontario. However, a few settlements get their water from private wells (see **Figure 2.2** and **Figure 2.3**).

These include:

- Village of Columbus
- Myrtle Station
- Myrtle
- Maple Grove
- Almond Village
- Ashburn
- Hampton
- Enniskillen
- Tyrone
- Burketon
- Raglan
- Enfield
- Solina
- Macedonian Village
- Mitchell's Corners
- Several other small rural areas north of the urban development boundary

Raw Water: Water that is in a drinking-water system or in plumbing that has not been treated in accordance with, (a) the prescribed standards and requirements that apply to the system, or (b) such additional treatment requirements that are imposed by the license or approval for the system.

It is expected that the Iroquois Beach and north to the boundary of the Greenbelt will become more developed over the next couple of decades. These areas will likely receive municipal water supplies sourced from Lake Ontario. At present, the Regional Municipality of Durham that is responsible for the provision of drinking water in the CLOSPA jurisdiction is not planning to develop groundwater supplies for the provision of drinking water.

As indicated, much of the population in the CLOSPA jurisdiction lives along the Lake Ontario shoreline and these urban areas mainly get their water from Lake Ontario. Three municipal water intakes are located in the CLOSPA jurisdiction. Durham's municipal network is interconnected and thus the intakes in CLOSPA along with the Ajax Water Treatment Plant (TRSPA), service residents in the Town of Whitby and Brooklin, the City of Oshawa, and the urban area of Bowmanville.

There are approximately 320,000 residents in the urban and rural areas of the CLOSPA jurisdiction that also fall within Durham Region (Statistics Canada, 2006). Approximately 95% of the population receive services from the water and wastewater systems that Durham Region owns and operates. The region is responsible for water treatment and distribution. **Figure 2.3** and **Figure 2.4** show the locations of private wells and other systems as defined in the legislation (170/03, 252/053, 243/07), respectively. Data regarding the water use for other systems are currently unavailable. Estimates of takings (water use) for all systems (systems that require a permit and ones that do not) are presented in the Water Budget in **Chapter 3**.

Other surface water users (for agricultural and golf course irrigation) extract water directly from streams.

2.3.1 Municipal Surface Water Sources and Water Treatment Plants (WTPs)

A licensed plant operator is responsible for collecting and testing water samples every day for bacteria, including:

- *Raw water* entering the plant;
- Treated water leaving the plant; and

- Water taken from various points along the distribution system.

Each of the three WTPs located in CLOSPA use a variety of water treatment processes. They include zebra mussel control, screening, pre-chlorination, low-lift pumping, coagulation, flocculation, direct filtration, post chlorination, storage, and high-lift pumping. All three WTPs also take part in the Ministry of the Environment's Drinking Water Surveillance Program (DWSP), see **Table 2.6**.

CLOSPA Wastewater Handling

The Region is responsible for treating wastewater and collecting it from the customer. The municipal wastewater systems include:

- Four water pollution control plants;
- No waste stabilization pond facilities;
- 23 sewage pumping stations;
- 17 km of forcemains; and
- 1,168 km of sanitary sewers.

For more details, see the Water Budget in **Chapter 3**.

	Oshawa WTP (2 intakes)		Whitby WTP (1 intake)	Bowmanville WTP (1 intake)
Location	Ritson Rd. South, Oshawa		Water St., Whitby	Port Darlington Rd., Bowmanville
Permit Number	00-P-3025		00-P-3026 1226-6NQQXG	00-P-3027, 2116-6LUSUR
Maximum Taking Allowed (litres per day)	134,000,000		144,000,000	47,700,000
Approximate Population Served Number (Durham Region Data 2010)	156,441 in Oshawa and 27,142 in Courtice *		114,982 in the Town of Whitby and the Village of Brooklin *	38,033
Intake Source	Lake Ontario			
Intake	West Intake	East Intake	Intake 1	Intake 1
Pipe Diameter (millimetres)	750	900	1,350	1,050
Distance Extending into Lake Ontario (metres)	831	924	1,710	1,550
Depth of Intake Structure (metres)	7.6	10.7	16.0	12.0
Plant Capacity (million litres per day)	134.0 (2 plants)		118.0	36..4
Distribution System (kilometres of watermains) –Jan 2009	732		525	168

	Oshawa WTP (2 intakes)	Whitby WTP (1 intake)	Bowmanville WTP (1 intake)
Treatment	Each of the three facilities uses a variety of water treatments, including zebra mussel control, screening, pre-chlorination, low-lift pumping, coagulation, flocculation, direct filtration, post chlorination, storage, and high-lift pumping.		
Monitoring	A licensed plant operator collects and tests samples on site every day. Raw water entering the plant, treated water leaving the plant, and water taken from various points along the distribution system is tested for bacteriological content. In addition, all three WTPs participate in the Ministry of the Environment's Drinking Water Surveillance Program (DWSP)—Oshawa since 1980, and Whitby and Bowmanville since 1996.		

*** Ajax, Whitby and Oshawa distribution lines are interconnected. Water may be pumped to population outside of the SPA boundary. Population served number thus do not correlate exactly with census population data for the SPA. The Ajax and the Newcastle WTPs are described in the Toronto and Ganaraska Assessment Reports respectively**

Table 2.6: Summary of Oshawa, Whitby, and Bowmanville Water Treatment Plants (Durham Region 2010 WTP Reports)

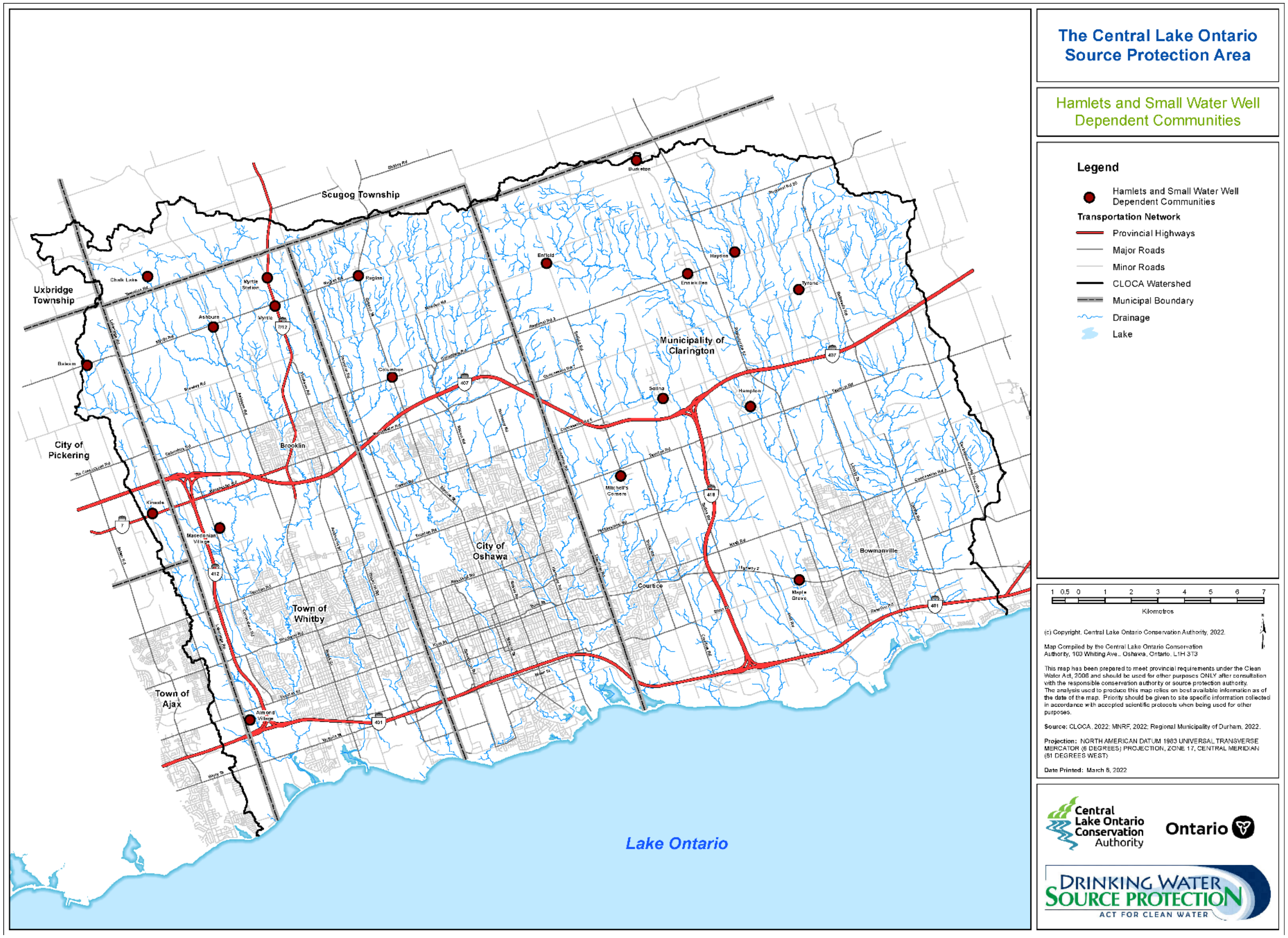

Figure 2.3: Hamlets and Small Water Well Dependent Communities

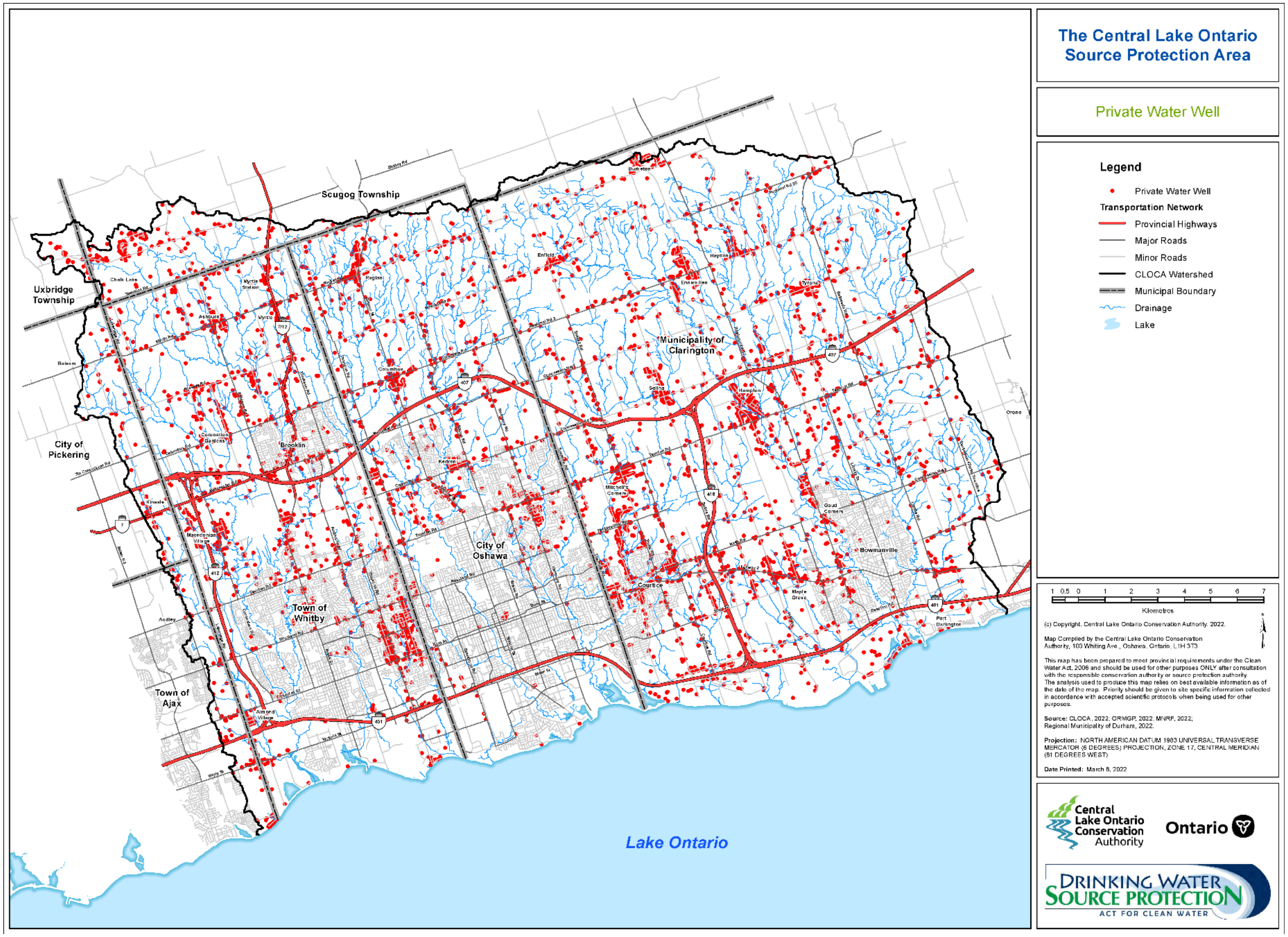

Figure 2.4: Private Water Wells

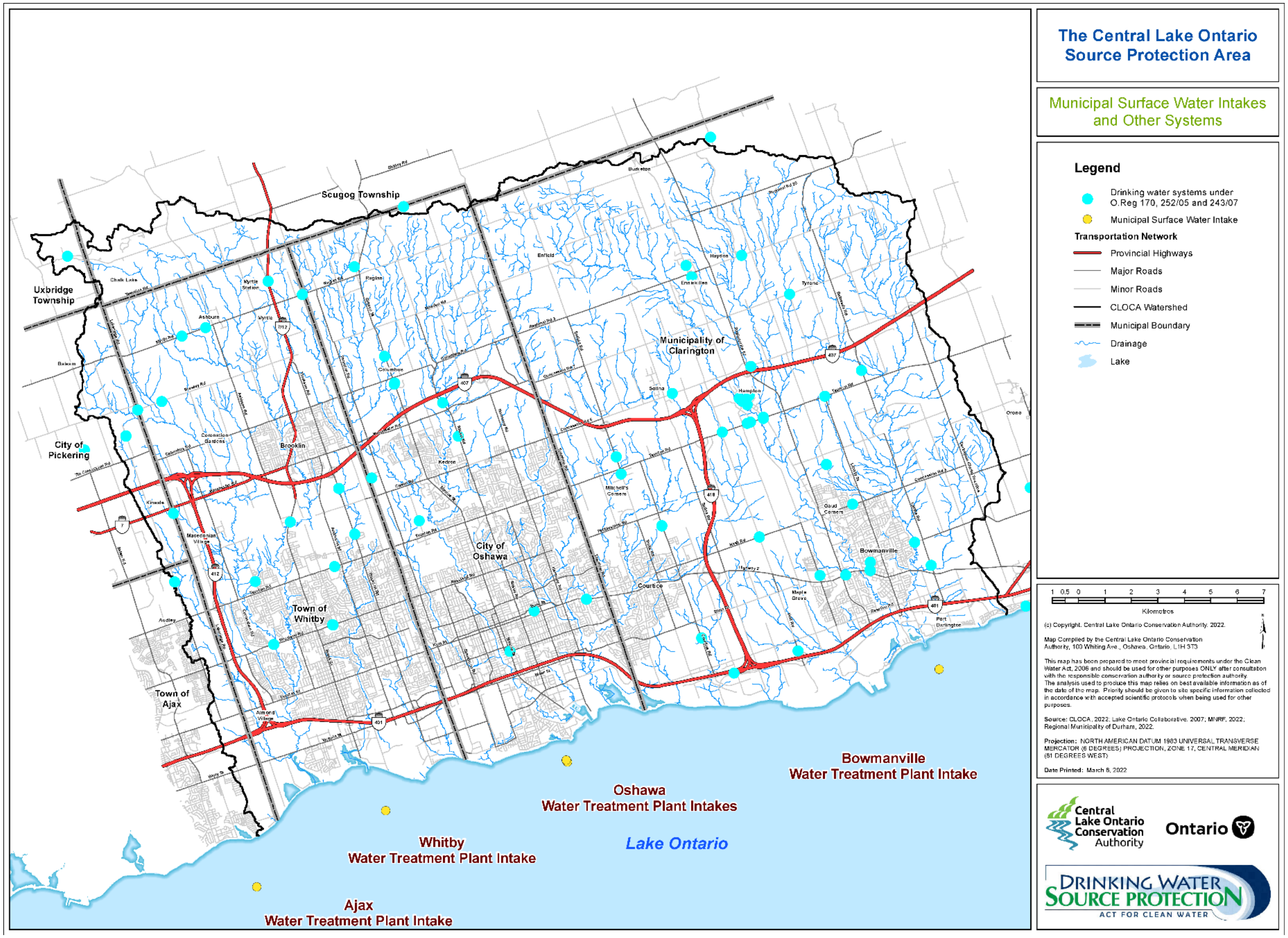

Figure 2.5: Municipal Surface Water Intakes and Other Systems

2.4 WATER QUALITY AND TRENDS

All municipal drinking water supplies for CLOSPA come from Lake Ontario. The *CWA, 2006* nonetheless, requires an assessment of water quality within the jurisdiction as a whole as a basis of watershed health assessment under this watershed characterization chapter. The general water quality of streams is assessed against water quality objectives and standards that exist to assess ecosystem components. It should be noted that these standards and objectives vary from drinking water standards that are used to assess drinking water for potential human health impacts.

A wide range of natural and human factors influence water quality. The most important natural influences relate to climate and geology. Both of these can affect how much water is available, and the water quality. Human activities, such as agriculture, industry, and urban development, can have a negative impact on ground and surface water quality. Therefore, uncovering both the natural and human factors in an area is a key for understanding what controls the quality of the water.

It is essential to identify the present surface and groundwater quality, as well as the long-term trends. This helps in understanding whether water quality is improving, getting worse, or staying the same.

2.4.1 CLOSPA Lake Ontario Drinking Water Intake Water Quality

The Lake Ontario drinking water intakes have provided a consistent source of high quality water to the residents of the CLOSPA and neighbouring areas. Each of the upper tier municipalities tests the source and treated waters regularly, and reports are available to the public via the internet.

Oshawa Water Treatment Plant

Water testing reports indicate that between 2004 and 2009 over 1,000 raw water samples were collected and tested for *E. coli* and total coliforms. Of these samples tested for *E. coli,* 960 samples were non-detect, 107 samples detected *E. coli* bacteria, and one sample exceeded the Provincial Water Quality Objectives (PWQO) of 100 counts/100mL. Total coliform results showed 636 non-detect, 431 samples detected total coliform bacteria, and two samples were above 1,000 counts/100 mL. The PWQO objective for total coliforms was revoked in 1994; however, it has been included in this report as a reference.

Whitby Water Treatment Plant

The reports indicate that between 2004 and 2009 over 1,200 raw water samples were collected and tested for *E. coli* and total coliforms. Of these samples tested for *E. coli,* 1165 samples were non-detect, and 65 samples detected *E. coli* bacteria. There were no exceedances of the PWQO for *E. coli* during the reporting period. Total coliform results showed 662 non-detect, 568 samples detected total coliform bacteria, and two samples were above 1,000 counts/100 mL.

Bowmanville Water Treatment Plant

The reports indicate that between 2004 and 2009 over 280 raw water samples were collected and tested for *E. coli* and total coliforms. Of these samples tested for *E. coli,* 273 samples were non-detect, and 16 samples detected *E. coli* bacteria. There were no exceedances of the PWQO for *E. coli* during the reporting period. Total coliform results showed 204 non-detect, and 82 samples detected total coliform bacteria.

Each of the WTPs located in CLOSPA uses a variety of water treatment processes to ensure that raw water from Lake Ontario is potable and aesthetically acceptable.

2.4.2 Contaminants of Emerging Concern

Contaminants of emerging concern include pharmaceuticals, personal care products, endocrine disruptors, antibiotics, and antibacterial agents. The public has expressed concern regarding the implications of these trace contaminants in finished drinking water and the issue has been highlighted in many publications. Justice O'Connor's recommendations in Part II of the *Walkerton Report (2002*) include the statement that "water providers must keep up with scientific research on endocrine disrupting substances and disseminate the information". Pharmaceuticals and personal care products are found where people or animals are treated with medications, and where people use personal care products. These contaminants are often found in rivers, streams, lakes and groundwater influenced by wastewater treatment plants.

The Ministry of the Environment and Climate Change recently released the findings of a survey of the occurrence of pharmaceuticals and other emerging contaminants in samples of source and treated water collected in 2005 and 2006 (MOE, 2010). The samples were collected from 17 different drinking water systems and were analyzed for 46 compounds including antibiotics, hormones, pharmaceuticals, and bisphenol A. Samples were drawn primarily from lake and river source waters, from treated drinking water, and from three groundwater sites (note that no municipal groundwater sources are located in the CLOSPA area). Of the compounds analyzed, 23 were detected in surface source water, and 22 were detected in finished drinking water. However, the concentrations measured well below any maximum acceptable daily intake levels for drinking water.

The report suggests that an individual would have to drink thousands of glasses of water in a day to reach the maximum acceptable level for the compounds detected. The Ministry of the Environment and Climate Change's report also indicated that existing treatment processes reduce the concentrations of most frequently detected compounds. Although at this time, future studies have not been defined, it is expected that work will continue in this area both in the academic and regulatory environment as this remains an important subject of public concern.

2.4.3 Pathogens

Lake Ontario is the source of drinking water for approximately 6 million Canadians. Despite this importance, there has been little systematic investigation of the occurrence of waterborne pathogens other than total coliforms and *E. coli* in the offshore waters that serve as the source water for many communities around Lake Ontario. Waterborne pathogens can enter the lake from a wide variety of potential sources of fecal pollution, including river and stream discharges, sewage treatment plant outfalls, storm sewers (combined and separated), and numerous other shoreline sources ranging from wildlife droppings to diverse urban and agricultural runoff activities. Once in the lake, waterborne pathogen persistence and transport can be influenced by a variety of physical, chemical, and biological processes such as: alongshore and offshore water movements, upwelling and downwelling events, precipitation events and flooding, seasonal fluctuations in water temperature, levels of nutrients and other biota in the water, and changes in climate and lake water levels. A better understanding of the occurrence of waterborne pathogens in offshore waters in Lake Ontario is needed to help water treatment plants continue to provide safe drinking water supplies for millions of Canadians living around the lake. However, it must be noted that drinking water standards have not yet been developed for several pathogens.

As part of the Lake Ontario Collaborative, a study was undertaken to investigate the occurrence of waterborne pathogens in offshore source water used by selected drinking water treatment plants on Lake Ontario. The study sought to establish a benchmark of waterborne pathogen occurrence that can be used to understand future trends in source water quality that may be influenced by aspects ranging from climate change, to increasing urbanization, and to changes in wastewater infrastructure or land uses around Lake Ontario. The study also investigated the value of different microbial water quality indicators in offshore settings, applying source tracking tools to identify sources of fecal contamination and pathogens at offshore locations, and providing data on waterborne pathogen occurrence to support quantitative microbial risk assessments of Lake Ontario sources of drinking water. The study focused on three drinking water treatment plants in the vicinity of the mouth of the Credit River in western Lake Ontario as a pilot to simulate the Lake Ontario Collaborative water treatment plants. The results of this study are presented in: *Progress Report on Investigation of Waterborne Pathogen Occurrence in Source Water of Lake Ontario Drinking Water Treatment Plants near the Credit River (2007-2008)*(Edge, *et al., 2008*)

2.4.4 CLOSPA Watersheds and Great Lakes Agreements

The creeks located in the CLOSPA study area drain directly into Lake Ontario and have the potential to contribute pollutants to the lake. These pollutants, including sediments and nutrients, as well as organic and inorganic contaminants, contribute to the overall water quality of the near-shore of Lake Ontario. As part of the information used to undertake the threats inventory and issues evaluation for these lake-based water systems, data was incorporated from the Great Lakes Surveillance Program, a program conducted by Environment Canada under the *Great Lakes Water Quality Agreement* between Canada and the United States.

In order to achieve water quality goals and objectives set under the *Great Lakes Water Quality Agreement*, Canadian and U.S. federal governments are developing Lakewide Action and Management Plans (LAMP) in conjunction with the Province of Ontario and the states within the Great Lake watersheds. Lakewide Action and Management Plans are broad plans to restore and protect water quality in each Great Lake (Ontario Ministry of Environment, 2007). Information compiled as part of the Lake Ontario LAMP was incorporated into the technical studies completed for the CLOSPA based water supply systems.

The work undertaken and described in this Assessment Report contributes to the achievement of Goal 6 under Annex 3: Lake and Basin Sustainability under the *Canada-Ontario Agreement Respecting the Great Lakes Basin Ecosystem* (Ontario Ministry of Natural Resources, 2005a). This report also addresses two key results identified under Goal 6 of Annex 3 by identifying and assessing the risks to drinking water sources on Lake Ontario (Result 6.1), and developing knowledge and understanding of water quality and water quantity issues of concern to Lake Ontario (Result 6.2).

The *Great Lakes – St. Lawrence River Basin Sustainable Water Resources Agreement* is a good faith agreement between the eight U.S. Great Lakes states and the provinces of Ontario and Quebec. The agreement is intended to implement the *Great Lakes Charter* and the *2001 Great Lakes Charter Annex*. The agreement sets out objectives for the signatories related to collaborative water resources management and the prevention of significant impacts related to diversions, withdrawals and losses of water from the Great Lakes Basin (Ontario Ministry of Natural Resources, 2005a). The agreement sets out conditions under which transfers of water from one Great Lake watershed to another (intra-basin transfer) can occur. Currently, 95 percent of the population in CLOSPA currently receives water from three surface water intakes located in Lake Ontario. The waste water is discharged back into Lake Ontario, thus there is no intra-basin transfer.

2.4.5 Lake Ontario Raw Water Quality Summary

In general, the source of drinking water was found to be of high quality. Operating authorities reported the source as excellent, predictable, and easy to work with. Fluctuations in raw water quality were the result of seasonal, weather-related events. This report used data from the 2004–2009 Annual Drinking Water Quality Reports published by the Regional Municipality of Durham (results are described in Section 4.3 of that report).

Contaminants of emerging concern (pharmaceuticals, personal care products, endocrine disruptors, antibiotics, and antibacterial agents) were sampled from groundwater, lake, river source waters, and from treated drinking water, and were analyzed for compounds including antibiotics, hormones, pharmaceuticals, and bisphenol A. The analyses revealed that the observed concentrations were found to compare well below any maximum acceptable daily intake levels for drinking water.

Pathogen issues have not been identified for the Lake Ontario intakes, and there has been little systematic investigation of the occurrence of waterborne pathogens other than total coliforms and *E. coli* in the offshore waters. Therefore, a better understanding of the occurrence of waterborne pathogens in offshore waters in Lake Ontario is needed to help water treatment plants continue to provide safe drinking water supplies for millions of Canadians living around the lake.

Canadian and U.S. federal governments have established *The Great Lakes Water Quality Agreement* and the *Great Lakes – St. Lawrence River Basin Sustainable Water Resources Agreement*. Under these agreements, Lakewide Management Plans (LAMP) are being completed. These plans will address the risks to drinking water sources and develop knowledge and understanding of water quality and water quantity issues of concern to Lake Ontario.

2.4.6 CLOSPA Surface Water Quality (Inland Watercourses)

Inland watercourses are not used for drinking water supplies within the CLOSPA. However, the creeks and rivers located in the CLOSPA drain directly into Lake Ontario and have the potential to contribute pollutants to the lake. These pollutants, including sediments and nutrients, as well as organic and inorganic contaminants, contribute to the overall water quality of the near-shore of Lake Ontario.

The data analysed for this report were collected under two programs, the Provincial Water Quality Monitoring Network (PWQMN) and the conservation authority's Surface Water Quality Monitoring Program. All sampling sites and their locations are listed in **Appendix B** (**Figure B-1**) and **Table 2.7**.

CLOCA ID	Watershed	Location	Program	First sampled	Last sampled	Re-started	PWQMN ID
SWQ14	Black Creek	Trulls Road, Courtice	PWQMN	2003			06011200602
SWQ4	Bowmanville Creek	West Beach Rd, Bowmanville	PWQMN	1964	1997	2003	06011600102
SWQ15	Bowmanville Creek	Hampton Conservation Area	PWQMN	2003			06011600502
SWQ17	Bowmanville Creek	Long Sault Conservation Area	PWQMN	2003			06011600602
SWQ16	Bowmanville Creek	Taunton Rd, Clarington	CLOCA	2004			
SWQ3	Farewell Creek	Colonel Sam Drive, Oshawa	PWQMN	1980	1997	2003	06011200302
SWQ13	Farewell Creek	Nash Road, Courtice	CLOCA	2005			
SWQ12	Harmony Creek	Bloor St, Oshawa	CLOCA/ HISTORIC PWQMN	1964	1981	2005	06011200102
SWQ1	Lynde Creek	Victoria St, Whitby	PWQMN	1964	1997	2003	06010800102

CLOCA ID	Watershed	Location	Program	First sampled	Last sampled	Re-started	PWQMN ID
SWQ8	Lynde Creek	Baldwin St, Brooklin	PWQMN	1977	1994	2003	06010800202
SWQ30	Lynde Creek	Baldwin St, N of Taunton Rd	HISTORIC PWQMN	1977	1978		06010800202
SWQ31	Lynde Creek	Winchester Rd, E of Hwy 7/12	HISTORIC PWQMN	1977	1988		06010800302
SWQ9	Lynde Creek	Heber Down Conservation Area	CLOCA	2004			
SWQ34	Montgomery Creek	Harbour Rd, Oshawa	HISTORIC PWQMN	1966	1994		06011100202
SWQ2	Oshawa Creek	Simcoe St. South, Oshawa	PWQMN	1964	1997	2003	06011100102
SWQ10	Oshawa Creek	Conlin Road, Oshawa	PWQMN	2003			06011100302
SWQ11	Oshawa Creek	Conlin Road, Oshawa	CLOCA	2004			
SWQ32	Pringle Creek	Brock St, Whitby	HISTORIC PWQMN	1964	1987		06010900102
SWQ33	Pringle Creek	Watson St, Whitby	HISTORIC PWQMN	1972	1994		06010900302
SWQ35	Soper Creek	King St E, Hwy 2, Bowmanville	PWQMN	1968	1990		06011600302
SWQ5	Soper Creek	West Beach Rd, Bowmanville	CLOCA/HISTORIC PWQMN	1967	1994	2003	06011600202
SWQ19	Soper Creek (east branch)	Taunton Rd, Clarington	CLOCA	2004			
SWQ20	Soper Creek (east branch)	Gibbs Rd north Conc. 7	CLOCA	2004			
SWQ21	Soper Creek (east branch)	Lambs Road, Clarington	CLOCA	2005			
SWQ18	Soper Creek (west branch)	Taunton Rd, Clarington	CLOCA	2004			

Table 2.7: All Surface Water Quality Monitoring Stations in the CLOSPA Study Area

Statistical Analysis

A number of statistical tests were performed on the surface water quality data for the study area. In addition to historical data inconsistently collected between 1964 and 1997, tests were completed on at least 40 samples for all water quality sites (PWQMN and CLOCA) for the past five years. Statistical tests were performed on chloride, nitrate, phosphorus, and copper as indicator parameters. Statistical tests were also done on parameters that exceeded the limits set by the Provincial Water Quality Objectives (PWQO, Feb 1999). The PWQOs are objectives set by the Province for water quality that are consistent with the protection of aquatic ecosystems and groundwater. These objectives are used in the assessment of watershed health. Where no PWQO exists for a parameter assessed (e.g., nitrate and chloride), water quality guidelines endorsed by the Canadian Council of Ministers of the Environment (CCME) were used.

Presently, there is no Canadian water quality guideline for chloride for protection of freshwater organisms. In the *Water Quality: Ambient Water Quality Guidelines for Chloride Overview Report* (BCMOE, 2003), it is cited that Evans and Frick (2001) evaluated the toxicity of chloride for freshwater organisms by stratifying the existing data according to the duration of chloride exposure. For the purposes of guideline derivation used in this report (150 mg/L), acute toxicity tests are defined as those in which duration of exposure was less than seven days. Toxicity tests of seven or more days in duration are considered to represent chronic exposures. The CCME endorses this guideline for use in Ontario (*Environment Canada—Canadian Sustainable Environmental Indicators Appendix 1*).

> **Mann-Kendall Test:** A non-parametric test used to detect trend in skewed time series data.

There is also no PWQO for nitrate. In this Assessment Report, the study team used the recommended CCME guideline of 3 mg/L (CCME, 2003), which is also recommended by the Environmental Commissioner of Ontario (ECO) (ECO, 2004). According to the ECO 2004 report, in southwestern Ontario surface water quality has become problematic because of run-off from farm fields, septic system discharge, effluent from sewage treatment plants and other problems that have arisen in the past few decades. In the 2001/2002 annual report, the ECO noted that nitrate concentrations appeared to be trending upward in surface waters in many of the river systems in agricultural areas of Ontario where sandy soils predominate. Many forms of aquatic life are adversely affected by elevated nitrate levels. Population declines of frog and salamander species have been linked to rising nitrate levels in water, according to Environment Canada.

Two types of statistical methods were used to describe the water data over time: parametric statistics (such as regression analysis), and non-parametric statistics (including median and inter-quartile range). The parametric statistics assume that observations are normally distributed and that the data reported is reliable and complete. Non-parametric tests do not assume a particular form of distribution and can handle “problem” data. Since surface water quality data typically show severely skewed distribution, are incomplete, and often contain extreme values, the more appropriate method for data analysis is non-parametric tests.

Parametric tests completed for this report include mean, standard deviation, and simple linear regression. The non-parametric tests performed include median, inter-quartile range, and the *Mann-Kendall test.* All results are shown in **Appendix B 1.5.**

Surface Water Quality Results

Nitrogen and phosphorus are the major nutrients contributing to eutrophication or increased concentration of chemical nutrients in surface waters. Eutrophication can cause excessive algae and macrophyte growth in surface waters, leading to oxygen depletion and fish kills, decreased biodiversity, water taste and odour problems, increased water treatment costs, and blue-green algae toxin production in areas with blue-green algae. Nuisance blooms of algae are a frequent problem in Lake Ontario.

Phosphorus

In the natural environment, phosphorus is found in the form of phosphates. Natural levels are typically less than 0.2 mg/L (200 µg/L). Higher concentrations of phosphates suggest that they have come from a source outside the natural environment, such as domestic and industrial wastes, detergents, or fertilizers (Hann, 1972).

The highest phosphorus concentrations in the CLOCA study area are found at Pringle Creek (SWQ3), with recorded levels as high as 24 mg/L (1970). With the exception of Pringle Creek, phosphorus levels are fairly consistent throughout the study area. Since the 1970s, phosphorus concentrations have been either steadily declining or remaining constant in all watersheds. Decreasing phosphorus concentrations are likely due to the reduction of phosphate in laundry detergents. In the past, approximately 50% of the phosphorus entering lakes and streams from municipal sewage came from detergents. Federal regulations reduced the phosphate ($P_2O_5^{-2}$) content in laundry detergents from approximately 50% to 20% in 1970, and then to 15% in 1973.

The interim Provincial Water Quality Objectives (PWQO) suggest phosphorus concentrations should be under 0.03 mg/L (30 µg/L) for streams and under 0.02 mg/L (20 µg/L) for lakes in order to prevent the excessive growth of plants such as algae (see **Figure 2.5**).

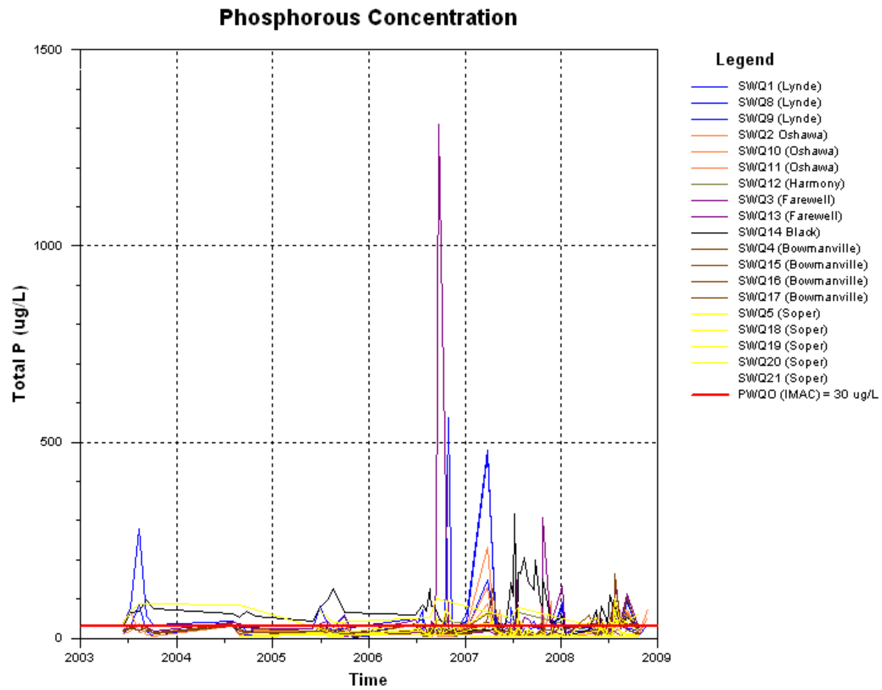

Figure 2.6: Phosphorus Concentrations in the Study Area
(Surface Water Quality Monitoring (SWQ) station locations are in Figure B.1 (Appendix B) and listed in Table 2.7.)

The concentrations of phosphorus in Lynde, Oshawa, Harmony, Black, and Soper creeks has remained fairly constant over the five-year observation period, while SWQ3 at Farewell Creek, and SWQ4 and SWQ15 at Bowmanville Creek show declining phosphorus concentrations. The highest phosphorus concentration of the CLOCA jurisdiction stations, during this observation period, was 1.31 mg/L (1310 µg/L) recorded at SWQ3 at Farewell Creek on September 25, 2006. Statistical analysis revealed that mean values for phosphorus concentrations are generally within the 30 µg/L limit set by the PWQO, except at SWQ1 (Lynde Creek), SWQ14 (Black Creek), and SWQ21 (Soper Creek – East) (see **Appendix B, Table B.9**).

Nitrates

When nitrogen decomposes in organic matter, it forms ammonia, nitrites, and nitrates. This process is known as nitrification. Nitrates (NO_3) were chosen as an indicator of surface water quality because they are an essential fertilizer for all types of plants, and are rarely found in high concentrations in surface waters under natural conditions.

- Overall nitrate concentrations in the study area increased or remained constant from the beginning of the record period (1964–1997).
- Nitrate concentrations increased significantly from 1964 to 1984 and have exceeded the Canadian Water Quality Guideline (CWQG) limit of 2.93 mg/L (CCME, 2003) in Lynde, Pringle, Oshawa, Harmony, Bowmanville, and Soper creeks (Pringle Creek had the highest concentration at 21 mg/L in the August 6, 1975, sample).

- Between 1984 and 1995, nitrate concentrations remained fairly constant in Oshawa, Bowmanville, Soper, Farewell, and Pringle creeks. During this period, the CWQG is still frequently exceeded, with the highest nitrate concentrations recorded in Pringle Creek.
- Between 2003 and 2008, nitrate concentrations remained constant or decreased for almost all streams in the study area. Some surface water monitoring stations at Soper (SWQ21 and SWQ5), Black (SWQ14), Farewell (SWQ3), Oshawa (SWQ2), and Lynde (SWQ9) creeks recorded nitrate concentration exceedances between 2006 and 2008 (see **Figure 2.7**).
- Work continues under conservation authority programs to explain these trends.

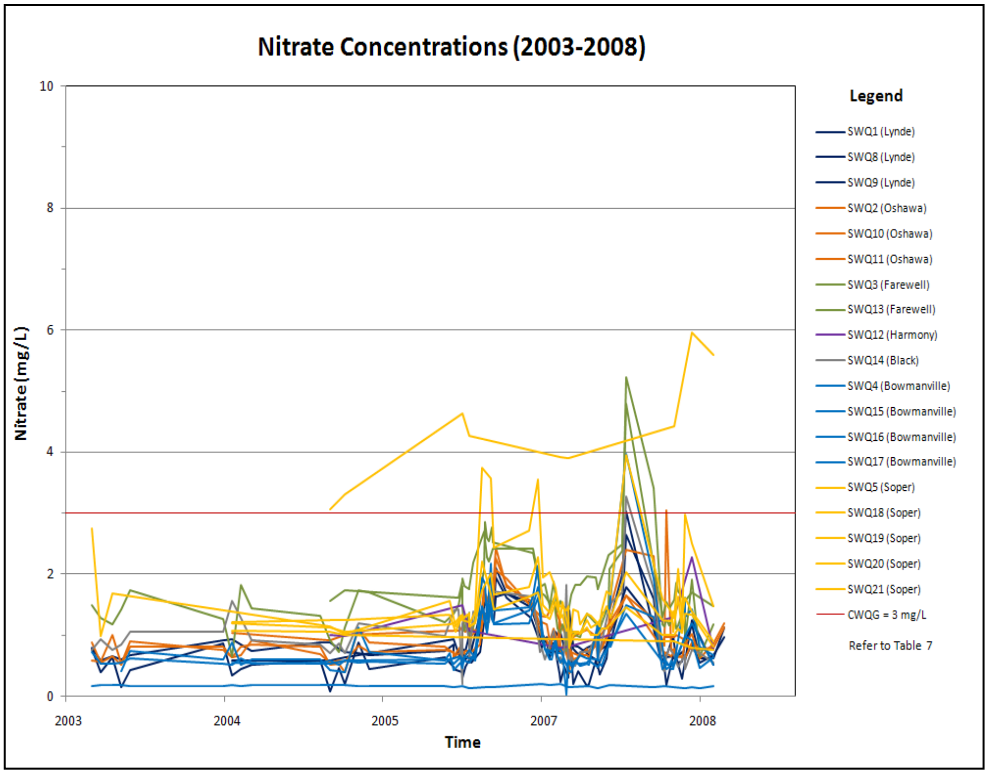

Figure 2.7: Nitrate Concentrations between 2003 and 2008
(Surface Water Quality Monitoring (SWQ) station locations are in Figure B.1 (Appendix B) and listed in Table 2.7.)

Laboratory methods for analyzing nitrate changed from filtered reactive to unfiltered reactive in 1994. Graphical interpretation was performed on only the more recent results derived from current laboratory procedure that started in 2003. From 2003 onwards, the nitrate concentrations at all stream monitoring stations, although generally observed to have declining concentrations, still show exceedances on the limit prescribed by the CWQG.

Using the Mann-Kendall test for the nitrate data, 19 stream-monitoring locations in CLOCA were evaluated between 2003 and 2008. No changes were observed in 11 of the stations, while decreasing nitrate concentrations were found in seven of the stations. Only SWQ21 (Soper Creek – East) showed increased nitrate concentrations. The decreasing nitrate trend observed for Oshawa Creek is likely due to increased urbanization, which reduces the use of nitrate-containing fertilizers and effluent from septic systems. The change in the laboratory method for analyzing nitrate may influence the trend analysis, and additional data is needed to substantiate the results.

Copper

At low concentrations, copper is a minor nutrient for both plants and animals. But when concentration increases even a little, copper becomes toxic to aquatic life. The copper found in streams has typically come from the corrosion of copper and brass tubing, from industrial effluents (e.g., plating, coating and refinishing processes), and from algaecides (copper compounds are often used to control undesirable plankton and other aquatic organisms).

Copper levels have been analysed in the study area since 1974.

- Since the beginning of the record period, Pringle, Oshawa, and Montgomery creeks have had the highest copper concentrations. Concentrations were well above the PWQO limit of 5 µg/L until 1989, when they suddenly started to decline.
- The observed decline in copper concentrations after 1989 may be attributed more to the differences in laboratory methodologies before and after 1990 rather than changes in ambient conditions.
- By 1994 copper concentrations were well under the PWQO, and have remained fairly constant. The most significant decreases can be seen in Oshawa Creek and Lynde Creek.
- Copper concentrations between 2003 and 2008 were fairly low except for some recorded spikes, one of which reached 67.8 µg/L at SWQ3 (Farewell Creek) on September 25, 2006.
- Concentrations slightly above the PWQO limit of 5 µg/L were detected in at least ten samples from seven stations in Lynde, Oshawa, Black, and Farewell creeks. However, these periodic spikes are not an issue for drinking water, as it is for aquatic life.

For the statistical analysis of copper concentrations between 2003 and 2008, 19 stream monitoring locations were evaluated. The Mann-Kendall test showed five stations with increasing concentrations and two stations with decreasing concentrations. The remaining 12 stations did not show any trend at all. Increasing trends with exceeded concentrations were observed at stream-monitoring stations SWQ9 (Lynde Creek), SWQ2 and SWQ11 (Oshawa Creek), and SWQ14 (Black Creek) (see **Figure 2.7** and **Table 2.7**).

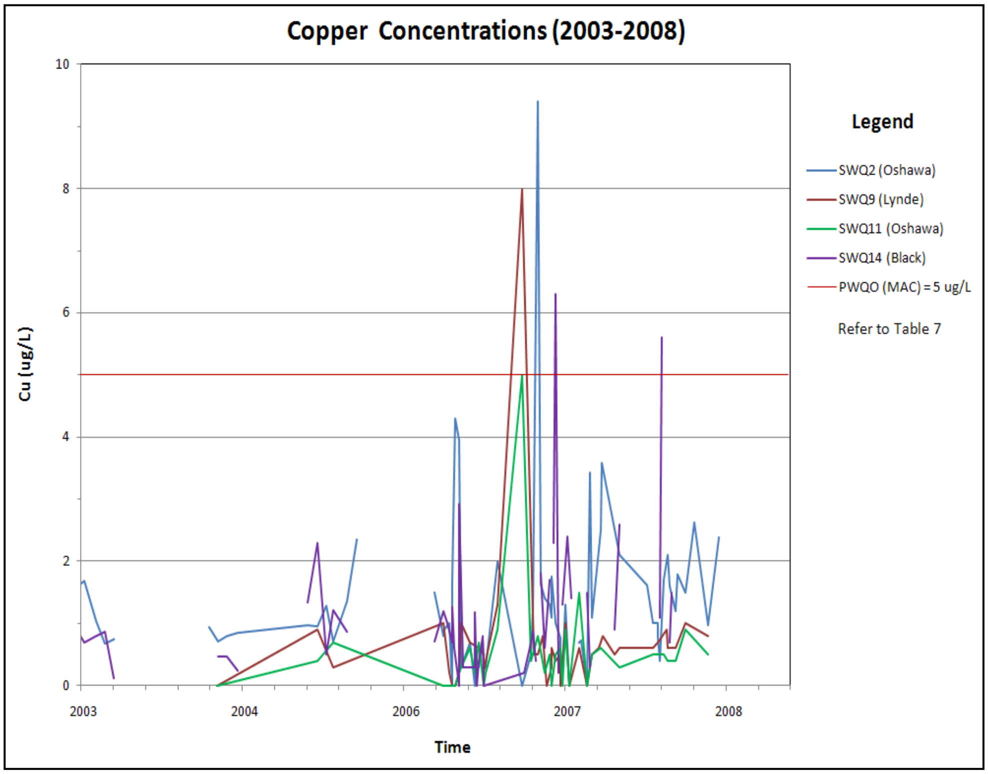

Figure 2.8: Stream Monitoring Stations where Increased Copper Concentrations also Exceeded the Limit Prescribed by the PWQO

(Surface Water Quality Monitoring (SWQ) station locations are in Figure B.1 (Appendix B) and listed in Table 2.7.)

Chlorides

Chlorides are found in almost all natural waters. Natural chloride sources include minerals and agricultural salts. Anthropogenic sources (sources from human activities) include leaching from road salt, waste sites, sewage systems, and underground pipes.

Chlorides continue to be a water quality indicator because of their toxicity to aquatic organisms. Once chlorides enter a solution, they tend to remain there, allowing their concentration to increase over time. To protect freshwater aquatic life from chronic effects, the average concentration of chloride (mg/L as NaCl) should not exceed 150 mg/L (BC MOE, 2003; Environment Canada, 2005).

Chloride concentrations have been increasing since the beginning of the record period (1964), but are still well below 150 mg/L. Concentrations in Lynde, Oshawa, Farewell, Bowmanville, and Soper (East) creeks show an increase over a five-year observation period (2003–2008). However, there are few recorded exceedances to the recommended 150 mg/L limit.

As expected, chloride concentrations are generally elevated in highly urbanized areas close to the lake, while concentrations decrease further upstream (see **Figure 2.9**). The highly urbanized western and central watersheds (Lynde, Oshawa, Black, Harmony and Farewell) show higher chloride concentrations than the watersheds of the less-developed Bowmanville and Soper. A possible explanation is the diluting effect of the significant amount of groundwater discharge to Bowmanville Creek. Chloride concentrations within Black, Harmony, and Farewell creeks have been increasing. Note that the Provincial Water Quality Monitoring Network ceased to operate between 1994 and 2003 when the authority was affected by provincial cutbacks. No data was collected during that period. Some stations were permanently discontinued (such as the SWQ34 Montgomery Station located in Oshawa south of the 401). This station showed the impacts of road salton the highway. The remaining stations show that chloride trends continue to increase.

Mean values showed that chloride concentrations are higher in monitoring locations in the south end of the study area (downstream locations SWQ 1, 2, 3, 12, 14, and 34). This is likely due to the south end of the study area having a higher degree of urbanization than the north end, which leads to a greater use of road salt. The highest chloride concentrations are found at stream-monitoring stations located at Lynde, Oshawa, Montgomery (discontinued in 1994), Farewell, Black, Harmony, Bowmanville (SWQ4), and Soper (SWQ5) stations.

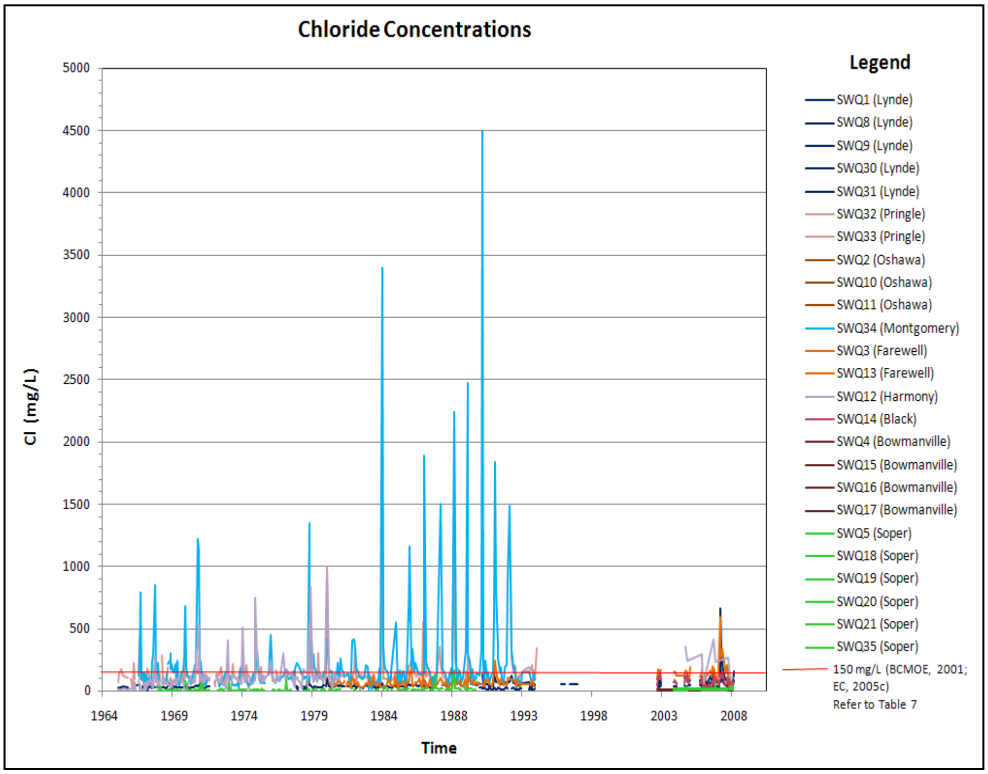

Figure 2.9: Chloride Concentrations in the Study Area (current and historical surface water quality monitoring stations) between 1964 and 2008. No data were available between 1994 and 2003
(Surface Water Quality Monitoring (SWQ) station locations are in Figure B.1 (Appendix B) and listed in Table 2.7.)

Increasing chloride concentrations were noticed at ten of the current stream-monitoring stations, while nine stations did not show any change between 2003 and 2008. Chloride is not currently a matter of concern in municipal drinking water supplies in CLOSPA as concentrations are not elevated at the Lake Ontario intakes. Concentrations in Lake Ontario (Durham Region intakes) are recorded between 20-30 mg/l in the raw water.

The surface water quality data also shows seasonal trends in chloride concentration. In Lynde Creek, concentrations are greatest in the winter months (December to March), when road saltapplication is most frequent (see **Figure 2.10**).

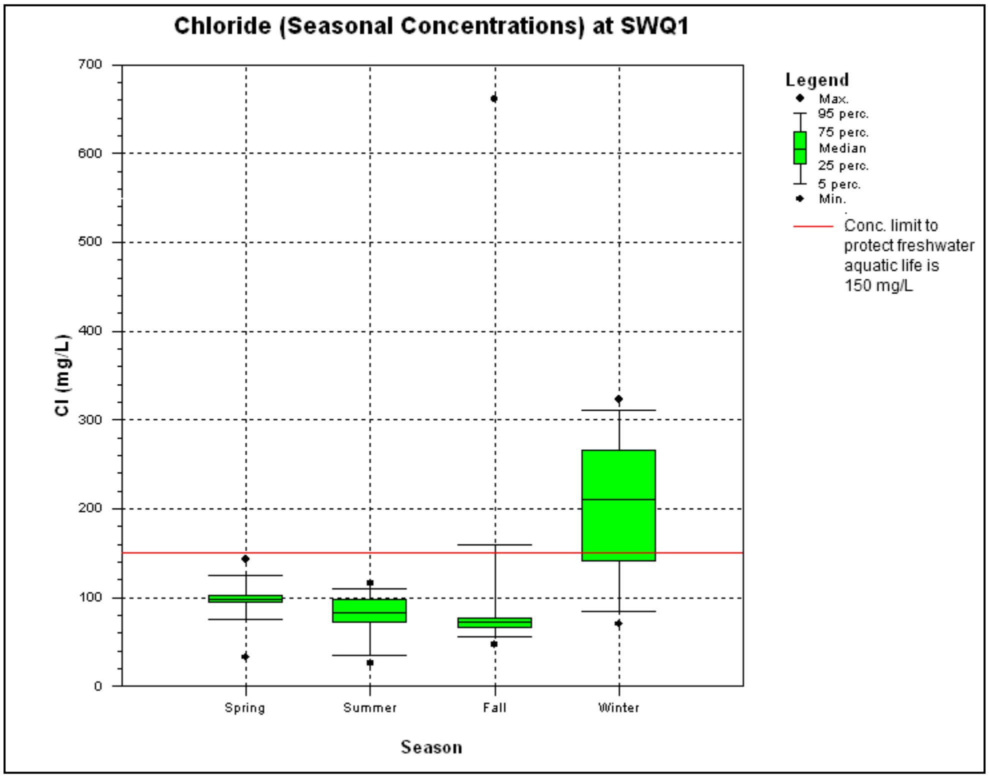

Figure 2.10: Seasonal Chloride Concentrations at Lynde Creek Stream-Monitoring Station (SWQ1) CLOCA

(Surface Water Quality Monitoring (SWQ) station locations are in Figure B.1 (Appendix B) and listed in Table 2.7.)

2.4.7 Tributary Loadings to Lake Ontario

It is important to recognize that the Niagara River accounts for 80 percent of the flow entering Lake Ontario. The Niagara River is the largest single source of materials entering the lake and has a dominating influence on the chemistry of the entire lake. However, contaminants from other water courses can influence near shore water quality along the CLOSPA shoreline of Lake Ontario following major storm events. These events typically occur in the summer months, and during periods of snow melt or rainfall induced runoff during frozen ground periods over winter. Whether water treatment plant intakes within the CLOSPA jurisdiction are affected depends on mixing and circulation patterns in the lake. Watershed inputs can, under certain “in-lake” mixing conditions, impact the quality of source waters entering the municipal drinking water treatment plants.

In CLOSPA there are limited stream flow measurements taken near the discharges of tributaries into Lake Ontario. This makes estimating pollutant loads for CLOSPA watersheds draining into the lake difficult. There are water quality surveys that encompass a full range of streamflow conditions. CLOSPA’s existing streamflow and water chemistry monitoring network was purposely designed for watershed planning and flood management purposes as oppose to estimating tributary loading. Water chemistry is monitored on a monthly basis during the late spring to early fall periods, which yields about eight observations a year. While the streamflow stations are well placed for monitoring, they are of limited value in quantifying contaminant loading in the lake. This challenge is not unique to CLOSPA. Agencies in both Canada and the United States face challenges in estimating loading from tributaries to Lake Ontario.

At times contaminants from other watercourses can influence near shore water quality along the CLOSPA shoreline of Lake Ontario. These times occur following major storm events in the summer months and during periods of snow melt or rainfall induced runoff during frozen ground periods over winter. Mixing and circulations patterns in the lake will in turn determine whether or not drinking water plant intakes within the CLOSPA region are affected. It is recognized that watershed inputs, can under the right “in lake” mixing conditions impact of the quality of source waters entering the Durham Region drinking water treatment plants. While the intakes have purposely been located to limit interference from watersheds, spill scenarios modelled as part of IPZ-3 studies (described in **Chapter 5**) show that spills of contaminants in the tributaries can reach intakes.

There are insufficient resources to monitor all watersheds entering Lake Ontario at the frequency required to provide accurate estimates of pollutant loads. Using data gathered as part of the lake wide studies for the Lake Ontario Collaborative, it is possible to estimate loads for total suspended solids for the CLOSPA watersheds. These estimates are based on detailed surveys conducted in 2008 and 2009 in the nearby Duffins Creek watershed. Load estimates for Duffins Creek watershed are extrapolated to CLOSPA watersheds. In developing these estimates assumptions are made that land use and climatic conditions are similar.

Figure 2.11 presents annual load estimates for total suspended solids a parameter which is recognized as being a good surrogate for pollutants that adhere to particulate matter. Suspended solids are also a key factor in the turbidity of nearshore areas. As expected, on an annual basis suspended solid loads are proportional to the drainage areas of the watersheds and runoff volumes. Seasonal patterns in suspended solid transport (**Figure** 2.12: and **Figure** 3.13:), show significantly higher monthly loads over the winter and spring periods. Year to year variations in seasonal loads are attributed to patterns in precipitation and snow melt conditions. During mild winters, the watersheds will respond immediately to snowmelt and large precipitation events. For colder winter months, with prolonged periods of snowfall accumulation- peak runoff will be delayed until milder temperatures melt the snow pack. Significant loading events occur when there is a combination of warm weather, and rainfall coupled with melting of the snow pack.

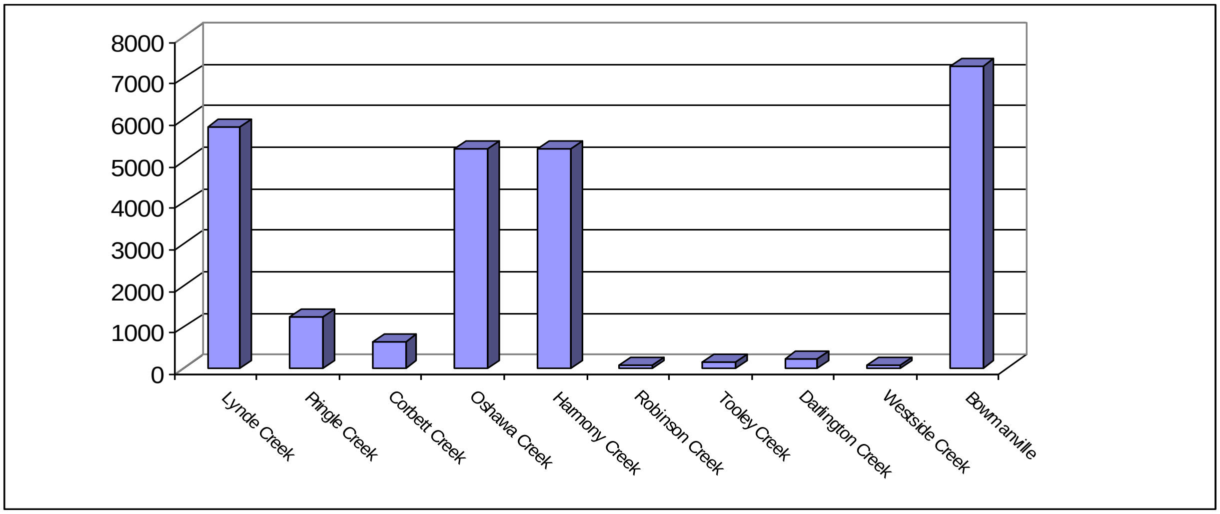

Figure 2.11: Annual Suspended Solid Load (Metric Tons) by Watershed

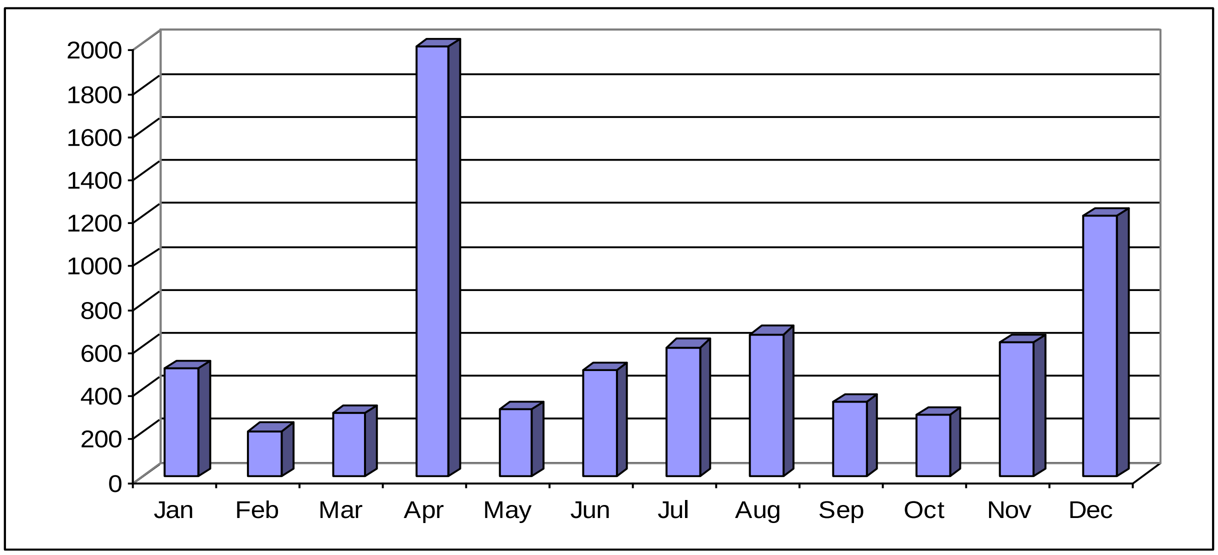

Figure 2.12: 2008 Monthly Suspended Solid Load (Metric Tons) Lynde Creek

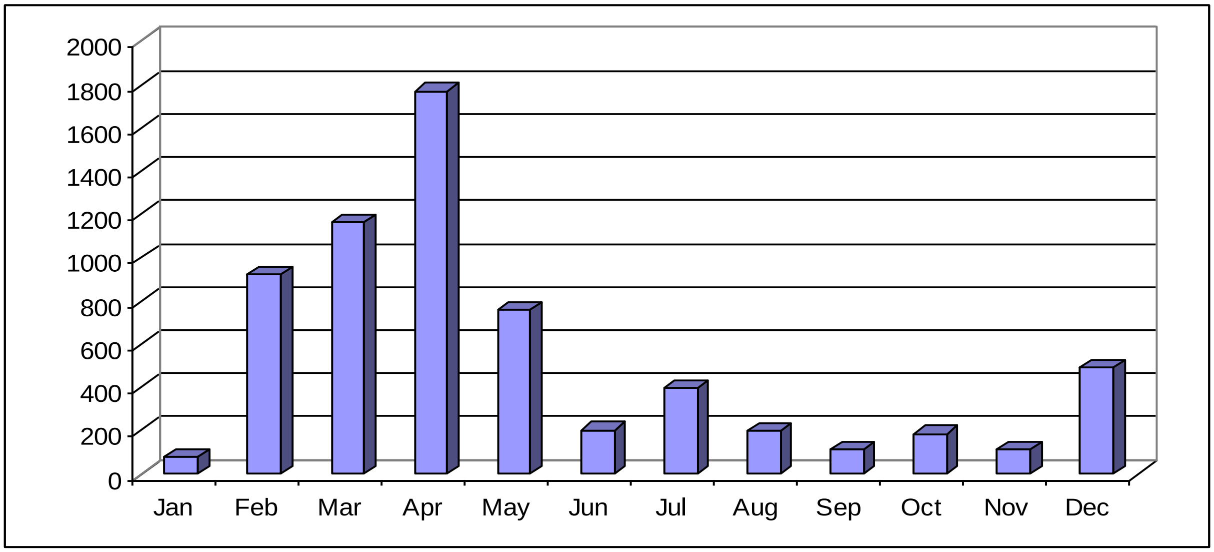

Figure 3.13: 2009 Monthly Suspended Solid Load (Metric Tons) Lynde Creek

Daily loads presented in **Figure** 4.14: illustrate that a few large events occur each year that transport a significant proportion of the load to the lake. It is during these periods that watershed influences will likely be observed at drinking water intakes in Lake Ontario. When and where spikes of turbidity occur at the intakes will depend upon physical mixing and transport functions of the nearshore zone. Lake wide modelling studies, undertaken as part of IPZ-3 studies (**Chapter 5**) can be of assistance in interpreting what constitutes important local watershed runoff events. Of course, extreme storm can occur at anytime- including the summer months.

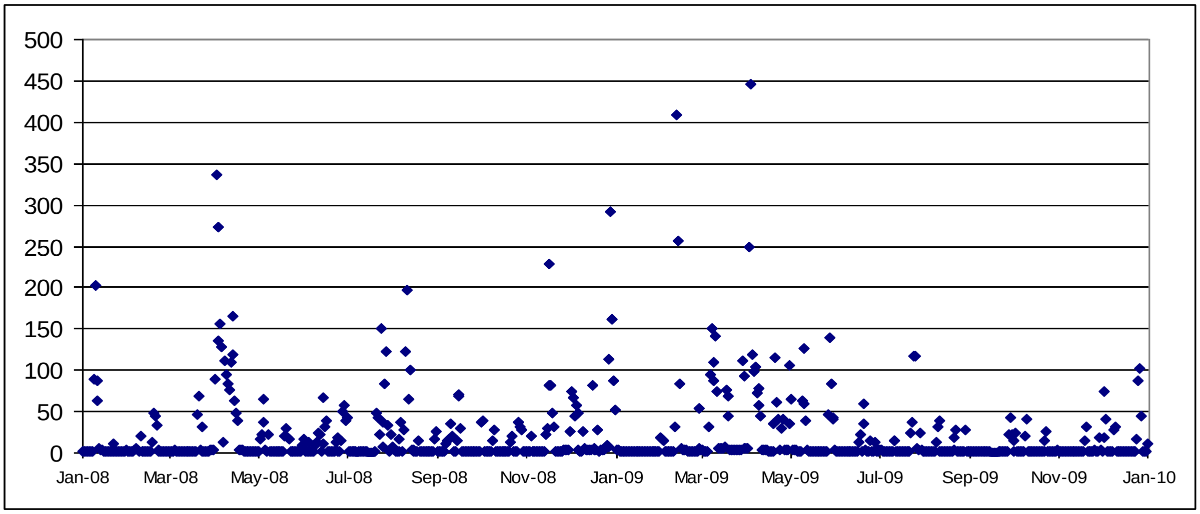

Figure 4.14: Daily Suspended Solid Load (Metric Tons) Lynde Creek in 2008 and 2009

2.4.8 Groundwater Quality

Monitoring Stations

All groundwater monitoring stations in the study area are part of the Provincial Groundwater Monitoring Network (PGMN) and are shown in **Figure 2.14.** The PGMN is a partnership program between the Province and all 36 Ontario conservation authorities and ten municipalities (in areas not covered by a conservation authority) to collect and manage information on groundwater quality and levels from key *aquifers* located across Ontario. These wells are maintained by the conservation authority and the Province.

Aquifer: An underground layer of water-bearing sediments (e.g., sand, gravel) or permeable rock from which groundwater can be usefully extracted via a water well.

CLOCA is currently collecting water quality samples from 16 monitoring wells biannually, once in spring and once in fall. All monitoring wells and their depths are listed below in **Figure 2.14** and **Table 2.8** CLOCA has been collecting groundwater quality samples for the PGMN since 2003. Samples have been historically collected twice per year up to 2010 when sampling frequency was reduced to once per year. To date there has been nine to 11 sample periods for each monitoring well since the start-up of the program.

Grouping	Rationale	Screen Depth (m)	Aquifer	Well Name
1	Recent Deposits & Depth <10m	5.8	Shallow Aquifer (Recent Deposits)	W0000263-1
		9.15		W0000040-1
		11.9		W0000044-2
2	Oak Ridges Moraine Deposits & Depth <30m	7.3	ORM	W0000264-2
		4.76		W0000167-1
		13.1		W0000049-1
		16.8		W0000262-1
		25.9		W0000261-1
3	Oak Ridges Moraine Deposits & Depth >30m	40.3		W0000166-1
		48.9		W0000264-3
		48.6		W0000042-1
4	Thorncliffe Fm	27.1	Thorncliffe Fm	W0000168-1
		36.48		W0000044-3
		34.7	Thorncliffe Fm – Bedrock Contact	W0000043-3
		45.2		W0000041-1
5	Scarborough Fm	122.5	Scarborough Fm	W0000265-2

Table 2.8: Groundwater Monitoring Wells Grouped Together for Analysis (Groupings are based on aquifer unit and depth)

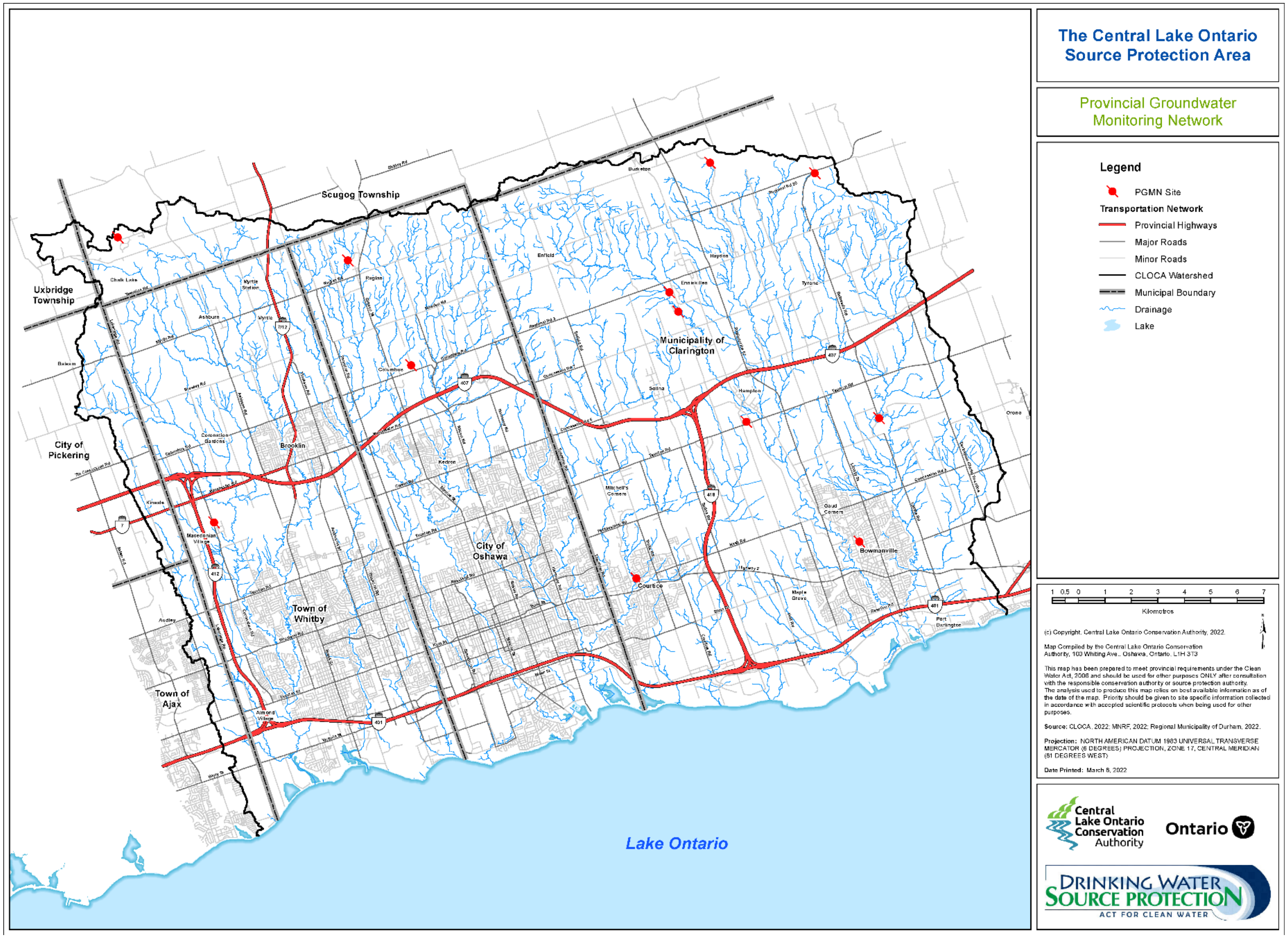

Figure 2.15 Provincial Groundwater Monitoring Network

Groundwater Quality Results

Water quality data for each monitoring site has been compared to the Ontario Drinking Water Standards (*ODWS*) to help identify water quality problems in the aquifers, which is the source for many private systems (wells). All groundwater samples are displayed in **Table A.3**, **Appendix A** and ODWS exceedances have been highlighted. Parameters that have exceeded the ODWS include 1, 4 Dichlorobenzene, aluminum, chloride, iron, manganese, sodium, colour, dissolved organic carbon, hardness, lead, selenium, zinc, and turbidity. Among the chemical constituents, sodium and iron are the parameters that tend to exceed most often. 1, 4 Dichlorobenzene was noted over the prescribed limit once (at W0000264-2) during the first round of sampling.

ODWS: Water quality standards through which the Provincial Government of Ontario regulates drinking water quality. Standards contain maximum allowable concentrations (MAC) for major inorganic and organic parameters in water.

Many of the monitoring wells in the study area have exceeded ODWS parameters consistently since the beginning of the sampling period. Each of the PGMN stations had recorded exceedances ranging from three to 49 on various parameters.

- The monitoring station at Enniskillen Centre (W0000167-1) was found to have the most exceeded parameters. Among the parameters that did not meet the aesthetic objectives and operational guidelines of the *ODWS* were iron, manganese and hardness (CaCO3), which adversely affected the turbidity and colour of the well water.

Many parameters that exceed the ODWS, such as sodium, manganese and iron, occur naturally. Naturally elevated parameters can be present due to geological materials in the area, the recharge environment, or other factors.

- Exceedances in iron concentrations were observed mostly in wells tapping the Oak Ridges Moraine Complex, except in the northeastern areas where W0000264-3 and W0000042-1 are located.
- Sodium was observed in elevated concentrations in both the recent deposits and the deeper aquifers of Thorncliffe and Scarborough formations, while it was generally low in the Oak Ridges Moraine Complex (except in the northeastern boundaries).

Chloride concentrations in groundwater samples were examined to determine whether groundwater has been impacted by surface sources of contamination. Typically, chloride concentrations in groundwater are relatively low. High chloride levels in combination with sodium may indicate that wells have been influenced by surface activities. **Figure 2.15** is a map showing the chloride concentrations for all PGMN wells within the study area. Three wells in the study area have average chloride concentrations that exceed the ODWS of 250 mg/L. The wells with the highest average chloride concentrations (W0000040-1, W0000043-3, and W0000263-1) are located in more urbanized and densely populated areas than those with low chloride concentrations.

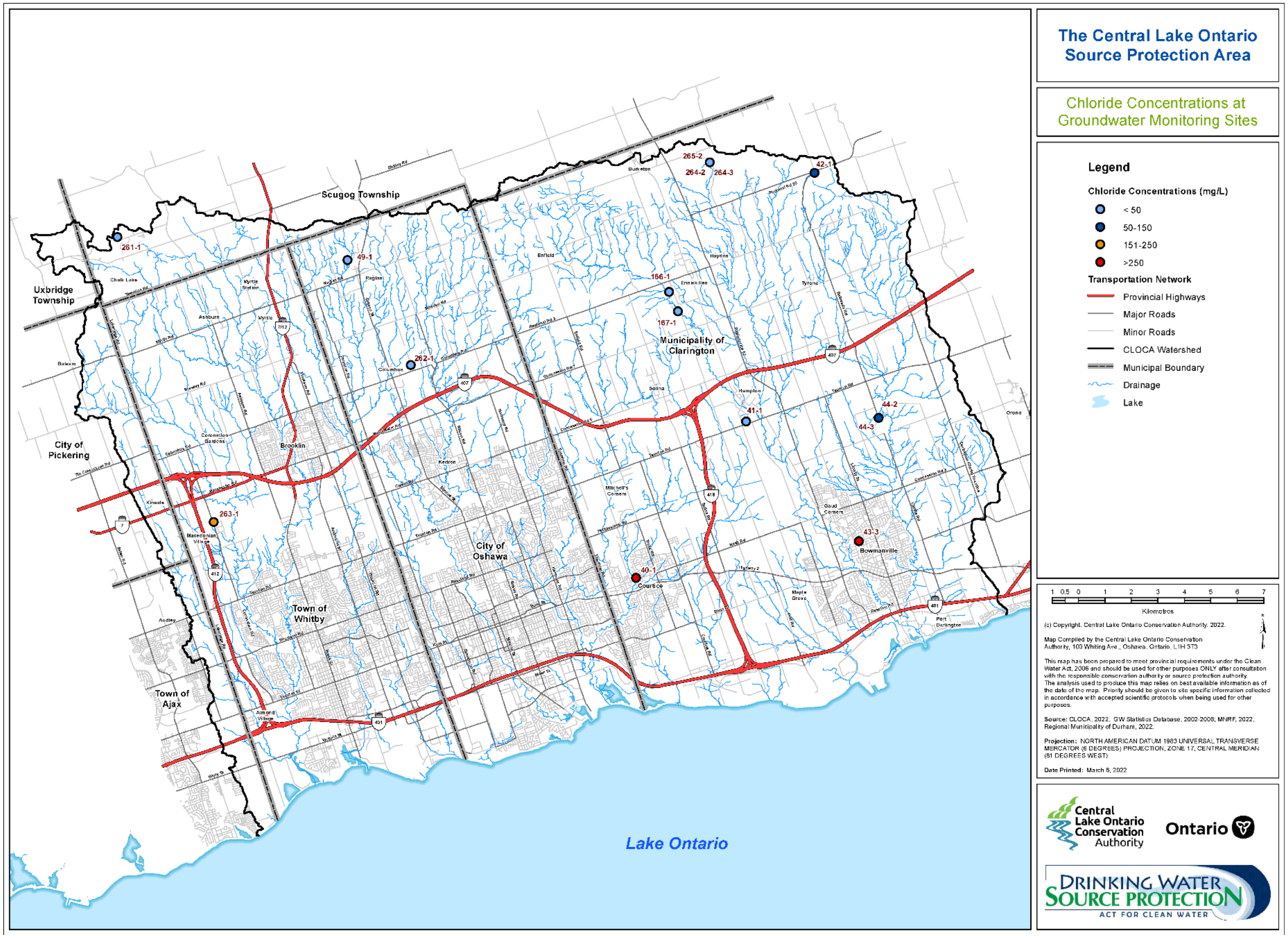

Figure 2.16: Chloride Concentrations at Groundwater Monitoring Sites

Analysis of Trends at Each Monitoring Well

Groundwater quality trends can be interpreted using time series plots and statistical software. Trends at the PGMN wells were analysed for each groundwater indicator parameter using AquaChem software, and statistical analysis was completed for general groundwater. Ideally, statistical analysis of groundwater should be based on a set of at least than 25 samples. The provincial groundwater monitoring program is relatively new, so this analysis includes only up to 12 samples from each monitoring well.

Table 2.9 summarizes trends indicated by the data points represented on the time series plots. The accuracy of these results may be limited by the small number of samples. Continued groundwater monitoring is needed to determine any long-term water quality issues or trends in the study area.

Well Name	Aquifer	Sulfate	Chloride	Nitrates	Nitrites	Sodium
W0000263-1	Shallow Aquifer (Recent Deposits)	Decreasing Trend	Decreasing Trend	No Trend	No Trend	Decreasing Trend
W0000040-1	Shallow Aquifer (Recent Deposits)	Decreasing Trend	No Trend	Decreasing Trend	No Trend	No Trend
W0000044-2	Shallow Aquifer (Recent Deposits)	No Trend	No Trend	No Trend	No Trend	No Trend
W0000264-2	ORM <30m	Decreasing Trend	No Trend	No Trend	No Trend	Decreasing Trend
W0000167-1	ORM <30m	No Trend	No Trend	No Trend	No Trend	No Trend
W0000049-1	ORM <30m	Increasing Trend	Increasing Trend	No Trend	No Trend	Decreasing Trend
W0000262-1	ORM <30m	No Trend	No Trend	No Trend	No Trend	No Trend
W0000261-1	ORM <30m	No Trend	No Trend	No Trend	No Trend	Decreasing Trend
W0000166-1	ORM >30m	Decreasing Trend	Increasing Trend	No Trend	No Trend	Increasing Trend
W0000264-3	ORM >30m	Decreasing Trend	Decreasing Trend	No Trend	No Trend	Decreasing Trend
W0000042-1	ORM >30m	Decreasing Trend	No Trend	Increasing Trend	No Trend	No Trend
W0000168-1*	Thorncliffe Fm	No Trend	No Trend	No Trend	No Trend	No Trend
W0000043-3	Thorncliffe Fm	No Trend	No Trend	No Trend	No Trend	No Trend
W0000044-3	Thorncliffe Fm	No Trend	Decreasing Trend	No Trend	No Trend	Decreasing Trend
W0000041-1	Thorncliffe Fm	No Trend	No Trend	No Trend	No Trend	No Trend
W0000265-2	Scarborough Fm	No Trend	No Trend	No Trend	No Trend	Decreasing Trend

Table 2.9: A Summary of Groundwater Quality Trends Found in Wells Located in the Study Area

***** W0000168-1 was decommissioned in December 2008.

Nitrite is the only indicator parameter that has no obvious trends for the sampling period, 2002–2008.

In the study period 2002–2008, chloride trends are evident in five monitoring wells in the study area. Two wells (W0000049-1 and W0000166-1) show increasing chloride levels, while three wells (W0000263-1, W0000264-3 and W0000044-3) show decreasing chloride levels.

Figure 2.17 is a time series graph for a dug well located in a residential area in Courtice. Even in this restricted sample, seasonal fluctuations are evident. Average chloride concentrations did not increase or decrease significantly, but spikes of extremely high chloride concentrations were observed in early spring or winter.

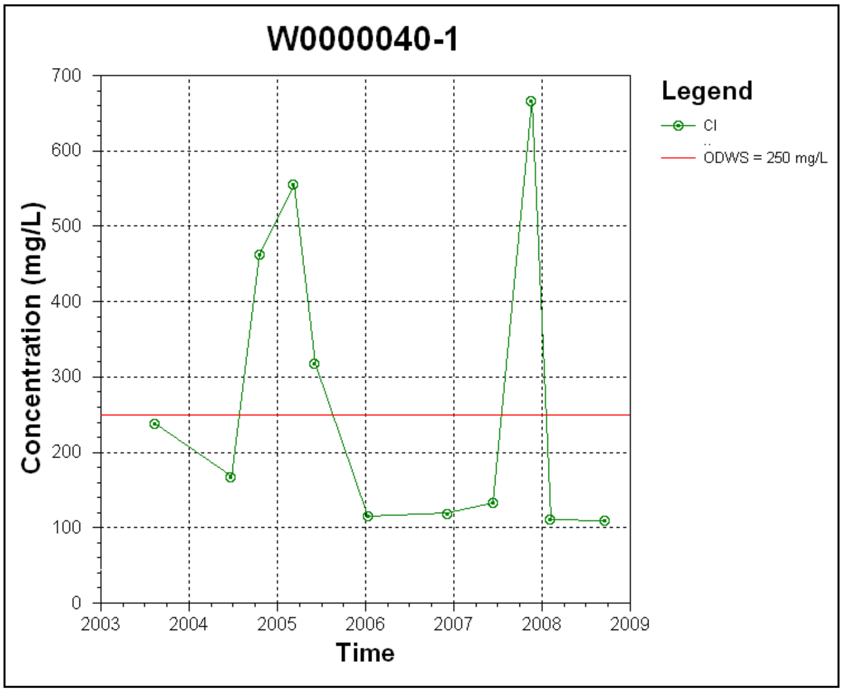

Figure 2.17: Chloride Concentrations in a Monitoring Well Located in a Residential Area in Courtice
Samples taken between 2003 and 2008. See also Table 2.9.

Nitrate trends are evident in two monitoring wells in the study period.

Figure 2.18 shows a comparison between well W000042-1, having slightly increasing nitrate levels, and the decreasing levels observed at well W0000040-1. The rest of the monitoring wells show no obvious trends within the relatively short sampling period.

Nitrate is a health related parameter that is sometimes found at elevated levels in groundwater supplies and may be a result of anthropogenic activities. As groundwater (often untreated) is a source used within the CLOSPA study area for drinking water purposes, it is important to monitor and note these trends. Nitrate is monitored at all 16 PGMN wells operated in CLOSPA. There were only two wells with observed nitrate trends from PGMN well data between 2002 and 2008 in CLOSPA.

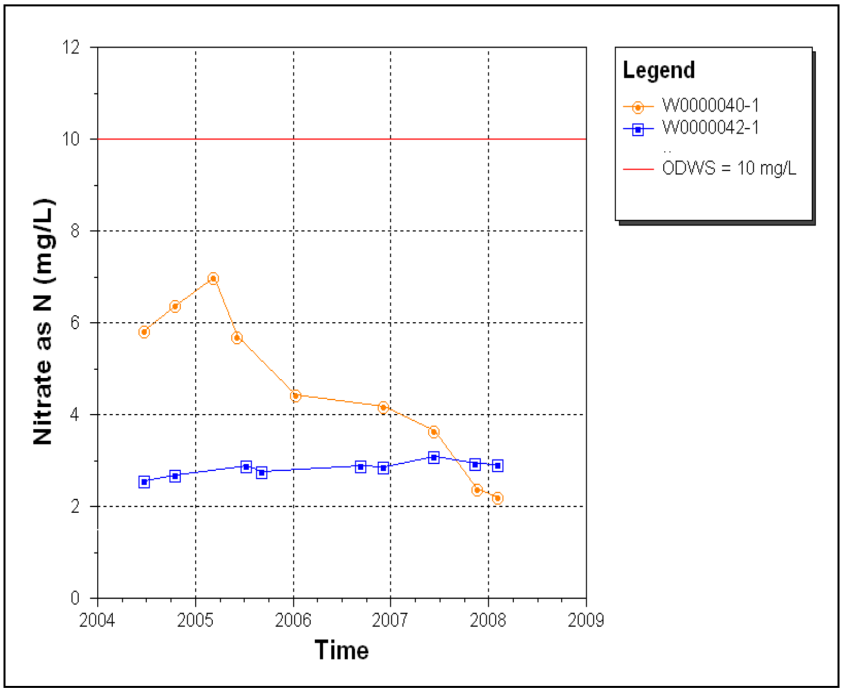

Figure 2.18: Nitrate Concentrations for Monitoring Wells W0000040-1 (Shallow Aquifer) and W0000042-1(ORM>30m)
Samples taken between 2004 and 2008. See also Table 2.9.

2.5 LAND USE

CLOSPA has developed an extensive inventory of the watershed using Ecological Land Classification (ELC) and land cover. For the ELC land cover data was derived from 2008 colour orthophotos and ELC categories used derived from the ELC for Southern Ontario (Lee *et al*., 1998*)* (see **Figure 2.18**).

2.5.1 Population, Distribution and Density

The Regional Municipality of Durham is the only upper-tier municipality within the CLOSPA. This upper-tier municipality comprises eight lower-tier municipalities - the City of Pickering, the Town of Ajax, the Town of Whitby, the City of Oshawa, the Municipality of Clarington, the Township of Uxbridge, the Township of Scugog, and the Township of Brock. Seven of these municipalities are located in whole or in part within CLOSPA (**Figure 2.1**).

- The Town of Whitby is the only municipality completely contained within the jurisdictional limits of CLOSPA.
- All but about 1.5 km^2 of the City of Oshawa lies within CLOSPA's boundaries.
- Portions of the City of Pickering, the Town of Ajax, the townships of Uxbridge and Scugog, and the Municipality of Clarington are found within CLOSPA.
- The Township of Brock is the only municipality within the Region of Durham that is not at least partially located within CLOSPA.

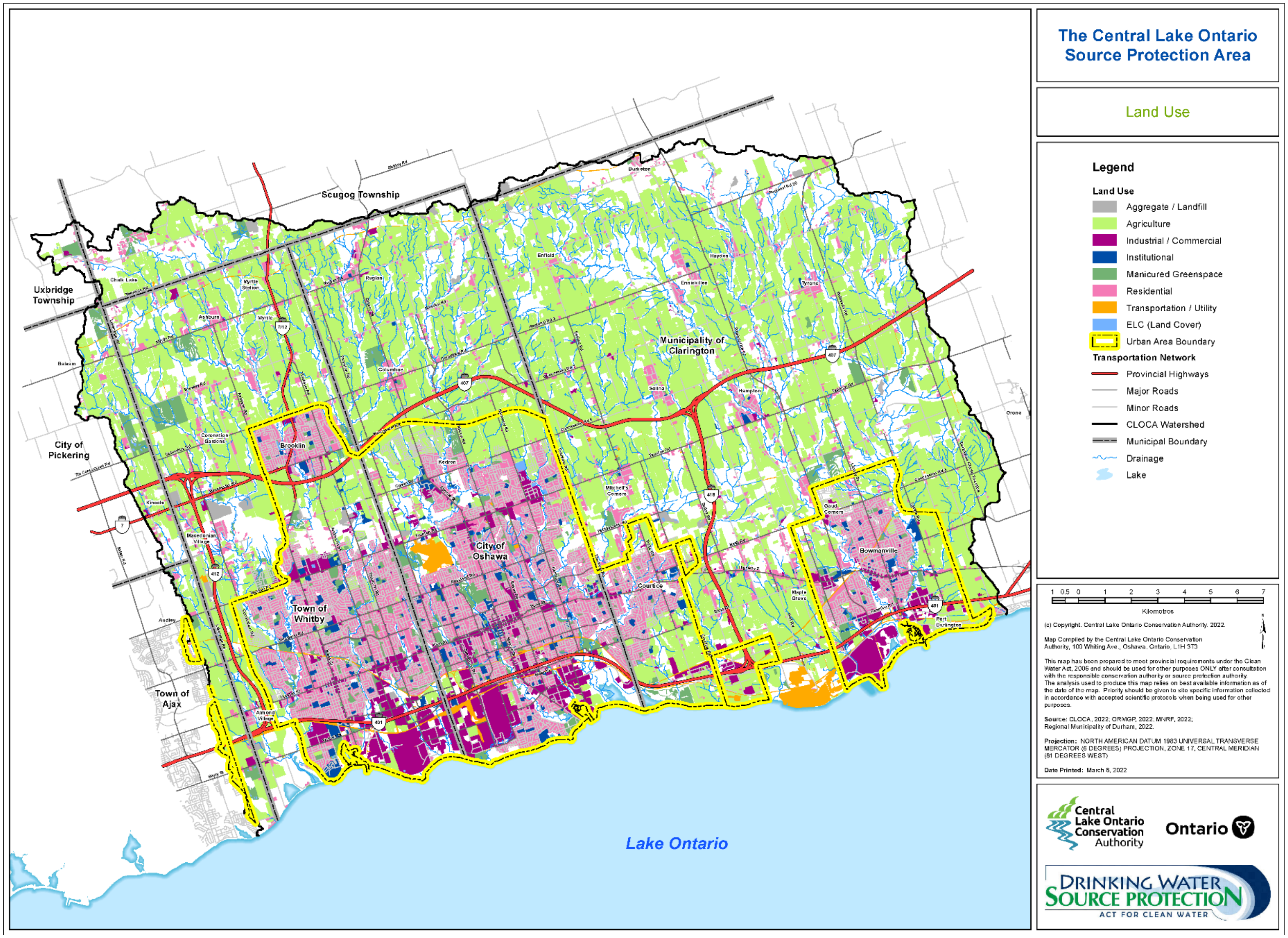

Figure 2.19: Land Use (2008)

Areas of settlement, as defined by the *Places to Grow Act, 2005*, are those lands within municipal urban boundaries, as well as hamlets and villages. Within CLOSPA, the major settlement areas dominate the Lake Ontario shoreline. This urbanized area contains the majority of the jurisdiction's population, and includes major areas of commerce and employment.

In addition to the urban settlement areas, there are 15 historic hamlets and villages scattered mostly throughout the northern portion of CLOSPA. These villages range in size and function, and their future growth and expansion is limited by provincial and municipal planning policies. Within CLOSPA, scattered rural residential development exists beyond the municipal urban boundaries and hamlets. Rural residential development includes not only farm residences, but also a good number of non-farm rural residences and some residential subdivisions. This rural development accounts for about 3% of the land area within CLOSPA.

Population density is the number of people living within of a given land area. Density can be calculated based on gross hectare or net hectare of land. When density is calculated based on net hectare, only those lands actually being used for residential purposes are included in the calculation. This means that roads, parks and institutional land areas are not included in the calculation. In this report, density has been calculated based on gross hectare of land. The methodology to determine density is consistent with Durham Region's approach. However, the boundaries for reporting are different as density is reflected in the region's analysis by lower tier municipality versus the Source Protection Authority boundary. Regional data may also be more current. **Figure 2.19** displays the population distribution in CLOSPA. Areas with the greatest population density are in Oshawa, Whitby, Courtice, and Bowmanville. The Town of Ajax has very little urban area within CLOSPA and has a population density that is similar to that of the rural areas. **Figure 2.19** also shows a connection between road networks and population density, and reflects the land cover (**Figure 2.2**) that is found within CLOSPA. The relationship between the urban area and the urban fringe (lands near existing urban areas) can also be observed. The urban fringe experiences higher average population density than land removed from urban areas.

Table 2.10 shows the total population density of the municipalities within CLOSPA and an approximation of the population density for those portions of municipalities that lie within CLOSPA. In 2006, the population density varied within CLOSPA, from a low of 0.13 persons/ha in Uxbridge to a high of 9.66 persons/ha in Oshawa. **Figure 2.19** and **Table 2.10** portray the importance of considering actual distribution of population density as opposed to average population density within a municipality.

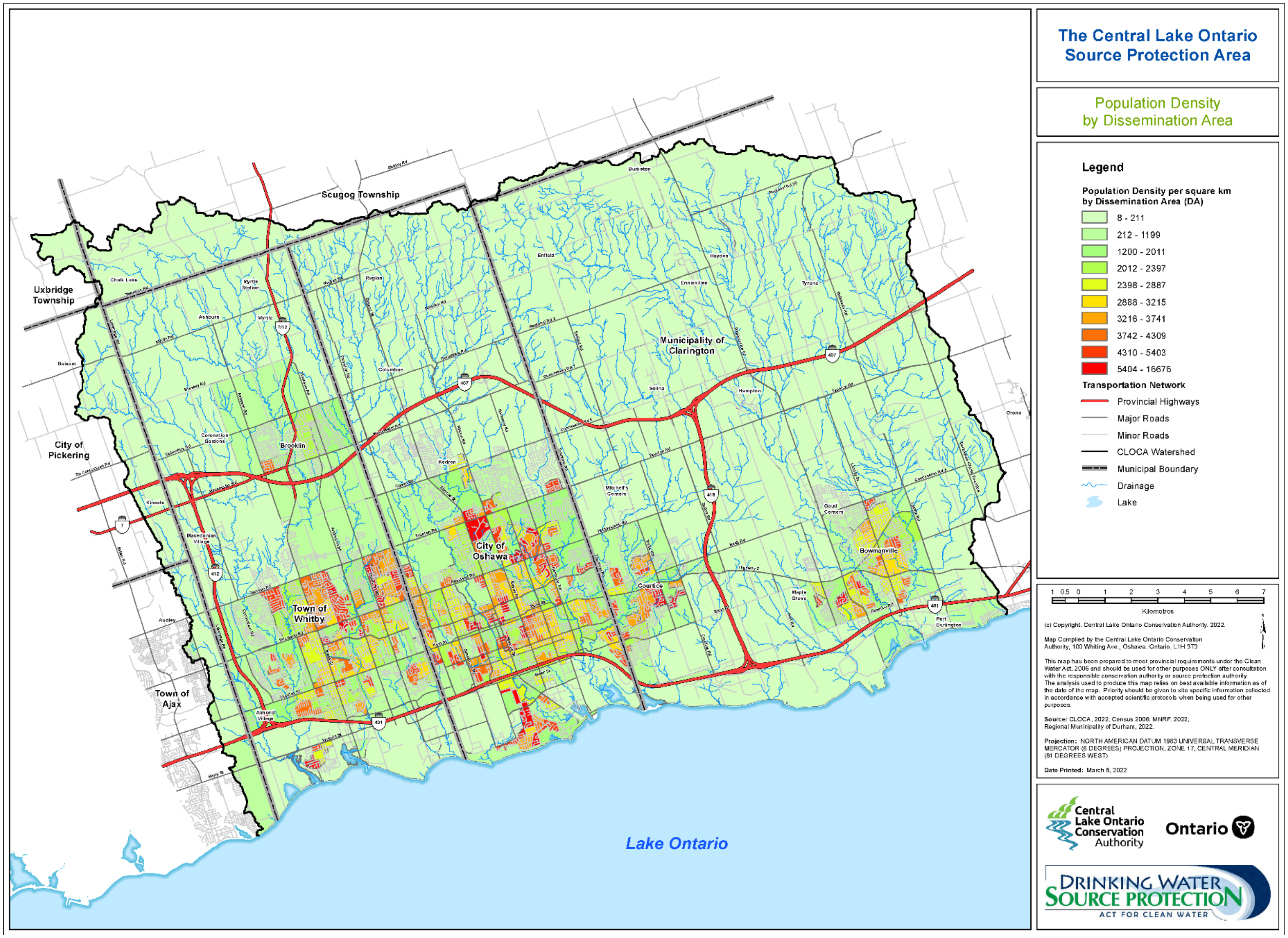

Figure 2.20: Population Density by Dissemination Area

Municipality	Area (ha)	Area (ha) in CLOSPA	2006 Population	Population Density (2006) (ha)	Approx. Population in CLOSPA* (Census Data 2006)	Approx. Population Density in CLOSPA* (Census Data 2006) (ha)
City of Pickering	23200	1309	87,838	4	293	0
Town of Ajax	6805	989	90,167	13	3285	3
Town of Whitby	14733	14733	111,184	8	111,184	8
City of Oshawa	14652	14509	141,590	10	141,556	10
Municipality of Clarington	61294	30177	77,820	1	62,978	2
Township of Uxbridge	42385	245	19,169	0	33	0
Township of Scugog	51887	1816	21,511	0	433	0
Regional Municipality of Durham	252315	63777	561,258	2	319,772	5

Table 2.10: Population Density by Municipality

(Source: extracted from Durham Region Profile Demographics and Socio-Economic Data, September 2009)

*Population and population density has been based on overall population (urban and rural) and the approximate population and the approximate population density for those portions of Pickering, Ajax, Uxbridge and Scugog that are within CLOSPA (SPA boundaries) as identified in the table do not reflect the rural nature and associated rural population distribution inherent in these areas.

The settlement areas, including growth areas identified in Amendment #128 to the Durham Region Official Plan (June 2009), are shown in **Figure 2.20**.

6.73% (4,301 ha) of the land area within CLOSPA has been designated as a future growth area (land that will be urbanized and become part of the urban boundary in the years to come). Amendment #128 was approved by the Ontario Municipal Board in January 2013.

Over the next 20 years, the Region of Durham will experience tremendous residential and employment growth (**Table 2.11**).

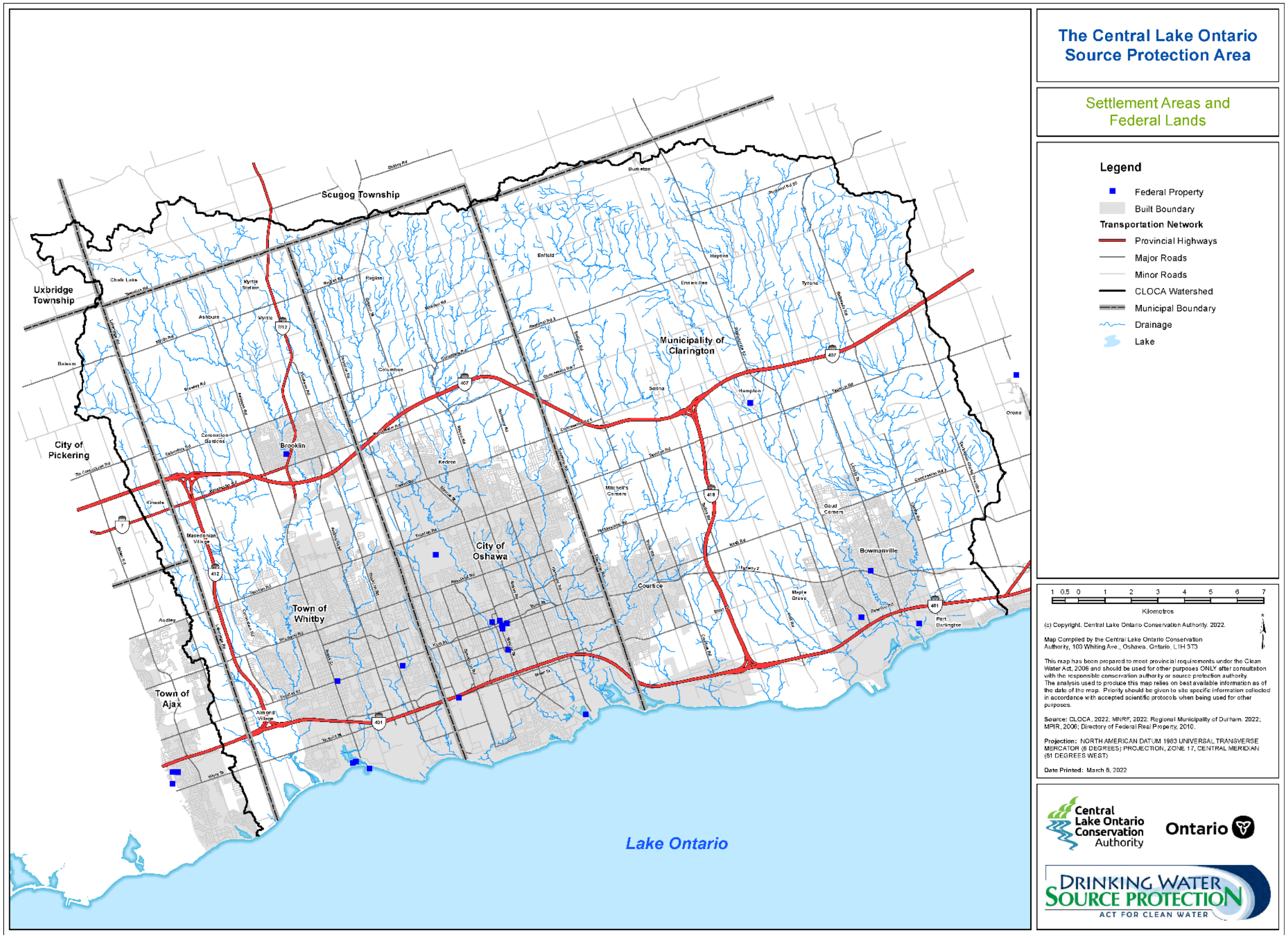

Figure 2.21: Settlement Areas and Federal Lands

It is assumed that all municipalities will experience growth in the CLOSPA, and that most of this growth will take place within those municipalities near the Lake Ontario shoreline, specifically Pickering, Whitby, Oshawa, and Clarington. Most of the job growth is predicted to occur within Pickering and Whitby. Serviced land (land that is ready to be built on) will be needed to support this growth, placing a tremendous demand on new, existing and planned infrastructure and services.

Municipality	Area (ha)	Area (ha) in CLOSPA	2006 Population	2031 Population	2006 Employment	2031 Employment
City of Pickering	23200	1309	87,838	225,670	37,220	76,720
Town of Ajax	6805	989	90,167	137,670	30,210	49,290
Town of Whitby	14733	14733	111,184	192,860	37,590	71,310
City of Oshawa	14652	14509	141,590	197,000	64,780	90,790
Municipality of Clarington	61294	30177	77,820	140,340	20,300	38,420
Township of Uxbridge	42385	245	19,169	26,965	5,610	8,970
Township of Scugog	51887	1816	21,511	25,390	7,610	9,480
Regional Municipality of Durham	252315	63777	561,258	960,000	207,180	350,000

Table 2.11: Municipal Population and Forecasted Growth 2006–2031
(Sources: Durham Region Profile Demographics and Socio-Economic Data, September 2009, and Durham Region Official Plan Amendment #128, Section 7.3.3, June 2009.)

As populations increase dramatically over the next 20 years, provincial and municipal planning practices and policies expect that population densities are also likely to increase. Dense populations promote the efficient use of existing and future infrastructure. Growth is expected to continue in the urban areas of Oshawa, Whitby, Courtice, and Bowmanville, while rural areas are not expected to experience a lot of growth.

2.5.2 Managed Lands

The *Technical Rules* require an evaluation of 'Managed Lands' which means land to which agricultural source material, commercial fertilizer, or non-agricultural source material is applied based on land use documented in the Municipal Property Assessment Corporation (MPAC) dataset. Analyses are related to the potential for nutrients to pose a threat to the quality of drinking water supplies (municipal and non-municipal). Nutrient application is listed on the provincial Tables of Drinking Water Threats as a prescribed threat. The study team must also assess the drinking water source protection vulnerable areas for livestock density for the same reason. Additionally, assessment of the percentage of impervious cover is required as an indicator of the area where winter de-icing material may be applied and potentially result in deteriorated water quality. These analyses and findings are presented in **Appendix E.**

2.5.3 First Nations Reserves and Federal Lands

There are no First Nations Reserves within the CLOSPA jurisdiction.

A description of federal lands (versus Federal buildings shown in **Figure 2.20**) is required under the *Technical Rules*. The only federal lands within CLOSPA are those associated with the Hamilton-Oshawa Port Authority, which was created in May 2009. These lands are situated at the confluence of the Oshawa Creek and the Lake Ontario shoreline. The Hamilton-Oshawa Port Authority is a Canada Customs port of entry that provides an ice-free port for full seaway-depth vessels. The facility provides bulk outdoor storage (70,000 square feet of indoor storage space), and equipment to handle loading and off-loading of cargo.

2.6 SUMMARY

The Watershed Characterization Chapter provides an overview of the watersheds in the Central Lake Ontario Source Protection Area (CLOSPA). It represents a description of the physical setting and existing conditions as they relate to overall watershed health. The chapter covers the following topics: local watershed description, ecology (including wetlands, aquatic life, and species at risk analyses), water systems and water use, water quality and trends, and land use. These discussions form the basis of a determination of drinking water status and sustainability (quantity and quality) analyses in the report as required under the *Clean Water Act, 2006.*

The watershed characterization analyses in this Assessment Report revealed that the water quality is generally good in Lake Ontario and within the study area. Raw water quality data at the intakes was available in *Lake Ontario Collaborative Intakes Protection Zone Studies* (2008). In general, the source water was found to be of high quality. The operators reported the source as excellent, relatively predictable and easy to work with. The operators reported that raw water quality fluctuations were the result of seasonal, weather-driven events. Great lake's sources of drinking are exempt from water quantity sustainability assessment.

Some increasing trends in drinking water quality parameters in shallow groundwater supplies that support private wells in the study area were observed (increases in sodium and chloride associated with the application of road salt or natural geologic formation). Shallow wells are naturally vulnerable to impacts from land-use activities. Water well construction guidelines under *Ontario Regulation 903* (Water Wells) should be strictly adhered to. Regular water quality testing is also advised.

Surface water quality is generally good with some elevated levels in phosphorus, nitrates, and copper (decreasing or no trend) and increasing trends observed with chlorides. Chloride levels while increasing are below ecosystem-based standards. Nitrate, phosphorus, and copper levels are often above the standards and are likely associated with nutrient application in agricultural and non-agricultural lands for nitrate and phosphorus and historical industrial land use for copper.

Daily loads illustrate that a few large storm events occur each year that transport a significant proportion of the load to the lake. It is during these periods that watershed influences will likely be observed at drinking water intakes in Lake Ontario. When and where spikes of turbidity occur at the intakes will depend upon physical mixing and transport functions of the nearshore zone. Lake-wide modelling studies, undertaken as part of IPZ3 studies can be of assistance in interpreting what constitutes important local watershed runoff events.

As populations increase dramatically over the next 20 years, provincial and municipal planning practices and policies suggest that population densities are also likely to increase. Dense populations promote the efficient use of existing and future infrastructure. Growth is expected to continue in the urban areas of Oshawa, Whitby, Courtice, and Bowmanville, while rural areas are not expected to experience a lot of growth. The Lake Ontario source is targeted as the drinking water supply to support growth in the CLOSPA jurisdiction.