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2.0 WATERSHED CHARACTERIZATION

The Watershed Characterization provides an overview of the *watershed* in the Credit Valley Source Protection Area (CVSPA). It is noted that the source protection jurisdiction covers the area that is managed by Credit Valley Conservation (CVC) where the Authority manages the conservation lands and conducts the monitoring programs.

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 both *aquifer* and surface water sources;
- **Water Quality and Trends:** Information on water quality (*groundwater* and *surface water*) and trends in the watershed to determine if 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.

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

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 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 CVSPA study area covers both groundwater and Lake Ontario sources, even where there are no groundwater sources for municipal drinking water. About 88% of the population in the CVSPA receives its drinking water from treatment plants that source water from Lake Ontario, while 12% receives drinking supplies from groundwater (aquifer) sources.

2.1 LOCAL WATERSHED DESCRIPTION

The characterization of the CVSPA has been detailed in the report *Interim Watershed Characterization of the Credit River Watershed, CVC, 2007*, 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, 2009*.

Additional work was undertaken in 2008/2009 on the data so that this 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 CVC, and by those made available through collaboration with various private and public organizations. Where possible, the data and information has also been updated in an attempt to bridge the time gap to 2009.

Environmental, hydrological, hydrogeological, water quality, and water quantity data have been collected, and chronicled through various CVC monitoring programs and data collection networks. The primary datasets maintained by the CVC and its municipal partners, and their respective roles in the characterization exercise are presented in **Appendix A and** summarized in sections below.

Many organizations have contributed in this effort, and include the federal government, provincial agencies, Conservation Ontario, member municipalities, and neighbouring conservation authorities. These organizations have been instrumental in completing this work and are listed in **Appendix B** along with specific data sets pertaining to inferences made in the characterization of the CVSPA.

The area managed by the Credit Valley Conservation (CVC):

- Is located in the Greater Toronto Area (GTA);
- Covers an area of 1000 km^2, bounded to the south by Lake Ontario, to the east by the Toronto and Region Source Protection Area (TRSPA), to the north by the Nottawasaga Valley Source Protection Area (NVSPA), and the Grand River Source Protection Area (GRSPA), and to the west by Halton-Hamilton Source Protection Area (HSPA); and
- Includes all or part of the:
    - Townships of Amaranth and East Garafraxa;
    - Towns of Orangeville, Mono, Erin, Halton Hills, Caledon, and Milton; and
    - Cities of Mississauga, Brampton, Oakville, and Toronto.

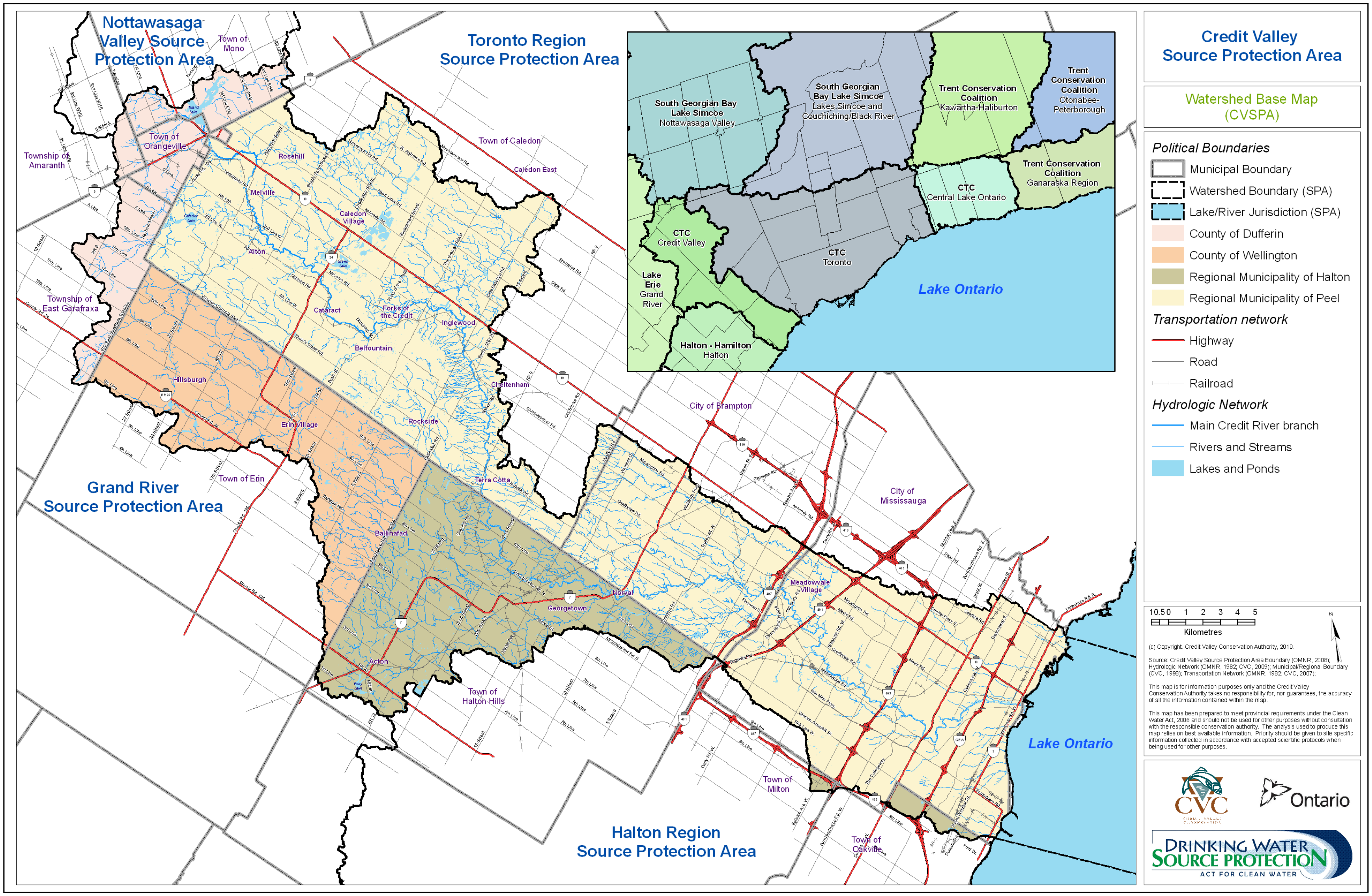
These areas are shown in **Figure 2.1**. CVC owns or manages a number of conservation areas within the study area. From north to south, they are as follows:

- Island lake
- Upper Credit
- Elora Cataract Trailway
- Belfountain
- Ken Whillans Resource Management Area
- Terra Cotta
- Silver Creek
- Limehouse
- Meadowvale
- Rattray Marsh

The Credit River Watershed contains 22 subwatersheds, each representing a major drainage area of the Credit River. These are listed in **Table 2.1** and shown in **Figure 2.2**. The Credit River meanders southeast for nearly 90 km from its headwaters at Orangeville, through nine municipalities, finally draining into Lake Ontario at Port Credit in Mississauga.

Table 2.1: Subwatersheds of the Credit River Watershed

Subwatershed Name	Number	Area (km^2)
Loyalist	1	9.83
Carolyn Creek	2	5.56
Sawmill Creek	3	16.45
Mullett Creek	4	32.94
Fletcher’s Creek	5	42.51
Levi Creek	6	24.72
Huttonville Creek	7	15.10
Springbrook Tributary	8a	4.78
Churchill Tributary	8b	8.45
Norval to Port Credit	9	72.83
Black Creek	10	79.28
Silver Creek	11	48.78
Credit River – Cheltenham to Glen Williams	12	62.08
East Credit River	13	50.58
Credit River – Glen Williams to Norval	14	23.12
West Credit River	15	105.56
Caledon Creek	16	51.99
Shaw’s Creek	17	72.04
Credit River – Melville to Forks of the Credit	18	39.19
Orangeville	19	59.82
Credit River – Forks of the Credit to Cheltenham	20	46.05
Lake Ontario Shoreline West Tributaries	21	33.05
Lake Ontario Shoreline East Tributaries	22	44.25



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Source: Credit Valley Source Protection Area Boundary (OMNR, 2008); Hydrologic Network (OMNR, 1982; CVC, 2009); Municipal/Regional Boundary (CVC, 1998); Transportation Network (OMNR, 1982; CVC, 2007);

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DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER

Figure 2.1: Watershed Base Map (CVSPA)

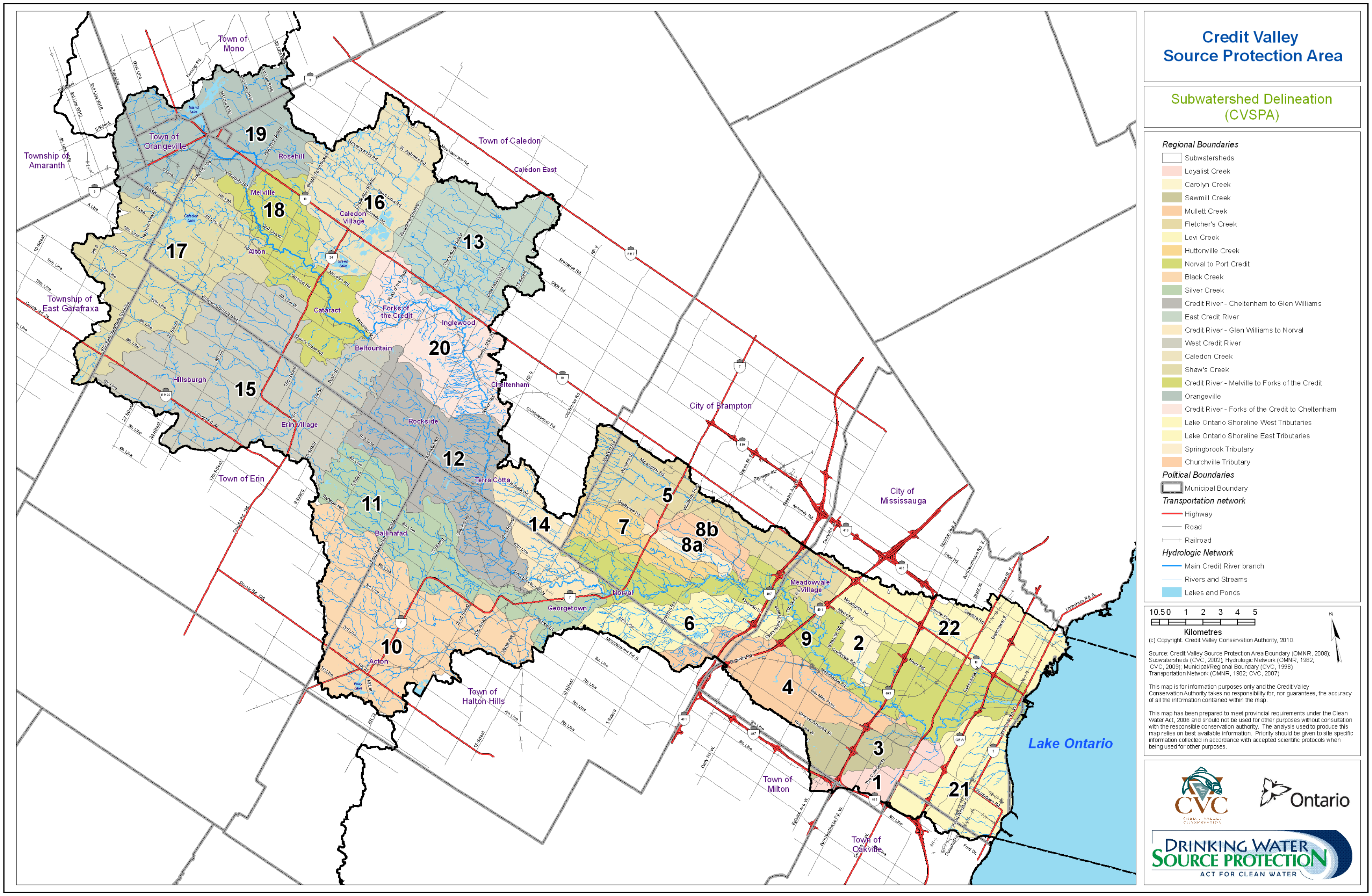


Figure 2.2: Subwatershed Delineation (CVSPA)

Several small streams that drain directly into Lake Ontario have been grouped into the "Lake Ontario Catchments" category (subwatersheds 21 and 22).

Nearly 1500 km of streams and creeks empty into the Credit River along its route including Black Creek, Silver Creek, West Credit River, Shaw's Creek, East Credit River, Fletchers Creek, Caledon Creek, and several others.

The Credit River consists of three main branches:

- The Main Credit River, through Orangeville and Alton;
- The West Credit River through Hillsburgh, Erin, and Belfountain; and
- The East Credit River at Inglewood.

Both the main branch and the West Credit River flow through deep re-entrant valleys in the Niagara Escarpment, joining at the Forks of the Credit. Downstream of this point, the valley forms a wide alluvial plain and is joined by the East Credit River at Inglewood. The River is then diverted northward by a barrier beach before flowing to Lake Ontario at Port Credit.

The CVSPA contains portions of three land features, which influence and inform the planning processes governing growth and development within member municipalities. These are indicated in **Figure 2.3**, and are as follows:

- A *Greenland system* covering about a third of the CVSPA, providing natural areas for wildlife, conservation and recreation;
- The *Niagara Escarpment*, which crosses the central area of the Credit River Watershed; and
- The *Oak Ridges Moraine* in the western limit located in the north-eastern section.

The CVSPA can be generally described as consisting of three *physiographic zones* **-** the upper, middle and lower zones.

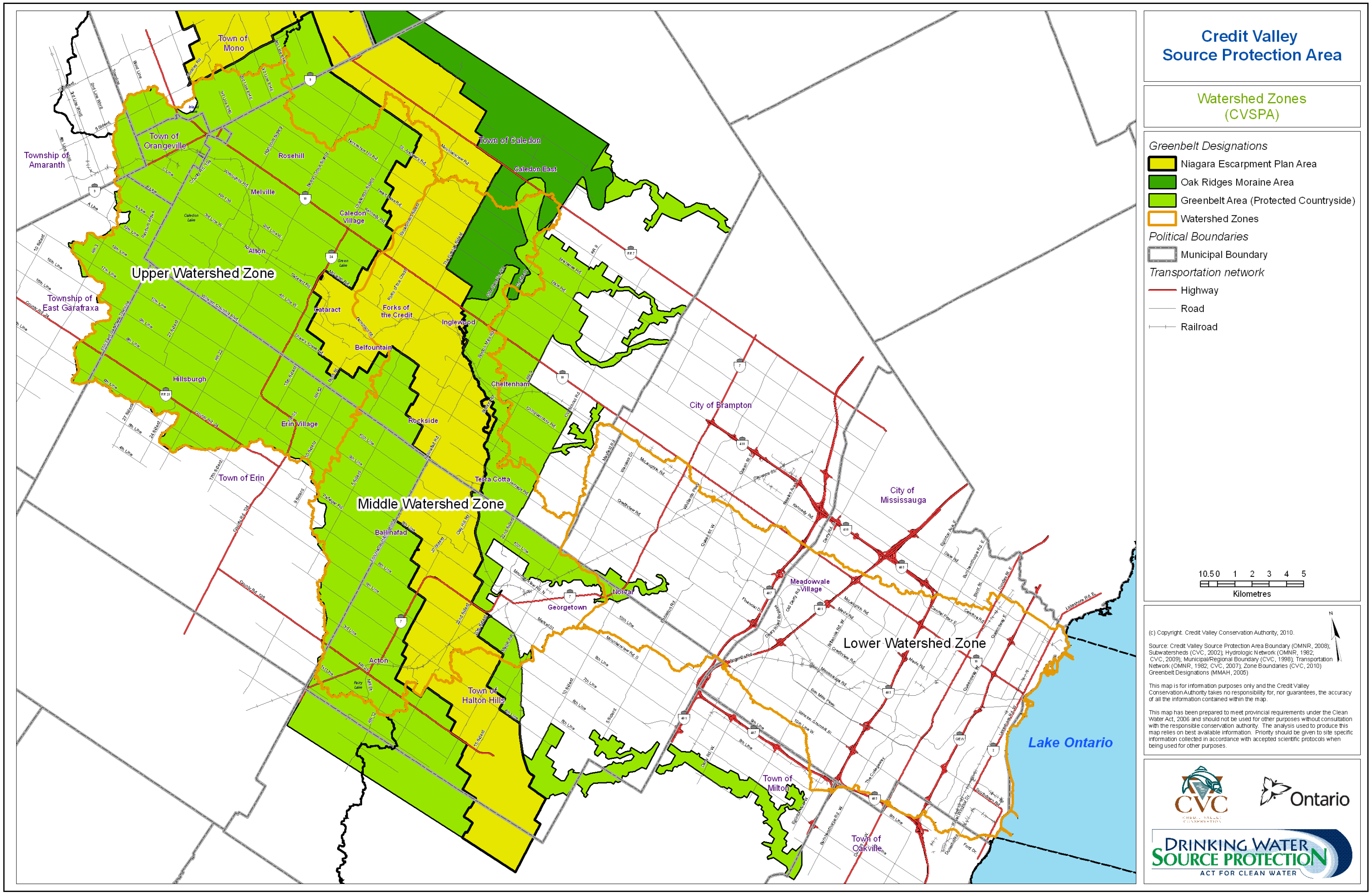
Physiographic zone: An unchanging continuous land form with a generally consistent topography, morphology, and geologic origin.

Upper Zone

This zone comprises subwatersheds 13, 15, 16, 17, 18 and 19 (total area – 379.2 km^2) and are areas existing on or above the Niagara Escarpment. Approximately 60% of this zone is a heavily forested greenland system, with dominant vegetation being deciduous forest and white cedar swamps. This zone is comprised of till plains, moraines, and glacial spillways. The ground surface is undulating, and this region is generally well drained. The soils have moderate to high permeability and are capable of permitting significant infiltration to support the regional groundwater system. The western tip of the Oak Ridges Moraine Complex outcrops in the eastern edge of the zone (Subwatershed 13). Urban centres here include Mono, Amaranth, East Garafraxa, Orangeville, Erin, Alton, and Hillsburgh.

The most significant hydrologic feature here is the Island Lake Reservoir and control structure. This reservoir, located in Subwatershed 19, forms the *headwaters* of the Credit River Watershed, and comprises two dams. Its primary objective is augmenting low flows in the headwaters and improving the water quality in the upper reaches of the river.

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



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Source: Credit Valley Source Protection Area Boundary (OMNR, 2008); Subwatersheds (CVC, 2002); Hydrologic Network (OMNR, 1982; CVC, 2009); Municipal/Regional Boundary (CVC, 1998); Transportation Network (OMNR, 1982; CVC, 2007); Zone Boundaries (CVC, 2010) Greenbelt Designations (MMAH, 2005)

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Figure 2.3: Watershed Zones (CVSPA)

In the Upper Zone baseflow to rivers and streams is maintained predominantly from springs and groundwater discharge, and water quality is generally good. Approximately 17% of the zone consists of upland communities where trees are the dominant vegetation type (i.e., forests and plantations). Dominant vegetation associations include sugar maple forests and white cedar swamps.

The river valley varies from a complex and highly developed system around the upper end of the Niagara escarpment to flat marshy areas in the headwater regions. The main land use in the area has traditionally been agriculture. However, in the past decade the amount of land under cultivation has decreased significantly as much of this land is being considered for rural estate development.

Middle Zone

This zone comprises subwatersheds 10, 11, 12, 14 and 20 (total area – 259. 3 km^2) and are areas which includes the Niagara Escarpment between Inglewood in the north and Norval/Georgetown to the south. This zone is heavily forested with mixed deciduous stands in upland areas and white cedar swamps in lowland regions. Wetlands occur towards the south of the escarpment.

Although the top of the escarpment is relatively flat, the predominant physiography is characterized by steep slopes, significant rock outcrops and thin overburden soil conditions. Average slopes can exceed 0.5 m/km and in some areas the escarpment is sharply defined by a cliff face. The topography in this area leads to relatively high runoff volumes and velocities, though the forest cover in this zone tends to slow the runoff and increase infiltration.

Most tributaries arise in massive headwater wetland complexes, which cover approximately 40% of the escarpment plateau. Below the escarpment the river cuts through clay plains and is characterized by steep-walled valleys with floodplains of varying widths.

The Credit River in this zone flows through a steep-walled narrow valley. Numerous small spring-fed creeks drain over the escarpment plateau into the main branch of the Credit River. The three major tributaries arising here are Silver Creek, Black Creek and East Credit. The Oak Ridges Moraine is a major feature of the East Credit River tributary.

The escarpment plateau is heavily forested with a mixture of deciduous stands in upland areas and coniferous swamps in lowland regions. Land use here is strictly regulated by the Niagara Escarpment Commission.

There are numerous recreational areas, and the Bruce Trail runs through the zone along the edge of the escarpment. Acton and Georgetown are the largest urban centres situated within this zone.

Lower Zone

This zone comprises subwatersheds 1-9, 21 and 22 (total area – 310.5 km^2) and has relatively flat topography with a gentle southward slope towards Lake Ontario. Surficial soils here have low infiltration rates in comparison to the other zones, but pockets of sand and gravels exist, and they feed local lakes and streams. In general, runoff is greater in this zone, and infiltration is significantly lower than other zones.

This zone is currently, highly urbanized and is continuing to grow. It includes the western edge of Brampton and most of Mississauga. Many of the tributaries in this zone have been channelized.

2.2 ECOLOGY

The CVSPA is home to a wide number of diverse ecological and terrestrial resources. A wide variety of aquatic plant and animal species rely on a constant supply of clean groundwater and surface water, and the reliability of this supply must be ensured for these species to thrive in the future. The Credit River supports diverse coldwater fisheries that are dependent on groundwater upwelling. Any assessment on water demand for human purposes must take into account the impact to sensitive flora and fauna dependent on groundwater and surface water features.

2.2.1 Natural Land Cover

Natural areas are important as refuges for rare plants, wildlife habitat, and as recreational areas, they are also critical to the hydrologic regime for their roles in groundwater recharge, groundwater discharge and flow attenuation.

Some natural areas are headwater discharge points, while others function as water storage or flood detention areas and provide sinks for sediments and contaminants.

Natural land cover within the CVSPA can be broadly classified into three categories: forest, w*etland,* and meadow. Treed swamps are listed under wetlands in this Assessment Report.

Within the CVSPA boundary, nearly 36% of the land cover is naturally occurring, either as forest, meadow, or wetland. This breaks down as follows:

- Forest — 14%;
- Wetland — 7%; and
- Meadow or successional, including thicket and savannah — 12 %.

Since policies protect these natural areas, forest cover is expected to increase over time as *successional areas* mature. Wetlands, woodlands, and vegetated *riparian* areas are all likely to have an impact on source water.

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

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 plants.

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

Cumulative: Increasing in effect, size, quantity, and so on by successive additions.

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.

The CVC has used ELC to map vegetation communities in the area. The level of detail in the maps 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. A single land classification map for the CVSPA was created by combining the CVC's ELC maps (1999) and recent (2008) urban land use mapping.

Figure 2.4 and **Table 2.2** show the vegetation communities that have been mapped for the CVSPA 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/*fen*, aquatic, and swamp. **Table 2.2** and **Table 2.3** list the vegetative areas (both dry land and wetland). They are also based on ELC mapping shown in **Figure 2.4**.

Table 2.2: Vegetated Areas (Dry Land) by percentage of the CVSPA Study Area

	Entire CVSPA		**Upper Zone**		**Middle Zone**		**Lower Zone**	
Classification	**Area (ha)**	**Area (%)**	**Area (ha)**	**Area (%)**	**Area (ha)**	**Area (%)**	**Area (ha)**	**Area (%)**
Other Natural Areas	**10,813**	**11.6%**	**5,212**	**16.1%**	**3,845**	**12.7%**	**1,756**	**5.7%**
Bluff	3	0.0%	0	0.0%	2	0.0%	1	0.0%
Beach/bar	52	0.1%	30	0.1%	2	0.0%	20	0.1%
Successional meadow	8,604	9.2%	4,424	13.7%	2,709	8.9%	1,471	4.7%
Successional savanna	1,891	2.0%	658	2.0%	1,008	3.3%	225	0.7%
Successional thicket	263	0.3%	100	0.3%	124	0.4%	39	0.1%

Table 2.3: Wetland Areas by percentage of the CVSPA Study Area

	Entire CVSPA		**Upper Zone**		**Middle Zone**		**Lower Zone**	
Classification	**Area (ha)**	**Area (%)**	**Area (ha)**	**Area (%)**	**Area (ha)**	**Area (%)**	**Area (ha)**	**Area (%)**
Wetlands	**6,632**	**7.1%**	**3,690**	**11.4%**	**2,594**	**8.6%**	**348**	**1.1%**
Aquatic	1,035	1.1%	600	1.9%	261	0.9%	174	0.6%
Thicket bog	2	0.0%	2	0.0%	0	0.0%	0	0.0%
Treed bog	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Marsh	1,037	1.1%	635	2.0%	310	1.0%	92	0.3%
Coniferous swamp	1,796	1.9%	1,129	3.5%	661	2.2%	6	0.0%
Deciduous swamp	1,282	1.4%	532	1.6%	707	2.3%	43	0.1%
Mixed swamp	750	0.8%	375	1.2%	367	1.2%	8	0.0%
Thicket swamp	730	0.8%	417	1.3%	288	1.0%	25	0.1%

Woodlands and Vegetated Riparian Areas

Southern Ontario's forests are the dominant historic ecosystem of the region, and harbour much of the region's biological diversity, ranging in scale from genetic material to species and communities.

In the CVSPA, only about 12% of the total area is currently covered by natural forests, though this number increases to 14% when plantations are included in **Table 2.4**. **Figure 2.4** shows the distribution of natural cover in CVSPA.

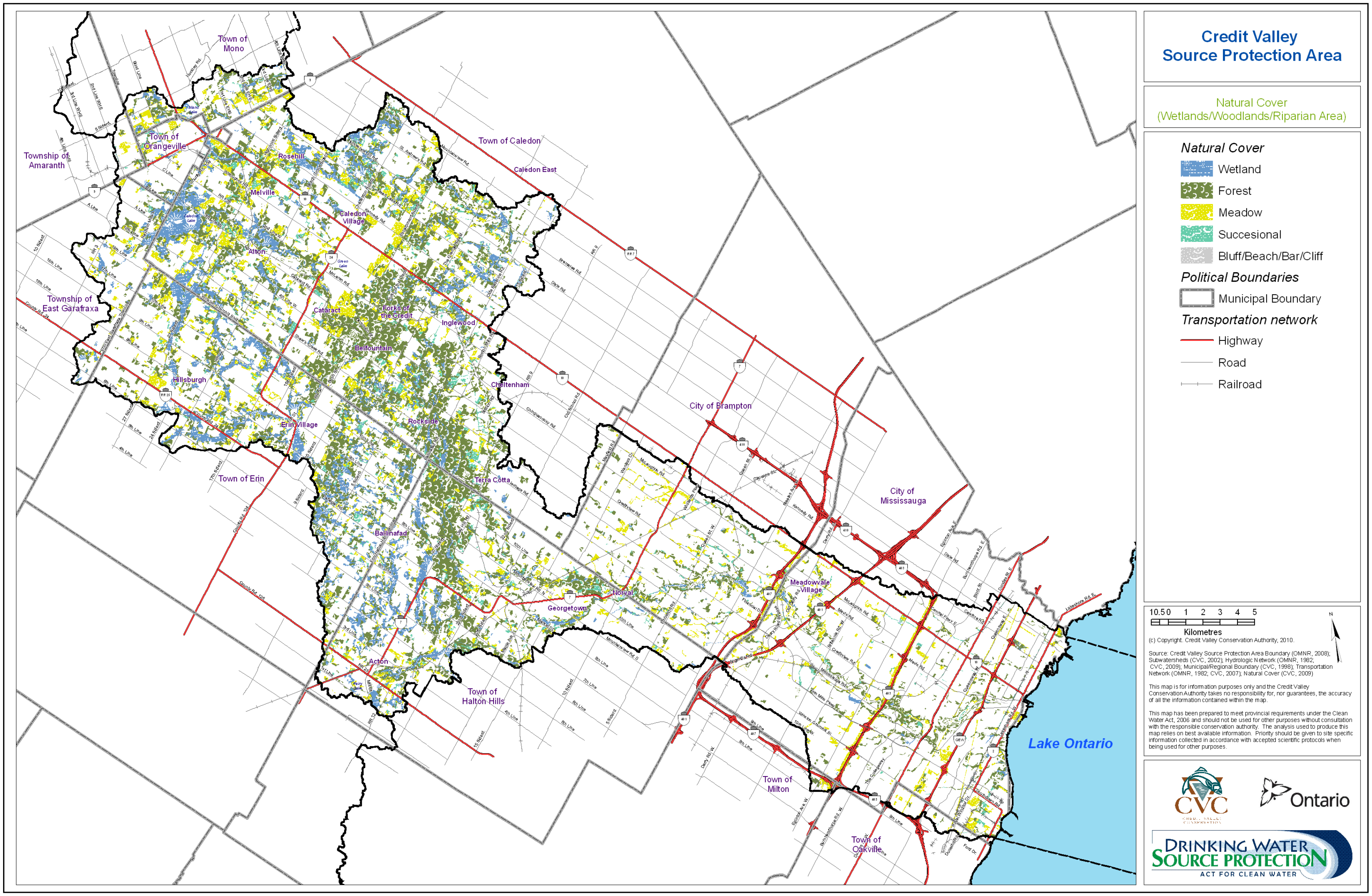
Table 2.4: Forest Communities of the CVSPA

Watershed Zone	Forest Type	Total Area (km^2)	Percentage
Upper	"Natural" (Deciduous, Mixed, Coniferous)	35.55	10.8
Upper	Plantation	16.76	5.1
Upper	**Combined**	**52.31**	**15.9**
Middle	"Natural" (Deciduous, Mixed, Coniferous)	60.49	19.5
Middle	Plantation	10.69	3.4
Middle	**Combined**	**71.18**	**23.9**
Lower	"Natural" (Deciduous, Mixed, Coniferous)	15.99	5.2
Lower	Plantation	0.42	0.1
Lower	**Combined**	**16.41**	**5.3**
Entire	"Natural" (Deciduous, Mixed, Coniferous)	112.04.	11.8
Entire	Plantation	27.89	2.9
Total		**139.93**	**14.7**

The riparian system includes those zones along a river that are flooded at least once every twenty years, and/or zones that have high water tables, are connected to the stream channel, and contain species of plants that can tolerate saturated roots for extended periods of time.

The quantity and quality of vegetation in the riparian zone is fundamentally connected to channel form and shape (geomorphology), aquatic habitat, water quality and temperature. Well-vegetated riparian stream banks help to control the form and shape of channels. Vegetated stream banks are fairly resistant to scouring. In such a system, streams are narrow, pools are deep, and total sediment eroded into the channel system is low. In streams without extensive riparian vegetation, stream width increases, pools get shallower, and more material is eroded from banks. Streams with lush riparian vegetation - shrubs and grasses, or trees and shrubs - have better pools and contain diverse habitats compared to streams with thinly grassed banks and active bank erosion.

The 1:10,000 scale mapping and 1: 8,000 scale aerial photographs that were used for the ELC mapping exercise (and subsequent analysis) are not suitable for detailed mapping of riparian vegetation communities. As a result, these communities have not been classified specifically within the ELC mapping layer.



Source: Credit Valley Source Protection Area Boundary (OMNR, 2008); Subwatersheds (CVC, 2002); Hydrologic Network (OMNR, 1982; CVC, 2009); Municipal/Regional Boundary (CVC, 1998); Transportation Network (OMNR, 1982; CVC, 2007); Natural Cover (CVC, 2009)

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Figure 2.4: Natural Cover (Wetlands, Woodlands, Riparian Areas)

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 CVC assesses its wetlands on a number of broad criteria. They include biological, social, hydrological, and special features.

2.2.2 Aquatic Habitats

Fish communities are recognized as indicators of the health of a watershed. As such, they also serve as barometers of human health and well-being. Furthermore, there are distinct recreational and other related economic and social values.

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

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

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 CVC has collected, and also provide recommendations with respect to the conservation, management, and protection of the aquatic resources.

Since developing these plans, CVC has continued to monitor the watershed each year and collected additional information that helps to assess aquatic health in the area.

This section summarizes the most recent aquatic information collected, including the types of aquatic habitats and species, and fish and invertebrates within the CVSPA.

The Credit River offers one of southern Ontario's most productive coldwater fisheries available ranging from small native brook trout to the large migratory salmon from Lake Ontario. More diversity lies within its lower warm water reaches and in other lakes and ponds within the watershed. Approximately 75 species of fish are dependent on the CVC watershed.

Fish communities were classified and mapped in several ways. Historical or potential habitat was first determined based on local physiography including:

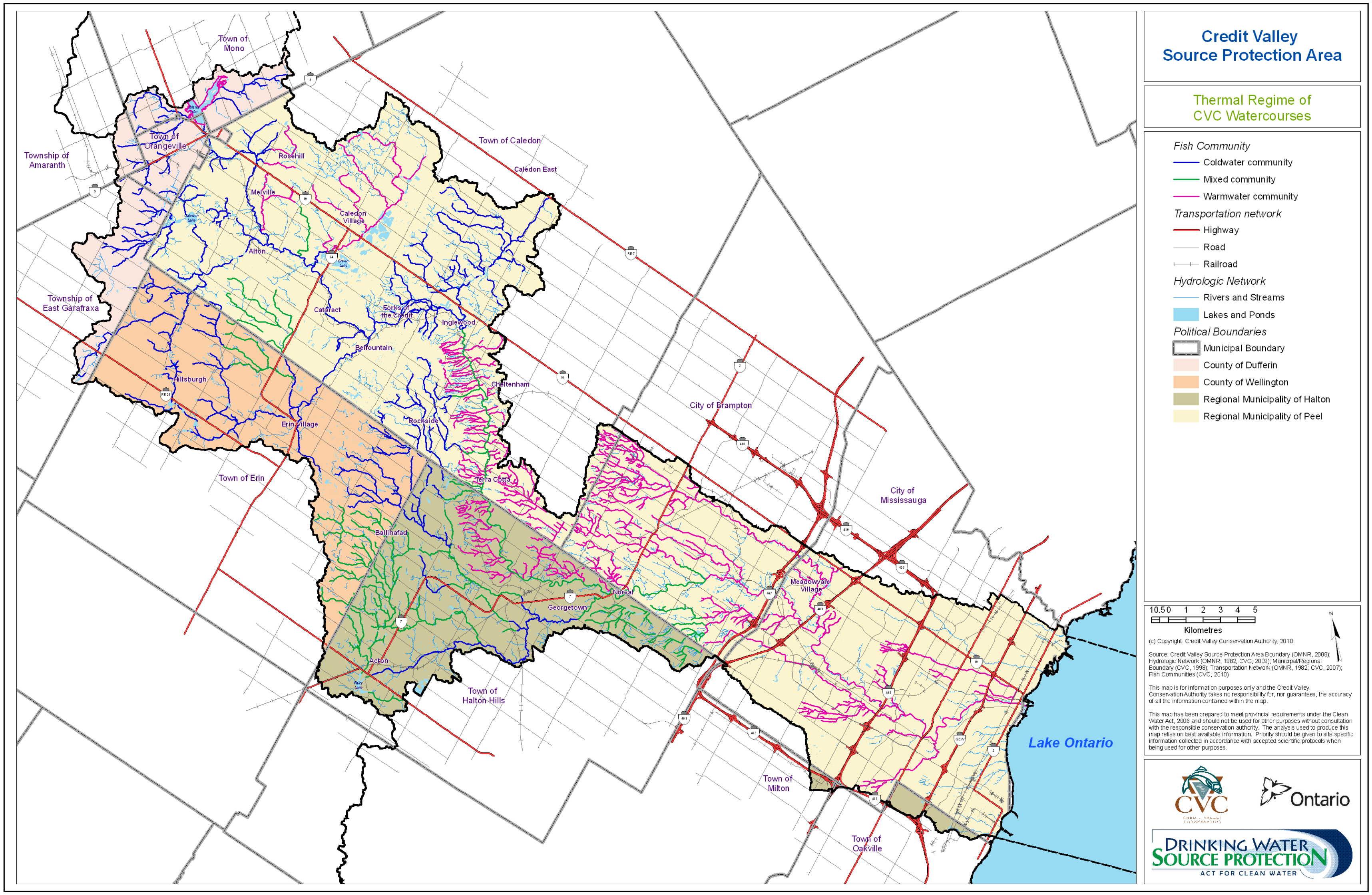
- Composition and structure of bedrock;
- Composition and location of overburden;
- Overburden thickness and valley cross-section;
- Human based modifications; and
- Local climatic conditions.

These geological and climatic factors represent the functions of groundwater contributions, temperature, and flow potential in relation to three basic fish community types mapped - coldwater, mixed water and warm water, as shown in **Figure 2.5.**

Existing fish communities were also independently classified based on present fish collection records using more descriptive categories, but are still compatible with the above:

- Coldwater (trout/sculpin);
- Mixed cold/cool water (Brown trout/Rainbow trout/sculpin/Brook lamprey/darters/hog sucker/stonecat);
- Mixed cool/warm water (migratory salmonids/Northern Redbelly dace/Redside dace);
- Small warm water (Creek chub/Blacknose dace/stickleback/minnows - including some sensitive species); and
- Large warm water (bass/pike/sunfish/perch/Bullhead catfish/Lake Ontario species).

Generally high recharge areas north of the Niagara Escarpment produce stable coldwater flows. Wetland areas also sustain good baseflows. Most wetlands south of the escarpment have been lost, but permanent baseflows are still maintained by a combination of agricultural soils, small wetland swales, sand lenses and lesser aquifers on shale and with urban stormwater techniques. Some reaches modified by land use stress have deviated from their historical potential.



(c) Copyright. Credit Valley Conservation Authority, 2010.

Source: Credit Valley Source Protection Area Boundary (OMNR, 2008); Hydrologic Network (OMNR, 1982; CVC, 2009); Municipal/Regional Boundary (CVC, 1998); Transportation Network (OMNR, 1982; CVC, 2007); Fish Communities (CVC, 2010)

This map is for information purposes only and the Credit Valley Conservation Authority takes no responsibility for, nor guarantees, the accuracy of all the information contained within the map.

This map has been prepared to meet provincial requirements under the Clean Water Act, 2006 and should not be used for other purposes without consultation with the responsible conservation authority. The analysis used to produce this map relies on best available information. Priority should be given to site specific information collected in accordance with accepted scientific protocols when being used for other purposes.

Figure 2.5: Thermal Regime of CVC Watercourses

Benthic Macroinvertebrates

The CVC currently has 49 benthic macroinvertebrate monitoring stations through the Integrated Watershed Management Program (IWMP). Macroinvertebrates are collected using a “kick and sweep” method and samples are identified to lowest practical taxonomic level.

The analysis indicates that stations along the middle and lower portions of the Credit River are in good to excellent condition. These stations have a higher diversity of invertebrates as well as a higher proportion of sensitive taxa. Although most of the lower portion of the CVSPA is urbanized, the apparently healthy condition is likely due to the river resiliency and ability to buffer potentially degrading *cumulative* impacts.

In general, the non-urbanized tributaries of the Credit River support a healthy macroinvertebrate community. These include the West and East branches of the Credit River as well as Shaw’s Creek. The Silver Creek Sub-watershed also ranks as good to excellent on the basis of the macroinvertebrate community. The macroinvertebrate communities along Black Creek, another partially urbanized sub-watershed, rank as fair to good. The station at Caledon Creek upstream of the Credit River confluence has received an average ranking of fair to good and this may reflect the influence of extreme changes (4 m) in the water table from early spring to fall.

Urban tributaries, including Carolyn, Mullet, and Fletcher’s Creeks in the lower portion of the CVSPA as well as Mill Creek and Lower Monora Creek in the upper portion of the watershed generally rank as fair to poor. The degraded macroinvertebrate communities along these tributaries may be attributed to impacts associated with urbanization such as contaminated surface runoff, a loss of groundwater upwellings and a loss of important habitat features including riparian cover. Tributaries found within sub-watersheds with primarily agricultural land-use including Huttonville Creek and the Glen Williams tributary are also associated with degraded macroinvertebrate communities. This may be the result of nutrient loading to the creeks and a lack of riparian vegetation.

2.2.3 Species at Risk

At present, the species at risk with the greatest profile in the CVSPA is the Redside dace (*Clinostomus elongates)*. The Redside dace is a small minnow commonly found in cool water streams with overhanging vegetation, and undercut banks. It is presently or historically known to exist within Fletchers Creek, Springbrook Creek, Huttonville Creek, 8B Tributary, Levis Creek, Silver Creek and Caledon Creek. It is currently considered a species of special concern at the federal level and is a threatened species provincially.

The status of Atlantic salmon (*Salmo salar)* is listed as extirpated from Lake Ontario and the Credit River. Atlantic salmon were originally depleted because of water degradation, dams acting as barriers and overfishing. The Atlantic Salmon Restoration Program is now being implemented for Lake Ontario with the Credit River selected as one of three top priority rivers for re-introduction stocking and habitat restoration projects.

In order to comply with the *Species at Risk Act,* habitat mapping for species at risk in Ontario has not been provided. The species at risk are mostly terrestrial species and include:

- The Jefferson salamander (A*mbystoma jeffersonianum)* is a species at risk dependent on vernal wetland pools dependent on local groundwater regimes. It is generally found along the Niagara Escarpment and Paris Moraine, but the Jefferson salamander is also found in wetlands of the Peel Plain including Mississauga.

- Bird species related to wetland or riparian habitats having records in the watershed include the Least bittern (*Ixobrychus exiles).*

Wetland plants that are species at risk are likely found in isolated areas across the watershed. Some bog and fen communities in the CVC have yet to be fully inventoried and may have further potential for species at risk. Some upland habitats may be partly dependent on groundwater tables and would contain the remaining species at risk in the CVSPA.

2.3 WATER SYSTEMS AND WATER USE

Municipal water supply in the CVSPA is drawn from both groundwater and surface water sources. The cities of Brampton, Mississauga and Toronto all obtain supplies from Lake Ontario while the remaining population centres are reliant on groundwater sources.

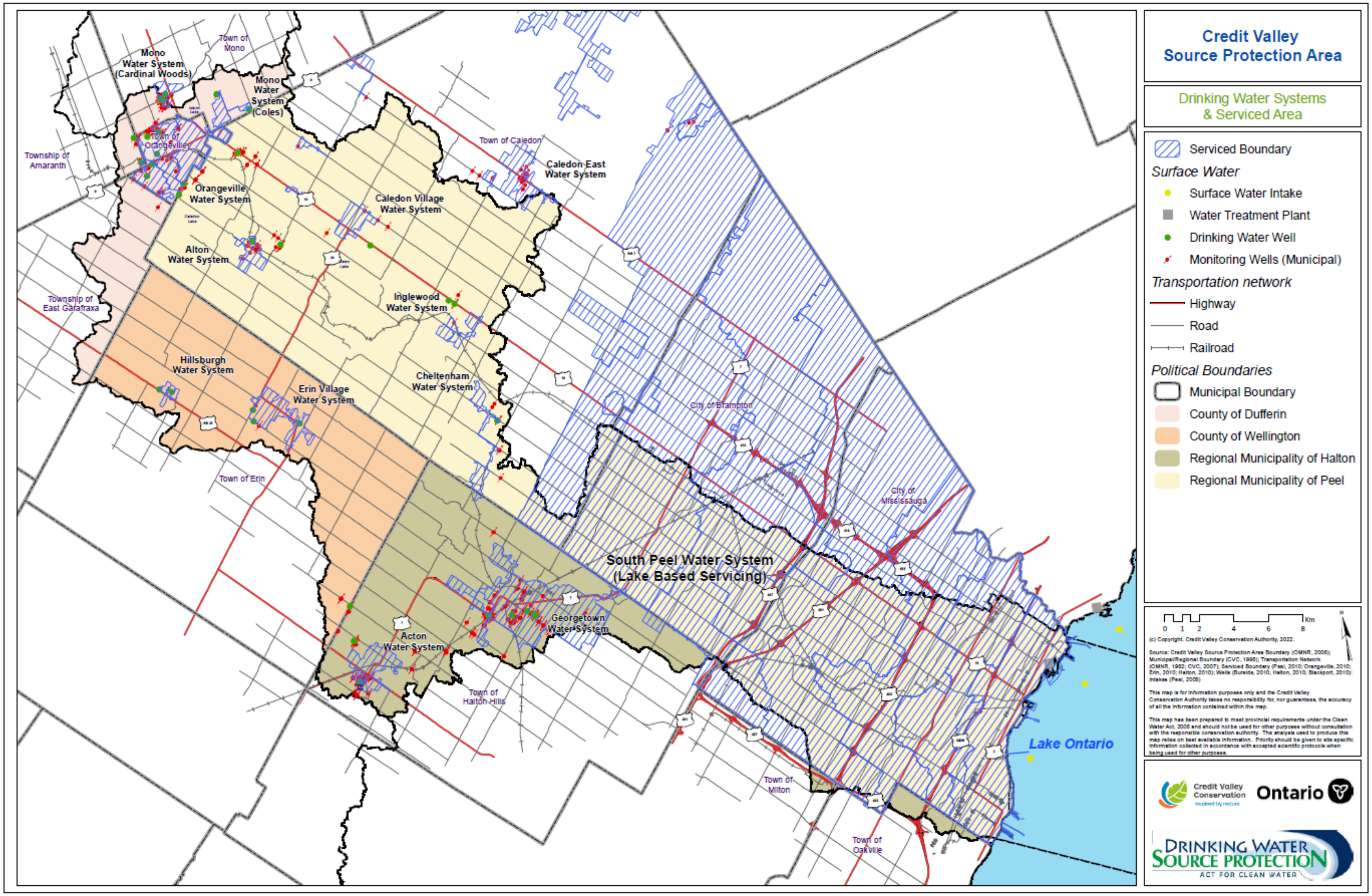
The Assessment Report must consider:

- Municipal drinking water systems that serve residences;
- Regulation 170 and 252 systems, including those that provide drinking water or that serve designated or public facilities (such as community centres, campgrounds, churches, schools, etc.); and
- Private water wells that serve residences.

The population of the CVSPA is spread throughout its area, from the towns of Orangeville, Mono and Amaranth in the headwaters, through Erin, Halton Hills, and Caledon in its middle zone, to the major cities of Brampton and Mississauga in the lower zone.

Population centers are grouped into municipalities, which are classified along a tiered structure. Detail on municipal organization and the population of the CVSPA is presented in **Section 2.6**. It is estimated that about 750,797 people in the CVSPA received municipal water supplies in 2010. Private water wells are referenced in **Section 2.5.**

Municipal supply is provided though Type 1 systems i.e., Municipal Residential Drinking Water Wells. There are thirteen municipal water systems operating in the CVSPA, two are surface water based – accessing Lake Ontario as the source – while the rest are groundwater-based. There are no municipal water sources on the Credit River. The municipal service boundaries for each water system are shown in **Figure 2.6.**



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Source: Credit Valley Source Protection Area Boundary (OMNR, 2008); Municipal/Regional Boundary (CVC, 1998); Transportation Network (OMNR, 1982; CVC, 2007); Serviced Boundary (Peel, 2010; Orangeville, 2010; Erin, 2010; Halton, 2010); Wells (Burside, 2010, Halton, 2010; Blackport, 2010); Intakes (Peel, 2008)

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Figure 2.6: Drinking Water Systems and Serviced Areas

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

The South Peel Drinking Water System (Arthur P. Kennedy (formerly Lakeview) Water Treatment Plant, and Lorne Park Water Treatment and Distribution System) are owned and operated by Peel Region, and supply water to Mississauga, Brampton, and part of York Region. The Arthur P. Kennedy and Lorne Park Water Treatment Plants (WTPs) both use Lake Ontario as the source. The system consists of two drinking water treatment plants, nine reservoirs and booster pumping stations, eleven underground storage reservoirs, three elevated storage tanks, two standpipes, three booster pumping stations and approximately 4,000 kilometres of trunk and distribution water mains. Details on these WTPs are given in **Table 2.5**.

Table 2.5: Municipal Surface Water Systems Serving the CVSPA

	Arthur P. Kennedy WTP* (1 intake)	**Lorne Park WTP (1 intake)**
Location	East Mississauga	West Mississauga
Permit Number	210000568	21000137
Maximum Taking Allowed (m^3 per day)	943,000	575,000
Approximate Number of Homes Supplied	N/A	N/A
Intake Source	Lake Ontario	
Intake	Type A	Type A
Pipe Diameter (millimetres)	2,550	1,800 (sub-marine) 2,400 (on-shore)
Distance Extending into Lake Ontario (m)	2,000	1550
Depth of Intake Structure (m)	18	10
Plant Capacity (m^3 per day)	923,000	500,000
Population Served	1,400,000	
Monitoring	Samples are collected and tested 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 both WTP's participate in the MOECC's Drinking Water Surveillance Program (DWSP).	

* Distributes to populations in both the CVSPA and the TRSPA – populations served numbers thus do not correlate exactly with census population data of for the SPA; also interconnected with York Region supply

The Arthur P. Kennedy WTP is divided into two treatment process type plants – conventional and advanced. The conventional treatment consists of raw water disinfection, coagulation, flocculation, sedimentation, and filtration unit processes while advanced treatment includes ozone application, biologically activated and membrane filtration (OBM). The water treated at the conventional and OBM plant is blended and undergoes disinfection, the last treatment process.

The Lorne Park WTP is a conventional treatment plant and consists of raw water disinfection, coagulation, flocculation, sedimentation and filtration, and disinfection.

In 2009, construction began to enlarge the plant's capacity to 500 million litres to ensure an adequate supply of safe drinking water to an increasing population. The upgrades to the plant include installation of modern, state of the art, membrane filtration and an ultraviolet (UV) light treatment system to inactivate pathogens and control taste and odours that are sometimes found in our water supply.

The resulting water quality at Arthur P. Kennedy and Lorne Park WTPs meets the ODWS criteria and is suitable for human consumption.

2.3.2 Municipal Groundwater Systems

Groundwater-based municipal water systems provide about 11% of CVSPA's drinking water supply, and service communities in the middle and northern zones of the CVSPA **(Figure 2.6)**. There are nine systems, comprising 43 active wells, providing drinking water to residents in the towns of Orangeville, Mono, Erin, Halton Hills, and Caledon. In addition, there are two other systems that are not currently operational.

An overview of the municipal service boundaries of water systems servicing residents in the CVSPA is shown in **Table 2.6**. Information pertaining to each water system and associated monitoring infrastructure is shown below, and also at a more local level in **Chapter 4**.

Table 2.6 shows the maximum annual abstraction rates for each system. This data reflects the maximum allowable abstraction per the Permit to Take Water (PTTW) issued by the MOECC. Average monthly and annual pump rates for each system are reported in **Appendix B 1.4**. Monthly rates reflect average daily pumping rates, and show seasonal variation in demand, while average annual rates report average daily pumping rates for the year.

Table 2.6: Municipal Groundwater Systems Serving the Population of the CVSPA

Drinking Water System Name & System Type	Drinking Water System MOECC Ref No.	Municipality (Town/ Township)	Number of Wells	Max. Annual Pump Rate (m^3/day)	Population Served*
Orangeville Well Supply, Type I	220003252	Orangeville	12	17,175	26,875
Island lake Supply, Type I	220008523	Mono	2	2,786	822
Coles Subdivision, Type I			2 (alternates)	655	
Cardinal Wood Subdivision, Type 1			3	3,142	888
Amaranth Pullen Well - Type I	designated	Amaranth	1-off-line	Never pumped	
Bel-Erin Subdivision, Type I	260003006	Erin	2 -off-line	Off since 2002	
Town of Erin, Type I	220000013	Erin	2	4,943	2,500
Town of Hillsburgh, Type I	220007285	Erin	2	1,637	810
Acton Well Supply, Type I	220001673	Halton Hills	5	8,355	9,779
Georgetown Well Supply, Type I	220001655	Halton Hills	7	44,513	39,373
Alton Well Supply Type I	220004000	Caledon	2	1,046	1,544
Caledon Village, Type I			2	5,237	2,914
Cheltenham, Type I	260002590	Caledon	2	1,469	816
Inglewood, Type 1	220004037	Caledon	2	2,590	1,223

* Based on 2010 numbers reported by municipalities, and thus may not correlate exactly with census population data for the SPA, which was calculated using census data from 2006.

Municipal Residential Groundwater Systems

Town of Orangeville – Orangeville Water System

The municipal system consists of twelve supply wells, two grade-level water storage reservoirs, one elevated water storage reservoir, and 112 km of water main. Three of the wells are located outside of its municipal boundary – one within the Township of Amaranth and two in the Town of Caledon. Average daily municipal demand stands at approximately 8,600 m^3/d.

The town has a monitoring network comprising of over 60 sentry wells (wells used for monitoring water levels and water quality within WHPAs) and conducts an intensive monitoring program in compliance with PTTW requirements and for the general management of the groundwater resources.

Since January 2008, enhanced water treatment facilities have been implemented at nine of the wells. Liquid sodium hypochlorite is used for disinfection at the other three wells. Liquid sodium silicate is also used at two wells for iron sequestration. The resulting water quality at Orangeville water system meets the *Ontario Drinking Water Standards Objectives and Guidelines (ODWS)* criteria and is suitable for human consumption.

Town of Mono - Mono Water System

The Town of Mono lies within the headwaters and extends east and north of Orangeville. It straddles both the CVSPA and the Nottawasaga Valley SPA (NVSPA). Its water system comprises of seven wells in three wellfields - Island Lake, Coles, and Cardinal Woods Subdivision. The water system is maintained and operated by the Town of Orangeville, on behalf of the Town of Mono. On an average day municipal demand on the municipal supply stands at about 453 m^3/d.

The Coles and Island Lake fields were originally separate but have since been connected. They comprise four wells, one back-up well and an elevated storage reservoir. The wells are all completed within the overburden sand and gravel aquifer. The Cardinal Woods field consists of three wells, one of which (MW 3) is located in the NVSPA, just outside of the CVSPA's boundary. The overall system is completed by a one grade level storage reservoir and high lifts pumping station.

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.

Treatment on these systems includes liquid sodium hypochlorite for disinfection and liquid sodium silicate for iron sequestration. The resulting water quality at Mono water system (Island Lake, Mono and Cardinal Woods) meets the ODWS criteria and is suitable for human consumption.

Town of Erin - Erin, Hillsburgh & Bel–Erin Water Systems

The Town of Erin is serviced by two water systems - Erin and Hillsburgh. Two additional wells exist within the Bel–Erin sub-division, south of Erin. These are relatively shallow wells drilled in the early 1990's to supply the subdivision but were taken offline **(Table 2.6)** in 2002 due to quality concerns amid stricter Ministry of the Environment and Climate Change (MOECC) requirements (Blackport Hydrogeology Inc, 2002). Though unused, they have not been abandoned.

The town also maintains two monitoring wells located in Erin. Average day municipal demand at Erin and Hillsburgh are about 950 m^3/d and 210 m^3/d, respectively (Town of Erin, 2009).

Treatment consists of disinfection using sodium hypochlorite, lead removal at Hillsburgh, and chlorine disinfection at Erin. The resulting water quality at Erin and Hillsburgh water systems meets the ODWS criteria and is suitable for human consumption.

Town of Halton Hills - Acton & Georgetown Water Systems

Halton Hills residents in the CVSPA receive municipal water supply through Acton and Georgetown water systems owned and operated by the Regional Municipality of Halton. The Acton system contains five wells within three well fields – Fourth Line, Davison (Third Line) and Prospect Park – while the Georgetown system has seven wells within three well fields - Lindsay Court, Princess Anne, and Cedarvale.

The Region also has a monitoring network comprised of at least 60 sentry wells and conducts an intensive monitoring program for their wells. The Acton and Georgetown water systems service average day demand of about 3,170 and 10,240 m^3/d (Region of Halton, 2009), respectively.

At Acton, all wells use ultraviolet (UV) light for primary disinfection with chlorine for secondary disinfection. Fluoride is added to the water from all three sources. The Prospect Park facility is equipped with greensand filters for the removal of manganese and iron from the water. Water from the three sources is pumped to the Churchill Reservoir, and then flows into the distribution system.

At Georgetown, the following treatment is implemented:

- Cedarvale – greensand filters for the removal of manganese and iron from the water, fluoridisation and disinfection using UV light;
- Princess Anne – disinfection with chlorine, and fluoride is added; and
- Lindsay Court - disinfection with chlorine, and fluoride is added.

The resulting water quality at the Acton and Georgetown water systems meets the Ontario Drinking Water Standards (ODWS) criteria and is suitable for human consumption.

Town of Caledon - Caledon Village – Alton Drinking Water System, Cheltenham & Inglewood Drinking Water Systems

The Town of Caledon is comprised of the Villages of Alton, Cheltenham, Inglewood, and Caledon Village. The Regional Municipality of Peel provides municipal water through three drinking water systems comprising nine wells.

In 2007, the Caledon Village – Alton Drinking Water Supplies were connected and began to operate as a single water system (one drinking water system number) in March 2008. It services an average day demand of about 1,007 m^3/d (Region of Peel, 2009).

The Alton municipal supply consists of two wells (Alton Wells 3 and 4A), which draw water from an unconfined sand and gravel aquifer. Alton Well 4A replaced previous supply well Alton Well 4, which operated until December 2015, and was subsequently decommissioned in May 2019. This well was installed in close proximity to the location of former Well 4.

Sodium hypochlorite is added for primary and secondary disinfection. Ultraviolet light is used to supplement the primary disinfection process. The treated water travels through a chlorine contact chamber before entering the water distribution system.

The Caledon Village supply comprises two wells (Wells 3 and 4) that draw supply from confined and unconfined sand and gravel aquifers. Sodium hypochlorite is added for primary and secondary disinfection, and ultraviolet light disinfection is included to meet the primary disinfection requirements. Additionally, greensand filters are used at Well 4 to remove iron.

The resulting water quality at the Caledon Village – Alton Drinking Water System meets the ODWS criteria and is suitable for human consumption.

The Inglewood Drinking Water System consists of two wells Inglewood Well 3 (ING-3) and Inglewood Well 4 (ING-4)). Both are relatively deep wells located in coarse-grained overburden sediments within a buried bedrock valley (Matrix, 2017). The system services an average daily demand of about 405 m^3/d.

A former supply well Inglewood Well 2 (ING-2) was completed in the shallow overburden and was determined to be susceptible to surface contamination. In May 2019, Inglewood Well 4 was brought online. Inglewood Well 2 was subsequently decommissioned in October 2021 and removed from the Inglewood Drinking Water System.

Raw water from Inglewood is treated by adding sodium hypochlorite to oxidize the iron and the water is then filtered through greensand filters to remove the iron. The water is then treated with sodium hypochlorite for primary and secondary disinfection before entering the water distribution system. The resulting water quality at the Inglewood water system meets the *ODWS* criteria and is suitable for human consumption.

The Cheltenham Drinking Water System comprises two wells (Wells 1 and 2) completed within a deep bedrock valley system. It services the communities of Cheltenham and Terra Cotta, with an average day demand of about 240 m^3/d (Region of Peel, 2009).

At Cheltenham, sodium hypochlorite and potassium permanganate are applied to the raw water to oxidize the iron and manganese in solution. The water is then filtered through greensand media to remove the iron and manganese and treated with sodium hypochlorite for primary and secondary disinfection. The resulting water quality at the Cheltenham Drinking Water System meets the ODWS criteria and is suitable for human consumption.

Designated Municipal Drinking Water Systems (Groundwater)

The townships of East Garafraxa and Amaranth partially lie within the headwaters of the CVSPA. These communities receive municipal supplies from water systems outside the CVSPA. In 2008, the Pullen Well **(Figure 2.6)** was designated by the Township of Amaranth for future municipal supply.

The Pullen Well was completed in 1990, on land approved for a planned development within the township, for the creation of an estate residential subdivision. Since municipal supply to the land was not available at the time, it was drilled to assess ground water supply, through the development approval process.

The Township of Amaranth has taken a decision to pursue the Pullen Well for future municipal supply. In accordance they have identified it as a designated system through council resolution (November 2008), and intends to use it as a standalone water supply for a future subdivision.

2.3.3 Wastewater Treatment

Mississauga and Brampton rely on full-scale municipal sewage disposal systems that treat the waste and then discharge to Lake Ontario. Several communities in the middle and upper zones of the CVSPA are also serviced by sewer disposal systems that treat the waste and discharges to the main Credit River or its tributaries, as shown in **Table 2.7**.

All other communities in the CVSPA rely on parcel-based septic systems. The use of Communal Sewage Disposal Systems (CSDS) has been proposed for several of them (Alton, Caledon Village, and Cheltenham), where full-scale municipal treatment works would otherwise not be feasible.

Table 2.7: Sewage Treatment Plants discharging to the Credit River

Sewage Treatment Plant	Treatment Processes	Receiving Watercourse	Average Daily Flow from 2009 (m^3/d)
Acton	Secondary biological + nitrification + sand filters + UV disinfection	Black Creek	4,500
Georgetown	Secondary biological + nitrification + sand filters + UV disinfection	Silver Creek	15,900
Orangeville	Secondary biological + nitrification/denitrification + effluent filters + chlorination	Credit River (headwaters)	13,600
Inglewood	Secondary biological + nitrification + sand filters + UV	Credit River	250

Adequate assimilative capacity for existing, expanding, and future wastewater discharges must be ensured. The receiving water's ability to provide dilution, chemical reaction, biological uptake and modification, and physical modification for the wastewater contaminants will determine the assimilative capacity of the watercourse. This issue is being assessed at Orangeville and at Halton Hills, through the Tier 3 Water Budget studies being undertaken for those municipalities.

The level of treatment of the wastewater effluent will also influence the assimilative capacity of these wastewater discharges on the Credit River and its tributaries.

2.4 WATER QUALITY AND TRENDS

As described in **Section 2.3**, most of the municipal drinking water supplies for the study area come from Lake Ontario. However, the majority of the communities in the middle and upper zones of the CVSPA rely on groundwater for municipal supplies.

In this section the general water quality of groundwater and surface water is assessed against water quality objectives and standards that exist to assess ecosystem components and drinking water supplies. 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 CVSPA 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 CVSPA 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.

Arthur P. Kennedy (formerly Lakeview) Water Treatment Plant

Water testing 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*, 990 samples were non-detect, 77 samples detected *E. coli* bacteria, and one sample exceeded the Provincial Water Quality Objectives (PWQO) of 100 counts/100 mL. Total coliform results showed 645 non-detections, 331 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 Assessment Report as a reference.

Lorne Park Water Treatment Plant

The 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*, 1250 samples were non-detect and 55 samples detected *E. coli* bacteria. There were no exceedances of the PWQO for *E. coli* during the reporting period. Total coliform results showed 702 non-detect, 368 samples detected total coliform bacteria, and two samples were above 1,000 counts/100 mL.

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)* includes 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 MOECC recently released the findings of a survey on 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 from groundwater, lake, and river source waters, and from treated drinking water. Of the compounds analyzed, 23 were detected in source water, and 22 were detected in treated 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 MOECC'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 the *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 CVSPA Watershed and Great Lake Agreements

The Credit River drains directly into Lake Ontario and has 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 Management Plans are broad plans to restore and protect water quality in each Great Lake (Environment Canada, 2005). Information compiled as part of the Lake Ontario LAMP was incorporated into the technical studies completed for the CVSPA water supply systems.

The work undertaken and described in this 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* (Environment Canada, 2007). 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 (Ministry of Natural Resources, 2005). The agreement sets out conditions under which transfers of water from one Great Lake watershed to another (intra-basin transfer) can occur. Almost 90 percent of the population in CVSPA currently receives water from two surface water intakes located in Lake Ontario. Most of the waste water is discharged back into Lake Ontario, thus there is little intra-basin transfer. The exception is the Region of Peel's Arthur P. Kennedy Intake, which is transferred out to augment York Region's drinking water supply.

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 Peel.

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 Action and 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.

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

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

2.4.6 CVSPA Surface Water Quality (Inland Watercourses)

Inland watercourses are not used for drinking water supplies within the CVSPA. However, the creeks and rivers located in the CVSPA 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 Characterization Report describes surface water quality of the Credit River based on the analyses of data collected between 1970 and 2005. Subsequent studies, reports etc., were referenced to supplement the data, and to check the relevance of inferences and recommendations made in the report.

Data was collected under two programs, the Provincial Water Quality Monitoring Network (PWQMN) and the conservation authority's Surface Water Quality Monitoring Program. The analyses involved eight representative stations within the CVSPA. All sampling sites and their locations are listed in **Appendix A** (**Figure A.1, Table A.7**).

Statistical Analyses

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). 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.

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*. Five percentiles (10th, 25th, 50th, 75th and 90th) were calculated except for *E. coli* where a geomean was calculated for each of the eight representative stations within the watershed.

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* (BC MOE, 2003) the toxicity of chloride for freshwater organisms is evaluated 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*).

There is also no PWQO for nitrate. In this 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.

The two types of statistical methods used to describe the water data over time were 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.

The results from the analysis demonstrate a number of trends in the CVSPA. Trends for phosphorus, nitrate, chloride, and bacterial levels are described below. Summaries of dissolved oxygen, aluminium, copper, nickel, iron, and zinc are presented below with additional supporting data available in **Appendix B 1.5**.

Surface Water Quality Results

Routine water quality monitoring on the Credit River is generally undertaken during dry weather conditions, when the Credit River is not being influenced by precipitation or snowmelt events. The discussion below reflects the inferences made from the data collected on the various parameters that were studied under these conditions.

Phosphorus

Nitrogen and phosphorus are the major nutrients contributing to eutrophication or an 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.

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. Trend analysis shows that while phosphorus levels in the upper zone of the CVSPA are still declining, levels in the mid and lower zone appear to be increasing (Credit R at Norval Hwy 7), see **Figure 2.7**.

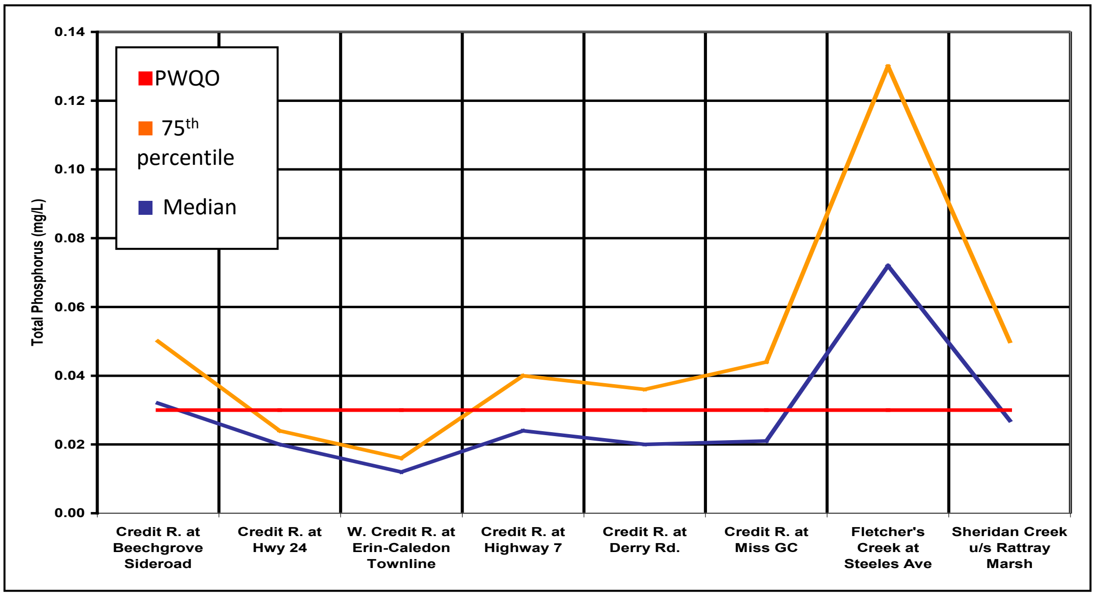


Figure 2.7: Phosphorus concentrations (1975-2005) in the upper, mid, and lower zones in the CVSPA compared to the PWQO

Trend analysis shows that for total phosphorus, levels have generally declined in the watershed from the 1970s. It is generally accepted that the introduction of phosphorus-free detergents and significant improvements in phosphorus treatment at STPs has caused this long-term decrease in phosphorus levels.

The upper and middle Credit River continues to have 75th percentile total phosphorus concentrations at or below the PWQO of 30 µg/l while the 75th percentile phosphorus concentrations in the lower portion of the Credit River are above the PWQO.

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.

Median nitrate levels for most of the Credit River watershed appear to be below 2.9 mg/L. However, Fletcher's Creek, an urbanizing area, experienced a violation occurrence of 14%. Another unexpected result was the increasing trend of nitrate levels in the West Credit River. This could be the result of intense farming practices involving manure application or fertilizers containing nitrogen or impacts from septic systems in Erin and Hillsburgh. The median values on the West Credit River were second only to the urban Credit River at the Mississauga Golf Club site, as shown in **Figure 2.8**.

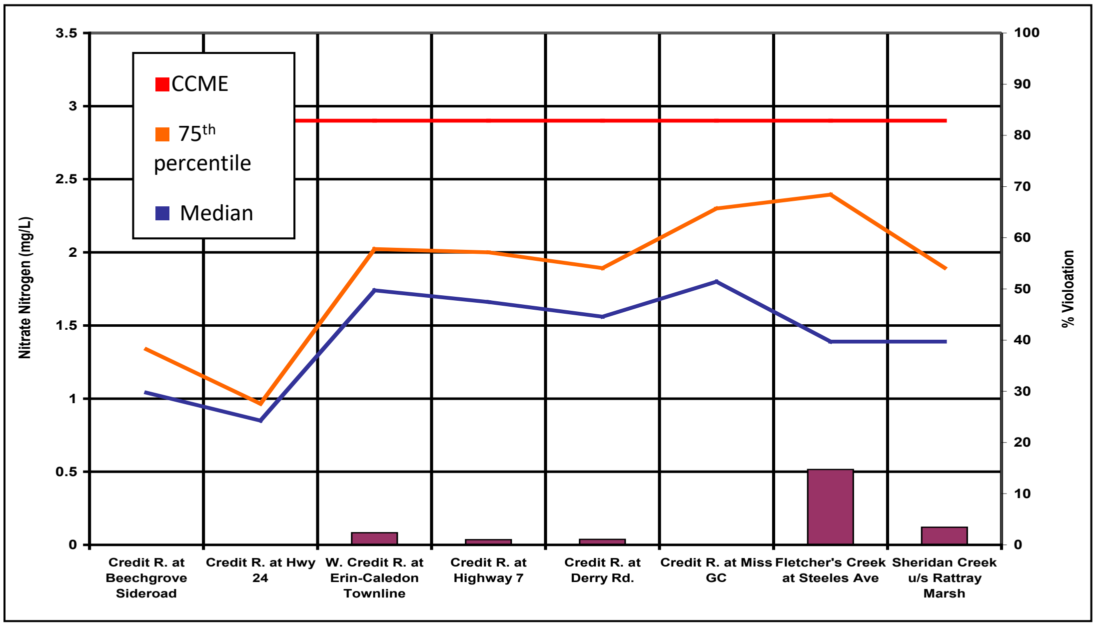


Figure 2.8: Nitrate levels (1975-2005) compared to the CCME and to the Percent Violations in the CVSPA

Trend analyses also indicate increasing nitrate levels in the upper and middle portions of the watershed. This could also be due to aforementioned intensive farming practices, increased loadings from upstream STPs, or the numerous rural villages located along the Credit River that are currently all serviced by septic systems.

Chlorides

Chlorides (Cl) are typically a good indicator of urban development. In the middle and upper portions of the watershed, hard water typically requires water softeners. Sodium chloride is used to regenerate water softening resins, with excess brine often discharged through septic tile beds to the groundwater system. In addition, chloride salts are commonly used in winter as road de-icing agents (sodium chloride) and in the summer as dust suppression (calcium chloride). Water softeners, salt storage facilities, and rural and urban runoff are some of the main sources of chlorides in the Credit River watershed. Salts added to the water supply from water softeners are not removed in individual septic systems or WWTPs.

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, 2005c).

Trend analysis from historical data for all the stations shows that, in general, chlorides have increased consistently over the past thirty years. A steeper linear increase was determined for those stations downstream of urban development as is evident in **Figure 2.9**.

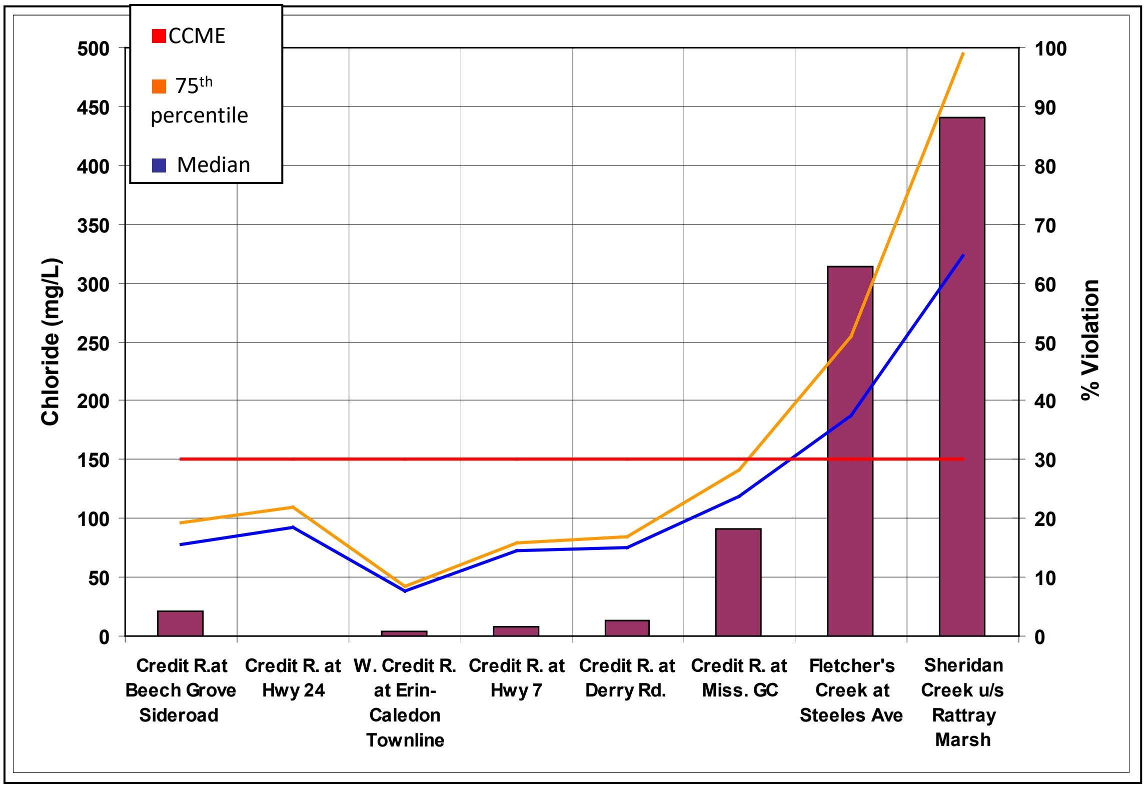


Figure 2.9: Chloride levels (1975-2005) compared to the CCME and to the Percent Violations in the CVSPA

As expected, chloride concentrations are generally elevated in more urbanized areas of the watershed, while concentrations decrease in the less urbanized areas. Higher chloride concentrations were recorded in areas in the upper zone of the CVSPA close to the towns of Orangeville, Acton, Georgetown, and in the lower zones in proximity to the cities of Brampton and Mississauga.

Bacteria

Although bacteria levels are typically more of a concern for human health compared to fisheries health, high bacteria levels can be indicative of an impaired watercourse. Livestock, wildlife, pets, septic systems, and treated and untreated sewage are the main sources of bacteria in the Credit River and tributaries.

The PWQO for *E. coli* was set for the safety of recreational uses, such as swimming and other water sports, and is therefore not necessarily an appropriate objective for fisheries health. Long-term geometric mean results were compared to the PWQO for comparison of bacterial levels between stations. In general, the geometric mean values for *E. coli* are below the PWQO of 100 counts/100 mL. However, very high *E. coli* levels, assumed to have been associated with run off from storm events, have been observed for all stations. Trend analysis indicated rising *E. coli* levels over time for all of the long-term stations. The results for *E. coli* are shown in **Figure 2.10**.

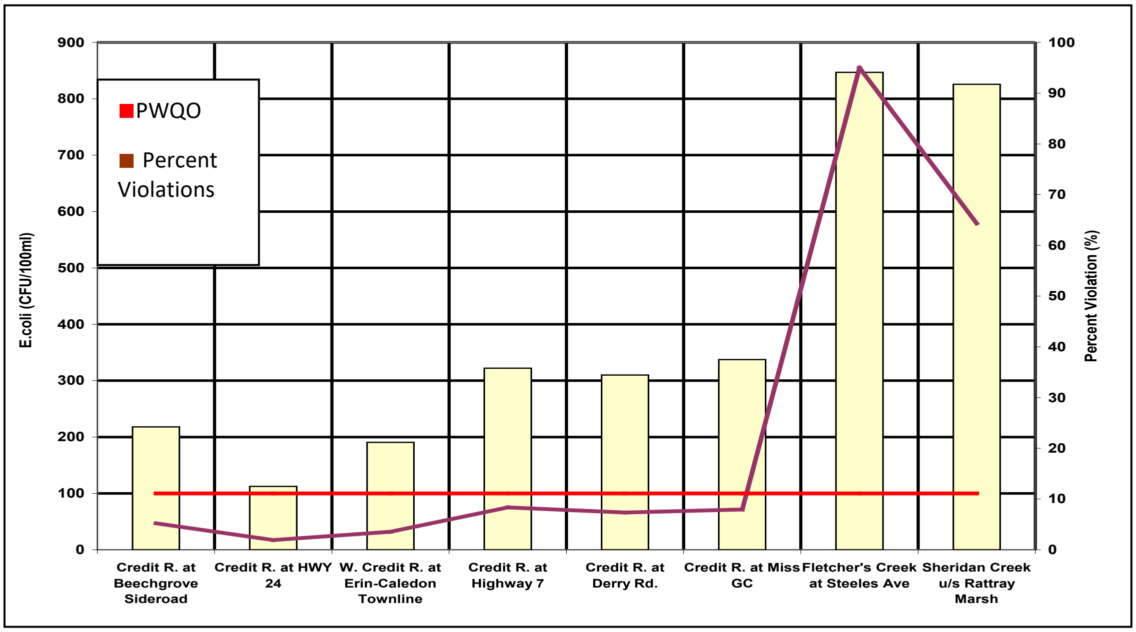


Figure 2.10: *E. coli* geomean concentrations and Percent Violations in the CVSPA

The urbanizing Fletchers Creek portrayed the highest *E. coli* geometric mean at 855 count/100 mL and samples' results violated the PWQO standard 94% of the time. Elevated levels of *E. coli* were also found in the urban creek of Sheridan Creek with a geometric mean of 579 and 91% violation occurrence.

Metals

Average total metal concentrations for a suite of commonly analyzed metals, including aluminum, copper, iron, and zinc were calculated based on 1996 to 2003 data. Elevated total metals levels may be from domestic and/or industrial wastewater, landfill leachate, erosion processes, and both rural and urban runoff. Iron and aluminum are typically found in clay soils and can be present in other geologic formations. Leaching minerals from rock and the natural and anthropogenic erosion of clay soils can increase aluminum and iron concentrations in local water courses. In general, most 75th percentile metal levels are below the PWQO for most of the stations with a few exceptions outlined below.

Median aluminum values are above the PWQO of 75 µg/l at Fletcher's Creek (210 µg/l), Credit River at the Mississauga Golf Course (121.0 µg/l), and at Sheridan Creek at Rattray Marsh (86.0 µg/l). In addition, median aluminum values appear to be increasing in the Credit River as it flows downstream. The median values consistently increase for each station from 38 µg/l at Beechgrove Sideroad 20, in the upper watershed to 121.0 µg/l at Mississauga Golf Course in the lower end of the watershed. An increasing trend was documented at each long-term station except for the lesser impacted West Credit River. The lowest median was calculated for the West Credit River station at 16 µg/l. A similar escalating pattern is evident for copper, as median values consistently increased with increased urbanization in the watershed. Each station portrayed an increasing trend except for Sheridan Creek. The West Credit again had the lowest median concentration of copper at 0.40 µg/l. The results for aluminum and copper are illustrated in **Figure 2.11** and **Figure 2.12**, respectively.

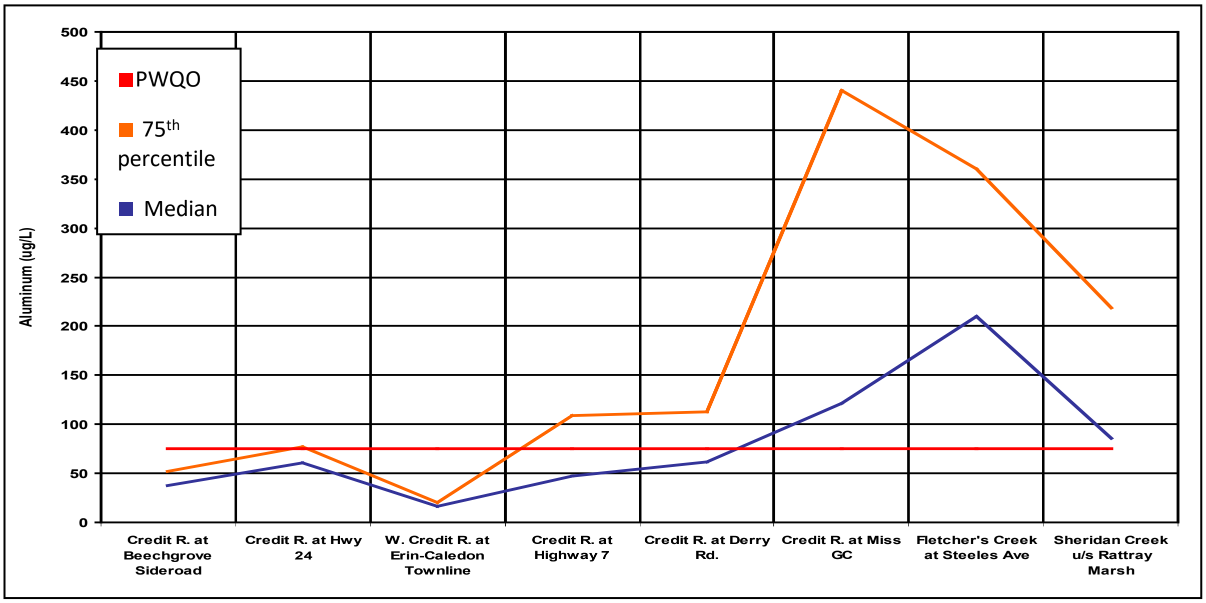


Figure 2.11: Aluminium percentile results (1996-2003) compared to the PWQO

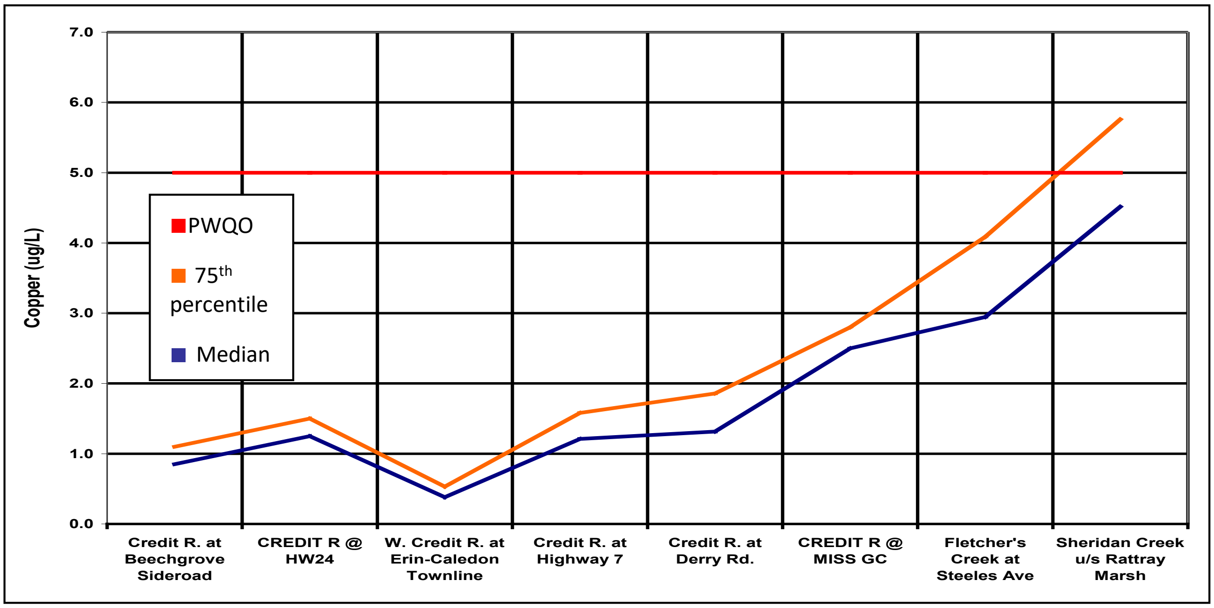


Figure 2.12: Copper percentile results (1996-2003) compared to the PWQO

The pattern for the iron results followed a slightly different pattern as median levels increased markedly between the upper zones of the CVSPA and the lower zone stations. Iron levels then dropped down to acceptable levels in the urban streams. Trend analysis also shows increasing iron levels as one moves downstream in the watershed. The 75th percentile was above the PWQO of 300 μg/l at the Credit River at Mississauga Golf Course but this was based on a relatively small two-year data set. This pattern can be observed in **Figure 2.13**.

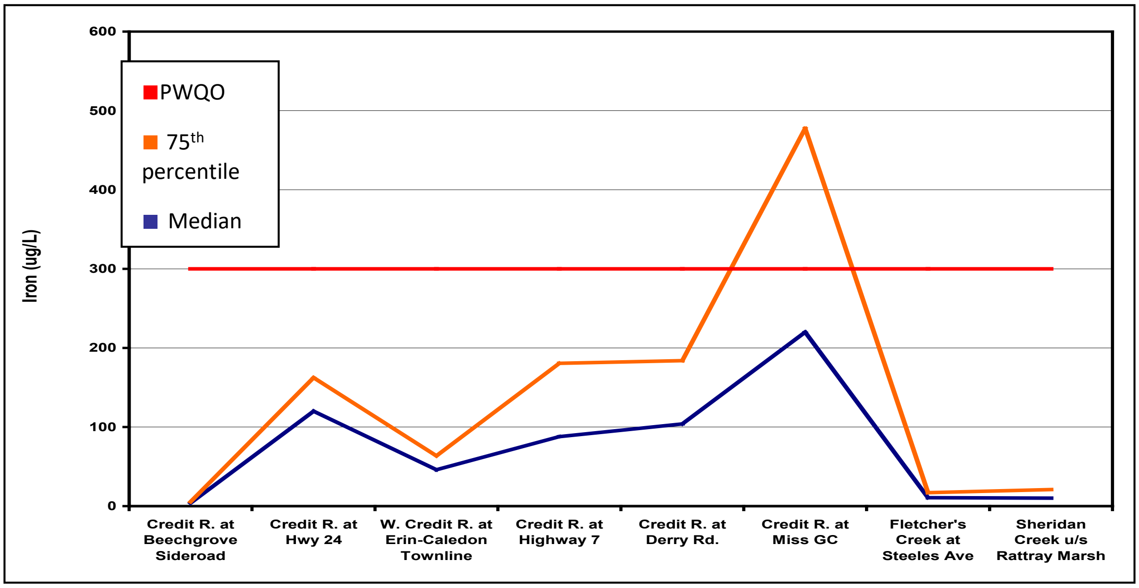


Figure 2.13: Iron percentile results (1996-2003) compared to the PWQO

There was no apparent pattern in the nickel and zinc results and none of the stations had median values over the revised interim PWQOs of 25 µg/l for nickel and 20 µg/l for zinc. No stations exhibited an increasing trend for nickel and there were no observed PWQO violations for nickel in the watershed. Elevated median levels for nickel were observed at Sheridan Creek, at values of 1.9 µg/l, the highest median for nickel. All stations except for the West Credit River displayed an increasing trend for zinc levels. The lower reaches of the watershed and urban streams experienced a slight increase in median zinc levels, but the change was not significant. The results for nickel and zinc are illustrated in **Figure 2.14** and **Figure 2.15**, respectively.

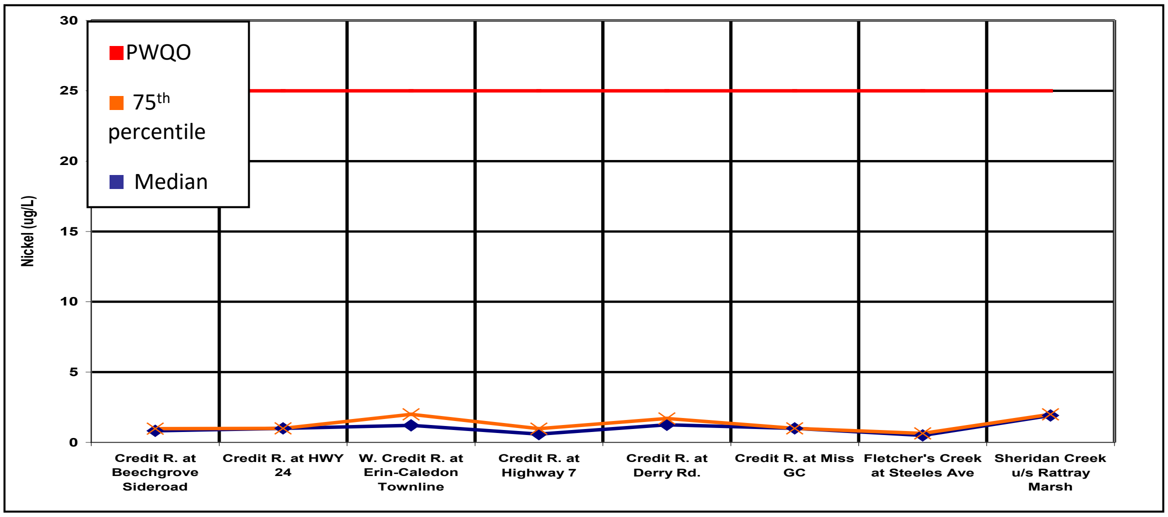


Figure 2.14: Nickel percentile results (1996-2003) compared to the PWQO

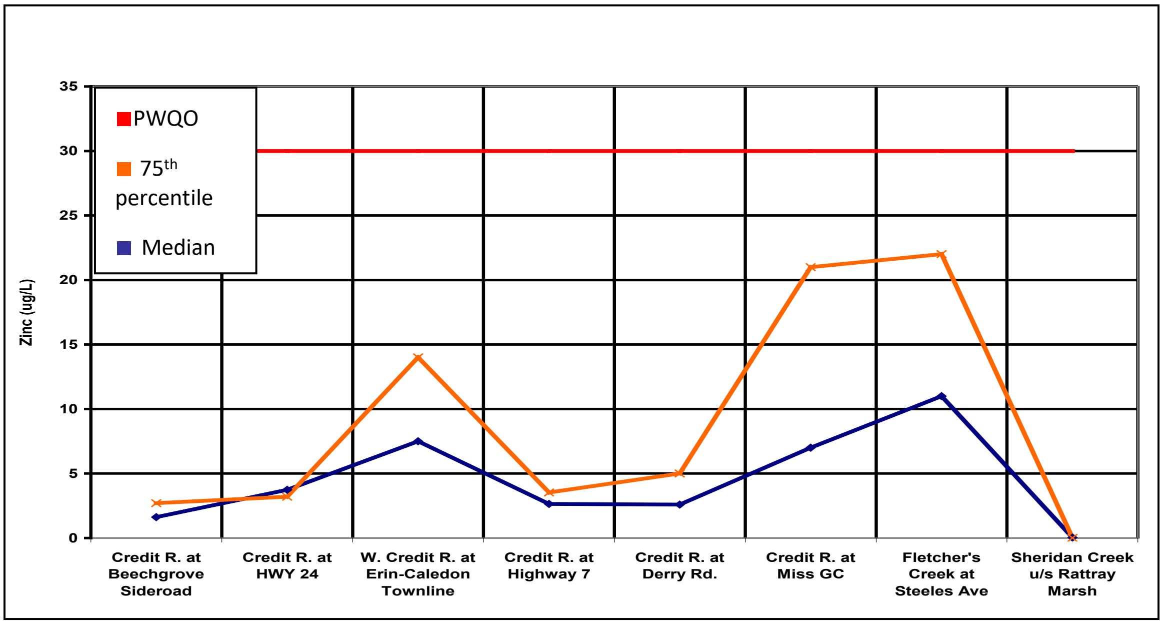


Figure 2.15: Zinc percentile results (1996-2003) compared to the PWQO

2.4.7 Tributary Loadings to Lake Ontario

It is important to recognize that the Niagara River accounts for 80% 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 entering Lake Ontario can influence nearshore water quality of the lake. These events typically occur after major storm events in the summer months, and during periods of snow melt or rainfall induced runoff during frozen ground periods over winter. Whether drinking water plant intakes within the CVSPA jurisdiction are affected depends on mixing and circulations 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.

Daily load data illustrates 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 interpretation of what constitutes important local watershed runoff events. Of course, extreme storm can occur at any time including the summer months.

The Credit River is the largest watercourse entering the nearshore environment of Lake Ontario from within the CVSPA. The other watercourses drain smaller sub-watersheds ranging in area from 167 to 424 ha and are not considered to have a significant influence on the nearshore of the lake at the depths and distances offshore that the drinking water intakes are located.

In 2008 and 2009, monthly water quality sampling was undertaken in the Credit River near the outlet to Lake Ontario, during major runoff events. Sampling was undertaken with CVC staff, and the surveys were designed to augment samples collected as part of CVC’s routine monitoring program. Using the data gathered, it was possible to estimate loads for total suspended solids (SS) for the CVSPA. In developing these estimates, assumptions are made that land use and climate conditions are similar.

Figure 2.16 illustrates the annual spatial patterns in tributary loads of total suspended solids from the CVSPA, to Lake Ontario. Total suspended solids is 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, total suspended solid loads are proportional to the drainage area of the watershed and runoff volumes.

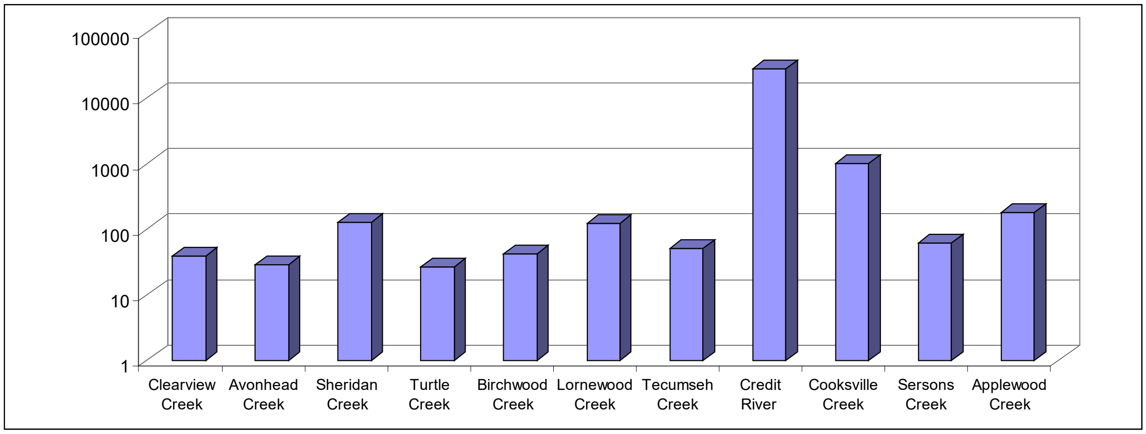


Figure 2.16: Total Annual Suspended Load (Mt) by CVC Watershed

Note that the Credit River loads are about three orders of magnitude larger than those of the other tributaries. The total annual load of suspended solids was 34,000 metric tons (Mt) in 2008 about 10,000 Mt higher than in 2009, with average suspended solids daily loads of 94 and 69 Mt respectively. From a drinking water intake perspective, it is important to understand both the magnitude and timing of inputs to the lake.

Monthly patterns in Credit River suspended solids loads are depicted in **Figure 2.17** and **Figure 2.18.** In 2008, the bulk of the load was transported during the month of February, most likely due to melting of the snowpack. Wet conditions and frozen ground (higher imperviousness) caused a secondary peak in December. Conditions in 2009 were markedly different with a much more pronounced, extended winter runoff and higher suspended solid load **(Figure 2.18)**. Another difference was the higher August loads in 2009.

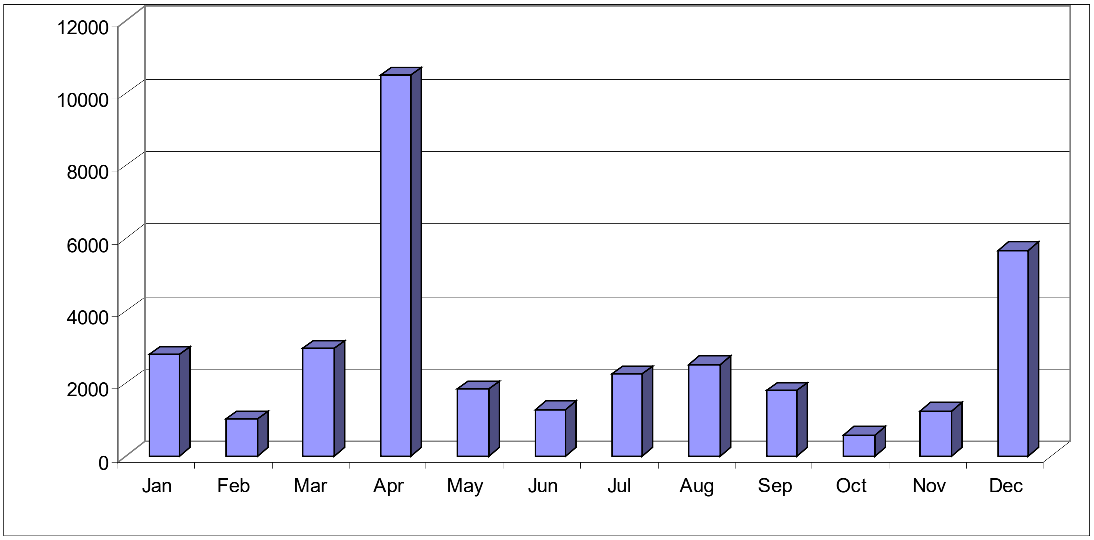


Figure 2.17: 2008 Monthly Suspended Solids – Credit River

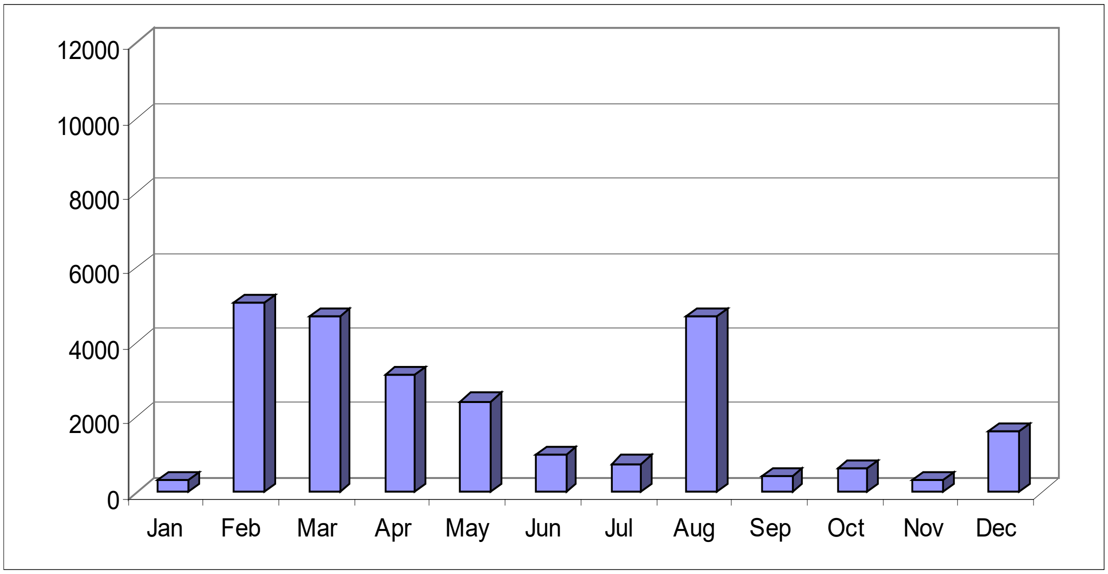


Figure 2.18: 2009 Monthly Suspended Solids – Credit River

Figure 2.19 and **Figure 2.20** compare daily suspended solids in 2008 and 2009. As expected, the temporal patterns in daily loads reflect the seasonal trends reported for monthly loads. The key factor from a drinking water intake perspective is the magnitude of the major events. In 2008, these large daily events occurred in the spring and early winter months. February March, April, and August exhibited days with over 600 Mt of suspended solids being transported to Lake Ontario. Wet months like August 2009 can transport suspended solid loads comparable in mass to that traditionally delivered during the spring snow melt.

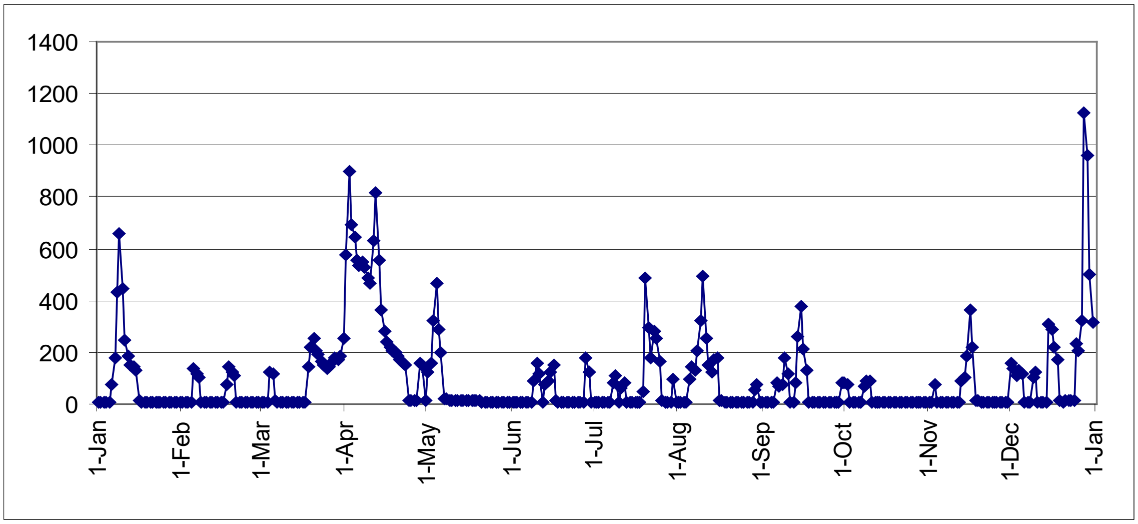


Figure 2.19: 2008 Daily Suspended Solids

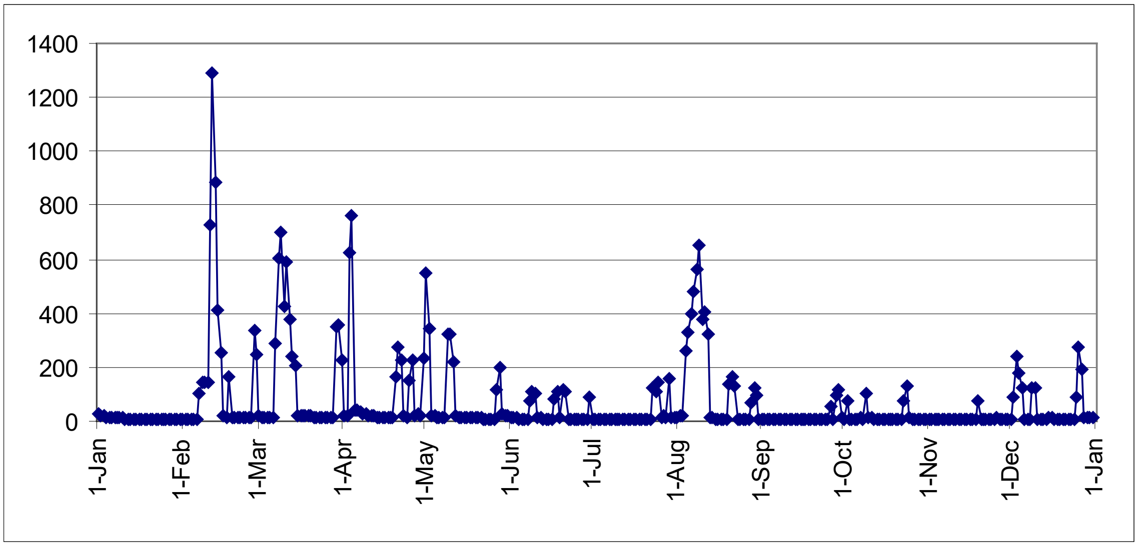


Figure 2.20: 2009 Daily Suspended Solids

2.4.8 Groundwater Quality

Groundwater quality data was obtained from the Provincial Groundwater Monitoring Network (PGMN), municipalities (through data requests, and Drinking Water Surveillance Program reports), and from other reports and studies.

Provincial Groundwater Monitoring Network (PGMN)

Groundwater quality is monitored by fourteen PGMN wells at ten sites within the CVSPA (**Appendix A1, Figure A.2**). Three wells are completed in bedrock and eleven are completed in overburden deposits. The PGMN has been in operation since 2001.

These wells are sampled twice a year (spring and fall) for general chemistry and metals. Wells located near agricultural activities are also sampled for pesticides and herbicides. The water quality data is compared to the MOECC Ontario Drinking Water Quality Standards (ODWS) criteria. General conclusions on the groundwater quality in the wider watershed areas are summarized in **Table 2.8**, while the supporting data is presented in **Appendix B 1.6.**

Table 2.8: Groundwater Quality - Wider Watershed, 2002-2009

Parameter	Summary
Chloride	• Chloride has been detected at concentrations above the ODWS aesthetic objective of 250 mg/L at two of the PGMN wells. These are shallow wells at Warwick and Georgetown. They are both located near roadways where road salting occurs, which is the likely source of the elevated chloride concentrations. Erin well also shows increasing trend in concentration.
Hardness	• Hardness has been detected at concentrations above the ODWS operational guideline of 80-100 mg/L at all 14 of the sampled PGMN wells. • The hardness concentrations in the PGMN wells are attributed to naturally high levels of calcium carbonate ($CaCO_3$) in the groundwater in most of the watershed.
Sodium	• Sodium has been detected at concentrations above the ODWS aesthetic objective of 200 mg/L at Warwick since 2004. • Sodium has been detected at concentrations above 20 mg/L at several other PGMN wells. The concentrations were typically in the20-40 mg/L range. • Possible sources include road salting, private septic systems where water softeners are used, and naturally occurring sodium in deeper bedrock zones.
Nitrate	• Nitrate has been detected at concentrations greater than 4 mg/L in some of the PGMN wells (ODWQS is 10 mg/L). However, the concentration at most PGMN wells is less than 1.5 mg/L. • Studies have identified private septic systems as a cause of locally high nitrate concentrations in groundwater supplies, with agricultural use of fertilizer as an additional possible source of nitrate in groundwater in rural areas.
Pesticides / Herbicides	• Pesticides and herbicides generally have not been detected in any of the groundwater samples from the PGMN wells within the CVSPA. The few detections of these parameters have been very close to the laboratory method detection limit, and well below applicable ODWS.
Volatile organic compound (VOC)	• As described above for pesticides and herbicides, VOCs also generally have not been detected in any of the groundwater samples from the PGMN wells within the CVSPA. The few detections of these parameters have been very close to the laboratory method detection limit, and well below applicable ODWS

Municipal Water Quality

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.

The Characterization Report describes groundwater quality based on the review of Drinking Water System Regulation O. Reg 170/03 reports between 2001 and 2005, and on the analyses of municipal raw water data, obtained directly from the municipalities. Data sets from 2005 to 2009, were subsequently obtained to supplement the database and to enable an update on the quality of groundwater used as a source for municipal supplies.

GUDI Wells

Several municipal wells are designated as Groundwater Under Direct Influence of Surface Water (GUDI) (O. Reg 170/03). Their sources were determined to be located within approximately 50 days horizontal saturated travel time from surface water or are within 100 m of surface water for overburden wells or within 500 m of surface water for bedrock wells (whichever is greater). GUDI wells are potentially susceptible to variations in surface water quality.

Municipal water supplied through a GUDI well is required to undergo treatment in the form of chemically assisted filtration and disinfection, unless a hydrogeological study shows to the satisfaction of the MOECC that the aquifer is providing effective in situ filtration.

The filtration effectiveness of the aquifer under these requirements can be regarded as:

- The ability of the aquifer and well (as constructed) to provide water with turbidity levels acceptable for adequate treatment (i.e., standard chlorination or other disinfection of groundwater sources); and
- The ability of the aquifer and well to provide adequate “filtration” and travel times (50 day minimum) to ensure microbiological protection at the well from potential sources.

All GUDI wells within the CVSPA are identified below, and further referenced in **Chapter 4** (groundwater vulnerable zones).

The data (annual reports, municipal data) shows that groundwater quality at municipal wellheads in the CVSPA has met ODWS for both organic and inorganic constituents. Water quality is presented below for each municipality served by groundwater sources.

Inorganic Parameters

An overview is provided in respect of the general characteristics of the groundwater used as a source for municipal water systems, but emphasis has been placed on three parameters — sodium (Na), chloride (Cl) and nitrate (NO_3) — since they are commonly sampled, are typical indications of surface activity, and are mobile in the groundwater flow system.

Sodium and chloride are naturally occurring components of groundwater, but levels can be elevated due to human activities, such as water softening (water treatment process) and the application of winter de-icing material. Nitrate contamination can originate from agricultural activities and from septic systems.

The ODWS for sodium is 200 mg/L. However, the local Medical Officer of Health should be notified when sodium concentration exceeds 20 mg/L so that doctors can advise their patients on a sodium restricted diet.

Chloride is generally found in salt (sodium chloride (NaCl). The ODWS for chloride is 250 mg/L.

Annual data shows that in 2009 *raw water* at all municipal wellheads in the CVSPA met the ODWS for sodium, chloride, and nitrate. However, the majority showed sodium concentrations over and above the 20 mg/L. **Appendix B1.7** presents a summary of annual average sodium, chloride, and nitrate concentrations in 2009 for each municipal well in CVSPA.

Historical Trends

Municipal raw water quality records dating back to the 1990's and in some instances, to the 1980's, were referenced in order to review the trends in these parameters at municipal wellheads. The major findings are as follows:

Towns of Orangeville and Mono

The Town of Orangeville owns and operates twelve municipal wells in nine wellfields, located mainly within urbanized areas in the western areas of the town.

The groundwater in the Orangeville area is naturally hard and high in iron and manganese. Many of the supply wells are equipped with filters to reduce concentrations of iron and manganese in the water. In addition, sodium silicate is used for iron sequestering in Well 6. The available data shows that the groundwater used for municipal supplies to both towns, meet the ODWS with respect to inorganic parameters, and is suitable for drinking. This data also shows that all organic parameters were non-detect at both municipal networks.

Historical water quality trends for sodium, chloride, and nitrates were originally reviewed for the period 1983 – 2009. In 2013, the Source Protection Committee requested that an updated assessment of water quality issues for the town's municipal wells be undertaken. This entailed the analyses of additional data to the end of 2012. This review is fully detailed in **Chapter 5.5.1**.

The trends for sodium, chloride, and nitrates (**Figures 2.21-2.23**, **Appendix B1.7**) indicate the following:

- Nitrate concentrations (ODWS 10 mg/L) at the majority of wells ranged from non-detect to 3.0 mg/L. Concentrations at wells 1, 3, 4, 6, 8B, C, 11, and 12 have generally remained relatively constant with a slight increase in trend over time. Concentrations at wells 9A, 9B, and 2A show greater increase in trends with time. Concentrations at Well 5 and 5A have consistently ranged between 4.0 and 5.0 mg/L;
- Chloride concentrations (ODWS 250 mg/L) in most wells have increased markedly over time but are still below the ODWS. Concentrations in Wells 2A, 5/5A, 6, 9, 10, and 11 have shown marked increases since 2000; and
- Sodium concentration (ODWS 200 mg/L) show similar trends to chloride. Increases at Wells 6 and 10 are the most prominent, though still below ODWS.

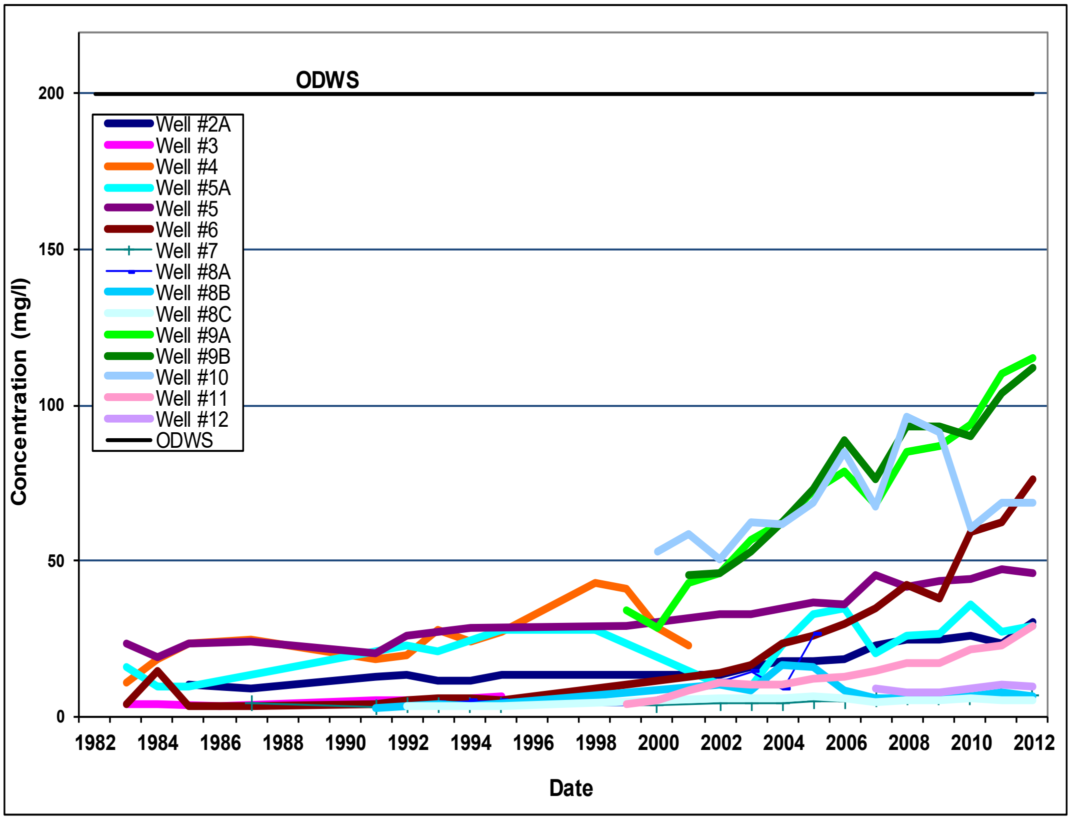


Figure 2.21: Orangeville Municipal Wells – Sodium Concentration 1982–2012

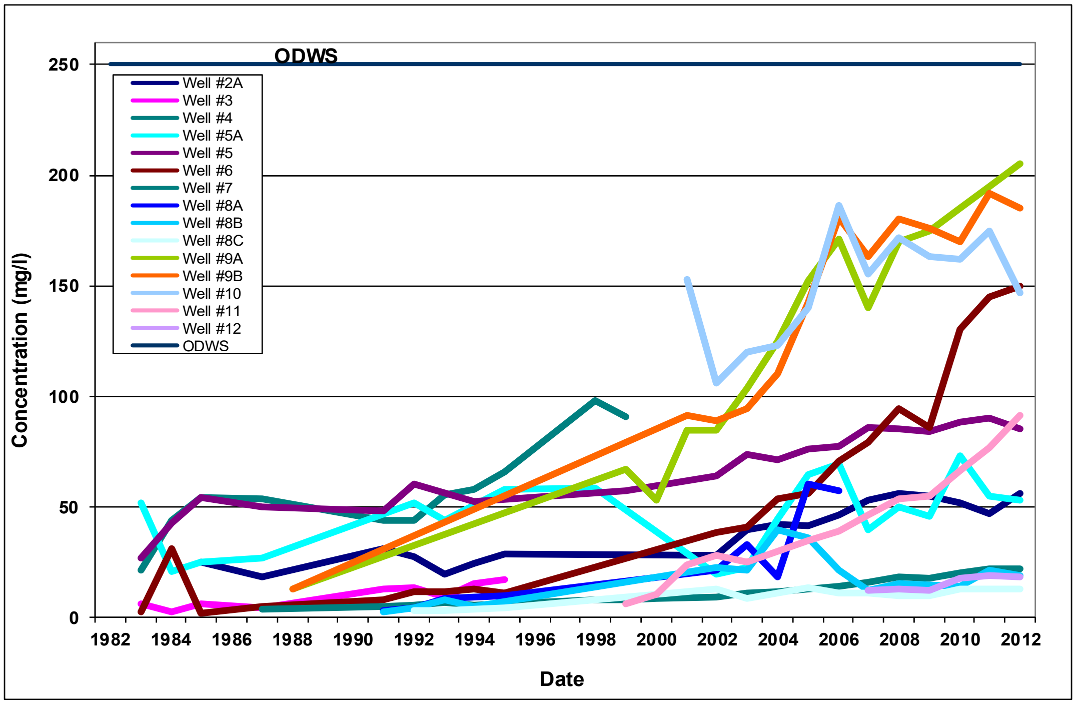


Figure 2.22: Orangeville Municipal Wells – Chloride Concentration 1982-2012

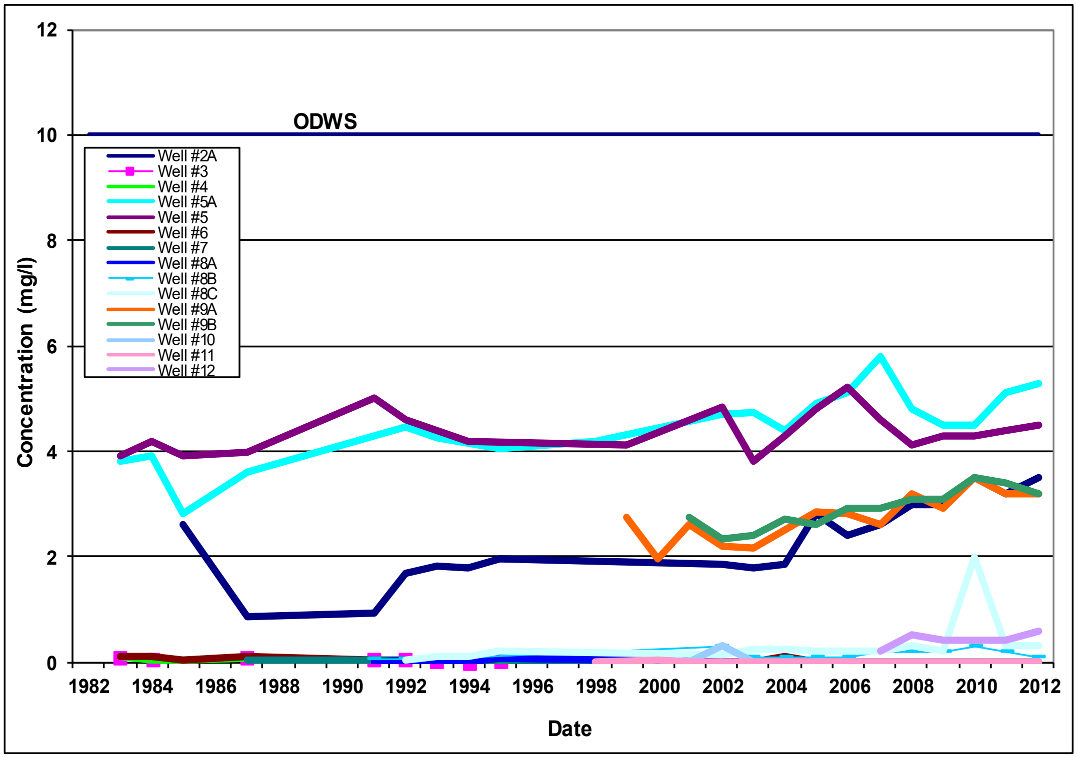


Figure 2.23: Orangeville Municipal Wells – Nitrate Concentration 1982–2012

The Town of Orangeville maintains Mono's municipal water system. Two of the three supply wells at Cardinal Woods Subdivision are GUDI with effective in-situ filtration.

The available historical data for Mono show that the groundwater used for municipal supplies meets the ODWS with respect to inorganic parameters and is suitable for drinking. The data also shows that all organic parameters were non-detect at both municipal networks.

The data for Mono (2002 – 2008) (**Figures 2.24-2.26**, **Appendix B 1.7),** indicates the following:

- Nitrate concentrations remain non-detect at Coles and Island Lake, and has been relatively consistent (no increase in trends) at Cardinal Wood MW-1 and MW-3;
- Chloride concentrations have remained relatively constant at the Coles Wellfield but have shown increases in the order of 10 – 20 mg/L at the other wellfields. Additional time series of data is required to be able to identify more discernable trends; and
- Sodium concentrations show similar trends to chloride.

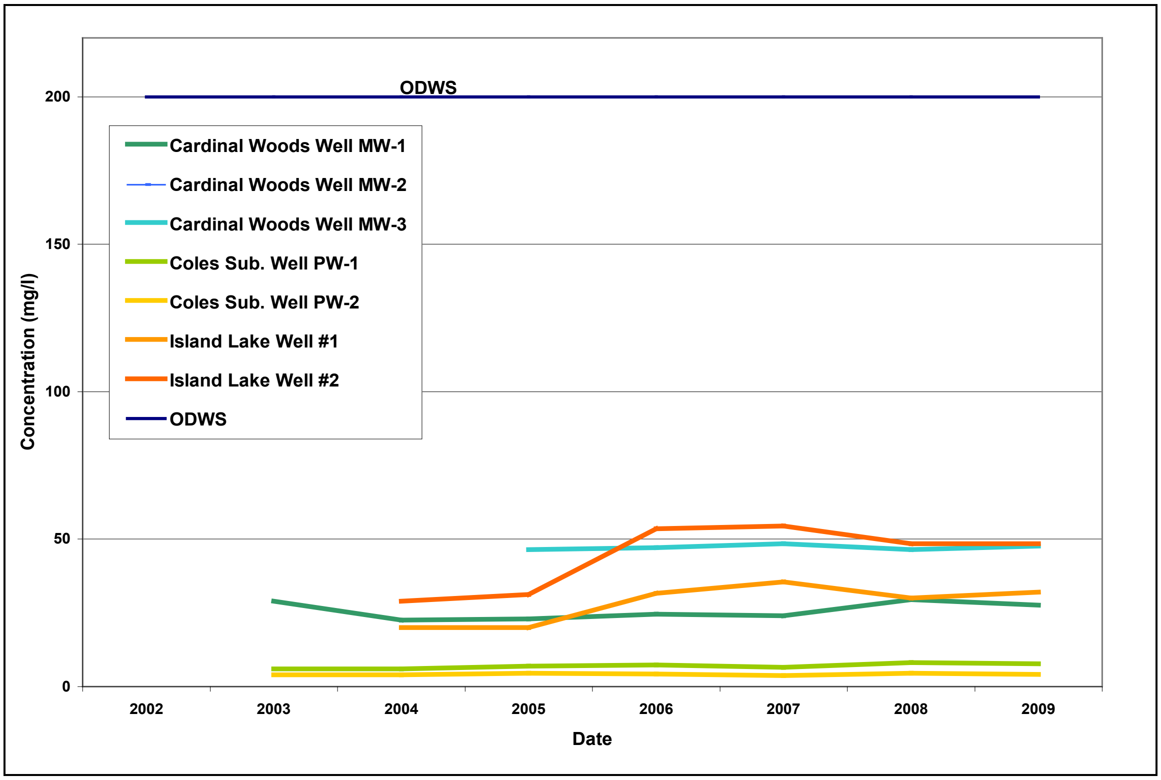


Figure 2.24: Mono Municipal Wells – Sodium Concentration 2002 – 2009

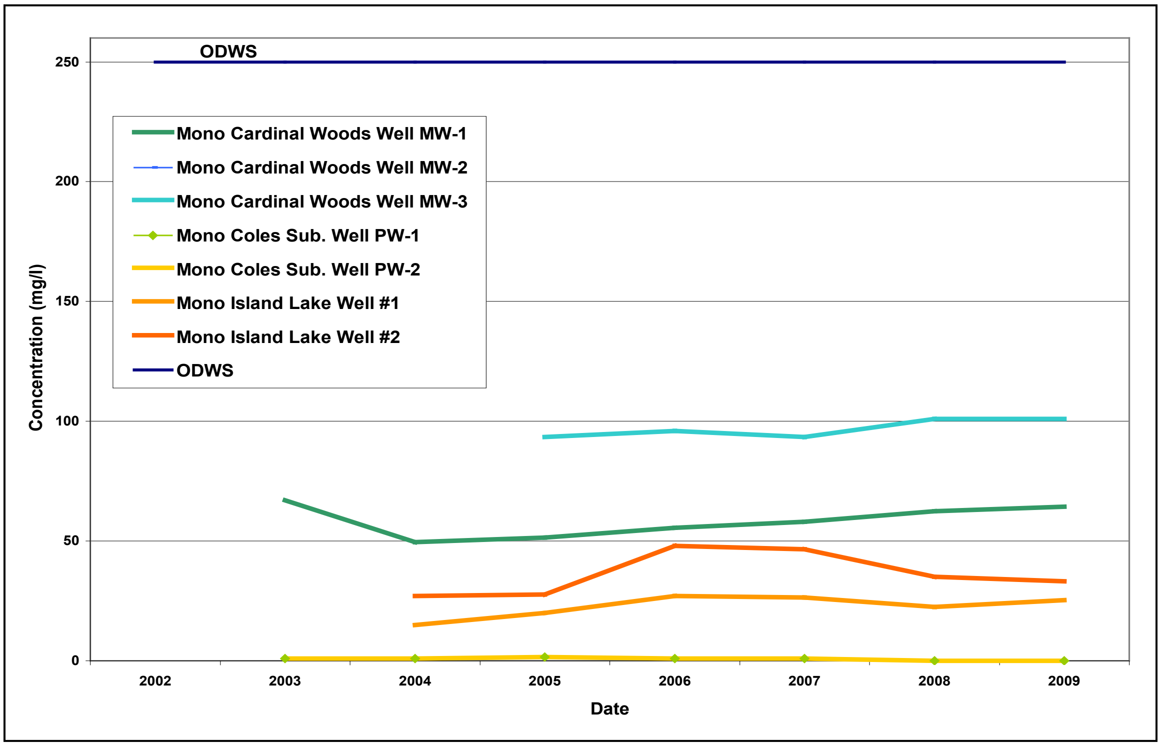


Figure 2.25: Mono Municipal Wells – Chloride Concentration 2002 – 2009

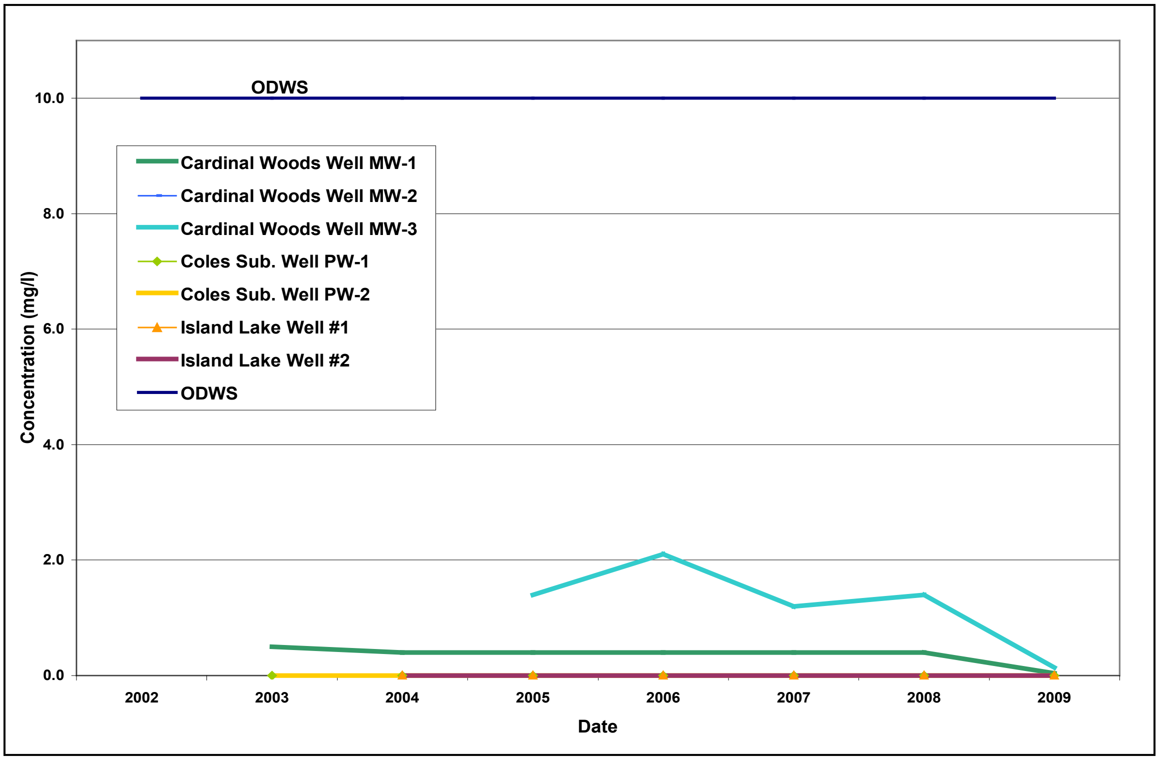


Figure 2.26: Mono Municipal Wells – Nitrate Concentration 2002 – 2009

Township of Amaranth – Pullen Well

The Pullen well has never been used and is not currently online. As a result, annual water quality data is not available. The only water quality data available were obtained in 2002 during a pumping test of the well. The sample results indicated that all parameters were below the ODWS (Burnside and Gartner Lee, 2004).

Based on the location of the well within agricultural lands and in close proximity to a roadway, the parameters expected to be of concern at this location are nitrates and chlorides. Water quality samples collected in 2002 reported concentrations of 0.4 mg/L for nitrates and 9.2 mg/L for chlorides. These levels are comparable to levels of 0.2 mg/L and 0.5 mg/L of nitrates reported for Orangeville Well 12 in 2007 (Burnside 2010). Chloride levels are also seen as consistent with the 12 mg/L and 12. 0 mg/L reported for Well 12 in 2007 (Burnside 2010). Orangeville Well 12 is the closest municipal well to the Pullen Well.

Town of Erin

The Town of Erin has four supply wells, two in Hillsburgh and two in the Village of Erin. The town also maintains two sentry wells in Erin to monitor municipal water quality. None of Erin's wells are GUDI. Two other wells, formerly supplying the Bel–Erin subdivision, were taken offline in 2002 due to a lack of adequate in situ filtration amid stricter MOECC requirements.

To review the parameter trends at the municipal wellheads, raw water quality records for Erin and Hillsburgh were accessed from drinking water standard annual reports dating back to the early 2000's, and also directly from the Town. There has been limited water quality data collected for Bel–Erin wells, primarily during the years from 1997 – 2002 when the wells were operating.

The records show that the groundwater quality meets the ODWS with respect to both inorganic parameters and organic parameters and is suitable for municipal drinking supply. This data also show that all organic parameters were non-detect at both networks. No exceedances of trace metals were noted. Trihalomethane concentrations range from 2.6 to 6.7 µg/L, well below the ODWS (100 µg/L).

The only parameter of concern was lead, which was found in low concentrations in raw water at Hillsburgh Well 2 (H2). A hydrogeological assessment of H2 in 2001, as part of the preparation of the Engineers Report (Triton Engineering Services Limited, 2001), concluded:

- Lead is naturally occurring;
- There were no potential historical sources of lead contamination;
- The well has a high level of natural protection; and
- There is no evidence of impacts from surface sources of contamination for any other water quality parameters.

A lead removal filtration system was added in 2004 as the lead concentration in the raw water was approaching 10 ug/L, the ODWS for lead. The filtration consists of dosing raw water with ferric chloride through a chemical feed pump, and then pumping the mixed water through a large diameter PVC pipe with filter elements that remove the particulate matter, included the lead that has precipitated through oxidation with ferric chloride. Historical (1995 – 2008) trends for sodium, chloride, and nitrates at the Town of Erin's systems (**Figures 2.27 – 2.29**) indicate the following:

- Nitrate concentrations (ODWS 10 mg/L) at the majority of wells typically ranged from non-detect (ND) to 1.5 mg/L. The majority of the wells show no discernable increase in trends;
- Chloride concentrations (ODWS 250 mg/L) in most supply wells ranged between 1 and 8 mg/L and appear to be relatively stable over time; and

- Sodium concentrations (ODWS 200 mg/L) showed similar trends to those of chloride, with relatively low increases at the majority of the town's wellfields. Concentrations have generally remained below 15 mg/L over the time period.

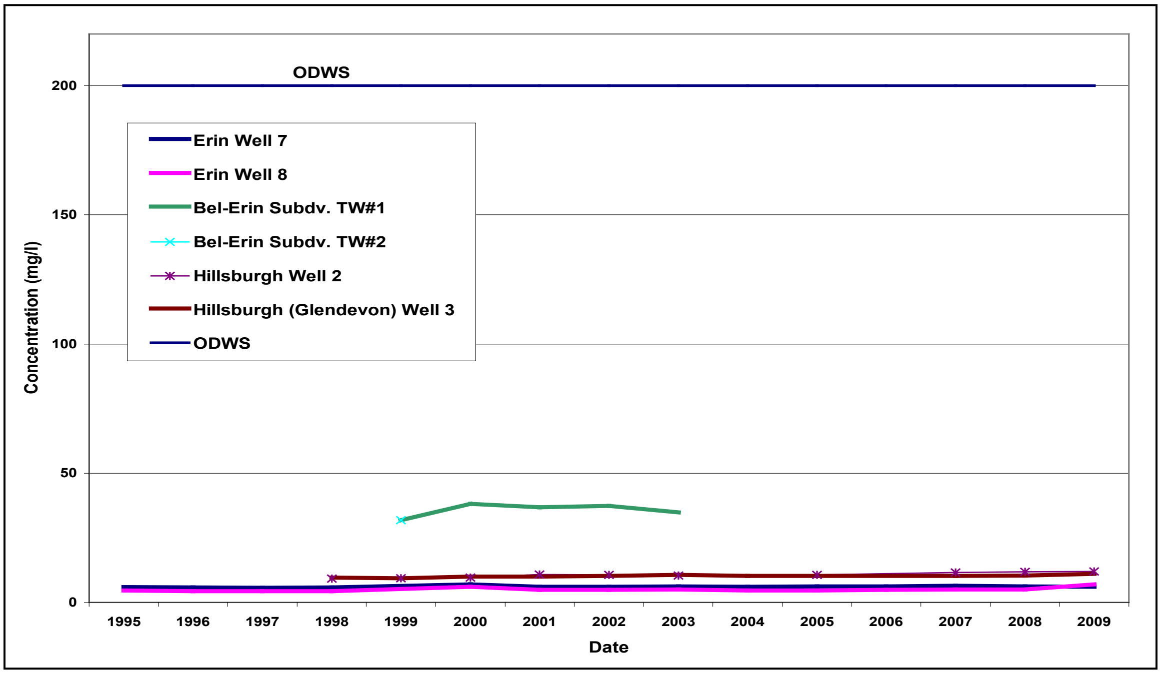


Figure 2.27: Erin Municipal Wells – Sodium Concentration 1995–2009

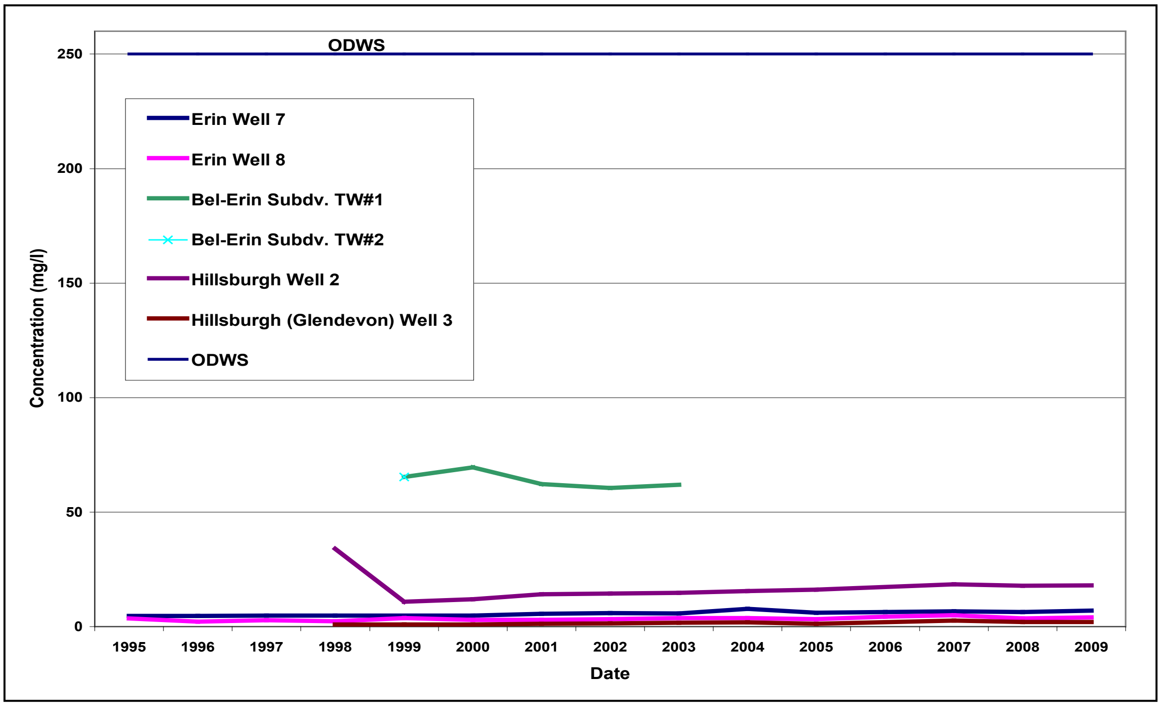


Figure 2.28: Erin Municipal Wells – Chloride Concentration 1995–2009

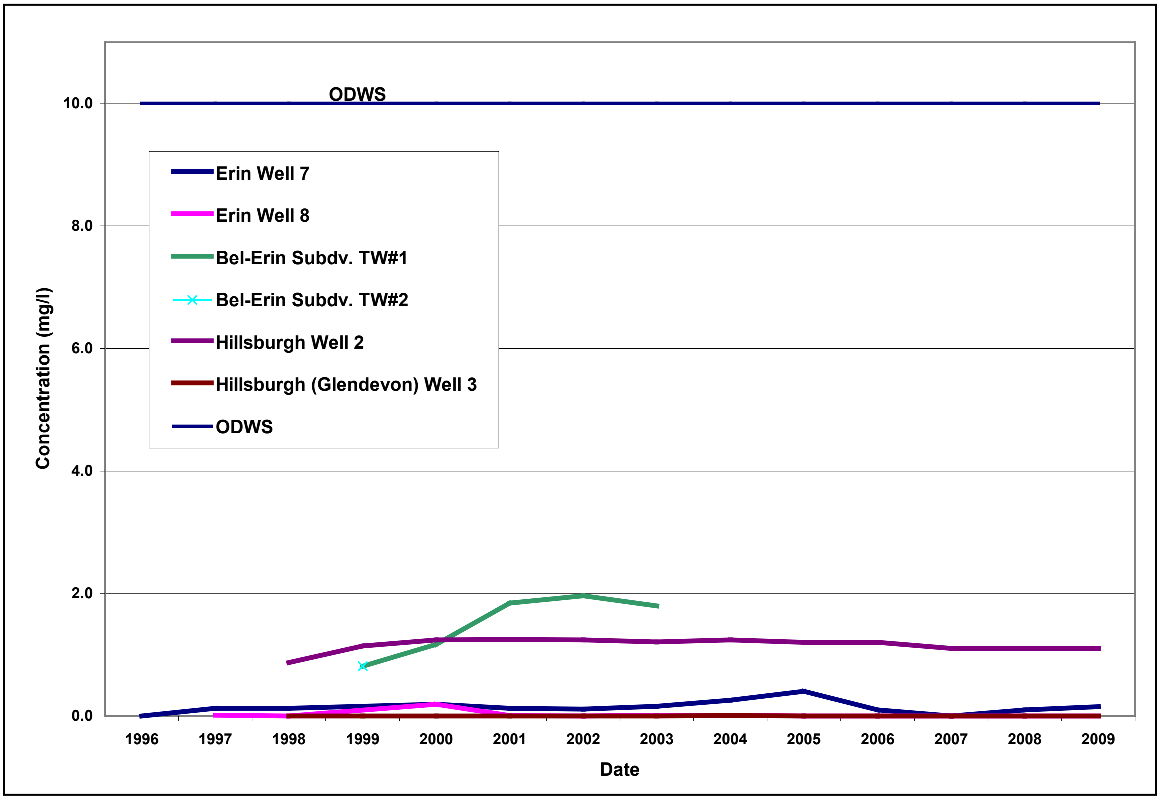


Figure 2.29: Erin Municipal Wells – Nitrate Concentration 1995–2009

Town of Halton Hills

Halton Region provides municipal water supply through five wells in three wellfields at Acton and seven wells in three wellfields at Georgetown. It also maintains a network of ten sentry wells (Georgetown) to monitor municipal water quality.

All wells at Acton are classified as GUDI, as are the Cedarvale wells at Georgetown. The available data shows that the groundwater supplies to both wellfields meet the ODWS with respect to both inorganic parameters and organic parameters and is suitable for municipal drinking supply.

The groundwater in general, is very hard and often exceeds the operational guideline range of 80-100 mg/L listed in the Technical Support Document for *Ontario Drinking Water Standards, Objectives and Guidelines, 2006 (ODWS*). Hardness is not a health-related parameter and therefore does not present a significant issue with respect to the use of the groundwater for municipal water supply.

Manganese levels are also naturally high in most wells. Manganese can be elevated as a result of reducing conditions and mineral deposits in the bedrock aquifer. The ODWS aesthetic objectives for manganese is 0.05 mg/L. It is not a health-related parameter. High levels may result in the staining of laundry and fixtures and may impair tastes in beverages.

Historical water quality trends for sodium, chloride, and nitrates were originally reviewed for the period 1986 – 2009. In 2013, Halton Region requested that an updated assessment of water quality issues for their wells at Acton and Georgetown be undertaken. This work included the analyses of additional data to the end of 2012. This review is fully detailed in **Chapter 5.5.5**. The trends for sodium, chloride, and nitrates at Acton (**Figures 2.30-2.32**, **Appendix B 1.7**) indicate the following:

- Chloride concentrations (ODWS 250 mg/L) at 4th Line and Davidson wellfields range from 10 mg/L to 30 mg/L, and have shown a relative increase over time, but are still well below the ODWS. Concentrations at Prospect Park #1 though, have also shown relative increase in the last five years, although stabilizing in the 2010 to 2012 period. Prospect Park #2 has hovered around 70 mg/L in the last 8 years;
- Sodium concentrations (ODWS 200 mg/L) show similar trends to those of chloride for all of Acton's wells; and
- Nitrate concentrations (ODWS 10 mg/L) at Prospect Park and 4th line typically ranged from 0.1 mg/L to 3.0 mg/L. These wellfields have exhibited slight increase in trend over the last two decades. The concentration at the Davidson wells range between 4 mg/L to 6 mg/L but has shown a distinct increase in the last decade.

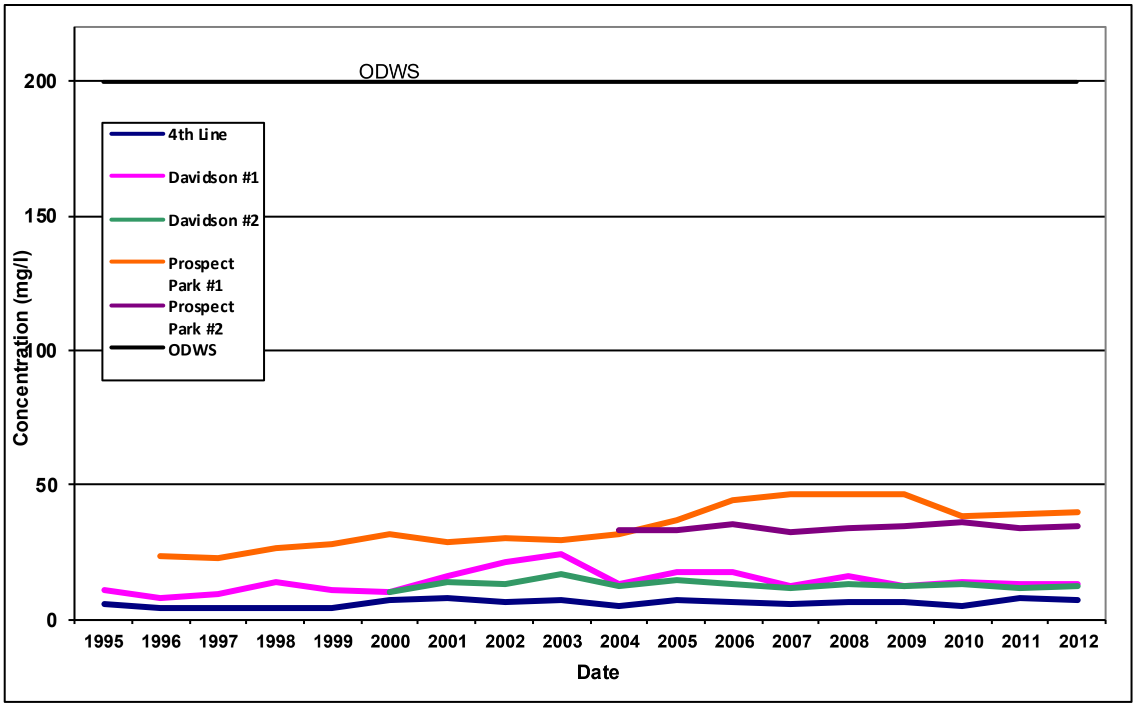


Figure 2.30: Acton Municipal Wells – Sodium Concentration 1986–2012

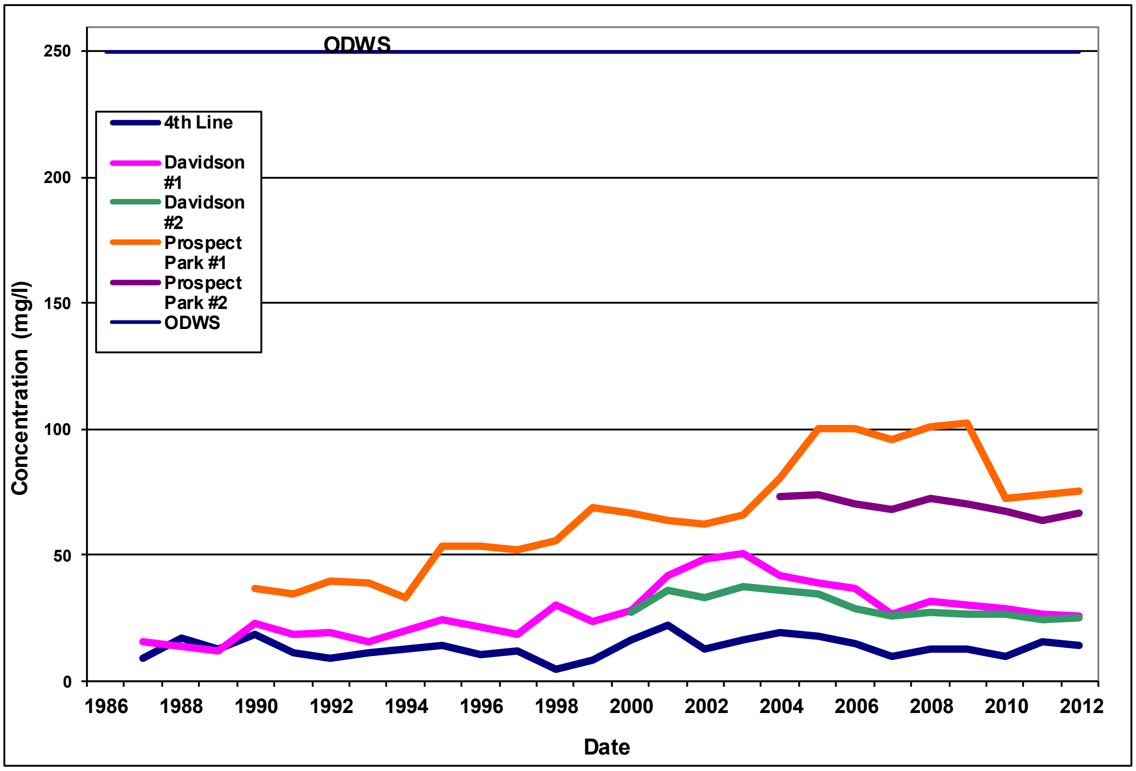


Figure 2.31: Acton Municipal Wells – Chloride Concentration 1986–2012

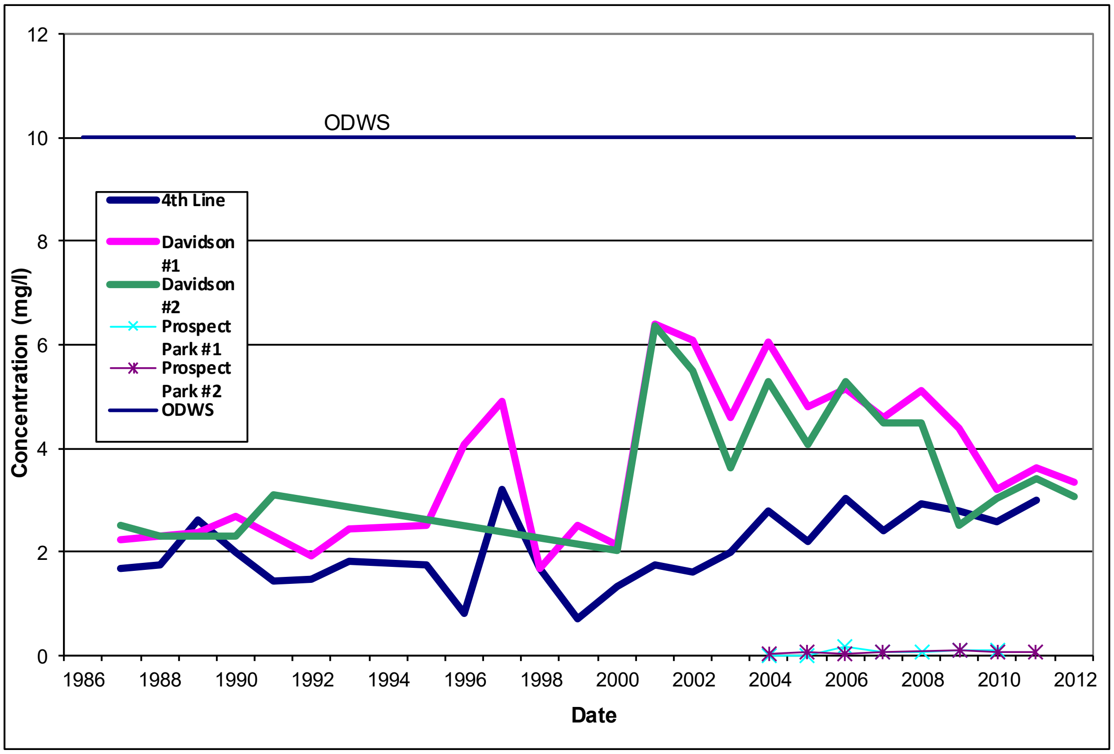


Figure 2.32: Acton Municipal Wells – Nitrate Concentration 1986–2012

Historical (1986 – 2008) trends for sodium, chloride, and nitrate at Georgetown (**Figures 2.33-2.35**, **Appendix B 1.7**) indicate the following:

- Nitrate concentrations at Cedarvale wellfield typically ranged from 0.2 mg/L to 1.5 mg/L, showing a slight increase in trend over the last two decades. Nitrate concentration at Lindsay Court, and Princess Anne wellfields have typically been greater, ranging between 1.7 and 4.5 mg/L;
- Chloride concentrations at Georgetown's wells, with the exception of Lindsay Court, typically range between 110 mg/L and 160 mg/L. Concentrations have shown sharp increases in the last decade, typically from around 70 mg/L to 170 mg/L). At Lindsay Court chloride concentration has remained relatively constant over the last decade (about 70 mg/L), dropping over the last few years; and
- Sodium concentrations (ODWS 200 mg/L) show similar trends to those of chloride, and typically range between 50 and 70 mg/L, with the exception of Lindsey Court, which has remained relatively constant at around 37 mg/L over the last five-plus years.

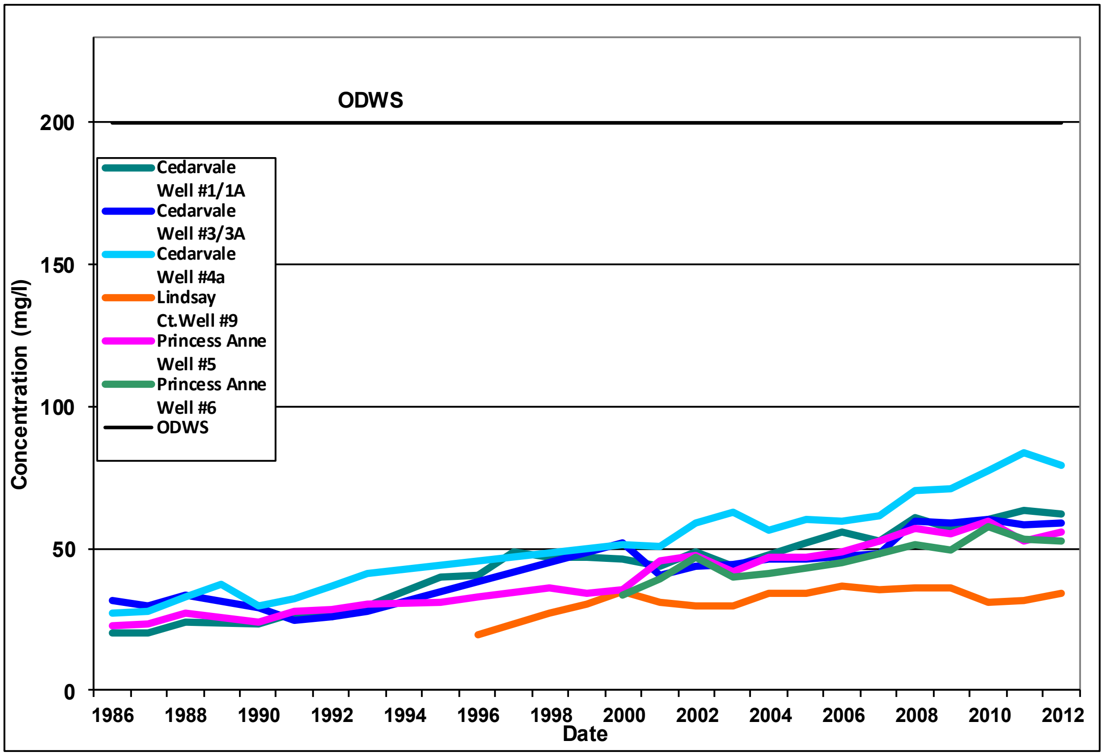


Figure 2.33: Georgetown Municipal Wells – Sodium Concentration 1986–2012

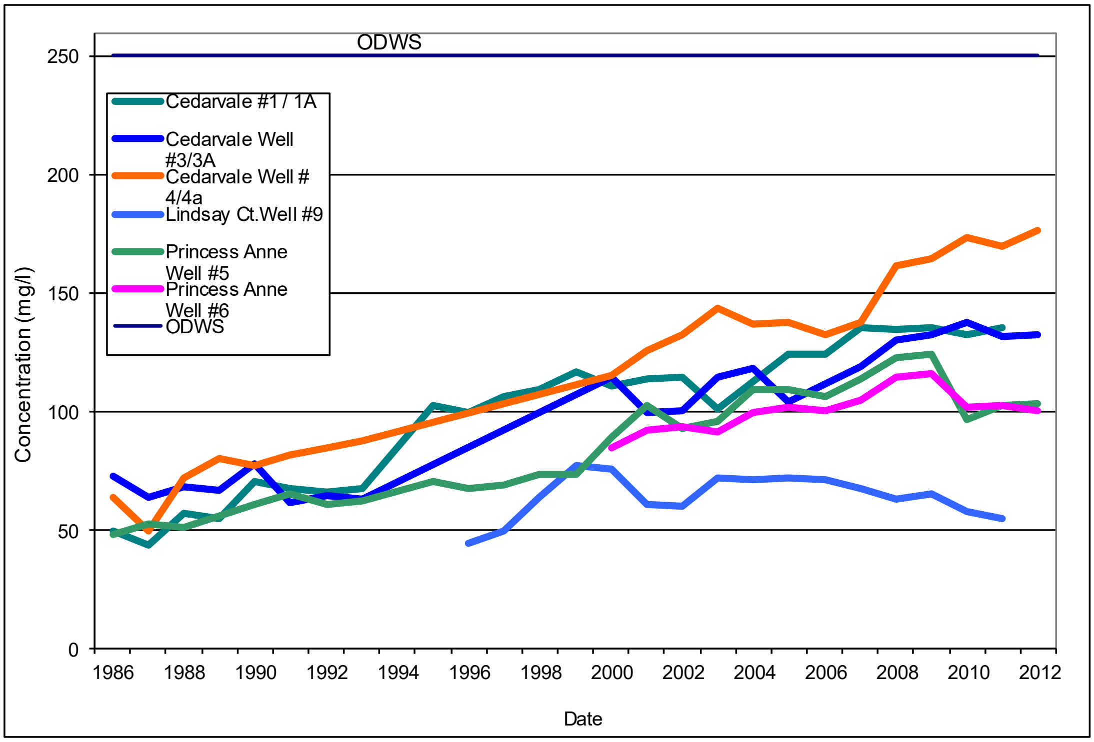


Figure 2.34: Georgetown Municipal Wells – Chloride Concentration 1986–2012

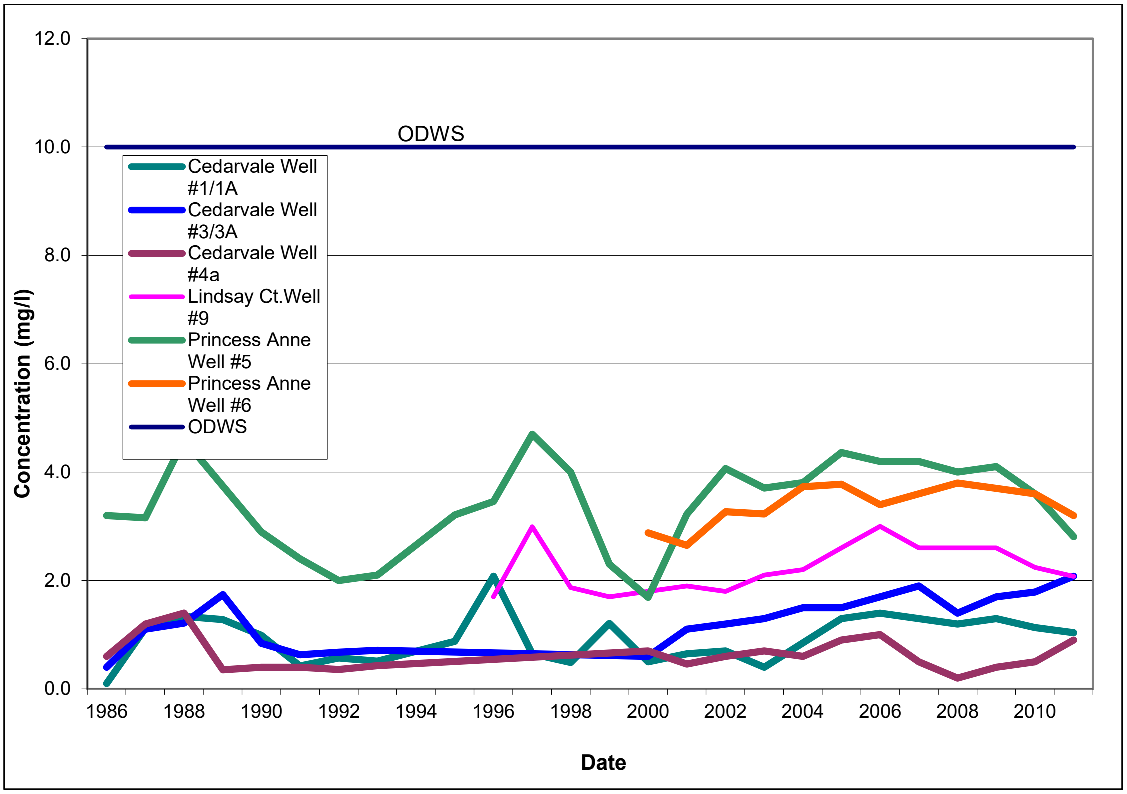


Figure 2.35: Georgetown Municipal Wells – Nitrate Concentration 1986–2012

Town of Caledon

The Regional Municipality of Peel owns and operates nine municipal wells in wellfields located in Alton, Caledon Village, Cheltenham, and Inglewood. The Region also maintains a monitoring network to observe and safeguard municipal water quality at each wellfield.

The groundwater in the area, in general, is very hard and often exceeds the operational guideline range of 80-100 mg/L listed in the *Technical Support Document for Ontario Drinking Water Standards, Objectives and Guidelines, 2006* (ODWS). Water samples collected in 2006 ranged in hardness between 176 mg/L to 715 mg/L. Hardness is not a health-related parameter and therefore does not present a significant issue to the use of the groundwater as a source for municipal water supplies.

The groundwater in this area has naturally high concentrations of iron. The guideline for iron is considered an aesthetic objective, which means that it may impair the taste, smell or colour of the water or interfere with good water quality control practices. Iron concentrations exceeded the ODWS aesthetic objective of 0.3 mg/L in the following wells: Cheltenham 1 and 2, Caledon Village Well 4, and at Inglewood Well 3. Greensand filters have been installed in many of the wells with high iron concentrations, and they have proven to adequately remove iron from the raw water, thereby reducing the potential impacts on the aesthetics and treatment of the groundwater.

Manganese can be elevated as a result of reducing conditions and mineral deposits in the bedrock aquifer and exceeds the ODWS aesthetic objective of 0.05 mg/L in the Cheltenham Wells 1 and 2. Manganese is not a health-related parameter. High levels may result in the staining of laundry and fixtures and may alter taste when used in beverages.

During the period that the initial water quality review was completed, the Region of Peel maintained two wells at the Alton wellfield - Alton Wells 3 and 4. A replacement well for Well 4 - named 4A - was drilled in 2019, and Well 4 decommissioned shortly thereafter. Future water quality trends will be assessed using data from Well 3 and Well 4A.

At the Inglewood wellfield, the Region previously maintained two wells - Inglewood Well 2 and Well 3. In May 2019, a deeper supply well - Inglewood Well 4 - was completed and brought on-line to replace Inglewood Well 2. Inglewood Well 2 was subsequently decommissioned in October 2021

Historical (1982 – 2009) trends for sodium, chloride, and nitrate (**Figures 2.36 - 2.38** and **Appendix B 1.7**) indicate the following:

- Nitrate concentrations (ODWS 10 mg/L) at the majority of Peel's wells typically ranged from non-detect to 3.0 mg/L;
- Chloride concentrations (ODWS 250 mg/L) at Alton Wells 3 and 4 have shown marked increases (from 50-100 mg/L) since 2000. Chloride concentrations at Caledon Village Well 4, Inglewood Well 3, and Cheltenham Wells 1 and 2 remained relatively stable and ranged between 10 and 50 mg/L; and
- Sodium concentrations (ODWS 200 mg/L) show similar trends to those of chloride, with relatively low increases at the majority of the wells. The most noticeable increase was observed at Alton Wells 3 and 4 with orders of approximately 60 and 80 mg/L, respectively.

Nitrate and chloride concentrations at Alton Wells 3 and 4 remain well below the ODWS but monitoring wells nearby have shown markedly increasing trends since the late 1990s. Therefore, the region instituted an "early warning" monitoring program in the early 2000s to monitor for groundwater contaminants and water levels.

This program comprises the following:

- A series of early warning wells at each WHPA;
- Water level monitoring conducted on a quarterly basis;
- Water quality monitoring conducted on a semi-annual basis; and
- Water quality monitoring parameters geared to land-uses in the vicinity of each municipal well (i.e., petroleum parameters near gas stations).

The program has actively been used to ensure the continued integrity of the municipal drinking water supply and to inform a water quality management plan for the wells.

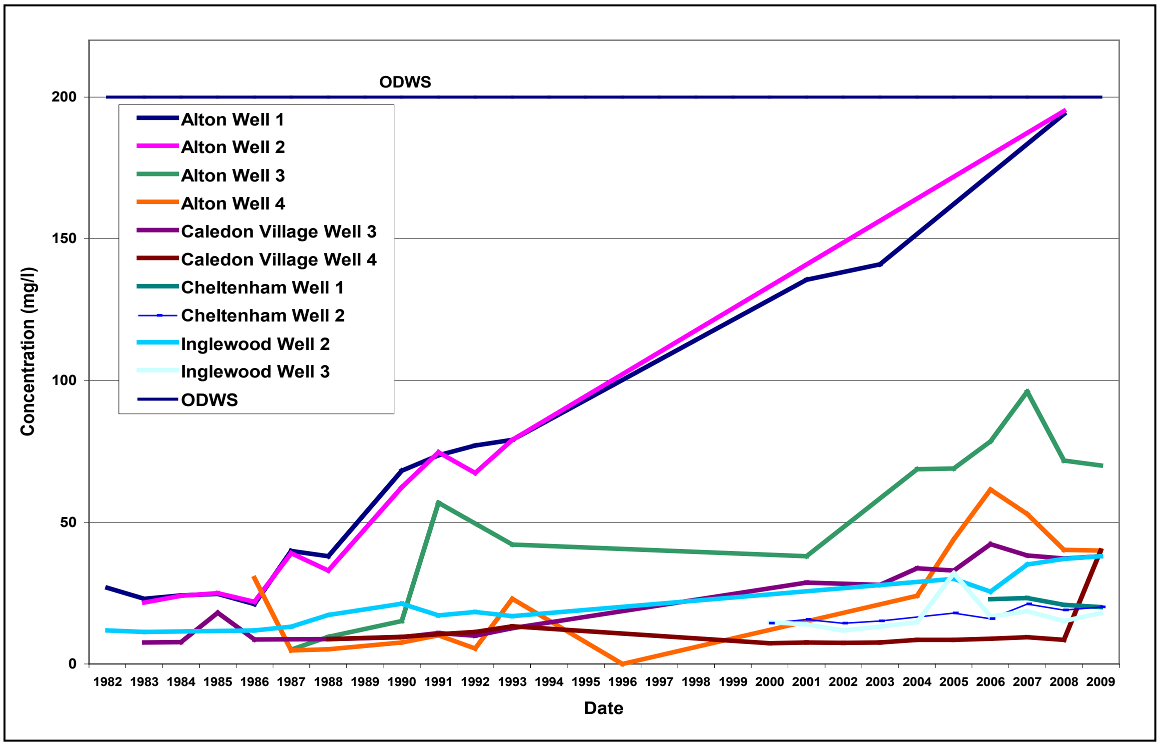


Figure 2.36: Peel Municipal Wells – Sodium Concentration 1982–2009

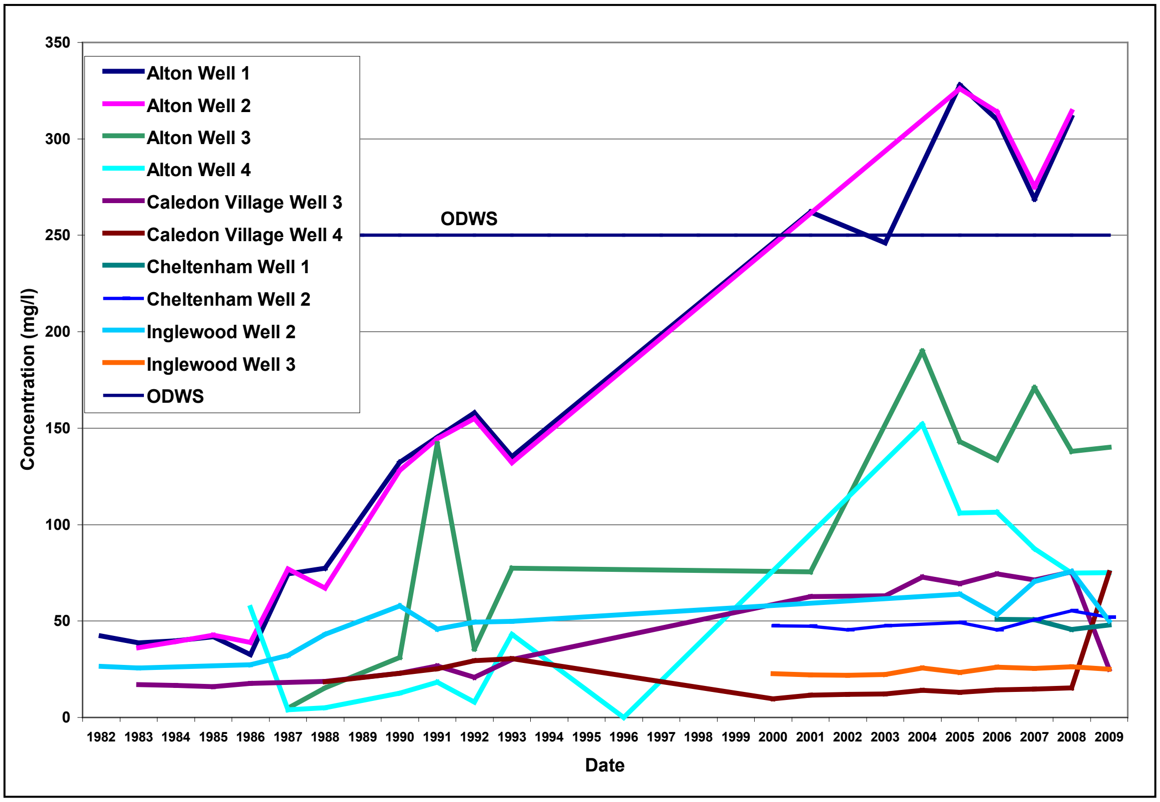


Figure 2.37: Peel Municipal Wells – Chloride Concentration 1982–2009

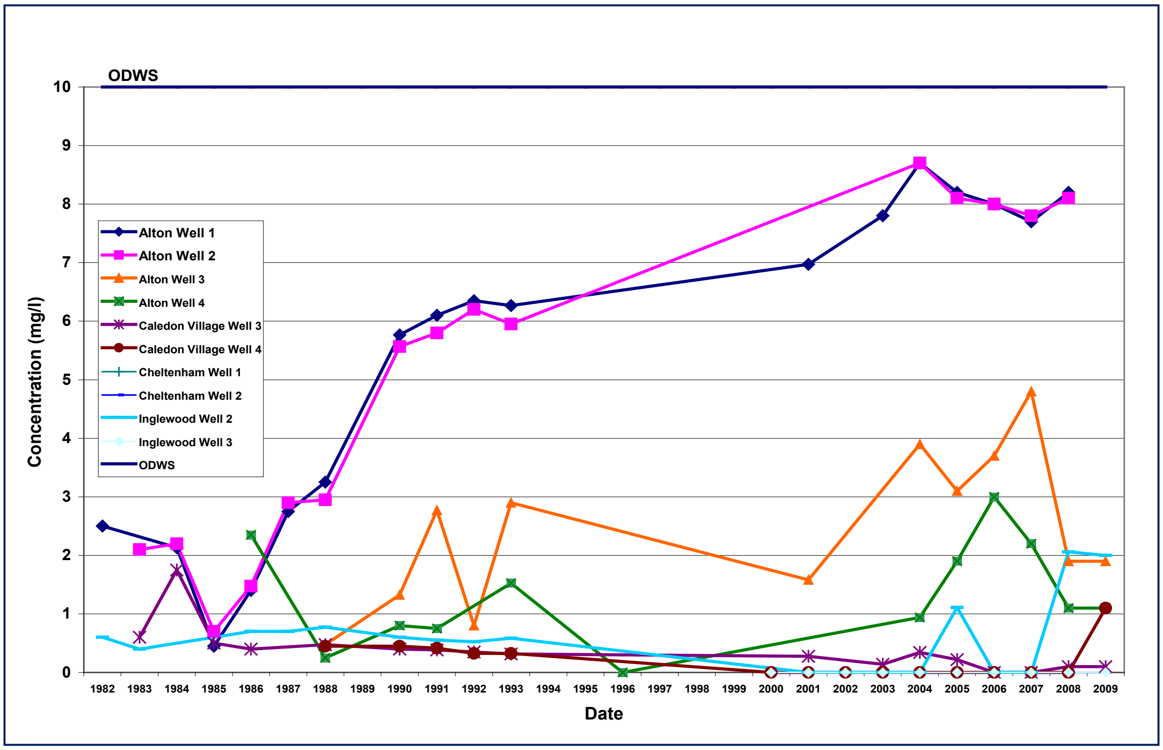


Figure 2.38: Peel Municipal Wells – Nitrate Concentration 1982–2009

Organic parameters

Microbial testing is routinely conducted on all municipal water supplies (per Regulation 170/03). Testing is undertaken on raw water samples, and treated water throughout the distribution system. Testing is conducted for *E. coli*, fecal Coliform bacteria, total Coliform bacteria, and Heterotrophic Plate Count.

Appendix B 1.7, Table B3 presents a summary of microbiological testing for the municipal wells for 2009. In some instances, (e.g., Halton), the municipality only provided raw water data from combined wells or a reservoir rather than from individual wells. Raw water sampling varied from less than once a week to up to four times per week.

No significant microbial incidences have been reported by municipalities, except at the Fourth Line and Davidson wells of the Acton water system. Analysis of raw water from the Davidson wells between 2003 and 2008 showed that 10% of 609 samples from Well 1, and 7% of 602 samples from Well 2, tested positive for *E. coli*. Also, 31% of 609 samples from Well 1, and 17% of 511 samples from Well 2 tested positive for total coliform. These wells are GUDI, and it was initially suspected that a small creek on a neighbouring property may have been a possible source, but further analysis indicated that the source of bacteria is unlikely to be surface water (Halton Region, 2002b). During these instances, routine chlorination brought the water to potable quality.

The water quality data for the Cedarvale wells at Georgetown, also shows the presence of the chemical cis-1, 2 Dichloroethylene (1, 2 DCE). 1, 2 DCE is an odourless, colourless organic liquid, which may occur in the environment as a result of the anaerobic degradation of chlorinated solvents commonly found in municipal and industrial landfills, including tetrachloroethylene (PCE), trichloroethylene (TCE), 1,1,1-trichloroethane, and 1,1,2,2-tetrachloroethane (California EPA, 2006). TCE is a known human carcinogen, and long-term consumption of cis-1, 2 Dichloroethylene contaminated water could result in liver problems (EPA, 2010).

1, 2 DCE may also originate from industrial sources as it is used as a refrigerant, in the extraction of rubber, oils and fats, metal working, and in the production of pharmaceuticals and artificial pearls (EPA, 2010).

Halton Region is aware of the presence of the chemical and has established an intensive monitoring program in support of the PTTW for the Cedarvale Wells. This program is being undertaken as part of the long-term management of the water supply and attempts to identify the source from which the chemical originates.

There is currently no maximum allowable concentration for 1, 2 DCE in the ODWS or CCME guidelines, but the World Health Organization (WHO) standard of 50 µg/L has been adopted by the region, as a surrogate standard, in its monitoring program. To further ensure safety of its drinking water sources, 50% of this standard is applied as a trigger threshold. While the concentration of 1, 2 DCE is still relatively low (0.5 -2.5 µg/L, **Figure 2.39**), it is recommended that a monitoring program be continued as part of the long-term management of the water supply.

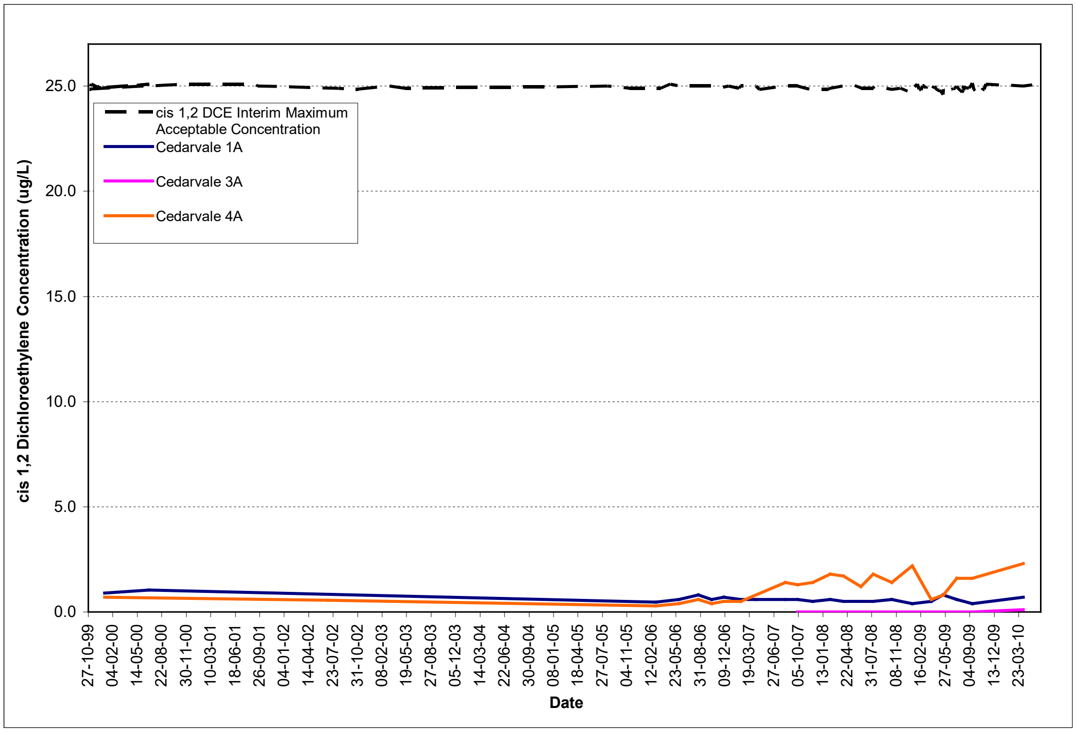


Figure 2.39: Cedarvale Wells (Halton Region) – cis-1, 2 Dichloroethylene 1982–2009

Non-municipal Water Usage

An assessment of water use in the CVSPA was undertaken in 2006 by the CVC, using an approach documented by the Grand River Conservation Authority (GRCA, 2005). This method estimates water use from the MOECC's PTTW database in addition to reported municipal pumping rates. The water takings are estimated by reviewing the hydrologic source(s) indicated in the permit and making adjustments for seasonal use. The top five water use sectors identified by this survey are shown in **Table 2.9**.

Table 2.9: Estimated Permitted Abstraction in CVSPA

	Specific Water Use	Percent Water Taking	Percent Consumption
1	Aggregate Washing	30%	20%
2	Municipal Supply	26%	69%
3	Groundwater Remediation	17%	4%
4	Golf Course Irrigation	11%	2%
5	Pit & Quarry Dewatering	10%	1%
	Total:	**94%**	**96%**

Table 2.9 reports that municipal takings are estimated to account for 26% of the water removed from the CVSPA. As such, the survey concludes that approximately 74% of abstraction permitted is for non-municipal usage.

The percent of water taking represents the amount of water physically pumped or extracted from the CVSPA by permit holders (identified in the PTTW database), while the percent consumption shows the amount permanently removed (or consumed). Much of this water would eventually be returned to the hydrologic system via surface water discharge, recharge to the groundwater system or through sewage treatment plants.

The evaluation of such consumptive demand is critical in assessing the sustainability of municipal supplies and in developing reliable water budget information for the CVSPA, which is addressed in detail in **Chapter 3**.

Private Drinking Water

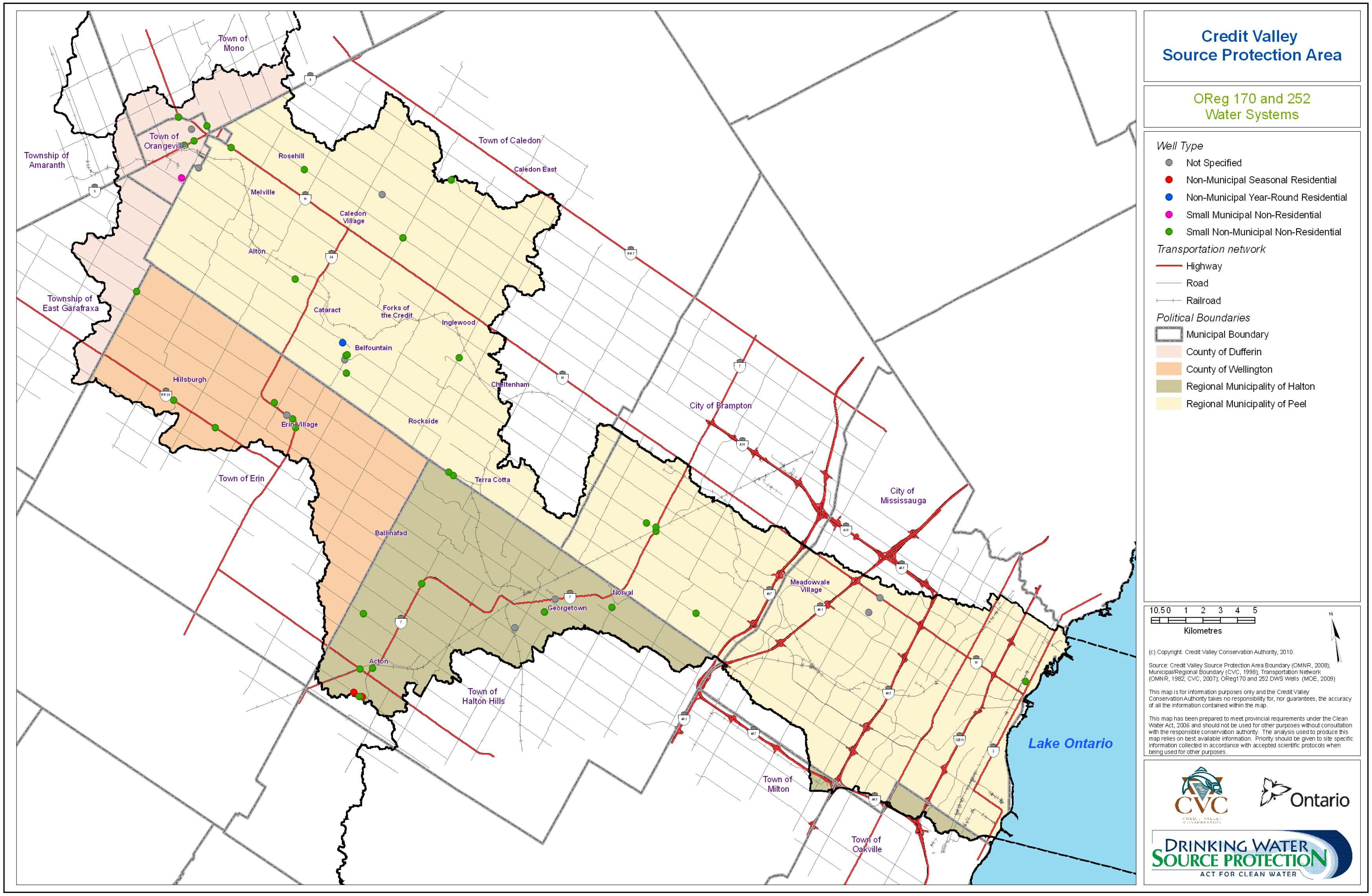
Privately owned water wells are also used for drinking water supplies in the middle and upper zones of the CVSPA. Based on population numbers from 2006 (Statistics Canada, 2008) and data received from municipalities, an estimated 33,000 residents receive water supply through private wells in the towns of Amaranth, Orangeville, Mono, Erin, and Caledon.

Regulation 170 and 252 Wells

Regulations 170, and 252 wells and intakes, includes those that provide drinking water and those that serve designated or public facilities, such as community centers, campgrounds, churches, schools, etc. In general, they include the following systems:

- Non-municipal seasonal residential;
- Non-municipal year-round residential;
- Small municipal non-residential; and
- Small non-municipal non-residential.

The location of these systems in the CVSPA, are shown in **Figure 2.40.**



(c) Copyright. Credit Valley Conservation Authority, 2010.

Source: Credit Valley Source Protection Area Boundary (OMNR, 2008); Municipal/Regional Boundary (CVC, 1998); Transportation Network (OMNR, 1982; CVC, 2007); OReg170 and 252 DWS Wells (MOE, 2009)

This map is for information purposes only and the Credit Valley Conservation Authority takes no responsibility for, nor guarantees, the accuracy of all the information contained within the map.

This map has been prepared to meet provincial requirements under the Clean Water Act, 2006 and should not be used for other purposes without consultation with the responsible conservation authority. The analysis used to produce this map relies on best available information. Priority should be given to site specific information collected in accordance with accepted scientific protocols when being used for other purposes.

Figure 2.40: O. Reg. 170 and 252 Water Systems

Ecological Water Needs

The CVSPA is home to a wide number of diverse ecological and terrestrial resources. A wide variety of aquatic plant and animal species rely on a constant supply of clean groundwater and surface water. The reliability of this supply must be ensured for these species to thrive in the future. The CVSPA supports diverse coldwater fisheries that are dependent on groundwater upwelling. Any future assessments of water demands must take into consideration the impact to sensitive flora and fauna dependent on groundwater and surface water features.

2.5 LAND USE

2.5.1 Population, Distribution and Density

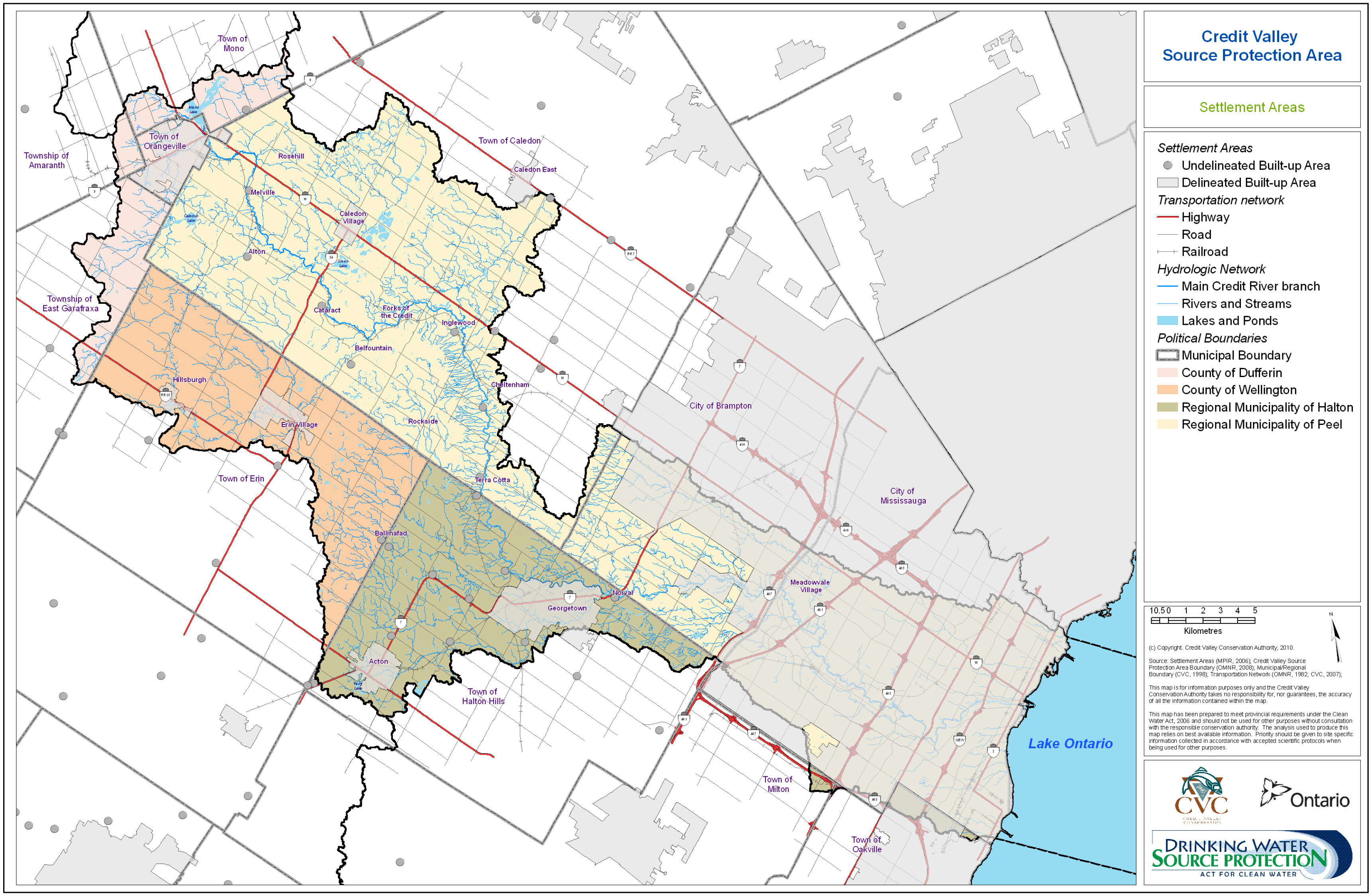
In 2006, CVSPA had a population of approximately 759,690 residing within its jurisdiction (Statistics Canada, 2008). The majority (about 87%) live within the lower zone in the cities of Mississauga and Brampton, while smaller populations exist in the middle (Town of Halton Hills) and upper zones.

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 CVSPA, the major areas of settlement are listed in **Table 2.10**, and shown on **Figure 2.41**.

Table 2.10: Municipalities of the CVSPA

REGION/COUNTY	TOWNSHIP/ CITY
Regional Municipality of Peel	Town of Caledon City of Brampton** City of Mississauga**
Regional Municipality of Halton	Town of Halton Hills Town of Milton Town of Oakville
County of Wellington	Town of Erin
County of Dufferin	Town of Orangeville Town of Mono Township of East Garafraxa Township of Amaranth
City of Toronto**	City of Toronto**

** denotes major city (Statistics Canada, 2008)



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Source: Settlement Areas (MPIR, 2006); Credit Valley Source Protection Area Boundary (OMNR, 2008); Municipal/Regional Boundary (CVC, 1998); Transportation Network (OMNR, 1982; CVC, 2007);

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Figure 2.41: Settlement Areas

Population centers are classified along a tiered structure. Hamlets, towns, and cities are Lower Tier municipalities, and are grouped into Upper Tier municipalities of the regions and counties. An Upper Tier municipality is composed of two or more Lower Tier Municipalities. There are also Single Tier Municipalities.

Population density is the number of people living within 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.

In this report, density was based on 2006 census data and computed using *dissemination areas*. Dissemination area boundaries respect census subdivision and census tract boundaries; thus, they can be added together or 'aggregated' to create any of the other standard geographic areas above census subdivisions and census tracts in the hierarchy.

Dissemination areas (Da) - the smallest standard geographic area for which all census data are disseminated (Census Canada).

Population density was determined by overlaying the CVSPA boundary on top of the census data. This clipped the census data by the SPA boundary. For dissemination areas not entirely contained within the SPA, their densities were assumed to be uniform across the dissemination area, and the population density based on the area of the SPA boundary. **Table 2.11** lists the estimated population (2006 census) and the density by municipality, while **Figure 2.42** shows the population density in the CVSPA.

The areas with the greatest population density are in Mississauga, Brampton, Halton Hills, and Orangeville. Those with the smallest are Milton, East Garafraxa, and Amaranth.

Planned growth within municipalities is impacted by the *Places to Grow Act*, as well as the *Greenbelt Act*. The legislation has a great impact on where municipalities are permitted to develop land, and urban expansion planning.

There is planned growth in all urban centres in the CVSPA both above and below the escarpment. However, growth is limited in some communities that are dependent on groundwater, and sewage treatment plants – that outlet to the Credit River – due to constraints in groundwater availability and assimilative capacity, respectively.

According to the Ministry of Public Infrastructure and Renewal's *Proposed Places to Grow Plan*, the Region of Peel is predicted to grow by almost 60% in 30 years while the Region of Halton is anticipated to grow by 100% over the same period. To accommodate this population growth, the greatest share of available developable lands in the western GTA lies within the City of Brampton.

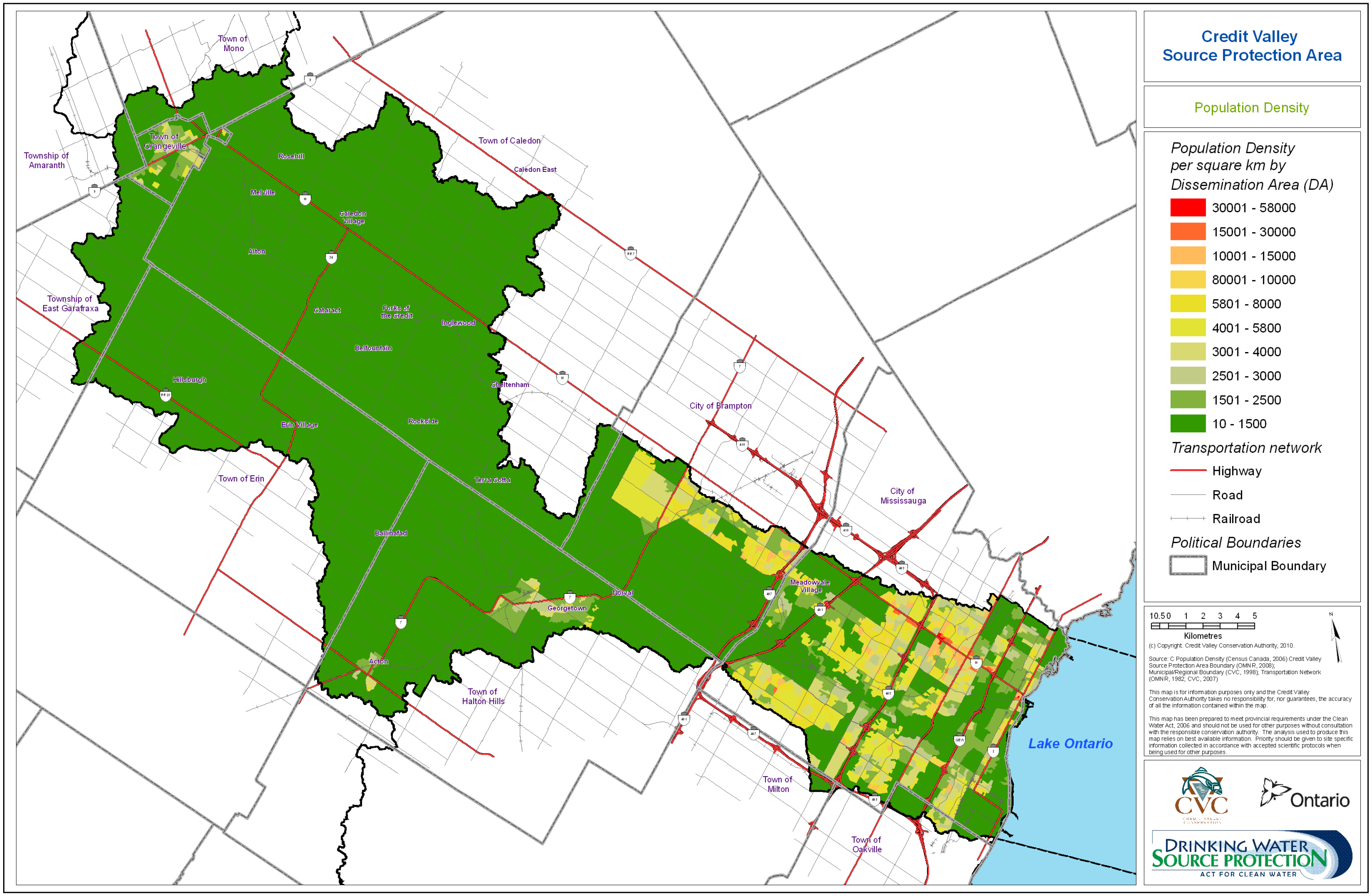
Currently, regional and county level Official Plans are being amended to conform with Growth Plan policies relating to population and employment projections, population intensification strategies, job density targets, etc. Therefore, it is difficult to presently determine where projected population and employment will be distributed in the existing settlement areas located within the CVSPA.

Table 2.11: Resident Population within the CVSPA (2006 Population Census)

Region/County	Municipality	Area within CVSPA		Population* CVSPA	Population Density
Upper Tier	**Lower Tier**	**km²**	**ha**		**Per ha**
Dufferin County	Orangeville	15.85	1585.43	26,925	16.98
	Mono	19.50	1950.17	1,744	0.89
	Amaranth	4.43	443.48	102	0.23
	East Garafraxa	26.41	2641.01	654	0.25
Wellington County	Erin	138.45	13845.33	7,540	0.55
Halton Region	Halton Hills	141.68	14168.20	44,966	3.17
	Milton	1.61	160.67	25	0.16
	Oakville	5.39	539.37	5,168	9.58
Peel Region	Caledon	310.52	31052.01	11,076	0.36
	Brampton	94.17	9416.65	137,908	14.65
	Mississauga	188.29	18828.80	523,582	27.8
City of Toronto	City of Toronto*	0.005	0.50	6	12.7
			All CVSPA	**759,690**	

Due to the CVSPA boundary location, a small area of the City of Toronto lies in the jurisdiction

*** based on 2006 Census Canada data**



Source: C Population Density (Census Canada, 2006) Credit Valley Source Protection Area Boundary (OMNR, 2008); Municipal/Regional Boundary (CVC, 1998); Transportation Network (OMNR, 1982; CVC, 2007)

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Figure 2.42: Population Density

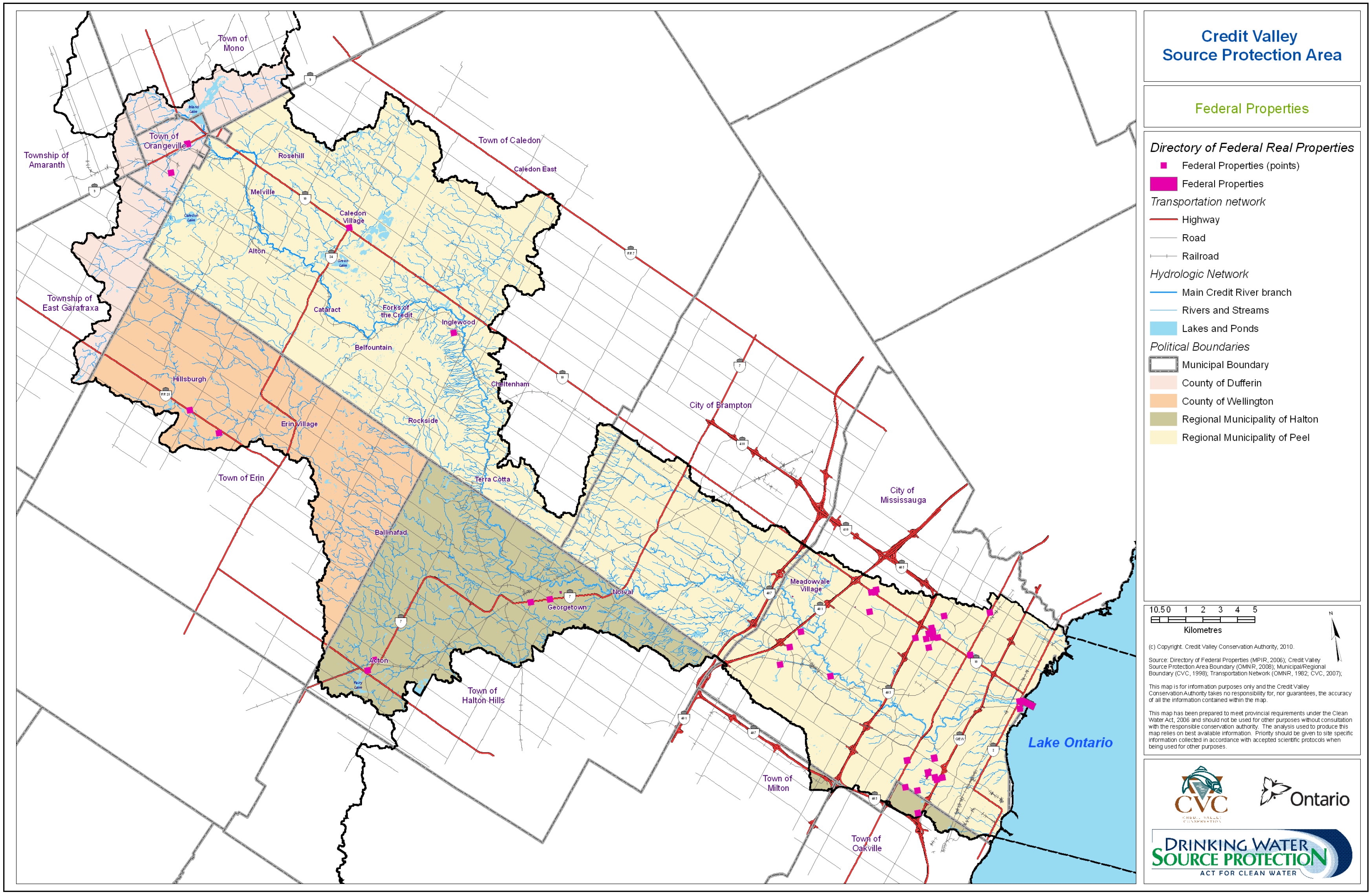
2.5.2 Managed Lands

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 threats tables as a prescribed threat. 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 de-icing salt may be applied and potentially result in deteriorated water quality. The 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 CVSPA jurisdiction.

The available data (MPIR, 2006) shows that there are about 52 federally owned and regulated properties in the CVSPA. These properties are shown in **Figure 2.43.** Federal lands in the CVSPA are associated with the Canada Post Corporation, Public Work and Government Services, and Atomic Energy of Canada. They also include those associated with Departments of National Defence, Transport Canada (aircraft and navigation beacons), and Fisheries and Oceans Canada (Boat Harbour – Port Credit).



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Source: Directory of Federal Properties (MPIR, 2006); Credit Valley Source Protection Area Boundary (OMNR, 2008); Municipal/Regional Boundary (CVC, 1998); Transportation Network (OMNR, 1982; CVC, 2007);

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Figure 2.43: Federal Properties

2.6 SUMMARY

The Watershed Characterization presents a description of existing conditions and overall watershed health within the CVSPA. It provides an overview of the physical setting, ecology (wetlands, aquatic life, and species at risk), and land-use within sub-watersheds comprising the SPA. The chapter also characterizes human settlement patterns and gives a review of the current status of water systems servicing member municipalities – both surface water and groundwater – in respect of water use, water quality, and sustainability.

The watershed characterization revealed interesting trends in the quality of water used as a source for municipal supplies. In general, parameter concentrations remain comfortably below the ODWS, indicating that both surface water and groundwater sources of municipal drinking water tend to be of high quality. However, several supply wells have shown increases in sodium and chloride over time, which are thought to be associated with the application of road salt. Nitrate increases were also observed in several wells, and thought to be linked to septic systems, and nutrient application (fertilizers and agricultural source material). Groundwater sources account for about 12% of the CVSPA's drinking water and supports vital ecosystem functions.

Under normal weather conditions, surface water quality in the streams discharging into Lake Ontario shows some elevated levels of chlorides, phosphorus, copper, and nitrates as compared against ecosystem and aquatic life standards. These contaminants are thought to be associated with the impact of urbanization and agricultural activities. With the exception of chlorides, which are still below the provincial standards, the other parameters showed decreasing or no trend. The surface water in streams is not used for drinking water, but for irrigation and other non-drinking water purposes, and is vital for supporting ecosystem functions.

A few large storm events occur each year and transport a significant proportion of the loads from tributaries 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.

As the population increases over the next 25 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 Mississauga, Brampton, Caledon, and Orangeville, while rural areas are not expected to experience substantial growth.

Lake Ontario is targeted as a drinking water supply to support growth in the lower zone of the CVSPA. Ongoing aquifer studies attempt to determine additional potential for groundwater extraction in the middle and upper zone.