Chapter 2 – Cataraqui Source Protection Area

2.0 Introduction

This chapter provides the reader with an overall perspective on the watersheds, physical geography, human geography, and Great Lakes aspects of the Cataraqui Source Protection Area (CSPA). For additional detail on these topics, the reader is invited to review the Watershed Characterization Report: Cataraqui Source Protection Area (CR

CA, 2008) in **Appendix 'L-2'**.

The Cataraqui Source Protection Area (CSPA) is located at the eastern end of Lake Ontario and the beginning of the St. Lawrence River (**Map 1-1**). It includes a portion of the Bay of Quinte, Hay Bay, the southern portion of the Rideau Canal and the Thousand Islands of the St. Lawrence River. The region includes approximately 1,000 kilometres of Great Lakes shoreline (Lake Ontario and the St. Lawrence River, including the islands) and about 200 *inland lakes*. It covers the jurisdiction of the Cataraqui Region Conservation Authority (CRCA), plus the municipality of Frontenac Islands (Howe and Wolfe Islands) and the waters up to the International Boundary between Canada and the United States of America (**Map 1-2**).

The landscape of the CSPA is extremely varied. The central region is characterized by the exposed *bedrock*, lakes and woodlands of the *Canadian Shield* (*Frontenac Axis*), while the south and west consist mainly of the agricultural landscape of the *limestone* and clay plains (**Map 2-1)**. In the east, the *surficial geology* is dominated by sand and gravel. The landscape is described in detail by Chapter 1 of the Watershed Characterization Report: Cataraqui Source Protection Area (CRCA, 2008) and it is illustrated by Figures 1-4 through 1-15 of that document.

Soil cover in the CSPA is generally thin (less than one metre) and discontinuous, with areas of exposed *bedrock*. Soil types range from clay to *loam*, with areas of sand and gravel and specialized deposits of organic material, and various combinations of these soil types occurring throughout. Generally, areas of clay occur along the shorelines of Lake Ontario and the St. Lawrence River within the CSPA.

2.1 Watersheds in the Source Protection Area

A *watershed* is an area of land that contributes water to a common lake, river or stream. There are 12 major *watersheds* in the CSPA (**Map 1-2**) which have been further subdivided into *subwatersheds* (**Map 2-2**) for the purpose of this report.

This chapter describes the major *watersheds* of the CSPA. They are introduced below in five groupings (western area, Cataraqui River, Gananoque River, Frontenac and Amherst Islands, and eastern area). Subsequent *watershed* descriptions detail the areas that they occupy, their natural features, the locations and types of vegetation, land uses, fish and wildlife habitats exemplified, as well as the ground and *surface water* quality within the *watershed*.

The Cataraqui and Gananoque River *watersheds* are the largest in the CSPA. Together, these two central basins make up about 50 per cent of the CSPA. The *watersheds* of the Bay of Quinte, Millhaven, Collins and Little Cataraqui Creeks, and Amherst, Frontenac and Howe Islands are smaller; flowing to Lake Ontario and the Bay of Quinte in the western end of the CSPA. The Lyn and Jones Creeks, and Buells and Butlers Creek *watersheds* flow into the St. Lawrence River in the eastern end of the CSPA.

2.1.1 Lake Ontario Watersheds

The Bay of Quinte, Millhaven Creek, Collins Creek, Little Cataraqui Creek, and several smaller *watersheds* are located in the western portion of the CSPA (**Map 2-2**). The western-most *streams* empty into the Bay of Quinte, while all others empty into Lake Ontario. Of these *watersheds*, only Millhaven and Collins Creek *watersheds* have substantial lakes in their *drainage basins*. These lakes are relatively small, accounting for only about five per cent of the total basin area of their respective *watersheds*.

These *watersheds* lie over *limestone* and clay plains, with some *drumlins*, especially in that of the Bay of Quinte. Most of the soils of each of these *watersheds* are well *drained*, reflecting the presence of various *loams* in the upper *watershed* and higher clay content towards Lake Ontario.

Harrowsmith, Wilton, Morven, Dorland, Adolphustown, Sandhurst and Bath are within the Bay of Quinte *watershed*. The *watershed* of Millhaven Creek includes the communities of Sydenham and Odessa, while that of Collins Creek includes Westbrook, Elginburg, Glenburnie, Inverary and a portion of Kingston. Amherstview is contained within a separate, minor *drainage basin* to the west of Collins Creek. The majority of the urban area of the City of Kingston is contained within the Little Cataraqui Creek *watershed*.

2.1.2 The Cataraqui River Watershed

The Cataraqui River *watershed* occupies the center portion of CSPA (**Map 2-2**). The Cataraqui River serves as the Rideau Canal route from Newboro to the LaSalle Causeway and is controlled by a series of locks and dams, as is shown in Figure 1-22 of the Watershed Characterization Report: Cataraqui Source Protection Area (CRCA, 2008). The Rideau Canal is recognized as a National Historic Site and a United Nations Educational, Scientific and Cultural Organization (UNESCO) World Heritage Site. Contained within the Cataraqui River *watershed* are the communities of Crosby, Perth Road, Battersea, Seeleys Bay, Joyceville, and a portion of the City of Kingston. The major *subwatershed*s within the Cataraqui River *watershed* are Devil Lake, Buck Lake, and Loughborough Lake, described in detail in the Watershed Characterization Report: Cataraqui Source Protection Area (CRCA, 2008).

The numerous *inland lakes* in this *watershed* cover 17 per cent of its total area and most of the soils of the *watershed* are well *drained* (54 per cent). The upper portion of the *watershed* lies over the *Frontenac Axis* (*Canadian Shield*), while the lower reaches are over the *limestone* and clay plains. As with many other *watersheds* in the CSPA, the upper reaches of the *watershed* are characterized by *loam* type soils, with clays occurring in the lower reaches (around Colonel By Lake and areas to the south). *Bedrock* outcrops and exposed rocks also occur in some areas of this *watershed*, especially the upper portion, where the *physiography* is dominated by rock ridges and shallow *till*.

2.1.3 Gananoque River Watershed

The Gananoque River *watershed* can be subdivided into five *subwatershed*s, as shown in **Map 2-2**. These *subwatersheds* are described in detail in the Watershed Characterization Report: Cataraqui Source Protection Area (CRCA, 2008). The communities of Phillipsville, Delta, Athens, Lyndhurst, Outlet and the town of Gananoque are within the boundaries of the Gananoque River *watershed*.

Like the Cataraqui River *watershed*, many of the watercourses in the Gananoque River *watershed* are controlled by *water control structures*, as is shown in Figure 1-22 of the Watershed Characterization Report: Cataraqui Source Protection Area (CRCA, 2008). The Gananoque River receives *drainage* from various landscape types, including wooded areas of the *Frontenac Axis*, flat farmlands of the clay plain, and forest covered areas of the *Canadian Shield*. Water accounts for just below eight per cent of the total *drainage basin* area of the Gananoque River.

Soils are classified as well-*drained* in roughly one third of the Gananoque River *watershed* and very poorly-*drained* in a similar proportion of the *drainage basin*. This is reflective of the different soil types found in different areas of the *drainage basin*. *Loam* and sandy *loams* cover much of the Gananoque *watershed*, with clays occurring below Lyndhurst Lake, below Outlet dam, and from the east below Marble Rock dam to the mouth of the river. *Peat* occurs as a component of the soil cover in the Wiltse Marsh area, combined with *loams* and clays.

2.1.4 Amherst Island and Frontenac Islands Watersheds

The Amherst Island and Frontenac Islands *watersheds* are found at the eastern end of Lake Ontario (**Map 2-2**). Amherst Island is part of Loyalist Township, while Howe and Wolfe Islands (along with several smaller islands) form the Township of Frontenac Islands.

Similar to adjacent *watersheds* on the mainland, these islands are classified as part of the clay and *limestone* plains (**Map 2-1**). All three islands have mainly clay soils, with some pockets of *loam*. The terrain is flat with limited tree cover, providing an ideal environment for farming, which historically has been the predominant land use on all three islands. Watercourses generally form near the centre of the islands, flowing in a southwest or a northeast direction.

Wind power is an emerging industry on and adjacent to the islands; notably, an 86 turbine wind farm was installed on the western portion of Wolfe Island in 2009.

Stella and Marysville are the most significant settlements on Amherst Island and Wolfe Island, respectively. At the time of writing this report, the Township of Frontenac Islands was considering the merits of a municipal residential drinking water system for Marysville. The related environmental assessment was incomplete, such that there was not yet a ‘planned’ system as defined under the Ontario Clean Water Act, 2006. If a system with a new intake into Lake Ontario is installed in the future, then *intake protection zones* around that intake can be included in future editions of this report.

2.1.5 St. Lawrence River Watersheds

The St. Lawrence *watershed* extends along the shoreline of the river from just east of Kingston to Brockville, and it includes the Thousand Islands (**Map 2-2**). A large portion of these *watersheds* lie over the *Frontenac Axis* (*Canadian Shield*) area (**Map 2-1**). The remaining area is comprised of *limestone* plains, with a small area of sand plain in the eastern extent.

LaRue Mills Creek flows through typical Leeds Knobs and Flats area (exposed rock between deep clay beds), with many municipal drains as tributaries. The soil type in the remainder of the *watershed* is *loam*.

A similar *drainage* pattern is observed for Jones Creek, but with a larger *drainage area*, including two ponds. One of these ponds forms the headwaters of Lyn Creek. Both the St. Lawrence *watershed* and the Lyn and Jones *watersheds* drain to the St. Lawrence River.

Buells and Butlers creeks also flow to the St. Lawrence River. Their *drainage basins* are largely sand plain, which is characteristic of the eastern portion of the CSPA. Both *watersheds* also have areas of highly organic soils within the upper/central areas. Due to poor *drainage* in the western portion of this *watershed*, there are numerous lakes and *swamps*. In contrast, the *bedrock* in the eastern portion is more level and flat with fewer lakes. Numerous river and *wetland* areas have formed where there is imperfect *drainage*.

2.2 Overview of Physical Geography

2.2.1 Physical Land Characteristics

Various physical land characteristic data have been obtained through the Ontario Geospatial Data Exchange. These data have been mapped across the CSPA and are included in the Watershed Characterization Report: Cataraqui Source Protection Area (CRCA, 2008) and Drinking Water Source Protection Water Budget Conceptual Report (CRCA, 2009)(see **Appendix 'L-3'**). The following sections express the physical land characteristics that are unique to the CSPA.

2.2.1.1 Bedrock Geology

There are seven general *bedrock* types in the CSPA. These are (from oldest to youngest) the *Precambrian,* consisting of *igneous* and *metamorphic rocks* of the *Canadian Shield*, and the Palaeozoic *sedimentary rock* of the *Nepean* (*sandstone*), March (*dolostone* and *sandstone*), Shadow Lake (*limestone*), Gull River (*limestone*), Bobcaygeon (*limestone*), and Verulam (*limestone*) Formations (see **Figures 2-1** and **Map 2-3**).

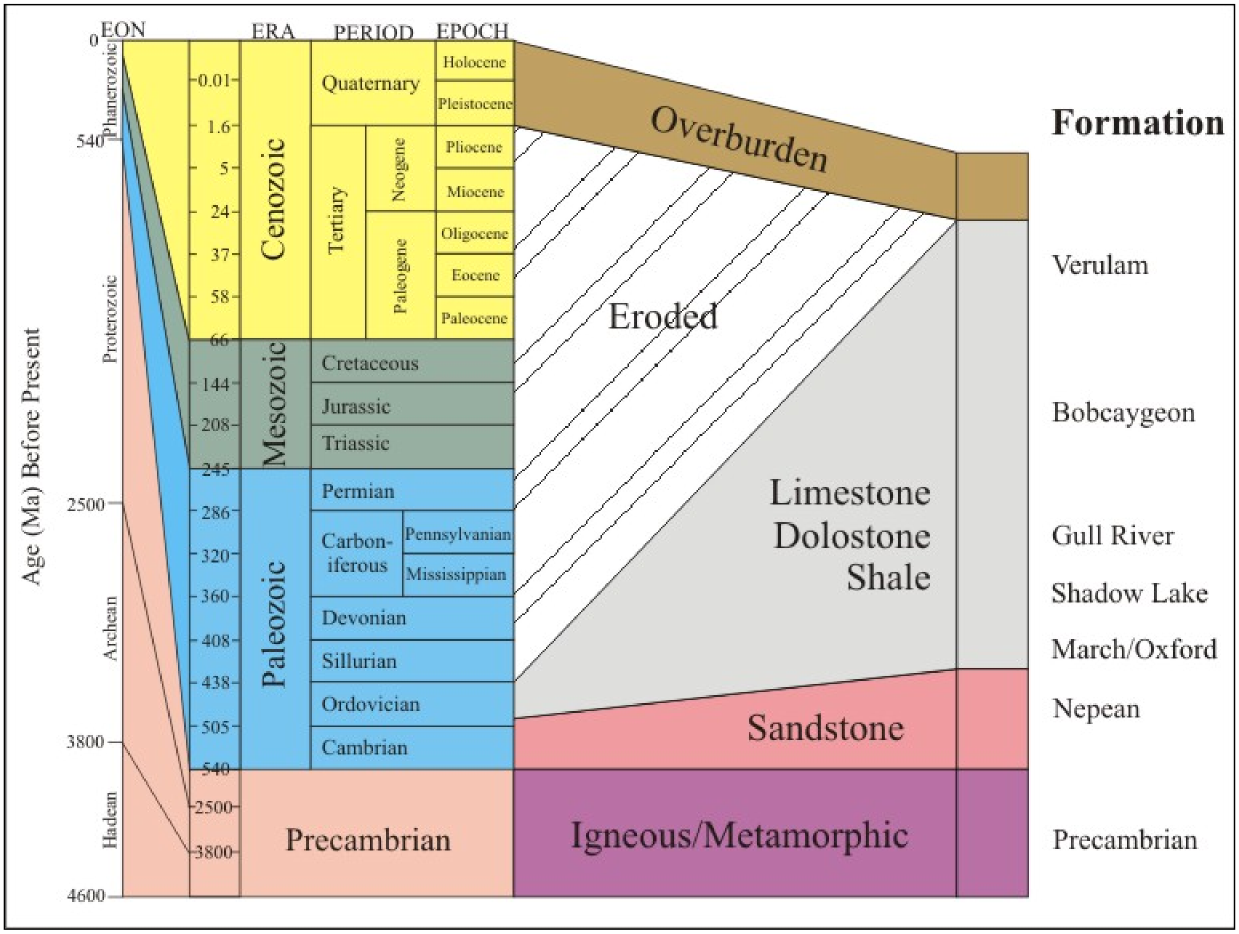

Figure 2-1: Geological Time Scale and Geological Events in the CRCA

Precambrian Geology

The metamorphic *Precambrian* rocks of the CSPA were originally deposited as *sediments* and consolidated into *sedimentary rocks* between approximately 1,100 and 950 million years before present. Between 800 and 600 million years ago, a mountain building episode called the Grenville orogeny produced very high mountains in the CSPA, which have slowly eroded to their present height.

The Grenville orogeny occurred as a northeast trending fold system that runs northwest/southeast from Algonquin Park to the Adirondack Mountains in New York State. *Precambrian* rocks underlie the entire CSPA and form the basement geological unit and are exposed at surface as part of the *Frontenac Axis*. Within the CSPA, the Axis exists from east to west between Kingston and Brockville, varying between 25 and 50 kilometres in width, and exists throughout the CSPA from the northwest to southeast.

Palaeozoic Geology

During the Palaeozoic Era, approximately 500 million years before present, Eastern Ontario was inundated with a shallow ocean that deposited eroded *sediment* from the *Precambrian* landmass along its shorelines. The *sediment* now exists as a series of flat lying *sedimentary rocks* that represent the shallow water depositional environment from 500 million to 450 million years before present.

The Palaeozoic strata occur in the CSPA northeast and southwest of the *Frontenac Axis*. Six Formations exist in the CSPA: *Nepean*, March, Shadow Lake, Gull River, Bobcaygeon, and Verulam. Each Formation is discussed in the following sections and **Figure 2-2** details the general bedding structure of the *bedrock* showing Palaeozoic Bedrock Formations overlying Precambrian Bedrock from southwest to northeast.

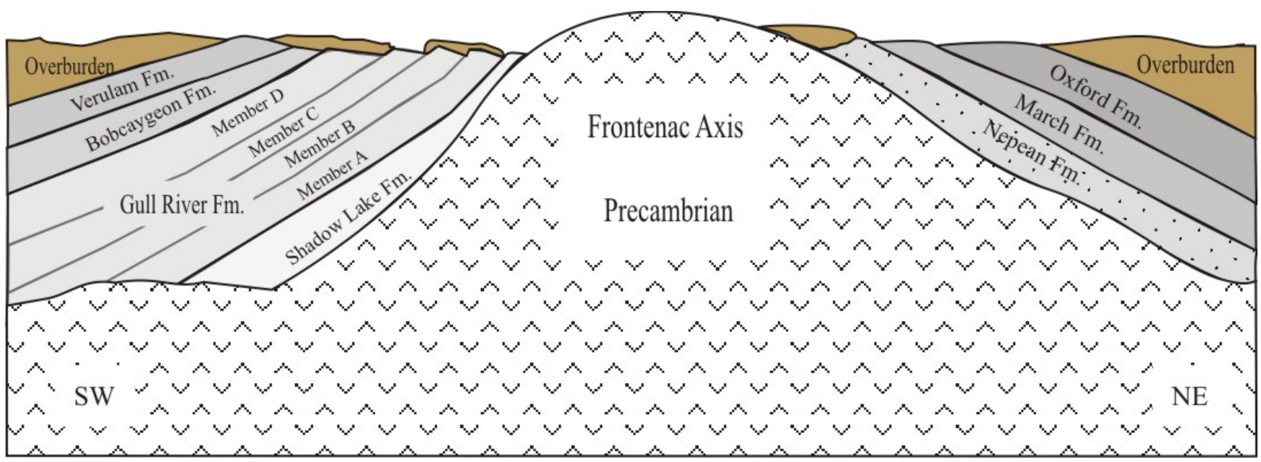

Figure 2-2: Schematic Geological Cross-Section of the CRCA

(not to scale)

Nepean Formation

The coarse conglomerates and *sandstones* of the *Nepean Formation* were mainly deposited east of the *Frontenac Axis*. The *Nepean Formation* consists of well-sorted *interbedded* quartz *sandstones* and conglomerates that were deposited on top of the *Precambrian* rock.

March Formation

Conformably overlying the *Nepean Formation* are the quartz *sandstones* and *dolostones* of the *March Formation*.

Shadow Lake Formation

The *Shadow Lake Formation* is comprised of *limestone* beds that overlie the *Precambrian* rock and *Nepean Formation* southwest of the *Frontenac Axis*. It is evident at surface in places along the interface between the western *limestone* plain and *Precambrian* shield.

Gull River Formation

The Gull River Formation lies above the *Shadow Lake Formation* and is divided into four members (named A, B, C, D), all *limestone*.

Bobcaygeon Formation

The *Bobcaygeon Formation* lies above the Gull River Formation and is comprised of alternating fine calcarenitic *limestone* and sublithographic *limestone*. The strata are known to contain many fossils.

Verulam Formation

The *Verulam Formation* lies above the Bobcaygeon Formation and is typified by the alternation of *limestone* and *shale*. This is the youngest *bedrock* formation in the area. This formation can also contain many fossils.

2.2.1.2 Fractured Bedrock

Much of the CSPA is characterized by shallow *overburden* over fractured *bedrock*. *Bedrock geology* influences the water quantity of the groundwater that flows through it. As noted above, in the CSPA, the *bedrock aquifers* predominantly consist of *Precambrian* metamorphic and *igneous* rocks, and Palaeozoic *limestones*, *dolostones*, *sandstones*, and *shales*.

Groundwater flow through fractured rock occurs predominantly through single fractures in local and regional scales; however the behaviour of groundwater flow through fractured rock on a regional scale is not well documented. Studies do show that *bedrock* fractures are difficult to identify and that flow through individual fractures is fast. Therefore, *bedrock aquifers* are inherently vulnerable to *contamination* and provide challenges with regard to quantifying *groundwater recharge* parameters in *water budget* exercises.

The *Precambrian* and Palaeozoic *bedrock* will have different effects on the groundwater quantity in the CSPA. As mentioned above, groundwater will flow primarily through fractures whether in *Precambrian* or Palaeozoic *bedrock*. *Precambrian igneous* and *metamorphic rocks* are particularly impermeable to water, save for flow through fractures. Palaeozoic *limestones* and *sandstones* are more permeable; however fractures are still the dominant form of water (and *contaminant*) transport.

In the CSPA, very little *overburden* overlies the *bedrock aquifers*. Less permeable *overburden*, such as silt, clay or *till*, can provide a barrier and offer protection to a fractured *bedrock aquifer*. A vertical *bedrock* fracture that is exposed at surface or covered by very permeable *overburden*, such as sand or gravel, produces a preferential pathway for groundwater and likewise, *contamination*.

2.2.1.3 Hydrogeology

Very little groundwater data has been gathered to date in the CSPA. Groundwater that originates in the CSPA may be migrating to neighbouring source protection areas, given the *topography* and *geology* of the CSPA. The *Frontenac Axis* acts as a topographic high and is flanked by more permeable Palaeozoic layers that slope gently towards the east and west.

Groundwater-Surface Water Interaction

Groundwater discharge can account for a significant percentage of streamflow, especially in a porous media setting. In fractured rock settings, it is less common to find *groundwater discharge* into a stream. Streamflow field *discharge* observations and *precipitation* records were used to establish possible *groundwater discharge* locations within the CSPA.

From spring to fall in 2006, 2007 and 2009, streamflow measurements were collected at sites within the CSPA. Many of the sites were visited more than once. If the sites had water continually through the field season, they were considered possible *groundwater discharge* sites, and further work was planned, including temperature *monitoring*, and isotope analyses. Additional research is required to confirm these sites.

During dry stream flow periods, *groundwater discharge* can be observed directly on streambeds if the piezometric surface is high. Therefore, during the dry summer periods, it can be assumed that *groundwater discharge* is limited if no surface flow is observed. Several *monitoring* sites were labelled as dry for their lowest water level distinction. The majority of these sites were labelled as such during the driest period of the field season, August, where there was the least amount of *precipitation*. However, streamflow was present at these sites following *precipitation* events in the spring. This indicates that streamflow at these sites is likely attributable mostly to direct *precipitation* rather than *groundwater discharge*.

2.2.1.4 Surficial Geology

Map 2-4 is a generalized *surficial geology* map of the Cataraqui area. It was developed by compiling *overburden geology* maps prepared by the Ontario Ministry of Northern Development and Mines.

Deposition of *overburden* is a result of the last period of *glaciation* in North America (the Wisconsinan *glaciation*) which ended approximately 10,000 years ago. Glaciers transported large quantities of eroded Palaeozoic and *Precambrian* rocks from the north and deposited them in the form of *till* sheets and *drumlins* over much of the *bedrock* surface. As the glacier ablated and receded, *glacial* melt waters transported sand and gravel to the ice margin where they were deposited as *eskers* and fan-like outwash features.

The mass of the ice also depressed the earth's crust, allowing for inundation of the area by the Atlantic Ocean. This ancient arm of the ocean, which covered a large proportion of the CSPA east of the *Frontenac Axis*, was called the Champlain Sea (approximately 13,000 to 10,000 years ago). The sea deposited clays and silts over the underlying *tills* and *esker* deposits. As the earth's crust rebounded, outlets were formed that *drained* the Champlain Sea. The lowering water level resulted in the exposure of elevated *till* areas such as *drumlins*. These *till* islands were reworked by wave action to form sand and gravel beaches. As the Champlain Sea further receded, an increased amount of *till* was exposed allowing for increased amounts of *sediments* to be reworked.

Around the same time, as the crust continued to rebound, and the *glacial* ice continued to recede, a precursor to Lake Ontario, Lake Iroquois, was formed (approximately 13,000 to 10,000 years ago). The lake was essentially an enlargement of the present Lake Ontario. It formed because the St. Lawrence River was blocked by the ice sheet near the Thousand Islands. The level of the lake was approximately 30 metres above the present level of Lake Ontario. The lake *drained* southeast to the Atlantic Ocean. The melting of the ice dam resulted in a lowering of the lake to its present level, and an outlet change to the St. Lawrence River.

2.2.1.5 Physiography

Chapman and Putnam (1984) identify four separate physiographic regions in the CSPA (see the Inset on **Map 2-5**). They are: Smiths Falls Limestone Plain, Leeds Knobs and Flats, Algonquin Highlands and Napanee Limestone Plain.

Smiths Falls Limestone Plain

The Smiths Falls Limestone Plain follows the northeastern region of the CSPA to Upper Rideau Lake where it meets a small undrumlinized *till* plain in the Westport-Newboro area. The *limestone* plain contains several bogs and *marshes*. Another small *till* plain can also be found in the Chantry and Brockville areas. It is characterized by shallow soil overlying mainly *limestone* or *dolostone* rock. Many parts of the area are poorly *drained* as evident by the occurrence of bogs, especially in the geographic townships of Kitley, Elizabethtown, the northern portions of Yonge and Escott, and the eastern third of Rideau Lakes. Deeper soils are present in some areas as a result of old beach deposits, isolated *drumlins*, and clay deposits that have filled depressions in the *bedrock* surface.

Leeds Knobs and Flats

The Leeds Knobs and Flats region lies in Leeds and Frontenac geographic counties north of the St. Lawrence River and the Thousand Islands (between Gananoque and Brockville and extending north to Crosby) and consists of rock knobs washed bare by the Champlain Sea and channels between them that contain deep and weakly calcareous clay beds. The largest area of clay lies west of the village of Lansdowne in the geographic Lansdowne Township.

Rock ridges protruding through relatively thick soils characterize this region. The soils consist of clay that was deposited during flooding of the area by the former *glacial* Lake Iroquois. The resulting land texture is of bare rock protruding through relatively level terrain.

Algonquin Highlands

The elevated land in the western side of Rideau Lakes Township and the eastern portion of South Frontenac Township is referred to as part of the Algonquin Highlands. The Algonquin Highlands are the upper part of the *Frontenac Axis*. This region is characterized by shallow sandy or stony soils and a relatively rugged *topography*. *Bedrock* outcrops throughout the region form numerous localized topographic highs. Numerous lakes such as Newboro Lake, Opinicon Lake and Sand Lake formed in the irregular depressions in the *Precambrian bedrock*.

Napanee Limestone Plain

The Napanee Limestone Plain is similar to the Smith Falls plain. It is characterized by very shallow soils, and some *alvars*, although deeper *glacial till* does occur in some stream valleys, there are also some shallow depressions of stratified clay.

Figure 1-12 (OGS, 1984) of the <u>Watershed Characterization Report: Cataraqui Source Protection Area</u> (CRCA, 2008) divides the CSPA into three primary Physiographic Regions. The northeast and northwest areas of the region are characterized as *limestone* plain. The eastern portion of South Frontenac, western portion of Rideau Lakes and the northern portion of Leeds and the Thousand Islands are characterized by shallow *till* and rock ridges. Clay plains exist along major river valleys in the west (Cataraqui River and Wilton Creek) as well as along the southern portions and Lake Ontario/St. Lawrence River shoreline of the region. Other smaller physiographic regions occur across the area, including bare rock ridges and shallow *till* in the vicinity of Perth Road Village, *peat* and muck north of Gananoque and Brockville, sand plain north and east of Brockville, *till* plain east of Brockville, *kame moraine* near Lyndhurst, an *esker* near Seeley's Bay and *drumlins* scattered throughout the Town of Greater Napanee and Loyalist Township.

Across the CSPA, *overburden* thickness (Figure 1-13 of the Watershed Characterization Report: Cataraqui Source Protection Area (CRCA, 2008)) is generally less than one metre, with exposed *bedrock* visible in some areas on the *limestone* plain and the *Precambrian* shield. The exceptions to this are river and creek valleys where notable thickness of *overburden* occurs. Localized accumulations of *overburden* also occur in the east end of the City of Kingston, the west end of the Town of Greater Napanee south of Hay Bay, northwest of Elgin, southeast of Athens, near Mallorytown, and northwest of Lansdowne.

Karst and fractured *bedrock* are common features in the *limestone* plain. New mapping completed by the Ontario Geologic Survey (Brunton, 2008) shows potential *karst* areas across the western area of the CSPA, with many of these areas having been confirmed by CRCA staff. Fractures in the *limestone bedrock* have been observed by Funk (1977) to generally be oriented in a northeast to southwest direction. They control the *drainage* in the regional *watersheds*, guiding the general southwest flow pattern.

2.2.1.6 Soil Characteristics

The Interim Watershed Plan (CRCA, 1983) describes the soils in the Kingston to Brockville corridor as generally shallow and tending to be acidic. The major soil types are Lansdowne and Napanee clay, as well as Farmington *loam*.

The southern portions of the CSPA (near Lake Ontario and the St. Lawrence River) predominantly consist of clay, while those areas further north are predominantly *loam* and sandy *loam* combinations (Figure 1-5a and b of Watershed Characterization Report: Cataraqui Source Protection Area (CRCA, 2008)). This is probably related to the elevation and the deposition of finer *sediments* by Lake Iroquois and the Champlain Sea.

A detailed description of the soils in each *watershed* is included in the Watershed Characterization Report: Cataraqui Source Protection Area (CRCA, 2008). The percentage area of each soil type is shown in **Table 2-1**, and it can be seen that the largest soil types are *loam*, sandy *loam*, and clay.

Table 2-1: Soil Characteristic and Percentage of Total Area

Soil Type	Percentage of CSPA Area
Loam	29.4%
Sandy Loam	27.4%
Clay	23.5%
Water	8.4%
Silty Loam	3.1%
Muck	2.9%
Clay Loam	1.0%
Rock Outcrop	0.7%
Peat	0.7%
Marsh	0.7%
Urban - Kingston	0.3%
Bottom Land	0.2%
Unclassified	1.6%

2.2.1.7 Topography

In the CSPA, elevation generally decreases in the south-westerly direction, towards Lake Ontario and the St. Lawrence River (see **Map 2-6**). Most of the watercourses in the CSPA originate in those elevated areas near the *Frontenac Axis*. As such, the highest elevation in the region occurs in the northwest, near Canoe Lake, at around 209.0 metres above sea level, while the stream bed elevation at the stream mouths is around 74.2 metres above sea level.

Amherst Island (Loyalist Township) and the Frontenac Islands are relatively flat, owing to their geologic origin as part of the bed of the predecessor lakes to Lake Ontario.

2.2.1.8 Land Cover and Land Use

The CRCA has used the Provincial Land Cover 28 geospatial data to characterize the CSPA (Figure 1-14 in Watershed Characterization Report: Cataraqui Source Protection Area (CRCA, 2008)), though the classes have been grouped together for ease of display as shown in **Table 2-2**.

The *land cover* data could be as much as 20 years old (it is an amalgam of data from 1986 to 1997, with most from the early 1990's), and may not reflect current land use/cover, and certainly cannot predict future information. But, given the uncertainty of other data sets, it is probably reasonable to use.

As is shown in **Table 2-2**, the predominant land use in the CSPA is agriculture, with forest and *swamp* as the next largest areas.

The Central Cataraqui Natural Heritage Study (CRCA, 2006) found that forested area is increasing in the City of Kingston and Loyalist Township. However, this increase comes due to the retirement of agricultural land, and new trees planted or natural regrowth. At the same time, settlement areas are increasing. Both of these increases imply that agricultural land area is decreasing.

Table 2-2: Comparison of Landuse and Land Cover in the CSPA

Land Cover Grouping	LandCover28 Grouping	Per cent of Total CSPA Area
Water	Water	8.2 %
Bedrock	Bedrock	0.9 %
Other	Mudflats	4.3 %
Forest	Forest – Dense Deciduous Forest – Dense Coniferous Forest Depletion – burns Forest Depletion – cuts	22.2 %
Swamp	Marsh – Intertidal Marsh – Inland Swamp – Deciduous Swamp – Coniferous Fen – Open	20.1 %
Settlement	Settlement and Developed Land	1.6 %
Agriculture	Pasture and Abandoned Fields Cropland	42.6 %

2.2.2 Water Quality and Quantity

Surface water quality and quantity vary across the CSPA. This is due to differences in *geology*, land use and development. This section presents a brief overview of the *surface water* quality in the major *watersheds* of the CSPA from a variety of provincial and local data sources. For a more detailed discussion, please see Chapter 2 of the Watershed Characterization Report: Cataraqui Source Protection Area (CRCA, 2008).

2.2.2.1 Surface Water Quality

Surface water quality in the major *watersheds* of the CSPA was evaluated based on selected variables. Concentrations of *phosphorus* and chloride were evaluated using data from the Provincial Water Quality Monitoring Network (PWQMN) and Lake Partner Program (phosphorus only). *Phosphorus* and chloride were selected as the primary considerations for this evaluation as they reflect both the natural features and land uses of this area. For both of these parameters, 75th percentile concentrations were evaluated and scored. The condition of *benthic macroinvertebrate* populations was also evaluated and scored. The scores these variables were used to assign a letter grade to each *watershed*, reflecting the quality of the *surface water* bodies within it. Unfortunately, there was insufficient information to complete this evaluation on in smaller Lake Ontario *drainage* areas or on Amherst and Frontenac Islands. Detailed methods used for this evaluation are given in **Appendix 'C'** and results are given in **Table 2-3** as well as shown on **Map 2-7**.

A more general description of the *surface water* quality trends in our area are as follows.

Table 2-3: Surface Water Quality Grades

Watershed	**Grade**	**Watershed**	**Grade**
Buells and Butler's Creek	C +	Amherst Island	*n/a*
St. Lawrence River	C	Little Cataraqui Creek	B -
Lyn and Jones Creek	B +	Collins Creek	B -
Gananoque River	B	Millhaven Creek	B +
Cataraqui River	B -	Bay of Quinte	B -
Frontenac Islands	*n/a*		

The PWQMN stations provide the greatest amount of insight into *surface water* quality in the CSPA (see Appendix 'F', 'G', 'H' of the Watershed Characterization Report: Cataraqui Source Protection Area (CRCA, 2008)). Data from 2000-2005 provide several key findings.

- Alkalinity and *hardness* are highest in the areas underlain by *limestone*. These areas, as well as those impacted by urban development, also have high concentrations of chloride, sodium and specific *conductivity*.
- Chloride, sodium and *conductivity* concentrations are all generally increasing throughout the *watershed*, likely linked to road salt application. Increasing chloride concentrations may be contributing to decreasing *hardness* levels at some stations.
- *Turbidity* is highest in *watersheds* with less forest cover and more urban or agricultural development. Shoreline stewardship work appears to be reducing *turbidity* levels in Wilton Creek.
- Copper levels at the Butlers Creek station are extremely high, but are decreasing. Concentrations of copper, iron and zinc are decreasing at all stations.

- High *phosphorus* concentrations occur throughout the CSPA, however, concentrations are decreasing. All other *nutrients* considered are within the guidelines, with the exception of nitrite at the Grants Creek *monitoring* station.

Watersheds underlain by *limestone* include the Bay of Quinte, Millhaven, Collins, Little Cataraqui, St. Lawrence River, Lyn and Jones, and Buells and Butlers.

Data from the Lake Partner Program and CRCA in-land sampling also indicate that elevated *phosphorus* concentrations are pervasive in the in-land lakes and *streams* of the CSPA (**Appendix 'C', Table 1** of this report and Appendix 'J' of the Watershed Characterization Report: Cataraqui Source Protection Area (CRCA, 2008), respectively) (Note: A correction was made to the Lake Partner Program data referred to in the Watershed Characterization Report: Cataraqui Source Protection Area such that the classification for some lakes has changed).

Most lakes in the CSPA are *mesotrophic* (accounting for 48 per cent of those examined) according to the Interim Provincial Water Quality Objectives. *Oligotrophic* lakes (21 per cent of those examined) generally occur closer to the headwaters of the tributaries, especially in the Cataraqui River *watershed* where *nutrients* appear to be collected and concentrated into downstream lakes. Gould Lake, an *oligotrophic* lake, is in the upper reaches of the Millhaven Creek *watershed*. The Gananoque River *watershed* is the most *nutrient* rich of those sampled, where six of the nine lakes in total are classified as *eutrophic* (31 per cent) based on *phosphorus* concentrations.

Cyanobacterial blooms are frequently associated with high concentrations of *nutrients* in waterbodies (Chorus *et al*., 2001). Cyanobacteria (commonly referred to as blue-green algae) are naturally occurring in lakes, rivers and are often harmless. Some groups are however capable of producing a variety of toxic compounds, known as cyanotoxins. In the CSPA, several *inland lakes* were found to contain groups of cyanobacteria capable of producing toxins as well as low concentrations of certain cyanotoxins (BlueLeaf Inc., 2009a and 2009b). While the concentrations of cyanotoxins at the time of sampling in the CSPA do not pose an imminent health risk (Health Canada, 1999), the occurrence of cyanotoxins has been recognized by the Ministry of the Environment as an emerging concern for sources of *drinking water* (MOE, 2009). There is a potential that these concerns may increase with climate change.

Health Unit bacterial beach counts and limited PWQMN data are used to evaluate the content of coliform bacteria in the *surface waters* of the CSPA (Appendix 'T' and Appendices 'F', 'G', 'H' of the Watershed Characterization Report: Cataraqui Source Protection Area (CRCA, 2008), respectively). Consistently high levels of bacteria are found in the Butlers Creek PWQMN station and at beaches near Bath, Gananoque and Brockville *drinking water* intakes.

A growing concern for surface water quality is the likely presence of pharmaceuticals, personal care products (PCPs), antibiotics, antibacterial agents and endocrine disruptors found in our lakes and *streams*. In general, these broad groups of contaminants contain compounds related to genetic mutations, hormone disruption and antibiotic resistance. The occurrences of these contaminants are found particularly in sewage treatment outflows and pose direct implications to the quality of our *drinking water.* The contaminants enter our surface water system through sewage disposal (toilet flushing), agricultural manure runoff (antibiotics) and landfill leachate.

Several publications discuss the environmental and human health hazards of these emerging contaminants. Very little is known about the long term effects of ingestion and accumulation of these contaminants in *drinking water* and the impacts to fish and wildlife.

2.2.2.2 Groundwater Quality

The natural groundwater in the *aquifers* in the CSPA is relatively young in age and its quality is determined primarily by *aquifer* type. The natural *weathering* and dissolution of carbonate rocks and the application of fertilizer/manure have been found to have a strong impact on water quality in this area.

Grades for groundwater quality were assigned based on the concentrations of chloride, sodium, nitrate and nitrite in areas within defined *bedrock* units. These parameters were chosen as being representative of groundwater quality in the CSPA owing to the strong influence of *aquifer* type on groundwater. The results of this assessment are given in **Table 2-4** and shown in **Map 2-8**. Details of the methods used for this evaluation are given in **Appendix 'C'**.

Groundwater quality data for this area-wide evaluation was obtained from the Provincial Groundwater Monitoring Network (PGMN) and two regional groundwater studies (the Western Cataraqui Groundwater Study (Trow Associates Inc., 2007) and the United Counties of Leeds and Grenville Groundwater Management Study (Dillon Consulting Ltd., 2001)).

There are some areas where bacteria in groundwater wells may cause problems, as described below. However, because the data on bacteria in groundwater are not consistent across the CSPA, and because exact locations and context for the samples collected are often lacking for data sources, they have not been included in the area-wide evaluation of groundwater quality.

A general description of the groundwater quality trends in our area follows.

Table 2-4: Groundwater Quality Grades

Bedrock Zone	Grade
Precambrian	B +
Verulam	C +
Bobcaygeon	B +
Gull River	B -
March	B
Nepean / Potsdame	B +
Oxford	B -

Five annual samples have been collected at each of the seven PGMN wells in the CSPA in an attempt to characterize the ambient quality across the CSPA. *Hardness* and reactive silicate were both found to consistently exceed the objectives. Sodium, *conductivity*, iron and manganese were also found to exceed the Ontario Drinking Water Quality Standards, as were chloride, organic nitrogen and total dissolved solids in particular wells (**Tables 2-1, 2-2 and 2-3 of Appendix 'C'**).

The proponents of many land subdivisions in the CSPA were required to generate hydrogeological studies that include hydrogeochemical information for standard *drinking water* quality parameters. Similar to results at PGMN wells, these subdivision reports also indicate exceedances in *hardness*, iron, manganese, sodium, chloride, fluoride, *turbidity* and total coliform. Excess nitrate, sulphate and aluminum were found in excess only at a few sites. Please see Appendix 'M' of the Watershed Characterization Report: Cataraqui Source Protection Area (CRCA, 2008) for detailed information related to the subdivision data.

The relevant findings of the Western Cataraqui Groundwater Study (Trow Associates Inc., 2007) and United Counties of Leeds and Grenville Groundwater Management Study (Dillon Consulting Ltd., 2001) are summarized in the Watershed Characterization Report: Cataraqui Source Protection Area (CRCA, 2008), with detailed information in Appendix 'O' and 'P' of that report, respectively. Overall, results are consistent with those from the PGMN wells. *Hardness* is high in all samples and iron, manganese, sodium, chloride, nitrate, sulphide and sulphate are also frequently found in excess of the *drinking water* quality objectives. Microbiological testing (carried out for the Western Cataraqui Groundwater Study (Trow Associates Inc., 2007)) revealed many positive results for bacteria (*Escherichia coli*, total coliform, and fecal coliform). Single exceedances were also found for fluoride, cadmium and pH in that study.

2.2.2.3 Surface Water Quantity

There are two main rivers in the CSPA, the Cataraqui and Gananoque Rivers, which flow in a southerly direction through the central part of the region to Kingston and Gananoque, respectively. The remainder of the CSPA is *drained* by smaller *streams* in a southerly direction to the Bay of Quinte, Lake Ontario and the St. Lawrence River. *Streams* on Amherst, Wolfe and Howe Islands typically drain from the center of the island to Lake Ontario and the St. Lawrence River. Flow in the CSPA is thought to be directed by the faulting and discontinuities of the *bedrock*, with lakes forming where depressions have been left by *glacial* scour.

Flow patterns are generally very similar across the CSPA, with peak flows during the spring snow melt and minimum flows during August and September. The 39 dams and *water control structures* currently in operation across the CSPA have significant effect on these flows in their respective watercourses. Controlled watercourses in the CSPA are Millhaven, Highgate and Little Cataraqui creeks, the Cataraqui and Gananoque rivers, and Lyn and Buells creeks. The locations of *water control structures* in the CSPA are shown on **Map 2-9**.

In the controlled watercourses, levels are lowered in the fall, providing stable ice levels and storage volume for the spring *freshet*. Levels stabilize in late spring and, over the summer *discharge* is reduced to maintain water levels. The exceptions are the Rideau Canal and Fortis Properties *water control structures* on the Cataraqui and Gananoque Rivers, respectively. Here, the water levels are allowed to decline gradually over the summer, providing augmented flows to the Canal and power company during the drier months.

A more detailed discussion of the annual and monthly flow variation across the CSPA and location and types of *water control structures* can be found in the Watershed Characterization Report: Cataraqui Source Protection Area (CRCA, 2008), Drinking Water Source ProtectionConceptual Water Budget Report (CRCA, 2009) and the Cataraqui Source Protection Area Tier 1 Water Budget Report (XCG Consultants Ltd., 2009)(see **Appendix 'L-4'**) and Chapter 3 of this report..

Groundwater discharge can be important to *surface water hydrology* in that it may allow a creek to maintain some amount of flow, even after prolonged periods of time without *precipitation*. Although most *streams* in the CSPA are warm water and many go dry over the summer months, there are potential cold water systems (lake and stream) identified in the CSPA. Cold water systems can be an indicator of groundwater contributions. These sites are located throughout the CSPA and additional research to confirm the occurrence of *groundwater discharge* is needed.

2.2.2.4 Groundwater Quantity

Generally, regional groundwater flow follows the *topography*, flowing south towards Lake Ontario and the St. Lawrence River. There is indication of groundwater flow between the CSPA and neighbouring Source Protection Regions (SPR); specifically, the Quinte SPR (Napanee River) and the Mississippi-Rideau SPR (Rideau River) (see Drinking Water Source Protection Conceptual Water Budget Report (CRCA, 2009) and Cataraqui Source Protection Area Tier 1 Water Budget Report (XCG Consultants Ltd., 2009)).

The CSPA is characterized by shallow *overburden* over fractured *bedrock*. This has an influence on both groundwater quality and quantity, as the rocks have either large or small fractures for water to move through. Flow through individual fractures can be fast and the fractures may act as pathways for *contaminants* to travel into the groundwater. Quantifying *groundwater recharge* in such areas is difficult. It has been determined that much of the CSPA could be considered a *recharge area*, because of the presence of shallow soil over fractured *bedrock*.

In the CSPA, most of the inland communities draw water from groundwater *aquifers*. This includes three of the 12 municipal residential *drinking water systems* (see **Map 2-10**). There are also approximately 20,000 private wells in the CSPA and numerous communal wells at campgrounds and trailer parks. Many other public *drinking water* supplies also rely on groundwater.

In some regions, private wells are known to go dry during extended periods of drought (Loyalist and Adolphustown). Because of the tight *bedrock* formations in these areas, groundwater sources on Wolfe and Amherst Islands are also limited. Groundwater quantity at two of the municipal residential groundwater wells (Cana, Lansdowne) has been evaluated and is discussed in Chapter 3 of this report (see **Map 2-11**) and the *monitoring* wells used for the related studies are shown in **Map 2-12**.

2.2.3 Locations and Types of Natural Vegetation

The CSPA benefits from a relatively high per cent of *wetland* cover (see **Map 2-13**), especially on the *Frontenac Axis*. Many of these *wetlands* are provincially or regionally significant. Based on review of provincial data, the overall per cent cover for *wetlands* in the CSPA is about nine per cent. The greatest overall cover for *wetlands* is located in the Buells and Butlers Creeks *watershed* (about 20 per cent) in contrast to the Bay of Quinte *watershed* which has the lowest per cent of *wetland* cover (about four per cent). It should be noted, however, that the Buells and Butlers Creeks *watershed* is very small in comparison and the Bay of Quinte contains the large and provincially significant Hay Bay *wetland*.

The CSPA also has widespread and diverse woodlands (see **Map 2-13**). The overall per cent cover in the CSPA for woodlands is about 42 per cent, based on a review of provincial data. The Lyn and Jones Creeks *watershed* has the most woodland cover (about 50 per cent), while the *watershed* with the least forest cover is the Amherst Island *watershed* (about 14 per cent).

Shoreline corridors are extensive in the CSPA, but limitations related to map scale and data quality do not allow for a complete analysis. It is expected that shoreline corridors are most widespread through the *Frontenac Axis* and other wooded areas, but more limited in more agricultural and urban areas. A *watershed* level summary of the per cent cover for each vegetation type can be found in **Appendix 'C', Table 3.**

2.2.4 Fish and Wildlife Habitat

The natural environment is an important component of the CSPA. Temperature and *precipitation* vary across the region as a result of its location within the Great Lakes – St. Lawrence region, which contributes to a diversity of habitat within the area. The transition between the Carolinian (southern) and Boreal (northern) zones within the jurisdiction of the CSPA gives rise to a diversity of plant and animal communities.

Large coastal *wetlands*, such as the Hay Bay, Cataraqui River and Big Sandy Bay (western end of Wolfe Island) *marshes* provide fish and wildlife habitat as well as opportunities for wildlife viewing. The region's shorelines, woodlands and *alvars* support a relatively intact *ecosystem* and contribute to the attractiveness of the area for both people and wildlife.

2.2.4.1 Fisheries

The CSPA contains a wide variety of lake and river fish habitats, which support a wide variety of both cold and warm water fisheries (as determined according to the thermal regime of the waterbody). Water depth, flow and temperature, and the associated fish habitat, are not well documented in the Cataraqui area. **Map 2-14** shows the temperature and inferred habitat sensitivity of waterbodies in the Cataraqui area. On this map, water temperature is used to represent the types of fish habitat that is expected to be present.

Warm water fish habitat occurs throughout the CSPA. Lake trout are stocked by the Ministry of Natural Resources in 13 cold water lakes across the CSPA. Of the 13 cold water lakes, ten occur in the Cataraqui River *watershed*, one (Gould lake) is in the headwaters of the Millhaven Creek *watershed*, and two (Red Horse and Charleston Lakes) are in the Gananoque River *watershed*.

The fishery for lake trout makes an important contribution to the tourism and recreation sector in these *watersheds*.

Significant recreational and sport fisheries also occur in the Bay of Quinte, Cataraqui River, Gananoque River and St. Lawrence River *watersheds*. Examples of important fish for this sector are walleye, rock and smallmouth bass, white and yellow perch, northern pike, brown bullhead, catfish, freshwater drum and pumpkinseed. Muskellunge is an important sport fish in the St. Lawrence River *watershed*. The St. Lawrence River *watershed* also carries important commercial fisheries for yellow perch and eel and supports over 80 other species of fish.

In addition to the sport and recreational fisheries noted above, the Gananoque *watershed* includes Willy's Brook, which is home to a population of brook trout. The island *watersheds* (Amherst, Howe, and Wolfe) are notably different in that there are no major *inland lakes* or watercourses and fisheries are limited to the surrounding areas of Lake Ontario and the St. Lawrence River.

Generally, much of the cold water fish habitat in the CSPA has been stressed by increasing water temperatures and *nutrient* enrichment. Warm water habitats have suffered under poor water quality through the 1960s and 1970s and the introduction of Zebra and Quagga mussels in the 1990s. Many fish populations throughout the CSPA have experienced marked declines due to environmental changes and habitat loss. Some populations have since stabilized at lower levels (bass, pike, walleye) while others have shown evidence of continued decline (eel).

For a more thorough discussion of fisheries and fish habitats in the CSPA, please refer to the Watershed Characterization Report: Cataraqui Source Protection Area, Section 1.5 (CRCA, 2008). Technical Rule 16(6) requires a comparison between the coldwater, mixed, and warm water fisheries in a source protection area and similar communities "not impacted by anthropogenic factors" (MOE, 2009). This is a *data gap* for the CSPA which will need to be considered in future editions of this *Assessment Report.*

2.2.4.2 Macroinvertebrates

Benthic macroinvertebrates can be excellent indicators of water quality and habitat condition. Sampling for *macroinvertebrates* by the CRCA began in 2003. The *Hilsenhoff Biotic Index* has been determined for each of these sampling sites. The results of this analysis are shown in **Map 2-15** and are given in **Table 4** of **Appendix 'C'**. Because the number of sampling sites and frequencies with which they were sampled are not consistent between *watersheds*, it is difficult to compare between them or distinguish any clear trends over time.

Overall, the *macroinvertebrate* communities at 39 of 44 sites in the CSPA (representing 88 per cent of sites sampled) were scored as fairly poor, poor or very poor. These sites occurred throughout the area, but were generally those close to urban centers or in areas of intensive agriculture. Four sites were scored as fair with regards to their *benthic* communities. These were primarily found in the mid-*watershed* area of Millhaven Creek. One site on Collins Creek ranked as good, becoming the best ranked site in the CSPA. This site was found immediately upstream of sites ranked as poor and very poor. Just south of the first site, there is development on one side of the creek. The fact that the *benthic* communities appear to have been impaired in close proximity to the residential development, but not upstream of it, may indicate that it has had an impact on the stream. There are insufficient data to distinguish such trends elsewhere in the CSPA.

Technical Rule 16(6) requires a comparison between the macroinvertebrate communities in a source protection area and similar communities "not impacted by anthropogenic factors" (MOE, 2009). This is a *data gap* for the CSPA which will need to be considered in future editions of this *Assessment Report.*

2.2.4.3 Species at Risk in the Cataraqui Source Protection Area

The CSPA is home to 15 *endangered* or *threatened* species, as well as five species of *special concern* under the federal Species at Risk Act (Canada, 2002). The Ministry of Natural Resources' Natural Heritage Information Centre (NHIC) lists three additional other species that occur in the Cataraqui area as being provincially *endangered*, *threatened* or of *special concern* (MNR, 2008). For a comprehensive list of species listed as *endangered*, *threatened* or of *special concern*, their habitat preferences, and major *threats* to their populations (as they relate to drinking water source protection) please see **Appendix 'C', Table 5.**

Development and site alteration, especially in shoreline areas and *wetlands*, are major contributors to population decline for many of these species. These practices may also pose risks to sources of *drinking water* through increased sedimentation rates and higher peak flows. Changes to the landscape not only modify plant and animal habitat, but may also decrease the environment's capacity to handle *contaminants* and speed the transport of these *contaminants* in surface *runoff* to intakes.

2.3 Overview of Human Geography

2.3.1 Population and Settlement

Water is not only important for drinking, it is vital to the economic well-being of its residents. The shoreline, islands, lakes and rivers attract tourists and seasonal residents to the area. The location along the St. Lawrence Seaway also attracts industries that use water transportation, as well as those that use large quantities of water in their manufacturing processes.

Water was a main factor determining the locations of early settlement within the CSPA. The first Europeans arrived in the 1600s; through the 1700s and 1800s they established communities along rivers and *streams* in locations suitable for water-powered saw and grist mills. Many of the mills and dams used to hold back water are still present today.

There are currently approximately 244,500 people living in Census Dissemination Areas that are completely or partly within the CSPA (Statistics Canada, 2007). The actual population within the CSPA *watersheds*; however, is approximately 209,441. The majority of this population lives in the City of Kingston with about 117,200 residents. The City of Brockville and the Township of South Frontenac also make substantial contributions, each with populations of between 21,000 and 22,000 people. Loyalist Township represents the third most populated municipal jurisdiction in the CSPA with just over 15,000 residents (**Appendix 'C', Table 6).**

The locations, areas and populations served, system classification, average volumes withdrawn, and locations of *monitoring* wells for municipal residential *drinking water systems* obtaining water from groundwater or *surface water* sources within the CSPA are given **Table 5-5** and **Table 6-3.**

In addition to the major centres, the CSPA contains a number of cottage, agricultural and rural developments and other smaller communities. Cottage developments are primarily around the lakes of the *Canadian Shield*, while agricultural developments are most common in the areas off the Shield.

The classifications of *drinking water systems* in the Cataraqui area are shown on **Map 2-10**, and the areas served with municipally treated *drinking water* are shown on **Map 2-11**.

Population density in the CSPA ranges from 13 to 1,089 persons per square kilometre. The highest municipal population density occurs in the City of Brockville, followed by the Town of Gananoque (1,089 and 609 persons per square kilometre, respectively). It is important to note that Brockville and Gananoque include mainly densely populated areas, whereas other municipalities such as the City of Kingston include both densely and sparsely populated areas. **Appendix 'C', Table 6** shows these areas integrated with their parent municipalities for more consistent comparison. The population and population density of all municipalities in the CSPA is given on **Map 2-16**.

All of the municipalities in the CSPA have official plans directing where future development is to occur. **Map 2-17** shows the areas of settlement and planned urban growth areas. Municipal sewage treatment is provided for most of these areas, including Sandhurst Shores, Amherstview, Bath, Odessa, Kingston, Gananoque and Brockville, as well as the village of Lansdowne.

2.3.2 Landuse

2.3.2.1 Impervious Surfaces

Urban development is generally accompanied by an increase in the amount of impervious surfaces. This comes in the form of roads, parking lots and buildings that support the population. This can be a concern for drinking water source protection as it changes the way that water moves through the landscape. In the CSPA, urban developments are concentrated in the lower reaches of the *watersheds*, especially south of the Highway 401 corridor (Kingston, Brockville, and Gananoque). The distribution of impervious surfaces in the CSPA is shown on **Map 2-18a-c**. **Table 7** of **Appendix 'C'** gives the amount of impervious surface by vulnerable area.

2.3.2.2 Agriculture, Managed Lands and Livestock Density

Agriculture is found in all areas of the CSPA, including the *Canadian Shield*, but the majority of agricultural land is found close to Lake Ontario and the St. Lawrence River. The key agricultural products in the CSPA are dairy products, fruits and vegetables, grain (including corn, barley and wheat), hay, poultry and eggs and beef products. At the southwest end of the region, where the temperature is moderated by Lake Ontario, there are specialty farms with apple orchards, berry patches and vineyards.

The distribution of managed lands (cropland, fallow land, improved pasture, golf courses, sports fields, and lawns) is broken down into two subsets: agricultural managed lands and non-agricultural managed lands. The per cent of managed land was evaluated in each vulnerable area by the CRCA, according to the method prescribed by the Ontario Ministry of the Environment (MOE, 2009a). The managed land evaluation method required each managed land use to be identified and grouped as either agricultural or non-agricultural. The sum of agricultural and non-agricultural land uses was then divided by the total area within the vulnerable area, and multiplied by 100. Results are shown on **Maps 2-19 a-c** and detailed information for the distribution of managed lands is given in **Appendix 'C', Table 8**.

Livestock density was also evaluated within each vulnerable area. Two methods were used based on the availability of data. The livestock density method prescribed by the Ontario Ministry of Environment (MOE, 2009a) was followed for evaluating wellhead protection areas and intake protection zones. CRCA staff used Municipal Property Assessment Corporation (MPAC) data to estimate the number of animals present within each specific farm type. Aerial photography was then used to verify farm locations and estimate the square footage of farm structures. The square footage was then divided by a conversion factor identified in the Ontario Nutrient Management Act, 2002 for that particular farm type, in order to quantify and standardize the number of nutrient units (NU) generated in that vulnerable area.

Permission was given by the Ministry, for CRCA staff, to evaluate livestock density in *highly vulnerable aquifers*, *significant groundwater recharge areas*, and *intake protection zone* 3 using an alternate method. Agricultural census data were used to identify actual animal numbers per census consolidated subdivision. Similar to the above method, conversion tables from the Ontario Nutrient Management Act, 2002 were used to convert to NUs by dividing actual animal numbers by the specified conversion factor. Results are shown on **Maps 2-20 a-c**, respectively. Detailed information for the distribution of livestock density is given in **Appendix 'C', Table 8**.

2.3.2.3 Industry and Tourism

The construction of the Rideau Canal following the war of 1812 is responsible for opening up the northern portion of the CSPA. It took advantage of the lakes, rivers and *streams* that flow through the Cataraqui River *watershed* to provide a safer transport alternative to the St. Lawrence River for shipping goods and soldiers from Montreal. The Rideau Canal is now an attraction to tourists and pleasure boaters, named a United Nations Educational, Scientific and Cultural Organization (UNESCO) World Heritage Site in 2007.

Although the St. Lawrence River and the Great Lakes had always been used for transportation, the construction of the St. Lawrence Seaway in the 1950s allowed larger ships to navigate through the Great Lakes. This opened up opportunities for shipping, trade and manufacturing for the communities along the shore.

The physical location of the CSPA, being in close proximity to larger centres and the US border, makes it an even greater attraction to tourists and industry. The CSPA falls within the major east-west transportation corridor between Toronto and Montreal, with connections to Ottawa to the northeast and the United States to the south. The main Canadian National Railway line and Highway 401 follow the north shore of Lake Ontario and the St. Lawrence River.

Green energy is an emerging industry in the Cataraqui area. A large (86 wind turbine) wind power installation was installed on Wolfe Island in 2009, and new programs in this field have been introduced at St. Lawrence College in Kingston. At this time of writing this report, numerous other wind and solar power projects had been proposed or approved under the Ontario *Green Energy Act, 2009,* including a large offshore wind power installation in Lake Ontario.

Tourism and recreation are important sectors of the economy in many of the communities in the CSPA. Recreational activities in the CSPA include boating, hunting, fishing, hiking and a host of other outdoor activities.

The area boasts a diversity of natural areas that are protected at the national, provincial and municipal levels of government; however, in terms of area, this represents only slightly more than three per cent of the CSPA. There are no First Nations reserves within the CSPA. **Map 2-21** shows the National Parks and Federal Crown lands that are identified in official plan and zoning documents, intended to represent the federal lands in the CSPA. This includes Canadian Forces Base Kingston, numerous penitentiaries, and the Rideau Canal. The only National Park occurring in the CSPA is the St. Lawrence Islands National Park, along the St Lawrence River, including several of the Thousand Islands.

2.4 The Cataraqui Area and the Great Lakes

2.4.1 Consideration of Great Lakes Agreements

In due course, each of the *watersheds* that make up the CSPA flow to either Lake Ontario or the St. Lawrence River. These water bodies also serve as the *drinking water* sources for eight of the 12 municipal residential *drinking water systems* addressed in this report. In addition, the *intake protection zone* (IPZ) for the Picton Water Treatment Plant (WTP) also extends into the CSPA in Lake Ontario from the neighbouring Quinte Source Protection Region.

The Ontario Clean Water Act, 2006 requires that source protection areas that contain water that flows into the Great Lakes or the St. Lawrence River consider the following documents in the preparation of the *Assessment Report*:

- Great Lakes Water Quality Agreement
- Canada-Ontario Agreement Respecting the Great Lakes Ecosystem
- Great Lakes Charter
- Other agreements relating to the Great Lakes Basin that are prescribed by the regulations, to which the Government of Ontario or the Government of Canada is a party (of which there are currently none).

The following sections will describe each of the prescribed documents and how they were considered in the preparation of the *Assessment Report* for the CSPA.

2.4.1.1 The Great Lakes Water Quality Agreement

The Great Lakes Water Quality Agreement, first signed in 1972, is a commitment by Canada and the United states to address the pollution of the Great Lakes (Environment Canada, 2004a). A new agreement in 1978 seeks to “restore and maintain the *chemical*, physical, and biological integrity of the waters of the Great Lakes Basin Ecosystem” through the development and implementation of Remedial Action Plans and Lakewide Management Plans.

A Remedial Action Plan is a management plan, designed to address specific issues in a given area (called an Area of Concern) that fails to meet the objectives set out in the agreement.

A Lakewide Management Plan, meanwhile, is designed to improve the environmental quality of the open waters of the Great Lakes, focusing on the identification of critical pollutants that affect beneficial uses of the lakes (Great Lakes Commission, 2004).

Bay of Quinte Area of Concern

Although primarily located within the Quinte and Trent Conservation Coalition Source Protection Regions, the Bay of Quinte Area of Concern falls partially within the CSPA (see **Map 2-22**). It includes, in whole or in part, the areas identified as the IPZs of the Sandhurst Shores, A.L. Dafoe, and Bath WTPs, as well as a portion of the IPZ for the Picton WTP, which extends into the CSPA in Lake Ontario.

The Bay of Quinte was designated an Area of Concern in 1985 in response to excessive bacteria, *nutrient* enrichment, persistent toxic *contaminants*, and the degradation of fish and wildlife populations and habitats in the Bay. The Remedial Action Plan process for the Bay, under the Great Lakes Water Quality Agreement, was formally initiated in 1987.

At the time this report was written, the ten impaired beneficial uses that lead to the designation of the Bay as an Area of Concern were under review, with many showing clear evidence of progress towards their respective delisting targets (Hodson, 2009). Source protection in and around the Bay can be expected to reinforce efforts to have the Bay of Quinte delisted as an Area of Concern. The reported emerging problem with algal taste, odour and toxins in portions of the Bay of Quinte Area of Concern is, however of particular interest with respect to *source water* protection as a potential *drinking water issue*.

2.4.1.2 Canada-Ontario Agreement Respecting the Great Lakes Ecosystem

The Canada-Ontario Agreement Respecting the Great Lakes Ecosystem is an agreement that supports the *restoration* and protection of the Great Lakes Basin Ecosystem (Environment Canada, 2004b). It sets out how the governments of Canada and Ontario will cooperate and coordinate their efforts to restore, protect, and conserve the Great Lakes basin *ecosystem*. The agreement contributes to meeting Canada’s obligations under the Great Lakes Water Quality Agreement, discussed above, and is geared towards the protection of water quality, but contains no specific technical information applicable to the preparation of this *Assessment Report*.

2.4.1.3 Great Lakes Charter

The Great Lakes Charter is a non-binding understanding between the provinces of Ontario, Quebec, and the eight Great Lakes States that set out broad principles for the joint management of the Great Lakes (Environment Canada, 2005). The original Charter was developed in 1985 in response to the growing use of water and proposals to divert large quantities of water out of the Great Lakes Basin (Ministry of Natural Resources, 2005). The understanding is intended to:

- conserve the levels and flows of the Great Lakes and their tributary and connecting waters
- protect and conserve the environmental balance of the Great Lakes Basin ecosystem

- provide for cooperative programs and management of the water resources of the Great Lakes Basin by the signatory States and Provinces
- make secure and protect present developments within the region
- provide a secure foundation for future investment and development within the region (Council of Great Lakes Governors, 1985).

The Great Lakes Charter Annex reaffirmed the principles of the Charter and commits the governors and premiers of the Great Lakes states and provinces to a common management regime (Environment Canada, 2005). The Annex supports the principles of the Charter (to protect, conserve, restore and improve the Waters and Water-Dependent Natural Resources of the Great Lakes Basin) and serves as a commitment to develop and implement a new, resource-based conservation standard and apply it to a new water withdrawal proposal from the Waters of the Great Lakes Basin (Council of Great Lakes Governors, 1985). The Great Lakes Charter Annex implementing agreements, including the Great Lakes-St. Lawrence River Basin Sustainable Water Resources Agreement, attempt to provide this water management system (Environment Canada, 2005).

Although this charter is geared towards the protection of water quality and quantity, it does not contain any specific technical information that was applicable to the preparation of this *Assessment Report*.

2.4.1.4 Great Lakes Targets

The Ontario Clean Water Act, 2006 allows for the Minister of the Environment to establish targets relating to the use of the Great Lakes as a source of *drinking water* for any of the source protection areas that contribute water to the Great Lakes. If targets are set, policies and steps would need to be established to achieve these targets. No targets have been set at this time.

2.4.2 Lake Ontario Working Group

The source protection areas and regions draining into Lake Ontario (Niagara, Halton-Hamilton, Credit-Toronto-Central Lake Ontario, Trent Conservation Coalition, Quinte, and Cataraqui) have formed a Lake Ontario Working Group (comprised of source protection *chairs* and project managers) to discuss and address common issues, share knowledge and engage in broader discussions on Great Lakes issues from a *drinking water* perspective.

2.4.3 Lake Ontario and the Cataraqui Source Protection Area

In addition to its importance as a source of *drinking water*, Lake Ontario has a substantial influence on the economy of the CSPA in terms of the opportunities it provides for industry, transportation, and recreation. The Lake also serves to moderate the *climate* of the shoreline areas of the CSPA. This has a beneficial effect on agriculture, especially on the islands (Amherst, Howe, and Wolfe) and in the Bay of Quinte *watershed* near Adolphustown.

The majority of industrial water use occurs along the north shore of Lake Ontario. Industry within the CSPA benefits from its location on the shore of Lake Ontario in two ways. First, the

Lake provides ample water used for industrial processes (industrial cooling accounts for the largest withdrawals from Lake Ontario in the CSPA). Second, the Lake provides easy access to shipping. The St. Lawrence Seaway is a major water transportation route, providing shipping from the Great Lakes to the Atlantic Ocean.

The transport of selected substances along transportation corridors was approved by the Ontario Ministry of the Environment as a local (non-prescribed) type of *drinking water threat* for the Cataraqui area in June 2010. It is therefore anticipated that the threat associated with spills along the St. Lawrence Seaway will be included in an updated edition of the A*ssessment Report* that will be published in 2011.