QUINTE CONSERVATION

Watershed Characterization

Version 1.1
April 2008

DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER

Quinte Region

DRAFT REPORT

FOR CONSIDERATION OF THE

QUINTE REGION SOURCE PROTECTION

COMMITTEE

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List of Acronyms

Acronym	Definition
ANSI	Area of Natural and Scientific Interest
AOC	Areas of Concern
BMI	Benthic Macroinvertebrates
BOD	Biological Oxygen Demand
BQRAP	Bay of Quinte Remedial Action Plan
CA	Conservation Authority
COD	Chemical Oxygen Demand
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CSI	Contaminant Source Inventory
CURB	Cleanup Rural Beaches Program
DFO	Department of Fishery and Oceans
DIC	Dissolved Inorganic Carbon
DOC	Dissolved Organic Carbon
DU	Ducks Unlimited
DWIS	Drinking Water Information System
DWS	Drinking Water System
DWSP	Drinking Water Surveillance Program
DWTP	Drinking Water Treatment Plant
E. Coli	*Escherichia coli*
EC	Environment Canada
EMAN	Environment Canada – Environmental Monitoring and Assessment Network
ERIS	Ecolog Environmental Risk Information Services
FDRP	Flood Damage Reduction Program

Acronym	Definition
FIPPA	Freedom of Information and Protection of Privacy Act
FTU	Formazin Turbidity Unit
GIS	Geographic Information Systems
GLFC	Great Lakes Fishery Commission
GLISN	Great Lakes Index Station Network
GLWQA	US-Canada Great Lakes Water Quality Agreement
GUDI Well	Groundwater Under the Direct Influence of Surface Water
HBI	Hilsenhoff Biotic Index
IBU	Impaired Beneficial Uses
IPZ	Intake Protection Zone
LIO	Land Information Ontario
LTRCA	Lower Trent Region Conservation Authority
Masl	Meters above sea level
MBQ	Mohawks of the Bay of Quinte
MISA	Municipal / Industrial Strategy for Abatement
MNR	Ontario Ministry of Natural Resources
MOE	Ontario Ministry of Environment
MRCA	Moira River Conservation Authority
MRW	Moira River Watershed
n	Number of observations
NHIC	Natural Heritage Information Centre
NRCA	Napanee River Conservation Authority
NRW	Napanee River Watershed
NTA	Nitrilotriacetic Acid

Acronym	Definition
NWRI	Environment Canada – National Water Research Institute
OBBN	Ontario Benthos Biomonitoring Network
ODWS	Ontario Drinking Water Standard
OFAH	Ontario Federation of Anglers and Hunters
OGDE	Ontario Geospatial Data Exchange
OMAFA	Ontario Ministry of Agriculture, Food and Rural Affairs
PERCA	Prince Edward Region Conservation Authority
PERW	Prince Edward Region Watershed
PGMN	Provincial Groundwater Monitoring Network
PPCP	Pollution Prevention and Control Plans
PQWO	Provincial Water Quality Objective
PSW	Provincially Significant Wetland
PTTW	Permit To Take Water
RAP	Remedial Action Plan
SFL	Sustainable Forrest License
SRW	Salmon River Watershed
TARBS	Tri-Authority Rural Beaches Study
TCU	True Colour Units
TKN	Total Kjeldahl Nitrogen
TP	Total Phosphorus
TSA	Test Site Analysis
TSSA	Technical Standards and Safety Authority

Acronym	Definition
UTM	Universal Transverse Mercator
WHPA	Wellhead Protection Area
WRIP	Ontario's Water Resources Information Project

Quinte Source Protection Region
Watershed Characterization

Executive Summary

This Watershed Characterization Report is a summary of the known information about the Quinte Region Watershed. Descriptions of the physical attributes, history as well as land and water issues are provided in this report. Other reports such as the Water Budget and individual Municipal Technical Studies on municipal drinking water systems are also being developed and will be used in conjunction with this summary to help the Source Protection Committee develop an Assessment Report and Source Protection Plan for this region.

The Quinte Watershed Region is based on the jurisdiction of Quinte Conservation which includes lands that drain into the Moira River, Salmon River, and Napanee River as well as all of Prince Edward County. Quinte Conservation was formed in 1996 when the Moira River, Napanee Region and Prince Edward Region Conservation Authorities were amalgamated with a combined area of approximately 6,200 square kilometers.

Quinte Conservation's jurisdiction can be divided into three distinct physiographic regions. The northern area, containing the head waters of the major rivers, is underlain by the Canadian Shield. This area is characterized by steep to rolling topography, Precambrian bedrock, numerous lakes and forested lands. South of this shield lies a limestone plain of more subdued topography and for the most part agricultural land. The third region is Prince Edward County which is a peninsula extending into Lake Ontario characterized by limestone bedrock with thin soil cover and relatively flat topography.

Groundwater is an important part of the hydrologic cycle in the Quinte Source Protection Region. In this cycle, groundwater throughout the region recharges directly from precipitation. It then moves through the underlying soil and rock; ultimately discharging into the local watercourses. This discharge is called base flow and is important in supporting the health of the aquatic environment. Prior to this discharge groundwater is intercepted by over 22,000 wells providing the sole source of water supply to approximately 50% of the residents in the Region. Other important uses are as a supply to many agricultural operations, as well as for commercial and industrial purposes.

Groundwater in this watershed is controlled by the geology of the region which is dominated by shallow soil over fractured limestone and Precambrian rocks of the Canadian Shield. Groundwater flows through the fractures in these rocks and due to their relative small size, the volume of groundwater intercepted by local wells is typically low making it suitable for domestic and other low use purposes. However, due to variability of the fractured bedrock some wells have encountered high volumes of groundwater, such as those providing municipal supply to the Villages of Madoc, Tweed, Deloro and also the Peats Point subdivision.

Other than an elevated hardness, in general the quality of the groundwater supply throughout the region is also suitable for multiple uses. However, protection of this quality is important, given the shallow soil conditions which do not provide much protection for the underlying fractured bedrock.   This creates the potential for movement of contaminants introduced near the ground surface into the underlying groundwater aquifers.

Human activities have evolved around the land and water resources of this area. Towns and villages grew along rivers and shorelines because the water provided power for mills and transportation for goods. Mining, logging and agriculture dominated the landscape in the early days. Industries also began to develop in areas along the Bay of Quinte.

Development has not come without costs to the environment. The Deloro Gold Mine site has left a legacy of arsenic contamination that has impacted water quality in the

Moira River. Cleanup efforts by the Ministry of the Environment are ongoing even though the mine closed in 1961.

Early clearing of the land for agricultural and forestry purposes resulted in soil erosion and runoff. The result was a decline in water quality in the Bay of Quinte. Adding to this problem was insufficient waste water treatment and increased contaminated stormwater from the urban areas. This resulted in the Bay of Quinte becoming an Area of Concern and eventually the formation of the Remedial Action Plan for the bay.

The Bay of Quinte is showing signs of recovery because of several factors. These include; the work that the agricultural community is doing to establish buffer strips and reduce cattle access to watercourses; new or upgraded waste water plants are being established; new development in the Bay of Quinte watershed is required to meet stringent stormwater criteria; efforts to naturalize shorelines; education programs raising the awareness of the water quality issues.

In the Quinte Source Protection Region there are 11 municipal drinking water systems that service about 50% of the population. Of these systems seven are intakes from surface water and four are groundwater systems that have wells drilled into the underlying aquifers.   The rest of the population gets their water from private wells using groundwater and in some cases surface water from shore wells.

There continue to be emerging issues like toxic blue-green algae, invasion species, such as zebra mussels and drought conditions that all will have an affect on the safe supply of drinking water. The Source Water Protection Staff Team at Quinte Conservation continues to monitor and collect data to add to what is already known about the watershed.

Although there are some knowledge gaps, this Watershed Characterization Report is a good starting point to help readers gain a better understanding of the Quinte Watershed Region.

1.0 INTRODUCTION

Purpose

The watershed characterization is a catalog and description of information for the Quinte Region, including the large Moira, Salmon, and Napanee Watersheds, as well as the Prince Edward Region. The watershed characterization has been compiled for three purposes:

1. In order to address the O'Connor Report (2002a, b) recommendations, Quinte Conservation has assessed the information available as of the writing of this characterization. This was the first step to identifying the further data and management implementations necessary to protect the Quinte Source Protection Region.
2. This characterization will serve as a resource for the Source Protection Committee formed under the Clean Water Act. It will serve as a shared body of knowledge about the Quinte Region for the Committee members with varied backgrounds and interests (e.g. scientists, municipal representatives, the conservation authority, water users, and land owners). This characterization has been written with this audience in mind; information is provided in a concise and broad manner, focusing on the entire Quinte Region, not specific watersheds. However, the characterization also includes numerous appendices for individuals who want more detail or localized information. Finally, maps have been provided so that Committee members can view the watersheds, municipalities, physical characteristics and environments of the entire Quinte Region, as well as their location of interest. This combination should help the Committee members understand how the entire Quinte Region functions, while also helping them to undertake the decisions involved in protecting sources of municipal drinking water.

3. Although this is written as a report for the Committee, it will be shared with municipalities and residents.

Ultimately, it will become the foundation of an online resource that will be available to anyone interested in the Quinte Region.

Quinte Conservation

The Quinte Conservation Association was originally formed from three separate conservation agencies: The Moira River Conservation Authority (Moira River watershed), The Napanee Region Conservation Authority (Napanee and Salmon River watersheds), and the Prince Edward Region (Prince Edward County) Conservation Authority. Consequently, the Quinte Region includes three large watersheds in addition to the numerous smaller watersheds that empty directly into the Bay of Quinte and Lake Ontario. Each of the larger watersheds descends from the northern Canadian Shield to the southern Limestone Terrain that borders the Bay of Quinte (Map 1). There are natural differences in ecosystems and water resources between these two zones that have been reflected in human settlement and land use. Finally, the Prince Edward Region functions as a third zone because it is surrounded by water, therefore, although much of the physiography and habitat are similar to the Limestone Terrain, surface water and groundwater patterns are not the same as those to the north. Throughout this characterization, these three zones will be used to highlight the ecological differences that have led to human induced differences – specifically differences in water quality and quantity.

Finally, while differences in land use have become a focus of water management and the focus of this characterization, the methods must not overlook that these stream headwaters and outlets, as well as the groundwater flowing beneath the surface, are part of a contiguous network. Water quality, quantity, and movement must be understood throughout the system if sources of drinking water are to be protected. In the end, protecting sources of drinking water not only provides for consumptive use, but also ensures an environment that protects natural habitats and recreational uses.

References

O'Connor, D. R. (2002a). "Report of the Walkerton Inquiry, Events of May 2000 and Related Issues, Part One."   Retrieved March 19, 2008, 2008, from http://www.attorneygeneral.jus.gov.on.ca/english/about/pubs/walkerton/.

O'Connor, D. R. (2002b). Report of the Walkerton Inquiry: A Strategy for Safe Drinking Water, Part Two. Toronto, Ontario Canada, Ontario Ministry of Attorney General**:** 518 + Appendices.

1.1 Data Sources

There were several different data sources available for producing this watershed characterization. Occasionally, it was difficult to determine which data source was the most reliable. In order to address this issue, the DRINKING WATER SOURCE PROTECTION Data Requirements Matrix was used to select and acquire data.

1.2 Data and Knowledge Gaps

Although an abundance of data was available for creating this watershed characterization, some gaps were encountered when available data was incomplete, inaccurate, or inadequate. When these gaps occurred, it was difficult to find trends, draw conclusions, and defend these findings. Quinte Conservation has reviewed the requirements for each component of the watershed characterization and has identified current knowledge and data gaps.

Known data gaps are identified at the end of each section. Maps which contain incomplete, inadequate, or inaccurate data were created but categorize these gaps within the data.

Knowledge gaps are more difficult to identify. A complete understanding of the Quinte Region watersheds and their interactions with the Bay of Quinte and Lake Ontario requires continued monitoring, data collection, and resource management.

Quinte Conservation will continue these actions and strive to eliminate any data or knowledge gaps that impair the management of natural resources.

2.0 WATERSHED DESCRIPTION

2.1 Source Water Protection Region

The Quinte Source Protection Region is based on the jurisdiction of the Quinte Conservation Association, which is the combined jurisdiction of the Moira River, Napanee Region and Prince Edward Region Conservation Authorities. Those three conservation authorities technically still exist; however, they formed the Quinte Conservation Association in 1996 to oversee their total operations. The total area is approximately 6,600 km^2 (including water and islands). The watersheds in the Quinte Region (Map 1) discharge into either the Bay of Quinte or Lake Ontario, which shares a chart datum of 74.8 masl (meters above sea level). The Quinte Source Protection Region extends into Lake Ontario for 22 kilometres from the most easterly and westerly points of Prince Edward County up to the International border (Map 1).

2.1.1 Conservation Authorities

Moira River Conservation Authority (MRCA)

The MRCA was formed in 1947 and included all of the land drained by the Moira River (approximately 2,772 km^2) plus a few small watersheds draining directly into the Bay of Quinte, including Potter Creek (31 km^2) to the west and Bell Creek (19 km^2) and Blessington Creek (66 km^2) to the east. The total area of these watersheds is 2,888 km^2. The Moira River originates on the Canadian Shield and descends 383 m through the Limestone Terrain to the Bay of Quinte.

Napanee Region Conservation Authority (NRCA)

The NRCA was formed in 1947 and was originally based on the Napanee River Watershed (~818 km^2). In 1965, the Salmon River (~925 km^2), Marysville Creek (52 km^2) and Selby Creek (130 km^2) watersheds were added, bringing the total area to 1,963 km^2. The Napanee and Salmon Rivers are similar to the Moira River in that they both originate on the Canadian Shield and drain through the Limestone Terrain to the Bay of Quinte, descending a total of 172 m and 267 m, respectively.

Prince Edward Region Conservation Authority (PERCA)

The PERCA was formed in 1965 and has a jurisdiction that is based on the peninsula that is Prince Edward County. There are many watersheds that drain from the peninsula into Lake Ontario and the Bay of Quinte; most flow through limestone. The total area is 1,761 km^2 (including water and islands) and the highest elevation is 156 masl.

2.1.2 Quinte Conservation's Mission and Vision

At Quinte Conservation the "Strategic Plan 2002 to 2010" declares that Quinte Conservation's "goals are driven by the ability to be innovative and imaginative" and that "Being passionate about preserving and protecting the environment for future generations" is critical to Quinte Conservation's mission.

Quinte Conservation's Mission

Quinte Conservation's mission is to work with watershed residents in creating a sustainable ecosystem where people and nature live in harmony with continued economic prosperity and quality of life.

Quinte Conservation's Vision

Quinte Conservation strives to be the lead community environmental agency in the watershed.

Quinte Conservation's Mandate

The MRCA, NRCA and PERCA were all formed under the Conservation Authorities Act which first appeared in 1946. Offered programs include Flood Forecasting, Floodplain Management, Owning and Operating Water Control Structures, Environmental Planning, Groundwater Protection, Low Water Response, Water Quality Monitoring, Owning and Operating Conservation Lands, Stormwater Management, Environmental Stewardship, Tree Seedling Orders, Participation in the Bay of Quinte Remedial Action Plan and Environmental Information and Education.

2.1.3 Human History and Natural Resource Use of the Quinte Region

Although the human history of the Quinte Region predates the arrival of Europeans in the early 17th century, it was this arrival and subsequent population increase that initiated modern water quality and quantity concerns (Figure 2.1).

First Nations people were present in the area when Samuel de Champlain first visited the Bay of Quinte in 1615. After initial settlement by the French and later settlement by Loyalists, agriculture and ample timber resources became a driving force behind township development. The development of ferries, steamers, and eventually roads by the middle of the 1800s enabled the Quinte Region to become a hub of agricultural and industrial productivity.

After 1825, the booming lumber trade spurred development as grist mills, sawmills and several wool carding mills sprang up on the Moira, Napanee and Salmon Rivers. Ironworks, distilleries, tanneries and asheries (converting hardwood ashes to lye and potash) were also established. Many mills still had largely a local trade, but some Belleville mills exported flour and lumber.

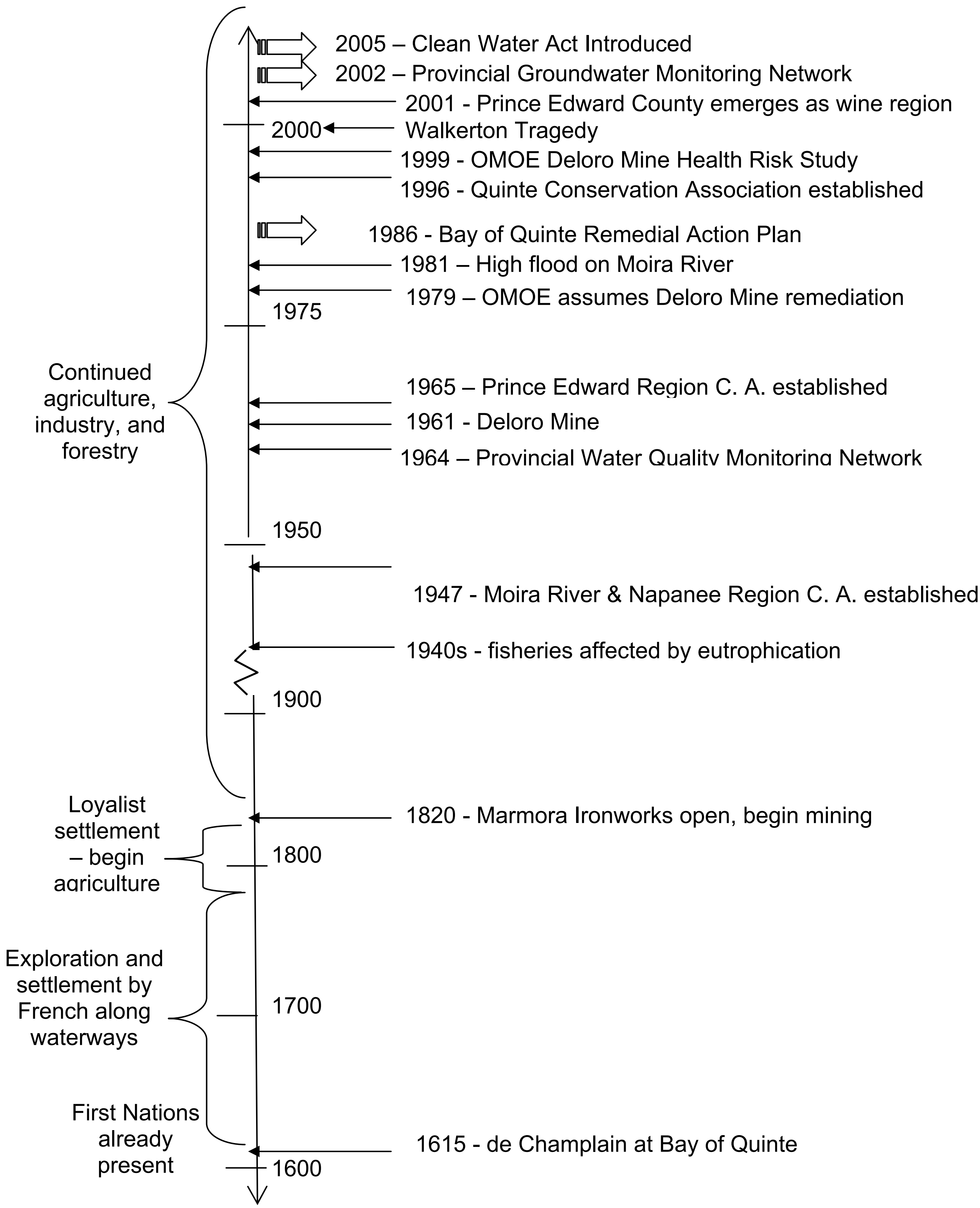


Figure 2.1. Human History and Natural Resource Use in the Quinte Region

Gold, sulfur, talc, actinolite, arsenic, copper, galena, limestone, marble, granite and slate have all been mined or quarried in the region, some of which is ongoing. The Deloro mine in the headwaters of the Moira River closed in 1961, leaving a toxic legacy including arsenic and some radioactivity. In 1979, the Ontario Ministry of the Environment began a remedial clean-up at the site that continues today.

The beginning of the 21st century sees a continuation of established forestry and agriculture, including orchards, corn, beef, and dairy, as well as new crops, especially wine grapes in Prince Edward County. At the same time, the region has become a travel and cottage destination, as people outside of the Quinte region learn about the beauty of the region's natural resources.

2.1.4 Key Studies and Initiatives

The Key Studies and Initiatives summarized below serve as excellent resources for understanding water management decisions and needs in the Quinte Region.

Key Studies

1) Conservation Reports - Beginning in the 1950s the provincial government, under various ministries, wrote Conservation Reports for the Moira (Richardson 1950), Napanee (Richardson 1957), Salmon (Barnes 1967) and Prince Edward (Barnes 1968) regions. These reports examined the natural resources of the each region and provide a good starting point for understanding the Quinte Region.
2) Watershed Plans (1980s) - As required by the Ontario Ministry of Natural Resources (MNR), these documents describe the characteristics of the Moira Watershed, Napanee Region (Interim Watershed Plan 1983), and Prince Edward Region and the Conservation Authority programs that were current at that time.
3) Preliminary Hydrogeologic Investigation of Prince Edward County (1985) - Water and Earth Science Associates conducted a preliminary analysis of the Prince

Edward Region groundwater resources, including an overview of availability and usage (WESA 1985).

4) Floodplain Mapping Studies - Floodplain mapping studies were undertaken throughout the region during the 1980s and early 1990s. There are maps for much of the Moira, Salmon and Napanee Rivers, the Bay of Quinte shoreline and some of the Lake Ontario shoreline, as well as some of the larger creeks that drain into the Bay of Quinte or Lake Ontario.
5) Belleville Pollution Control Planning Study (1996 & 1999) - This study was undertaken as part of the Bay of Quinte Remedial Action Plan initiative (CG&S 1996, 1999).
6) Moira River Study (2001) - This Ministry of the Environment (MOE) Study examined the effects of the Deloro Mine Site on the Moira River. It provided an understanding of the arsenic contamination downstream through the Moira River system.
7) Prince Edward County Growth and Settlement/Servicing Strategy (2003) - Implementation of the County's recommendations will affect settlement on the Prince Edward Region over the next 20 years, impacting water management (McComb 2003). The recommendations follow the Provincial Policy Statement, and encourage limiting growth to existing settlement areas. The study identifies Picton and Wellington as the primary centres for growth in the County. Focusing growth in serviced settlement areas reduces the strain on rural lands to absorb residential growth, as well as the need for private wells.
8) Permit to Take Water Monitoring and Reporting Pilot Study (2003) - Quinte Conservation and Long Point Region Conservation Authority jointly investigated the feasibility of implementing requirements for monitoring and reporting of actual daily water usage (XCG 2003). The study was initiated by the MOE in response to a known data gap between permitted water usage and actual usage. It was found through surveys conducted with water users of all categories that a majority of takers lacked the technical ability or the willingness to comply with an added requirement. The study concluded that monitoring and reporting requirements in permits to take water should be phased in after a need for the

information is determined and after compliance by takers is confirmed. The study also found that there were a large number of takers that were not in compliance with the existing conditions on their permits, who had expired permits, or who had no permit at all.

9) Potential Sources of Contamination Inventory in the Bay of Quinte Watershed (2004) - In response to The Bay of Quinte Remediation Action Plan, the Lower Trent Region Conservation Authority compiled known inventories of contaminated sites or areas of potential risk. During the Quinte Region Groundwater Study (Dillon 2004), staff of participating municipalities were interviewed and provided local knowledge of waste disposal sites or other high risk areas for potential contaminant concern that may not have been previously inventoried.
10) Quinte Regional Groundwater Study (2004) - Dillon Consulting Limited was hired by Quinte Conservation and Hastings County to assess groundwater use and vulnerability (Dillon 2004). The study concluded that the Quinte Region is intrinsically susceptible to groundwater contamination because the soil cover is thin, thus there is little to prevent downward migration of contaminants. The study also included a preliminary look at water usage and found that there is an abundant annual supply of water.
11) Deloro Mine Site Cleanup, Integrated Cleanup Plan - Draft Executive Summary (2004) - This is the technical report of the cleanup plan for the Deloro Mine Site created by the Ministry of the Environment's engineering consulting firm CH2M HILL Canada Limited (Szabo 2004).
12) Update to Pollution Control Studies (2005) - This update was undertaken to promote pollution control studies in other watershed municipalities, such as Picton, Deseronto and Napanee (XCG 2005, 2006).

Key Initiatives (all are ongoing)

1) Bay of Quinte Remedial Action Plan (BQRAP) - Quinte Conservation's General Manager serves as the co-chair of the BQRAP Restoration Council. BQRAP is a

series of studies, recommendations and projects to improve water quality in the Bay of Quinte.

2) Development, Interference with Wetlands and Alterations to Shorelines and Watercourses Regulations - Quinte Conservation monitors development in and around waterways, floodplains, wetlands and hazard lands in order to avoid adverse environmental outcomes.
3) Environmental Planning Services - Quinte Conservation advises its constituent municipalities on regional planning. As required under the Planning Act, all applications (severance, subdivision, Official Plan, and Zoning By-law amendments) are forwarded to the Conservation Authority for review based on local planning policies, the Provincial Policy Statement and the Conservation Authority's policies (including regulatory and non-regulatory programs). Through this service, municipalities obtain comments and input related to a wide variety of environmental planning issues including the protection of water resources.
4) Stormwater Management Plan Review and Approval - As part of the Bay of Quinte Remedial Action Plan, Quinte Conservation is the lead agency for the stormwater quality control program. This program addresses the maintenance and improvement of stormwater runoff quality affected by urban development within the watershed.
5) Surface Water Quality Monitoring - In conjunction with the MOE, Quinte Conservation staff conduct monthly stream water sampling during the ice-free season. Samples are tested at certified labs for heavy metals, turbidity, pH, phosphorus, suspended solids and bacteriological parameters. The monthly test results are compiled in MOE's Provincial Water Quality Monitoring Network database.
6) Surface Water Quantity Monitoring - In conjunction with the Flood Forecasting mandate, Quinte Conservation monitors streamflow throughout the region. Some of these gauges were part of the original Water Survey of Canada and provide historical data from the early 1900s.
7) Groundwater Monitoring Network - Quinte Conservation, in partnership with the MOE, operates a network of 31 monitor wells. These wells are equipped with

water level loggers allowing continuous monitoring of groundwater levels. Water quality is also monitored on annual basis through collection of samples and laboratory analysis for a suite of chemical parameters. This program is part of a provincial network comprising over 400 wells.

8) Ontario Benthos Biomonitoring Network (OBBN) - The OBBN is an environmental tool designed to use benthic (bottom-dwelling) organisms as indicators of stream health. It was co-operatively developed by Environment Canada – Environmental Monitoring and Assessment Network (EMAN), Environment Canada – National Water Research Institute (NWRI), and the Ontario Ministry of the Environment (MOE). Quinte Conservation participates by monitoring 27 sample sites.
9) Watershed Stewardship and Habitat Protection and Restoration - Quinte Conservation works in partnership with other conservation organizations and landowners to implement stewardship projects to improve water quality and wildlife habitat. Ideas and technical advice are provided to landowners. Some grants are available through partnership agencies.
10) Conservation Communications - Education, Information and Awareness Building - Each year, Quinte Conservation offers information (media releases, website, brochures, displays, etc.), programs, events and workshops to the public (adults and children) and member municipalities (staff and members of council) on a wide range of relevant nature/conservation topics. Improvements and updates to www.quinteconservation.ca and www.quintesourcewater.ca are ongoing.
11) Working with Community Partners - Partnerships contribute to Quinte Conservation's success. The primary partners for Quinte Conservation are member municipalities. Working with local individuals and community groups, such as members of the Watershed Watch, lake associations, 'Friends of' groups, and other volunteers help to achieve environmental goals. Cooperation and partnerships with all levels of government and other local agencies like the Health Units are also important to Quinte Conservation's success.

2.1.5 Stakeholders and Partners

Municipalities

Quinte Conservation serves three upper tier, three single tier and 15 lower tier municipalities in the watersheds of the Moira, Napanee and Salmon Rivers, and Prince Edward County Region (peninsula) (Map 1). There is a very close working relationship between the conservation authority and these municipalities whose representatives serve on the Quinte Conservation Executive board.

County of Hastings (Mostly Moira River Watershed (MRW) unless indicated) – Upper Tier
Lower Tier

- Township of Stirling/Rawdon
- Municipality of Centre Hastings
- The Corporation of the Township of Madoc
- Municipality of Marmora & Lake
- Municipality of Tweed
- Townships of Tudor & Cashel
- Town of Deseronto (Napanee Region Watershed (NRW))
- Township of Tyendinaga (NRW)

Lennox & Addington County (Mostly NRW unless indicated) – Upper Tier
Lower Tier

- The Corporation of the Township of Addington Highlands (MRW)
- Township of Stone Mills
- Town of Greater Napanee
- Loyalist Township

County of Frontenac (NRW) **–** Upper Tier
Lower Tier

- Township of North Frontenac
- Township of Central Frontenac
- Township of South Frontenac

The Corporation of the County of Prince Edward (Prince Edward Region Watershed (PERW)) – Single Tier
Amalgamated

- Picton Ward
- Bloomfield Ward
- Wellington Ward

- Ameliasburgh Ward
- Athol Ward
- Hallowell Ward
- Hillier Ward
- North Marysburgh Ward
- South Marysburgh Ward
- Sophiasburg Ward

The Corporation of the City of Belleville – Single Tier
Amalgamated

- Thurlow Ward

The City of Quinte West – Single Tier
Amalgamated

- Sidney Ward

Provincial Agencies

Quinte Conservation has developed a working relationship with several agencies, both local and provincial, in order to effectively manage water resources. These partnerships include:

Ministry of the Environment

Quinte Conservation has developed a working relationship with MOE both locally and provincially that involve water related issues.

Locally

- Enforcement issues
- Approval process for stormwater approvals and regulations

Provincially

- Partnering with MOE to administer programs
    - Clean Up Rural Beaches Program – (discontinued)
    - Provincial Groundwater Monitoring Network
    - Provincially Water Quality Monitoring Network

- Ontario Benthos Biomonitoring Network

- Source Water Protection Program
- Data from the Lake Partner Program
- Pilot Study for Permit to Take Water Program
- Groundwater studies
- Grants for Wellhead Protection Area and Intake Protection Zones
- Data source sharing
- Deloro Mine Site cleanup

Ministry of Natural Resources

Quinte Conservation has developed a working relationship with MNR both locally and provincially that involve water related issues.

Locally

- Enforcement issues
- Approval process for water and fisheries related approvals and regulations

Provincially

- Snow course sampling program
- Flood forecasting and low water response
- Dam operations
- Fisheries projects
- FDRP - Flood Damage Reduction Program

Ministry of Health and Long Term Care

Quinte Conservation has worked with the local Health Units on a number of local initiatives and studies.

- The Local Health Units were represented on the Steering Committee for the Quinte Region Groundwater Study
- Quinte Conservation and the local Health Units have jointly presented at local seminars on water quality issues. These were known as Well Aware

Seminars and they were designed to provide landowners with information about their wells, septic systems and groundwater issues.

- The Local Health Units were represented on the local Clean Up Rural Beaches Committee that awarded grants to landowners to help prevent pathogens from entering the water and impacting local swimming beaches.
- Quinte Conservation cooperated with the local Health Unit on their West Nile Virus Program.
- Quinte Conservation has partnered with the local Health Unit in promoting healthy, active living and the use of conservation areas.

Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA)

Quinte Conservation has worked the Ontario Ministry of Agriculture, Food and Rural Affairs on a number of local initiatives and studies.

- OMAFRA and Quinte Conservation were both partners in delivering the Clean Up Rural Beaches Program
- OMAFRA and Quinte Conservation were both involved in the Bay of Quinte Remedial Action Plan
- Quinte Conservation has been actively promoting the use on anaerobic digesters on diary farms to produce electricity and reduce potential pathogens from entering watercourses. Quinte Conservation helped a local farm develop an anaerobic digester project that has now been funded by OMAFRA.

Ministry of Northern Development and Mines

Quinte Conservation and the Ministry of Northern Development and Mines have been involved in the Deloro Mine site clean up effort.

Ministry of Municipal Affairs and Housing

Quinte Conservation has on occasion worked with the Ministry of Municipal Affairs and Housing when necessary on planning issues that relate to water.

Neighbouring Conservation Authorities

Quinte Conservation has worked with the neighbouring Conservation Authorities extensively over the years.

The list of relevant efforts includes:

- Bay of Quinte Remedial Action Plan Initiatives
- Joint communication efforts (example – O'Connor Commission Report)
- Source Protection Technical and GIS Committee
- Data sharing

Conservation Ontario

- Communication strategies
- Technical support

Federal Government

Environment Canada

- Bay of Quinte Remedial Action Plan Initiatives
- The Mohawks of the Bay of Quinte (pilot project; please see below)
- Tree planting for the Kyoto efforts (pilot project)
- Employment programs – providing staff for water related projects
- FDRP - Flood Damage Reduction Program
- Meyer's Pier Cleanup Project
- Canadian Wildlife Habitat funding for local projects

Department of Fisheries and Oceans

- Quinte Conservation works directly with DFO assisting them with fisheries inspections

First Nations

In the Quinte Region, First Nations lands include the Tyendinaga Mohawk Territory located along the shores of the Bay of Quinte at the lower end of the Salmon River Watershed. The land includes a tract of approximately 7,275 ha supporting a population of 2,037. Most of this area is serviced by private wells and septic systems, with a small subdivision serviced by the Deseronto water and sewer utilities. Quinte Conservation and the Mohawks of the Bay of Quinte (MBQ) have participated in a pilot project jointly funded by Environment Canada and MOE. The purpose of this project was to work together on the following:

- Review of existing surface water and groundwater information,
- Collection of surface water and groundwater data ,
- Develop a working relationship,
- Collaboration on source water protection.

The most recent report from this pilot project is in Appendix 1.

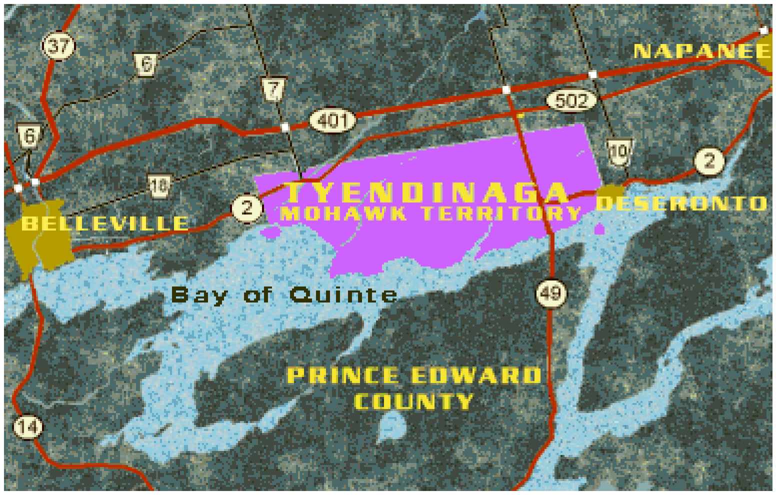
The following excerpt is from the MBQ (MBQ 2008).

The ancestral homeland of the Mohawk Nation is the Mohawk River Valley of present day New York State. The Mohawks are considered the easternmost tribe within the Iroquois/Six Nations Confederacy consisting of the Mohawk, Oneida, Onondaga, Cayuga, Seneca and Tuscarora Nations. Several Mohawks and others of the Confederacy were respected allies of the British during the American Revolution, and in consequence of their alliance were forced from their homeland by their Rebel counterpart. In compensation for losses suffered, the British Crown promised land to the Mohawks and others of the Confederacy displaced by the war. Captain John Deserontyon, a Mohawk serving in the British army, selected land here on the shores of the Bay of Quinte. On the 22nd of May 1784, Captain John Deserontyon and about 20 families arrived here on the shores of the Bay of Quinte. [We,] the Mohawks of the Bay of Quinte, have been here ever since.

Location of the 5 Nations People ~1600?

Tyendinaga Mohawk Territory

On the 1st of April 1793, a tract of land the size of a township was granted to the Six Nations people by the Lieutenant-Governor of Upper Canada, John Graves Simcoe, in a document known as the "Simcoe Deed" (also referred to as Treaty 3 1/2.) The original area of the territory was the size of a township, approximately 92,700 acres. Over the years [our] the land has been reduced by land alienations and surrenders to approximately 18,000 acres. Originally referred to as the Mohawk Tract, Tyendinaga Mohawk Territory is located approximately eight miles east of Belleville and approximately 50 miles west of Kingston. Tyendinaga, when translated in English, means "placing the wood together." Of special significance, the name is derived from "Thayendanegea," Captain Joseph Brant's Mohawk name and reflects the belief that "our strength shall be in unity."



Mohawk Landing/ Landing of the Mohawks

The Landing is an annual commemoration of the historic arrival of the Mohawks here on May 22, 1784, although archival cartographic maps show Iroquois settlement on the north shore of Lake Ontario more than 150 years prior. Celebrated since 1929, "Mohawk Landing" is held on the Sunday closest to May 22. Activities include a reenactment of the landing of the canoes, a special church service, and traditional teachings at the local community centre. Traditional dress and Iroquoian food also enhance this unique historical celebration.

Population

Upon arrival on the shores of the Bay of Quinte in 1784, there were approximately 20 families or 100 individuals. As of 1996, the Mohawks of the Bay of Quinte number over 6,000 with those residents on the Territory numbering approximately 2,200.

Interested Stakeholders, Engaged Public and Non-Governmental Organizations

Quinte Conservation has partnered, advises and coordinates with a number of stakeholder groups that have already been engaged in some type of activity related to watershed planning and/or rehabilitation and restoration work. Some of this work is ongoing while other projects have been assumed by the independent agency. Quinte Conservation continues to look for ways of partnering with local agencies and residents. Current partnerships include:

Waring Creek Improvement Association

- Developed a Watershed Report Card
- Creek rehabilitation projects
- Tree planting

Palliser Creek Improvement Association

- Rehabilitation projects
- Creek studies
- Manure management improvements
- Tree planting

Kennebec Lake Association

- Currently working on a lake plan
- Lake level and benthic monitoring programs have been set up

Prince Edward Round Table on Environment and Economy

- Organized County-wide Household Hazardous Waste Days (now run by County)

Ducks Unlimited

- Quinte Conservation has partnered with DU on waterfowl projects

Garrison Lake Property Owner's Association

- Communication – Quinte Conservation provided extension notes for naturalizing shorelines

Friends of Black River (PERW)

- Group concerned about water quality of the river
- Water samples collected at additional locations for water chemistry in 2007

Friends of East Lake

- Group concerned about water quality of the lake
- Water samples collected at additional locations for water chemistry in 2007

Friends of Salmon River

- Data sharing

References

Barnes, A. S. L. (1967). Napanee Region Conservation Report 1967: Salmon River Report Section. Toronto, Ontario Canada, Ontario Department of Energy and Resources Management, Conservation Authorities Branch**:** 40.

Barnes, A. S. L. (1968). Prince Edward Region Conservation Report: Land, Forest, Water, Wildlife. Toronto, Ontario Canada, Ontario Department of Energy and Resources Management, Conservation Authorities Branch**:** 161.

CG&S (1996). Belleville Pollution Control Planning Study Draft Report Phases 1 and 2, CH2M Gore & Storrie Ltd.**:** 46 + Appendices.

CG&S (1999). Belleville Pollution Control Planning Study 1996 to1997 Draft Report, CH2M Gore & Storrie Ltd.**:** 78 + Appendices.

Dillon (2004). Quinte Regional Groundwater Study, Prepared by Dillon Consutling Ltd. for Quinte Conservation**:** 194 + Appendices.

Interim Watershed Plan (1983). Napanee, Ontairo Canada, Napanee Region Conservation Authority**:** 91 + Appendices.

MBQ (2008). About Us. http://p7.hostingprod.com/@mbq-tmt.org/modules.php?op=modload&name=PagEd&file=index&topic_id=0&page_id=73 Retrieved on March 25, 2008.

McComb, B. R. (2003). Prince Edward County Growth & Settlement / Servicing Strategy Background Report. Official Plan Amendment. Picton, Ontario Canada, The Corporation of the County Prince Edward 175 + Appendices.

The Moira River Study (2001). Prepared by Golder Associates Ltd. and GlobalTox International Consultants Inc. for the Ontario Ministry of Environment**:** 25.

Potential Sources of Contamination in the Bay of Quinte Watershed (2004). Trenton, Ontario Canada, Prepared by Lower Trent Conservation for Bay of Quinte Remedial Action Plan Restoration Council**:** 36 + Appendices.

Richardson, A. H., A. S. L. Barnes, H. A. Smith, F .G. Jackson, J. W. Murray, G.S. Bartlett, C. E. Bush, J. P Bruce, K. M. Mayall, V. B. Blake, H. F. Crown, W. D. Adlam, R.V. Brittain, M. Chubb, Coutts, K. G. Higgs, H.G. Hooke, L. N. Johnson, A. D. Latornell, C. R. Leuty, R. M. Lewis, E. F. Sutter (1957). Napanee Valley 1957 Conservation Report. Toronto, Ontario Canada, Ontario Department of Planning and Development, Conservation Branch.

Richardson, A. H., W. J. P. Creswick, A. S. L. Barnes, B. O. Smith, C. E. Bush, J. W. Murray, K. M. Mayall, V. B. Blake, H. F. Crown, L. N. Johnson, G. Newson (1950). Moira Valley Conservation Report 1950. Toronto, Ontario Canada, Ontario Department of Planning and Development, Conservation Branch.

Szabo, P. A. (2004). Deloro Mine Site Cleanup, Integrated Cleanup Plan - Draft Executive Summary, Prepared by CH2M HILL for Ontario Ministry of Natural Resources**:** 13.

WESA (1985). Preliminary Hydrogeologic Investigation of Prince Edward County: Final Report, Water and Earth Science Associates Ltd.**:** 42 + Appendices.

XCG (2003). Permit to Take Water Monitoring and Reporting Pilot Study. Kingston, Ontario Canada, XCG Consultants Ltd. In association with Quinte Conservation and Long Point Region Conservation Authority Submitted to Conservation Ontario**:** 11 + Appendices.

XCG (2005). Bay of Quinte Remedial Action Plan Pollution Control Planning for Picton, Napanee and Deseronto: Interim Project Report. Kingston, Ontario Canada, Prepared by XCG Consultants Ltd. for Bay of Quinte Remedial Action Plan and Lower Trent Conservation Authority**:** 31 + Appendices.

XCG (2006). Bay of Quinte Remedial Action Plan Advancement of Pollution Prevention & Control Plans for Bay of Quinte Municipalities: Project Report. Kingston, Ontario Canada, Prepared by XCG Consultants Ltd. for Bay of Quinte Remedial Action Plan and Lower Trent Conservation Authority**:** 11 + Appendices.

2.2 The Physical Description

The Quinte Region lies along the border of two distinct physiographic regions: the Great Lakes Lowlands and the Canadian Shield. These two regions exhibit contrasting physical conditions with the rocky highlands of the Canadian Shield to the north and the limestone plains of the Great Lakes Lowlands at the south along the shores of the Bay of Quinte and Lake Ontario. A summary of the physical conditions of these areas is reported below.

2.2.1 Bedrock Geology

Because the soil and sediment cover is thin, the bedrock geology has a large influence on the physical landscape, surface water and groundwater flow patterns in the Quinte Region. The geology has been evaluated through review of existing information including government reports, maps, and studies, in particular the Municipal Groundwater Study (Dillon 2004). The bedrock consists of *Precambrian* bedrock underlying the entire region with a capping by as much as 300 m of Paleozoic *limestone* throughout the area at the south in Prince Edward County. The surface boundary or contact between these two types of rocks extends in a southeasterly direction following a line extending diagonally from Marmora, through Madoc, Tweed, and Tamworth. The various geologic units have been mapped as illustrated by Map 2 with a north south cross section in Figure 2.2 extending from Tweed to Lake Ontario, denoted as A to A’ on Map 2.

Precambrian Bedrock

Precambrian rocks underlie the entire Quinte Region and are comprised of *igneous* (cooled from lava) and *metamorphic* (rock that was later heated and reformed while still below the surface) rocks that form the core of North America. These rocks range between 0.9 and 1.6 billion years in age and are visible at or near surface throughout the Canadian Shield portion of the Region. Because of complex geology of the rocks within this area the region has been mapped in belts with each belt having different terrains based on the types of rocks found in the individual belt. In the Quinte Region, the main belt is the Central Metasedimentary Belt which is comprised of the following main terrains.

Elzevir Terrain

The Elzevir Terrain is exposed over most of central Hastings County, from Bancroft to the northern fringe of the boundary with Paleozoic rocks near Marmora, Madoc, Tweed, and Enterprise. This terrain contains a high percentage of felsic plutonic rocks such as granite and tonalite. Two distinctly different groups are the Mazinaw and the Flinton Group, which appear between these felsic rocks. The Mazinaw Group consists of mafic metavolcanic and meta-volcanoclastic rocks that appear in long thin bands. Also less frequently found are metacarbonates (marble, dolostone) and a greater percentage of clastic metasedimentary rocks. The Flinton Group has fewer carbonaceous metasediments present and contains less mature metaconglomerates, metapelites, and metamorphosed quartz arenites (sandstones).

Sharbot Lake Terrain

The Sharbot Lake Terrain is a wedge-shaped region of rocks that is bound to the north by the Elzevir Terrain and to the south by Paleozoic bedrock. This terrain is exposed at surface in Stone Mills and Central Frontenac townships. Calcitic and dolomitic marbles dominate this terrain. Other common rocks include gabbro, granodiorite and granite. The southern and northern boundaries of the terrain are marked by southwest to northeast trending faults.

Frontenac Terrain

There is only a small portion of the Frontenac Terrain within the Region. It is exposed along the far eastern extremity of the Quinte watershed in Central and South Frontenac townships. There are several rock types in this terrain including calcitic/dolomitic marbles, quartz arenites, and metamorphosed felsic plutonic rocks. Metavolcanic diorite-gabbros are also found along the boundary with the Sharbot Lake Terrain. Major faults are congruent with the boundaries of both the Sharbot Lake Terrain and the Paleozoic sedimentary rocks to the east.

Paleozoic Bedrock

In most of the southern part of the Quinte region, the Precambrian bedrock is overlain by sedimentary rocks of the *Paleozoic* era (approximately 500 million years in age). These rocks were formed after the area was inundated by an ocean and sediments accumulated on the bottom along the continental shores. This sediment was then compacted and cemented – forming the carbonate rich limestone and other sedimentary rocks that characterize most of this area. The various formations found in the Quinte region are summarized by Table 2.1 and are individually described as follows:

Lindsay Formation

The Lindsay Formation is the youngest sedimentary unit in the Quinte region underlying most of the southern two-thirds of Prince Edward County. The formation is divisible into upper and lower members with both members containing nodular limestone and shale partings. The limestone is typically grey-brown in colour weathering to a blue-grey. The shale interbeds are up to 5 cm thick and are dark grey. The formation has an estimated thickness of 20 to 30 m where exposed; however, natural gas exploration wells in the area suggest the formation may be of greater thickness.

Verulam Formation

The Verulam Formation makes up a large proportion of the exposed Paleozoic bedrock in the Quinte region. It is found below most of Belleville and the northern portion of Prince Edward County, as well as the southern portion of Tyendinaga Township. The Formation is of Middle Ordovician age and consists of 3 to 15 cm thick grey, finely crystalline limestone beds with interbeds of shale up to 15 cm thick. This formation overlies the Bobcaygeon Formation at variable thickness but can range up to 70 m, as observed near Cherry Valley (Prince Edward County). This formation underlies most of Prince Edward County either directly below soil cover in the northern portion of the County or beneath the Lindsay Formation throughout the south as illustrated by the cross section in Figure 2.2.

Bobcaygeon Formation

The Bobcaygeon Formation is a Middle Ordovician limestone that is divisible into upper and lower members. The lower member consists of pale to dark brown and grey crystalline limestone interbedded with calcarenite, weathering to pale grey, buff or brown. The upper member consists of interbedded crystalline limestone, with increasing shale content toward the surface. This formation lies over the Gull River Formation and appears as the surface bedrock unit over much of Centre Hastings and the central portions of Tyendinaga Township. Deep boreholes located in Tyendinaga Township and Prince Edward County reveal that this formation increases in thickness towards the south.

Gull River Formation

The Gull River Formation is complex and as such is divided into upper, lower and middle members. The upper member is comprised of beds of semi-crystalline limestone, the middle member ranges from shaly to massive layers of limestone toward the surface, and the lower is mottled crystalline dolomitic limestone. The formation is exposed at surface in the northeast portion of Tyendinaga Township as well as portions of Hungerford and Stone Mills Township. Natural gas exploration wells indicate a formation thickness in the range of 20 to 30 metres.

Shadow Lake Formation

The Shadow Lake Formation consists of red and green arkosic sandstones, siltstones and shales with clasts of granite, quartz and feldspar. This formation lies unconformably on top of the Precambrian rock. The formation is rarely exposed in the Study Area, but does crop out near the northern fringe of the boundary between Paleozoic and Precambrian bedrock. Natural gas wells drilled in Prince Edward County indicate that the formation extends beneath the southern half of the Study Area and attains a thickness of 15 m at Cherry Valley (Prince Edward County) at a depth of 250 m below ground surface. In Tyendinaga Township natural gas is found closer to surface, at a depth of 80 m with a thickness of 20 m.

Table 2.1. Paleozoic Bedrock Formations. Table modified from Quinte Regional Groundwater Study Final Report (Dillon 2004).

Formation	Member †	Map Unit‡	Thickness	Lithology
SIMCOE GROUP				
Lindsay	Upper	6b	0 to 90 m (usually <30m)	limestone and shale
	Lower	6a		nodular limestone with shale interbeds
Verulam Formation		5	0 to 70 m	interbedded limestone and shale
Bobcaygeon	Upper	1c, 4b	0 to 60 m	limestone with shaly partings
	Lower	1c, 4a		limestone and calcarenite
Gull River Formation	Upper	1b, 3, 3c	0 to 30 m	dolomitic limestone and weathered limestone
	Middle	1b, 3, 3b		shaly laminated limestone and massive bedded
	Lower	1b, 3, 3a		crystalline limestone
BASAL GROUP				
Shadow Lake Formation		1a,2	0 to 20 m	dolostone with interbeds of sandstone and shaly partings

† Formation correlates to map units displayed on Map 2 and Figure 2.2
‡ *Member* is a subgroup of a Formation.

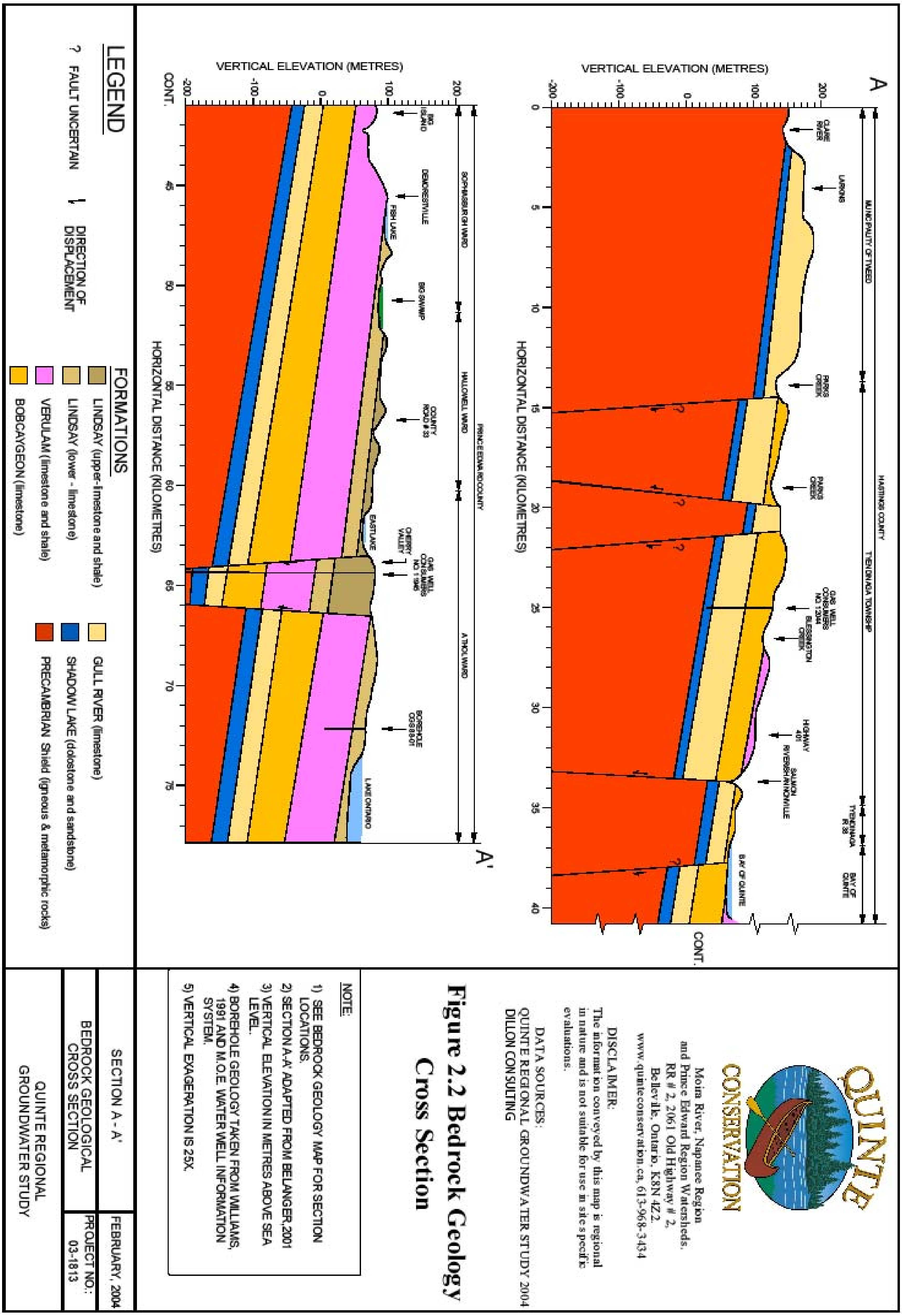


Figure 2.2. Geological Cross-Section of Paleozoic Formations

Bedrock Surface and Structural Geology

The surface of the bedrock is variable in the Quinte Region but generally slopes in a southerly direction as illustrated by Map 3. The Precambrian bedrock exhibits an undulating surface of variable relief but generally sloping to the south. Elevations range from approximately 450 masl at the northern tip of the watershed to 200 masl in the vicinity of the contact with Paleozoic bedrock near Madoc and Tweed.

The limestone rocks are generally flat lying with gentle dip predominantly in a southerly direction. Exceptions are in the vicinity of Precambrian outcrops near Shannonville and Ameliasburgh which have resulted in doming of the surrounding limestone strata.

There are two major faults in the region as delineated on Map 2. The Salmon River fault follows the course of the southern reaches of the Salmon River and extends from the Kaladar area onto the Prince Edward Region. This fault is reported to be a *normal fault* (extensional movement along a slip plane in the rock) for which the northwest side has dropped by approximately 30 m. Another normal fault has been mapped as extending from Deseronto to Picton following the Long Reach on the Bay of Quinte. At Picton this fault separates into two to three smaller faults extending into Athol Ward towards the Sandbanks. These faults govern local stream patterns and groundwater movement; this will be addressed in later sections. Several other smaller faults are found throughout.

2.2.2 Surficial Geology

Surficial geology in the Quinte region has been shaped by the most recent glacial period (ending approximately 10,000 years ago). This period has resulted in removal and deposition of sediments throughout the watershed with the majority of the area being scraped and scoured leaving behind a thin cover (less than 1 metre) of drift over bedrock. However there are some areas of the watershed with notable deposits of different soil units which are as illustrated by the surficial geology Map 4, the overburden thickness Map 5 and as discussed below. The thicker deposits of till soils and associated glacial landforms are present in isolated areas throughout but most notably in the southern portion of the Moira Watershed and isolated areas of the Prince Edward and Napanee Regions. Significant landforms associated with this soil are summarized in Table 2.2 with the main soil units described individually below. These formations range from kame moraine to till plains and eskers. Please note the soil unit numbers listed below correspond with soil types as listed on Map 4.

Map Unit # 1 - Till

This soil is comprised of a mix of silt, sand, gravel and boulders. This is the soil resulting from the action of the glacier on underlying bedrock and soils. Till was deposited by the glaciers and found throughout the watershed, deposited as either a sheet of soil or in ground moraines and some drumlins.

Map Unit # 2 - Glaciofluvial Ice Contact Deposits of Sand and Gravel

This soil is comprised of coarse sand and gravel and some till which was deposited by glacial melt water and/or the Champlain Sea resulting from the melting of glaciers. Landforms associated with this soil type are areas of undulating topography and ridges formed as raised beaches, eskers, as well as in plains of till and sand.

Map Unit # 3 - Glaciofluvial Outwash and Deltaic Sands

This soil includes gravel and coarse material with some sand and till. Deposition is from glacial melt water and/or post glacial rivers. Landforms associated with this soil type are ridges (beaches, kames and deltas) and shallow ridges in areas of undulating topography. These soils are typically found in bedrock depressions and valleys.

Map Units # 7, 8 and 9 - Glaciolacustrine

This soil is comprised of clay, silt, sands and gravels deposited from pro – glacial lakes. The landforms associated with these deposits are plains of near shore sediments and beaches.

Map Units # 10 & 12 - Alluvium

This soil is silty or sandy organic rich material that has been deposited by rivers and creeks. As such these soils are often found in riverbeds and terraces.

Map Unit # 13 - Organic Deposits

This unit is made up of muck and other organic rich soils such as peat. These soils have accumulated as a result of decomposition of vegetation and have been deposited in lowlands, wetlands and areas of poor drainage.

Map Unit # 14 - Eolian Sand

These soils were deposited by the wind and are found in dune formations particularly along the various sand bar and beach formations on the Lake Ontario shoreline of Prince Edward County.

Table 2.2. Localized significant landforms.†

Municipality	Description	Typical Thickness (metres)
Quinte West	Kame Moraine – extension of oak Ridges	70
Madoc	Till plain and eskers	<20
Centre Hastings	Dummer moraines, drumlins, & eskers	<20 - 80
Tweed	Till plain, Dummer moraines, eskers	<10 - 40
Belleville	Dummer moraines and drumlin field north of Moira River, eskers, -Thurlow	<20 - 80
Tyendinaga	Till plain, clay deposits near Shannonville	Mainly shallow
Stone Mills	Till plain in Erinsville-Tamworth	Mainly shallow
Prince Edward County	Esker, Cherry Valley & Picton-West Lake	20 - 25

† Table modified from Quinte Regional Groundwater Study Final Report (Dillon 2004)

2.2.3 Topography

The topography of the Quinte Region is variable, ranging from rugged in the rocky highlands of the Canadian Shield to areas of flat, low relief along the shores of the Bay of Quinte and Lake Ontario. Elevations range from a maximum of 458 masl in the extreme north of the Moira Watershed to 75 masl along the shore of the Bay of Quinte and Lake Ontario. Mapping of topography and slope using a digital elevation model identified areas of hilly (> 3% - meaning a change of 3 m vertically for every 100 m horizontally), rolling (1.5-3%), and flat slope (< 1.5%) (Table 2.3 and Map 6). Based on this classification system, areas of high slope are concentrated in the Canadian Shield portion of the Moira, Salmon, and Napanee watersheds; to the south, in the Limestone Terrain and Prince Edward Region, there is a predominance of low slopes.

Table 2.3. Areal Extent of Slope Ranges in the Quinte Region

Slope Classification	Slope Range %	Quinte Region %	Canadian Shield %	Limestone Terrain %	Prince Edward Region %
Flat	< 1.5	39.1	27.5	44.5	60
Rolling	1.5-3	24.4	22.6	27.5	23.4
Hilly	> 3	36.6	49.5	27.9	16.6

2.2.4 Physiography

Physiography refers to the land forms that have shaped and defined the landscape of the Region. There have been a variety of geologic processes that have influenced the shape of the Quinte Watershed resulting in a total of six distinct physiographic regions. Each of these regions is as located by Map 7 and described individually below. Information regarding the physiographic regions has been taken from The Physiography of Southern Ontario – Third Edition – Ontario Geological Survey, L.J. Chapman and D.F. Putnam 1984 (Chapman 1984).

Algonquin Highlands

The Algonquin Highlands extend over the northern tip of the Moira watershed and north eastern portion of the Napanee watershed. This region is characterized by bare crystalline bedrock, rugged topography, shallow soil and numerous irregular shaped lakes that have formed in the bedrock depressions. Soils are generally shallow and stony with bedrock outcrops extending 20 to 60 metres above the surrounding area.

Agriculture in this area is marginal and the population is low with few areas of settlement. The region is used extensively for forestry, mining and recreation with cottages located on many of the small lakes.

Georgian Bay Fringe

The Georgian Bay Fringe borders the Algonquin Highlands and extends over the majority of the northern area of both the Moira and Napanee watersheds. This region is characterised by very shallow soil with bare rock knolls and ridges of rolling and moderately rugged topography. Because of shallow soil there is very little agricultural use of this area with minimal population and settlement. The primary use of this region is for forestry and recreation.

Dummer Moraines

The Dummer Moraines extend in a belt along the border of the Canadian Shield and southern limestone plain. This region exhibits low hummocky topography with undulating knolls of till soil. These soils are of coarse texture and are littered with fragments and boulders of both limestone and Precambrian rock.

Land use is agricultural with farms comprised of small fields with rock fence lines as a result of the stony soils. Woodlots are also abundant throughout this area. Settlements include Marmora, Madoc, Tweed and Tamworth. These communities grew along waterways and the railroad as both were important transportation routes for lumbering days. Madoc and Marmora were also once important mining centres, however many of the deposits have been depleted. Still active today are a talc mine in Madoc and another facility for the mining of aggregates for the manufacture of shingles.

Peterborough Drumlin Field

The Peterborough drumlin field is located over the area of the City of Belleville, and the Municipality of Centre Hastings. The area includes rolling till plains, many drumlins, eskers, as well as the kame moraine along the south western boundary of the Moira watershed.

Land use of this region is primarily agricultural with rural residential development. The latter is becoming popular in this region due to aesthetic appeal, attraction of rural landscape and views afforded from the top of drumlins and rolling terrain.

Napanee Plain

The Napanee plain is a flat to slightly undulating area of thin soil over limestone bedrock throughout the southern portion of the Napanee watershed over the Town of Napanee, Municipality of Stone Mills, and Tyendinaga Township. This region includes small drumlins and deposits of clay soils in bedrock depressions.

The region along the Bay of Quinte includes some of the earliest settled areas by the Empire Loyalists. This includes the Town of Napanee which was largely settled because of the availability of water power from the Napanee River and transportation along the waterways. Agriculture and rural residential land use are prominent in this area due to relatively low land cost and close proximity to transportation routes.

Prince Edward Region

The Prince Edward Region is the southerly extension of the Napanee plain into the eastern part of Lake Ontario. This area exhibits flat topography with shallow soil cover over limestone bedrock. The region which is a peninsula exhibits an irregular shoreline defined in some areas by steep bedrock escarpment and other areas of bay mouth sand bars.

Similar to the Napanee plain, early settlement of Prince Edward County was by the United Empire Loyalists. In the early days land use was primarily agriculture. However, agriculture has been declining with increased development of rural residential properties. Summer recreation and tourism is a big industry in Prince Edward with many vineyards, beaches and resort areas attracting visitors.

2.2.5 Soil Characteristics

The soils in the Quinte Region have developed in relation to the underlying parent bedrock geology and from glacial activities. Given the bedrock geology there are numerous different soil types in the region as listed by Table 2.4 and illustrated by Map 8. In general the soils are thin and well drained. These soils have formed in place as a result of the slow and ongoing physical and chemical breakdown of the *parent material* (bedrock and sediment) that occurs as a result of normal plant, animal, water, and atmospheric processes. The soils of the different regions are as described below.

On the Canadian Shield the hard bedrock material is resistant to erosion and as a result, marginal soil development has occurred in this region. The soils found are poorly developed and are quite often stony from bedrock material that has not been fully broken down. Given the marginal soil conditions, agricultural land use is limited and restricted to isolated pockets of good soil. Significant land uses of the shield region include forestry, mining and recreation.

In the Limestone Terrain region to the south of the shield the soils are predominantly comprised of till and developed from the underlying soft limestone bedrock. The soils of this region are favourable for agriculture with much of the region cleared of forest and cultivated. The soils vary from north to south with higher content of stone and bedrock fragments at the north due to the influence of the Canadian Shield. To the immediate south the soils are of loam and sandy texture and represent the best agriculture soils of this region. The southern tip of this region, adjacent to the Bay of Quinte, is comprised of soils that were deposited by glacial lakes including lower permeability silt and clay. These soils are not as productive for agricultural crops; however, livestock farming is more predominant in this area.

On the Prince Edward Region the soils are similar to the Limestone Terrain and are mainly comprised of till derived from the underlying soft limestone bedrock. In low lying areas and adjacent to watercourses, lower permeability clays are found as deposited by glacial lakes. The soils in Prince Edward can also vary, subject to the type of underlying limestone. For example, soils found throughout Hillier Township have high shale content due to the bedrock. The soils of this region in combination with favourable climate have resulted in extensive agricultural land use throughout.

Table 2.4. Generalized Soil Descriptions.†

Geographic Area	**Soil Series**	**Drainage**	**Other Characteristics**	**Resultant Land Use**
Canadian Shield	• Monteagle • Tweed • St. Peters	well to well drained	• sandy loam surface layer • non-calcareous • stony • 2-5 cm plant litter layer • 2-5 cm leached surface layer • 25-30 cm depth to rock	Sparse agriculture and settlement resulted in large tracts of forested land being preserved
Limestone Terrain	• Dummer • Farmington • Otonabee	well drained	• loam to sandy loam surface layer • calcareous • 8 cm surface layer • 25-35 cm depth to rock	Mix of agricultural, livestock, and non-agricultural lands; more population centers.
Prince Edward Region	• Farmington • Hillier • Ameliasburgh	imperfectly to very well drained	• clay loam to loam surface layer • stony • calcareous • 5-15 cm surface layer • 30-90 cm depth to rock	High agricultural capacity.

† Gillespie 1962, Richards 1948

References:

Chapman, L. J., D. F. Putnam (1984). The Physiography of Southern Ontario. Toronto, Ontario Canada, Ontario Ministry of Natural Resources.

Dillon (2004). Quinte Regional Groundwater Study, Prepared by Dillon Consulting Ltd. for Quinte Conservation**:** 194 + Appendices.

Gillespie, J. E., R.E. Wicklund, B. C. Matthews (1963). The Soil Survey of Lennox & Addington County. Guelph, Ontario Canada, Research Branch, Canada Department of Agriculture and the Ontario Agricultural College**:** 63 + Maps.

Gillespie, J. E., R.E. Wicklund, N. R. Richards (1962). Soil Survey of Hastings County. Guelph, Ontario Canada, Research Branch, Canada Department of Agriculture and the Ontario Agricultural College 72 + Maps.

Richards, N. R., F. F. Morwick (1948). Soil Survey of Prince Edward County. Guelph, Ontario Canada, Experimental Farms Services, Dominion Department of Agriculture and the Ontario Agricultural College**:** 86 + Map.

2.3 Hydrology

Historical human activity, including clearing of the land for agriculture, harvesting of timber, and the construction of water control structures, has influenced the way runoff events drain from the watersheds within the Quinte Region (Table 2.5). In the northern Canadian Shield portion of the Moira, Salmon, and Napanee watersheds, human settlement and the resulting changes to the land cover were less dense than in the southern Limestone Terrain, where more productive soils led to a concentration of agriculture and population.

Table 2.5. Hydrologic Characteristics of Quinte Region

Region	Land Use	Resultant Drainage Characteristics
Canadian Shield	Preserved forest and wetlands	• higher infiltration, • lower peak volume in streams, • lower total volume of streamflow after rainfall or melt conditions.
Limestone Terrain and Prince Edward Region	Agricultural and urbanized regions	• lower infiltration due to paving and soil compaction, • higher peak volume in streams, • increased total volume of streamflow after rainfall or melt conditions.

Once heavily forested, much of the southern region was cleared of trees and put into service for the agricultural industry in the 1800s. For example, aerial photographs of the Prince Edward Region from the 1910s and 1920s show that most of the trees were gone and the landscape was denuded. However, beginning in the early 1900s and continuing to the present, agriculture and the associated communities have declined. Consequently, many fields are no longer used in crop production and a regeneration of forest cover in old fields is occurring.

Early settlers also drained and filled swamps and marshes, preventing these wetlands from performing their natural functions of storing runoff and recharging aquifers. Wetlands in the northern portions of the Quinte Region escaped this decimation largely due to the poor access and low quality farmland.

Quinte Conservation owns 39 dams and maintains several more dams in Quinte Region (Map 9). Not all of the dams presently owned by Quinte Conservation were constructed by Quinte Conservation. Many are of a considerable age and are a part of the local history, some being originally constructed as mill dams or to provide water for former local businesses. These existing dams have been acquired by Quinte Conservation since 1947. For many, the most familiar Quinte Conservation dams are the six ice control dams on the Moira River in Belleville. These dams work together to reduce the downstream threat to people's lives and property from the dangers of flooding due to ice jamming. But, Quinte Conservation has many more dams than just the ice control structures and they serve many other purposes. Critical water levels, fish migration and upstream and downstream conditions are some of the factors that determine when and how the dams are operated. At many of the dams, water levels are drawn down after Thanksgiving each year to provide additional storage space for spring melt waters. Following the spring runoff, dams are adjusted again, often by replacing stop logs that were removed in the fall, to ensure adequate water levels throughout the summer months. Maintenance of Quinte Conservation dams is an ongoing task. For an inventory of dams owned and operated by Quinte Conservation see Appendix 2.

Aside from land use or human activities within the watershed, the hydrology of the Quinte watersheds is influenced by many other factors including climatic, physiographic and geologic conditions. How rainfall is received by the land and returned back through the hydrologic cycle (through evaporation, infiltration, transpiration, runoff, and groundwater movement) will be outlined in this section of the report (this topic is also expanded upon in the Water Budget – Quinte Conservation 2006).

2.3.1 Surface Water Hydrology

Surface water flow in the Quinte Region north of the Bay of Quinte generally follows a north to south path, following the topographic descent of the land from the Precambrian rock divide to Lake Ontario (Table 2.6). The three primary watersheds in the Quinte Region (from east to west) are the Napanee, Salmon, and Moira Rivers, each of which is a well integrated system of tributaries and trunk streams. Smaller streams, including Selby, Marysville, Blessington, Bell, and Potter Creeks, drain the area between the larger watersheds and discharge directly into the Bay of Quinte; these streams are not gauged. The Prince Edward Region, which is essentially an island in Lake Ontario separated from the mainland by the Bay of Quinte, is drained by numerous, smaller watersheds that flow radially out to the lake and bay; Consecon Creek, the largest watershed in Prince Edward Region, drains from northeast to southwest. A list of watersheds gauged by Environment Canada is illustrated in Table 2.7.

Table 2.6. Watersheds draining the Canadian Shield & Limestone Terrain of the Quinte Region.†

Watershed	Highest Point	Area
	masl	km^2
Potter Creek	178	31
Moira River	458	2735
Bell Creek	125	23
Blessington Creek	167	66
Salmon River	342	915
Marysville Creek	152	52
Selby Creek	157	130
Napanee River	247	818

† Watersheds are listed from west to east. Each stream listed discharges into the Bay of Quinte or Lake Ontario (74.8 masl).

Table 2.7. Environment Canada Stream Gauges in the Quinte Region.

Stream System	Gauge Location	Identification	Record
Napanee River			
	Depot Creek at Bellrock	02HM002	1957-present
	Napanee River at Camden East	02HM002	1974-present
	Napanee River at Napanee	02HM001	1915-1974
Salmon River			
	Tamworth	02HM010	2002-present
	Shannonville	02HM003	1958-present
Moira River			
	Moira River near Deloro	02HL005	1965-present

Stream System	Gauge Location	Identification	Record
	Moira River near Foxboro	02HL001	1915-present
	Black River near Actinolite	02HL003	1955-present
	Skootamatta River near Actinolite	02HL004	1955-present
	Moira River near Tweed	02HL101	1968-1977
	Moira River near Tweed	02HL007	2002-present
	Moira River near Thomasburg	02HL104	1969-1970
	Clare River near Bogart	02HL102	1968-1977
	Parks Creek near Latta	02HL006	1984-1992
	Parks Creek near Latta	02HL103	1968-1977
Prince Edward			
	Consecon Creek at Allisonville	02HE002	1969-present
	Bloomfield Creek at Bloomfield	02HE001	1970-1992
	Demorestville Creek at Demorestville	02HE003	1970-1977

Napanee Watershed

The Napanee River flows in a pre-glacial valley that reaches depths of 50 m. The headwaters of this system are comprised of numerous lakes and swamps of the Canadian Shield. In addition, two of the larger lakes of this watershed, Varty Lake and Camden Lake, formed in shallow, localized bedrock depressions of the Limestone Terrain, near the contact with the Canadian Shield. Creeks draining into the Napanee system include Depot Creek from the Depot Lakes area, Varty Creek, and Hardwood Creek.

Salmon Watershed

The Salmon River originates in the Canadian Shield and follows a south-westward path along the Salmon River bedrock fault. The northern part of this system includes many lakes: Kennebec Lake, Big Clear Lake, Buck Lake, Bull Lake, Horseshoe Lake, Sheffield Lake and Beaver Lake. The southern portion of the system contains fewer lakes and drains through a well entrenched valley in the Limestone Terrain which, in some areas, reaches over 30 m depth.

Moira Watershed

The Moira River watershed also originates in the rocky highlands and marshy lake filled area of the Canadian Shield, however, this watershed is more than twice the size of the others in the Quinte Region. The major tributaries, the Black and Skootamatta Rivers, comprise approximately 40% of drainage basin. The Clare River and Parks Creek drain another 20% with the balance being covered by the Moira River trunk stream and smaller tributaries such as Palliser and Chrysal Creeks. Major lakes in the watershed include Skootamatta, Deerock, Lingham, Moira and Stoco Lakes. The southern portion of the River, from Stoco Lake onward, flows through the Limestone Terrain in a well-defined bedrock valley.

Prince Edward Region

The Prince Edward Region is drained by numerous small watercourses, typically of short length and discharge into either the Bay of Quinte or Lake Ontario. The main streams and their drainage areas are: Consecon (186 km^2), Sawguin (84 km^2), Black (72 km^2), Hubbs (46 km^2), Bloomfield (55 km^2), Demorestville (40 km^2), Hillier (22 km^2), Lane (16 km^2), Waring (13 km^2), Waupoos (15 km^2) and Cressy (4 km^2). Stream courses are largely controlled by bedrock faults. Peak streamflows occur during periods of heavy precipitation or in the spring months during winter thaw. Several of the streams discharge into lakes and bays on the Lake Ontario side of Prince Edward

Region that are isolated from the larger water body by sand spits, effectively buffering the interaction between the stream water and the Lake.

Marshlands are present in low-lying areas adjacent to Lake Ontario, where they connect water bodies, and between bedrock highs such as the Big Swamp and Little Swamp. Other features include Roblin Lake near Ameliasburgh, Fish Lake near Demorestville, and Lake on the Mountain near Glenora. These water bodies have formed in topographic depressions on the top of escarpments, and their presence is attributed to the low permeability of the underlying limestone rock.

2.3.2 Groundwater and Hydrogeology

Groundwater plays an important role in the hydrologic cycle, serving as a vital source of drinking water for residents in the watershed, as well as an important recharge as base flow to the many streams and rivers throughout the area. In the Quinte Region, groundwater serves as water supply to agriculture, industry, rural residents, and some urban-centered municipalities. Approximately 50% of the watershed population is rural residents for whom the main water supply is groundwater. This includes those serviced by municipal groundwater supply systems in the Villages of Deloro, Tweed, and Madoc, as well as a small subdivision referred to as Peats Point, located in Prince Edward County (Map 41).

Quinte Conservation is in the process of gathering and analyzing data about the groundwater flow and the available volumes of groundwater though completion of a water budget. Much information about groundwater in the Quinte Region was taken from existing reports including the Quinte Regional Groundwater study (Dillon 2004) and the Preliminary Hydrogeologic Investigation of Prince Edward County (WESA 1985). Additional information on groundwater levels in the region is currently being collected and analyzed from a network of 31 monitoring wells. These wells are a part of the Provincial Groundwater Monitoring Network and are installed into the various aquifers throughout for the monitoring of both groundwater levels and quality. There have also been four monitoring wells established on the Mohawk Tyendinaga Territory.

The summary below is a brief overview of local hydrogeologic conditions and the reader is directed to water budget reports for additional information (Quinte Conservation 2006).

Aquifer Properties

Aquifers are water bearing units whose permeability and thickness result in them providing an economically significant amount of water consistently over time. Given the prevalence of bedrock and minimal soil cover in the Quinte Region, the main aquifers are found in bedrock. A review of records for wells drilled in the Quinte Region indicates that approximately 95% obtain water supply from fractured bedrock aquifers. The remaining 5% tap into overburden aquifers which are of limited area. A summary of the various geologic units and corresponding aquifer is provided in Table 2.8, together with relative yield and water quality. Overall the bedrock aquifers provide poor to moderate quantities of water with water quality ranging from hard to fresh and in some cases mineral when wells are drilled too deep. The limited overburden aquifers are associated with deposits of sand and gravel in the form of eskers and kames. These aquifers often present the best conditions for the best yield and quantity.

In the region there are records for approximately 22,000 wells for which locations are as illustrated by Map 10. As can be seen from this map, the wells correspond with the populated areas of the watershed primarily to the south of Highway # 7. Ninety-five percent of these wells obtain water from bedrock aquifers, including the Precambrian bedrock in the north and the limestone bedrock in the south. In bedrock aquifers groundwater flows through horizontal and vertical fractures in the bedrock which are quite often connected to either at or near ground surface. The quantity of water produced by a well depends on how many water bearing fractures are intercepted, the lateral extent of these fractures, and how well they are connected to other water bearing fractures. The density and frequency of these fractures decreases with depth in the bedrock. Given this variability the upper portions of the bedrock are typically classified as unconfined and the deep as confined to semi confined.

Table 2.8. Properties of Aquifers in Quinte Region

Material/ Formation	Lithology	Water Quality†	Yield‡
Upper Lindsay	Limestone/shale	Hard, sometimes sulphury	Poor
Lindsay	Limestone	Hard, sometimes sulphury	Poor
Verulam	Limestone/shale	Hard, often sulphury	Poor to Moderate
Bobcaygeon	Limestone	Hard	Poor to Moderate
Gull River	Dolostone/shale/ Sandstone	Hard	Poor to Moderate
Shadow Lake	Sandstone/siltstone	Fresh, sometimes mineral	Very Good
Precambrian	Igneous/metamorphic	Fresh, sometimes mineral	Moderate
Nearshore & Beach	Sand and silt	Fresh, mineral	Very Good
Eskers/Kames	Sand and gravel	Fresh, mineral	Very Good
Clay	Silt and clay	Sulphury	Poor
Till	Sand, silt, gravel	Fresh, mineral	Moderate

† Hard denotes water rich in calcium that leaves a residue on pipes and fixtures.

‡ This ranking is qualitative and is based on the amount of water that is normally needed to supply an individual household. A poor well seldom meets this requirement, while a moderate well just barely meets this requirement. A good or very good well usually or always meets this requirement.

The Precambrian aquifers include igneous and metamorphic rocks that supply wells in the Canadian Shield portion of the Quinte Region. For domestic needs, a 30 m well depth is typically adequate to intercept a water bearing fracture. The yield of wells in this area is typically low but sufficient for satisfying most residential and small agricultural needs. Exceptions are the wells supplying the Villages of Deloro, Madoc, and Tweed, where high yields were encountered because these wells are deeper than normal and are located in areas of complex geology that involved folding and faulting, increasing the number of fractures available for groundwater flow. Within the

Precambrian bedrock, water from granitic rock aquifers is often of higher quality than that from the metamorphic rock aquifers which often have higher total dissolved solids.

In the Limestone Terrain and the Prince Edward region, the bulk of the wells intercept the various limestone formations as listed in Table 2.8. Water is encountered at a range of depths, but most commonly in the upper 10 to 15 m of the limestone bedrock. The yield of wells in these formations is typically low, but adequate to meet domestic needs. The variability in the frequency and orientation of fractures in the limestone results in a tremendous range with some wells completely dry and others at high volume. Dry holes occur when wells are installed in areas of low fracture density or do not intercept a water-bearing fracture. Water quality from these limestone aquifers is average with a high level of hardness and some areas of natural water quality problems such as sulphur, salt and gas. Quite often, these problems are encountered in very deep wells or in groundwater discharge areas where groundwater is naturally approaching the surface after a long travel time through the rock has resulted in dissolving of minerals.

Overburden aquifers are not extensive in the Quinte Region, but are present where sufficient depth of sand and gravel deposits exists such as those features as listed in Table 2.2 and as located by Map 4 and Map 5. These aquifers are not continuous and restricted to the area of the formations where wells intercept groundwater that is located in the spaces between the sand and gravel particles.

Groundwater Flow

The groundwater level, or water table, in the Quinte Region generally reflects the surface topography, with regional flow in a southerly direction following topography. An illustration of the water table elevation surface and contours is provided by Map 11 showing flow in the Moira and Napanee regions to be generally in a southern direction. The exception is the Prince Edward Region where groundwater flows from high inland plateaus outward towards the surrounding water bodies (Bay of Quinte and Lake Ontario) again following the regional topography.

Recharge to the local aquifers is from the direct infiltration of precipitation. As the soil and sediments throughout the Region are generally thin, recharge into the underlying fractured bedrock can occur quickly during rainfall and snow melt events. Given such recharge conditions the supply aquifers are considered susceptible to contamination from the surface, including fertilizers, pesticides and insecticides, septic systems, and waste disposal. Groundwater recharge occurs throughout the Quinte region, however locally significant recharge areas coincide with topographic highs, including areas with thick glacial deposits, headwaters of streams in the Canadian Shield, and the high plateaus of the Prince Edward Region. Discharge areas occur in topographic lows, at surface water boundaries and where there is an abrupt change in elevation (e.g. through bedrock escarpments and/or road cuts through bedrock). Timing of recharge usually coincides with periods of high surface water runoff in the spring and fall. Low periods are during the summer months and in winter under frozen ground conditions. This trend is exemplified by the hydrograph of a groundwater monitoring well in the Quinte Region as provided by Figure 2.3. As the main aquifers are in fractured bedrock there is minimal storage of groundwater in the Quinte Area. Under these conditions the yield of wells can diminish under prolonged periods of dry weather or frozen ground. In some areas the residents are required to use cisterns and import water during these events.

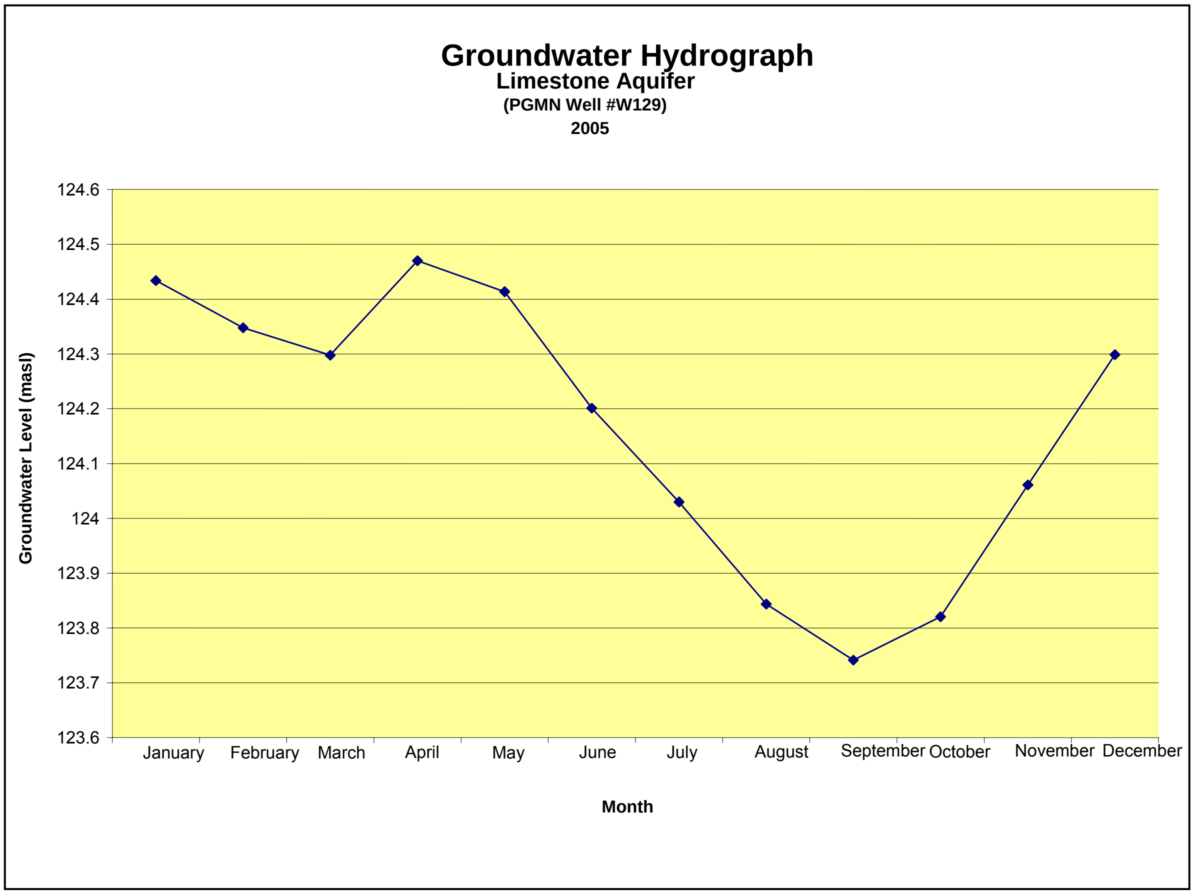


Figure 2.3. The hydrograph of a groundwater monitoring well in the Quinte Region.

2.3.3 Surface – Groundwater Interactions

Although surface water and groundwater are inventoried and sampled separately for water quality and quantity analyses, they are actually part of the same system. Groundwater provides base flow to the many watercourses throughout the region and, during high flow events, surface water replenishes groundwater supplies. A review of both groundwater and surface hydrographs for monitoring stations in the Quinte Region has revealed strong interaction between surface water and groundwater. More information is available in the Water Budget (Quinte Conservation 2006). Streams in the Quinte Region have been observed to be predominantly warm water in nature and some smaller watercourses dry up completely in an average summer; both of these characteristics suggest rapid travel of rain to streams along surface and near-surface routes and reveal the impact of warming during surface storage in lakes and streams. Some Moira River tributaries, however, have reaches with cooler water temperatures, suggesting that those streams are mainly fed by groundwater. In contrast, Karst topography, where limestone rock has dissolved to create large fractures and caves, may divert surface flows into groundwater. This is suspected in portions of the Moira and Salmon systems. No confirmatory work has been carried out to investigate this and more information is needed to understand the surface water – groundwater interactions of the Quinte Region streams.

The Base flow in the Great Lakes Basin project (USGS Scientific Investigations Report 2005) completed hydrograph separation for various gauged watersheds draining into the Great Lakes in order to develop base flow indices for non-gauged areas like those in the Quinte Region. Base flow indices were derived for the Moira, Napanee, and Salmon River watersheds as well as the streams draining the Prince Edward Region. The initial work corroborates the base flow index developed by the BFLOW method; it is estimated that 40 to 44% of the flow in these watercourses is provided by groundwater.

To confirm conditions within the watershed, Quinte Conservation is in the process of implementing a program to measure base flow in tributaries throughout the summer months through a combination of stream gauging and temperature measurements. This work will be completed in accordance with the Ontario Stream Assessment Protocol in an attempt to identify cold water streams and areas of groundwater discharge. In combination with the this work, Quinte Conservation is adding to groundwater recharge/discharge information using well data in order to build on mapping from the Municipal Groundwater Study (Map 12).

2.3.4 Climate

A key component of any Watershed Characterization Study and Water Budget is the water entering the watershed and that being "lost" to plants and evaporation. An understanding of climate is therefore absolutely essential. For example, during the summer, plant water use (shown in red in Figure 2.4) exceeds incoming rainfall (shown in blue in Figure 2.4) – because plants are using all incoming precipitation plus any moisture stored in the soil, there is no water left over to recharge groundwater and surface water supplies.

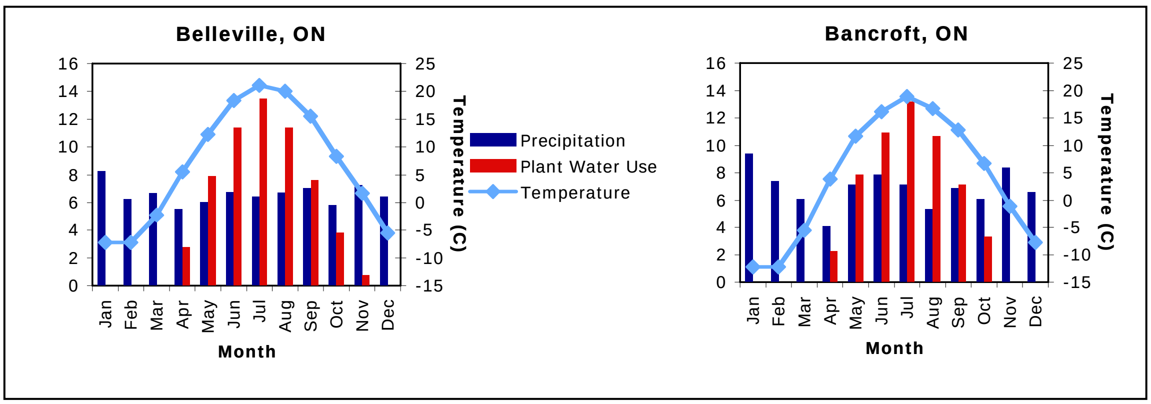


Figure 2.4. Average monthly values for temperature, precipitation, and plant water use at one Limestone Terrain (Belleville) and one Canadian Shield (Bancroft) location in the Quinte Region. Note that from May until September, plant water usage (red) exceeds incoming rainfall (blue). However, from October until April, plant use is negligible, allowing recharge of surface water and groundwater supplies. Mean annual values: Belleville - 6.7˚C with 79.2 cm of precipitation and Bancroft - 4.0˚C with 32.4 cm of precipitation. Precipitation and Plant Water Use both measured in cm of liquid water. (Gillespie et al. 1962)

The Quinte Region is currently monitored for rain and snow amounts (Map 13 and Appendix 3). There are currently six electronic rain gauges that are operated by Quinte Conservation and more are being added throughout all watersheds. Some of these gauges have been in operation for 20 years. In addition, Quinte Conservation conducts snow course sampling every two weeks throughout the winter. The snow depth and weight are measured so that the water equivalent of the snow can be determined. There are 15 stations that are sampled throughout the region. This snow course data has been collected for over 20 years. Environment Canada also has several stations throughout the watershed that collect both rain and temperature data. Finally, Quinte Conservation has a Watershed Watch Program that uses volunteers to collect rain data. There are currently 43 volunteers spread out over the entire region collecting rain data. This is a relatively new program so the number of years of data ranges from less than one year to four years.

2.3.5 Climatic and Meteorological Trends

The prediction of climatic and meteorological trends would be valuable knowledge particularly when attempting to plan for water supply issues within a watershed. However through the Water Budget exercise and the associated peer review of that work, it was determined that it would not be productive, at this point in time, to try and develop or rely on a predictive model of climatic and meteorological trends. The rationale was that with both short term and long term trends existing that it would be impossible to predict with any degree of certainty what the impact of global climate change would have on the local condition.

The Water Budget (Quinte Conservation 2006) and Tier 1 Water Budget Reports address climatic and meteorological issues and provide details based on the best available science.

References

Dillon (2004). Quinte Regional Groundwater Study, Prepared by Dillon Consutling Ltd. for Quinte Conservation**:** 194 + Appendices.

Gillespie, J. E., R.E. Wicklund, N. R. Richards (1962). Soil Survey of Hastings County. Guelph, Ontario Canada, Research Branch, Canada Department of Agriculture and the Ontario Agricultural College 72 + Maps.

Neff, B. P., S. M. Day, A. R. Piggott, L. M. Fuller (2005). Base Flow in the Great Lakes Basin. Scientific Investigations Report. Reston, Virginia USA, U.S. Geological Survey and U.S. Department of the Interior**:** 23.

Quinte Conservation (2006). Conceptual Water Budget: Quinte Region: Final Report. Belleville, Ontario Canada, Quinte Conservation**:** 68 + Appendices.

WESA (1985). Preliminary Hydrogeologic Investigation of Prince Edward County: Final Report, Water and Earth Science Associates Ltd.: 42 + Appendices.

2.4 Naturally Vegetated Areas

Naturally vegetated areas are critical to the protection of drinking water because these areas decrease the ability of precipitation to erode and denude the landscape while increasing the amount of precipitation that is filtered through the soil to groundwater and surface water. Over 400,000 ha of naturally vegetated areas, including wetlands and forests, are distributed throughout the Quinte Region (Table 2.9), but most are preserved in the Canadian Shield region where human development has been limited (see Maps 14 and 15). These areas should be protected, especially those in the southern portion of the Quinte Region that have more development pressures.

Table 2.9. Summary of forested and wetland features.†

Watershed	**MRW‡**		**SRW‡**		**NRW ‡**		**PERW†‡**		**Total**	
	ha	**%**	**ha**	**%**	**ha**	**%**	**ha**	**%**	**ha**	**%**
Total Area (ha)	284,804		91,801		104,157		108,147		588,909	
Woodlands	189,611	66.6	60,167	65.5	50,538	48.5	35,224	32.6	335,540	57.0
Waterbodies	15,311	5.4	5,149	5.6	6,321	6.1	2,989	2.8	29,770	5.1
Permanent Wetlands	24,619	8.6	9,942	10.8	9,335	9.0	7,004	6.5	50,900	8.6
TOTAL	**229,541**	**80.6**	**75,258**	**82.0**	**66,194**	**63.6**	**45,216**	**41.8**	**416,209**	**70.7**
OMNR Wetlands§	8,411	3.0		0.0	12,478	12.0	8,796	8.1	29,685	5.0
Provincial Parks	2,780	1.0	3,280	3.6	1,023	1.0	10.5	N/A	7,083	1.2
ANSI Life Science¶	18,616	6.5		0.0	13,972	13.4	6,705	6.2	39,293	6.7
Rare Species Occurrences	220		252		170		N/A		642	

† Modified table from McNevin 2005; Prince Edward Region Watershed values include the entire peninsula, not just the portion that drains into the Bay of Quinte.
‡ MRW: Moira River Watershed, SRW: Salmon River Watershed, NRW: Napanee River Watershed, PERW: Prince Edward Region Watershed.
§ Evaluated by OMNR using the Ontario Wetland Evaluation System.
¶ Evaluated by OMNR as including significant representative ecological features.

The latest information describing the extent of woodland, wetland (including the Provincially Significant Wetland (PSW)), and waterbody features are from the Ontario

Geospatial Data Exchange (OGDE) distributed by Land Information Ontario (LIO), Government of Ontario. In addition, the Bay of Quinte Remedial Action Plan (BQRAP) committee gathered the spatial data on Provincial Parks and rare species occurrences (McNevin 2005).

The Life Science Areas of Natural and Scientific Interest (ANSI) and evaluated wetlands were queried from the Natural Heritage Information Centre webpage. ANSIs describe areas that have been identified by the Ontario Ministry of Natural Resources (MNR) as having provincially or regionally significant representative ecological features. Full lists of significant wetlands and ANSIs are provided in Appendix 4.

2.4.1 Wetlands

Historically, the loss and degradation of wetlands have been significant, particularly in southern Ontario where approximately half of wetlands have been destroyed. Wetland habitats are essential to the existence of wildlife for shelter, food, and reproduction. Many Great Lakes fish and wildlife species, including many species at risk, inhabit wetlands during part of their life cycles. Wetlands also perform essential water quantity and quality improvement functions, such as the attenuation of stream flows and water filtration (CWC 2004). The Canadian Wildlife Service of Environment Canada has developed guidelines for ecosystem categories of which wetland is but one. For the purpose of rehabilitating local watersheds and landscapes, the Canadian Wildlife Service recommends at least 10% wetland habitat with a ≥ 100 m buffer of vegetation adjacent to wetland areas.

Wetlands and wildlife habitat are not uniformly distributed in the Quinte Region (Table 2.10, Map 14 and Appendix 5). The greatest proportion of wetlands and wildlife habitat in the Quinte Region is preserved in the Canadian Shield. The Limestone Terrain includes fewer wetlands for two reasons: (1) the natural environment of limestone resulted in less wetland development because there are more direct paths to groundwater and thus less water stored at the surface; (2) there has been more development in this southern area, so fewer natural environments remain.

The proportion of wetlands in the Quinte Region does not satisfy the 10% guideline recommended by the Canadian Wildlife Service. The Salmon River Watershed is the only watershed with a proportion of wetlands greater than 10%, but it only exceeds the guideline by 1%. Consequently, preservation and restoration of wetlands is recommended for the watersheds in the Quinte Region.

Table 2.10. Large Wetlands & ANSI-Life Science Wildlife Habitats in the Quinte Region (NHIC 2005).

	Wetland	**ANSI-LS Wildlife Habitat**
Canadian Shield	Kennebec Complex-Wetland (SRW†)	Elzevir Peatlands and Barrens (MRW†)
	Killaloe Swamp (MRW†)	Kennebec Complex Wetland (SRW†)
	Spring Lake Wetland Complex (NRW†)	Spring Lake Wetland Complex (NRW)
Limestone Terrain	Cameron Swamp (NRW†)	Cameron Creek Swamp (NRW†)
	Foxboro Swamp (MRW†)	Mud Lake Wetland (SRW†)
	Mud Lake Wetland (SRW†)	Dry Lake – Lime Lake Fens, Marlbank Esker (MRW†)
Prince Edward Region	Sawguin Creek Marsh	Big Swamp
	Big Swamp/Little Swamp Complex	Huffs Island Coastal Wetland
	Big Island Marsh	Bloomfield Creek Wetland

† MRW: Moira River Watershed, NRW: Napanee River Watershed, SRW: Salmon River Watershed.

2.4.2 Woodlands and Vegetated Riparian Areas

Woodlands and riparian zones (buffer strips of woodland next to stream channels) are important land cover features that help maintain healthy ecosystems. Woodlands have the capability of intercepting rainfall, increasing infiltration to the soil and groundwater, reducing the volume and speed of runoff, and filtering nutrients out of runoff, thereby preventing erosion and regulating evapotranspiration. Riparian zones control bank erosion due to runoff, therefore reducing sedimentation of surface waters and reducing the concentration of nutrients, pesticides and pathogens that enter surface waters and groundwater.

The Canadian Wildlife Service has defined guidelines (Table 2.11) for forested woodlands and riparian areas in order to maintain the minimal conditions that would allow these features to function effectively at controlling erosion and sedimentation, as well as nutrient, pesticide, and pathogen concentrations. Quinte Conservation used data layers provided by MNR (Map 15) to evaluate the percentage of the Quinte Region that fulfills the complete guideline (i.e. meets all criteria), however the current woodland data layer has made it difficult to identify individual patches of woodland.

By the 1950s, little virgin forest remained in the Quinte Region and most had been replaced by young growth or second growth of poplar stands, with patches of maple in the northwest (Table 2.12, Richardson 1950, 1957). The major causes of vegetation change included forest fires and logging, resulting in the dominant white and red pine species giving way to other species throughout the northern areas. Most preserved woodland and riparian habitat is located in the headwaters of the regional streams, within the Canadian Shield, where the percentage of forest cover far exceeds the Canadian Wildlife Services minimum recommendation.

Table 2.11. Forested woodlands and riparian requirements and coverage.

Feature	Description of Requirement	CWS Guideline†	Quinte Region Area‡ %
Riparian	Proportion of stream length naturally vegetated	> 75%	69%
	Natural vegetation adjacent to streams	> 30 m	
Forest	Proportion of forest cover	> 30%	Not yet available
	Circular or square forest patch	> 200 ha	
	Width of largest forest patch	> 500 m	
	Interior area that is > 100 m from edge of patch	> 10%	
	Area that is > 200 m from edge of patch	> 5%	
	Proximity to other forest patches	< 2 km	

† Canadian Wildlife Service (CWS 2004)
‡ Ontario Ministry of Natural Resources (MNR 2006)

Table 2.12. Historically observed tree species in the Moira, Napanee, and Salmon Watersheds.†

Ash - black	Birch - white	Hickory	Pine - red
Ash - white	Birch - yellow	Ironwood	Pine - white
Aspen	Cedar - red	Maple - silver	Poplar
Balsam	Elm	Maple - sugar	Maple - red
Basswood	Elm - white	Oak - burr	Spruce - black
Beech	Hemlock	Oak - red	Spruce - white
		Oak - white	Tamarack

† Richardson 1950, Richardson 1957

In the 1960s, commercial woodlands covered 18% (18,227 ha) of the Prince Edward Region; various other forests or semi-forested, non-commercial conditions covered an additional 12% (11,919 ha (Barnes 1968)).
The greatest proportions were located in Sophiasburgh Township (presently Ward 10) and Hallowell Township (Ward 6). Predominant species were silver maple and white elm; in addition to many of the species listed in Table 2.12, pin cherry, cottonwood, black oak, and black locust were also observed on the Prince Edward Region.

References

Barnes, A. S. L. (1968). Prince Edward Region Conservation Report: Land, Forest, Water, Wildlife. Toronto, Ontario Canada, Ontario Department of Energy and Resources Management, Conservation Authorities Branch**:** 161.

CWC (2004). How Much Habitat is Enough? A Framework for Guiding Habitat Rehabilitation in Greater Lakes Areas of Concern. 2nd Edition. . Ontario Canada, Canadian Wildlife Service of Environment Canada**:** 80.

McNevin, B. (2005). Backgrounder - Wildlife and Wildlife Habitat Restoration of the Bay of Quinte. Belleville, Ontario Canada, Bay of Quinte Remedial Action Plan**:** 65 + Appendices.

NHIC. (2005). "Natural Heritage Information Centre. Rare Species and Natural Spaces by Jurisdiction." Retrieved May 31, 2005, 2005, from http://nhic.mnr.gov.on.ca/MNR/nhic/species/species_jur.cfm.

2.5 Aquatic Ecology

Information on biological aquatic communities and habitat characteristics contribute to the comprehension of factors that affect water quality and to improved understanding of the relation among physical, chemical, and biological characteristics of streams.

2.5.1 Fisheries

Fish community composition and abundance are often used as indicators to water quality. Fish are excellent indicators because different species respond to pollution in different ways. As a biological indicator, fish will detect the presence of various forms of pollution that water chemistry analysis may miss. As a result, the quality of a stream is assessed based on the diversity and abundance of fish populations. In addition, the presence of sensitive fish species, i.e. trout, are a good indicator of water quality as they can be sensitive to changes in the aquatic environment, e.g. pollution and water temperatures.

Overall, there is a concern about the state of the fish populations in the region for many factors. In some cases the assessment of whether the decline in fish populations is associated to water quality or quantity can be difficult because they are just two factors next to the fact that most sport fish have been over harvested by commercial fisheries and recreational fishermen. Most of the information referred to on fish distribution and abundance for the Quinte Source Protection Region was concerning the Bay of Quinte. Generally, a link between fish and water quality and quantity in the long run was observed in reports and studies.

Bay of Quinte

Currently, there are very few written reports describing the conditions of fish populations in the Quinte Source Protection Region. Sensitive fish species can be considered those that are declining in abundance because of changes in the environment. In most cases, the reason for the decline in sport and commercial fish populations is over-fishing. Some populations decline to the point where they are considered at risk for becoming extinct and will become extinct if the causes of their decline are not minimized.

Potential pollutants vary between the different watersheds of the Quinte Region and are mainly a function of the presence of agriculture, industry, and mining. Land clearing and loss of wetlands along the shoreline of the Bay of Quinte have contributed to increased runoff to the Bay and loss of habitat. The changing nutrient status that has occurred overtime in the Bay has been linked with the combination of increased phosphorous concentrations from agriculture lands, detergents, industrial discharge, and domestic sewage and the biological invaders, e.g. Zebra Mussel. These circumstances contributed to the decline in valuable sport fish and commercial fish species between 1930 and 1978 (Ewaschuk 2005).

General trends in fishery use and health of the Bay of Quinte can be summarized from the historic account of dominant fish species that was described by the Remedial Action Plan committee (Ewaschuk 2005). Since aquatic species are indicative of ecosystem health, it is important to review both general populations and those specific to local fisheries.

Around the 1940s, eutrophication (increased algal growth caused by increased phosphorus and nitrogen concentrations in runoff to water bodies) caused water clarity and submergent plant abundance to decrease, resulting in fish community changes. There was a shift in commercial harvest to less-valued species of smaller size, eventually resulting in White Perch and Carp (both invasive) becoming the most abundantly harvested fish in the Bay in terms of biomass (Ewaschuk 2005). By 1980, phosphorus control had begun and the fish community began to change once again, eventually steadying to four dominant species by the 1990s (Table 2.13). Although the Walleye populations showed signed of recovery in the 1990's the state of the Walleye populations has not yet recovered enough to become commercially viable for the second time. Recent declines in Lake Whitefish and increasing numbers of Sunfish may be attributed to a Zebra Mussel invasion in 1995. Habitat conditions, especially phosphorus concentrations, greatly influence the abundance of specific fish species and the resulting harvest. Therefore habitat management plans should consider the value of specific species to the commercial fishing industry.

Table 2.13. Commercially important fish species observed in the Bay of Quinte (Michalski 1987).

Pre-1940s	Post-1940s	Post-1990s
Lake herring Lake whitefish Walleye Northern pike Yellow perch White perch Bullheads Catfish American eel Carp Sunfish	Yellow perch White perch Bullheads Catfish Sunfish American eel Carp (invasive)	Lake whitefish Brown bullhead Yellow perch Sunfish

The Bay of Quinte Remedial Action Plan (BQ RAP) committee has highlighted some observations regarding the Bay of Quinte sensitive fish species. Of the 76 fish species historically identified in the Bay of Quinte (Table 2.14, Appendix 6), several species are currently identified as *species at risk* or were not observed in the 1986 survey (Table 2.14) (Ewaschuk 2005; MNR 2007).

Table 2.14. Sensitive Fish Species in the Bay of Quinte.

At Risk as of 2006 (Ewaschuk 2005) (MNR 2007)	**Not Observed in Bay of Quinte in 1996 (Hurley, 1986 cited in Ewaschuk, 2005)**	**Extinct in Lake Ontario (Crossman 1979)**
Lake Ontario • Atlantic Salmon (*Salmo salar*) • Shortnose Cisco (*Coregonus reighardi*) • Deepwater Sculpin (*Myoxocephalus thompsonii*) • Bigmouth Buffalo (*Ictiobus cyprinellus*) • Kiyi (*Coregonus kiyi*) • American Eel (*Anguilla rostrata)* • Lake Sturgeon (*Acipenser fulvescens*) Bay of Quinte • Spotted Gar (*Lepisosteus oculatus*) • Bridle Shiner (*Notropis bifrenatus*) • Channel Darter (*Moxostoma carinatum*) • River Redhorse (*Moxostoma carinatum*)† Moira and Salmon Rivers • Channel Darter (*Percina copelandi*) Napanee River • Bridle Shiner (*Notropis bifrenatus)*	• Tadpole Madtom *(Noturus gyrinus)* • Bridle Shiner *(Notropis bifrenatus)* • Central Mudminnow (*Umbria limi*) • Sauger (*Stizostedion canadense*) • Slimy Sculpin (*Cottus cognatus*) • Ninespine Stickleback (*Pungitius pungitius*) • Round Whitefish (*Prosopium cylindraceum*)	• Blue Pike (*Stizostedion vitreum glaucum*) • Atlantic Salmon (*Salmo salar*)

† Presently not listed in the Bay of Quinte under the species at risk website, but was sampled around Trenton by DFO electro-fishing sampling in 1999.

Recent Fish Populations in the Bay of Quinte

The Lake Ontario Management Unit of the Ontario Ministry of Natural Resources (MNR) is responsible for monitoring and managing fish and fisheries the state of recreation fisheries. Fish harvest records based on the local commercial fishing industry reflect the ecosystem changes that have occurred in the Bay in recent years.

There are three MNR zones that are within the Bay of Quinte (and a portion of Lake Ontario) defined as fishing quota zones that they use to manage fish populations. These zones and data were used to report dominant sport fish populations (Figure 2.5). Most of the Quinte Source Protection Region's streams drain into the Bay of Quinte in the Big Bay area (MNR's quota zone 1-3). Streams on the Prince Edward Region drain into Big Bay to the north, the Conway area (quota zone 1-4) to the north-east, and Lake Ontario (quota zone 1-2) to the south and south-east. All of the referenced fish species are considered native to this part of Ontario and a viable resource to the commercial fishing industry.

After reviewing the data describing the top three sport fish species (Brown Bullhead, Yellow Perch, and Lake Whitefish) caught by commercial fisherman, it is clear that the dominant fish species were different in each of the three zones between 1998 and 2006 and were of the more tolerant species (Figure 2.6). The Brown Bullhead was consistently the most dominant species caught in the Big Bay zone of the Bay of Quinte however it is not as frequently caught in Conway and Lake Ontario zones. Brown Bullhead is a member of the Catfish family and is considered to be very tolerant to conditions of temperature, oxygen, and pollution which may explain why its population is doing well. Yellow Perch was by far the most dominant species caught in the Conway zone and also one of the top three species in the other two zones. Both zones in the Bay of Quinte showed the decline of the Lake Whitefish being caught. It was no longer one of the top three species in the Big Bay zone after 2002 and in Conway after 2003, but it remained a dominant catch in the Lake Ontario zone (quota zone 1-2). There was discussion by the MNR recommending that Walleye be temporarily banned from the commercial and sport fish industry from 2001 and reviewed in three years to give the population a chance to recover its numbers. It is unclear how long the ban had occurred, however the absence of the Walleye being one of the top three caught fish can be seen in Figure 2.6 in Lake Ontario and Conway. It was never one of the top three species caught in Big Bay from 1998 to 2006. Overall, compared to the Bay of Quinte fish populations, the top three species caught in the commercial fish industry were more stable in Lake Ontario, where shifts in dominant species were not as evident. As for the other popular sport fish species, some like the American Eel have given reasons for concern as their populations have declined severely in the last decade. For example, in 2004 the province banned the commercial American Eel fishing in Lake Ontario and the St. Lawrence River, and ended the sport fishing of eel in all of Ontario.

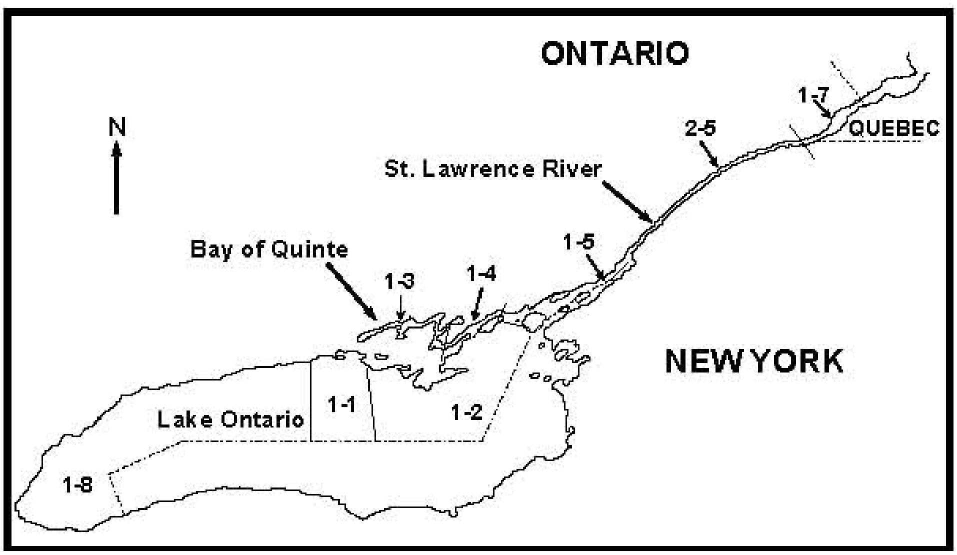


Figure 2.5. Map of Lake Ontario and St. Lawrence River showing commercial fishing quota zones in Canadian Waters (MNR 2001).

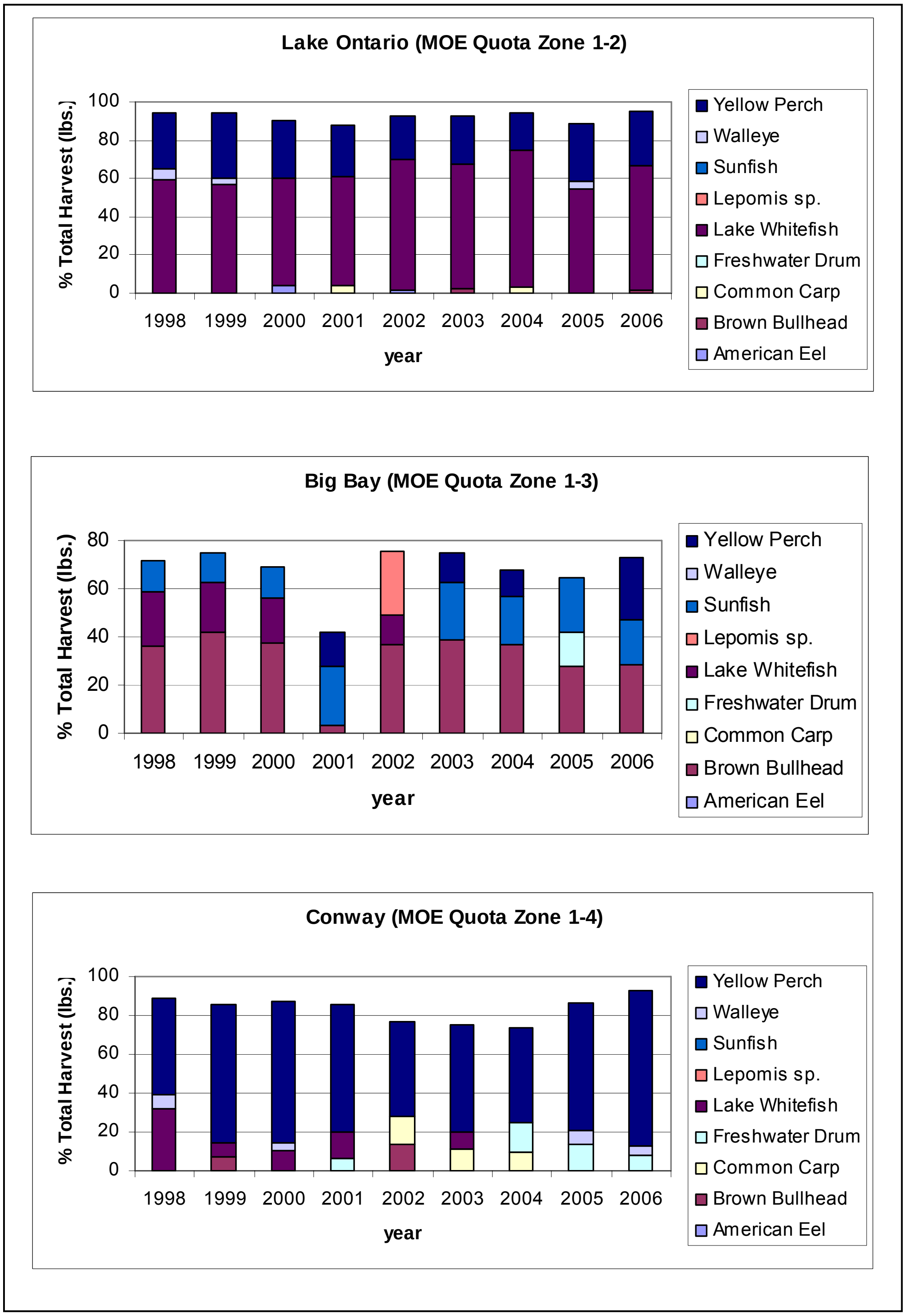


Figure 2.6. Top three fish species caught in the Bay of Quinte, Conway Area, and Lake Ontario by the commercial fishing industry between 1998 and 2006. Modifed from Lake Ontario Fish Communities and Fisheries: Annual Reports of the Lake Ontario Management Unit (MNR 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007).

There are many reasons why fish populations, such as the Lake Whitefish, Walleye, and those species listed as at Risk in column one of Table 2.14, have declined in the Bay of Quinte and Lake Ontario. The most obvious is the over harvesting by the commercial fishing industry, but there are others. Invasive species, such as the Zebra Mussel and Black Crappie, have changed the population dynamics (MNR). The mussels have cleared up the waters and allow the increased growth of aquatic plants thus changing the fish habitat. Species like the Walleye prefer darker, cloudier waters and with the clearing of the water they must move to find darker climates. The Eurasian Watermilfoil, an invasive plant, is an aggressive plant that forms very dense mats and can deplete the oxygen concentrations that the fish need as the plant regenerates by decaying; Black Crappie competes with the native fish for food and feed on the young native fish; the flood control structures that have been installed up rivers have reduced the ability for fish to reach their spawning grounds; loss of shoreline fish habitat has been a result of development along the waters edge; increased acid rain, contamination, and nutrient loading have impaired the water quality. Improvements, such as fish ladders; fish stocking programs, more efficient sewage treatment plants that meet Province's new strict effluent quality limits and the better protection of wetlands to name a few have improved the situation for these fish.

Fish Habitat Management Plan for the Bay of Quinte

In 1985, the Bay of Quinte was identified as one of several Great Lake Areas of Concern (AOC) because of excessive nutrient enrichment, nuisance algae growth, low oxygen concentrations at the bottom of Lake Ontario, and localized bacterial concerns. The Areas of Concern were identified by the US-Canada Great Lakes Water Quality Agreement (GLWQA) as hot spots in the Great Lakes Basin that were considered severely impaired based on criteria called impaired beneficial uses (IBU). The Bay of Quinte AOC had 10 IBUs identified where the Degradation of Fish Populations (IBU 3.1) and the Loss of Fish Habitat (IBU 14.1) were but two IBUs (Johanson 2007). Impacts to fish populations and fish habitat for the Bay of Quinte were defined as loss and degradation of coastal wetlands, barriers to fish migration areas, degradation of nearshore habitat, loss of natural shorelines and the impact of aquatic invasive species (Johanson 2007).

Water quality conditions of the lake have been compromised by the loss and degradation of wetlands. Wetlands not only provide valuable feeding, spawning, nursery and rearing habitat for fish, but they also slow the flow of runoff into the lake and help filter out nutrient and other contaminants before entering into the water. The reduction of wetland along the shoreline of the lake has reduced the buffering capacity of the environment to protect the lake and its inhabitants. Restoring coastal wetlands and vegetation along the shorelines will help improve the water quality conditions. Given that there is a link between protecting fish habitat areas and water quality, the regulations, legislation, and other provisions which are in place to protect fish habitat will also support the restoration and protection of water quality (Table 2.15).

Table 2.15. Summary of agencies, their effort and action relating to the protection of fish and fish habitat (modified from Johanson and McNevin, 2007).

Agency	Effort	Action
Department of Fisheries and Oceans Canada (DFO)	Fisheries Act	Conservation and protection of fish and fish habitat supporting Canadian fisheries. Provisions of the act include orders to restore impacted fish habitat.
	Great Lakes Laboratory for Fisheries and Aquatic Sciences	Tools and information to help make decisions when dealing with land owners, stakeholder, resource users.
Environment Canada (EC)	Fisheries Act (Section 36 (3)	Enforcement against the release of deleterious substances
	Species at Risk Act	The development of recovery strategies for species at risk
Parks Canada	Historic Canals Regulations and	Protecting ecological integrity will take precedence in acquiring,

Agency	Effort	Action
	National Parks Act	managing, and administering heritage places and programs. Gives Park Wardens the authority to enforce the Fisheries Act.
Ontario Ministry of Natural Resources (MNR)	Lakes and River Improvement Act, Public Lands Act, Crown Forest Sustainabilty Act, Aggregate Resources Act	Screening and referring work permit applications, and issues time restrictions for in-water work and provides fishery information to CAs and DFO. This includes administering work permits for removing aquatic plants by physical or mechanical means. Gives Fishery Officers the authority to enforce the legislation relating to fish habitat provisions. Review and finalize fishing quotas for the Great Lake zones.
	2005 Provincial Policy	Fish habitat is identified as a Natural Heritage Feature and development and site alteration shall not be permitted in fish habitat (including in significant coast wetlands) except in accordance with provincial and federal requirements.
	Provincial Planning Policy	Ensures that natural resource values (including fish habitat) are protected.
Ontario Ministry of the Environment (MOE)	Ontario Water Resources Act	Prohibits discharges that may impair the quality of any waters
	Environmental Protection Act	Prohibits discharges of anything that causes or is likely to cause an adverse effect on the environment.
	Nutrient Management Act	Management of nutrients applied to agricultural lands.
	Fisheries Act	Utilized the pollution prevention

Agency	Effort	Action
		measures of the act to assist in the protection of the environment.
	Pesticides Act	Manages the aquatic herbicide use in Ontario.
Department of National Defense	Owner of in the Bay of Quinte watershed	Completed an Environmental Assessment that recommended improving fish and wildlife habitat.
Local Municipalities	Planning Act, Provincial Policy Statement, Official Plans	Guiding development within their area away from sensitive areas.
Mohawks of the Bay of Quinte (MBQ)	Bay of Quinte Remedial Action Plan	Plays an important role in protecting fish habitat as the Tyendinaga Mohawk Territory is located along the Bay of Quinte shores.
Conservation Authorities (CA)	Conservation Authority Act	Undertakes programs to further conservation, development, restoration, development, and management of natural resources on a watershed basis. Prohibit or give permission to interfere with an existing channel, wetland, or watercourse. Prohibit or give permission to undertake development in area where the control of flooding, erosion, dynamic beaches, pollution, or the conservation of lands may be affected.
	Fisheries Act	First point of contact in fish habitat referral process.
	Official Plans	Assist local municipalities in their Official Plan review to ensure that fish and fish habitat are protected.
Stakeholders and Conservation	Businesses in recreation,	Generates income for the local community and makes the Bay of

Agency	Effort	Action
Groups	commercial and bait fisheries, tourism-based activities, related service industries	Quinte an attractive area to live and visit.
	Shorefront private landowners	Preserve and restore shoreline habitat.

Sensitive Fish Species in Inland Waters

Historically, Richardson (1950) reported in the Moira Valley Conservation Report that temperature, and abundance of sheltering logs, pools, and vegetation appeared to be satisfactory for most fish species of concern in the Moira River Watershed. Results from a 1948 survey revealed that there were a considerable amount of streams that were suitable for Speckled Trout, a fish that requires permanent cold-water streams (Richardson 1950). Despite this the fish species was only caught in three streams during the survey, the Coulter's Hill Stream, the tributary immediately west of Plainfield, and the stream which formerly fed O'Hara's Mill in Madoc Township (Richardson 1950).

Besides Speckled Trout, Lake Trout was also collected in the 1940's survey in the Moira River Watershed. Out of all the lakes surveyed, Lake Trout was found in the two-deep water lakes, the Skootamatta (Loon) Lake and Joe Perry Lake of the Moira River Watershed (Richardson 1950). Lake Trout prefer deep water lakes because they tend to inhabit the deep cool waters. Richardson (1950) noted that very few Lake Trout (10) were caught in Skootamatta Lake in 1948 during their survey, while the lake was abundant with these fish ten to twelve years prior. Joe Perry Lake still had abundant Lake Trout in the 1948 survey. The big reason for the decline of this species in Skootamatta Lake was the over fishing of the Lake Trout as well as many other sport fish while in comparison Joe Perry Lake was extremely difficult to access by land and most fisherman used float planes to get to the lake.

There were no Speckled Trout or Lake Trout observed in the 1950 and 1956 lakes survey in the Napanee River watershed. Thirty-three fish species were observed in the streams in these fish surveys of the Napanee River watershed and Brown and Brook Trout were the only trout species. Out of the eight largest lakes that were included in the survey, Howes Lake was the only one with trout, the Brown Trout (Richardson 1957). Barnes (1967) reported that there were 27 fish species identified in streams of the Salmon River watershed, but there was no discussion about the distribution of trout or of any other fish other than those referred to as bait fish (e.g. Golden Shiner, Pearl Dace, the Common Shiner, Creek Chub, and the Fathead Minnow). Very little was found about historic accounts of fish distribution and trout collection on the Prince Edward Region. Of the waterbodies surveyed in the 1968 conservation report, Waring Creek was the only stream. There were no trout found in Waring Creek at the time of the survey, but the insects and other species of fish found indicated that it was a potential trout stream (Barnes 1968). In addition, there was a trout hatchery on the creek.

Location of sensitive fish species in groundwater discharge areas

Often sections of streams that are permanent headwaters are fed by groundwater and considered to be cold-water streams (<19°C). Certain fish species require these cold temperatures to thrive hence these fish species (i.e. trout) are good indicators of groundwater discharge streams. However, studies that locate fish species in groundwater discharge areas and headwaters are currently a data gap for the Quinte Region. Fish distribution data that are currently available are limited to historic stream and lake surveys for the Moira (Richardson 1950), Napanee (Richardson 1957), and Salmon (Barnes 1967) watersheds. The best current accounts of fish species observed inland is the database associated with the Ontario Stream Assessment Protocol managed by the Lake Ontario Fish Management Unit of the Ministry of Natural Resources. Unfortunately, as of 2006, there were no data for fish in the Quinte Source Protection Region for inland waters.

Fisheries related temperature studies

It is important to identify streams that are cold-water because it is assumed that they are fed by groundwater and can support sensitive fish species like trout. The cold-water streams should be protected as a source of groundwater and as important fish habitat. Richardson (1950) created a map of the Moira River Watershed that identified stream temperature conditions by classifying sections of streams as warm, cool and cold-water (Table 2.16, Appendix 7). There were 28 stream sections that can be counted as cold-water streams in the Moira River Watershed in 1948. For the Napanee Region Watershed Richardson (1957) described the Napanee region as having only one stream out of the several surveyed as having ideal conditions for Brook Trout (Richardson 1957). This cold stream section was the west branch of the headwaters of Cole Creek, north of Godfrey. There was no historic information about the locations of cold-water streams or stream temperature surveys found for the Salmon River watershed and Prince Edward Region with the exception that Barnes (1968) mentioned that Waring Creek on the Prince Edward Region had the potential of supporting trout.

In an attempt to identify where current cold-water streams were located in the Quinte Region, Quinte Conservation began measuring water temperature in different streams in the summers of 2006 and 2007. Stream temperatures were measured using temperature data loggers following the Ontario Stream Assessment Protocol (Stanfield 2005). The protocol states that water temperatures are incorporated into the assessment when taken between July 1 and September 10 in a well-mixed section of the stream between 4:00 PM and 4:30 PM on days when maximum air temperature exceeded 24.5 degrees Celsius during a heat wave (at least two days with maximum temperatures greater than 24.5 deg Celsius a-prior) with no rainfall that affected baseflow. Results of water temperature for 2006 and 2007 were used to classify streams as warm, cool, and cold-water. Some stations were only measured in one year and some where measured in both years. Stations with two years of water temperature data were averaged. Results show that temperature stations in Chrysal Creek (CHC05), Number Ten Creek (NTC02), Palliser Creek (PAC06), and Parks Creek (PKC10), Waring Creek (WAR2, WAR3, and WAR4) were considered cold-water

(Table 2.17, Map 16). None of the streams sampled in 2006 in the Napanee Region Watershed were found to be cold-water. Quinte Conservation plans to continue to sample summer water temperatures of streams in the Quinte region to identify more cold-water streams.

Table 2.16. Moira River Watershed cold-water sections of headwater streams from the 1948 survey by the Conservation Branch of the Ontario Department of Planning and Development. This list was translated from the 1948 map in the Moira Valley Conservation Report 1950. The stream names are in counter clockwise order starting in the Belleville area.

Stream Name
Palliser Creek
Chrysal Creek
Number Ten Creek
Noname Creek
Goose Creek
Tributary that flows in the Moira River west channel, downstream from Stoco Lake
Otter Creek
Sulphide Creek
Little Skootamatta River
Flinton Creek
Tributary that flows in the Skootamatta River, upstream from Elzevir Creek inlet.
Tributary 1 to the Black River
Tributary 2 to the Black River
Tributary 3 to the Black River
Queensborough Creek, a tributary to Black River
Cannif Creek headwater
Tributary to the Black River, upstream to Lingham Lake
Headwater of Moira River
Headwater of Jordan River
Tributary to Jordan River
Gawley Creek, tributary to Moira River north of the Village of Deloro
Tributary to the Moira River, upstream from the inlet from Gawley Creek
Tributary to Moira River that drains from Jarvis Lake (Jarvis Creek)
Tributary of Madoc Lake with an inlet located east of Madoc Village

Table 2.17. Streams and their average water temperatures used to classify temperature regimes based on preferred temperature of fish (<19°C cold, 19 to 25°C cool, >25°C warm-water) (Coker 2001).

			Water Temperature			
Station ID	Watercourse	Year	Minimum	Maximum	Median	Average
Moira River Watershed						
BSC01	Blessington Creek	2006	17	24.5	19.5	20.25
CHC05	Chrysal Creek	2006	16.5	20.5	18.5	**18.34**
GOC03	Goose Creek	2006	21	28.5	23.75	24.38
		2007	18.5	29	24.25	23.97
MOR01	Moira River	2006	17	24.00	20.75	20.70
		2007	18	24.00	21	21.05
MOR02	Moira River	2006	20.5	28.5	25	24.87
		2007	20	28	24.5	24.45
MOR03	Moira River	2006	17	25.5	22	21.53
		2007	18.5	26.5	23	22.85
MOR09	Moira River	2006	20	27.5	24.5	23.79
NTC02	Number Ten Creek	2006	16	22.5	18.5	**18.82**
		2007	14	21	17	**17.33**
PAC06	Palliser Creek	2006	11.5	14	13	**12.92**
PKC10	Parks Creek	2006	15	19.5	17	**17.38**
		2007	14.5	19	17	**17.05**
POC01	Potter Creek	2006	20	29	24.5	24.65
UNC03	Noname Creek	2006	18.5	25	20.75	21.00
		2007	16	25	22	21.35
Napanee Region Watershed						
CRC01	Crooked Creek	2006	13.5	32.5	24	23.61
DPC01	Depot Creek	2006	22	27.5	23.5	24.12
FIC02	Fisher Creek	2006	20	29.00	25.5	24.98
NPR07	Napanee River	2006	21	27	23.5	24.13
OTC01	Otter Creek	2006	20.5	31	24.25	25.09
PNC01	Pennels Creek	2006	19.5	28.5	23	23.41
Prince Edward Region Watershed						
BLC01	Bloomfield Creek	2006	18.5	22.5	20	20.07
HBC02	Hubbs Creek	2006	20.5	24	22	22.10
HLC02	Slab (Hillier) Creek	2006	17	25.5	24	22.83
WAR2	Waring Creek	2006	17	21	19.5	19.42
		2007	14.5	19	17.25	**17.13**
WAR3	Waring Creek	2006	17	19.5	18	**18.07**
WAR4	Waring Creek	2006	13.5	13.5	13.5	**13.50**
		2007	16	18	16.5	**16.79**

For the most part, the stream temperature classifications from the 1948 survey and 2006/2007 surveys were similar. All the Moira River Watershed streams that were found to be cold-water in the 2006 and 2007 survey by Quinte Conservation were classified as cold-water in the historic 1948 survey. The exceptions were Noname Creek, Goose Creek, and Otter Creek that were no longer observed to be cold-water streams. The limitation to these direct comparisons is that the exact location of the 1948 temperature stations and the protocol for classifying streams are unknown and could be different to the stations and the protocol of the more recent survey. Depending on where the 1948 stations were located, Noname Creek, Goose Creek, and Otter Creek may still be cold-water in sections that are located farther upstream to the 2006 and 2007 survey locations.

Most streams surveyed in the Moira River Watershed during the 1948 survey were warm-water (maximum water temperature over 24°C in summer) supporting warm-water fish species, e.g. Small-Mouth Bass. In comparison, most streams in the 2006 and 2007 survey were cool (>19 and >25°C) and only one was considered warm-water (>25°C) and that was Otter Creek (Table 2.17). Even taking into account the different temperature criteria used this observation still stands, and there were fewer cold-water streams in both surveys.

Water quality concerns and the state of Inland fisheries resources

Historically, pollution along the Moira River tributaries was not severe (Richardson 1950). Pollution control efforts made by industries at Deloro were evident, but those at Sulphide and Corbyville were insufficient as evidenced by the water quality (Richardson 1950). A concurrent study showed that grist mills, septic systems, and sawdust had rendered the Napanee River bottom sterile and reduced the bottom fauna (Richardson 1957). An even larger contributor was the effluent from the Strathcona paper-making mill which depleted oxygen levels in stream and river water and released phenol at levels that are harmful to fish species (Richardson 1957). There was no historic information that could be found linking water quality data and the fishery resources for the Salmon River watershed. However, in general terms Barnes (1967) did mention that logging and agriculture were the main land uses of the Salmon River watershed in the past. These activities could have acted as sources of pollution for these streams. In the Prince Edward Region in the 1960s, two cheese factories were releasing waste in streams and rivers that had high biochemical oxygen demand, causing an increase in aquatic plant and algae growth, thus depleting dissolved oxygen levels (Barnes 1968). Also during this time period, cattle were allowed to wade into streams and ponds, causing increased sedimentation and waste contamination. Agricultural land was also identified as a source of pollution because fertilizers washed into streams and lakes during heavy rain events, causing dense macrophyte and algae growth and the resultant depletion of dissolved oxygen. Herbicide and insecticide runoff was also a concern because they accumulate in fish lipids and are later ingested by humans in harmful amounts.

2.5.2 Aquatic Macroinvertebrates

Benthic macroinvertebrates (BMI) are aquatic invertebrate (organisms without spines) that live on the bottom of streams and lakes and are large enough to be seen with the naked eye. Since these organisms spend most, if not all, of their lives on the stream bottom, their community composition indicates the general health of the stream. They also have a smaller migration range compared to other biological indicators (like fish) allowing for better local representation of water quality conditions. Some types of BMI are sensitive to nutrient enrichment of phosphorous and nitrogen and their abundance are used as a base for assessing water quality in a stream. The benefit of using BMI over water chemistry is that water chemistry may not detect elevated concentrations at the time of the sampling while the benthic community will reflect the conditions well after the release of contamination from non-point sources of pollution. Nutrient enrichment is only one factor affecting the health of benthic communities. Although their communities will reflect the presence of more toxic substances than nutrients, they will also respond to changes in habitat characteristics, i.e. the presence of vegetated buffer strips, and substrate particle size.

The presence of naturally vegetated areas helps control the water temperature, decrease the amount of sediment that is eroded and delivered to the channel, and improve infiltration of precipitation to replenish groundwater table and feed streams. Substrate type will determine the type of benthos that colonize, e.g. predictors like some species of caddisfly prefer gravel and cobble while scuds thrive in finer substrate. There are benthic assessment methods where the presence of tolerant types of benthos is used to determine nutrient enrichment. Because there are usually multiple factors that influence benthic composition it is wise to review water chemistry and habitat characteristics to help determine whether nutrient enrichment or habitat characteristics play a role in poor benthic community composition. The purpose of this review is to identify those stations in streams that have compromised aquatic macroinvertebrate communities and to explain the existing results from water chemistry analysis and dominant substrate type.

Quinte Conservation participates in the provincial-wide monitoring program called the Ontario Benthos Biomonitoring Network (OBBN). The OBBN program is coordinated by MOE, and the sampling is performed by staff at the conservation authority following the OBBN protocol (Jones 2005). This program monitors rivers, lakes, and wetlands however Quinte Conservation currently samples only rivers and streams at locations that are wade-able for benthic macroinvertebrates and water chemistry. Due to staffing constraints, there are currently no intensions on expanding the sampling to lakes or wetlands.

The OBBN requires the establishment of reference sites that were relatively unimpaired from human activities. Sites considered to be a candidate reference site for this program were established in 2003 and sites that were perceived to be possibly impaired (test sites) were established in 2006 (Map 17). The assigning of reference sites will be assessed by the program coordinator at the Ontario Ministry of the Environment (MOE) based on provincial benthic conditions. Pre-assigned reference sites were chosen because they had the presence of vegetated areas along the banks that help control the temperature of the water, decrease the amount of sediment that is eroded and delivered to the channel, and improve infiltration of runoff. The presence of riparian vegetated areas do not guarantee protection from nutrient enrichment, however they do reduce the impact to stream BMI communities.

It is common that a BMI sampling station is sampled in spring and fall to incorporate the seasonal changes of land use stressors and of natural seasonal variations of benthic communities due to water temperatures and leaf development. Due to staff constraints at Quinte Conservation it was decided that each OBBN station be sampled once a year. The three watersheds are sampled once a year during alternate seasons: the Moira River in the fall and the Salmon, Napanee, and Prince Edward Region streams in the spring.

There are various methods available to assess the BMI community composition. Since the reference sites have yet to be confirmed, the MOE recommended Test-Site Analysis (TSA) cannot be used (Jones 2005). Until then the Hilsenhoff Biotic Index (HBI) will be calculated to describe the water quality conditions at the OBBN stations in the Quinte Region. HBI was selected because it is commonly used in biological assessments and simple to calculate. Hilsenhoff Biotic Index (HBI) is a weighted average for a set of organism groups that are assigned tolerant values based on how the general group reacts to nutrient enrichment (Stanfield 2005). An HBI is calculated for each sample date at each station. A sample with an HBI less than 6 is considered to be unimpaired, 6 to 7 is possibly impaired, and any values above 7 is considered to be impaired (Kilgour 1998). The benthic indices, water chemistry, and the dominant substrate type for these stations were reviewed in order to determine whether the high HBI was linked with poor substrate habitat or water chemistry conditions.

The HBI results confirm that most of the sites that were pre-assigned to be reference sites were in good condition with some exceptions (Table 2.18) (Appendix 8). Moira River Watershed sites for fall of 2007 have yet to be analyzed. A few of these sites were not sampled in fall of 2006 because of deep water and high velocities caused by rain events. For those stations that were not sampled in fall of 2007 there was no-to-low flow during very dry fall conditions.

Sites that had a HBI greater than 5.9 in previous years should be monitored closely in future as they could be nutrient enriched. In the MRW, Chrysal Creek, Palliser Creek, Parks Creek, and Potter Creek had high HBI. In NRW, Selby Creek had high HBI. In PERW, Demorestville Creek, Hillier Creek and Waring Creek high HBI (Table 2.18).

Table 2.18. HBI results for benthic macroinvertebrates at OBBN stations in the Quinte Region.

Site ID	Waterbody Name	Season	n	2003	2004	2005	2006	2007
Moira River Watershed								
CHC01	Chrysal Creek	fall	3	6.6	6.3	5.9		
CHC05	Chrysal Creek	fall	4	4.2	4.2	1.9	2.8	
CLR05	Clare River	fall	2		5.6	5.6		
GOC03	Goose Creek	fall	4	5.4	5.3	5.2	5.2	
MOR09	Moira River	fall	2		4.6	5.4		
NTC01	Number Ten Creek	fall	2		6.1	5.9		
NTC02	Number Ten Creek	fall	4	5.3	5.5	5.5	4.7	
PAC01	Palliser Creek	fall	3	6.6	5.1	6.6		
PAC06	Palliser Creek	fall	4	5.9	6.3	6.7	6.3	
PKC01	Parks Creek	fall	3	4.2	4.2	4.6		
PKC07	Parks Creek	fall	2		6.7	5.7		
PKC10	Parks Creek	fall	4	4.4	4.8	4.6	4.7	
POC01	Potter Creek	spring	1		4.5			
POC01	Potter Creek	fall	3		6.6	5.6	4.7	
POC02	Potter Creek	fall	4	6.7	5.1	5.2	5.0	
UNC03	Unknown Creek 2	fall	4	5.2	5.0	5.4	5.4	
Napanee Region Watershed								
CRC01	Crooked Creek	spring	2				5.0	5.1
CRC01	Crooked Creek	fall	2			4.7	4.9	
FIC02	Fisher Creek	spring	3			5.2	5.2	5.1
NPR07	Napanee River	spring	3			5.1	5.8	5.7
OTC01	Otter Creek	spring	2				5.7	5.8
PNC01	Pennells Creek	spring	3			4.1	5.0	5.0
SEC15	Selby Creek	spring	3			6.7	5.0	5.6
SMR03	Salmon River	spring	3			4.7	4.8	4.7
SMR05	Salmon River	spring	3			4.9	5.2	4.8
SUC01	Selby/Sucker Creek	spring	4		5.0	4.8	3.7	5.6
Prince Edward Region Watershed								

Site ID	Waterbody Name	Season	n	2003	2004	2005	2006	2007
CSC02	Consecon Creek	spring	4		5.0	4.8	3.7	5.6
CSC03	Consecon Creek	spring	1				4.6	
DVC03	Demorestville Creek	spring	4		5.9	5.7	5.6	6.5
HBC01	Hubbs Creek	spring	4		5.1	5.1	4.9	4.9
HBC02	Hubbs Creek	spring	4		5.6	6.0	3.8	4.3
HLC01	Hillier Creek	spring	2				6.3	3.5
HLC02	Hillier Creek	spring	3			6.5	3.8	6.0
HLC02	Hillier Creek	fall	1	6.9				
WAR1	Waring Creek	spring	1					6.7
WAR2	Waring Creek	spring	1					4.8
WAR4	Waring Creek	spring	1					4.8
WAR1	Waring Creek	fall	1					7.0
WAR2	Waring Creek	fall	1					5.1
WAR4	Waring Creek	fall	1					5.1

Impaired	Possibly Impaired	Not Impaired	Source
>7	6 to 7	<6	Kilgour (1998)

Benthic community composition can often be explained by concentrations of water chemistry and habitat quality. Reviewing the water chemistry results for the Quinte Region, only total phosphorus and iron concentrations were above the Provincial Water Quality Objective (PWQO), thus exceeding the threshold for the protection of aquatic life (Table 2.19). Since phosphorous is actively taken up by plants, it is rarely found in high concentrations in surface water unless there is an anthropogenic source. Total Phosphorous (TP) concentrations above 0.03 mg/L were observed at most OBBN stations and may be the result of runoff from fertilized agricultural lands, domestic sewage, industrial effluents, and phosphates from detergents (McNeely 1979) (Table 2.20).

Iron is from natural weathering of rock, but sources can be anthropogenic when exceeding the PWQO of 0.3 mg/L. Some sources of iron can be from industrial waste, the atmospheric transport of the burning of coke and coal, acid drainage, mineral processing, and corrosion of iron and steel (McNeely 1979). Four of the benthic stations exhibited iron concentrations above the PWQO: Number Ten Creek (NTC02), Parks Creek (PKC10), Crooked Creek (CRC01), and Selby Creek (SEC15) (Table 2.21).

Water chemistry parameters that did not have a provincial water quality standard for comparison were compared with the concentrations that were considered typical for Canadian surface waters in 1979 (Table 2.19). Water chemistry parameters with atypical concentrations in the Quinte Region between 2005 and 2007 were Dissolved Organic Carbon (DOC), Manganese, and Nitrite. Some sources of these parameters are natural. For example, Manganese and Nitrite can come from weathered rock and DOC comes from decaying organic materials in aquatic environments. However, since most OBBN stations are situated in small streams of headwaters in rural areas, high concentrations of DOC and nitrite could be coming from rural land runoff of septic systems, manure, and in some instances from urban waste waters.

Instead of being above the typical concentration, Calcium concentration at one station was below typical Canadian concentration for surface waters of 15 mg/L. These low values for Calcium were more than likely associated with the type of soils and geology found in the area. Stations with low calcium are often located on the Precambrian Shield while the stations with typical calcium concentrations are usually located on Limestone, e.g. southern portions of both MRW and NRW and all of PERW. In this case, the station with low calcium concentrations was in Crooked Creek located in the Napanee Region Watershed on the Precambrian Shield where the samples with low calcium were taken in spring of 2006 and 2007.

Table 2.19. 2005 to 2007 water chemistry results at OBBN stations in the Quinte region and comparisons to water quality standards and concentrations that are typically found in Canadian surface waters. Typical concentrations were taken from McNeely et al. (1979). Atypical minimum and maximum values are in bold.

Parameter	Unit	No. of Obs.	Min	Max	Average	Median	PWQO	% Obs. Above PWQO	ODWS	% Obs. Above ODWS
Alkalinity	mg/l CaCO3	79	12	288	191	206	Typical is > 500			
Bicarbonate	mg/l	76	12	288	191	205				
Calcium	mg/l	75	**4.9**	124	73	76.7	Typical is >15			
Carbonate	mg/l	76	3.0	3.0	3.0	3.0				
Chloride	mg/l	79	1.00	157	26.1	10.5			250	0
Conductivity	uS/c	70	37	990	448	441				
Copper	mg/l	11	0.002	0.002	0.002	0.002	0.005	0		
DIC	mg/l	33	4.8	76	45	50				
DOC	mg/l	72	1.8	**42.1**	9.1486	8.4	Typical is 1 to 30			
Fluoride	mg/l	72	0.1	0.5	0.14167	0.1	Typical is <1		1.5	0
Hardness	mg/l	14	86	299	199.5	220.5			500	0
Iron	mg/l	79	0.007	0.541	0.12523	0.102	0.3	**6**		
Magnesium	mg/l	75	1.01	17	7.9212	6.48	Typical is 1 to 100			
Manganese	mg/l	12	0.001	**0.56**	0.061917	0.0195	Typical is < 0.2			
Nitrates, Total	mg/l	72	0.005	6.7	0.81771	0.1			10	0
Nitrite	mg/l	72	**0.005**	**0.5**	0.1084	0.1	Typical is < 0.001			
Nitrogen, Total Kjeldahl	mg/l	79	0.1	1.6	0.58608	0.6	Typical is 0.1 to 0.5			
pH	pH scale	79	6.48	8.18	7.4692	7.53	8.5	0		
Phosphorous, Total	mg/l	79	0.01	0.82	0.042278	0.02	0.03	**37**		
Potassium	mg/l	79	0.2	5.8	1.5253	1.3	Typical is < 10			
Silica	mg/l	67	0.46	16.9	6.6082	5.48	Typical is < 5			
Sodium	mg/l	79	0.9	76.3	13.234	5.9			200	0
Sulphate	mg/l	79	1	60	14.506	8				
Zinc	mg/l	11	0.005	0.005	0.005	0.005	0.03	0		

Table 2.20. 2005 to 2007 Total Phosphorous (mg/L) results at OBBN stations and percent of observations that were above the PWQO of 0.03 mg/L for rivers and streams.

Station ID	Name	No. of Obs.	Minimum	Maximum	Average	Median	% Obs. Above PWQO
Moira River Watershed							
CHC01	Chrysal Creek	2	0.01	0.01	0.01	0	0
CHC05	Chrysal Creek	2	0.02	0.03	0.03	0	50
CLR05	Clare River	2	0.02	0.02	0.02	0	0
GOC03	Goose Creek	2	0.01	0.02	0.02	0	0
MOR09	Moira River	1	0.06	0.06	0.06	0	100
NTC01	Number Ten Creek	1	0.01	0.01	0.01	0	0
NTC02	Number Ten Creek	3	0.01	0.06	0.03	0.01	33
PAC01	Palliser Creek	1	0.02	0.02	0.02	0	0
PAC06	Palliser Creek	3	0.01	0.05	0.03	0.02	33
PKC01	Parks Creek	2	0.01	0.01	0.01	0	0
PKC07	Parks Creek	1	0.02	0.02	0.02	0	0
PKC10	Parks Creek	3	0.01	0.19	0.08	0.05	67
POC01	Potter Creek	3	0.01	0.04	0.03	0.03	67
POC02	Potter Creek	3	0.01	0.05	0.03	0.04	67
UNC03	Unknown Creek 2	3	0.01	0.10	0.05	0.03	67
Napanee Region Watershed							
CRC01	Crooked Creek	2	0.02	0.03	0.03	0	50
FIC02	Fisher Creek	3	0.01	0.22	0.08	0.02	33
NPR07	Napanee River	3	0.01	0.04	0.03	0.03	67
OTC01	Otter River	2	0.01	0.01	0.01	0	0
PNC01	Pennells Creek	3	0.01	0.03	0.02	0.01	33
SEC15	Selby Creek	3	0.05	0.14	0.10	0.10	100
SMR03	Salmon River	3	0.01	0.02	0.01	0.01	0
SMR05	Salmon River	3	0.01	0.03	0.02	0.02	33
SUC01	Selby/Sucker Creek	1	0.82	0.82	0.82	0	100
Prince Edward Region Watershed							
CSC02	Consecon Creek	3	0.01	0.08	0.04	0.02	33
CSC03	Consecon Creek	1	0.01	0.01	0.01	0	0
DVC03	Demorestville Creek	3	0.01	0.04	0.02	0.01	33
HBC01	Hubbs Creek	3	0.01	0.04	0.02	0.02	33
HBC02	Hubbs Creek	3	0.03	0.04	0.04	0.04	100
HLC01	Hillier Creek	2	0.01	0.02	0.02	0	0
HLC02	Hillier Creek	3	0.01	0.19	0.07	0.02	33
WAR1	Waring Creek	2	0.01	0.01	0.01	0	0
WAR2	Waring Creek	2	0.01	0.02	0.02	0	0
WAR4	Waring Creek	2	0.01	0.01	0.01	0	0

Table 2.21. 2005 to 2007 Iron (mg/L) results at OBBN stations and percent of observations that were above the PWQO of 0.3 mg/L for rivers and streams.

Station ID	Name	No. of Obs.	Minimum	Maximum	Average	Median	% Obs. Above PWQO
Moira River Watershed							
CHC01	Chrysal Creek	2	0.028	0.068	0.048	0	0
CHC05	Chrysal Creek	2	0.028	0.155	0.0915	0	0
CLR05	Clare River	2	0.063	0.225	0.144	0	0
GOC03	Goose Creek	2	0.023	0.062	0.0425	0	0
MOR09	Moira River	1	0.017	0.017	0.017	0	0
NTC01	Number Ten Creek	1	0.133	0.133	0.133	0	0
NTC02	Number Ten Creek	3	0.049	0.488	0.19767	0.056	33
PAC01	Palliser Creek	1	0.073	0.073	0.073	0	0
PAC06	Palliser Creek	3	0.007	0.049	0.029667	0.033	0
PKC01	Parks Creek	2	0.021	0.031	0.026	0	0
PKC07	Parks Creek	1	0.017	0.017	0.017	0	0
PKC10	Parks Creek	3	0.014	0.541	0.19133	0.019	33
POC01	Potter Creek	3	0.016	0.176	0.085667	0.065	0
POC02	Potter Creek	3	0.024	0.121	0.073667	0.076	0
UNC03	Unknown Creek 2	3	0.088	0.137	0.108	0.099	0
Napanee Region Watershed							
CRC01	Crooked Creek	2	0.318	0.342	0.33	0	100
FIC02	Fisher Creek	3	0.068	0.149	0.121	0.146	0
NPR07	Napanee River	3	0.061	0.205	0.14867	0.18	0
OTC01	Otter River	2	0.072	0.078	0.075	0	0
PNC01	Pennells Creek	3	0.058	0.092	0.076667	0.08	0
SEC15	Selby Creek	3	0.155	0.435	0.27733	0.242	33
SMR03	Salmon River	3	0.15	0.171	0.16367	0.17	0
SMR05	Salmon River	3	0.136	0.161	0.15133	0.157	0
SUC01	Selby/Sucker Creek	1	0.102	0.102	0.102	0	0
Prince Edward Region Watershed							
CSC02	Consecon Creek	3	0.16	0.28	0.222	0.226	0
CSC03	Consecon Creek	1	0.205	0.205	0.205	0	0
DVC03	Demorestville Creek	3	0.071	0.112	0.093667	0.098	0
HBC01	Hubbs Creek	3	0.065	0.173	0.11367	0.103	0
HBC02	Hubbs Creek	3	0.054	0.198	0.125	0.123	0
HLC01	Hillier Creek	2	0.114	0.155	0.1345	0	0
HLC02	Hillier Creek	3	0.118	0.197	0.157	0.156	0
WAR1	Waring Creek	2	0.1	0.129	0.1145	0	0
WAR2	Waring Creek	2	0.059	0.114	0.0865	0	0
WAR4	Waring Creek	2	0.073	0.08	0.0765	0	0

Only some stations with high HBI can be explained by elevated nutrient concentrations. Stations in Palliser Creek (PAC06), Potter Creek (POC 01, POC02), Selby Creek (SEC15, SUC01), Demorestville Creek (DVC03), and Hillier Creek (HLC02) with HBI values above 5.9 were observed to have total phosphorus concentrations above the PWQO of 0.03 mg/L at one time or another (Table 2.20). Looking at the rest of the stations, the water chemistry may not have reflected nutrient enrichment at the time of collecting aquatic macroinvertebrates, but it may still be a factor when HBI is above 5.9. This is because a representative sample of water chemistry is dependent upon the time when the non-point source of pollution is actively releasing runoff.

Looking at the dominant substrate type, the fine substrate particles (clay and slit) or the uniform rock that does not provide much shelter (bedrock) can explain some of the high HBI values for these stations with a HBI above 5.9 (Table 2.22). Chrysal Creek (CHC01), Number Ten Creek (NTC01), Selby Creek (SEC15), and Selby/Sucker Creek (SUC01), Demorestville Creek (DVC03), and Waring Creek (WAR01) may have had their benthic communities compromised by the observed silt, clay and or bedrock. These stations did not have a rich substrate habitat to support a healthy benthic community.

Other factors that have not yet been explored may explain the high HBI at Parks Creek (PKC07) and Hillier Creek (HLC02) stations where water chemistry or dominant substrate type could not. Some factors could be water temperatures, food sources, or water chemistry parameters that were not tested. As mentioned before, another possible reason for high HBI at these stream stations is that nutrient enrichment may have occurred sometime prior to the water chemistry sampling, detected through the benthic community analysis, but was not detected in the chemistry at the time that the water was collected. Confirmation of enrichment can only be obtained with long term benthic data combined with water chemistry data. Data collection continues at OBBN stations in the Quinte Region (Map 17).

Table 2.22. Dominant substrate type for OBBN stations with HBI greater than 5.9.

Site ID	Waterbody Name	Authority	Date sampled	Season	HBI	Domiant Substrate
Moira River Watershed						
CHC01	Chrysal Creek	MRW	10/31/2003	fall	6.6	Clay
CHC01	Chrysal Creek	MRW	10/4/2004	fall	6.3	Sand to Gravel
NTC01	Number Ten Creek	MRW	10/21/2004	fall	6.1	Silt
PAC01	Palliser Creek	MRW	10/1/2003	fall	6.6	Bedrock, Cobble, Sand
PAC01	Palliser Creek	MRW	10/25/2005	fall	6.6	Cobble, Clay
PAC06	Palliser Creek	MRW	9/29/2004	fall	6.3	Sand, Cobble
PAC06	Palliser Creek	MRW	10/20/2005	fall	6.7	Gravel
PAC06	Palliser Creek	MRW	10/13/2006	fall	6.3	Silt, Sand, Gravel
PKC07	Parks Creek	MRW	10/15/2004	fall	6.7	Cobble
POC01	Potter Creek	MRW	10/26/2004	fall	6.6	Gravel, Cobble
POC02	Potter Creek	MRW	10/23/2003	fall	6.7	Gravel, Boulder
Napanee Region Watershed						
SEC15	Selby Creek	NRW	5/26/2005	spring	6.7	Silt
SUC01	Selby/Sucker Creek	NRW	5/31/2006	spring	6.8	Bedrock
SUC01	Selby Sucker Creek	NRW	5/28/2007	spring	6.4	Bedrock
Prince Edward Region Watershed						
DVC03	Demorestville Creek	PERW	4/30/2007	spring	6.5	Bedrock
HLC01	Hillier Creek	PERW	5/25/2006	spring	6.3	Cobble
HLC02	Hillier Creek	PERW	9/23/2003	fall	6.9	Gravel
HLC02	Hillier Creek	PERW	5/19/2005	spring	6.5	Cobble
HLC02	Hillier Creek	PERW	5/2/2007	spring	6.0	Gravel, Cobble
WAR1	Waring Creek	PERW	5/23/2007	spring	6.7	Silt
WAR1	Waring Creek	PERW	10/26/2007	fall	7.0	Silt

2.5.3 Species and Habitats at Risk

Data on species at risk are recorded by the Royal Ontario Museum, Committee on the Status of Endangered Wildlife in Canada (COSEWIC), and the Ontario Ministry of Natural Resources. Not all of the lists by these different agencies are the same. Rare species are classified independently by each of these organizations from vulnerable to being extinct from the wild. It is important to identify rare species in the Quinte region for source protection especially aquatic species that could be at risk of extinction due to water quality and quantity. The occurrence of these rare aquatic species can suggest the presence of unique habitat characteristics and should be taken into account in a source protection plan.

The Ontario Ministry of Natural Resources (MNR) is a good source and has distribution data available of rare species occurrences in 1 km square boxes in order to protect the communities from further risk of becoming extinct. Most of the rare species in the Quinte source protection region were located in the lower portion of the Salmon and the Napanee River watersheds (Map 18). The rare species occurrences were associated with natural areas of shorelines along lakes, rivers, wetlands and forested areas. In addition, there were some located in urban areas, such as Tweed, Belleville, and Picton.

The full list of rare species designated by COSEWIC and MNR was gathered for the Quinte region from the Natural Heritage Information Centre (NHIC) based on watershed region without revealing their specific location (NHIC 2005). The list includes mammals, amphibians, fish, birds, and plants of both terrestrial and aquatic species. As of 2005, there were 63 rare species in the Moira River Watershed, 66 in Napanee Region Watershed, and 35 identified on the Prince Edward Region Watershed (Appendix 9). Local observations of species at risk are limited to those in the Moira River watershed (Blaney 2005) (Table 2.23).

Table 2.23. Species at Risk reported to be found in the Moira River Watershed (Blaney 2005).

Species	Location	Comments
Least Bittern (*Ixobrychus exilis*)	Stoco Fen, Cassidy Block	While this species is not common, it does occur in many cattail marshes in the area.
Black Tern (*Chlidonias niger*)	Foxboro Marsh, Frink Centre	Declining – The number of pairs nesting in the Foxboro Marsh has declined significantly in the past few years. Only two nesting pairs confirmed in 2005.
Red-shouldered Hawk (*Buteo lineatus*)	Baptist Church Road Woods, Vanderwater CA, Cassidy Block	Occurs in many suitable wooded areas in Centre Hastings, often near water.
Cerulean Warbler (*Dendroica cerulea*)	Cassidy Block	Nests in small numbers in the mature woodlands around Deroche Lake

Channel Darter Study

As of May 2002 the Channel Darter was designated as threatened in the provinces of Ontario and Quebec (NHIC 2005). The Channel Darter (*Percina copelandi*) is a small, light brown or olive-coloured, bottom-dwelling fish with a whitish underbelly and brown speckles on its back (Figure 2.7). Channel Darters collected in Canadian waters range from 34 to 61 mm in length (Environment Canada 2006). Channel Darter populations are dispersed throughout central North America west of the Appalachian Mountains, but their populations are patchy and the northern populations located in Canada are considered to be rare (Environment Canada 2006). Channel Darters' suitable spawning habitat is declining due to changes in water temperature (associated with climate changes or loss of shade due to development activities), erection of barriers, and increased suspended sediment, competition from other species, and the deterioration of water quality due to agriculture and urban development (Environment Canada 2006).

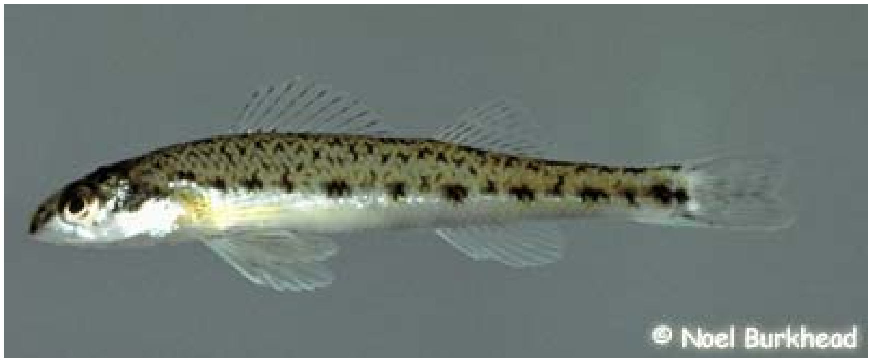


Figure 2.7. Channel Darter, *Percina copelandi* (Environment Canada 2006).

A study conducted in 2001 and 2003 identified locations of Channel Darter populations in five rivers in the Quinte Conservation Source Protection Region (Reid 2005). Sampling sites were selected based on Ontario Ministry of Natural Resources and the Royal Ontario Museum historic records of capture, surficial geology, and the location of suitable habitat consisting of riffles and waterfalls. All five rivers sampled were fragmented by old mill, low flow, augmentation, and flood control dams. Forty-seven sampling sites were selected in the five rivers. Channel Darters were captured at fifteen of these sites through electro-fishing efforts (Table 2.24). Although all 47 sites were considered suitable for this species, the low capture rate was attributed to the restriction of the Channel Darter by natural barriers (waterfalls) upstream. Each of the sites where Channel Darters were observed had riffles flowing into deep pools or runs.

The description of preferred habitat characteristics from studies like this can be used to improve the understanding of the spatial distributions and importance of stream characteristics (e.g. riffles and pools) to species. Information about preferred habitat characteristics and lessons learned as a result of declining populations of native species can be used to help protect and create habitats for the Channel Darter and other species at risk.

Table 2.24. Channel Darter observations.†

Watershed	River segment	Number of sites	Sites where Channel Darter observed
Moira Watershed	Moira River	18	5
	Black River	4	1
	Skootamatta River	6	2
Napanee Watershed	Napanee River	6	0
Salmon Watershed	Salmon River	13	7

† (Reid 2005)

In this section the rare species located in the Quinte region and the general locations of the rare species occurrences were identified. However, with the exception of the Channel Darter study reports were not found to support a detailed discussion on distribution of species at risk in relation to water quality or quantity conditions in the Quinte Region. Loss of fish habitat was discussed in section 2.5 and loss of wetlands was discussed in section 2.4.

2.5.4 Invasive Species

The introduction of invasive species to Canada is done through the transportation of a species to an area further than they can naturally travel. Invasive species, also known as alien species, often arrive by ship (e.g. ballast water), vehicle, and air transport, both intentionally and accidentally. Examples of species arriving intentionally are those associated with agricultural and horticulture, the pet trade, and medical research. The problem occurs when these invasive species are released into the environment and thrive because there are no natural means of controlling their population. Invasive species affect native species by competing for habitat and food, preying upon them, weakening the gene pool by interbreeding with them, weakening and killing them through new parasites and disease, and altering their environment threatening their existence. There is legislation in place to control the release of invasive species, but this is not always successful. Invasive plant and animal species have been observed in the Quinte Region. The following discussion includes known observations; however, further observations by volunteers and responsible agencies (e.g. Federation of Anglers and Hunters and Ontario Ministry of Natural Resources) would help to understand species numbers, locations, and their impact on water quality and ecosystem health. Aquatic invasive species are especially important to source protection because they pertain to water quality and quantity.

In the Quinte Region, aquatic and plant invasive species have been a problem in the past and continue to be an issue (Table 2.25). The Round Goby and the Zebra Mussel are the most widely spread exotics in the region (Proctor 2006). Invasive species have been spotted and confirmed by the Ontario Federation of Anglers and Hunters (OFAH) in Lake Ontario, the Bay of Quinte, and rivers, and in inland lakes of the Quinte source protection region (Map 19). As of 2006, OFAH reported Zebra Mussels being spotted and confirmed in the Bay of Quinte, Lake Ontario (bays), Stoco Lake (Moira River Watershed) and Kennebec Lake (Napanee Region Watershed), Beaver Lake (Napanee Region Watershed), and Consecon Lake (Prince Edward Region Watershed) (Map 19). The Round Goby has been spotted in the Bay of Quinte and Napanee River (Map 19). European Frogbit (free-floating aquatic plant resembling a small water lily), the Fish-Hook Water Flea (zooplankton), and the Flowering Rush (emergent aquatic plant) also had confirmed sightings in the region (Map 19).

Table 2.25. Invasive species in the Quinte Region.

Species	*Scientific Name*	Environment	Impact
European Frogbit	*Hydrocharis morsus-ranae*	Calcium-rich water where there is limited wave action.	Forms very dense, impenetrable mats of floating vegetation that prevent sunlight from reaching the submersed aquatic plants below; impede the movement of large fish and diving ducks.
Flowering Rush	*Butomus umbellatus*	New land exposed by lower water levels; salinity limits extent.	Displaces native shoreline vegetation such as bulrushes, willows and cattails because of its thick root system.
Zebra Mussels	*Dreissena polymorpha*	Tolerates a wide range of environmental conditions.	Alter water clarity and fish populations; compete with native fish for zooplankton prey.
Round Goby	*Neogobius melanostomus*	Prefer rocky and sandy bottoms; occupy a broad range of depths but are most abundant near shore.	Still unknown - abundant numbers; consume zebra mussels, are consumed by native fish and birds, potentially spreading infections and increasing toxin concentrations.

Zebra Mussel

Lake Ontario has seen quite a shift in water quality over the years as a result of the effects from excessive concentrations of phosphorous that lead to the excessive growth of algae and emergent aquatic plants (reduction of submerged plants). The introduction of Zebra Mussels to Lake Ontario in 1989 had altered water quality conditions again by increasing water clarity and changing fish habitat and causing a shift in the fish community (GLFC 2004). Zebra Mussels compete with the zooplankton for food (green algae) and declines fish populations that depend on zooplankton for prey. The Zebra Mussel not only competes for food with other organisms, but their populations have cleared the water to the point where submerged plants and other fish populations are recovering, e.g. largemouth bass, pumpkinseed, bluegill, and black crappie (GLFC 2004). In general, the upper and middle parts of the Bay of Quinte have become more suitable for pike, muskellunge, and small fishes that prefer the submerged plants that create shelter and hunting grounds (Ewaschuk 2005). Fish that are light sensitive predators like the Walleye, preferring darker and open waters have moved to deeper waters (Ewaschuk 2005).

It is important to know where invasive species are located, but it is also important to understand where the Zebra Mussels have not yet invaded. For example, in 1995, Roblin Lake, located in Prince Edward Region Watershed, did not contain zebra mussels (Taylor 1995). East Lake and the Outlet River also in Prince Edward Region Watershed were reported to be infested with zebra mussels, and the species threatens to inhabit the remaining lakes and rivers in the Prince Edward Region Watershed County (Taylor 1995).

Recently the Quagga Mussel that contributes to the increased water clarity has become a concern in Lake Ontario as it has a wider habitat range. They not only inhabit the shallow waters where Zebra Mussels (<10 m) like to be, but they have spread to depths of 400 feet in Lake Ontario. No observations were found on the Quagga Mussel distribution in the Bay of Quinte, or up the Moira, Salmon or the Napanee Rivers. The Quagga Mussel may become a concern in the Bay of Quinte and tributaries in the future.

Round Goby

The Round Goby, is a bottom-dwelling fish from Eurasia that was reported to be introduced in Lake Ontario in 1998 and in the Bay of Quinte in 2001 (GLFC 2004). It is rapidly becoming abundant in the nearshore waters. This species is aggressive as it spawns several times in a year and it feeds on mussels (including Zebra Mussels and Quagga Mussels), aquatic insects, fish eggs, and small (juvenile) fish (GLFC 2004). The Round Goby competes with other bottom-dwelling fish in nearshore zones, such as darters, sculpins, and logperch, which will most likely decline in numbers as the gobies increase.

Indicators of pollution

Round Gobies and the Zebra / Quagga Mussels are affected by water quality or by the contaminants in the sediment. Round Gobies and any other bottom-dwelling species, accumulate toxins in their bodies by feeding on mussels and other benthic organisms that are exposed to contaminated sediment. Mussels are filter feeders and are exposed to any contaminants that become water-born on the sediment floor. Recent outbreaks of botulism have been linked to Zebra / Quagga Mussels and Round Gobies, which get passed on to birds, fish, and other predators that feed on these bottom-dwelling organisms (GLFC 2004). In summer when there is a breakout of botulism, dead fish and birds have been spotted on beaches in Prince Edward Region Watershed and the main land of the Bay of Quinte.

References

Barnes, A. S. L. (1967). Napanee Region Conservation Report 1967: Salmon Report Section. Toronto, Ontario Canada, Ontario Department of Energy and Resources Management, Conservation Authorities Branch**:** 40.

Barnes, A. S. L. (1968). Prince Edward Region Conservation Report: Land, Forest, Water, Wildlife. Toronto, Ontario Canada, Ontario Department of Energy and Resources Management, Conservation Authorities Branch**:** 161.

Blaney, J. (2005). Personal Communication: Species at Risk and Invasive Species in our watersheds: MRW. J. Schulenburg. Belleville, Ontario.

Coker, G. A., C.B. Portt, C.K. Minns (2001). Morphological and Ecological Characteristics of Canadian Freshwater Fishes. Burlington, ON, C. Portt and Associates and Great Lakes Laboratory for Fisheries and Aquatic Sciences, Fisheries and Oceans Canada, Bayfield Institute.**:** iv+89p.

Crossman, E. J., H. D. Van Meter (1979). Annotated list of the fishes of the Lake Ontario Watershed. Great Lakes Fishery Commission Technical Report, Great Lakes Fishery Commission**:** 25.

Environment Canada. (2006). "Species at Risk." Retrieved May 2006, from http://www.speciesatrisk.gc.ca/default_e.cfm.

Ewaschuk, M. (2005). Backgrounder: Bay of Quinte Fish Habitat Management Plan. Trenton, Ontario Canada, Bay of Quinte Remedial Action Plan**:** 84.

GLFC (2004). 2003 Update: Fish Community Objectives for Lake Ontario. Special Publication, Lake Ontario Committee, Great Lakes Fishery Commission**:** 7.

Johanson, P., B. McNevin (2007). A Fish Habitat Management Plan for the Bay of Quinte, Bay of Quinte Remedial Action Plan**:** 47.

Jones, C., K.M. Somers, B. Craig, and T.B. Reynoldson. (2005). Ontario Benthos Biomonitoring Network Protocol Manual. Dorset, Ontario Canada, Ontario Ministry of the Environment**:** 111.

Kilgour, B. W. (1998). Developing an index of nutrient status based on rapid assessment methodology for collecting benthic macroinvertebrates, Water Systems Analysis for the Ontario Ministry of Natural Resources.

McNeely, R. N., V.P. Neimanis, and L. Dwyer (1979). Water Quality Sourcebook: A Guide to Water Quality Parameters. Ottawa, Ontario Canada, Inland Waters Directorate, Water Quality Branch**:** 89.

Michalski, M. (1987). Bay of Quinte Remedial Action Plan Progress Report., Michael Michalski Associates Prepared for Bay of Quinte Remedial Action Plan Coordinating Committee**:** 107.

MNR Walleye State of the Resource Report for Southern Ontario., Ontario Ministry of Natural Resources.

MNR (2000). Lake Ontairo Fish Communities and Fisheries: 1999 Annual Report of the Lake Ontario Management Unit. Niagara-on-the-Lake, Ontario, Prepared for the Lake Ontario Committee Meeting, Great Lakes Fishery Commission.

MNR (2001). Lake Ontairo Fish Communities and Fisheries: 2000 Annual Report of the Lake Ontario Management Unit. Niagara Falls, New York, Prepared for the Lake Ontario Committee Meeting, Great Lakes Fishery Commission.

MNR (2002). Lake Ontario Fish Communities and Fisheries: 2001 Annual Report of the Lake Ontario Management Unit. Buffalo, New York, Prepared for the Lake Ontario Committee Meeting, Great Lakea Fishery Commission.

MNR (2003). Lake Ontario Fish Communities and Fisheries: 2002 Annual Report of the Lake Ontario Management Unit. Niagara Falls, Ontario, Prepared for the Lake Ontario Committee Meeting, Great Lakes Fishery Commission.

MNR (2004). Lake Ontario Fish Communities and Fisheries: 2003 Annual Report of the Lake Ontario Management Unit. Grand Island, New York, Prepared for the Lake Ontario Committee Meeting, Great Lakes Fishery Commission.

MNR (2005). Lake Ontario Fish Communities and Fisheries: 2004 Annual Report of the Lake Ontario Management Unit. Niagara Falls, Ontario Canada, Prepared for the Great Lakes Committee Meeting, Great Lakes Fishery Commission.

MNR (2006). Lake Ontario Fish Communities and Fisheries: 2005 Annual Report of the Lake Ontario Management Unit. Windsor, Ontario, Prepared for the Great Lakes Committee Meeting, Great Lakes Fishery Commission.

MNR (2007). Lake Ontario Fish Communities and Fisheries: 2006 Annual Report of the Lake Ontario Management Unit. Ypsilanti, Michigan, Prepared for the 2007 Upper and Lower Great Lakes Committee Meetings, Great Lakes Fishery Commission.

NHIC. (2005). "Natural Heritage Information Centre. Rare Species and Natural Spaces by Jurisdiction." Retrieved May 31, 2005, 2005, from http://nhic.mnr.gov.on.ca/MNR/nhic/species/species_jur.cfm.

Proctor, C. (2006). Personal Communication: Invasive species confirmed in the Quinte source protection region by Ontario Federation of Anglers and Hunters. J. Schulenburg. Belleville, Ontario Canada, Quinte Conservation.

Reid, S. M., Carl, L. M., Lean, J. (2005). "Influence of riffle characteristics, surficial geology, and natural barriers on the distribution of the channel darter, Percina copelandi, in the Lake Ontario basin." Environmental biology of fishes [Environ. Biol. Fish.]. Vol. 72, no. 3, pp. 241-249. 2005.

Richardson, A. H., A. S. L. Barnes, H. A. Smith, F .G. Jackson, J. W. Murray, G.S. Bartlett, C. E. Bush, J. P Bruce, K. M. Mayall, V. B. Blake, H. F. Crown, W. D. Adlam, R.V. Brittain, M. Chubb, Coutts, K. G. Higgs, H.G. Hooke, L. N. Johnson, A. D. Latornell, C. R. Leuty, R. M. Lewis, E. F. Sutter (1957). Napanee Valley 1957 Conservation Report. Toronto, Ontario Canada, Ontario Department of Planning and Development, Conservation Branch.

Richardson, A. H., W. J. P. Creswick, A. S. L. Barnes, B. O. Smith, C. E. Bush, J. W. Murray, K. M. Mayall, V. B. Blake, H. F. Crown, L. N. Johnson, G. Newson (1950). Moira Valley Conservation Report 1950. Toronto, Ontario Canada, Ontario Department of Planning and Development, Conservation Branch.

Stanfield, L., Ed. (2005). Ontario Stream Assessment Protocol. Version 7. Peterborough, Ontario, Fish and Wildlife Branch, Ontario Ministry of Natural Resources.

Taylor, K. (1995). Roblin Lake Study. Belleville, Ontario Canada, Quinte Conservation.

2.6 Human Characterization

2.6.1 Population Distribution and Density

The total population of the Quinte Region is 117,933 (Statistics Canada 2000), with an approximate equal distribution between urban (49%) and rural (51%) dwellers. The distribution and density of this population is illustrated by Map 20 with general population numbers for each municipality summarized in Table 2.26. The main urban centers include the City of Belleville, Towns of Napanee, & Picton as well as the Villages of Wellington, Madoc & Tweed. From the population density Map 20 it can be seen that highest densities are for those municipalities located south of the Canadian Shield in the Limestone Terrain and Prince Edward Region. In the rural areas of these southern municipalities the population density is typically in the range of 11 to 40 people per square kilometer. Exception is the rural area around the City of Belleville and Quinte West at densities of 41 to 1250 people per square kilometer. Compared to the areas of higher population, the density for the municipalities covering northern portions of the watershed is in the range of one to ten people per square kilometer.

Table 2.26. Municipal Populations and Water Use (Statistics Canada 2000).

Municipality	Total Population	Number of People Supplied			% Population Supplied by Groundwater		
		Municipal Groundwater	Surface Water	Private Wells	Total	Municipal Wells	Private wells
Tweed	5612	1539	0	4073	100	27.4	72.6
Belleville	45986	0	38306	7680	16.7	0	16.7
Tyendinaga	3769	0	0	3769	100	0	100
Deseronto	1796	0	1796	0	0	0	0
Stone Mills	7337	0	0	7337	100	0	100
Madoc	2044	0	0	2044	100	0	100
South Frontenac	3447	0	0	3447	100	0	100
Centre Hastings	3127	1730	0	1397	100	55.3	44.7
Addington Highlands	1056	0	0	1056	100	0	100
Greater Napanee	11667		7760	3907	33.5	0	33.5
North Frontenac	18	0	0	18	100	0	100
Central Frontenac	2096	0	0	2096	100	0	100
Marmora	527	50	0	477	100	9.5	90.5
Quinte West	3528	0	0	3528	100	0	100
Stirling Rawdon	465	0	0	465	100	0	100
Tudor & Cashel	319	0	0	319	100	0	100
Loyalist	238	0	0	238	100	0	100
Prince Edward	24901	50	9901	14950	60.2	0.2	60
Totals	**117933**	**3369**	**57763**	**56801**	**51**	**2.9**	**48.2**

The break down of urban and rural populations as summarized in Table 2.26 is based on Statistics Canada Census data as well as apportionment of the percentage of population falling within the Quinte watershed Region. However, the designations may be somewhat varied by what some municipalities consider as urban areas. For example, some municipalities have several hamlets that are considered as urban settlement areas (i.e. the Growth and Development Strategy for Prince Edward County considers 40% of the population to be urban versus 26% as defined by Statistics Canada Census). For the most part, many of these hamlet areas are serviced by individual wells and septics and some with partial services.

Growth of population in the Quinte Region has been reviewed based on projections of the Ontario Ministry of Finance (MOF 2000), as well as from various official plans. The data received from the Ministry of Finance for Hastings and Lennox & Addington Counties shows an average annual increase of approximately 0.5%, resulting in an approximate increase in population of 10.5% by 2026. Review of official plans for the two largest urban centers in the area (Cities of Belleville and Quinte West, 2001) estimate population growth in the order of 0.7 and 0.8% per year. The Prince Edward County Growth and Development Strategy indicates historic growth of that region to be in the order of 1.1% per year (McComb 2003). However, recent trends in demographics of that area indicate a lower number of persons per household and a growing retirement population has caused a declining population but increased building and development. Other information regarding growth and settlement in the area, taken from the Hastings County Official Plan indicates that there has been a higher population increase in rural areas than in the urban centers (Ainley 2001).

2.6.2 Land Use

Land use in the Quinte watershed region includes a mix of urban, rural, agricultural and local hamlets that provide services for surrounding rural residential, recreational and agricultural communities. Land use is illustrated by Map 21; however, please note that this map is in progress as there are many municipalities that do not have digital mapping to permit completion. As a result, statistics were not computed to quantify the various land uses throughout the Quinte Region watersheds. The information provided below is a qualitative summary as well as a brief summary of the planning process.

There are a variety of levels of government within the watershed with some municipalities operating under a one tier system and others a two tier. From a planning perspective the majority operate under a one tier system such as the City of Belleville, Quinte West, Prince Edward County and municipalities within Lennox and Addington County. However, municipalities within Hastings County (i.e. Madoc, Tyendinaga, Tweed, and Centre Hastings) operate under a two tier system whereby the County develops the official plan and the township level municipalities develop zoning bylaws.

The diversity of land use in the Quinte Region is largely a result of the physiography and settlement patterns as discussed in previous sections. The majority of the urban, industrial and commercial businesses are located in the urban centers such as Belleville and Napanee. However some industry is located throughout the countryside which incorporates various cheese factories and aggregate related activities which include a cement factory near Picton, shingle aggregate factory near Madoc and a tire plant near Napanee. The settlement of the area has been largely influenced by the physical features of the watershed and can be summarized as follows:

Canadian Shield - Sparsely populated with few settlement areas and vast areas of forested lands. Many small lakes support an active recreation industry with seasonal cottages and residents;

Limestone Terrain - This area contains some of the best agricultural land and as such agriculture is a significant land use. This region also contains the larger urban centers with associated industry and commercial business as well as transportation routes (i.e. highway 401 and railroad);

Prince Edward Region - Supports a significant agricultural and seasonal recreational land use with productive soils and abundant shoreline along the Bay of Quinte and Lake

Ontario. Population of this area is moderate with small urban centers, limited industry and commercial business.

2.6.3 Settlement Areas

The major settlement areas in the Quinte Region each have their own growth and development strategies. With a few exceptions, proposed growth in the Quinte Region is mainly focused on existing urban centers where adequate servicing is available.
A review of the various official plans indicates that larger urban centers such as Belleville and Napanee are planning for growth in the urban and municipally serviced areas. However, in contrast, some municipalities are planning for a balanced growth between both urban and rural areas.   In some regions, the rural countryside is what attracts people to move to these areas, however, the difficulty lies in balancing the growth in the rural areas without undue pressure on agricultural land and environmental features.

Some excerpts from a random selection of Official Plans are provided as follows to provide the reader with an idea of how local municipalities plan to accommodate future development.

City of Belleville (2002) - Settlement in rural areas is to reflect the diversity and character of the municipality while being sensitive to and/or separated from agricultural, environmentally sensitive, hazardous, and aggregate areas (City of Belleville Official Plan 2002). This diversity will be preserved and enhanced by protecting the historic landscapes and natural features, while directing future growth towards the urban service areas. The hamlets through out the municipality (Foxboro, Plainfield, Latta, Roslin, Halloway and Point Anne) are to function as local service centers, but their growth will be limited.

City of Quinte West (2001) - Diversity will be maintained while improving economic conditions for the creation of jobs, promotion of tourism and development, and enhancement of infrastructure and the environment (Official Plan for the City of Quinte

West 2001). New growth is to occur in the existing urban and rural settlement areas where adequate municipal services are available.

Hastings County (2001) - Further development is planned in the area south of Highway 7, where the economy is diversified and a healthy agricultural industry exists (Ainley 2001). Land use and settlement north of Highway 7 is dependent upon raw resources, supporting forestry, mining, tourism, and recreation. This economic pattern reflects how the economy of the county relates to the physical geography. Development will be directed to the urban centers where adequate municipal services are available. Rural development will be permitted where such development is proven to be environmentally sustainable. Agriculture, forestry, aggregate extraction, and recreational uses shall be encouraged in areas best suited to these activities.

Prince Edward County (2003) - Planned growth for Prince Edward County is based on a combination of land use planning, infrastructure engineering, and financial modeling (McComb 2003). The Picton-Hallowell and Wellington areas have been identified as the main urban centers, where land is already mostly designated but further growth is still expected. In contrast, Bloomfield, Rossmore, Consecon, Ameliasburgh, and Carrying Place all have room for future development. Growth has been targeted for an average of 180 residential units per year for the next 20 years, with the continuation of Picton as the primary urban centre and growth being focused among the seven settlement areas.

The Addington Highlands (2004) - This area anticipates growth within the existing community base, with servicing by private wells and subsurface sewage disposal systems (Cumming 2003). Residential development is to continue around Skootamatta Lake and resource areas such as forests, minerals and aggregate deposits will be protected from incompatible development. Environmentally sensitive areas such as wetlands and fish habitat are to be protected. Approximately 70% of the township is to remain as crown land. Seasonal land use is significant due to the abundance of small lakes in this area.

Cottage and Camp Development

A phenomenon being experienced by some municipalities in rural areas of the Canadian Shield and along the Bay of Quinte/Lake Ontario shoreline is an increased seasonal population with many people attracted to the numerous lakes and summer retreat opportunities (Cumming 2003). An issue associated with this trend is that properties that originated as *seasonal residential* are being converted to year-round use as people retire and decide to take up full time occupancy at their summer properties. This change in land use is common and is not reflected through the securing of proper zoning bylaws. The official plans do not generally indicate a difference between seasonal and permanent residential as this is reflected in the zoning. The percentage of lands in the watershed that are designated as seasonal, and those that might be unofficially year-round must be determined.

Industrial Land Use

Industrial land use is distributed throughout the Quinte Region but predominantly concentrated in the larger urban centers such as Belleville. Industry in the rural areas is typically associated with mining and aggregate extraction operations. Examples are the IKO facility (Asphalt Shingle Plant) near Madoc and the Essroc Cement Plant on the outskirts of Picton. Other significant industrial areas are the Goodyear Plant near the Town of Napanee as well as cheese and other food processing factories located in the agricultural areas near Belleville and in Prince Edward County.

2.6.4 Brownfields

Brownfields are areas that have historically been used for industrial and commercial purposes and therefore can be contaminate sources. As suitable areas for development become scarce a lot of the old properties that were previously used for an activity that may have caused contamination are now becoming more attractive for re-development in some form or another. Such properties range from old gas stations to full service factories. Examples of some brownfields in the Quinte Region include, but are not limited to:

- the Deloro Mine site,
- Meyers Pier on the Belleville waterfront,
- the Bakelite property in Belleville,
- old canning factories in Prince Edward County

Review of the official plans indicated the majority of municipalities do not have specific provisions for dealing with brownfield sites. However, the City of Belleville has provision in the plan which encourages the redevelopment of such sites. The City of Belleville has also recently completed a study to develop a strategy for dealing with brownfields within the City. From this study, an incentive program has been established to provide financial assistance to people in cleaning up and redeveloping such properties. Other municipalities follow the Ministry of the Environment Regulations and record of site condition process to entertain applications for development of brownfield properties. It is anticipated that as municipalities update their official plans, that provisions for incorporating brownfields will be provided.

2.6.5 Landfills

The Quinte Regional Groundwater Study (Dillon 2004) records 205 landfill sites within the Quinte Region (includes the Quinte Region plus all of Hastings County; Map 22). Seventy seven of the sites are considered active for either land filling or as a transfer station, of which 17 are known to be managed by local municipalities; the remainder are privately owned and operated. Many old sites located throughout the watershed are closed and not in use. Others have under gone optimization studies to extend their life.

Recently there was an environmental assessment completed for a large, privately owned site located near Napanee and Deseronto. The Ministry of the Environment denied the application for expansion and the present site is near capacity. As this is a central site used by many of the local municipalities in the watershed, solid waste is now being exported out of the region to other large landfill sites located throughout the Province. The site that remains produces leachate that is gathered via a collection system and discharged to the Town of Napanee Water Pollution Control Plant.

In some municipalities, there is no curb-side pick-up of trash, so residents must travel to the numerous smaller landfills. The common practice of smaller sites is to bury waste without the use of a liner system, thus relying on natural attenuation of contaminants to protect the groundwater. However, the hydrogeologic conditions of the Quinte Region, mainly shallow soil over fractured bedrock, result in a strong potential for leaching of contaminants from these sites and consequent contamination of aquifers. Additional research is required to confirm the status of the various landfills.

2.6.6 Mining and Aggregate Extraction

Mining and aggregate extraction is active in the watershed to varying degrees. Mining activities are concentrated in the Canadian Shield, specifically the northern part of the Moira Watershed (Map 23). Some of the resources have been exploited and abandoned mines are abundant (i.e. Marmoraton Mine near Marmora and fluorite mines near Madoc). These depleted facilities are potential threats to groundwater because they are open conduits to groundwater surrounded by exposed, ground-up, and chemically altered rock. A listing of abandoned sites for the Quinte Region has been obtained from the Ministry of Northern Development and Mines and a review of the location of these sites is needed. In addition to the abandoned mines, exploration holes are often left open or are improperly sealed, creating conduits into the aquifer. The location and details of new holes are typically registered with the Ministry of Northern Development and Mines. Further investigation of the potential impact of these activities is required.

Significant sand and gravel resources in the watershed include a number of ancient beach deposits formed from glacial lakes, as well as outwash deposits which were formed by melt waters (MNR 1975) and the vast quantities of varying quality limestone bedrock. A summary of some of the overburden deposits which serve as reserve for sand and gravel are listed in Table 2.27. These landforms include the Picton Esker, Tweed Esker, and Oak Hills (Kame Moraine). Many of these overburden features also serve as localized important recharge areas for groundwater thus they are often of great ecological significance. Regardless, there are active pits excavated into this resource, however the number and volume of bedrock quarries is greater with numerous sites used for the production of construction aggregate material. Notable sites are located near Belleville at Point Anne, Anniston and Shannonville. Others are located near Picton and Napanee where there is a demand for construction materials. Quarries are also located at Picton for the manufacture of cement and near Madoc for the production of shingle aggregate. Also of interest is a licensed pit for the extraction of clay used for covering and lining a large private landfill site near Napanee and Deseronto.

Table 2.27. Sand and gravel sources in the Quinte Region (MNR 1975).

Location	Landform	Characteristics
Thurlow – Sidney - Huntingdon	Eskers and Beach Deposits	• estimated 100 million tons. • feature is discontinuous over considerable distance.
Sheffield – Tyendinaga	Esker	• estimated 70 million tons. • feature is discontinuous over 40 km length
Picton	Esker	• estimated 80 million tons. • Feature is discontinuous

2.6.7 Oil and Gas

Natural gas is frequently encountered by water wells drilled in the limestone formations throughout the watershed but most notably in the Prince Edward County region. This presents an explosion hazard for well drilling contractors and users of the groundwater due to the potential for build up of gases. Exploration for oil and gas in the Quinte Region took place in the 1930's. Records of boreholes indicate that deep wells were drilled in the limestone units near Belleville, Napanee and in Prince Edward County. A gas pool located beneath the Town of Picton was utilized for a short period by the Picton Natural Gas Company. Historic information about this activity needs to be reviewed; however, it is thought that the exploration indicated the resource to be of limited extent.

2.6.8 Forestry

To understand the current condition of the forest cover in the Quinte Region it is important that the history of forest use be known.

The forests of Eastern Ontario would have first been commercially exploited in the late 18^{th} and early 19^{th} century. Napoleon had cut off Britain's traditional Baltic supplies of timber, forcing her to look west to Canada to supply her needs. White pine for masts and oak for shipbuilding were the earliest targets of the lumberjack. Later, up until the mid 1800's, the square timber trade concentrated on white pine.

In the 1850's, the westward expansion of the United States saw unprecedented amounts of roundwood and sawn timber exported to the south to fuel the associated building boom. By the 1920's very little of the original forest was left.

Natural disturbances (fire, ice storms, insect infestations and wind) also played and continue to play a role in the development of the forest.

Approximately 65% of the Quinte Region is forested. The watershed falls in site region 5E and 6E (Hills 1952) and is considered to be part of the Great Lakes-St. Lawrence Forest Region (Portions of Prince Edward County exhibit Carolinian characteristics and is considered to be part of the Deciduous Forest Region). The forest ranges in age from young, newly established forests to large mature stands. The bulk of the forest is in the 61-100 year old age class.

Settlement patterns and agriculture have left us with a variety of forests. Small fragmented and interlinked forests tend to occupy the southern third of the watershed while the northern two thirds of the watershed tend to be core forests with multiple ownerships.

Fragmented forests or forest islands are small isolated areas of forest cover with an abundance of forest edge. Invasive species are more common and animals that are dependant on forest interior cannot utilize these stands.

Interlinked forests refer to broken blocks of forest (<100ha) connected by treed fencerows, riparian zones or other natural areas. They permit better movement by animals and exchange of genetic material than fragmented forest or forest islands. However, they have more forest edge per hectare than core forest making them more susceptible to invasive species.

Core forest refers to unbroken blocks of forested land, at least 100 hectares in size that contain large areas of interior forests. These forests support species and genetic diversity that are important on a regional scale.

The correlation between forest cover and water quality/quantity and air quality is well documented and there is no need to cover those details here. Large, healthy, productive core forests are better at providing these benefits than forest islands are but any tree cover is beneficial.

The forest in the Quinte Region is still very much a working forest and plays an important social and economic role in the watershed.

The largest sawmill in the watershed is Chisholms (Roslin) Ltd. and is considered to be a medium sawmill with an annual output of between 5,000 to 50,000 cubic meters a year. Vallieres, Wilson's Forest Products, Empey, and Murphy Lumber, all of Madoc, are considered to be small mills with outputs of less than 5,000 cubic meters per year.

In Hastings County, 1,945 jobs are directly related to the forest industry. Local industry suggests that the amount of stumpage paid to public and private landowners for roundwood delivered to their mills is approximately $5,000,000 per year. The finished products from mills in Hastings County have a combined estimated value of $90,000,000 (Hastings County Stewardship Council 2007).

Close to 70% of the land north of highway seven, in the watershed, is crown land. The responsibility of managing the crown forests lies with the Mazinaw/Lanark Sustainable Forest Licence (SFL) and the Bancroft/Minden Sustainable Forest Licence. The bulk of these lands would be managed (due to existing species cover and site suitability) using the Selection Silvicultural System and to a much lesser extent the Shelterwood Silvicultural System. Both of these systems emulate natural disturbances and are both partial removal systems. Forest operations occur on approximately 400ha per year.

The SFLs and compliance officers from the Ontario Ministry of Natural Resources closely monitor harvests. Areas of concern are identified in Forest Management Plans and modified operations or no operations are allowed. Wetlands, streams, steep slopes, shallow soils, rare plant communities and wildlife requirements are all taken into account when prescriptions are set and operations planned. Seasonal seeps and runoff areas are avoided when laying out skid trails.

Quinte Conservation owns approximately 12,100 ha of land with 9,400 ha in a Managed Forest Plan. Due to site conditions, a large portion of the forest will never be “working forest” but will be retained as is for environmental objectives. Forest operations have occurred on an average of 30 ha/year over the past five years. It is estimated that within 20 years an annual allowable cut of 110 ha will be achievable. Half of this will be in the Red and White Pine Working Group (artificially established plantations) and the other half in the Tolerant Hardwoods Working Group. Restrictions, similar to those on crown lands, are put in place to ensure environmental and wildlife requirements are met.

Private forests in the watershed are under no restrictions. Some municipalities in neighbouring watersheds have enacted tree-cutting bylaws in an attempt to control less than desirable harvesting activities. Unfortunately these bylaws tend to be based on a diameter limit, which does not encourage healthy productive forests.

There are no free private lands forest management outreach programs in the watershed. The Ontario Woodlot Association, Stewardship Councils and the Upper Canada Woods Co-operative are all organizations that landowners can contact for information and advice on maintaining their forests. There are a number of private consultants who will provide services for a fee within the watershed.

There are 930 properties for a total of 156,000 ha involved in the Managed Forest Tax Incentive Program in Hastings County. This is not a guarantee of acceptable forest management practices being applied but at least these participants have received some information on recognized silvicultural practices.

Not maintaining buffers around wetlands and waterways, improper stream crossings, harvesting in times of the year where soil compaction and residual stand damage are increased and excessive rutting are all too common on private lands.

Another disturbing trend seen on private lands is the expansion of agricultural fields through the removal of treed fence lines. This eliminates travel corridors for wildlife and increases soil erosion through the action of wind and precipitation.

The two major urban centres in the watershed, Napanee and Belleville, have both seen the demise of woodlots due to development.

Recreational use of crown forests and Quinte Conservation forests are steadily increasing with detrimental effects. Users of all terrain/off road vehicles are continually pushing new unauthorized trails across the landscape. Little thought is given to the environment as trails are generally put down the path of least resistance. As trails with stream crossings and trails through wetlands or areas of high moisture regime become unusable vehicle operators travel either side of the damage, increasing the associated negative impact.

Challenges to maintaining and improving the health of forest cover in the Quinte Region include the following:

Climate change - the effects and approaches taken to counteract detrimental effects are unclear at this time.

Private forest owners - Forest management educational opportunities are available to private landowners, unfortunately poor practices still occur. The lack of a free outreach service and no legislation may be factors.

Disease and Insect infestation - a number of introduced pests have the potential to damage forest cover in the future.

On a positive note, tree cover has increased over the last 30 years in the watershed. Marginal farmlands in the north and to a lesser extent in the south are being allowed to revert to tree cover either through natural succession or through tree planting.

2.6.9 Transportation

The major transportation infrastructure in the watershed region includes provincial highways connecting the major urban centers (see Map 1). Secondary municipal roads connect the other communities throughout the watershed. Rail service is centrally focused, with the main line passing in an east-west direction through Belleville and Napanee. Other lines existed historically but have been abandoned and converted to recreational trails. Non-military airports are few, with a regional airport in Quinte West, small private flying clubs, and air strips in Belleville, Picton, and Napanee. Larger military air transport operations are operated at CFB Trenton to the west of Belleville which includes a satellite facility located at Mountainview in Prince Edward County. This facility as well as the former military air base in Picton is used extensively in the summer months by air cadets in the flying of glider planes.

Local waterways are used primarily for recreation and leisure; however, commercial shipping is still active from the cement plant in Picton for transport of product. A historic port at Picton is also used occasionally. This port was originally used for the transportation of iron ore from the mine near Marmora which was brought to the port via railroad. Other water transport includes a provincially operated ferry service which links Prince Edward County to Loyalist Township.

2.6.10 Wastewater Treatment

There are a number of wastewater treatment plants across the region that treat municipal and non-municipal waste. Municipal wastewater treatment facilities are as shown on Map 24 and include large water pollution control plants for the major urban centers of Belleville, Napanee, Deseronto, Picton, and Wellington. Tweed and Madoc are serviced by lagoons which discharge seasonally to surface water under high flow conditions. The Village of Deloro is serviced by a central subsurface septic system. The wastewater treatment facilities as listed above predominantly service all of the urban areas within the respective municipalities as illustrated by Map 24. Other wastewater treatment facilities exist for industrial and commercial facilities, including industrial factories, settling ponds for aggregate operations, and large septic systems at trailer parks and campgrounds. Wastewater receivers were inventoried in the Quinte Regional Groundwater Study (Dillon 2004).

Serviced versus Non-serviced Areas

Large urban municipalities are typically serviced with both water and sewer. However smaller population centers, especially in Prince Edward County, are serviced with water only (i.e. Ameliasburgh, Peats Point, Bloomfield, Consecon, Carrying Place, and Rossmore) and maintain individual, private septic systems. These serviced areas are as delineated on Map 24 which illustrates areas that are serviced by municipal water and sewer as well as areas that are serviced by municipal water only. The balance of the rural areas, which comprise the majority of the area of the watershed are serviced by private wells and septic systems. In terms of population of the watershed, approximately 52% of the residents in the watershed are provided with Municipal services and 48% utilize individual private services.

In spite of the above, in some municipalities there is a small amount of mixed servicing whereby there are isolated properties that do not have complete services. This is evident in the Village of Madoc as well as in other centres where either partial or full services have been extended. In such situations some individual or groups of residences are serviced by individual private septic systems and/or wells.

Septic Systems and Wastewater Treatment Facilities

In the Quinte Region, septic system inspection/approvals are completed by the municipalities through the building officials. Some municipalities in Lennox and Addington County contract these services to the Kingston, Frontenac, Lennox and Addington Health Unit. Large septic systems with total daily sewage flows greater than 10,000 litres per day, or where sewage disposal is off site, are the responsibility of the MOE. Records are kept of septic system locations by the respective authority.

Given large areas of rural land that are not municipally serviced there are many septic systems throughout the Quinte Region existing for both individual private homes as well as for communal systems servicing campgrounds, schools, churches, etc. The number of private septic systems can be estimated and requires review of the number of permits issued by the different authorities in comparison to the number of rural dwellings. A review of data on communal water systems in the region indicates there may be upwards of 200 communal wastewater systems in the area. For the most part such systems would be conventional septic tanks and leaching fields.

Stormwater Management

Quinte Conservation acts as the lead agency for the Stormwater Management Program of the Bay of Quinte Remedial Action Plan (Appendix 10). One of the recommendations of the Bay of Quinte Remedial Action Plan was that stormwater quality control must be provided for new urban development in municipalities with frontage on the Bay of Quinte. A stormwater quality control program was initiated for the Bay of Quinte in 1991 to ensure that this recommendation was addressed. Many stormwater management treatment systems have now been constructed (see Map 25 for a sample of some). A common technique used for these systems is the installation of ponds or wetlands areas. These ponds allow the storm runoff to slow down, temporarily storing excess water and allowing sediment to settle out of the water. As many contaminants adsorb to sediment, water quality improves in direct relationship with settling time. The aquatic plant life in the ponds also helps absorb some of the nutrients in the water. Furthermore, the ponds retain the water longer, allowing the sunlight to kill some of the bacteria.

There are other mechanical systems to treat stormwater but the installation of ponds is often preferred if there is enough room to construct them because they are relatively inexpensive to install and require very little maintenance.

Quinte Conservation's Water Resources Engineer coordinates the Bay of Quinte Stormwater Management Program. Water quality and quantity targets are set to meet Bay of Quinte Remedial Action Plan guidelines. The Water Resources Engineer reviews all applications for new development to ensure compliance with these guidelines. As municipalities updated Official Plans and Secondary Land Use planning documents, policies were included that recognize the need for stormwater management.

2.6.11 Agricultural Resources

Agricultural Sector Distribution

Agriculture is the major land use in the southern Quinte Region, where 20 to 90 cm of soil commonly overlies the limestone rock and sediment (Gillespie 1962; Richards 1948). In Hastings County, approximately 20% of land is classified as agricultural (Dillon 2004; Statistics Canada 2000); this estimate will be used for the entire Quinte Region until specific information is available for the other counties.

Trends in Agriculture

The number of farms in the area has recently decreased, but the total area of farmland has only slightly decreased, suggesting conglomeration of small properties into larger farms. The area of intensively cultivated crops such as corn and soybeans has been increasing while that of hay, oats and barley has been decreasing. Fruit and vegetable area has decreased with a few minor exceptions.

Overall, agriculture is changing in the Quinte Region, to increased intensity over a smaller area. Therefore, water and waste management will need to plan for this shift. Agriculture, as a large industry in the region, is an important factor to be considered when planning for ground and surface water resources.

2.6.12 Recreation

The Quinte Region has an abundance of recreational activities taking place on waterways and various types of land. Tourism and recreation have a huge economic and environmental impact in the region, most of which revolves around waterways (see Section 2.7 – Recreational Water Use). In addition, numerous Conservation Areas, Conservation Lands, Crown Land, Provincial Parks, ski and snowmobile trails, golf courses, and hiking and biking trails are distributed throughout the Quinte Region (see Map 26). These recreational activities present a range of issues related to drinking water source protection. For example, maintenance of a golf course requires irrigation, fertilization, and pest management, leading to issues with both water quality and quantity.

2.6.13 Protected Lands

Much of the protected land in the Quinte Region is also valuable habitat (see Section 2.4 – Naturally Vegetated Areas). In addition to protected wetlands and habitats, some areas have been set aside for environmental or aboriginal use (Map 27 and Appendix 9). In these protected areas, invasive activities, for example, road construction or resource extraction usually require pre-approval and permitting from the appropriate management agency in order to avoid or minimize environmental impact. Where people occupy (live on) or use (carry out commercial activities on) protected land, they may be granted "tenure" over the land and provided exclusive rights. Most of the protected land in the Quinte Region is administered by the Ministry of Natural Resources. However, some protected lands fall under the control of the federal government, including aboriginal territory, harbours and canal systems.

References

Ainley (2003?). Official Plan of the County of Hastings. Belleville, Ontario Canada, Ainley Group.

City of Belleville Official Plan (2002). Belleville, Ontario Canada, City of Belleville and Ainley Graham & Associates Ltd.**:** 120 + Appendices.

Cumming (2003). The Official Plan of the Township of Addington Highlands - Draft No.2. London, Ontario Canada, Cumming Cockburn Ltd.**:** 76 + Appendices.

Dillon (2004). Quinte Regional Groundwater Study, Prepared by Dillon Consutling Ltd. for Quinte Conservation**:** 194 + Appendices.

Gillespie, J. E., R.E. Wicklund, N. R. Richards (1962). Soil Survey of Hastings County. Guelph, Ontario Canada, Research Branch, Canada Department of Agriculture and the Ontario Agricultural College 72 + Maps.

Hastings County Stewardship Council (2007). Forest Management in Hastings County and Forest Services Directory: 28.

Hills, G.A. (1952). The Classification and Evaluation of Site for Forestry. Report No. 24. Ontario Department of Lands and Forests: 142.

McComb, B. R. (2003). Prince Edward County Growth & Settlement / Servicing Strategy Background Report. Official Plan Amendment. Picton, Ontario Canada, The Corporation of the County Prince Edward 175 + Appendices.

MNR. (2000) A Silvicultural Guide to Managing Southern Ontario Forests, Version 1.1.Ont.Ministry of Natural Resources. Queen’s Printer for Ontario. Toronto: 648.

MOF. (2000). "Ontario Population Projections Update." from http://www.fin.gov.on.ca/english/economy/demographics/projections/.

Official Plan for the City of Quinte West (2001). Trenton, Ontario Canada, City of Quinte West Planning & Development Department**:** 88 + Maps.

Richards, N. R., F. F. Morwick (1948). Soil Survey of Prince Edward County. Guelph, Ontario Canada, Experimental Farms Services, Dominion Department of Agriculture and the Ontario Agricultural College: 86 + Map.

Statistic Canada. (2000). "2000 Community Profiles. 2001 Census." Statistics Canada Catalogue no. 92-591-XWE, from http://www12.statcan.ca/english/census06/data/profiles/community/Index.cfm?Lang=E.

2.7 Water Uses

The estimated water use from the Quinte Region water resources totals 29.7 million cubic meters per year ($m^3\ yr^{-1}$), with 16.4 million $m^3\ yr^{-1}$ acquired from groundwater and the remaining 13.3 million $m^3\ yr^{-1}$ from surface water. These volumes are maximum permitted values and are not currently considered as actual usage. The figures do not include water use from the Great Lakes (Lake Ontario, Bay of Quinte, and connecting channels), only the surface water and groundwater that actually pass through the Quinte Region watersheds. The breakdown of water use in the Quinte Region illustrated by Figure 2.8 includes industry (mainly aggregate quarries), private wells, agriculture and municipal needs.

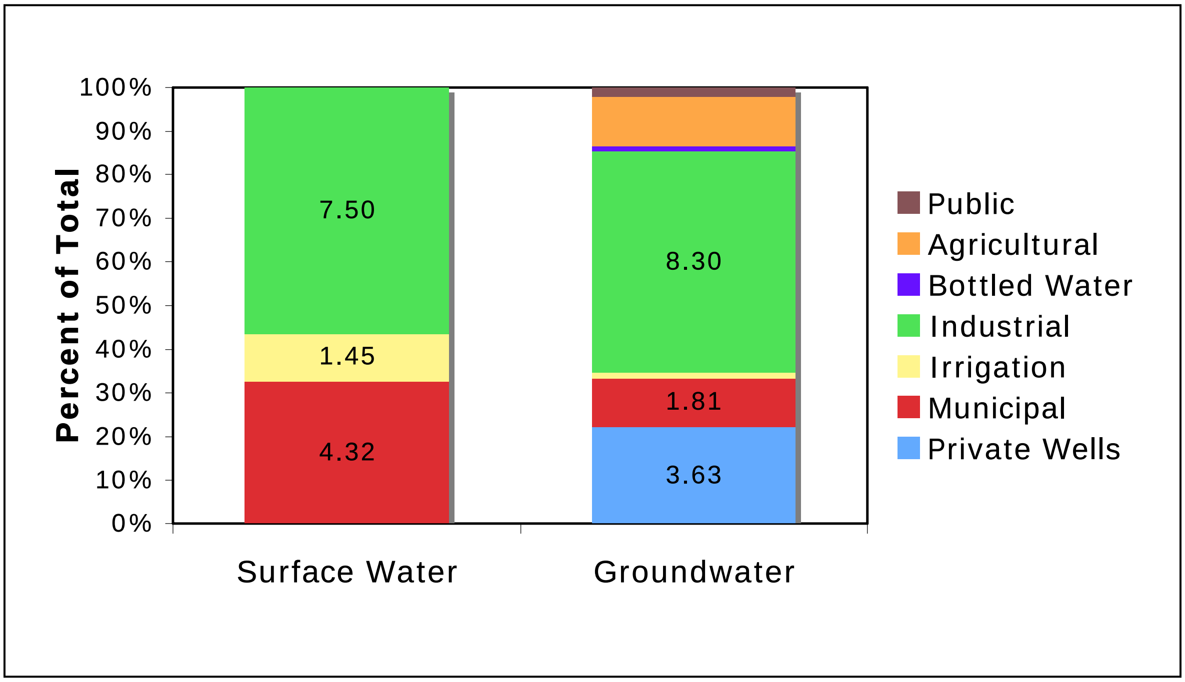


Figure 2.8. Water Use in the Quinte Region. Surface and groundwater supplies provide approximately equal amounts of water in the Quinte Region; however, the uses from these supplies differ. The largest water uses for surface water and groundwater have been labeled with amounts (numbers are in million m^3 yr^{-1}).

Water Use in the Quinte Region has been detailed under water budget studies completed by Quinte Conservation (Quinte Conservation 2006). Please note that the total use figures as listed above are based on permitted values as opposed to actual use. As such it is anticipated that industrial use of water (mainly dewatering of quarries) is not the actual highest user of water in the Quinte Region. This requires further review of the Permit to Take Water (PTTW) process. Additional information about the PTTW program is summarized in a pilot study (XCG 2003) which was completed in 2003 for Quinte Conservation and the Long Point Region Conservation Authority. The purpose of this study was to assess how monitoring and reporting is completed under the MOE Permit to Take Water Program. The study found the issue to be complex and identified short comings in the existing MOE PTTW Database. A recommendation of the report was to phase in monitoring requirements to allow permit holders to gather more accurate data on water use.

2.7.1 Drinking Water Sources

Drinking water sources in the Quinte Region are divided almost equally between groundwater and surface water as illustrated by Figure 2.9. Approximately half of the watershed population that live in the urban centres, are serviced by municipal drinking water systems from surface water sources. Most of the remaining residents are serviced by private groundwater wells, shore wells, and direct private intakes from the Bay and Lake. Approximately 3% of the total population located in Madoc, Tweed, Deloro and Peats Point are serviced by municipal groundwater wells.

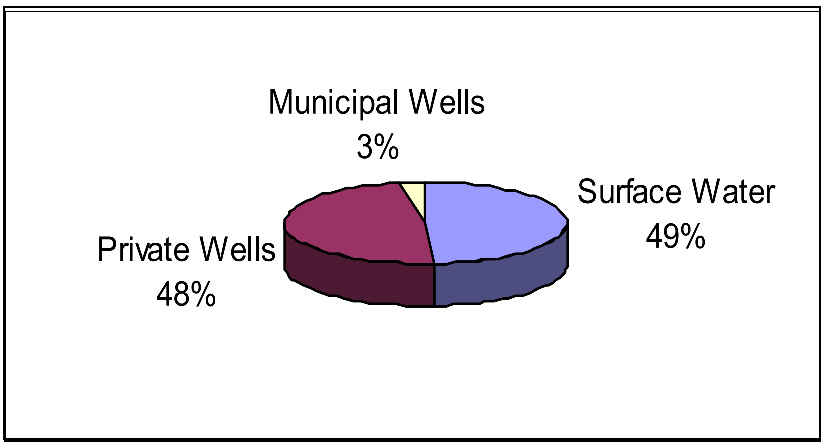


Figure 2.9. Water sources in the Quinte Region.

Surface water, including rivers, lakes, and the Great Lakes sources, are used by most municipalities. Most groundwater is accessed by private wells. The various sources of drinking water used by the region include bedrock aquifers, small lakes and the Great Lakes as listed in Table 2.28. Please note a small area in the northwest corner of Prince Edward County (Hamlets of Carrying Place and Consecon) is serviced by municipal water from a system that is located outside of the Quinte Region watershed as is the main drinking water intake for the Town of Napanee.

Table 2.28. Municipal Sources of Drinking Water for the Quinte Region.

Municipality	Source		
	Surface Water	***Groundwater Aquifer***	***Great Lakes***
Ameliasburgh	Roblin Lake		
Belleville			Bay of Quinte
Carrying Place	Trent River (Quinte West)		
Consecon	Trent River (Quinte West)		
Deloro		Precambrian	
Deseronto			Bay of Quinte
Madoc		Precambrian	
Napanee	Napanee River (backup)		Lake Ontario
Peats Point		Limestone	
Picton			Bay of Quinte
Point Anne			Bay of Quinte
Tweed		Precambrian	
Wellington			Lake Ontario

Municipal Groundwater Systems

Four small urban centres are serviced by municipal wells with the locations as illustrated by Maps 28 - 31. The well head protection areas have been delineated for each of these groundwater systems as part of the Municipal Groundwater Study program recently completed across the province. The Quinte Regional Groundwater Study is part of this program under which three-dimensional modeling of groundwater flow in the Tweed, Madoc, and Peats Point systems was completed. The Deloro system was evaluated under the Trent Conservation Coalition study. These assessments also include an inventory of potential sources of contaminants within the well head protection zones.

Communal Groundwater Supplies

Communal groundwater supplies are located throughout the Quinte Region at the locations as illustrated by Map 10. There are approximately 200 systems in the Quinte region which service a range of facilities including churches, camp grounds, schools, municipal halls, nursing homes etc. Other than the location of these systems little is known about the quantity and quality of supply at each well.

Private Groundwater Supplies

Private drilled and dug wells supply 48% of the Quinte Region residents. Information about these supplies may be obtained from Ontario Water Well Records, for which there are approximately 22,000 within the Quinte Region. The location of wells with reliable UTM co-ordinates have been plotted on Map 10, which illustrates the majority of the wells are located in the populated areas throughout the area south of Highway # 7. A comparison of the number of wells with the rural population equates to approximately 3 persons per well. In Prince Edward County this number is higher due to the prevalence of shore and dug wells which are largely unregistered. Current regulation requires all new dug wells to be registered, however there was a period in the past when this was not the case. Further information regarding the aquifers that these wells intercept is discussed under the hydrogeology section of this report. A well density map has been developed to show density of private wells (Map 44).

Municipal Surface Water

Within the Quinte Region, seven municipal water supplies access surface water at the locations illustrated by Map 32. All but two of the intakes draw water from Lake Ontario or the Bay of Quinte with the remaining intakes located on the Napanee River and at Roblin Lake. These two intakes service the Hamlet of Ameliasburgh and the Town of Napanee (backup intake). Currently, intake protection zones are being delineated for all of these systems in order to inventory the potential sources of contaminants within these zones.

2.7.2 Recreational Water Use

Water-based recreational activities provide a strong economic base for the entire Quinte Region (Table 2.29). In addition to tourism revenue, the water-based recreation industry on the Bay of Quinte has attracted numerous canoe, kayak and sport fishing companies. For example, Clearwater Designs, a major Canadian canoe and kayak manufacturer, recently moved its operation from Kingston to the shores of the Bay of Quinte and increased its workforce to 20.

Table 2.29. Water-Based Recreation in the Quinte Region

Activity	Location	Additional Information Source
Recreational Boating	• Trent-Severn Waterway • Bay of Quinte • Lake Ontario • Numerous lakes	www.ftsw.com/ www.quinte.on.ca/sites/maps.html#
Sport Fishing ice & open water	• Bay of Quinte • Lake Ontario • Numerous lakes &streams	www.lennox-addington.on.ca/tourism/ www.quintefishing.com/MNRwinter2004update.htm
Waterfront Trail	• connects communities along the shores of Lake Ontario and the Bay of Quinte. • includes over 500 km of shoreline cycling trails	www.waterfronttrail.org/pdfs/US_Sec123.pdf
Camping and Day Use	• Provincial Parks • Beaches • Conservation Areas	www.ontarioparks.com/english/sr3.html www.pec.on.ca/other/conserv.html www.quinteconservation.ca/index.php
Birdwatching	• wetlands • protected trails • boardwalks • Prince Edward County Birding Festival	www.web-nat.com/bic/ont/pecounty.html www.pec.on.ca/other/birds.html

Activity	Location	Additional Information Source
Waterfront Festivals	• Belleville Waterfront Festival • Wellington Waterfront Festival • Quinte Spirit Festival (Napanee) • Horn Trip Festival (Prince Edward County) • Tyendinaga Mohawk Powwow • Music, Concerts and Shakespeare in the Park throughout the Quinte Region	www.bellevillewaterfrontfestival.com/ www.pecchamber.com/events.htm www.pec.on.ca/quintecal/index.php

2.7.3 Ecological Water Use

Although the focus of this characterization is source water protection, a natural outcome of clean and plentiful water is the benefit to ecosystems. In turn, healthy ecosystems help protect water resources through attenuation of streamflow, prevention of accelerated erosion, and filtration of surface water. Details of ecological needs in the Quinte Region are still required.

Lake residents have formed lake associations on several lakes in the Quinte Region. Some lake associations are participating in lake management planning that involves lake association members working with local government to provide direction on future development around the lake. Important environmental, social, and cultural values are identified during the lake planning process while visualizing the larger planning, watershed, and land use context. The outcomes of the visualizing exercises and lake association mandates give good insight into the environmental and ecological needs of the residents in the Quinte Region.

The Kennebec Lake Association has been working with Quinte Conservation since December of 2005. Kennebec Lake, located north of Highway #7 near Arden in the Township of Central Frontenac has identified their environmental mandate as preserving and enhancing the water quality, air quality, peace and tranquility, nature and wildlife, and lifestyle in the Kennebec lake watershed. The specifics of these elements are still to be defined through monitoring and the development of guidelines during the planning process. Water quality monitoring and regular visualizing continue to play an important role in the lake planning stage.

Quinte Conservation plans to work with more stakeholder groups in the same capacity as with the Kennebec Lake Association. These partnerships will allow for better working relationships with stakeholders and allow for a better understanding of the region's ecological needs.

2.7.4 Agricultural Water Use

Approximately 1.86 million m^3 (DeLoe 2002) of water are used in the Quinte Region each year for agriculture, including livestock watering, irrigation and miscellaneous agricultural uses (i.e. filling of sprayers). A study was completed on agricultural water use in Ontario on a sub-watershed basis. This study provides agricultural water use data including livestock watering and irrigation using 1996 Agricultural Census information. Because agriculture is vital to the economy of the Quinte Region, a full understanding of water needs must be achieved, including what is used for livestock, irrigation, and processing. In addition, the possible impact of agriculture on surface water and groundwater resources is to be assessed.

2.7.5 Industrial Water Use

Industrial water uses account for approximately 15.8 million m^3 yr^{-1} in the Quinte Region, including that used for resource extraction and processing. As previously mentioned, this volume accounts for permitted use and is not currently reflective of actual use. The Permit to Take Water pilot study will enable us to assess industrial uses of water, including where and when it is taken.

References

DeLoe, R. (2002). Agricultural Water Use in Ontario by Subwatershed: Estimates for 2001. August 15, 2002, Ontario Ministry of Natural Resources.

QuinteConservation (2006). Water Budget: Quinte Region: Final Report. Belleville, Ontario Canada, Quinte Conservation**:** 68 + Appendices.

XCG (2003). Permit to Take Water Monitoring and Reporting Pilot Study. Kingston, Ontario Canada, XCG Consultants Ltd. In association with Quinte Conservation and Long Point Region Conservation Authority Submitted to Conservation Ontario**:** 11 + Appendices.

2.8 Knowledge and Data Gaps for Watershed Description

Fisheries

Studies that locate sensitive fish species in groundwater discharge areas and headwaters.

3.0 WATER QUALITY

The purpose of this section is to provide a general assessment of current surface water and groundwater quality and to eventually identify spatial and temporal trends using data from various sources. The objectives are to:

a) Inventory existing sources of information and document deficiencies in information – Data has been compiled from existing sources that are listed in the following sections;
b) Describe the current state of surface and groundwater quality – Water quality issues have been identified for both surface water and groundwater (Table 3.1.) and will be explained further in the following sections; continued monitoring will enable us to identify any other issues;
c) Identify long-term trends in order to identify improvements or deteriorations in water quality.

Table 3.1. General water quality issues in the Quinte Region

Surface Water	**Groundwater**	
Arsenic Phosphorus Nitrogen (inorganic and organic) Water clarity Pathogens	Chloride Sodium Methane gas Hydrogen Sulphide Hardness Uranium	Pathogens Nitrogen Hydrocarbons

Surface Water

Existing surface water quality data for the Quinte Region is available from a variety of sources, each with its own monitoring program (Table 3.2). These monitoring programs are ongoing and help track the major water quality concerns for the Region (Table 3.3).

Table 3.2. Sources of data for surface water quality in the Quinte Region.

Program	What is monitored for Quinte Region	Earliest Available Data
Provincial Water Quality Monitoring Network (PWQMN)	• Effectiveness of pollution control on rivers and streams • 29 current sites plus 13 sites no longer active	1964
Ontario Lake Partner Program	• Nutrient and clarity conditions of lakes • 22 lakes monitored	2002
Drinking Water Information Systems (DWIS)	• Quality of raw and treated drinking water • 15 drinking water systems	2003
Drinking Water Surveillance Program (DWSP)	• Quality of raw, treated, and distributed drinking water • 5 drinking water systems	1987
Bay of Quinte Remedial Action Plan (RAP)	• Quality of surface water	1985
Ontario Benthos Biomonitoring Network (OBBN)	• Quality of surface water and benthic macroinvertebrate composition • 27 reference sites	2005
Health Unit Beach Closures	• *E.coli* results from beach sampling	2006

Table 3.3. Surface Water Concerns for the Quinte Region.

Water Quality Concern	**Implications**	**Known Sources of Contamination**	**Geographic Extent**	**Water Quality Data Source**
Arsenic	• Acutely or chronically toxic to humans and a threat to aquatic biota • Arsenic has settled out along the Moira River downstream from Deloro, therefore any disturbed sediment releases arsenic to stream water from Deloro.	• Former Deloro Mine site (closed in 1961). Contaminated substrate in the Moira River and outflow into the Bay of Quinte.	• High concentrations have been found in the Moira River downstream from the Village of Deloro and in Moira Lake.	PWQMN, DWSP, Bay of Quinte RAP
Phosphorus	• Runoff that contains phosphorus may lead to increased growth of aquatic plants and algal blooms resulting in eutrophic conditions.	• Runoff of fertilizers, sewage, and waste water from industrial, agricultural, and domestic sources including septic systems located throughout the Quinte Region.	• Many streams monitored in Quinte Region exceeded the provincial objective. • 3 of 22 Lake Partner Program lakes are eutrophic. • Bay of Quinte was hyper-eutrophic in the 1950s and concentrations have improved.	PWQMN, Lake Partner Program, DWSP, Bay of Quinte RAP, Quinte Conservation OBBN.

Water Quality Concern	Implications	Known Sources of Contamination	Geographic Extent	Water Quality Data Source
Nitrogen	• Runoff that contains organic nitrogen may lead to increased growth of aquatic plants and algal blooms resulting in eutrophic conditions. • Nitrate (inorganic nitrogen) in drinking water at high concentrations can be harmful to humans and animals, if consumed. Infants and pregnant women exposed to elevated concentrations of nitrate in drinking water are susceptible to blue baby syndrome where blood has a limited capacity to be oxygenated.	• Runoff from sewage, septic systems, and barn yards found in agricultural, rural area, and urban developed areas with sewage treatment plants in the Quinte Region.	• All streams monitored in Quinte Region exceeded the provincial standard. • Marsh Creek in Prince Edward Region was the only monitored stream with total nitrates (inorganic) greater than the provincial standard.	PWQMN, DWSP, Quinte Conservation OBBN.
Clarity of water	• Reduced clarity impedes light and gas diffusion into water. • Measured as *turbidity* (floating particles and *total residue* (dissolved substances) in streams. • Measured as *clarity* in lakes • Hazardous or toxic at high concentrations when the	• Runoff of eroded soils and fine sediments during rain events. • Municipal/industrial effluent runoff and spills, nutrient runoff, and aerosol fallout. • Waterbodies that do not have adequate	• Riparian buffer strips less than 30 m wide are found throughout the Quinte Region. • Most monitored streams in Quinte Region exceeded the provincial standard for turbidity. • Some monitored streams	PWQMN, DWSP

Water Quality Concern	Implications	Known Sources of Contamination	Geographic Extent	Water Quality Data Source
Clarity of water	dissolved or suspended material is toxic algae or materials.	vegetated riparian buffers.	exceeded the provincial standard for total residue. • 3 of 22 Lake Partner Program lakes had poor clarity.	
Pathogens (*E.coli*)	• Hazardous to humans and animals. • An indicator of fecal contamination, including bacteria and viruses.	• Runoff of animal farm yards and fields, parks, etc. • Swimming beaches had high counts.	• Many monitored streams in the Quinte Region exceeded the provincial objective. • Bay of Quinte has elevated counts at inflows and swimming beaches.	PWQMN, DWIS, Bay of Quinte RAP

Major Surface Water Concerns in the Quinte Region:

Arsenic

Arsenic is known to be carcinogenic and acutely or chronically toxic to humans and is a threat to aquatic biota at high concentrations. It can accumulate overtime in the fat of animals (bioaccumulate) and, in severe cases, this poisoning leads to death. Small quantities of arsenic compounds are found naturally in certain waters from dissolution of minerals like those found in the Precambrian rocks of the Canadian Shield. Concentrations from natural sources are not a concern to the health of aquatic ecosystems, but surface drinking water should be treated for arsenic as a precaution. Sources of arsenic from human activity include industrial discharge, arsenical insecticides, and herbicides. Industrial products that use arsenic include manufacturing of glass, pigments, textiles, paper, metal adhesives, ceramics, linoleum, mirrors, wood preserves, paints, and electrical semi-conductors. Arsenic is also present in precipitation and dust due to the combustion of fossil fuels (McNeely et al. 1979). Finally, arsenic is a by-product of smelting and "roasting" of ores from copper, lead, gold, silver, and cobalt. This is the predominate reason for arsenic occurring in the watershed.

The mine in the Village of Deloro was built as a gold mine in the late 1860's and operated through to the early 1900's. At that point, the site began to process silver and cobalt ores imported from other mines (MOE, 2001). The mine became inactive in 1961 when the Deloro Mining and Smelting Company closed its plant. The historic activities of the Deloro mine allowed arsenic to travel downstream, past several urban settlements, to the mouth of the Moira River in Belleville and into the Bay of Quinte for almost 150 years. Arsenic has settled out along the flow path resulting in the adoption of the current regulation against dredging in the Moira River anywhere downstream from the Village of Deloro. The MOE assumed responsibility for the management of the former mine site as "remediator of last resort" in 1979. These remedial actions have significantly reduced the contamination of arsenic and many other heavy metals by 80%

(MOE 2001). However, arsenic concentrations (greater than 0.1 mg/L) in the Moira River downstream from Deloro continue to be a concern.

Phosphorus and Nitrogen

Phosphorus and nitrogen are essential nutrients for healthy biological function and are naturally found in waterbodies, but can create nuisance algae and macrophytes (aquatic plants) when these nutrients are present in overabundant concentrations. Total Phosphorus (TP) is a measure of organic and inorganic forms of phosphorus that are found in the aquatic environment. Natural sources of the phosphorus element are the weathering of igneous rock and the decay of organic matter. Human caused sources are domestic sewage (with human excrement and phosphates from detergents), industrial effluents, and runoff of fertilizers from agricultural fields, urban lawns, and golf courses. Phosphorus is subject to atmospheric transport and deposition. Chemically similar to phosphorous, phosphates are known to be one type of passive corrosion inhibitors that are added to water supplies to prevent scale formation on the metal equipment, inhibit corrosion, and enhance laundry and cleaning efficiency (McNeely 1979).

Similar to phosphorus, organic nitrogen may lead to eutrophication (high nutrient conditions) of waterbodies when released into the aquatic environment (McNeely et al. 1979). Nitrogen levels are measured in the form of Total Kjeldahl Nitrogen (TKN) which is both inorganic nitrogen (Ammonia) and organic nitrogen. Anthropogenic (human) sources of organic nitrogen are septic tank and sewage effluent. Inorganic nitrates are measured as Total Nitrates and are naturally occurring in the environment as they are produced from the decomposition of vegetation and animal debris when nitrogen is exposed to oxygen. Industrial discharges and municipal sewage discharges, particularly human excrement, and fertilizer runoff from agricultural lands and urban lawns are potential sources of inorganic nitrogen.

Consuming water for drinking with elevated inorganic Nitrate concentrations (greater than 10 mg/L = ODWS) decreases the oxygen-carrying capacity of the blood and should be avoided by humans and animals (McNeeley 1979). Infants and pregnant women are particularly vulnerable as over exposure to nitrates can cause blue baby syndrome.

The presence of these nutrients can be controlled through responsible land use management practices; otherwise they will contaminate surface water and groundwater during precipitation events and irrigation. Phosphate controls were put into place by the Canadian government in the 1970s, restricting the content of phosphates in laundry detergents at 5% down from as much as 45%. Products, such as phosphate-free laundry detergents and the development of a phosphorus substitute called nitrilotriacetic acid (NTA), have assisted in the decline of phosphorus pollution in Canada.

Turbidity

Turbidity measures the effect of suspended particles on the clarity of surface water. Weathering of bedrock and soil erosion, algae and aquatic plants, decaying plant matter, particles from water treatment processes, and air bubbles all result in suspended and dissolved substances in surface water. The presences of these substances decrease how gases and light are transmitted through the water, affecting ecosystem health (reducing plant photosynthesis and plant food for fish, etc). Turbidity can be hazardous or toxic at high concentrations when the suspended material is toxic algae or asbestiform minerals.

E. coli

Escherichia coli (*E. coli*) is the only microbial indicator with data in the monitoring program for the PWQMN. Sampling for E.coli in the PWQMN has been discontinued at most stations in the Quinte region with the exception of those in Prince Edward County. This type of bacteria has hundreds of strains, most of which are harmless. They live in the intestines of humans, insects and other animals, and are naturally present in soils. However, some strains produce toxins that cause illness if ingested by animals (including humans). As bacterial tests for water are not specific to any one strain of *E. coli*, the count is only an indicator of pathogens (as a threat of illness) due to fecal contaminants, including other bacteria and viruses. Sources of contamination include runoff from pastures, barn yards, and sewage treatment plants, in addition to improperly placed and poorly maintained septic systems.

3.1 Surface Water Quality - Selecting Indicator Parameters

Water chemistry variables are indicators of water quality conditions and help identify potential sources of pollution for both surface water and groundwater. Various data sources were used to interpret and understand the overall surface water quality condition in the Quinte region. Parameters that were chosen were considered to be of most concern for the region based on those with concentrations above the water quality standards (Figure 3.1) and based on public knowledge and concern.

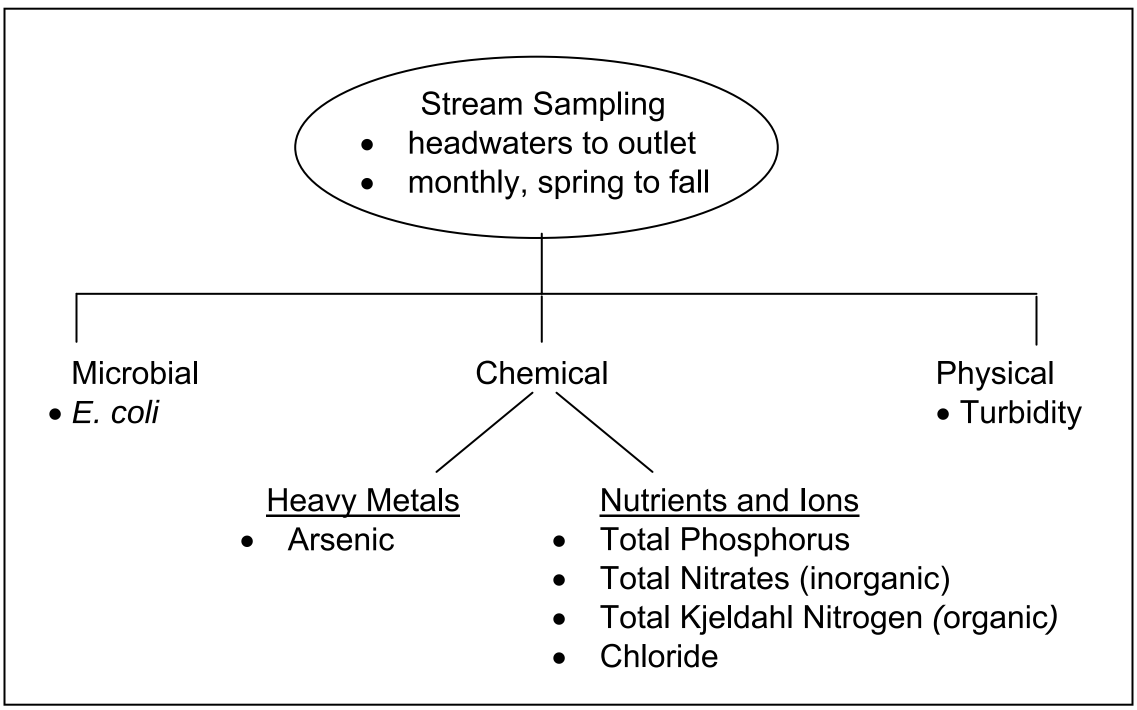


Figure 3.1.Sampling and analysis strategy for surface water samples.

3.2 Surface Water Quality - Data Analysis and Reporting

Analysis of surface water quality data is an ongoing process as monitoring occurs several times a year at some stations, e.g. Provincial Water Quality Monitoring Network. Data analysis and interpretations involved the following:

- Comparison of data to provincial standards using statistics and scatter plots;
- Analysis of long-term trends using the Mann-Kendall analysis from AquaChem (version 5.1) to identify trend direction (steady, improving or deterorating);

The duration of sampling and the number of sampling stations for each data source determined what statistical methods used. For example, long term trend analysis was not done for parameters with less than 30 samples to fairly make conclusions.

Data were compared with two sets of provincial standards set by the Ontario Ministry of Environment (MOE). The Provincial Water Quality Objectives (PWQO) for Ontario are applicable for all surface waters (lakes, rivers, and streams) and they are conservative estimates of water quality conditions intended to protect aquatic life and recreational water uses (swimming, bathing, and other activites that require immersion) (MOE 1999). On occasion an Interim PWQO was used as a comparison to the results. The Interim PWQO is a water quality objective that the MOE intends to upgrade to a PWQO status as sufficient information becomes available and after a peer and public review. The Ontario Drinking Water Standards (ODWS) are intended to be used as a comparison with drinking water sample results for the protection of public health (MOE 2006).

3.2.1 Provincial Water Quality Monitoring Network (PWQMN)

The Provincial Water Quality Monitoring Network (PWQMN) monitors water chemistry parameters which are indicators of water quality conditions. A standard suite of water chemistry variables are monitored at each PWQMN station (Map 33; Appendix 11) and seven parameters have been chosen as indicators for the Quinte Region (Figure 3.1) some of which are analyzed in various other provincial monitoring programs. Following the PWQMN protocols, conservation staff collect water samples between five (on the Prince Edward Region Watershed) and eight (all other monitored streams) times per year on a monthly basis during the ice-free season. Samples are sent to the MOE laboratory in Toronto to be analyzed for water chemistry and results are forwarded to Quinte Conservation when requested.

The measurement period of the chosen parameters is different among the various Quinte Region streams. Chloride, Total Kjeldahl Nitrogen (TKN), and total phosphorus have been sampled since the mid-1960's in the Moira, Napanee, and Salmon Watersheds and since 1975 on the Prince Edward Region Watershed. Turbidity has been sampled since 1973 for all PWQMN stations. *E. coli* and total nitrates (unfiltered samples) have been sampled since the 1980s for all stations, but *E.coli* has been discontinued at most. Arsenic has been sampled since 1964 at stations in the Moira River Watershed (MRW), from 1976 to 1995 in the Napanee River and Salmon River Watersheds (NRW), and from 1981 to 1995 on the Prince Edward Region Watershed (PERW).

Arsenic, *E.coli*, and total phosphorus were the three parameters out of seven selected that had a PWQO. All three parameters had samples with exceedences above the PWQO at some time or another (Table 3.4). Samples of chloride, total nitrates (inorganic nitrates), and turbidity concentrations were compared to the ODWS and all but chloride, had samples greater than this drinking water standard (Table 3.4). Although Chloride is not currently a water quality issue for the Quinte Region, it is being measured because it is frequently associated with wastewater and road salt runoff which are local concerns. Total Kjeldahl Nitrogen (TKN - Ammonia and Organic Nitrogen) does not have a provincial water quality standard, but was compared to the concentration found typically in Canadian surface waters based on a water quality sourcebook published by Environment Canada in 1979 (McNeely 1979). TP is the biggest issue for the Quinte region watershed, because 73% of the samples from 1964 to 2006 were above the PWQO of 0.03 mg/L.

Table 3.4. Basic summary statistics and percent of samples above the PWQO and the ODWS for PWQMN samples in the Quinte Region by watershed.

Parameter	Unit	No. of Obs.	Min	Max	Average	Median	PWQO	% Above PWQO	ODWS	% Above ODWS
Moira River Watershed - 1964 to 2006										
Arsenic	mg/l	6769	0	8.2	0.030809	0.007	0.1	4		
Chloride	mg/l	3595	0.3	115	7.0819	5.4			250	0
E.coli	Counts	59	2	660	115.47	52	100	37		
Nitrates, Total	mg/l	1625	0.005	7.14	0.13984	0.05			10	0
Nitrogen, Total Kjeldahl	mg/l	3304	0.13	23.5	0.63202	0.56	0.5*	66		
Phosphorous, Total	mg/l	3617	0.001	12.876	0.045276	0.023	0.03	32		
Turbidity	FTU	2842	0.35	160	2.1955	1.595			5	5
Napanee Region Watershed - 1964 to 2006										
Arsenic	mg/l	419	0.001	0.008	0.001031	0.001	0.1	0		
Chloride	mg/l	1365	1	138	9.1	7.7			250	0
E. coli	Counts	293	2	15000	207	28	100	24		
Nitrates, Total	mg/l	775	0.005	1.5	0.16267	0.112			10	0
Nitrgen, Total Kjeldahl	mg/l	1358	0.09	31	0.729	0.6	0.5 *	71		
Phosphorous, Total	mg/l	1481	0.002	10.5	0.058	0.028	0.03	43		
Turbidity	FTU	1283	0.40	35	3.3	2.32			5	15
Prince Edward Region Watershed - 1975 to 2006										
Arsenic	mg/l	830	0.001	0.008	0.001059	0.001	0.1	0		
Chloride	mg/l	1284	1	212	17.44	9.8			250	
E. coli	Counts	587	2	80000	296.91	12	100	16		
Nitrates, Total	mg/l	900	0.005	11.8	0.84467	0.07			10	0.1
Nitrgen, Total Kjeldahl	mg/l	1335	0.06	25.5	0.96597	0.76	0.5*	76		
Phosphorous, Total	mg/l	1773	0.001	4.58	0.12282	0.04	0.03	61		
Turbidity	FTU	1655	0.01	985	4.8753	1.97			5	20

* Typical Canadian concentration (McNeely 1979)

The long-term trends were assessed using Mann-Kendall statistic and its approximate z-value to determine probability of a directional trend. A parameter with a z-value above the crucial value of 1.96 was considered to have an upward trend (deteriorating), while a z-value below -1.96 had a downward trend (improving). Reviewing the long-term trends of the seven parameters in the Quinte Region, *E.coli* was the only parameter that was considered to be an issue as counts increased overtime between 1988 and 2001 at the PWQMN stations in the Moira River Watershed (Table 3.5). Counts for E.coli and concentrations of total nitrates were improving overtime in the NRW. Total Nitrates concentrations in PERW were improving as well. The rest of the parameters were steady (neither improving nor degrading).

Table 3.5. Long-term trend analysis results for PWQMN stations in the three major watersheds of the Quinte Region.

Parameter	**Unit**	**No. of Obs.**	**Mann Kendall (M-K) Statistic**	**M-K Statistic, Z value**	**Trend (C.V. = 1.96)**
Moira River Watershed - 1964 to 2006					
Arsenic	mg/l	6769	-5988690	0	steady
Chloride	mg/l	3595	1279428	0	steady
E.coli	Counts	59	348	2.269	deteriorating
Nitrates, Total	mg/l	1625	-177546	0	steady
Nitrogen, Total Kjeldahl	mg/l	3304	-1109726	0	steady
Phosphorous, Total	mg/l	3617	-2371097	0	steady
Turbidity	FTU	2842	-187934	0	steady
Napanee Region Watershed - 1964 to 2006					
Arsenic	mg/l	419	698	0.2434	steady
Chloride	mg/l	1365	203703	0	steady
E. coli	Counts	293	-5706	-3.404	improving
Nitrates, Total	mg/l	775	-29228	-4.060	improving
Nitrgen, Total Kjeldahl	mg/l	1358	-108445	0	steady
Phosphorous, Total	mg/l	1481	-231539	0	steady
Turbidity	FTU	1283	-105068	0	steady
Prince Edward Region Watershed - 1975 to 2006					
Arsenic	mg/l	830	4053	0.508	steady
Chloride	mg/l	1284	210353	0	steady
E. coli	Counts	587	2719	0.573	steady
Nitrates, Total	mg/l	900	-21828	-2.423	improving
Nitrgen, Total Kjeldahl	mg/l	1335	-45903	0	steady
Phosphorous, Total	mg/l	1773	-144527	0	steady
Turbidity	FTU	1655	87377	0	steady

Assessing each individual station on its own by calculating the percent of samples that exceeded water quality standards or objectives is a good first indication of the level of degradation at surface water stations. There were no samples that exceeded the arsenic PWQO in the NRW or PERW. The presence of arsenic in samples from MRW stations exceeded the PWQO from 1964 to 2006. These exceedences occurred more regularly earlier in this period, but with the ongoing cleanup efforts the situation is gradually improving. After reviewing the PWQMN data for arsenic at the Highway #7 station downstream from the Village of Deloro and the abandoned Deloro Mine (17002601302), arsenic concentrations declined overtime with a downward trend and ranged between 0 to 8.2 mg/L. More recently, arsenic concentrations from 2002 to 2006 were reduced in concentration ranging from 0.007 to 0.190 mg/L, but the trend was no longer declining at least not in the five year period. In this recent time period 17% of the samples were above the PWQO of 0.1 mg/L, while 100% of the samples were above the Interim PWQO of 0.005 mg/L. This shows that arsenic is an issue for the Moira River at this station. Arsenic is a health risk to aquatic wildlife that spend most, if not all, of their lifecycle in the river.

Concentrations of arsenic declined spatially in the Moira River according to the PWQMN from 1964 to 2006. Arsenic concentrations in the Moira River were lower at the upstream station, in Malone (17002601902), where naturally occurring arsenic had not been above the Interim PWQO since August 2000 and had not been above the PWQO since 1988. Frequency of samples with concentrations greater than the PWQO for arsenic declined at stations downstream from Deloro as shown by the Highway #7 station being at 34% of the time, Moira Lake station at 15%, and the Footbridge at the end of Catherine St in Belleville at 1% from 1964 to 2006 (Table 3.6). The percent samples above the interim PQWO had a similar pattern except for Moira Lake being a little higher than the upstream site. This may reflect that metals often accumulate more in pooling types of environments, such as ponds and lakes where it takes longer to flush out a substance compared to rivers.

Table 3.6. 1964 to 2006 summary Arsenic concentrations (mg/L) for four PWQMN stations along the Moira River. The PWQO for Arsenic is 0.1 mg/L and the Interim PWQO is 0.005 mg/L.

No. of Obs.	Min	Max	Average	Median	% Above PWQO	% Above Interim PWQO	Mann Kendall (M-K) Statistic	M-K Statistic, Z value	Trend (CV = 1.96)
17002601902	***Moira River, Malone, upstrm Deloro***								
429	0	1	0.011	0.001	1	22	-31641	-10.664	improving
17002601302	***Moira River, Hwy 7, dwnstrm Deloro***								
535	0	8.2	0.225	0.042	34	93	-45930	-11.119	improving
17002601101	***Moira Lake, Hwy 62, S of Madoc***								
547	0	0.75	0.055	0.042	15	95	-45000	-10.538	improving
17002600102	***Moira River, Footbridge, end of Catharine St, Belleville***								
516	0	0.68	0.014	0.008	1	69	-62808	-16.052	improving

There are natural sources of arsenic that come from the weathering of Precambrian rock in the Moira River headwaters. This can be seen at the station in Malone, upstream to Deloro. There is a concern that the Deloro Mine is a source of arsenic contamination to the river even after the Ontario Ministry of the Environment stated that 80% of the arsenic at the mine has been cleaned up. This downward trend of declining concentrations can be seen in trend analysis results (Table 3.6). Despite this, the pattern in the PWQMN data still showed frequently high arsenic concentrations downstream of the village of Deloro, with a decline in frequency at the next downstream station along the Moira River in Moira Lake and in the City of Belleville. This suggested that the Deloro Mine is still a major source of arsenic in the river. According to the PWQO, the risk to aquatic wildlife health is an issue, but as a place of recreation for humans and pets it is only a concern. It should be noted that the PWQO does not consider water quality for human consumption. Arsenic however, is potentially a risk to human health and therefore as a precaution surface drinking water should be treated for arsenic.

No PWQMN stations in the three major watersheds had chloride concentrations above the ODWS of 250 mg/L (aesthetic objective) between 1964 and 2006. A few of the sites from the MRW and several from the PERW and the NRW had *E. coli* present in numbers that exceeded the PWQO of 100 counts (Appendix 12). High *E.coli* counts may be attributed by rural or urban community septic systems or agricultural lands with livestock. Marsh Creek station in Picton was the only station that exceeded the ODWS for total nitrates (inorganic) (Appendix 12). There was just one sample with high nitrates at this station that was observed in September 1987 with no potential explanation other than being an outlier. Most stations that were tested for TKN exceeded the concentration that was considered to be typical for Canadian surface waters (0.5 mg/L). Most stations in the Quinte region had samples with total phosphorus concentrations above the PWQO of 0.03 mg/L and turbidity concentrations that exceeded the ODWS of 5.0 FTU (Appendix 12).

Potentially, the PWQMN is the best available source for bacteriological data to characterize the watersheds since it has stations located at the outlets of the Quinte Region basins. However, on a spatial scale there are data gaps associated with the PWQMN and microbial indicators have not been consistently sampled over the monitoring period. Most of the stations are located south of Highway #7 leaving the headwaters with unknown conditions as a reference to downstream. Microbial parameters, such as total coliform, were discontinued in the PWQMN in the 1970s, fecal coliform in the 1990s, and fecal streptococcus and *E.coli* were discontinued in 2002.

3.2.2 Beach Postings

The Clean Up Rural Beaches (CURB) program is a good source of historic information on beach closures posted by the Health Units and additional water chemistry data monitored by the CURB program. The number of days a beach is closed in a season gives a measure of water quality. The CURB program was established in 1985 by the Ontario Ministry of Environment after beach closures increased in the early 1980's. At that time it was called the Provincial Rural Beaches Management Strategy Program. Following a MOE research stage, Lower Trent Region (LTRCA), Moira River (MRCA), and Napanee Region (NRCA) Conservation Authorities teamed up in May of 1991 to address the concern of deteriorating water quality at rural beaches in their respective regions. They initiated the Tri-Authority Rural Beaches Study (TARBS) program that was funded by Ontario Ministry of Environment and the Bay of Quinte Remedial Action Plan (RAP). Prince Edward Region Conservation Authority (PERCA) also participated in CURB program by monitoring beaches in its region.

General chemistry and bacterial parameters were sampled at the selected beaches in the Tri-Authority region and PERCA region from 1991 to 1992. In addition to the CURB sampling, local Health Units were responsible for monitoring the bacteria counts of Fecal Coliform and *E.coli*. In the 1990's the Health Unit posted beaches as closed based on whether the geometric mean of five Fecal Coliform samples was greater than 100 counts/100 mL. In more recent times the protocol uses *E.coli* counts instead.

In the Tri-Authority region, four swimming beaches were monitored through the CURB program located in the Quinte Source Protection Region (Table 3.7). Reviewing the number of posted days that occurred between 1989 to 1992 at the four beaches the summers of 1990 and 1991 had the greatest number of postings (Table 3.8).   Riverside Park Beach in Belleville on the Moira River was closed the most often while Forest Mills beach was closed the least (Table 3.8). There was a limited amount of historic information on beach postings for PERCA beaches.

Table 3.7. Study areas monitored in the Tri-Authority Rural Beaches Study (Brunatti 1993) and the Prince Edward Region Conservation Authority Rural Beaches Program 1991 summary report (Childerhose 1992).

Beach/River	Municipality and Township	Location Description	Current Authority Region
Newburgh Conservation Area Beach on the Salmon River	Stone Mills Township, Camden East Township	In the Village of Newburgh	NRW
Kingsford Conservation Area Beach on the Salmon River	Tyendinaga Township	1 km south of Hamlet of Kingsford	NRW
Forest Mills Conservation Area Beach on the Salmon River	Town of Greater Napanee, Richmond Township	South of Roblin	NRW
Riverside Park Beaches on the Moira River	City of Belleville	North end of Belleville, east and west side of the river in a pool created by the Yardmen Dam	MRW
Sandbanks Provincial Park Beach	Corporation of the County of Prince Edward	Southeast of Wellington in Athol Bay	PERW
Outlet River	Corporation of the County of Prince Edward	Flows from west end of East Lake to Athol Bay	PERW
Wellington Beach	Corporation of the County of Prince Edward	South of Wellington	PERW
Lane Creek	Corporation of the County of Prince Edward	Flows north of Wellington, through town and into Lake Ontario west of Wellington Beach	PERW

Table 3.8. Number of beach closures posted by the local Health Units between 1989 and 1992. Modified from the Tri-Authority Rural Beaches Study Program CURB plan (Brunatti 1993) and the Prince Edward Region Conservation Authority Rural Beaches Program 1991 summary report (Childerhose 1992).

Beach	Year	# of Days Posted as Closed
Newburgh Conservation Area Beach on the Salmon River	1989 1990 1991 1992	n/a 47 67 42
Kingsford Conservation Area Beach on the Salmon River	1989 1990 1991 1992	15 49 22 0
Forest Mills Conservation Area Beach on the Salmon River	1989 1990 1991 1992	n/a 11 0 0
Riverside Park Beaches on the Moira River	1989 1990 1991 1992	71 67 93 81
Sandbanks Provincial Park Beach on Athol Bay of Lake Ontario	1990	5 (first posting ever on August 10-24, 1990)
Wellington Beach	1991	Posted numerous times
North Beach Provincial Park	1990	Posted briefly in summers of 1988 to 1990

Moira River Watershed

There were 32 stations in the Moira River watershed sampled through CURB in 1991. Un-named Creek (MR14 and MR14A) near Plainfield was the most degraded stream in the Quinte region according to the 1991 CURB summary report. The stream had high concentrations of *E.coli* at a maximum of 137,000 counts/100 ml (MR14 mean=4,197, n=10), TP of 0.60 (MR14A mean=0.575, n=2), TKN at 4.60 mg/L (MR14A mean=3.75 mg/l, n=2), Chloride at a maximum of 608 mg/L (MR14 mean=146.3, n=5), and Turbidity at 9.5 FTU (MR14 mean=4.5, n=5). Palliser Creek at Main St in Foxboro (MR8) also had the highest concentration of TKN at 4.60 mg/l (mean=1.26, n=7). Number Ten

Creek (MR12) had high concentrations of Nitrate at a maximum of 3.20 mg/L (mean=2.30 mg/l, n=7).

Napanee River Watershed

In the Napanee River Watershed, Un-named Creek (NR6) was the most degraded stream in 1991 with a maximum *E.coli* count of 11,200 counts/100 ml in August (geometric mean=1,153 counts/100 ml, n=14), and the highest concentration of Nitrate at a maximum of 1.85 mg/L in August (mean = 1.21 mg/L, n=5) (Brunatti 1992). A second station (NR5) in Un-named Creek had the greatest concentration of Chloride at 43.6 mg/L in July (mean = 32.4 mg/L, n=2) and the highest Turbidity of 7.0 FTU (mean=4.7 mg/L, n=2) (Brunatti 1992). This stream drains directly to into the Napanee River upstream of the Newburgh Conservation Area beach. Varty Creek (NR15) in the NRW had the highest concentration of TKN at 4.30 mg/L in July (mean = 2.22, mg/l, n=3) and the highest concentration of Total Phosphorous (TP) at 0.970 mg/L in July (mean = 0.777 mg/l, n=3) (Brunatti 1992).

Salmon River Watershed

There were 20 stations in the Salmon River watershed in 1991. Mud Creek and the Salmon River near Tamworth were the most degraded in the watershed that year. Mud Creek had the greatest concentration of *E.coli* at 840 counts/100ml (SR9A geometric mean = 108, n =7) in the watershed and the highest concentration of TKN at 0.78 mg/L (SR9 mean=0.87, n=1) (Brunatti 1992). The Salmon River near Tamworth had Nitrates at 0.86 mg/l (SR13A mean=0.61, n=4) and Chloride at 35.7 mg/l (SR13 mean = 15.8, n=7) (Brunatti 1992). Salmon River at Kingsford (SR3) had the highest concentration of TP at 0.120 mg/l (mean = 0.038 mg/l, n=4) (Brunatti 1992). Black Creek (SR11) had the highest Turbidity at 3.6 FTU (mean= 2.5 FTU, n=4) yet it was still below the PWQO of 5 FTU (Brunatti 1992).

Prince Edward Region Watershed

In 1991 there were 75 stations sampled in PERW and only bacteria counts were reported in the summary report (Childerhose 1992). There were a few stations that had

E.coli counts greater than 100 counts/100 ml. The highest *E.coli* count observed was 14,000 counts in a 100 ml water sample taken from the Sandbanks Provincial Park monitoring station located 300 m north of the main entrance (PE46) of the park. Outlet River stations had *E.coli* as high as 1,790 counts/100 ml. Lane Creek in Wellington (PE39) had a maximum *E.coli* count of 9,100 /100 ml water sample. Gardenville Creek outflow into Wellers Bay had a maximum *E.coli* count of 1,470 /100 ml.

Summary

The greatest contribution to the bacteria loading to Newburgh CA, Kingsford CA, and Forest Mills CA beaches was found to be direct cattle access to the watercourse (Brunatti 1993). The greatest contribution of bacteria loadings at Riverside Park Beaches were gulls and pigeons (Brunatti 1993). Bacteria problems at Wellington Beach and Sandbanks Provincial Park seem to be local (Childerhose 1992). There was good reason to believe that Ring-billed gulls were a source of elevated bacteria levels (Childerhose 1992). The summer of 1991 was dry so agricultural runoff may not have affected water quality as much as in previous years because of the limited flow in the creeks (Childerhose 1992).

Recent Beach Sample Results

Local Health Units are local area offices of the Ministry of Health and Long Term Care that provide various public health services. Health Unit staff sample public swimming beaches for *E.coli* once a week from May to September. On the day of sampling a minimum of five water samples are taken along the shoreline at specified depths. The geometric mean of the sampling date is calculated for *E.coli* and when the mean is greater than the PWQO of 100 counts/100 ml a beach closure is issued. The beach is re-opened when three consecutive samples are above the PWQO.

Beach samples results from the few years were received from the Hastings and Prince Edward Counties Health Unit (Table 3.9). The Health Unit covers the two counties which are the western and southern portions of the Quinte region. Beaches at Centennial Park in Deseronto, Moira Lake, Stoco Lake, Wellington, Roblin Lake, Centennial Park in Northport, and Lake Ontario were posted because of *E.coli* since 2002.

Beach sample results from the 2006 swimming season were received from the Kingston, Frontenac, and Lennox & Addington Health Unit. The Health Unit covers the eastern portion of the Quinte Source Protection Region that overlaps with Frontenac and Lennox & Addington counties. Arden beach was the only beach in these counties located in the Quinte region that had a beach posting due to *E.coli.*

The greater the number of days a beach is posted as closed due to bacteria counts the greater the indication that the water quality conditions are poor. Comparing the number of days posted by the Health Unit in the 1990's based on Fecal Coliform to recent Health Unit postings based on *E.coli* would not be a fair comparison. The maximum *E.coli* counts measured in the 1990's CURB program were higher then the more recent Health Unit beach data. For example, the maximum E.coli counts recorded from the 1990's CURB program was 137,000 counts/100 ml from Un-named Creek near Plainfield upstream to Riverside Park beach east side of the Moira River that had a maximum *E.coli* count of 1,200 / 100 ml. The highest E.coli count observed in recent data from the Health Unit was 1,000 *E.coli* counts / 100 ml at Stoco Lake beach in 2005 and 2007. A direct comparison of locations was not possible as the sampling stations were not the same in the CURB summary and the recent Health Unit data summary.

Table 3.9. Beach Closures in the Quinte region (data from local Health Units).

Beach	Year	# of Times Closed	# of Days Posted as Closed
Hastings County			
Centennial Park - Deseronto	2006 2007	3 1	20 n/a
Zwicks's Island Park - Belleville	2006 2007	0 0	0 0
Moira Lake	2002 2003 2004 2005 2006 2007	1 0 0 0 0 0	n/a 0 0 0 0 0
Stoco Lake	2005 2006 2007	2 7 3	n/a 62 n/a
Prince Edward County			
Wellington	2006 2007	3 2	32 12
Roblin Lake	2006 2007	0 1	0 6
Centennial Park - Northport	2006 2007	0 1	0 7
West Lake	2007	0	0
Lake Ontario	2007	1	n/a
Outlet Beach	2007	0	0
Central Frontenac Township			
Arden	2006	1	n/a
Big Clear Lake	2006	0	0
Camp Kennebec CSR	2006	0	0
Kennebec Lake	2006	0	0
South Frontenac Township			
Verona (Lion's Club)	2006	0	0
Stone Mills Township			
Beaver Lake	2006	0	0
Centennial Park	2006	0	0
Colebrook Conservation Area	2006	0	0
Nevilles Point	2006	0	0
Town of Greater Napanee			
Adolphustown Park W	2006	0	0
Brooks Ferry Landing	2006	0	0

3.2.3 Bay of Quinte Remedial Action Plan

The quality of the waters of the Bay of Quinte has been a local concern since the latter half of the 20th century. It was declared an international Area of Concern in 1985 and a Remedial Action Plan was developed in order to arrest the water quality degradation and attempt to return the Bay to healthier conditions.

Several water quality problems have been observed, including toxic substances, bacterial contamination, and nutrient enrichment. In fact, the high nutrient loading (approaching 90 µg/L of TP) shifted the Bay of Quinte into a hyper-eutrophic state in the 1950s. Recent efforts to reduce phosphorus inputs into the Bay have led to a decrease in algal blooms, taste and odour issues in drinking water, as well as turbidity. Present TP levels are in the 40 µg/L range, still within the eutrophic range.

Bacterial contamination continues to limit the use of the Bay of Quinte for swimming and drinking without treatment. This was traced to sources in the river systems which flow into the bay. The sources were primarily urban discharge and stormwater runoff. To combat bacterial contamination, tighter controls have been placed on urban runoff to manage stormwater in both new and existing development areas. Both Belleville and Trenton (now part of Quinte West) prepared and adopted pollution prevention and control plans (PPCPs) that have guided local efforts to improve the quality of stormwater runoff. Other municipalities are considering taking similar action. Despite stormwater management actions, bacterial contamination persists and the few remaining actively-used beaches in the bay still experience some health related postings.

Heavy metals and other persistent toxins can be found in the water column and sediments of the Bay as well as within tissue of the fauna. Of those found in the Bay of Quinte water; metals such as cadmium, copper and iron exceed standards. Many metals in the sediment also exceed dredging disposal limits particularly arsenic, chromium, cadmium, copper, iron, mercury, nickel, lead and zinc. Sources of the metals are thought to include industrial and mining activities, past agricultural practices, sewage treatment plants, as well as atmospheric deposition.

3.2.4 Lake Partner Program

The Lake Partner Program, previously known as the Self-Help Program, is a province-wide, volunteer-based, water quality monitoring program coordinated by the Ontario Ministry of the Environment. According to the protocol, volunteers are asked to collect one water sample for Total Phosphorus (TP) in May for lakes on the Canadian Shield and one sample each month (May-Oct) for lakes that are off the Shield. In addition, volunteers are asked to make a minimum of six (monthly) water clarity observations using a Secchi disk. These clarity observations effectively measure the combination of turbidity (suspended material) and total residue (dissolved material) that is measured for streams, although using a Secchi disk is less of a quantitative measurement. Water samples and Secchi disk observations are mailed to the Dorset Environmental Science Centre of the Ministry of the Environment (MOE) for analysis and processing. This information will enable the early detection of deterioration in the health of the lakes due to the impacts of shoreline development, climate change and other stresses.

Total Phosphorus

Total phosphorus (TP) concentrations are commonly used to classify lakes by nutrient status because TP is a limiting factor for algae growth. Algae are microscopic aquatic plants that have existed in surface water on earth for a very long time, however, increased concentrations of nutrients due to human activity stimulate algae growth; algal blooms can reduce water clarity and cause aesthetic and odour problems. Some human sources of phosphorus include industrial effluent, urban and agricultural runoff of fertilizers, and faulty septic systems. The right conditions for algal blooms include extended periods of warm, sunny weather, in shallow, slow moving waters with a source of nutrients. Algae blooms are a common phenomenon in recent times. In severe cases, some blue-green algae (cynobacteria) species can produce toxins that can be harmful to humans and animals.

Scientists have classified lakes into three broad categories depending on their nutrient status (Table 3.10). Lakes with less then 10 µg/L are considered to be *oligotrophic* with low primary productivity, lakes with TP between 10 µg/L and 20 µg/L are *mesotrophic* and considered to be moderately productive and lakes with more than 20 µg/L are considered to be *eutrophic* (nutrient enriched). According to the Provincial Water Quality Objective (PWQO), lakes with average TP concentrations of 20 µg/L or more will have nuisance concentrations of algae growth during late dry summers and early fall (MOE 1999).

Table 3.10. Descriptions of *oligotrophic* and *eutrophic* lakes. Modified from Horne and Goldman, 1994.

Factor	**Oligotrophic (unproductive)**	**Eutrophic (productive)**
Nutrients	Low levels and low supply rates of at least one major nutrient (nitrogen, phosphorus, silica).	High winter levels and high supply rates of all major and minor nutrients.
Oxygen	Does not vary much from the top and bottom of the lake.	Great variation between the lake water depth layers.
Biota	Low primary productivity of algae (net photosynthesis). Low densities and yields of phytoplankton, zooplankton, zoobenthos, and fish.	High primary productivity of algae. High densities and yields of phytoplankton, zooplankton, zoobenthos, and fish.
Basin shape and watershed	Deep lakes with steep sides. Infertile soils and undisturbed, rocky watersheds.	Shallow lakes with gently sloping sides. Often unstratified. Cultivated, disturbed, or naturally fertile watersheds.

There are 22 lakes in the Quinte Region Source Protection Area that are a part of the Lake Partner Program; some lakes have more than one station in order to monitor different bays or deep portions of a lake. Total phosphorus data is from 2002 to 2005; some lakes have older data values that have been excluded from the analysis because sampling and lab procedures changed in 2002. Since 2002, the sampling protocol has required water samples to be filtered in the field during collection, minimizing the chance of large zooplankton adding disproportionate amounts of TP.

Two replicate water samples are taken for TP measurement in order to minimize sampling error. The average TP concentrations as mentioned earlier are used to classify lakes as oligotrophic, mesotrophic, and eutrophic (Map 34 and Appendix 13). Occasionally, a lake with more than one sampling station showed characteristics of more than one nutrient status, e.g. Beaver Lake and Hungry Lake. This could suggest a lake in which the water does not mix uniformly or portions of the lake have different light settings and surface water contributions. Some samples have a large disparity of TP, as much as 21 μg/L, between replicates; this is most likely caused by contamination during collection. To minimize the effect of these outliers, any replicates with a disparity for the same site on the same day of more than 8.16 μg of TP (three standard deviations) were omitted; this omitted five of 228 sites (2%).

Secchi Disk Depth

A Secchi disk is used to measure the clarity of lake water which is dependent upon the amounts of dissolved organic carbon (DOC), floating sediment and bubbles, and algae. The Secchi disk is a flat, circular, black and white disk that is lowered off the side of a boat at the deepest part of a lake. The distance from *the surface of the water to just before the disk disappears from sight* is the Secchi depth. The Secchi depth is approximately one-third of the depth of the *photic zone* (the upper zone of a lake where light can penetrate and the most productive zone for plants to photosynthesize; Horne and Goldman 1994).

Secchi disk depths can be used to monitor changes over time in a lake and may detect conditions that otherwise go unobserved when measuring TP concentrations. Lakes with shallow Secchi disk depths (<2 m) indicate either high densities of algae or high densities of suspended material. In contrast, the presence of zebra mussels, an invasive species, can cause the lake water to have good clarity (Secchi depth >2 m) even when TP concentrations are elevated. Lake clarity in all lakes will vary with the change of seasons due to algal blooms or an increase in suspended solids (DOC or non-biological turbidity) from rainfall events.

The minimum of six measurements taken by the Lake Partner volunteers within a single year have been averaged by the Ministry of the Environment. A minimum of three measurements per year is enough to determine the nutrient status of the lake. The differences between years are normally minimal. Outliers may be identified with further sampling. Lakes with Secchi measurements from 0-2 m are considered eutrophic unless additional measurements (either clarity or TP) suggest otherwise.

The Secchi measurements from the years 1995 to 2005 for the Quinte Region ranged between 0.8 to 6.4 meters (Appendix 13). None of the lakes that were sampled have the combination of high TP concentrations and good clarity indicative of severe zebra mussel infestations. Lakes with poor clarity suggesting high DOC, turbidity, or dense algae conditions include:

- Cole Lake site 1 of 2,
- Sheffield Long Lake,
- West Lake sites 1 and 3.

Implications

Five of the 22 lakes sampled have at least one indication of a degraded environment. Cole Lake site 1 and the Sheffield Long Lake site have moderate TP concentrations and an average Secchi depth of less than or equal to 2 m suggesting that DOC or non-biological suspended solids may be present at times. Both West Lake sampling sites have elevated TP concentrations and a shallow average Secchi depth suggesting that algal blooms may be occurring with the right conditions of sunlight and water temperatures. Both sampling sites at Moira Lake have high TP concentrations and an average Secchi depth of slightly more than 2 m, suggesting that there is a possibility that zebra mussels are present in the lake helping to clarify the water (Map 34). There are no Secchi depth measurements for Hungary Lake, but the elevated TP concentrations indicate eutrophic conditions. The rest of the lakes have TP concentrations and clarity typical of oligotrophic and mesotrophic lakes.

References

Brunatti, R. (1992). Tri-Authority Rural Beaches Program Study: Year one summary report., Prepared for the Ontario Ministry of Environment and Energy, Lower Trent Region Conservation Authority, Moira River Conservation Authority, and Napanee Region Conservation Authority.**:** 114 + Appendices.

Brunatti, R. (1993). Tri-Authority Rural Beaches Study Program: Clean Up Rural Beaches (CURB) Plan, Prepared for the Ontario Ministry of Environment and Energy, Lower Trent Region Conservation Authority, Moira River Conservation Authority, and Napanee Region Conservation Authority.**:** 64 + Appendices.

Childerhose, K. (1992). Prince Edward Region Conservation Authority: PERCA Rural Beaches Program 1991 Summary Report, Prepared for the Ontario Ministry of Environment and Energy and Prince Edward Region Conservation Authority**:** 50 + Appendices.

McNeely, R. N., V.P. Neimanis, and L. Dwyer (1979). Water Quality Sourcebook: A Guide to Water Quality Parameters. Ottawa, Ontario Canada, Inland Waters Directorate, Water Quality Branch**:** 89.

MOE (1999). Water Management Policies, Guidelines, and Provincial Water Quality Objectives. Toronto, Ontario Canada, Ontario Ministry of Environment**:** 31.

MOE (2006). Technical Support Document for Ontario Drinking Water Standards, Objectives, and Guidelines. Toronto, Ontario Canada, Ontario Ministry of Environment**:** 40.

3.3 Groundwater Quality – Data Analysis and Reporting

Groundwater is an important resource to the residents of the Quinte watershed with approximately 50% of the population using this resource for their water supply. Other important uses include meeting demands for watering of livestock, irrigation, and industry. Groundwater also serves an important role in the overall function and health of the Quinte Region ecosystem through contributing base flow in rivers and streams. Given the high use of groundwater in the Quinte watershed, the quality of this supply is important. In some parts of the watershed it can make the difference between a residence having a usable or unusable water supply. Contamination of groundwater can also result in the migration of contaminants to the surface water.

Quinte Region Aquifers

As previously discussed under the hydrology section of this report there are three main types of aquifers in the Quinte Region as listed below in Table 3.11. These comprise Overburden, Limestone, and Precambrian bedrock aquifers.

Table 3.11. Summary of Characteristics of Quinte Region Aquifers.

Aquifer Type	Material	Natural Water Quality†
Overburden	Mainly sand and gravel with some areas of silt and clay	Fresh, mineral, sulphury when high amount of clay
Limestone	Limestone (calcium carbonate based bedrock) and other sedimentary rocks	Hard, sometimes sulphury; fresh and sometimes mineral if mainly sandstone and siltstone
Precambrian	Igneous/metamorphic	Fresh, sometimes mineral

† Hard denotes water rich in calcium and magnesium

The quality of groundwater is largely dependent on the geologic material that it is flowing through and the length of time the water is contained within this formation. Also associated with the quality of the supply from the various aquifers is the vulnerability of the aquifer from contamination resulting from land use activities occurring either at or near ground surface. The following section is an overview of groundwater quality in the Quinte Region through discussion of the following items:

1) Sources of information used for obtaining information about local groundwater quality,

2) Vulnerability of the Quinte Region aquifers to contamination,

3) Land use activities within the Quinte Region that present potential concerns to groundwater,

4) A summary of the groundwater quality of the various aquifers at present based on the available information sources,

5) Identification of potential groundwater quality problems and issues,

6) Identification of indicator parameters that serve as surrogates for groundwater health.

Sources of Information

To collect and review information about groundwater quality in the Quinte Region there are a variety of sources to draw from. These sources range from hydrogeologic studies to water quality testing completed on municipal groundwater wells, microbiological testing as completed through the local Health Units, Ontario Water Well Record database, and water quality monitoring though the Provincial Groundwater Monitoring Network. A brief description and overview of some of these sources is provided below.

Hydrogeology Studies/Reports

For the Quinte region there are several hydrogeology reports summarising water quality conditions on a provincial, municipal, and site specific level. These reports, as listed below, contain background and general water quality information.

1. Preliminary Hydrogeologic Investigation of Prince Edward County - Water & Earth Science Associates Ltd. - March 1985 (WESA 1985).

2. Water Resources of the Moira River River Drainage Basin - Water Resources Report No. 6, Ministry of the Environment -1974

3. Groundwater in Ontario: Hydrogeology, Quality Concerns and Management - National Hydrology Research Institute (Environment Canada) Contribution No. CS-94011, November 1994.

4. Hydrogeology of Southern Ontario - 2nd edition S.N. Singer, C.K. Cheng, M.G. Scafe, Environmental Reporting Branch MOE, 2003 (Singer 1997, 2003).

5. Municipality of Centre Hastings - Hamlets of Crookston, Fuller, Ivanhoe, Moira, and Roslin Groundwater Management Study (Baker 2001).

6. Quinte Regional Groundwater Study Final Report, Dillon Consulting, October 2004 (Dillon 2004).

In addition to the above mentioned reports, there is an abundance of groundwater quality data available through hydrogeological assessments for land development applications, such as subdivisions, monitoring programs around quarries, land fills and other types of facilities.

Ontario Water Well Records

The provincial government maintains the water well information system which contains records for wells constructed in the Province. When the well is installed and water is intercepted the contractor gives the water a qualitative rating as fresh, salty, gas sulphur, gas or mineral.   This information is then recorded on the well record and submitted to the Ministry of the Environment as a requirement under the water well regulation.

Provincial Groundwater Monitoring Network

The Provincial Groundwater Monitoring Network (PGMN) is a provincial program that is a partnership of Conservation Authorities and the Ministry of the Environment. To date there are over 400 wells in the Province of which there are 31 wells in the Quinte watershed region at the locations as illustrated by Map 35.   Currently, data is collected at 31 wells that are distributed throughout the Quinte Region (Map 35) and sample from each of the three main aquifer types:

- 4 wells in overburden aquifers,
- 21 wells in limestone aquifers,
- 6 wells in Precambrian bedrock aquifers.

Quinte Conservation began annual collection of water quality samples at the PGMN wells in 2003. These samples were originally analysed for five categories of parameters:

- Heavy metals,
- General chemistry,
- Pesticides,
- Volatile organic compounds,
- Radionuclides

Following the initial round of sampling for the complete package, the annual sampling was reduced to heavy metals and general chemistry. The complete package will be repeated every five years to permit establishing a baseline. However in the event one of the parameters is detected above the standard the frequency of monitoring is increased. In cases of parameters that are a health concern, any exceedences are confirmed by a second round of sampling. Since sampling began, one or more of the following eleven substances have exceeded the Ontario Drinking Water Standards at one or more of the wells:

- Hardness
- Manganese
- Fluoride
- Sodium
- Chloride
- Iron
- Chromium
- Selenium
- Boron
- Dissolved organic carbon
- Benzene (repeat sampling did not confirm presence)

Baseline Water Quality Surveys

In addition to the monitoring well network, Quinte Conservation has also completed baseline surveys of private water wells at various locations within the watershed relevant to various land developments. These surveys typically provide data representative of the water quality of private wells.

Health Unit Microbiological Testing

The local Health Units provide service to local residents whereby residents in the watershed are permitted to submit a sample of their drinking water to the Health Unit for analysis of microbiological quality (e.coli and total coliform). There is no direct charge for this service and the Health unit maintains a record of this testing.

Dataset Deficiencies

Some deficiencies in the data sets described above include the microbiological testing of data maintained from the Health Unit. This data has not yet been gathered and may be limited in information (i.e. location) for the protection of personal privacy. While much data is also available from hydrogeological assessments for land development and monitoring programs through both municipal and provincial offices, it is generally not in a readily available format. Collection and interpretation of this data is a large task which will take time to gather, compile and interpret. Overall the readily available data may be sufficient to provide an overview of quality in the watershed; however review of site specific information may be required on an individual basis to assess potential impacts from various land uses or activities.

3.3.1 Aquifer Vulnerability

The vulnerability of an aquifer can have a significant influence on the water quality due to influence from land use activities at or near the ground surface. Given shallow soil conditions and the unconfined nature of the regional aquifers the groundwater in the Quinte Region is vulnerable to contamination. Mapping of aquifer vulnerability was completed through the Quinte Regional Groundwater Study (Dillon 2004) as illustrated by Map 36 which indicates the entire region to exhibit high vulnerability. In addition to aquifer vulnerability from natural conditions the overall quality of water in a given well can be influenced by improper construction of the well (MacRitchie 1994).

3.3.2 Land Use & Potential Concerns

Given the vulnerability of the watershed and significant development on private services in portions of the watershed, there are several potential concerns for contamination of the groundwater from human activities, as summarized in Table 3.12 and briefly discussed below.

Table 3.12. Human Sources of Groundwater Contamination

Parameter	Source	Implications	Potential Areas of Concern
Pathogens	• Septic Systems • Livestock waste	• Health related – water borne diseases	• Throughout the Quinte Region
Nitrates	• Septic Systems • Fertilizers • Livestock Waste	• Health related – toxic to infants and pregnant women	• Throughout the Quinte Region
Sodium & Chloride	• Septic Systems • Road Salt	• Health related for people on sodium restricted diets • Corrosive to plumbing • Salty taste	• Along major highways, intersections, and municipal salt storage facilities
Hydrocarbons	• Fuel Storage Tanks	• Health related	• Former and active gas stations • Tank Farm in the vicinity of Belleville

Road Salting

Road salt is commonly used as a winter deicing agent throughout the region. This can result in wide spread contamination of groundwater and wells located near roads; especially wells that are shallow in nature or improperly constructed. Other contamination can result from the storage practices of salt especially where piles are not placed under cover allowing for leaching into the groundwater. Elevated levels of salt in water can make it unsuitable for human consumption.

Landfill sites

There are numerous landfill sites both existing and closed which can result in contamination of the groundwater by organic chemicals and other parameters related to the waste. Given historic practice of land filling without the use of liners or leachate collection systems this can be a significant concern for contamination on a local scale.

Petroleum Storage Tanks

Leaks and spills over the years from petroleum storage tanks at gas stations, bulk transfer stations, and home heating oil tanks can result in contamination of the groundwater. These occurrences are typical of such tanks and have happened throughout the Quinte watershed.

Accidental Spills

Accidental spills of various chemicals, fuels etc. can result in environmental contamination and the groundwater given minimal soil cover and protection of underlying aquifers. Such spills are recorded by the MOE Spills Action Centre and can result from vehicular accidents, train derailments, industrial accidents, etc.

Septic Systems and Inadequate Well Construction

Given the high percentage of rural residential development in the Quinte Region, private septic systems present probably the largest source of potential contamination. These systems in combination with improper well construction can result in widespread contamination of groundwater with parameters such as chloride, bacteria and nitrates.

Agriculture

Agriculture can result in groundwater contamination from the application of pesticides, fertilizers, and animal manure. A comprehensive survey of farm wells throughout the Province was completed between 1991 and 1992. Of the wells included in the survey, 37% were contaminated with one or more target parameters which included bacteria in 31% of the samples and nitrate in 13%. Pesticides were detected in 7.5% of the samples with only one sample above the drinking water limit. As part of this survey the results of the water quality analysis were compared with well construction details such as age, type of well and it was generally found that contamination was directly related to improper well construction. Other factors included soil permeability but the type of agriculture was not a major factor.

Mining

Mining can be a significant source of contaminants to groundwater from the waste rock and tailings. The contamination potential is linked to how the tailings and waste rock are managed and what type of mining was completed. In the Quinte watershed the former Deloro mine and refinery is a significant source of localized groundwater contamination. The existence of mine shafts also creates a potential conduit for surface water contamination to reach the groundwater aquifer.

3.3.3 Quinte Region Groundwater Quality

Natural groundwater is typically of high quality and presents an excellent source of drinking water. However, some groundwater can be naturally high in the concentration of some constituents which can reduce it’s suitability for use as a water supply. This problem can result from groundwater that has been in the ground a long time allowing for increased dissolution of minerals in the geologic material it is flowing through. Groundwater for the most part is also naturally free of high levels of bacteria, organic chemicals, and nitrates. Therefore, detection of these chemicals at high levels in the groundwater is an indicator of contamination from anthropogenic (human activity) sources. With the above as general premise, a discussion of groundwater quality in the Quinte Region is provided below.

General Water Quality

An overall indicator of natural water quality can be determined from a review of Ontario Water Well Records. A review of this information indicates that over 90% of the wells recorded as yielding fresh water. Some natural water quality problems were recorded for wells that are drilled in limestone bedrock located throughout the Limestone Terrain and the Prince Edward Region. These problems are associated with salt, sulphur, and gas. In these areas 2 to 3% of the wells were reported as intercepting salty water with the chances of intercepting salt water increasing with well depth. Sulphur was reported as being encountered between 5 to 15% of the wells; however the depth of the well does not seem to correlate with occurrence. Other problems in this limestone are natural gas which is not detected as frequently at less than 1% of the wells. The water quality of the Overburden and Precambrian aquifers is reported as fresh with the fewest water quality problems reported in wells drilled in the northern portions of the watershed near Madoc and Tweed. A brief summary of the range of the water quality as reported for individual municipalities is as follows:

- Fresh : 80 -99.5%
- Mineral: 0 – 1.5%
- Salt: 0 -3%
- Gas: 0 -0.25%
- Sulphur: 0 -15%

From this information it can be generalized that groundwater in the Quinte Region is suitable for domestic use. However, natural water quality problems are associated with sulphur, salt, natural gas, and hardness. Sulphur and hardness are related to aesthetic quality but are easily treated. Problems associated with salt and natural gas are not as easily treated and can render a supply as not suitable for domestic use.

<u>Detailed Groundwater Quality</u>

Currently, data analysis of groundwater quality in the Quinte Region has been based on regional studies (i.e. Quinte Regional Groundwater Study), data from Municipal wells, and the Provincial Groundwater Monitoring Network. A summary of current knowledge of water quality for the main aquifers in the Quinte Region is provided below.

Overburden Aquifer

Analysis of water quality from the Overburden Aquifer indicates it is low in dissolved solids and is classified as calcium bicarbonate type. The water is also very low in sodium and chloride, suggesting it is fresh and associated with recent recharge. Comparison of the water quality analysis with the Ontario Drinking Water Standards (ODWS) indicated the exceedences as illustrated by Figure 3.2 which included Hardness, Dissolved Organic Carbon, Iron and Aluminum. From Figure 3.2 it can be seen that hardness and iron are the most frequently detected. Analysis did not result in detection of any elevated levels of pesticides or organic contamination.

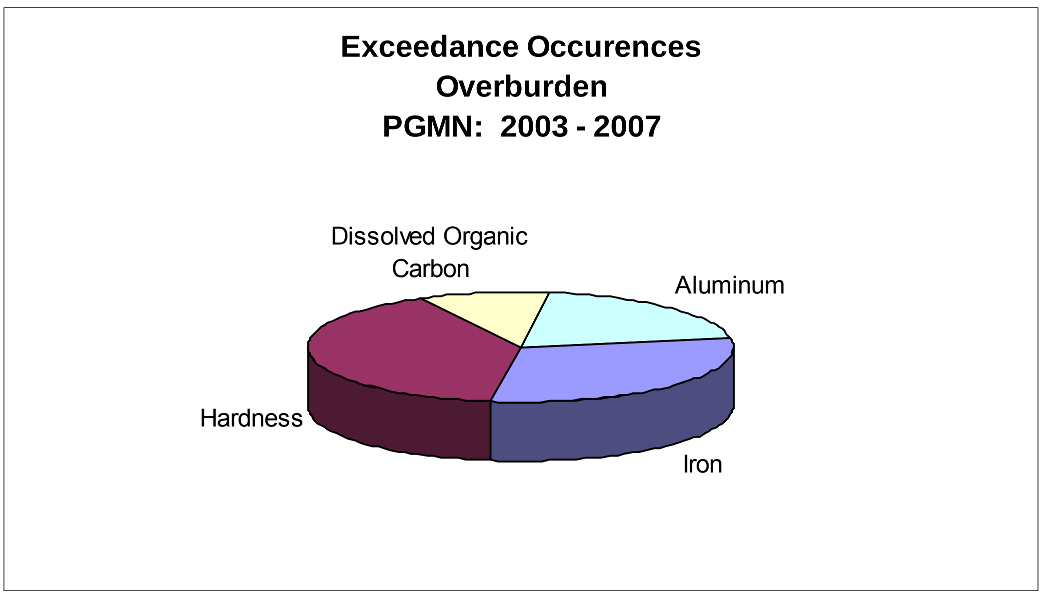


Figure 3.2. Proportion of groundwater samples by parameter that exceeded a Drinking Water Quality Standard that were collected in the Overburden Aquifer of Quinte Region.

Limestone Aquifer

In the Quinte area the limestone aquifer receives frequent and rapid recharge from infiltrating precipitation. Thus the water from this type of aquifer is typically fresh in the shallow parts of the aquifer. However, some limestone rock is relatively easy to dissolve in water. As the water moves deeper in the system there is greater time and potential for the water to contact and dissolve minerals in the rock. Given this phenomenon and confirmation of these conditions by the Ontario Water Well Record Database, the results of water quality analysis from this aquifer(s) has been divided between wells that are less than and greater than 20 metres in depth. As such, the quality of the water can vary in depth with shallow wells generally exhibiting fresh water and deeper wells a higher concentration of sodium, chloride, potassium, and sulphate. With an increase in the concentration of these minerals, the classification of the type of water can change from calcium bicarbonate to calcium sulphate and sodium chloride type water. The results of analysis from the PGMN wells installed in the limestone aquifers were reviewed relative to depth with the division between wells that are less than and greater than 20 metres in depth.

Limestone Aquifer (wells less than 20 metres in depth)

For the shallow limestone there are eight PGMN wells less than 20 metres in depth. A review of the water quality data indicates that this water is of the calcium bicarbonate type similar to the Overburden aquifer. From this testing the parameters as illustrated by Figure 3.3 were noted as exceeding the Ontario Drinking Water Standards.

Other parameters that exceeded the drinking water limit but not frequently include selenium, aluminum, and nitrate. From the chart of exceedences it is evident that the parameters most frequently exceeding the objectives were Hardness, Dissolved Organic Carbon, and Iron in similar comparison to the Overburden Aquifer.

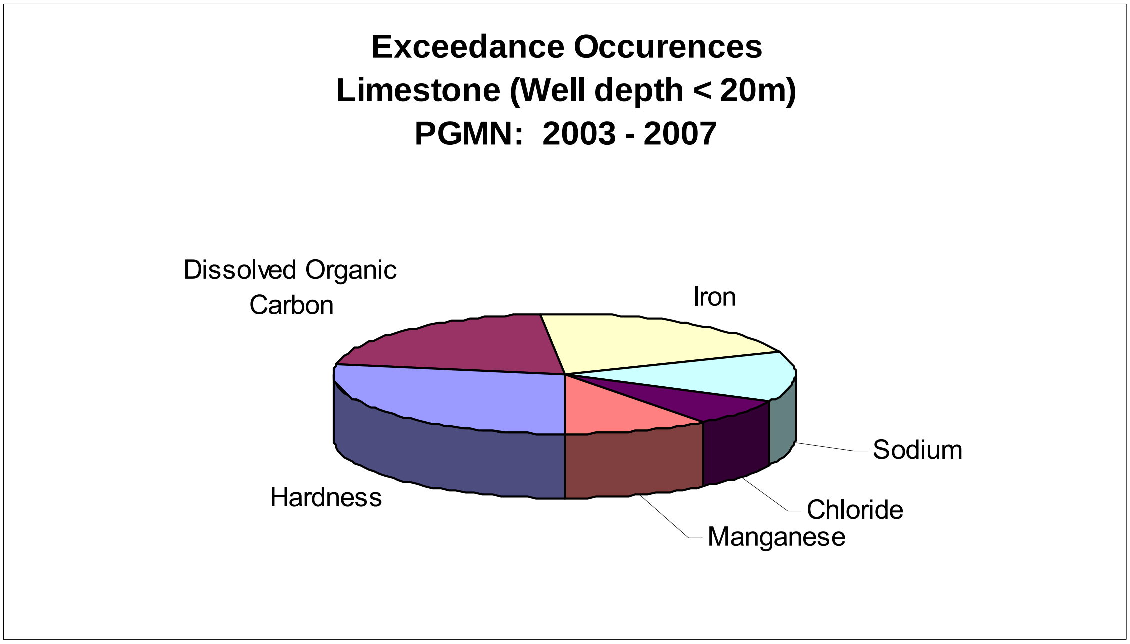


Figure 3.3. Proportion of groundwater samples by parameter that exceeded an Ontario Drinking Water Standard that were collected in the Limestone Aquifer of Quinte Region with a well depth of less than 20 metres.

Limestone aquifer (wells greater than 20 metres in depth)

There are 13 PGMN wells which are located in the limestone aquifer at depths of greater than 20 metres. A review of the water quality data suggest that in this zone there is an increase in the concentration of total dissolved solids which can result in a shift of the water quality characterisation from calcium bicarbonate type to sodium chloride and calcium sulphate type water. The parameters that were most frequently noted as exceeding the ODWS are summarized in Figure 3.4 and similar to the other aquifers include hardness, dissolved organic carbon and iron. However, other parameters detected frequently in the deep limestone at levels exceeding the ODWS were sodium, chloride, and manganese. These exceedences for the most part were related to natural water quality problems. Other parameters not illustrated in Figure 3.4 but detected in isolated occurrences are sulphate, boron, and benzene.

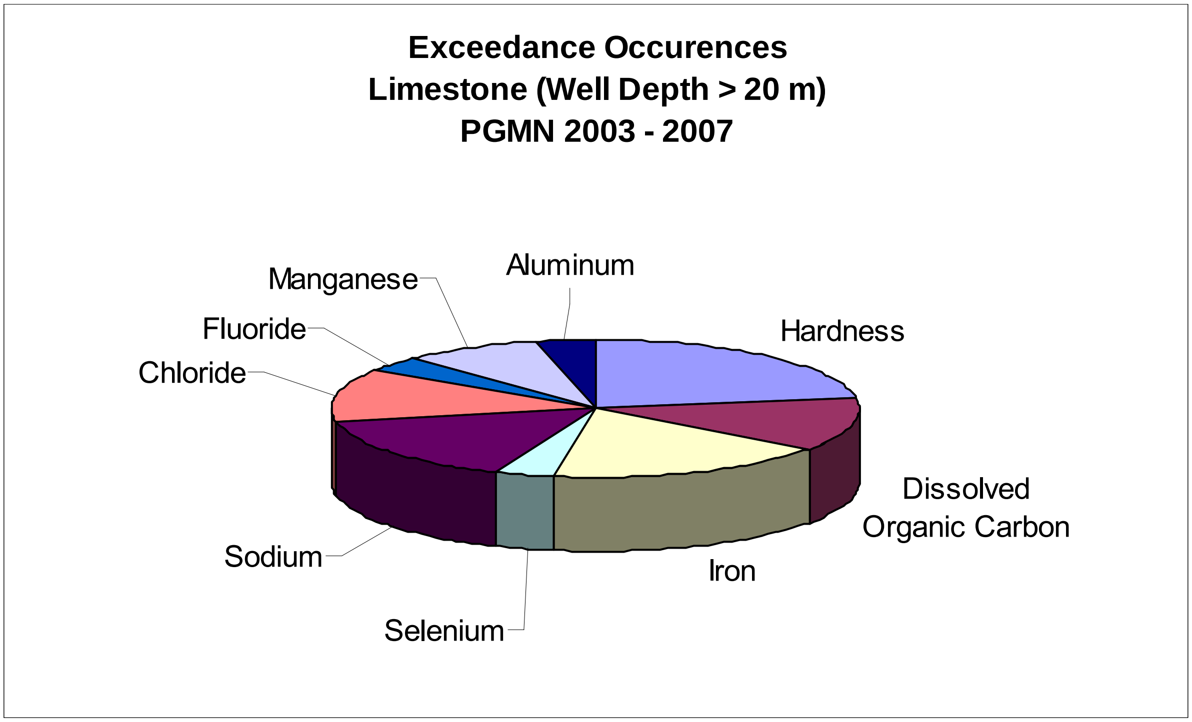


Figure 3.4. Proportion of groundwater samples by parameter that exceeded an Ontario Drinking Water Standard that were collected in the Limestone Aquifer of Quinte Region from wells with depths greater than 20 meters.

Precambrian (Igneous and Metamorphic Rock)

Precambrian rocks are typically resistant to weathering. The aquifer in this region often receives direct recharge from precipitation. Thus the water from these aquifers is typically fresh and low in total dissolved solids. Calcium and bicarbonate are the dominant ions for this aquifer and similar to the other aquifers, this water is grouped into the calcium bicarbonate classification. There are a total of six PGMN wells in the Precambrian Aquifer. The water quality results indicated similar conditions to the shallow limestone and overburden aquifers with few exceedences of the Ontario Drinking Water Standards exception of Hardness, Dissolved Organic Carbon, Iron, and Sodium as indicated in Figure 3.5. Parameters also noted as being detected above the ODWS but less frequently include nitrate and aluminum.

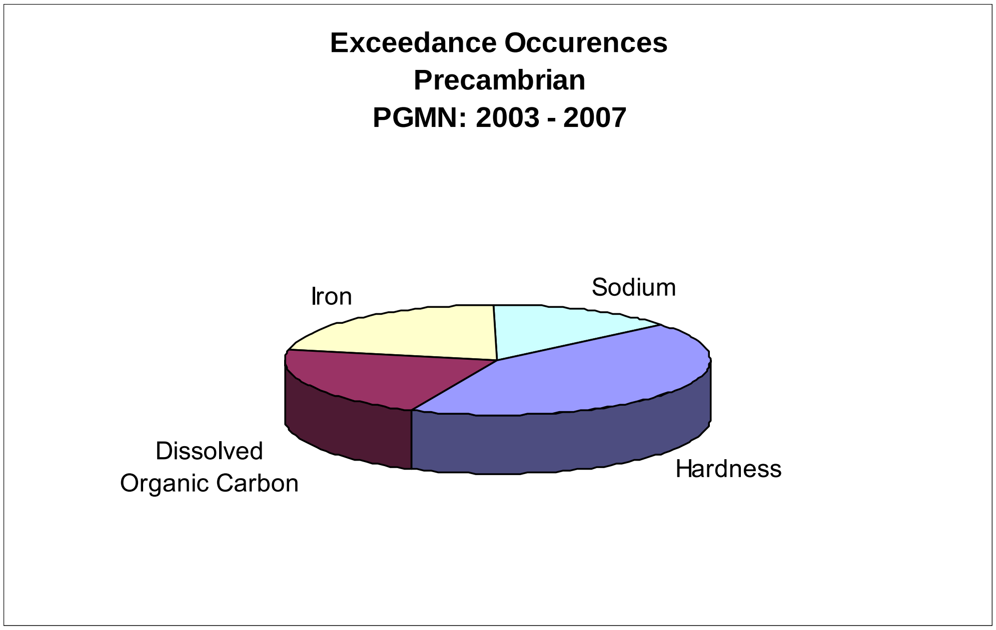


Figure 3.5. Proportion of groundwater samples by parameter that exceeded an Ontario Drinking Water Standard that were collected in the Precambrian Aquifer of Quinte Region.

Overall the natural groundwater quality in the Quinte Region can be considered as suitable for domestic use. Exception may be wells installed in the deep limestone aquifer which may intercept natural water quality problems related to salt and high total dissolved solids as well as other parameters. A summary of the water quality exceedences from all PGMN wells combined is illustrated by Figure 3.6.

The aesthetic quality of the water from all aquifers in the Quinte Region may be diminished somewhat with elevated levels of hardness and iron. Well records also indicate potential for intercepting sulphur in both shallow and deep limestone aquifers. Health related parameters detected at high levels in isolated PGMN wells include boron, benzene, nitrate, sodium, fluoride, and selenium. These detections were not widespread and all occurrences are presently under assessment to determine the source of potential contamination and reason for detection.

In addition to water quality data from PGMN wells, extensive water quality data is available for municipal wells used for drinking water supply. The majority of these wells are in the Precambrian aquifer and indicate general concurrence with the above noted observations. However, this data also revealed further natural water problems related to the detection of uranium and antimony above the ODWS. A municipal well, located in an area of agricultural land, was noted as exhibiting a high nitrate level when first installed. However, following startup and pumping for a period of time, an apparent flushing of the aquifer occurred and the nitrate level decreased.

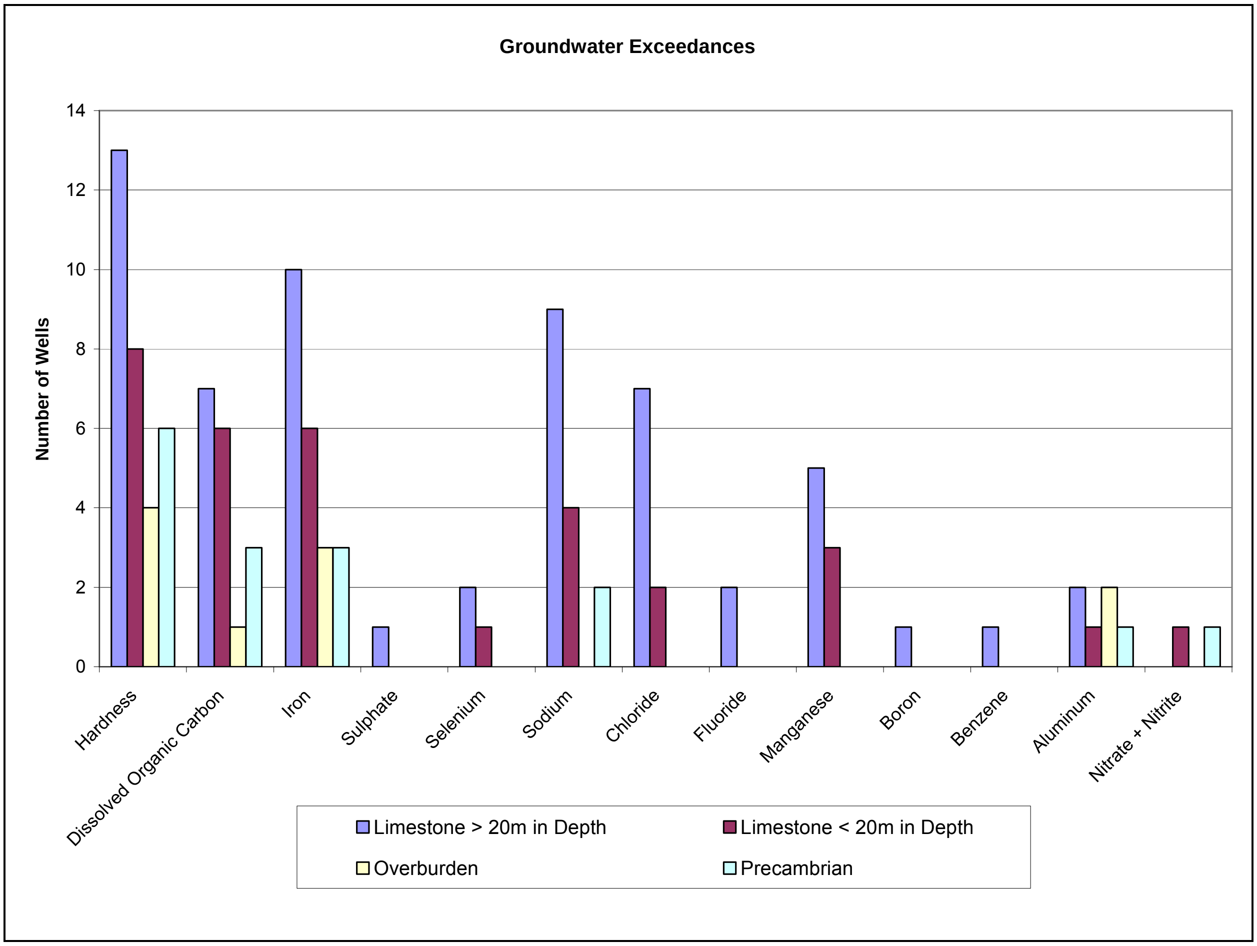


Figure 3.6. Number of PGMN wells that exceeded an Ontario Drinking Water Standard between 2003 and 2007.

Water Quality Problems & Issues

As discussed above there are a number of natural water quality problems of the Quinte Region aquifers that are summarized in Table 3.13. Aside from these problems, additional information about water quality problems was obtained through review of municipal and regional hydrogeologic reports. The majority of these reports indicate that areas of localized contamination can occur from human activities in the Vicinity of Hamlets and Villages where there is higher density development and homes that are serviced by wells and septic systems.

The Hydrogeologic Study of Prince Edward County reports that this type of groundwater contamination has either occurred or is under investigation in the Hamlets of Rossmore, Rednersville and the Village of Bloomfield (WESA 1985). Another study completed by the Municipality of Centre Hastings evaluated groundwater quality around Hamlets in the Municipality which included Roslin and Moira within the Quinte watershed (Baker 2001). From this study it was indicated that these hamlets are located in areas with thin soil over limestone bedrock with some areas having a high use of shallow dug wells. A range of 25 to 42% of the wells tested high for bacteriological contamination and elevated to unacceptable chlorides were evident of some wells located close to the roads (contaminated from road salt).

Baseline water quality surveys of other areas within the watershed were completed by the Conservation Authority. These included a survey of rural residential homes (Municipality of Tweed) in 2004 and residential homes in select area of the Village of Newburgh in 2007. In both cases the areas were serviced entirely by wells and septic systems. In the rural area the majority of the residents obtained supply from drilled wells in a bedrock aquifer. This survey indicated 60% of the samples had low to moderate levels of bacteriological contamination. Some of the samples also indicated elevated levels of hardness, iron and manganese.

Table 3.13. Natural Groundwater Quality Problems

Parameter	Aquifer	Source	Implications	Location
Chloride	Limestone	– Leaching from rocks	– Salty taste to water – Corrosive to plumbing	– Deep aquifers in southern Quinte Region
Sodium	Limestone	– Leaching from rocks	– Important to people on sodium restricted diets	– Deep aquifers in southern Quinte Region
Methane gas	Limestone	– Decay of organic matter	– Potential explosion hazard	– Southern Quinte Region
Hydrogen Sulphide	Limestone and Overburden	– Decay of organic matter – chemical reaction	– At low levels unpleasant odour in water	– Deep aquifers in southern Quinte Region
Hardness	All	– Leaching of calcium & magnesium from rock.	– Aesthetic – difficult to lather soap – Residue on pipes and fixtures	– Throughout the Region
Uranium	Precambrian Bedrock	– Leaching from rocks	– Health hazard - Toxic	– Canadian Shield – Village of Tweed
Fluoride	Precambrian Bedrock	– Leaching from rocks	– High concentrations can be toxic	– Canadian Shield – Village of Tweed
Sulphate	Limestone	– Leaching from rocks	– Objectionable taste – Potential laxative	– Deep aquifers in southern Quinte Region

From the survey of residents in the Village of Newburgh the majority of residents were found to use Bedrock Aquifer drilled wells that were constructed with well pits. From the water quality analysis all wells were found to exceed the drinking water standard for hardness, 45% of the samples had bacteriological contamination, and 15% had elevated salt levels potentially associated with nearby roads. In both the Village and rural residential situations low level nitrates were detected above what would be considered background but were well below the drinking water standard. Also observed were several wells that were not constructed in accordance with present code (probably within code at the time of construction).

Aside from documentation about localized contamination in Villages and Hamlets the only other reference to groundwater contamination was of the Environment Canada Report on Groundwater Quality in Ontario which reports contamination of groundwater in Prince Edward County by pesticides (MacRitchie 1994). However, this is the only reference to this issue and analysis of groundwater from PGMN monitor wells has not indicated this to be a problem.

Indicators of Groundwater Quality

A list of indicator parameters for groundwater in the Quinte Region has been established and provided below. These parameters are to allow detection of natural water quality problems which occur in the watershed as well as impact from land use. Based on present knowledge it would appear that these parameters indicate an impact from septic systems and agricultural. In isolated areas of landfills and other point source of pollution more comprehensive testing would be required and such requirements would be established in reference to relevant activity.

Groundwater Indicator Parameters:

- Sodium & Chloride
- Hardness
- Total Dissolved Solids
- Methane Gas
- Nitrate
- Bacteriological Parameter

References

Baker, R. B. (2001). Municipality of Centre Hastings: Hamlets of Crookston, Fuller, Ivanhoe, Moira and Roslin Groundwater Management Study: Final Report, TSH Engineers Architects Planners**:** 32 + Appendices.

Dillon (2004). Quinte Regional Groundwater Study, Prepared by Dillon Consutling Ltd. for Quinte Conservation**:** 194 + Appendices.

MacRitchie, S. M., C. Pupp, G. Grove, K. W. F. Howard, and P. Lapcevic (1994). Groundwater in Ontario: Hydrogeology, Quality Concerns and Management. Toronto, Ontario Canada, National Hydrology Research Institute, Environment Canada**:** 11.

Singer, S. N., Cheng, C. K. and M. G. Scafe (1997). The Hydrogeology of Southern Ontario. Hydrogeology of Ontario, Ontario Ministry of Environment. **1**.

Singer, S. N., Cheng, C. K. and M. G. Scafe (2003). The Hydrogeology of Southern Ontario, Second Edition. Hydrogeology of Ontario. Toronto, Ontario Canada, Environmental Monitoring and Reporting Branch, Ontario Ministry of Environment.

WESA (1985). Preliminary Hydrogeologic Investigation of Prince Edward County: Final Report, Water and Earth Science Associates Ltd.**:** 42 + Appendices.

3.4 Raw Water Characterization for Drinking Water Sources

Municipal surface water intakes and wells are considered vulnerable to water quality threats as they supply the drinking water systems with the intention of servicing the public with potable drinking water. It is necessary to review the results of water quality indicators for the drinking water system to determine current conditions that will help identify issues for section 7.0. There are various data sources that monitor raw water for water quality conditions at the drinking water system for both surface and groundwater sources (Table 3.14). The Drinking Water Information System (DWIS) and the Drinking Water Surveillance Program (DWSP) are good sources for raw water quality data at the drinking water source. Data is collected by the municipality and submitted to the Ministry of Environment under direction of the drinking water systems Regulation (O.Reg. 170/03) of the Safe Drinking Water Act (2002).

Table 3.14. Data sources for drinking water systems.

Program	What is monitored for Quinte Region	Earliest Available Data	Raw Water Variables
Drinking Water Information Systems (DWIS)	• Quality of raw and treated drinking water • 11 drinking water systems (7 intakes, 4 wells)	2002	Microbial, hysical, chemical, metals, volatile organics, radionuclides, pesticides
Drinking Water Surveillance Program (DWSP)	• Quality of raw, treated, and distributed drinking water • 4 drinking water systems (3 intakes, 1 well)	1987	Physical, chemical, metals, volatile organics, radionuclides, pesticides
Provincial Water Quality Monitoring Network (PWQMN)	• Rivers and streams • 29 current sites plus 13 sites no longer active • Appendix 11	1964	Suite of physical, chemistry, metals, radionuclides, microbial
Provincial Groundwater Monitoring Network (PGMN)	• 31 wells monitored • Appendix 14 & 15	2002	Suite of physical, chemical, metals, Radionuclides
Municipality	• 7 intakes • 4 wells	2002	Microbial, Alkaliniy, Colour, pH, Temperature, Turbidity

DWIS is a mandatory program for all drinking water systems. There are seven drinking water system intakes and four well supplies systems located in the Quinte Region. Unlike DWIS, the DWSP program is a voluntary program where only three of the seven surface water intakes and one out of four well supplies monitor for a more extensive set of water quality parameters.

Another source of raw water data is the Provincial Water Quality Monitoring Network (PWQMN). This program helps characterize water quality upstream of a drinking water system intake. The Provincial Groundwater Monitoring Network (PGMN) can be used to assess groundwater quality in an aquifer that serves as a source of drinking water.

3.4.1 Drinking Water Information System (DWIS) Surface Water Intakes

The DWIS in the Quinte Region monitors data for seven municipal surface water intakes and six well supplies (Map 37). In the DWIS, intake and well systems report on different parameters. Most drinking water system intakes in the Quinte region only monitored their raw water for microbial indicators where the data for these parameters will be reviewed in the section 3.5. In addition to the microbial indicators, arsenic and sodium were monitored at two intakes in the Quinte region. Belleville drinking water system and Point Anne Hamlet drinking water system measured raw water for arsenic once at their intakes in 2004. Arsenic was 0 µg/L, falling below the threshold of the PWQO (5 ug/L) and the ODWS (25 ug/L) (Table 3.15). Sodium was sampled once at the Belleville drinking water system in 2004 and twice at the Point Anne Hamlet drinking water system in 2003 and 2004. Sodium concentrations measured at Belleville in January 2004 was 8 mg/L and at Point Anne Hamlet were 33 mg/L in October 2003 and 9 mg/L in January 2004. All three sodium concentrations were below the ODWS threshold of 200 mg/L.

Table 3.15. DWIS raw water results from drinking water system (DWS) intakes in 2002 to 2006 based on non-microbial parameters.

DWS_Name	Sample Date	Parameter	Unit	Result	PWQO	% of Exceed-ences	ODWS	% of Exceed-ences
Belleville	1/14/2004	ARSENIC	µg/L	0	5	0	25	0
Belleville	1/14/2004	SODIUM	mg/L	8.1			200	0
Point Anne Hamlet	1/13/2004	ARSENIC	µg/L	0	5	0	25	0
Point Anne Hamlet	10/20/2003	SODIUM	mg/L	32.5			200	0
Point Anne Hamlet	1/13/2004	SODIUM	mg/L	18.6			200	0

3.4.2 DWIS Well Supplies

There is a larger set of parameters monitored through DWIS for raw water at the well supplies, but some well supplies only monitor microbial parameters. The non-microbial parameters analyzed in this section were selected based on results being above the method detection limit and have an Ontario Drinking Water Standard (ODWS) for comparison. Deloro drinking water system (May 2003 to Sept 2006) and Peats Point Subdivision drinking water system (Feb 2003 to Sept 2006) well supplies did not have any additional data from the raw water monitoring other data on microbial indicators which will be reviewed in section 3.5. The two wells for Madoc drinking water system (May 2003 to Sept 2006) did not have concentrations of nitrates, nitrite, or sodium above the threshold of the ODWS (Table 3.16).

Table 3.16. DWIS raw water results from groundwater drinking water system (DWS) well supplies taken in 2002 to 2006 based on non-microbial parameters. Note: Ontario Drinking Water Standards (ODWS).

DWS Name	Parameter	Unit	No. of Obs.	Min	Max	Average	Median	ODWS	% of Exceedences
Madoc (Rollins Well)	NITRATES	mg/L	12	1.79	3.92	2.94	2.94	10	0
	NITRITES	mg/L	6	0.005	0.011	0.011	0.011	1	0
	SODIUM	mg/L	1	50.2	50.2	50.20	50.20	200	0
Madoc (Whytock Well)	NITRATES	mg/L	16	0.82	3.81	2.52	2.63	10	0
	NITRITES	mg/L	8	0.005	0.011	0.01	0.011	1	0
	SODIUM	mg/L	1	23.1	23.1	23.1	23.1	200	0
Tweed (Crookston Well No.3)	FLUORIDE	mg/L	2	0.78	0.87	1	0.825	1.5	0
	URANIUM	µg/L	45	4.6	33.8	21.3	22	20	69
Tweed (Main Well No.1)	URANIUM	µg/L	5	21.0	203	128	193	20	100

Fluoride was sampled from the raw water of Crookston Well #3 of the Tweed drinking water system twice in December 2003. Both results were below the 1.5 mg/L ODWS (Table 3.16). Groundwater usually has higher fluoride concentrations than surface waters because it is found in mineral deposits particularly in the Madoc area. Typical natural concentrations of fluoride in Canadian groundwater can be as high as 10 mg/L

(McNeely 1979). Unfortunately, there were no DWIS results for Fluoride in raw water at the well supplies of the Madoc drinking water system.

Tweed drinking water system (May 2003 to Sept 2006) had high concentrations of uranium in both wells. Uranium concentrations in Crookston Well #3 ranged from 4.6 to 33.8 µg/L of 45 samples taken from May of 2003 to April 2004 where 69% of the samples were above the uranium ODWS of 20 µg/L (Table 3.16). Uranium concentrations in the Main Street Well #1 ranged from 21 to 203 µg/L in the five samples taken in the fall of 2003. All of these results were above the ODWS (Table 3.16). A possible natural source of uranium in the well supplies of the Tweed drinking water system is igneous rock.

3.4.3 Drinking Water Surveillance Program (DWSP)

The DWSP program monitors several water chemistry parameters for raw water collected from the intake at various frequencies (from once a year to several times a year) depending on the drinking water system. The water chemistry data for DWSP received from the Ontario Ministry of Environment was in the format of annual minimum, maximum and average values for each participating drinking water system in this voluntary program.

Out of the many variables that are collected under DWSP, a small set of parameters for raw water were selected to be analyzed (Table 3.17). They were selected because they characterize taste and odour, associated with microbiological conditions, or they pose a health risk if concentrations are above their provincial water quality standard. Generally a high concentration of a parameter indicates land use activities effecting raw water in the vicinity of the municipal intake or well.

Table 3.17. DWSP parameter description and summary results for raw water at drinking water systems (DWS).

Parameter	Description	PWQO	ODWS	Other	Comments
Alkalinity (mg/L)	Contribute to total dissolved solids that are vectors for bacteria		30>x>500 *		No exceedences
Arsenic (µg/L)	A heavy metal that is a carcinogen when ingested at high concentrations	5 (interim)	25		Not measured at intakes. No exceedences at wells
Chromium (µg/L)	A heavy metal that is toxic when ingested at high concentrations	8.9	50		Deseronto DWS exceeded PWQO in 2002
Colour (TCU)	An aesthetic parameter		5*		All DWS exceeded ODWS at one point in time except Deloro well supply
DOC (mg/L)	Indicates level of vegetation growth and decomposition		5		All DWS exceeded ODWS at one point in time except Deloro well supply
Geosmin (ng/L)	Organic compound produced by microbes when they die and is an indicator of taste and odour			5	All DWS at one point in time. No data for Deloro well supply
Nitrates (mg/L)	High concentrations are linked to excessive algae blooms		10		No data from intakes. No exceedences at Deloro well supply
pH	Effects other parameters	6.5>x>8.5	6.5>x>8.5 *		No exceedences except once at Belleville DWS in 2001 (n=2)
Phosphorus, Total	High concentrations are linked to excessive algae blooms	0.02		0.03	All DWS exceeded ODWS except for Deloro well supply

Parameter	Description	PWQO	ODWS	Other	Comments
Turbidity (FTU)	Measure of number of particles that are vectors for bacteria		5		Belleville (2001) and Deseronto (2002) intakes had exceedences

* operational or aesthetic guideline

The following drinking water systems had participated in DWSP in the last 6 years.

- Belleville intake (2000 to 2004)
- Deseronto intake (2000 to 2002)
- Picton intake (2000 to 2005)
- Deloro well supply (2000 to 2003)

Napanee's A. L. Dafoe drinking water system intake is located in Lake Ontario with a backup intake in the Napanee River. Although there is data for the A. L. Dafoe drinking water system, there is no DWSP data for the backup intake. Cataraqui Region Conservation Authority is reporting on the A. L. Dafoe drinking water system because the main intake is located in their Source Protection Area. Very little data has been gathered from the Greater Napanee Utilities on the raw water quality for the Napanee River backup intake as it is very rarely in use.

Alkalinity

Alkalinity is the capacity of water to neutralize acid and the unit of measure is expressed as the equivalent of calcium carbonate ($CaCO_3$) (McNeely 1979). It indicates the presence of carbonates, bicarbonates, and hydroxides, and less significantly, borates, silicates, phosphates, and organic substances. These substances contribute to the total dissolved solids in water that may have come from municipal and industrial effluents, agricultural runoff, and aerosol fallout. The Ontario Drinking Water Standard (ODWS) recommends alkalinity of water being in the range of 30 to 500 mg/L. This assists with floc formation during coagulation process of water treatment and avoids corrosion or scaling of metal equipment. Belleville drinking water system ranged from 86 to 126 mg/L between 2000 and 2004. Deseronto drinking water system ranged from 52 to 119 mg/L between 2000 and 2002. Picton drinking water system ranged from 93 to 125 mg/L between 2000 and 2005. Deloro well supply ranged from 208 to 322 mg/L between 2000 and 2003. All are within the recommended guideline.

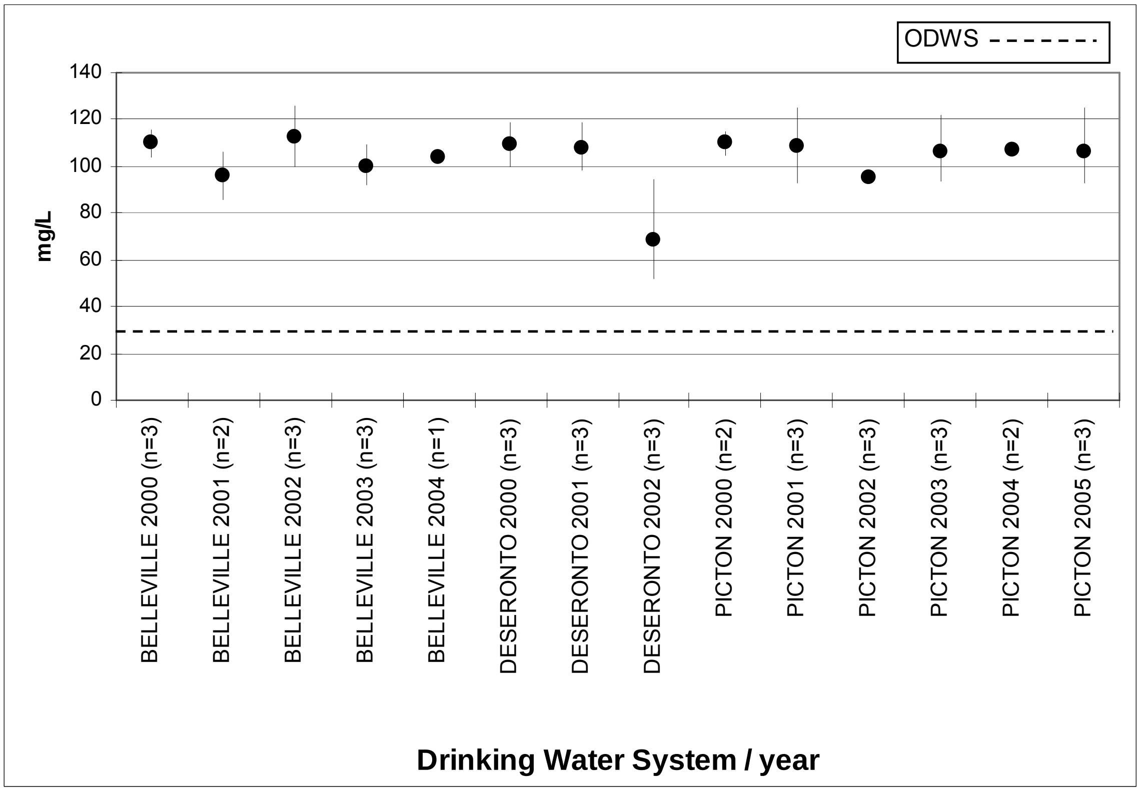


Figure 3.7.Alkalinity results for municipal intakes in the Quinte Source Protection Region. The line in the graph represents the minimum and maximum, the dot represents the average value, and n is the number of samples. ODWS = <30 and >500 mg/L.

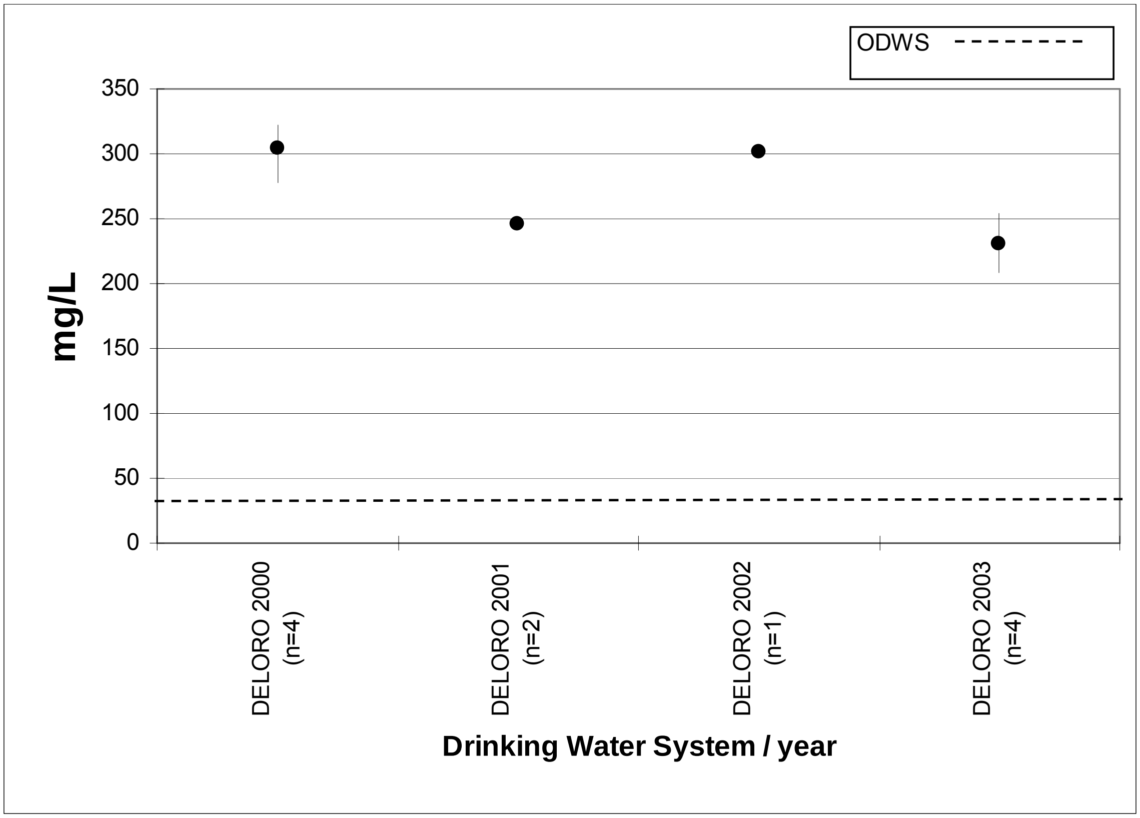


Figure 3.8.Alkalinity results for the Deloro municipal well supply in the Quinte Source Protection Region. The line in the graph represents the minimum and maximum, the dot represents the average value, and n is the number of samples. ODWS = <30 and >500 mg/L.

Arsenic

Arsenic is naturally present in most surface waters at low concentrations. Levels are higher in groundwater in hard rock areas, such as the Canadian Shield. Arsenic can also be released into the surface water or groundwater from mine drainage waters, and in some mine leachates. The ODWS is 25 µg/L and the Provincial Water Quality Objective (PWQO) is 5 µg/L for arsenic. This parameter was not measured at the intakes, but was measured at the Deloro well supply. Concentrations of arsenic ranged from 4.2 to 7.2 µg/L between 2000 and 2003, never exceeding the drinking water standard.

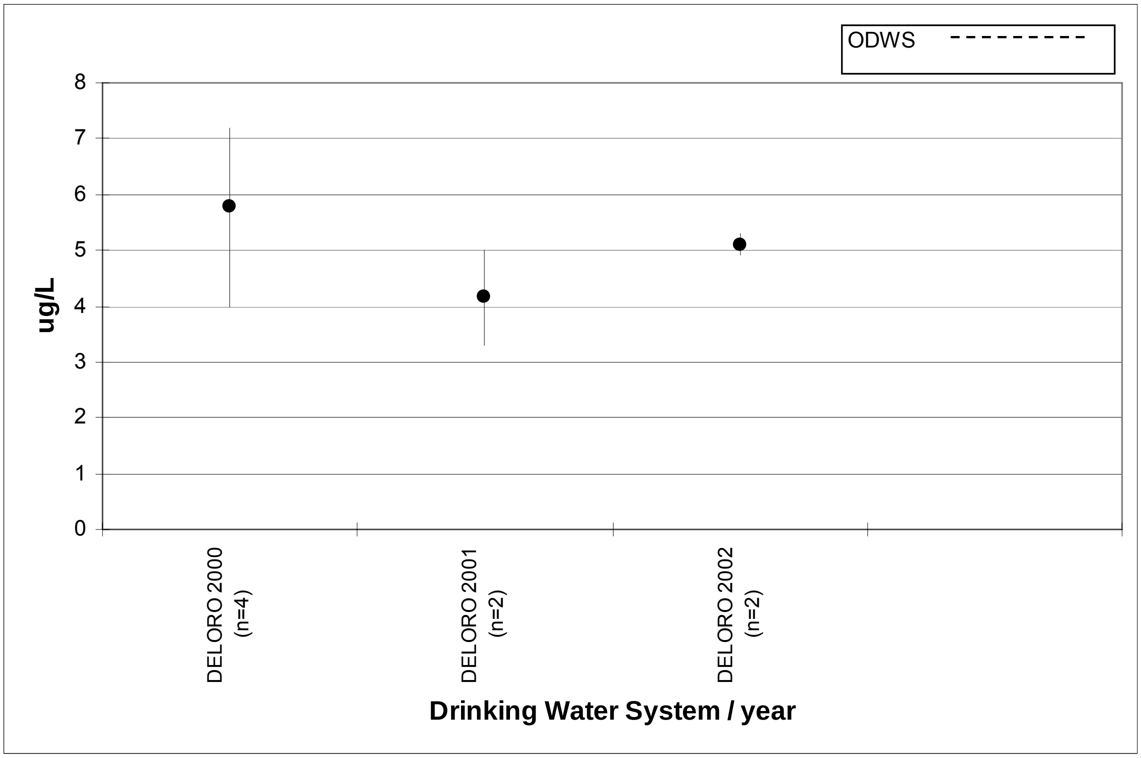


Figure 3.9. Arsenic results for the Deloro municipal well supply in the Quinte Source Protection Region. The line in the graph represents the minimum and maximum, the dot represents the average value, and n is the number of samples. ODWS = 25 µg/L.

Chromium

Trivalent chromium is a metal found in igneous rock in its natural state and is not considered to be toxic. It is only considered toxic when present in raw water and proceeds to oxidize to hexavalent chromium (a more harmful form) during the chlorination process in a drinking water system. The more oxidized form of chromium is present in older yellow paints, in residues from plating operations, and in old recirculating water cooling systems. The PWQO for this variable is 8.9 µg/L and the ODWS is 50 µg/L. The Belleville drinking water system ranged from 0.4 to 1.3 µg/L between 2000 and 2004. Deseronto drinking water system ranged from 0.1 to 11.3 µg/L between 2000 and 2002. Picton drinking water system ranged from 0.3 to 1.9

µg/L between 2000 and 2005. Deloro well supply ranged from 1.5 to 3.5 µg/L between 2000 and 2003. All, but Deseronto drinking water system were within the recommended guidelines. Deseronto drinking water system exceeded the PWQO in 2002.

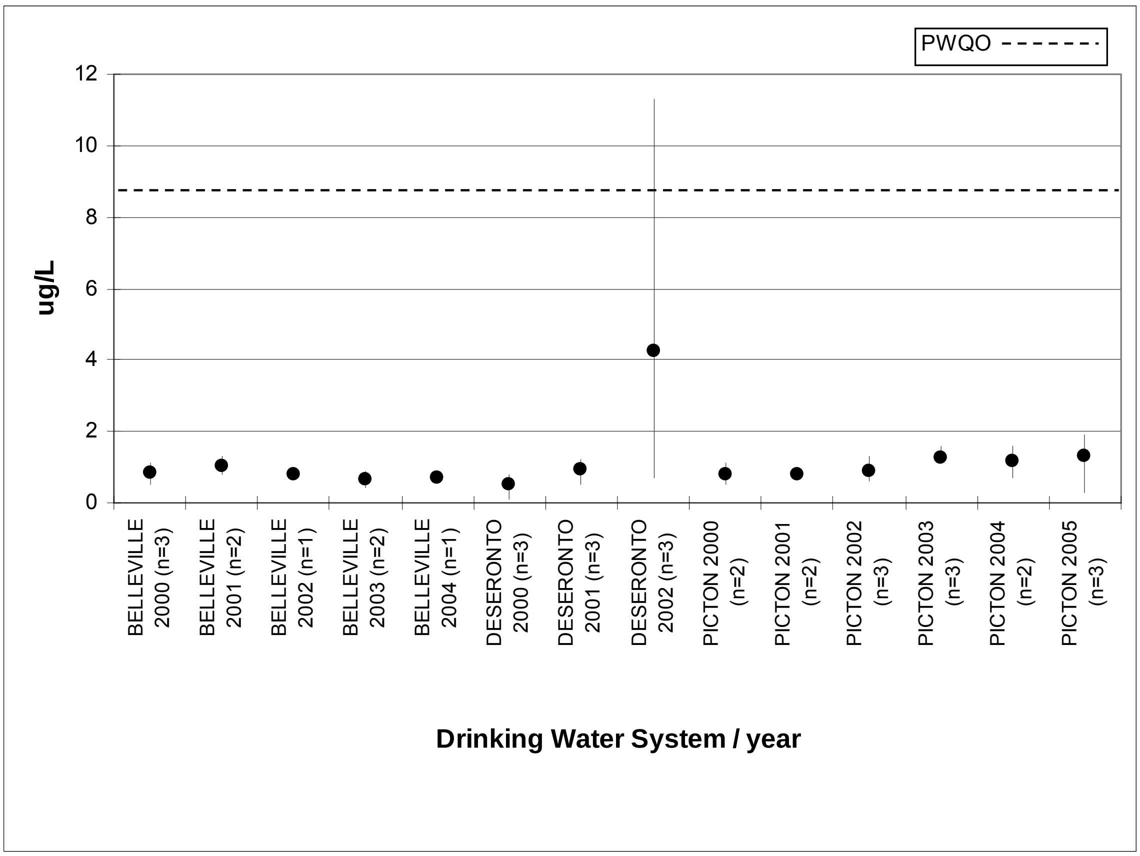


Figure 3.10. Chromium results for municipal intakes in the Quinte Source Protection Region. The line in the graph represents the minimum and maximum, the dot represents the average value, and n is the number of samples. PWQO = 8.9 µg/L.

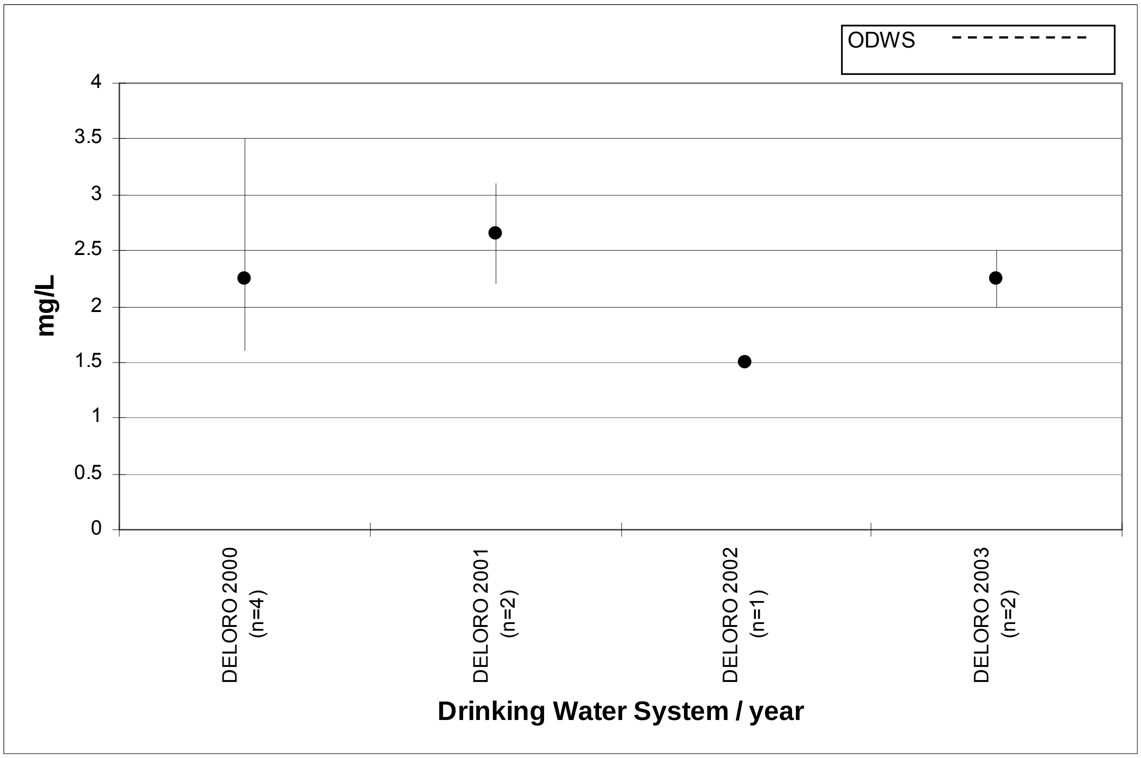


Figure 3.11. Chromium results for the Deloro municipal well supply in the Quinte Source Protection Region. The line in the graph represents the minimum and maximum, the dot represents the average value, and n is the number of samples. ODWS = 50 µg/L.

Colour

True colour measures the dissolved colouring compounds attributed by organic and inorganic materials that absorb various light frequencies. The colour of water is derived from natural mineral compounds, such as iron and manganese. Organic sources can be algae, protozoa (unicellular parasites), or natural products from decaying vegetation. Other sources of organic and inorganic materials that may colour water are from Industry and agriculture. The aesthetic ODWS for true colour is 5 TCU. The Belleville drinking water system ranged from 12 to 20.8 TCU between 2000 and 2004. Deseronto drinking water system ranged from 0.9 to 28.2 TCU between 2000 and 2002. Picton drinking water system ranged from 5.8 to 26.3 TCU between 2000 and 2005. Deloro well supply ranged from 0.2 to 1.6 TCU between 2000 and 2003. All drinking water systems exceeded the recommended aesthetic guideline at one point in time with the exception of the Deloro well supply.

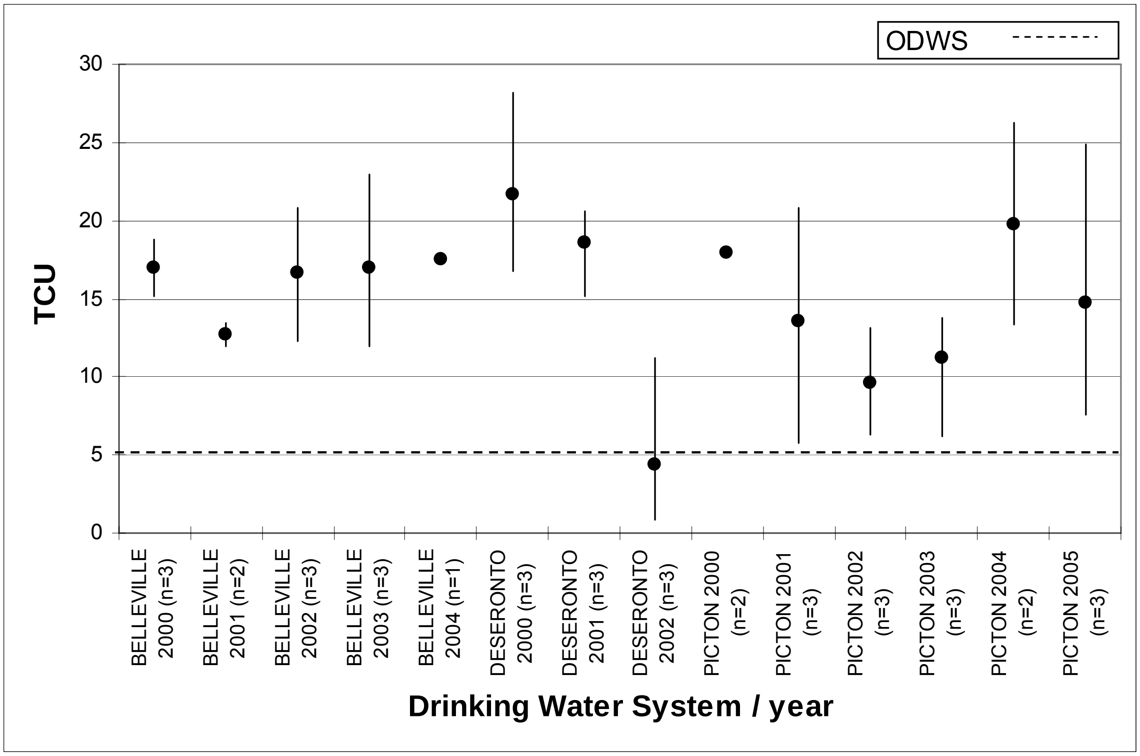


Figure 3.12. Colour results for municipal intakes in the Quinte Source Protection Region. The line in the graph represents the minimum and maximum, the dot represents the average value, and n is the number of samples. ODWS = 5 TCU.

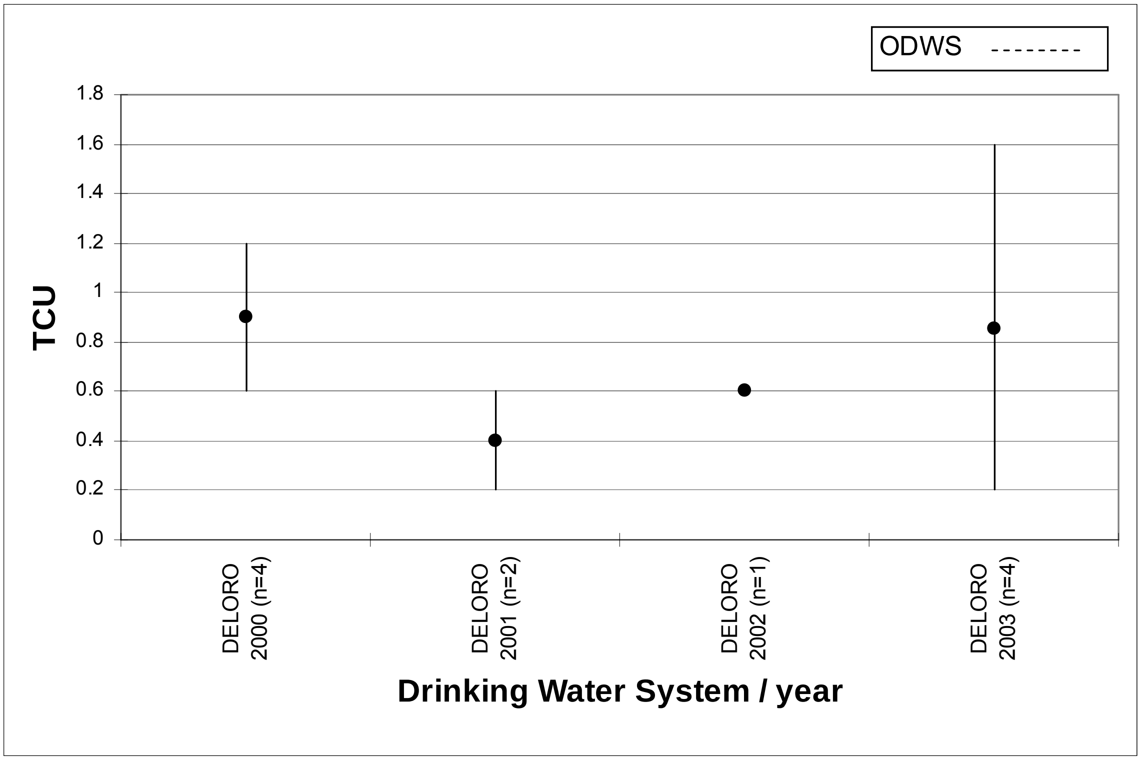


Figure 3.13. Colour results for the Deloro municipal well supply in the Quinte Source Protection Region. The line in the graph represents the minimum and maximum, the dot represents the average value, and n is the number of samples. ODWS = 5 TCU.

Dissolved Organic Carbon

Dissolved organic carbon (DOC) is a measure of humic substances and partly degraded plant and animal materials and is resistant to bacterial growth. Runoff from agricultural lands and municipal and industrial waste discharges are sources of DOC. The aesthetic objective for drinking water is 5 mg/L. The Belleville drinking water system ranged from 5.5 to 6.5 mg/L between 2000 and 2004. Deseronto drinking water system ranged from 2.4 to 9.8 mg/L between 2000 and 2002. Picton drinking water system ranged from 3.0 to 7.7 mg/L between 2000 and 2005. Deloro well supply ranged from 0.5 to 1.1 mg/L between 2000 and 2003. All drinking water systems exceeded the recommended aesthetic guideline at one point in time except at the Deloro well supply.

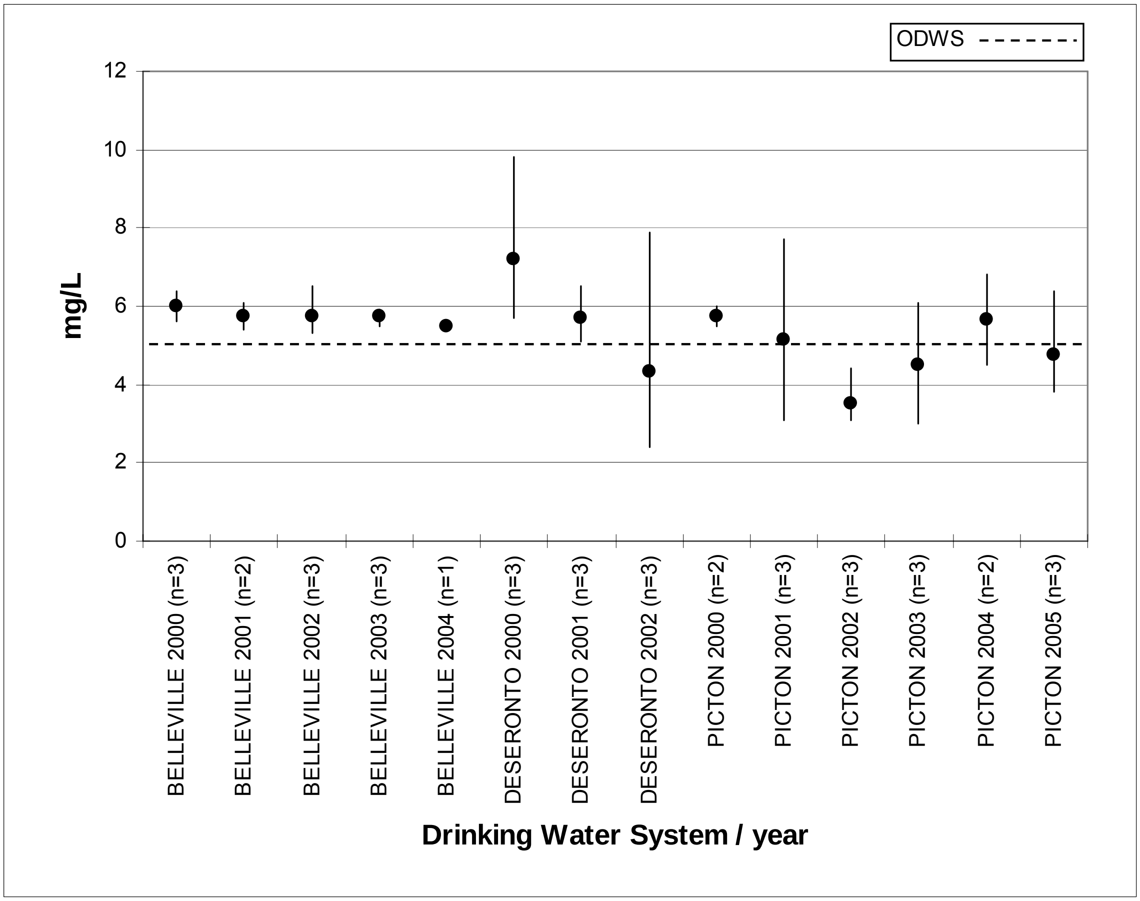


Figure 3.14. DOC results for municipal intakes in the Quinte Source Protection Region. The line in the graph represents the minimum and maximum, the dot represents the average value, and n is the number of samples. ODWS = 5 mg/L.

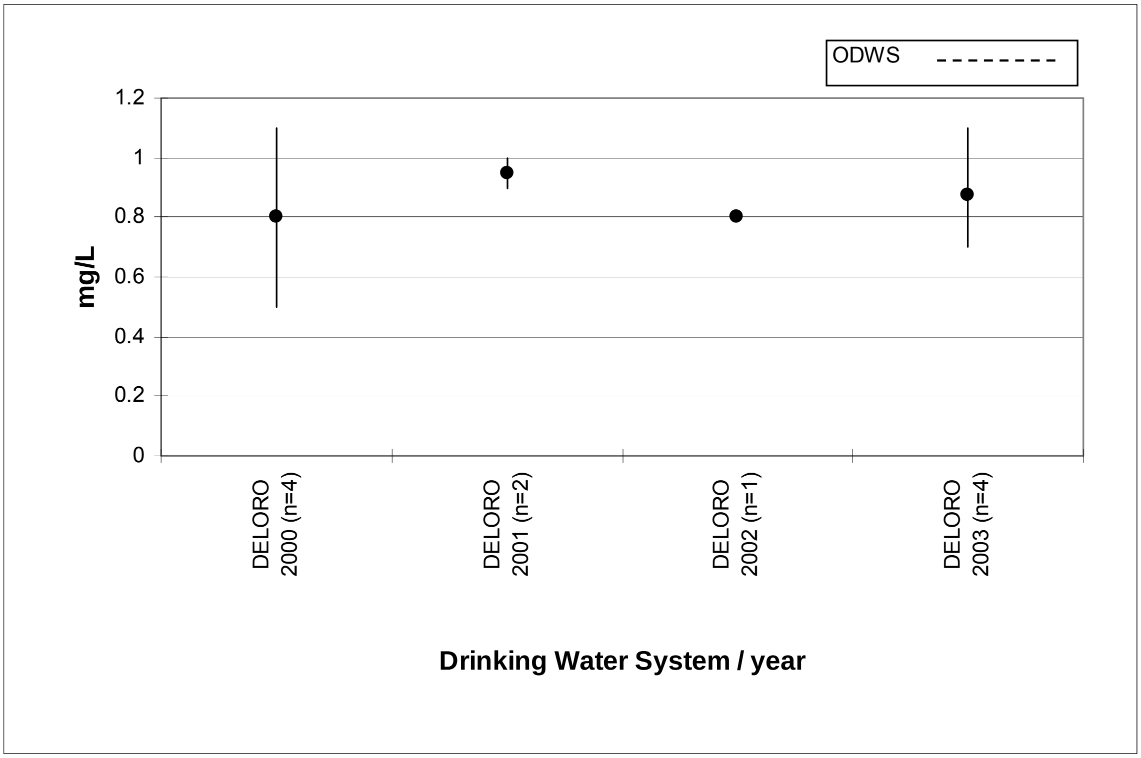


Figure 3.15. DOC results for the Deloro municipal well supply in the Quinte Source Protection Region. The line in the graph represents the minimum and maximum, the dot represents the average value, and n is the number of samples. ODWS = 5 mg/L.

Geosmin

Geosmin is an organic compound is an indicator of taste and odour in water quality monitoring. This compound is produced by several classes of microbes, including cyanobacteria (blue-green algae) and actinobacteria, and is released when these microbes die. Communities whose water supply depends on surface water can periodically experience unpleasant-tasting water when a sharp drop in the population of these bacteria releases geosmin into the local water supply. Under acidic conditions, geosmin decomposes into odourless substances. Water at the intakes and well supply do not have acidic conditions, therefore the release of geosmin combined with the presence of bacteria most likely have an unpleasant taste and odour. Currently, there are no PWQO or ODWS, but the human nose can detect odour at concentrations down to 5 ng/L. The Belleville drinking water system ranged from 3.3 to 43 ng/L between

2000 and 2004. Deseronto drinking water system ranged from 1 to 18 ng/L between 2000 and 2002. Picton drinking water system ranged from 2.0 to 9.1 ng/L between 2000 and 2005. All of these drinking water systems had geosmin concentrations at a detectable limit during the analyzed time period.

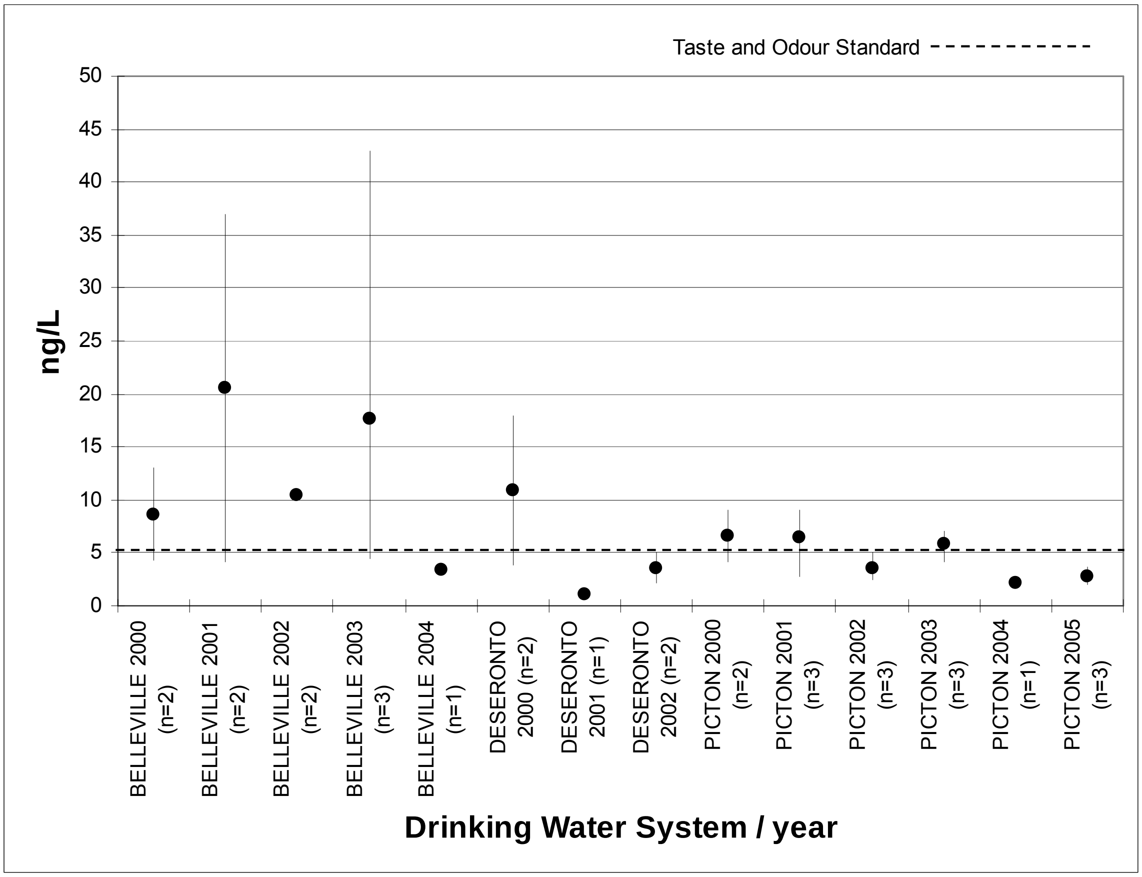


Figure 3.16. Geosmin results for the municipal intakes in the Quinte Source Protection Region. The line in the graph represents the minimum and maximum, the dot represents the average value, and n is the number of samples. Taste and odour standard = 5 ng/L.

Nitrates

As discussed in previous sections, nitrates are present in water, particularly in groundwater as a result of decay of plant and animal material, runoff of fertilizers and domestic sewage or treated wastewater, or soils containing soluble nitrogen compounds. The ODWS for nitrate is 10 mg/L and there is no PWQO for this parameter. The Belleville drinking water system ranged from 0.005 to 0.36 mg/L between 2000 and 2004. Deseronto drinking water system ranged from 0.14 to 0.27 mg/L between 2000 and 2002. Picton drinking water system ranged from 0.02 to 0.42 mg/L between 2000 and 2005. Deloro well supply ranged from 0.15 to 2.17 mg/L between 2000 and 2003. All drinking water systems were below the ODWS and not considered an issue.

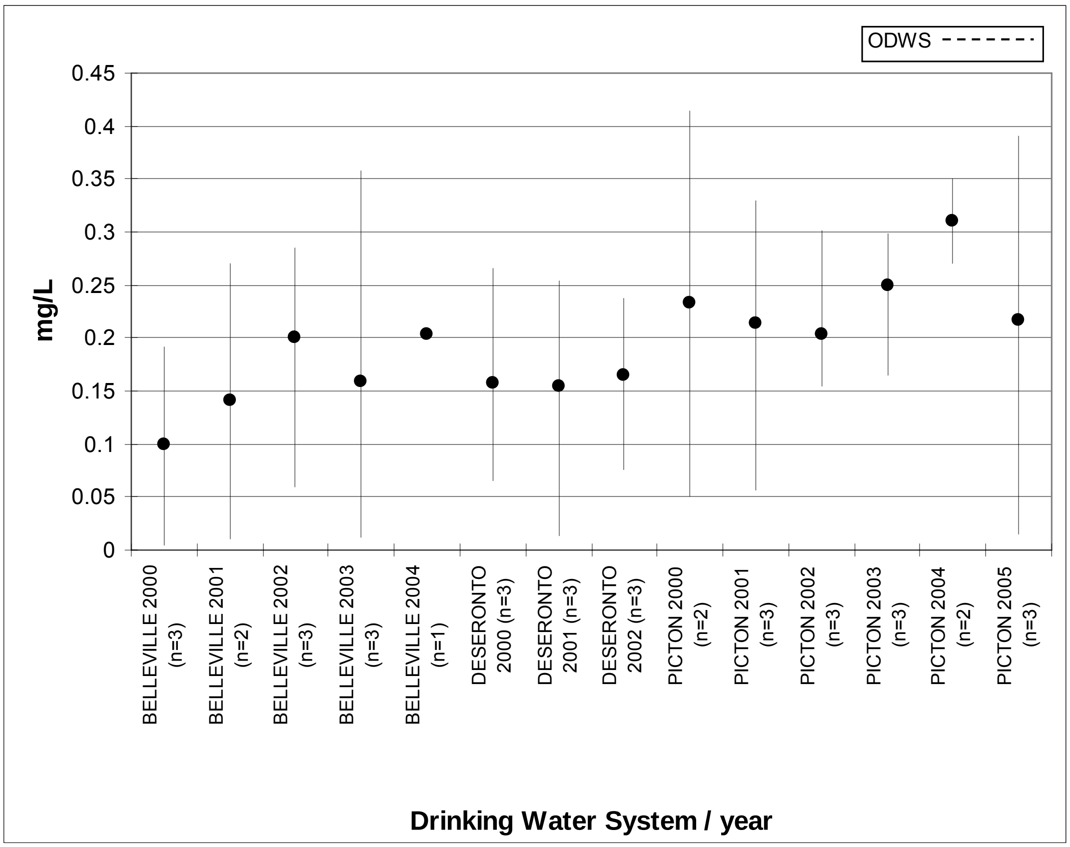


Figure 3.17. Nitrates results for the municipal intakes in the Quinte Source Protection Region. The line in the graph represents the minimum and maximum, the dot represents the average value, and n is the number of samples. ODWS = 10 mg/L.

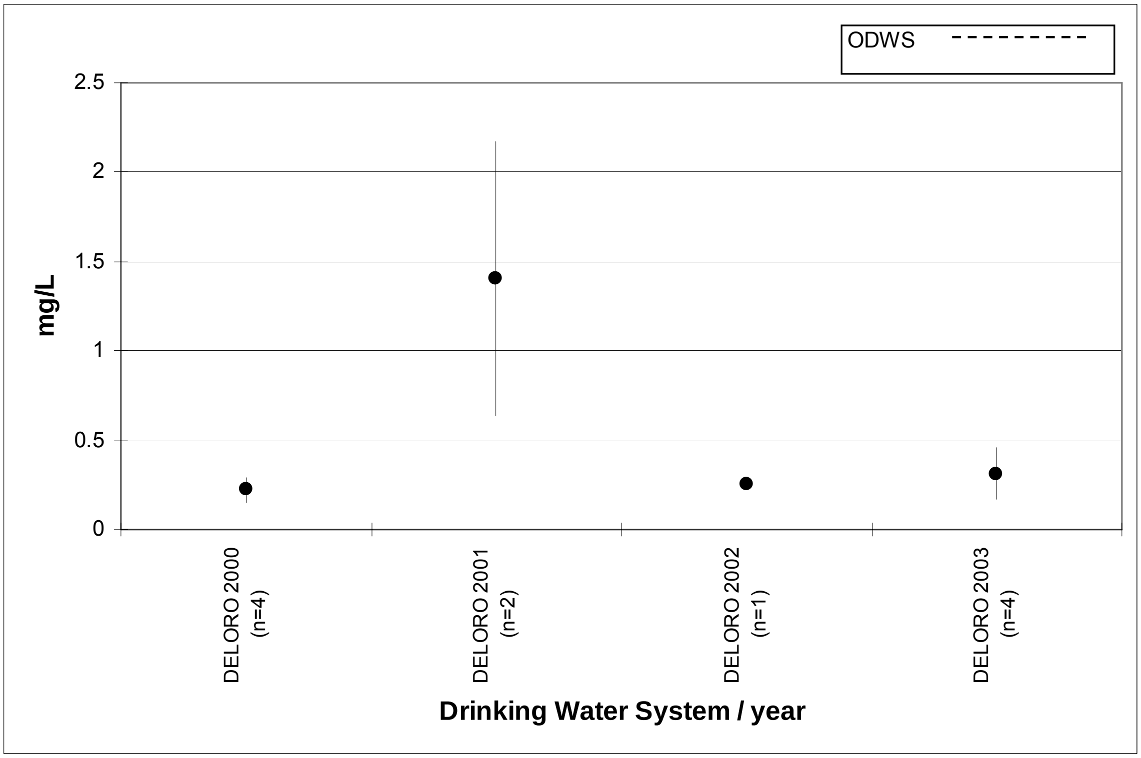


Figure 3.18. Nitrates results for the Deloro municipal well supply in the Quinte Source Protection Region. The line in the graph represents the minimum and maximum, the dot represents the average value, and n is the number of samples. ODWS = 10 mg/L.

pH

The pH of water is a physical-chemical parameter that measures the strength of the hydrogen ion and indicates the level of acidity or alkalinity of water on an exponential scale from 1 (acid) to 14 (alkaline) where 7 is neutral (Horne 1994). It is a key element to the dynamics of the aquatic environment and the potential effects of the acidification of aquatic environments on wildlife are numerous. This includes an increase in the availability of contaminants; modification of the ionic balance of organisms; lower reproductive success for certain species; and decline in wildlife abundance and diversity. There is an operational ODWS for pH that is recommended to control corrosion or incrustation in drinking water systems. The PWQO for pH is the same. At a pH of 8.5 and over a bitter taste can occur. The PWQO for pH is greater than or equal to 6.5 and less than 8.5, to protect aquatic life. The Belleville drinking water system ranged from a pH of 7.6 to 8.7 between 2000 and 2004. Deseronto drinking water system ranged from a pH of 7.1 to 8.4 between 2000 and 2002. Picton drinking water system ranged from a pH of 7.2 to 7.9 between 2000 and 2005. Deloro well supply ranged from a pH of 6.9 to 7.9 between 2000 and 2003. All drinking water system were within the ODWS and the PWQO pH range of 6.5 to 8.5 with the exception of one sample take in 2001 at the Belleville drinking water system.

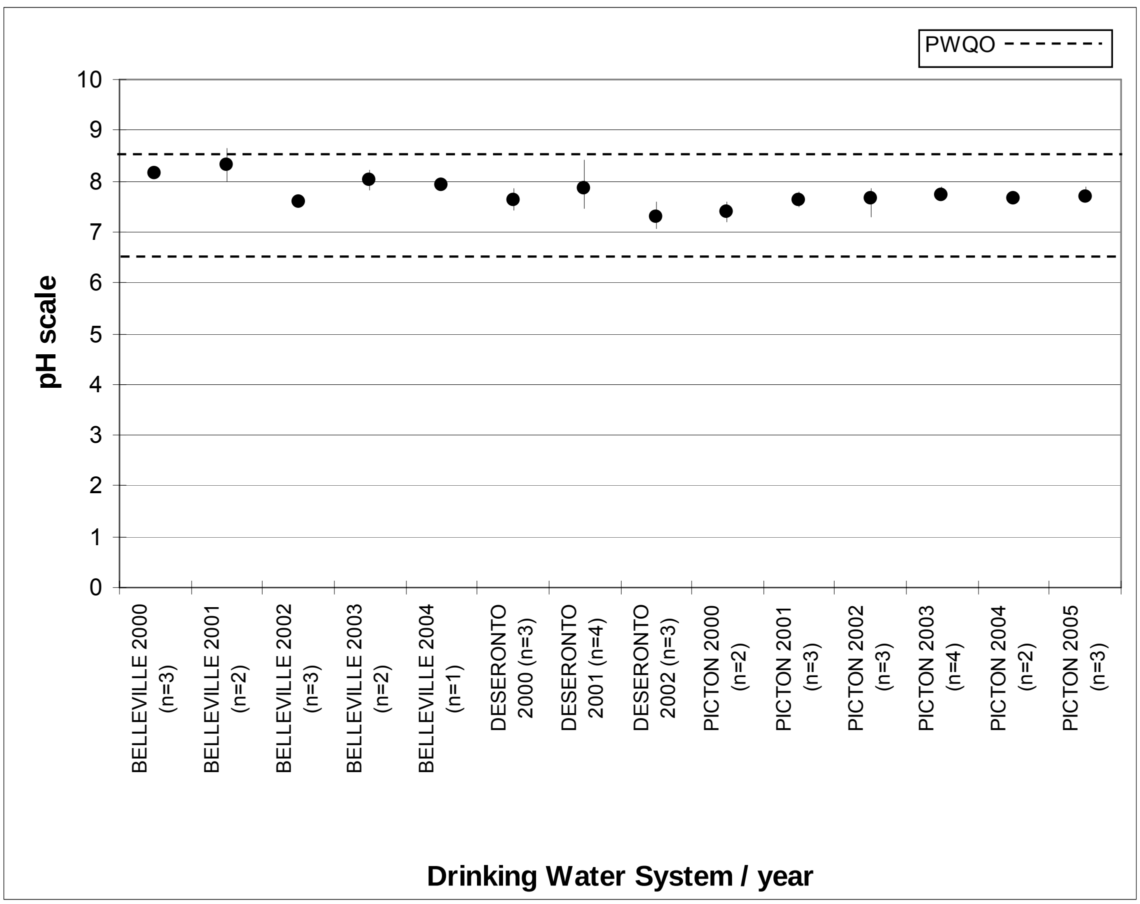


Figure 3.19. pH results for the municipal intakes in the Quinte Source Protection Region. The line in the graph represents the minimum and maximum, the dot represents the average value, and n is the number of samples.

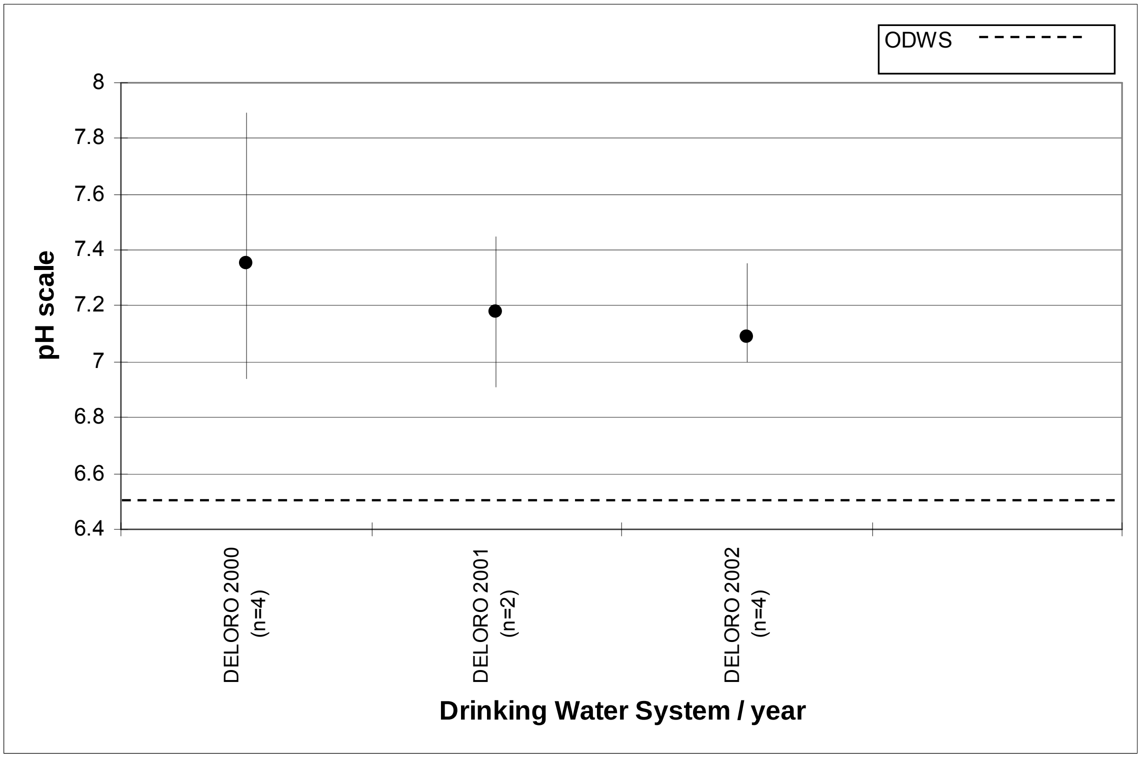


Figure 3.20. pH results for the Deloro municipal well supply in the Quinte Source Protection Region. The line in the graph represents the minimum and maximum, the dot represents the average value, and n is the number of samples. ODWS = <6.5 and >8.5.

Total Phosphorus

Total Phosphorus (TP) is an essential plant nutrient and can equate to algae blooms in surface water with high concentrations of the nutrient. Phosphorus comes naturally from igneous rock and decomposing organic material. When conditions have high concentrations of TP the source is usually anthropogenic. Some examples are domestic sewage with human excrement and phosphates from detergents, industrial effluents, fertilizers and from atmospheric deposition. The PWQO for TP is 0.02 mg/L for lakes and the Bay of Quinte RAP interim objective of 0.03 mg/L (German 1993). The Belleville drinking water system ranged from 0.012 to 0.068 mg/L between 2000 and 2004. Deseronto drinking water system ranged from 0.002 to 0.058 mg/L between

2000 and 2002. Picton drinking water system ranged from 0.014 to 0.046 mg/L between 2000 and 2005. Deloro well supply ranged from 0.002 to 0.007 mg/L between 2000 and 2003. All three surface water drinking water system have had TP concentrations higher then the PWQO and the BQ RAP objective, and the Deloro well supply had concentrations well below the water quality objectives.

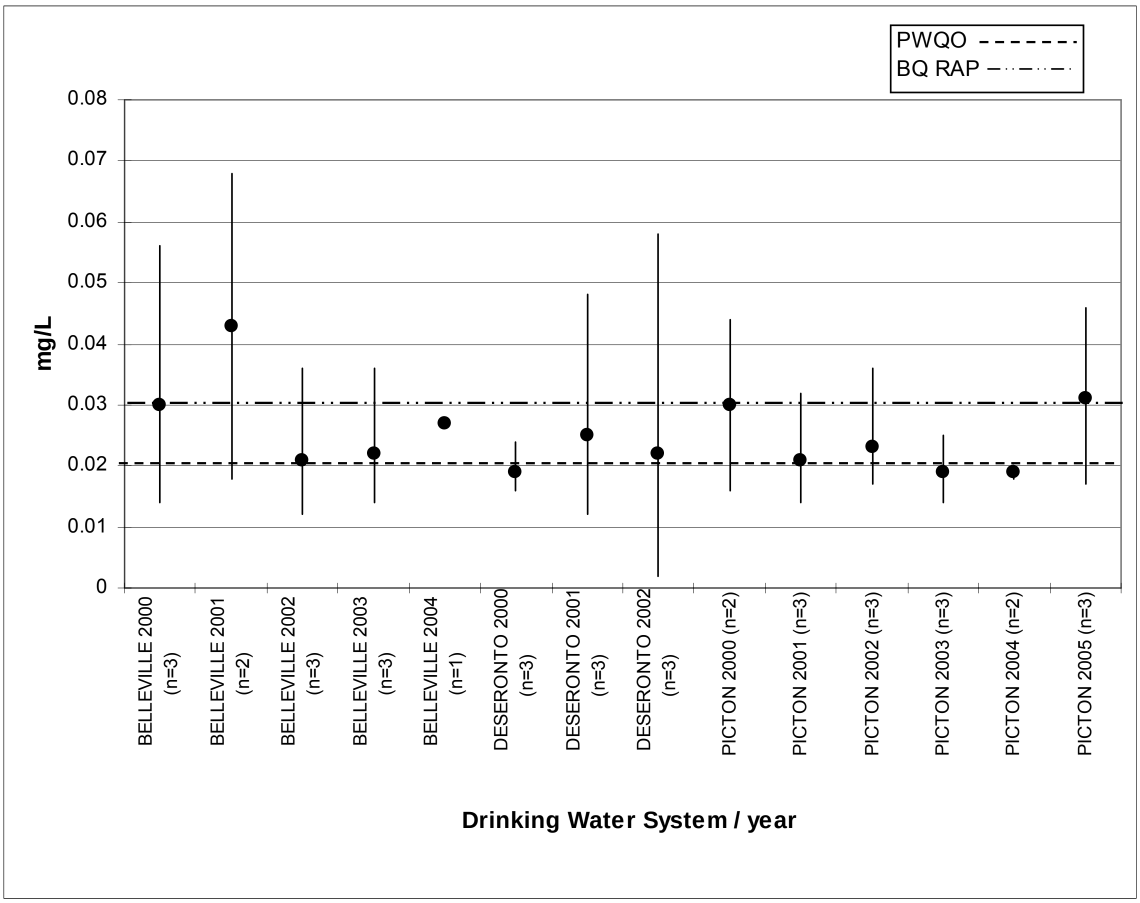


Figure 3.21. TP results for the municipal drinking water system intakes in the Quinte Source Protection Region. The line in the graph represents the minimum and maximum, the dot represents the average value, and n is the number of samples. ODWS = 0.02 mg/L and BQ RAP = 0.03 mg/L.

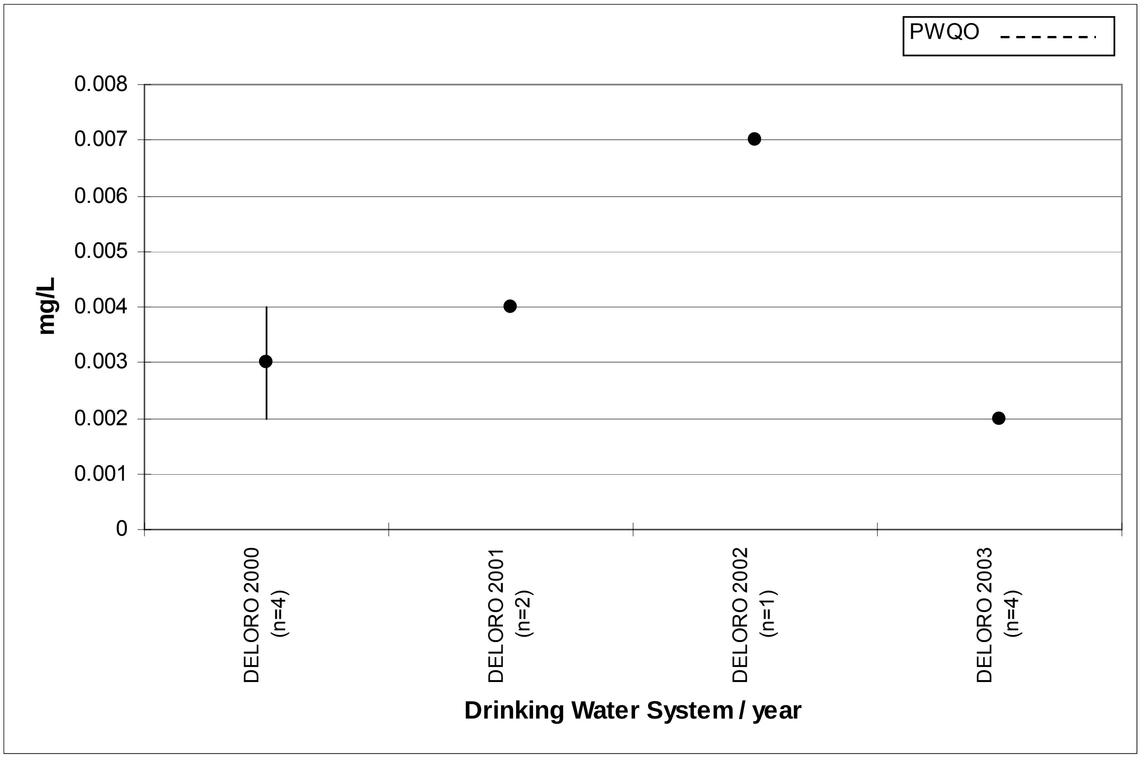


Figure 3.22. TP results for the Deloro municipal well supply in the Quinte Source Protection Region. The line in the graph represents the minimum and maximum, the dot represents the average value, and n is the number of samples. . ODWS = 0.02 mg/L and BQ RAP = 0.03 mg/L.

Turbidity

Turbidity is the measure of suspended solids, such as clay silt, organic matter, plankton, and microscopic organisms that are usually suspended in turbulent water. Turbidity may be a result of erosion, runoff, or algae blooms and is typically high during spring snowmelt. Turbidity is an indicator of the potential presence of disease-causing organisms that can attach themselves to particles and be sheltered from the disinfection process of drinking water treatment. Turbid water can also be abrasive to pumps, pipes and other equipment it is in contact with. The ODWS of 5.0 FTU has been set for aesthetic purposes. Although there is no current PWQO, high turbidity can reduce photosynthesis of submerged plants and algae which in turn may suppress fish community productivity. The Belleville drinking water system ranged from 0.94 to 9.38

FTU between 2000 and 2004. Deseronto drinking water system ranged from 0.05 to 21.9 FTU between 2000 and 2002. Picton drinking water system ranged from 0.25 to 4.58 FTU between 2000 and 2005. Deloro well supply ranged from 0.01 to 0.17 FTU between 2000 and 2003. The raw water results for Picton intake and Deloro well supply had acceptable turbidity levels while Belleville and Deseronto intakes occasionally exceeded the ODWS.

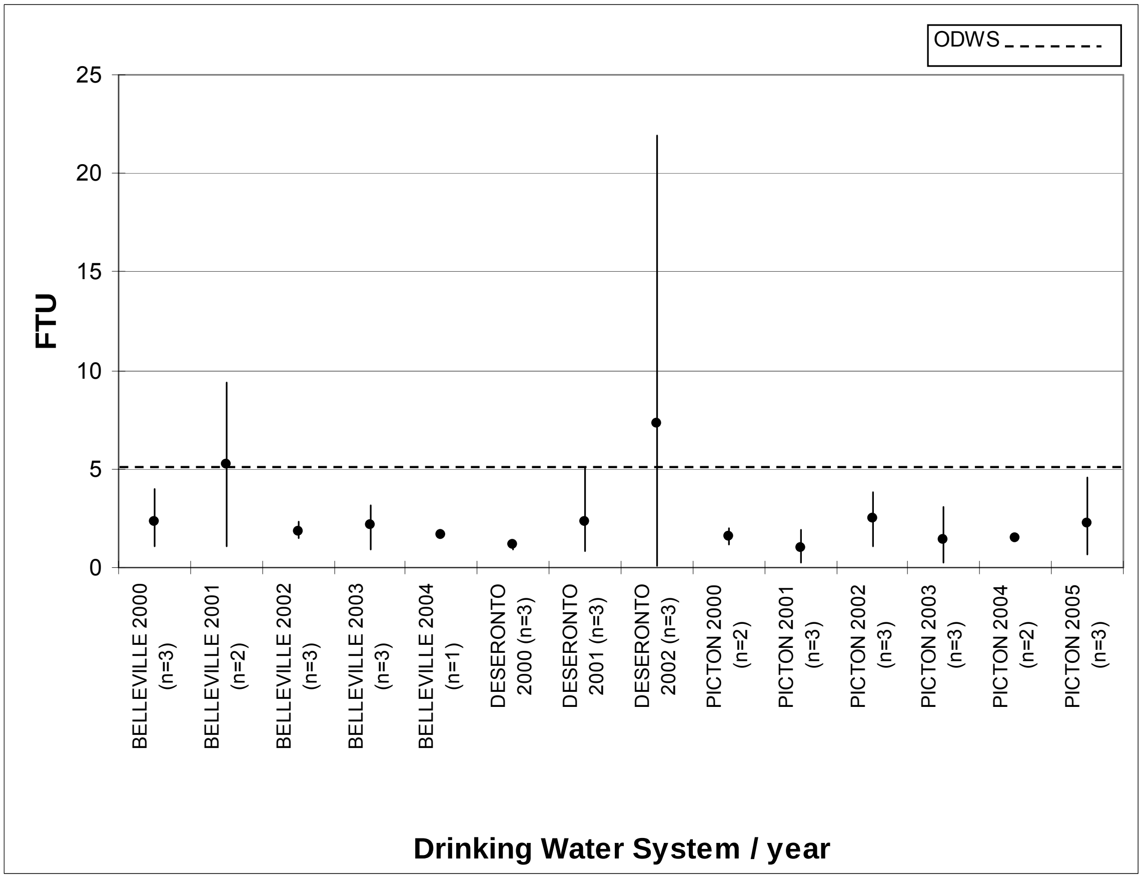


Figure 3.23. Turbidity results for the municipal intakes in the Quinte Source Protection Region. The line in the graph represents the minimum and maximum, the dot represents the average value, and n is the number of samples. ODWS = 5.0 FTU.

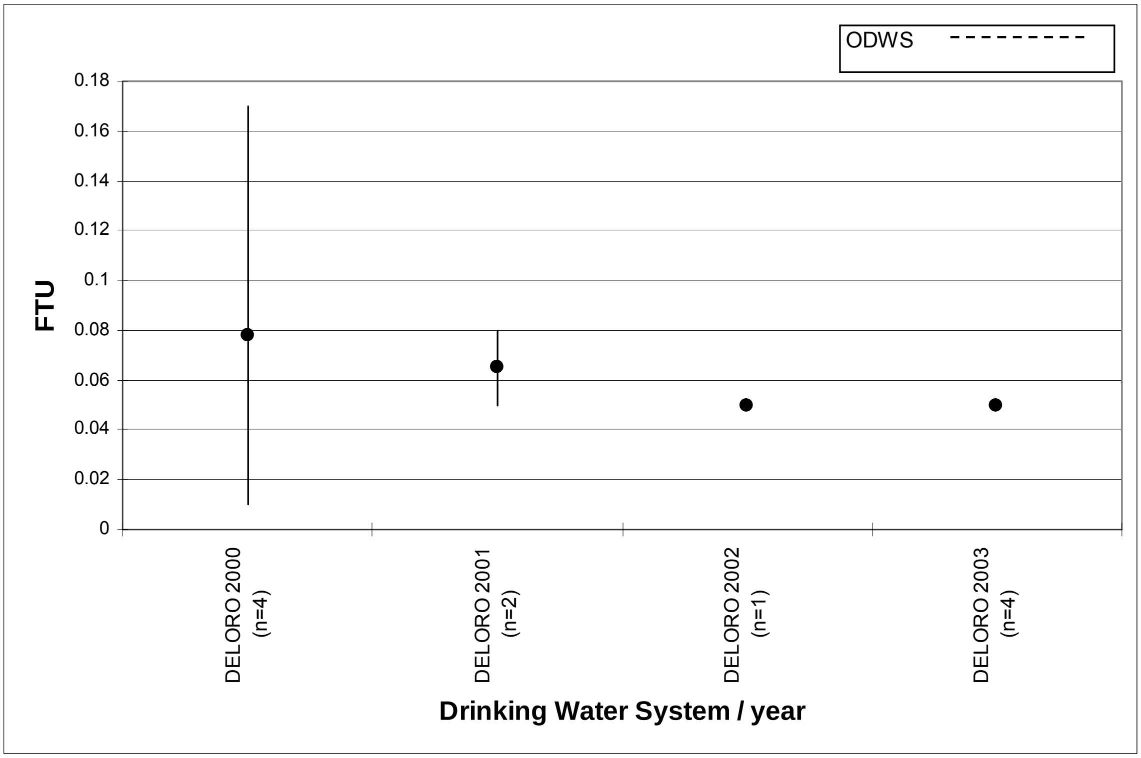


Figure 3.24. Turbidity results for the Deloro municipal well supply in the Quinte Source Protection Region. The line in the graph represents the minimum and maximum, the dot represents the average value, and n is the number of samples. ODWS = 5.0 FTU.

References

German, M., M. Koechlin (1993). The Big Cleanup - Bay of Quinte Remedial Action Plan: Time to Act Stage 2 Report. Time to Act. Trenton, Ontario Canada, Bay of Quinte Remedial Action Plan & Public Advisory Committees.**:** 257.

Horne, A. J., and C. R. Goldman (1994). Limnology. Toronto, Ontario Canada, McGraw-Hill, Inc.

McNeely, R. N., V.P. Neimanis, and L. Dwyer (1979). Water Quality Sourcebook: A Guide to Water Quality Parameters. Ottawa, Ontario Canada, Inland Waters Directorate, Water Quality Branch**:** 89.

3.5 Microbial Source Water Characterization

Monitoring for microbial indicators at a drinking water system and throughout the watershed is important to understanding the potential sources of fecal contamination. All sources of drinking water should be monitored regularly for microbial pathogens, including bacteria and viruses. There are various microbial indicators that are used to monitor the level of fecal contamination. Total coliform (as a general indicator of the presence of coliform) and *E.coli* (a type of coliform that may carry pathogens) are commonly used in water quality assessments.

Total coliforms are naturally occurring in soils, and in the intestinal track of animals and humans. Fecal coliforms are a subset of total coliforms that grow in elevated temperatures.

E.coli is a type of coliform found in the intestines of animals and humans. The presence of *E.coli* in water indicates a recent contamination of fecal matter that may contain disease-causing bacteria, viruses or protozoa (unicellular parasites). Sources with total coliform counts may not be considered safe to drink, but sources with *E.coli* are definitely not safe to drink. Surface water intakes and groundwater wells that were observed to have total coliform and *E.coli* counts present in raw water samples should have their sources of contamination located and removed.

The best source of data for current *E.coli* counts and historic total coliform counts is the Drinking Water Information System (DWIS) for the intake and well supplies. In DWIS, there is no water quality data for the backup intake for the A. L. Dafoe Drinking water system which is located in the Napanee River. The Provincial Water Quality Monitoring Network (PWQMN) data for two upstream stations in the Napanee River is the best available data to characterize this backup intake. Total Coliform sampling was discontinued at the two PWQMN stations in the Napanee River by 1979 and *E.coli* by 2002. PWQMN discontinued sampling microbial indicators and PGMN had never sampled for them.

3.5.1 Assessment of the Raw Water Microbiological Quality at the Intake or Well

DWIS data on raw water results for microbial parameters were analyzed in this section. There are 15 municipal drinking water systems in DWIS database, collected under the Drinking Water Systems Regulations (O. Reg. 170/03) of the Safe Drinking Water Act (2002). Raw water is regularly sampled at the drinking water systems on a weekly basis for *E.coli* and total coliform. Monitoring of raw water at the intakes and wells aid in understanding microbial conditions of the drinking water sources.

DWIS Surface Water

DWIS microbial results (collected from 2003 to 2006) indicate that high *E.coli* counts were an issue for those drinking water systems that had more than the PWQO of 100 counts in raw water samples. Ameliasburgh, Belleville, Deseronto, Picton, and Wellington drinking water system had *E.coli* counts below 100 (Figure 3.25). Point Anne Hamlet drinking water system was observed to have an issue with *E.coli* where counts reached over 100 counts more regularly than the other Quinte region surface water intakes and had up to 3,000 counts at one point in time (Figure 3.25). Point Anne Hamlet drinking water system was observed to have the highest *E.coli* and total coliform counts between 2003 and 2006 (Figure 3.25 and Figure 3.26). Wellington drinking water system had the lowest counts in both total coliform and *E.coli*.

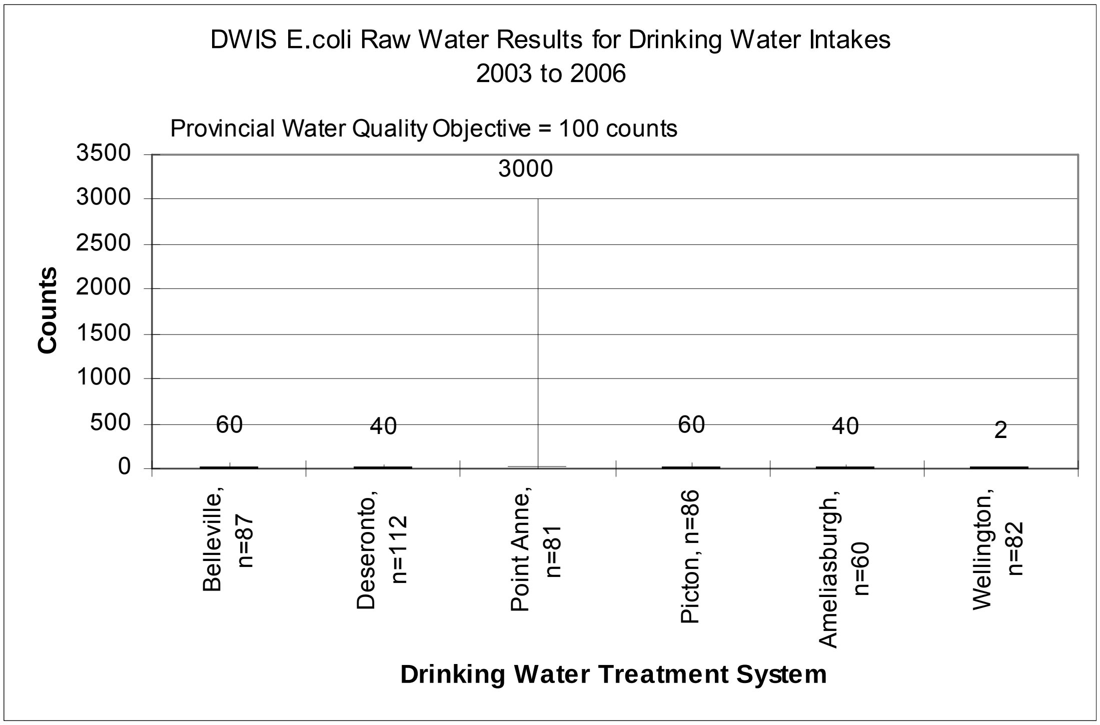


Figure 3.25. DWIS raw water intake results for *E.coli*. The vertical line in the graph represents the minimum and maximum, the horizontal line represents the range between the 25th and 75th percentiles, and n is the number of samples.

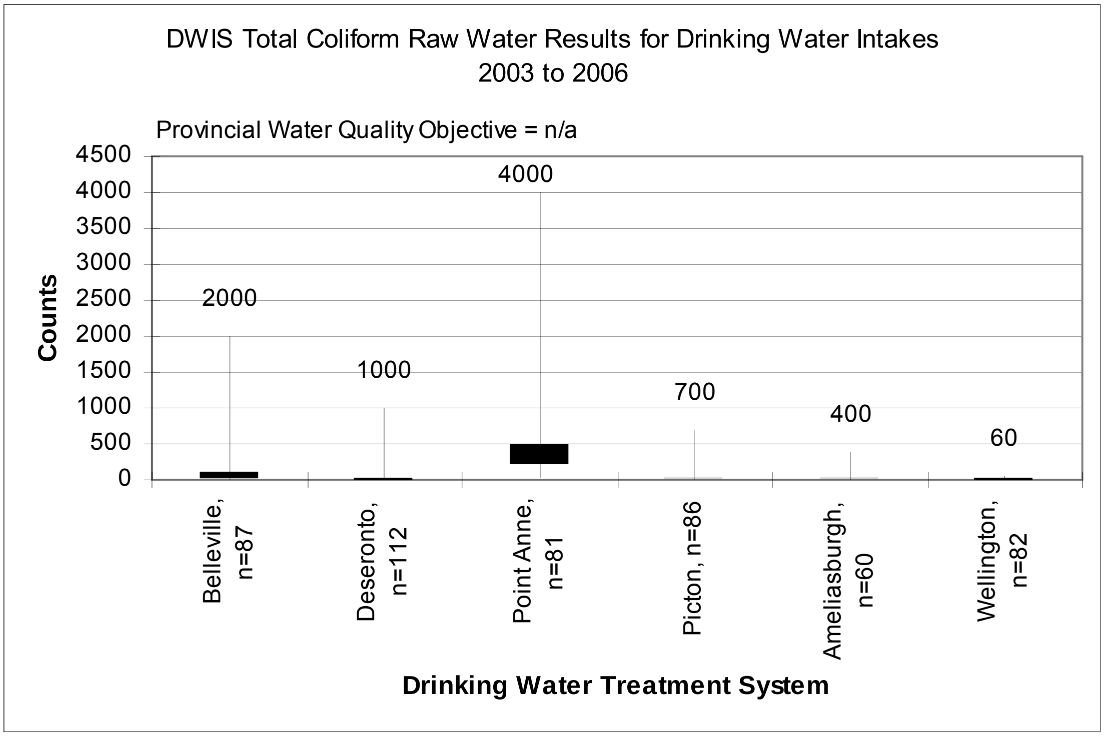


Figure 3.26. DWIS raw water intake results for total coliform. The vertical line in the graph represents the minimum and maximum, the horizontal line represents the range between the 25th and 75th percentiles, and n is the number of samples.

DWIS Groundwater

It is common to find bacteria in surface water because of the open system, but groundwater sources are expected to have low to no microbial counts because soil acts as a natural filter. The municipal well supplies in the Quinte Region have been observed to have bacteria present in raw water samples due to the fractured bedrock in the area making groundwater sources of drinking water vulnerable to contamination.

The presence of total coliform in well supplies is an indication that these wells are prone to surface water infiltration and therefore may be more at risk to contamination. Those well supplies with *E.coli* counts above zero have been contaminated. The DWIS results for raw water show that Madoc well supplies 1 and 2, and Peat's Point were observed to have *E.coli* counts above the ODWS of 0 counts on several occasions between 2003 and 2006 (Figure 3.27). Total coliform was observed in raw water samples in all well supplies with the exception of the Tweed well 3 that had zero (Figure 3.28). Madoc and Peat's Point well supplies have been contaminated by surface water influence.

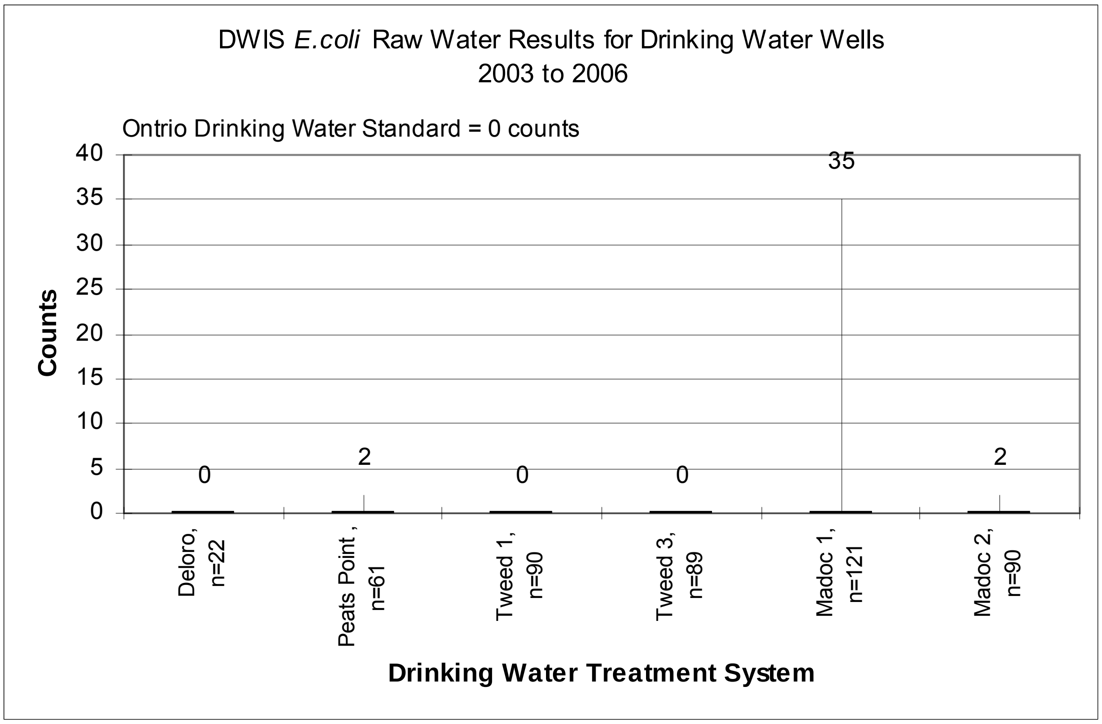


Figure 3.27. DWIS raw water well supply results for *E.coli*. The vertical line in the graph represents the minimum and maximum, the horiizontal line represents the range between the 25th and 75th percentiles, and n is the number of samples.

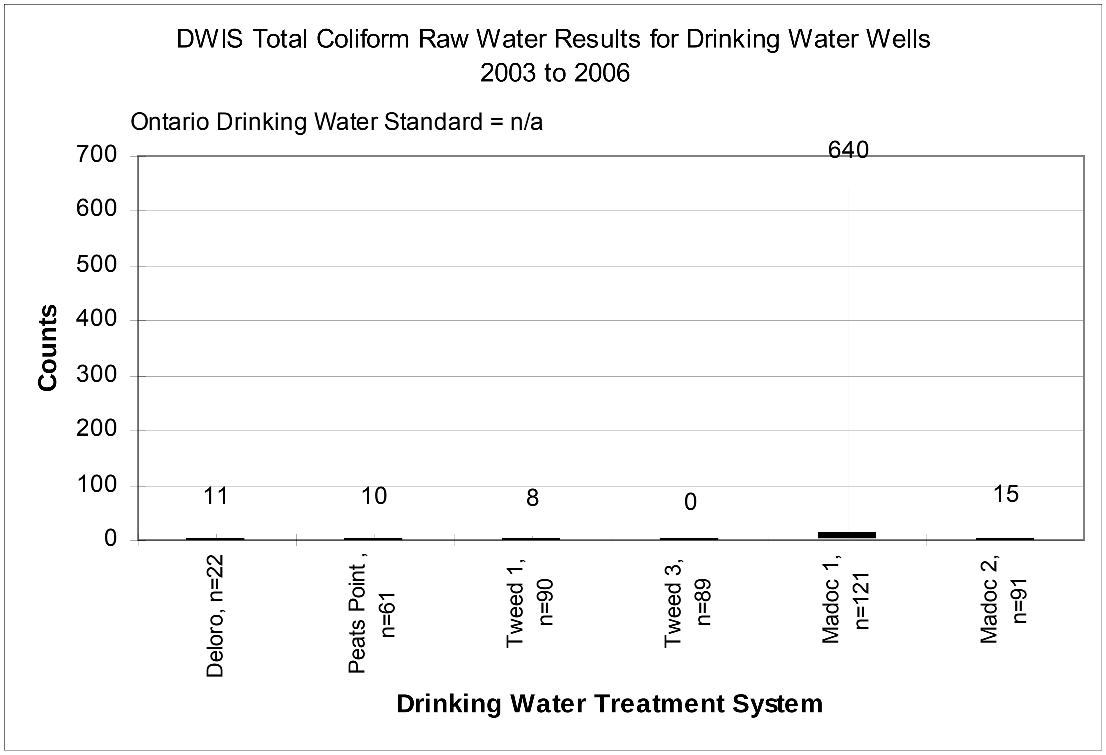


Figure 3.28. DWIS raw water well supply results for total coliform. The vertical line in the graph represents the minimum and maximum, the horizontal line represents the range between the 25th and 75th percentiles, and n is the number of samples.

PWQMN for A. L. Dafoe Drinking Water System Backup Intake

Since there is limited water quality data available for the backup intake system for the A. L. Dafoe drinking water system the water quality results from the upstream PWQMN stations were analyzed. The A. L. Dafoe drinking water system services the population of the Greater Napanee area. The backup intake is located in the Napanee River at the drinking water system that is located at 75 East Street in Napanee. There are two current PWQMN stations located upstream to Napanee at Newburgh. The network samples many types of parameters that include metals, nutrients, radionuclides and microbials. Microbial parameters have been discontinued for most stations including those in the Napanee River. Total coliform was discontinued being sampled in the Napanee River in 1979 and *E.coli* in 2002.

In the early 1980s the A. L. Dafoe intake in the Napanee River became a backup intake system after establishing a new intake in Lake Ontario towards Adolphus Reach in Lennox and Addington County. The reason for the discontinued use of the intake was taste and odour problems of the Napanee River water. Reviewing the historic microbial results for the two upstream stations to the backup intake indicated that *E.coli* counts were above the PWQO of 100 counts 30% of the time at County Rd 1 downstream of Newburgh and 28% of the time at County Rd 27 in Newburgh. Although there is no current PWQO for total coliform the results for this parameter were also above 100 counts with a maximum recorded count of 340,000 in August of 1976 at the station located downstream from Newburgh.

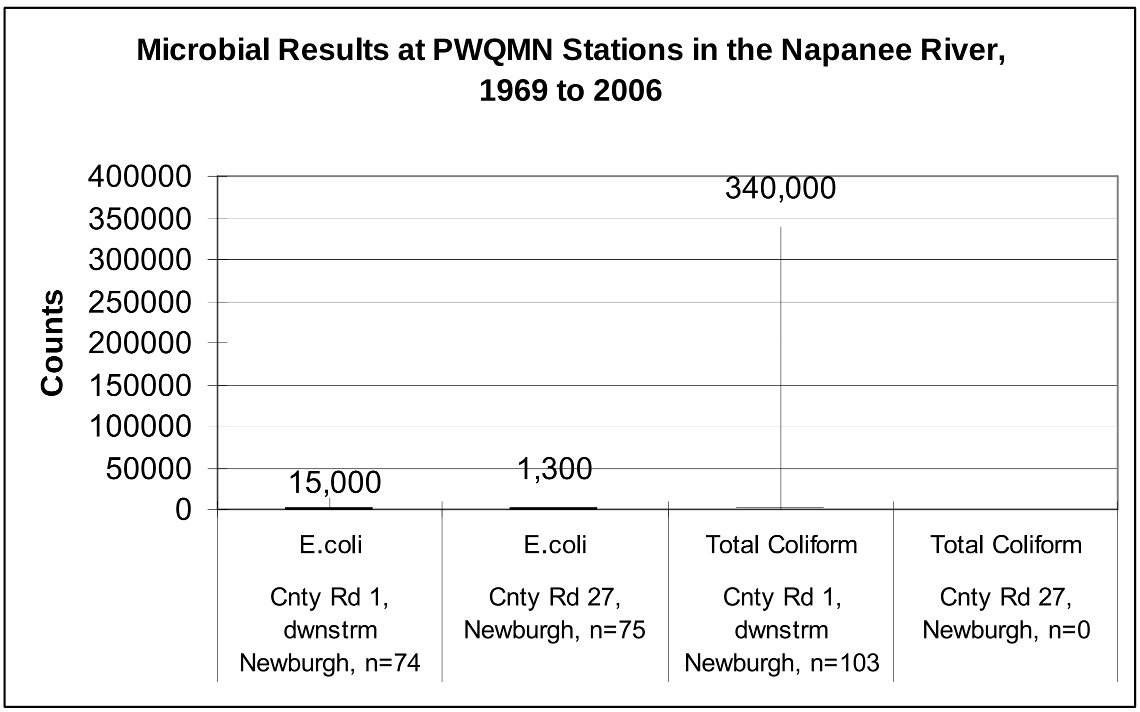


Figure 3.29. PWQMN results for two stations located upstream to the backup intake for the A. L. Dafoe drinking water system in the Napanee River - *E.coli* from 1969 to 2002 and total coliform from 1969 to 1979. The vertical line in the graph represents the minimum and maximum, the horizontal line represents the range between the 25^{th} and 75^{th} percentiles, and n is the number of samples.

3.5.2 Assessment of Microbiological Quality of Water in the Watersheds

This section is meant to review microbial conditions from locations in the watershed other than at the municipal drinking water system intakes or wells to help characterize the microbial conditions throughout the watershed. Some local municipalities may have monitored microbial indicators in other studies (for example municipal beach closures). Other sources of microbiological data in the Quinte region may be the conservation authority, academic researchers, or government agencies. Other than data from the conservation authority, there are still data gaps for the Quinte region.

The Health Unit is a source of *E.coli* data for private well supplies. The raw well water is collected by private well owners and analyzed by the Health Unit. The quality assurance and quality control of these microbiological samples are not considered reliable as protocols are not always followed by the general public. It is suspected that some water samples are taken from a treated source not from a pre-treated source dictated by the protocol.

Surface Water Special Projects

In 2007, a special project that monitored surface water quality in East Lake and Black River watersheds of the Prince Edward Region included *E.coli* as a measure of pathogens. Monthly water chemistry sampling was done at seven stations in East Lake watershed and at five stations in Black River watershed from May to November 2007. Currently the only data received were results from one sample taken at each station in May. *E.coli* ranged from 6 to 110 counts at stream stations of East Lake watershed and 2 counts at the deepest point of the lake. The station that had counts over the PWQO of 100 counts in May was the station located south of Thompson Rd in a tributary stream that flows into the east end of the lake. The five stations in Black River had E.coli counts that ranged from 8 to 140. The station which is in a tributary to Black River called Jacksons Creek was observed having the highest *E.coli* counts in May over the PWQO at 140 counts. Based on only one sample, it is difficult to interpret the data however *E.coli* counts were lower downstream at the Cheese Factory Bridge on County Rd 13. The rest of the data for both East Lake and Black River stations is required for a more objective interpretation.

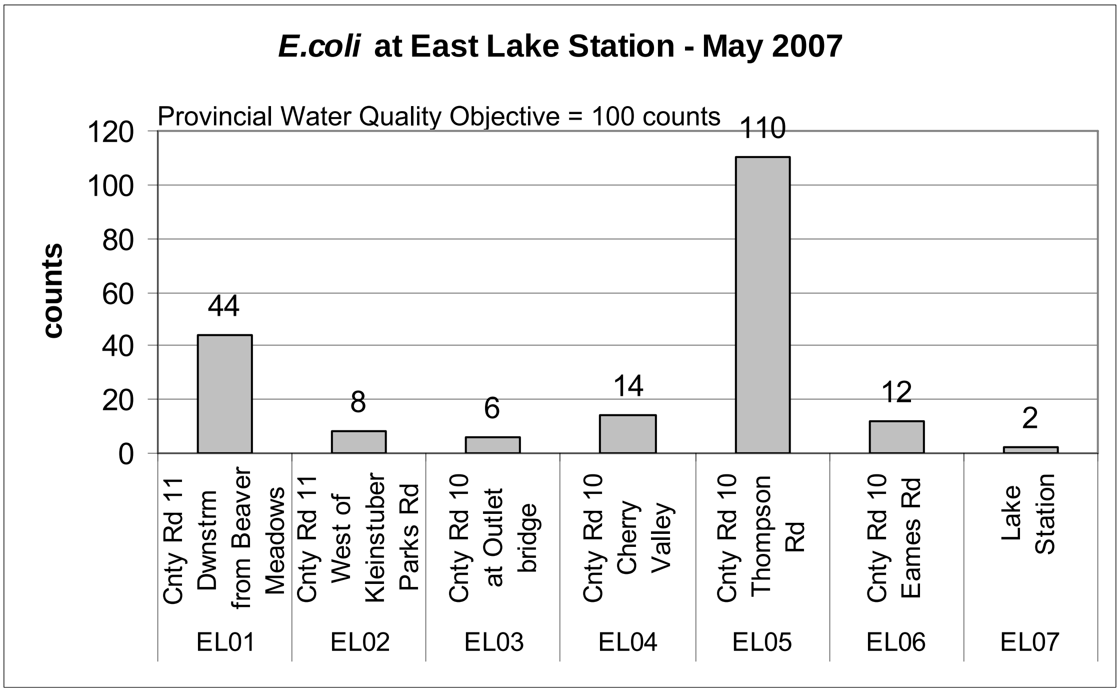


Figure 3.30. *E.coli* results (one sample taken from each station) from East Lake watershed stations in May 2007 (PERW).

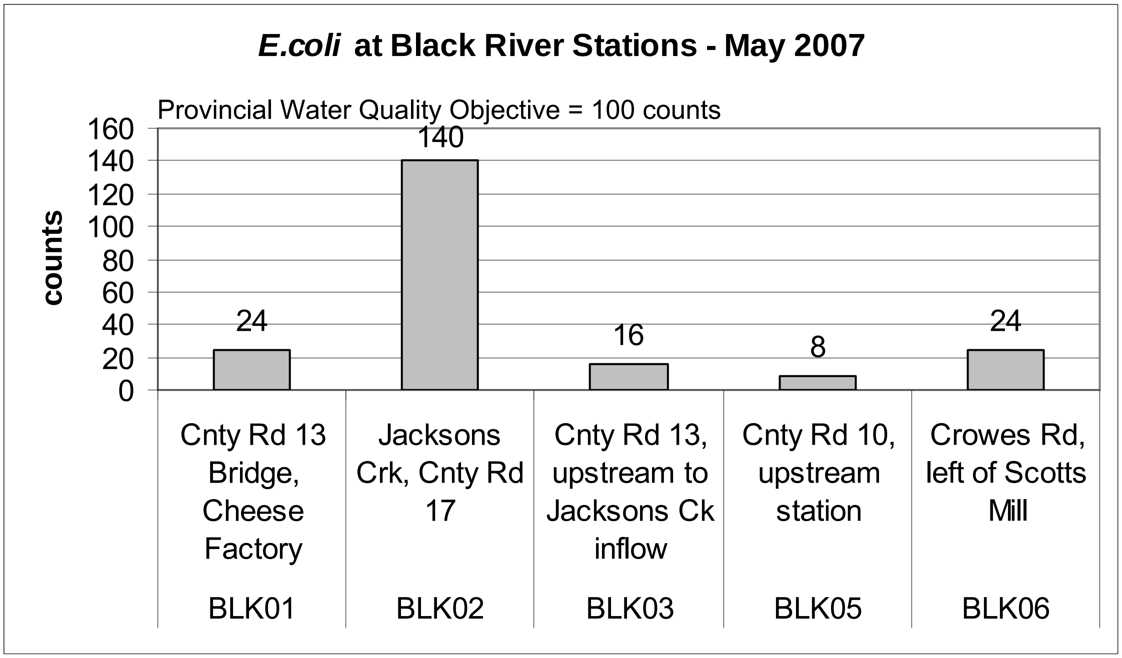


Figure 3.31. *E.coli* results (one sample taken from each station) from Black River watershed stations in May 2007 (PERW).

3.6 Data and Knowledge Gaps for Water Quality

Historic Water Quality Data

It is believed that the Ontario Ministry of the Environment is the keeper of this primary data.

PWQMN

A summary and discussion on more parameters at individual stations could be done – Cadmium, Copper, Iron, Zinc from German et al 1993 Time to Act (section 3.2). Microbiological parameters, such as total coliform and E.coli were discontinued from being monitored in the PWQMN by 1979 and 2002 respectfully. It is understood that microbial parameters were discontinued because only one sample was taken. It is preferred that a minimum of five samples on the sampling data be taken and a geometric mean of the samples for the day be calculated to better represent the conditions. The Ontario Ministry of Environment (MOE) would have to reconsider sampling microbial indicators in the PWQMN again.

PGMN

The current data is not sufficient in length to identify long term trends (Section 3.3).

DWIS

Raw water quality parameters for most municipal intakes only have microbial indicators which were reviewed in section 3.5. Trends to compare total coliform counts in well supplies between seasons and after wet weather events (precipitation data) are still outstanding (section 3.5.1). According to the guidelines, the E,coli results should be compared to results from those stations (from programs that sample *E.coli*) with limited impact from anthropogenic sources instead of the PWQO of 100 counts. This analysis is still outstanding for section 3.5.3 because of finding stations and programs that sample *E.coli* in relatively pristine locations to compare with the drinking water system results.

DWSP

Data that was received included name of the drinking water system, location, population served, average and maximum daily flow rates, and raw water quality. Water quality data on private drinking water system were not released to the CA as they are protected from being released to members of the public under the Freedom of Information and Protection of Privacy Act (FIPPA).

Municipal Industrial Strategy for Abatement (MISA)

Data files were received from WRIP, but the files are many and are poorly labeled. Files pertaining to the Quinte Region have not been identified. File layout and formatting is not user friendly therefore data analysis was not performed.

OBBN

Data analysis for benthos is found in section 2.5.2 of the Aquatic Ecology section. Water chemistry data for these stations was not part of the OBBN, but was added at the expense of Quinte Conservation. Quinte Conservation should consider adding microbial indicators data in the set of water chemistry parameters that is monitored at the OBBN stations (section 3.5.2). The knowledge gaps are the analysis and discussion that includes MRW fall 2007 data for HBI, water chemistry, and substrate characteristics. Fall MRW benthos were not enumerated and identified at the time of the report.

Municipal Micobiological Studies and Monitoring

Studies on pathogens and fecal indicator bacteria (*E.coli*) for surface water and groundwater in the Quinte Region is a data gap.

Other Surface Water Studies

There are data gaps for microbial indicators in the set of water chemistry parameter monitored in special projects, e.g. Kennebec Lake 2006, Waring Creek 2007. Microbial indicators, e.g. *E.coli* and total coliform should be added to future monitoring studies in the Quinte region. May results from water chemistry sampling of East Lake and Black River watersheds (PERW) was reviewed, but the rest of 2007 water chemistry lab results were still required from MOE Kingston (Victor Castro).

Health Unit

Water collected by private well owners that is analyzed by the Health Unit is a source of *E.coli* and total coliform data from private well supplies. As previously mentioned, the quality assurance and quality control of these microbiological samples are not considered reliable as protocols are not always followed by the members of the public. There are no summary reports available at the Hastings and Prince Edward Counties Health Unit and Kingston, Frontenac, and Lennox & Addington Health Unit.

4.0 WATER QUANTITY

4.1 Water Use

Water use is discussed earlier in this report under section 2.7 and in the Water Budget Report in more detail (Quinte Conservation 2006). To refresh the reader, the water supply in the Quinte Region is divided approximately equally between surface water and groundwater with 49% of the population using surface water and 51% groundwater. In addition to the use of the water resource for drinking water there are various other users ranging from agriculture to industrial. Some of these uses fall under the Permit to Take Water process and others are not regulated. The following section discusses the various permitted uses with information largely taken from the MOE Permit to Take Water Database and a Permit to Take Water Monitoring and Reporting Pilot Study completed for Quinte Conservation and the Long Point Region Conservation Authority, prepared by XCG Consultants Ltd. and dated December, 2003.

4.1.1 General Water Use

The Quinte Region watersheds include a wide range of land uses which entails the use of both surface and groundwater. Presently on record there are approximately 130 permits across the Quinte Region with users including:

- a mix of agricultural activities including dairy, swine, sheep, and poultry farms, irrigated orchard operations and increasing grape cultivation,
- seasonal tourist facilities such as campgrounds and resorts,
- existing and proposed golf course developments,
- continuing rural residential development of severance lots with private wells,
- Municipalities, and
- Industry.

In addition to the above consumptive uses, there are various in-stream needs on the Rivers and the smaller tributaries. For example, the Deloro mine requires a minimum flow in order to meet Certificate of Approval arsenic concentration objectives for the Moira River. Also, several smaller urban centres have timed sewage releases from lagoons that depend upon minimum flows in the Moira River.

Rivers in the Quinte area experienced low water conditions in 2001, 2002, 2003 and 2007. In 2002 there was also a problem with low water levels in Lake Ontario, although these low levels were related to flow regulation problems in the St. Lawrence River, not drought.

4.1.2 Types of Permits

In the Quinte region there is a wide mix of permit holders, as classified in Table 4.1. The biggest category of permits is miscellaneous which includes wildlife conservation for which Ducks Unlimited and Quinte Conservation hold the majority. The permit capacities range from small, less than 100,000 litres/day to very large, greater than 10,000,000 litres/day. The largest users again are Ducks Unlimited and the Conservation Authority for things such as operation of the river water level control structures, however, these uses may be considered as non-consumptive uses. Other than these large permits the majority are in the range of 100 to 5,000 cubic metres/day for uses such as municipal supply, irrigation etc.

Table 4.1. Quinte PTTW Sector Mix

Category	Purpose	# of Permits	% of Total
Miscellaneous	Wildlife Conservation	42	34
	Dams & Reservoirs	7	6
	Pumping Test	2	2
	Miscellaneous Sub-total:	51	42
Water Supply	Municipal	10	8
	Other Water Supply	9	7
	Communal	3	2
	Campgrounds	2	2
	Water Supply Sub-total:	24	19
Commercial	Golf Course Irrigation	11	9
	Other Commercial (water bottler, nursery)	3	2
	Commercial Sub-total:	14	11
Dewatering		11	9
Agricultural		10	8
Industrial		9	7
Remediation		5	4

4.1.3 Water Use

Based on the permits reviewed, the majority of the water use in the Quinte Region is from surface water at 76%, followed by groundwater at 20% and the remaining (4%) classified as both. However, this grouping is largely skewed by the Permits for large wildlife conservation (Ducks Unlimited) and water level control structures. Because of these types of takings the duration of takings is largely unknown. However, for the balance of the permits the majority are seasonal followed by continuous (year around) (Map 38).

Given the large percentage of permits for wildlife conservation and dams a more realistic idea of actual water use in the Quinte Region was completed by excluding these permits. Water takings from the Great Lakes which include the Bay of Quinte were also excluded to allow further accuracy on the estimate of water use within the watershed. This exercise indicated groundwater use at 40% of total permits and surface water at 60% in contrast to the permits in total.

A review of the permits also indicates that water use increases by 2 to 4% of annual total during the summer months for both ground and surface water. This trend is attributed to an increased demand on the water resource for irrigation of golf courses, lawns and agricultural crops. This period of higher water use coincides with the period of low water levels in both the ground and surface water resources and is likely the time at which stress on the water resources of the region could be experienced.

When reviewing the water use numbers in consideration of stress, the actual or consumptive water use is important to consider. For example, a water use where all water is returned to the watershed may not result in much stress; however a use where all the water is removed from the watershed could. Actual water use numbers were not available, so an estimate of consumptive use was made by applying factors developed as part of the Water Budget Guidelines. In this estimate, water that is retuned to the watershed is excluded. As a result, it is estimated that approximately 27% of both ground and surface water use is consumptive. Please note that this estimate is a combined average as some uses may be for the most part consumptive such as golf course irrigation.

4.1.4 Spatial Distribution of Water Use

The location of all permits is as illustrated by Map 38 showing that takings are largely centered in the southern portion of the Moira and Napanee watersheds and Prince Edward County. Maps 39 and 40 illustrate the distribution of ground and surface water use by individual sub watershed after permits for wildlife conservation and water level control structures have been excluded. These maps confirm higher taking and use in the southern portions of the Moira and Napanee watersheds as well as Prince Edward County. High groundwater use watersheds are evident of the sub watersheds of the Moira River area, largely attributed to a higher percentage of municipal wells in this area. These same areas and the southern portions of the Napanee watershed also exhibit high surface water use, potentially attributed to seasonal use by the golf courses located throughout this area.

References

Quinte Conservation (2006). Conceptual Water Budget: Quinte Region: Final Report. Belleville, Ontario Canada, Quinte Conservation: 68 + Appendices.

4.2 Knowledge and Data Gaps for Water Use

Some gaps exist in reference to actual water usage for the following reasons:

1. These PTTW only reflect permitted water use as opposed to actual water use (metered water use). They also do not apply to water takings under 50,000 litres per day or livestock watering. Consequently, there is doubt as to the accuracy of the total volume used each day.
2. The magnitude of water that is returned to the watershed and in what form is also currently estimated through the use of consumptive factors.

4.2.1 Recommendations for Future Permit to Take Water Process

From the Permit to Take Water Pilot Project it was identified that there is some resistance of permit holders to record and submit daily water taking. It was also identified that there is a lack of awareness amongst permit holders (and non permit holders) about the need and requirements for a permit. As an outcome of this study, several recommendations were provided in effort to improve the program. A brief summary is as follows:

1.) Conduct training and education for permit holders to inform them of basic hydrology, potential impacts from water withdrawals, and permit process/requirements.

2.) The MOE should review what a water taking constitutes and consider the taking for wildlife conservation and water control structures as this is not an actual taking which makes it difficult to consider for resource management.
3.) Monitoring and reporting on water use should be phased in over time. Caution on this approach was recommended to avoid creating potential compliance problems.
4.) A more detailed assessment of water sources in terms of capacity and withdrawals should be completed to provide better management of the resource and decide where restrictions should be implemented.

5.0 DESCRIPTION OF VULNERABLE AREAS

5.1 Identification of Source Water Protection Areas

There are four municipal groundwater systems (Map 41) and seven municipal surface water intakes (Map 42) within the Quinte Conservation jurisdiction; there are also two intakes outside the jurisdiction that serve residents within the Quinte Region (Table 5.1). Source Water Protection Areas have been identified for the four groundwater systems. The Source Water Protection Areas for surface water intakes will be identified once the relevant studies are completed.

Table 5.1. Municipal Water Sources in the Quinte Region.

Municipality	Community Served	Type of System	Details of System	Status of Study
City of Belleville	Belleville	Intake (connecting channel)	Within Region	Initiated
City of Belleville	Point Anne	Intake (connecting channel)	Within Region	Initiated
Napanee	Napanee	Intake (Great Lakes)	Outside Region	Initiated
Napanee	Napanee	Intake (backup -river)	Within Region	Initiated
Prince Edward County	Ameliasburgh	Intake (inland lake)	Within Region	Initiated
Prince Edward County	Picton	Intake (Great Lakes)	Within Region	Initiated
Prince Edward County	Wellington	Intake (Great Lakes)	Within Region	Initiated
Deseronto	Deseronto	Intake (connecting channel)	Within Region	Initiated
Quinte West	Consecon and Carrying Place	Intake	Outside Region	Initiated
Prince	Peat's Point	Wellhead	Small system	Completed in

Municipality	Community Served	Type of System	Details of System	Status of Study
Edward County				Groundwater Study
Tweed	Tweed	Wellhead	Two Wells	Completed in Groundwater Study
Centre Hastings	Madoc	Wellhead	Two Wells	Completed in Groundwater Study – re studying through Municipal Grant
Marmora and Lake	Deloro	Wellhead	One well	Completed in Groundwater Study

5.2 Groundwater: Wellhead Protection Areas (WHPAs)

In the Quinte Region there are four individual groundwater systems with associated well head protection areas as illustrated by Maps 28-31. A wellhead protection area is the area around the well where land use activities have the potential to affect the quality of water flowing towards the well. These areas are determined by studying the physical hydrogeologic conditions around a well which include the depth to groundwater, soil conditions, the direction and speed groundwater is flowing, as well as the rate at which the well is being pumped. The areas delineated for the municipal wells in the Quinte Region were determined through development of three dimensional groundwater flow models for each system. These models are developed to represent how groundwater flows and delineate the various horizontal times of travel for determining individual well head protection areas including 100 metre, 2, 10 and 25 year time of travel (i.e. 2 year time of travel is the zone that represents where groundwater would take 2 years to flow towards the well). A general description of the four groundwater systems is provided below and more detail individual reports for each well head protection area are available.

Deloro Well

The Deloro system consists of one bedrock well installed in 1976 into a granite aquifer. The well is 29.9 metres deep with an average daily pumping rate of approximately 68 m^3/day servicing approximately 150 people. The well is situated on the south-western border of the Village with surrounding land use including residential, open space, agriculture, and industrial (former Deloro mine site now being remediated). The well head protection area extends to the north toward a topographic high where it terminates. This area is generally comprised of shallow soil over limestone and granite bedrock.

Madoc Wells

The Village of Madoc (comprised of approximately 1500 people) is serviced by two operating wells referred to as the Whytock and Rollins Well. The Rollins well is the main supply as it is produces the greater volume of water. This well is 48 metres deep and obtains supply from a fractured Precambrian bedrock aquifer. This well was originally installed in 1955; however a new well was drilled in 2006 immediately adjacent. The Whytock well, drilled in 1978, is located to the north of the Rollins well and supplements the water needs of the Village. This well is 90 metres deep obtaining supply from fractured Precambrian bedrock. The well head protection area for both wells extends to the north of the Village with a mix of land use comprising residential, recreational, commercial and agricultural lands. The area is generally characterized by thin soil over fractured bedrock with some areas of bedrock outcropping. Because of soil conditions and close proximity of these wells to Madoc Creek both are classified as GUDI wells (Groundwater Under the Direct Influence of Surface Water).

Peats Point Well

Peats Point is a small residential subdivision in Prince Edward County comprising 20 homes. Water supply is obtained from a single well located on the south side of the subdivision which covers a narrow peninsula extending into the Bay of Quinte. This well is 35 metres deep obtaining supply from a limestone aquifer and classified as a GUDI well due to close proximity to the Bay. The well head protection area extends to the south under the Bay of Quinte through an area comprised of rural residential homes and agricultural land. Topography is relatively flat with thin soils over fractured limestone bedrock.

Tweed Wells

The Village of Tweed, comprising approximately 1,500 people, is serviced by two wells referred to as the Main well and the Crookston well. The Main well located at the north has historically met the water supply needs for the Village in the past. However, due to natural water quality problems (elevated uranium) and necessity for treatment, this well is now only used for backup purposes. The well is 132 metres deep and penetrates a sand and gravel esker 12.5 metres deep, with water found in the underlying Precambrian granite. The Crookston well is located to the south and was constructed in 1995 to serve as the main supply for the Village. This well penetrates through 10 metres of sand and gravel esker to complete at a depth of 122 metres in Precambrian granite. Water was intercepted at depths of 15 and 47 metres with the shallow producing zone resulting in this well being classified as GUDI. The well head protection area for both wells extends to the west and encompasses primarily agricultural lands with some rural residential development and open wetland areas.

Aquifer Vulnerability

The vulnerability of an aquifer is typically based on how deep the water is located underground, the type of rock or soil the groundwater is located in, and the type of soil or rock covering the aquifer. All of these factors control how fast the water moves from ground surface into the aquifer. In areas where the water moves quickly from ground surface to the aquifer, the vulnerability is considered to be high.

In the Quinte Region the majority of the area is characterised by thin soils over fractured bedrock (see overburden thickness Map 5). As such this area can be considered to exhibit high aquifer vulnerability conditions. Mapping of aquifer vulnerability in the Quinte Area was completed through the Quinte Region Groundwater Study (Dillon

2004) by the ISI (Intrinsic Susceptibility Index) methodology. This work resulted in the preparation of Map 36 which shows the entire region to be highly vulnerable.

Significant Recharge Areas

Because of shallow soil conditions over fractured bedrock, recharge occurs throughout the Quinte Region. However, there are some areas that may be considered more significant than others. Delineation of these areas is presently being reviewed under the Water Budget Activities of Quinte Conservation. Preliminary results, as illustrated by areas of high recharge on Map 43, would suggest that areas with significant deposits of sand and gravel are also important recharge areas as they often serve to retain water for longer periods then the underlying fractured rock. This assists in the gradual replenishment or recharge of the underlying fractured rock. Further information on these areas is forthcoming in the Water Budget reports.

5.3 Surface Water Intake Protection Zones (IPZs)

An Intake Protection Zone (IPZ) the area around the intake where land use activities have the potential to affect the quality of water flowing towards the intake.

Ameliasburgh

The Hamlet of Ameliasburgh, home to approximately 75 residences, is serviced by a surface water intake located in Roblin Lake. Roblin Lake is an inland lake that has been theorized to be a spring-fed lake as there are no contributing watercourses to the lake. The intake was first installed in 1985, but has seen many upgrades as populations' increase, the last upgrade occurring in 2005. The intake is 200 mm in diameter and extends 115 m into the lake. The IPZ for the intake are fairly small in area as the surrounding land is very flat and there are no tributaries to the lake.

Belleville

The City of Belleville's drinking water system draws water from the Bay of Quinte. This intake serves approximately 40,000 people in Belleville as well as in Rossmore and Fenwood Gardens in the County of Prince Edward. The water treatment plant and its intake were built in 1887 and upgraded in 2001. The intake consists of a 750 mm pipe that extends approximately 430 meters out and 5.5 m down into the Bay of Quinte. The IPZs extend in a north-west direction within the City of Belleville and also cover the most northern tip of the County of Prince Edward.

Deseronto

The Town of Deseronto has one municipal water intake within the Quinte Source Protection Region extending 480 m off the shore of the Bay of Quinte and 6m below the mean lake surface level. The intake was built in the 1970s as a private system for the Town of Deseronto and operations were taken over by Greater Napanee Utilities in 2003. The intake protection zones extend to the west along the shores of the Bay of Quinte and encompass mainly residential and commercial land uses.

Napanee

The Town of Greater Napanee has two municipal intake systems, the main intake that draws water from Lake Ontario and the backup system on the Napanee River. Napanee's water treatment plant and intake were built in the late 1880s. This intake drew water from Napanee River just upstream from the Springside Dam. A century later this intake became a backup when a new intake was extended into Lake Ontario. The Napanee River intake has not been used for approximately five years. The main intake falls within the Cataraqui Source Protection Region and services 8,500 people. If the main intake were to fail or need to be shut-down the backup intake would be used to service these people. The IPZs of the backup intake extend north upstream on the Napanee River. Land use within these zones is predominately urban and agricultural uses.

Picton

The Town of Picton and the Village of Bloomfield, comprising approximately 6,500 people, are serviced by a surface water intake in the Bay of Quinte. There are actually two intakes, a north and south intake however the north intake is not currently used. The south intake is a 400 mm screened pipe that extends 91 m into the Picton Bay of the Bay of Quinte and the intake crib lies 3.3 m below the water surface. The Intake protection zones follow the east and west shores of the Bay and extend southwards into the Town of Picton. Within the IPZs main land use activities are residential, agricultural, and commercial.

Point Anne

The Point Anne drinking water system consists of one gravity intake pipe extending 105 m out into the Bay of Quinte. This intake supplies an intake well that is influenced both from the water being pumped from the Bay of Quinte as well as groundwater making this system a GUDI. The Point Anne Hamlet was historically serviced by the Point Anne cement plant water system in the early 1900s. The current system was built in 1974, was inherited by the City of Belleville in 1998, and was last updated in 2005. The system currently services the 55 people living in the Point Anne Hamlet. The IPZs extend in a south-western direction and contain mostly industrial and residential land uses.

Wellington

The Village of Wellington, consisting of approximately 1,700 people, is serviced by a surface water intake drawing water from Lake Ontario. The intake extends 1,475 m into Lake Ontario and lies at a depth of 10 m below the water's surface. The IPZ contains mainly agricultural and residential land uses.

References

Dillon (2004). Quinte Regional Groundwater Study, Prepared by Dillon Consutling Ltd. for Quinte Conservation**:** 194 + Appendices.

5.4 Data and Knowledge Gaps for Vulnerable Areas

Work is in progress to identify sensitive groundwater recharge areas, especially those in the Precambrian Area of the Region (Map 36).

There is no available information at this time regarding future drinking water supplies.

6.0 EXISTING SPECIFIC THREATS INVENTORIES

Specific threats may be defined as any contaminant (chemical or pathogen) having the potential to negatively impact or interfere with the use or availability of any drinking water source. Currently, detailed studies are being completed to inventory threats within the vulnerable areas of the Quinte Region including well head and intake protection zones. Individual reports are in the process of being prepared to summarize the threats to each system.

To provide information about potential threats within the Quinte Region a review of the contamination assessment contained in the Quinte Regional Groundwater Study (Dillon 2004) has been completed. This assessment provides an inventory of known sources of contaminants within the Quinte Region including potential point sources such as gas stations, landfills, and manufacturing plants, as well as larger scale non point sources such as the use of fertilizers and pesticides or the spreading of sewage on agricultural land.

References

Dillon (2004). Quinte Regional Groundwater Study, Prepared by Dillon Consutling Ltd. for Quinte Conservation**:** 194 + Appendices.

6.1 Threats to Groundwater and Surface Water Quality

Threats to water quality in the Quinte Region include both long-term contamination issues that stem from a localized source as well as regional water quality issues that stem from land use. The Contaminant Source Inventory (CSI) includes data from various levels of government, commercial sources, public and private databases, as well as verbal survey of government personnel and deals mainly with long-term contamination issues. A summary of the various data sources reviewed under the Groundwater study are as listed in Table 6.1.

A general summary of the type of contaminant sources found in the watershed are provided in Table 6.2 with general locations as illustrated by Map 45. These contaminant sources have been inventoried as potential point and non point sources of groundwater contamination, however some contaminants may also be considered as potential threats to surface water. Overall, the types of contaminants range from petroleum fuel storage to septic systems to agriculture.

In addition to threats from known and potential sources of contaminants, a potential large threat to groundwater in the Quinte Region includes improperly constructed and abandoned wells. Improperly constructed wells include those that do not comply with today's regulation and can allow the entry of shallow surface water into the aquifer. Examples of such wells are those constructed without the proper depth of watertight sealed casing, constructed with well pits or do not have the well casing extending sufficient distance above ground. Aside from improper well construction there are potentially thousands of wells throughout the country side that have been abandoned and forgotten about. These wells often fall into a state of disrepair and can allow the direct entry of surface water into the aquifer.

Table 6.1. Contaminant Site Inventory Data Sources

Study Categorization	Database (Author/supplier) †
Gas Stations	Retail Fuel Storage Tanks (MOE/TSSA/ERIS) Municipal Survey
Fuel/Chemical Storage	Retail Fuel Storage Tanks (MOE/TSSA/ERIS) Private Fuel Storage Tanks (TSSA/ERIS)
Landfills – Active Landfills – Closed	Waste Disposal Site Inventory, (MOE/ERIS) Anderson's Waste Disposal Sites (ERIS) Municipal Survey
Sewage Treatment Plants	Wastewater Discharger Database (MOE)
Waste Generators	Ontario Regulation 347 Waste Generators (MOE/ERIS)
Waste Receivers	Ontario Regulation 347 Waste Receivers (MOE/ERIS)
Manufacturing/Industrial	Scott's Manufacturing Directory (Scott's) Municipal Survey
Coal Gasification	Inventory of Coal Gasification Plants (MOE/ERIS)
PCB Storage	Ontario Inventory of PCB Storage Sites (MOE/ERIS)
Pesticide Storage	Pesticide Register (MOE/ERIS)
Salt Storage	Municipal Survey
Auto Scrap yard	Automobile Wrecking & Supplies (ERIS) Municipal Survey
Spills	MOE Spills Database (MOE)
Known Contaminated Sites	Federal Contaminated Sites (Canada) Ontario MOE Interviews Municipal Survey

†MOE: Ministry of the Environment, ERIS: Ecolog Environmental Risk Information Services, Scott's: Scott Business Directories, TSSA: Technical Standards & Safety Authority

Table 6.2. Potential Water Quality Threats in the Quinte Region

Source	Potential Contaminant	Vulnerability	Potential Areas of Concern
Agriculture	Fertilizers	Leaching of nitrogen and phosphorus from the soil into the surface water and groundwater	Agricultural areas of Prince Edward County, northern portion of the City of Belleville and in Stone Mills Township
	Manure	Potential for pathogens to enter surface water and groundwater where livestock density and aquifer vulnerability are high	Agricultural areas in Prince Edward County, Tamworth & Newburgh in Stone Mills

Source	Potential Contaminant	Vulnerability	Potential Areas of Concern
	Pesticides, fungicides and insecticides	Leaching of biocides from the soil into the surface water and groundwater	Agricultural & Cosmetic use throughout the region.
	Municipal biosolids as fertilizer	Leaching of pathogens and nutrients into the surface water and groundwater	Common practice for all municipalities with sewage treatment plants.
Private Septic Systems	Bacteria, nutrients, sodium & chloride	Potential for contamination of both groundwater and surface water	Unserviced areas throughout the region where both water table and soil depth are shallow.
Road Salt / De-icing	Sodium & chloride	Potential for impact on soils (vegetation growth), groundwater and surface water.	Areas along major highways, intersections and municipal salt storage facilities (13 in total)
Landfills	Leachate potentially containing nitrogen, sodium, chloride, boron, iron, COD/BOD.	Threats to both groundwater and surface water quality	There are a total of 99 landfills in the watershed (28 are active)
Industrial & Commercial chemicals	Fuels, lubricating oil, solvents, coal tar, mine tailings, etc.	Threats to both ground and surface water from spills & leaks	Former gas stations throughout, Bakelite, Myers Pier, Nortel, Rexcan and Tank Farm in the City of Belleville, Crowe property in Prince Edward County and the former Deloro mine site in the Municipality of Marmora & Lake
Municipal Sewage Treatment Plants/Lagoons	Microbiological & Nutrients	Potential surface water threat from nutrients and pathogens; groundwater threat from leaky lagoons.	Facilities located in all major urban centres throughout the Region.

6.2 Knowledge and Data Gaps

As previously discussed, the contaminant inventory will need to be reviewed in order to more accurately categorize the threat as surface or groundwater. A more detailed inventory of contaminants will be completed through completion of the risk assessment. This will include a review of an inventory recently completed under the Bay of Quinte RAP.

7.0 SUMMARY OF IDENTIFIED ISSUES AND CONCERNS

Following is a current list of issues and concerns for the Quinte Region (Map 46). These issues and concerns fall into three main categories:

- Discrete locations, or point sources, that have presented a long-term contamination issue (e.g. the Deloro Mine).
- Regional issues of water quality including stormwater management (e.g. Marsh Creek).
- Water quantity issues like Permits for Taking Water and violations of these permits.

Throughout the Stakeholder Consultation process concerns raised by stakeholder groups will be noted.

7.1 Issues and Concerns

Wellhead Protection Areas

- There are four municipal groundwater systems
- Potential water quality threats and issues are currently being identified for each system

- Some water quality threats have been already been identified in the Tweed, Madoc, and Deloro systems
- These include things like private sewage disposal systems, fuel storage, improperly constructed wells, agricultural activities, etc.
- For further information refer to individual municipal drinking water study

Surface Water Intakes

- There are seven surface water systems in the watershed
- Potential water quality threats and issues are currently being identified for each
- Issues include things such as aesthetic concerns (taste and odour), occasional high metals concentrations (copper and iron have exceeded PWQO), potential pathogen loadings during wet weather, high nutrient levels, etc.
- Examples of threats include fuel storage, road salt applications, storm sewer outfalls, etc.
- For further information refer to individual municipal drinking water study

Richmond Landfill Expansion

- many watershed residents were opposed to this expansion
- MOE did not approve the proposed expansion

Deloro Arsenic Contamination

- this has been address in the Water Quality Section 3.1
- MOE involved in cleanup

Bakelite Property

- brownfield site adjacent to Bay of Quinte
- activities were being undertaken in violation of various regulation
- charges were laid and a conviction obtained
- restoration of the site, shoreline and wetlands is the goal

Meyer's Pier

- Brownfield site
- There are plans for remediation

Mohawk of the Bay of Quinte

- concerns as to how DRINKING WATER SOURCE PROTECTION plans will impact First Nation Community
- Pilot Project initiated
- Work relationship is developing

Bay of Quinte – Remedial Action Plan

- International Area of Concern due to nutrient rich water
- Successfully moving to become an Area of Recovery

Marsh Creek Rehabilitation

- Marsh Creek could influence Picton Intake
- Sewage Treatment Plant effluent, stormwater and former landfill site could be potential concerns.
- Some rehabilitation work has taken place.
- Sewage Treatment plant being upgraded.