DRINKING WATER SOURCE PROTECTION
Our Actions Matter

LAKE ERIE SOURCE PROTECTION REGION

Long Point Region Source Protection Area

ASSESSMENT REPORT
Consultation Draft

Prepared on behalf of:
Lake Erie Region Source Protection Committee

Under the *Clean Water Act, 2006*
(Ontario Regulation 287/07)

Version 4
October 30, 2025

This project has received funding support from the Government of Ontario.

Ontario

Note: Please refer to Volume I of the Long Point Region Source Protection Plan for a complete list of version numbering and a high-level description of amendments that have been made since original approval.

SECTION 36 DOCUMENT AMENDMENTS

The following provides a high-level summary of amendments made to the Long Point Region Assessment Report (AR) under Section 36 of the *Clean Water Act, 2006*. Amendments were made using the 2021 Technical Rules.

Multiple sections:

- General formatting edits
- References to Provincial Groundwater Monitoring Network Wells changed to Provincial Groundwater Monitoring Network Locations
- References to Issue Contributing Areas updated to include Wellhead Protection Area (WHPA-ICA).
- Maps and text updated to follow the percent impervious surface categories in the 2021 Technical Rules
- Identification of Drinking Water Quality Threats tables removed from each system section and replaced with a single table in Chapter 3.
- Transport Pathway maps removed. Transport Pathway Area of Influence maps remain.

Chapter 2 – Watershed Characterization

- Updated numbers of municipal system users, land cover values, and water use'
- Updated Map 2-1 to include municipal names and surrounding Source Protection Regions

Chapter 3 – Water Quality Risk Assessment

- Significant edits to improve description of water quality risk assessment methods
- Insertion of master table for identification of threats (system specific tables removed)

Chapter 4 – County of Oxford

- Updated system descriptions / methods / data where appropriate
- Text and table deletions to reduce future edit burden and improve conciseness
- Updated threats data and table presentation

- Serviced area map for Tillsonburg updated to differentiate between areas serviced by Tillsonburg and areas served by surrounding systems
- Updated water quality issues evaluation

Chapter 5 – Norfolk County

- Updated system descriptions / methods / data where appropriate
- Text and table deletions to reduce edit burden and improve conciseness
- Updated threats data and table presentation
- Order of some maps changed
- Updated water quality issues evaluation

Chapter 6 – Haldimand County

- Updated system descriptions / methods / data where appropriate
- Text and table deletions to reduce edit burden and improve conciseness
- Updated threats data and table presentation
- Updated water quality issues evaluation

Chapter 7 – Elgin County – Municipality of Bayham

- Updated system descriptions / methods / data where appropriate
- Text and table deletions to reduce edit burden and improve conciseness
- Updated threats data and table presentation
- Updated water quality issues evaluation, including Nitrate ICA monitoring

Chapter 11 – State of Climate Change Research in the LER

- Resolved issue of two repeated subsections (effects of Climate Change)

Chapter 12 – Consideration of Great Lakes Agreements

- Long Point Region Watershed and Great Lakes Agreements updated to include updated information and improve structure

Chapter 13 – Conclusions

- Summarized information with high edit burden removed (repeated information found in multiple chapters).

Chapter 14 – References

- References updated and reorganized, as needed.

EXECUTIVE SUMMARY

~~In July 2010 the Lake Erie Region Source Protection Committee released the Draft~~ The Long Point Region Source Protection Area Assessment Report ~~for a 35-day public comment period, during which members of the public, municipalities and others had the opportunity to view the draft, attend public meetings and submit comments to the Committee. Comments received during the consultation period were taken into consideration by the Committee, and revisions to the document were made, where necessary. These revisions were reflected in the Proposed Long Point Region Source Protection Area Assessment Report.~~

~~The Proposed Assessment Report was posted for a second 30-day public comment period beginning October 8, 2010. All comments received during this second comment period were forwarded~~was submitted to the ~~Ontario~~ Ministry of the Environment ~~with the submission of the Proposed Long Point Region Source Protection Area Assessment Report~~ on November 25, 2010~~.~~, and ~~The Long Point Region Source Protection Area Assessment Report~~ received approval ~~from the Ministry of the Environment~~ on April 29, 2011. Since that time, the Assessment Report has been revised, updated and approved a number of times to incorporate new information made available over the years.

~~When new information became available, revisions were made to the Updated Long Point Region Source Protection Area Assessment Report. This report was posted for a public comment period beginning on April 15, 2011. All comments received during this comment period were considered by the Lake Erie Region Source Protection Committee. The Ministry of the Environment approved the Updated Long Point Region Assessment Report on February 27, 2012.~~

~~Following the 2012 approval of the Updated Assessment Report, further updates and new information has beenwas added to the Long Point Region Assessment Report; these updates included new information regarding a nitrate Issue Contributing Area (WHPA-ICA) in Oxford County and a new drinking water system located in the Municipality of Bayham. A 30-day public consultation period took place from February 9 to March 10, 2015 and a separate, focused consultation was held from March 16 to April 10, 2015 for the new Elgin County – Municipality of Bayham section of the Assessment Report. The Long Point Region Source Protection Authority submitted the Updated Long Point Region Assessment Report to the Ministry of Environment and Climate Change for approval on June 3, 2015. Following the June 2015 submission, additional comments were addressed and the Assessment Report was re-submitted for approval October 27, 2015. The Ministry of the Environment and Climate Change approved the Updated Long Point Region Assessment Report November 4, 2015.~~

~~The approved Assessment Report was then amended to include a Tier 3 Water Budget and Local Area Risk Assessment and Wellhead Protection Area (WHPA) updates in the communities of Delhi, Simcoe, Waterford and the Village of Richmond. The Ministry of the Environment, Conservation and Parks approved the updated Assessment Report on March 11, 2019.~~

~~New information has since been added to the Long Point Region Assessment Report for the Oxford South (Oxford County) Drinking Water System, Otterville wellfield~~

~~including . An additional water quality technical study has been undertaken since approval of the Long Point Region Assessment Report in March 2019: Wellhead Protection Area (WHPA) delineations, vulnerability, threats and issues assessment and delineation of a n Issue Contributing Area (WHPA-ICA) in the Oxford South (Oxford County) Drinking Water System, Otterville wellfield.~~

The Assessment Report summarizes the technical studies undertaken in the Long Point Region Source Protection Area (watershed) to delineate areas around municipal drinking water sources that are most vulnerable to contamination and overuse. Within these vulnerable areas, historical, existing and possible future land use activities were identified that could pose a threat to municipal water sources. Technical studies include a characterization of the human and physical geography of the watershed, a water budget and water quantity stress and risk assessment, an assessment of groundwater and surface water vulnerability, a land use activity inventory, and an evaluation of existing water quality contamination Issues.

~~The Assessment Report provides an introduction to the Source Protection Planning process, and the roles and responsibilities of the Lake Erie Region Source Protection Committee, municipalities and conservation authorities. Section 2 of the Assessment Report provides a summary of the human and physical geography of the Long Point Region watershed area, while Section 3 summarizes the water quality risk assessment process and summarizes groundwater vulnerability, including Highly Vulnerable Aquifer areas. Sections 4, 5, 6 and 7 summarize the studies undertaken for the municipal residential drinking water systems in the Counties of Oxford, Norfolk, Haldimand and Elgin, respectively, including delineation of vulnerable areas (groundwater Wellhead Protection Areas and surface water Intake Protection Zones) and summaries of the threats assessment and Issues evaluation in each vulnerable area.~~

~~Sections 8, 9 and 10 summarize the results of water quantity studies undertaken, specifically the Tier 2 and Tier 3 Water Budgets and Local Area Stress Assessment and the Tier 3 Water Budget and Local Area Risk Assessment. Section 11 provides information on how climate change in the area may affect the results of the Assessment Report and how Great Lakes agreements were considered as part of the work undertaken. Sections 12 through 15 include the consideration of Great Lakes Agreements, conclusions, references and maps and citations, respectivielyrespectively.~~

~~The Long Point Region watershed area contains ten municipal drinking water systems, sourced within the Region.~~Within the Long Point Region Source Protection Area (SPA), the Counties of Elgin, Haldimand, Norfolk and Oxford supply drinking water through ten municipal drinking water systems, sourced within the Region. Six systems draw water from groundwater sources; one system is supplied from both groundwater and surface water (North Creek in the Big Creek watershed); and three systems are supplied by intakes in Lake Erie.

~~Three systems are located in Oxford County in the communities of Dereham Centre, Oxford South (communities of Norwich, Otterville and Springford) and the Town of Tillsonburg, all of which are groundwater systems. Combined, the systems serve over 22,000 people, the majority of which are in the Town of Tillsonburg.~~

~~Norfolk County has five municipal-residential drinking water systems in the communities of Delhi, Port Dover, Port Rowan, Simcoe and Waterford. The Delhi system draws water from both surface and groundwater sources. Port Dover and Port Rowan draw water from intakes in Lake Erie. The communities of Simcoe and Waterford rely solely on groundwater sources. In total, approximately 34,600 people rely on municipal water supplies in Norfolk County, which represents almost half of the total population.~~

~~One municipal-residential drinking water system is located in the portion of Haldimand County that falls in the Long Point Region watershed area. The Nanticoke water system, operated by Haldimand County, draws water from Lake Erie. The system serves the communities of Hagersville, Jarvis, Townsend, and the New Credit Reserve, as well as the Lake Erie Industrial Park.~~

~~Elgin County has one municipal residential drinking water system, located in the Municipality of Bayham that serves the village of Richmond. The system is a groundwater system and serves approximately 140 people in the village of Richmond.~~

The findings of the Tier 2 Water Budget and Stress Assessment studies indicated that three municipal water systems required additional Tier 3 Water Quantity Stress Assessments (Tier 3 Assessments): Delhi-Courtland, Simcoe, and Waterford in Norfolk County. The subwatersheds within which these water supplies fall were assessed as having either the potential for moderate or significant stress under current or future conditions. The Tier 3 Water Quantity Risk Assessment for these three systems was completed in April 2015. The Tier 3 Assessment identified a “significant” water quantity risk for the Simcoe water supply. To follow up on the significant risk classification a ~~technical study, referred to as a~~ Risk Management Measures Evaluation Process (RMMEP)~~,~~ was completed in November 2016. This process identified and ranked water quantity threats to the Simcoe municipal supplies and evaluated which Water Quantity Risk Management Measures (RMM) could be used to effectively manage water quantity risks to the Simcoe supply. The Tier 2 Water Budget and Tier 3 Water Budget and Risk Assessment can be found in Chapters 8, 9 and 10 of the Assessment Report.

The results of the technical studies and information contained in the Assessment Report have been used to develop and revise policies to protect sources of municipal drinking water. These policies have been developed under the leadership of the Lake Erie Source Protection Committee by municipality and conservation authority staff, in ~~consulation~~consultation with property and business owners, farmers, industry, health officials, community groups and others working together to develop a fair, practical and implementable Source Protection Plan. Public input and consultation ~~has~~have played a significant role throughout the process. ~~The Updated Long Point Region Assessment Report was submitted for approval on January 18, 2018. The Ministry of the Environment, Conservation and Parks approved the Updated Long Point Region Assessment Report March 11, 2019.~~

~~An additional water quality technical study has been undertaken since approval of the Long Point Region Assessment Report in March 2019: Wellhead Protection Area (WHPA) delineations, vulnerability, threats and issues assessment and delineation of an~~

~~Issue Contributing Area (WHPA-ICA) in the Oxford South (Oxford County) Drinking Water System, Otterville wellfield.~~

~~**Note:** In June 2014, the Ministry of the Environment changed its name to the Ministry of the Environment and Climate Change, and in June 2018, to the Ministry of the Environment, Conservation and Parks. In June 2014, the Ministry of Natural Resources changed its name to the Ministry of Natural Resources and Forestry, and in June 2021, was re-organized into the Ministry of Northern Development, Mines, Natural Resources and Forestry. The new and former names of these Ministries are used within this document.~~**Note:** New and former names of Provincial Ministries are used within this document. Name changes are documented as follows:

Ministry of Environment, Conservation and Parks (MECP)

Date	Name
Pre-2014	Ministry of the Environment (MOE)
2014	Ministry of Environment and Climate Change (MOECC)
2018	Ministry of the Environment, Conservation and Parks (MECP)

Ministry of Natural Resources (MNR)

Date	Name
Pre-2014	Ministry of Natural Resources (MNR)
2014	Ministry of Natural Resources and Forestry (MNRF)
2021	Ministry of Northern Development, Mines, Natural Resources and Forestry (NDMNRF)
2022	Ministry of Natural Resources and Forestry (MNRF)
2024	Ministry of Natural Resources (MNR)

Ministry of Agriculture, Food and Agribusiness (OMAFA) and Ministry of Rural Affairs (OMRA)

Date	Name
Pre-2024	Ministry of Agriculture, Food and Rural Affairs (OMAFRA)
2024	Ministry of Agriculture, Food and Agribusiness (OMAFA) and Ministry of Rural Affairs (OMRA)

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1.0 INTRODUCTION TO DRINKING WATER SOURCE PROTECTION

Following the public inquiry into the Walkerton drinking water crisis in May 2000, Justice Dennis O'Connor released a report in 2002 containing 121 recommendations for the protection of drinking water in Ontario. Since the release of the recommendations, the Government of Ontario has introduced legislation to safeguard drinking water from the source to the tap, including the *Clean Water Act* in 2006. The Act provides a framework for the development and implementation of local, watershed-based source protection plans, and is intended to implement the drinking water source protection recommendations made by Justice Dennis O'Connor in Part II of the Walkerton Inquiry Report. The Act came into effect in July 2007, along with the first five associated regulations.

The intent of the *Clean Water Act, 2006* is to ensure that communities are able to protect their municipal drinking water supplies now and in the future from overuse and contamination. It sets out a risk-based process on a watershed basis to identify vulnerable areas and associated drinking water threats and Issues. It requires the development of policies and programs to reduce or eliminate the risk posed by significant threats to sources of municipal drinking water through science-based source protection plans.

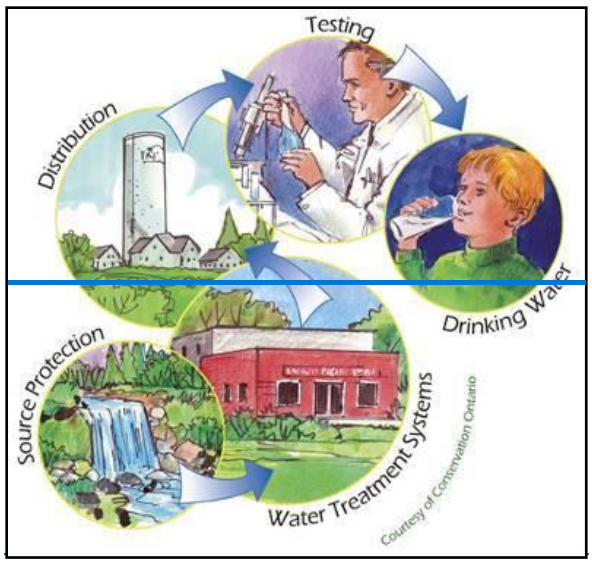
Source Protection Committees are working in partnership with municipalities, Conservation Authorities, water users, property owners, the Ontario Ministry of the Environment, Conservation and Parks (MECP), Ministry of ~~Northern Development, Mines,~~ Natural Resources ~~and Forestry~~ (~~ND~~MNR~~F~~), and other stakeholders to facilitate the update of local, science based source protection plans.

~~Source water protection~~

~~Adequate treatment~~

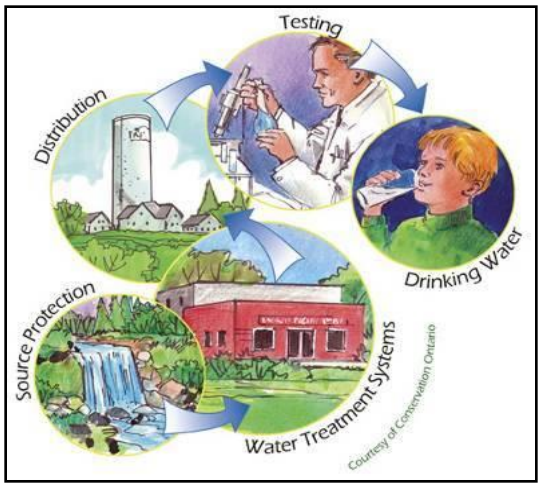
~~Secure distribution system~~

~~Monitoring and warning systems~~



The *Clean Water Act, 2006* and Drinking Water Source Protection are one component of a multi-barrier approach to protecting drinking water supplies in Ontario. The five steps in the multi-barrier approach include:

- Source water protection
- Adequate treatment
- Secure distribution system
- Monitoring and warning systems
- Well thought-out responses to adverse conditions



After the Walkerton Inquiry, the Government of Ontario enacted the *Safe Drinking Water Act, 2002*, which provides new requirements and rules for the treatment, distribution and testing of municipal drinking water supplies. Together, the *Clean Water Act, 2006* and *Safe Drinking Water Act, 2002*, along with their associated regulations, provide the legislative and regulatory framework to implement the multi-barrier approach to municipal drinking water protection in Ontario.

The protection of municipal drinking water supplies through the *Clean Water Act, 2006* is one piece of a much broader environmental protection framework in Ontario. Water resources in Ontario are protected directly and indirectly through the federal and provincial governments, municipalities, conservation authorities and public health units. These agencies are responsible for protecting and improving water quality, water quantity and aquatic habitats, providing land use planning and development rules to ensure that water resources are not negatively affected, providing flood management and responses to low water availability, and many others. For more information on how water resources are protected in Ontario, please visit www.ontario.ca/page/ministry-environment-conservation-parks or call 1-800-565-4923.

1.1 Source Protection Planning Process

The key objectives of the source protection planningis process are tohe completeion of science-based Assessment Reports that identify the risks to municipal drinking water sources, and to locally developed local Source Protection Plans that put set out policies in place to reduce the risks to protect current and future sources of drinking water. A detailed description of the source protection planning process within the Lake Erie Source Protection Region can be found in Volume I of the Long Point Region Source Protection Plan.

During all phases of Source Protection Plan development, including creation of the Terms of Reference and Assessment Report, consultation with stakeholders and the public has been undertaken in accordance with the requirements of the *Clean Water Act, 2006*. A summary of all consultation activities can be found in Volume I of the Long Point Region Source Protection Plan and a summary of any comments that impacted the development of Plan policies can be found in the Explanatory Document.Since 2005, municipalities and conservation authorities have been undertaking studies to delineate areas around municipal drinking water sources that are most vulnerable to contamination and overuse. Within these vulnerable areas, technical studies have identified historical, existing and possible future land use activities that are or could pose a threat to municipal water sources. This Assessment Report is a compilation of the findings of the technical studies undertaken in the Long Point Region Source Protection Area (watershed area

The Draft Long Point Region Assessment Report was posted for a 35-day public consultation period in July 2010. During this time members of the public, municipalities and other interested bodies had the opportunity to provide comments on the draft report. All comments received during this period were considered by the Lake Erie Region Source Protection Committee and revisions to the document were made. The

Proposed Long Point Region Assessment Report was then posted for a second period of public consultation in October 2010. The Proposed Long Point Region Assessment Report was submitted to the Ministry of the Environment on November 25, 2010. The Long Point Region Assessment Report received approval from the Ministry of the Environment on April 29, 2011.

An Updated Assessment Report (*June 16, 2011*) was submitted to the Ministry of the Environment on July 7, 2011. This occurred when new information created the need to update the Long Point Region Source Protection Area Assessment Report. Following minor clarifications requested by the Ministry of the Environment, the Updated Assessment Report (*December 15, 2011*) was re-submitted by the Long Point Region Source Protection Authority in January 2012 and was approved by the Ministry of the Environment on February 27, 2012.

In 2014, further studies were undertaken to better delineate the wellhead protection areas for wells located in the Tillsonburg North wellfield and a new section characterizing a municipal drinking water system serving the Municipality of Bayham was added. The Draft Updated Assessment Report was posted for a 30-day public consultation period from February 9 to March 10, 2015. A separate, focused consultation was held from March 16 to April 10, 2015 for the new Municipality of Bayham section that has been added to the Assessment Report. The comments and feedback received during the comment period were reviewed by the Source Protection Committee and considered in the finalization of this report. The Long Point Region Source Protection Authority submitted the Proposed Updated Assessment Report to the Minister on June 3, 2015.

Following the June 2015 submission, additional comments were addressed and the Assessment Report was re-submitted for approval October 27, 2015. The Ministry of the Environment and Climate Change approved the Updated Long Point Region Assessment Report November 4, 2015.

The approved Assessment Report was then amended to include a Tier 3 Water Budget and Local Area Risk Assessment and Wellhead Protection Area (WHPA) updates in the communities of Delhi, Simcoe, Waterford and the Village of Richmond. The Ministry of the Environment, Conservation and Parks approved the updated Assessment Report on March 11, 2019.

New information has since been added to the Long Point Region Assessment Report for the Oxford South Drinking Water System, Otterville wellfield.

The Source Protection Plan is a document that contains policies to protect sources of drinking water against threats identified in the Assessment Report. The Plan sets out:

how the risks posed by drinking water threats will be reduced or eliminated;

policy, threat and Issues monitoring programs;

who is responsible for taking action;

timelines for implementing the policies and programs; and

how progress will be measured.

The task of plan development involved municipalities, conservation authorities, property and business owners, farmers, industry, health officials, community groups and others working together to develop a fair, practical and implementable Source Protection Plan. Public input and consultation played a significant role throughout the process.

Following Source Protection Plan approval, annual progress reports on implementation are required. Implementation of the Source Protection Plan is led by municipalities and provincial agencies in most cases. In some cases, conservation authorities, public health units, or other organizations may be involved in implementing policies in the Source Protection Plans. The implementers use a range of voluntary and regulatory programs and tools, including education and outreach; incentive programs; land use planning (zoning by-laws, and Official Plans); new or amended provincial instruments; Risk Management Plans; and prohibition. Actions to reduce the risk posed by activities found to be significant threats are mandatory, since the *Clean Water Act, 2006* requires that all identified significant threats cease to be significant.

Source Protection Authorities and Regions

The province has organized the Source Protection Program using watershed boundaries, rather than municipal or other jurisdictions. The watershed boundary is the most appropriate scale for water management, since both groundwater and surface water flow across political boundaries. For Source Protection planning purposes, the watershed is referred to as a Source Protection Area under the *Clean Water Act, 2006*. The Long Point Region watershed area is called the Long Point Region Source Protection Area. Similarly, conservation authorities are referred to as Source Protection Authorities under the *Clean Water Act, 2006* and are responsible for facilitating and supporting the development and update of source protection plans.

For the purposes of source protection, the Long Point Region Source Protection Authority is partnered with the Catfish Creek Source Protection Authority, Kettle Creek Source Protection Authority and Grand River Source Protection Authority to create the Lake Erie Source Protection Region. The Lake Erie Source Protection Region is one of 19 regions established across the province. The Grand River Source Protection Authority acts as the lead Source Protection Authority in the Lake Erie Region.

1.1.1

Message from the Committee

The overall objective of the Lake Erie Region Source Protection Committee, in partnership with local communities and the Ontario government, is to direct the development of source protection plans that protect the quality and quantity of present and future sources of municipal drinking water in the Lake Erie Source Protection Region. We will work with others to gather technical and traditional (local and aboriginal) knowledge on which well-informed, consensus-based decisions can be made in an open and consultative manner. In developing the Source Protection Plan, the Lake Erie Region Source Protection Committee intends to propose policies that are environmentally protective, effective, economical, and fair to local communities.

The committee will strive to develop policies that are practical and implementable, and that focus limited resources on areas that net the greatest benefit, while recognizing that the plan must address significant threats so that they cease to be significant. Where possible, the committee will strive to develop policies and programs that also provide a benefit to broader protection of water quality and quantity. The process to assess drinking water threats and issues will be based on the best available science, and where there is uncertainty, we will strive to follow the precautionary approach.

The Committee's Terms of Reference for the Long Point Region Source Protection Area Assessment Report and Source Protection Plan was submitted to the Minister of the Environment in December 2008. The Terms of Reference sets out the work plan for completing both the Assessment Report and Source Protection Plan , and received Ministerial approval on July 13, 2009. A copy of the Long Point Region Source Protection Area Terms of Reference can be found at:on the www.sourcewater.caLake Erie Source Protection Region website.

Financial Assistance

Section 97 of the *Clean Water Act, 2006* establishes the Ontario Drinking Water Stewardship Program. The purpose of the program is to provide financial assistance to those whose activities and properties may be affected by the implementation of the Source Protection Plan. The program also provides for outreach and education programs to raise awareness of the importance and opportunities for individuals to take actions to protect sources of drinking water. Ontario Regulation 287/07 (General) further clarifies the details of the Ontario Drinking Water Stewardship Program.

The program received funding from 2008 until 2014. By way of committee resolutions and letters to the Ministry, the Lake Erie Source Protection Committee requested that the Province of Ontario continue to support funding of the Ontario Drinking Water Stewardship Program beyond 2014. The Joint Advisory Committee (JAC) continues to encourage the Province to re-establish and rejuvenate the stewardship program to support local source protection plan implementation. The committee believes ongoing funding is needed to provide financial assistance to property owners affected by new policies and risk reduction strategies as a result of the Source Protection Plan.

1.2 Framework of the Assessment Report

The Long Point Region Source Protection Area Assessment Report was completed in compliance with Ontario Regulation 287/07 (General) under the *Clean Water Act, 2006*, which sets out the minimum requirements for Assessment Reports. In addition, the technical work summarized in this Assessment Report was completed in conformance with the Technical Rules: Assessment Report under O. Reg. 287/07. The technical work was undertaken by municipalities and the Grand River Conservation Authority, as the lead source protection authority in the Lake Erie Source Protection Region. Funding to complete the technical studies for the Assessment Report was provided by the Ministry of the Environment, Conservation and Parks.

Within the Long Point Region Source Protection Area (SPA), the Counties of Elgin, Haldimand, Norfolk and Oxford supply drinking water through ten municipal drinking water systems, sourced within the Region. Seven~~ix~~ systems draw water from groundwater sources; one system is supplied from both groundwater and surface water

~~(North Creek in the Big Creek watershed);~~ and three systems are supplied by intakes in Lake Erie.

The *Clean Water Act, 2006* focuses on the protection of municipal drinking water supplies; however, the Act allows for other water systems to be considered, including clusters of private wells, communal systems, and other non-municipal supplies. Only municipalities within which the supplies are located, or the Minister of the Environment, Conservation and Parks have the power to add non-municipal systems. To date, no municipalities in the Long Point Region Source Protection Area have designated non-municipal drinking water supplies under the *Clean Water Act, 2006*.

The technical studies summarized in this Assessment Report start with information at the watershed scale and then move to the municipal drinking water system scale. The document is organized into the following sections: Watershed Characterization; Water Quality Risk Assessment (including Groundwater Vulnerability, Wellhead Protection Areas and Intake Protection Zones); Water Quantity Process; Tier 2 Water Budget; Tier 3 Water Budget, State of Climate Change Research; Great Lakes Considerations; and Conclusions.

~~The descriptions of the technical work provided in the Assessment Report are summaries of more detailed technical reports. In order to find more detail on any of the components of the Assessment Report, the reader is encouraged to view the technical studies and background reports available online in full on the at www.sourcewater.caLake Erie Source Protection Region website.~~

1.3 Continuous Improvement

The findings of this Assessment Report are based on the best available information. It is recognized that new information that informs the findings of this Assessment Report will become available in the future. Beyond the completion of this Assessment Report, municipalities and conservation authorities will continue to refine and improve the findings and attempt to address the data gaps documented in this report. As new or improved information becomes available, the relevant components of the Assessment Report will be amended as required. Opportunities for input and review of updated Assessment Reports will be made available to those affected by the proposed changes.

The first draft of the Assessment Report underwent several revisions before Version 1 of the Source Protection Plan was approved in 2015. At that time, the Assessment Report became part of the Source Protection Plan and both documents are now amended and assigned a version number together. Previous versions of the Assessment Report were referred to as drafts or updates. Numerical versioning has since been implemented to better track amendments following approval in 2015.

A list of version numbering and a high-level description of amendments can be found at the beginning of Volume I of the Source Protection Plan and will be kept updated as future amendments occur.

~~Public Consultation~~

Throughout the development of the Long Point Region Assessment Report there have been multiple periods of public consultation. During each consultation period members of the public, municipalities and other interested bodies were invited to review the Assessment Report documents. These documents were made available via the www.sourcewater.caLake Erie Source Protection Region website website and hard copies were also available at the conservation authority and municipal administrative offices. Public meetings were also held during public consultation periods. **Table 1-2Table 1-2** below provides details regarding each of the public consultation periods held regarding the Long Point Region Assessment Report.

Table 1-2:Long Point Region Assessment Report – Public Consultation Periods

Document / Notice	Notification Date	Consultation Period	Public Meetings	
			Date	Location
Draft Assessment Report	Jul 9, 2010	Jul 9, 2010 – Aug 17, 2010	Aug 5, 2010	Long Point Region Conservation Authority, Tillsonburg
			Aug 10, 2010	Talbot Gardens Arena (Simcoe)
Proposed Assessment Report	Mar 5, 2010	Mar 5, 2010 – Apr 9, 2010	N/A *	N/A *
Draft Updated Assessment Report	Apr 15, 2011	Apr 15, 2011 – May 21, 2011	May 9, 2011	Talbot Gardens Arena (Simcoe)
Updated Assessment Report	Feb 9, 2015	Feb 9, 2015 – Mar 10, 2015	Feb 17, 2015	Long Point Region Conservation Authority, Tillsonburg
			Feb 19, 2015	Simcoe Recreation Centre
Updated Assessment Report: Elgin County – Municipality of Bayham Section	Mar 16, 2015	Mar 16, 2015 – Apr 10, 2015	Mar 26, 2015	Richmond United Church
Draft Updated Assessment Report (Tier 3, Norfolk, Elgin, S.34)	Oct 9,2017	Oct 9, 2017 – Nov 15, 2017	Oct 30, 2017	Richmond United Church
			Nov 1, 2017	Royal Canadian Legion 79 (Simcoe)
Draft Updated Assessment Report (Oxford, S.34)	Sep 23, 2019	Sep 23 – Oct 27, 2019	October 1, 2019	Norwich Community Centre

* no public meeting required – comments received were appended to the submission package

~~During each period of public consultation members of the public, municipalities or other interested bodies were able to submit comments to the Source Protection Committee. Comments could be submitted via regular mail, e-mail, fax, or in person at a public consultation meeting. The Committee in turn, considered these comments following each period of public consultation.~~

~~Comments received by the Source Protection Committee during the most recent period of public consultation are included in **Appendix A**.~~

2.0 WATERSHED CHARACTERIZATION

Understanding the human and physical characteristics of a watershed is important to protecting and managing its water. Interactions between surface water, groundwater, potential sources of contamination, and the overuse of water require an understanding of the physical characteristics of the bedrock and surficial geology, physiographic regions, climate and significant natural features within the watershed. Additionally, how the people of the watershed interact with these physical characteristics plays an ever-increasing role in determining the overall health of the ecosystem. The following sections are intended to provide information on the physical and human characteristics of the Long Point Region watershed area.

2.1 Lake Erie Source Protection Region

In an effort to share knowledge and resources for the purpose of developing source protection plans, a partnership was formed in 2004 between the Grand River, Long Point Region, Catfish Creek and Kettle Creek Conservation Authorities to form the Lake Erie Source Protection Region. The partnership was formalized in 2007 by Ontario Regulation 284/07 (Source Protection Areas and Regions) under the Clean Water Act, 2006. The Grand River Conservation Authority, referred to in the regulation as the Grand River Source Protection Authority, acts as the lead source protection authority for the region **Map 2-1**.

Map 2-1: Lake Erie Source Protection Region shows the areal extent of the Lake Erie Source Protection Region, including municipal boundaries and main rivers and tributaries. The four Source Protection Authorities agreed to jointly undertake research, public education, and watershed planning and management for the advancement of drinking water source protection for the respective watersheds. The watersheds have a long history of partnership and cooperation and also have a natural association by containing the majority of inland rivers and streams flowing from Ontario directly into Lake Erie.

With a population of approximately ~~more than~~ 1.2 million people (Statistics Canada Census 2021~~2006 & 2017; GSP Group, 2010~~), the Lake Erie Source Protection Region represents a diverse area, ranging from intense agricultural production to large and rapidly expanding urban areas. The region spans an area from the City of St. Thomas in the west, to Halton Hills on the east, and as far north as the community of Dundalk. The area includes, in whole or in part, 49 upper, lower and single tier municipalities, as well as two First Nations communities (LPRCA, 2008). **Table 2-1** lists the municipalities in the Long Point Region Watershed Area.

2.2 Long Point Region Source Protection Area

The Long Point Region watershed area covers an area of approximately 2,900 km^2 in Southern Ontario. **Map 2-2** shows the several watercourses and watersheds that form Long Point Region, each with their own unique traits and values. The combined length of all the streams and their tributaries equals over 3,700 km. The Long Point Region watershed area is almost 100 km at its widest point and 60 km running north to south.

The Region spans 225 km of Lake Erie shoreline, including the internationally renowned Long Point sand spit.

The ground surface elevation ranges from 357 m above sea level in the northwest (west of Norwich), to 169 m above sea level in the southeastern limits of the Long Point Region along the Lake Erie shoreline. Moderate relief is apparent in the central part of the Region (north of Tillsonburg, Otterville, Courtland, and Waterford) corresponding to the Tillsonburg, Courtland, St. Thomas and Paris moraines.

Flat plains, which are characteristic of the Long Point Region, attracted early settlers because they were easily cleared. Other attractions were the transportation afforded by Lake Erie, the abundance of fish, wildlife, and fur as well as the moderate climate. The clearing of the plains and harvest of the surrounding heavily forested lands has had a significant impact on modern day surface and groundwater quality and quantity.

Although there are two First Nations communities located in the Lake Erie Region, neither of these communities are in the Long Point Region Watershed. As such, a map representing the First Nations communities is not included in the Long Point Region Source Protection Area Assessment Report.

~~2.3 Population, Population Density and Future Projections~~

According to the 2021~~16~~ Statistics Canada Census, the Long Point Region watershed area has~~d~~ a population of approximately 118,848~~3,808~~ people. The population of the watershed that receives municipal water supplies sourced within the Long Point Region watershed area is approximately 67,000, which represents over 56% of the 2021 watershed population. **Table 2-2** provides a breakdown of the serviced population by municipality. There are no residents in Brant County or Township of Malahide that are within the Long Point Region watershed that are serviced by municipal drinking water. ~~**Table 2-2** shows a summary of the population in each municipality for the area that falls within the Long Point Region boundaries. These values were based on the 2021 population figures from Statistics Canada, aggregated at the dissemination area (DA) level. In cases where a dissemination area falls only partly within the Long Point Region Source Protection Area, the population for that DA was adjusted based on the area within Long Point relative to the total area of the DA. **Table 2-2Table 2-2** summarizes the 2026 and 2056 population projections by municipality. The 2026 projections are based on municipal population projection estimates from municipal official plans, master servicing plans or other municipal documents from 2006. The same growth rates and assumptions used for the 2026 projections were applied for the period up to 2056 to estimate the 2056 projections. A detailed summary of population and population projections in the Long Point Region watershed area is provided in the report entitled *Grand River, Long Point Region, Catfish Creek and Kettle Creek Watershed Areas: Population Forecasts, January 2010*, available online on theat www.sourcewater.caLake Erie Source Protection Region website.~~

Table 2-1: Municipalities in the Long Point Region Watershed Area

Upper/Single Tier Municipality	Lower Tier Municipality
Oxford County	Township of Southwest Oxford
Oxford County	Town of Tillsonburg
Oxford County	Township of Norwich
County of Brant	n/a
Norfolk County	n/a
Haldimand County	n/a
Elgin County	Municipality of Bayham
Elgin County	Township of Malahide

~~**Table 2-2: Population and Population Projections in the Long Point Region Watershed Area**~~

~~Municipality~~	~~202116 Population*~~
~~County of Brant~~	~~1,2852383~~
~~Haldimand County~~	~~12,933182~~
~~Norfolk County~~	~~65,7864,044~~
~~Township of Norwich~~	~~9,467791~~
~~Township of Southwest Oxford~~	~~19032,517~~
~~Town of Tillsonburg~~	~~18,6155,872~~
~~Municipality of Bayham~~	~~7,013396~~
~~Township of Malahide~~	~~74821~~
~~Total~~	~~113,808118,848~~

~~Source: Statistics Canada Census, 2021.16; GSP Group Inc., 2010.~~
~~* Projected population within Long Point Region watershed area boundary by municipality based on 2006 projections.~~

~~The population of the watershed that receives municipal water supplies sourced within the Long Point Region watershed area is approximately 61,72067,000, which represents over 54 percentovernearly 5660% of the 202116 watershed population. **Table 2-3** provides a breakdown of the serviced population by municipality for 2016.~~

Table 2-2: ~~2016~~ Municipally Serviced Population in the Long Point Region Watershed Area

Municipality	~~2016~~ Population*
County of Brant	0
Haldimand County	~~5,092~~5,200~~**~~
Norfolk County	36,800~~34,018***~~
Township of Norwich	~~4,943~~6,002

Township of Southwest Oxford	~~227~~84
Town of Tillsonburg	~~16,340~~19,120
Municipality of Bayham	~~1,100~~59
Township of Malahide	0
Total	**~~61,720~~67,265**

~~Source: Statistics Canada Census, 2006; GSP Group Inc., 2010.~~

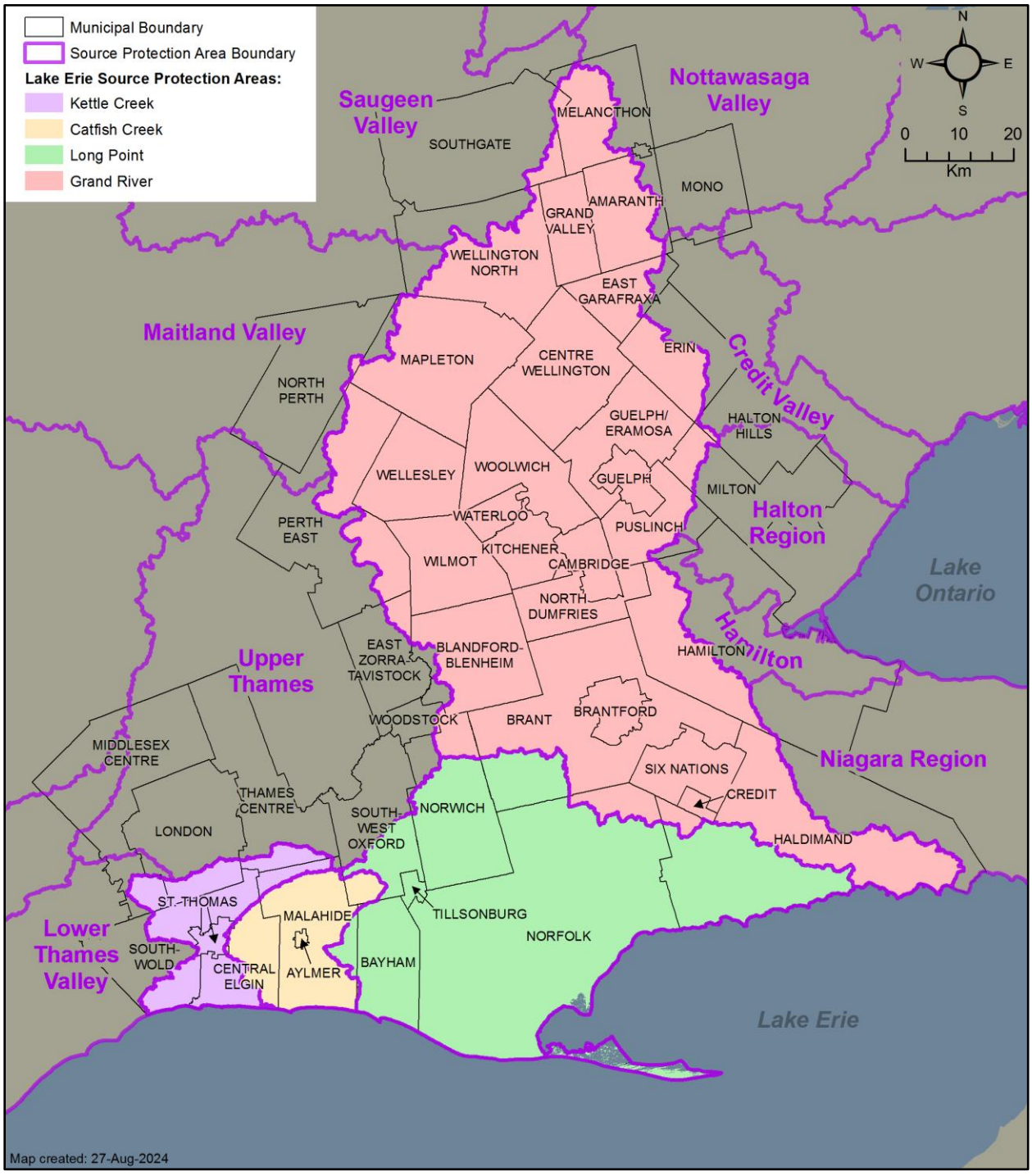
*Number of users served by drinking water systems sourced ~~Population receiving municipality serviced drinking water~~ within Long Point Region watershed area boundary by municipality; data obtained from 2022 annual drinking water system reports.

~~**Haldiman County population based on 2011 data~~

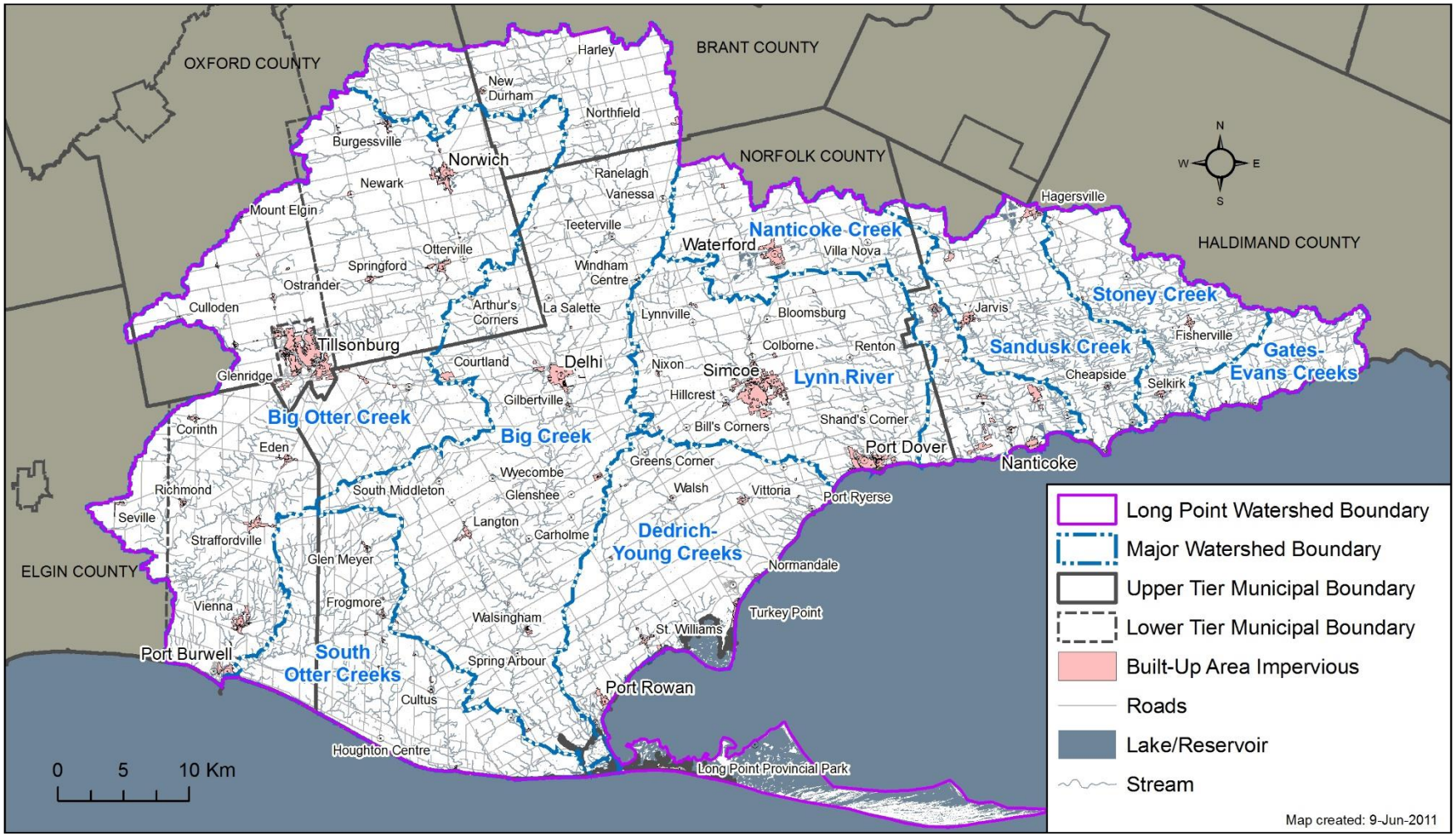
~~***Norfolk County population based on 2017 data~~

~~There are no residents in Brant County or Township of Malahide that are within the Long Point Region watershed that are serviced by municipal drinking water.~~

Map 2-1: Lake Erie Source Protection Region



Map 2-2: Long Point Region ~~Watershed Boundary~~Subwatershed Boundaries



~~2.4~~2.3 Physiography

The physiographic features (as mapped by Chapman and Putnam, 1984) within the Long Point Region watershed area are presented in **Map 2-3.** These landforms were shaped by glacial processes occurring during the Late Wisconsinan glaciation and define the three main physiographic regions within the Long Point Region: The Horseshoe Moraines, the Norfolk Sand Plain, and the Haldimand Clay Plain.

There are direct relationships between physiography, groundwater and surface water hydrology. In general, areas with fine-grained clays lying at the surface (e.g., the Haldimand Clay Plain) tend to have more tributaries than those areas where coarse-grained sediments dominate the surficial sediments. This is due to the low infiltration capacity of clay-rich soils. Precipitation falling on the clay plain commonly travels as overland flow to surface water features rather than infiltrating to the groundwater system. In contrast, areas with coarser sands and gravels at the surface (e.g., the Norfolk Sand Plain and moraines) have fewer tributaries as a larger portion of precipitation percolates downward to recharge the groundwater system.

~~2.4.1~~2.3.1 Norfolk Sand Plain

The Towns of Tillsonburg, Delhi, Simcoe, and Waterford are found within the physiographic region known as The Norfolk Sand Plain which borders the Mount Elgin Ridges to the northwest, the Horseshoe Moraines to the northeast, the Haldimand Clay Plain to the east, and the Ekfrid Clay Plain to the west (Chapman and Putnam 1984). This region is characterized by relatively flat to undulating glaciolacustrine deltaic deposits of sands (up to 27 m thick) and silts which are observed to cover or partially cover the moraines in the area (Chapman and Putnam 1984; Barnett 1982). The moraines rise up to 23 m above the surrounding terrain, whereas the Big Otter and Big Creeks have incised into this plain up to 38 m (Chapman and Putnam 1984; Barnett 1982). While some finer-grained sands exist, the local soils are predominantly coarse-grained and both the coarse and fined grained sands have been historically well suited to the tobacco farming industry (Chapman and Putnam 1984). More recently, the type of crop planted is in a state of flux as acreage devoted to tobacco production has declined, with the acreage devoted to fruits, vegetables and ginseng increasing. ~~Anecdotal evidence does suggest that the decline in tobacco acreage has ceased, and may have started to increase again.~~

~~2.4.2~~2.3.2 Haldimand Clay Plain

The area to the east of Waterford and Simcoe is characterized by a low-relief lacustrine clay plain (Chapman and Putnam, 1984), referred to as the Haldimand Clay Plain. The Clay Plain consists of fine-grained silts and clays deposited at the bottom of a deep glacial lake basin during the Port Huron Stade, about 13,000 years ago. In areas farther to the north where the clay deposits are among moraines and relief increases, the clay thins and is interbedded with till (Chapman and Putnam 1984). Soils of the region are predominantly fine-grained, which often prevents adequate drainage, but coarser grained soils are also locally present (Chapman and Putnam 1984).

~~2.4.3~~2.3.3 Horseshoe Moraines and Mount Elgin Ridges

The Horseshoe Moraines physiographic region represents the southward extent Paris and Galt Moraines that are located just to the east of Delhi and west of Simcoe, respectively~~.~~. The Paris and Galt Moraines, oriented in a north-south direction, are scarcely visible in the Long Point Region as they have been either eroded or buried by overlying glaciolacustrine or glaciofluvial sediments (Barnett, 1982). The moraines in this area are primarily composed of the Wentworth Till, but outwash deposits, glaciolacustrine deposits, and stratified drift also make up the structure of the ridges (Barnett 1978). Well-drained surficial soils, categorized as Huron clay loam, can be found both on and off the moraine (Chapman and Putnam 1984). While not identified as hummocky topography, the general locations of these moraines are shown in **Map 2-4**.

The Mount Elgin Ridges are situated in the northwestern portion of the Long Point Region. They include several end moraines that provide low to moderate relief above the surrounding sand plain and in some areas exhibit slightly hummocky topography. Several of these moraines were deposited at the front of the Lake Erie ice sublobe during the Wisconsin glaciation (Chapman and Putnam, 1984). These moraines, which run east-west roughly paralleling the current Lake Erie shoreline, include (from north to south) the St. Thomas, Norwich, Tillsonburg, Courtland, and Mabee Moraines. These moraines are shown as hummocky topography on **Map 2-4**.

All the end moraines within the Long Point Region are kilometres in length. In general, the surface relief of the moraines decreases southward toward Lake Erie. The moraines located nearest to Lake Erie (including the north-trending Paris and Galt moraines) are more subdued as they were subjected to increased erosion and burial by the encroachment of glacial Lake Erie (Barnett 1982; Chapman and Putnam 1984). The St. Thomas Moraine (the oldest of the moraines in the area) shows the greatest relief (Chapman and Putnam 1984). It is located in the northwest corner of the watershed~~,~~ and extends beneath the towns of Mount Vernon and Mount Elgin (Barnett, 1982).

~~2.5~~2.4 Ground Surface Topography

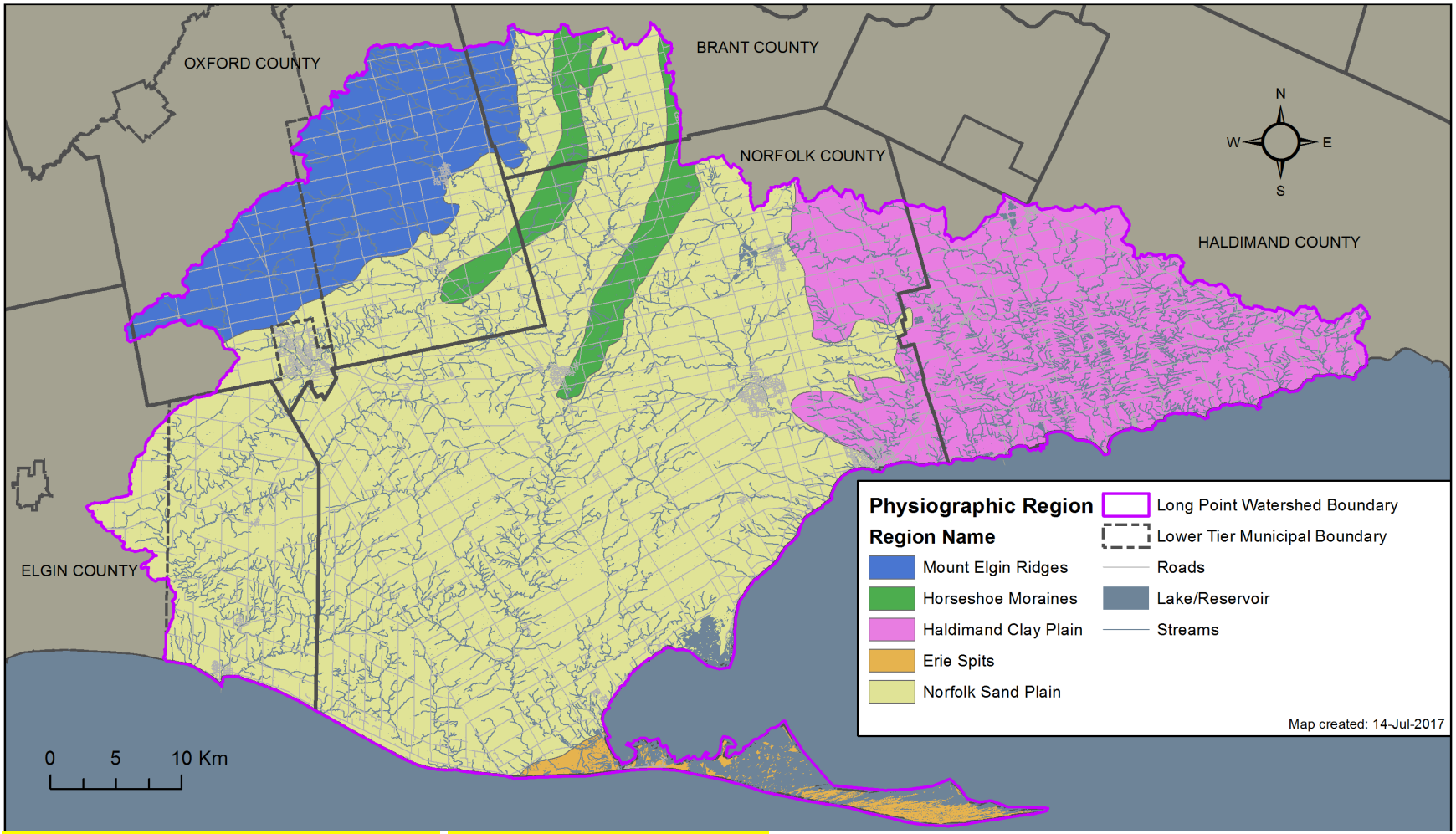
The present-day ground surface topography evolved from erosional and depositional processes that occurred during glacial and post-glacial times. **Map 2-5** shows the topography of the Long Point Region watershed. The ground surface elevation ranges from 357 masl in the northwest on the St. Thomas Moraine, to 169 masl in the southeastern limits along the Lake Erie shoreline. Areas mapped as hummocky topography are minimal through the Long Point Region~~,~~ and are illustrated on **Map 2-4**.

~~2.5.1~~2.4.1 Bedrock Topography

In Ontario, there was an extensive period of time between the final deposition of the Paleozoic sedimentary rocks (approximately 200 million years ago) and the earliest record of glacial deposition during the Wisconsinan Glaciation approximately 115,000 years ago. During this period, the exposed bedrock surface was likely subjected to glacial and fluvial erosion and weathering that shaped the underlying bedrock surface. Much of

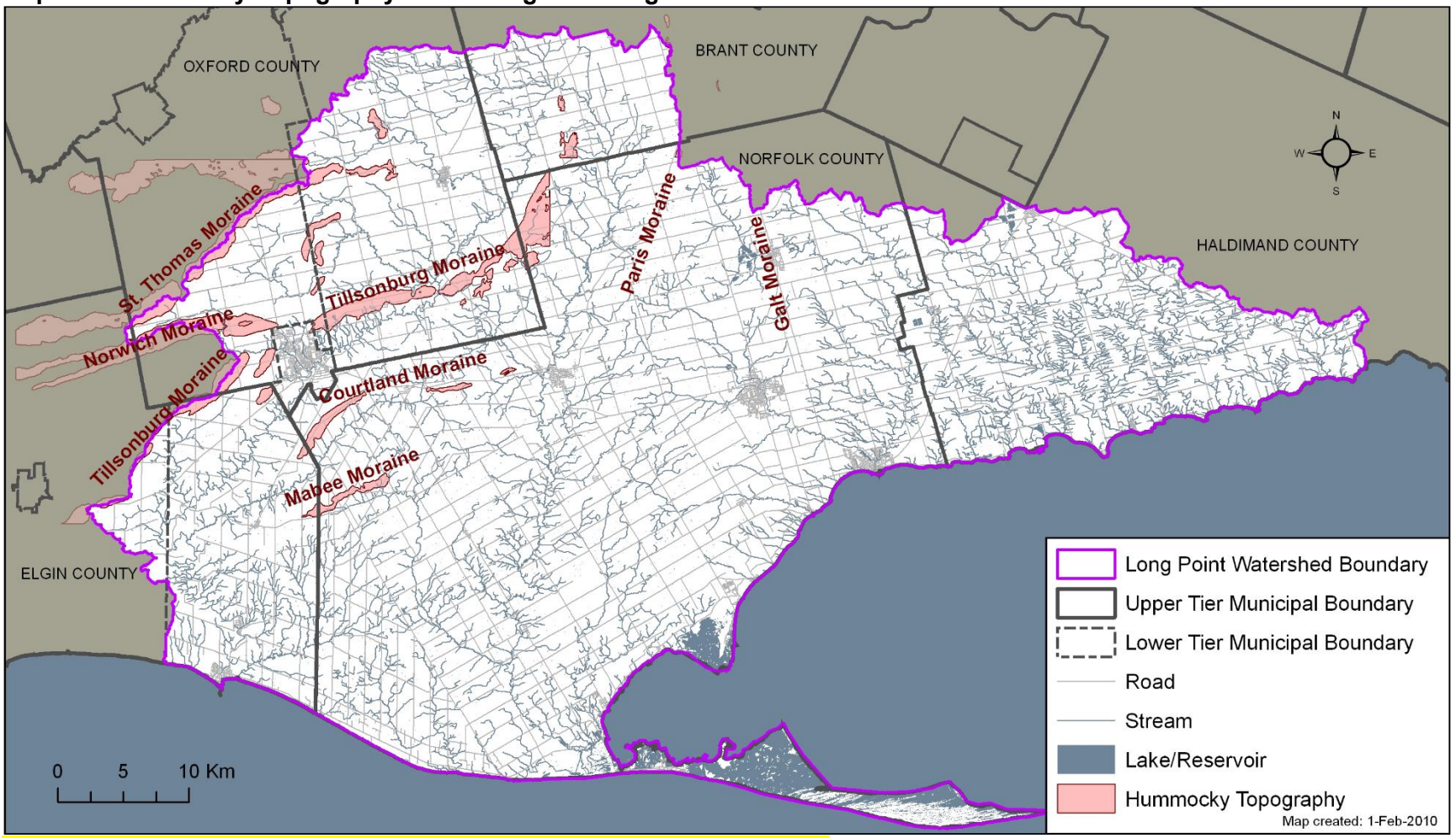
the bedrock surface's irregular topography is attributed to fluvial erosion whereby paleo-drainage was focused along the bedrock for extensive periods of time. This led to the erosion of river valleys in the bedrock, which in some places were subsequently infilled with sediment. Generally, bedrock topography slopes from the north towards the south. **Map 2-6** illustrates bedrock topography across the Long Point Region.

Map 2-3: Physiography of the Long Point Region Watershed Area



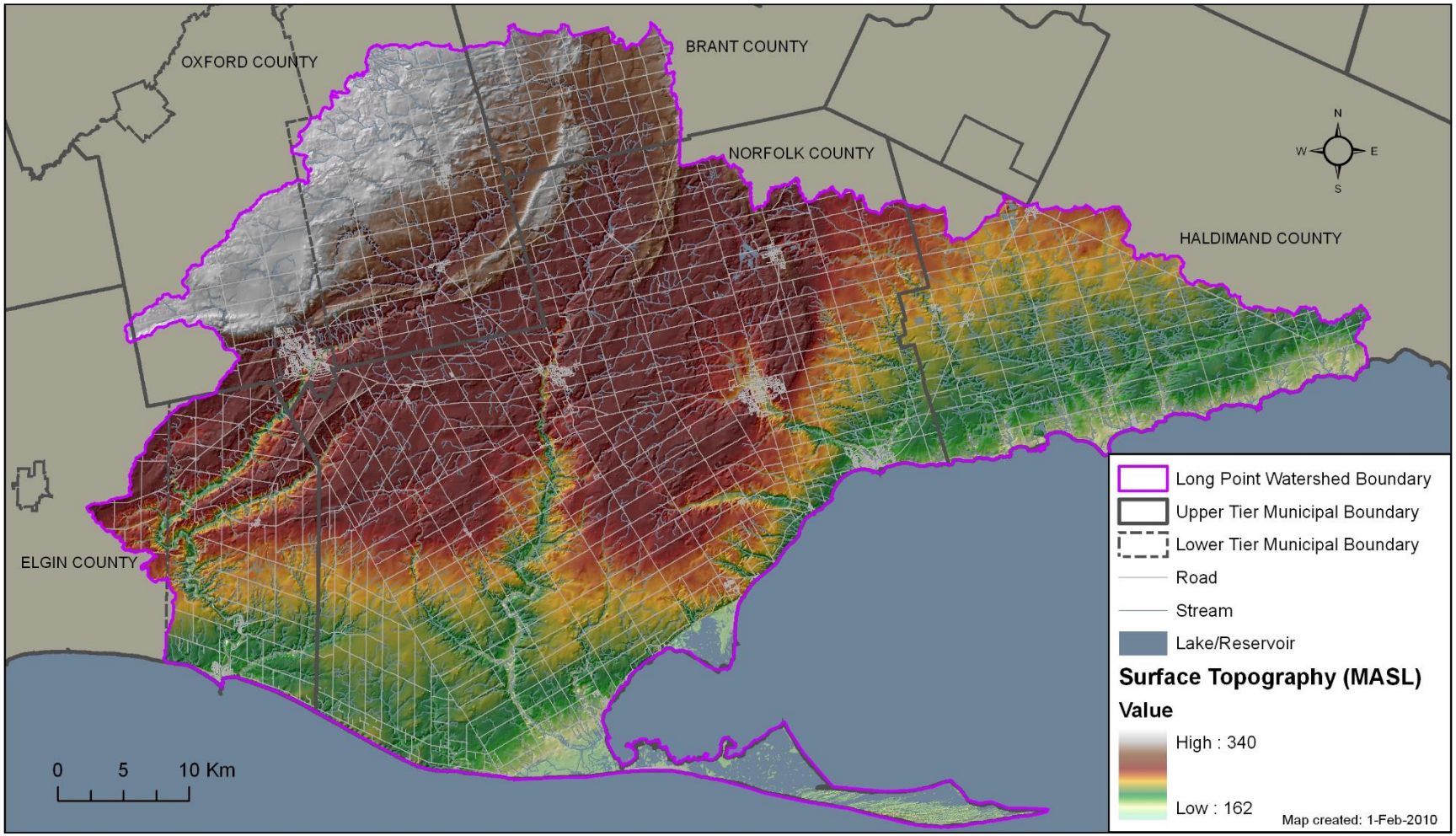
Source: Physiographic region data from (Chapman and Putnam, 2007.)

Map 2-4: Hummocky Topography in the Long Point Region Watershed

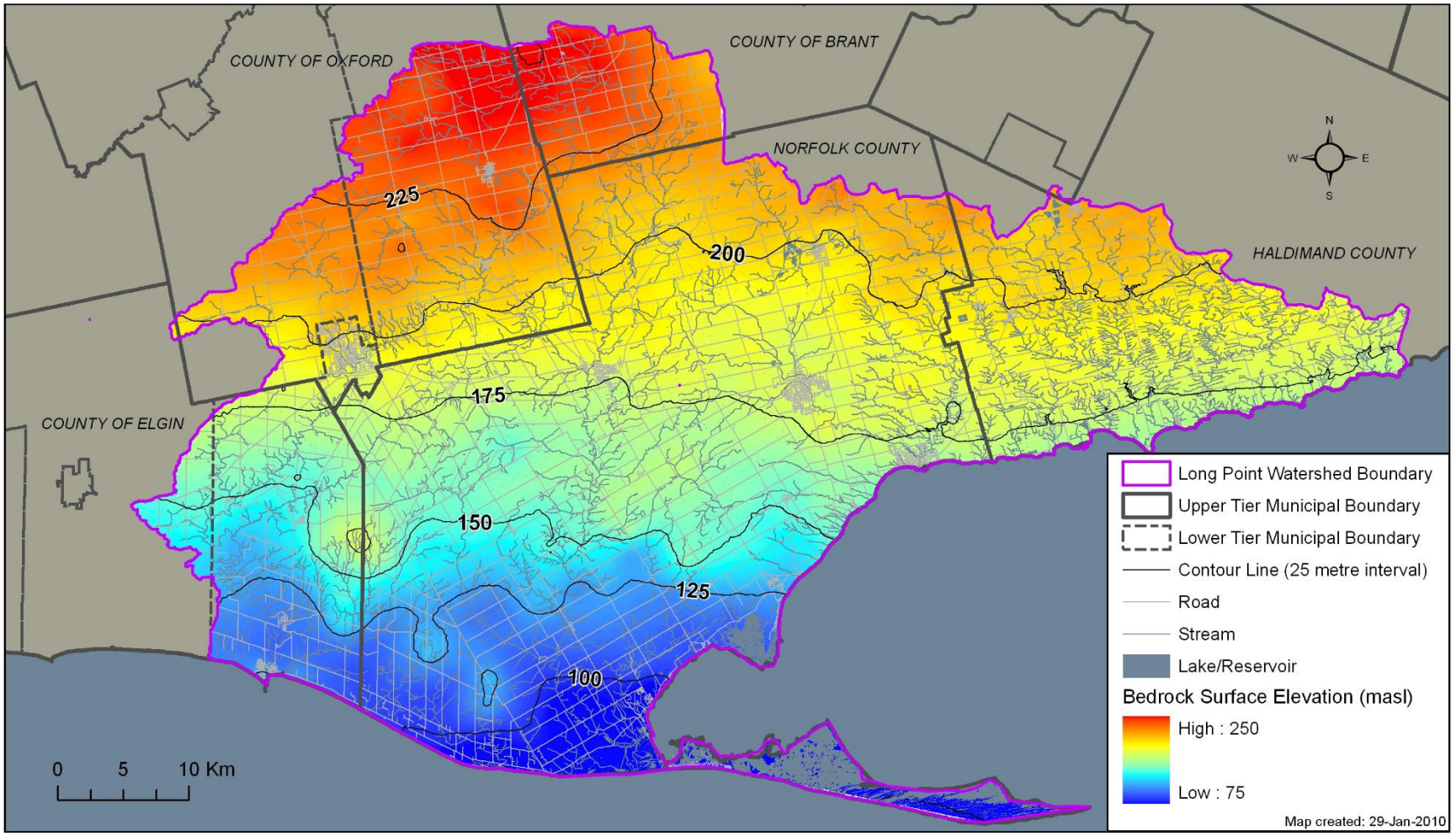


Source: Hummocky topography data from Ontario Geological Survey, 2003.~~: tbd~~

Map 2-5: Ground Surface Topography in the Long Point Region Watershed



Map 2-6: Bedrock Topography in the Long Point Region Watershed



~~2.6~~2.5 Geology

The watershed is underlain by a series of gently dipping Paleozoic sedimentary rocks consisting of deep-water shales interbedded with shallow water carbonates and sandstone. These rocks are overlain by unconsolidated Quaternary-aged sediments of variable thickness that were laid down after the last glaciation. Paleozoic bedrock outcrops in the Long Point Region in only a few areas in the east near Hagersville; in the remainder of the Long Point Region, bedrock is buried beneath a thick veneer of sediments.

~~2.6.1~~2.5.1 Bedrock Geology

Glacial sediments in the Long Point Region are underlain by Upper Silurian to Middle Devonian bedrock consisting mainly of limestones, dolostones and shales. This Paleozoic succession is subdivided into 10 formations. In order from oldest to youngest, these are the Salina, Bertie and Bass Island, Oriskany, Bois Blanc, Onondaga, Amherstburg, Lucas, Dundee and Marcellus Formations. The bedrock geology presented in **Map 2-7** was assembled by the Ontario Geological Survey (OGS) in 2007.

The oldest subcropping Paleozoic bedrock in Long Point Region is the Salina Group. This formation consists of interbedded shale, mudstone, dolostone, and evaporites (including gypsum and salt; Johnson et al., 1992). Within the Long Point Region, the Salina Group subcrops in the far northern reaches near Hagersville (Johnson et al., 1992), and outside the village of Springvale. Subcropping south of the Salina Group is the younger (Late Silurian) Bertie / Bass Islands Formation. The contact between the Salina Group and the overlying Bertie / Bass Islands Formation is conformable. The Bertie / Bass Island Formations form a narrow, 1-3 km wide band of oolitic and microsucrosic brown dolostone with minor thin beds of shaley dolostone along the northern edges of the Long Point Region (Hewitt, 1972; Barnett, 1982; Johnson et al., 1992).

The Oriskany Formation is a very small and localized (approximately 6 km^2) subcrop of Lower Devonian coarse-grained, calcareous, quartz sandstone with a thin basal conglomerate approximately 10 km east of Hagersville that pinches out laterally between the Bertie and Bois Blanc Formations. It is estimated to have a maximum thickness of less than 6 m (Johnson et al. 1992). The contact between the Oriskany Formation and the underlying Bertie Formation is sharp and disconformable, showing pronounced small-scale karst features (Johnson et al., 1992).

Resting stratigraphically above the Oriskany and Bertie / Bass Islands Formations, is the Early Devonian Bois Blanc Formation. This formation consists of cherty brownish grey, fossiliferous limestone and is estimated to be roughly 3 to 15 m thick (Johnson et al., 1992). The Bois Blanc Formation and the underlying Bass Islands are separated by a major regional unconformity (Hewitt, 1972; Johnson et al., 1992). This feature may be significant from a hydrogeologic perspective as the upper surface of the Bois Blanc is interpreted to be weathered, highly fractured and therefore, able to transmit greater volumes of water than the more competent rock at depth.

The middle Devonian Detroit River Group (Onondaga, Amherstburg and Lucas Formations) stratigraphically overlies the Bois Blanc Formation and extends from Norwich and Otterville, beneath Waterford eastward to Lake Erie. East of Hagersville, the Bois Blanc Formation is overlain by the Onondaga Formation. The contact between the Bois Blanc and Onondaga formations is poorly understood but is believed to be disconformable (Johnson et al. 1992). The Middle Devonian rocks of the Onondaga Formation consist of cherty fossiliferous limestone (Johnson et al. 1992; Telford and Tarrant, 1975). West of Hagersville, the crinoidal limestones and dolostones of the Amherstburg Formation overlie the Bois Blanc Formation. The contact between the Bois Blanc and Amherstburg formations is poorly defined and largely interpretative. The lateral contact between the contemporaneous Amherstberg Formation (deposited in the Michigan basin) and the Onondaga Formation (deposited in the Appalachian basin) is gradational (Johnson et al. 1992). The Lucas Formation conformably overlies the Amherstberg Formation and consists of microcrystalline limestone (Johnson et al. 1992). The Lucas Formation is thickest in the western part of the Long Point Region. It gradually thins and pinches out near Port Dover.

The Dundee Formation is a grey to brown fossiliferous limestone that lies stratigraphically above the Detroit River Group. The Dundee Formation is the subcrop strata across much of the central and southern portions of the Long Point Region and is buried beneath Quaternary sediments throughout the majority of the Long Point Region. The formation outcrops along Black Creek, Nanticoke Creek, a small area just north of the town of Nanticoke, as well as the Lake Erie shoreline between Port Dover and Nanticoke. Several karst features have been mapped in association with the Dundee Formation (Barnett, 1978). Karst is a distinctive type of topography or terrain, formed primarily by the dissolution of carbonate rocks, such as limestone or dolostone, by groundwater. In areas near Port Dover, the mildly acidic groundwater reacts with carbon dioxide in the atmosphere and soil, and enlarges the openings in the Dundee Formation limestone, creating a subsurface drainage system. Barnett (1982) mapped several sinkholes within the Long Point Region, ranging up to 15 m in diameter and 8 m deep. From a hydrogeological standpoint, bedrock aquifers in these karstic areas are highly susceptible to groundwater contamination because surface water and contaminants tend to flow directly into the aquifers via sinkhole drains.

The youngest Paleozoic bedrock formation to subcrop beneath the Long Point Region is the Marcellus Formation. This formation is restricted to the southwestern portions of the Long Point Region on the north shores of Lake Erie where it conformably overlies the Dundee Formation. The Marcellus Formation is described as a black, organic-rich shale, with a few minor, thin, impure carbonate interbeds and ranges in thickness between 3 and 15 m (Barnett, 1982, 1993; Johnson et al., 1992). The Marcellus Formation marks a sharp change in the bedrock from older carbonate-dominated bedrock to shale-dominated strata (Johnson et. al., 1992).

~~2.6.2~~2.5.2 Quaternary (Surficial) Geology

Quaternary-aged overburden sediments within the watershed provide a detailed record of glacial and interglacial events that took place throughout the most recent

Wisconsinan Glaciation. During the Wisconsinan glacial period (beginning 30,000 years before present), the Laurentide Ice Sheet, a continental-scale glacier, repeatedly advanced and retreated across Ontario, extending southward into the states of Ohio and Indiana (Barnett, 1992). The ice front advanced forward during cold periods (glacial stades) and retreated when the climate temporarily warmed (glacial interstades) leaving behind a complex sediment record. As the Laurentide Ice Sheet advanced across southern Ontario, it scoured the Paleozoic bedrock surface and reworked the vast majority of pre-existing sediments.

Within the Long Point Region, the advance of ice during the Late Wisconsinan glacial period essentially erased over 250,000,000 years of climatic history (the period of time between the deposition of the Paleozoic rocks (350 million years ago) and the deposition of pre-Wisconsinan overburden sediments (100,000 years ago)). The Late Wisconsinan glacial period extended from 23,000 years ago to 10,000 years ago (Dreimanis and Goldthwait, 1973). It was during this period that the Laurentide Ice Sheet reached its most southerly extent, advancing through Ontario and extending southward into the United States. During this period, the ice sheet began to thin and a series of sublobes developed, each moving independently of one another at different rates, and in different directions. The sublobes deposited a series of distinct subglacial tills and landforms within the Long Point Region. Overburden within the Region was predominately deposited by the Erie sublobe, or at times by the Ontario-Erie sublobe, when the two sublobes temporarily amalgamated. The glacial events of the Late Wisconsinan resulted in the most commonly occurring and extensive deposits in the Long Point Region.

Table 2-3presents a list of the sediments identified in the Long Point Region, their distribution, and the general time period in which the deposits were laid down (OGS, 2007). **Map 2-8,** shows the spatial distribution of these units at surface across the Region.

Table 2-3: Quaternary Deposits Located Within the Long Point Region Source Protection Study Area

Age (y.b.p) *	Glacial Stage	Substage	Glacial Stade/ Interstade	Associated Deposits
5000- 11,500	Wisconsinan	Late Wisconsinan	Holocene/ Recent	Modern alluvium, organic deposits, Long Point spit, Eolian sand dunes
11,500- 12,000			Twocreekean Interstade	Shoreline Formation Glaciolacustrine Deposition
12,000- 13,200			Port Huron Stade	Wentworth Till, Norfolk Sand Plain, Haldimand Clay Plain
13,200- 14,000			Mackinaw Interstade	Paris/ Galt Moraines
14,000- 15,500			Port Bruce Stade	Port Stanley Till, Glaciolacustrine Deposits
15,500- 18,000			Erie Interstade	Glaciolacustrine Deposits
18,000- 25,000			Nissouri Stade	Catfish Creek Till
25,000- 53,000	Middle Wisconsinan		Undifferentiated tills and deposits	
53,000- 80, 000	Early Wisconsinan			

* y.b.p. represents number of years before present

The most extensive subglacial till sheet in southern Ontario is the Catfish Creek Till (deVries and Dreimanis, 1960; Barnett, 1978; 1992; 1993), which was deposited during the Nissouri Stade, when the Laurentide ice sheet last advanced as one thick cohesive ice sheet. The till is composed of stacked layers of subglacial lodgement till as well as stratified glaciofluvial and glaciolacustrine sediments and supraglacial till layers and lenses (Dreimanis, 1982; Barnett, 1992). The till is described as a highly calcareous, gritty, sandy silt till. It is often described as hardpan in water well drillers' records because of its stoniness and hardness (Barnett, 1978; 1982; 1992). The till occurs primarily as a buried till plain across the Long Point Region watersheds, but it outcrops along the Tillsonburg Moraine and on selected drumlins in the northeast near Hagersville (Barnett, 1978; 1982).

The Port Stanley Till is described as a silt to clayey silt till with few clasts (Barnett, 1982). Within the watershed, the `till complex' consists of up to 5 layers of subglacial till separated by glaciolacustrine sediments resulting from glacial lake level fluctuations within the Lake Erie basin (Barnett, 1982; 1992). Further inland, the Port Stanley Till consists of only one layer of subglacial till with associated glaciofluvial sediments (Barnett, 1992). The Port Stanley Till is buried beneath younger glaciolacustrine

sediments across most of the Long Point Region; however, it outcrops north of Tillsonburg (Barnett and Girard, 1982). The Till also makes up the vast majority of the sediments within the east-trending end moraines in the Long Point Region, including (from oldest to youngest) the St. Thomas, Norwich, Tillsonburg, Courtland and Mabee Moraines (Barnett, 1993).

The Wentworth Till is the youngest till within the watershed and is commonly buried beneath younger glaciolacustrine sediments (Barnett, 1982); however, it outcrops in some areas northeast of Delhi along the Paris Moraine, in areas approximately 3 km north of Port Rowan, and in drumlins north of Hagersville (Barnett, 1978). Within the Long Point Region, Wentworth Till is a very poorly sorted massive clayey silt to silty clay containing minor coarse sand, pebbles and boulders, which becomes gradually coarser grained toward the northwest (Barnett, 1978). The Paris and Galt Moraines are both composed of Wentworth Till (Barnett, 1978)

Glacial Lake Whittlesey followed by Glacial Lake Warren, each flooded the Long Point Region throughout the Port Huron Stade (Barnett, 1992). It was at the base of these lakes that the Haldimand Clay Plain and extensive Norfolk Sand Plain were deposited (Barnett, 1982). The Haldimand Clay Plain was deposited in the eastern part of the Long Point Region as fine-grained silts and clays settled to the bottom of the deep lake basin. The Norfolk Sand Plain lies across the western and central parts of the Region and forms an extensive surficial feature deposited when the sediment laden Grand River (historic alignment) emptied into the deep glacial lake. The Grand River deposited a deltaic sequence of sands and silts throughout the western portion of the Region at the front of the eastward retreating ice front (Chapman and Putnam, 1984). Norfolk Sand Plain sands are described as fine to medium-grained, ranging in thickness from less than 1 m to roughly 27 m (although this estimate may include deeper, and older sands; Barnett, 1982). Within the Long Point Region watershed area, the Norfolk Sand Plain forms an important aquifer across the area which is used for private groundwater supply.

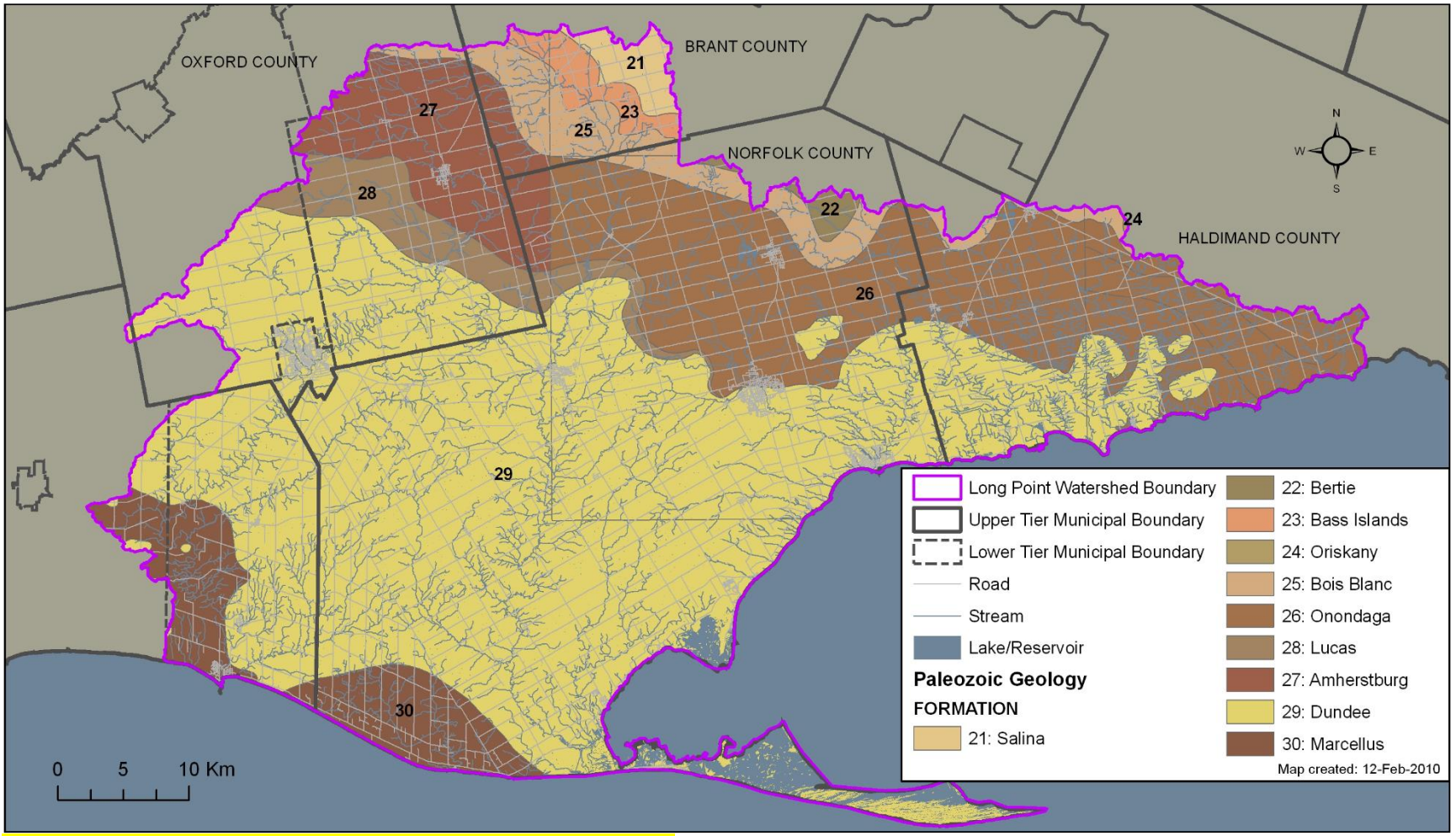
Postglacial and erosional processes during the Holocene continued to shape the landscape within the Long Point Region. The 40 km Long Point sand spit began to form in Lake Erie roughly 7,600 years ago when coarse grained sediments were carried by long shore currents from the west, and this process has continued ever since (Davidson-Arnott and Van Heyningen, 2003). Most sand spits or peninsulas become eroded or separated from the mainland during storms or high-water events (Davidson-Arnott, 1988) and the distance between the Long Point sand spit and the mainland will continue to fluctuate with time as deposition and erosion rates fluctuate with the climate. In the Tillsonburg area of the Long Point Region, portions of the Norfolk Sand Plain have been modified to varying extents throughout the Holocene by the wind as it forms large dunes, some reaching 6 m high (Barnett, 1982). In addition, modern alluvial deposits are scattered throughout the Long Point Region and are associated with Big Creek, Big Otter Creek and the Grand River (Barnett, 1993).

~~2.6.3~~2.5.3 Overburden Thickness

Overburden thickness is an important feature as it provides an indication of the relative protection of buried overburden and bedrock aquifers. Overburden thickness and grain size distribution of those sediments control the infiltration rate of precipitation, as well as the rate of movement of surface contamination into these aquifers.

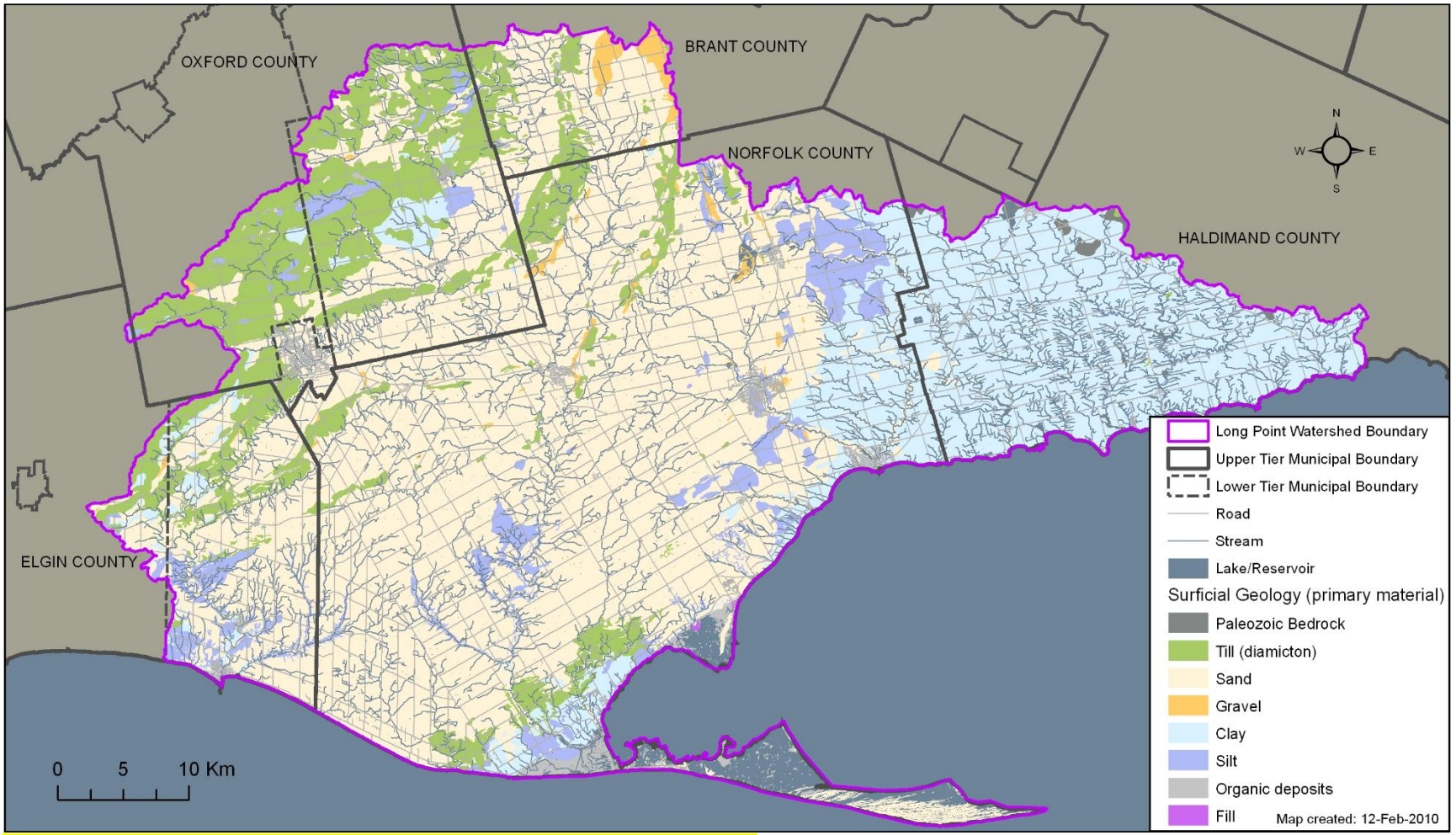
Overburden thickness was derived by subtracting the bedrock topographic surface (see above) from the ground surface digital elevation model (DEM). **Map 2-9** shows the distribution of overburden throughout the watershed and illustrates the presence of moraines and incised river valleys. Overburden thickness ranges from zero along some river valleys and on the Haldimand Clay Plain, to over 115 m in areas where the end moraines overlie thick till deposits. The thickest overburden materials are found in the southern regions of the watershed along the Lake Erie shoreline. In addition, the thicknesses of the Norwich, Tillsonburg, Mabee, Courtland, Paris and Galt Moraines are also readily identifiable on this map.

Map 2-7: Bedrock Geology in the Long Point Region Watershed



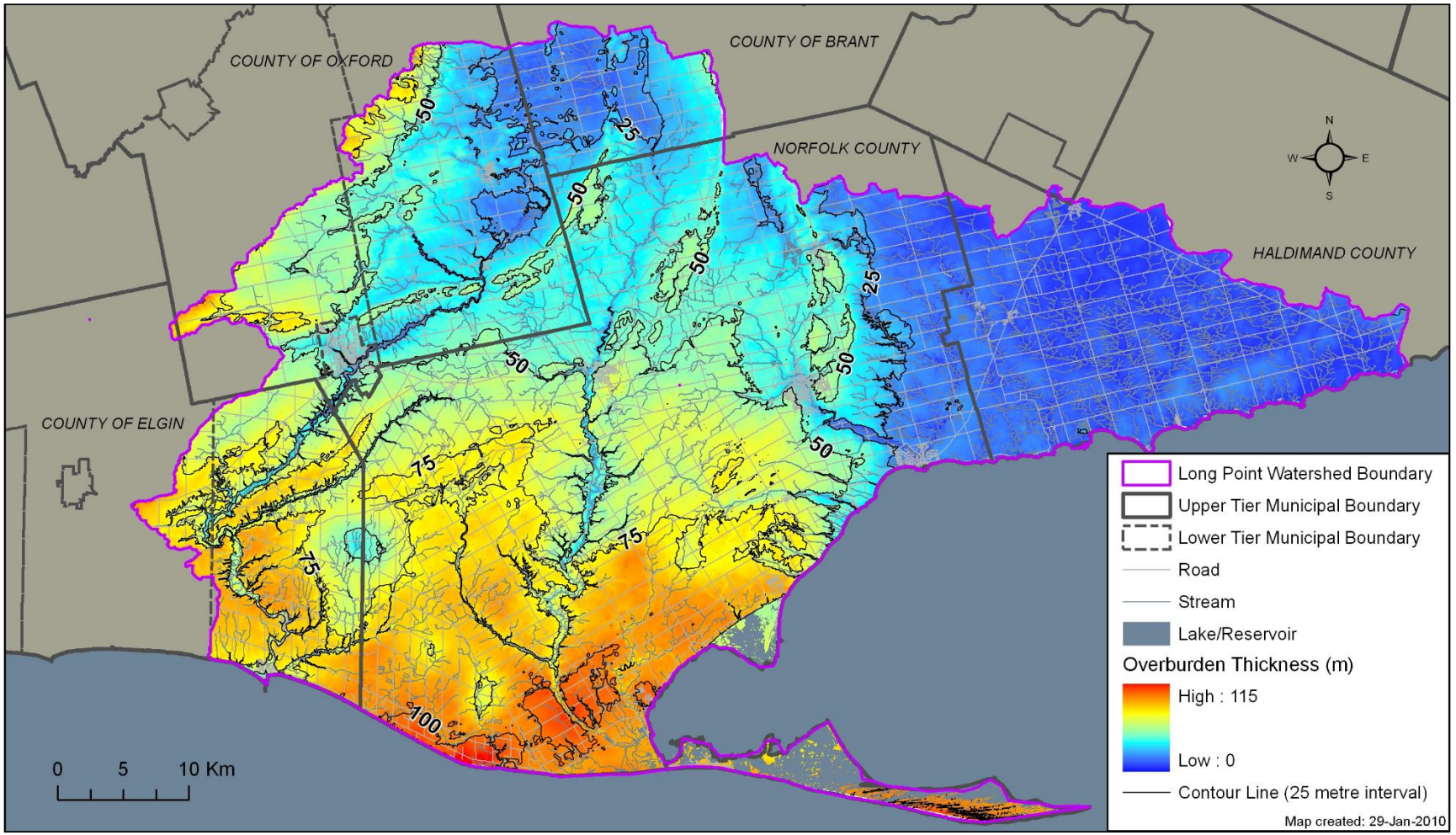
Source: Paleozoic geology from Armstrong and Dodge, 2007.

Map 2-8: Quaternary (Surficial) Geology in the Long Point Region Watershed



Source: Surficial geology data from Ontario Geological Survey, 2003. ~~tbd~~

Map 2-9: Overburden Thickness in the Long Point Region Watershed



Source: Overburden thickness ~~obtained~~ from Waterloo Hydrogeologic Inc., 2003.

~~2.7~~2.6 Groundwater

Groundwater resources within Long Point Region are utilized by much of the population for domestic and municipal water supply, agricultural, and industrial use. Groundwater also supplies baseflow to cold and cool surface water features such as streams, creeks and wetlands, maintaining cool stream temperatures during warm summer months and providing additional flow.

To a large extent, the regional groundwater flow system in Long Point Region is a reflection of the ground surface topography. Groundwater moves from areas of high hydraulic head to areas of low hydraulic head, generally following topographic relief, unless it is impeded by geologic conditions, or local changes in relief such as stream valleys that intersect the water table.

In areas where rivers, streams or wetlands intersect the water table, groundwater discharges into the stream or river and contributes baseflow to the surface water feature. Understanding the movement of groundwater through the subsurface, and through interactions with surface water features requires an understanding of the location and extent of the Region's aquifers (water bearing units) and aquitards (confining units) as well as the location of significant recharge areas.

The most recent characterization and quantification of groundwater resources in Long Point Region has been through the completion of the Long Point Region Tier 3 Water Budget and Local Area Risk Assessment (Matrix, 2015). A full summary of the Tier 3 Water Budget Summary is located in Section 10 of this report.

~~2.7.1~~2.6.1 Regional Hydrostratigraphy

Hydrostratigraphic units are derived from the bedrock and overburden stratigraphic units based on their general hydrogeologic properties. The interpretation of hydrostratigraphic units is based primarily on the glacial history of Long Point Region, as summarized in Section 2.5.2, and high quality corehole data collected as a part of the Tier 3 Water Budget Study.

Units composed primarily of coarse-grained overburden materials (e.g., sands and gravels) or higher transmissivity bedrock units are referred to as aquifers and units composed of lower permeability overburden (e.g., clay or fine-grained tills) or poorly transmissive bedrock units are referred to as aquitards.

Within Long Point Region, a total of 11 overburden and 1 bedrock hydrostratigraphic layers have been identified (Matrix Solutions, 2015) as summarized in **Table 2-4.** While some of the units are regional in extent, many are restricted to certain areas due to the spatial variability of the depositional environments.

Table 2-4: Regional Hydrostratigraphy of Long Point Region

Layer Number	Geologic Unit	Glacial Period	Aquifer/Aquitard
1	Haldimand Clay Plain / Surficial Clay	Holocene	Aquitard
2	Norfolk Sand Plain / Interstadial Sediment	Mackinaw Interstade / Port Huron Stade	Aquifer
3	Wentworth Drift	Mackinaw Interstade / Port Huron Stade	Aquitard
4	Coarse-grained Interstadial Sediment (Sand, Gravel)	Mackinaw Interstade / Port Huron Stade	Aquifer
5	Wentworth Drift	Mackinaw Interstade / Port Huron Stade	Aquitard
6	Coarse-grained Interstadial Sediment (Sand, Gravel)	Mackinaw Interstade / Port Huron Stade	Aquifer
7	Port Stanley Drift	Port Bruce Stade	Aquitard
8	Coarse-grained Interstadial Sediment (Sand, Gravel)	Port Bruce Stade	Aquifer
9	Port Stanley Drift	Port Bruce Stade	Aquitard
10	Coarse-grained Interstadial Sediment (Sand, Gravel)	Erie Interstade	Aquifer
11	Catfish Creek Drift	Nissouri Stade	Aquitard
12	Paleozoic Bedrock		Aquifer/Aquitard

The Norfolk Sand Plain is a thick and spatially extensive unconfined aquifer and is found in the central portion of Long Point Region. An intermediate aquifer is located below the Norfolk Sand Plain, which is confined by the Wentworth or Port Stanley Drift. Further to the east, the Haldimand Clay Plain is found at the surface and is not interpreted to overlie any overburden aquifer units. In this area, the carbonate bedrock aquifers of the Dundee and Onondaga Formations are used for domestic water supply. Bedrock aquifers exist in other parts of the regional area (e.g., Dundee, Lucas, and Amherstburg Formations) however, water quality can be sulphurous (Armstrong and Carter 2010), and these bedrock aquifers may not be used due to the availability of transmissive overburden aquifers at shallower depths.

~~2.8~~2.7 Regional Overburden Aquifers

Overburden aquifers in Long Point Region are abundant and include coarse-grained interstadial outwash and glaciolacustrine deposits. These deposits lie between till layers (Table 2-4**)** which creates a complex aquifer system.

The Norfolk Sand Plain is the most spatially extensive aquifer within Long Point Region. The aquifer is unconfined and lies at the surface across much of the central portion of the Region. The thickness of the sands exceeds 20 m in some areas including Delhi (**Map 2-9**). The unit is primarily fine- to medium-grained sand with some silt and gravel in areas.

An intermediate aquifer is located beneath the upper Norfolk Sand Plain aquifer that is commonly confined by either fine-grained Wentworth or Port Stanley Till. The fine- to medium-grained sand aquifer pinches out in the eastern portions of the Long Point Region, where the Haldimand Clay Plain is mapped at the surface. There are no interpreted overburden aquifers within the eastern portions of Long Point Region beneath the clay plain. Deeper sand aquifers may exist within the Long Point Region however, due to the highly transmissive nature of the shallow and intermediate aquifers, few boreholes penetrate to depth and there is little information regarding the spatial extent of these aquifers, or the associated water quality within them.

~~2.8.1~~2.7.1 Regional Bedrock Aquifers

Bedrock aquifers are seldom used in the western and central portions of Long Point Region where overburden aquifers are thick and transmissive. In the eastern portions of Long Point Region where the Haldimand Clay Plain lies at surface, the uppermost aquifers, consisting of limestone and dolostone units of the Dundee and Onondaga Formations, are used for domestic water supply. The Dundee Formation lies south of Tillsonburg and is a productive aquifer, although water quality is sulphurous (Armstrong and Carter 2010).

~~2.9~~2.8 Regional Groundwater Flow

~~Long Point Region contains both overburden and bedrock aquifers that are used for water supply. Overburden aquifers that lie at depth tend to be localized, while those that lie at or close to ground surface (such as the Norfolk Sand Plain) extend across much of the Region.~~

~~Fractured bedrock aquifers are more regional in scale, however due to the abundance of overburden aquifers within the area, the bedrock aquifers are not often used for municipal water supply.~~ To help visualize the groundwater flow directions across Long Point Region, a map of the shallow (**Map 2-10**) and deeper (**Map 2-11**) water levels was created at a regional scale. Static water levels reported in MECP~~MOECC~~ water well records (for wells with location reliability less than 200 m) and higher quality observation wells were interpolated across the Region to create these maps. The water levels in the MECP~~MOECC~~ water well database correspond to water levels measured and recorded by water well drillers after drilling a well. These static water levels were collected over decades and may represent pre-pumping water level conditions that are not indicative of present~~-~~-day levels, which can be influenced by localized pumping (municipal or otherwise).

Despite the limitations, the data used to create the water level maps (**Map 2-10** and **Map 2-11**) are the best available, and the maps are considered a reasonable representation of regional groundwater flow conditions at the scale applied.

Shallow groundwater is interpreted to flow towards and discharge into the deeply incised surface water features such as Big Creek, which runs through Teeterville and Delhi, Big Otter Creek, which runs through Tillsonburg and the Lynn River that runs

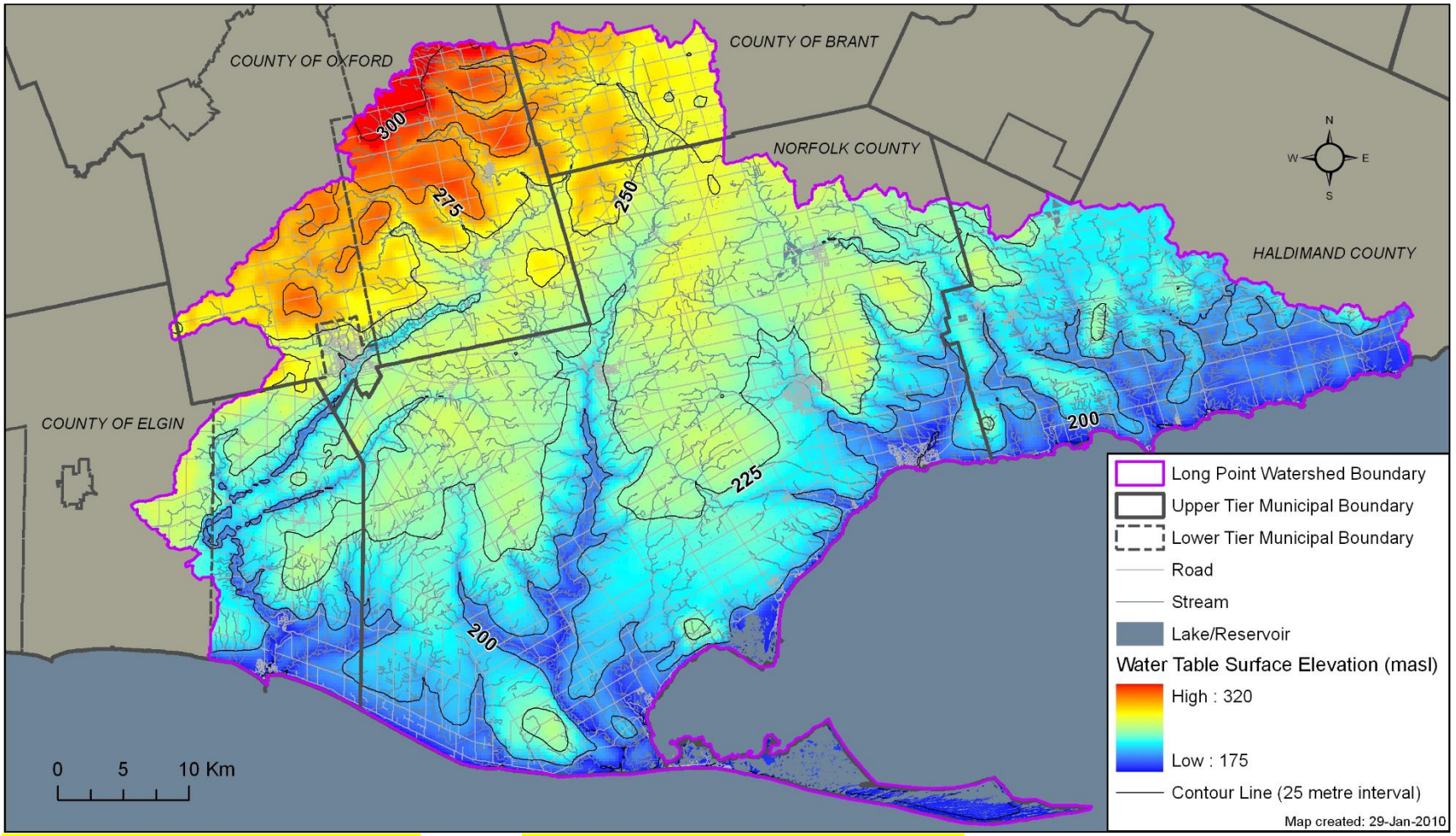
through Simcoe. The deeper water levels show a similar pattern to the shallow water levels with the highest water level elevations occurring in the northwest and the lowest along the deeply incised surface water features and the Lake Erie shoreline.

~~2.10~~2.9 Provincial Groundwater Monitoring

In Long Point Region, long term groundwater conditions are monitored through the Provincial Groundwater Monitoring Network (PGMN), a network of wells distributed throughout the province that provide insight on long-term ambient trends and conditions. The monitors are typically sited to be reflective of broad hydrogeologic conditions, away from areas where pumping or contamination may impact the data collected. The Ministry of the Environment, Conservation and Parks owns the monitoring infrastructure and manages the data gathered through the program, but the program is locally administered by the Long Point Region Conservation Authority.

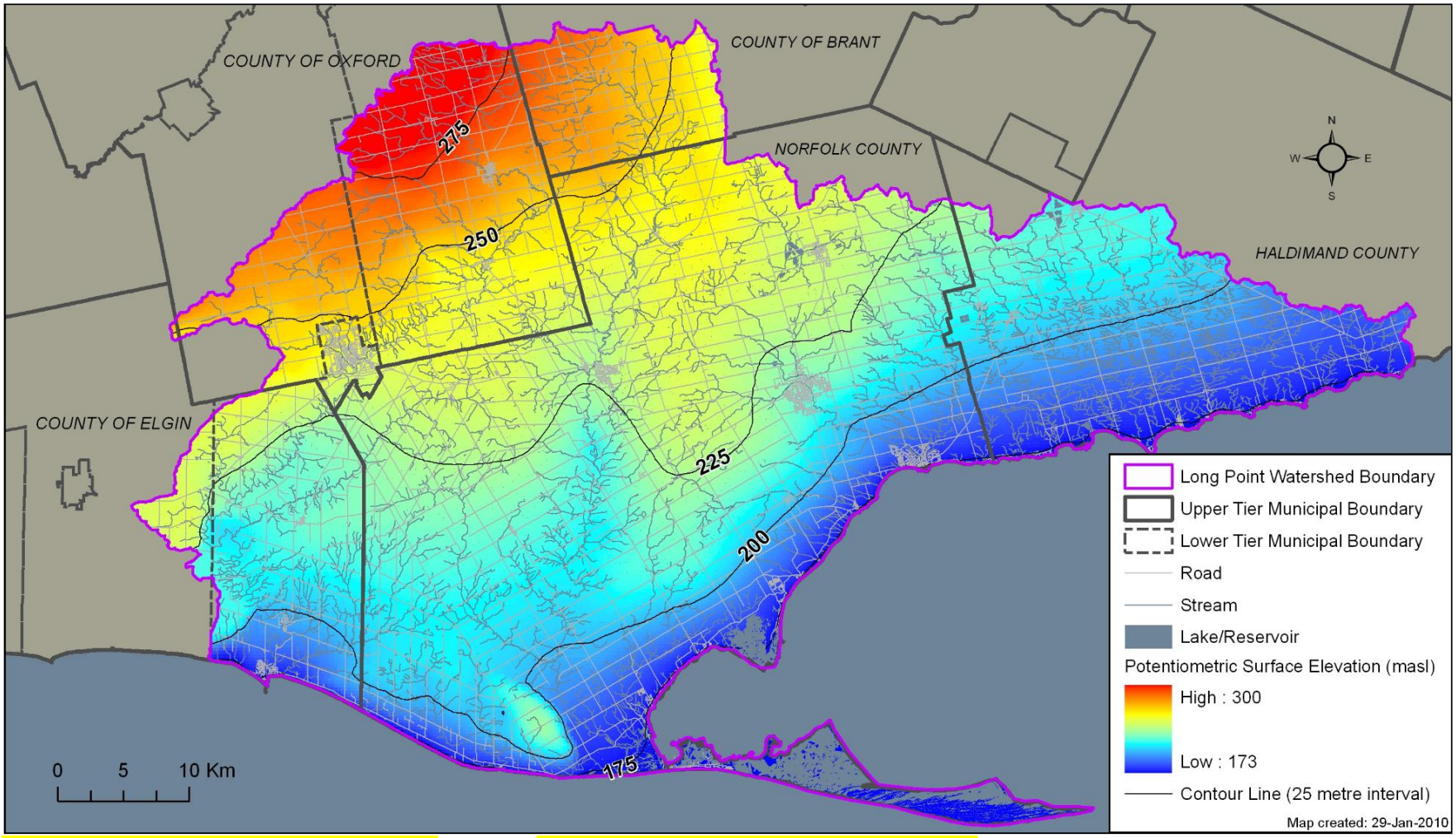
There are currently twelve PGMN wells located at nine sites within Long Point Region **Map** 2-12 The wells are located throughout the central portion of the Region with eleven wells completed in overburden and one well completed in bedrock. Each well is equipped with an electronic datalogger which records hourly water levels and the wells are sampled annually for a suite of general water quality parameters. Data collected from the PGMN wells is considered high quality and often used as calibration points in groundwater models, or as background data for land use applications such as urban development or aggregate pits.

Map 2-10: Water Table Surface in the Long Point Region Watershed



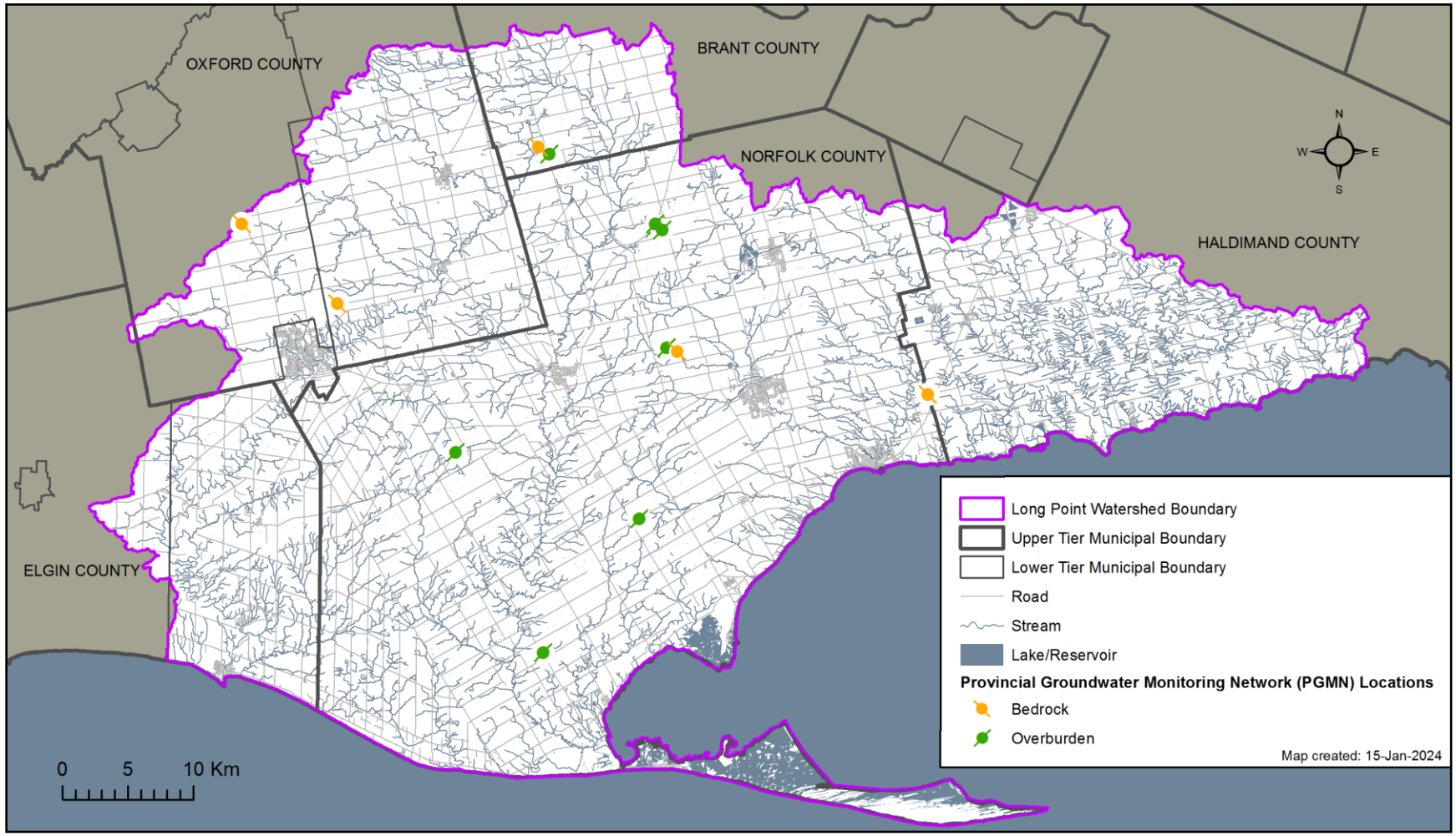
Source: Water table surface elevation ~~obtained~~ from Waterloo Hydrogeologic Inc., 2003.

Map 2-11: Bedrock Potentiometric Surface in the Long Point Region Watershed



Source: Potentiometric surface elevation ~~obtained~~ from Waterloo Hydrogeologic Inc., 2003.

Map 2-12: Provincial Groundwater Monitoring ~~Well~~ Locations in the Long Point Region Watershed



~~2.11~~2.10 Groundwater Quality Across the Watershed

The characterization of groundwater chemistry is an important consideration in hydrogeological studies. As well as being available in sufficient quantities, the geochemical properties of groundwater must be compatible with the intended use (e.g., potable, agricultural, industrial).

The geochemical composition of groundwater is a result of many processes, including interaction with atmospheric gases, reaction with minerals, bacteriological processes, anthropogenic effects, and other subsurface reactions and processes. Although there is a public perception that all instances of undesired compounds in groundwater are a result of anthropogenic contamination, groundwater may be rendered unusable due to entirely natural geochemical processes. For instance, some industrial processes are very sensitive to scaling issues, which may eliminate groundwater high in hardness from use. Groundwater may have attained naturally high concentrations of arsenic or total dissolved solids which would eliminate it from use as a source of potable water. Consequently, there is a need to better understand the ambient quality of groundwater and its controlling processes. This in turn allows for a stronger understanding of the impacts other contaminants may have on groundwater and provides insight into pollution trends and their effects on the aquifer system.

Groundwater geochemistry generally evolves as it moves along its flow path. Typically, groundwater originates as precipitation and is generally low in total dissolved solids, slightly acidic, and somewhat oxidizing (Freeze and Cherry, 1979). Upon infiltration, the recent precipitation tends to increase in acidity and begins to react with the geologic material it encounters. As groundwater continues along its flow path, it may evolve from being dominated by the anion bicarbonate and having relatively low total dissolved solids to sulphate domination and finally domination by the anion chloride and having relatively high total dissolved solids (Freeze and Cherry, 1979). This sequence is commonly referred to as the Chebotarev sequence and can account for the spatial variations in geochemistry that are often observed. The process of geochemical mapping and the recognition of geochemical trends can assist in distinguishing provenance and source identification (i.e. natural versus anthropogenic).

Within Long Point Region, there have been no long-term groundwater quality monitoring programs, but there have been several studies which have characterized groundwater quality through small-scale sampling programs. The following is a description of findings from previous studies within Long Point Region:

A. Blackport & Associates (1997) completed a survey evaluating groundwater quality for the Regional Municipality of Haldimand-Norfolk. The report reviewed and evaluated the water quality and septic system survey data from 10 hamlets, the majority of which were located on the Norfolk Sand Plain. The report discussed the potential for contamination of the shallow groundwater system within the Norfolk Sand Plain where the more permeable sandy aquifer commonly overlays less permeable silt and clay. Flow in the shallow system is predominantly horizontal, and the direction is locally controlled by streams and topography. Blackport & Associates

(1997) concluded that the hamlets situated on the more permeable, shallow hydrogeologic systems were more susceptible to degraded groundwater quality (i.e. bacteria, NO_3^{2-}, Cl^-) from septic system effluent and the application of fertilizer and road salt.

B. As a part of the County of Oxford Phase II Groundwater Protection Study (Golder, 2001), a groundwater quality survey for untreated drinking water was carried out at selected domestic residences within the County. The study focused on sampling wells that were completed in both the shallow overburden aquifer and bedrock aquifer for organic, inorganic and microbiological parameters. The results of the survey concluded that the quality of the raw water within the County was generally good. However, high concentrations of chloride and nitrate in the shallow aquifer reflected a higher susceptibility of that aquifer to surficial sources of contamination such as fertilizer and road salt. The bedrock aquifer was found to contain elevated concentrations of total dissolved solids and SO_4^{2-} and higher levels of specific conductivity. However, these were considered to be natural characteristics of the aquifer.

More recently, in collaboration with the Ontario Geological Survey, Environment Canada and the Grand River Conservation Authority, a small-scale groundwater quality study was completed across the Long Point Region (Banks et. al., 2007). As a component of this study, a total of 91 groundwater samples were collected from private residences from the three aquifers across the Region and analyzed for a suite of major/minor ions, metals and general physical properties. The geochemical data was used to understand the chemical processes occurring in the Region and its relation to groundwater quality.

Generally, the groundwater quality found within Long Point Region was found to vary significantly between the 3 different aquifers. These variations were the results of the geologic setting (overburden versus bedrock) and from surficially-derived chemicals entering the groundwater system. The variation between aquifers suggested different provenance (anthropogenic versus natural) for these parameters.

Comparisons with Ontario Drinking Water Quality Standards (MOE, 2006) show that the bedrock aquifer ~~to~~ supplies~~y~~ the 'poorest' relative quality and most mineralized groundwater. The nature of this water however, generally appeared to be related to the ambient geochemistry of the groundwater system rather than anthropogenic activity. Where anthropogenic impacts were apparent within the bedrock aquifer, it was likely a result of poorly constructed or improperly maintained wells and less so through recharge entering the groundwater system. The water quality issues within the shallow overburden aquifer also showed poorer quality in accordance with the Ontario Drinking Water Standards, but the degraded quality is likely the result of fertilizer, road salt, manure, septic systems etc. that have entered the aquifer system. Notably higher NO_3^{2-} and associated elevated K^+ concentrations in the overburden aquifers suggests the downward migration of fertilizers into the aquifer systems. The deep overburden aquifer displayed the best relative groundwater quality because it was afforded a certain degree of protection from surficial activities by the overlying confining sediments and has not been affected by the same geologic processes as the bedrock-derived groundwater.

~~2.12~~2.11 Climate

The Long Point Region has low latitude and elevation compared to many other parts of southern Ontario, being situated on the northern shore of Lake Erie. The Long Point region has a moderate temperate climate, denoted by evenly distributed precipitation throughout the year and temperatures ranging from warm to hot and humid in the summer to below freezing in winter. Winters are mild compared to the rest of Ontario due to its southerly location, as the proximity to Lake Erie creates a moderating effect. With Lake Erie to the south, winds coming across the lake are often warmer in winter and cooler in summer than the land, thereby moderating air temperatures over the watershed.

This region's climate consists of four seasons, including winters that see some precipitation in the form of snow, and summers that are hot and humid. **Figure 2-1** shows the daily average temperatures for each month of the year, from the Delhi CDA (Canada Department of Agriculture) station and Delhi CS (Climate Station), located centrally in the watershed. Winter is generally considered to have temperatures lower than 0°C, beginning in December and lasting until late February or early March. Spring usually lasts two months, followed by four months (June to September) of summer and two months of autumn. The average annual temperature is about 8.0°C.

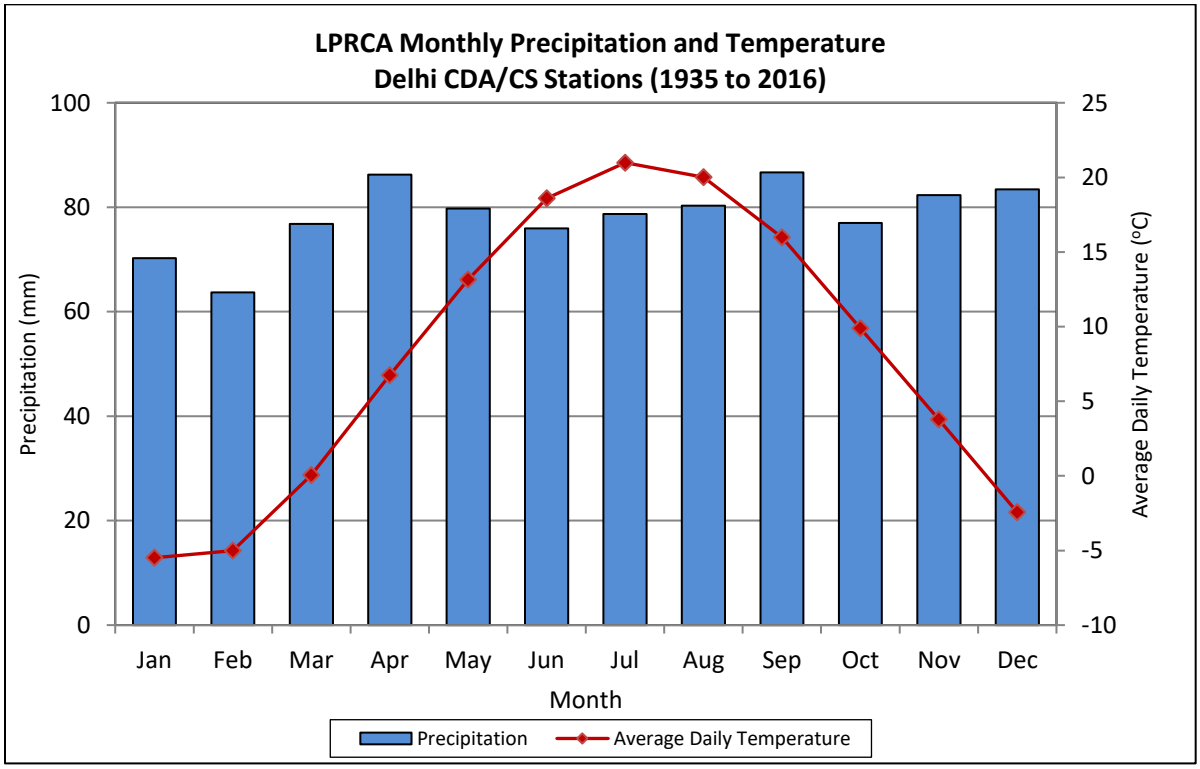


Figure 2-1: Long Point Region Watershed Area Average Monthly Precipitation and Temperature, 1935 to 2016

Precipitation is fairly evenly distributed throughout the year, although the intensity, duration and frequency of precipitation are quite different among the seasons. The accumulation of snow in the winter months prolongs the effects of precipitation, as infiltration is delayed until a thaw. Spring thaw is often accompanied by long, low intensity rainfall; this coupled with the melting snow can make the spring season appear to be constantly wet and overcast. The summer often brings rainfall events that are of high intensity and short duration. The duration of these events, coupled with the high evapotranspiration rates between events, leaves an impression of less rain than in other seasons in terms of frequency of rain-created runoff and recharge. Annual average precipitation in the watershed from 1935 to 2016 is 940 mm.

There is a large annual variation in precipitation (**Figure 2-2**) which can have a large effect on stream flow and water demand in the watershed. The departure from annual precipitation was calculated using the average annual precipitation (1935 to 2016) from the Delhi CDA/CS of 940 mm.

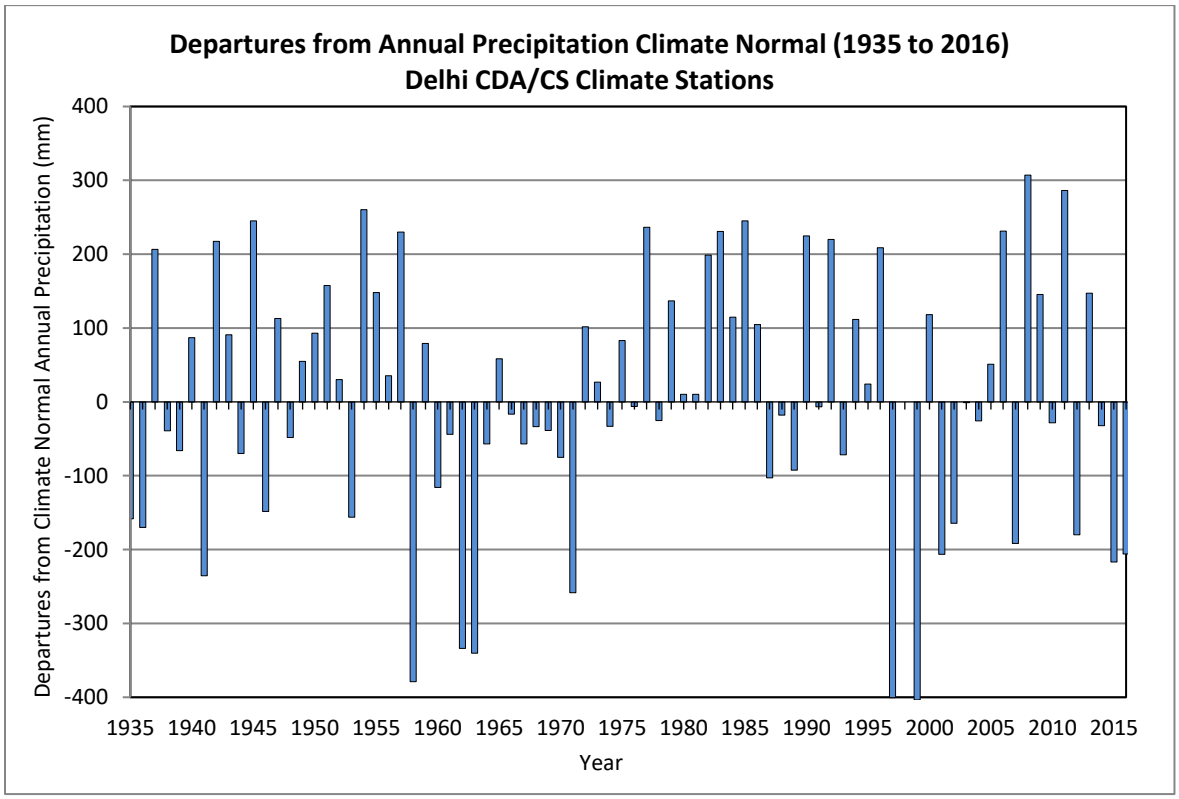


Figure 2-2: Departures from Annual Precipitation (Climate Normal)

~~2.13~~2.12 Land Cover and Land Use

Land uses in the Long Point Region watershed area are characterized by a few small urban commercial, industrial and residential centres, surrounded by less-populated rural land used for intensive agricultural production. **Map 2-13** shows the distribution of land

cover across the watershed. The map illustrates the dominance of agricultural land uses in rural areas of the watershed; however, it does not specifically identify the significant proportion of resort residential development along the lakeshore. According to the 2001 census, about 78% ~~percent~~ of the total land area of the watershed is actively farmed. ~~In some parts of the watershed, the proportion of farmland is even higher, especially in the Norfolk Sand Plain where soils are well drained and the land is relatively flat.~~

~~2.13.1~~2.12.1 Forest and Vegetation Cover

The amount of forest cover in the Long Point Region declined from over 70% ~~per cent~~ in the 1850s to less than 15% ~~per cent~~ by the 1960s. In the mid-1800s some of the crop land had started to become less productive due to erosion and loss of nutrients. The loss of useful crop land due to wind and water erosion prompted the establishment of the first Provincial Forestry Station at St. Williams in 1908. Reforestation and other forms of regeneration have regained some of the forest losses and cover as of 2006 is estimated at about 21% ~~percent~~, as shown in **Table 2-5** and **Map 2-14**, with areas in the Clay Plain generally having less forest cover than those in the Sand Plain.

The Long Point Region watersheds fall within the Deciduous Forest Region of Canada. Forests within this region are typically dominated by maple, beech, ash and oak species. However, there are significant forest pockets which are representative of the broader Carolinian Life Zone that include species such as Tulip tree, Black Gum, Sassafras, Black Oak, and Cucumber Tree. These tree species are rare in Canada and occur naturally only in southern parts of Ontario north of Lake Erie.

The Long Point Region Conservation Authority has a rich history of forest management dating back to 1948 and is one of the most significant forest landowners in the watershed, along with the Province of Ontario and Norfolk County. Through a private land reforestation program, the Long Point Region Conservation Authority adds close to 20~~45~~ hectares of future forests to the land cover annually. The Authority continues to recognize the acquisition and wise management of forest lands for integrated uses as an important part of its mandate, including for source water protection. It is now widely accepted that an integrated ecosystem-based approach to forest management is required to maintain the ecological integrity and productive capacity of the forests while providing multiple benefits to society (Heilman, 1990; Kimmins, 1992).

Table 2-5: Land Cover in the Long Point Watershed Area[1] ~~as of 2006~~

	Area (hectares)	% of Total Watershed Area
Forest and Vegetation Cover	70532.81~~60673.2~~	24.4~~21.0~~%
Wetlands	20148.69~~25540.7~~	7.0~~8.8~~%
Total	90681.5~~86213.9~~	31.3~~29.8~~%

[1] Data sourced from the 2023 Long Point Region Conservation Authority Watershed Report Card

~~2.13.2~~2.12.2 Wetlands

Wetlands are a significant feature of the Long Point Region. Although a large percentage of the original wetlands have been lost through clearing, filling and drainage, there are still almost 260 square kilometres of evaluated wetlands in the Long Point Region watersheds (**Table 2-5**~~Table 26~~ and **Map 2-14**). The Long Point wetland complex, which includes the wetlands at the mouth of Big Creek, covers 75 square kilometres on its own. This wetland is internationally recognized under the Ramsar Convention and as the Long Point Biosphere Reserve.

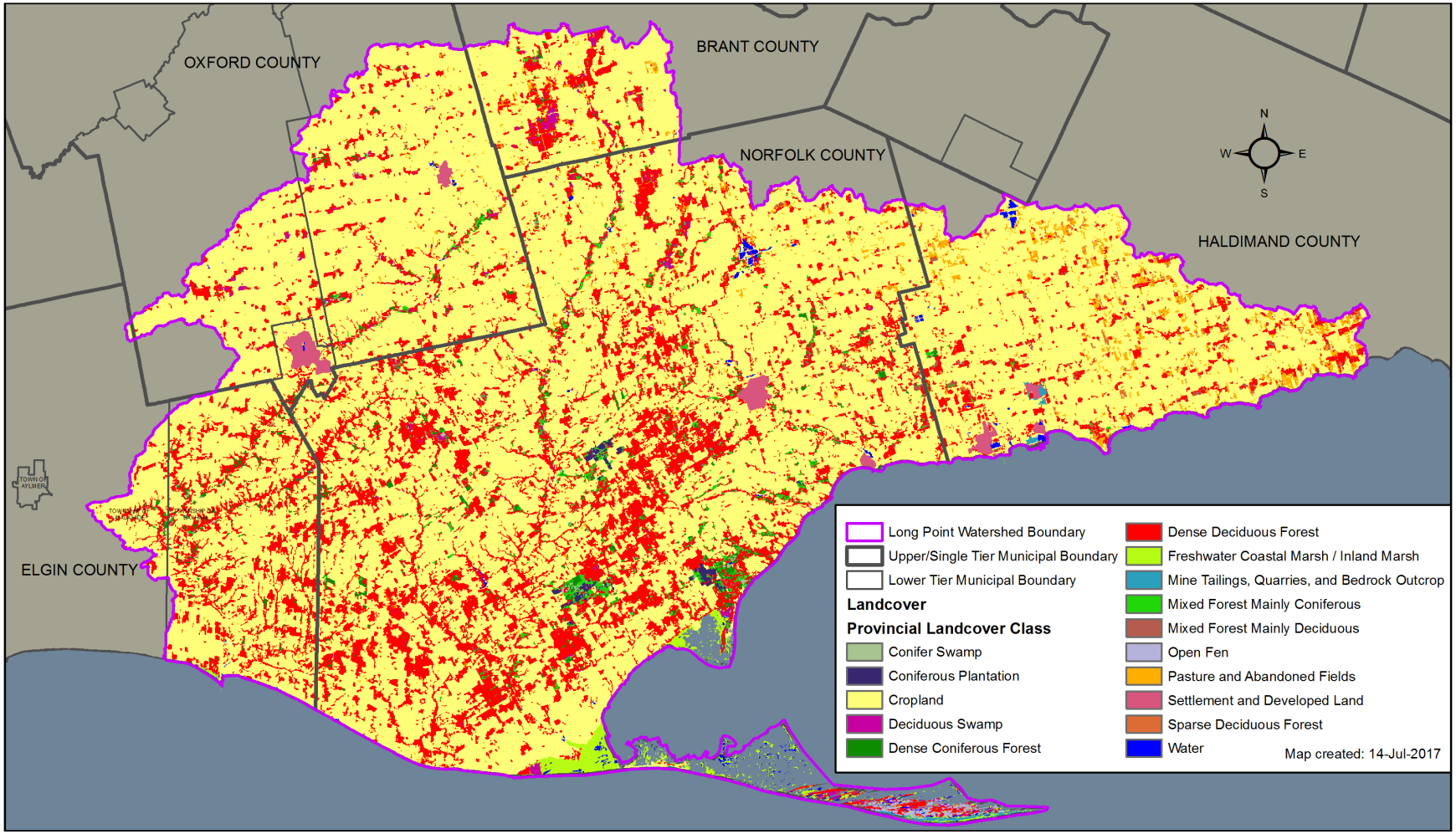
Wetlands play an important role in many of the watersheds' hydrological and ecological processes. The hydrologic function of wetlands vary, with some wetlands being groundwater discharge areas that provide baseflow during low flow periods, while other wetlands provide recharge to the underlying aquifer system during dry periods of the year. Wetlands are also critical as they retain surface runoff and reduce downstream flood flows. They also act as water filters and capture sediment, dissolved nutrients and other contaminants, improving the surface water quality. Wetlands are also typically highly productive ecological habitats, with great biodiversity, and often home to a large number of species.

~~2.13.3~~2.12.3 Wetland and Forest Riparian Areas

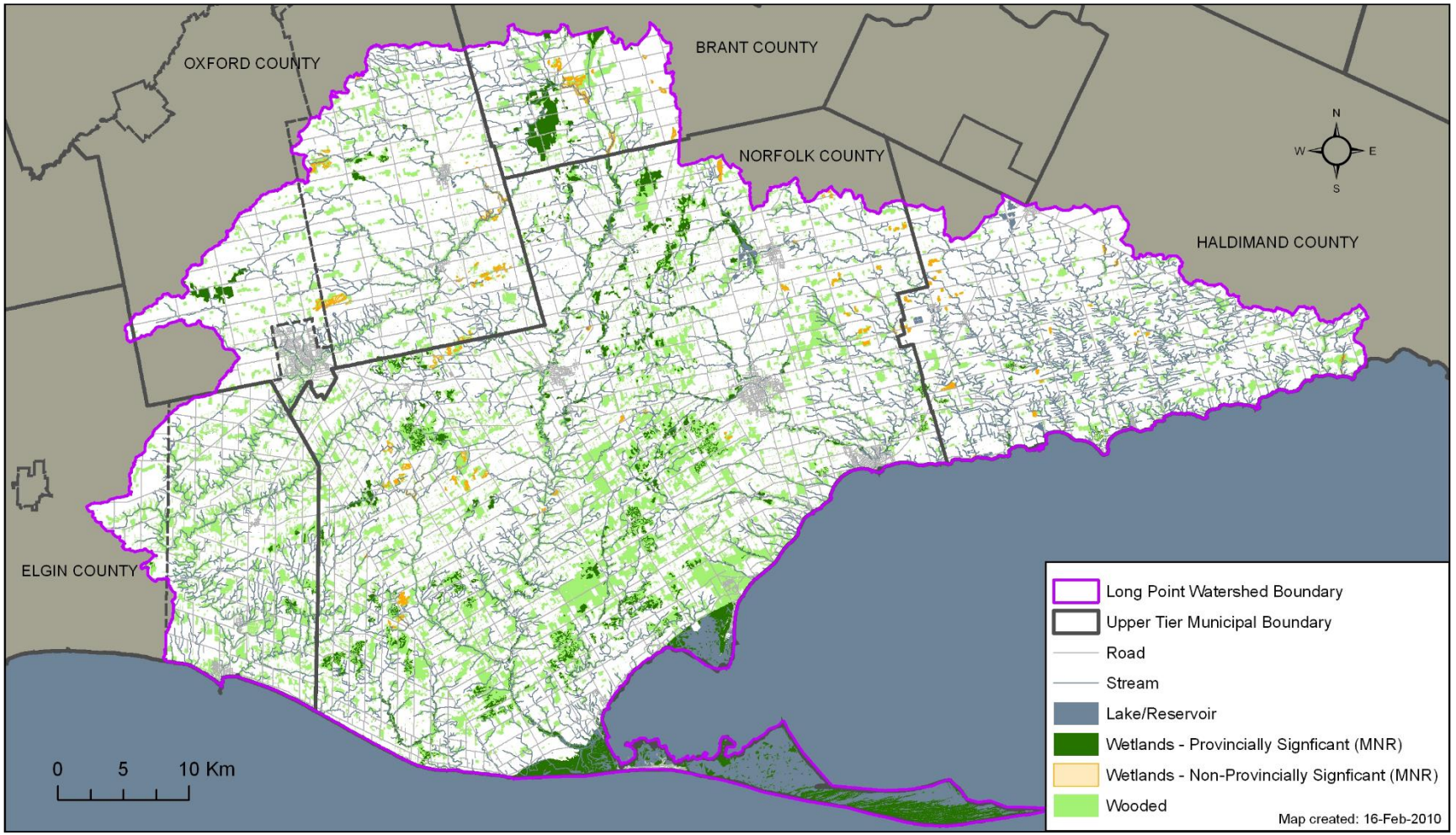
All wetlands and forest cover help protect and enhance water quantity and quality values of the watershed. Depending on the issues impacting the water resources, the forest and wetland cover that acts as an immediate buffer to the surface streamflow can be even more valuable.

Within the Long Point Region watersheds, the amount of riparian forest and wetland along the watercourses are estimated at 40 percent, (based on a 15~~-~~metre buffer on each side of the stream). In addition, many of these watercourses have been provided with a grassed buffer by landowners using best management practices.

Map 2-13: Land Cover in the Long Point Region Watershed



Map 2-14: Vegetation in the Long Point Region Watershed



~~2.14~~2.13 Surface Water

~~2.14.1~~2.13.1 Surface Water Characterization

The Long Point Region is comprised of numerous watersheds and watercourses. The combined length of all the streams and their tributaries within the Long Point Region is over 3,700 kilometres. Most of the western watersheds are found largely within the Norfolk Sand Plain; an area characterized by low runoff, high soil infiltration and sustained baseflows. The upper and western parts of Big Otter Creek are located in the till plain. The eastern watersheds drain through the Haldimand Clay Plain, an area characterized by high runoff and low soil infiltration. The eastern watersheds have a higher density of tributaries than the western watersheds with the river systems being shallower and with a tendency to dry up during the summer months.

The Long Point Region has among the highest number of permitted surface and ground water users of any area in Southern Ontario (LPRCA, 2008). Demand for irrigation water during the summer months can affect stream flow throughout the region~~,~~ but is focused in the western watersheds on the Norfolk Sand Plain.

~~2.14.2~~2.13.2 Surface Water Monitoring

Streamflow monitoring within the Long Point Region watershed area is predominantly carried out by the Water Survey of Canada (WSC). Rating curves and gauge infrastructure are frequently maintained, with observed data undergoing extensive quality assurance and quality controls. As such, streamflow data from WSC stations is considered to be the highest quality streamflow data available.

The flow monitoring network in the Long Point Region has been expanded in recent years with the re-opening of a number of historic gauges. There are 10 active WSC gauges in the Long Point Region. The gauge network is denser in the western part of the region and is focused on the larger watercourses. There are three active gauges in the Big Otter Creek Watershed that cover most of the watershed area. Stream flow data is available beginning in 1948 with the longest continuous data set from 1960 to present. There are 4 active stream gauges in the Big Creek Watershed with 2 gauges in continuous operation since 1955 and 2 recently re-opened gauges.

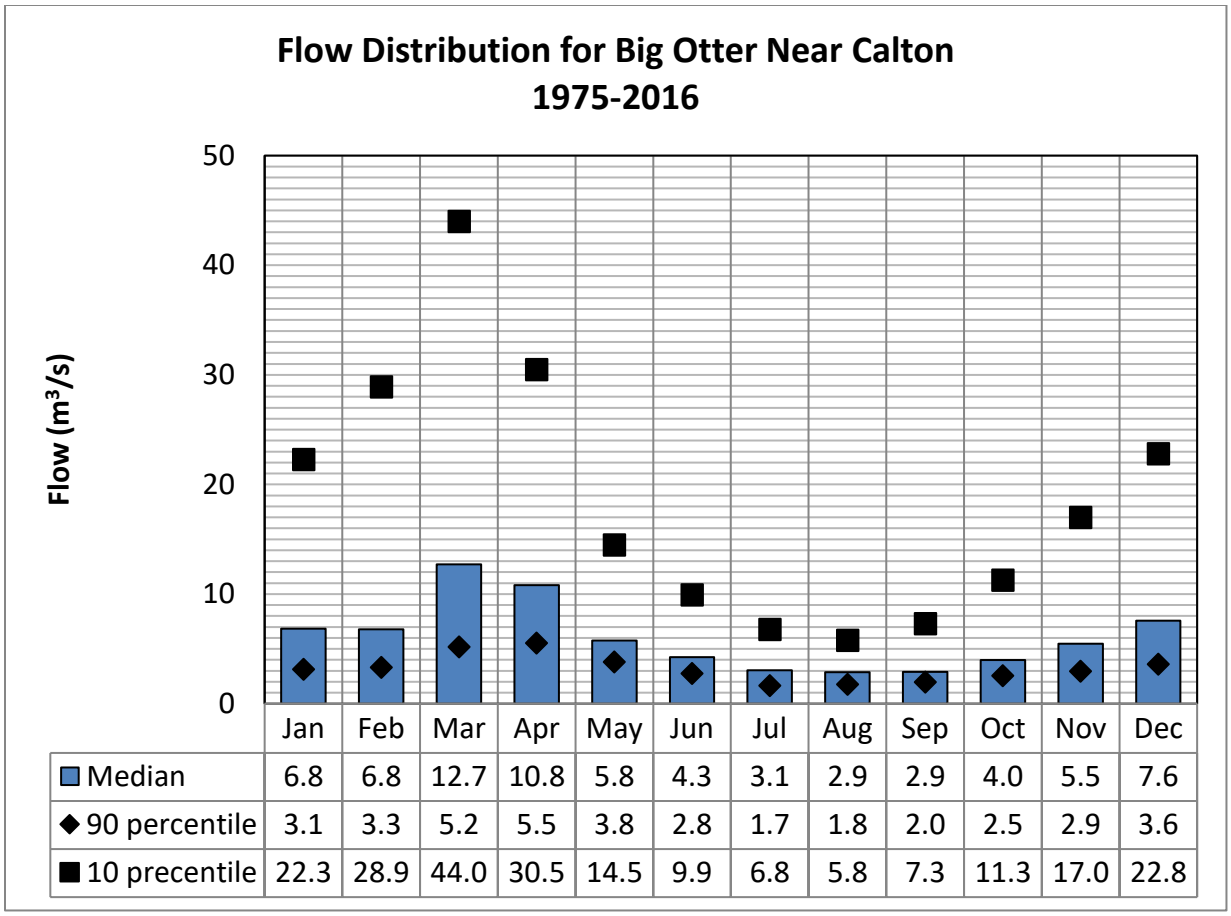
The other 3 stream gauges are on Young Creek, Nanticoke Creek and the Lynn River. The gauge on Young Creek has been operated for various periods since 1963. The Lynn River gauge has a continuous data set beginning in 1957. The Nanticoke Creek gauge is the only gauge in the eastern part of the region and has been in operation since 1969. There is also flow data available from abandoned stations for Hemlock Creek, Little Otter Creek, South Otter Creek, North Creek, Dedrick Creek, Fishers Creek, and Patterson Creek in the western part of the Region, and Sandusk Creek in the eastern part of the Region.

~~2.14.3~~2.13.3 Big Otter Creek

Big Otter Creek is the second largest watershed in the region, draining an area of approximately ~~712~~ 738 km^2. The upper part of the watershed in the northwestern corner of the region lies in the till plain. The creek flows southward in the Norfolk Sand Plain through the communities of Norwich, Otterville, and Tillsonburg before draining to Lake Erie at Port Burwell. The Big Otter Watershed is characterized by moderate runoff, soil infiltration, and baseflows. Spittler Creek joins the Big Otter just south of Otterville and ~~drains about 116 km^2.~~ t~~T~~he largest tributary, Little Otter Creek, joins ~~Big Otter Creek~~ past Straffordville. Little Otter is classified as a ~~water~~cold-water stream ~~and drains approximately 118 km^2.~~.

There are three active Water Survey Canada gauges in the Big Otter Creek Watershed. The first one is located in the upper part of the watershed above Otterville, and it was installed in 1964. The second gauge is located at the Town of Tillsonburg. This gauge is the oldest active gauge in the Big Otter Creek watershed and has been in operation since 1960, except for a brief period from 1998-2002 when the rating curve was not maintained; however, water levels were continuously recorded during this time. The third gauge is located near the community of Calton, and it has been in operation since 1975 and captures approximately 95% of the drainage area including Little Otter Creek. Prior to 1975 the gauge was located downstream near the community of Vienna where it had been in operation since 1948. The flow distribution at the Calton gauge is illustrated in **Figure 2-3**. A stream gauge operated on the Little Otter between 1963 and 1992.

The distribution in **Figure 2-3** shows both a runoff component with high 10th percentile flows in the spring and a strong groundwater fed baseflow component with steady median and 90th percentile low flows throughout the summer months.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Median	6.8	6.8	12.7	10.8	5.8	4.3	3.1	2.9	2.9	4.0	5.5	7.6
◆ 90 percentile	3.1	3.3	5.2	5.5	3.8	2.8	1.7	1.8	2.0	2.5	2.9	3.6
■ 10 precentile	22.3	28.9	44.0	30.5	14.5	9.9	6.8	5.8	7.3	11.3	17.0	22.8

Figure 2-3: Flow Distribution for Big Otter Creek near Calton Gauge

There are two reservoirs on Big Otter Creek; the Norwich Dam in Norwich, and the Otterville Dam in Otterville. The Norwich Dam is operated by the LPRCA, and its functions include supporting recreational activities, water supply, flood control and flow augmentation; the flow through the dam can be augmented ~~is controlled~~ by a control valve. The Otterville Dam is passively operated by the municipality. Other major control structures in the watershed include Black Bridge and Lake Lisgar. There are also numerous small, private control structures within the watershed that are used to store water for irrigation in the summer months. In 2024, a~~A~~bout ~~269~~ 203 Permit to Take Water (PTTW) takings ~~presently~~ existed in this~~e~~ watershed.

~~2.14.4~~2.13.4 South Otter and Clear Creeks

South Otter Creek drains an area ~~of approximately 111 km^2~~ adjacent to the lower portion of Big Otter Creek along the Lake Erie shoreline;~~.~~ Clear Creek ~~is similar in size and~~ drains an area ~~of approximately 106 km^2~~ ~~to the~~ east of this ~~South Otter Creek~~. Both creeks are within the Norfolk Sand Plain and are characterized by low runoff, high infiltration, and groundwater fed baseflows. They have a combined drainage area of approximately 237 km^2. There are no active gauges in this watershed grouping, but there was a historic gauge located on South Otter Creek near its outlet to Lake Erie at

Port Burwell that operated from 1964 to 1978. In 2024, a~~A~~bout ~~146~~95 Permit to Take Water (PTTW) takings existed in these~~each~~ watersheds.

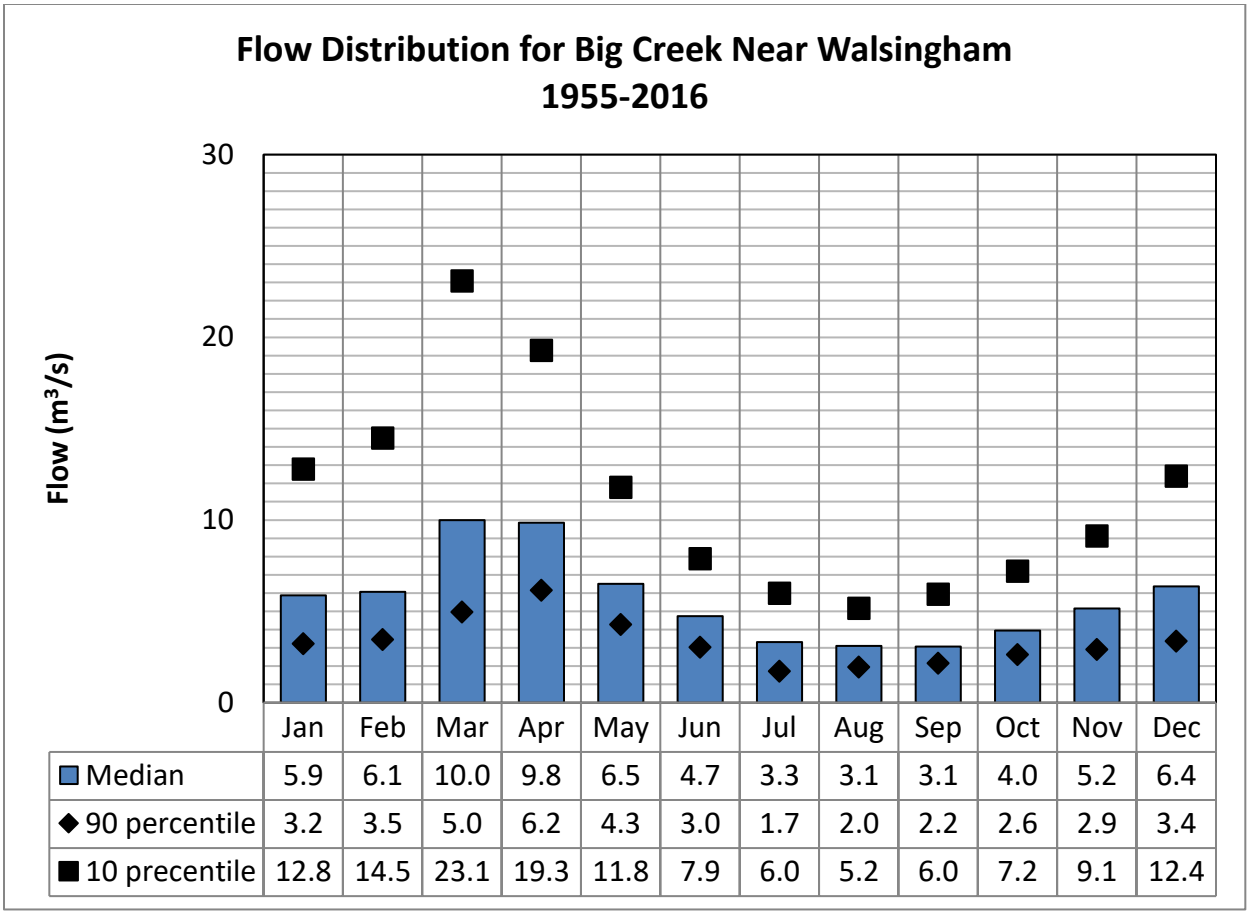
~~2.14.5~~2.13.5 Big Creek

Big Creek is the largest watercourse in the Long Point Region with a total drainage area of 722~~50~~ km^2. Big Creek's headwaters are at the most northerly part of the Long Point Region. The creek flows predominately southward, passing through the community of Delhi, where it is joined by North Creek via Lehman's Reservoir. From Delhi, stream flow continues southward, merging with Venison Creek (the largest tributary ~~draining 98 km^2~~) downstream of Walsingham and finally draining into Lake Erie near Port Rowan.

The Big Creek watershed is predominately in the Norfolk Sand Plain and is characterized by very low runoff and high baseflow. Water use within the drainage area is significant with about ~~741~~ 510 Permit to Take Water (PTTW) takings in 2024. Irrigation is the primary water use within the watershed and water takings have the potential to reduce summer flows in the creek during dry years.

There are three reservoirs in the Big Creek Watershed; Teeterville, Lehman and Deer Creek Reservoirs. All three reservoirs are operated by the Long Point Region Conservation Authority. The Teeterville Reservoir is located in the upper portion of the watershed on Big Creek, and it is used primarily for recreation~~, flood control, and low flow augmentation~~. Lehman's Reservoir is located in the community of Delhi on North Creek, and it is used for flow control/augmentation and recreational shore fishing downstream of the flow control structure. The reservoir was also used to supplement the community of Delhi's drinking water supply until it was decommissioned in January 2021. The final reservoir is located on Deer Creek, a tributary of Big Creek. Most of the Big Creek tributaries have small private dams and reservoirs used for irrigation.

There are four active Water Survey Canada gauges in the Big Creek Watershed. The first one is located in the upper part of the watershed near Kelvin, which has operated periodically since 1963. The second gauge is located near Delhi and has been in continuous operation since 1955. A gauge on Venison Creek near Walsingham has operated periodically since 1966. A gauge further downstream on Big Creek near Walsingham captures about 75% of the entire drainage area and has also been in operation since 1955. The flow distribution plot for the Big Creek at Walsingham gauge is included in **Figure 2-4**. The narrow range of median, 10th and 90th percentile flows in **Figure 2-4** shows the moderating effects of large annual recharge amounts, significant groundwater storage volumes, and reservoir operations upstream of the gauge. There is a very high baseflow component throughout the year with fairly steady median and 90th percentile flows. A stream gauge existed on North Creek between 1954 and 1966.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Median	5.9	6.1	10.0	9.8	6.5	4.7	3.3	3.1	3.1	4.0	5.2	6.4
◆ 90 percentile	3.2	3.5	5.0	6.2	4.3	3.0	1.7	2.0	2.2	2.6	2.9	3.4
■ 10 precentile	12.8	14.5	23.1	19.3	11.8	7.9	6.0	5.2	6.0	7.2	9.1	12.4

Figure 2-4: Flow Distribution for Big Creek near Walsingham Gauge

~~2.14.6~~2.13.6 Dedrick-Young Creeks

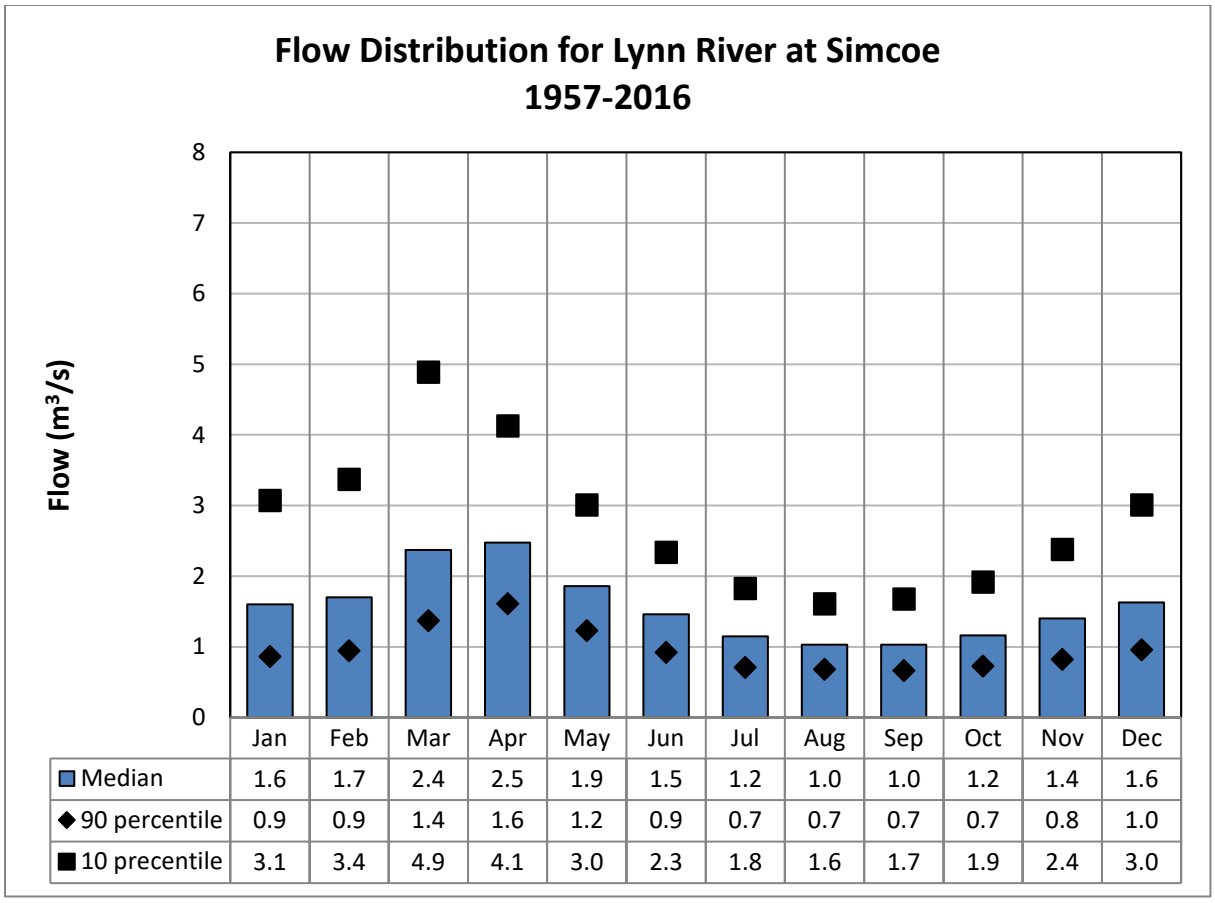
The Dedrick-Young Creek watershed group drains a combined area of ~~263~~ 256 square kilometres. The main watercourses in this watershed group are Dedrick, Forestville, Young, and Hay creeks, but this area also includes numerous other small Lake Erie tributaries. These watersheds are mainly located within the Norfolk Sand Plain. With groundwater fed creeks and streams the area contains several significant cold-water fisheries. There are two reservoirs, both used for recreation, the Hay Creek Dam on Hay Creek and Vittoria Pond on Young Creek. The Long Point Region Conservation Authority operates both reservoirs. There is one reactivated stream gauge on Young Creek downstream of the Vittoria Pond Reservoir which has been in operation for various periods since 1963. There was also a stream gauge on Dedrick Creek near its outlet to Lake Erie at Port Rowan. This gauge was in operation from 1963 to 1984. Fishers Creek also had a stream gauge in operation during a period of 8 years beginning in 1969. In 2024, t~~T~~here we~~a~~re ~~currently~~ about ~~171~~ 104 active permitted (PTTW) takings in these watersheds.

~~2.14.7~~2.13.7 Lynn River-Black Creek

The Lynn River flows from north of the community of Simcoe to the southeast to Lake Erie at Port Dover. It is joined by Black Creek in Port Dover just prior to draining into Lake Erie. The combined drainage area of this watershed group is approximately ~~285~~ 300 km^2.

The watershed drains two different physiographic regions. The Lynn River, a cool water fishery, is largely located in the Norfolk Sand Plain, where there is low surface runoff, high recharge amounts, and sustained baseflows. Black Creek drains through the Haldimand Clay Plain, and this part of the watershed is characterized by high runoff, low baseflows, and predominantly warmwater fish communities. In 2024, t~~T~~here we~~a~~re about 163~~203 current~~ permitted (PTTW) takings in this watershed, with most of these concentrated in the western area on the Sand Plain.

There is one active stream gauge on the Lynn River located in the Village of Simcoe. It has been in continuous operation since 1957, with the flow regime for this gauge illustrated in **Figure 2-5**. The narrow monthly flow distribution and high baseflows show the moderating influence of the Norfolk Sand Plain and the relatively small drainage area upstream of the gauge. There are also two controlled reservoirs on the Lynn River, Crystal Lake (Quance Dam) in Simcoe and Silver Lake (Misner Dam) in Port Dover, both of which are operated by Norfolk County. A stream gauge operated on Patterson Creek for a period of 29 years beginning in 1963. There are no stream gauges on Black Creek.

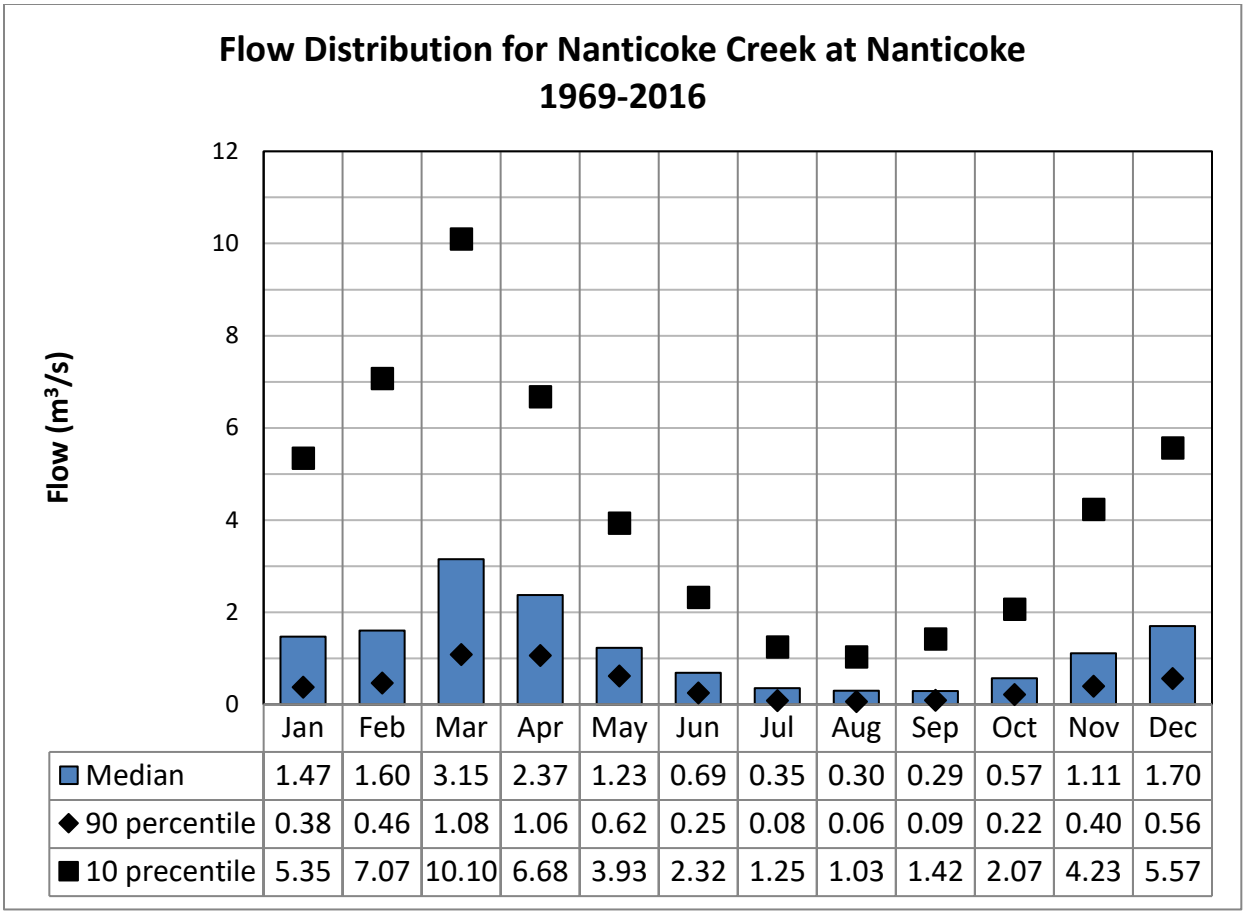


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Median	1.6	1.7	2.4	2.5	1.9	1.5	1.2	1.0	1.0	1.2	1.4	1.6
◆ 90 percentile	0.9	0.9	1.4	1.6	1.2	0.9	0.7	0.7	0.7	0.7	0.8	1.0
■ 10 precentile	3.1	3.4	4.9	4.1	3.0	2.3	1.8	1.6	1.7	1.9	2.4	3.0

Figure 2-5: Flow Distribution for Lynn River at Simcoe Gauge

~~2.14.8~~2.13.8 Nanticoke Creek

The headwaters of Nanticoke Creek contain cool water fisheries, as these headwaters sit within the Norfolk Sand Plain where groundwater discharge is strong. The Creek migrates through the Waterford Ponds, a series of lakes, ponds, and wetlands near the community of Waterford and then heads southeastward onto the Haldimand Clay Plan where it changes to a warm water fishery on its way to discharging in Lake Erie at Nanticoke. There is one stream gauge near Nanticoke which captures most of the watershed. The gauge has been in operation since 1969, and its flow distribution is given in **Figure 2-6**. Low flows, shown by the 90th percentile flow, are very low throughout the year. Median flows are also low during the summer months. The wide monthly distribution shows a large runoff component to the flow regime, as is expected due to the influence of the Haldimand Clay Plain. The area of the watershed is approximately 216 km^2 and includes some smaller watercourses to the east and west that drain directly into Lake Erie, including Faurie's, Stelco and Hickory Creeks. In this area, t~~T~~here we~~a~~re about ~~146~~ 93 permitted takings (PTTW) in 2024 ~~in this watershed~~, almost all in the northwestern portion of the Nanticoke watershed, in the Sand Plain.~~.~~



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Median	1.47	1.60	3.15	2.37	1.23	0.69	0.35	0.30	0.29	0.57	1.11	1.70
90 percentile	0.38	0.46	1.08	1.06	0.62	0.25	0.08	0.06	0.09	0.22	0.40	0.56
10 precentile	5.35	7.07	10.10	6.68	3.93	2.32	1.25	1.03	1.42	2.07	4.23	5.57

Figure 2-6: Flow Distribution for Nanticoke Creek at Nanticoke Gauge

~~2.14.9~~2.13.9 Eastern Tributaries

The Eastern Tributaries includes many relatively small watercourses such as Sandusk, Stoney, and Evans~~, Hickory and Fories-Stelco~~ Creeks covering a combined area of about 349~~67~~ km^2. The largest of these systems are Sandusk (165~~58~~ km^2) and Stoney (125~~18~~ km^2) Creeks. These watercourses drain directly into Lake Erie, and their drainage areas are entirely contained within the Haldimand Clay Plain. They have high runoff, low soil infiltration and very little baseflow. There are no active stream gauges within this watershed; however, two historical gauges on Sandusk Creek operated for short periods in the 1990's. In 2024, t~~T~~here we~~a~~re relatively few permits to take water in these watersheds compared to those to the west.

~~2.14.10~~2.13.10 Water Control Structures

In addition to the large water control structures described in the previous sections, several hundred small dams have been constructed on virtually every tributary of Big Creek and Big Otter Creek and other small watercourses in the Norfolk Sand Plain, to store water as a source for irrigation. They were constructed mainly in the last half of

the 20th century. There are also several old mill dams that were constructed in the 1800's and replaced or maintained in various states since. In addition, the LPRCA, ~~ND~~MNR~~F~~ and municipalities in the Region operate a number of small dams for multipurpose uses, including flood control, low flow augmentation, drinking water supply, irrigation, recreation and wildlife habitat. Selected dams and reservoirs in the Long Point Region are shown on **Map 2-15**.

~~2.15~~2.14 Surface Water Quality

The following describes the general surface water quality conditions found in the rivers and creeks in the Long Point Region Conservation Authority (LPRCA), as described in the Long Point Region Water Quality and Conditions report (Evans, 2007). The observations are based on data from the Ministry of the Environment's Provincial Water Quality Monitoring Network in addition to specific reports that describe the conditions within each watershed.

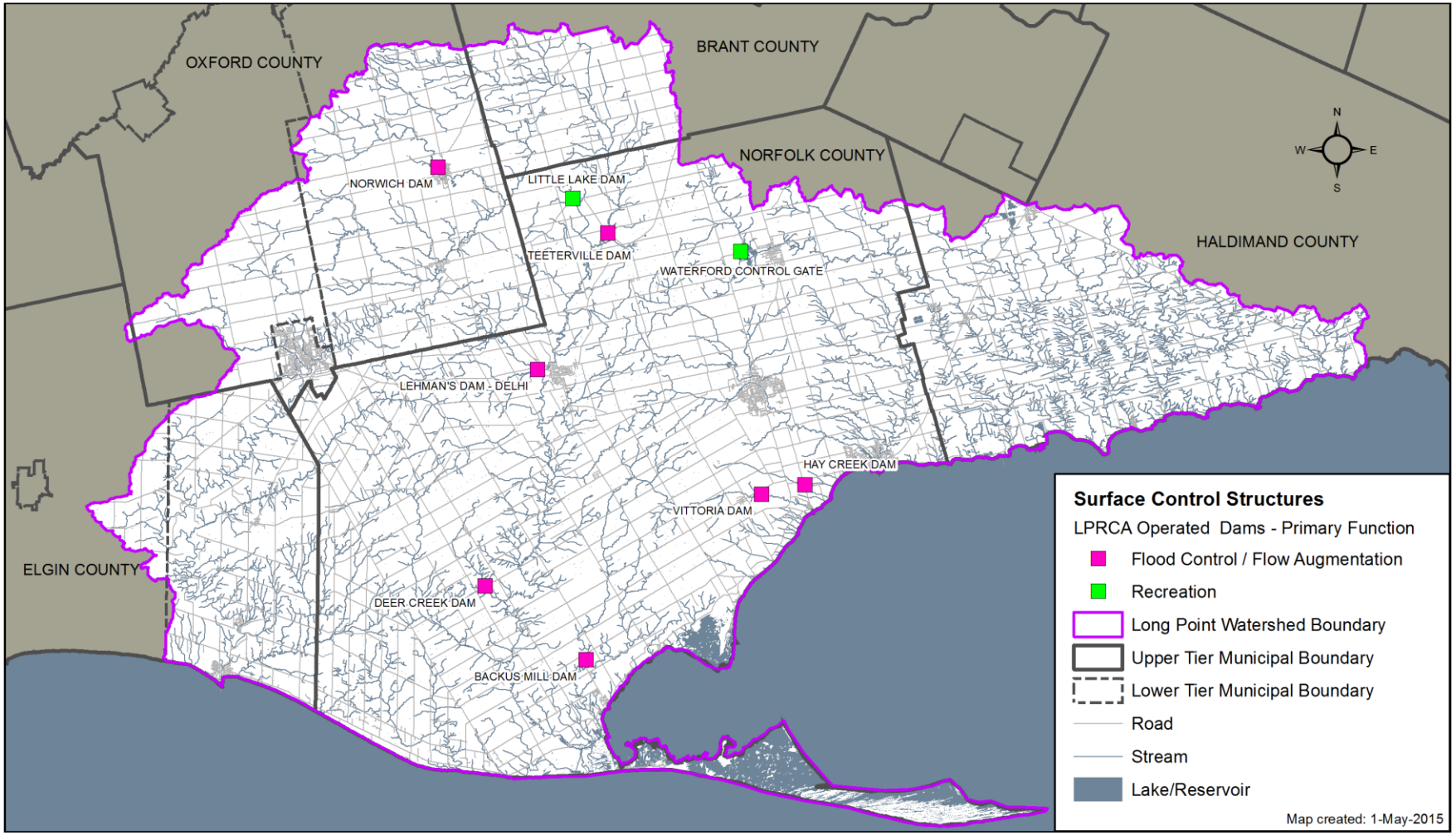
The most recent five~~-~~-year contiguous set of water quality data for Provincial Water Quality Monitoring Network sites were used to evaluate surface water quality conditions. Ten Provincial Water Quality Monitoring Network sites in the region had a sufficient number of data points to make meaningful observations. The Region was divided into six subbasins: Big Otter Creek, Big Creek, Lynn River, Nanticoke Creek, Sandusk Creek and Dedrick-Young Creek. See **Map 2-16** for the location of the ten monitoring sites. The most complete dataset for these sites was for the period of 2002-2005.

Water quality sampling for chemical and physical parameters in the Long Point Region watersheds resumed in 2002 following a lengthy period of not participating in the provincial water quality monitoring network. When LPRCA resumed sampling at ten sites, samples were collected on a routine basis however flow was not always considered. Generally, sampling was completed during low to moderate stream flows and peak flows were missed routinely. Therefore, the description of water quality conditions for the Long Point Region is generally limited to low/base flow conditions.

In general, the inherent geology and current land use practices appear to influence surface water quality Issues in the Long Point Region. For example, watersheds draining the clay and till plains tend to have the highest non-filterable residue and phosphorus concentrations (e.g., Big Otter Creek and Nanticoke Creek). These areas support livestock operations and general cash crop production. Conversely, irrigated specialty crops are produced on the Norfolk Sand Plain, but the high recharge and subsequent discharge of cool groundwater helps to sustain cold water fisheries. Consequently, water quality in the creeks draining the Norfolk Sand Plain (e.g., Young, Trout, Venison and Kent Creeks) tends to have better water quality with the exception of elevated nitrate levels. In addition to land use, point source discharges such as W~~w~~ater P~~p~~ollution C~~c~~ontrol P~~p~~lants (WPCP) also influence stream water quality in the Region. There are nine small towns/cities with municipal wastewater treatment plants or lagoons that discharge continuously or seasonally into the creeks and rivers of the Region; there is also one municipal industrial lagoon that discharges into a local stream. Summary

and descriptive statistics for priority chemical parameters (e.g., nutrients and chloride) are listed in **Table 2-6** for each of the ten sampling sites.

Map 2-15: Selected Surface Water Control Structures in the Long Point Region Watershed



Map 2-16: Provincial Water Quality Monitoring Network Sites in the Long Point Region Watershed

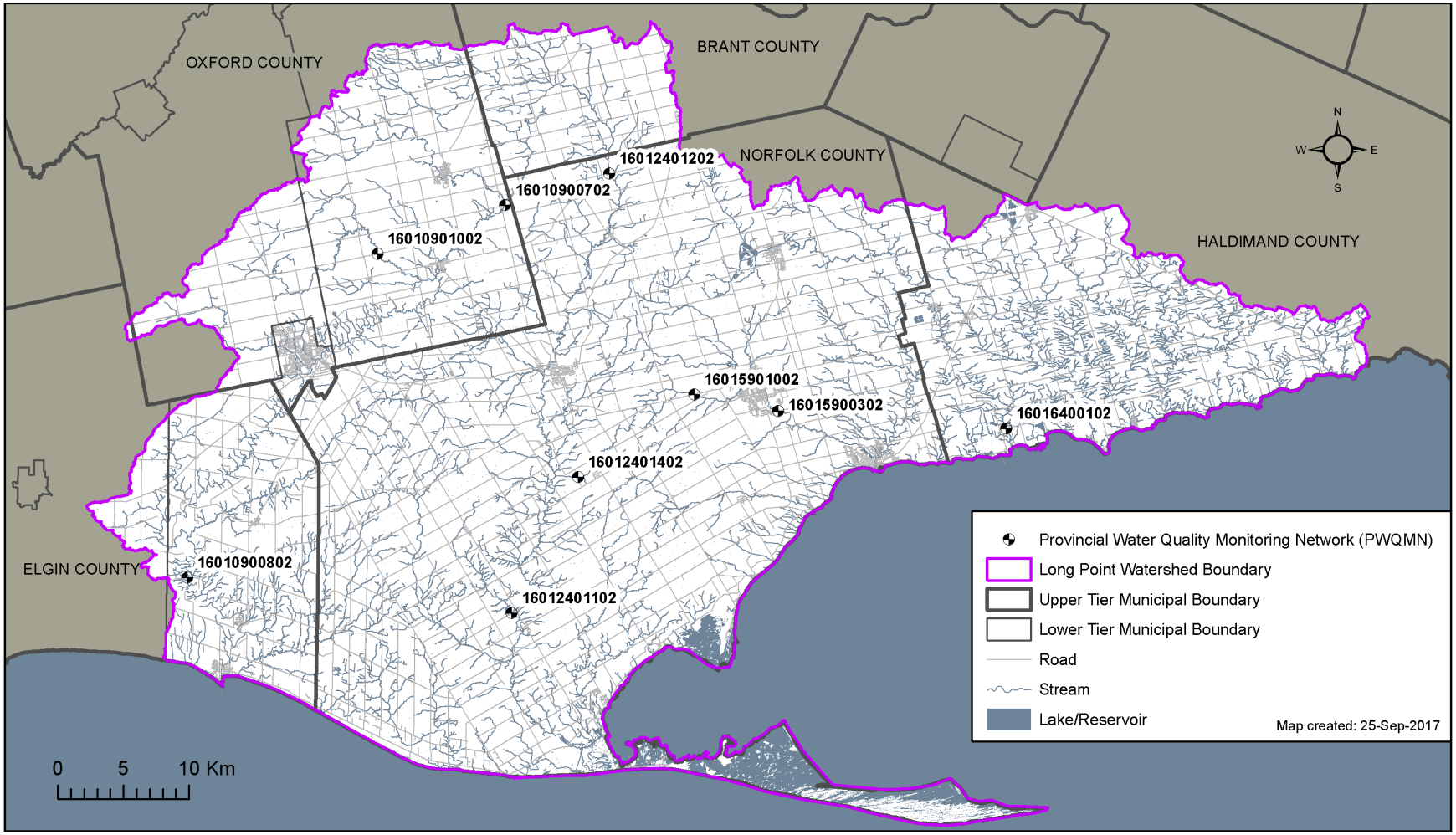


Table 2-62 ~~-7~~: Summary and Descriptive Statistics for Priority Chemical Parameters

Variable	Statistic	Big Otter Watershed			Big Creek Watershed				Lynn River Watershed		Nanticoke Watershed	Guideline or Benchmark
		Big Otter		Spittler Creek	Big Creek		Venison	Trout	Kent	Lynn River	Nanticoke Creek	
		PWQMN #9007	PWQMN #9008	PWQMN #9010	PWQMN #24012	PWQMN #24011	PWQMN #24013	PWQMN #24014	PWQMN #59010	PWQMN #59003	PWQMN #64001	
Nitrates (mg/L)	5th %	2.67	2.56	0.00	2.70	2.38	2.09	2.33	1.98	2.33	0.07	2.93
	Median	3.76	3.43	4.13	3.23	2.97	2.39	2.76	2.49	2.86	1.31	2.93
	75th %	5.11	4.39	9.12	4.14	3.20	2.57	2.87	3.00	3.21	2.50	2.93
	95th %	6.70	6.14	11.64	6.32	4.15	3.05	2.96	3.28	3.93	4.65	2.93
Nitrite (mg/L)	5th %	0.018	0.007	0.004	0.012	0.016	0.013	0.005	0.009	0.049	0.008	0.06
	Median	0.032	0.022	0.027	0.022	0.026	0.025	0.008	0.018	0.159	0.024	0.06
	75th %	0.042	0.040	0.076	0.039	0.031	0.030	0.009	0.022	0.185	0.038	0.06
	95th %	0.060	0.054	0.148	0.055	0.039	0.047	0.014	0.032	0.309	0.143	0.06
Un-ionized Ammonia (mg/L)	5th %	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.016
	Median	0.001	0.001	0.002	0.001	0.001	0.001	0.000	0.000	0.007	0.002	0.016
	75th %	0.001	0.001	0.003	0.002	0.001	0.001	0.000	0.001	0.021	0.005	0.016
	95th %	0.005	0.003	0.011	0.006	0.003	0.005	0.001	0.004	0.065	0.020	0.016
Total Nitrogen (mg/L)	5th %	3.24	3.01	0.73	3.17	2.86	2.47	2.63	2.45	3.18	0.94	n/a
	Median	4.45	3.92	5.02	3.88	3.50	2.75	3.00	2.92	4.05	2.26	n/a
	75th %	6.27	5.29	10.21	4.79	3.92	3.15	3.09	3.37	4.42	3.63	n/a
	95th %	7.61	7.53	12.53	7.35	4.86	3.79	3.32	3.60	5.20	5.88	n/a
	5th %	0.029	0.020	0.020	0.018	0.014	0.016	0.014	0.008	0.030	0.051	0.03

Variable	Statistic	Big Otter Watershed			Big Creek Watershed				Lynn River Watershed		Nanticoke Watershed	Guideline or Benchmark
		Big Otter		Spittler Creek	Big Creek		Venison	Trout	Kent	Lynn River	Nanticoke Creek	
		PWQMN #9007	PWQMN #9008	PWQMN #9010	PWQMN #24012	PWQMN #24011	PWQMN #24013	PWQMN #24014	PWQMN #59010	PWQMN #59003	PWQMN #64001	
Total Phosphorus (mg/L)	Median	0.057	0.063	0.053	0.032	0.051	0.046	0.027	0.020	0.061	0.113	0.03
	75th %	0.071	0.119	0.082	0.039	0.061	0.063	0.038	0.026	0.100	0.143	0.03
	95th %	0.208	0.526	0.287	0.149	0.195	0.108	0.078	0.037	0.171	0.402	0.03
Non-Filterable Residue (mg/L)	5th %	2.0	3.0	2.2	1.3	2.9	3.0	2.9	0.7	3.8	12.0	25
	Median	7.6	26.9	11.3	2.7	20.8	18.8	7.7	3.4	12.4	38.4	25
	75th %	12.2	77.8	17.6	4.3	31.0	25.3	11.9	4.8	17.7	63.2	25
	95th %	25.8	367.3	91.0	13.0	95.2	36.6	34.8	9.9	29.1	154.5	25
Chloride (mg/L)	5th %	17.5	19.5	19.4	17.5	18.6	10.4	15.3	21.6	36.8	24.6	250
	Median	28.5	30.3	36.5	24.5	26.2	12.7	17.2	26.8	57.7	39.6	250
	75th %	33.4	32.5	45.6	28.4	27.6	13.9	17.5	28.2	61.4	44.1	250
	95th %	43.2	34.8	60.8	30.9	28.6	22.5	19.3	30.6	71.6	49.4	250

~~2.15.1~~2.14.1 Conditions Specific to the Big Otter Creek Watershed

Nitrate, phosphorus, and non-filterable residue concentrations were found to be the major water quality issue within the Big Otter Creek watershed.

Nitrate and phosphorus concentrations were consistently above the Canadian Environmental Quality Guideline and Provincial Water Quality Objective, and as a result, are the most serious nutrient issues within the Big Otter Creek watershed. In fact, median nitrate levels within Spittler Creek, a tributary of Big Otter Creek, were among the highest across the entire Long Point Region. Spittler Creek was the most impaired area within the watershed with respect to all water quality parameters tested, except for phosphorus and total non-filterable residue levels, which were higher downstream on lower Big Otter Creek.

Land -use including intensive agricultural production, urban development, ~~water pollution control plant~~WPCP effluents, and the underlying geology and the topography within the Big Otter Creek watershed are all likely contributing to the degradation in water quality. The higher nitrate concentrations found in Spittler Creek are likely a result of the intensive agriculture within this region but may also be from nitrate-rich groundwater that discharges to the stream; further research is required to confirm this. Fausto & Finucan (1992) found that phosphorus inputs to Big Otter Creek were mainly anthropogenically driven by fertilizers, household effluent, industry and improper milk-house wash water disposal.

Big Otter Creek has been identified as Canada's largest source of sediment contamination to Lake Erie (Cridland, 1997). Although median values were just over the 25 mg/L benchmark, the 95th % value (367.25 mg/L) indicated that there were events when significant concentrations were measured. Big Otter Creek reacts to event flows extremely quickly and tends to be flashy (Stone, 1993) resulting in increased erosion and sedimentation. This phenomenon is also compounded by the soil type (clayey-till), lack of riparian vegetation and the deeply incised banks within the lower portion of the watershed.

Bacterial concentrations have also been identified as an issue within the Big Otter Creek watershed. Regular beach postings within the watershed prompted the start of the Clean Up Rural Beaches (CURB) program in 1992. As a result of this study, tributaries within the upper watershed were found to have higher bacterial counts relative to the main branch, and therefore improvement measures were focused within those areas (e.g., Spittler Creek). Since the implementation of the program, bacterial counts have decreased; however, beach postings still occur at Port Burwell. It has been hypothesized that some of the bacteria found at the Port Burwell beaches may be originating from the high bacterial concentrations emptying into Lake Erie from Silver Creek in the Catfish Creek watershed (McCarron and McCoy, 1992).

~~2.15.2~~2.14.2 Conditions Specific to the Big Creek Watershed

Generally, water quality is better in Trout Creek compared to other sites sampled in the Big Creek watershed. The upper Big Creek region was the most impaired with respect to nitrogen and chloride concentrations, but Venison Creek and lower Big Creek were the most impaired with respect to phosphorus and non-filterable residue concentrations.

The intensive agricultural production in the upper region of the Big Creek watershed is likely contributing to the high nitrate concentrations found in the creek. The relatively low nitrate concentrations found in the downstream tributaries of Trout and Venison Creeks is likely having a positive impact on the water quality in lower Big Creek, which is likely why nitrogen levels are lower downstream.

Phosphorus levels were routinely above the provincial objective (0.03 mg/L) in lower Big Creek and Venison Creek and are likely a result of the cumulative inputs from the Delhi ~~Water Pollution Control Plant~~WPCP and the intensive agricultural production in the watershed.

Compared to other watersheds within the Long Point Region, Big Creek is not a major contributor of nutrients or non-filterable residue (NFR) to Lake Erie (Stone, 1993). Flow in Big Creek is partially regulated through several wetlands. Stone (1993) suggests that the wetlands likely reduce the intensities of flow which helps to keep the sediment in the watershed as opposed to discharging to Lake Erie. Due to the wetlands, light soils and high degree of riparian cover, the Big Creek watershed does not react as quickly to event flows relative to Big Otter Creek.

The Lehman Dam Reservoir was built to supply the Town of Delhi with a municipal drinking water system. The reservoir is no longer used as a supply for the drinking water system as it was replaced with a two new groundwater wells (3a and 3b) as part of the Delhi Watet Supply System. The reservoir itself is situated on North Creek, a tributary to Big Creek, and is equipped with an operational dam but it is not used for flood control. The reservoir is also fed by South Creek which similar to North Creek has a good rainbow and brown trout fishery. Spawning has been noted to occur in both South and North Creeks so the dam on North Creek has been fitted with a fish ladder to accommodate this.

~~2.15.3~~2.14.3 Conditions Specific to the Lynn River Watershed

The impact of urban development on the Lynn River is reflected by the extremely high concentrations of nitrite, ammonia and phosphorus found in the river directly downstream to the town of Simcoe. Tributaries such as Kent Creek, which is a groundwater fed creek with minimal urban or agricultural impacts, have significantly better water quality than the Lynn River. Rarely do samples taken on the Lynn River, downstream of the ~~Water Pollution Control Plant (~~WPCP~~)~~, meet the Canadian environmental quality guideline for nitrite or the Provincial Water Quality Objective for total phosphorus. High nitrite and un-ionized ammonia levels found in aquatic systems tend to be associated with organic pollution through the disposal of sewage or organic

waste (Hem, 1985; Hydromantis Inc. et al., 2005). In the Lynn River, the high nitrite and un-ionized ammonia levels are likely a result of the Simcoe WPCP. Both un-ionized ammonia and nitrite are considered toxic to aquatic life which likely is having a negative effect on the aquatic life downstream of the plant.

Non-filterable residue (NFR) did not appear to be an issue in the Lynn River; however, the numerous impoundments upstream of the monitoring site along the Lynn River may be acting as sediment sinks.

Although the Lynn River below Simcoe does not appear to have the best water quality, it does support a very good brown trout fishery downstream of Simcoe and below Brook's Dam (Gagnon and Giles. 2004). The higher ammonia and nitrite concentrations are likely buffered by the higher water quality in the groundwater being discharged into this section of the Lynn River. This combined with reduced siltation in the lower Lynn River from Brook's Dam, likely results in more exposed gravel substrate suitable for sustaining fish populations. Other tributaries in the Lynn River watershed are fairly good cold-water streams (e.g., Kent & Patterson Creeks).

The better water quality found in Kent Creek is likely having a positive influence on the Lynn River further downstream of its confluence and thereby improving the quality of the water reaching Lake Erie.

Another concern with the high nutrient concentrations occurring in the Lynn River is its limited assimilative capacity especially in light of the population growth forecasted for the town of Simcoe. Currently Norfolk County is carrying out an assimilative capacity study to better understand the Lynn River's ability to effectively assimilate the WPCP effluent from the Simcoe Plant (pers. comm. Bob Fields).

The primary water quality issues in Black Creek, a major tributary of the Lynn River, were high non-filtered residue (NFR), intermittent stream flow and low dissolved oxygen (Gagnon & Giles, 2004).

~~2.15.4~~2.14.4 Conditions Specific to Nanticoke Creek Watershed

The upper-most headwaters of Nanticoke Creek reside in the Norfolk Sand Plain and tend to have better water quality when compared to the rest of the creek which flows through the Haldimand Clay Plain (Van De Lande, 1987). For instance, nitrogen and phosphorus concentrations significantly increase as Nanticoke Creek flows out of the Norfolk Sand Plain and into the Haldimand Clay Plain. The increase in nutrient levels is likely a result of the cumulative urban impact from the town of Waterford, the WPCP effluent and the transition in soil types in the contributing drainage area from sandy- to clay-based soils.

High total phosphorus and non-filterable residue concentrations are the most significant water quality issues in the watershed and appear to progressively increase from upstream to downstream. Phosphorus has been shown to historically increase during the summer low flow season which could be related to the increased NFR levels that also occur during this time (LPRCA, 1979a). Although Nanticoke Creek was not

historically considered a major contributor of nutrient concentrations to Lake Erie (LPRCA, 1979a), recent data indicates that the highest median NFR and phosphorus concentrations are found near the mouth of Nanticoke Creek relative to other tributaries in the Long Point Region. However, Nanticoke Creek does not appear to be as event-driven as Big Otter Creek whose maximum concentrations for NFR and phosphorus were much higher.

Dissolved oxygen levels have been found to decrease downstream of Waterford rendering the creek beyond this point unsuitable cold water fish habitat (Van De Lande, 1987). G. Douglas Vallee Ltd. (2004) speculated that the low dissolved oxygen levels found in the summer were likely as a result of the effluent from the Waterford WPCP making up a substantial percentage of the summer base-flow. Norfolk County has since developed a contingency plan detailing the necessary monitoring and appropriate actions required to mitigate these impacts. Currently, an assimilative capacity study is underway to help determine if an upgrade to the Waterford WPCP is required for Nanticoke Creek to effectively assimilate its effluent (pers. comm. Bob Fields). Upgrades such as tertiary treatment, or the addition of sand filters and disinfectants could potentially help reduce effluent contaminants levels thereby resulting in improved downstream water quality.

~~2.15.5~~2.14.5 Conditions Specific to Sandusk Creek

High phosphorus and non-filterable residue levels are the primary water quality issues in Sandusk Creek. Levels tend to progressively increase from upstream to downstream. Sandusk Creek drains the Haldimand Clay Plain which has a natural tendency for higher sedimentation and sediment associated nutrient concentrations, such as phosphorus. There are no natural retention areas within the Sandusk Creek watershed to help augment summer low flows (Morse et al., 1982). Therefore, Sandusk Creek tends to be ‘flashy’ during rain events due to soil type (clay), lack of forest cover and the lack of infiltration capacity of the soils (LPRCA, 1979b). However, given the relatively low flows found in this creek, it is only considered to be a moderate contributor of nitrate and phosphorus to Lake Erie yet potentially significant source of atrazine (a common herbicide for row-crops) (LPRCA, 1979b).

~~2.15.6~~2.14.6 Conditions Specific to Dedrick-Young Creek

Water quality in the Dedrick - Young Creek tends to be fairly good. Young Creek has been identified as a significant salmonid cold-water stream (LPRCA, 1979c; Edmonds et al., 1976). Young Creek tends to be of better water quality compared to Dedrick Creek, which is likely due to the numerous groundwater springs in the creek that recharge higher quality water into the system (Van de Lande, 1987).

~~2.16~~2.15 Summary of Water Use

~~2.16.1~~2.15.1 Municipal Systems

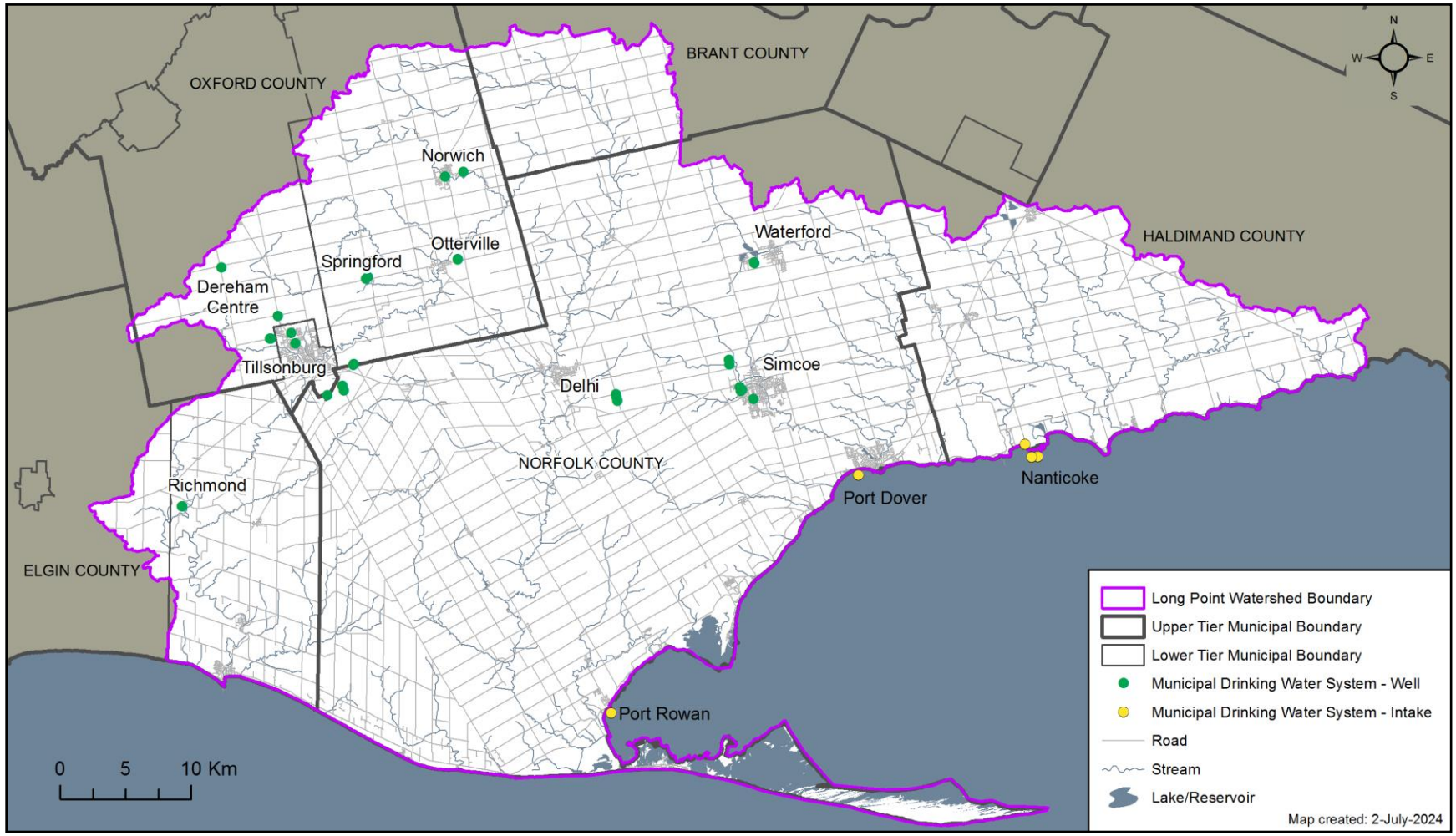
Municipalities within the Long Point Region rely on groundwater and~~, Lake Erie, and inland~~ surface water for their municipal drinking water needs. The communities on

groundwater supplies include Simcoe, Tillsonburg, Waterford, Norwich, Otterville, Springford, Dereham Centre, Delhi, Courtland, and Richmond. A groundwater source in the Upper Thames Region Source Protection supplies water to residents of Mount Elgin in South-West Oxford.

Communities reliant on Lake Erie for their municipal water supply include Port Rowan, Saint Williams, Port Dover, Hagersville, Jarvis and Townsend. Some communities within the Municipality of Bayham and the Township of Malahide also obtain their water supplies from Lake Erie through the Elgin Primary Water System.

~~Municipal water use within the watershed is estimated at 10.4 million m^3/yr, with this volume servicing approximately 60,000 residents.~~ The location of the municipal water wells and surface water intakes within Long Point Region are illustrated on **Map 2-17**.

Map 2-17: Municipal Water Wells and Intakes in the Long Point Region Watershed



~~2.16.2~~2.15.2 Private Drinking Water Supplies

As of the year ~~2009~~2024, ~~7,613~~9,727 domestic wells were identified in the Long Point Region Source Protection Area, according to the MECP~~MOECC~~'s Water Well Information System (WWIS). Of these domestic wells, ~~1,531 (20%)~~1,519 (16%) were classified as bedrock wells and ~~5,922 (78%)~~8,208 (84%) as overburden wells. The locations of these wells are shown on **Map 2-18** and **Map 2-19,** respectively.

Domestic bedrock wells are generally located in the eastern and north-western portions of Long Point Region (**Map 2-18**). These areas correspond to the locations of the Haldimand clay plain and Mount Elgin Ridges which often do not provide an adequate supply of groundwater for domestic use within overburden deposits.

Domestic overburden wells (**Map 2-19**) are most frequently located in the west-central portion of Long Point Region, corresponding to the location of the Norfolk Sand Plain.

~~Unserviced domestic water use was estimated across Long Point Region by following the methodology documented in the Grand River Water Use Study (Bellamy & Boyd, 2005). Rural domestic water use was estimated by combining Census of Population data for areas known not to be serviced by a municipal system with a per capita water use rate of 160 L/d/cap (Vandierendonck and Mitchell, 1997). Unserviced domestic water use, which is summarized in Table 2-8, was pro-rated by area to the subwatershed areas and assumed all water takings were groundwater sourced.~~

~~Consistent with the water consumption ratios for other Water Supply categories, the consumptive ratio (water not returned to it's source) was assumed to be 0.2. For domestic water wells, this assumption implied that 80% of pumped water is returned to groundwater system through septic systems.~~

~~Table 2-8: Un-serviced Domestic Water Use~~

		~~Rural Domestic Demand (m^3/s)~~
~~Big Otter~~	~~Otter Above Maple Dell Road~~	~~0.003~~
	~~Otter at Otterville~~	~~0.003~~
	~~Otter at Tillsonburg~~	~~0.006~~
	~~Spittler Creek~~	~~0.004~~
	~~Lower Otter~~	~~0.007~~
	~~Little Otter~~	~~0.005~~
~~Lake Erie Tribs~~	~~South Otter~~	~~0.004~~
	~~Clear Creek~~	~~0.003~~
~~Big Creek~~	~~Big Above Cement Road~~	~~0.003~~

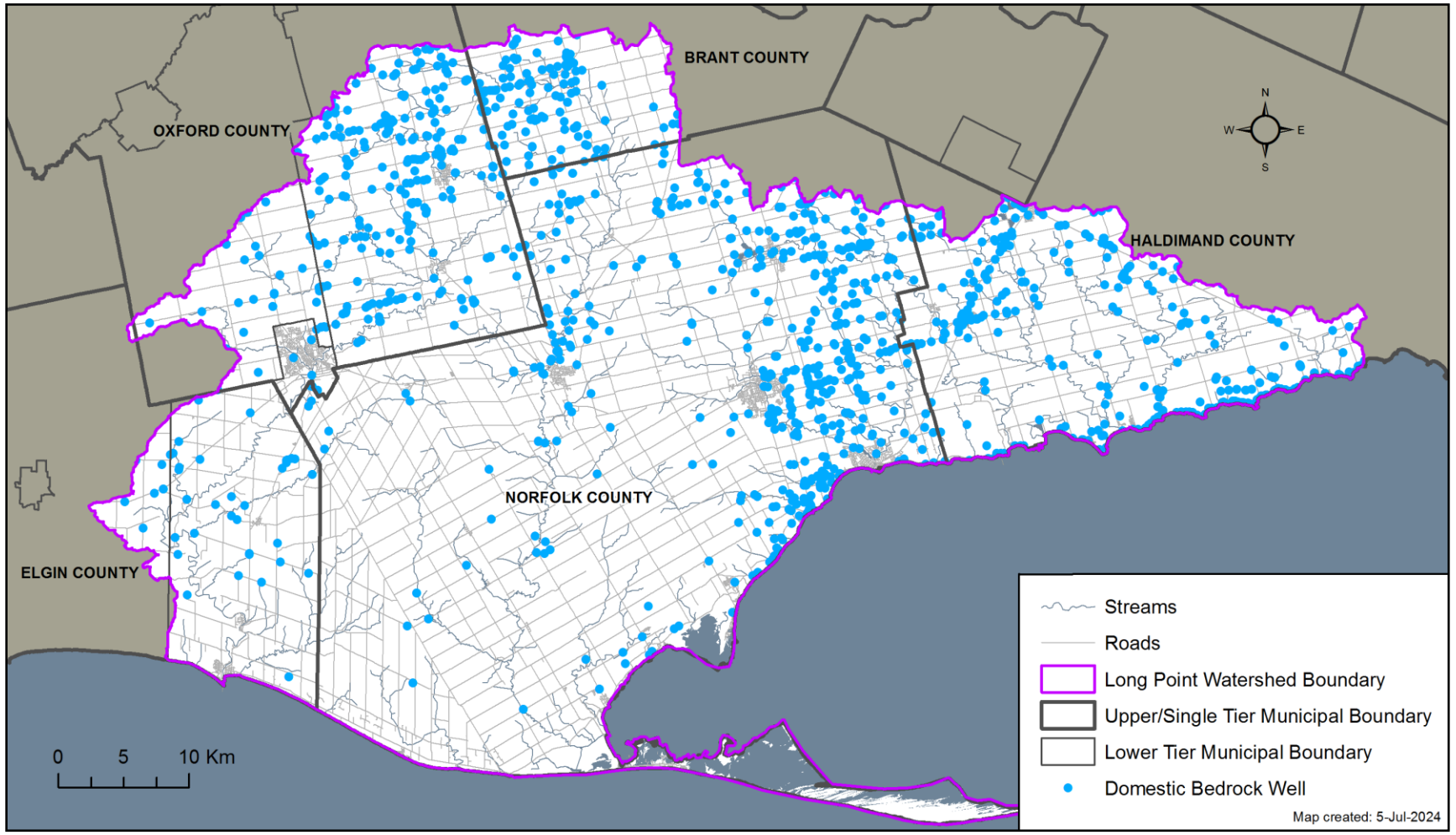
		Rural Domestic Demand (m^3/s)
	Big Above Kelvin Gauge	0.002
	Big Above Delhi	0.005
	North Creek	0.002
	Big Above Minnow Creek	0.003
	Big Above Walsingham	0.004
	Venison Creek	0.003
	Lower Big	0.006
Lake Erie Tribs	Dedrick Creek	0.005
	Young/Hay Creeks	0.009
Lynn River	Lynn River	0.007
	Black Creek	0.004
Nanticoke Creek	Nanticoke Upper	0.003
	Nanticoke Lower	0.006
Eastern Tribs	Sandusk Creek	0.007
	Stoney Creek	0.005

2.16.32.15.3 Non- Drinking Water Use

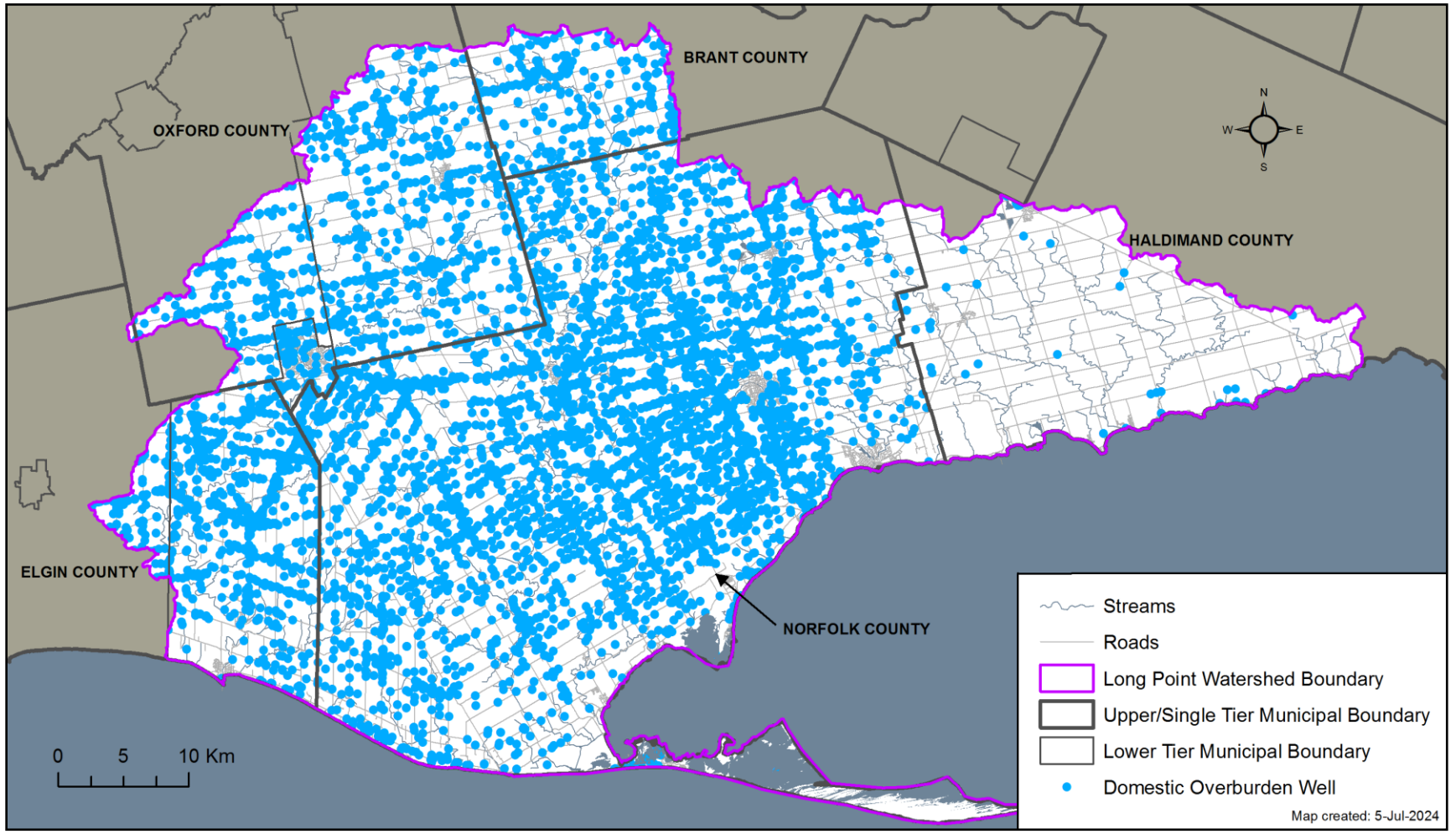
Long Point Region has one of the highest densities of permitted water takings in the pProvince. As of 20241717, Long Point Region had approximately 11831701 active individual permits, focused primarily within the Norfolk Sand Plain as is illustrated on **Map 2-20**.

Approximately 4951% of the permits withdraw water from groundwater sources, 275% from surface water bodies, and 24% from both groundwater and surface water supplies. Agricultural irrigation accounts for over 932% of the total number of permits in the region, with permits for commercial uses (e.g., golf courses), municipal water supply systems, and miscellaneous uses comprising the remainder of the permits.

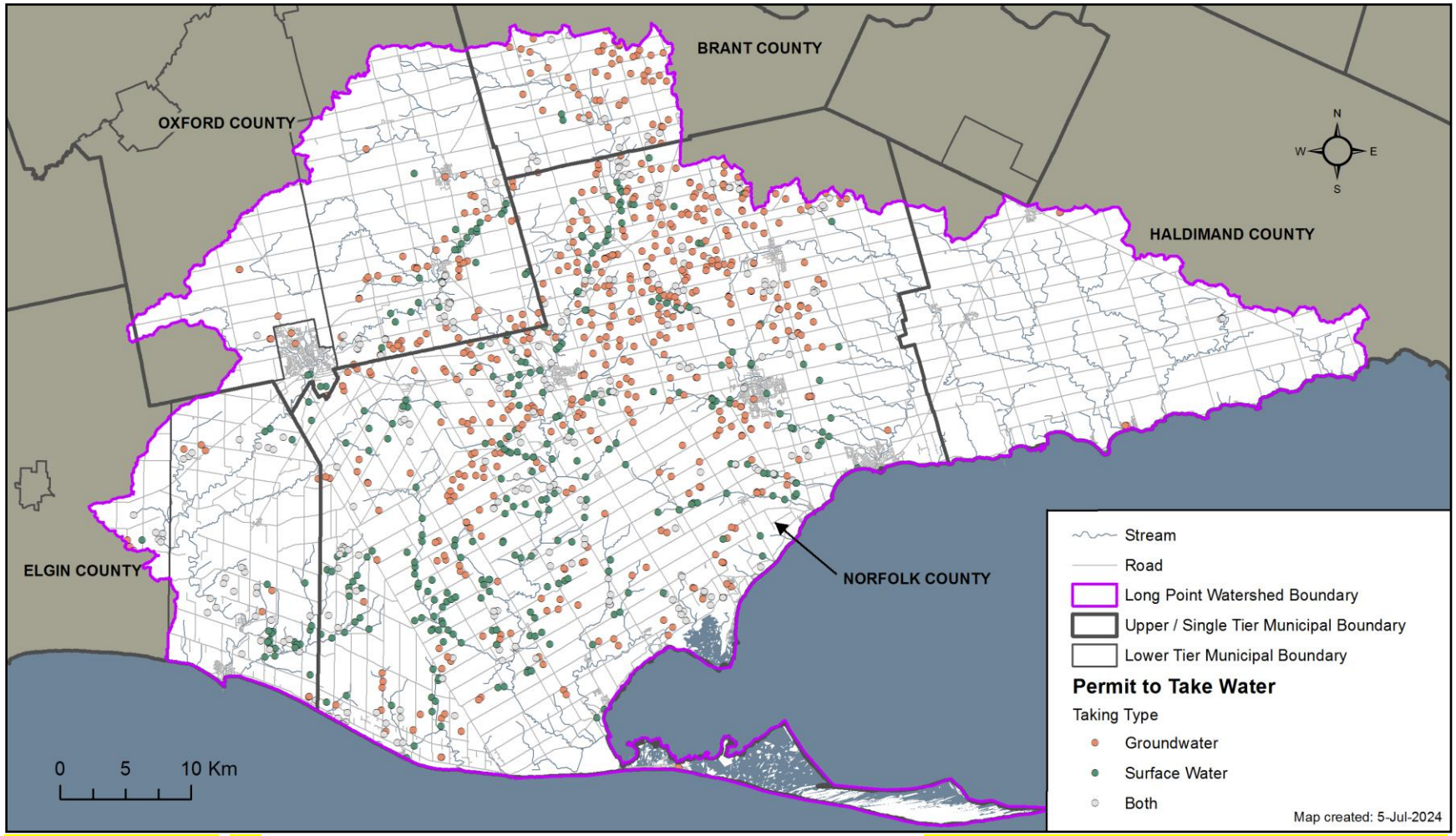
Map 2-18: Domestic Bedrock Wells in the Long Point Region Watershed



Map 2-19: Domestic Overburden Wells in the Long Point Region Watershed



Map 2-20: Permits to Take Water in the Long Point Region Watershed



Data source: Permits to ~~Take Water issued by the Ontario Ministry of the Environment.~~take water data from Ministry of the Environment, Conservation and Parks, 2025.

~~Permitted Rate~~

~~Permitted rates are provided in the MOECC's Permit-To-Take-Water (PTTW) database. Table 2-9 shows the total permitted rate of active permitted water takings categorized by subwatershed and source. The total permitted rates are 34 m^3/s for groundwater and 20 m^3/s for surface water sources, representing a total rate of 54 m^3/s.~~

~~Table 2-9:Permitted Rate (based on 2009 PTTW data)~~

~~Subwatershed~~	~~Groundwater (m^3/s)~~	~~Surface Water (m^3/s)~~	~~Groundwater (mm)~~	~~Surface Water (mm)~~
~~Otter Above Maple Dell Road~~	~~0.57~~	~~0.31~~	~~182~~	~~99~~
~~Otter at Otterville~~	~~0.69~~	~~0.50~~	~~291~~	~~210~~
~~Otter at Tillsonburg~~	~~1.39~~	~~1.41~~	~~286~~	~~291~~
~~Spittler Creek~~	~~0.07~~	~~0.07~~	~~19~~	~~18~~
~~Lower Otter~~	~~0.57~~	~~1.52~~	~~108~~	~~285~~
~~Little Otter~~	~~1.15~~	~~0.89~~	~~309~~	~~239~~
~~South Otter~~	~~1.23~~	~~1.88~~	~~324~~	~~496~~
~~Clear Creek~~	~~1.41~~	~~0.61~~	~~512~~	~~220~~
~~Big Above Cement Road~~	~~0.28~~	~~0.12~~	~~97~~	~~41~~
~~Big Above Kelvin Gauge~~	~~1.91~~	~~0.08~~	~~937~~	~~39~~
~~Big Above Delhi~~	~~4.90~~	~~2.09~~	~~1000~~	~~427~~
~~North Creek~~	~~1.00~~	~~1.04~~	~~545~~	~~565~~
~~Big Above Minnow Creek~~	~~2.65~~	~~1.02~~	~~1156~~	~~443~~
~~Big Above Walsingham~~	~~1.89~~	~~2.32~~	~~486~~	~~596~~
~~Venison Creek~~	~~1.76~~	~~1.84~~	~~570~~	~~593~~
~~Lower Big~~	~~0.68~~	~~0.64~~	~~224~~	~~209~~
~~Dedrick Creek~~	~~1.27~~	~~1.20~~	~~291~~	~~275~~
~~Young/Hay Creeks~~	~~1.48~~	~~0.94~~	~~387~~	~~247~~
~~Lynn River~~	~~3.70~~	~~0.92~~	~~680~~	~~168~~

Subwatershed	Groundwater (m^3/s)	Surface Water (m^3/s)	Groundwater (mm)	Surface Water (mm)
Black Creek	0.61	0.03	144	6
Nanticoke Upper	4.20	0.61	1160	168
Nanticoke Lower	0.01	0.00	5	0
Sandusk Creek	0.19	0.00	32	0
Stoney Creek	0.00	0.02	1	3
Total	34	20		

Pumped Rate

Pumped rates include the estimated pumped rates from both permitted uses and non-permitted uses. To calculate the pumped rates from permitted uses, reported rates were used where available. If reported rates were not available, pumped rates for non-agricultural permits were estimated based on maximum permitted rates and a monthly demand factor based on the specific purpose listed for the permit to take into consideration the seasonality of the taking based on the work in the Grand River Water Use Study (Bellamy & Boyd, 2005).

For agricultural permits, pumping rates were estimated by applying an irrigation demand model (Bellamy & Wong, 2005) which uses soil moisture generated by the hydrologic model to determine the occurrence of an irrigation event. By multiplying the number of days of active pumping for each irrigation event (4) with the median number of irrigation events (8), the typical irrigation system is estimated to be pumping water for 32 days per year. A pumping factor of 60% of the permitted rate was determined based on a number of reported pumping rates. The number of irrigation dates and the pumping factor were used to determine pumping rates on an average annual basis.

For non-permitted (permit exempt) water uses, the GRCA developed a methodology to quantify non-permitted agricultural water use as part of the Grand River Water Use Study (Bellamy & Boyd, 2005). Legal non-permitted agricultural water use includes livestock watering, equipment washing, pesticide/herbicide application or any other minor use of water. Kreutzwiser and de Loë (1999) developed a series of coefficients, that when applied to the Census of Agriculture Data, can be used to estimate agricultural water use. The Water Use Assessment applied this methodology to estimate water use on a watershed basis. Table 2-10 pro-rates these watershed-based estimates for each subwatershed by area.

Table 2-10: Non-Permitted Agricultural Water Use

Subwatershed	Non-Permitted Agricultural Demand (m^3/s)
Otter Above Maple Dell Road	0.006

Subwatershed	Non-Permitted Agricultural Demand (m^3/s)
Otter at Otterville	0.005
Otter at Tillsonburg	0.006
Spittler Creek	0.007
Lower Otter	0.004
Little Otter	0.003
South Otter	0.001
Clear Creek	0.001
Big Above Cement Road	0.003
Big Above Kelvin Gauge	0.002
Big Above Delhi	0.006
North Creek	0.000
Big Above Minnow Creek	0.002
Big Above Walsingham	0.002
Venison Creek	0.002
Lower Big	0.001
Dedrick Creek	0.001
Young/Hay Creeks	0.006
Lynn River	0.005
Black Creek	0.004
Nanticoke Upper	0.003
Nanticoke Lower	0.006
Sandusk Creek	0.004
Stoney Creek	0.003

~~Due to the census-based estimation technique, it is not possible to reliably determine the source of water for the agricultural water users. In the absence of this information, it is assumed that half of the demand is serviced through groundwater sources, and half is serviced through surface water sources.~~

~~Table 2-11 summarizes the estimates of the volume of water pumped, expressed as an annual average rate, for all users. The pumped rate is the average annual amount of water that has been withdrawn from watercourses or aquifers, without allowing for the consumptive nature of the taking. Pumped demand shows approximately 3.6 m^3/s pumped on an annual average basis, compared to 54 m^3/s that is permitted. This large difference is attributed primarily to the seasonality of agricultural permits, which are the dominant water use within the region.~~

~~Table 2-11: Average Rate Pumped~~

~~Subwatershed~~	~~Groundwater (m^3/s)~~	~~Surface Water (m^3/s)~~
~~Otter Above Maple Dell Road~~	~~0.04~~	~~0.07~~
~~Otter at Otterville~~	~~0.03~~	~~0.02~~
~~Otter at Tillsonburg~~	~~0.15~~	~~0.06~~
~~Spittler Creek~~	~~0.01~~	~~0.01~~
~~Lower Otter~~	~~0.03~~	~~0.05~~
~~Little Otter~~	~~0.07~~	~~0.03~~
~~South Otter~~	~~0.05~~	~~0.07~~
~~Clear Creek~~	~~0.06~~	~~0.02~~
~~Big Above Cement Road~~	~~0.02~~	~~0.01~~
~~Big Above Kelvin Gauge~~	~~0.14~~	~~0.00~~
~~Big Above Delhi~~	~~0.21~~	~~0.12~~
~~North Creek~~	~~0.11~~	~~0.09~~
~~Big Above Minnow Creek~~	~~0.14~~	~~0.04~~
~~Big Above Walsingham~~	~~0.06~~	~~0.31~~
~~Venison Creek~~	~~0.06~~	~~0.08~~
~~Lower Big~~	~~0.03~~	~~0.03~~
~~Dedrick Creek~~	~~0.05~~	~~0.47~~

Subwatershed	Groundwater (m^3/s)	Surface Water (m^3/s)
Young/Hay Creeks	0.10	0.18
Lynn River	0.24	0.04
Black Creek	0.05	0.00
Nanticoke Upper	0.18	0.02
Nanticoke Lower	0.00	0.00
Sandusk Creek	0.02	0.00
Stoney Creek	0.01	0.01
Total	1.86	1.73

* Total = Estimated +Reported. Due to rounding errors, small summing discrepancies may exist

Consumptive Use

Table 2-12 summarizes the estimated consumptive demand (source scale) within each subwatershed. The consumptive nature of water use is a point of uncertainty. In the absence of source specific information, standard consumptive use factors (AquaResource, 2009a) were used based on the specific purpose as listed on the permit to take water.

The table shows the maximum and minimum monthly and average annual demand for both surface water and groundwater sources. On an average annual basis, 1.45 m^3/s of water is estimated to be consumed from aquifers and 0.79 m^3/s is consumed from rivers and creeks.

There is significant monthly variability within most subwatersheds in the Long Point Region due to the dominant agricultural sector water usage, which removes water only during the summer months. Consumptive demands for groundwater are larger than for surface water due to the fact that groundwater takings are not recycled back to the aquifer.

Table 2-12: Consumptive Demand (By Hydrologic Source Unit)

Subwatershed	Maximum Monthly Groundwater Demand (m^3/s)	Minimum Monthly Groundwater Demand (m^3/s)	Average Annual Groundwater Demand (m^3/s)	Maximum Monthly Surface Water Demand (m^3/s)	Minimum Monthly Surface Water Demand (m^3/s)	Average Annual Surface Water Demand (m^3/s)
Otter Above Maple Dell Road	0.09	0.01	0.03	0.04	0.00	0.02

Subwatershed	Maximum Monthly Groundwater Demand (m^3/s)	Minimum Monthly Groundwater Demand (m^3/s)	Average Annual Groundwater Demand (m^3/s)	Maximum Monthly Surface Water Demand (m^3/s)	Minimum Monthly Surface Water Demand (m^3/s)	Average Annual Surface Water Demand (m^3/s)
Otter at Otterville	0.10	0.00	0.03	0.07	0.00	0.02
Otter at Tillsonburg	0.24	0.08	0.12	0.18	0.00	0.06
Spittler Creek	0.02	0.01	0.01	0.01	0.00	0.01
Lower Otter	0.08	0.00	0.02	0.17	0.00	0.05
Little Otter	0.17	0.03	0.06	0.08	0.00	0.02
South Otter	0.15	0.00	0.03	0.23	0.00	0.07
Clear Creek	0.19	0.00	0.04	0.06	0.00	0.02
Big Above Cement Road	0.04	0.00	0.01	0.02	0.00	0.01
Big Above Kelvin Gauge	0.32	0.05	0.11	0.01	0.00	0.00
Big Above Delhi	0.67	0.01	0.16	0.26	0.01	0.08
North Creek	0.20	0.06	0.09	0.11	0.01	0.04
Big Above Minnow Creek	0.40	0.02	0.11	0.12	0.00	0.04
Big Above Walsingham	0.20	0.00	0.05	0.25	0.04	0.10
Venison Creek	0.20	0.00	0.05	0.17	0.00	0.05
Lower Big	0.08	0.00	0.02	0.06	0.00	0.02
Dedrick Creek	0.15	0.00	0.03	0.12	0.05	0.07
Young/Hay Creeks	0.24	0.03	0.08	0.13	0.01	0.05
Lynn River	0.60	0.07	0.20	0.14	0.00	0.04
Black Creek	0.09	0.02	0.04	0.01	0.00	0.00
Nanticoke Upper	0.54	0.02	0.14	0.06	0.00	0.02

Subwatershed	Maximum Monthly Groundwater Demand (m^3/s)	Minimum Monthly Groundwater Demand (m^3/s)	Average Annual Groundwater Demand (m^3/s)	Maximum Monthly Surface Water Demand (m^3/s)	Minimum Monthly Surface Water Demand (m^3/s)	Average Annual Surface Water Demand (m^3/s)
Nanticoke Lower	0.00	0.00	0.00	0.00	0.00	0.00
Sandusk Creek	0.01	0.01	0.01	0.00	0.00	0.00
Stoney Creek	0.01	0.00	0.00	0.01	0.00	0.00
Total			1.45			0.79

Although efforts have been made to determine actual pumping rates for permit holders, there is still a number of permits without reported pumping rates in which standard seasonality and consumption factors had to be used. The biggest water use sector, agricultural, has the most uncertainty since this use is climate driven. Ongoing changes in the dominant crops being grown also contributes to the uncertainty. Production of high water use crops, such as tobacco, has been in decline in the past decade, and the choice of long term replacement crops for these fields is not yet clear. At the same time, domestic water use in the Long Point Region subwatersheds is relatively steady. The low population growth forecast outlined in Table 2-2 (approximately 0.7%) combined with recent trends in water conservation may result in reduced domestic consumption. Therefore, currently there is no indication of increasing water use over time.

2.172.16 Aquatic Habitat

The Long Point Region consists of nine major watersheds draining the Horseshoe Moraine, Norfolk Sand Plain and the Haldimand Clay Plain. Given the predominance of agricultural production and the numerous small cities, towns and villages throughout the region, there are very few areas with limited anthropogenic impact in the Long Point Region. The physiographic features, along with land use and management characteristics in the watershed establish the quality and quantity of aquatic habitat available for aquatic life.

Human actions can have a dramatic impact on aquatic habitats. Water habitats can be impacted by the deforestation of riparian areas – those lands adjacent to streams and rivers. This reduces the amount of shade available to keep waters cool during the summer. Losses of forests and wetlands can lead to degraded aquatic habitat through the reduction in groundwater recharge and subsequent reduced baseflows; increased erosion; and the loss of nutrient and sediment filtration. Further, many streams and watercourses in the Region have been straightened or modified in urban and rural areas to promote drainage. Numerous small dams have also been constructed to impound water for water supply or flood reduction. Besides creating thermal regimes more conducive to warm water fish species, these dams can also create barriers for migratory cold-water fish. Consequently, land use and management including intensive

agricultural production, tile drainage, urban development, and wastewater treatment plant effluents have all contributed to the degradation of water quality and aquatic habitats found in the Long Point Region (Evans, 2007).

In addition to the chemical characteristics of the waterway, the suitability of aquatic habitat is dependent on three physical factors: temperature, oxygen and clarity. The thermal regimes in the waterways in the Long Point Region include cold-, cool- and warm-water (**Map 2-21**). For example, the waterways along the western and central portion of the Long Point Region (e.g., lower Big Otter, Big and Dedrick-Young creeks) contain many cold water fish ~~species however;~~species; however, this region also boasts the highest number of permits to take water. The high number of permitted agricultural water takings on the sand plain can also impact stream flow levels and temperatures as these takings tend to be most active during dry periods in the summer/fall when stream flows are typically at their lowest. On the other hand, watersheds draining the clay plain in the eastern portion of the Region tend to be warm water habitats.

Many of the tributaries within the Long Point Region are thermally stressed (P. Gagnon, pers. comm.). The warming trend in summer stream temperatures across several watersheds, including Big and Patterson creeks, is a concern (Evans, 2007). High temperatures can limit the diversity of aquatic species present as well as impact dissolved oxygen levels. Therefore, prolonged periods of time that temperatures are above the threshold for cold-cool water fish (24°C) limits the creeks ability to support these species. Although there appears to be a warming trend across the Region, there continues to be streams within the Long Point Region that have temperatures and habitats still suitable for supporting cold water fish species (e.g., Young Creek, Trout Creek and Kent Creek).

Dissolved oxygen is also an important indicator of a river's ability to sustain aquatic life. Levels can be affected by reduced stream flows, increased water temperatures, and increases in pollutants loads that have a high oxygen demand (e.g., wastewater discharges). Although dissolved oxygen has routinely been measured in streams and rivers within the Long Point Region, spot measurements typically occur during the day – the time oxygen tends to be produced through photosynthesis and therefore, does not provide for a good assessment of the dissolved oxygen regime in the river. However, spot measurements showed levels that were rarely below six milligrams per litre (Evans, 2007). Continuous monitoring, as opposed to spot measurements, is recommended to properly characterize dissolved oxygen levels in streams and rivers in the Long Pont Region.

The Long Point Region watersheds sustain a variety of fish species and habitats. Some of the local cold water streams support resident and migratory salmonid populations that include brook, brown and rainbow trout, and pacific salmon. Young Creek, for instance, has been identified as a biologically significant salmonid cold water stream habitat (Long Point Region Conservation Authority, 1979c; Edmonds et al., 1976). In many places, however, poor land use practices have degraded the salmonid habitat, which has impacted their populations. Further, dams, impoundments and other anthropogenic

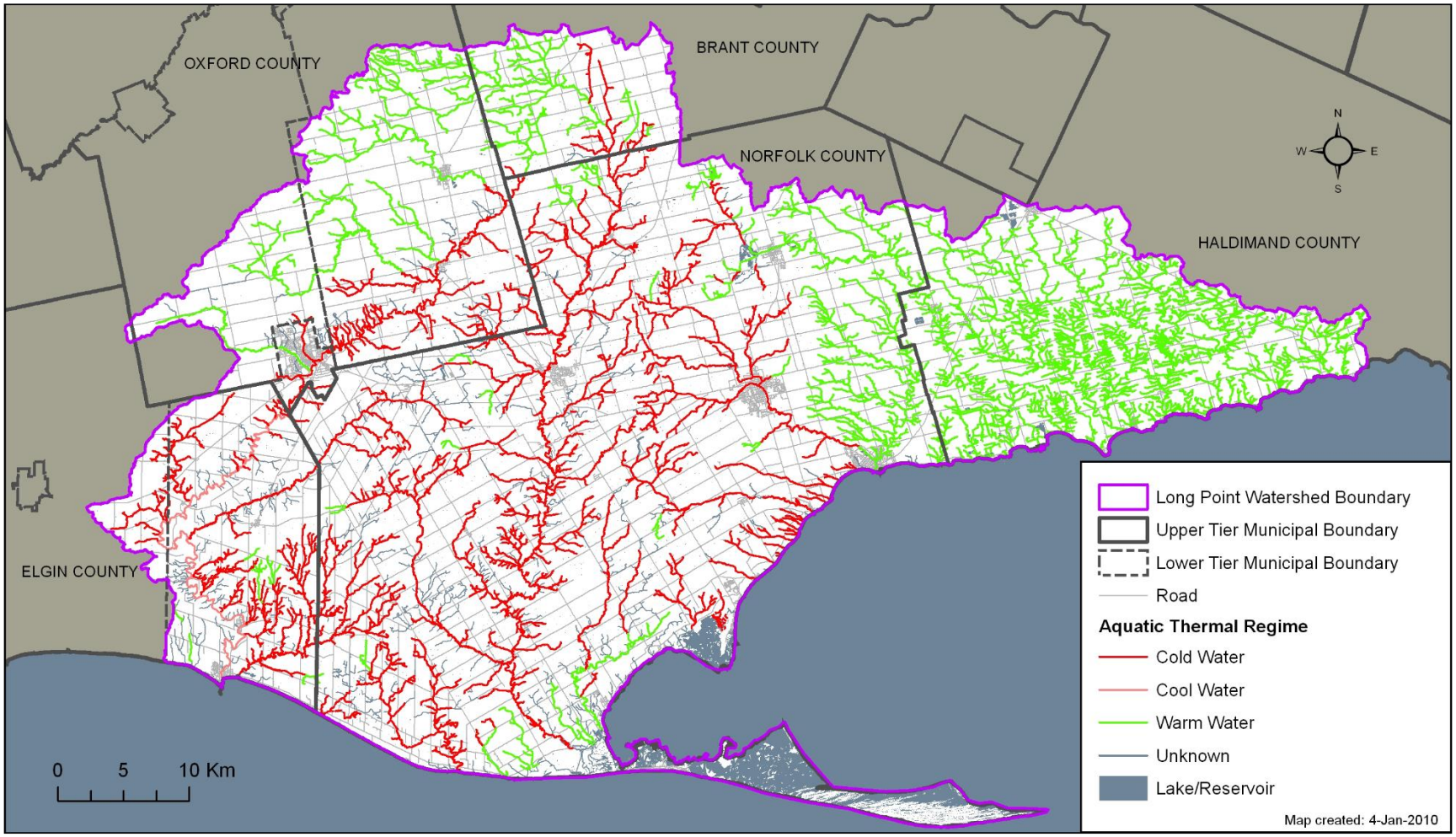
drainage features (e.g., tile drains) have led to the degradation of many of the natural cold-water habitats in the Region.

Warm water systems in the Region support bass, pike, perch, sunfish, bull head, channel catfish and other panfish species (Ontario Ministry of Natural Resources, 1990b). Warm water systems are usually found where heavier soils are dominant such as the Haldimand Clay Plain; till moraines of the north-west; near the Lake Erie shoreline; and in some areas where water is held back through artificial storage. For example, Nanticoke Creek transitions from a cold-water system on the Norfolk Sand Plain upstream of Waterford, passing through the Waterford Ponds area, and into a warm-water system as it progresses downstream through the Haldimand Clay Plain. Further, the flows and habitats of this creek have been greatly altered since pre-settlement times. Dissolved oxygen levels have been found to decrease downstream of Waterford, rendering the creek beyond this point unsuitable as cold water fish habitat (Van De Lande, 1987). G. Douglas Vallee Ltd. (2004) speculated that the low dissolved oxygen levels found in the summer were likely a result of the effluent from the Waterford WWTP making up a substantial percentage of the summer base-flow.

In addition to a wide variety of lotic or stream aquatic habitats in the Long Point Region, there are also significant lentic or lake and lake-like aquatic habitats. Many of the inland lakes and ponds are small reservoirs or rehabilitated gravel extraction pits (e.g., Waterford Ponds). Fish populations in these lakes and ponds include large mouth bass, yellow perch, sunfish and crappie. In addition, Lake Erie provides valuable spawning and nursery habitat through shoreline marshes, an example of which includes the Long Point Bay. Species found in Long Point Bay include largemouth and smallmouth bass, yellow perch, northern pike, sunfish, rock bass, carp and bull head (Ontario Ministry of Natural Resources, 1990b). Long Point Region watersheds mainly encompass the eastern basin of Lake Erie, which includes species such as: rainbow smelt, yellow perch, rainbow and brown trout, pacific salmon, lake whitefish, lake herring and lake trout.

Two fisheries management plans are followed within the watersheds: the Aylmer District Fisheries Plan 1987-2000 (Ontario Ministry of Natural Resources, 1990a); and the Simcoe District Fisheries Management Plan 1987-2000 (Ontario Ministry of Natural Resources, 1990b). The Aylmer District Fisheries Plan focuses mainly on the Big Otter watershed. The focus of the fisheries management plan for the Big Otter watershed is to decrease sediment loading due to siltation, decrease nutrient levels in the river and maintain or decrease where possible the temperature of the river. The Simcoe District Fisheries Management Plan 1987-2000 outlined four key fish management issues for the Region: habitat destruction; demand/supply imbalances; resource use conflict; and inadequate knowledge about the fishery. These issues can have significant implications on the fish population and habitat and therefore a fisheries management plan is needed to help reduce impacts, protect habitat and increase and protect resident fish populations in the Region.

Map 2-21: Aquatic Habitat in the Long Point Region Watershed



~~2.18~~2.17 Species at Risk

A complete list of species of animals and plants known to be at risk, rare or endangered in the Long Point Region watersheds is included in **Table 2-7~~Table 2-13~~**.

Table 2-7~~2-13~~: List of Species at Risk in Long Point Region Watersheds*

Taxonomy	Common Name	Scientific Name	~~ON~~D~~MNRF~~ Status	Notes
Fish	Lake Sturgeon (Upper Great Lakes/St. Lawrence population)	*Acipenser fulvescens*	Threatened	Lake Sturgeon is found in all the Great Lakes, and in all drainages of the Great Lakes
Plants	Colicroot	*Aletris farinosa*	Threatened	Charlotteville
Amphibians	Jefferson Salamander	*Ambystoma jeffersonianum*	Threatened	SW part of Norfolk County
Fish	Eastern Sand Darter	*Ammocrypta pellucida*	Threatened	Norfolk, Western Haldimand, Southern Brant and Oxford, Eastern Elgin
Birds	Henslow's Sparrow	*Ammodramus henslowii*	Endangered	Southern Norfolk County
Amphibians	Fowler's Toad	*Anaxyrus fowleri*	Threatened	southern part of Long Point Region
Reptiles	Spiny Softshell	*Apalone spinifera*	Threatened	SW Norfolk
Plants	Green Dragon	*Arisaema dracontium*	Special Concern	
Birds	Short-eared Owl	*Asio flammeus*	Special Concern	Eastern part of Long Point Region
Insects	Frosted Elfin	*Callophrys irus*	Extirpated	last recorded near St. Williams in Norfolk County in 1988
Birds	Whip-poor-will	*Caprimlugus vociferus*	Threatened	
Plants	American Chestnut	*Castanea dentata*	Endangered	
Birds	Chimney swift	*Chaetura pelagica*	Threatened	
Reptiles	Snapping turtle	*Chelydra serpentina*	Special Concern	
Plants	Spotted Wintergreen	*Chimaphila maculata*	Endangered	SE Norfolk
Birds	Black Tern	*Chlidonias niger*	Special Concern	
Birds	Common nighthawk	*Chordeiles minor*	Special Concern	
Reptiles	Spotted Turtle	*Clemmys guttata*	Endangered	
Fish	Redside Dace	*Clinostomus elongatus*	Endangered	Brant & Haldimand Counties
Birds	Olive-sided flycatcher	*Contopus cooperi*	Special Concern	
Plants	Eastern Flowering Dogwood	*Cornus florida*	Endangered	Long Point Region, except NW part
Plants	Small White Lady's-slipper	*Cypripedium candidum*	Endangered	near St. Williams in Norfolk County
Insects	Monarch	*Danaus plexippus*	Special Concern	
Birds	Cerulean Warbler	*Dendroica cerulea*	Special Concern	
Plants	Horsetail Spike-rush	*Eleocharis equisetoides*	Endangered	Near Long Point
Birds	Acadian Flycatcher	*Empidonax virescens*	Endangered	

Taxonomy	Common Name	Scientific Name	~~ONDF~~MNR~~F~~ Status	Notes
Reptiles	Blanding's Turtle	*Emydoidea blandingii*	Threatened	
Fish	Lake Chubsucker	*Erimyzon sucetta*	Threatened	Elgin, in the drainages of Lake Erie
Insects	Eastern Persius Duskywing	*Erynnis persius persius*	Extirpated	SW Norfolk, but not observed in Ontario in over 18 years
Fish	Grass Pickerel	*Esox americanus vermiculatus*	Special Concern	SW Norfolk
Mosses	Pygmy Pocket Moss	*Fissidens exilis*	Special Concern	NW Norfolk
Reptiles	Northern Map Turtle	*Graptemys geographica*	Special Concern	
Plants	Kentucky Coffee-tree	*Gymnocladus dioicus*	Threatened	SE Oxford
Birds	Bald Eagle	*Haliaeetus leucocephalus*	Special Concern	
Reptiles	Eastern Hog-nosed Snake	*Heterodon platirhinos*	Threatened	except eastern part of Long Point Region in Haldimand
Plants	Swamp Rose-mallow	*Hibiscus moscheutos*	Special Concern	coastal marshes of S Norfolk
Fish	Northern Brook Lamprey	*Ichthyomyzon fossor*	Special Concern	S drainages of Lake Erie
Birds	Yellow-breasted Chat	*Icteria virens*	Special Concern	
Plants	Large Whorled Pogonia	*Isotria verticillata*	Endangered	SW Norfolk
Birds	Least Bittern	*Ixobrychus exilis*	Threatened	
Plants	Butternut	*Juglans cinerea*	Endangered	
Plants	American Water-willow	*Justicia americana*	Threatened	W Norfolk, E Elgin
Reptiles	Milksnake	*Lampropeltis triangulum*	Special Concern	
Fish	Spotted Gar	*Lepisosteus oculatus*	Threatened	SE Elgin
Insects	Karner Blue	*Lycaeides melissa samuelis*	Extirpated	Near St. Williams in S. Norfolk, but considered extirpated provincially
Fish	Silver Chub	*Macrhybopsis storeriana*	Special Concern	Lake Erie
Plants	Cucumber Tree	*Magnolia acuminata*	Endangered	S. Norfolk
Birds	Red-headed Woodpecker	*Melanerpes erythrocephalus*	Special Concern	
Mammals	Woodland Vole	*Microtus pinetorum*	Special Concern	
Fish	Pugnose Shiner	*Notropis anogenus*	Endangered	W&S Norfolk, SW Haldimand
Fish	Silver Shiner	*Notropis photogenis*	Special Concern	Oxford, Brant, N. Norfolk
Plants	American Ginseng	*Panax quinquefolius*	Endangered	
Reptiles	Eastern Foxsnake (Carolinian population)	*Pantherophis gloydi*	Endangered	Lake Erie shore in Norfolk, Bayham
Reptiles	Gray Ratsnake (Carolinian population)	*Pantherophis spiloides*	Endangered	SW Norfolk, central Haldimand
Fish	Channel Darter	*Percina copelandi*	Threatened	tributaries of Lake Erie in E. Elgin, S. Oxford, W. Norfolk

Taxonomy	Common Name	Scientific Name	~~OND~~MNR~~F~~ Status	Notes
Plants	Broad Beech Fern	*Phegopteris hexagonoptera*	Special Concern	
Insects	West Virginia White	*Pieris virginiensis*	Special Concern	
Molluscs	Round Pigtoe	*Pleurobema sintoxia*	Endangered	May persist around Long Point
Birds	Prothonotary Warbler	*Protonotaria citrea*	Endangered	
Plants	Common Hoptree	*Ptelea trifoliata*	Threatened	SE Elgin & SW Norfolk Lake Erie shoreline, Long Point
Mammals	Mountain Lion or Cougar	*Puma concolor*	Endangered	
Molluscs	Mapleleaf Mussel	*Quadrula quadrula*	Threatened	large rivers draining into Lake Erie
Birds	King Rail	*Rallus elegans*	Endangered	in large marshes on shore of Lake Erie in Elgin, SW Norfolk
Reptiles	Queen Snake	*Regina septemvittata*	Threatened	sites in W. Norfolk & W. Haldimand
Plants	Toothcup	*Rotala ramosior*	Endangered	Norfolk
Birds	Louisiana Waterthrush	*Seiurus motacilla*	Special Concern	
Plants	Round-leaved Greenbrier	*Smilax rotundifolia*	Threatened	SW Norfolk
Reptiles	Eastern Musk Turtle	*Sternotherus odoratus*	Threatened	Southern Charlotteville and Walsingham, Long Point
Plants	Crooked-stem Aster	*Symphyotrichum prenanthoides*	Threatened	E. Elgin, SW Oxford, & W. Norfolk
Mammals	American Badger	*Taxidea taxus*	Endangered	largest population in Ontario
Plants	Virginia Goat's-rue	*Tephrosia virginiana*	Endangered	Norfolk: only known populations in Ontario
Reptiles	Eastern Ribbonsnake	*Thamnophis sauritus*	Special Concern	
Molluscs	Fawnsfoot	*Truncilla donaciformis*	Endangered	Lower portions of large Great Lakes tribs.
Birds	Greater Prairie-Chicken	*Tympanuchus cupido*	Extirpated	Extirpated in Ontario
Birds	Barn Owl	*Tyto alba*	Endangered	SE Oxford, S Brant, N&E Norfolk, Haldimand
Mammals	Grey Fox	*Urocyon cinereoargenteus*	Threatened	
Birds	Golden-winged Warbler	*Vermivora chrysoptera*	Special Concern	SW Norfolk
Plants	Bird's-foot Violet	*Viola pedata*	Endangered	Central Norfolk
Birds	Canada warbler	*Wilsonia canadensis*	Special Concern	
Birds	Hooded Warbler	*Wilsonia citrina*	Special Concern	
Insect	Rusty-patched Bumble Bee	*Bombus affinis*	Endangered	
Insects	Northern Barrens Tiger Beetle	*Cicindela patruela*	Endangered	Charlotteville
Birds	Bobolink	*Dolichonyx oryzivorus*	Threatened	
Plants	Virginia Mallow	*Sida hermaphrodita*	Endangered	Oneida
Insects	Laura's Clubtail	*Stylurus laurae*	Endangered	Big Creek, Big Otter Creek

* Source: Species at Risk in Ontario (SARO) List, 2009

~~2.19~~2.18 Interactions Between Human and Physical Geography

Land use practices in the watershed can have an increased risk to ground and surface water depending on the geology of the area. The geology can determine the infiltration, runoff and recharge rate of precipitation which corresponds to how fast and easily contaminants may be able to move and infiltrate the ground and surface water. The Norfolk Sand Plain is very permeable, and this can be a concern as runoff from agricultural practices such as fertilizers and pesticides can easily move into the soil and into groundwater supplies. In addition, agricultural crops in the area often require higher levels of water for irrigation since the available soil moisture available for crop uptake may be depleted quickly due to high infiltration rates.

The Haldimand Clay Plain provides moderate to good protection to the groundwater as infiltration of clay is low. However, precipitation moves very quickly over clay which can increase surface runoff. Agricultural land uses in this area may benefit from having water storage on the surface; however, fertilizers, pesticides and manure have an increased chance of moving into water systems through runoff. In addition, paved land in and surrounding the area increases the runoff rate and quickly moves precipitation over the clay and possibly into ground and surface water systems.

The geology and current land use practices appear to be driving some of the chronic groundwater and surface water quality issues within the Long Point Region watersheds. Watersheds that drain the clay and till plains tend to have the highest non-filterable residue and nutrient concentrations in the Long Point Region (~~e.g.~~e.g., Big Otter Creek, and Nanticoke Creek) (Evans, 2007). Land use practices such as intensive agricultural production or urban development (such as in the Lynn River watershed) are also contributing to the overall high nutrient levels found within the Long Point Region (Evans, 2007).

~~2.20~~2.19 Watershed Characterization Data Gaps

The following data gaps (**Table 2-8**) have been identified in the Watershed Characterization component of the Long Point Region Source Protection Area Assessment Report.

Table 2-8: Data gaps in watershed characterization

Data	Plan to Address Data Gap	Progress to Address Data Gap
Location of federal lands in the watershed	Data on the location of federal lands is not currently available. As new information is released, it will be included in an updated Assessment Report.	Data on the location of federal land is not available as of October 2017.
List of non-municipal drinking water systems	Working with the public health units and the Ministry of the Environment	This item remains as a data gap as efforts are still being made to fully characterize existing non-municipal drinking water systems.

Data	Plan to Address Data Gap	Progress to Address Data Gap
	to improve the available data on non-municipal drinking water systems. This information will be included in an amendment to the Assessment Report.	
Location of monitoring wells related to drinking water systems	Working with municipalities to improve the available data on ~~non-municipal drinking water systems~~municipal monitoring wells. This information will be included in an amendment to the Assessment Report.	Municipal monitoring well data is provided where there have been studies to delineate WHPAs. Although the data is used in local groundwater models for model calibration it has not been documented in the updated Assessment Report.
Geologic characterization	While the regional flow system is thought to be insensitive to the varying geologic characterizations, local flow systems may be significantly impacted. To reduce uncertainty associated with local studies, it is recommended that additional effort be expended on accurately characterizing the subsurface, including, interpreting cross sections and drilling additional boreholes (LESPR, 2010).	One of the key uncertainties identified during the Tier 2 Assessment (AquaResource, 2009a) was the lack of detailed geological and hydrogeological data beneath the upper sand aquifer. To address these data gaps, a drilling program was undertaken to improve the understanding of the geology across the Focus Area of the Long Point Region Tier 3 Water Budget Study ~~and Local Area Risk Assessment~~. ~~Twenty six~~Twenty-six boreholes were drilled into the top of bedrock as part of the drilling program with the main purpose of refining the regional geology of the area. The 26 boreholes were converted into monitoring well nests with typically one to three monitoring wells per location and a total of 58 monitoring wells were installed. Nine drive-point piezometers were installed in various reaches of Patterson Creek, Stoney Creek and Kent Creek to refine the understanding of how groundwater and surface water interact in these creeks. Water level monitoring was conducted, water quality was sampled in 51 wells, and hydraulic testing was undertaken at 48 monitoring wells. The data collected in the field program was assembled and used to develop an improved understanding of the geology and hydrogeology of the Long Point area.

~~2.21~~2.20 Watershed Characterization Section Summary

- The Long Point Region watershed is located in ~~south western~~southwestern Ontario and covers an area of approximately 2,900 km^2, being almost 100km at its widest and 60km running north to south.

- The watershed has 225 km of Lake Erie shoreline, including the internationally renowned Long Point sand spit.

- Many different watercourses make up the Long Point Region, each with their own traits and values. The combined length of all streams and tributaries in Long Point Region watershed is over 3,700 km.

- Much of the land area of the watershed is used for agricultural purposes. Several medium-sized urban centres including Tillsonburg (Oxford County), Simcoe and Delhi (Norfolk County) make up the majority of the watershed area's population.

- Long Point Region watershed is home to ~~over~~ 1184,8452~~8~~ residents, with over 564% serviced by municipal water supplies.

- Long Point Region is divided into 24 subwatersheds for the purpose of the water budget; prominent streams in the region include Big Creek, Big Otter Creek, Lynn River, Nanticoke Creek, and Sandusk Creek.

- There are 3 major physiographic regions in Long Point region: the Norfolk Sand Plain, the Haldimand Clay Play and the Horseshoe Moraine/Mount Elgin Ridges.

    - Much of the central and western portion of the watershed is within the Norfolk Sand Plain, with high infiltration, high groundwater recharge and good baseflows in the creeks.

    - The eastern side of the watershed is in the Haldimand Clay Plain, characterized by fine-grain silts and clays resulting in high runoff from poorly drained soils.

    - The northwestern portion of the watershed is comprised of low to moderate relief till moraines of the Horseshoe Moraine/Mount Elgin Ridges.

- The watershed is underlain by a series of gently dipping sedimentary rocks consisting of shales, carbonates and sandstone. These rocks are overlain by unconsolidated sediments of variable thickness and porosity.

- Two overburden aquifers are the main source of water for private supplies in the central portion of the watershed, while bedrock aquifers are used in the eastern portion of the Haldimand Clay Plain.

- The shallow upper overburden aquifer mainly supports most of the private water supplies, for domestic and agricultural purposes, as well as some municipal wells in the Norfolk Sand Plain.

- The deeper overburden aquifer can range from 0 to 30 m thick, disappearing when the shallower aquifer is more than 20 m thick.

- The Long Point Region has amongst the highest density of Provincial Permits-to-take-water in Southern Ontario. Most of these permits are for agricultural irrigation.

- Annual average precipitation from the years 1935 to 2016 is 940 mm, which is distributed fairly evenly throughout the year.

- Stream flows are quite variable throughout the year, with high flows in the spring from snowmelt, and much lower flows in the summer months which can be exacerbated by high irrigation demand in the Norfolk Sand Plain, or lack of groundwater contribution in the Haldimand Clay Plain.

- There are 10 active streamflow (WSC) gauges, 10 water quality monitoring stations (PWQMN) and 10 LPRCA operated water control structures for flow augmentation, flood control and recreation across the Long Point Region watershed.

- The land area is dominated by intensive agriculture, yet forest cover has recovered to 21%. Wetlands are a significant feature of the watershed area, making up almost 9% of the land area.

- Stream water quality and temperature is influenced by the geology and current land use.

    - The Haldimand Clay Plain and moraine areas support livestock operations and general cash crop production. Lack of vegetative cover and low groundwater recharge and discharge results in both higher water temperatures and phosphorus concentrations from runoff.

    - Specialty crops and high irrigation rates in the Norfolk Sand Plain result in elevated nitrate levels due to runoff and infiltration. However, high groundwater recharge and discharge rates create sufficient water quality to support cold water fisheries.

- There are ten municipal wastewater treatment plants and lagoons that discharge continuously or seasonally into the creeks, and two that discharge into Lake Erie.

- Nutrient levels, primarily nitrate, phosphorus and non-filterable residue, are the main surface water quality concerns throughout the Long Point Region watershed area.

- As of 2009, there are 85 species at risk found in Long Point Region watershed area, including 14 reptiles and amphibians, 30 birds and insects, 14 fish and mollusks, 23 plants and mosses and 4 mammals

3.0 WATER QUALITY RISK ASSESSMENT METHODOLOGY

3.1 Overview of the Source Protection Risk Assessment Process

~~A~~ Source Protection Area Assessment Report~~s are summaries~~ ~~is a summary~~ of technical studies that identify: ~~have the objective of:~~

- The vulnerable areas around municipal-residential drinking water sources
- How "vulnerable" the vulnerable areas are
- Where potential threats to water quality and quantity can be found in each vulnerable area
- The activities that pose the biggest threat to human health
- How significant the risk of the threat is of contaminating or depleting the water supply

~~Mapping areas surrounding municipal drinking water sources in which land use activities could impact the water quality or water supply to the municipal water source. These are termed Wellhead Protection Areas (WHPAs).~~

~~Ranking areas within WHPAs that have an increased potential or vulnerability for impacting the municipal supply~~

~~Identifying potential water quality and water quantity threats to the municipal supply within the WHPAs.~~

~~Identifying activities that pose the largest potential threat to the quality or quantity of the municipal supply.~~

~~Ranking the significance of threats and activites to potentially impacting the quality or quantity of the municipal supply.~~

3.1.1 Vulnerable Areas

What are vulnerable areas?

The *Clean Water Act, 2006* identifies four types of vulnerable areas related to drinking water sources:

- Highly Vulnerable Aquifers (HVA)
- Significant Groundwater Recharge Areas (SGRA)
- Wellhead Protection Areas (WHPA)
- Intake Protection Zones (IPZ)

The first three vulnerable areas are associated with groundwater, while intake protection zones are associated with surface water (rivers and lakes). The Highly Vulnerable Aquifer areas, Significant Groundwater Recharge Areas and Wellhead Protection Areas are determined through complex modelling of the geology and groundwater flow in an area, as well as the permeability of surface material above the groundwater (aquifers). Details regarding the methodology for mapping SGRAs are found in Section 10.3.4. The

Intake Protection Zones are determined by assessing the flow of surface water in the river or lake.

Wellhead Protection Areas and Intake Protection Zones are developed specifically around municipal water supplies (around groundwater wells or surface water intakes). Highly Vulnerable Aquifers and Significant Groundwater Recharge Areas are assessed at the watershed scale, and are not necessarily associated with any existing groundwater municipal drinking water systems.

~~Highly Vulnerable Aquifers, Significant Groundwater Recharge Areas and Wellhead Protection Areas are delineated through qualitative and quantitative assessments of the geology and groundwater flow in an area. Intake Protection Zones are generated through the assessment of surface water flow in the watercourse or lake where a municipal intake is located.~~

~~Wellhead Protection Areas and Intake Protection Zones are developed specifically for municipal groundwater and surface water supplies. Highly Vulnerable Aquifers and Significant Groundwater Recharge Areas are assessed at the watershed scale, and are not necessarily associated with an existing municipal drinking water system.~~

~~What is vulnerability?~~

~~"Vulnerability" describes the sensitivity a of drinking water source such as an aquifer or surface water feature to negative water quality impacts from anthropogenically derived materials. The vulnerability of an area is applied as a score, ranging from 1 to 10, with 10 being the most vulnerable. The process for assessing vulnerability differs between aquifers and surface water.~~

Groundwater

Wellhead Protection Areas

A WHPA is a policy area used to describe scientifically based capture zones delineated for water supply wells. The Technical Rules ~~(MECP, 2021)~~ require that WHPAs for groundwater quality be delineated for each municipal drinking water supply well. A WHPA consists of four zones which are based on the time it takes for groundwater to travel from the water table surface to the municipal well. The zones are defined as follows:

- WHPA-A: 100 m radius around the municipal well
- WHPA-B: Time of travel to the municipal well is 2 years or less
- WHPA-C: Time of travel to the municipal well is equal to or less than 5 years and greater than 2 years
- WHPA-D: Time of travel to the municipal well is equal to or less than 25 years and greater than 5 years

A WHPA-E can be delineated for groundwater wells when there is an interaction between the surface water and ground water supply that may impact the water quality at the well.

~~*Methodology for WHPA*~~ *Delineation of Wellhead Protection Areas*

Within the Long Point Region watershed, calibrated, numerical groundwater flow models are used to delineate capture zones. A groundwater flow model is a simplified representation of a complex physical, hydrologic and hydrogeologic system where natural and anthropogenic processes affect the rates and direction of groundwater flow.

Using the groundwater flow models, capture zones in the Long Point Region watershed are delineated through time of travel assessments using particle tracking. Virtual particles are released in the groundwater flow model at the well screen of the municipal well and tracked backward through the saturated portion of the aquifer for specified time intervals. The resulting particle paths are then projected to ground surface and plotted in plan view. Time-of-travel capture zones are subsequently created by drawing polygons around the wells and the particles path lines at specific times. As such, capture zones represent the land areas beneath which groundwater and associated contaminants may migrate toward a well within a specified period.

WHPA-Es are mapped from the point of interaction between groundwater that is the source of raw water supply for the well and the surface water that is directly influencing that groundwater. In cases where the point of interaction is unknown, the WHPA-E is delineated from the point in the surface water body influencing the raw water supply for the well that is closest in proximity to the well.

Aquifer Vulnerability

Municipal wells draw their water from aquifers located beneath the ground surface. Aquifers are replenished when surface water infiltrates into the groundwater system. Sometimes, the water infiltrating from the ground surface can carry pollutants into the groundwater system, such as road salt, nitrate from fertilizers, or industrial chemicals from associated land use activities.

An aquifer vulnerability analysis is a physically based evaluation of the geologic and hydrogeologic character of the sediments and bedrock overlying the municipal aquifer. The resulting calculations provide a rating of the intrinsic vulnerability for the aquifer of interest. The calculated vulnerability is highly dependent upon a number of factors which include the geologic structure, the hydraulic character of the sediments, the vertical hydraulic gradient, and the hydraulic connection between the surficial recharge water and the aquifer of interest.

Numerous approaches are available to estimate groundwater intrinsic vulnerability such as the Intrinsic Susceptibility Index (ISI), Aquifer Vulnerability Index (AVI), Surface to Well Advective Time (SWAT), Surface to Aquifer Advective Time (SAAT), all of which are approved under the ~~*Clean Water Act* (2006)~~ Technical Rules. The results from the aquifer vulnerability assessment are classified to map areas of high, medium and low intrinsic vulnerability.

The ISI and AVI methods use a scoring system that reflects the thickness and the type of overburden or bedrock material. Aquifers which have a high calculated vulnerability

have an ISI or AVI score less than 30, meaning the overlying material is thin and/or permeable. Aquifers with a low vulnerability have an ISI or AVI score greater than 80, meaning the overlying material is thicker and/or less permeable. Aquifers with a medium vulnerability will have a score that falls between 30 and 80.

The SAAT and SWAT methods for determining aquifer intrinsic vulnerability are determined through use of the calibrated numerical groundwater flow models. SWAT is determined as the zone in which all particles are assumed to be able to travel from ground surface down to a well screen. SWAT is equivalent to the Unsaturated Zone Advective Time (UZAT) plus the Water table to Well Advective Time (WWAT). SAAT is determined as the zone in which all particles are assumed to be able to travel from ground surface to the top of the pumped aquifer (or top of the water table if the pumped well is in an unconfined aquifer). Aquifers with a high calculated vulnerability have a SAAT/SWAT score less than five years. Aquifers with a low calculated vulnerability have a SAAT/SWAT score 25 years or greater. Aquifers with a medium vulnerability have a score that falls between five and 24 years.~~Municipal wells draw their water from underground areas called “aquifers.” These are places where water fills cracks in bedrock or spaces between grains of sand or gravel.~~

~~Aquifers are replenished when water from rain and melting snow soaks into the ground. Sometimes, the water can carry pollutants from the surface to an aquifer.~~

~~It can take years, or even decades, for water to move from the surface to the aquifer or to move within an aquifer toward a well. The rate at which groundwater moves depends on the characteristics of the soil, bedrock in the area and the pumping rate of other nearby wells.~~

~~Sometimes, water can find a shortcut from the surface to the aquifer, such as through an abandoned well or an old gravel pit. These are referred to in the Assessment Report as transport pathways.~~

~~To determine the vulnerability score for an aquifer, the following questions must be considered:~~

~~How quickly does water move vertically from the surface down to the aquifer?~~

~~This is called “intrinsic vulnerability” and is ranked as low, medium or high, depending on the characteristics of the soil and bedrock in the area.~~

~~The answer to this question was used to delineate Highly Vulnerable Aquifers within Long Point Region.~~

~~How quickly does water move horizontally through an aquifer to the well?~~

~~This information was used to map Wellhead Protection Areas (WHPAs) around municipal groundwater supply wells. A WHPA is the area around the municipal wellhead where land use activities have the greatest potential to affect the quality of water that flows into the well. A WHPA consists of up to four separate areas (WHPA-A to WHPA-~~

~~D) based on how long it takes water within the aquifer to reach the well. This is also known as the time-of-travel (TOT). The exception is the WHPA closest to the well (WHPA-A), which is simply a 100m radius around the well established to offer maximum protection to the well. Other WHPAs include; WHPA-B (2 year TOT), WHPA-C (5 year TOT), WHPA-D (25 year TOT). To obtain the vulnerability score for a WHPA, both the rates of vertical and horizontal movement of water through the ground are used and a scoring matrix is applied according to the Technical Rules (MOE, 2009).~~

Vulnerability Scoring within WHPAs

To obtain the vulnerability score within a WHPA, a scoring matrix is applied which intersects the WHPA zones with the aquifer vulnerability classification. The scores applied, as shown in **Table 3-1** and **Table 3-2** below, are dependent on the method used for the vulnerability analysis.

Table 3-1: Wellhead Protection Area Vulnerability Scores – ISI/AVI

Groundwater Vulnerability Category for the Area	WHPA-A	WHPA-B	WHPA-C	WHPA-D
High	10	10	8	6
Medium	10	8	6	4
Low	10	6	4	2

Table 3-2: Wellhead Protection Area Vulnerability Scores – SAAT/SWAT

Groundwater Vulnerability Category for the Area	WHPA-A	WHPA-B	WHPA-C	WHPA-D
High	10	10	8	6
Medium	10	8	6	4
Low	10	6	2	2

Vulnerability within WHPA-Es is assessed relative to how an IPZ-2 is assigned vulnerability scores. The area vulnerability factor for IPZ -2 is assigned a value ranging between 7 and 9 using professional judgement, where 9 is the highest vulnerability score (Technical Rule 89).

Transport Pathways

A constructed transport pathway is a shortcut, which can make it easier for a contaminant to be transported to a drinking water source. The vulnerability of the municipal aquifers accounts only for the natural protection provided by the materials overlying the aquifers of interest; however, anthropogenic activities can bypass this natural physical protection thereby increasing the vulnerability. Examples of transport

pathways include unused or improperly decommissioned water wells, construction of underground services, subsurface excavations, pits and quarries.

The vulnerability of the municipal supply aquifer may be increased by any land use activity or feature that disturbs the surface above the aquifer, or which artificially enhances flow to that aquifer. In areas where transport pathways exist, the vulnerability can be increased to reflect the higher vulnerability caused by the constructed pathway (i.e., from low to moderate or high, and moderate to high). In some cases, the intrinsic vulnerability index is already high and cannot be further increased.

The vulnerability of the aquifer is only increased to account for a transport pathway where there is sufficient confidence in the available data to justify the increase in vulnerability.

Surface Water

Some municipalities rely on surface water to supply drinking water to their residents. Surface water is transported through an intake pipe directly from the lake or river into a water treatment system. Protecting the area around a surface water intake means protecting the surrounding water and, in most cases, the land that surrounds the water. This area of water and land is known as an Intake Protection Zone, or IPZ.

The Technical Rules classify surface water intakes according to their location, with slightly different rules for delineating the IPZ and vulnerability score for the four different classifications.

The four classifications are:

- Type A: Intake or the planned intake is or would be located in a Great Lake;
- Type B: Intake or the planned intake is or would be located in a connecting channel;
- Type C: Intake or the planned intake is or would be located in a river and neither the direction nor velocity of the flow of the water at the intake is affected by a water impoundment structure; or
- Type D: If the intake is not Type A, B or C.

Delineation of Intake Protection Zones

For each of the four surface water intake types, three IPZs (IPZ-1, IPZ-2, IPZ-3) are identified. The methodologies for delineation of the vulnerable areas around a surface water intake are detailed as follows.

IPZ-1 is a fixed distance from the intake based on the sensitivity analysis of a massive sudden spill in the vicinity of the intake. For intake types A and D, the IPZ-1 is defined by a 1 km radius centered on the crib of the intake. The IPZ-1 for intake type B is defined by a semi-circle that has a radius of 1 km extending upstream from the crib of the intake and a rectangle with a length of 2 km centred on the crib of the intake and a

width of 100 metres extending downstream from the crib of the intake. For intake type C, the IPZ-1 is defined by a semi-circle that has a radius of 200 metres extending upstream from the crib of the intake and a rectangle with a length of 400 metres centred on the crib of the intake and a width of 10 metres downstream of the intake.

IPZ-2 represents the operator response time to shut down the drinking water system in case of a spill. For intake types A, B, C and D, the IPZ-2 is defined as the area that may contribute water to the intake where the time of travel to the intake is equal to or less than the time that is sufficient to allow the operator of the system to respond to an adverse condition in the quality of the surface water. The Technical Rules indicate that a minimum 2-hour time of travel should be used to delineate the IPZ-2 (excluding IPZ-1).

IPZ-3 is an area beyond the IPZ-1 and 2 and is delineated differently based on the intake type. For intake types A, B, C and D, the IPZ-3 is defined as the area of the water and land that may lead to contaminants reaching an intake during an extreme event such as a one in one hundred year rainfall as determined through modeling or other methods. Significant threats are then identified if it can be shown through modeling that a release of a contaminant during an extreme event may be transported to the intake. For intake types C and D not located in Lake Nipissing, Lake Simcoe, Lake St. Clair, or the Ottawa River, the IPZ-3 is defined as the area within each surface water body that may contribute water to the intake within the watershed boundary.

For all intake types where the IPZ-1, IPZ-2 and IPZ-3 abuts land, a setback of less than or equal to 120m or the Conservation Authority Regulation limit is included, whichever, is greater. The setback is measured from the high-water mark of the surface water body that encompasses the area where overland flow drains into the surface water body and the areas of the Conservation Authority Regulation limit along the abutted land.

According to Technical Rule 72 and 73 (MECP, 2021), where an area that is an IPZ-2 or IPZ-3 includes a setback from a surface waterbody delineated with sub rules 65(1), 68(2), 70(2) the area may be extended to include an area that contributes water to the IPZ-2 or IPZ-3, through a natural or anthropogenic transport pathway. The following factors shall be considered when determining the extended area:

- The hydrological conditions of the area where the transport pathway is located.
- Where a transport pathway is anthropogenic in origin, the type and design of the pathway.
- In respect of an IPZ-2, the time of travel for water to enter into and pass through the transport pathway.

Vulnerability Scoring of Intake Protection Zones

The vulnerability score (V) is a numerical expression of the susceptibility of the intake to contamination. Vulnerability scores are assigned for each type of intake for IPZ-1 and IPZ-2 and for type C and type D intakes for IPZ-3. The vulnerability scores are based on the attributes of the intakes (e.g., length and depth), type of source water body, and the physical characteristics of the environment it is situated in. The vulnerability score (V) is

a unitless factor and is calculated by multiplying area vulnerability factor (B) by the source vulnerability factor (C).

The area vulnerability factor (B) is unique for each IPZ and relates to features and processes in the local environment that may impact the intake. The area vulnerability factor was prescribed by the Technical Rules for all IPZ-1s, which receive a score of 10, regardless of the type of intake. Typical factors that may dictate the area vulnerability factor for IPZ-2s include percentage of the area of the IPZ-2 that is composed of land, land cover, soil type, permeability and slope and hydrological conditions in the area that contribute water to the area via transport pathways. The area vulnerability factor for IPZ-3s must be based upon the above listed factors as well as proximity to the intake. The source vulnerability factor (C) relates to the type of water body, intake characteristics (length, depth) and number of recorded drinking water issues.

The IPZ-3 related to type A intake or type B intake is not assigned a vulnerability score, while areas within an IPZ-3 related to type C intake and type D intake are. According to Technical Rule 91, the area vulnerability factor for the IPZ-3, or an area within it, cannot be greater than the area vulnerability factor for IPZ-2.

~~Surface Water Vulnerability~~

~~River intakes can be contaminated when dangerous materials are spilled into the water or on nearby land. It may take only a few minutes or hours for spilled material to reach a drinking water intake on a river or lake.~~

~~Intake Protection Zones (IPZ) have been established around each municipal intake. These are areas within which a spill or leak may get to the intake too quickly for the operators of the municipal water treatment plant to shut the intake down before the pollutant passes by.~~

~~As part of the technical studies, researchers determined how quickly water moves downstream or across a lake in various conditions. They identified streams, municipal storm sewers or rural drains that enter the river or lake upstream of, or close to the intake. Vulnerability scores range from 1 to 10, with 10 being the most vulnerable.~~

~~River Intakes~~

~~The vulnerability of river-based intakes is assessed differently than lake-based intakes. River intakes have three Intake Protection Zones:~~

~~**IPZ-1**~~

~~The 200-metre area immediately upstream of the intake. Vulnerability scores range from 9 to 10.~~

~~**IPZ-2**~~

~~This is the area where water can reach the intake in a specified time, usually two to six hours, based on how much time the operator needs to shut down the intake when a spill occurs upstream. Vulnerability scores range from 6.3 to 9.~~

~~**IPZ-3**~~

~~Areas further upstream that may affect an intake. The vulnerability score would be less than the IPZ-2 score for that intake.~~

~~Great Lake Intakes~~

~~For Lake Erie intakes, researchers studied how water moves in the area around the intake, based on currents, winds and other factors. They also identified onshore areas~~

~~drained by rivers, streams, storm sewers and other drains that empty into the lake near the intake.~~
~~There are three types of Intake Protection Zones for lake intakes:~~
~~**IPZ-1**~~
~~A one-kilometre circle around the intake, which may include some onshore areas. Vulnerability score ranges from 5 to 7.~~
~~**IPZ-2**~~
~~This is the area where water can reach the intake in a specified time, usually two to six hours, based on how much time the operator needs to shut down the intake when a spill occurs upstream. Vulnerability scores range from 3.5 to 6.3.~~
~~**IPZ-3**~~
~~An area where the storage or handling of a chemical in large amounts could, if the facility fails, seriously affect the quality of water at the intake. All such activities are considered significant threats. No vulnerability score is assigned to a Great Lake IPZ-3.~~

Uncertainty Assessment

An analysis of the uncertainty, characterized by “high” or “low”, is made on the vulnerability of each delineated WHPA and IPZ (Technical Rules 13 and 14) (MECP, 2021). The uncertainty rating should consider the following:

1. The distribution, variability, quality and relevance of data used in the preparation of the assessment report.
2. The ability of the methods and models used to accurately reflect the flow processes in the hydrological system.
3. The quality assurance and quality control procedures applied.
4. The extent and level of calibration and validation achieved for models used or calculations or general assessments completed.
5. The accuracy to which the groundwater vulnerability categories effectively assess the relative vulnerability of the underlying hydrogeological features.
6. The accuracy to which the area vulnerability factor and the source vulnerability factor effectively assesses the relative vulnerability of the hydrological features.

3.2 ~~Municipal Drinking Water Threats~~ Drinking Water Threats Assessment – Water Quality

The Ontario *Clean Water Act, 2006* defines a Drinking Water Threat as “an activity or condition that adversely affects or has the potential to adversely affect the quality or quantity of any water that is or may be used as a source of drinking water and includes an activity or condition that is prescribed by the regulation as a drinking water threat.”

~~What are threats to drinking water?~~

~~Researchers have studied the areas around municipal wells and intakes to identify the human activities that could threaten municipal water supplies.~~

~~There are three categories of threats – chemicals, pathogens and water quantity threats.~~

~~**Chemical** threats include solvents, fuels, fertilizers, pesticides and similar products. They can be found in many different places such as factories, storage depots, gasoline stations or farms.~~

~~A **pathogen** is a dangerous micro-organism (e.g. bacteria or virus) found in human or animal waste. For example, human pathogens can be found in septic tanks; farm manure contains animal pathogens.~~

~~**Water quantity** threats are activities that reduce the ability of water to "recharge" or migrate from the ground surface to an aquifer, and activities that contribute to the overuse of water in an area.~~

~~How are the locations of potential threats identified?~~

The Technical Rules ~~(MECPMOE, 2009a2021)~~ list five ways in which to identify a drinking water threat:

a) Through an activity prescribed by the Act as a Prescribed Drinking Water Threat;
b) Through an activity identified by the Source Water Protection Committee as an activity that may be a threat and (in the opinion of the Director) a hazard assessment confirms that the activity is a threat;
c) Through a condition that has resulted from past activities that could affect the quality of drinking water;
d) Through an activity associated with a drinking water issue; and
e) Through an activity identified through the events-based approach ~~(this approach has not been used in this Assessment Report).~~

3.2.1 Threats from Activities

The province has identified 22 activities where, if present in vulnerable areas, now or in the future, could pose a threat to drinking water quality or quantity (listed in Section 1.1 of O. Reg. 287/07). Twenty of these activities are relevant to drinking water quality threats, while two are relevant to drinking water quantity threats (Threats 19 and 20). **Table 3-3** lists the prescribed drinking water threats alongside typical land use activities that are associated with the threat.

Table 3-3: Drinking Water Threats

Prescribed Drinking Water Threat	Land Use / Activity
1.The establishment, operation or maintenance of a waste disposal site within the meaning of Part V of the Environmental Protection Act.	Landfills – Active, Closed Hazardous Waste Disposal Liquid Industrial Waste
2. The establishment, operation or maintenance of a system that collects, stores, transmits, treats or disposes of sewage.	Sewage Infrastructures Septic Systems, etc.

Prescribed Drinking Water Threat	Land Use / Activity
3. The application of agricultural source material to land.	e.g., manure, organic soil conditioners, anaerobic digestion output, etc.
4. The storage of agricultural source material.	e.g., manure, organic soil conditioners, anaerobic digestion output, etc.
5. The management of agricultural source material.	Aquaculture
6. The application of non-agricultural source material to land.	e.g., organic waste matter derived from the production of biodiesel, organic Soil conditioners, pulp, paper and sewage biosolids
7. The handling and storage of non-agricultural source material.	e.g., organic waste matter derived from the production of biodiesel, organic Soil conditioners, pulp, paper and sewage biosolids
8. The application of commercial fertilizer to land.	Agriculture Fertilizer
9. The handling and storage of commercial fertilizer.	General Fertilizer Storage
10. The application of pesticide to land.	Pesticides
11. The handling and storage of pesticide.	General Pesticide Storage
12. The application of road salt.	Road Salt Application
13. The handling and storage of road salt.	Road Salt Storage
14. The storage of snow.	Snow Dumps
15. The handling and storage of fuel.	Petroleum Hydrocarbons
16. The handling and storage of a dense non-aqueous phase liquid.	DNAPLs
17. The handling and storage of an organic solvent	Organic Solvents
18. The management of runoff that contains chemicals used in the de-icing of aircraft.	De-icing
19. An activity that takes water from an aquifer or a surface water body without returning the water taken to the same aquifer or surface water body.	Private water taking
20. An activity that reduces the recharge of an aquifer.	Impervious Surfaces
21. The use of land as livestock grazing or pasturing land, an outdoor confinement area or a farm-animal yard.	Agricultural Operations
22. The establishment and operation of a liquid hydrocarbon pipeline. O. Reg. 385/08, s. 3; O. Reg. 206/18, s. 1.	Liquid Hydrocarbon Pipelines

Reference: Clean Water Act, 2006 O. Reg. 287/07 Section 1.1

Assessing Threats from Activities

Once lists of threats have been compiled, the next step is to determine circumstances under which the threats may be low, moderate, or significant for each vulnerable area. The Ministry's Tables of Drinking Water Quality Threats outline the circumstances (including managed lands, livestock density, and impervious surface area) under which a given activity is classified as a low, moderate, or significant threat. The Source Water Protection Information Portal can be used as a complementary tool to aid threat identification. **Table 3-4** provides a summary of threat levels possible for Chemical, Dense Non-Aqueous Phase Liquid (DNAPL), and Pathogen threats for a given vulnerable area and vulnerability score. Vulnerability score maps as well as maps of managed lands, livestock density, and impervious surface area are found within each municipal Assessment Report chapter. Vulnerability score ranges shown in **Table 3-4** may overlap for low, moderate, and significant threat categories due to the different threat activities possible within a given threat type.

~~Ministry's tables of drinking water quality threatsreferenced~~The enumeration of land use activities that may be associated with prescribed drinking water threats is based on a review of multiple data sources, including public records, data provided by municipal officials, previous contaminant/historical land use information, and data collected during windshield surveys. When available, site-specific information is collected to confirm the presence of drinking water threats and the level of management determined.

The method for determining when an activity is a threat is based on a semi-quantitative risk assessment. The assessment considers both the nature of the activity or condition (the hazard rating) and the vulnerability of the affected area (WHPA-A to E, IPZ-1, IPZ-2 and IPZ-3). Both the vulnerability and calculated hazard scores are used to determine a risk score.

All significant threats must be addressed in the Source Protection Plan. The ~~LESPR~~Lake Erie Source Protection Region SPC may choose to develop policies to address low or moderate drinking water threats.

Table 3-4: Identification of Drinking Water Quality Threats in Vulnerable Areas

Threat Type	Vulnerable Area	Significant Threat Scores	Moderate Threat Scores	Low Threat Scores
Chemical	WHPA-A	10	10	10
Chemical	WHPA-B	8 – 10	6 – 10	6 – 10
Chemical	WHPA-C	8	6 – 8	6 – 8
Chemical	WHPA-D	-	6	6
Chemical	WHPA-E	8 – 9	6.3 – 9	4.2 – 9
Chemical	IPZ-1	8 – 10	6 – 10	5 – 10
Chemical	IPZ-2	8 – 9	6.3 – 9	4.2 – 9
Chemical	IPZ-3	8 – 9	6 – 9	4.2 – 9

Threat Type	Vulnerable Area	Significant Threat Scores	Moderate Threat Scores	Low Threat Scores
Chemical	HVA	-	6	6
DNAPL	WHPA-A	10	-	-
DNAPL	WHPA-B	6 – 10	-	-
DNAPL	WHPA-C	2 – 8	-	-
DNAPL	WHPA-D	-	-	6
DNAPL	WHPA-E	9	7 – 9	4.5 – 8.1
DNAPL	IPZ-1	9 – 10	7 – 10	5 – 8
DNAPL	IPZ-2	9	7 – 9	4.5 – 8.1
DNAPL	IPZ-3	9	7 – 9	4.5 – 8.1
DNAPL	HVA	-	-	6
Pathogen	WHPA-A	10	10	-
Pathogen	WHPA-B	10	8 – 10	6 – 8
Pathogen	WHPA-C	-	-	-
Pathogen	WHPA-D	-	-	-
Pathogen	WHPA-E	8 – 9	6.3 – 9	4.2 – 9
Pathogen	IPZ-1	8 – 10	6 – 10	5 – 10
Pathogen	IPZ-2	8 – 9	6.3 – 9	4.2 – 9
Pathogen	IPZ-3	8 – 9	6 – 9	4.2 – 9
Pathogen	HVA	-	-	-

~~Threats can fall into one of the following four categories:~~

~~Chemical threats can include toxic metals, pesticides, fertilizers, petroleum products and industrial solvents;~~

~~Pathogenic threats are microorganisms that could cause illness; and~~

~~Dense non-aqueous phase liquids (DNAPLs) are chemicals which are denser than water and do not dissolve in water, such as chlorinated solvents.~~

~~Through a condition that has resulted from past activities that could affect the quality of drinking water.~~

~~Researchers working for municipalities or conservation authorities have used a variety of means to identify the locations of potential threats. They include things such as provincial pesticide registries, publicly available industrial databases, interviews with property owners, questionnaires and other means.~~

Details on individual threats, including their location and information will not be identified in the Assessment Report. Property owners are notified directly if it is believed that an activity on their land is a potential threat in order to confirm the information.

Assigning 'Hazard Ratings' to Activities

Not all threats are equal. The level of risk to human health posed by particular chemicals and pathogens depends on several factors including:

The amount

The toxicity

How it behaves in the environment (e.g. Does the chemical move rapidly or slowly through the ground? How long do bacteria live in groundwater?)

The Ontario Ministry of the Environment, Conservation and Parks has produced a table identifying hundreds of potential chemical and pathogen threats. The threats have been given a score on a scale of 1 to 10 with 10 being the most dangerous. This is known as the "hazard rating." The table indicates where activities will be threats, based on the level of vulnerability. This information is available online at: http://swpip.ca.

Calculating Threat Level: Low, Moderate or Significant

The goal of the *Clean Water Act, 2006* is to reduce the risk posed by significant threats to water and to prevent new significant threats from developing. So, it is necessary to sort out which potential threats are significant and which pose low or moderate risks. This is done by calculating the "risk score."

The risk score is a combination of two factors: the vulnerability of the water source (on a scale of 1 to 10) and the hazard rating of the threat (also on a scale of 1 to 10).

The risk score is calculated by multiplying the two factors together to provide a score out of 100. The score is then put into one of three categories; significant, moderate, or low.

Threat	Risk Score
Significant	80 – 100
Moderate	60 - 79
Low	41 – 59
(Threats with risk scores lower than 40 do not have to be dealt with under the *Clean Water Act, 2006*.)	

Examples

Significant Chemical Threat

~~A chemical used in manufacturing has been identified as a possible cause of cancer in humans. It moves easily through the ground and does not break down. It has a hazard rating of 9. A factory just 100 metres upstream from a river intake has a storage tank containing a large amount of the chemical. If the tank were to leak, the chemical could get to the intake in a few minutes. The vulnerability score where the tank is located is 9. The risk score (vulnerability x hazard) would be 81, making it a significant threat.~~

~~Significant Pathogen Threat - Residential~~

~~A home near a municipal well has an old, failing septic system and untreated sewage is leaking into the ground. The area has a vulnerability score of 10 and the sewage has a hazard rating of 10. The result is a risk score of 100 making it a significant threat.~~

~~Significant Pathogen Threat – Farm~~

~~A farmer spreads manure on his fields to fertilize them. There is a municipal well on the property next door. The vulnerability score for the farmer's land is 8. The hazard rating for manure is 10. The result is a risk score of 80, making it a significant threat.~~

~~What does this mean for your property?~~

~~A property owner or business can use the Assessment Report to determine whether an activity on their property might be classified as a significant threat. If your property is close to a municipal drinking water system, you can use the vulnerability maps in Sections 4 to 7 and 10 of this report and the Tables of Drinking Water Threats complied by the Ministry of the Environment, Conservation and Parks (http://swpip.ca), to determine whether your property is in a vulnerable area where Source Protection Plan policies may apply.~~

~~If an activity is identified as a significant threat, the owner will be required to reduce the risk posed by the activity, or demonstrate that actions taken by the owner have already reduced the risk.~~

~~That is why it is a good idea to think about any opportunities you have right now to decrease the risk that an activity on your land could pollute a municipal water source.~~

~~That action might include:~~

~~For an industry: developing a spill response program or upgrading chemical storage facilities~~

~~For a rural resident: upgrading an old septic system or decommissioning an old well~~

~~For a farmer: upgrading fuel tanks or developing a nutrient management plan~~

3.2.2 Threats from Conditions

Conditions relate to past or historic activities. Conditions must fall into one of the statements below which are listed in Rule 126 of the Technical Rules (MECP, 2021). If the source protection committee is aware of one of the following conditions that results from a past activity, the committee shall list it as a drinking water threat.

- The presence of a non-aqueous phase liquid in groundwater in a highly vulnerable aquifer or wellhead protection area.

- The presence of a single mass of more than 100 litres of one or more dense non-aqueous phase liquids in surface water in a surface water intake protection zone.
- The presence of a contaminant in groundwater in a highly vulnerable aquifer or a wellhead protection area, if the contaminant is listed in Table 2 of the Soil, Ground Water and Sediment Standards, is present at a concentration that exceeds the potable groundwater standard set out for the contaminant in that Table, and the presence of the contaminant in groundwater could result in the deterioration of the groundwater for use as a source of drinking water.
- The presence of a contaminant in surface soil in a surface water intake protection zone if, the contaminant is listed in Table 4 of the Soil, Ground Water and Sediment Standards is present at a concentration that exceeds the surface soil standard for industrial/commercial/community property use set out for the contaminant in that Table and the presence of the contaminant in surface soil could result in the deterioration of the surface water for use as a source of drinking water.
- The presence of a contaminant in sediment in an intake protection zone, if the contaminant is listed in Table 1 of the Soil, Ground Water and Sediment Standards and is present at a concentration that exceeds the sediment standard set out for the contaminant in that Table, and the presence of the contaminant in sediment could result in the deterioration of the surface water for use as a source of drinking water.
- The presence of a contaminant in groundwater that is discharging into an intake protection zone, if the contaminant is listed in Table 2 of the Soil, Ground Water and Sediment Standards, the concentration of the contaminant exceeds the potable groundwater standard set out for that contaminant in the Table, and the presence of the contaminant in groundwater could result in the deterioration of the surface water for use as a source of drinking water.

3.2.3 Threats from Issues ~~and Issue Contributing Areas (WHPA-ICAs / IPZ-ICAs)~~

A drinking water Issue is defined as the presence of a parameter, listed in Schedules 1, 2, or 3 (listed below) of O. Reg. 170/03, or Table 4 of the Technical Support Document for the Ontario Drinking Water Quality Standards (ODWQS) Objectives and Guidelines, at a concentration or a trend of increasing concentration, that may result in the deterioration of the quality of water for use as a source of drinking water. Pathogens are also considered an Issue if they are present at concentrations or a trend of increasing concentrations that may result in the deterioration of the quality of water for use as a source of drinking water. In addition to these parameters, the SPC may identify other parameters for the Issues evaluation.

- **Schedule 1 Parameters***:* These include two indicator microorganisms namely E. coli and total coliform. These microorganisms are present in fecal matter (e.g., sewage effluents) and their presence indicates the presence of harmful pathogens, such as Giardia and Cryptosporidium.
- **Schedule 2 Parameters***:* Schedule 2 parameters include chemical parameters (e.g., metals, inorganics, pesticides and neurotoxins). These parameters are

potentially toxic and may adversely affect human health at or above certain concentrations in drinking water. Some of these parameters occur naturally in the environment, while others are results of human activities.

- **Schedule 3 Parameters***:* These parameters include radio-active materials such as uranium-235. These parameters are potentially toxic and may adversely affect human health at or above certain concentrations in drinking water.
- **Schedule 4 Parameters***:* These consist mostly of parameters that may impair the taste, odour or colour of the water. These parameters may adversely impact the treatment, disinfection and the distribution of the treated water. The ODWQS identifies either aesthetic objectives (AOs) or operational guidelines (OGs) for the parameters.

Where a drinking water Issue is identified, the objective is to identify all sources and threats that may contribute to the Issue within an Issue Contributing Area (WHPA-ICA or IPZ-ICA) and manage these threats appropriately. All threats related to a particular Issue within the WHPA-ICA or IPZ-ICA are classified as significant drinking water threats, regardless of the vulnerability.

There are drinking water systems with identified nitrate Issues in Long Point Region. All prescribed threat activities that are associated with nitrogen and that would be identified as a significant drinking water threat if they exist within a nitrate WHPA-ICA / IPZ-ICA are listed in **Table 3-5**.

Table 3-5: Activities that Contribute to Nitrogen Issues within an Issue Contributing Area (WHPA-ICA / IPZ-ICA)

Threat Sub-Category	Quantity Threshold for Significant Threat
1.1 Disposal of Hauled Sewage to Land	Any quantity for IPZs/WHPA-Es and WHPAs
1.2 Application of Processed Organic Waste to Land	Any quantity for IPZs/WHPA-Es and WHPAs
1.4 Landfilling (Hazardous Waste or Liquid Industrial Waste)	Any quantity for IPZs/WHPA-Es and WHPAs
1.5 Landfilling (Municipal Waste)	Any quantity for IPZs/WHPA-Es and WHPAs
1.8 Storage of Hauled Sewage	Any quantity for IPZs/WHPA-Es and WHPAs
1.9 Storage of Processed Organic Waste or Waste Biomass	Any quantity for IPZs/WHPA-Es and WHPAs
1.14 Storage, Treatment and Discharge of Tailings From Mines	Any quantity for IPZs/WHPA-Es and WHPAs
2.1 Industrial Effluent Discharges	Any quantity for IPZs/WHPA-Es and WHPAs
2.2 Onsite Sewage Works	Any quantity for IPZs/WHPA-Es and WHPAs
2.3 Storm Water Management Facilities and Drainage Systems: Outfall from a Storm Water Management Facility or Storm Water Drainage System	Any quantity for IPZs/WHPA-Es and WHPAs

Threat Sub-Category	Quantity Threshold for Significant Threat
2.4 Storm Water Management Facilities and Drainage Systems: Storm Water Infiltration Facility	Any quantity for IPZs/WHPA-Es and WHPAs
2.5 Wastewater Collection Facilities and Associated Parts: Sanitary Sewers	>250 m^3/day for IPZs/WHPA-Es Any quantity for WHPAs
2.6 Wastewater Collection Facilities and Associated Parts: Outfall of a Combined Sewer Overflow (CSO), or a Sanitary Sewer Overflow (SSO) from a Manhole or Wet Well	Any quantity for IPZs/WHPA-Es > 250 m^3/day for WHPAs
2.7.1 - 2.7.5 Wastewater Collection Facilities and Associated Parts: Sewage Pumping Station or Lift Station Wet Well	> 250 m^3/day for IPZs/WHPA-Es Any quantity for WHPAs
2.7.6 - 2.7.10 Wastewater Collection Facilities and Associated Parts: a Holding Tank or a Tunnel	> 250 m^3/day for IPZs/WHPA-Es Any quantity for WHPAs
2.8 Wastewater Treatment Facilities and Associated Parts	Any quantity for IPZs/WHPA-Es and WHPAs
3.1 Application of Agricultural Source Material (ASM) to land	Any quantity for IPZs/WHPA-Es and WHPAs
4.1 Storage of Agricultural Source Material (ASM)	Any quantity for IPZs/WHPA-Es and WHPAs
6.1 Application of Non-Agricultural Source Material (NASM) to land	Any quantity for IPZs/WHPA-Es and WHPAs
7.1 Handling and Storage of Non-Agricultural Source Material (NASM)	Any quantity for IPZs/WHPA-Es and WHPAs
8.1 Application of Commercial Fertilizer to Land	Any quantity for IPZs/WHPA-Es and WHPAs
9.1 Handling and Storage of Commercial Fertilizer	Any quantity for IPZs/WHPA-Es and WHPAs
21.1 Agricultural Source Material (ASM) Generation - Livestock Grazing or Pasturing	Any quantity for IPZs/WHPA-Es and WHPAs
21.2 Agricultural Source Material (ASM) Generation - Outdoor Confinement Area (OCA) or Farm Animal Yard	Any quantity for IPZs/WHPA-Es and WHPAs

3.3 Aquifer Vulnerability in Long Point Region Watershed ~~Area~~

~~An aquifer's susceptibility to contaminants introduced at the ground surface can be evaluated through an aquifer vulnerability assessment: a physically based evaluation of the geologic and hydrogeologic character of the overlying sediments. The resulting vulnerability is highly dependent upon a number of factors which include the geologic structure, the hydraulic character of the sediments, the vertical hydraulic gradient, and~~

~~the hydraulic connection between the surficial recharge water and the aquifer of interest.~~

~~Numerous models are available to evaluate groundwater vulnerability [i.e. Intrinsic Susceptibility Index (ISI), Aquifer Vulnerability Index (AVI), Surface to Well Advective Time (SWAT), Surface to Aquifer Advective Time (SAAT).~~ For the majority of the Long Point Region, the SAAT model was chosen to estimate aquifer vulnerability on the watershed scale (Earthfx, 2008). Note that the method(s) used at the scale of individual drinking water systems described throughout the remainder of the Assessment Report may differ from the original watershed scale assessment presented here. ~~The modelling to determine groundwater vulnerability is based upon information current to 2008.~~The SAAT method estimates the travel time for a particle of water to move vertically from the ground surface to the top of the aquifer that is being pumped. Areas of common travel time are mapped as being less than 5 years (high vulnerability), greater than or equal to 5 and less than 25 years (medium vulnerability), or greater than or equal to 25 years (low vulnerability).

Aquifer vulnerability mapping across Long Point Region is shown on **Map 3-1**. North-south trending areas of high and medium vulnerability located throughout the central portion of the watershed generally correspond to the shallow unconfined aquifer of the Norfolk Sand Plain. The western and eastern extents of the watershed are predominantly mapped as low vulnerability. These two areas are generally comprised of the clay-rich Port Stanley Till to the west and the Haldimand Clay Plain to the east, both of which provide protection to the deeper, confined aquifers.

3.3.1 Methodology

The primary source of data for the SAAT vulnerability calculation was the ~~MOECC's~~ MECP's Water Well Information System (WWIS). This database was then further built upon by adding information from the Ministry of Transportation's GEOCRES database. Datasets were then refined to remove low-quality data using the following methods:

- Location Quality Assurance (QA) update: Much of the pre-2004 data in the Lake Erie Source Protection Region database had location information that was processed and corrected by the MNR. ~~More recent l~~information~~,~~ made available by the MECP~~MOE~~ in August 2006, did not include the MNR location assessment and corrections and, instead, relied on an older location classification system. The different QA classification codes were ~~reconciled~~reconciled, and a consistent classification system was developed.
- Ground surface elevations assigned to all boreholes: Consistent surface elevations are required for assessing aquifer geometry, water table and potentials in the deeper aquifers. The digital elevation model (MNR Version 2.0 DEM) elevation was assigned to the ground surface recorded for each borehole. All elevation related information, including well construction, geology and water level data was then corrected to the new reference elevation. Boreholes with ground elevations based on engineering surveys (QA code 1) were assumed to

have better elevation data than the DEM and were not assigned the DEM elevation.

- Selection of high-quality wells: Wells with an integrated QA code of less than 6 were considered to be of “high quality” and were used in the vulnerability calculations.
- Bedrock flags updated: Shallow bedrock wells were handled specially. Although the number and extent of these wells is limited, they are important in some areas. The bedrock flag code in the database was checked against the bedrock lithology material codes for consistency. Other internal consistency checks were also performed to confirm the selection of these wells.
- Well screen classifications updated: Correct well screen data is important for identifying the target aquifer. Many wells in the MECP~~MOE~~ WWIS database have missing or incomplete information on well construction and do not have a well screen zone defined. A series of procedures and QA checks were made to assign screen zones to those wells.

The SAAT method estimates aquifer vulnerability in units of time. The travel time has two components: unsaturated zone advective time (UZAT) and the water table to aquifer advective time (WAAT).

The input parameters and data sources for each parameter for the unsaturated zone advective time (UZAT) and water table to aquifer advective time (WAAT) calculations are listed below.

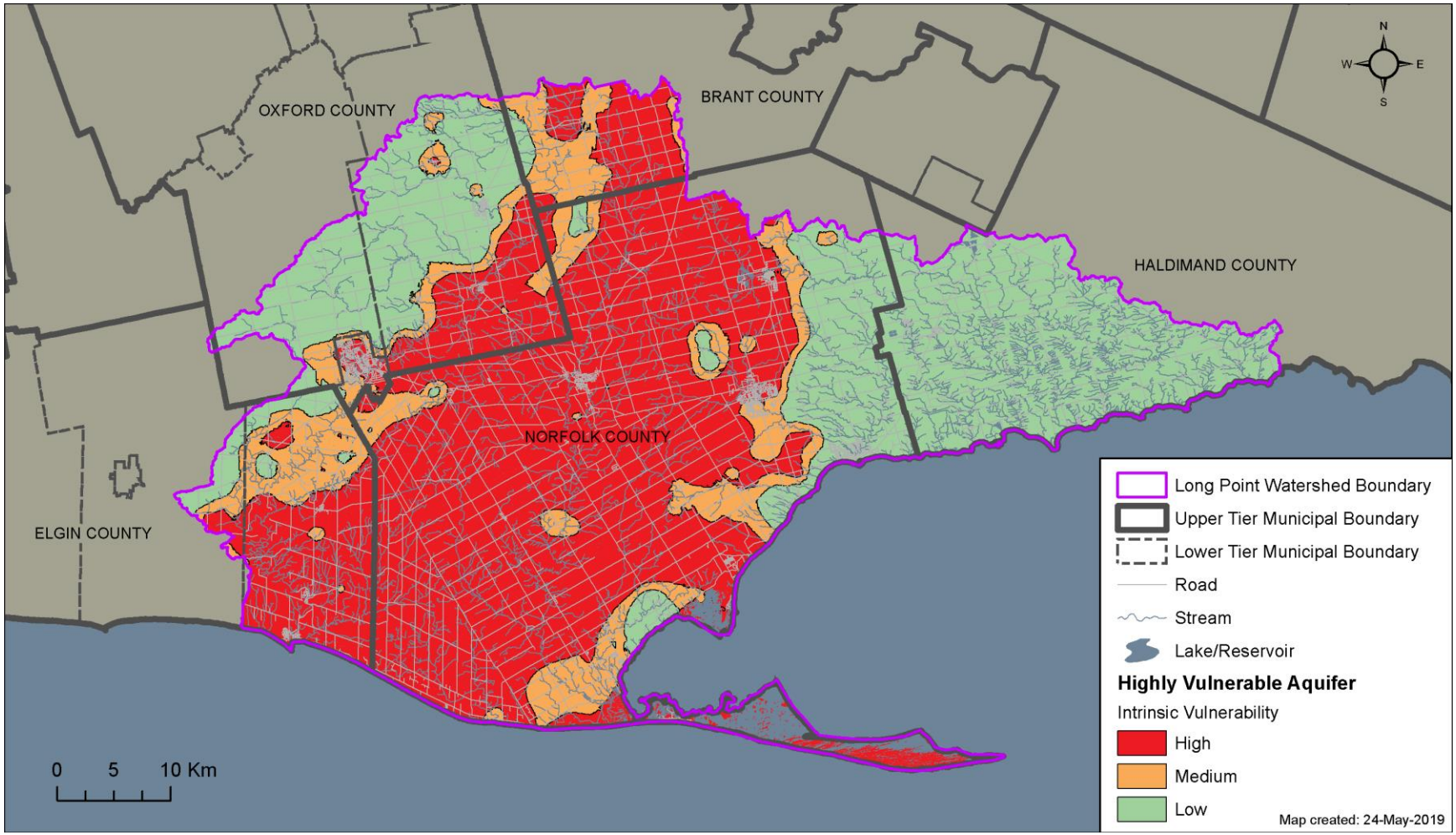
For the unsaturated zone advective time (UZAT) calculation, the following inputs were required:

- Depth to water table~~;~~ computed by subtracting the interpolated water table surface from the land surface digital elevation model (MNR Version 2.0 DEM),
- Mobile moisture content~~;~~ assigned to each geologic material based on specific yield values obtained from Todd (1980), and
- Infiltration rate~~;~~ assumed to be equal to recharge rates developed by Schroeter & Associates (2006c).

The water table to aquifer advective time (WAAT) calculation required the following inputs:

- Aquifer porosity~~;~~ estimated for each geological material from Todd (1980),
- Thickness of the geologic layer~~;~~ calculated from the borehole logs, and
- Vertical hydraulic conductivity~~;~~ estimated based on the geologic materials listed in the borehole logs.

Map 3-1: Aquifer Vulnerability



Estimated depth to water table was computed by subtracting the interpolated water table surface from land surface elevation. The mobile moisture content of the surface material was used as a surrogate for the average moisture content of the soil under steady-state drainage at the infiltration rate. The value of average moisture content under steady state drainage should lie somewhere between field capacity and porosity for the particular soil. Guidance Module 3 (MOE, 2006b) suggests values for mobile moisture content that can be applied to a map of the quaternary geology. However, it was felt that the mobile moisture content in the unsaturated zone was more likely to be related to the drainable porosity than to field capacity. Accordingly estimates of mobile moisture content were assigned to each geologic material based on representative specific yield and porosity values obtained from Table 2.5 in Todd (1980).

It was assumed that the infiltration rate was equal to the recharge rate determined from maps developed by Schroeter & Associates (2006a, 2006b, 2006c) using the GAWSER model.

If multiple layers of different types of unsaturated materials were present, the travel time through each layer was calculated and then summed over the total depth to get a total travel time.

Finally, the Technical Rules (~~MOE, 2009a~~MECP, 2021) indicate SAAT values are translated into aquifer vulnerability categories according to the following thresholds:

- <5 years represents high vulnerability
- ≥ 5 years, < 25 years represents medium vulnerability
- ≥ 25 years represents low vulnerability

Vulnerability for the Erie Spits physiographic region, located at the southeast portion of the Long Point Region, was assigned a high vulnerability based on professional review of the surficial geology layer and other resources available for this location. This region is comprised of predominantly sand deposits with a limited elevation above the lake with groundwater levels at or near lake level.

Peer Review

The Earthfx (2008) SAAT report was peer reviewed by Chris Neville of S.S. Papadopulos and Associates. The review found the Earthfx (2008) report to be in compliance with the *Clean Water Act, 2006* Technical Rules. ~~The reviewer's general impression was that the SAAT evaluation approach described in Sections 4, 5 and 6 of the report is consistent with the MOE Technical Rules for Groundwater Vulnerability.~~ In the reviewer's opinion, the examination of uncertainty in the evaluation was particularly well done. In general, the results of the vulnerability assessment are reasonable.

Given that the peer review comments would not change the overall outcome of the Earthfx (2008) study, no changes were made to the report following the review.

3.3.2 Limitations and Uncertainty

Although numerous steps were taken to exclude WWIS data of lower reliability, the uncertainty associated with several of the components of the WWIS (location accuracy, reliability of geologic log, measurement of water level, etc.) represent a significant limitation in the assessment. There is also natural variability in the hydraulic conductivity which is not captured in the analysis.

However, given that the SAAT approach~~analysis~~ used~~s~~ the most current methods (under the *Clean Water Act, 2006* Technical Rules) and data available (at the time of analysis), the uncertainty rating ~~at this time~~ can be considered low.

3.4 Highly Vulnerable Aquifers

Areas classified as having a high vulnerability are considered Highly Vulnerable Aquifers (HVAs) and can have water quality policies associated with them. Highly Vulnerable Aquifer areas in the Long Point Region Source Protection Area are identified as the red areas on **Map 3-2**.

3.4.1 Vulnerability Scoring in Highly Vulnerable Aquifers

According to the Technical Rules, highly vulnerable aquifer areas outside of the Wellhead Protection Areas are assigned a vulnerability score of 6. The highly vulnerable aquifer areas illustrated on **Map 3-2** therefore, receive a vulnerability score of 6.

3.4.2 Managed Lands and Livestock Density for Highly Vulnerable Aquifers

This section provides a description of the methodology used to calculate the percent managed land and the livestock density for the HVA areas in the Long Point Region watershed.

The methods to calculate the managed lands and livestock density follow the Technical Bulletin entitled “Proposed Methodology for Calculating Percentage of Managed Lands and Livestock Density for Land Application of Agricultural Source of Material, Non Agricultural Source of Material and Commercial Fertilizers” issued by the Province in September 2009, and following guidance provided in the “Preliminary Technical Memo issued by GRCA for Lake Erie Region technical studies: Managed Lands and Livestock Density” ~~on September 23,~~in December 2009.

Managed Lands Area Methodology

Managed lands are divided into two categories:~~,~~ agricultural managed lands (AML) and non-agricultural managed lands (NAML). Agricultural managed land includes cropland, fallow and improved pasture~~-~~land that may receive agricultural source material (ASM). Non-agricultural managed lands include golf courses, residential lawns and other turf that may receive commercial fertilizer or non-agricultural source material (NASM).

Land use classifications for land area are based on data from the Municipal Property Assessment Corporation (MPAC), who provide a parcel layer in GIS format (**Table 3-8**~~Table 3-3~~). Each parcel has a code describing the main land cover classification, including codes for agricultural land, residential, commercial and industrial land. All MPAC farm codes (3-digit numbers starting with 2) were considered in the agricultural managed lands calculation, if they were within or partially within (intersecting) the HVA areas. All other categories were considered in the non-agricultural category to determine the amount of non-agricultural managed lands~~,~~ if they intersected the HVA areas.

In some cases, additional classification was required where the MPAC data layer did not provide enough information on which to determine the land use on a parcel of land. Using the 2006 ortho-photo (**Table 3-8**~~Table 3-3~~), air photo interpretation was used to determine whether a parcel of land should be classified as agricultural or non-agricultural.

In the managed lands calculations, areas of wetlands, impervious area, wooded areas, water bodies and aggregate license areas were removed from consideration. To account for buildings and other areas that may not receive nutrients, all farm parcels were given a managed lands ratio of 0.9, meaning that 90% of the parcel was subject to ASM and considered agriculturally managed land.

Agricultural Managed Lands Calculation

All parcels of land classified as agricultural within the HVA were used in the calculation of agricultural managed lands. For each separate (discontinuous) unit of HVA, the total area of agricultural managed land was summed. Where a parcel of land fell only partially within a HVA area, only that portion contained by the HVA was included in the calculation. These agricultural managed lands area would be summed with the non-agricultural managed lands area to get the total percent managed land in each HVA area.

Non-Agricultural Managed Land Calculation

All parcels touching the HVA areas that had a non-agricultural MPAC code or were classified as non-agricultural using air photo interpretation were used in the calculation of non-agricultural managed lands. To account for buildings and other areas that may not receive nutrients, all parcels were given a managed lands ratio as seen in **Table 3-6**~~Table 3-1~~.

The non-residential values in **Table 3-6**~~Table 3-1~~ were generated through aerial photo interpretation. Areas that were deemed to be managed lands in each category were compared to the rest of the area within the parcel to determine an appropriate ratio. The average value for each parcel estimated in each category was rounded to the nearest 5% to give an overall managed land ratio.

The managed land ratio for residential areas is based on impervious cover analysis completed for the Alder Creek Subwatershed Study in the City of Kitchener (Rungis, G.,

pers. comm.). The percentage of pervious cover used in this study provides a good estimate of the area that may receive commercial fertilizer on residential properties.

For each discontinuous unit of HVA, the total area of non-agricultural managed land within the HVA was summed. Where a parcel of land fell only partially within a HVA area, only that portion contained by the HVA was included in the calculation. The non-agricultural managed lands and the agricultural managed lands areas were then summed and divided by the area of the HVA area to get the total percent managed land. Final results are shown in **Map 3-3**.

Table 3-6~~3-4~~: Managed Land Ratios for land use categories

Major Category	Specific Category	Managed Land Ratio
Farm	all types of farms	0.9
Golf Course	Driving range/golf centre - stand alone, not part of a regulation golf course	0.6
Golf Course	Golf course	0.95
Institutional	Non-school, i.e., hospitals	0.6
Institutional	School (elementary or secondary, including private)	0.65
Open Space	Residential development land	0.55
Open Space	Vacant land condominium (residential)-defined land that is described by a condominium plan	0.55
Other	Cemetery	1
Other	Large office building (generally multi - tenanted, over 7,500 s.f.)	0.45
Other	Local government airport	0.9
Other	Place of worship - with a clergy residence	0.55
Other	Place of Worship - without a clergy residence	0.55
Other	Private airport/hangar	0.65
Other	Property in process of redevelopment utilizing existing structure(s)	0.55
Recreational	Amusement park	0.5
Recreational	Commercial sport complex	0.45
Recreational	Exhibition grounds/fair grounds	0.7
Recreational	Municipal Park (excludes Provincial parks, Federal parks, campgrounds)	0.65
Recreational	Non-commercial sports complex	0.5
Recreational	Recreational sport club - non commercial (excludes golf clubs and ski resorts)	0.6
Residential	High-density, multi-unit	0.55
Residential	Residential-Low Density (standard single dwelling units)	0.45

Livestock Density Methodology

The calculation of livestock density within HVA areas utilized the calculation of agricultural managed lands to determine the Nutrient Units per acre (NU/ac).

Barn Identification and Nutrient Units

To determine the Nutrient Units, each parcel of land that intersects the HVA areas was assessed using air photo interpretation for the presence of a livestock barn. The size of the barn is used as a surrogate for the number of livestock and the amount of nutrients that could be generated by those livestock on that farm unit. The description in the MPAC farm code was used initially to screen for the livestock parcels in determining the livestock type. Barns on these parcels were inspected for livestock housing areas. Other parcels on agricultural lands were also scanned for the presence of livestock barns using interpretation of the 2006 air photo. Assistance from in-house stewardship staff familiar with agricultural livestock practices increased confidence in the interpretation of housing structures in the imagery. Where housing structures could potentially house livestock but appeared in the 2006 air photo to be empty, the housing structure was included in the livestock density calculation.

Partial coverage of building footprints was available for the study area, but where data gaps existed, the buildings on parcels having a farm code were digitized based on images seen through air photo interpretation of ortho-imagery from 2006.

Each type of livestock has a unique NU conversion factor, to determine the number of animals that generate 1 NU. For instance, one beef cow produces 1 NU and requires 100 sq. ft. of living space in a barn, so the relationship for beef barns is 100 sq. ft./NU. The ratio assumes that the capacity of each livestock barn is at the maximum to generate or have the potential to generate that amount of nutrients.

Through air photo interpretation, the type of livestock housed in each barn was determined, and the area of the housing area was measured using the ArcMap geometry calculation function. A table provided in the technical memos provided by GRCA (GRCA, 2009) and MECP~~MOE~~ (MOE, 2009b) summarize the relationship between barn area, livestock type and Nutrient units generated. This information~~table~~ is provided in **Table 3-7~~Table 3-2~~** below. By multiplying the area of the barn by the NU per area ratio, the total number of NU for the farm unit was determined.

Table 3-7~~3-5~~: Barn/Nutrient Unit Relationship ~~Table~~

Livestock Type	sq. ft./NU	sq. m/NU
Dairy	120	11
Swine	70	7
Beef	100	9
Chickens	267	25
Mixed	140	13

Turkeys	260	24
Horse	275	26
Goat	200	19
Sheep	150	14
Fur	2400	223

Livestock Density Calculation

To determine the nutrient units generated only within the HVA areas, NU values for each farm unit were area weighted for the percent of the farm unit land area within the HVA. For the calculation livestock density, all the NU values for all the barns were summed and then divided by the total acreage of agricultural managed land for that particular HVA area, as calculated and detailed in previous sections. Final livestock density results for the HVA are shown on ~~(~~**Map 3-4**~~)~~.

Input Data

The calculations for managed land and livestock density were completed as a desk-top exercise. The input data used to calculate the percent managed land and the livestock density are listed in **Table 3-8~~Table 3-3~~.** Information is given on the source of the data layer, the purpose for using the data and a description of where the data originated.

Verification of the results through field inspection could provide more accurate estimates of the type of livestock and the identification of housing structures; however, this was not completed for the HVA areas in the Long Point Region.

Table 3-8~~3-6~~: Data used for Managed Land and Livestock Density Calculations

Data Input	Description	Source	Purpose
Parcels (polygon)	Municipal Property Assessment Corporation parcel fabric with primary roll number	Sub-license from Municipal Property Assessment Corporation (MPAC) under the Ontario Parcel Agreement	Minimum map unit for identifying different classes of property and farm operation types
Tax assessment record (partial) (table)	Municipal Property Assessment Corporation tax assessment database by primary roll number containing property code and farm operation code	Sub-license from Municipal Property Assessment Corporation (MPAC)	Linked to parcels, identifies tax-assessed land use, and for agricultural properties identifies primary farm operation, livestock or crop
Wetlands (polygon)	Natural Resources Values Information System (NRVIS)	Sub-license from Ontario Ministry of Natural Resources (MNR)	Used to mask for non managed land
Water body (polygon)	Natural Resources Values Information System (NRVIS)	Sub-license from Ontario Ministry of Natural Resources (MNR)	Used to mask for non managed land

Data Input	Description	Source	Purpose
License Aggregate Areas (polygon)	Pits and quarries from the Natural Resources Values Information System (NRVIS)	Sub-license from Ontario Ministry of Natural Resources (MNR)	Used to mask for non managed land
Wooded Areas (polygon)	Southern Ontario Land Resource Information System (SOLRIS)	Sub-license from Ontario Ministry of Natural Resources (MNR)	Used to mask for non managed land
Building footprints (polygon)	Building outlines digitized from digital orthorectified aerial photography from spring 2006	Grand River Conservation Authority (GRCA)	Minimum map unit for calculating livestock density per structure identified as contributing animal nutrient units
SGRA/HVA (polygon)	Significant Groundwater Recharge Area polygon and Highly Vulnerable Area	Lake Erie Source Protection Area	Reporting unit

Known Limitations and Data Gaps

The property code and farm operation code values used to identify a candidate parcel is a single descriptor assigned by MPAC during the generation of the tax assessment record. It does not necessarily represent the current land use activities on each property. None of the data used as input to the analysis was verified in the field. A quantitative estimate of data accuracy is not known. Therefore, the results should be considered as only an approximation.

The input data layers used to identify the non-managed land areas (wetlands, water bodies, wooded areas, etc.) have spatial and content accuracies of varied and unknown degrees. The NRVIS data is intended to represent 1:10,000 scale hardcopy mapping. The data layers were acquired from Land Information Ontario, and represent the best available data for their thematic content at the time of the analysis.

The values of nutrient unit per square metre of livestock type were generated by the Ontario Ministry of Agriculture, Food and Rural Affairs (Table 1 of the Nutrient Management Tables of O. Reg. 267/03 made under the *Nutrient Management Act, 2002*). The values are meant to approximate the maximum potential nutrient unit production for the size of the livestock barn structure based on best management practices. The livestock NU calculations were not field verified; therefore, the results should be considered as only an approximation.

The estimation of barn size was also approximate, as air photo interpretation cannot decipher between areas of the barn that house livestock and areas that do not. Also, the ability to determine whether the barn had one storey or two stories of housing areas was impossible through air photo interpretation and all barns were assumed to be single storey. Where there was question on livestock type, the more conservative conversion factor was used. For example, housing structures are similar between cattle and horses, but as beef generate more NU than horses per unit area, the beef conversion factor was

used. Verification of the livestock type and size of actual livestock housing area may yield more accurate results.

The ratios for non-agricultural managed lands were done using averages estimated through air photo interpretation. However, each parcel category could show very different percentages of managed land area and should only be used as approximation. Additional information from municipal by-laws on pervious cover requirements may be very useful in refining the estimates.

3.4.3 Percent Impervious Surfaces for Highly Vulnerable Aquifers

To determine whether the application of road salt poses a threat to the HVA areas, the percent impervious surface where road salt can be applied per square kilometre in each HVA area was calculated as per Technical Rule 16(11) (MOE, 2009a). The input data used to calculate the percent impervious surfaces per square kilometre are listed in **Table 3-9**~~Table 3-4~~.

The percentage of i~~I~~mpervious surface area~~s~~ in HVAs ~~areas~~ in the Long Point Region watershed ranges from 0 to < 30%~~constitute less than 8 percent of the total area~~, as shown in **Map 3-5**. ~~which represents a low percentage. Based on these results, t~~The application of road salt does not pose a threat to ~~Highly Vulnerable Aquifers~~HVAs in these areas~~Long Point Region watershed~~.

Methodology

To calculate the percent impervious surfaces, information on land cover classification was used. The Southern Ontario Land Resource Information System (SOLRIS) represents the land surface data, including road and highway transportation routes, as continuous 15x15 metre grid cells with land cover classifications. All the cells that represent highways and other impervious land surfaces used for vehicular traffic were re-coded with a cell value of “1” and all other land cover classifications were given a “0” value, to identify only the road areas.

Using the Spatial Analyst module of ArcGIS software, the total number of road cells was summed for each square kilometre area in all HVA areas. The summed value for each cell in the output equaled the total number of road cells within each 1km x 1km window. The value of summed cells was converted to the square kilometer equivalent to determine the percent impervious road surface per square kilometer. ~~The analysis is the most representative analysis of road density and adheres to the principle of the Technical Rules.~~

Known Limitations and Data Gaps

Impervious surfaces such as parking lots, pedestrian walkways and other related surfaces that may receive salt application were not considered, as data was not available for these features within the study area.

Table 3-9~~3-7~~: Input Data for Impervious Surfaces in Highly Vulnerable Aquifers

Data Input	Description	Source	Purpose
Road areas (raster)	Road and highway transportation routes as represented by the Southern Ontario Land Resource Information System (SOLRIS) version 1.2 May 2008, 15 metre raster cell format	Sub-license from Ontario Ministry of Natural Resources (MNR)	Continuous 15 x 15 metre cells represent surface areas of all highways and other impervious land surfaces used for vehicular traffic
HVA (polygon)	Highly Vulnerable Aquifer area polygon	Lake Erie Source Protection Region	Boundary of reporting unit

3.4.4 Drinking Water Threats in Highly Vulnerable Aquifers

~~**Table 3-5** indicates the possible levels of threat posed by chemicals, pathogens and dense non-aqueous phase liquids (DNAPL) within the Highly Vulnerable Aquifer areas in the Long Point Region watershed, which are illustrated on **Map 3-2**.~~ At the time of this report, a drinking water threats analysis is not necessary for Highly Vulnerable Aquifers, since no significant threats can occur in a Highly Vulnerable Aquifer with a vulnerability score of 6. Additionally, no conditions resulting from past activities have been identified in the Highly Vulnerable Aquifer areas in the Long Point Region watershed.

~~A checkmark indicates that the threat classication is possible; a blank cell indicates that it is not. The level of threat that an activity poses to a drinking water supply depends on the vulnerability scores within a vulnerable area. Since Highly Vulnerable Aquifer areas receive a vulnerability score of 6, even the most hazardous activities are not classified as significant threats. However, some chemicals and DNAPLs are or would be considered moderate and low drinking water threats in the areas illustrated in red on **Map 3-2**.~~

~~The Ontario Ministry of the Environment, Conservation and Parks produced tables that list all of the threats and associated circumstances that are or would be moderate and low drinking water threats in Highly Vulnerable Aquifer areas. These tables are no longer in use, but corresponding information is available online on the following website: http://swpip.caSource Water Protection Information Portal. This information can be used along with Map 3-2 and Table 3-5 to help the public determine where certain activities are or would be significant, moderate and low drinking water threats.~~

~~Table 3-8:Identification of Drinking Water Quality Threats in Highly Vulnerable Aquifers (HVA)~~

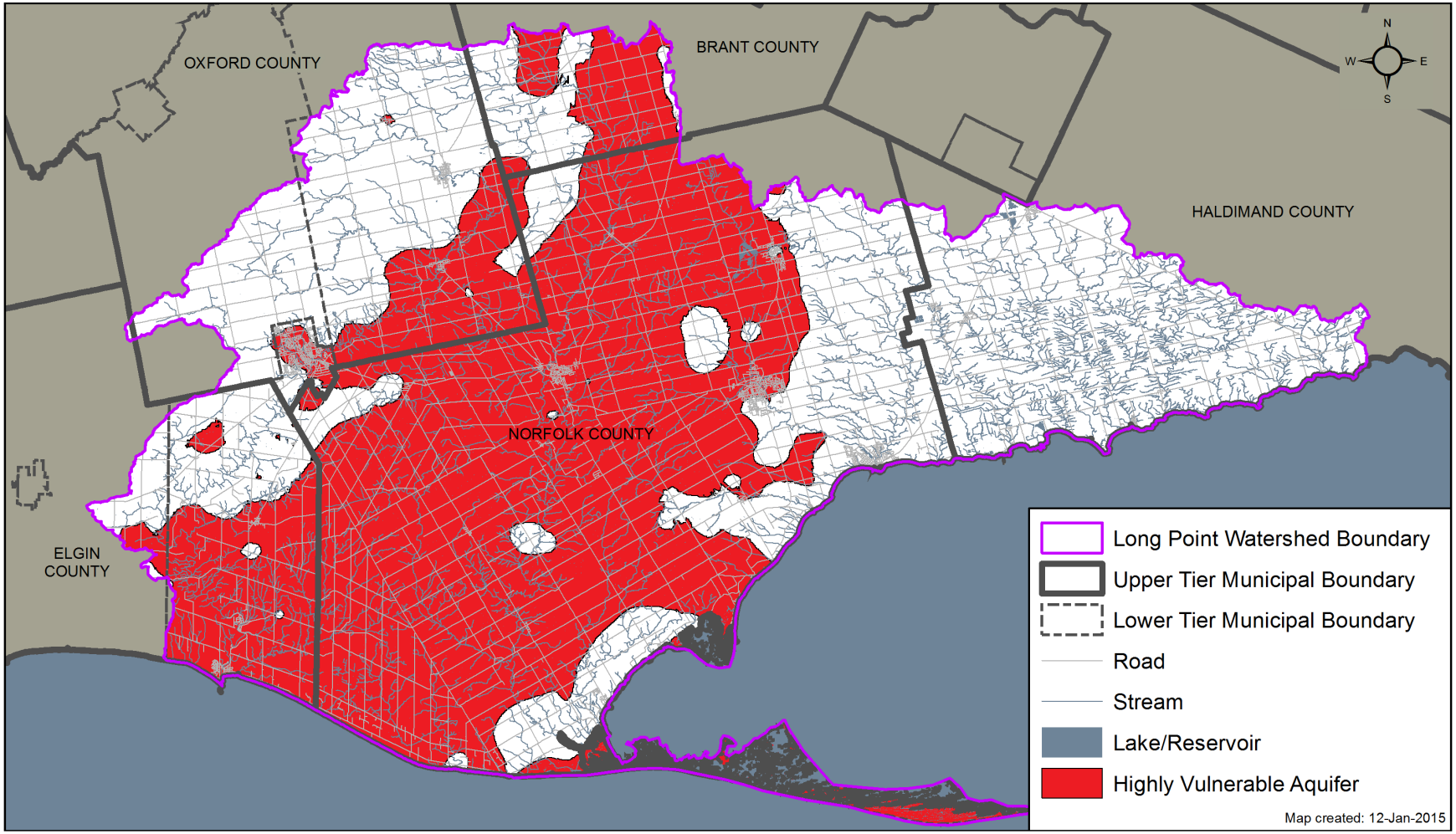
~~Threat Type~~	~~Vulnerability Score in HVA~~	~~Significant 80+~~	~~Moderate 60 to <80~~	~~Low >40 to <60~~
~~Chemical Threats~~	~~6~~		~~-~~	~~-~~
~~Handling / Storage of DNAPLs~~	~~6~~		~~-~~	~~-~~
~~Pathogens~~	~~6~~			

~~At the time of this report, a drinking water threats analysis is not necessary for Highly Vulnerable Aquifers, since no significant threats can occur in a Highly Vulnerable Aquifer with a vulnerability score of 6. Additionally, no conditions resulting from past activities have been identified in the Highly Vulnerable Aquifer areas in the Long Point Region watershed.~~

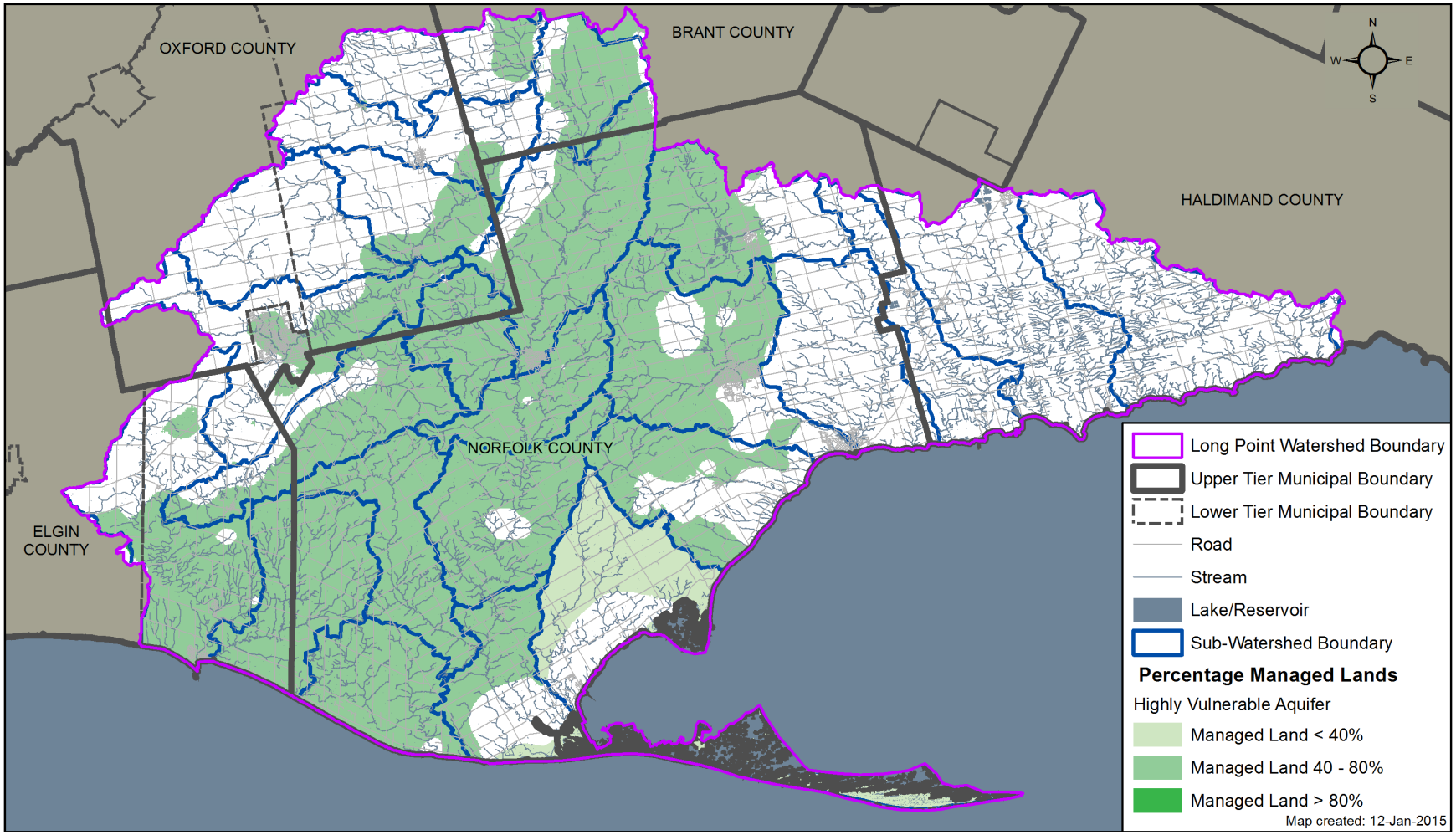
3.4.5 Drinking Water Issues in Highly Vulnerable Aquifers

No Issues have been identified in the Highly Vulnerable Aquifers to date. ~~Public Health Units are undertaking risk assessments of all small drinking water systems, and may, through that process, identify possible Issues for an updated Assessment Report.~~

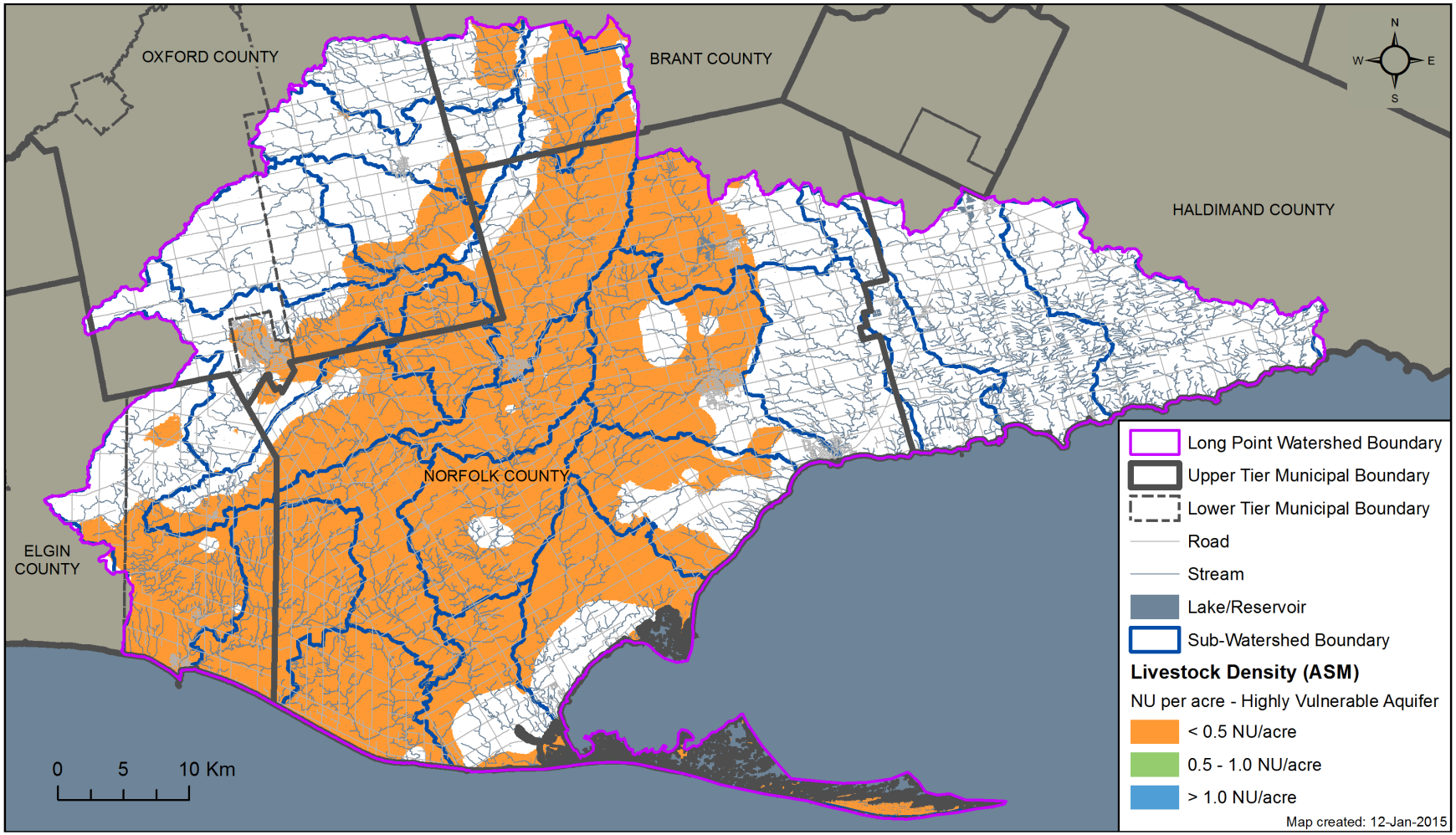
Map 3-2: Highly Vulnerable Aquifers



Map 3-3: Percent Managed Lands in Highly Vulnerable Aquifers



Map 3-4: Livestock Density in Highly Vulnerable Aquifers



Map 3-5: Impervious Surface Related to Road Salt in Highly Vulnerable Aquifers