DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER

LAKE ERIE SOURCE PROTECTION REGION

Lake Erie Region Source Protection Committee
Agenda

Thursday, October 4, 2018
1:00 pm
Auditorium
Grand River Conservation Authority
400 Clyde Road, Box 729
Cambridge, ON N1R 5W6

Pages

1. **Call to Order**

2. **Roll Call and Certification of Quorum – 17 Members Constitute a Quorum (2/3 of Members plus Chair)**

3. **Chair's Remarks**

4. **Review of Agenda**

5. **Declarations of Pecuniary Interest**

6. **Minutes of the Previous Meeting**

7. **Hearing of Delegations**

8. **Presentations**

9. **Correspondence**

    a. RE: The continued value of the Source Water Protection Program 1

    Correspondence from John Williamson, Cataraqui Source Protection Committee, on behalf of the 19 Chairs of the Source Protection Committees to the Honourable Rod Phillips, Minister of the Environment, Conservation and Parks

10. Reports

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h.	SPC-18-10-08 Draft Updated Grand River Assessment Report and Source Protection Plan: City of Hamilton and Oxford County	81
i.	SPC-18-10-09 Draft Updated Grand River Assessment Report: Non-municipal Sections	215

11. Business Arising from Previous Meetings

a. Lake Erie Region Source Protection Committee request under Technical Rule 119, from February 3, 2011, Re: rehabilitation activities at an aggregate operation within a vulnerable area of a municipal drinking water system that allows ponding of water.

12. Other Business

13. Closed Meeting

14. Next SPC Meeting

December 6, 2018 at 1:00pm, Grand River Conservation Authority, 400 Clyde Rd., Cambridge.

15. Adjourn

July 20, 2018

Hon. Rod Phillips;
Ministry of Environment, Conservation and Parks
77 Wellesley St. West
11th Floor, Ferguson Block
Toronto, ON M7A 2T5

minister.mecp@ontario.ca

First let me congratulate you on behalf of my colleagues on your appointment as the new Minister of Environment, Conservation and Parks.

In your new role we; the nineteen Chairs of Source Protection Committees appointed by the Minister, look forward to continuing to work in partnership with your staff in the Ministry, Ontario municipalities and Conservation Authorities to help deliver the multi-barrier approach to Source Water Protection as recommended by Justice O'Connor in his report on the Inquiry following the Walkerton disaster in 2000. The events left seven people dead, including a two year old child, and thousands severely ill. Many of those people continue to suffer adverse health effects today.

We have all completed Source Protection Plans for our respective areas which the Ministry has approved and are working in partnership with municipalities to implement risk management plans. This program has been a model that other provinces and countries have adopted. In addition; in some areas, we have had good partnerships with First Nations and need to continue to work with them. In fact, we have accomplished a lot and need to continue the program and it's evolution and have it continue to evolve as an essential component of the multi-barrier system of drinking water protection.

There is still much to do in Ontario to implement the full slate of recommendations from the Inquiry including working with municipalities in parts of Ontario, particularly the North, not represented by Conservation Authorities. As well, we have yet to add protection for the sources of drinking water for small rural hamlets across Southern Ontario with multiple private wells and for those rural facilities where our vulnerable members of society; the elderly and school children, reside or attend school. We have not looked at the sources of drinking water nor provided any additional protection to those sources of drinking water that are used by the roughly 25% of the population of Ontario that are rural residents. Many of these areas presently have a high percentage of wells that do not meet the standard for drinking water, in our area up to 40% in some places. We have identified large areas of Ontario with highly vulnerable ground water but have more work to do to ensure it is protected. This is very much a public health issue which helps to address one of the Premier's priorities, namely health. We are pleased that climate is included under Conservation in the new Ministry and in a year like this summer quantity becomes an issue in many areas. One only has to sit at one of the popular boat launches in the Cataraqui area to see the number of homeowners and farmers filling tanks and containers with water to augment their wells.

We generally have one of our semi-annual face-to-face meetings in the fall and we invite you to join us at our next one to share your vision with us as well as to hear our recommendations and success stories.

In closing, I quote the Canadian Environmental Law Society in Litigating Canada's Environment" chapter 6 "Tragedy on Tap: Representing Concerned Walkerton Citizens at the Walkerton Inquiry" where they reference the many lessons learned from the Inquiry "including the resilience of a community facing the previously unthinkable fact that water from our taps could be deadly if the legal system doesn't work".

We look forward to working with you to continue helping to protect the citizens of Ontario and the sources of drinking water for future generations of Ontario and to meeting with you.

Sincerely,

John Williamson,

Chair Cataraqui Source Protection Committee
(On behalf of the nineteen Source Protection Chairs)

4145 Holmes Rd. RR#1 Inverary, ON K0H 1X0

willj@kos.net

Cc. Heather Malcomson, Director, Source Protection Programs Branch.

Pat Kinch, Manager, Source Protection Programs Branch

Kim Gavine, General Manager Conservation Ontario

LAKE ERIE REGION SOURCE PROTECTION COMMITTEE

REPORT NO. SPC-18-10-01 **DATE:** October 4, 2018

TO: Members of the Lake Erie Region Source Protection Committee

SUBJECT: **Source Protection Program Update**

RECOMMENDATION:

THAT the Lake Erie Region Source Protection Committee receives report SPC-18-10-01 – Source Protection Program Update – for information.

REPORT:

Protocol for implementing regulatory requirements under the Clean Water Act, 2006, S.48 (1.1)(b) of O. Reg. 287/07

In April 2018, the Ministry of the Environment and Climate Change (MOECC) posted two decision notices on the Environmental Registry. The regulatory changes that came into effect July 1, 2018 require municipal residential drinking water system owners ensure work to assess the vulnerability of new or expanding drinking water systems is completed and accepted by the local source protection authority (SPA) before they can apply for a drinking water works permit, and that the water not be provided to the public until the source protection plan that protects the system is approved. Local SPAs must issue a notice under Section 48(1.1)(b) of the Clean Water Act, 2006 to the drinking water system owner when they are satisfied that work to update vulnerable area information for any new or expanding drinking water system has been completed.

Lake Erie Region staff have worked with the Municipal Implementation Working Group (IWG), and specifically staff from the Region of Waterloo and City of Guelph, to develop an administrative protocol for use by municipalities and SPAs in the Lake Erie Region to help implement the new requirements. On August 29, 2018, the protocol has been endorsed by the Lake Erie Region Management Committee, and has subsequently been released to municipalities and SPAs. The protocol is attached for your information.

Concurrently, Grand River SPA staff have requested and received authorization to issue the Section 48(1.1)(b) notice from the Grand River SPA on August 24, 2018. The first two notices have been issued the same day to the Township of Southgate (Dundalk) and City of Hamilton (Lynden) for completed source protection work for new wells expanding the respective drinking water systems.

SPC Member Terms of Appointment Plan

At the most recent SPC meeting on June 21, 2018, staff presented the draft SPC Member Terms of Appointment Plan that took into account the regulatory changes in 2015 and subsequent discussions with the Source Protection Committee and Lake Erie Region

Management Committee. The plan guides the decisions around member appointments and aims to balance member renewal and retention of expertise. On August 29, 2018, the Lake Erie Region Management Committee has reviewed and endorsed the revised SPC Member Terms of Appointment Plan. The final version is attached for your information.

SPC Meeting Outlook

Lake Erie Region is planning to complete two S.34 updates of the Grand River Source Protection Plan in the coming year.

The first update will be for the County of Grey, Township of Southgate (Dundalk), City of Hamilton (Lynden), and County of Brant (Airport, St. George, Bethel, and Mt. Pleasant) municipal water supply systems. These updates are accelerated to support earlier approval of the Grand River Source Protection Plan and Assessment Report that includes these updates. Timely approval is needed by municipalities to provide water to the public from these expanded systems as a result of the regulatory changes that came into effect July 1, 2018.

The second larger “bundled” update to the Grand River Source Protection Plan and Assessment Report will include updates for all other municipal water supply systems.

Technical studies and updates to the Grand River Assessment Report and Source Protection Plan sections are on track and are continued to be presented to the Source Protection Committee as work is completed over the next three (3) committee meetings including October 4, 2018. The next committee meetings are proposed for December 6, 2018, and February 7, 2019. The meeting originally scheduled on January 17, 2019 is proposed to be cancelled.

For the Southgate/Hamilton/Brant update a complete draft updated Assessment Report and Source Protection Plan is scheduled for release for pre-consultation on December 6, 2018. Public consultation follows in February/March 2019 and any comments with additional proposed revisions brought back to the SPC on April 4, 2019. The Grand River Source Protection Authority is expected to submit the amended Grand River Assessment Report and Source Protection Plan with updates for Southgate/Hamilton/Brant to the MECP at its meeting on April 26, 2019.

Pre-consultation for the “bundled” update is scheduled to start following the February 7, 2019 SPC meeting. The anticipated timeline for presenting the completed updated Assessment Report and Source Protection Plan to the SPC remains unchanged and is scheduled for April 4, 2019, at which time the draft updated Assessment Report and Plan would be released for formal public consultation. Any comments will be brought back to the SPC on June 20, 2019 with additional proposed revisions, as necessary. The Grand River Source Protection Authority is expected to submit the amended Assessment Report and Source Protection Plan to the MECP at its meeting on June 28, 2019.

The following table provides an overview of the next several SPC meetings and anticipated agenda items related to the S.34 Southgate/Hamilton/Brant and S.34 “bundled” Grand River updates. The timeline includes an additional SPC meeting on April 25, 2018 in case additional time is needed to complete the water quantity policies for the Guelph-Guelph/Eramosa area. Submission of the updated Grand River Source Protection Plan would remain the same following public consultation and the SPC meeting on June 20, 2018.

SPC Meeting Date	Agenda Items	
	S. 34 Southgate/Hamilton/Brant Update	**S.34 "bundled" Grand River Update (all other sections)**
October 4, 2018	• Bethel water quality technical study • Mt. Pleasant water quality technical study • Draft updated AR and SPP sections: Hamilton	• Draft updated AR and SPP sections: Oxford • Draft updated AR sections: introduction, watershed characterization update, overview of water budget framework, Tier 2 water budget
December 6, 2018	• Draft updated AR and SPP sections: Brant • Complete draft updated AR and SPP (Southgate, Hamilton, Brant): release for pre-consultation and public consultation process	• Draft water quantity policy approaches (Guelph-Guelph/Eramosa) • Water quality technical reports • Draft updated AR and SPP sections: Guelph-Guelph / Eramosa Tier 3, Whitemans Tier 3, Water Quality Risk Assessment
February 7, 2019		• Draft water quantity policies (Guelph-Guelph/Eramosa) • Draft updated AR and SPP sections; release for pre-consultation and public consultation process • Revised draft water quantity policies
December 10, 2018 – February 5, 2019	Municipal and ministry pre-consultation period (8 weeks)	
February 11 – March 25, 2019		Municipal and ministry pre-consultation period (6 weeks)
February 12 – March 18, 2019	Formal public consultation period (36 days)	
April 4, 2019	• Revised draft updated AR and SPP (Southgate, Hamilton,	• Revised water quantity policies and updated municipal SPP

SPC Meeting Date	Agenda Items	
	S. 34 Southgate/Hamilton/Brant Update	**S.34 “bundled” Grand River Update (all other sections)**
	Brant): receive public comments for consideration; release the document to the Grand River Source Protection Authority for submission to the Ministry	sections (Guelph-Guelph/Eramosa) • Complete draft updated “bundled” AR and SPP (all other sections)
April 8 – May 21, 2019		Formal public consultation period (44 days)
April 25, 2019 (if needed *)		• Further revised water quantity policies and updated municipal SPP sections (Guelph-Guelph/Eramosa)
April 29 – June 3, 2019 (if needed *)		Formal public consultation period (35 days)
June 20, 2019		• Revised draft updated AR and SPP: receive public comments for consideration; release the document to the Grand River Source Protection Authority for submission to the Ministry

* The April 25, 2018 SPC meeting is scheduled in case an additional SPC meeting is needed to complete the water quantity policies and release them for public consultation.

Prepared by:

Ilona Feldmann
Source Protection Program Assistant

Approved by:

Martin Keller, M. Sc.
Source Protection Program Manager

Appendix A

Protocol for implementing regulatory requirements under the Clean Water Act, 2006, S.48 (1.1)(b) of O. Reg. 287/07

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Protocol for Implementing Regulatory Requirements under the *Clean Water Act, 2006,* S.48 (1.1)(b) of O. Reg. 287/07

August 30, 2018

Purpose

The Protocol for implementing regulatory requirements under the *Safe Drinking Water Act, 2002,* O. Reg. 205/18 and *Clean Water Act, 2006,* S.48 (1.1)(b), O. Reg. 287/07, provides a local framework to support municipalities and source protection authorities (SPA) in the Lake Erie Source Protection Region incorporate source water protection planning in the municipal residential drinking water supply process.

Background

The *Safe Drinking Water Act, 2002* and the *Clean Water Act, 2006* were amended to ensure that source water protection planning is incorporated at an early stage in the municipal residential drinking water supply process.

Effective July 1, 2018, the new amendments require that system owners ensure that work to assess the vulnerability of a new or expanding drinking water systems is completed and accepted by the local SPA before the owner can apply for a drinking water works permit/license, and that the water not be provided to the public until the updated source protection plan that protects the system is approved. The SPA must provide a notice to the drinking water system owner stating that the SPA is satisfied that the technical work has been completed for the purposes of identifying amendments to the source protection plan that are anticipated to be necessary and the timing to submit any proposed amendments to the Ministry of the Environment, Conservation and Parks (MECP).

Implementing the Regulations in Lake Erie Region

To help with the implementation of these new requirements, a Lake Erie Region Protocol has been developed by the Lake Erie Region Implementation Working Group. The Protocol provides a local framework linking source water protection work to the Municipal Class Environmental Assessment and drinking water works permit/license process. The Protocol is comprised of three components:

1. Protocol Flow Diagram
   Depicts the general process to integrate new or altered drinking water systems into the source protection plan from a municipal system owner and SPA perspective (**Appendix A**);
2. Class Environmental Assessment and Source Protection Planning Matrix
   Describes potential project categories for new or altered municipal drinking water systems and how each category fits into the source protection planning process (**Appendix B**); and

3. Source Protection Authority Notice of Amendments to Source Protection Plan (template)
   To be used by the SPA of the source protection area in which the system is or will be located to provide notice to the system owner pursuant to subsection 48(1.1) of Ontario Regulation 287/07 under the *Clean Water Act, 2006.* The notice is administrative in nature (does not approve or assess the merit of technical work), and provides written confirmation that the SPA is satisfied that technical work is complete for the purpose of identifying a list of anticipated amendments, and a timeline for incorporating those amendments into an update of the source protection plan (**Appendix C**).

Roles and Responsibilities

Clarification of roles and responsibilities; see Protocol Flow Diagram:

- Step 3: Early planning – system owner contacts the local SPA to initiate early discussions on the owner's intent to create or alter a system. Grand River SPA will be invited to participate by the local SPA to lead early planning and technical discussions.

- Step 4: Notice from owner – system owner provides written notice of intent to apply for a drinking water works permit/license to the local SPA. The local SPA provides electronic copy of written notice of intent to the Grand River SPA (electronically) within two weeks of receipt of the written notice.

- Step 6: Source protection work – system owner submits electronic completed technical work to the Grand River SPA. System owner to contact Grand River SPA for submission requirements for technical work (i.e., data and report format, database template).

- Step 7: Notice from SPA – Grand River SPA technical staff reviews technical work to ensure it is complete as per the regulation. If the work is complete, the Grand River SPA technical staff provides a memo to the local SPA recommending that the notice be issued by the local SPA to the system owner.

Grand River SPA Contact:

Martin Keller
Source Protection Program Manager, Lake Erie Region
mkeller@grandriver.ca
519-620-7595

Protocol for Implementing Regulatory Requirements under the *Clean Water Act, 2006,* S.48 (1.1)(b) of O. Reg. 287/07

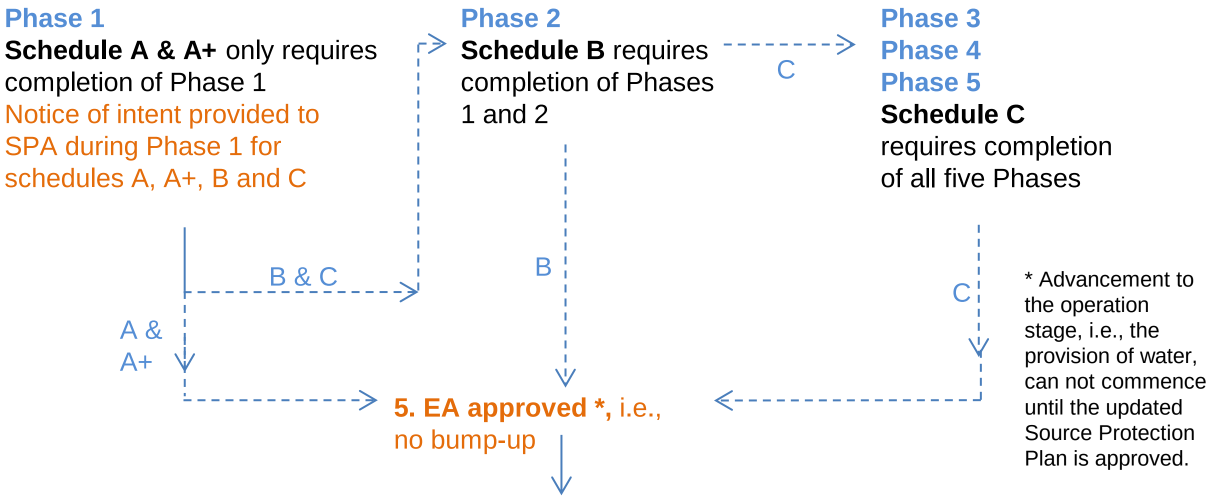
Flow Diagram

1. Municipal intention: municipal residential drinking water system owner (system owner) establishes intent to create or alter a system, and identifies municipal Class EA Planning and Design Process (A, A+, B or C).

2. Category confirmation: system owner conducts preliminary technical work (if applicable) to confirm municipal well / intake alteration category

3. Early planning: GRCA SPA leads discussion with municipal residential drinking water system owner and local SPA to discuss the owner's **intention** of establishing or altering a system.

4. Notice from owner (287/07, S.48 1.1): system owner conducts technical EA and source protection work (mapping and vulnerability) in parallel, gives written notice of intent (of applying for a permit/licence) to the local SPA. Local SPA shares written notice of intent with the GRCA SPA.



Phase 1
Schedule A & A+ only requires completion of Phase 1
Notice of intent provided to SPA during Phase 1 for schedules A, A+, B and C

Phase 2
Schedule B requires completion of Phases 1 and 2

Phase 3
Phase 4
Phase 5
Schedule C requires completion of all five Phases

5. EA approved *, i.e., no bump-up

* Advancement to the operation stage, i.e., the provision of water, can not commence until the updated Source Protection Plan is approved.

6. Source protection work: completed and submitted to the GRCA SPA

7. Notice from SPA (287/07, S.48 1.1b): GRCA SPA checks the technical work and if complete, recommends that the local SPA issue a notice to the owner stating that the work is complete. Owner can then apply for a drinking water works permit/licence.

8. SPP update: SPC updates the SPP and incorporates the new drinking water system technical work. Update process includes, at a minimum, 35-day public consultation period. Estimated minimum four-month timeframe from completion of the updated plan to submission of the revised updated plan to the Ministry.

9. SPP submission: Updated SPP submitted to the Ministry for review and approval.

10. Provision of water: SPP is approved. The system owner can supply water to the public upon approval.

	Category #	Municipal Supply Well / Intake Categories	Class EA Schedule	Technical Work required to Confirm Category	Technical Work for AR (modeling)	Changes to AR	Changes to Time of Travel	Notice Required	Content of Notice	Type of Amendment*	Clean Water Act Public Consultation Required	Comment
New Supply Well	**1a**	direct replacement well (same depth, same Capture Zone Delineation Rate, same property/no new threats)	A	No	No	Minor	No	Yes	satisfied that work is complete (exisiting WHPA provides protection for new well)	S.34 or S.36	formal 35-day public consultation period for AR and SPP	Only WHPA-A shift, amendment type dependent on magnitude of change to WHPAs. Work may not alter the vulnerable area scoring, affected properties and threats. In this situation the Source Protection Plan amendment can be made at a later date, i.e. the system owner can provide water to the public before the updated plan is approved by the Province. The SPA notice would indicate that plan amendments are not necessary at this time.
	1b	direct replacement well (same depth, same Capture Zone Delineation Rate, different property/new threats)	A	No	No	Minor	No	Yes	satisfied that work is complete (exisiting WHPA provides protection for new well)	S.34 or S.36	formal 35-day public consultation period for AR and SPP + property owner notification	Only WHPA-A shift
	2	direct replacement well (same depth, decreased Capture Zone Delineation Rate, same property)	A	No	Yes	Minor	Yes	Yes	satisfied that work is complete (exisiting WHPA provides protection for new well)	S.34 or S.36	formal 35-day public consultation period for AR and SPP + property owner notification	Smaller WHPAs, amendment options (s.34/36) a matter or timing and priorties.
	3	direct replacement well (same depth, increased Capture Zone Delineation Rate)	A	No	Yes	Minor/Major	Yes	Yes	satisfied that work is complete (new technical work)	S.34	formal 35-day public consultation period for AR and SPP + property owner notification or property owner notification + public open house	Larger WHPAs
	4a	new well, existing water supply system (back-up capacity); close proximity (same Capture Zone Delineation Rate, same property/no new threats)	A	No	No	Minor	No	Yes	satisfied that work is complete (exisiting WHPA provides protection for new well)	S.34 or 36	formal 35-day public consultation period for AR and SPP	Assumes backup well is same or less Capture Zone Delineation Rate and within defined WHPA, new WHPA-A added, type of amendment dependent on magnitude of change to WHPAs. Work may not alter the vulnerable area scoring, affected properties and threats. In this situation the Source Protection Plan amendment can be made at a later date, i.e. the system owner can provide water to the public before the updated plan is approved by the Province. The SPA notice would indicate that plan amendments are not necessary at this time.
	4b	new well, existing water supply system (back-up capacity); close proximity (same Capture Zone Delineation Rate, different property/new threats)	A	No	No	Minor	No	Yes	satisfied that work is complete (exisiting WHPA provides protection for new well)	S.34 or 36	formal 35-day public consultation period for AR and SPP + property owner notification	
	5	new well, existing water supply system; new location	B	No	Yes	Major	Yes (new)	Yes	satisfied that work is complete (new technical work)	S. 34	formal 35-day public consultation period for AR and SPP + property owner notification or property owner notification + public open house	New WHPA
	6	new well system at new location	C	No	Yes	Major	Yes (new)	Yes	satisfied that work is complete (new technical work)	S. 34	formal 35-day public consultation period for AR and SPP + property owner notification or property owner notification + public open house	New WHPA
Existing Supply Well	**7**	increase in capacity at existing well	B	No	Yes	Minor	Yes	Yes	satisfied that work is complete (new technical work)	S.34	formal 35-day public consultation period for AR and SPP + property owner notification	Larger WHPAs
	8	installation of liner or casing in existing well (no substantive change where water coming from)	A	No	No	No	No	Yes	satisfied that work is complete (exisiting WHPA provides protection for new well)	N/A	No	
	9	installation of liner or casing in exisiting well (substantive change where water coming from)	A	Yes	Yes	Minor	Yes	Yes	satisfied that work is complete (new technical work)	S.34 or S.36	formal 35-day public consultation period for AR and SPP + property owner notification	Amendment type dependent on magnitude of change to WHPAs.
	10	deepening existing well (no substantive change where water coming from)	A/B	Yes	No	No	No	Yes	satisfied that work is complete (exisiting WHPA provides protection for new well)	N/A	No	Assume same aquifer, no change in Capture Zone Delineation Rate.
	11	deepening existing well (substantive change where water coming from)	A/B	Yes	Yes	Minor	Yes	Yes	satisfied that work is complete (new technical work)	S.34 or S.36	formal 35-day public consultation period for AR and SPP + property owner notification	Amendment type dependent on magnitude of change to WHPAs.
	12	addition of treatment systems to supply wells	A/B	No	No	No	No	Yes	satisfied that work is complete (exisiting WHPA provides protection for new well)	N/A	No	
	13	well decommissioning	N/A	No	No	Minor	N/A	No	N/A	S. 51	N/A	Council resolution not required to remove the well from the plan as per O.Reg. S51.
New Intake	**14**	new intake at new location (existing system)	B	No	Yes	Major	Yes (new)	Yes	satisfied that work is complete (new technical work)	S. 34	formal 35-day public consultation period for AR and SPP + property owner notification or property owner notification + public open house	New IPZ
	15	new intake at new location (new system)	C	No	Yes	Major	Yes (new)	Yes	satisfied that work is complete (new technical work)	S. 34	formal 35-day public consultation period for AR and SPP + property owner notification or property owner notification + public open house	New IPZ
Existing Intake	**16**	any infrastructure to current intake	A/B	Yes	No	No	No	Yes	satisfied that work is complete (exisiting IPZ provides protection for new well)	N/A	No	
	17	intake decommissioning	N/A	No	No	Minor	N/A	No	N/A	S. 51	N/A	Council resolution not required to remove the intake from the plan as per O.Reg. S51.

*Section 51: adminstrative, in-house, does not require Minister approval
Section 34: initiated by the SPA, major revisions, requires Minister approval
Section 36: top-down (ordered by the Minister), major/minor revisions, requires Minister approval

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NOTICE OF AMENDMENTS TO SOURCE PROTECTION PLAN

(pursuant to section 48(1.1)(b) of Ontario Regulation 287/07)

Existing or planned municipal drinking water system (system):

____

Name of owner of existing or planned municipal drinking water system (owner):

____

Applicable Source Protection Area (SPA):

____

The [insert name of Source Protection Authority] is the Source Protection Authority for the Source Protection Area under the *Clean Water Act, 2006*.

The [insert name of Source Protection Authority] has received written notice from the owner about an intended application under the *Safe Drinking Water Act, 2002* for an existing or planned system that is located within the Source Protection Area.

The [insert name of Source Protection Authority] is satisfied that technical work required pursuant to subsection 48(1.1) of Ontario Regulation 287/07 under the *Clean Water Act, 2006* is completed for the purposes of identifying anticipated amendments to the source protection plan for the Source Protection Area.

The [insert name of Source Protection Authority] anticipates the amendments set out in Schedule A of this notice will be required as a result of the intended application. The list of anticipated amendments in Schedule A is provisional and will undergo consultations with stakeholders and the source protection committee. All amendments must be approved by the Ministry of the Environment, Conservation and Parks and are subject to change after this notice is issued. The timing for approval of the amendments by the Ministry of Environment, Conservation and Parks is not within the control of the Source Protection Authority. The Schedule A also indicates amendments that have been completed.

All actions by [insert name of Source Protection Authority] for the purposes of this notice are undertaken as the Source Protection Authority for the above noted Source Protection Area and are subject to the *Clean Water Act, 2006*. This notice does not exempt the Owner from obtaining the required licence or permit to operate the System under the *Safe Drinking Water Act, 2002.*

Issued by:

Name
Title

______________________________ **Date:** ____________________

Schedule A – List of Anticipated and Completed Amendments to Source Protection Plan

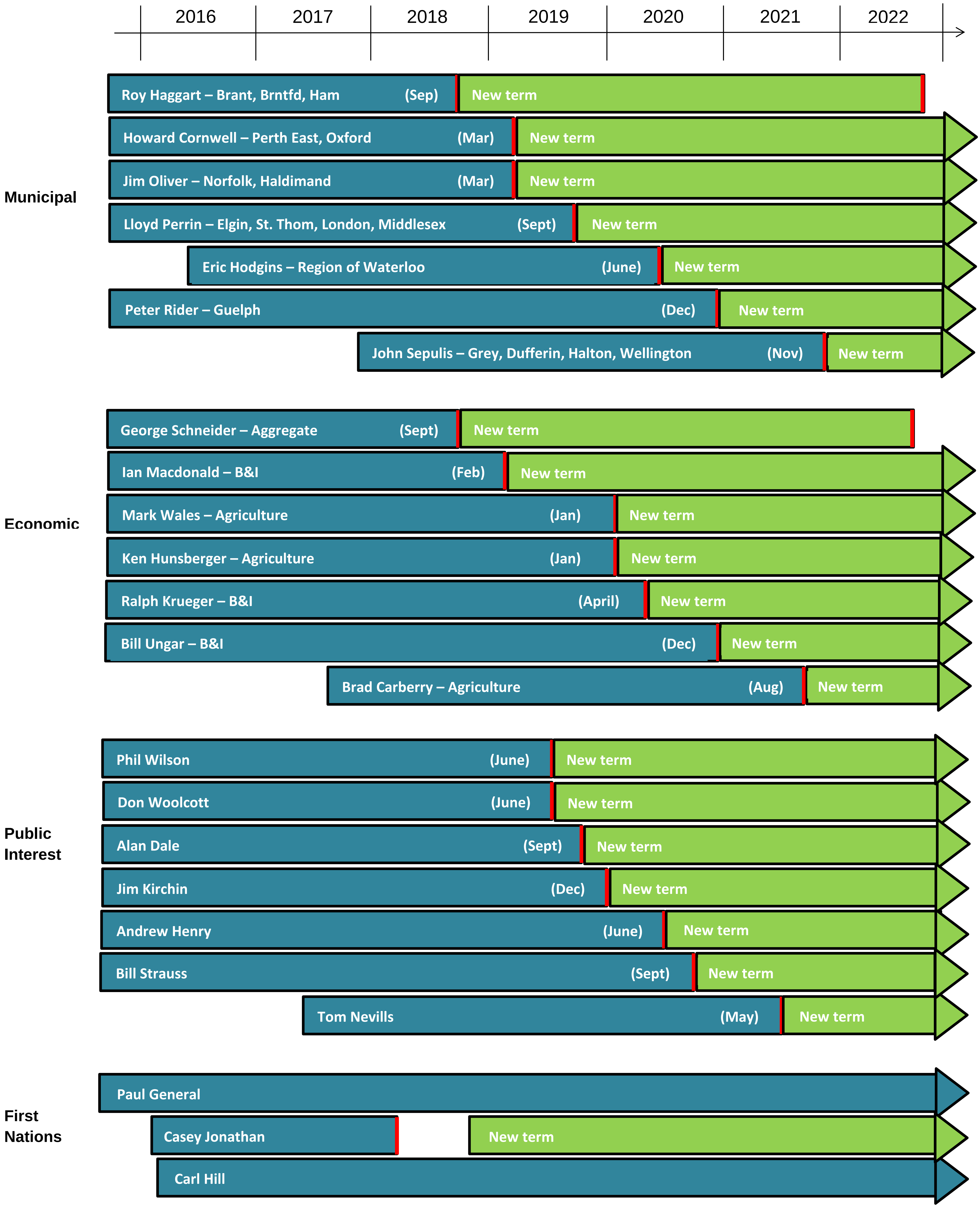
No.	Section of Source Protection Plan / Assessment Report	Brief Description of Potential and Completed Amendment	Estimated Timing to Submit Proposed Amendment to Ministry of the Environment, Conservation and Parks

Appendix B

Proposed SPC Member Terms of Appointment Plan

August 29, 2018

Proposed Lake Erie Region Source Protection Committee Member Terms of Appointment Plan



Of Note:

- There are no term limits for Source Protection Committee members, i.e., members can re-apply or be re-appointed for successive terms
- 4-year term applies to all member re-appointments and new appointments, as recommended by the Lake Erie Region Management Committee
- First Nations member nominations and term selection is the responsibility of the respective Band Council

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LAKE ERIE REGION SOURCE PROTECTION COMMITTEE

REPORT NO. SPC-18-10-02 **DATE:** October 4, 2018

TO: Members of the Lake Erie Region Source Protection Committee

SUBJECT: **Proposed Source Protection Committee Meeting Schedule**

RECOMMENDATION:

THAT the Lake Erie Region Source Protection Committee receives report SPC-18-10-02 – Proposed Source Protection Committee Meeting Schedule - for information.

REPORT:

Lake Erie Region staff propose the following Source Protection Committee meeting schedule to support the development and completion of water quantity policies for the Guelph-Guelph/Eramosa area and the update and submission of the updated Grand River Source Protection Area Assessment Report and Source Protection Plan under Section 34 of the *Clean Water Act, 2006*.

The scheduled SPC meeting on Thursday, January 17, 2019 is proposed to be cancelled.

Proposed Schedule

Thursday, December 6, 2018, 1pm at the GRCA

Thursday, February 7, 2019, 1pm at the GRCA

Thursday, April 4, 2019, 1pm at the GRCA

Thursday, April 25, 2019, 1pm at the GRCA

Thursday, June 20, 2019, 1pm at the GRCA

Prepared by:	Approved by:
Ilona Feldmann Source Protection Program Assistant	Martin Keller, M. Sc. Source Protection Program Manager

LAKE ERIE REGION SOURCE PROTECTION COMMITTEE

REPORT NO. **SPC-18-10-03** **DATE:** October 4, 2018

TO: Members of the Lake Erie Region Source Protection Committee

SUBJECT: **Interim Source Protection Committee Chair**

RECOMMENDATION:

THAT the Lake Erie Region Source Protection Committee receives report SPC-18-10-03 – Interim Source Protection Committee Chair – for information.

REPORT:

Lake Erie Region Source Protection Committee chair W. Wright-Cascaden will be away starting in December 2018 until early 2019. For the December 6, 2018 SPC meeting and possibly the first SPC in early 2019 an interim chair will need to be selected to chair the source protection committee meetings.

The process for selecting an interim chair has been discussed at the Lake Erie Region Management Committee meeting on August 29, 2018. The Management Committee passed a resolution endorsing Committee chair W. Wright-Cascaden to select an interim chair to act on her behalf while she is away.

Prepared by:

Ila Feldmann

Ilona Feldmann
Source Protection Program Assistant

Approved by:

Martin Keller, M. Sc.
Source Protection Program Manager

LAKE ERIE REGION SOURCE PROTECTION COMMITTEE

REPORT NO. SPC-18-10-04 **DATE:** October 4, 2018

TO: Members of the Lake Erie Region Source Protection Committee

SUBJECT: **Section 36 Catfish Creek and Kettle Creek Workplans**

RECOMMENDATION:

THAT the Lake Erie Region Source Protection Committee receives report SPC-18-10-04 – Section 36 Catfish Creek and Kettle Creek Workplans – for information;

THAT the Lake Erie Region Source Protection Committee releases the Workplan for Comprehensive Review and Update of the Catfish Creek Source Protection Plan to the Catfish Creek Source Protection Authority for submission to the Ministry of the Environment, Conservation and Parks;

AND THAT the Lake Erie Region Source Protection Committee releases the Workplan for Comprehensive Review and Update of the Kettle Creek Source Protection Plan to the Kettle Creek Source Protection Authority for submission to the Ministry of the Environment, Conservation and Parks.

REPORT:

Background

At the time of approval for each Lake Erie Region Source Protection Plan, the Minister specified the timeline and process for the comprehensive review and update of the respective Assessment Report and Source Protection Plan under Section 36 of the Act.

Specifically, the approval letters tasked the lead source protection authority (Grand River SPA) to develop a workplan for each assessment report and plan in consultation with the Source Protection Committee, other Source Protection Authorities, municipalities and the Ministry of the Environment, Conservation and Parks (MECP) as part of the review process. The workplan sets out what aspects of the assessment report and plan should be reviewed. Kettle Creek and Catfish Creek workplans are due for submission to the MECP by November 30, 2018.

Workplan Development Process

The workplan development process led by the Grand River SPA included the establishment of two working groups, one comprised of staff from Catfish Creek SPA, Oxford County and Long Point Region SPA for the Catfish Creek workplan, and one with staff from Kettle Creek SPA, the municipality of Central Elgin, Elgin Area Primary Water Supply System (EAPWSS) staff, and Long Point Region SPA for the Kettle Creek workplan.

The working groups considered and evaluated nine factors, as per the provincial guidance document, which include:

1. Results of environmental monitoring programs
2. Growth and infrastructure changes
3. Council resolutions
4. Policy effectiveness
5. Implementation challenges
6. Technical rule changes
7. Impacts of prohibition policies on the agricultural community
8. Specific directions in some source protection plan approval letters
9. Other local considerations.

Proposed Reviews and Updates in the Catfish Creek and Kettle Creek Workplans

A summary of the proposed reviews and updates, with associated timelines, in the Catfish Creek and Kettle Creek Workplan are summarized in **Table 1**.

Table 1 – Proposed Review and Update to Catfish and Kettle Creek Workplan

Update No.	Description of Proposed Review and Update	Applicable Document	Timeframe for Completion of the Update
1	Assess changes resulting from the Phase II Technical Rules Project and make appropriate updates as required to the AR and SPP.	AR and SPP	Within two years from the time the Phase II Technical Rules Amendments become available
2	Make appropriate updates to align with the new prescribed threat per *Clean Water Act, 2006 O. Reg. 287/07* - liquid hydrocarbon pipeline	AR and SPP	By March 2020
3	Review and assess potential climate change additions to the technical framework and make appropriate updates to the AR and SPP, as applicable.	AR and SPP	Within two years from the time the climate change guidance becomes available
4	Assess and make appropriate updates to align with the March 2017 Technical Rule change to: • SGRA vulnerability scoring • update the terminology in the assessment report and source protection plan with updated 'short names' in the Tables of Drinking Water threats	AR and SPP	By March 2020
5	Include identified transport pathways, including updated vulnerability mapping, scoring and enumeration of potential significant drinking water threat activities	AR and SPP	By March 2020

The proposed Section 36 Catfish Creek and Kettle Creek Workplans in their entirety are attached in **Appendix A and B**, respectively.

Early draft copies of the two workplans have been sent to MECP staff for their preliminary review and their comments have been considered and incorporated, where applicable.

Next Steps

Following release of the Section 36 workplans by the Lake Erie Region Source Protection Committee the workplans will be considered by the respective Source Protection Authority and subsequently submitted to MECP by November 30, 2018.

The MECP is expected to issue Section 36 orders that will detail the review of the Kettle Creek and Catfish Creek Source Protection Plans and that will be informed by the respective Section 36 work plans. Implementation of the Section 36 orders will depend on ongoing and sustainable provincial funding.

The overall timeline for completion of all of the proposed updates is by March 2020, or two years after the release of the Phase II Technical Rules or climate change guidance documents. Provided that provincial funding is available, the Grand River SPA will complete the proposed changes with support from the Lake Erie Region SPC, and in consultation with the Catfish Creek SPA, Kettle Creek SPA, the MECP, and other applicable implementing bodies. Consultation may also take place with persons engaged in significant drinking water threat activities, if any policy changes affect persons engaged in existing significant threat activities.

Staff recommends that the Lake Erie Region Source Protection Committee releases the Workplan for Comprehensive Review and Update of the Kettle Creek Source Protection Plan to the Kettle Creek Source Protection Authority for submission to the Ministry of the Environment, Conservation and Parks.

Staff also recommends that the Lake Erie Region Source Protection Committee releases the Workplan for Comprehensive Review and Update of the Catfish Creek Source Protection Plan to the Catfish Creek Source Protection Authority for submission to the Ministry of the Environment, Conservation and Parks.

Prepared by:

Emily Hayman

Emily Hayman, M. Sc., P.Geo
Source Water Hydrogeologist

Approved by:

Martin Keller, M. Sc.
Source Protection Program Manager

Appendix A

Proposed Workplan for Comprehensive Review and Update of the Catfish Creek Source Protection Plan

Catfish Creek Source Protection Area

Workplan for Comprehensive Review and Update of the Catfish Creek Source Protection Plan

Per Clean Water Act (2006) - Section 36

October 4, 2018

Prepared By

Grand River Source Protection Authority

400 Clyde Road, Cambridge, Ontario

DRINKING WATER
SOURCE PROTECTION
Our Actions Matter

LAKE ERIE
SOURCE PROTECTION
REGION

CATFISH CREEK
CONSERVATION AUTHORITY

Executive Summary

Section 36 (S. 36) of the *Clean Water Act, 2006* is intended to ensure that assessment reports (ARs) and source protection plans (SPPs) undergo a comprehensive review and update on a periodic basis.

An order was issued under S. 36 of the *Clean Water Act, 2006* to the Grand River Source Protection Authority (SPA) by the Minister of the Environment and Climate Change on September 19, 2014. The Grand River SPA is the lead SPA for the Lake Erie Region Source Protection Region (SPR), which also includes the Catfish Creek SPA, Kettle Creek SPA and Long Point Region SPA.

The S. 36 order issued by the Minister specified that the lead SPA prepare and submit a workplan to the Ministry of the Environment and Climate Change (MOECC), now Ministry of the Environment, Conservation and Parks (MECP) by November 30, 2018. The order required that the workplan include detailed steps for the comprehensive review and update of the AR and SPP, and be developed in consultation with the Lake Erie Region Source Protection Committee (SPC), participating municipalities of the Catfish Creek Source Protection Area, the Catfish Creek Source Protection Authority, and the MECP.

The Catfish Creek Source Protection Area includes Catfish Creek and its tributaries. They drain 490 square kilometres of agricultural and urban lands before entering Lake Erie at Port Bruce. The area includes parts of Elgin and Oxford counties. The watershed has one municipal water system in the village of Brownsville in the Township of Southwest Oxford. The system is comprised of two wells serving about 300 people. A number of communities are also serviced with municipal water from the Elgin Area Primary Water Supply. The SPP established policies to address significant drinking water threat for the Brownsville system.

The Catfish Creek SPP was approved by the Minister on September 19, 2014, with an effective date of January 1, 2015. Source Protection Plan policy implementation is well underway, with 56 policies being implemented by different implementing bodies. The first annual progress report was prepared and submitted to MOECC on April 24, 2018. Source Protection Plans are developed under Ontario's *Clean Water Act, 2006*. This legislation was passed in response to Justice O'Conner's inquiry and recommendations stemming out of the water contamination tragedy that occurred in Walkerton, Ontario, in May 2000.

This document provides a workplan proposal for a comprehensive review of and update to the Catfish Creek SPP and the related AR, in accordance with the S. 36 Order. A preliminary analysis was conducted based on the factors specified in the December 2016 MOECC bulletin, also utilizing guidance provided in the MOECC support information bulletins of October 2017 and March 2018.

The required consultation on the workplan was undertaken per the S. 36 order. A working group was established to develop the workplan and included regular meetings with Oxford County, the MECP, Catfish Creek SPA, Long Point Region SPA, and the SPC.

The proposed review and any necessary updates to the ARs and SPP will represent current and future status of the local scientific information and policy implementation, as it relates to ensuring the protection of municipal drinking water sources per the *Clean Water Act, 2006*. The proposed reviews and updates contained in this workplan are summarized in the **Table** below.

Update No.	Description of Proposed Review and Update	Applicable Document	Timeframe for Completion of the Update
1	Assess changes resulting from the Phase II Rule Project and make appropriate updates as required to the AR and SPP.	AR and SPP	Within two years from the time the Phase II Rules Project becomes available
2	Make appropriate updates to align with the new prescribed threat per *Clean Water Act, 2006 O. Reg. 287/07* - liquid hydrocarbon pipeline	AR and SPP	March 2020
3	Review and assess potential climate change additions to the technical framework and make appropriate updates as applicable to the AR and SPP.	AR and SPP	Within two years from the time the climate change guidance becomes available
4	Assess and make appropriate updates to align with the March 2017 Technical Rule change to: • SGRA vulnerability scoring • update the terminology in the assessment report and source protection plan with updated 'short names' in the Tables of Drinking Water threats	AR and SPP	March 2020
5	Include identified transport pathways, including updated vulnerability mapping, scoring and enumeration of potential significant drinking water threat activities	AR and SPP	March 2020

The overall timeline for completion of all of the proposed updates is March 2020 or two years after the release of the Phase II Technical Rules or climate change guidance documents. The

Lake Erie Region SPC will complete the proposed changes with support from Grand River SPA, and in consultation with Oxford County, Catfish Creek SPA, the MECP, and other applicable implementing bodies. Consultation may also take place with persons engaged in significant drinking water threat activities, if the policy changes affect persons engaged in existing significant threat activities.

The Grand River SPA acknowledges the efforts and support of Oxford County, Catfish Creek SPA, Long Point Region SPA, Lake Erie Region SPC, and the MECP in the preparation of this workplan. The MECP is also thanked for their continued support through capacity funding under the Ontario Drinking Water Source Protection program.

Table of Contents

1. Introduction

Ontario's *Clean Water Act, 2006* helps protect sources of municipal drinking water systems in order to protect human health and the environment. The Act was created in response to the "Report of the Walkerton Inquiry - by Justice Dennis R. O'Connor", which was released in 2002. The inquiry was called in response to E. coli bacteria contamination of the municipal drinking water system in Walkerton, Ontario in May of 2000. This contamination was the cause of seven deaths and thousands of residents becoming ill. Justice O'Connor emphasized that protecting drinking water at the source is the first step in a multi-barrier approach and an important part of ensuring the health of people, ecosystems, and economies. "We should never be complacent about drinking water safety" - Justice Dennis R. O'Connor.

The *Clean Water Act, 2006* ensures communities protect their drinking water supplies through prevention - by developing collaborative, watershed-based source protection plans (SPPs) that are locally driven and based on science.

The Act established source protection areas and source protection regions. It also created a local multi-stakeholder source protection committee for each region. These committees identify significant existing and future risks to municipal drinking water sources and develop plans to address these risks.

Assessment reports (ARs) and SPPs must be comprehensively reviewed and updated per section 36 (S. 36) of the Act to ensure sustained protection of the municipal drinking water sources and for the SPPs to stay current. Together with the approval of the Catfish Creek SPP on September 19, 2014, a S. 36 order was issued to the Grand River Protection Authority (SPA) from the Minister of the Ministry of Environment and Climate Change (MOECC), now Ministry of the Environment, Conservation and Parks (MECP). The Grand River SPA (lead) is one of four SPAs in the Lake Erie Source Protection Region (LESPR), which also includes the Catfish Creek SPA, Kettle Creek SPA and Long Point Region SPA.

The S. 36 order issued by the Minister specified that the lead SPA prepare and submit a workplan to the MECP by November 30, 2018. The order required that the workplan include detailed steps for the review and update of the Source Protection Plan (SPP) and be developed in consultation with the Lake Erie Region Source Protection Committee (SPC), participating municipalities of the source protection authority, and the MECP. The order also required that the information gained from implementing the SPP and from the first annual progress report (2017) be taken into consideration in preparation of the workplan.

1.1 Catfish Creek Source Protection Area

The Catfish Creek Source Protection Area includes Catfish Creek and its tributaries. They drain 490 square kilometres of agricultural and urban lands before entering Lake Erie at Port Bruce. The area includes parts of Elgin and Oxford counties. The watershed has one municipal water system in the village of Brownsville in the Township of Southwest Oxford. The system is comprised of two wells serving about 300 people. A number of communities are also serviced with municipal water from the Elgin Area Primary Water Supply. The SPP established policies to address significant drinking water threats for the Brownsville system.

1.2 Source Protection Plan Implementation - Highlights

The Catfish Creek SPP was approved by the Minister on September 19, 2014, with an effective date of January 1, 2015. SPP policy implementation is well underway, with 56 policies being implemented by different implementing bodies. The experience gained from implementing the SPP to date is considered in this workplan.

1.3 Annual Progress Report - Highlights

The first annual progress report was prepared and submitted to MOECC on April 24, 2018. Only 19 existing significant drinking water threat (SDWT) activities were identified in the Catfish Creek Source Protection Area when the SPP went into effect, all within 100 metre radius around a well. Since implementation of the SPP, 13 of the 14 (93%) confirmed significant drinking water threats have been addressed with only one outstanding threat remaining. The negotiation of a Risk Management Plan (RMP) for the storage and handling of fuel is in progress. Additionally, all applicable plan policies that address significant drinking water threats are implemented or in progress.

2. Workplan Development

The Grand River SPA has followed the guidance provided in MOECC bulletins in developing the S. 36 workplan. In December 2016, the MOECC produced a bulletin, "Overview of Requirements for Assessment Report and Source Protection Plan Amendments under S. 36 of the *Clean Water Act, 2006*". The bulletin indicates that the S. 36 updates are intended to "build in new information that advances the understanding of risks to sources of drinking water and incorporates local growth". The three supplemental information bulletins listed below were also used to develop this S. 36 workplan.

- Municipal Engagement (October 2017)
- Prohibition of Agricultural Policies Outside of WHPA-A or IPZ-1 (March 2018)
- Updates to Director Technical Rules and Tables of Drinking Water Threats (July 2018, updated in August 2018).

The three main components of the S. 36 process that lead to workplan submission by source protection authorities are:

- Preliminary analysis including review factors and considerations
- Consultation for stakeholder engagement
- Workplan.

The workplan development process led by the Grand River SPA included the establishment of a working group which included staff from Catfish Creek SPA, Oxford County and Long Point Region SPA. The results of the evaluation of the nine factors specified in the December 2016 MECP bulletin are described in detail below.

2.1 Preliminary Analysis

A preliminary analysis of the AR and SPP was conducted considering the nine factors specified in the December 2016 MECP bulletin:

- Results of environmental monitoring programs
- Growth and infrastructure changes
- Council resolutions
- Policy effectiveness
- Implementation challenges
- Technical rule changes
- Impacts of prohibition policies on the agricultural community
- Specific directions in some source protection plan approval letters
- Other local considerations.

The evaluation of each of these factors is considered below.

2.1.1 A: Results of Environmental Monitoring Programs

No drinking water issues have been identified to date in the Catfish Creek Source Protection Area. The municipality has not identified any water quality changes or trends that could necessitate including drinking water issues in this workplan.

Oxford County performs water quality monitoring and testing in accordance with the requirements of the *Safe Drinking Water Act, 2002* and the system's Municipal Drinking Water License. No anthropogenic water quality issues or concerns have been identified with the Brownsville supply wells.

2.1.2 B: Growth and Infrastructure Changes

2.1.2.1 Growth:

No substantial growth has occurred in the Catfish Creek Source Protection Area since the Source Protection Plan was approved in September 2014; the population in 2006 was an estimated 19,860, projected to grow to 25,974 by 2026 and 34,865 by 2056. No new growth is planned in the municipality that was not considered in the approved plan and Oxford County is not identified in the *Places to Grow Act, 2005*. The Oxford County Official Plan designates Brownsville as a Partially Serviced Village and as such growth is limited to minor infilling. The municipality is able to meet its water demand with the existing Brownsville system.

2.1.2.2 Infrastructure:

The Catfish Creek Source Protection Area has one municipal drinking water system in the village of Brownsville in the Township of Southwest Oxford. The system is comprised of two wells. There is currently no plan to change or expand the Brownsville system or add new drinking water systems in the Catfish Creek Source Protection Area to meet future water demands.

2.1.2.3 Safe Drinking Water Act (2002) O. Reg. 205/18:

Any future changes to the Brownsville drinking water system or the addition of any new municipal system in the Catfish Creek Source Protection Area that requires the completion of a drinking water works permit, will follow the Lake Erie Source Protection Region Protocol for implementing regulatory requirements under the Clean Water Act, 2006, S.48 (1.1)(b) of O. Reg. 287/07. The protocol ensures that the Source Protection Authority provides a notice to the system owner that source protection technical work has been completed prior to applying for a drinking water works permit.

The protocol was developed collaboratively by the Grand River Conservation Authority (GRCA), Region of Waterloo and City of Guelph, in consultation with the Lake Erie Region Implementation Working Group. The protocol has been endorsed by the Lake Erie Region Management Committee, and released to all municipalities in the Lake Erie Source Protection Region.

2.1.3 C: Council resolutions

There were no council resolutions that resulted in any findings for inclusion in the proposed Catfish Creek S.36 Workplan. There are no municipal plans to include other types of systems (non-residential, communal) in the source protection process, and First Nations band council resolutions are not required.

2.1.4 D: Policy Effectiveness

2017 annual progress reporting results have been reviewed and no policy gaps have been identified. Nineteen existing significant drinking water threats were identified in the Catfish Creek Source Protection Area when the plan took effect. Since implementation of the plan, 93% of confirmed significant drinking water threats have been addressed with only one outstanding threat remaining. Additionally, all applicable plan policies that address significant drinking water threats are implemented or in progress.

2.1.5 E: Implementation Challenges

No challenges have been noted since implementation of the SPP.

2.1.6 F: Technical Rule Changes

Phase II Rule Project

The Grand River SPA, in consultation with Oxford County, Catfish Creek SPA and the Source Protection Committee, will review and consider incorporating changes to the technical rules once they are finalized and become available.

Addition of liquid hydrocarbon pipelines

The conveyance of oil by way of an underground pipeline, now a prescribe drinking water threat as per recent changes to O.Reg. 287/07, was approved as a local threat for source protection plans in the Lake Erie Source Protection Region in 2011. However, no pipelines were identified and addressed in the approved Catfish Creek Source Protection Plan and the Grand River SPA is not aware of any new pipelines constructed since plan approval. The Catfish Creek Assessment Report will be updated to reflect that liquid hydrocarbon pipelines are now a prescribed drinking water threat.

Changes to above grade fuel handling and storage in a WHPA-E or IPZ

The MECP has modified the underlying calculations that determine whether above grade fuel handling and storage can be a significant drinking water threat. As a result the activity would be identified as a significant drinking water threat in Intake Protection Zones (IPZs) with vulnerability scoring of 9.0 or higher and at lower volumes. The changes do not apply to the Catfish Creek Source Protection Area as there are no IPZs or WHPA-Es delineated.

Climate change

Conservation Ontario is developing guidance for incorporating climate change into Source Protection Plan water quality risk assessments. Grand River SPA, in consultation with Oxford County, Catfish Creek SPA and the Source Protection Committee, will review and consider the guidance once it is finalized and becomes available.

Significant Groundwater Recharge Area vulnerability scoring

The approved Catfish Creek Source Protection Plan includes the delineation of and vulnerability scoring for Significant Groundwater Recharge Areas (SGRAs). Vulnerability scores will need to be updated, i.e., removed, in accordance with the Phase 1 updates to the Technical Rules and Tables of Drinking Water Threats (March 2017). There are no SGRAs in the Catfish Creek Source Protection Area that require removal from the plan as per Rule 45 (systems that are excluded from the SGRA delineation requirements).

Sewage/septic systems and holding tanks

No issues-based threats were identified for the Brownsville water supply. The removal of sodium and chloride references from the circumstances related to on-site sewage systems and holdings tanks does not apply to the Catfish Creek Source Protection Area.

Handling and storage of fuel

The Catfish Creek Source Protection Area does not have an Intake Protection Zone (IPZ). The addition of above grade fuel storage as a potential significant drinking water threat in an IPZ scoring 9 or higher is not applicable.

Removal of the term “dairy producer”

The Catfish Creek Assessment Report and Source Protection Plan do not contain the term “dairy producer”.

Tables of Drinking Water Threats

The Grand River SPA will update terminology in the Catfish Creek Assessment Report and Source Protection Plan to reflect changes to “Short Names” in the Table of Drinking Water Threats.

2.1.7 G: Impacts of Prohibition Policies on the Agricultural Community

The Catfish Creek Source Protection Plan does not prohibit agricultural activities outside of a WHPA-A, and as a result, no changes to the Catfish Creek SPP policies are proposed.

2.1.8 H: Specific directions in some source protection plan approval letters

The Catfish Creek Source Protection Plan approval letter did not include specific direction.

2.1.9 I: Other local considerations

The identification of any transport pathways are captured through notices submitted to the Grand River SPA as per Lake Erie Region's Transport Pathway Guidance. Potential transport pathways will be analyzed, and changes to vulnerability mapping are proposed, where appropriate, for the Assessment Report. There are currently no transport pathway notices under consideration.

2.2 Workplan Consultation

Consultation on the workplan was conducted in a variety of forms. This included emails, teleconferences and phone calls with staff from Oxford County, Catfish Creek SPA, Long Point Region SPA, the MECP, and a meeting with the SPC.

The purpose of the consultation was to discuss the proposed workplan and receive comments and feedback. The following list outlines the consultation conducted.

No.	Date	Consultation Details
1	June 18, 2018	A teleconference was held with the Lake Erie Region Project Manager, Program Assistant and staff from Catfish Creek SPA, Long Point Region SPA and Oxford County to discuss the workplan process and the nine factors specified in the December 2016 MOECC bulletin and other items that could be included in the review.
2	June 26, 2018	The Project Manager and Program Assistant participated in a teleconference with the MECP to discuss the progress of the workplan.
3	July 23, 2018	A teleconference was held with the Lake Erie Region Project Manager, Program Assistant and staff from Catfish Creek SPA, Long Point Region SPA and Oxford County to review a first draft of the workplan and obtain feedback.
4	August 2, 2018	A meeting was held with the Lake Erie Region Project Manager, Program Assistant and Hydrogeologist to review the March 2017 Director Technical Rule amendments for potential inclusion in the workplan.
5	August 29, 2018	Feedback obtained from Catfish Creek SPA, Long Point Region SPA and Oxford County staff on the second draft of the workplan.
6	August 31, 2018	Draft workplan for S. 36 updates provided to the MECP for their

No.	Date	Consultation Details
		review as part of consultation process.
7	October 4, 2018	Draft workplan for S. 36 updates was reviewed and discussed by the SPC.
8	TBD, 2018	A SPA meeting was held to approve the proposed workplan.
9	TBD, 2018	The proposed S. 36 workplan was submitted electronically to MECP.

3. Proposed Review and Updates

Based on the preliminary analysis, consultations with various stakeholders, and feedback from the MECP on the draft proposal, the Grand River SPA recommends that updates be carried out under S. 36 of the *Clean Water Act, 2006* as described below. Most of the proposed updates result in updates to both the AR and SPP.

3.1. Proposed Update 1

Review Factor: Technical Rule Changes – Phase II Rule Project

Through the preliminary analysis, anticipated changes resulting from the MECP's Phase II Rule Project have been identified that will likely need to be reflected in an update to the AR and SPP. The complete list of changes to the rules has not been identified to this point, nor has the timeline for completion of the Project.

Grand River SPA will work closely with Oxford County and the Catfish Creek SPA to ensure that the new rules are reviewed and considered for incorporation in the AR and SPP once they are finalized and become available.

This update will be completed by the Lake Erie Region SPC within two years from the time the Phase II Rules Project becomes available. The Grand River SPA recommends that this update be part of the S. 36 update based on discussions with Oxford County and the Catfish Creek SPA. A two year timeframe will ensure that there is adequate flexibility to also work on workplans and SPP updates for Grand River, Long Point Region and Kettle Creek. The expected completion date of this proposed update will be dependent on workload and capacity across the Lake Erie Region.

3.2 Proposed Update 2

Review Factor: Technical Rule Changes - liquid hydrocarbon oil pipeline threat

Oil pipelines were listed as a "local threat" in the approved Catfish Creek AR and SPP. However, no existing pipelines are identified in the AR, and therefore none are addressed in the approved SPP. Additionally, no pipeline threats have been identified since SPP approval and there is little prospect that future pipelines will be built where they could be a significant drinking water threat. Any text and tables in the Catfish Creek AR and SPP referring to pipelines as a local threat will be updated to reflect that pipelines are now a "prescribed drinking water threat".

This update will be completed by the Lake Erie Region SPC by March 2020. The Grand River SPA recommends that this update be part of the S. 36 update based on discussions with Oxford County and the Catfish Creek SPA. The submission of the updated AR and SPP may be dependent on the timeline for completion of other S. 36 updates.

3.3 Proposed Update 3

Review Factor: Technical Rules Changes – Climate Change

Conservation Ontario's guidance for incorporating climate change into SPP water quality risk assessments may result in changes to the assessment that could be considered in updates to the AR and SPP.

Grand River SPA will work closely with Central Elgin, EAPWSS and the Kettle Creek SPA to ensure that the guidance is reviewed and the outcomes carefully considered for incorporation in the AR and SPP once the guidance document is finalized and becomes available. Conservation Ontario anticipates to submit the final guidance to the MECP in November 2018 for consideration under the source protection technical framework.

This update will be completed by the Lake Erie Region SPC within two years from the time the climate change guidance becomes available. The Grand River SPA recommends that this update be part of the S. 36 update based on discussions with Oxford County and the Catfish Creek SPA. A two year timeframe will ensure that there is adequate flexibility to also work on workplans and SPP updates for Grand River, Long Point Region and Kettle Creek. The expected completion date of this proposed update will be dependent on workload and capacity across the Lake Erie Region.

3.4 Proposed Update 4

Review Factor: Technical Rules Changes – SGRA vulnerability scoring and Tables of Drinking Water Threats "Short Names"

The AR and SPP will be updated to incorporate changes to significant groundwater recharge areas (SGRA). Specifically, vulnerability scoring will be removed from the SGRAs and the delineated SGRAs (scores of 2, 4, and 6) will be grouped into a single SGRA. Text and maps will be updated accordingly. Text in the AR and SPP will be updated to incorporate changed terminology regarding the prescribed drinking water threat "Short Names".

These updates will be completed by the Lake Erie Region SPC by March 2020. The Grand River SPA recommends that this update be part of the S. 36 update based on discussions with Oxford County and the Catfish Creek SPA. The submission of the updated AR and SPP may be dependent on the timeline for completion of other S. 36 updates.

3.5 Proposed Update 5

Review Factor: Other local considerations – transport pathways

Any identified transport pathways that the SPA will become aware of in accordance with section 27 of the General Regulation (287/07) will be considered for inclusion in the AR and SPP. The AR updates may include updated WHPA vulnerable area mapping, and the associated vulnerability scores, which will be used to determine and include identification of areas where an activity is or would be a significant drinking water threat. The SPP policy applicability maps would also be updated to reflect changes to the AR.

This update will be completed by the Lake Erie Region SPC by March 2020. The Grand River SPA recommends that this update be part of the S. 36 update based on discussions with Oxford County and the Catfish Creek SPA. The submission of the AR and SPP may be dependent on the timeline for completion of other S. 36 updates.

3.6 Project Management and MECP Support for Updates

The MECP provides support through its capacity funding under the DWSP program, technical bulletins, guidance, and feedback, and this support for local program delivery is acknowledged.

The Grand River SPA continues to lead the Source Protection Region efforts. The Lake Erie Region Source Protection Committee with support by the Grand River SPA will lead the updates to the Catfish AR and SPP in accordance with the S. 36 workplan, in addition to the source protection work needed in Kettle Creek, Grand River and Long Point Region. The continuation of support by MECP will be necessary to undertake the proposed updates under S. 36 and the required consultation. This includes Lake Erie Region staff capacity and expertise, Source Protection Committee meetings, Lake Erie Region Implementation Working Group meetings, and stakeholder engagement workshops prior to submission of an updated SPP including AR. The Grand River SPA recommends that staff levels within the Lake Erie Region be maintained in order to carry out the proposed updates.

4. Conclusion

Through consultation in 2018 with stakeholders, the following updates are proposed to the SPP including the AR:

Update No.	Description of Proposed Review and Update	Applicable Document	Timeframe for Completion of the Update
1	Assess changes resulting from the Phase II Rule Project and make appropriate updates as required to the AR and SPP.	AR and SPP	Within two years from the time the Phase II Rules Project becomes available
2	Make appropriate updates to align with the new prescribed threat per *Clean Water Act, 2006* O. Reg. 287/07 - liquid hydrocarbon pipeline	AR and SPP	March 2020
3	Review and assess potential climate change additions to the technical framework and make appropriate updates as applicable to the AR and SPP.	AR and SPP	Within two years from the time the climate change guidance becomes available
4	Assess and make appropriate updates to align with the March 2017 Technical Rule change to: • SGRA vulnerability scoring • update the terminology in the assessment repot and source protection plan with updated 'short names' in the Tables of Drinking Water threats	AR and SPP	March 2020
5	Include identified transport pathways, including updated vulnerability mapping, scoring and enumeration of potential significant drinking water threat activities	AR and SPP	March 2020

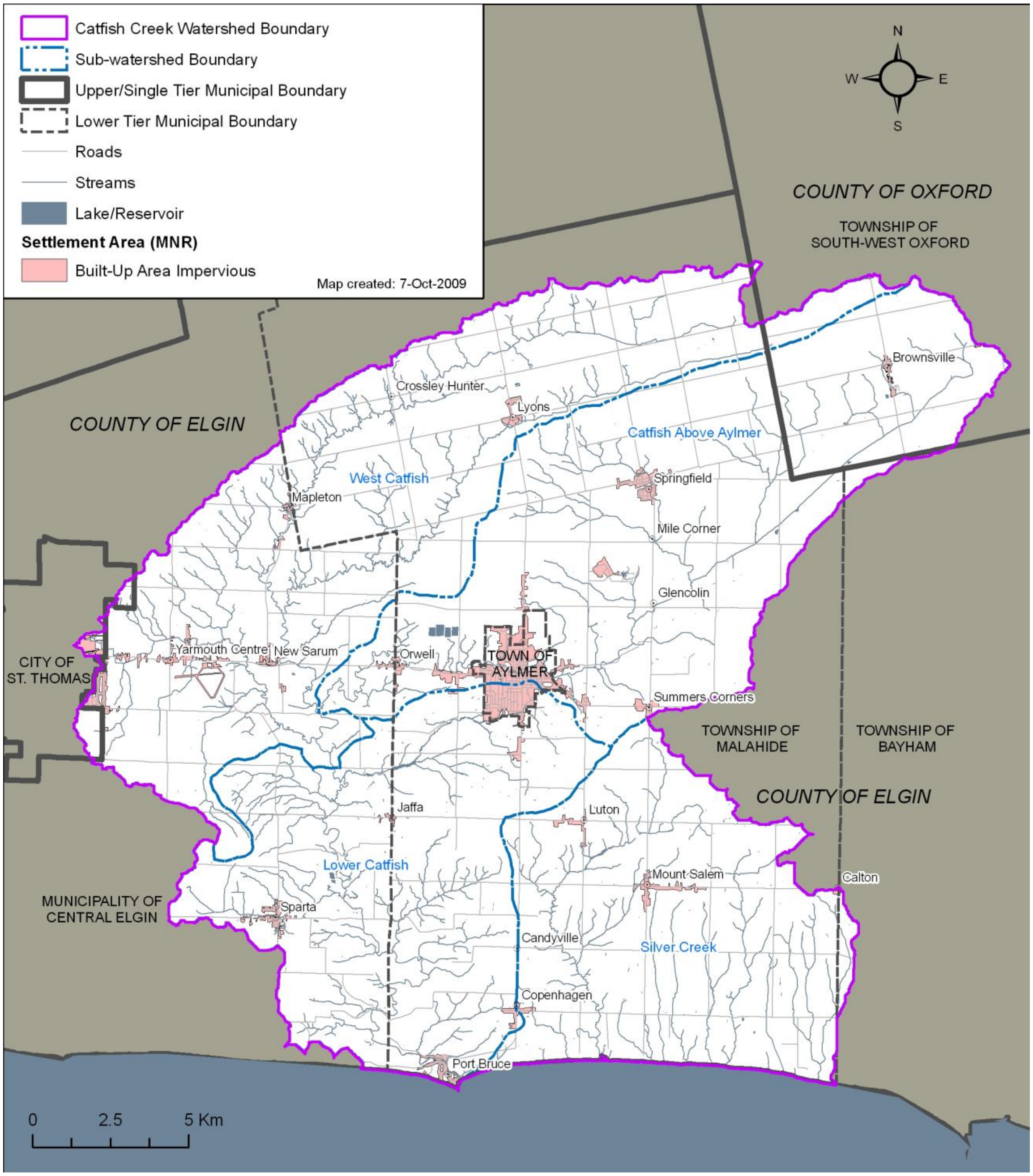
The overall timeline for completion of all of the proposed updates is March 2020, or two years after the release of the Phase II Technical Rules or climate change guidance documents. Submission of the updated Kettle Creek AR and SPP would be expected four months after completion of the technical work. The Lake Erie Region SPC will complete the proposed changes with support from the Grand River SPA, and in consultation with the Catfish Creek SPA, Oxford

County, the MECP, and other applicable implementing bodies. Consultation may also take place with persons engaged in significant drinking water threat activities, if the policy changes affect persons engaged in existing significant threat activities.

Appendix A:
S. 36 Order from Minister of the Environment and Climate Change

Appendix B:
Catfish Creek Watershed Boundary

Map: Catfish Creek Watershed



Appendix B

Proposed Workplan for Comprehensive Review and Update of the Kettle Creek Source Protection Plan

Kettle Creek Source Protection Area

Workplan for Comprehensive Review and Update of the Kettle Creek Source Protection Plan

Per Clean Water Act (2006) - Section 36

October 4, 2018

Prepared By

Grand River Source Protection Authority

400 Clyde Road, Cambridge, Ontario

Executive Summary

Section 36 (S. 36) of the *Clean Water Act, 2006* is intended to ensure that assessment reports (ARs) and source protection plans (SPPs) undergo a comprehensive review and update on a periodic basis.

An order was issued under S. 36 of the *Clean Water Act, 2006* to the Grand River Source Protection Authority (SPA) by the Minister of the Environment and Climate Change on September 8, 2014. The Grand River SPA is the lead SPA for the Lake Erie Region Source Protection Region (SPR), which also includes the Kettle Creek SPA, Catfish Creek SPA and Long Point Region SPA.

The S. 36 order issued by the Minister specified that the lead SPA prepare and submit a workplan to the Ministry of the Environment and Climate Change (MOECC), now Ministry of the Environment, Conservation and Parks (MECP) by November 30, 2018. The order required that the workplan include detailed steps for the comprehensive review and update of the AR and SPP, and be developed in consultation with the Lake Erie Region Source Protection Committee (SPC), participating municipalities of the Kettle Creek Source Protection Area, the Kettle Creek Source Protection Authority, and the MECP.

The Kettle Creek Source Protection Area includes Kettle Creek and its tributaries. They drain 520 square kilometres of agricultural and urban lands before entering Lake Erie at Port Stanley. The area includes parts of Elgin County, Middlesex County, the City of St. Thomas, and City of London. About 80 per cent of the watershed is farmland, 15 per cent is forested or marginal land and five per cent is urbanized. Two municipal drinking water systems serve the communities of the watershed: a well system in Belmont and the Elgin Area Primary Water Supply System (EAPWSS) in Port Stanley. The SPP established policies to address significant drinking water threats for both systems.

The Kettle Creek SPP was approved by the Minister on September 8, 2014, with an effective date of January 1, 2015. Source Protection Plan policy implementation is well underway, with 27 policies being implemented by different implementing bodies. The first annual progress report was prepared and submitted to MOECC on April 25, 2018. Source Protection Plans are developed under Ontario's *Clean Water Act, 2006*. This legislation was passed in response to Justice O'Conner's inquiry and recommendations stemming out of the water contamination tragedy that occurred in Walkerton, Ontario, in May 2000.

This document provides a workplan proposal for a comprehensive review of and update to the Kettle Creek SPP and the related AR, in accordance with the S. 36 Order. A preliminary analysis was conducted based on the factors specified in the December 2016 MOECC bulletin, also utilizing guidance provided in the MOECC support information bulletins of October 2017 and March 2018.

The required consultation on the workplan was undertaken per the S. 36 order. A working group was established to develop the workplan and included regular meetings with Kettle Creek SPA, the municipality of Central Elgin, Elgin Area Primary Water Supply System (EAPWSS) staff, the MECP, Long Point Region SPA, and the SPC.

The proposed review and any necessary updates to the ARs and SPP will represent current and future status of the local scientific information and policy implementation, as it relates to ensuring the protection of municipal drinking water sources per the *Clean Water Act, 2006*. The proposed reviews and updates contained in this workplan are summarized in the **Table** below.

Update No.	Description of Proposed Review and Update	Applicable Document	Timeframe for Completion of the Update
1	Assess changes resulting from the Phase II Rule Project and make appropriate updates as required to the AR and SPP.	AR and SPP	Within two years from the time the Phase II Rules Project becomes available
2	Make appropriate updates to align with the new prescribed threat per *Clean Water Act, 2006* O. Reg. 287/07 - liquid hydrocarbon pipeline	AR and SPP	March 2020
3	Review and assess potential climate change additions to the technical framework and make appropriate updates as applicable to the AR and SPP.	AR and SPP	Within two years from the time the climate change guidance becomes available
4	Assess and make appropriate updates to align with the March 2017 Technical Rule change to: • SGRA vulnerability scoring • update the terminology in the assessment report and source protection plan with updated ‘short names’ in the Tables of Drinking Water threats	AR and SPP	March 2020
5	Include identified transport pathways, including updated vulnerability mapping, scoring and enumeration of potential significant drinking water threat activities	AR and SPP	March 2020

The overall timeline for completion of all of the proposed updates is March 2020 or two years after the release of the Phase II Technical Rules or climate change guidance documents. The Lake Erie Region SPC will complete the proposed changes with support from Grand River SPA, and in consultation with the municipality of Central Elgin, EAPWSS, Kettle Creek SPA, the MECP, and other applicable implementing bodies. Consultation may also take place with persons engaged in significant drinking water threat activities, if the policy changes affect persons engaged in existing significant threat activities.

The Grand River SPA acknowledges the efforts and support of Central Elgin, EAPWSS, Kettle Creek SPA, Long Point Region SPA, Lake Erie Region SPC, and the MECP in the preparation of this workplan. The MECP is also thanked for their continued support through capacity funding under the Ontario Drinking Water Source Protection program.

Table of Contents

1. Introduction

Ontario's *Clean Water Act, 2006* helps protect sources of municipal drinking water systems in order to protect human health and the environment. The Act was created in response to the "Report of the Walkerton Inquiry - by Justice Dennis R. O'Connor", which was released in 2002. The inquiry was called in response to *E. coli* bacteria contamination of the municipal drinking water system in Walkerton, Ontario in May of 2000. This contamination was the cause of seven deaths and thousands of residents becoming ill. Justice O'Connor emphasized that protecting drinking water at the source is the first step in a multi-barrier approach and an important part of ensuring the health of people, ecosystems, and economies. "We should never be complacent about drinking water safety" - Justice Dennis R. O'Connor.

The Clean Water Act ensures communities protect their drinking water supplies through prevention - by developing collaborative, watershed-based source protection plans (SPPs) that are locally driven and based on science.

The Act established source protection areas and source protection regions. It also created a local multi-stakeholder source protection committee for each region. These committees identify significant existing and future risks to municipal drinking water sources and develop plans to address these risks.

Assessment reports (ARs) and SPPs must be comprehensively reviewed and updated per section 36 (S. 36) of the Act to ensure sustained protection of the municipal drinking water sources and for the SPPs to stay current. Together with the approval of the Kettle Creek SPP on September 8, 2014, a S. 36 order was issued to the Grand River Source Protection Authority (SPA) from the Minister of the Ministry of Environment and Climate Change (MOECC), now Ministry of the Environment, Conservation and Parks (MECP). The Grand River SPA (lead) is one of four SPAs in the Lake Erie Source Protection Region (SPR), which also includes the Kettle Creek SPA, Catfish Creek SPA and Long Point Region SPA.

The S. 36 order issued by the Minister specified that the lead SPA prepare and submit a workplan to the MECP by November 30, 2018. The order required that the workplan include detailed steps for the review and update of the Source Protection Plan (SPP) and be developed in consultation with the Lake Erie Region Source Protection Committee (SPC), participating municipalities of the source protection authority, and the MECP. The order also required that the information gained from implementing the SPP and from the first annual progress report (2017) be taken into consideration in preparation of the workplan.

1.1 Kettle Creek Source Protection Area

The Kettle Creek Source Protection Area includes Kettle Creek and its tributaries. They drain 520 square kilometres of agricultural and urban lands before entering Lake Erie at Port Stanley. The area includes parts of Elgin County, Middlesex County, the City of St. Thomas, and City of London. About 80 per cent of the watershed is farmland, 15 per cent is forested or marginal land and five per cent is urbanized. Two municipal drinking water systems serve the communities of the watershed: a well system in Belmont and the Elgin Area Primary Water Supply System (EAPWSS) in Port Stanley. The SPP established policies to address significant drinking water threats for both systems.

1.2 Source Protection Plan Implementation - Highlights

The Kettle Creek SPP was approved by the Minister on September 8, 2014, with an effective date of January 1, 2015. Source Protection Plan policy implementation is well underway, with 27 policies being implemented by different implementing bodies. The experience gained from implementing the SPP to date is considered in this workplan.

1.3 Annual Progress Report - Highlights

The first annual progress report was prepared and submitted to MOECC on April 25, 2018. Only two existing significant drinking water threats (SDWT) were identified in the Kettle Creek Source Protection Area when the Plan took effect. Since that time, both threats have been addressed: one no longer exists and the other is managed through a Risk Management Plan. Many of the applicable plan policies (68%) that address significant drinking water threats are implemented or in progress. 25% of the plan policies that address significant drinking water threats did not require a response or were not applicable. For the remaining 7% no information was available/no response was received.

Additionally, a local campaign spearheaded by Kettle Creek Conservation Authority and Elgin St. Thomas Public Health promoted the importance of keeping the local municipal drinking water safe. The #ichoosetapwater campaign consisted of a video contest and a reusable water bottle giveaway. The contest invited Grades 3 to 7 classes to submit a video highlighting the importance of choosing tap water over bottled water. Classrooms were provided messaging on the importance of keeping municipal drinking water safe to be incorporated into the videos.

2. Workplan Development

The Grand River SPA has followed the guidance provided in MOECC bulletins in developing the S. 36 workplan. In December 2016, the MOECC produced a bulletin, "Overview of Requirements for Assessment Report and Source Protection Plan Amendments under S. 36 of the *Clean Water Act*". The bulletin indicates that the S. 36 updates are intended to "build in new information that advances the understanding of risks to sources of drinking water and incorporates local growth". The three supplemental information bulletins listed below were also used to develop this S. 36 workplan.

- Municipal Engagement (October 2017)
- Prohibition of Agricultural Policies Outside of WHPA-A or IPZ-1 (March 2018)
- Updates to Director Technical Rules and Tables of Drinking Water Threats (July 2018, updated in August 2018).

The three main components of the S. 36 process that lead to workplan submission by source protection authorities are:

- Preliminary analysis including review factors and considerations
- Consultation for stakeholder engagement
- Workplan.

The workplan development process led by the Grand River SPA included the establishment of a working group which included staff from Kettle Creek SPA, the municipality of Central Elgin, Elgin Area Primary Water Supply System (EAPWSS) and Long Point Region SPA. The results of the evaluation of the nine factors specified in the December 2016 MOECC bulletin are described in detail below.

2.1 Preliminary Analysis

A preliminary analysis of the AR and SPP was conducted considering the nine factors specified in the December 2016 MOECC bulletin:

- Results of environmental monitoring programs
- Growth and infrastructure changes
- Council resolutions
- Policy effectiveness
- Implementation challenges
- Technical rule changes
- Impacts of prohibition policies on the agricultural community
- Specific directions in some source protection plan approval letters
- Other local considerations.

The evaluation of each of these factors is considered below.

2.1.1 A: Results of Environmental Monitoring Programs

Lake Huron and EAPWSS has been regularly sampling raw water quality at the Elgin Area Primary Water Supply intake. No significant long-term trends have been identified that would warrant further scrutiny and inclusion in the workplan. However, pharmaceutically active compounds and other emerging issues continue to be areas of “general concern” and will continued to be monitored.

Sampling for Microsystin-LR at the Elgin Primary intake has been undertaken between June and November each year since 2014. Monitoring results identify the toxin as either non-detect or trace. Continued and enhanced environmental monitoring through the Ministry’s Drinking Water Surveillance Program and through the Lake Huron and EAPWSS’ own monitoring program, is recommended.

2.1.2 B: Growth and Infrastructure Changes

2.1.2.1 Growth:

No substantial growth has occurred in the Kettle Creek Source Protection Area since the Source Protection Plan was approved in September 2014; the population in 2006 was an estimated 48,940, projected to grow to 64,813 by 2026 and 86,604 by 2056. No new growth is planned in the municipality that was not considered in the approved plan and Central Elgin is not identified in the *Places to Grow Act, 2005.* The municipality is able to meet its water demand with the existing Belmont and Elgin Primary systems.

The Municipality of Central Elgin acquired approximately 28 acres of land from the Federal Government in 2010 as a result of Transport Canada’s “Ports Asset Transfer Program” (PATP). In addition to these lands the municipality also acquired a further 7.5 acres of waterfront industrial land from private ownership. The Municipality of Central Elgin is undertaking the completion of a new Secondary Plan for the Port Stanley Harbour lands. The study area incorporates the 35.5 acres of municipally owned lands as well as an additional 25 acres of privately owned lands in and around the Port Stanley Harbour and waterfront. This Secondary Plan is intended to provide increased detail from what is currently identified in the Municipality’s Official Plan for future development of these lands. It is currently being contemplated to develop these lands for future use as commercial, public open space as well as medium density residential. This secondary plan will provide the principal of land use, as well as engineering master planning for the study area in the areas of environmental risk management, stormwater management, transportation planning and site servicing. More detail work respecting these topics will be required at the time of future development. Of the total 60.5 acres in the study area approximately 50 acres are located in the IPZ-2 of the Elgin Area Primary Water Supply System. This area will be developed with the security of the water system and Source Water Protection in mind.

Potential land use changes, for example changes in transport pathways such as stormwater drains and changes in impervious areas as a result of development and their impact on the delineation and scoring of the vulnerable areas will be assessed, and changes to the Assessment Report and Source Protection Plan identified. Depending on the magnitude of any changes, the Lake Erie Region Source Protection Committee, in consultation with the Kettle Creek Source Protection Authority and municipalities, will decide whether any updates should be included as a Section 34 or 36 update.

2.1.2.2 Infrastructure:

Two municipal drinking water systems serve the communities of the Kettle Creek Source Protection Area: a well in Belmont and the Elgin Area Primary Water Supply System (EAPWSS) Lake Erie intake in Port Stanley. There is currently no plan to change or expand the two systems or add new drinking water systems in the Kettle Creek Source Protection Area to meet future water demands.

2.1.2.3 Safe Drinking Water Act (2002) O. Reg. 205/18:

Any future changes to the two municipal drinking water systems or the addition of any new municipal system in the Kettle Creek Source Protection Area that requires the completion of a drinking water works permit, will follow the Lake Erie Source Protection Region Protocol for implementing regulatory requirements under the Clean Water Act, 2006, S.48 (1.1)(b) of O. Reg. 287/07. The protocol ensures that the Source Protection Authority provides a notice to the system owner that source protection technical work has been completed prior to applying for a drinking water works permit.

The protocol was developed collaboratively by the GRCA, Region of Waterloo and City of Guelph, in consultation with the Lake Erie Region Implementation Working Group. The protocol has been endorsed by the Lake Erie Region Management Committee, and released to all municipalities in the Lake Erie Source Protection Region.

2.1.3 C: Council resolutions

There were no council resolutions that resulted in any findings for inclusion in the proposed Kettle Creek S.36 Workplan. There are no municipal plans to include other types of systems (non-residential, communal) in the source protection process, and there are no First Nations within the Kettle Creek Source Protection Area.

2.1.4 D: Policy Effectiveness

2017 annual progress reporting results have been reviewed and no policy gaps have been identified. Two existing significant drinking water threats were identified in the Kettle Creek Source Protection Area when the plan took effect. Since implementation of the plan, both threats have been addressed. Additionally, many of the applicable plan policies (68%) that address significant drinking water threats are implemented or in progress. 25% of the plan policies that address significant drinking water threats do not require a response or are not applicable.

2.1.5 E: Implementation Challenges

It is fortunate that the two municipal water supplies within the Kettle Creek Source Protection Area are well protected and are not adversely affected by a number of threats. The Belmont water system has no existing significant threats, conditions or issues that have been enumerated within the Belmont Wellhead Protection Area. With respect to the EAPWSS there were only two significant drinking water threats that have been identified. The bulk storage of urea ammonium nitrate fertilizer within the IPZ-2 was ceased in 2013 and therefore the threat eliminated. The second identified threat was the bulk storage of diesel fuel that is used to power the standby generator for the Elgin Area Water Treatment plant has been managed through the implementation of a Risk Management Plan. Given the foregoing it has not been difficult to implement the policies identified in the plan. The Municipality of Central Elgin however, remains diligent in any proposed land use changes or changes on the landscape to ensure that new threats do not become a reality.

2.1.6 F: Technical Rule Changes

Phase II Rule Project

The Grand River SPA, in consultation with Central Elgin, EAPWSS, Kettle Creek SPA, staff and the Source Protection Committee, will review and consider incorporating changes to the technical rules once they are finalized and become available.

Addition of liquid hydrocarbon pipelines

The conveyance of oil by way of an underground pipeline, now a prescribed drinking water threat as per recent changes to O.Reg. 287/07, was approved as a local threat for source protection plans in the Lake Erie Source Protection Region in 2011. However, no pipelines were identified and addressed in the approved Kettle Creek Source Protection Plan and the Grand River SPA is not aware of any new pipelines constructed since plan approval. The Kettle Creek Assessment Report will be updated to reflect that liquid hydrocarbon pipelines are now a prescribed drinking water threat.

Changes to above grade fuel handling and storage in a WHPA-E or IPZ

The MECP has modified the underlying calculations that determine whether above grade fuel handling and storage can be a significant drinking water threat. As a result the activity would be identified as a significant drinking water threat in Intake Protection Zones (IPZs) with vulnerability scoring of 9.0 or higher and at lower volumes. Above grade fuel handling and storage remains a low drinking water threat in the Kettle Creek Source Protection Area as the IPZ vulnerability does not exceed scoring of 5.0.

Climate change

Conservation Ontario is developing guidance for incorporating climate change into Source Protection Plan water quality risk assessments. Grand River SPA, in consultation with Central Elgin, EAPWSS, Kettle Creek SPA, and the Source Protection Committee, will review and consider the guidance once it is finalized and becomes available.

Significant groundwater recharge area vulnerability scoring

The approved Kettle Creek Source Protection Plan includes the delineation of and vulnerability scoring for Significant Groundwater Recharge Areas (SGRAs). Vulnerability scores will need to be updated, i.e., removed, in accordance with the Phase 1 updates to the Technical Rules and Tables of Drinking Water Threats (March 2017). There are no SGRAs in the Kettle Creek Source Protection Area that require removal from the plan as per Rule 45 (systems that are excluded from the SGRA delineation requirements).

Sewage/septic systems and holding tanks

No issues-based threats were identified for the Belmont water supply and the EAPWSS. The removal of sodium and chloride references from the circumstances related to on-site sewage systems and holdings tanks does not apply to the Kettle Creek Source Protection Area.

Removal of the term “dairy producer”

The Kettle Creek Assessment Report and Source Protection Plan do not contain the term “dairy producer”.

Great Lakes Intake increased vulnerability scoring through Technical Rule 95.1

The EAPWSS Intake is not considered near-shore nor are there any water quality concerns associated with the intake that could be addressed within the framework of the *Clean Water Act, 2006.* As a result, no change to the vulnerability score of the EAPWSS intake protection zones is necessary.

Tables of Drinking Water Threats

The Grand River SPA will update terminology in the Kettle Creek Assessment Report and Source Protection Plan to reflect changes to “Short Names” in the Table of Drinking Water Threats.

2.1.7 G: Impacts of Prohibition Policies on the Agricultural Community

The Kettle Creek Source Protection Plan does not prohibit agricultural activities outside of a WHPA-A or IPZ-1, and as a result, no changes to the Kettle Creek SPP policies are proposed.

2.1.8 H: Specific directions in some source protection plan approval letters

The Kettle Creek Source Protection Plan approval letter did not include specific direction.

2.1.9 I: Other local considerations

The identification of any transport pathways are captured through notices submitted to the Grand River SPA as per Lake Erie Region's Transport Pathway Guidance. Potential transport pathways will be analyzed, and changes to vulnerability mapping are proposed, where appropriate, for the Assessment Report. There are currently no transport pathway notices under consideration.

2.2 Workplan Consultation

Consultation on the workplan was conducted in a variety of forms. This included emails, teleconferences, and phone calls with staff from Central Elgin, EAPWSS, Kettle Creek SPA, Long Point Region SPA, the MOECC/MECP, and a meeting with the SPC.

The purpose of the consultation was to discuss the proposed workplan and receive comments and feedback. The following list outlines the consultation conducted:

No.	Date	Consultation Details
1	June 5, 2018	A teleconference was held with the Lake Erie Region Project Manager, Program Assistant and staff from Kettle Creek SPA, Long Point Region SPA, EAPWSS, and the municipality of Central Elgin to discuss the workplan process.
2	June 22, 2018	A meeting was held with the workplan development team (see list of participants above) to discuss the nine factors specified in the December 2016 MOECC bulletin and other items that could be included in the review.
3	June 26, 2018	The Project Manager and Program Assistant participated in a teleconference with the MECP to discuss the progress of the workplan.
4	July 31, 2018	A teleconference was held with the workplan development team to review a first draft of the workplan.
5	August 2, 2018	A meeting was held with the Lake Erie Region Project Manager, Program Assistant and Hydrogeologist to review the March 2017 Director Technical Rule amendments for potential inclusion in the workplan.

No.	Date	Consultation Details
5	August 17, 2018	Feedback obtained from Kettle Creek SPA, Long Point Region SPA and Central Elgin and EAPWSS staff on the second draft of the workplan.
6	August 31, 2018	Draft workplan for S. 36 updates provided to the MECP for their review as part of consultation process.
7	October 4, 2018	Draft workplan for S. 36 updates was reviewed and discussed by the SPC.
8	TBD, 2018	A SPA meeting was held to approve the proposed workplan.
9	TBD, 2018	The proposed S. 36 workplan was submitted electronically to MECP.

3. Proposed Review and Updates

Based on the preliminary analysis, consultations with various stakeholders, and feedback from the MECP on the draft proposal, the Grand River SPA recommends that updates be carried out under S. 36 of the *Clean Water Act, 2006* as described below. Most of the proposed updates result in updates to both the AR and SPP.

3.1 Proposed Update 1

Review Factor: Technical Rule Changes – Phase II Rule Project

Through the preliminary analysis, anticipated changes resulting from the MECP's Phase II Rule Project have been identified that will likely need to be reflected in an update to the AR and SPP. The complete list of changes to the rules has not been identified to this point, nor has the timeline for completion of the Project.

Grand River SPA will work closely with Central Elgin, EAPWSS and the Kettle Creek SPA to ensure that the new rules are reviewed and considered for incorporation in the AR and SPP once they are finalized and become available.

This update will be completed by the Lake Erie Region SPC within two years from the time the Phase II Rules Project becomes available. The Grand River SPA recommends that this update be part of the S. 36 update based on discussions with Central Elgin, EAWPSS and the Kettle Creek SPA. A two year timeframe will ensure that there is adequate flexibility to also work on workplans and SPP updates for Grand River, Long Point Region and Catfish Creek. The expected completion date of this proposed update will be dependent on workload and capacity across the Lake Erie Region.

3.2 Proposed Update 2

Review Factor: Technical Rule Changes - liquid hydrocarbon oil pipeline threat

Oil pipelines were listed as a "local threat" in the approved Kettle Creek AR and SPP. However, the Grand River SPA is not aware of any pipelines in the Kettle Creek Source Protection Area, no existing pipelines are identified in the AR, and therefore none are addressed in the approved SPP. Additionally, no pipeline threats have been identified since SPP approval and there is little prospect that future pipelines will be built where they could be a significant drinking water threat. Any text and tables in the Kettle Creek AR and SPP referring to pipelines as a local threat will be updated to reflect that pipelines are now a "prescribed drinking water threat".

This update will be completed by the Lake Erie Region SPC by March 2020. The Grand River SPA recommends that this update be part of the S. 36 update based on discussions with Central Elgin, EAWPSS and the Kettle Creek SPA. The submission of the updated AR and SPP may be dependent on the timeline for completion of other S. 36 updates.

3.3 Proposed Update 3

Review Factor: Technical Rules Changes – Climate Change

Conservation Ontario's guidance for incorporating climate change into SPP water quality risk assessments may result in changes to the assessment that could be considered in updates to the AR and SPP.

Grand River SPA will work closely with Central Elgin, EAPWSS and the Kettle Creek SPA to ensure that the guidance is reviewed and the outcomes carefully considered for incorporation in the AR and SPP once the guidance document is finalized and becomes available. Conservation Ontario anticipates to submit the final guidance to the MECP in November 2018 for consideration under the source protection technical framework.

This update will be completed by the Lake Erie Region SPC within two years from the time the climate change guidance becomes available. The Grand River SPA recommends that this update be part of the S. 36 update based on discussions with Central Elgin, EAWPSS and the Kettle Creek SPA. A two year timeframe will ensure that there is adequate flexibility to also work on workplans and SPP updates for Grand River, Long Point Region and Catfish Creek. The expected completion date of this proposed update will be dependent on workload and capacity across the Lake Erie Region.

3.4 Proposed Update 4

Review Factor: Technical Rules Changes – SGRA vulnerability scoring and Tables of Drinking Water Threats "Short Names"

The AR and SPP will be updated to incorporate changes to significant groundwater recharge areas (SGRA). Specifically, vulnerability scoring will be removed from the SGRAs and the delineated SGRAs (scores of 2, 4, and 6) will be grouped into a single SGRA. Text and maps will be updated accordingly. Text in the AR and SPP will be updated to incorporate changed terminology regarding the prescribed drinking water threat "Short Names".

These updates will be completed by the Lake Erie Region SPC by March 2020. The Grand River SPA recommends that this update be part of the S. 36 update based on discussions with Central Elgin, EAWPSS and the Kettle Creek SPA. The submission of the updated AR and SPP may be dependent on the timeline for completion of other S. 36 updates.

3.5 Proposed Update 5

Review Factor: Other local considerations – Impacts on delineation of Intake Protection Zone from potential land use changes including transport pathways

Potential land use changes, for example changes in transport pathways such as stormwater drains and changes in impervious areas as a result of development and their impact on the delineation and scoring of the vulnerable areas will be assessed, and changes to the

Assessment Report and Source Protection Plan identified. Depending on the magnitude of any changes, the Lake Erie Region Source Protection Committee, in consultation with the Kettle Creek Source Protection Authority and municipalities, will decide whether any updates should be included as a Section 34 or 36 update.

Any identified transport pathways that the SPA will become aware of in accordance with section 27 of the General Regulation (287/07) will also be considered for inclusion in the AR and SPP. The AR updates may include updated WHPA/IPZ vulnerable area mapping, and the associated vulnerability scores, which will be used to determine and include identification of areas where an activity is or would be a significant drinking water threat. The SPP policy applicability maps would also be updated to reflect changes to the AR.

This update will be completed by the Lake Erie Region SPC by March 2020. The Grand River SPA recommends that this update be part of the S. 36 update based on discussions with Central Elgin, EAWPSS and the Kettle Creek SPA. The submission of the AR and SPP may be dependent on the timeline for completion of other S. 36 updates.

3.6 Project Management and MECP Support for Updates

The MECP provides support through its capacity funding under the DWSP program, technical bulletins, guidance, and feedback, and this support for local program delivery is acknowledged.

The Grand River SPA continues to lead the Source Protection Region efforts. The Lake Erie Region Source Protection Committee with support by the Grand River SPA will lead the updates to the Kettle Creek AR and SPP in accordance with the S. 36 workplan, in addition to the source protection work needed in Catfish Creek, Grand River and Long Point Region. The continuation of support by MECP will be necessary to undertake the proposed updates under S. 36 and the required consultation. This includes Lake Erie Region staff capacity and expertise, Source Protection Committee meetings, Lake Erie Region Implementation Working Group meetings, and stakeholder engagement workshops prior to submission of an updated SPP including AR. The Grand River SPA recommends that staff levels within the Lake Erie Region be maintained in order to carry out the proposed updates.

4. Conclusion

Through consultation in 2018 with stakeholders, the following updates are proposed to the SPP including the AR:

Update No.	Description of Proposed Review and Update	Applicable Document	Timeframe for Completion of the Update
1	Assess changes resulting from the Phase II Rule Project and make appropriate updates as required to the AR and SPP.	AR and SPP	Within two years from the time the Phase II Rules Project becomes available
2	Make appropriate updates to align with the new prescribed threat per Clean Water Act O. Reg. 287/07 - liquid hydrocarbon pipeline	AR and SPP	March 2020
3	Review and assess potential climate change additions to the technical framework and make appropriate updates as applicable to the AR and SPP.	AR and SPP	Within two years from the time the climate change guidance becomes available
4	Assess and make appropriate updates to align with the March 2017 Technical Rule change to: • SGRA vulnerability scoring • update the terminology in the assessment repot and source protection plan with updated 'short names' in the Tables of Drinking Water threats	AR and SPP	March 2020
5	Assess potential land use changes, including identified transport pathways, to update vulnerability mapping (WHPA, IPZ), scoring and enumeration of potential significant drinking water threat activities	AR and SPP	March 2020

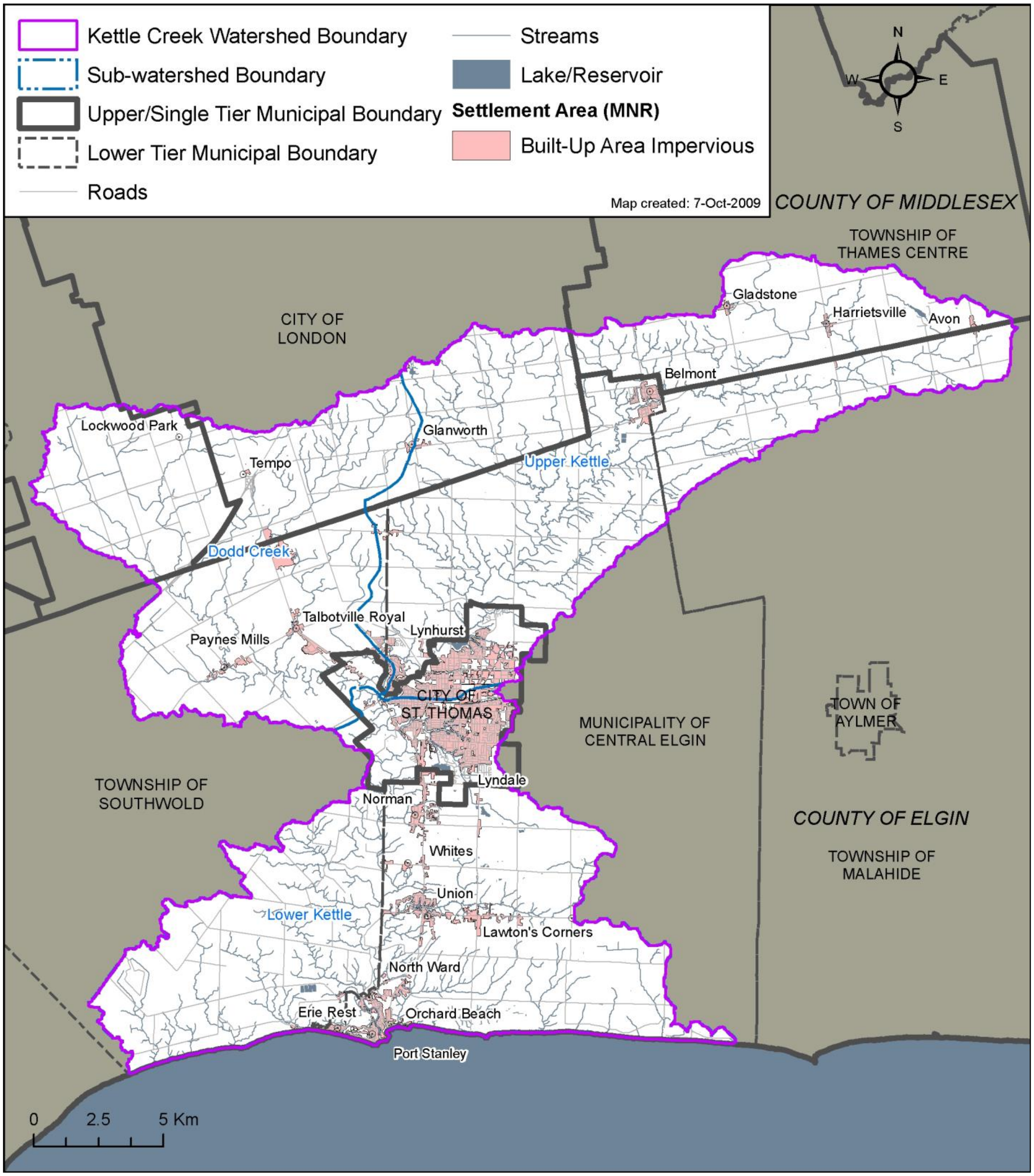
The overall timeline for completion of all of the proposed updates is March 2020, or two years after the release of the Phase II Technical Rules or climate change guidance documents. Submission of the updated Kettle Creek AR and SPP would be expected four months after completion of the technical work. The Lake Erie Region SPC will complete the proposed changes with support from the Grand River SPA, and in consultation with the Kettle Creek SPA, Central

Elgin, EAPWSS, the MECP, and other applicable implementing bodies. Consultation may also take place with persons engaged in significant drinking water threat activities, if the policy changes affect persons engaged in existing significant threat activities.

Appendix A:
S. 36 Order from Minister of the Environment and Climate Change

Appendix B:
Kettle Creek Watershed Boundary

Map: Kettle Creek Watershed



LAKE ERIE REGION SOURCE PROTECTION COMMITTEE

REPORT NO. **SPC-18-10-05** **DATE:** October 4, 2018

TO: Members of the Lake Erie Region Source Protection Committee

SUBJECT: **Progress Report Grand River Assessment Report and Source Protection Plan Update**

RECOMMENDATION:

THAT the Lake Erie Region Source Protection Committee receives report SPC-18-10-05 – Progress Report Grand River Assessment Report and Source Protection Plan Update – for information.

REPORT:

This report provides an update on progress of technical studies in the Grand River watershed. Progress reports and results of technical studies will be presented to the Source Protection Committee as they are completed with recommendations to update the Grand River Assessment Report and Source Protection Plan. Once the technical studies are presented, complete municipal sections of the Assessment Report and Plan will be presented to the Source Protection Committee.

Technical Studies

County of Brant

Water quality WHPAs and vulnerability assessments were completed for four water supply systems in the County of Brant. The four water supply systems include St. George, Airport, Bethel and Mt. Pleasant. The St. George and Airport technical studies were presented at past Source Protection Committee meetings on June 21, 2018 and July 6, 2017, respectively. The Bethel and Mt. Pleasant studies were completed in September 2018 and are presented in Reports SPC-18-10-06 and SPC-18-10-07, respectively. The complete updated Brant County section of the Assessment Report and Plan will be brought to the December 6, 2018 Source Protection Committee meeting.

Guelph-Eramosa (Hamilton Drive, Rockwood) and Centre Wellington WHPA and Issue Contributing Area Delineation

Water quality WHPAs and vulnerability assessments are currently being completed for Guelph-Eramosa (Hamilton Drive and Rockwood water supply systems) and Centre Wellington (Fergus and Elora water supply systems) using Tier 3 models. In Centre Wellington, chloride Issue Contributing Areas are being developed for two municipal wells where chloride has been identified as a drinking water Issue under the Technical Rules. Both the Guelph-Eramosa and Centre Wellington studies are currently underway and are expected to be completed in Fall 2018. It is anticipated that both technical studies will be presented at the December 6, 2018 Source Protection Committee meeting.

Centre Wellington Scoped Tier 3 Water Budget study

The Centre Wellington Scoped Tier 3 Water Budget Study began in August 2016 to assess potential risks to the Centre Wellington municipal drinking water system. The project is managed by the GRCA on behalf of the Township of Centre Wellington. The study is being completed in coordination with the Township's Water Supply Master Plan which began earlier this year.

The project consultants have completed the draft Groundwater Flow Development and Calibration Report, which has been reviewed by the Provincial peer review team and presented to the Community Liaison Group (CLG) on May 15. A project update was provided to Township council on May 22. A series of stakeholder meetings with members from the CLG are currently being held to discuss comments provided on the draft modelling report. The project is currently at the uncertainty assessment phase, where the sensitivity of model parameters is evaluated. Following the uncertainty assessment, the risk assessment phase will begin with input provided by the Township's Water Supply Master Plan.

Information about the Centre Wellington study including reports, CLG presentations, and meeting summaries are available at www.sourcewater.ca/CW-Scoped-Tier3

Prepared by:

Emily Hayman

Emily Hayman, P.Geo.
Source Water Hydrogeologist

Prepared by:

Sonja Strynatka, P.Geo.
Senior Hydrogeologist

Approved by:

Martin Keller, M. Sc.
Source Protection Program Manager

LAKE ERIE REGION SOURCE PROTECTION COMMITTEE

REPORT NO. **SPC-18-10-06** **DATE:** October 4, 2018

TO: Members of the Lake Erie Region Source Protection Committee

SUBJECT: **Bethel Water Quality WHPA Update Technical Study**

RECOMMENDATION:

THAT the Lake Erie Region Source Protection Committee receives report SPC-18-10-06 – Bethel Water Quality WHPA Update Technical Study - for information.

AND THAT the Lake Erie Region Source Protection Committee direct staff to incorporate the results of the Bethel Water Quality WHPA Update Technical Study into the Draft Updated Grand River Assessment Report and Source Protection Plan.

SUMMARY:

The Bethel Road Wellfield is one of the three active wellfields that supply water to the Town of Paris and consists of four production wells. Wellhead Protection Areas (WHPAs) were last delineated for the municipal wells in 2014. Since that time, the Whitemans Creek Tier 3 groundwater flow model has been developed, which represents the most current science and conceptual understanding of the area. The objective of the current technical study is to delineate WHPAs and assign vulnerability scores for the Bethel municipal wellfield using the Whitemans Creek Tier 3 groundwater flow model.

Results are recommended to be incorporated into the update to the Draft Updated Grand River Watershed Assessment Report and Source Protection Plan.

REPORT:

System Overview

The Bethel wellfield is operated by the County of Brant and primarily services water to the Brant 403 Business Park and the south end of Paris. The Bethel wellfield is located south of Highway 403 and in the urban area of Paris on Bethel Road, just west of the intersection with Rest Acres Road. The Bethel wellfield consists of four overburden wells, P51, P52, P53 and P54. The wells are screened within the unconfined intermediate to deep overburden deposits from approximately 22.5 to 30.5 metres below ground surface. The production wells at the Bethel wellfield are Groundwater Under Direct Influence of Surface Water (GUDI) with effective filtration (EF) designation.

Wellhead Protection Areas

The source aquifer for the Bethel wellfield is interpreted as having an upper and lower unit partially separated by a till confining unit. The lower aquifer is comprised of sand and gravel (Waterloo Moraine equivalent sediments) and is confined to the north of the Bethel Wellfield by the Port Stanley Till. To the south of the wellfield, the aquifer becomes less confined where it contacts the Norfolk Sands. The Port Stanley Till is absent or discontinuous in the vicinity of the

Bethel municipal wells, allowing for connectivity between the upper and lower aquifer units.

WHPAs were delineated for the four drinking water supply wells (P51, P52, P53 and P54) using the Whitemans Creek Tier 3 groundwater flow model. The Whitemans Creek Tier 3 model was updated to incorporate the Brant Business Park storm water management pond and infiltration gallery, located 300 m north of the wellfield. Manual water level data in the pond and infiltration gallery were used to understand the influence these features have on local groundwater flow patterns. The modelled recharge rates within the area included the contribution from the Brant Business Park infiltration.

Four different model configurations were tested to investigate capture zone sensitivity which include; allocated demand (15.9 L/s), the average instantaneous pumping rate from 2016 to 2018 (18.26 L/s) with and without the infiltration gallery, and the wellfield pumping at 19.46 L/s, corresponding to the simulated maximum allowable drawdown with the infiltration gallery. The WHPAs were delineated based on the largest composite of the four sensitivity scenarios.

The water levels in the overburden aquifer indicate that the regional groundwater flow is towards the Grand River. Flows are locally influenced by the presence of Whitemans Creek which, similar to the Grand River, is a groundwater discharge feature. The 25 year capture zone, which extends approximately 1.5 km to the west upgradient of the general direction of regional groundwater flow, is approximately 1 km wide across the centre.

The resulting WHPAs are shown on **Figure 1** along with the previous WHPAs. Differences between the 2014 and 2018 WHPA shape and size result from a number of factors including:

- revised hydrostratigraphic conceptualization,
- revised recharge rates and distribution developed from the Tier 3 study, and
- inclusion of the Brant Business Park storm water management pond and infiltration gallery in the model as a recharge feature.

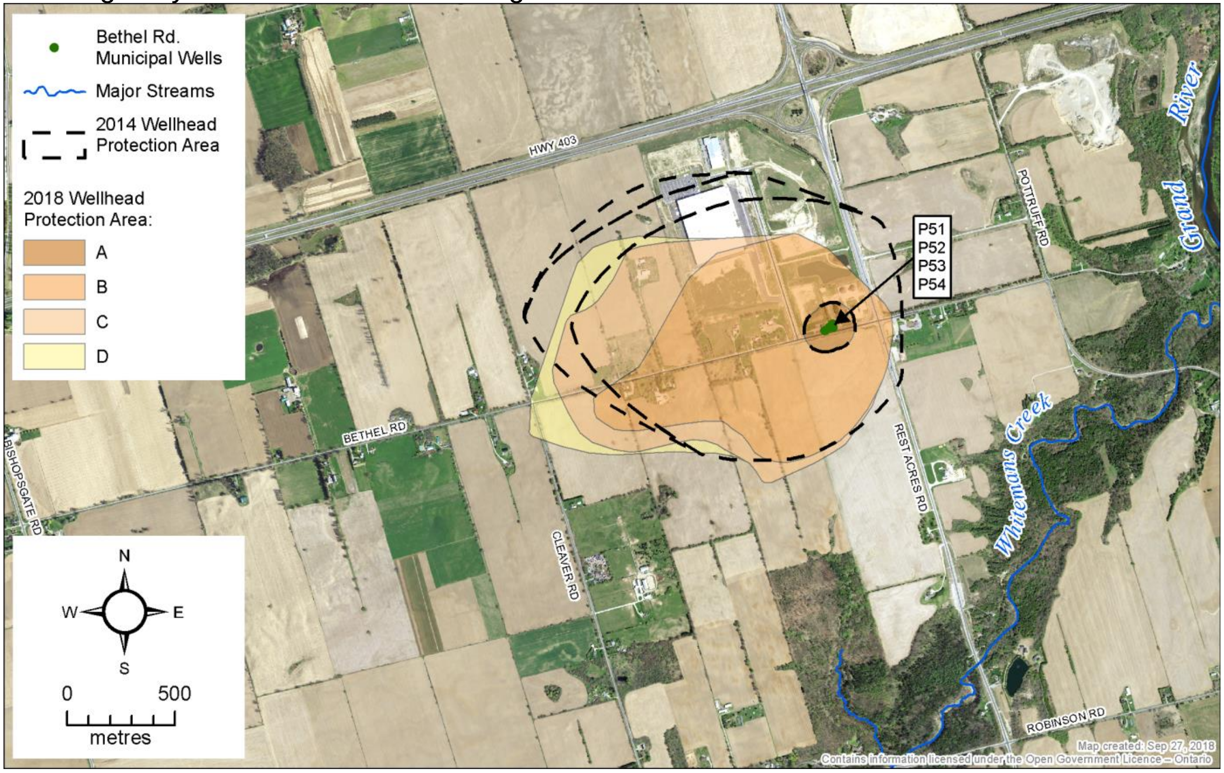


Figure 1: Bethel WHPAs – comparison of 2014 and 2018 WHPAs.

The Bethel municipal wells are considered groundwater under the direct influence of surface water with effective filtration (GUDI-EF), however it was not within the scope of the current technical study to delineate a WHPA-E and/or WHPA-F. Co-ordination between the County of Brant and the GRCA is currently ongoing to determine WHPA-E and/or WHPA-F delineations.

Vulnerability Scoring

The surface to well advective time (SWAT) method was used to delineate areas of low, medium and high vulnerability within the WHPAs. Resulting vulnerability scores within the Bethel WHPAs were determined based on the vulnerability scoring matrix in **Table 1.**

Table 1: WHPA Vulnerability Scores – SWAT

	Surface to Well Advective Time (SWAT)		
	High (0 to 5 years)	Medium (5 to 25 years)	Low (>25 years)
WHPA – A	10	10	10
WHPA – B	10	8	6
WHPA – C	8	6	2
WHPA – D	6	4	2

Potential transport pathways were reviewed as part of the current study and resulted in the identification of: 1) wells identified within MECP's Water Wells Information System constructed prior to 1990, 2) an aggregate extraction pit located to the south of the municipal wells, and 3) the Brant Business Park storm water management pond.

Vulnerability scores were not adjusted to account for wells due to the potential inaccuracy of the Water Well Records. It is recommended that the vulnerability not be increased for the presence of non-municipal wells until a well inventory is completed to verify their location and status.

One active aggregate pit operation located to the south of the wellfield, and the Brant Business Park storm water management pond to the north, lie within the vulnerable area. No adjustments to the vulnerability levels were required as the pit and pond are already located in an area of high vulnerability.

The resulting map with vulnerability scores within the new WHPAs is shown on **Figure 2**.

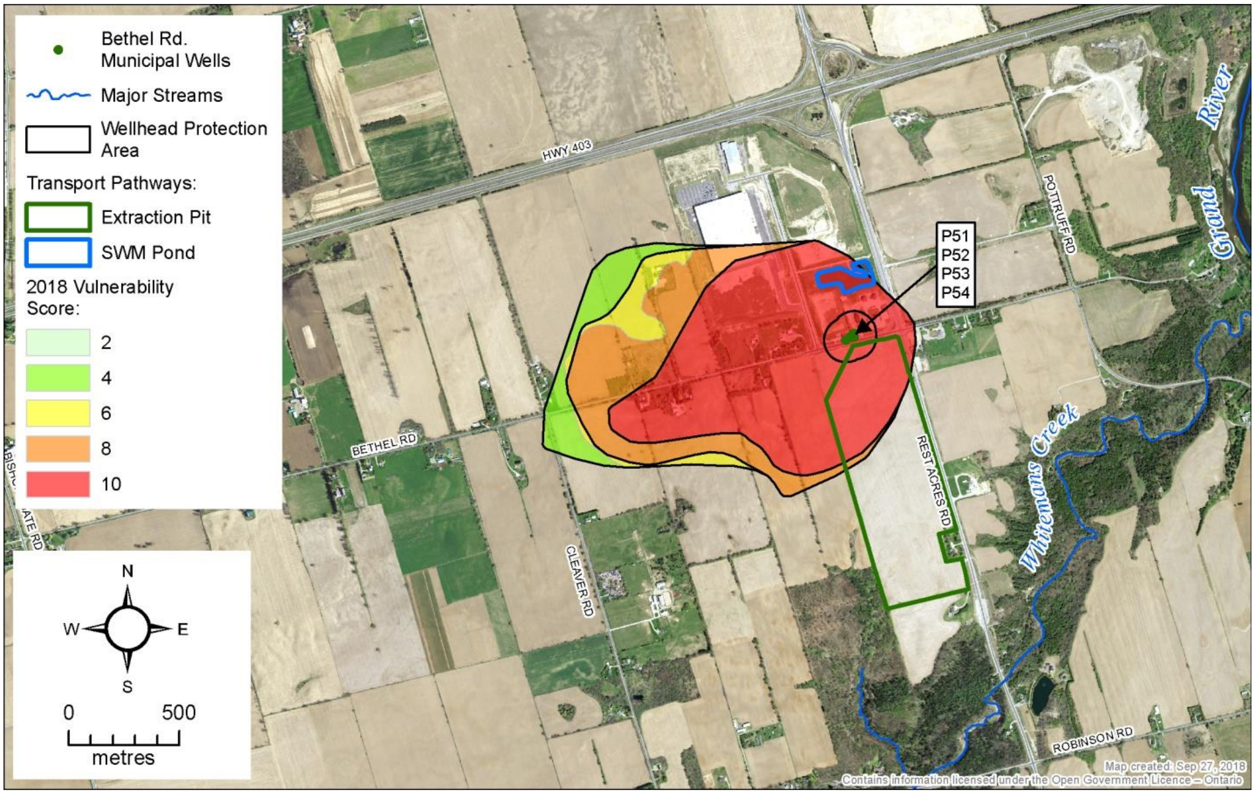


Figure 2: Vulnerability scoring within Bethel Wellfield WHPAs

Next Steps

The results of this study are recommended to be incorporated into the Draft Updated Grand River Watershed Assessment Report and Source Protection Plan.

Prepared by: Reviewed by:
Prepared by: Reviewed by:

Emily Hayman

Emily Hayman, M.Sc., P.Geo.
Source Water Hydrogeologist

Sonja Strynatka, P.Geo.
Senior Hydrogeologist

Approved by:

Martin Keller, M. Sc.
Source Protection Program Manager

LAKE ERIE REGION SOURCE PROTECTION COMMITTEE

REPORT NO. **SPC-18-10-07** **DATE:** October 4, 2018

TO: Members of the Lake Erie Region Source Protection Committee

SUBJECT: **Mt. Pleasant Water Quality WHPA Update Technical Study**

RECOMMENDATION:

THAT the Lake Erie Region Source Protection Committee receives report SPC-18-10-07 – Mt. Pleasant Water Quality WHPA Update Technical Study - for information.

AND THAT the Lake Erie Region Source Protection Committee direct staff to incorporate the results of the Mt. Pleasant Water Quality WHPA Update Technical Study into the Draft Updated Grand River Watershed Assessment Report and Source Protection Plan.

SUMMARY:

Two groundwater supply wells provide municipal water to the village of Mt. Pleasant, within the County of Brant. Wellhead Protection Areas (WHPAs) were last delineated for the municipal wells in 2010. Since that time, the Whitemans Creek Tier 3 groundwater flow model has been developed, which represents the most current science and conceptual understanding of the area. The objective of the current technical study is to delineate WHPAs and assign vulnerability scores for the Mt. Pleasant municipal wellfield using the Whitemans Creek Tier 3 groundwater flow model.

Results are recommended to be incorporated into the update to the Draft Updated Grand River Watershed Assessment Report and Source Protection Plan.

REPORT:

System Overview

The Mt. Pleasant wellfield is operated by the County of Brant and services the surrounding area including 627 residences and 25 commercial accounts. The wellfield is located 1.3 kilometers northwest of the Mt. Pleasant village centre, approximately 8 kilometers southwest of the city centre of Brantford. The Mt. Pleasant municipal wellfield consists of two overburden wells, Well 1 and Well 2. The wells are screened from approximately 29.5 to 36 metres below ground surface within a sand and gravel aquifer. Neither of the wells are classified as groundwater under the direct influence of surface water (GUDI) as per the criteria outlined in MOECC (2001).

Wellhead Protection Areas

The Mt. Pleasant municipal wellfield's source aquifer is primarily composed of extensive unconfined glaciolacustrine deposits. Across the majority of the area, this aquifer is in direct contact with the underlying sands and gravels of the Grand River Valley outwash aquifer, effectively forming a single unconfined sand and gravel aquifer unit with a thickness up to 65 m. Locally however, the municipal aquifer is confined by the Wentworth Till aquitard in the vicinity of the wellfield.

The water levels in the overburden aquifer indicate that the regional groundwater flow is towards the Grand River to the east. Flows are locally influenced by the presence of Whitemans Creek which, similar to the Grand River, is a groundwater discharge feature.

Mt. Pleasant WHPAs were simulated using a cumulative municipal pumping rate equivalent to 80% of the maximum permitted rate for the wellfield. A continuous rate of 10.6 L/s was applied to Well 1 and Well 2 for a combined rate of 21.2 L/s.

The resulting WHPAs are shown on **Figure 1** along with the previous WHPAs. WHPA-D extends approximately 2.5 km to the west following the general direction of local groundwater flow patterns in this area. Differences between the 2010 and 2018 WHPA shape and size result from a number of factors including:

- revised hydrostratigraphic conceptualization,
- revised recharge rates and distribution developed from the Tier 3 study, and
- differing approaches to address uncertainty; the 2010 WHPAs were adjusted by an overall shape factor, the 2018 WHPAs accounted for uncertainty by reducing recharge and porosity.

Figure 1: Mt. Pleasant WHPAs. Dashed lines represent previous WHPAs.

As Well 1 and Well 2 are both classified as non-GUDI, a WHPA-E was not delineated.

Vulnerability Scoring

The surface to well advective time (SWAT) method was used to delineate areas of low, medium and high vulnerability within the WHPAs. Resulting vulnerability scores within the Mt. Pleasant WHPAs were determined based on the vulnerability scoring matrix in **Table 1.**

Table 1: WHPA Vulnerability Scores – SWAT

	Surface to Well Advective Time (SWAT)		
	High (0 to 5 years)	Medium (5 to 25 years)	Low (>25 years)
WHPA – A	10	10	10
WHPA – B	10	8	6
WHPA – C	8	6	2
WHPA – D	6	4	2

Additionally, potential transport pathways were reviewed as part of this study, the results of which included two sources of potential pathways: 1) wells identified within MECP's Water Wells Information System constructed prior to 1990 and 2) aggregate extraction pits.

Vulnerability scores were not adjusted to account for wells due to the potential inaccuracy of the Water Well Records. It is recommended that the vulnerability not be increased for presence of non-municipal wells until a well inventory is completed to verify their location and status.

Currently there is one active aggregate operation that lies partially within the delineated WHPAs. The aggregate area of extraction is of concern as it represents a large scale industrial operation that removes the overburden over a significant area. Vulnerability scores were adjusted within the aggregate operation limits (mostly with WHPA-D) to reflect the increased risks posed by the potential reduced surface to well travel times.

The resulting map with vulnerability scores adjusted to incorporate transport pathways, within the new WHPAs, is shown on **Figure 2**.

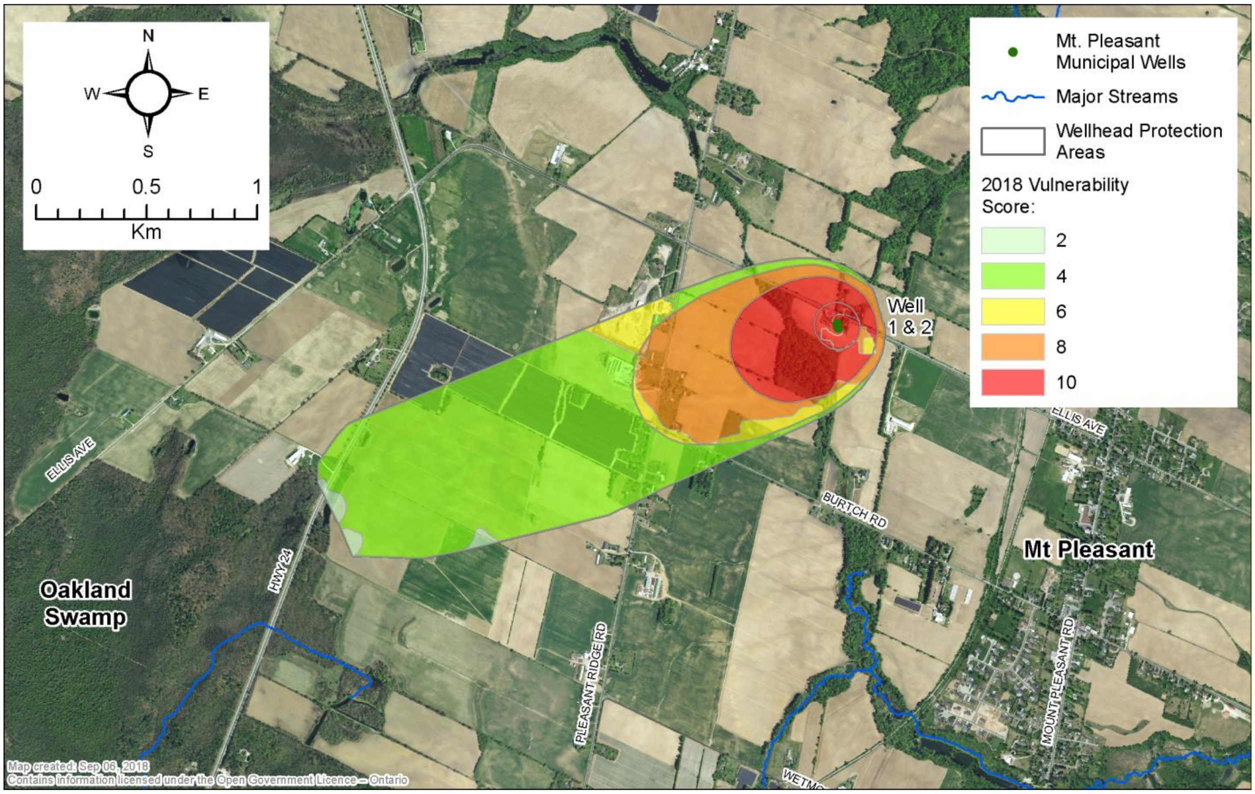


Figure 2: Vulnerability scoring within Mt. Pleasant WHPAs

Next Steps

The results of this study are recommended to be incorporated into the Draft Updated Grand River Watershed Assessment Report and Source Protection Plan.

Prepared by:

Emily Hayman

Emily Hayman, M.Sc., P.Geo.
Source Water Hydrogeologist

Reviewed by:

Sonja Strynatka, P.Geo.
Senior Hydrogeologist

Approved by:

Martin Keller, M. Sc.
Source Protection Program Manager

LAKE ERIE REGION SOURCE PROTECTION COMMITTEE

REPORT NO. SPC-18-10-08 **DATE:** October 4, 2018

TO: Members of the Lake Erie Region Source Protection Committee

SUBJECT: **Draft Updated Grand River Assessment Report and Source Protection Plan: City of Hamilton and Oxford County**

RECOMMENDATION:
THAT the Lake Erie Region Source Protection Committee receives report SPC-18-10-08 – Draft Updated Grand River Assessment Report and Source Protection Plan: City of Hamilton and Oxford County – for information.

REPORT:

Updates to the Assessment Report

Oxford County – Bright groundwater supply system

In addition, technical work to update WHPAs for the Bright groundwater supply system has been completed and was also presented to the SPC on June 21, 2018 (Report SPC-18-06-08). Results of the Bright water quality technical study have been incorporated into an updated County of Oxford section (11) of the assessment report. Updated enumeration of Significant Drinking Water Threats is not yet complete; threat numbers will be updated in the coming months and included in the complete draft updated Grand River Assessment report package that will be presented to the SPC in early 2019.

City of Hamilton – Lynden groundwater supply system

Technical work to update Wellhead Protection Areas (WHPAs) for the expanded Lynden groundwater supply system has been completed and was presented to the SPC on June 21, 2018 (Report SPC-18-06-05). Results of the Lynden water quality technical study have been incorporated into an updated City of Hamilton section (12) of the assessment report. Updated enumeration of Significant Drinking Water Threats and Water Quality Issues Evaluation are complete and included in the assessment report updates.

Both the City of Hamilton and County of Oxford assessment report sections have been updated for brevity and added clarity.

Updates to the Source Protection Plan

As a result of the technical updates in the assessment report, the Grand River Source Protection Plan was updated to include a revised policy applicability map for both the Lynden and Bright drinking water supply systems. Minor editorial changes have been made to reflect updates to Technical Rule changes. These included changes to the short form of the threat activities, and the inclusion of the oil pipeline as a prescribed drinking water threat, following regulatory changes from earlier this year. City of Hamilton and County of Oxford staff did not identify any policies that required revision.

Please see Appendix A and B for sections 11 (Oxford) and 12 (Hamilton), respectively of the assessment report and updated well supply policy applicability maps.

Prepared by:

Emily Hayman

Emily Hayman, M. Sc., P.Geo.
Source Water Hydrogeologist

Approved by:

Martin Keller, M. Sc.
Source Protection Program Manager

Appendix A

County of Oxford: Draft Updated Grand River Assessment Report and Source Protection Plan

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11.0 COUNTY OF OXFORD

11.1 Oxford County Water Quality Risk Assessment

Three municipal groundwater systems are located within the portion of the County of Oxford that falls within the Grand River Source Protection Area: Bright, Drumbo-Princeton, and Plattsville (**Table 11-1**). The areas serviced by these systems ~~can be seen~~ are shown on **Map 11-1**.

Table 11-1: Municipal Residential Drinking Water Systems Information for Oxford County in the Grand River Source Protection Area (Bright, Drumbo-Princeton and Plattsville Water Systems)

DWS Number	DWS Name	Operating Authority	GW or SW	System Classification[1]	Number of Users served[2]
220009050	Bright Water System	Oxford County	GW	Large municipal residential	~~409~~436
220007515	Drumbo-Princeton Water System	Oxford County	GW	Large municipal residential	~~803~~1,540
210001291	Plattsville Water System	Oxford County	GW	Large municipal residential	1,~~168~~506

[1] as defined by O. Reg. 170/03 (Drinking Water Systems) made under the *Safe Drinking Water Act, 2002.*
[2] Based on County of Oxford ~~2009~~ 2017 Water System Reports

~~These sections outline the common methodology that was used to delineate wellhead protection areas, vulnerability and threats assessment, and Issues and uncertainty evaluations for each of these systems.~~

Table 11-2: Annual and Monthly Average Pumping Rates for Oxford County Municipal Residential Drinking Water Systems in the Grand River Source Protection Area

Well or Intake	Annual Avg. Taking[1] (m^3/d)	Monthly Average Taking[1] (m^3/d)											
	2017	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Bright Water System	72~~87~~	71~~84~~	74~~86~~	72~~88~~	72~~86~~	73~~98~~	78~~96~~	73~~98~~	67~~86~~	73~~90~~	78~~79~~	74~~77~~	70~~81~~
Drumbo-Priceton Water System	266~~167~~	238 ~~157~~	238 ~~149~~	283 ~~150~~	325 ~~170~~	257~~176~~	297 ~~179~~	285 ~~173~~	252~~171~~	265~~183~~	269~~165~~	241~~161~~	247 ~~172~~
Plattsville Water System	442~~435~~	480 ~~400~~	500 ~~416~~	400 ~~459~~	443 ~~375~~	422~~410~~	416 ~~470~~	440 ~~530~~	430~~420~~	418~~476~~	486~~439~~	435~~430~~	433 ~~394~~

[1] source: Oxford County annual summary reports, based on ~~2009~~ 2017 monitoring data

11.1.1 Bright Water System

The Bright water system is ~~currently~~ supplied by two wells, Well 5 and Well 4A, located in the west part of the village~~, referred to as Well 4 (Piggot 4)4A and Well 4A (Piggot 5),5, located at a site in the in the west part of the village~~.

Well 5, constructed in 2003, was refurbished in 2008 through the installation of a new well screen and completed to a depth of 25.9 m below gound surface (bgs) in the Waterloo Moraine sand and gravel aquifer. Well 4A, constructed in 2009, replaced Well 4 which was taken offline in 2010. Well 4A is completed to a depth of 26.7 m bgs and is screened across the Waterloo Moraine sand and gravel aquifer.

~~Both~~None of the wells are ~~-~~considered ~~not~~ to be grounderwater under the direct influence of surface water (GUDI) according to the County of Oxford Water Systems Drinking Water Quality Management System Operational Plan.

Wells 5~~4A~~ and ~~5~~4A are permitted to operate at a maximum pumping rate of 3.78 L/s under Permit to Take Water (PTTW) 7467-84BQEE. Well 4A supplies the majority of the water demand.~~Well 4 was constructed in 1989 and equipped with a well screen set from approximately 21.6 – 23.5 m below surface. Well 4A was constructed in 2003 and equipped with a well screen set from approximately 23 – 25 m below surface. Well 4 was included in the Wellhead Protection Area (WHPA) modelling performed as part of the Phase II Groundwater Protection Study (2001) (Well 4 is referred to as the Piggot well in that study). The well was considered to be part of the intermediate aquifer, and was modelled using a forecast pumping rate of 97.5 m3/day (1.1 L/s). The WHPA was updated following the construction of Well 4A in 2003. Two other supply wells, the Bright Baird wells, are not currently in use.~~

11.1.2 Drumbo-Princeton Water System

The Drumbo-Princeton water system is supplied by three~~two~~ production wells: ~~(Well 2A and Well 3~~Well 1, Well 2A, and Well 3~~)~~. ~~The County is in the process of building a new system that would include servicing of the entire village of Princeton with municipal water from an expanded Drumbo water system.~~

Well 1, brought online in 2013, is located on the east side of County Road 3 in the north part of Drumbo. ~~In Drumbo,~~ Well 2A is located on the east side of the village of Drumbo on the north side of County Road 29 (Drumbo Road). Well 3 is located in the northwest part of the village. ~~A third well (Well 1), not yet part of the water supply system, brought online in 2013, is located on the east side of County Road 3 in the north part of Drumbo. Well 1 has been considered in the forecast pumping schedule used to develop capture zones for this water system although it is currently not operating.~~

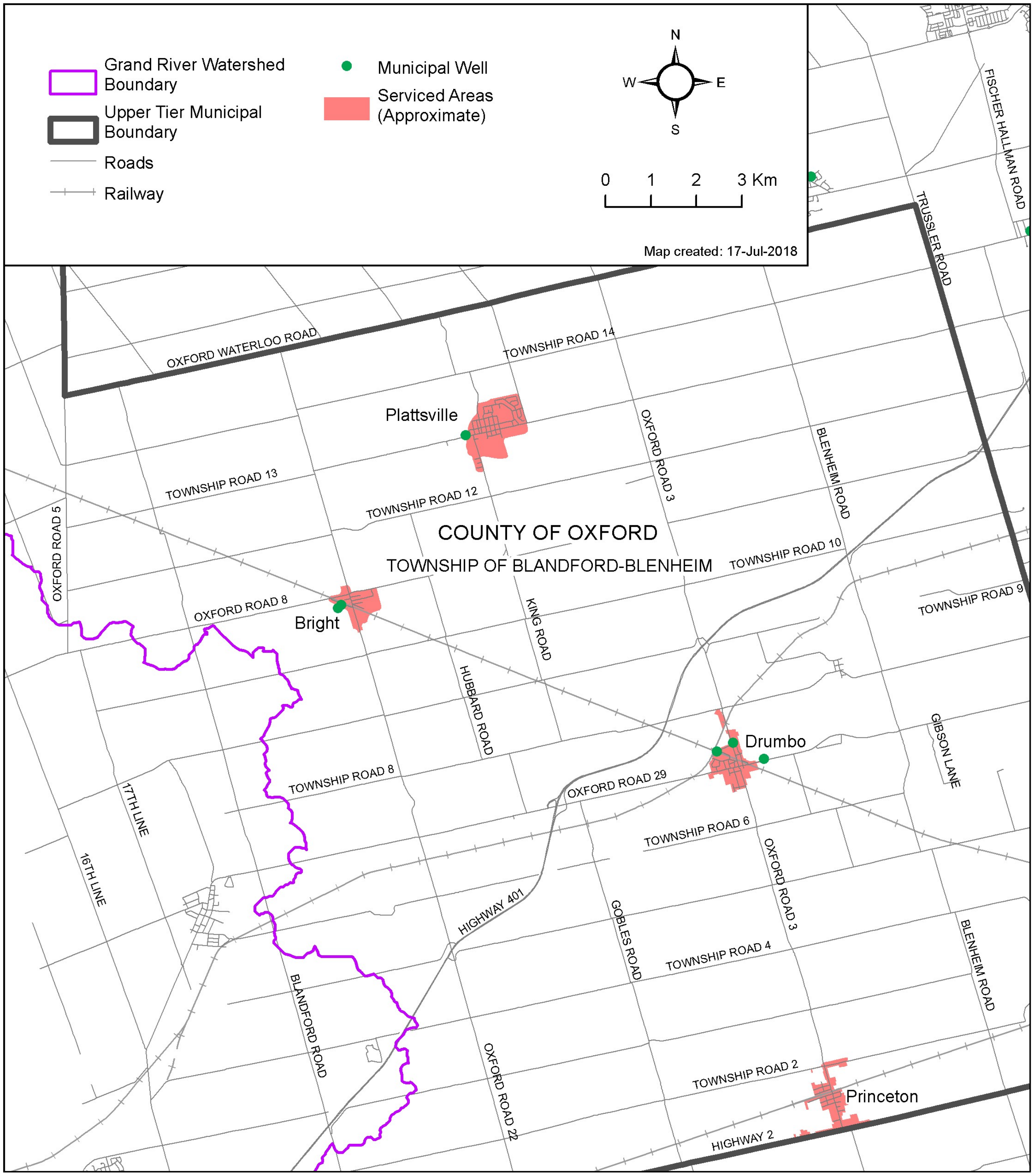
Well 1 is screened over a depth interval of 33 to 37 m bgs. Water well records indicate that the approximate screen depth intervals are 40 ~~–~~ to 44 m bgs at Well 2A and 26 ~~–~~ to 32 m bgs at Well 3. ~~Well 1 is screened over a depth interval of 33 – to 37 m bgs.~~ The well completion zones were considered to be part of the deep overburden sand silty aquifer ~~-~~(Golder, 2001).

11.1.3 Plattsville Water System

The Plattsville water system is supplied by two overburden wells located on the western edge of the community (north side of County Road 42), approximately 60 m from the Nith River. The well completions are reported to be in a sand and gravel aquifer with screen settings from about 12 ~~–~~ to 15 m ~~below surface~~bgs (Golder, 2001).~~ The Phase II Groundwater Protection Study~~

~~states that the aquifer is unconfined (shallow aquifer) and directly connected to the Nith River. However,~~ ~~subsequent work indicated that~~ Neither of the supply wells are ~~not~~considered GUDI.

Map 11-1: County of Oxford Supply Serviced Areas (within the Grand River Watershed)



11.1.4 Vulnerability Analysis

Delineation of Wellhead Protection Areas for the Bright Water System

The Bright WHPAs were delineated using the Whitemans Creek Tier 3 groundwater flow model (EarthFX, 2017a). The Whitemans Creek Tier 3 groundwater flow model was built using the U.S. Geological Survey (USGS) MODFLOW code (Harbaugh, 2005). The MODFLOW-NWT (Niswonger *et al.*, 2011) version of the code was used in this study because it is especially well suited for representing thin aquifers and sharp changes in model layer stratigraphy such as that occurring along the incised valleys of Whitemans Creek and the Grand River. The conceptual geologic model comprises of 17 layers, which were used to generate a 12- layer groundwater flow model for the Whitemans Creek area. Refer to Chapter 21 of this report for additional information on the Whitemans Creek Tier 3 groundwater flow model.

Groundwater recharge rates for the Wellhead Protection Area (WHPA) delineation~~study area~~ was~~ere~~ ~~estimated~~calculated using the PRMS hydrologic submodel delveloped for the Whitemans Creek Tier 3 study (Earthfx, 2017a). The groundwater recharge ~~estimates~~rates reflect the effects of spatial variation in climate, topography, land cover, and soil properties. Overall, the model was not overly sensitive to changes in recharge.

The Bright municipal supply wells are screened in Waterloo Moraine equivalent sediments and are referred as the Waterloo Moraine Aquifer. The aquifer is composed of sand and gravel and is between 5 and 30 m thick in the wellfield vicinity. The aquifer is confined within the wellfield vicinity; however it becomes less confined to the northeast and to the south where the Port Stanley Till thins. The Waterloo Moraine aquifer pinches out to the west and northwest and is generally continuous in all other directions. Below the Waterloo Moraine Aquifer, the Maryhill Till aquitard, and the older Catfish Creek Till aquitard provide vertical confinement for the deeper overburden aquifers, however, are generally thin and discontinuous in the study area.

The water levels in both the overburden and bedrock aquifers indicate that regional groundwater flow is from northwest to southeast. Locally high groundwater levels are observed in the overburden to the east of the municipal wellfield, where high recharge is believed to occur. Here, groundwater flow in the overburden fans out in multiple directions and causes groundwater flow through the municipal wellfield to be from the northeast to the southwest.

The pumping rates used to model WHPAs for Well 4A and Well 5 were 3.0 L/s and 0.78 L/s, respectively. The modelled rates were selected to represent a realistic distribution of the maximum permitted rates for the two wells. The 25-year capture zone extends approximately 1.4 km to the northeast following the general direction of local groundwater flow patterns in the area, as determined through interpolation of MECP water levels.

Well 4A and Well 5 are both classified as non-GUDI, therefore a WHPA-E and WHPA-F were not delineated.

Map 11-2 illustrates the time-related capture zones for the Bright Water System.

~~The delineation of Wellhead Protection Areas (WHPA) represents the foundation of a municipal groundwater protection strategy. Wellhead Protection Areas associated with the municipal water supply represent the areas within the aquifer that contribute groundwater to the well over a specific time period. According to the *Clean Water Act* Technical Rules (MOE, 2009b), four~~

~~Wellhead Protection Areas are required, one a proximity zone and the three others time-related capture zones:~~

- ~~WHPA-A 100 m radius from wellhead~~
- ~~WHPA-B 2-year Time of Travel (TOT) capture zone~~
- ~~WHPA-C 5-year Time of Travel capture zone~~
- ~~WHPA-D 25-year Time of Travel capture zone~~

~~All of the capture zones for the Bright, Drumbo and Plattsville Water Systems were delineated using numerical models that were developed for each municipal production well system and calibrated to the available hydrogeological data. The models were developed using the computer programs MODFLOW and MODPATH, and the procedures and results are described in detail in the Phase II Groundwater Protection Study (Golder, 2001) report. The specific method used to delineate each of the wellhead protection areas for each municipal system within Oxford County is described below.~~

~~*Modelling Approach for the Bright Water System*~~

~~The principal aquifer in the Bright area is considered to be the Intermediate Aquifer. The Shallow Aquifer is also present, although is relatively thin and typically separated from the Intermediate Aquifer by lower permeability silty sand and clay materials. Based on the above, the Bright Groundwater Model was constructed using three overburden layers; a thin layer (2 m thick) to represent the Shallow Aquifer; a 12.5 m thick low permeability layer underlying the Shallow Aquifer; and a 6.5 m thick layer at the bottom of the model representing the Intermediate Aquifer. The base of the model was assumed to be defined by the base of the Intermediate Aquifer.~~

~~Groundwater flow in the Intermediate Aquifer at Bright is inferred to occur in a southeasterly direction and the Bright Groundwater Model was, therefore, oriented in this direction. To the northwest and southeast of Bright the model boundaries follow inferred groundwater contours and were assigned as constant head boundary conditions. To the northwest, a constant head boundary elevation of 325 m above sea level (masl) was assigned. To the southwest, the groundwater model follows Horner Creek, while to the northeast it follows Wilmot Creek and the Nith River. A constant head boundary condition was assigned along these boundaries at an elevation consistent with the topography (surface water elevation) in the Digital Elevation Model (DEM). Groundwater flow will occur across the constant head boundaries.~~

~~The Shallow Aquifer is assumed to be connected to the surface drainage systems in the Bright area. However, it was assumed that the surface drainage systems were not directly connected to the Intermediate Aquifer targeted by the water supply wells. Therefore, the constant head boundary conditions were only applied to the top layer in the model (Surficial Aquifer) and not to the Intermediate Aquifer. This assumption is consistent with the general conceptualization that a relatively thick layer of lower permeability material overlies the Intermediate Aquifer in the Bright area.~~

~~Three separate recharge zones were established for the model to reflect the variability in overburden sediments that overlie the Intermediate Aquifer around Bright; a recharge rate of 50 millimetres per year (mm/yr) was assigned where there is surficial sands present (as defined by the quaternary geology information); a recharge rate of 200 mm/yr was assigned where there are areas of Shallow Aquifer present; and a recharge rate of 20 mm/yr was assigned where there is only relatively low permeability material present over the Intermediate Aquifer. These values were established through the model calibration process and are consistent with the~~

~~range in recharge rates (3 to 70 mm/yr) estimated by Charlesworth (1992) for the buried aquifers in the Bright area.~~

~~A review of the historical aquifer test results for the Bright area wells indicates that the hydraulic conductivity of the Intermediate Aquifer ranges from 1.8x10^{-5} metres per second (m/s) to 1.4x10^{-3} m/s, with a geometric mean estimate of 7.4x10^{-5} m/s. The hydraulic conductivity of the Intermediate Aquifer in the Bright Groundwater Model was assigned at 5x10^{-5} m/s, with an effective porosity of 25 per cent.~~

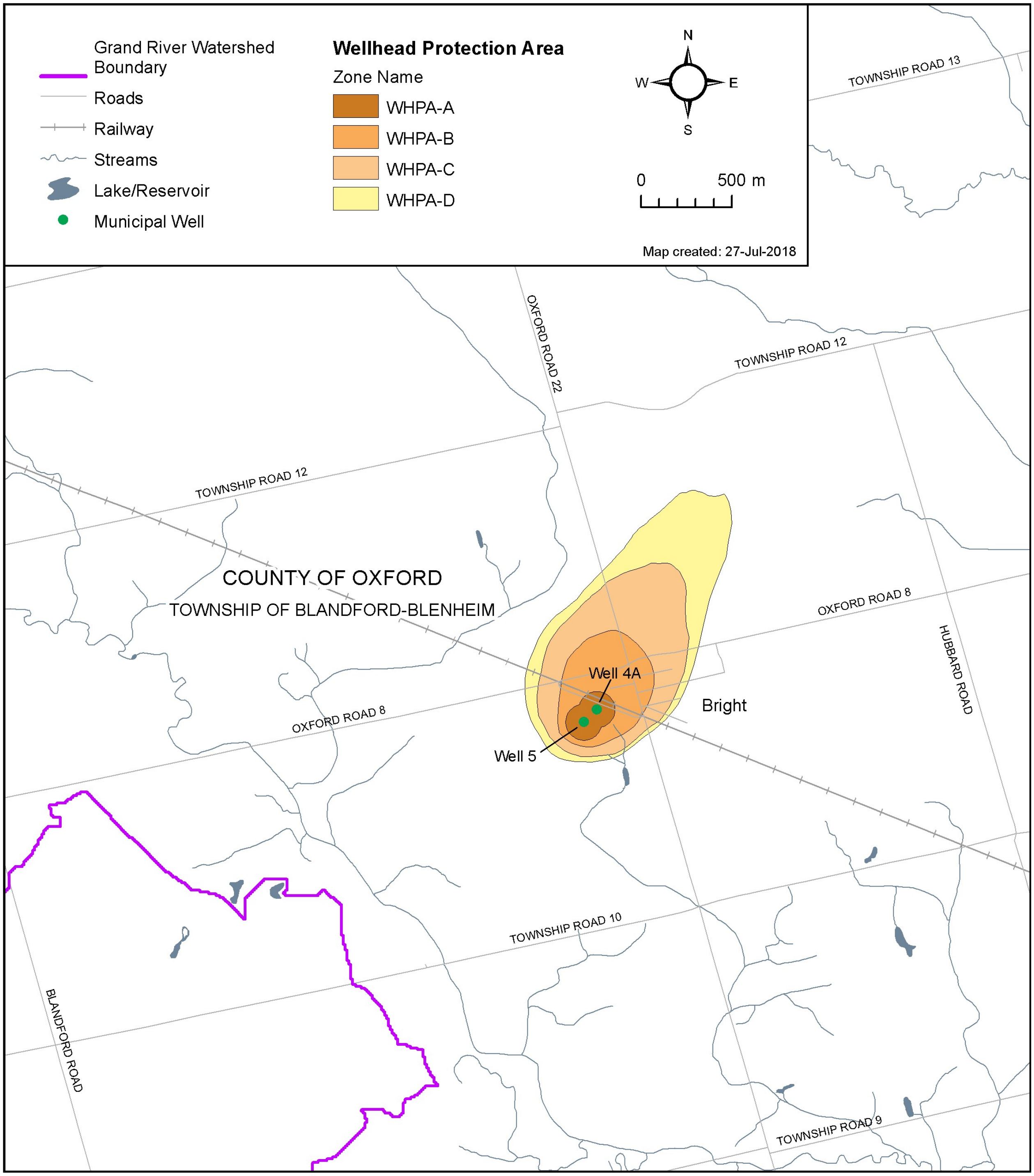
~~The Shallow Aquifer hydraulic conductivity was also assigned at 5x10^{-5} m/s, while the lower permeability (till) materials were assigned a hydraulic conductivity of 3.5x10^{-6} m/s. These values were established through the model calibration process.~~

~~There were no significant private water takings from the Intermediate Aquifer identified in the review of the MOE PTTW Database for the Bright area. Bright Cheese & Butter, located approximately one kilometre to the north of the Bright water supply wells has a well drilled into the upper bedrock and has a permit to pump (on average) approximately 7.6 Igpm. This well was not included in the Bright Groundwater Model, and is not expected to have a measureable impact on the capture zones for the Bright Water Supply System.~~

~~Calibration of the Bright Groundwater Model involved the adjustment of the recharge rates and hydraulic conductivity of the Intermediate Aquifer, until there was a reasonable match between the simulated groundwater elevations and the recorded groundwater elevations for Bright area overburden wells in the MOE Well Record Database. As defined above, the hydraulic conductivity of the Intermediate Aquifer was estimated to be 5x10^{-5} m/s, with recharge rates ranging from 20 mm/yr to 200 mm/yr. The average annual pumping rate in 1999 (of 97.5 m^{3}/day) was used in the calibration process.~~

~~**Map 12-2** illustrates the time-related capture zones for the Bright Water System. The capture zones incorporate uncertainty in both the aquifer data and groundwater flow direction through the adjustments (shape factors) and extend approximately 4.3 km north of the wells through mostly agricultural areas.~~

Map 11-2: Bright Water Supply Wellhead Protection Areas



Delineation of Wellhead Protection Areas ~~Modelling Approach~~ for the Drumbo-Princeton Water System

A local-scale~~The MODFLOW~~ numerical groundwater flow model was used to generate ~~the Wellhead~~ WHPAs ~~protection areas~~ for the Drumbo municipal wells ~~water system~~ (Golder, 2001). The model covers an area of approximately 13 km², and is oriented in a northwest to southeast direction, parallel to the direction of regional groundwater flow in the deep overburden aquifer. The following provides a summary of the Drumbo Groundwater Model based on the available hydrogeological information at the time of the Golder (2001) study.

The bedrock is overlain in the Drumbo area by about 50 to 70 m of glacial drift which includes predominantly fine grained materials in the upper 40 m which are typically underlain by more permeable sands and gravels at depth. Permeable lenses of aquifer material are also found at shallow and intermediate depths. The Drumbo-Princeton wells are considered to lie within the Deep Aquifer, with an assumed aquifer thickness of about 4 m. This aquifer is considered to be semi-confined. Based on the above, the Drumbo Groundwater Model was constructed as a single layer model with vertical leakage into the aquifer from above. The base of the model was assumed to be defined by the base of the Deep Aquifer pumped by the Drumbo water supply wells. Groundwater flow in the Deep Aquifer at Drumbo is inferred to occur in a southeasterly direction. ~~To the northwest and east/southeast of Drumbo the model boundaries follow inferred groundwater contours and were assigned as constant head boundary conditions. To the northwest, a constant head boundary elevation of 305 masl was assigned. Groundwater will flow into the model across this boundary. To the east/southeast, a constant head boundary elevation of 280 masl was assigned. Groundwater will flow out from the model across this boundary. To the west and northeast of Oxford the model boundaries follow inferred groundwater flowlines, and were therefore assigned as "no flow" boundaries. It is assumed that groundwater flow in the Deep Aquifer does not occur across these boundaries.~~

Groundwater flow directions in the overburden aquifers are influenced by the presence of the Nith River. The Nith River is expected to be a groundwater discharge location for the shallow, and perhaps deeper aquifers. The Nith River was not directly included in the Drumbo Groundwater Model although its effect is indirectly included by the assignment of a constant head boundary along the eastern/southeastern model limit. This boundary allows groundwater flow to occur from the Deep Aquifer in the direction of the Nith River.

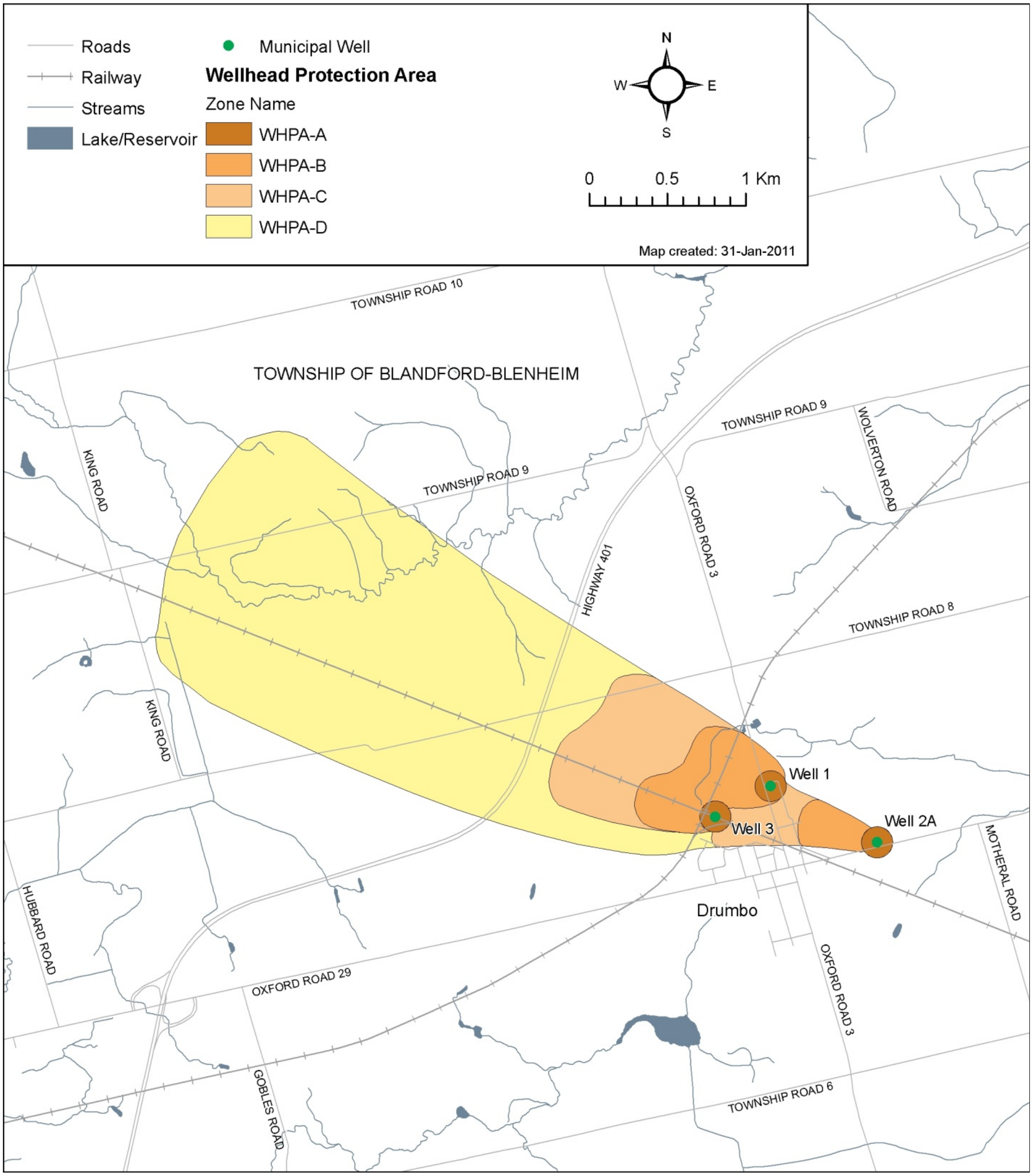
Groundwater ~~R~~recharge was applied uniformly across the model area to the Deep Aquifer at a rate of 20 mm/yr. ~~This value was established through the model calibration process.Following model calibration, the hydraulic conductivity of the Deep Aquifer in the Drumbo Groundwater Model was assigned at 3x10~~$^{-4}$ ~~m/s, with an effective porosity of 25 per cent.. The average annual pumping rate in 1999 (152 m³/day) was used in the calibration process.~~

~~Capture zone modelling results~~WHPAs are presented on **Map 11-3** ~~illustrates the time-related capture zones~~ for the Drumbo municipal wells~~-Princeton Water System~~. ~~They incorporate u~~Uncertainty was addressed in both the aquifer data and groundwater flow direction through ~~the~~ adjustments (shape factors) to the capture zones (Golder, 2001). The projected population growth and increase in water use demand for the Drumbo area is 30 percent relative to water usein 1999. Therefore, the pumping rate ~~for the Drumbo-Princeton Water System wells~~ used to forecast the time-related capture zones for the Drumbo wells was increased by 30 percent compared to rates estimated for 1999 (~~i.e.~~ 197 m³/day).

Historical testing data from the Deep Aquifer at Drumbo Well 3 estimates the transmissivity of this location to be approximately 44 to 51 m^3 per day. Assuming an aquifer thickness of about 4.3 m at this location, this corresponds to an aquifer hydraulic conductivity on the order of $1.3x10^{-4}$ m/s. Historical testing at Well 2 indicated a wider range in transmissivity; from 8.6 to 86 m^2/day. Assuming an aquifer thickness of 3.7 m at this location, this corresponds to a range in hydraulic conductivity from $2.7x10^{-5}$ m/s to $2.7x10^{-4}$ m/s.

~~There were no significant private water takings from the Deep Aquifer identified in the review of the MOE PTTW Database for the Drumbo area. It was assumed in the model that the Drumbo water supply wells provide the only water takings from the Deep Aquifer in this area.~~

Map 11-3: Drumbo Water Supply Wellhead Protection Areas



~~Calibration of the Drumbo Groundwater Model involved the adjustment of the recharge rate and hydraulic conductivity of the Deep Aquifer, until there was a reasonable match between the simulated groundwater elevations and the inferred groundwater elevations for the Deep Aquifer in the Drumbo area. As defined above, the hydraulic conductivity of the Deep Aquifer was estimated to be $3x10^{-4}$ m/s, with a recharge rate of 20 mm/yr.~~

~~Capture Zone Modelling Results presented on **Map 12-3** illustrates the time-related capture zones for the Drumbo Water System. They incorporate uncertainty in both the aquifer data and groundwater flow direction through the adjustments (shape factors). The projected population growth and increase in water use demand for the Drumbo area is 30 per cent. Therefore, the pumping rate for the Drumbo Water System wells used to forecast the time-related capture zones was increased by 30 per cent compared to rates estimated for 1999 (i.e. 197 m³/day).~~

Delineation of Wellhead Protection Areas ~~Modelling Approach~~ for the Plattsville Water System

~~The MODFLOW~~A local-scale numerical groundwater flow model covering ~~s an~~ area of approximately 7 km²~~,~~ was developed to delineate WHPAs for the Plattsville municipal wells (Golder, 2001). ~~and is oriented in a northeast to southwest direction in the direction of groundwater flow.~~ The following provides a summary of the Plattsville Groundwater Flow Model based on the available hydrogeological information:

The Plattsville area is underlain by an extensive glaciofluvial outwash sand and gravel deposit that generally follows the floodplain of the Nith River. These deposits comprise the Shallow Aquifer that provides groundwater to the Plattsville Water System. In the Plattsville town area the Shallow Aquifer is underlain by about 20 to 30 m of silt and clay sediments which in turn are underlain by bedrock. To the east, the topography rises from about 300 masl at the Nith River to about 325 masl at the contact between the outwash deposits and the silty clay to sandy silt till plain (Port Stanley Till). ~~). A Shallow Aquifer is mapped on the till plain although this aquifer would be of lower permeability than the outwash sand and gravels in the Nith River valley.~~ The Plattsville Groundwater Model was constructed using two overburden layers. Along the Nith River valley both layers are represented by the high permeability outwash sands and gravels. To the east, the upper model layer is comprised of a Shallow Aquifer while the lower model layer is defined by finer grained, lower permeability silts and clays.

~~Groundwater flow in the Shallow Aquifer at Plattsville is inferred to occur in a west to southwesterly direction towards the Nith River. The north and south model boundaries generally follow inferred groundwater flowlines and therefore were assigned as "no flow" boundary conditions. It is assumed that groundwater flow does not occur across these boundaries. The western model boundary is defined by the Nith River and is assigned as a constant boundary at elevations consistent with the topography (surface water elevation) along the Nith River. The eastern model boundary follows Washington Creek and is also assigned as a constant head boundary at elevations consistent with the topography (surface water elevation) along the creek. Groundwater discharge from the model will occur to both the Nith River and Washington Creek.~~

The Shallow Aquifer in the Plattsville area is unconfined and assumed to be directly connected to the Nith River. The western boundary of the model follows the Nith River and the surface water elevation in the creek (from the DEM) was assumed to be similar to the Shallow Aquifer groundwater elevation beneath the creek. Groundwater flow in the Shallow Aquifer at Plattsville is inferred to occur in a west to southwesterly direction towards the Nith River. ~~Washington Creek was assumed to be directly connected to the surficial aquifer at the east end of the model.~~

~~Two separate recharge zones were established for the model to reflect the variability in surficial sediments in the Plattsville area. Over the outwash sand and gravel deposits recharge would be relatively high, and was assigned a recharge rate of 350 mm/yr. To the east, a recharge rate of 150 mm/yr was applied to the Shallow Aquifer that is present on the till plain. These values were estimated through the model calibration process.~~

~~The transmissivity of the Shallow Aquifer was estimated from the results of a pumping test at Plattsville Wells 1 and 2 in October 1999 to be about 1100 m^2/day. Assuming an aquifer thickness of about 30 m, this corresponds to an aquifer hydraulic conductivity of about 4x10^{-4} m/s.~~

~~Single well response tests completed in the aquifer resulted in a hydraulic conductivity of 8.5x10^{-5} m/s. The hydraulic conductivity in the Plattsville Groundwater Model was assigned at 1x10^{-4} m/s as a result of model calibration, with an effective porosity of 25 per cent. Additional hydraulic conductivity zones in the model were assigned as follows: 6x10^{-5} m/s for the Shallow Aquifer on the till plain; 5x10^{-6} m/s for the areas of finer grained surficial sediments; and 1x10^{-8} m/s for the lower till.~~

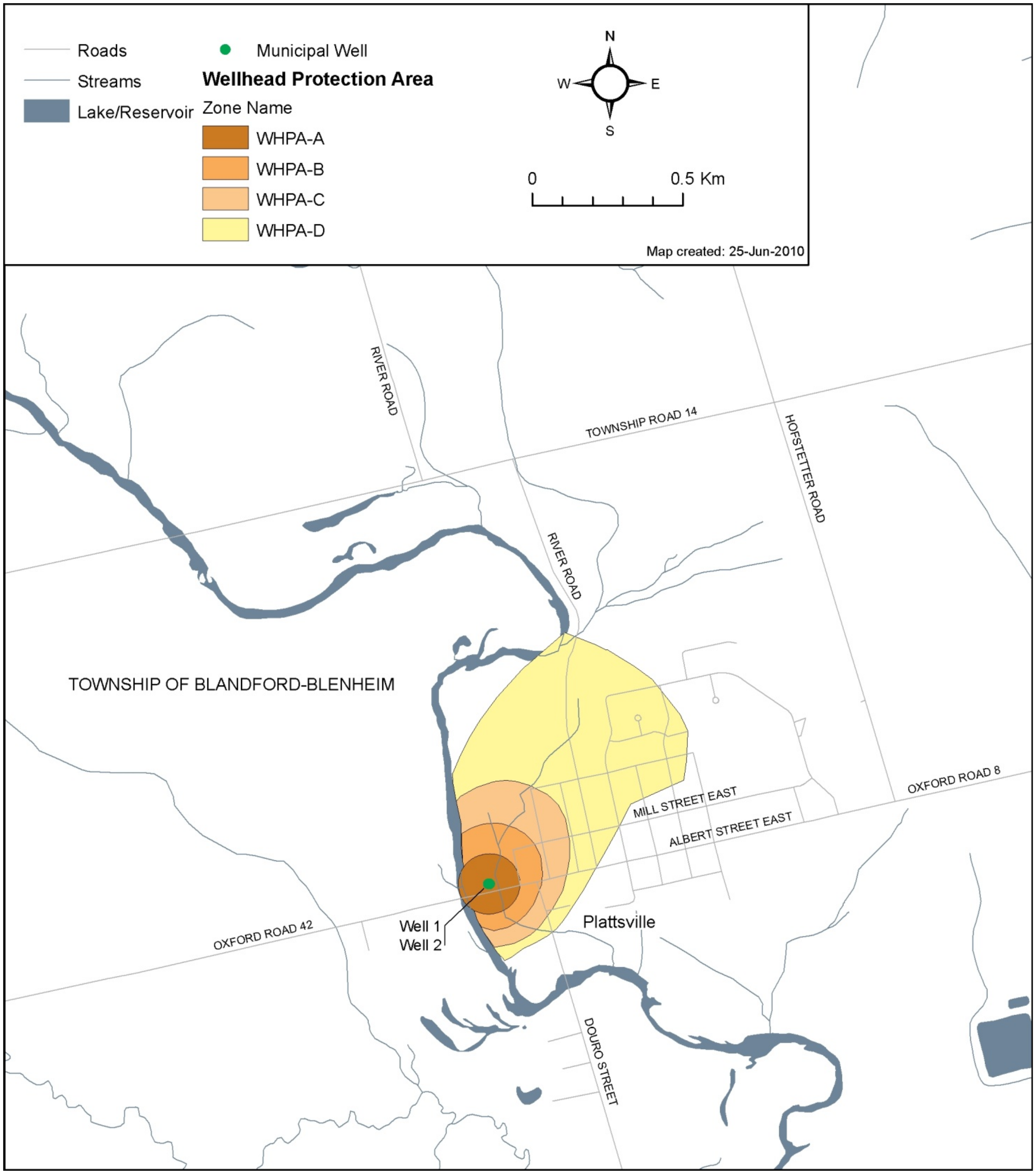
~~Carborundum Abrasives Inc. (88-P-1037) have a permit to extract groundwater from the overburden aquifer approximately 300 m to the southeast of the Plattsville water supply wells. The Carborundum water well was included in the groundwater model, with an average annual pumping rate of 37 m^3/day. This is the permitted groundwater extraction rate. There were no other private water taking wells located in the Plattsville area identified in the MOE PTTW Database.~~

~~Calibration of the Plattsville Groundwater Model involved the adjustment of the recharge rates into the various overburden materials and the hydraulic conductivity of the overburden aquifers until there was a reasonable match between the simulated groundwater elevations and the recorded groundwater elevations for Plattsville area overburden wells in the MOE Well Record Database. As defined above, the~~ The hydraulic conductivity of the aquifer in the Nith River valley was estimated to be 1x10^{-4} m/s, with recharge rates ranging from 350 mm/yr into the outwash sands to 150 mm/yr into the surficial materials along the till plain. The average annual pumping rate in 1999 was used in the calibration process.

Map 11-4 illustrates the ~~time-related capture zones~~WHPAs for the Plattsville ~~Water~~ water ~~System~~system. ~~They~~ The ~~capture zones~~WHPAs incorporate uncertainty in both the aquifer data and groundwater flow direction through~~ the~~ adjustments (shape factors) to the length and width of the WHPAs. The projected population growth in the Plattsville area is 20 per~~-~~cent relative to 1999 pumping rates.. Therefore, the pumping rate for the Plattsville water supply wells used to forecast the ~~time-related capture zones~~WHPAs was increased by 20 per~~-~~cent compared to 1999 (~~i.e.~~ 619 m^3/day).

The ~~capture zones for the~~ Plattsville WHPAs~~ wells~~ extend to the north/northeast of the ~~pumping~~municipal wells over a fairly broad area. The WHPAs~~,~~ include~~s~~ the river floodplain and the western and central parts of the community and the west edge underlies the Nith River. This suggests that surface water from the Nith River is recharging the Shallow Aquifer and is part of the overall capture of the Plattsville water supply wells.

Map 11-4: Plattsville Water Supply Wellhead Protection Area



Uncertainty in the Delineation of ~~the Bright~~ Wellhead Protections Areas

An uncertainty factor of “high” or “low” was assigned to each WHPA delineated based on the results of the uncertainty analysis.

Bright

Results of the uncertainty analysis are discussed below and final uncertainty factors for the WHPA delineation is provided in Table 11-3.

There is inherent variation in the level of confidence with numerical modelling studies, which includes the quality of the input data and the model output due to computational assumptions within the model. Overall the model produced good matches to the observed water levels; however, the ability of the model to exactly reproduce local flow patterns is not certain. There is a high level of uncertainty surrounding the aggregate pit, north of the WHPA, where future expansion may alter recharge and local groundwater flow patterns. For this reason the ability of the model to reflect the processes of the hydrogeologic system has been given a high level of uncertainty.

Table 11-3: Summary of Uncertainty Analysis for WHPA Delineation

Uncertainty Element	**Uncertainty**
Distribution, variability, quality and relevance of data	Low
Ability of the methods and models used to accurately reflect the flow processes in the hydrogeological system	High
Quality assurance and quality control procedures applied	Low
Extent and level of calibration and validation achieved for models used or calculations or general assessments completed	Low
Overall	**High**

~~Uncertainty in the Delineation of the Bright, Drumbo-Princeton and Plattsville Wellhead Protection Areas~~Drumbo-Princeton and Plattsville

The ~~Well Head Protection Areas (~~WHPAs~~)~~ for the ~~municipal well systems in the County of Oxford~~Drumbo-Princeton and Plattsville drinking water systems were delineated using numerical modelling procedures (MODFLOW and MODPATH) as part of the Phase II Groundwater Protection Study (Golder, 2001). The models developed for the municipal well systems were calibrated to existing conditions at the time (1999). Pumping rates required to service the projected population growth were then input to the models and used to delineate the predicted capture zones by way of particle tracking within the groundwater saturated zone. The capture zones were then projected to ground surface to create a capture area at ground surface. It was recognized at the time that a level of conservatism was built into the process by neglecting to account for the travel time from surface to the water table.

Sources of uncertainty associated with the capture areas were recognized and addressed as part of the Phase II Groundwater Protection Study (Golder, 2001). One example was the effect of uncertainty in the hydraulic conductivity (K). It was noted that a lower K can result in a wider, but shorter capture zone, whereas a higher K can result in a narrower, but longer capture zone. A second example was the effect of uncertainty in the direction of regional groundwater flow, which was based on interpretation of MOE water well record data. It was noted that a difference of 5 degrees in the direction of groundwater flow may be insignificant near the production wells but would be much more significant further upgradient of the wells (Golder, 2001). To address these uncertainties, the shape of the capture zone was adjusted using two shape factors. The first shape factor was a 20% increase in the overall shape of the capture zone (20% increase in width at the centreline, and a 20% increase in length upgradient and downgradient of the production well). The second shape factor was the addition of a 5 degree angle added to the centreline of the capture zone, in effect increasing the width at increasing distances from the pumping well. The objective of applying the second shape factor was to compensate for uncertainty in the regional groundwater flow direction. For capture zones intersecting groundwater flow divides and recharge boundaries (i.e. river boundaries), those boundaries were still used to limit the extent of the capture zone, notwithstanding the adjustments made in applying the shape factors.

As noted previously, a number of the WHPAs have been modified since 2001 to incorporate changes to the municipal well systems, well locations, and flow rates~~, and some minor adjustments to the municipal production well locations~~. All of the modifications were performed by Golder and some were undertaken in 2007 as part of the source protection program. The net result is that the WHPA delineation for the active municipal production wells ~~in the County of Oxford~~ at the Drumbo-Princeton and Plattsville drinking water systems has been undertaken using a consistent and well documented modelling procedure, based on hydrogeological interpretations, and incorporating practical measures to address uncertainty.

In general, the WHPAs for the Drumbo-Princeton and Plattsville production wells appear to be reasonable approximations and can be considered as having a relatively low level of uncertainty.

~~The WHPA for the Bright Water System appears to have relatively long and narrow shape. It is questionable whether this WHPA represents the real capture area (capture zone projected to surface) for this municipal well system. However, it is reasonable to classify the WHPA for Bright as having a relatively low level of uncertainty with respect to the modelling methodology used in their development.~~

Vulnerability Scoring of Wellhead Protection Areas

~~Following their delineation,~~The ~~the~~ intrinsic vulnerability of the aquifer within each ~~Wellhead Protection Area~~ WHPA ~~i~~was assessed using one of the methods approved under the *Clean Water Act* Technical Rules. The resulting maps rank aquifer vulnerability as high, medium or low. The intrinsic vulnerability for the Bright, Drumbo-Princeton and Plattsville ~~Wellhead Protection Areas~~ WHPAs are~~is~~ shown on **Map 11-5**, **Map 11-7**and **Map 11-9**.

In the County of Oxford, aquifer vulnerability mapping within the Drumbo-Princeton and Plattsville W~~e~~HPAs ~~llhead Protection Areas~~ was completed using the Aquifer Vulnerability Index (AVI) (Golder, 2001). Aquifer vulnerability mapping within the Bright WHPAs was completed using the surface to well advective time (SWAT) method (EarthFX, 2018).

The aquifer vulnerability mapping recognized three overburden units based on depth, with the classification of units as follows: Shallow aquifers occurring from surface to 15 m, intermediate aquifers occurring from 15 – 30 m, deep aquifers occurring at depths greater than 30 m. The bedrock aquifer was also recognized as a fourth unit. The capture zone delineation included the 2, 5, 10 and 25 year time of travel.

~~The AVI method involves assigning a numerical score at each known well location that is related to the hydrualic conductivity (K) and thickness of the geological layers (stratum) overlying the aquifer (Golder, 2001). The aquifer vulnerability is classified on the basis of the AVI scoring following the thresholds provided by Technical Rule 38(1): High Vulnerability (AVI score <30), Medium Vulnerability (AVI score >30 and <80) or Low Vulnerability (AVI score >80).~~

~~The AVI scoring method was used to develop vulnerability maps for each of the four aquifers identified as part of the aquifer mapping (shallow overburden, intermediate overburden, deep overburden, bedrock). The results were also used to develop a composite AVI map for the County. The composite AVI map reflects the vulnerability of the first aquifer present at each well location in the County.~~

~~The resulting 'low', 'medium' or 'high' aquifer vulnerability rating is then intersected with the four Wellhead Protection Area zones, and translated into an overall vulnerability score ranging from 2 to 10, where a score of 2 represents lowest relative aquifer vulnerability and a score of 10 represents highest vulnerability.~~ ~~**Table 12-3**~~ ~~below summarizes the Wellhead Protection Area vulnerability scoring for the AVI method as stated in the Technical Rules.~~

~~**Table 12-3: Wellhead Protection Area Vulnerability Scores - AVI**~~

~~**Groundwater Vulnerability Category for the Area**~~	~~**WHPA-A (100m zone)**~~	~~**WHPA-B (2-year time-of-travel)**~~	~~**WHPA-C (5-year time-of-travel)**~~	~~**WHPA-D (25-year time-of-travel)**~~
~~High~~	~~10~~	~~10~~	~~8~~	~~6~~
~~Medium~~	~~10~~	~~8~~	~~6~~	~~4~~
~~Low~~	~~10~~	~~6~~	~~4~~	~~2~~

~~At the completion of the vulnerability mapping and scoring, the County of Oxford completed an assessment of transport pathways was completed. The results of the transport pathway assessment were reviewed using professional judgment to determine whether to increase the vulnerability based on the presence of the pathways.~~

Identification of Transport Pathways and Vulnerability Adjustment

Following a review of the initial vulnerability scoring maps, an assessment of transport pathways was ~~undertaken~~ completed to determine whether adjustments to the vulnerability assessment were warranted. ~~Technical Rules 39 – 41 address the general process of how transport pathways would increase vulnerability.~~ Transport pathways for groundwater based drinking water systems include: wells (existing and abandoned), pits and quarries, mines, construction activities, storm water infiltration, septic systems, sanitary sewer infrastructure.

~~To evaluate the transport pathways, the Wellhead Protection Areas were superimposed on 2006 aerial photography available from the County. Well locations in the vicinity of the Wellhead Protection Areas, available from the County well information system (based originally on the MOE Water Well Information System), were plotted on the aerial photograph maps. Information on the location of sanitary sewers, septic systems, storm water infiltration facilities and pits/quarries available from the County information systems were also plotted on the aerial photograph maps. The locations of petroleum wells within 100 m of the Wellhead Protection Areas were plotted on maps, based on information available from the oil & gas well database at the County.~~

~~The maps were then reviewed in detail to identify areas where the vulnerability scoring procedure should incorporate the presence of transport pathways. The process was based on professional judgment. During the review of the transport pathways and intrinsic vulnerability mapping, identified areas on the map where other adjustments to the mapping should bewere made based on professional judgement, such as (a) filling minor gaps/misaligments within the Wellhead Protection Area, (b) smoothing of the contacts between areas with different vulnerability ranking/scores and (c) removing what appear to be anomalies in the scoring that could not clearly be supported by the available hydrogeological information.~~

~~*Adjusted Vulnerability Scoring to Account for Transport Pathways*~~

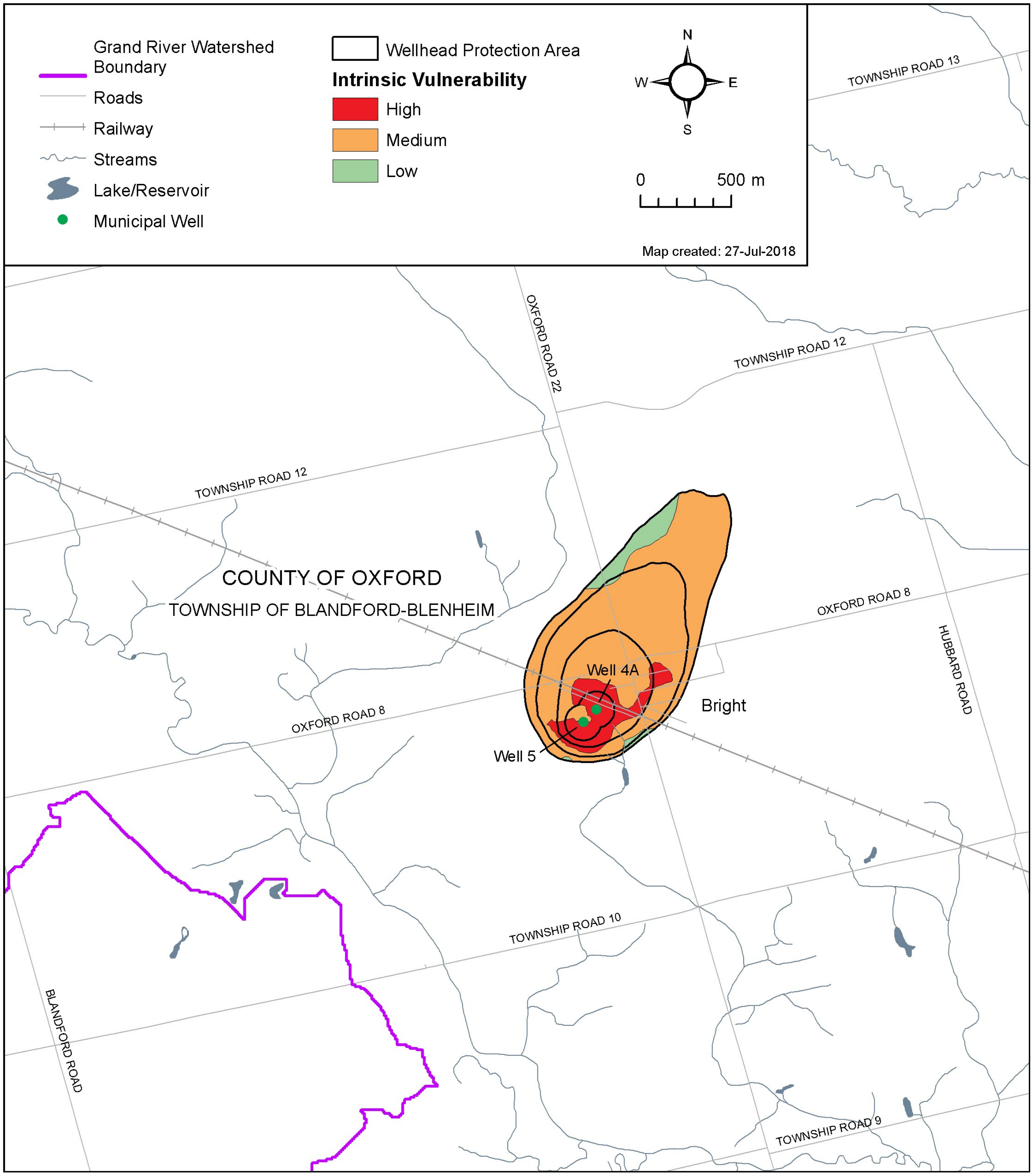
~~At the completion of the transport pathways assessment, the Technical Rules allow investigators to modify the vulnerability scoring if there is a concern that the identified transport pathways within the Wellhead Protection Areas may increase the vulnerability of the aquifer beyond that represented by the intrinsic vulnerability. Modification of the vulnerability score is performed by increasing the vulnerability of the underlying aquifer vulnerability map from either a low to moderate value or moderate to high value. An initial aquifer vulnerability value of high cannot be increased.~~

Adjusted Vulnerability Scoring for the Bright Wellhead Protection Areas

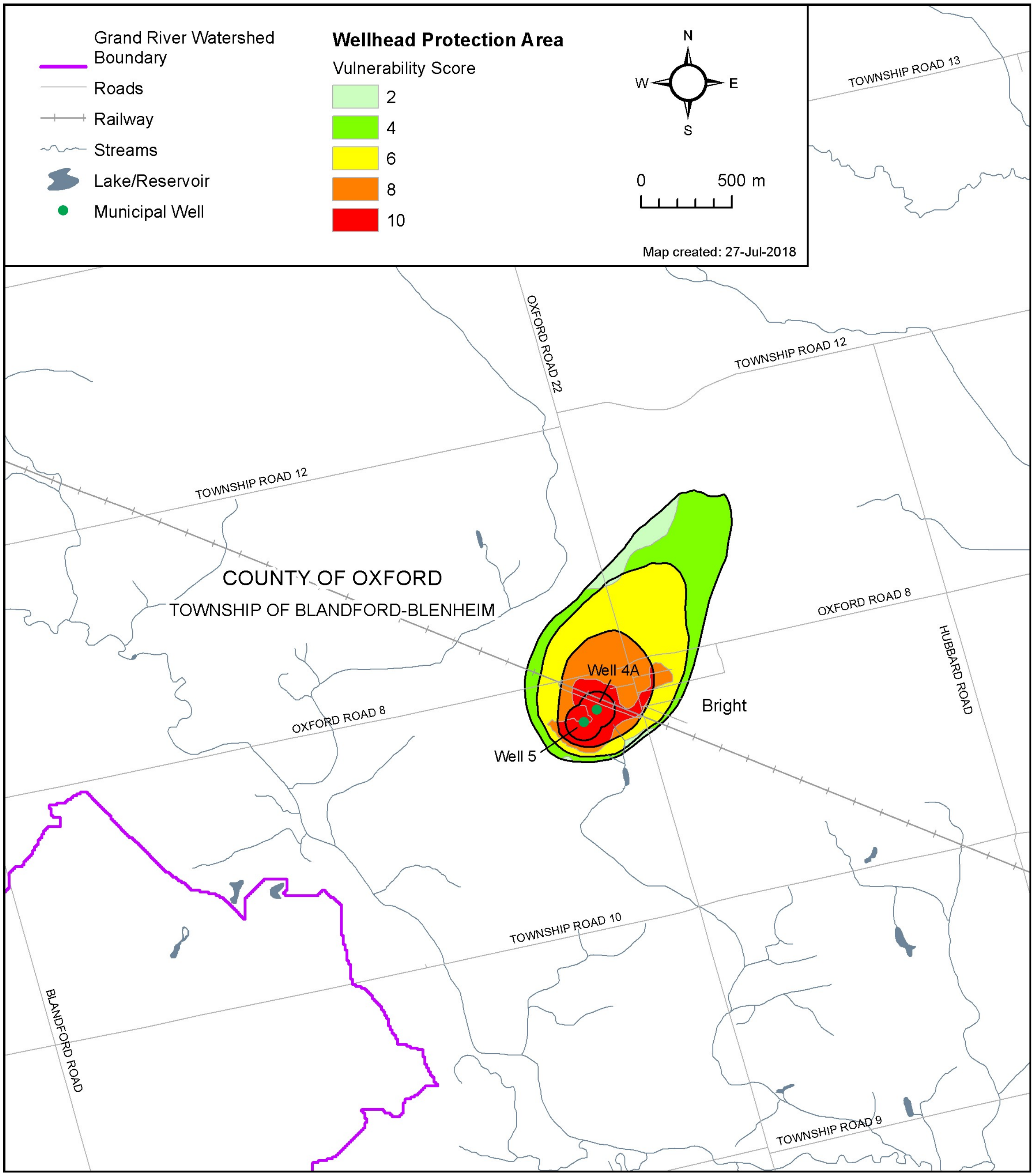
~~There appear to be no transport pathways warranting an adjustment to the intrinsic vulnerability within the Wellhead Protection Area. Some minor adjustments have been made to the AVI to produce more consistent scoring within Zone B, Zone C and part of Zone D. A gap in the AVI mapping within the Zone D was addressed by extending the low AVI over the entire zone. The results indicate vulnerability scores of 6 in Zone B (2 year TOT), 4 in Zone C (5 year TOT) and 2 in Zone D (25 year TOT).~~ Due to the uncertainties related to the estimation of unsaturated travel times, the unsaturated zone travel times (UZAT) were not factored into the calculation of SWAT values, resulting in a more conservative vulnerability assessment. Potential pathways for shortened travel times to the wells were also evaluated. A total of 33 wells were identified within the WHPAs which were assessed based on likely construction quality and potential to be in communication with the aquifer pumped by the municipal supply wells. While some wells were identified as moderate to high risk, no adjustments were made to the vulnerability scores~~,~~ due to the uncertainty of well locations. Further investigation into the location and condition of the identified wells is recommended in order to properly assess their vulnerability. In addition, two aggregate extraction pit operations were identified as possible preferential pathways; however they were not considered a risk because they were outside the WHPA. No adjustments to the intrinsic vulnerability were made due to transport pathways.

T~~t~~he final vulnerability map is presented in **Map 11-6.** High local recharge to the northeast of the wellfield resulted in moderate vulnerability scores with some locally higher scores in the WHPA-B and WHPA-C. Low scores within the WHPA-C and WHPA-D corresponded to areas in which particles did not arrive at the wells during the forward particle tracking analysis.

Map 11-5 Bright Water Supply Intrinsic Vulnerability



Map 11-6: Bright Water Supply Wellhead Protection Area Vulnerability



Adjusted Vulnerability Scoring for the Drumbo-Princeton Wellhead Protection Areas

The Wellhead Protection Areas for Well 1, Well 2A, and Well 3 extend approximately 4 km to the northwest, and are based on a forecast pumping rate of 197 m^3/day (2.3 L/s). There ~~appear to be~~are no transport pathways warranting an adjustment to the intrinsic vulnerability within the ~~Wellhead protection area~~WHPA. Gaps in the vulnerability mapping within Zone D were filled by extending the low vulnerability index that occurred over most of the remaining portion of Zone D. The resulting vulnerability scores are 6 in Zone B, 4 in Zone C and 2 in Zone D as shown on **Map 11-8**.

Adjusted Vulnerability Scoring for the Plattsville Wellhead Protection Areas

An adjustment was made to the vulnerability mapping to remove an anomalous area within a portion of Zones C and D, which resulted in a decrease in the vulnerability scores for the adjusted area. This adjustment was based on professional judgement. Sanitary sewer lines and a few private wells appear to occur within the ~~Wellhead Protection Area~~WHPA. However, these potential transport pathways were not considered sufficient to warrant adjustments to the vulnerability mapping. The results indicate vulnerability scores of 10 in Zone B, 8 in Zone C and 6 in Zone D as shown on **Map 11-10**.

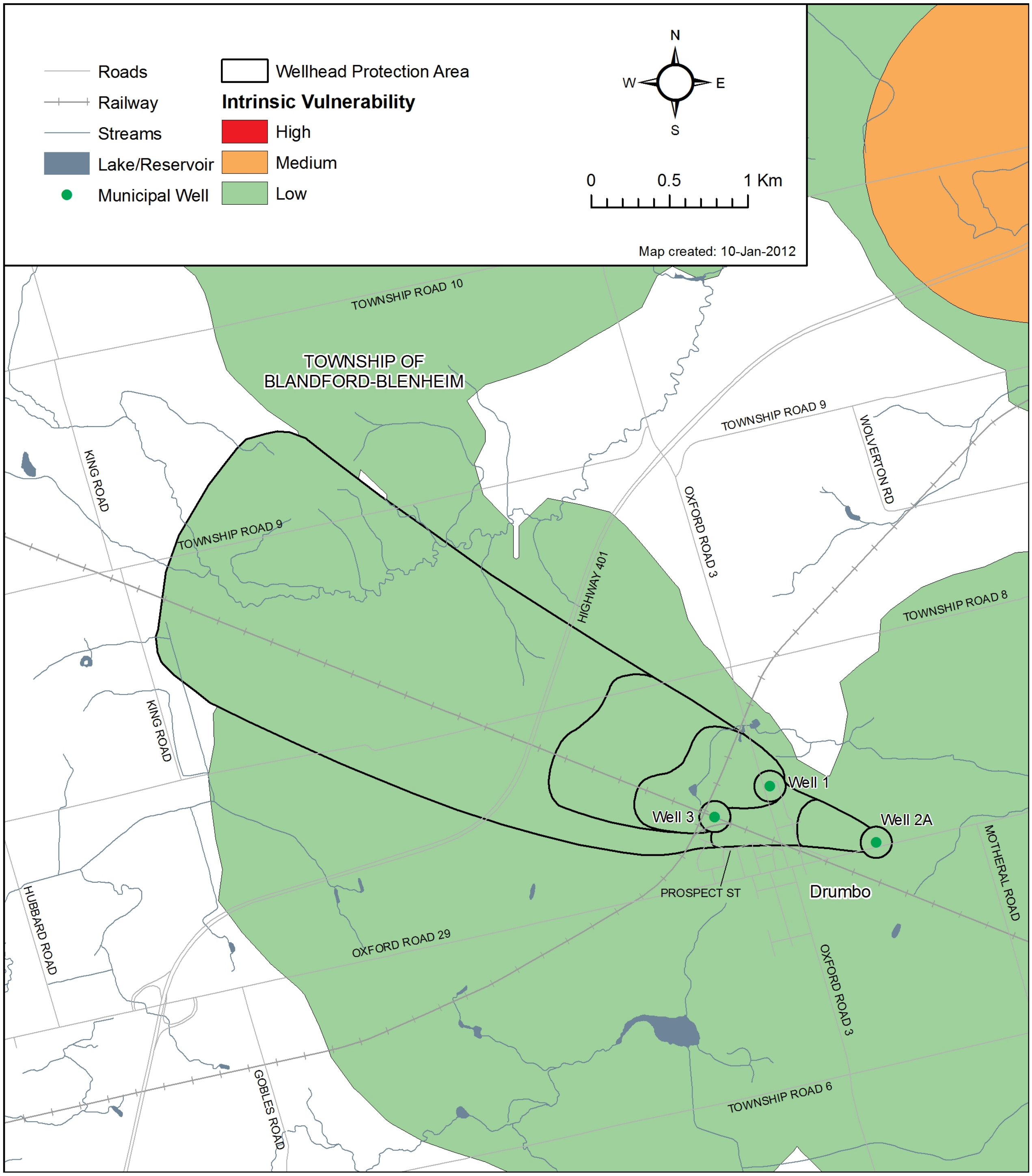
~~Peer Review of WHPAs and Vulnerability~~

~~The Bright, Drumbo and Plattsville Wellhead Protection Areas (Golder, 2001) were completed in advance of the Clean Water Act through the MOE-funded Municipal Groundwater Protection Studies. Oxford County has reported that the Wellhead Protection Areas were reviewed at the time of the report by MOE staff as a component of these groundwater protection studies.~~

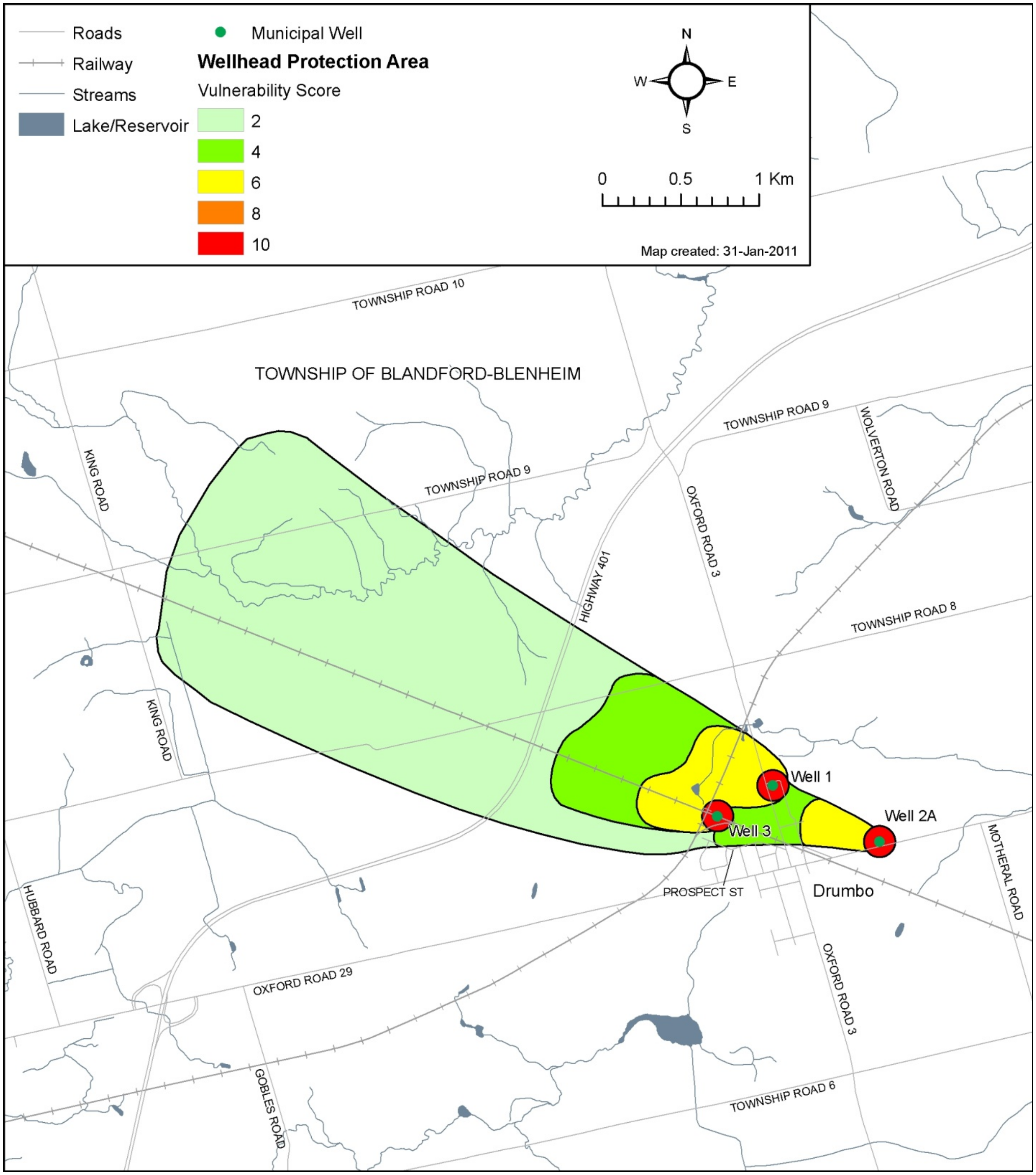
~~In addition, a peer review committee was formed to review vulnerability analyses within Oxford County. The committee consists of the following members:~~

- ~~Gregg Zwiers, Grand River Conservation Authority~~
- ~~Stan Denhoed, Harden Environmental~~
- ~~Stu Seabrook, HCCL~~
- ~~Rob Schincariol, University of Western Ontario~~

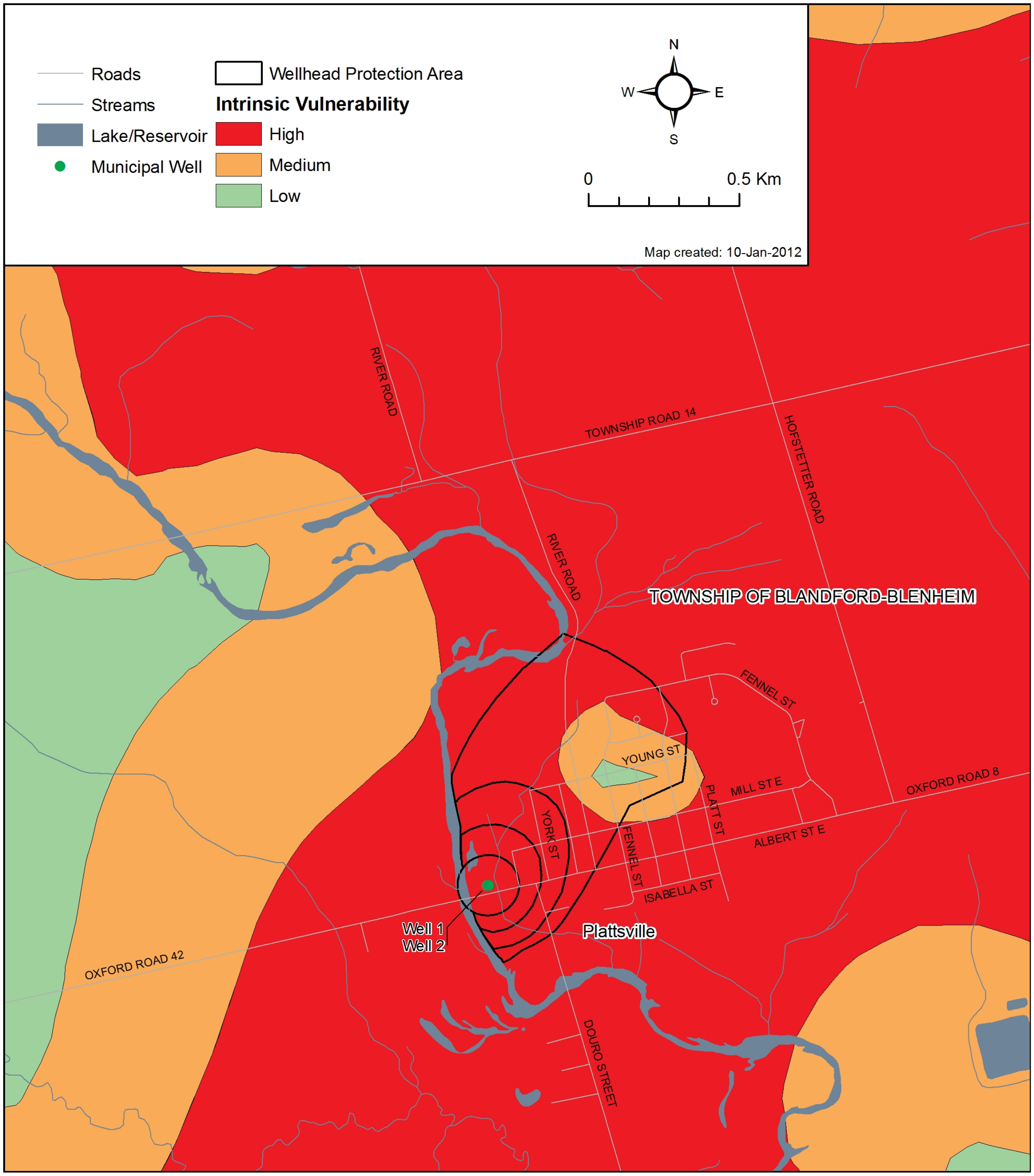
Map 11-7 Drumbo-Princeton Well Supply Intrinsic Vulnerability



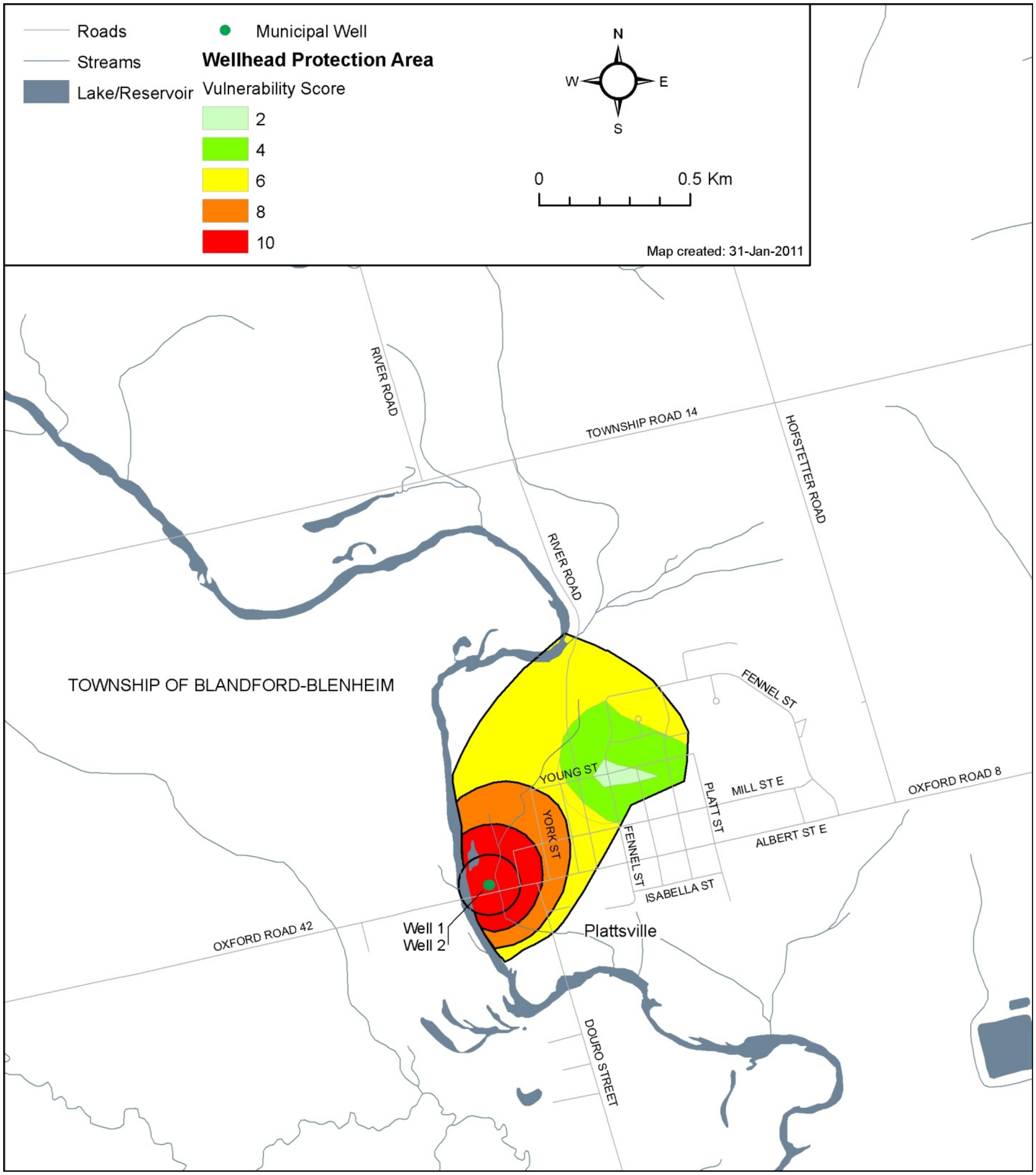
Map 11-8: Drumbo-Princeton Water Supply Wellhead Protection Area Vulnerability



Map 11-9 Plattsville Water Supply Intrinsic Vulnerability



Map 11-10: Plattsville Water Supply Wellhead Protection Area Vulnerability



Managed Lands within the County of Oxford Wellhead Protection Areas

Managed ~~Lands~~ lands, defined as ~~are~~ lands to which nutrients are applied, are~~. Managed lands can be~~ categorized into two groups: agricultural managed land and non-agricultural managed land. Agricultural managed land includes areas of cropland, fallow, and improved pasture that may receive nutrients. Non-agricultural managed land includes golf courses, sports fields, lawns and other built-up grassed areas that may receive nutrients (primarily commercial fertilizer). ~~Determining the location and percentage of managed lands, the location of agricultural managed lands, and the calculation of livestock density were used to determine whether the application of agricultural source material (ASM), non-agricultural source material (NASM), and fertilizer were significant threats within the Wellhead Protection Areas.~~

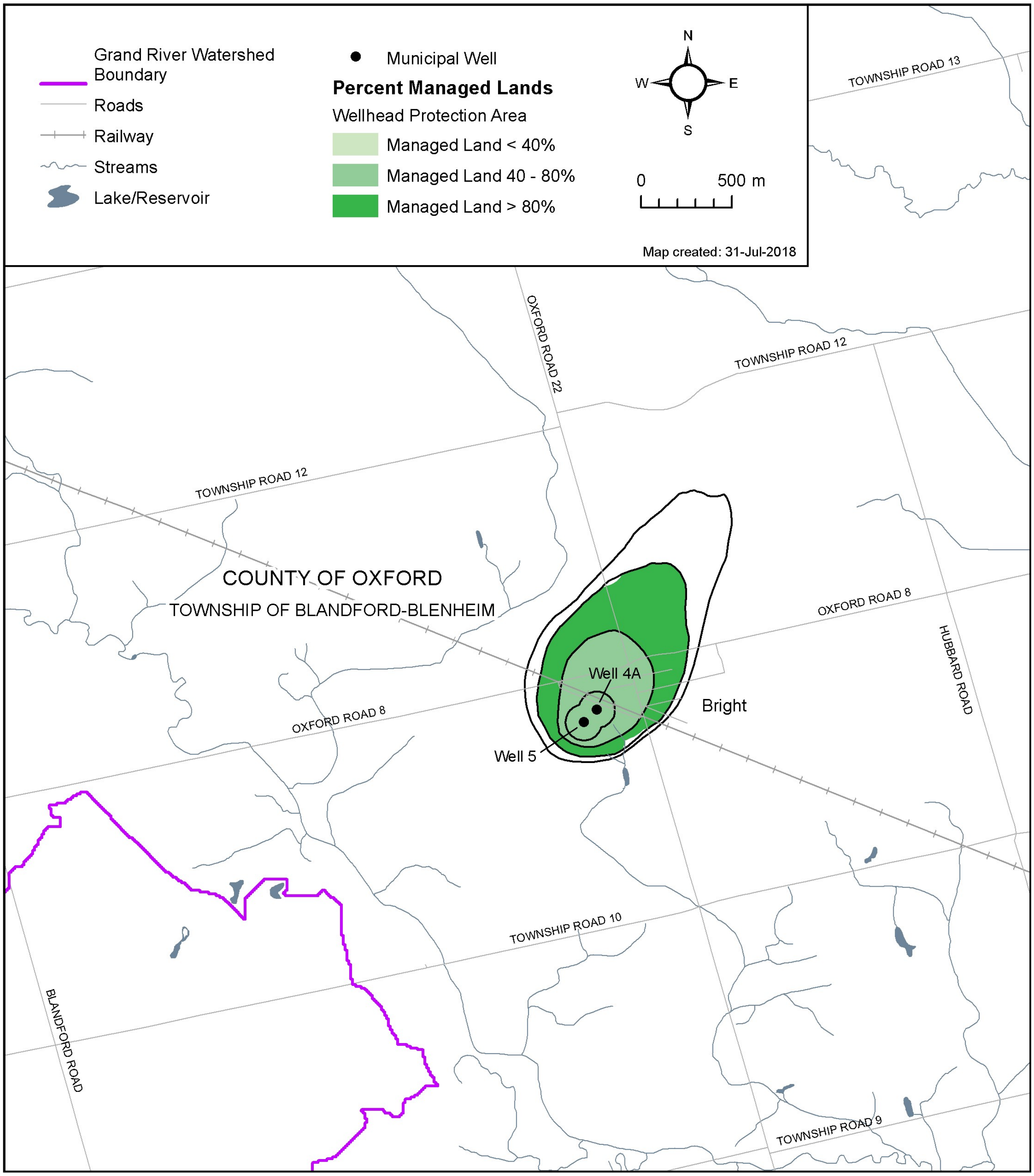
The managed land mapping was completed for the WHPAs ~~and WHPA-C zones~~ where the vulnerability score ~~i~~was high enough ~~in these zones~~ for related activities~~threats~~ to be considered low, moderate or significant threats (vulnerability score of 6 or higher). Managed lands were completed ~~,~~ using the methodology outlined in Section 3 of this Assessment Report. ~~Calculation of the percentage of managed lands was done in accordance with Part II, Rule 16(9) of the Technical Rules (MOE, 2009b). Mapping the percentage of managed lands area is not required where the vulnerability score for an area is less than the vulnerability score necessary for the activity to be considered a significant threat. Therefore, the percentage of managed lands were only calculated where the vulnerability score in each WHPA was 6 or greater.~~

The ~~calculations~~percent managed lands for the Bright, Drumbo-Princeton and Plattsville ~~well systems can be seen~~WHPAs are presented in **Table 11-4.** These are further illustrated on **Map 11-11**, **Map 11-12** and **Map 11-13**.

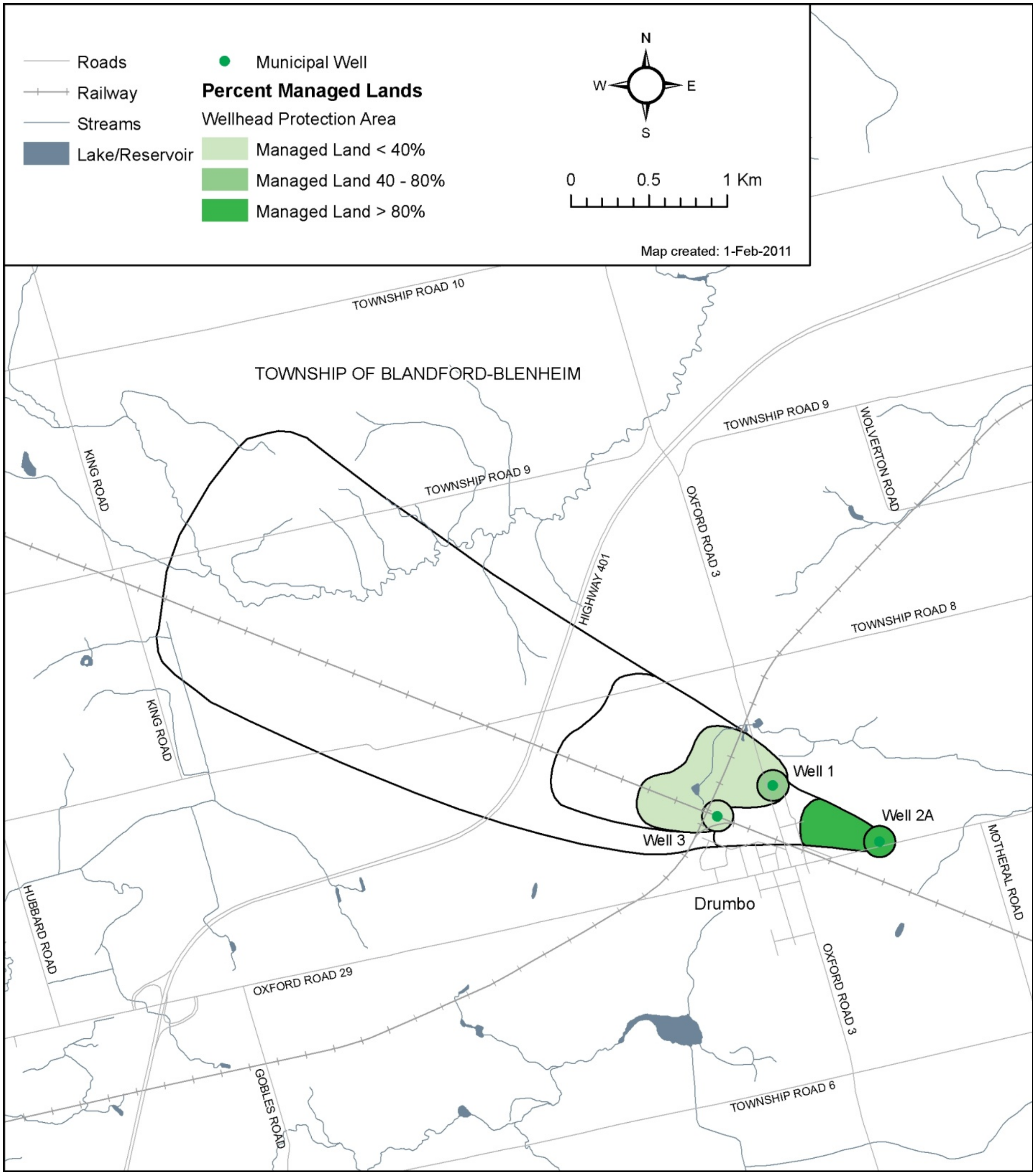
Table 11-4: Percent Managed Lands in the County of Oxford Wellhead Protection Areas

County	Location	Well	WHPA-A	WHPA-B	WHPA-C	WHPA-D
Oxford	Bright	Well 4A and~~/~~ Well 5 ~~(Piggot 4/5)~~	~~81%~~79.6%	~~87%~~62.3%	~~71%~~87.8%	No
	Drumbo-Princeton	Well 2A	89%	95%	No	No
		Well 1	44%	17%	No	No
		Well 3	11%	17%	No	No
	Plattsville	~~W1 / W2~~Well 1 and Well 2	21%	21%	47%	67%

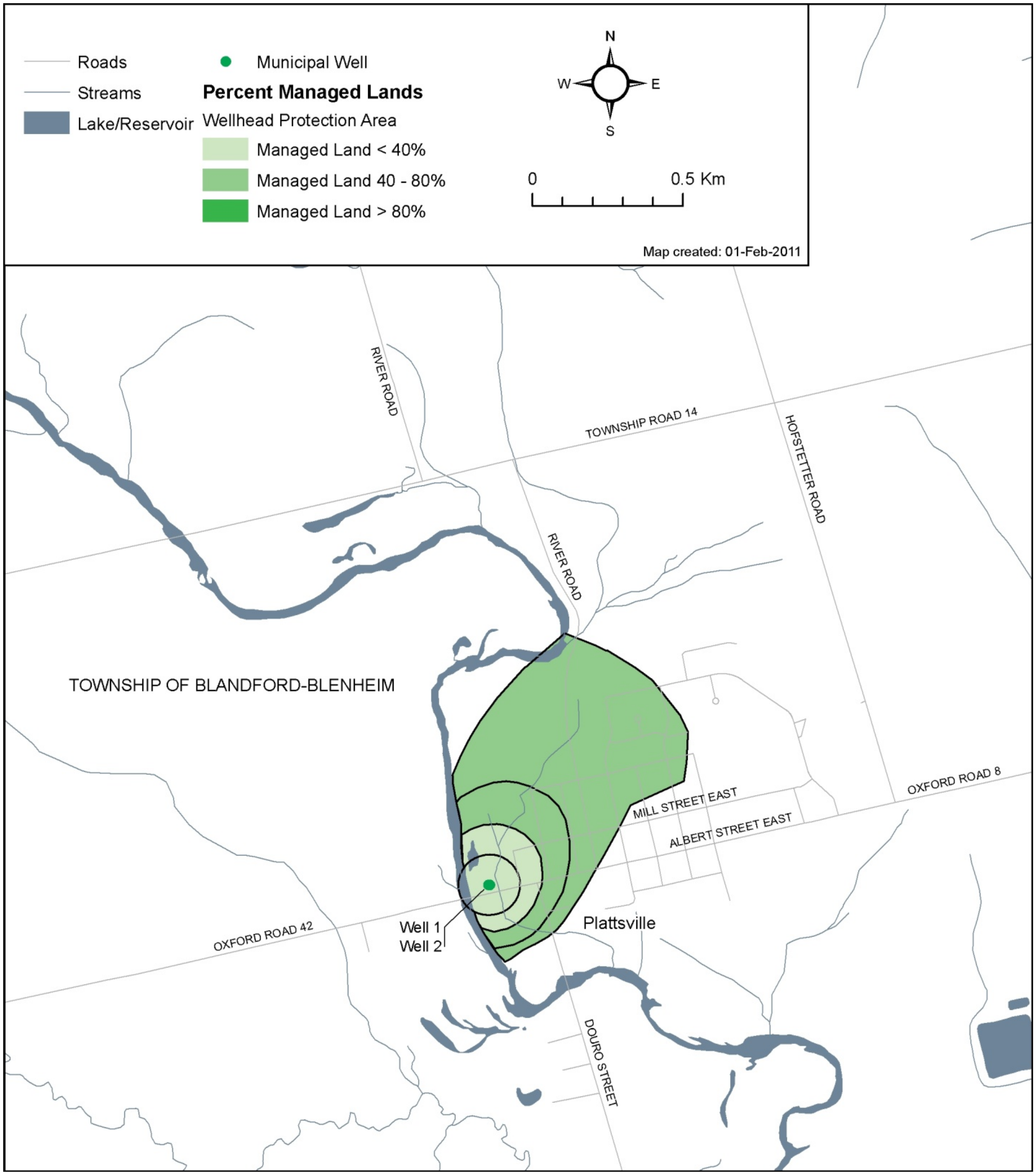
Map 11-11: Bright Water Supply Percent Managed Lands



Map 11-12: Drumbo-Princeton Water Supply Percent Managed Lands



Map 11-13: Plattsville Water Supply Percent Managed Lands



Livestock Density within the County of Oxford Wellhead Protection Areas

Livestock density is ~~used as~~ a measure to determine the intensity of livestock animals and ~~as such can be used as a measure of the potential~~as such, can be used as a surrogate measure for the generation~~ing~~, storage~~ing~~ and land appl~~ying~~ication of agricultural source material. Livestock density methodoly is detailed in Section 3 of this Assessment Report.

~~The calculation of livestock density is required to determine the amount of Nutrient Units (NU) generated in each vulnerable WHPA scenario. This calculation is only completed when there are building structures that could house livestock on a farm parcel that intersects a vulnerable WHPA. This means that for each farm parcel that has a portion of their land in the WHPA and also has a livestock barn on their property (regardless of whether the barn is in the WHPA), the livestock density in Nutrient Units per acre (NU/ac) is calculated. The Nutrient Units generated by each farm parcel is area weighted to determine the proportion applied in each WHPA. The total amount of Nutrient Units applied in each WHPA is divided by the amount of agricultural managed land in that same WHPA to determine the livestock density. The agricultural managed lands in each WHPA scenario was calculated under the guidance of Part II, rule 16(10) of the Technical Rules (MOE, 2009b), and as previously described. Each parcel of land that intersects each WHPA needs to be assessed for the presence of a livestock barn. The nutrients that are generated by the livestock are assumed to be applied only onto that farm parcel.~~

~~Farm parcels intersecting each WHPA, as determined in the previous section, were assessed through air photo interpretation for the presence of barns or other livestock housing facilities. To aid in verifying the livestock type and whether the structure was used to house livestock, all available land use information from Oxford County records and databases were used including incorporating local knowledge from Planners, Township Chief Building Officials (CBOs) and other municipal staff who may have been able to provide local knowledge about a given farm operation.~~

~~After all available knowledge was considered, a reasonable estimation was made about the type of livestock that was housed or could be housed in a particular structure.~~

~~Once a livestock barn type was identified, the area of the barn was estimated using measuring tools in ArcMap. The barn area and livestock type were then compared to the Barn/Nutrient Unit Relationship Table provided by the GRCA in their Technical Memomorandum, issued September 23, 2009 (GRCA, 2009a). Where the number of livestock is unknown, barn area is used as a surrogate for the number of animals (and consequently the amount of nutrients generated) that could be housed in the farm structure, based on best management practices for barn capacities. A nutrient unit conversion factor can also be used if the number of livestock present on a farm is known. Each type of livestock has its own 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 barn space, so the relationship for beef barns is 100sq.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.~~

The livestock density for each ~~municipal water system~~WHPA is shown in **Table 11-5**. All areas fall into the "low" livestock density category.

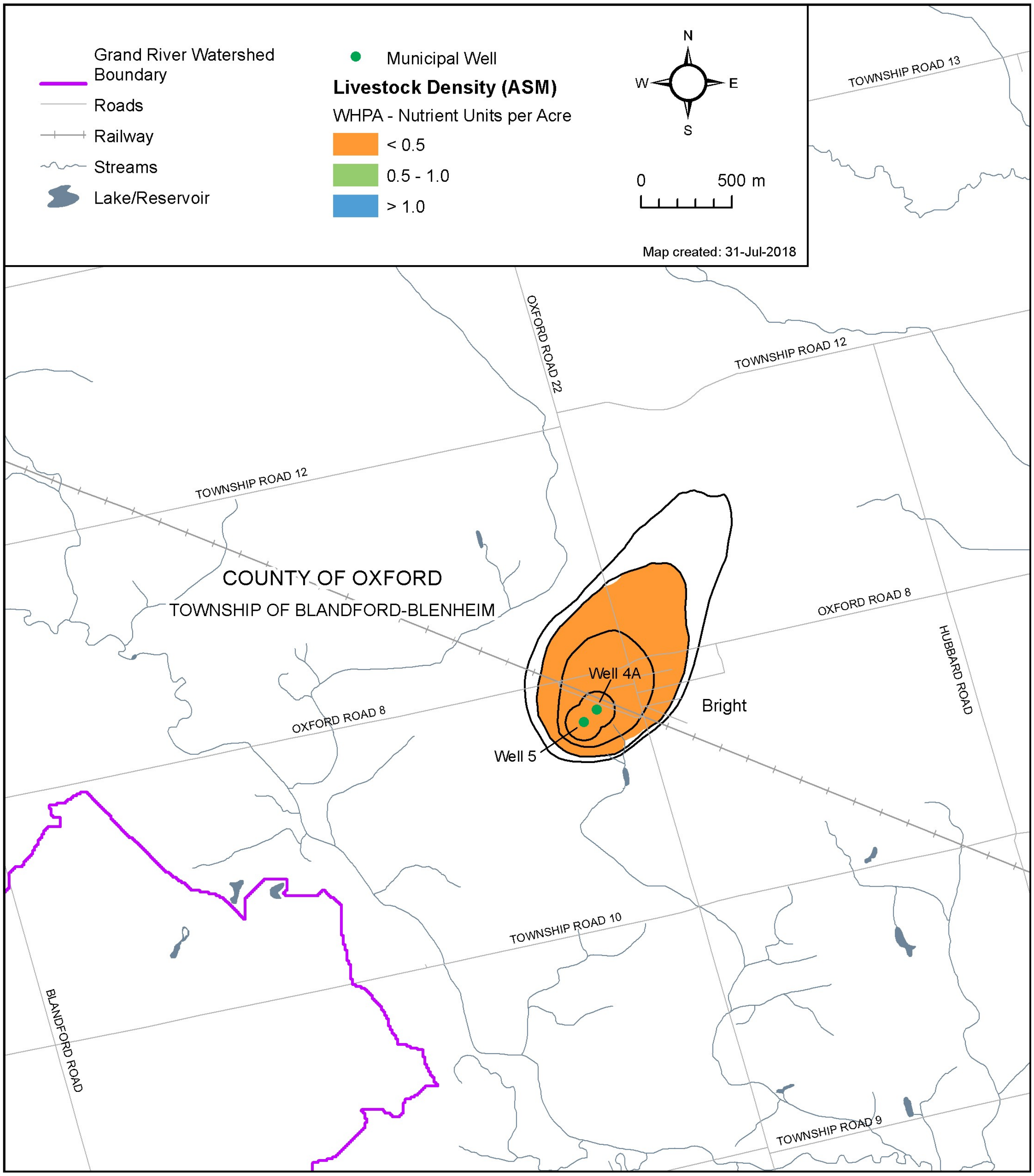
Table 11-5: Livestock Density (NU/acre) in the County of Oxford Wellhead Protection Areas

County	Location	Well	WHPA-A	WHPA-B	WHPA-C	WHPA-D

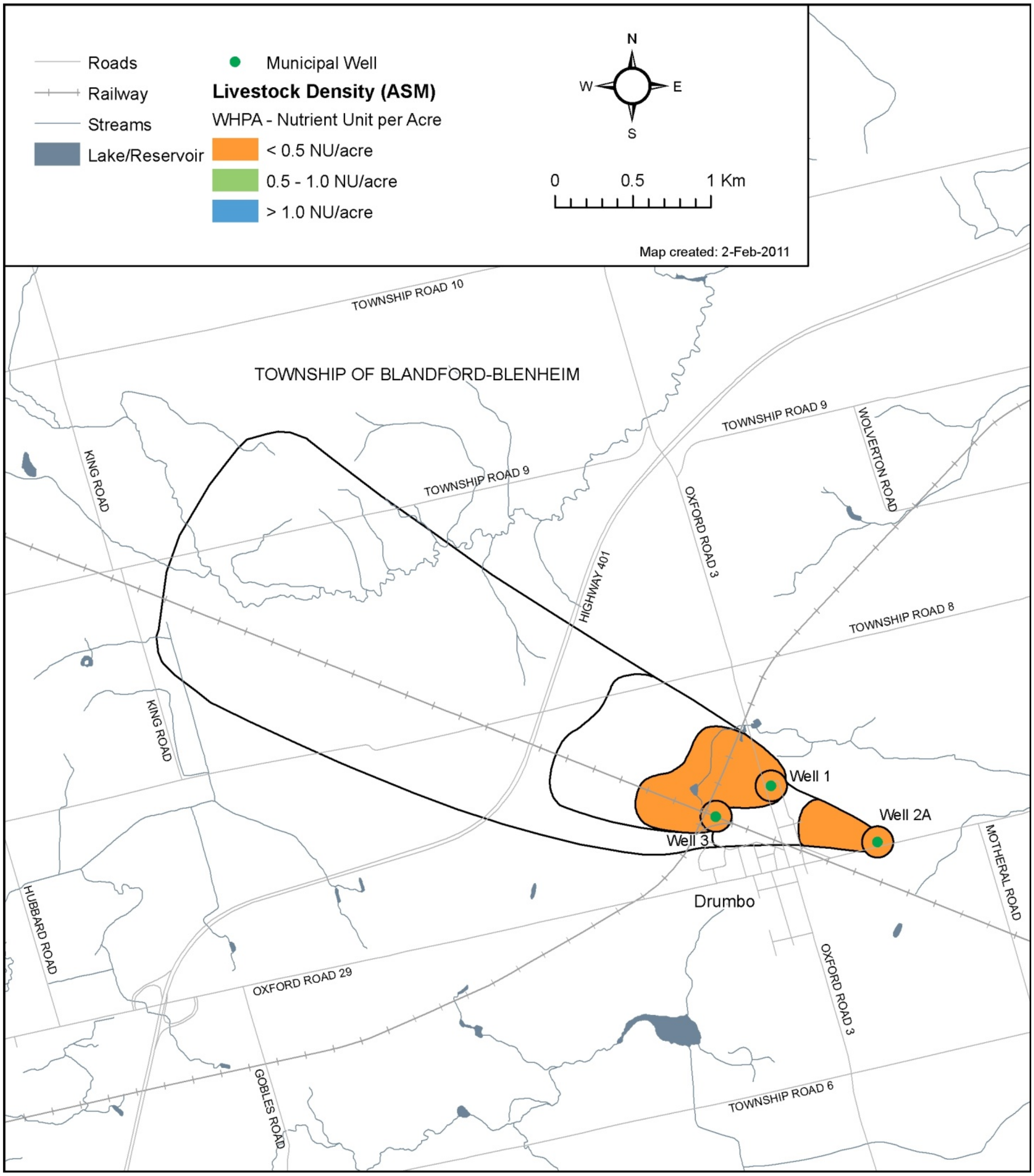
Table 11-5: Livestock Density (NU/acre) in the County of Oxford Wellhead Protection Areas

County	Location	Well	WHPA-A	WHPA-B	WHPA-C	WHPA-D
Oxford	Bright	Well 4A ~~/~~ and Well 5	0.0	0.0	0.0	N/A
	Drumbo	Well 2A	0.1	0.0	N/A	N/A
		Well 1	0.0	0.0	N/A	N/A
		Well 3	0.0	0.0	N/A	N/A
	Plattsville	~~W1 / W2~~Well 1 and Well 2	0.0	0.0	0.0	0.0

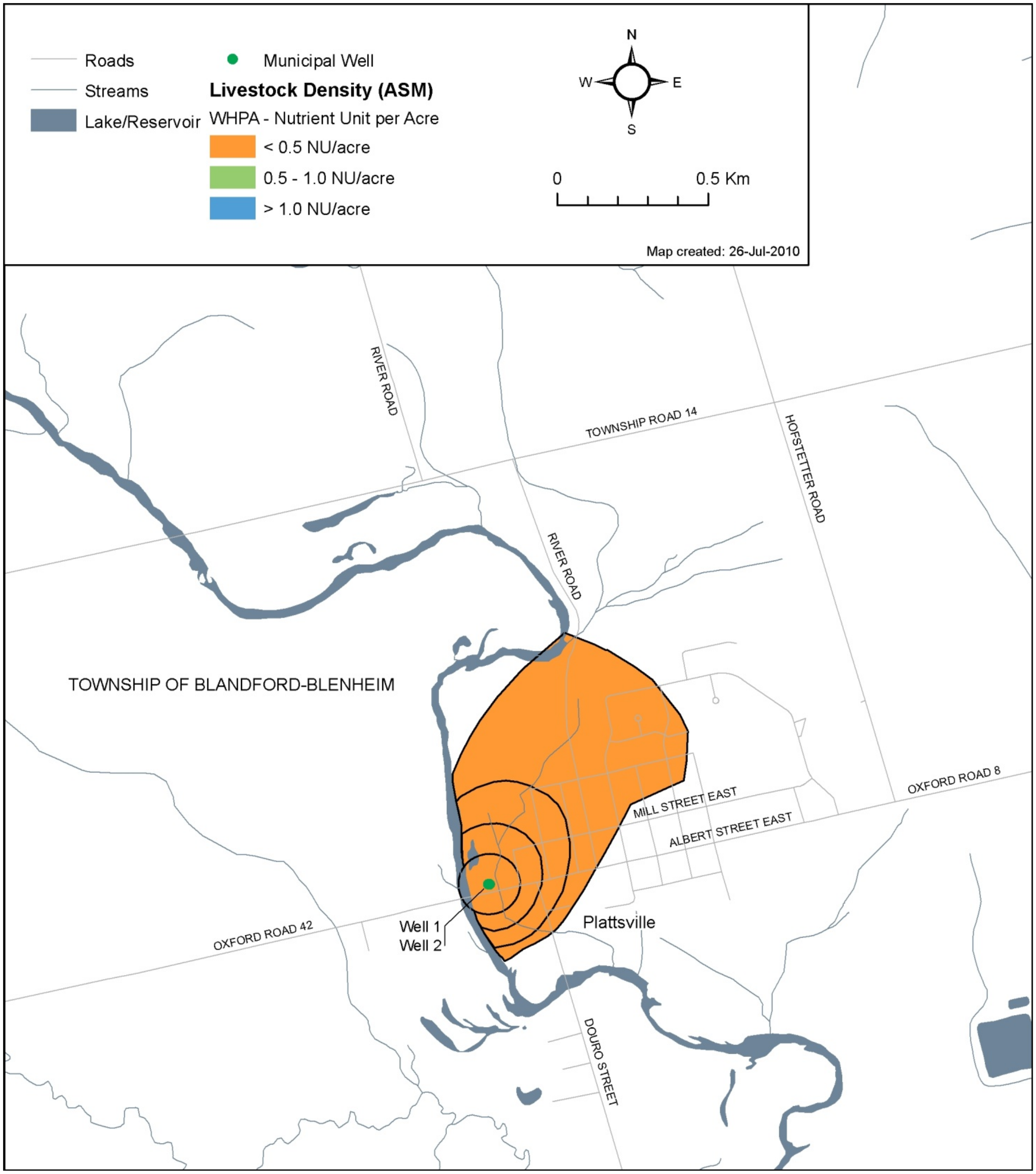
Map 11-14: Bright Water Supply Livestock Density



Map 11-15: Drumbo-Princeton Water Supply Livestock Density



Map 11-16: Plattsville Water Supply Livestock Density



Percentage of Impervious Surface Area within the County of Oxford Wellhead Protection Areas

To determine whether the application of road salt poses a threat in the County of Oxford, the percentage of impervious surface~~ where road salt can be applied per square kilometre was calculated as per the Technical Rules 16(11) and 17.~~ was calculated using the window-moving average approach for the Bright and Drumbo ~~water supply systems~~WHPAs, while impervious surface was calculated using the 1X1 kilometre grid approach for the Plattsville ~~water supply system~~WHPAs. Furhter detail on the impervious surface calculation methodology is described in Section 3.

~~To calculate percentage of impervious surface, guidance from the rules mentioned above were used to create a 1km by 1km grid over the vulnerable area. In the most recent amendment (November 16, 2009) of the technical rules, rule 17 from Part II changed to state that the 1 kilometer by 1 kilometer grid to be centred over the "source protection area" as opposed to the original "vulnerable area".~~

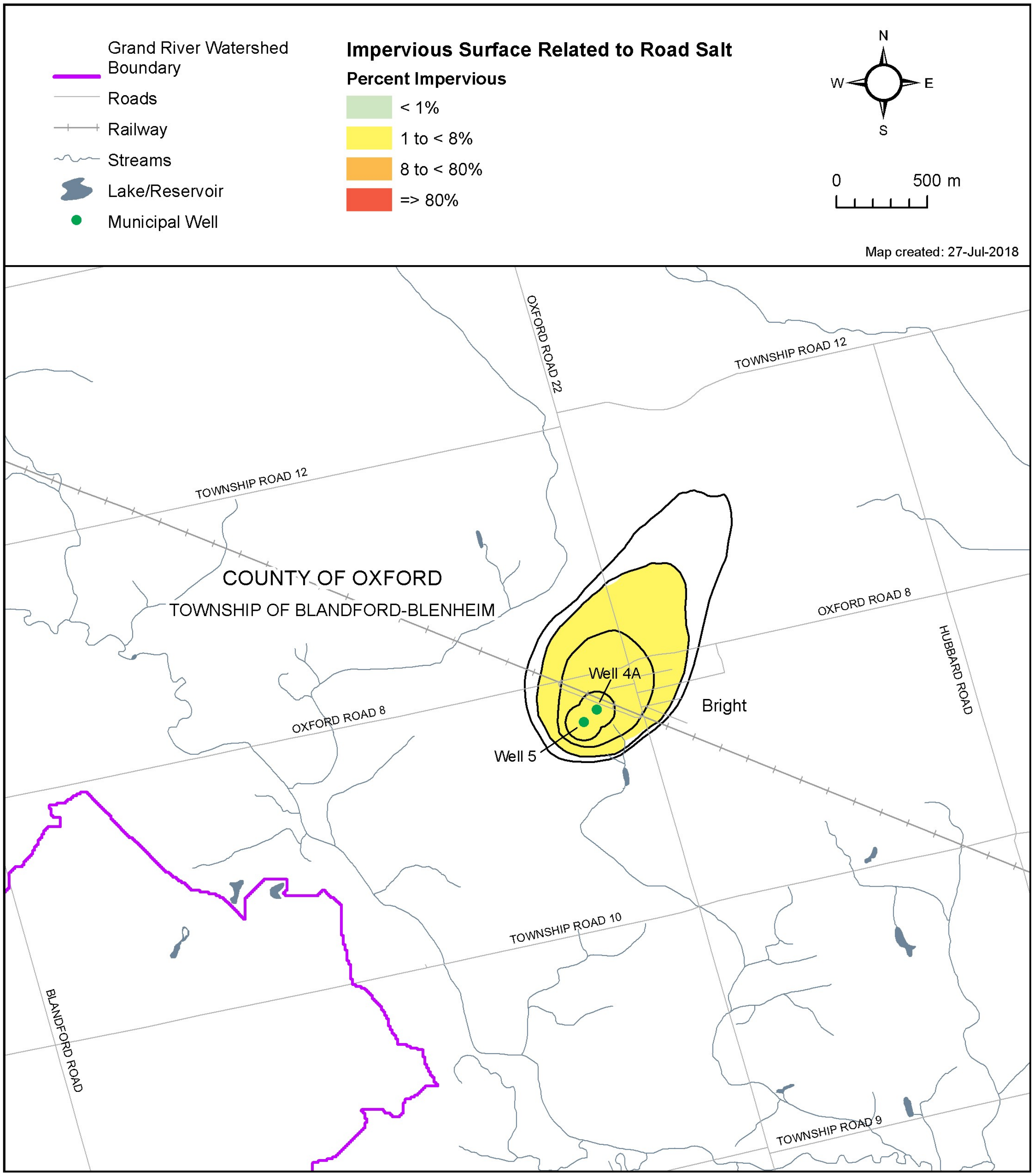
~~The application of road salt can only be a threat in areas with a vulnerability score of 6 or greater; therefore the percent impervious calculation was only completed in areas with a score of 6 or greater.~~

~~Roadways, sidewalks, driveways and parking lots were digitized on screen using ArcMap and 30cm resolution SWOOP orthoimagery from 2006 displayed at a scale of 1:500, to represent impervious surfaces. The impervious surface data layer was created in two sections. The Lower Thames Valley Conservation Area (LTVCA) GIS team digitized all impervious surfaces in the portion of the County within the Thames Sydenham and Region Source Protection Region, and Oxford County Staff digitized all impervious surfaces in the portion of the County within the Lake Erie Source Protection Region. Grids centred over each source protection area were provided by the LTVCA and the GRCA.~~

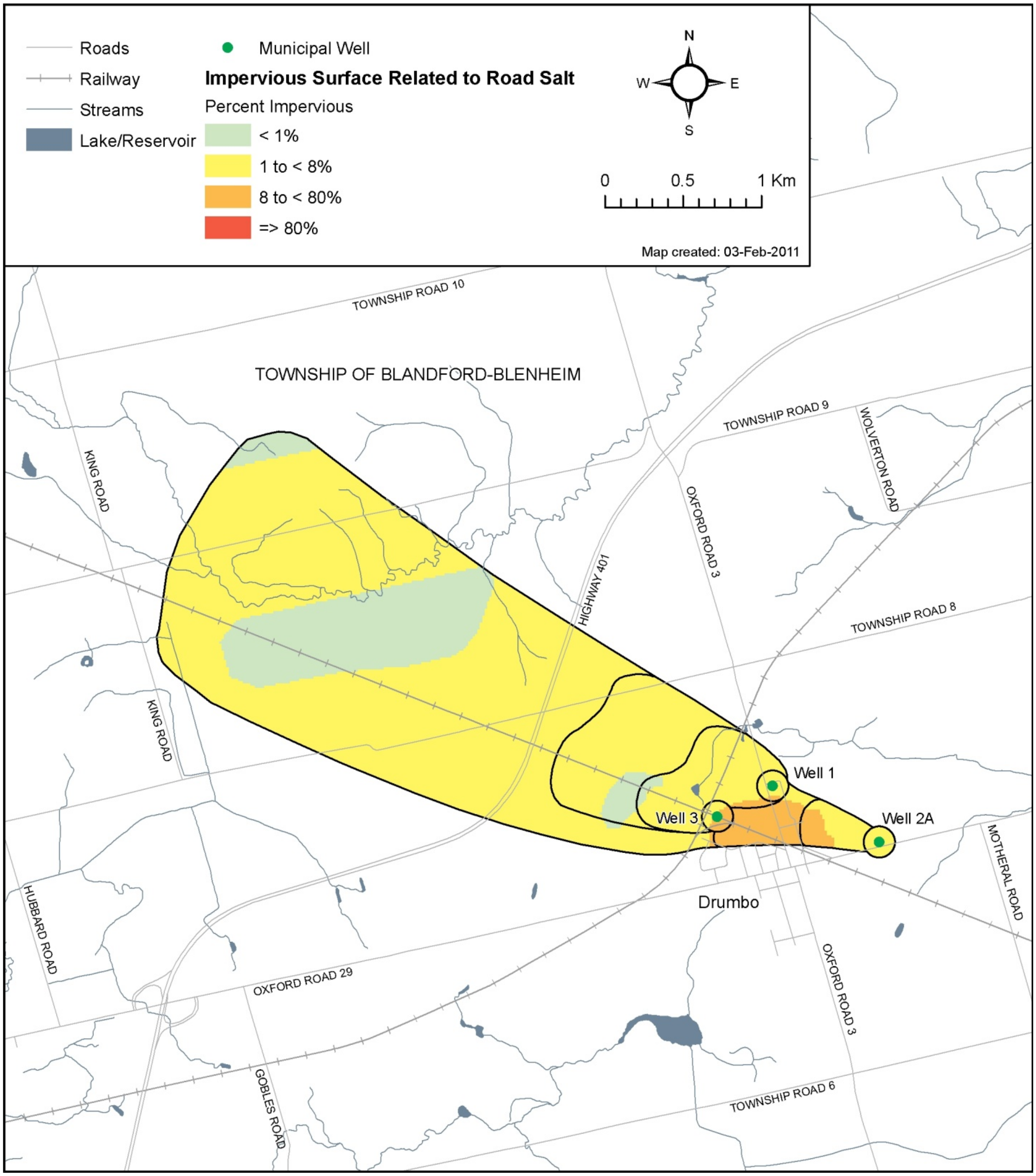
~~The impervious surface percentage in each grid cell was calculated by dividing the total impervious surface area in each grid cell by the total vulnerable area (with vulnerability scoring equal to or greater than 6) in that same grid cell. It should be noted that where a grid cell contains a portion of a Wellhead Protection Area with vulnerability score less than 6, this portion on the Wellhead Protection Area was not used in the calculation of impervious surfaces. For road salt to be considered a significant threat, the percent of impervious surface must be greater than 80%.~~

The results of the impervious surface calculations indicate that there are low percentages in Bright (**Map 11-17**), Drumbo **(Map 11-18)** and Plattsville **(Map 11-19)** and that the application of road salt would not be a significant threat.

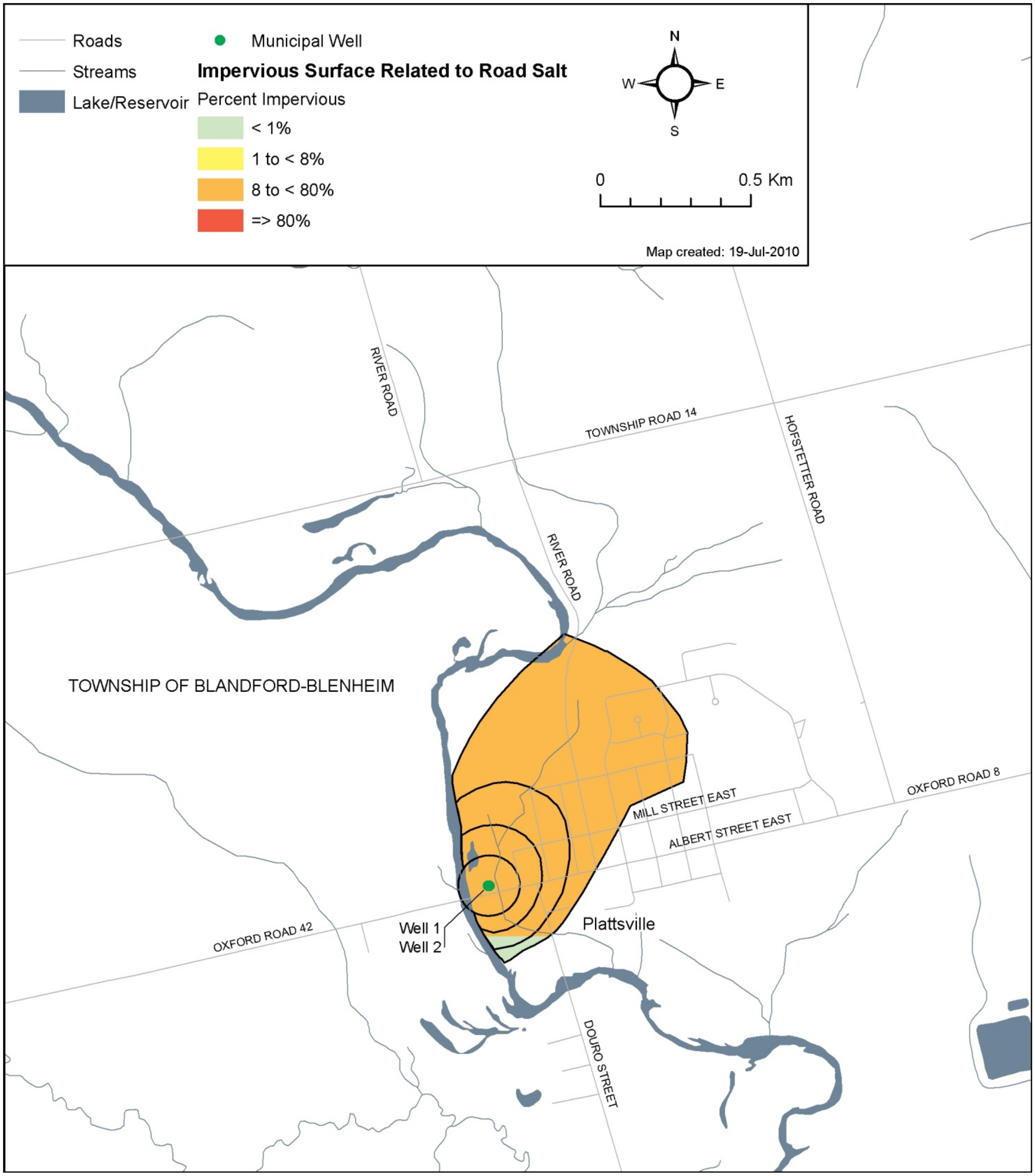
Map 11-17: Bright Water Supply Percent Impervious Surfaces



Map 11-18: Drumbo-Princeton Water Supply Percent Impervious Surfaces



Map 11-19: Plattsville Water Supply Percent Impervious Surfaces



11.1.5 Drinking Water Quality Threat Assessment

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.” Further details on the drinking water quality threats assessment are detailed in Section 3 of this Assessment Report.

~~The Technical Rules (MOE, 2009b) 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).~~

~~Activities that Are or Would be Drinking Water Quality Threats in the Wellhead Protection Areas~~

~~Ontario Regulation 287/07, pursuant to the *Clean Water Act*, *2006* provides a list of Prescribed Drinking Water Quality Threats that could constitute a threat to drinking water sources. **Table 12-6** lists the activities that are prescribed as water quality related prescribed drinking water threats. Listed beside the prescribed drinking water threats are the typical land use activities that are associated with the threat.~~

~~In addition, there is one local threat that has been identified in the Lake Erie Source Protection Region: the transportation of oil and fuel products through a pipeline.~~

~~A spill of oil and fuel products could result in the presence of petroleum hydrocarbons or BTEX in groundwater. The conveyance of oil by way of an underground pipeline that would be designated as transmitting or distributing “liquid hydrocarbons”, including “crude oil”, “condensate”, or “liquid petroleum products”, and not including “natural gas liquids” or “liquefied petroleum gas”, within the meaning of Ontario Regulation 210/01 under the *Technical Standards and Safety Act* or is subject to the *National Energy Board Act,* was approved as a local threat. The letter of approval from the Director of the Source Protection Programs Branch and table of hazard ratings is found in **Appendix D**.~~

~~Table 12-6: Drinking Water Quality Threats~~

~~Prescribed Drinking Water Quality Threat~~ ~~Ontario Regulation 287/07 s.1.1.(1)~~		**~~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~~

~~Table 12-6: Drinking Water Quality Threats~~

~~**Prescribed Drinking Water Quality Threat**~~ ~~Ontario Regulation 287/07 s.1.1.(1)~~		~~**Land Use / Activity**~~
~~2~~	~~The establishment, operation or maintenance of a system that collects, stores, transmits, treats or disposes of sewage.~~	~~Sewage Infrastructures~~ ~~Septic Systems, etc.~~
~~3~~	~~The application of agricultural source material to land.~~	~~e.g. manure, whey, etc.~~
~~4~~	~~The storage of agricultural source material.~~	~~e.g. manure, whey, etc.~~
~~5~~	~~The management of agricultural source material.~~	~~aquaculture~~
~~6~~	~~The application of non-agricultural source material to land.~~	~~Organic Soil Conditioning~~ ~~Biosolids~~
~~7~~	~~The handling and storage of non-agricultural source material.~~	~~Organic Soil Conditioning~~ ~~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~~

~~**Local Drinking Water Threat**~~	~~**Land Use / Activity**~~
~~The conveyance of oil by way of an underground pipeline that would be designated as transmitting or distributing “liquid hydrocarbons”, including “crude oil”, “condensate”, or “liquid petroleum products”, and not including “natural gas liquids” or “liquefied petroleum gas”, within the meaning of the Ontario Regulation 210/01 under the *Technical Standards and Safety Act* or is subject to the *National Energy Board Act.*~~ [1]	~~Oil pipeline~~

~~1: As confirmed by the letter from the Director of the Source Protection Programs Branch in Appendix D.~~

Identification of Significant, Moderate and Low Drinking Water Threats for the County of Oxford Drinking Water Systems in the Grand River Watershed

~~The identification of a land use activity as a significant, moderate, or low drinking water threat depends on its risk score, determined by considering the circumstances of the activity and the type and vulnerability score of any underlying protection zones, as set out in the Tables of Drinking Water Threats available through www.sourcewater.ca. Information on drinking water threats is also accessible through the Source Water Protection Threats Tool: http://swpip.ca. For~~

~~local threats, the risk score is calculated as per the Director's Approval Letter, as shown in **Appendix C**. The information above can be used with the vulnerability scores shown in **Map 12-6**, **Map 12-8** and **Map 12-10** to help the public determine where certain activities are or would be significant, moderate and low drinking water threats.~~

Table 11-6, **Table 11-7** and **Table 11-8** provide a summary of the threat levels possible in the County of Oxford Drinking Water Systems for Chemicals, ~~Chemical,~~ Dense Non-Aqueous Phase Liquids (DNAPLs), and Pathogens~~, and Local Threats (Oil Pipelines).~~. A checkmark indicates that the threat classification level is possible for the indicated threat type under the corresponding vulnerable area / vulnerable score; a blank cell indicates that it is not. The colours shown for each vulnerability score correspond to those shown in the maps.

Table 11-6: Identification of Drinking Water Quality Threats in the Bright Water Supply Wellhead Protection Areas

Threat Type	Vulnerable Area	Vulnerability Score	Threat Classification Level		
			Significant 80+	Moderate 60 to <80	Low >40 to <60
Chemicals	WHPA-A/B	10	✓	✓	✓
	WHPA-B/C	8~~8~~	✓	✓	✓
	WHPA-~~B/~~C	6		✓	✓
	WHPA-C/D	2 & 4			
Handling / Storage of DNAPLs	WHPA-A/B/C	Any Score	✓		
	WHPA-D	2 & 4			
Pathogens	WHPA-A/B	10	✓	✓	
	WHPA-B	8		✓	✓
	WHPA-	Any Score~~6~~			~~✓~~

Table 11-7: Identification of Drinking Water Quality Threats in the Drumbo-Princeton Water Supply Wellhead Protection Areas

Threat Type	Vulnerable Area	Vulnerability Score	Threat Classification Level		
			Significant 80+	Moderate 60 to <80	Low >40 to <60
Chemicals	WHPA-A	10	✓	✓	✓
	WHPA-B	6		✓	✓
	WHPA-C/D	2 & 4			
Handling / Storage of DNAPLs	WHPA-A/B/C	Any Score	✓		
	WHPA-D	2			
Pathogens	WHPA-A	10	✓	✓	
	WHPA-B	6			✓
	WHPA-C/D	Any Score			

Table 11-8: Identification of Drinking Water Quality Threats in the Plattsville Wellhead Protection Areas

Threat Type	Vulnerable	Vulnerability	Threat Classification Level

	Area	Score	Significant 80+	Moderate 60 to <80	Low >40 to <60
Chemicals	WHPA-A/B	10	✓	✓	✓
	WHPA-C	8	✓	✓	✓
	WHPA-D	6		✓	✓
	WHPA-D	2 & 4			
Handling / Storage of DNAPLs	WHPA-A/B/C	Any Score	✓		
	WHPA-D	6		✓	✓
	WHPA-D	2 & 4			
Pathogens	WHPA-A/B	10	✓	✓	
	WHPA-C/D	Any Score			

11.1.6 Enumeration of Significant Drinking Water Quality Threats

Available desktop information, publicly available databases, air photo interpretation and local County staff knowledge was used to determine the types of land use activity information and potential threats associated with these land uses. To associate the prescribed drinking water threats listed with land use activities, the County of Oxford has compiled a land use inventory. The inventory was based on a review of multiple data sources which included previous groundwater-related work undertaken by the County, public records, local knowledge and windshield surveys.

Consultation with property owners will be undertaken to verify the existence of circumstances that constitute a significant threat.

Enumeration of Significant Drinking Water Quality Threats for the Bright Water System

For the Bright municipal wells, significant threats that were enumerated occured in WHPA-A and WHPA-B. A list of significant threat types identified in Bright is located in . These threats are current to the end of 2014.

Table 11-9: Significant Drinking Water Quality Threats for the Bright Water System (current to the year 2014)

PDWT[1] #	Threat Subcategory[2]	Number of Activities	Vulnerable Area
2	Sewage System or Sewage Works- Onsite Septic System	7	WHPA-A
3	Application of Agricultural Source Material to Land	1	WHPA-A
8	Application of Commercial Fertilizer	1	WHPA A
10	Application of Pesticides to Land	1	WHPA A
16	Handling and Storage of DNAPLs	1	WHPA B
Total Number of Properties		**9**	
Total Number of Activities		**11**	

Table 11-9: Significant Drinking Water Quality Threats for the Bright Water System (current to the year 2014)

PDWT[1] #	Threat Subcategory[2]	Number of Activities	Vulnerable Area

1: Prescribed Drinking Water Quality Threat Number refers to the prescribed drinking water threat listed in O.Reg 287/07 s.1.1.(1).

2: Where applicable, waste, sewage, and livestock threat numbers are reported by sub-threat; fuel and DNAPL by Prescribed Drinking Water Threat category

Certain types of activities on residential properties that are incidental in nature and that are significant drinking water threats are not enumerated. These threats include the application of commercial fertilizer on residential properties, the storage of organic solvents (dense non-aqueous phase liquids) on residential properties, and the storage of fuel (e.g., heating fuel tanks) on residential properties in natural gas serviced areas.

Note: Storm sewer piping is not considered to be part of a storm water management facility.

Enumeration of Significant Drinking Water Quality Threats for the Drumbo Water System

In Drumbo, the significant threats that were enumerated occur in WHPA-A and WHPA-B. A list of all significant threat types identified in Drumbo is located in below. The threats are current to the end of 2014.

Table 11-10: Significant Drinking Water Quality Threats for the Drumbo Water System (current to the end of 2014)

PDWT[1] #	Threat Subcategory[2]	Number of Activities	Vulnerable Area
2	Sewage System or Sewage Works- Onsite Septic System	2	WHPA A
	Sewage System or Sewage Works- Sanitary Sewers and related pipes	3	WHPA A
	Sewage System Or Sewage Works - Sewage Treatment Plant Effluent Discharges (Includes Lagoons)	1	WHPA-A
	Sewage System Or Sewage Works - Sewage Works Storage – Treatment or Holding Tanks	1	WHPA-A
3	Application of Agricultural Source Material to Land	4	WHPA A
8	Application of Commercial Fertilizer	4	WHPA A
21	Management or handling of Agricultural Source Material- Agricultural Source Material (ASM) Generation	1	WHPA A
Total Number of Properties		**8**	
Total Number of Activities		**16**	

1: Prescribed Drinking Water Quality Threat Number refers to the prescribed drinking water threat listed in O.Reg 287/07 s.1.1.(1).

2: Where applicable, waste, sewage, and livestock threat numbers are reported by sub-threat; fuel and DNAPL by Prescribed Drinking Water Threat category

Note: The threat point representing linear feature infrastructure such as sanitary sewers was not added into the total number of properties, since this feature is not attached to one specific property.

Certain types of activities on residential properties that are incidental in nature and that are significant drinking water threats are not enumerated. These threats include the application of commercial fertilizer on residential properties, the storage of organic solvents (dense non-aqueous phase liquids) on residential properties, and the storage of fuel

Table 11-10: Significant Drinking Water Quality Threats for the Drumbo Water System (current to the end of 2014)

PDWT[1] #	Threat Subcategory[2]	Number of Activities	Vulnerable Area

(e.g., heating fuel tanks) on residential properties in natural gas serviced areas.

Note: Storm sewer piping is not considered to be part of a storm water management facility.

Enumeration of Significant Drinking Water Quality Threats for the Plattsville Water System

Within Plattsville, inventoried significant threats occur in WHPA-A and WHPA-B. A list of all significant threat types identified in the Plattsville WHPA is presented in below. The threats are current to the end of 2014.

Table 11-11: Significant Drinking Water Quality Threats for the Plattsville Water System (current to the end of 2014)

PDWT[1] #	Threat Subcategory[2]	Number of Activities	Vulnerable Area
1	Waste Disposal Site- Storage of wastes described in clauses (p), (q), (r), (s), (t) or (u) of the definition of hazardous waste	1	WHPA-B
2	Sewage System or Sewage Works- Sanitary Sewers and related pipes	1	WHPA-B
3	Application of Agricultural Source Material to Land	2	WHPA-A
10	Application of Pesticides to Land	1	WHPA-A
15	Handling and Storage of Fuel	3	WHPA-B
16	Handling and Storage of DNAPLs	3	WHPA-B
17	Handling and Storage of Organic Solvents	2	WHPA-B
Total Number of Properties		**6**	
Total Number of Activities		**13**	

1: Prescribed Drinking Water Quality ThreatNumber refers to the prescribed drinking water threat listed in O.Reg 287/07 s.1.1.(1).

2: Where applicable, waste, sewage, and livestock threat numbers are reported by sub-threat; fuel and DNAPL by Prescribed Drinking Water Threat category

Note: The threat point representing linear feature infrastructure such as sanitary sewers was not added into the total number of properties, since this feature is not attached to one specific property.

Certain types of activities on residential properties that are incidental in nature and that are significant drinking water threats are not enumerated. These threats include the application of commercial fertilizer on residential properties, the storage of organic solvents (dense non-aqueous phase liquids) on residential properties, and the storage of fuel (e.g., heating fuel tanks) on residential properties in natural gas serviced areas.

Note: Storm sewer piping is not considered to be part of a storm water management facility.

Uncertainty and Limitations in the Enumeration of Significant Drinking Water Quality Threats

There was a general lack of information on the presence/absence of contamination associated with historical land uses. As a result, no condition-related drinking water threats (if present) were identified. In addition, the type and amount of chemicals stored at the commercial and industrial operations within the wellhead protection areas is unknown. Further, for other land use types, the types and amounts of potential contaminants often had to be assumed based on the land use practice. Where assumptions had to be made, often a worst case scenario approach was taken and circumstance values were assigned based on that assumption so significant threats would be flagged for follow-up.

In terms of data limitations, the most problematic dataset was septic systems. The records maintained by the County Board of Health lack accurate locational information. The sanitary sewer infrastructure layer was used to determine which properties were serviced by municipal services. Using this method, there remained instances where service connection was questionable. At present County Public Works has not yet digitized all of the sanitary sewer infrastructure in the County, although this is a work in progress.

For the impervious surface dataset, digitizing was completed by both Oxford County and the Lower Thames River Conservation Authority (LTRCA). Heads-up digitizing from two different sources could introduce error when identifying impervious surfaces in Oxford County. Also, each organization may have access to different supplementary data sets to complete the analysis. Since the County has access to more current roads data, road centre lines were buffered to average road widths to create the initial impervious surface layer. Edits were then made to ensure the roadways were accurately represented and to add in sidewalks, driveways and parking lots. Human error may have occurred while digitizing the impervious surfaces.

Since there is no agricultural census information available to the County at the property scale, reasonable assumptions about the type of livestock housed in a farm structure were based on the best available information. This information ranged from local knowledge of County and municipal staff to land use information recorded in various County records. Where this information was unavailable, air photo interpretation was used to determine barn type, and therefore, livestock type. Air photo interpretation and the use of GIS for area calculations could be considered limitations to the work, since the resulting shapefiles are representations and not 100 percent accurate. This limitation also applies to the layer extraction step when delineating managed lands. Certain structures, in particular residential dwellings, do not necessarily reflect actual foot prints of the structures. However, manual edits to the shapefile were completed for larger layers if deemed necessary through air photo interpretation.

11.1.7 Conditions Evaluation for the County of Oxford's Well Supply Systems

The Technical Rules state that if there is evidence that a Condition is causing off-site contamination, a hazard rating of 10 is applied. If there is no evidence of off-site contamination, the hazard rating is 6, which ~~would~~ results in a moderate or low drinking water threat within the WHPA.

~~The *Clean Water Act, 2006* Technical Rules require a list of conditions that are drinking water threats resulting from a past activity where the following conditions are present:~~

1) ~~The presence of a non-aqueous phase liquid in groundwater in a highly vulnerable aquifer, significant groundwater recharge area or wellhead protection area;~~
2) ~~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;~~
3) ~~The presence of a contaminant in groundwater in a highly vulnerable area, significant groundwater recharge area or wellhead protection area listed in Table 2 of the Soil,~~

~~Groundwater and Sediment Standards and present at a concentration that exceeds the potable groundwater standard set out for the contaminant in that Table;~~

~~4) The presence of a contaminant in surface soil in a surface water intake protection zone listed in Table 4 of the Soil, Ground Water and Sediment Standards and 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~~

~~5) The presence of a contaminant in sediment listed in Table 1 of the Soil, Ground Water and Sediment Standards and present at a concentration that exceed the sediment standard set out for the contaminant in that Table.~~

~~All of County of Oxford's water supply is obtained from groundwater sources. Therefore, only conditions 1 and 3 as listed above are applicable.~~

~~***Conditions Evaluation for the County of Oxford Drinking Water Systems***~~

After review of the available data, ~~there were~~ no conditions were identified in the Bright, Drumbo-Princeton and Plattsville drinking water systems.

11.1.8 Drinking Water Quality Issues Evaluation

The objective of the Issues evaluation is to identify drinking water Issues where the existing or trending concentration of a parameter or pathogen at an intake, well or monitoring well c~~w~~ould result in the deterioration of the quality of water for use as a source of drinking water. The parameter or pathogen must be listed in Schedule 1, 2 or 3 of the Ontario Drinking Water Quality Standards (ODWQS) or Table 4 of the Technical Support Document for Ontario Drinking Water Standards, Objectives and Guidelines (Technical Rules XI.1 (114 – 117)). Elevated concentrations of selected parameters that are naturally occurring or where effective treatment is in place are not considered drinking water Issues.

~~Once 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 and manage these threats appropriately. If at this time the Issue Contributing Area cannot be identified or the Issue cannot be linked to threats then a work plan must be provided.~~

~~If an Issue is identified for an intake, well or monitoring well, then all threats related to a particular Issue within the Issue Contributing Areas are significant drinking water threats, regardless of the vulnerability.~~

Methodology for Drinking Water Quality Issues Evaluation

The water quality data used in this evaluation was compiled by the Oxford County Public Works Department. The data comprises the analytical results taken as part of operating the systems in addition to water quality results received as part of other programs/projects. The ~~bulk~~ majority of the data used in this evaluation ~~is~~ dates from 2001 to 2017 for the Bright water supply system and from 2001 to 2014 for the Drumbo-Princeton and Plattsville water supply systems ~~present~~. Older data has been used where relevant.

~~The Issues evaluation for the County of Oxford focused on the water quality parameter groupings outlined in the Ontario Drinking Water Quality Standards (ODWQS) identified in Ontario Regulation 169/03 under the *Safe Water Drinking Act* and the related technical support document. These parameters include: a) Pathogens. b) Schedule 1 Parameters, c) Schedule 2 and 3 parameters and, d) Table 4 parameters.~~

~~Parameters have been screened for closer investigation where any of the following criteria have been met:~~

- ~~Consistent presence of microbiological parameters;~~
- ~~The parameter has a health related Maximum Acceptable Concentration (MAC) associated with it and the concentration in the raw or treated water exceeds half of the MAC level (with the exception of fluoride); and~~
- ~~The parameter does not have a health related MAC but the concentration observed exceeds the objective or guideline associated with the ODWQS.~~

~~Water quality parameters meeting the screening threshold above were further reviewed to determine whether to identify them as Issues. The considerations included:~~

- ~~Whether the concentration is at or trending towards a health related MAC;~~
- ~~The frequency with which the parameter meets the screening threshold;~~
- ~~Capabilities of the treatment facility;~~
- ~~The ability of the parameter to interfere with/upset the treatment process;~~
- ~~Whether the parameter is related to issues raised by the public; and~~
- ~~Importance of the well to the overall supply.~~

Drinking Water Quality Issues Evaluation for the Bright Water Supply

The system has several operational or aesthetic parameters that exceed the associated objectives or guidelines as detailed below.

Hardness, which has a guideline range from 80 to 100 mg/L, is typically exceeded in groundwater systems. The Bright hardness concentration is typically between~~around~~ 300 to ~~400~~ 500 mg/L. This parameter is naturally occurring in the groundwater and does not pose a health risk nor does it impact the treatment process.

The sodium concentration ranges from 39 to ~~52~~ 64 mg/L, which is above the reporting level of 20 mg/L, but well below the aesthetic objective of 200 mg/L. Chloride ~~levels in the system~~concentrations are quite low; this suggest~~ing~~ that the sodium concentrations are not related to the application of ~~is not caused by~~ road salt application but may be~~rather is~~ naturally occurring. No increasing trend is evident in the results.

Total Dissolved Solids (TDS) levels in the Bright system exceed the objective of 500 mg/L and are around 600 mg/L. TDS is an aesthetic parameter and does not impact health or the treatment process. No increasing trend is evident in the results.

The raw water in the system exceeds the objective of 0.3 mg/L for iron. The raw water ~~is around~~iron concentrations range from 0.5 to 0.8 mg/L. Iron is an aesthetic parameter and does not interfere with the treatment process. No increasing trend is evident.

Summary of the Drinking Water Quality Issues Evaluation for the Bright Water Supply

The parameters in the Bright Water Supply System that meet the screening threshold are ~~Hardness~~hardness, TDS and ~~Iron~~iron. These parameters are all naturally occurring and typical of ~~to~~ groundwater sources. They do not affect the treatment process and there is no evidence of upward trending. ~~, therefore, n~~No Issues were ~~noted~~identified under Technical Rule 114.

Drinking Water Quality Issues Evaluation for the Drumbo Water Supply

No health-related parameters were found to exceed their MAC. Microbiological results are consistently good at Well 3. Well 2A has had periodic positive low level results for total coliforms while not in regular service. This is not uncommon where wells are only periodically pumped as is the case with Well 2A and does not necessarily indicate a concern. The well recently began a rotational production schedule.

With the exception of ~~H~~hardness, no operational or aesthetic parameters exceed the associated objectives or guidelines. Hardness, which has a guideline range from 80 to 100 mg/L, is typically exceeded in groundwater systems. The Drumbo hardness concentration is typically between 230 to 330 mg/L.

Summary of Drinking Water Quality Issues Evaluation for the Drumbo Water Supply

The only parameters in the Drumbo Water Supply System that meets the screening threshold are total coliform and hardness. The total coliform presence is likely ~~due to~~the result of ~~the~~ Well 2A being maintained in standby mode and not operated frequently. Hardness is naturally occurring and typical to groundwater sources. It does not affect the treatment process and there is no evidence of upward trending. No Issues ~~have been~~were identified for the Drumbo Water Supply under Technical Rule 114.

Drinking Water Quality Issues Evaluation for the Plattsville Water Supply

No parameters were found to exceed their ~~Maximum Acceptable Concentration (~~MAC~~)~~. ~~Microbiological results are consistently good.~~

The system has several operational or aesthetic parameters which exceed the associated objectives or guidelines as detailed below.

Hardness, which has a guideline range from 80 to 100 mg/L, is typically exceeded in groundwater systems. The system's hardness concentration is very high, typically around 1000 to 1340 mg/L. This parameter is naturally occurring in the groundwater and is not a heath risk nor does it hinder the treatment process.

Total Dissolved Solids (TDS) levels in the system exceed the objective of 500 mg/L and are 1620 to 1880 mg/L. TDS is an aesthetic parameter and does not impact health or the treatment process. No increasing trend is evident in the results.

The raw water in the system exceeds the objective of 0.3 mg/L for iron. The raw water is around 0.48 to 0.6 mg/L. Iron is an aesthetic parameter and does not interfere with the treatment process. No increasing trend is evident.

Sulphates have an objective of 500 mg/L and in the Plattsville~~Innerkip~~ system, concentrations range from 870 to 1000 mg/L. Sulphates are an aesthetic concern and are naturally occurring in the groundwater.

The system typically exceeds the aesthetic objective of 0.05 mg/L for manganese with concentrations in the 0.06 – 0.08 mg/L range. There is no increasing trend to the concentration and its presence does not interfere with the treatment process.

Summary of Drinking Water Quality Issues Evaluation for the Plattsville Water Supply

The parameters in the Plattsville System that meet the screening threshold are ~~Hardness~~hardness, TDS, i~~I~~ron, m~~M~~anganese and ~~Sulphates~~sulphates. These parameters are all naturally occurring and do not affect the treatment process. There is no evidence of upward trending. No Issues have been identified for the Plattsville ~~Water~~ water s~~S~~upply under Technical Rule 114.

~~11.1.9 Enumeration of Significant Drinking Water Quality Threats~~

~~Available desk top level land use information, air photo interpretation and local knowledge of County and municipal staff was used to determine the types of land use activity information and therefore, the threats and circumstances associated with these land uses. In most cases, professional judgment and assumptions were made when determining the presence of significant threats for each property. Consultation with property owners will be undertaken to verify the existence of circumstances that constitute a significant threat~~

~~*Data Sources for the Enumeration of Significant Drinking Water Threats*~~

~~To associate the prescribed drinking water threats listed in **Table 12-6** with land use activities, the County of Oxford compiled a land use inventory. The inventory was based on a review of multiple data sources which included previous groundwater-related work undertaken by the County, public records, local knowledge and windshield surveys.~~

~~The datasets used to form the basis of the threats inventory are provided in **Table 12-10** and **Table 12-11**.~~

~~Table 12-10: Datasets for the Significant Drinking Water Quality Threats Enumeration for the County of Oxford~~

~~**Threats Point Datasets**~~		
~~**Name**~~	~~**Purpose**~~	~~**Comments**~~
~~**Water Wells Record Database(MOE)**~~		
~~The database includes locations of both private and municipal wells, as well as additional information including the operating status of the well.~~	~~To identify potential transport pathways.~~	~~- Current to 2000~~ ~~- Accuracy of all points is questionable~~
~~**Certificates of Approval (MOE)**~~		
~~Contains Certificates of Approval for Air, Industrial Wastewater and Municipal/Provincial Sewage and Waterworks~~	~~To flag potential circumstances.~~	~~- Dataset received October 2003~~ ~~- Dataset incomplete~~
~~**Existing Land Uses (County of Oxford)**~~		
~~A detailed inspection of land use in the County's WHPAs, identified according to its NAICS code.~~	~~To flag potential circumstances~~	~~- Completed in 2004~~ ~~- Updated in 2007~~
~~**O. Reg 347 – Waste Generators Summary, Waste Receivers Network (HWIN)**~~		
~~HWIN is a web-based service that allows hazardous waste generators, receivers, and carriers to register their activities with the MOE on-line~~	~~To flag potential circumstances.~~	~~- Database last received January 2004~~
~~**Historical Land Uses (County of Oxford)**~~		
~~Represent sites where industrial operations were formerly established. Identification of sites was completed using historical fire~~	~~To flag potential conditions.~~	~~- Maps dated 1876 to 1984~~ ~~- No record on quantity or type of contaminants~~

~~Table 12-10: Datasets for the Significant Drinking Water Quality Threats Enumeration for the County of Oxford~~

~~Threats Point Datasets~~		
~~Name~~	**~~Purpose~~**	**~~Comments~~**
~~insurance maps.~~		
~~Patrol Yards (Oxford) Potential salt storage.~~		
	~~To identify salt storage locations~~	~~- Updated as required by County~~
~~Ontario Inventory of PCB Storage Sites (MOE)~~		
	~~To flag potential circumstances~~	~~- Current to 2000~~
~~Petroleum Wells (MNR)~~		
~~Petroleum wells, both producers and those that are abandoned, have been included in the inventory.~~	~~To identify potential transport pathways.~~	~~- This information ranges in date from 1967 to 1973.~~
~~Private Fuel Storage Tanks (TSSA)~~		
~~The Technical Standards and Safety Authority (TSSA) maintain a database of all registered commercial and industrial underground storage tanks.~~	~~To flag potential threats.~~	~~- Database received October 2003~~ ~~- Database contains no date information~~
~~Wastewater Treatment Facilities (County of Oxford)~~		
	~~To flag potential threats.~~	~~-Updated as required by County Staff~~
~~Pits and Quarries (Oxford)~~		
~~The County's LRIS contains a data layer of operating pits and quarries. This layer was varied using air photo interpretation.~~	~~To identify potential transport pathways.~~	~~- Inventoried in 2007~~ ~~- Requires periodic update~~
~~Storm Water Infiltration (Oxford)~~		
~~This dataset was compiled based on information about stormwater ponds provided by the Chief Building Official's of the area municipalities.~~	~~To identify Potential transport pathways.~~	~~- Inventoried in 2007~~ ~~- Requires periodic update~~
~~Septic Systems (Oxford)~~		
~~This data layer was created based on the absence of sanitary sewer infrastructure and the presence of a dwelling.~~	~~To flag potential threats or transport pathways.~~	~~- Will require updates as certain settlements are serviced with sanitary sewers.~~
~~Sanitary Sewer Infrastructure (Oxford)~~		
~~This data layer was created and provided by the County of Oxford Public Works Department.~~	~~Potential threat circumstance.~~	~~- Will require updates as new infrastructure is installed~~
~~Gas pipelines (Sun Canada, Enbridge, Union Gas, Imperial Oil)~~		
~~Data provided by gas companies~~	~~Potential threat circumstance.~~	~~- May require periodic updates~~
~~2006 Orthoimagery (SWOOP)~~		
	~~Air photo Interpretation~~	~~- 30 cm Resolution~~

~~Table 12-11: Other Supporting Datasets for the Significant Drinking Water Quality Threats Enumeration for the County of Oxford~~

~~Name and Source~~	**~~Purpose~~**	**~~Comments~~**

~~Table 12-11: Other Supporting Datasets for the Significant Drinking Water Quality Threats Enumeration for the County of Oxford~~

~~Name and Source~~	~~Purpose~~	~~Comments~~
~~Municipal Supply Well (County)~~	~~Location of Municipal Wells~~	~~N/A~~
~~Property and Assessment Lines (County)~~	~~Cartographic/mapping~~	~~The data used to create this layer was obtained from the registry office and mapped by the County~~
~~Road (County)~~	~~Cartographic/mapping~~	~~N/A~~
~~Upper and Lower Tier Municipal Boundaries (County)~~	~~mapping~~	~~N/A~~
~~Drainage and Waterbodies (County and MNR)~~	~~Cartographic/mapping~~	~~Created from NRVIS (Natural Resources Values Information System). County added additional attributes~~
~~Provincially Significant Wetlands and Locally Significant Woodlots (MNR and County)~~	~~Cartographic/mapping~~	~~N/A~~
~~Serviced Areas (County)~~	~~Cartographic/mapping~~	~~N/A~~
~~Settlements (County)~~	~~Cartographic/mapping~~	~~N/A~~
~~WHPA Footprints (County and Golder Associates)~~	~~Threats Inventory~~	~~WHPAs were modeled by Golder Associates and mapped by the County~~
~~WHPA Vulnerability Scoring (County)~~	~~Threats Inventory~~	~~N/A~~
~~Impervious Surface Layers (County and LTVCA)~~	~~Impervious Surface Calculations~~	~~Created in house in co-operation with the Lower Thames Valley Conservation Authority (LTVCA). Based off of air photo interpretation – may contain some degree of error~~
~~Structures (County)~~	~~Managed Lands Calculations~~	~~Structure shapefile does not accurately delineate structure shape, only locations~~
~~Woodlots (County)~~	~~Managed Lands Calculations~~	~~Edited in house using air photo interpretation – may contain some degree of error~~
~~Zoning (County)~~	~~Managed Lands Calculations~~	~~N/A~~
~~Official Plan Data (County)~~	~~Managed Lands Calculations~~	~~N/A~~
~~Threats Points (and associated attribute table) (County)~~	~~Threats Inventory~~	~~Professional judgment used~~
~~Threats Count Table (County)~~	~~Threats Inventory~~	~~Professional judgment used~~
~~WHPA Table (County)~~	~~Threats Inventory~~	~~Professional judgment used~~
~~2006 Orthoimagery (SWOOP) (First Base Solutions)~~	~~Air photo Interpretation~~	~~30 cm Resolution~~

~~In 2004, the County of Oxford participated in a groundwater protection pilot project known as the Land Use and Chemical Occurrence (LUCO) Inventory. The objective of the inventory was to~~

~~identify past and present sources of potential threats that may represent risks to aquifers or are within Wellhead Protection Areas. The inventory was based on the guidelines from the provincial Groundwater Studies' Technical Terms of Reference (MOE, 2001). Data was obtained primarily through government and commercial databases. This information was used as the starting point for the current threats enumeration.~~

~~Wherever possible, County and Township staff's local knowledge was used to supplement the datasets. Local knowledge was used to confirm road salt application, details of activities undertaken on properties, and type and number of livestock on agricultural properties.~~

~~Windshield surveys were conducted to gain information on current land uses, confirm land uses, and confirm locations of potential drinking water threats. The surveys were conducted within the County of Oxford between the spring and fall of 2007. The windshield surveys were often used for verification of data obtained from various other sources.~~

~~The County of Oxford obtained a number of government and commercial databases during the 2004 LUCO study. Updated versions of these datasets were obtained for the current land use inventory wherever possible.~~

~~Other data sources other than those previously described were primarily used for data verification and improvement. These sources include the County of Oxford On-Line Directory (COOLOxford), the County of Oxford's Land Related Information System (LRIS), the North American Industry Classification System (NAICS), Industry Canada's website, and the Yellow Pages.~~

~~The COOLOxford website provides access to a database of public notices, events, businesses, organizations, and services in Oxford County.~~

~~The County's LRIS, which is maintained by the County of Oxford, is a Geographic Information System (GIS) that combines digital maps of the area with related information, such as:~~

- ~~Property owner and registry,~~
- ~~Assessment and apportionments,~~
- ~~Property dimensions,~~
- ~~Structure locations and characteristics,~~
- ~~Topographic features including flood plains and vegetation,~~
- ~~Cultural information including zoning and Official Plan designation, and~~
- ~~Aerial photography.~~

~~For the purposes of the initial threats inventory, NAICS codes were used to determine land use activity names and potential associations with land uses that constitute threats.~~

~~Industry Canada provides business and consumer information via the internet. Their website was used to obtain business/industry profiles.~~

~~The on-line version of the yellow pages was used to locate businesses and provided links to business websites which helped determine activities undertaken by companies.~~

~~*Land Use Activity Assumptions*~~

~~A standardized set of assumptions were made for each land use type and activity. The assumptions are summarized in **Table 12-12**.~~

~~Table 12-12: Land Use Activity Assumptions~~

~~Scenario~~	**~~Assumption~~**
~~Agricultural property with residence and outbuildings~~	~~• Storage and handling of pesticides, fuel, commercial fertilizer, agricultural source material, septic system.~~ ~~• application of pesticide, commercial fertilizer, agricultural source material.~~
~~Agricultural property with residence and outbuilding – buildings not in WHPA~~	~~• Circumstances related to storage and handling or septic systems are not applied. Those related to application are applied.~~
~~Agricultural property without farm buildings and structures~~	~~• Circumstances related to storage and handling or septic systems are not applied. Those related to application are applied.~~
~~Residence with no gas line~~	~~• Oil furnace~~
~~Organic solvent~~	~~• Storage below grade in a quantity that would make it a significant threat~~
~~No sanitary sewer infrastructure~~	~~• Septic system~~
~~Presence of any chemical~~	~~• Storage is below grade~~
~~Multiple PINs associated with one Assessment Roll number~~	~~• One threat point assigned to the entire assessed property.~~
~~Where an assessment line transects a property, but has one PIN~~	~~• One threat point assigned to the entire property.~~
~~Lawn/turf~~	~~• Potential application of commercial fertilizer (ID dependent on the percent of managed land and the application of NU to the surrounding properties)~~
~~Municipal well sites~~	~~• Commercial fertilizer not applied unless the well is within a municipal park, in which case there is potential that fertilizer is applied.~~
~~All properties~~	~~• If buildings and structures are located outside the vulnerable area – circumstance IDs associated with storage and handling are not applied~~
~~Septic system~~	~~• In serviced villages where sanitary services are being phased in, but have not yet reached the mandatory connection date, it is assumed private septic systems are still present.~~
~~Sanitary sewers~~	~~• A sanitary sewer is a linear feature. For the purposes of enumeration of threats, where a sanitary sewer is present one threat point is assigned to represent the sanitary sewer in each WHPA.~~
~~Storm sewer piping~~	~~• Storm sewer piping is not consider storm sewer piping to be part of a storm water management facility.~~

~~*Enumeration of Significant Drinking Water Quality Threats for the Bright Water System*~~

~~In the case of Bright, the significant threats that were enumerated occur in WHPA-A and WHPA-B. A list of all significant threat types identified in Bright is located in~~ **~~Table 11-9Table 12-13~~** ~~below. The threats are current to the end of 2018.~~

~~Table 11-913: Significant Drinking Water Quality Threats for the Bright Water System~~

~~PDWT~~[1] ~~#~~	**~~Threat Subcategory~~[2]**	**~~Number of Activities~~**	**~~Vulnerable Area~~**

~~Table 11-913: Significant Drinking Water Quality Threats for the Bright Water System~~

~~PDWT[1] #~~	~~Threat Subcategory[2]~~	~~Number of Activities~~	~~Vulnerable Area~~
~~2~~	~~Sewage System or Sewage Works- Onsite Septic System~~	~~7~~	~~WHPA-A~~
~~3~~	~~Application of Agricultural Source Material to Land~~	~~1~~	~~WHPA-A~~
~~8~~	~~Application of Commercial Fertilizer~~	~~1~~	~~WHPA-A~~
~~10~~	~~Application of Pesticides to Land~~	~~1~~	~~WHPA-A~~
~~16~~	~~Handling and Storage of DNAPLs~~	~~1~~	~~WHPA-B~~
~~Total Number of Properties~~		**~~9~~**	
~~Total Number of Activities~~		**~~11~~**	

~~1: Prescribed Drinking Water Quality Threat Number refers to the prescribed drinking water threat listed in O.Reg 287/07 s.1.1.(1).~~

~~2: Where applicable, waste, sewage, and livestock threat numbers are reported by sub-threat; fuel and DNAPL by Prescribed Drinking Water Threat category~~

~~Certain types of activities on residential properties that are incidental in nature and that are significant drinking water threats are not enumerated. These threats include the application of commercial fertilizer on residential properties, the storage of organic solvents (dense non-aqueous phase liquids) on residential properties, and the storage of fuel (e.g., heating fuel tanks) on residential properties in natural gas serviced areas.~~

~~Note: Storm sewer piping is not considered to be part of a storm water management facility.~~

~~*Enumeration of Significant Drinking Water Quality Threats for the Drumbo Water System*~~

~~In the case of Drumbo, the significant threats that were enumerated occur in WHPA-A and WHPA-B. A list of all significant threat types identified in Drumbo is located in Table 11-10Table 12-14 below. The threats are current to the end of 2014.~~

~~Table 11-1014: Significant Drinking Water Quality Threats for the Drumbo Water System~~

~~PDWT[1] #~~	~~Threat Subcategory[2]~~	~~Number of Activities~~	~~Vulnerable Area~~
~~2~~	~~Sewage System or Sewage Works- Onsite Septic System~~	~~2~~	~~WHPA-A~~
	~~Sewage System or Sewage Works- Sanitary Sewers and related pipes~~	~~3~~	~~WHPA-A~~
	~~Sewage System Or Sewage Works - Sewage Treatment Plant Effluent Discharges (Includes Lagoons)~~	~~1~~	~~WHPA-A~~
	~~Sewage System Or Sewage Works - Storage Of Sewage (E.G. Treatment Plant Tanks)Sewage Works Storage – Treatment or Holding Tanks~~	~~1~~	~~WHPA-A~~
~~3~~	~~Application of Agricultural Source Material to Land~~	~~4~~	~~WHPA-A~~
~~8~~	~~Application of Commercial Fertilizer~~	~~4~~	~~WHPA-A~~
~~21~~	~~Management or handling of Agricultural Source Material- Agricultural Source Material (ASM) Generation~~	~~1~~	~~WHPA-A~~
~~Total Number of Properties~~		**~~8~~**	
~~Total Number of Activities~~		**~~16~~**	

~~1: Prescribed Drinking Water Quality Threat Number refers to the prescribed drinking water threat listed in O.Reg 287/07 s.1.1.(1).~~

~~**Table 11-1014: Significant Drinking Water Quality Threats for the Drumbo Water System**~~

~~PDWT[1] #~~	~~Threat Subcategory[2]~~	~~Number of Activities~~	~~Vulnerable Area~~

~~2: Where applicable, waste, sewage, and livestock threat numbers are reported by sub-threat; fuel and DNAPL by Prescribed Drinking Water Threat category~~

~~Note: The threat point representing linear feature infrastructure such as sanitary sewers was not added into the total number of properties, since this feature is not attached to one specific property.~~

~~Certain types of activities on residential properties that are incidental in nature and that are significant drinking water threats are not enumerated. These threats include the application of commercial fertilizer on residential properties, the storage of organic solvents (dense non-aqueous phase liquids) on residential properties, and the storage of fuel (e.g., heating fuel tanks) on residential properties in natural gas serviced areas.~~

~~Note: Storm sewer piping is not considered to be part of a storm water management facility.~~

~~*Enumeration of Significant Drinking Water Quality Threats for the Plattsville Water System*~~

~~In the case of Plattsville, significant threats inventoried occur in WHPA-A and WHPA-B. A list of all significant threat types identified in the Plattsville Wellhead Protection AreaWHPA can be seen in **Table 11-11Table 12-15** below. The threats are current to the end of 2014.~~

~~**Table 11-1115: Significant Drinking Water Quality Threats for the Plattsville Water System**~~

~~PDWT[1] #~~	~~Threat Subcategory[2]~~	~~Number of Activities~~	~~Vulnerable Area~~
~~1~~	~~Waste Disposal Site- Storage of wastes described in clauses (p), (q), (r), (s), (t) or (u) of the definition of hazardous waste~~	~~1~~	~~WHPA-B~~
~~2~~	~~Sewage System or Sewage Works- Sanitary Sewers and related pipes~~	~~1~~	~~WHPA-B~~
~~3~~	~~Application of Agricultural Source Material to Land~~	~~2~~	~~WHPA-A~~
~~10~~	~~Application of Pesticides to Land~~	~~1~~	~~WHPA-A~~
~~15~~	~~Handling and Storage of Fuel~~	~~3~~	~~WHPA-B~~
~~16~~	~~Handling and Storage of DNAPLs~~	~~3~~	~~WHPA-B~~
~~17~~	~~Handling and Storage of Organic Solvents~~	~~2~~	~~WHPA-B~~
~~**Total Number of Properties**~~		~~**6**~~	
~~**Total Number of Activities**~~		~~**13**~~	

~~1: Prescribed Drinking Water Quality ThreatNumber refers to the prescribed drinking water threat listed in O.Reg 287/07 s.1.1.(1).~~

~~2: Where applicable, waste, sewage, and livestock threat numbers are reported by sub-threat; fuel and DNAPL by Prescribed Drinking Water Threat category~~

~~Note: The threat point representing linear feature infrastructure such as sanitary sewers was not added into the total number of properties, since this feature is not attached to one specific property.~~

~~Certain types of activities on residential properties that are incidental in nature and that are significant drinking water threats are not enumerated. These threats include the application of commercial fertilizer on residential properties, the storage of organic solvents (dense non-aqueous phase liquids) on residential properties, and the storage of fuel (e.g., heating fuel tanks) on residential properties in natural gas serviced areas.~~

~~Note: Storm sewer piping is not considered to be part of a storm water management facility.~~

~~*Uncertainty and Limitations in the Enumeration of Significant Drinking Water Quality Threats*~~

~~There was a general lack of information on the presence/absence of contamination associated with historical land uses. As a result, no condition-related drinking water threats (if present) were identified. In addition, the type and amount of chemicals stored at the commercial and industrial operations within the wellhead protection areas is unknown. Further, for other land use types, the types and amounts of potential contaminants often had to be assumed based on the land use practice. Where assumptions had to be made, often a worst case scenario approach was taken and circumstance values were assigned based on that assumption so significant threats would be flagged for follow-up.~~

~~In terms of data limitations, the most problematic dataset was septic systems. The records maintained by the County Board of Health lack accurate locational information. The sanitary sewer infrastructure layer was used to determine which properties were serviced by municipal services. Using this method, there remained instances where service connection was questionable. At present County Public Works has not yet digitized all of the sanitary sewer infrastructure in the County, although this is a work in progress.~~

~~For the impervious surface dataset, digitizing was completed by both Oxford County and the Lower Thames River Conservation Authority (LTRCA). Heads-up digitizing from two different sources could introduce error when identifying impervious surfaces in Oxford County. Also, each organization may have access to different supplementary data sets to complete the analysis. Since the County has access to more current roads data, road centre lines were buffered to average road widths to create the initial impervious surface layer. Edits were then made to ensure the roadways were accurately represented and to add in sidewalks, driveways and parking lots. Human error may have occurred while digitizing the impervious surfaces.~~

~~Since there is no agricultural census information available to the County at the property scale, reasonable assumptions about the type of livestock housed in a farm structure were based on the best available information. This information ranged from local knowledge of County and municipal staff to land use information recorded in various County records. Where this information was unavailable, air photo interpretation was used to determine barn type, and therefore, livestock type. Air photo interpretation and the use of GIS for area calculations could be considered limitations to the work, since the resulting shapefiles are representations and not 100 percent accurate. This limitation also applies to the layer extraction step when delineating managed lands. Certain structures, in particular residential dwellings, do not necessarily reflect actual foot prints of the structures. However, manual edits to the shapefile were completed for larger layers if deemed necessary through air photo interpretation.~~

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12.0 COUNTY OF OXFORD

The following County of Oxford Source Protection Plan policies apply to the following Well Systems as presented in Schedule A, B and C within the Grand River Watershed. Reference should be made to the Long Point Region, Catfish Creek and Thames Sydenham & Region Source Protection Plans for Source Protection Policies that would apply outside of the Grand River watershed.

- Schedule A: County of Oxford, Bright Water System
- Schedule B: County of Oxford, Drumbo-Princeton Water System
- Schedule C: County of Oxford, Plattsville Water System

12.1 Definitions

General definitions are provided in Volume I of the Source Protection Plan or in the *Clean Water Act, 2006.* Defined terms are intended to capture both the singular and plural forms of these terms.

The following definitions shall apply to the County of Oxford Source Protection policies.

Area Municipality – means one or more of the eight lower tier municipalities located within the County of Oxford, consisting of the City of Woodstock, Town of Tillsonburg, Town of Ingersoll and Townships of Blandford-Blenheim, East Zorra-Tavistock, Norwich, Southwest-Oxford and Zorra.

County – means the County of Oxford.

Existing – means undertaken or established as of the date the Source Protection Plan takes effect, or at some point prior to the date the Source Protection Plan takes effect with a demonstrated intent to continue.

New or Future – means not existing, as defined herein.

12.2 County of Oxford Source Protection Plan Policies

Policy Number	Source Protection Plan Policies within the County of Oxford
Transitional Policies and Implementation Timing	
OC-CW-1.1 *Implement. & Timing*	Except as set out below or as otherwise prescribed by Section 57 or 58 of the *Clean Water Act*, 2006 the policies contained in this Source Protection Plan shall come into effect on the date set by the Minister. a. For Section 57 of the *Clean Water Act,* 2006 if an activity was engaged in a particular location before this Source Protection Plan takes effect, policies regarding prohibited activities do not apply to a person who engages in the *activity* at that location until 180 days from the date the Source Protection Plan takes effect; b. For Section 58 of the *Clean Water Act*, 2006 if an activity was engaged in at a particular location before this Source Protection Plan takes effect and the Risk Management Official gives notice to a person who is engaged in the activity at that location that, in the opinion of the Risk Management Official, policies regarding regulated activities should apply to the person who engages in the activity at that location on and after a date specified in the notice that is at least 120 days after the date notice is given;

Policy Number	Source Protection Plan Policies within the County of Oxford
	c. For Section 59 of the *Clean Water Act*, 2006 restricted land use policies shall come into effect on the day the Source Protection Plan takes effect; d. For Section 43 of the *Clean Water Act*, 2006 if an activity was engaged in a particular location before this Source Protection Plan takes effect, amendments to Prescribed Instruments shall be completed within three (3) years from the date the Source Protection Plan takes effect; e. For Section 40 and 42 of the *Clean Water Act*, 2006 the amendments to the Official Plan required to conform with the significant threat policies shall be adopted by the *County* within five (5) years of the effective date of the Source Protection Plan. The amendments to the Zoning By-Laws required to conform with the significant threat policies in this Source Protection Plan shall be adopted by the Area Municipalities within three (3) years of the effective date of the above noted amendments to the Official Plan; and f. Where the Source Protection Policies require the development of education and outreach programs as the primary tool for managing or eliminating a particular significant threat, such programs shall be developed and implemented within five (5) years from the date the Source Protection Plan takes effect.
OC-CW-1.2 *Transition*	a) Notwithstanding the definition of existing, where development is being proposed by one or more of the following applications: a. A site specific amendment to a zoning by-law under subsection 34(10) of the *Planning Act*; b. A site plan under subsection 41(4) of the *Planning Act*; or c. A building permit under the *Building Code Act*, a significant drinking water threat activity that is to be established as part of the proposed development may be considered existing for the purposes of complying with the applicable significant drinking water threat policies, provided that: i. The application was deemed to be complete by the applicable approval authority as of the date this Source Protection Plan takes effect; and ii. The applicant has certified to the satisfaction of the implementing body named in the applicable significant drinking water threat policy that a particular significant drinking water threat activity is to be undertaken as part of the proposed development. Where further development approvals are required to establish the development and related significant drinking water threat activity proposed by such application, that activity may also be considered as existing for the purposes of determining whether those subsequent approvals comply with the applicable significant drinking water threat policies. The above noted transition provisions shall cease to apply where any of the approvals or applications required to implement the proposed development have been denied by the applicable approval authority and, where applicable, the relevant appeal body, or have lapsed or been withdrawn b) Notwithstanding the definition of existing, where a significant drinking water threat activity is directly related to a land use permitted by existing zoning and does not require any approvals under the *Planning Act* or Ontario *Building Code Act* to be lawfully established on a property, such

<table>
<tr><th>Policy Number</th><th>Source Protection Plan Policies within the County of Oxford</th></tr>
<tr><td></td><td>activity shall be considered existing for the purposes of compliance with the applicable significant drinking water threat policies. This provision shall cease to apply at such time as a Risk Management Inspector has conducted a property specific assessment and documented the significant drinking water threat activities that are undertaken or established on a property as of that point in time, following which any significant drinking water threat activity not so documented shall be considered new or future.

c) Notwithstanding the definition of existing, where a significant drinking water threat activity is being proposed by way of a new or amended Prescribed Instrument, it shall be considered existing for the purposes of complying with the applicable significant drinking water threat policies provided that the application for the new or amended Prescribed Instrument was deemed to be complete by the applicable approval authority as of the date this Source Protection Plan takes effect.</td></tr>
<tr><td colspan="2">Uses and Areas Designated as Restricted Land Uses</td></tr>
<tr><td>OC-CW-1.3

<i>Part IV- RLU</i></td><td>In accordance with Section 59 of the <i>Clean Water Act</i>, 2006 all land uses identified within the County Official Plan and/or Area Municipal Zoning By-Laws, with the exception of residential uses, that are located within an area where sections 57 and/or 58 of the <i>Clean Water Act,</i> 2006 applies (Well Head Protection Areas (WHPA) A, B or C), are hereby designated for the purposes of section 59 (Restricted Land Uses). Within these designated land use categories and areas, a notice from the Risk Management Official in accordance with section 59(2) of the <i>Clean Water Act,</i> 2006 shall be required prior to approval of any <i>Planning Act</i> or Building Permit application.

Despite the above policy, a Risk Management Official may issue written direction specifying the situations under which a planning authority or building official may be permitted to make the determination that a site specific land use is not designated for the purposes of section 59. Where such direction has been issued, a site specific land use that is the subject of an application for approval under the <i>Planning Act</i> or for a permit under the <i>Building Code Act</i> is not designated for the purposes of Section 59, provided that the planning authority or building official, as applicable, is satisfied that:
a. the application complies with the written direction issued by the Risk Management Official; and
b. the applicant has demonstrated that a significant drinking water threat activity designated for the purposes of section 57 or 58 will not be engaged in, or will not be affected by the application.</td></tr>
<tr><td colspan="2">Official Plan and Zoning By-law Amendment(s) Policies</td></tr>
<tr><td>OC-MC-1.4

<i>Future Land Use Planning</i></td><td>The County shall amend the Official Plan and the Area Municipalities shall amend their respective Zoning By-Laws to:
a. Identify the WHPAs in which a significant drinking water threat could occur;
b. Indicate that within the areas identified, any use or activity that is, or would be, a significant drinking water threat is required to conform with all applicable Source Protection Plan policies and, as such, may be prohibited, restricted or otherwise regulated by these policies in the Source Protection Plan;
c. Identify the significant drinking water threats that are prohibited through Prescribed Instruments, or Section 57 of the <i>Clean Water Act, 2006</i> in accordance with the significant drinking water threat specific policies contained in this Source Protection Plan;</td></tr>
</table>

Policy Number	Source Protection Plan Policies within the County of Oxford
	d. Incorporate any other amendments required to conform with the significant drinking water threat specific land use policies identified in this Source Protection Plan.; and e. Incorporate a cross-reference indicating a planning application cannot be made unless it includes a notice issues by the Risk Management Official as set out in Section 59(1) of the Clean Water Act, 2006 and Section 62 of O. Reg. 287/07.
Education and Outreach Programs	
OC-CW-1.5 *Existing/Future Education & Outreach*	The County, in collaboration with Conservation Authorities and other bodies wherever possible, may develop and implement education and outreach programs directed at any, or all, significant drinking water threats, where such programs are deemed necessary and/or appropriate by the County and subject to available funding. Such programs may include, but not necessarily be limited to, increasing awareness and understanding of significant drinking water threats and promotion of best management practices.
Incentive Programs	
OC-CW-1.6 *Existing/Future Incentive*	The County, in collaboration with the Ministry of the Environment, Conservation and Parks ~~and Climate Change~~, Conservation Authorities and other bodies wherever possible, may develop and implement incentive programs directed at various significant drinking water threats, where such programs are deemed necessary and/or appropriate by the County and subject to available funding.
OC-NB-1.7 *Existing/Future Incentive*	The Ministry of the Environment, Conservation and Parks ~~and Climate Change~~ and other provincial ministries shall consider providing, continued funding and support for incentive programs, such as the Ontario Drinking Water Stewardship Program, to assist in protecting existing and future drinking water sources and addressing significant drinking water threats.
Annual Reporting	
OC-CW-1.8 *Monitoring*	The County shall provide a report to the Source Protection Authority, by February 1st of each year, summarizing the actions taken by the County to implement the Source Protection Plan policies, where specifically required by the policies and not forming part of the report from the Risk Management Official required under OC-CW-1.10. Where the County is required to implement education and outreach programs as the primary means of managing the risk associated with significant drinking water threats, the County shall provide a report to the Source Protection Authority. This report must indicate, at a minimum, the properties where these programs were implemented and additional details on how the significant drinking water threat was managed and/or ceased to be significant.
OC-CW-1.9 *Monitoring*	Where this Source Protection Plan requires the County or Area Municipality to amend their Official Plan and/or Zoning By-law and provide confirmation of such amendments to the Source Protection Authority, they shall provide a copy of such compliance within 30 days of adoption of the amendment(s) by County and/or Area Municipal Council or, where the matter has been appealed to the Ontario Municipal Board, the date of their decision to approve.
OC-CW-1.10 *Monitoring*	The Risk Management Official shall provide a report to the Source Protection Authority, by February 1st of each year, summarizing the actions taken by the Risk Management Official to implement the Source Protection Plan policies, in

Policy Number	Source Protection Plan Policies within the County of Oxford
	accordance with the *Clean Water Act*, 2006 and associated regulations.
OC-CW-1.11 *Monitoring*	Where the Source Protection Plan policies may result in amendments to a Prescribed Instrument or the issuance of a new Prescribed Instrument, the applicable Ministry shall summarize the actions taken the previous year to implement the policies and provide a written report summarizing this information to the Source Protection Authority and the County by February 1st of each year.
OC-CW-1.12 *Monitoring*	Where the Source Protection Plan policies prohibit an activity through the use of a Prescribed Instrument, the applicable Ministry shall summarize the actions taken the previous year to implement the policies and provide a written report summarizing this information to the Source Protection Authority and the County by February 1st of each year.
~~Local Threat: The Conveyance of Oil by way of Underground Pipelines~~	
~~OC-NB-1.13~~ *~~Future~~* *~~Specify Action~~* *~~WHPA-A-v.10;~~* *~~WHPA-B-v.10~~* *~~Monitoring~~*	~~To reduce the risks to municipal drinking water sources due to the conveyance of oil by way of underground pipeline within the meaning of O. Reg. 210/01 under the *Technical Safety and Standards Act* or that is subject to the *National Energy Board Act* within a WHPA-A and WHPA-B with a vulnerability score of 10, the National Energy Board, Ontario Energy Board and the pipeline proponent shall provide the Source Protection Authority and the County with the location of any new pipelines proposed within the Source Protection Region.~~ ~~The Source Protection Authority shall document in the annual report the number of new pipelines proposed within WHPAs, where they would be a significant drinking water threat.~~
Environmental Compliance Approvals and Consultation with Oxford County	
OC-NB-1.14 *Existing/Future* *Specify Action*	The Ministry of Environment and Climate Change should, collaboratively with the County develop a consultation process related to document sharing and consultation on the issuance and/or notification of Prescribed Instruments, which could be used to guide information exchange between the two agencies to protect municipal drinking water sources.
Strategic Action	
Spill Prevention, Spill Contingency or Emergency Response Plans	
OC-NB-1.15 *Existing/Future* *Specify Action*	To ensure spill prevention plans, contingency plans, and emergency response plans are updated for the purpose of protecting municipal drinking water sources with respect to spills that occur within a WHPA along highways, or railway lines, a. The County is requested to incorporate the location of WHPAs into their emergency response plans in order to protect municipal drinking water sources when a spill occurs along highways or rail lines. b. The Ministry of the Environment, Conservation and Parks ~~and Climate Change~~ is requested to provide mapping of the identified vulnerable areas to the Spills Action Centre to assist them in responding to reported spills along transportation corridors.
Transport Pathways	
OC-NB-1.16 *Existing/Future* *Specify Action*	The Ministry of Environment and Climate Change should consider providing sufficient staff and financial resources to ensure the effective implementation of ongoing programs to decommission abandoned water wells, in accordance with O. Reg. 903 of the *Ontario Water Resources Act*.

Policy Number	Source Protection Plan Policies within the County of Oxford
Interpretation	
OC-CW-1.17 *Interpretation of Source Protection Plan*	The Source Protection Plan provides policies to meet the objectives of the *Clean Water Act, 2006*. The Source Protection Plan consists of the written policy text and Schedules. a. The Schedules in the Source Protection Plan identify the areas where the policies of the Source Protection Plan apply. The boundaries for the circumstances shown on the Plan Schedules are general. More detailed interpretation of the boundaries relies on the mapping in the approved Assessment Report and the Specific Circumstances found in the Tables of Drinking Water Threats, *Clean Water Act, 2006*. b. Where any Act or portion of an Act of the Ontario Government or Canadian Government is referenced in this Plan, such reference shall be interpreted to refer to any subsequent renaming of sections in the Act as well as any subsequent amendments to the Act, or successor thereof. This provision is also applicable to any policy statement, regulation or guideline issued by the Province or the municipality.
Prescribed Instruments Issued Under the Nutrient Management Act	
OC-MC-1.18 *Existing/Future Prescribed Instrument*	Any Prescribed Instrument issued under the *Nutrient Management Act* that is created or amended or is used for the purposes of obtaining an exemption from a Risk Management Plan under section 61 of O. Reg. 287/07 shall incorporate terms and conditions that, when implemented, manage the activities they regulate such that those activities cease to be or never become, a significant drinking water threat. The Ministry of Agriculture, Food and Rural Affairs is expected to review all Prescribed Instruments issued under the *Nutrient Management Act* in areas where the activities they regulate are, or would be, significant drinking water threats to ensure the Prescribed Instruments contain such terms and conditions, including the Prescribed Instruments that are not directly created or issued by the Ministry of Agriculture, Food and Rural Affairs, such as Nutrient Management Plans.
OC-NB-1.19 *Existing/Future Specify Action*	The Ministry of Agriculture, Food and Rural Affairs, and other creators/issuers of Prescribed Instruments under the *Nutrient Management Act*, are expected to consult with the Risk Management Official with respect to any modifications or requirements that may need to be incorporated into such Prescribed Instruments to ensure the activities they regulate cease to be or never become significant drinking water threats.

12.3 Policies Addressing Prescribed Drinking Water Threats

Policy Number	Policies Addressing Prescribed Drinking Water Threats within the County of Oxford
1. Establishment, Operation or Maintenance of a Waste Disposal Site, within the Meaning of Part V of the *Environmental Protection Act*	
OC-MC-2.1 *Existing Prescribed Instr. WHPA-A v.10; WHPA-B- v.10; WHPA-B- v.8; WHPA-C- v.8*	For any existing waste disposal site within the meaning of Part V of the *Environmental Protection Act* that is subject to an Environmental Compliance Approval, where this activity is a significant drinking water threat, the Ministry of the Environment, Conservation and Parks ~~and Climate Change~~ shall review, and where necessary, amend Environmental Compliance Approvals to incorporate terms and conditions that, when implemented, ensure the activity ceases to be a significant drinking water threat.

Policy Number	**Policies Addressing Prescribed Drinking Water Threats within the County of Oxford**
OC-CW-2.2 *Existing* *Part IV-RMP* *WHPA-A- v.10;* *WHPA-B- v.10;* *WHPA-B- v.8;* *WHPA-C- v.8;*	For any existing waste disposal site, or aspect thereof, within the meaning of Part V of the *Environmental Protection Act* that is not subject to an Environmental Compliance Approval, where this activity is a significant drinking water threat, it shall be designated for the purpose of Section 58 of the *Clean Water Act,* 2006 and a Risk Management Plan shall be required to ensure the activity ceases to be a significant drinking water threat.
OC-MC-2.3 *Future* *Prescribed Instr.* *WHPA-A- v.10;* *WHPA-B- v.10;* *WHPA-B- v.8;* *WHPA-C- v.8*	For any new waste disposal site within the meaning of Part V of the *Environmental Protection Act* that requires an Environmental Compliance Approval*,* where this activity would be a significant drinking water threat, the Ministry of the Environment, Conservation and Parks ~~and Climate Change~~ shall prohibit this activity through the Environmental Compliance Approvals process to ensure the activity never becomes a significant drinking water threat.
OC-CW-2.4 *Future* *Part IV- Prohibit* *WHPA-A- v.10;* *WHPA-B- v.10;* *WHPA-B- v. 8;* *WHPA-C- v.8*	With the exception of the following waste disposal site threat subcategories: a. storage of wastes described in clauses (p), (q), (r), (s), (t), or (u) of the definition of hazardous waste, or in clause (d) of the definition of liquid industrial waste; or b. storage of hazardous or liquid industrial waste, where any new waste disposal site, or aspect thereof, within the meaning of Part V of the *Environmental Protection Act,* that does not require an Environmental Compliance Approval, would be a significant drinking water threat, it shall be designated for the purpose of Section 57 of the *Clean Water Act* and shall be prohibited so that it never becomes a significant drinking water threat.
OC-CW-2.5 *Future* *Part IV- RMP* *WHPA-A- v.10;* *WHPA-B- v.10;* *WHPA-B- v. 8;* *WHPA-C- v.8*	Where a new waste disposal site, or aspect thereof, within the meaning of Part V of the *Environmental Protection Act* does not does not require an Environmental Compliance Approval and comprises one of the following waste disposal site threat subcategories: a. storage of wastes described in clauses (p), (q), (r), (s), (t), or (u) of the definition of hazardous waste, or in clause (d) of the definition of liquid industrial waste; or b. storage of hazardous or liquid industrial waste, and where such waste disposal site would be a significant drinking water threat, it shall be designated for the purpose of Section 58 of the *Clean Water Act* and a Risk Management Plan shall be required to manage the activity such that it never becomes a significant drinking water threat. The requirements of the Risk Management Plan may be based on Ministry of the Environment, Conservation and Parks ~~and Climate Change~~ tools and requirements for such activities, as set out in the *Environmental Protection Act*, but may also include any modifications or additional requirements that are deemed necessary or appropriate by the Risk Management Official.
2. Establishment, Operation or Maintenance of a System That Collects, Stores, Transmits, Treats or Disposes of Sewage	
Sewage System or Sewage Works – Onsite Sewage~~Septic~~ System Sewage System or Sewage Works – ~~and~~ Onsite Sewage~~ptic~~ System Holding Tanks	
OC-CW-3.1	For any existing onsite sewage~~ptic~~ system or onsite sewage~~ptic~~ system holding

Policy Number	**Policies Addressing Prescribed Drinking Water Threats within the County of Oxford**
Existing/Future *Specify Action* *WHPA-A- v.10;* *WHPA-B- v.10*	tank regulated under the *Ontario Building Code Act*, including expansions, modifications or replacements of such systems, where this activity is a significant drinking water threat, or for any new onsite sewage~~ptic~~ system or onsite sewage~~ptic~~ system holding tank regulated under the *Ontario Building Code Act* that is required for a municipal water supply well, where this activity would be a significant drinking water threat, the County shall implement an on~~-~~site sewage~~ptic~~ system maintenance inspection program, as required by the *Ontario Building Code Act,* to ensure these activities cease to be or never become significant drinking water threats.
OC-MC-3.2 *Future* *Land Use Planning* *WHPA-A- v.10;* *WHPA-B- v.10*	For a new onsite sewage~~septic~~ system or onsite sewage~~ptic~~ system holding tank, with the exception of a new onsite sewage~~ptic~~ system or onsite sewage~~ptic~~ system holding tank regulated under the *Ontario Building Code Act* that is required for a municipal water supply well, where these activities would be significant drinking water threats, the Area Municipalities shall amend their respective Zoning By-laws to prohibit uses, buildings and/or structures that would require a new onsite sewage~~ptic~~ system or onsite sewage~~septic~~ system holding tank to be located within such areas, to ensure these activities never become significant drinking water threats.
OC-MC-3.3 *Existing* *Prescribed Instr.* *WHPA-A- v.10;* *WHPA-B- v.10*	For an existing onsite sewage~~ptic~~ system or onsite sewage~~ptic~~ system holding tank subject to an Environmental Compliance Approval in accordance with the *Ontario Water Resources Act*, where these activities are significant drinking water threats, the Ministry of the Environment, Conservation and Parks~~ and Climate Change~~ shall review, and where necessary, amend Environmental Compliance Approvals, to incorporate terms and conditions that, when implemented, ensure these activities cease to be significant drinking water threats. The terms and conditions should include, but not necessarily be limited to, requirements for the proponent/applicant to undertake mandatory monitoring of groundwater impacts, contingencies in the event that drinking water quality is adversely affected, regular and ongoing compliance monitoring, mandatory system inspections at least every five (5) years, annual reporting to the Source Protection Authority and the County on any required inspection or monitoring programs and upgrading of these onsite sewage~~septic~~ systems to current standards, where necessary.
OC-MC-3.4 *Future* *Prescribed Instr.* *WHPA-A- v.10;* *WHPA-B- v.10*	For a new onsite sewage~~ptic~~ system or onsite sewage~~ptic~~ system holding tank requiring an Environmental Compliance Approval, in accordance with the *Ontario Water Resources Act*, where these activities would be significant drinking water threats, the Ministry of the Environment. Conservation and Parks~~ and Climate Change~~ shall prohibit these activities through the Environmental Compliance Approvals process to ensure these activities never become significant drinking water threats.
Sewage System or Sewage Works- Sewage Works Storage -~~ of Sewage (e.g.,~~T~~ t~~reatment or Holding~~plant~~ T~~t~~anks~~)~~ Sewage System or Sewage Works- Sewage Treatment Plant Effluent Discharges	
OC-MC-3.5 *Existing* *Prescribed Instr.* *WHPA-A- v.10;* *WHPA-B- v.10*	For any existing sewage treatment plant effluent discharges or storage of sewage, where these activities are significant drinking water threats, the Ministry of the Environment, Conservation and Parks~~ and Climate Change~~ shall review, and where necessary, amend Environmental Compliance Approvals to incorporate terms and conditions that, when implemented, ensure these activities cease to be significant

Policy Number	Policies Addressing Prescribed Drinking Water Threats within the County of Oxford
WHPA-B-v.8; *WHPA-C-v.8*	drinking water threats.
OC-MC-3.6 *Future* *Prescribed Instr.* *WHPA-A- v.10;* *WHPA-B- v.10* *WHPA-B-v.8;* *WHPA-C-v.8*	For any new sewage treatment plant effluent discharge or storage of sewage, where these activities would be significant drinking water threats, the Ministry of the Environment, Conservation and Parks ~~and Climate Change~~ shall prohibit these activities through the Environmental Compliance Approvals process to ensure these activities never become significant drinking water threats.
Sewage System or Sewage Works – Sanitary Sewers and Related Pipes	
OC-MC-3.7 *Existing/Future* *Prescribed Instr.* *WHPA-A- v.10;* *WHPA-B- v.10*	For any existing or new sanitary sewer and related pipes, where this activity is, or would be a significant drinking water threat, the Ministry of the Environment, Conservation and Parks ~~and Climate Change~~ shall ensure that the Environmental Compliance Approval for this activity is prepared, or, where necessary, amended to incorporate terms and conditions that, when implemented ensure this activity ceases to be or will never become a significant drinking water threat. The terms and conditions may include, but not necessarily be limited to, requirements for regular maintenance and inspections by the holder of the Environmental Compliance Approval.
Sewage System or Sewage Works – Discharge ~~of Stormwater~~ from a Stormwater Management Facility	
OC-MC-3.8 *Existing* *Prescribed Instr.* *WHPA-A- v.10;* *WHPA-B- v.10*	For any existing stormwater management facility that discharges stormwater, where this activity is a significant drinking water threat, the Ministry of the Environment, Conservation and Parks ~~and Climate Change~~ shall review and, if necessary, amend Environmental Compliance Approvals to incorporate terms and conditions that, when implemented, will ensure this activity ceases to be a significant drinking water threat.
OC-MC-3.9 *Future* *Prescribed Instr.* *WHPA-A- v.10;* *WHPA-B- v.10*	For any new stormwater management facility that would discharge stormwater where this activity would be a significant drinking water threat, the Ministry of the Environment, Conservation and Parks ~~and Climate Change~~ shall prohibit this activity through the Environmental Compliance Approvals process to ensure this activity never becomes a significant drinking water threat.
3. The Application of Agricultural Source Material	
OC-CW-4.1 *Existing/Future* *Part IV-Prohibit* *WHPA-A-v.10*	For any new or existing application of agricultural source material to land within a WHPA-A, where this activity is, or would be, a significant drinking water threat, it shall be designated for the purpose of Section 57 of the *Clean Water Act, 2006* and shall be prohibited to ensure this activity ceases to be or never becomes a significant drinking water threat.
OC-CW-4.2 *Existing/Future* *Part IV-RMP* *WHPA-B-v.10*	For any new or existing application of agricultural source material to land outside of a WHPA-A, where this activity is, or would be, a significant drinking water threat, it shall be designated for the purpose of Section 58 of the *Clean Water Act,* 2006 and a *Risk Management Plan* shall be required to ensure this activity ceases to be or never becomes a significant drinking water threat. The requirements of the Risk Management Plan will generally be based on the requirements of a Nutrient Management Plan and/or Strategy under the *Nutrient Management Act*, but may also include any modifications or additional requirements deemed necessary or appropriate by the Risk Management Official. However,

Policy Number	Policies Addressing Prescribed Drinking Water Threats within the County of Oxford
	nothing in this policy grants the Risk Management Official the authority to specify requirements for a Prescribed Instrument issued under the *Nutrient Management Act*, or where a person is seeking an exemption from a Risk Management Plan under section 61 of O. Reg 287/07.
4. The Storage of Agricultural Source Material	
OC-CW-5.1 *Future* *Part IV-Prohibit* *WHPA-A- v.10;* *WHPA-B- v.10*	For any new storage of agricultural source material, where this activity would be a significant drinking water threat, it shall be designated for the purpose of Section 57 of the *Clean Water Act, 2006* and shall be prohibited to ensure this activity never becomes a significant drinking water threat.
OC-CW-5.2 *Existing* *Part IV-RMP* *WHPA-A- v.10;* *WHPA-B- v.10*	For any existing storage of agricultural source material, where this activity is a significant drinking water threat, it shall be designated for the purpose of Section 58 of the *Clean Water Act, 2006* and a Risk Management Plan shall be required to ensure this activity ceases to be a significant drinking water threat. The requirements of the Risk Management Plan will generally be based on the requirements of a Nutrient Management Plan and/or Strategy under the *Nutrient Management Act*, but may also include any modifications or additional requirements deemed necessary or appropriate by the Risk Management Official. However, nothing in this policy grants the Risk Management Official the authority to specify requirements for a Prescribed Instrument issued under the *Nutrient Management Act*, or where a person is seeking an exemption from a Risk Management Plan under section 61 of O. Reg 287/07.
6. The Application of Non-Agricultural Source Material (NASM)	
OC-MC-6.1 *Existing/Future* *Prescribed Instr.* *WHPA-A- v.10;* *WHPA-B- v.10* *In the Platsville well system policy only applies to the application of NASM from a meat plant or sewage works*	For any existing or future application of non-agricultural source material to land where this activity is, or would be, a significant drinking water threat, the Ministry of Agriculture, Food and Rural Affairs or the Ministry of the Environment, Conservation and Parks ~~and Climate Change~~, as applicable, shall prohibit this activity through the Non-Agricultural Source Material (NASM) Plan process, in accordance with the *Nutrient Management Act,* or through the Environmental Compliance Approval process, in accordance with the *Environmental Protection Act*, to ensure this activity ceases to be or never becomes a significant drinking water threat.
7. The Handling and Storage of Non-Agricultural Source Material (NASM)	
OC-MC-7.1 *Existing* *Prescribed Instr.* *WHPA-A- v.10;* *WHPA-B- v.10*	For any existing facility for the handling and storage of non-agricultural source material where this activity is a significant drinking water threat, the Ministry of Agriculture, Food and Rural Affairs, or Ministry of the Environment, Conservation and Parks ~~and Climate Change~~, as applicable, shall review, and if necessary, amend the required Non-Agricultural Source Material (NASM) Plan, in accordance with the *Nutrient Management Act*, or Environmental Compliance Approval, in accordance with the *Environmental Protection Act*, to ensure such Plans/Compliance Approvals incorporate terms and conditions that, when implemented, ensure this activity ceases to be a significant drinking water threat.
OC-MC-7.2 *Future* *Prescribed Instr.* *WHPA-A- v.10;*	For any new handling and storage of non-agricultural source material, where this activity would be a significant drinking water threat, the Ministry of Agriculture, Food and Rural Affairs or Ministry of the Environment, Conservation and Parks ~~or Climate Change~~, as applicable, shall prohibit this activity through the Non-Agricultural

Policy Number	Policies Addressing Prescribed Drinking Water Threats within the County of Oxford
WHPA-B- v.10	Source Material (NASM) Plan process in accordance with the *Nutrient Management Act*, or through the Environmental Compliance Approval process in accordance with the *Environmental Protection Act*, to ensure this activity never becomes a significant drinking water threat.
8. The Application of Commercial Fertilizer to Land	
OC-CW-8.1 *Existing/Future Part IV-RMP WHPA-A- v.10; WHPA-B- v.10* *Currently does not apply to the application of commercial fertilizer in the Plattsville well system due to managed land and livestock density calculations*	For the existing or future application of commercial fertilizer to land, on properties zoned for any other use than residential, where this activity is, or would be, a significant drinking water threat, it shall be designated for the purpose of Section 58 of the *Clean Water Act, 2006* and a Risk Management Plan shall be required to ensure this activity ceases to be or never becomes a significant drinking water threat.
OC-CW-8.2 *Existing/Future Education & Outreach WHPA-A- v.10; WHPA-B- v.10* *Currently does not apply to the application of commercial fertilizer in the Plattsville well system due to managed land and livestock density calculations*	For the existing or future application of commercial fertilizer to land, on properties zoned as residential in the Area Municipal Zoning By- Laws, where this activity is, or would be, a significant drinking water threat, The County, in collaboration with the Source Protection Authority, Area Municipalities, the Ministry of the Environment, Conservation and Parks~~ and Climate Change~~, and/or other bodies wherever possible, shall develop and implement an education and outreach program directed at the owners and/or occupants of such properties to ensure this activity ceases to be or never becomes a significant drinking water threat. The program may include, but not necessarily be limited to, the provision of education material and information about the nature of the threat and how commercial fertilizer can be applied appropriately.
9. The Handling and Storage of Commercial Fertilizer	
OC-CW-9.1 *Existing Part IV-RMP WHPA-A- v.10; WHPA-B- v.10*	For any existing handling and storage of commercial fertilizer, where this activity is a significant drinking water threat, it shall be designated for the purpose of Section 58 of the *Clean Water Act, 2006* and a Risk Management Plan shall be required to ensure this activity ceases to be a significant drinking water threat.
OC-CW-9.2 *Future Part IV-Prohibit WHPA-A- v.10; WHPA-B- v.10*	For any new handling and storage of commercial fertilizer, where this activity would be a significant drinking water threat, it shall be designated for the purpose of Section 57 of the *Clean Water Act, 2006* and shall be prohibited to ensure this activity never becomes a significant drinking water threat.
10. The Application of Pesticides	
OC-CW-10.1 *Existing/ Future Part IV-RMP WHPA-A- v.10; WHPA-B- v.10*	For the existing or future application of pesticide to land where this activity is, or would be, a significant drinking water threat, it shall be designated for the purpose of Section 58 of the *Clean Water Act, 2006* and a Risk Management Plan shall be required to ensure this activity ceases to be or never becomes a significant drinking water threat.
11. The Handling and Storage of Pesticides	

Policy Number	Policies Addressing Prescribed Drinking Water Threats within the County of Oxford
OC-CW-11.1 *Existing* *Part IV-RMP* *WHPA-A- v.10;* *WHPA-B- v.10*	For any existing facility for the handling and storage of pesticides where this activity is a significant drinking water threat, it shall be designated for the purpose of Section 58 of the *Clean Water Act, 2006* and a Risk Management Plan shall be required to ensure this activity ceases to be a significant drinking water threat.
OC-CW-11.2 *Future* *Part IV-Prohibit* *WHPA-A- v.10;* *WHPA-B- v.10*	For any new handling and storage of pesticide, where the total mass of all materials stored that contain a pesticide prescribed under the *Clean Water Act, 2006*, in any form, including liquid or solid, is more than 2500 Kilograms, and where this activity would be a significant drinking water threat, this activity shall be designated for the purpose of Section 57 of the *Clean Water Act, 2006* and shall be prohibited to ensure this activity never becomes a significant drinking water threat.
OC-CW-11.3 *Future* *Part IV-RMP* *WHPA-A- v.10;* *WHPA-B- v.10*	For any new handling and storage of pesticide threat circumstances not addressed by policy OC-CW-11.2, where this activity would be a significant drinking water threat, it shall be designated for the purpose of Section 58 of the *Clean Water Act, 2006* and a Risk Management Plan shall be required to ensure this activity never becomes a significant drinking water threat.
13. The Handling and Storage of Road Salt	
OC-CW-12.1 *Existing/Future* *Part IV-Prohibit* *WHPA-A- v.10;* *WHPA-B- v.10*	For any existing or new handling and storage of road salt, where this activity is, or would be, a significant drinking water threat, it shall be designated for the purpose of Section 57 of the *Clean Water Act, 2006* and shall be prohibited to ensure this activity ceases to be or never becomes a significant drinking water threat.
14. The Storage of Snow	
OC-CW-13.1 *Existing* *Part IV-RMP* *WHPA-A- v.10;* *WHPA-B- v.10*	For any existing storage of snow, where this activity is a significant drinking water threat, it shall be designated for the purpose of Section 58 of the *Clean Water Act, 2006* and a Risk Management Plan shall be required to ensure this activity ceases to be a significant drinking water threat.
OC-CW-13.2 *Future* *Part IV-Prohibit* *WHPA-A- v.10;* *WHPA-B- v.10*	For any new storage of snow, where this activity would be a significant drinking water threat, it shall be designated for the purpose of Section 57 of the *Clean Water Act, 2006* and shall be prohibited to ensure this activity never becomes a significant drinking water threat.
15. The Handling and Storage of Fuel	
OC-CW-14.1 *Existing* *Part IV-RMP* *WHPA-A- v.10;* *WHPA-B- v.10*	For existing handling and storage of fuel, where this activity is a significant drinking water threat, it shall be designated for the purpose of Section 58 of the *Clean Water Act, 2006* and a Risk Management Plan shall be required to ensure this activity ceases to be a significant drinking water threat.
OC-CW-14.2 *Future* *a)Part IV-Prohibit* *WHPA-A- v.10;* *WHPA-B- v.10* *b)Part IV- RMP* *WHPA-A- v.10;* *WHPA-B- v.10*	For new handling and storage of fuel, where this activity would be a significant drinking water threat, a. This activity shall be designated for the purpose of Section 57 of the *Clean Water Act, 2006* and shall be prohibited to ensure this activity never becomes a significant drinking water threat. b. Notwithstanding OC-CW-14.2a), any handling and storage of fuel required for back-up generators at municipal supply wells shall be designated for the purpose of Section 58 of the *Clean Water Act, 2006* and a Risk Management Plan shall be required to ensure this activity never becomes a significant drinking water threat.

Policy Number	Policies Addressing Prescribed Drinking Water Threats within the County of Oxford
16. The Handling and Storage of a Dense Non-Aqueous Phase Liquid (DNAPL)	
OC-CW-15.1 *a)Existing/ Future Education&Outreach WHPA-A/B/C* *b)Existing/ Future Part IV-RMP WHPA-A/B/C*	For any existing or new handling and storage of a dense non-aqueous phase liquid, on properties zoned exclusively for residential and/or environmental protection purposes in the Area Municipal Zoning By-Laws, where this activity is, or would be, a significant drinking water threat, a. The County, in collaboration with the Source Protection Authority, Area Municipalities, the Ministry of the Environment, Conservation and ~~Climate Change~~Parks ~~and Climate Change~~, and/or other bodies wherever possible, shall develop and implement an education and outreach program directed at the owners and/or occupants of such properties to ensure this activity ceases to be or never becomes a significant drinking water threat. The program may include, but not necessarily be limited to, the provision of education material and information about the nature of the threat, how DNAPLs can be identified, handled and disposed of appropriately. b. Notwithstanding OC-CW-15.1a), where the quantity and/or volume of DNAPLs handled or stored on a property exceeds that typical of household use, the handling and storage of a dense non-aqueous phase liquid shall be designated for the purpose of Section 58 of the *Clean Water Act* and a Risk Management Plan shall be required to ensure this activity ceases to be or never becomes a significant drinking water threat.
OC-CW-15.2 *Existing Part IV-RMP WHPA-A/B/C*	For any existing handling and storage of a dense non-aqueous phase liquid, on properties zoned for any other use than residential and/or environmental protection in the Area Municipal Zoning By-Laws, where this activity is a significant drinking water threat, it shall be designated for the purpose of Section 58 of the *Clean Water Act, 2006* and a Risk Management Plan shall be required to ensure this activity ceases to be a significant drinking water threat.
OC-CW-15.3 *Future Part IV-Prohibit WHPA-A-v.10; WHPA-B-v.10*	For any new handling and storage of a dense non-aqueous phase liquid, on properties zoned for any other use than residential and/or environmental protection in the Area Municipal Zoning By-Laws and located within a WHPA-A or B with a vulnerability score equal to ten (10), where this activity would be a significant drinking water threat, it shall be designated for the purpose of Section 57 of the *Clean Water Act, 2006* and shall be prohibited to ensure this activity never becomes a significant drinking water threat.
OC-CW-15.4 *Future Part IV-RMP WHPA-B-8,6,4; WHPA-C*	For any new handling and storage of a dense non-aqueous phase liquid, on properties zoned for any other use than residential and/or environmental protection in the Area Municipal Zoning By-Laws and located within a WHPA-B with a vulnerability score of less than ten (10), or a WHPA-C, where such an activity would be a significant drinking water threat, it shall be designated for the purpose of Section 58 of the *Clean Water Act, 2006* and a Risk Management Plan shall be required to ensure this activity never becomes a significant drinking water threat.
17. The Handling and Storage of an Organic Solvent	
OC-CW-16.1 *Existing Part IV-RMP WHPA-A- v.10; WHPA-B- v.10*	For existing handling and storage of an organic solvent where this activity is a significant drinking water threat, it shall be designated for the purpose of Section 58 of the *Clean Water Act, 2006* and a Risk Management Plan shall be required to ensure this activity ceases to be a significant drinking water threat.
OC-CW-16.2	For new handling and storage of an organic solvent, where this activity would be a significant drinking water threat, it shall be designated for the purpose of Section 57

Policy Number	Policies Addressing Prescribed Drinking Water Threats within the County of Oxford
Future *Part IV-Prohibit* *WHPA-A- v.10;* *WHPA-B- v.10*	of the *Clean Water Act, 2006* and shall be prohibited to ensure this activity never becomes a significant drinking water threat.
18. The Management of Runoff that Contains Chemicals Used in De-icing of Aircraft	
OC-CW-17.1 *Future* *Part IV-RMP* *WHPA-A- v.10;* *WHPA-B- v.10*	For a new airport where there could be runoff containing de-icing chemicals, where this activity would be a significant drinking water threat, it shall be designated for the purpose of Section 58 of the *Clean Water Act, 2006* and a Risk Management Plan shall be required to ensure this activity never becomes a significant drinking water threat.
21. The Use of Land as Livestock Grazing or Pasturing Land, an Outdoor Confinement Area or a Farm Animal Yard	
OC-CW-18.1 *Existing/Future* *Part IV-RMP* *WHPA-A- v.10;* *WHPA-B- v.10*	For the existing or future use of land as livestock grazing or pasturing land, an outdoor confinement area or a farm-animal yard, where these activities are, or would be, a significant drinking water threat, they shall be designated for the purpose of Section 58 of the *Clean Water Act, 2006* and a Risk Management Plan shall be required to ensure these activities cease to be or never become a significant drinking water threat.
22. The Establishment and Operation of a Liquid Hydrocarbon Pipeline	
OC-NB-19.1 *Future* *Specify Action* *WHPA-A-v.10;* *WHPA-B-v.10* *Monitoring*	To reduce the risks to municipal drinking water sources due to the conveyance of oil by way of underground pipeline within the meaning of O. Reg. 210/01 under the *Technical Safety and Standards Act* or that is subject to the *National Energy Board Act* within a WHPA-A and WHPA-B with a vulnerability score of 10, the National Energy Board, Ontario Energy Board and the pipeline proponent shall provide the Source Protection Authority and the County with the location of any new pipelines proposed within the Source Protection Region. The Source Protection Authority shall document in the annual report the number of new pipelines proposed within WHPAs, where they would be a significant drinking water threat.

12.4 Appendix A: List of Policies as Per Section 34 of Regulation 287/07

LIST A

Title: Significant threat policies that affect decisions under the *Planning Act* and *Condominium Act*, 1998

Opening Statement: “Clause 39 (1)(a), subsections 39 (2), (4) and (6), and sections 40 and 42 of the *Clean Water Act*, 2006 apply to the following policies:”

Content: OC-CW-1.1, OC-CW-1.2, OC-CW-1.3, OC-MC-1.4, OW-MC-3.2

LIST B

Title: Moderate and low threat policies that affect decisions under the *Planning Act* and *Condominium Act*, 1998

Opening Statement: “Subsection 39 (1) (b) of the *Clean Water Act*, 2006 applies to the following policies:”

Content: No Applicable Policies

LIST C

Title: Significant threat policies that affect Prescribed Instrument decisions

Opening Statement: “Subsection 39 (6), clause 39 (7) (a), section 43 and subsection 44 (1) of the *Clean Water Act*, 2006 apply to the following policies:”

Content: OC-CW-1.1, OC-CW-1.2, OC-MC-1.18, OC-MC-2.1, OC-MC-2.3, OC-MC-3.3, OC-MC-3.4, OC-MC-3.5, OC-MC-3.6, OC-MC-3.7, OC-MC-3.8, OC-MC-3.9, OC-MC-6.1, OC-MC-7.1, OC-MC-7.2

LIST D

Title: Moderate and low threat policies that affect Prescribed Instrument decisions

Opening Statement: “Clause 39 (7) (b) of the *Clean Water Act*, 2006 applies to the following policies:”

Content: No Applicable Policies

LIST E

Title: Significant threat policies that impose obligations on municipalities, source protection authorities and local boards

Opening Statement: “Section 38 and subsection 39 (6) of the *Clean Water Act*, 2006 applies to the following policies:”

Content: OC-CW-1.1, OC-CW-1.2, OC-CW-1.5, OC-CW-1.6, OC-CW-1.17, OC-CW-3.1, OC-CW-8.2, OC-CW-15.1a

LIST F

Title: Monitoring policies referred to in subsection 22 (2) of the *Clean Water Act*, 2006

Opening Statement: “Section 45 of the Clean Water Act, 2006 applies to the following policies:”

Content: OC-CW-1.8, OC- CW-1.9, OC- CW-1.10, OC- CW-1.11, OC- CW-1.12, OC-NB-19.1~~.13~~

LIST G
Title: Policies related to section 57 of the *Clean Water Act*, 2006

Opening Statement: "The following policies relate to section 57 (prohibition) of the Clean Water Act."

Content: OC-CW-1.1, OC-CW-1.2; OC-CW-2.4, OC-CW-4.1, OC-CW-5.1, OC-CW-9.2, OC-CW-11.2, OC-CW-12.1, OC-CW-13.2, OC-CW-14.2a, OC-CW-15.3, OC-CW-16.2

LIST H
Title: Policies related to section 58 of the *Clean Water Act*, 2006

Opening Statement: "The following policies relate to section 58 (Risk Management Plans) of the Clean Water Act."

Content: OC-CW-1.1, OC-CW-2.2, OC-CW-2.5, OC-CW-4.2, OC-CW-5.2, OC-CW-8.1, OC-CW-9.1, OC-CW-10.1, OC-CW-11.1, OC-CW-11.3, OC-CW-13.1, OC-CW-14.1, OC-CW-14.2b, OC-CW-15.1b, OC-CW-15.2, OC-CW-15.4, OC-CW-16.1, OC-CW-17.1, OC-CW-18.1

LIST I
Title: Policies related to section 59 of the *Clean Water Act*, 2006

Opening Statement: "The following policies relate to section 59 (restricted land use) of the *Clean Water Act*."

Content: OC-CW-1.1, OC-CW-1.3

LIST J
Title: Strategic Action policies

Opening Statement: For the purposes of section 33 of Ontario Regulation 287/07, the following policies are identified as strategic action policies:

Content: OC-NB-1.14, OC-NB-1.15, OC-NB-1.16, OC-NB-1.19

LIST K
Title: Significant threat policies targeted to bodies other than municipalities, local board or source protection authorities for implementation

Opening Statement: The following policies are identified as non-legally binding policies.

Content: OC- NB-1.7, OC-NB-19.1~~.13~~

12.5 Appendix B: Prescribed Instruments and Policy Summary Tables

Table 1: Prescribed instruments which apply to source protection plan policies in Lists C and D above (s.34(4) of O. Reg. 287/07)

Policy #	Legal Effect	Environmental Protection Act	Nutrient Management Act	Ontario Water Resources Act
OC-CW-1.1	Comply With	X	X	X
OC-CW-1.2	Comply With	X	X	X
OC-MC-1.18	Must Conform		X	
OC-MC-2.1	Must Conform	X		X
OC-MC-2.3	Must Conform	X		X
OC-MC-3.3	Must Conform	X		X
OC-MC-3.4	Must Conform	X		X
OC-MC-3.5	Must Conform	X		X
OC-MC-3.6	Must Conform	X		X
OC-MC-3.7	Must Conform	X		X
OC-MC-3.8	Must Conform	X		X
OC-MC-3.9	Must Conform	X		X
OC-MC-6.1	Must Conform		X	
OC-MC-7.1	Must Conform		X	
OC-MC-7.2	Must Conform		X	

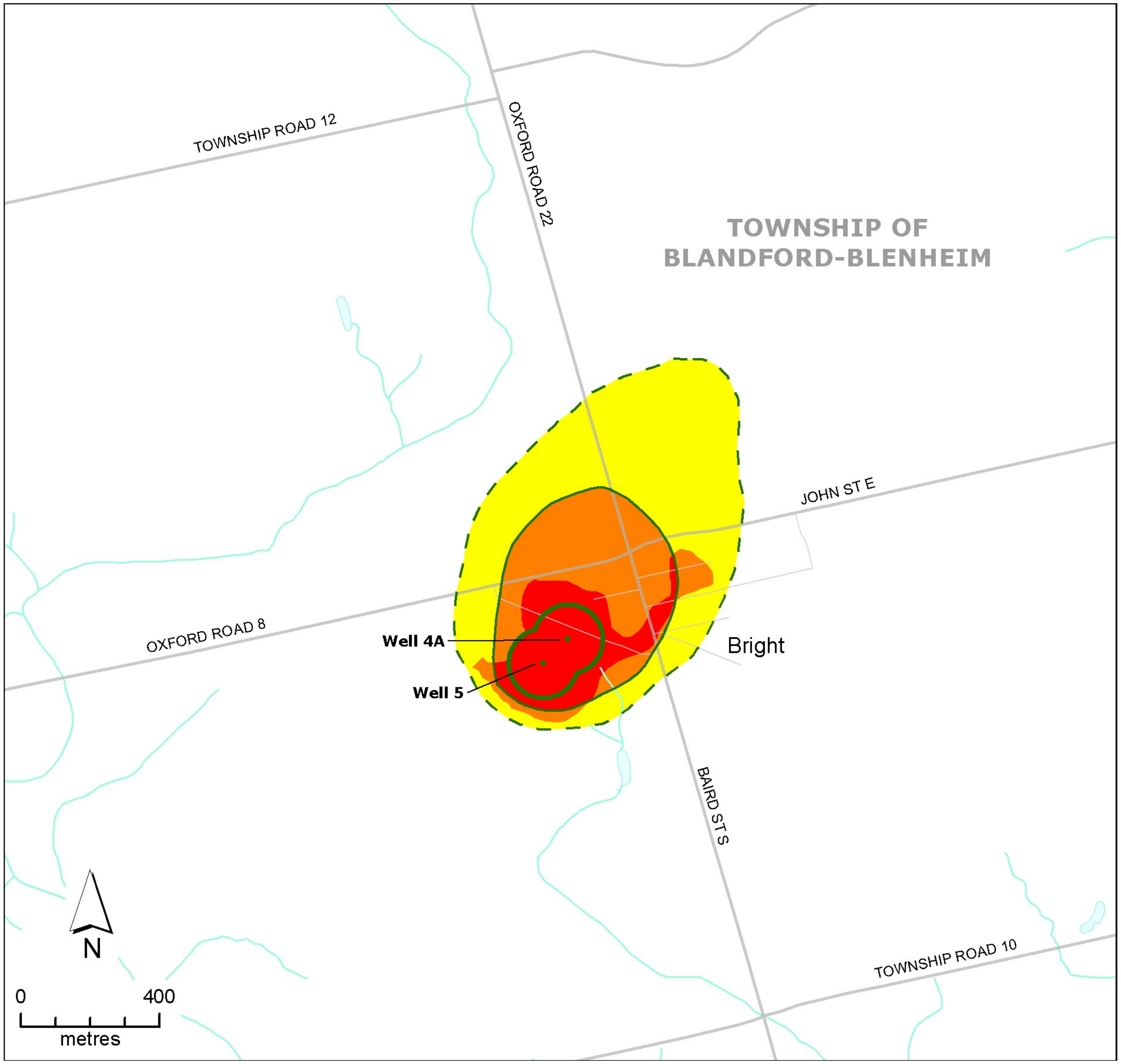
Table 2: Policy Summary Matrix

Policy ID#	Legal Effect (conform with, have regard to, non-binding)	Policy affects decisions under the Planning Act and Condominium Act, 1998 (Lists A and B)	Policy affects Prescribed Instrument decisions (Lists C and D)	Significant threat policies that impose obligations on municipalities, source protection authorities and local boards (List E)	Monitoring policies referred to in s.22(2) of the CWA (List F)	Part IV Policies - Significant threat policies that are designated in the plan as requiring a Risk Management plan, are prohibited under s. 57, or to which s. 59 of the CWA applies (Lists G, H, and I)	Strategic Action Policies (List J)	Significant threat policies which designate a body other than a municipality, source protection authority or local board as responsible for implementing the policy (List K)
OC-CW-1.1	Comply With	X	X	X		X		
OC-CW-1.2	Comply With	X	X	X		X		
OC-CW-1.3	Comply With	X				X		
OC-MC-1.4	Must Conform	X						
OC-MC-1.18	Must Conform		X					
OC-MC-3.2	Must Conform	X						
OC-MC-2.1	Must Conform		X					
OC-MC-2.3	Must Conform		X					
OC-MC-3.3	Must Conform		X					
OC-MC-3.4	Must Conform		X					
OC-MC-3.5	Must Conform		X					
OC-MC-3.6	Must Conform		X					
OC-MC-3.7	Must Conform		X					

Policy ID#	Legal Effect (conform with, have regard to, non-binding)	Policy affects decisions under the Planning Act and Condominium Act, 1998 (Lists A and B)	Policy affects Prescribed Instrument decisions (Lists C and D)	Significant threat policies that impose obligations on municipalities, source protection authorities and local boards (List E)	Monitoring policies referred to in s.22(2) of the CWA (List F)	Part IV Policies - Significant threat policies that are designated in the plan as requiring a Risk Management plan, are prohibited under s. 57, or to which s. 59 of the CWA applies (Lists G, H, and I)	Strategic Action Policies (List J)	Significant threat policies which designate a body other than a municipality, source protection authority or local board as responsible for implementing the policy (List K)
OC-MC-3.8	Must Conform		X					
OC-MC-3.9	Must Conform		X					
OC-MC-6.1	Must Conform		X					
OC-MC-7.1	Must Conform		X					
OC-MC-7.2	Must Conform		X					
OC-CW-1.5	Comply With			X				
OC-CW-1.6	Comply With			X				
OC-CW-1.17	Comply With			X				
OC-CW-3.1	Comply With			X				
OC-CW-8.2	Comply With			X				
OC-CW-15.1a	Comply With			X				
OC-CW-1.8	Comply With				X			
OC-CW-1.9	Comply With				X			
OC-CW-1.10	Comply With				X			
OC-CW-1.11	Comply With				X			
OC-CW-1.12	Comply With				X			
OC-CW-2.4	Comply With					X		
OC-CW-4.1	Comply With					X		
OC-CW-5.1	Comply With					X		
OC-CW-9.2	Comply With					X		
OC-CW-11.2	Comply With					X		
OC-CW-12.1	Comply With					X		
OC-CW-13.2	Comply With					X		
OC-CW-14.2a	Comply With					X		
OC-CW-15.3	Comply With					X		
OC-CW-16.2	Comply With					X		
OC-CW-2.2	Comply With					X		
OC-CW-2.5	Comply With					X		
OC-CW-4.2	Comply With					X		
OC-CW-5.2	Comply With					X		
OC-CW-8.1	Comply With					X		
OC-CW-9.1	Comply With					X		
OC-CW-10.1	Comply With					X		
OC-CW-11.1	Comply With					X		
OC-CW-11.3	Comply With					X		
OC-CW-13.1	Comply With					X		
OC-CW-14.1	Comply With					X		
OC-CW-14.2b	Comply With					X		

Policy ID#	Legal Effect (conform with, have regard to, non-binding)	Policy affects decisions under the Planning Act and Condominium Act, 1998 (Lists A and B)	Policy affects Prescribed Instrument decisions (Lists C and D)	Significant threat policies that impose obligations on municipalities, source protection authorities and local boards (List E)	Monitoring policies referred to in s.22(2) of the CWA (List F)	Part IV Policies - Significant threat policies that are designated in the plan as requiring a Risk Management plan, are prohibited under s. 57, or to which s. 59 of the CWA applies (Lists G, H, and I)	Strategic Action Policies (List J)	Significant threat policies which designate a body other than a municipality, source protection authority or local board as responsible for implementing the policy (List K)
OC-CW-15.1b	Comply With					X		
OC-CW-15.2	Comply With					X		
OC-CW-15.4	Comply With					X		
OC-CW-16.1	Comply With					X		
OC-CW-17.1	Comply With					X		
OC-CW-18.1	Comply With					X		
OC-NB-1.14	Non-Binding						X	
OC-NB-1.15	Non-Binding						X	
OC-NB-1.16	Non-Binding						X	
OC-NB-1.19	Non-Binding						X	
OC-NB-1.7	Non-Binding							X
OC-NB-19.1~~.13~~	Non-Binding				X			X

12.6 Schedule A: County of Oxford – Bright Water System



DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER

Significant Drinking Water Threat Policy Applicability

Significant Drinking Water Threat Policy Categories		Vulnerability Scores on Map		
		10	8	2,4,6
1.	Waste Disposal	🟥	🟧	
2.	Sewage Systems	🟥	🟧	
3, 4.	Agricultural Source Material	🟥		
6, 7.	Non-Agricultural Source Material*	🟥		
8, 9.	Commercial Fertilizer*	🟥		
10, 11.	Pesticide	🟥		
12, 13.	Road Salt*	🟥		
14.	Storage of Snow	🟥		
15.	Fuel	🟥		
16.	DNAPLs	🟥	🟧	🟨
17.	Organic Solvents	🟥		
18.	Aircraft De-icing	🟥		
21.	Livestock Area	🟥		
Local Threat	Oil Pipelines	🟥		

Note: This table provides a summary of the activities listed in the Clean Water Act (2006) that apply as Prescribed Drinking Water Threats (PDWT) within the Non-GUDI Wellhead Protection Zones shown on this map. For details refer to the text of the Source Protection Plan and the Ministry of the Environment Drinking Water Threats Tables.
*Application of Commercial Fertilizer, Non-Agricultural Source Material, and Road Salt may not be a significant drinking water threat in some areas due to the % managed land, livestock density, and/or % impervious surface calculations for these areas. See the text of the plan for further details.

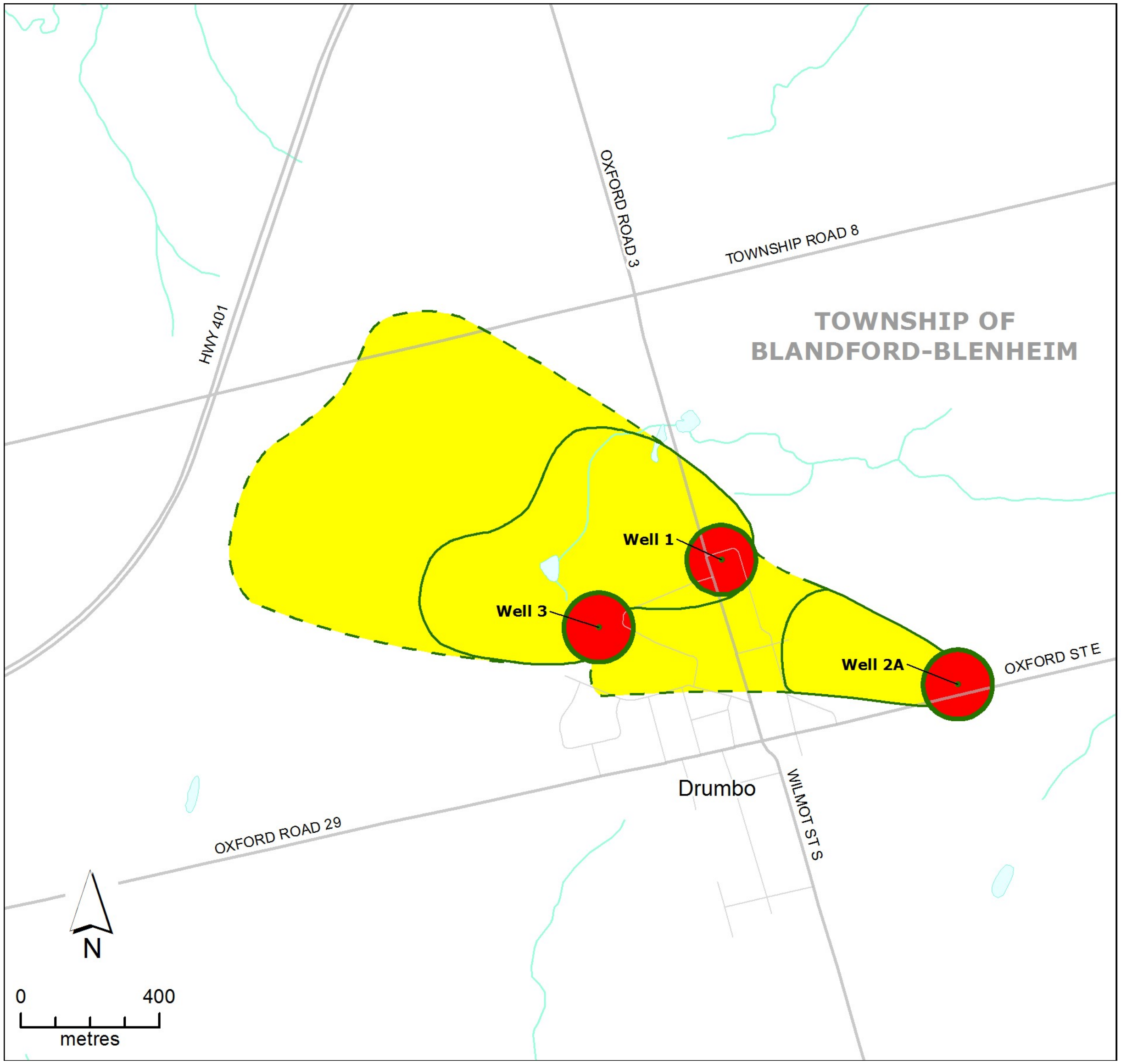
● Well
Road
Minor River
Lake / Main River

Wellhead Protection Zones:
WHPA-A
WHPA-B
WHPA-C

Ontario
Grand River Conservation Authority

1. Updated July 27, 2018
2. Larger scale mapping of some map layers, including roads and vulnerability scores, is available at www.sourcewater.ca.
3. This map is for illustrative purposes only. Information contained hereon is not a substitute for professional review or a site survey and is subject to change without notice. The Grand River Conservation Authority takes no responsibility for, nor guarantees, the accuracy of the information contained on this map. Any interpretations or conclusions drawn from this map are the sole responsibility of the user.

12.7 Schedule B: County of Oxford – Drumbo-Princeton Water System



DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER

Significant Drinking Water Threat Policy Applicability

Significant Drinking Water Threat Policy Categories		Vulnerability Scores on Map		
		10	8	2,4,6
1.	Waste Disposal	🟥	🟧	
2.	Sewage Systems	🟥	🟧	
3, 4.	Agricultural Source Material	🟥		
6, 7.	Non-Agricultural Source Material*	🟥		
8, 9.	Commercial Fertilizer*	🟥		
10, 11.	Pesticide	🟥		
12, 13.	Road Salt*	🟥		
14.	Storage of Snow	🟥		
15.	Fuel	🟥		
16.	DNAPLs	🟥	🟧	🟨
17.	Organic Solvents	🟥		
18.	Aircraft De-icing	🟥		
21.	Livestock Area	🟥		
Local Threat	Oil Pipelines	🟥		

Note: This table provides a summary of the activities listed in the Clean Water Act (2006) that apply as Prescribed Drinking Water Threats (PDWT) within the Non-GUDI Wellhead Protection Zones shown on this map. For details refer to the text of the Source Protection Plan and the Ministry of the Environment Drinking Water Threats Tables.
*Application of Commercial Fertilizer, Non-Agricultural Source Material, and Road Salt may not be a significant drinking water threat in some areas due to the % managed land, livestock density, and/or % impervious surface calculations for these areas. See the text of the plan for further details.

● Well
— Road
〰 Minor River
▨ Lake / Main River

Wellhead Protection Zones:
◯ WHPA-A
◯ WHPA-B
◌ WHPA-C

Ontario

Grand River Conservation Authority

1. Updated November 18, 2014
2. Larger scale mapping of some map layers, including roads and vulnerability scores, is available at www.sourcewater.ca.
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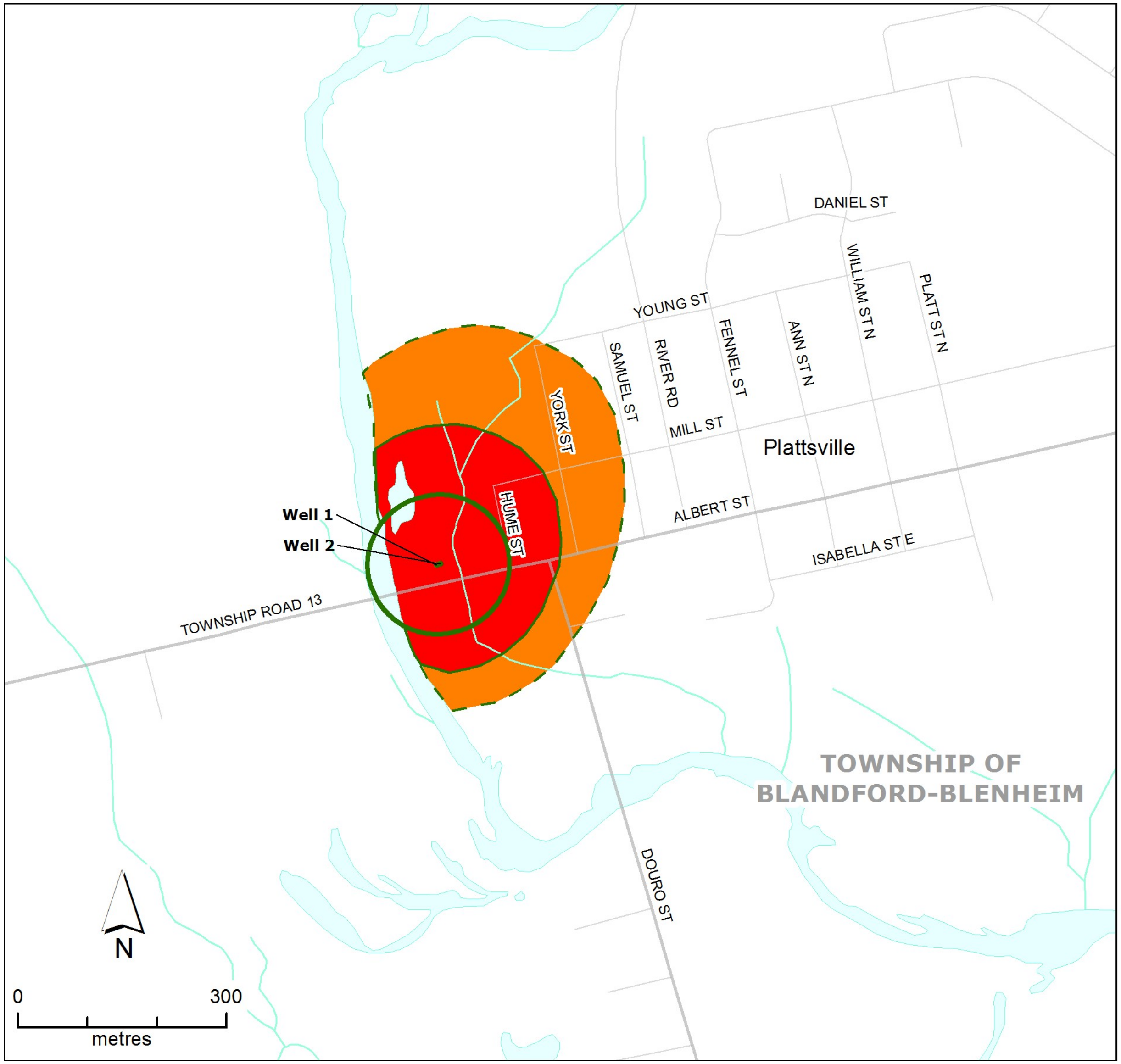
12.8 Schedule C: County of Oxford – Plattsville Water System



DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER

Significant Drinking Water Threat Policy Applicability

Significant Drinking Water Threat Policy Categories		Vulnerability Scores on Map		
		10	8	2,4,6
1.	Waste Disposal	🟥		
2.	Sewage Systems	🟥	🟧	
3, 4.	Agricultural Source Material	🟥		
6, 7.	Non-Agricultural Source Material*	🟥		
8, 9.	Commercial Fertilizer*	🟥		
10, 11.	Pesticide	🟥		
12, 13.	Road Salt*	🟥		
14.	Storage of Snow	🟥		
15.	Fuel	🟥		
16.	DNAPLs	🟥	🟧	🟨
17.	Organic Solvents	🟥		
18.	Aircraft De-icing	🟥		
21.	Livestock Area	🟥		
Local Threat	Oil Pipelines	🟥		

Note: This table provides a summary of the activities listed in the Clean Water Act (2006) that apply as Prescribed Drinking Water Threats (PDWT) within the Non-GUDI Wellhead Protection Zones shown on this map. For details refer to the text of the Source Protection Plan and the Ministry of the Environment Drinking Water Threats Tables.
*Application of Commercial Fertilizer, Non-Agricultural Source Material, and Road Salt may not be a significant drinking water threat in some areas due to the % managed land, livestock density, and/or % impervious surface calculations for these areas. See the text of the plan for further details.

● Well
Road
Minor River
Lake / Main River

Wellhead Protection Zones:
WHPA-A
WHPA-B
WHPA-C

Ontario
Grand River Conservation Authority

1. Updated November 18, 2014
2. Larger scale mapping of some map layers, including roads and vulnerability scores, is available at www.sourcewater.ca.
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Appendix B

City of Hamilton: Draft Updated Grand River Assessment Report and Source Protection Plan

TABLE OF CONTENTS

LIST OF MAPS

LIST OF TABLES

12.0 CITY OF HAMILTON

12.1 Lynden Communal Well System

The City of Hamilton operates a groundwater ~~source~~ water supply and distribution system located in the Lynden Rural Settlement Area~~, which is part of the former Town of Flamborough (amalgamated with the City of Hamilton in 2001)~~. The system collects water from a single pumping well (FLD-01) located at 3630 Governors Road. ~~The system currently supplies, on average, approximately 103 m^3/d of potable water to 363 residents (127 metered connections) (BCOS, City of Hamilton, 2008; Genivar, 2007). The well field has been in operation since 1984-1985 (Dillion, 2010).~~ In 2015, a new production well, FDL-03 was drilled 230 m to the south of FDL-01. Both wells are screened in a confined overburden ~~(gravel)~~ aquifer between 50 and 55 metres below ground surface. The aquifer is locally confined by a thick deposit of clay and silt. Neither well meets the requirements to be considered groundwater under the direct influence of surface water (GUDI) (WSP, 2016). ~~The 200 millimetre diameter well is screened in a confined gravel aquifer and partially penetrates into the underlying dolostone bedrock of the Guelph Formation.~~

The location of the existing well site and serviced area is shown on **Map 12-1**. The system currently supplies, on average, approximately 103 m^3/d of potable water to 380 residents (City of Hamilton, 2017). With the addition of FDL-03, the system will have a capacity of 518.4 m^3/day (Earthfx, 2018). The raw water passes through a two-stage treatment process to remove naturally occurring hydrogen sulphide and provide disinfection.

The system operates under ~~an Amended~~ Permit to Take Water (PTTW No. ~~88P~~0634-~~2000~~ASERU8)~~; issued on April 10, 2001.~~. **Table 12-1** to **Table 12-2** summarize~~s~~ the system characteristics.

Table 12-1: Municipal Residential Drinking Water System Information for the City of Hamilton in the Grand River Source Protection Area (Lynden Communal Well System)

DWS Number	DWS Name	Operating Authority	GW or SW	System Classification[1]	Number of Users served[2]
250001830	Lynden Communal Well System ~~FDL01~~	City of Hamilton	GW	Large Municipal Residential System	~~363~~380

[1] as defined by O. Reg. 170/03 (Drinking Water Systems) made under the *Safe Drinking Water Act, 2002.*

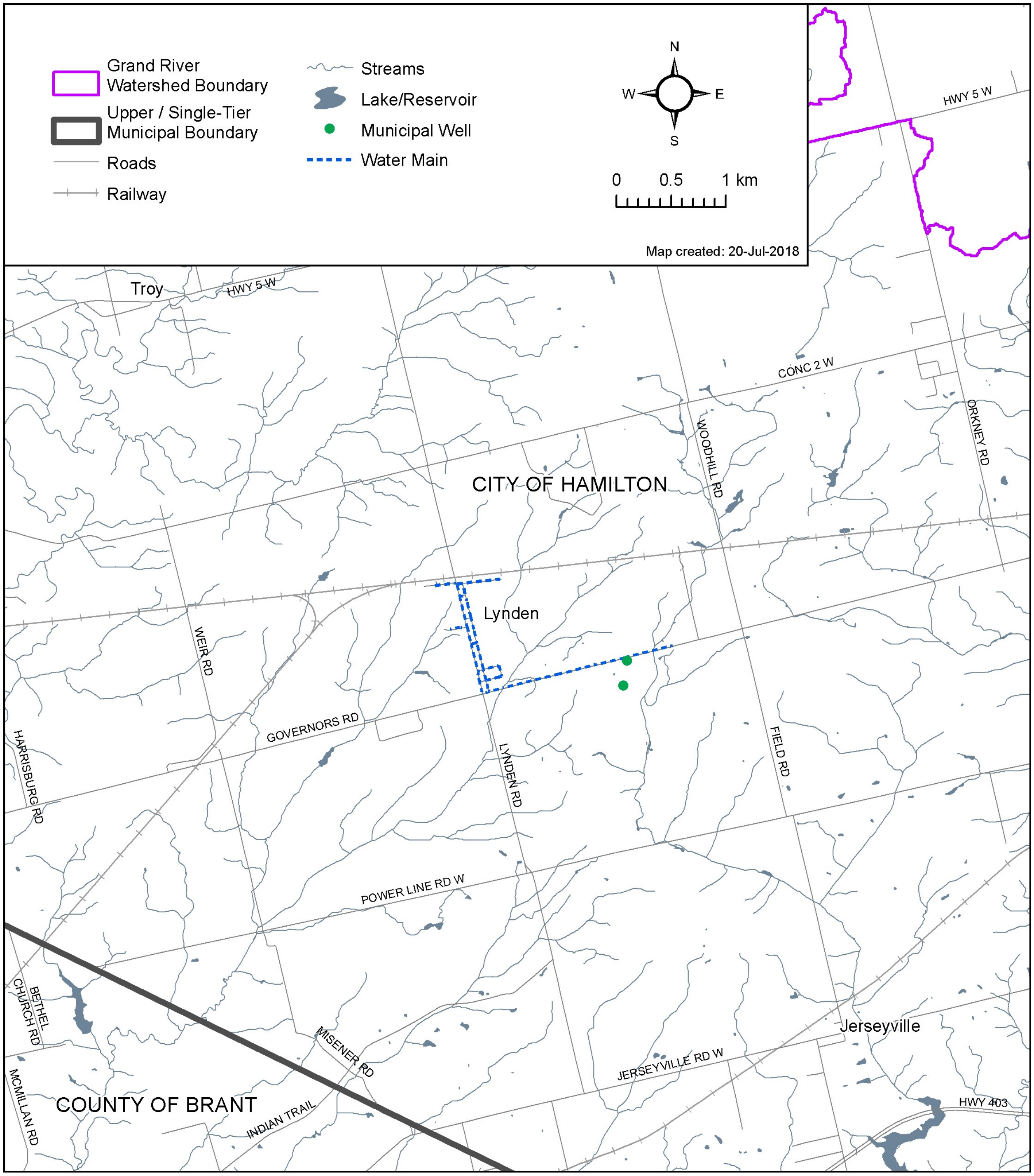
[2] Drinking Water Sytem Regulation 170/03, ~~2009b~~2017

Table 12-2: Annual and Monthly Average Pumping Rates for the Lynden Communal Well System

Well or Intake	Annual Avg. Taking[1] (m^3/d)	Monthly Average Taking[1] (m^3/d)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
FDL01	~~60.65~~82.75	~~76.38~~ 84	~~77.14~~ 77	~~68.34~~ 78	~~70.70~~ 82	~~80.08~~ 83	~~83.70~~ 85	~~56.22~~ 92	~~48.72~~ 80	~~41.24~~ 84	~~43.82~~ 80	~~42.50~~ 81	~~38.90~~ 87

[1] source: City of Hamilton ~~2009~~ 2017 annual summary report

Map 12-1: Lynden Communal Well System Serviced Areas



~~12.1.2~~12.1.1 Delineation of Wellhead Protection Areas for Lynden Communal System

A numerical groundwater flow model and a hydrologic model for the Fairchild Creek subwatershed were developed to delineate wellhead protection areas for the Lynden Communal Wells System (Earthfx, 2018). Five different pumping configurations were tested in order to simulate a wide range of operational conditions. The most conservative and/or most realistic WHPA was delineated based on the different capture zones generated under different pumping configurations.

Groundwater recharge rates for the study area were estimated using a new hydrologic model developed for this study area using the USGS PRMS hydrologic modelling code. The model was calibrated to match observed streamflow at Water Survey of Canada gauges on Fairchild and Spencer creeks. In addition, updated conceptual geologic and hydrostratigraphic models were developed as part of this study, which incorporated geologic datasets from the OGS and a previous study by Earthfx (2010).

A single WHPA was delineated for the two Lynden supply wells because of their close proximity to one another and because they both draw from the same deep sand and gravel aquifer. Pumping was distributed 2:1 in favour of the new supply well (FDL-03), with a total wellfield production equal to the maximum permitted rate of 6 L/s. ~~The Lynden WHPA was less sensitive to pumping configuration and more sensitive to changes in porosity estimates. Decreasing the porosity by 10% resulted in considerably larger capture zones; however, the baseline porosities already reflect sufficiently conservative assumptions. Capture zones~~The WHPA ~~are~~ is oriented ~~in~~in a the northern direction and does not appear to be influenced by any major hydrogeologic features. T~~he result of t~~he Lynden Communal System ~~Wellhead Protection Area~~WHPA ~~delineation~~ is presented on **Map 12-2**.

~~Delineation requirements of the Wellhead Protection Area (WHPA) associated with the municipal water supply is specified in Part V of the Technical Rules (MOE, 2009b). The Wellhead Protection Area represents the area within the aquifer that contributes groundwater to the well over a specific time period. The Technical Rules specify the delineation of the following four Wellhead Protection Areas:~~

~~WHPA-A~~	~~100 m radius from wellhead~~
~~WHPA-B~~	~~2-year Time of Travel (TOT) capture zone~~
~~WHPA-C~~	~~5-year Time of Travel capture zone~~
~~WHPA-D~~	~~25-year Time of Travel capture zone~~

~~***Modelling Approach for the Lynden Communal Well System***~~

~~Capture zones and time-of-travel (TOT) zone analyses were conducted using the USGS MODPATH code (Pollock, 1989). MODPATH uses simulated heads and flow rates from the MODFLOW model output along with estimates of aquifer porosity to calculate average groundwater velocity in each model cell. The MODPATH code uses these velocities to track virtual particles from their point of entry to a point of discharge. For example, it can track the path of a particle that enters the system (e.g., as recharge to an upper layer cell) as it travels through the aquifers and aquitard layers and eventually to the point where it discharges to a well or stream. Whenever the virtual particle crosses the boundary of a finite-difference cell, the particle location and time are recorded. These points are linked to form pathlines. Multiple virtual particles are released to ensure that all likely pathways are defined. MODPATH also has the~~

~~ability to backward-track particles from a discharge point (e.g., a well) back to the point of entry to the aquifer by manually drawing a polygon around the well that encompassed all particle locations at 2, 5, and 25 years.~~

~~The time of travel zone is based on the vertical projection of the three dimensional particle tracks onto a two-dimensional map. This has little effect when dealing with unconfined aquifers, but is a very conservative assumption when dealing with municipal wells screened in confined aquifers. The vertical travel time through the confining units can add years to the actual time of travel from the surface. The difference between the time of travel represented by the Wellhead Protection Area zones and the estimated time of travel from the surface to the well was considered when assigning vulnerability scores to subzones within the Wellhead Protection Areas.~~

~~*Lynden Wellhead Protection Areas*~~

~~*Peer Review*~~

~~A peer review of the report *Hamlet of Lynden, City of Hamilton, Source Protection Study: Vulnerability Analysis Report #1* (Dillon Consulting Limited, October 22, 2009) was completed by Christopher Neville of S. S. Papadopulos & Associates, Inc. The overall impressions of the report by the peer review are as follows:~~

~~*"In our opinion, the approaches adopted for the Lynden vulnerability assessment are consistent with the Clean Water Act Technical Rules (December 12, 2008) and the Ontario Ministry of the Environment Source Water Protection Guidance Documents. The analyses have been conducted at an appropriate level of detail."*~~

~~Responses to the peer review comments were incorporated into the final report. The responses to the peer review comments enhanced the overall defensibility of the report but did not impact the outcome of the WHPAs or vulnerability scoring.~~

Vulnerability Scoring in Wellhead Protection Areas

Aquifer vulnerability was mapped using the Surface to Well Advection Time (SWAT) method which utilizes the groundwater flow model by tracking particles forward in the model to estimate their time of travel from ground surface to the municipal wells.

Vulnerability scores were calculated by combining the WHPAs with the vulnerability indices (High, Medium, and Low) from the SWAT analysis.

The Lynden supply wells ~~is completed~~are screened beneath a thick deposit of clay till and simulated water levels indicate relatively little connection with the shallow groundwater system. Accordingly, the intrinsic vulnerability scores are low. The intrinsic vulnerability of the Lyden Communal Well System is shown on **Map 12-3.**

~~Mapping of the aquifer vulnerability and development of vulnerability scores was performed by Earthfx Inc. (2010). Mapping of the intrinsic vulnerability of the aquifer was performed using the Surface to Aquifer Advective Time (SAAT) approach outside of the wellhead protection areas. This approach involves estimating the travel time for a particle of water to move vertically from the surface to the top of the aquifer that is being pumped. The surface to well advective time (SWAT) was used within the WHPAs for Lynden as defined in the Technical Rules (MOE, 2009). The SWAT method considers the actual time of travel for a potential contaminant to move from the point of application at land surface to the well screen.~~

~~Areas of common travel time are mapped as being either <5 years, 5 to 25 years, and >25 years. To complete this task, Earthfx Inc. used a numerical groundwater flow model to estimate vertical time of travel from the surface to the aquifer. The 2-year wellhead protection area includes only the area projected to ground surface through which water flows to the well within the 2-year period not the entire aquifer.~~

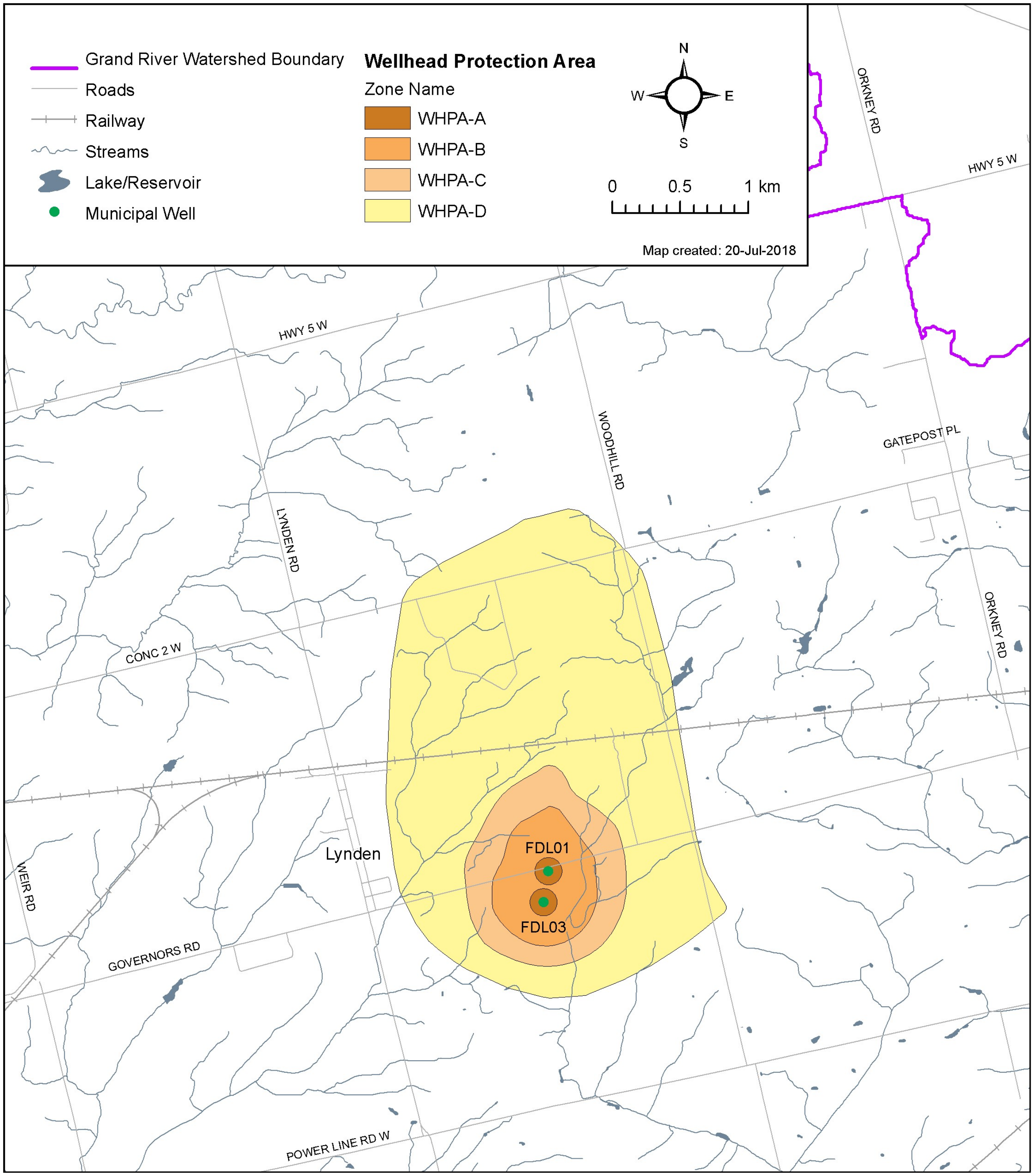
~~Vulnerability scores were determined from areas of intersection between the capture zones and the aquifer vulnerability values, as outlined in **Table 13-3**. The initial intrinsic vulnerability of the Lyden Communal Well System is shown on **Map 13-3.** The initial vulnerability scoring for the Lynden Communcal Well System is shown on **Map 13-4.**~~

~~Table 12-3: Vulnerability Scoring Matrix Using SWAT~~

~~Time of Travel Zone/ (Vulnerability Category)~~	**~~Aquifer Vulnerability (SAAT)~~**		
	~~0 to 5 years (High)~~	**~~5 to 25 years (Medium)~~**	**~~> 25 years (Low)~~**
~~WHPA-A (100m radius)~~	~~10~~	~~10~~	~~10~~
~~WHPA-B (0-2 year)~~	~~10~~	~~8~~	~~6~~
~~WHPA-C (2-5 year)~~	~~8~~	~~6~~	~~2~~
~~WHPA-D (5-25 year)~~	~~6~~	~~4~~	~~2~~

~~Scoring based on Table 2(b) MOE Technical Rules (MOE, 2009b)~~

Map 12-2: Lynden Communal Well System Wellhead Protection Areas



Identification of Transport Pathways and Vulnerability Adjustment

Adjustments to the vulnerability scores are needed to account for the presence of transport pathways (i.e., constructed preferential pathways) that might bypass the natural protective geologic layers. ~~Preferential pathways can include improperly constructed wells; improperly decommissioned wells, pits and quarries, storm water ponds and ditches, and pipeline bedding for storm and sanitary sewers. According to the Technical Rules, the vulnerability of an area identified as low vulnerability can be increased to medium or high vulnerability because of the presence of a transport pathway that is anthropogenic in origin (Rule 39). Similarly, an area assigned a medium vulnerability can be increased to high vulnerability (Rule 40). The assessment of increased vulnerability should consider:~~

~~(1) hydrogeological conditions;~~
~~(2) the type and design of the transport pathways;~~

~~(3) the cumulative impact of the transport pathways; and~~
~~(4) assumptions used in the assessment of groundwater vulnerability.~~

~~With respect to Item 4, the SWAT method rather than the SAAT method was used within the WHPAs (Earthfx, 20102018). Further, the u~~Unsaturated zone travel times were not considered in the analysis of SWAT times. Therefore, constructed pathways that could possibly reduce unsaturated zone travel times, such as stormwater ponds and pipeline bedding, would not result in an increase in the vulnerability scores already assigned. The focus, therefore, was ~~on~~ to identify~~ing~~ ~~those~~ constructed pathways that could reduce travel times in the saturated zone. This~~ese~~ included a review of:

- ~~bedrock wells that may leak or have been improperly abandoned; and~~
- ~~gravel pits and quarries that extend to or below the water table.~~

- Wells that may leak or have been improperly abandoned;
- Pits and quarries that breech the upper confining unit;
- Lakes in connection with the municipal aquifer system;
- Landfills located in former pits or quarries that may breach the upper confining unit; or
- Other deep excavations.

Transport Pathways in the Lynden Wellhead Protection Areas

The d~~D~~ischarge of contaminants to deep wells could provide a pathway ~~to deeper zones within the unconfined aquifers or~~ to the underlying confined aquifer~~s~~. As an initial screening, all wells that penetrated the bedrock aquifers were identified. Of these, the wells that were installed after 1990, when Ontario Regulation 903 (Wells) under the *Ontario Water Resources Act*), set out minimum standards for the construction and proper decommissioning of all types of wells, were assumed to be less likely to have failures of the casing or annular seals.

A total of 68 wells were identified within the delineated WHPA-A through WHPA-D areas for the Lynden supply wells. ~~There are~~Of these, 13 wells ~~in Lynden that are~~were considered high risk ~~wells that likely~~by potentially ~~do~~ not meeting the current MECP well standards and are in connection with the aquifer used for municipal supply. ~~Recent digital mapping provided by MNR was used to locate active and inactive pits and quarries in the study area. One former gravel pit was identified in the Wellhead Protection Area for the Lynden well, as shown on **Map 13-5.** The~~

~~vulnerability classification within the area outlined by the gravel pits was increased by one category (e.g., low to medium or medium to high), and the transport pathway area of influence is shown on **Map 13-6.** Vulnerability scores were adjusted within the area of the gravel pits intersected by the Wellhead Protection Area, as shown on **Map 13-7.**~~

Adjusted Vulnerability Scoring for the Lynden Wellhead Protection Areas

No adjustments due to transport pathways were made to the ~~Vulnerability~~ vulnerability scores for the Lynden WHPAs.~~were adjusted within the areas intersected by the Wellhead Protection Area as presented in **Map 13-4.** Transport pathways were used to increase the vulnerability in WHPA-D from low to medium within the northern portion of the Wellhead Protection Area.~~

The ~~final results of the~~ vulnerability scoring ~~analys~~is ~~are summarized below in Table 12-4 and~~ presented ~~graphically~~ in **Map 12-4.** ~~As shown on the map, the initial vulnerability scores vary across the capture zones.~~ The Lynden supply wells ~~is~~are completed beneath a thick deposit of clay till and simulated water levels indicate relatively little connection with the shallow groundwater system. Accordingly, the vulnerability scores are low ~~as the technical rules allow~~for the WHPA-C and D, medium vulnerability for WHPA-B and high vulnerabilty for WHPA-A~~s~~ (Earthfx, 2018).

~~Based on the results of the Wellhead Protection Area delineation and the aquifer vulnerability mapping, vulnerability scores were calculated by Earthfx. WHPA-A received a score of 10, while WHPA-B received a moderate vulnerability score of 6. Both WHPA-C and WHPA-D received a low vulnerability score 2; with a small portion of WHPA-D near its northern extent being classified with a score of 4.~~

~~Table 12-4: Adjusted Vulnerability Scores for the Lynden Wellhead Protection Areas~~

~~Wellhead Protection Area~~	~~Vulnerability Score~~
~~WHPA-A~~	~~10~~
~~WHPA-B~~	~~6~~
~~WHPA-C~~	~~2~~
~~WHPA-D~~	~~4~~
	~~2~~

Limitations and Uncertainty in the Wellhead Protection Area Delineation and Vulnerability Scoring for the Lynden Communal Well System

~~Technical Rules 13, 14 and 15 of the Technical Rules require that the u~~Uncertainty associated with ~~wellhead protection areas~~WHPAs must be identified as either High or Low. There are uncertainties and limitations related to both the ~~wellhead protection area~~WHPA modeling, the aquifer vulnerability assessment and the mapping of transport pathways. Results of the final uncertainty factors for the WHPA delineation and vulnerability scoring are summarized in **Table 12-3**.

Table 12-3: Summary of Uncertainty Analysis

Uncertainty Element	**Uncertainty for WHPA Delineation**	**Uncertainty for Vulnerability Scoring**
Distribution, variability, quality and relevance of data	Low	Low
Ability of the methods and models used to accurately reflect the flow processes in the hydrogeological system	High	High
Quality assurance and quality control procedures applied	Low	Low
Extent and level of calibration and validation achieved for models used or calculation or general assessments completed.	Low	Low
Accuracy to which the groundwater vulnerability categories effectively assess the relative vulnerability of the underlying hydrogeological features.	Not applicable	High
Overall	**High**	**High**

While a good overall calibration was achieved, we recognize that the Fairchild Creek model may be overpredicting drawdown and underpredicting water levels. For that reason, the model uncertainty is considered to be high.

Average groundwater recharge, a common source of uncertainty in groundwater models, was estimated by developing and calibrating a separate hydrologic model (PRMS). The uncertainty and limitations associated with PRMS include the absence of field measured values for groundwater recharge, limited ability to represent groundwater feedback using an uncoupled surface model, and uncertainty in the input and calibration target data.

While the application of a calibrated numerical groundwater model to delineate the WHPAs is considered to be the most robust and precise of the options available for determining the time of travel to a well, sources of uncertainty are introduced from both the groundwater flow model and the time of travel analysis itself. Subtle variations in the flow directions near the wells caused by local variation in aquitard or aquifer thickness, aquifer and aquitard hydraulic conductivity values, and/or recharge rates can lead to significant changes in the flow paths of the particles. For this study, the uncertainty in the groundwater flow patterns was relatively low due to the uniformity of the municipal aquifer system.

The overall uncertainty of the vulnerability score has been assessed and is considered to be high, consistent with the low level of uncertainty associated with the groundwater flow component of the study.

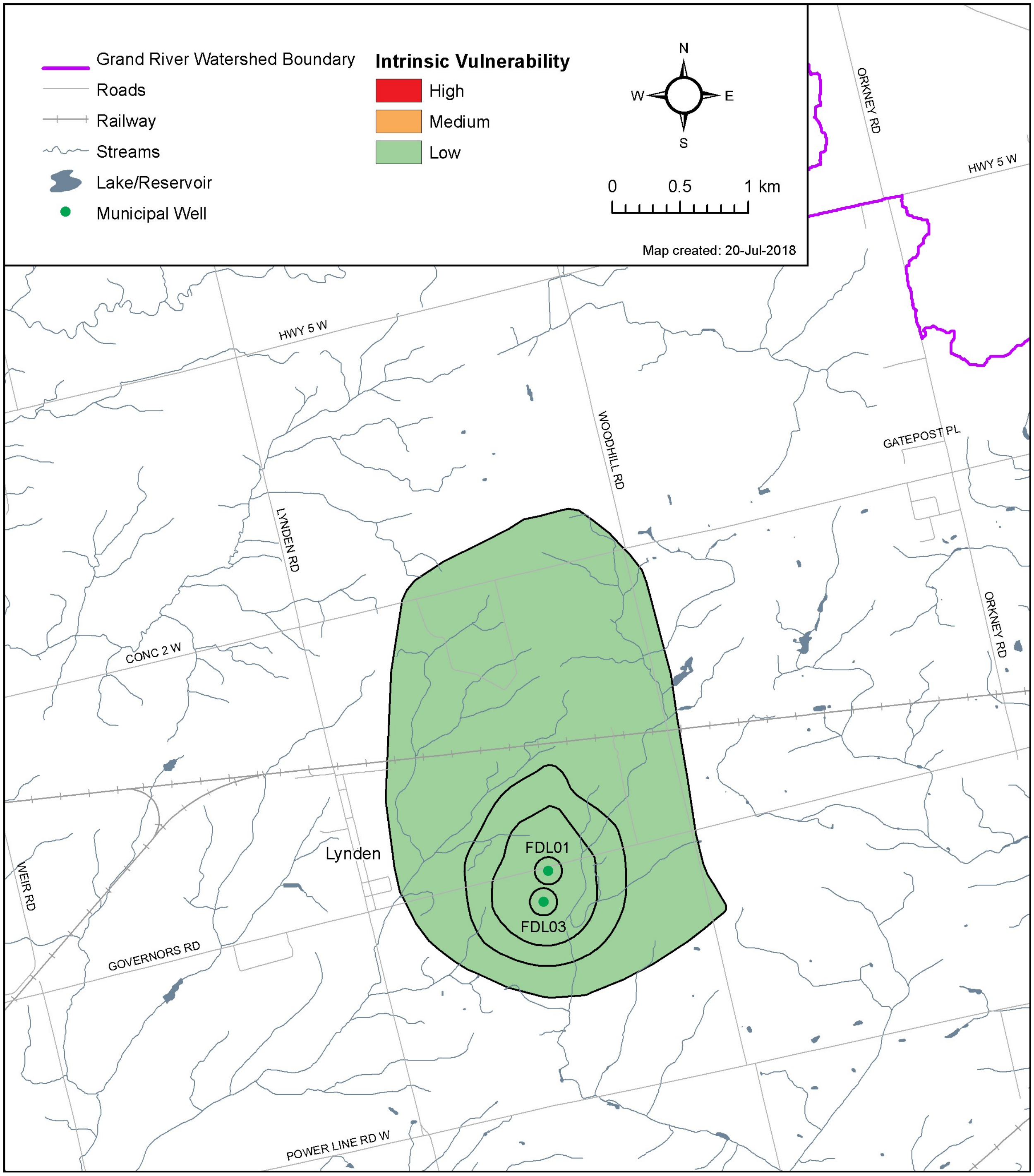
~~Uncertainties associated with the vulnerability score map are controlled largely by uncertainties associated with both the wellhead protection area modelling, and calculation of the aquifer vulnerability. A third source of uncertainty is the application of transport pathway information to modify the aquifer vulnerability, which in turn is used to modify the vulnerability scoring.~~

~~Since information on the presence or absence of transport pathways did not involve confirmatory site visits, the actual presence of the identified transport pathways is unknown. Therefore, the mapped extent of the area where these transport pathways exist is deemed conservative. Furthermore, the degree to which any transport pathway is contributing to reducing the natural protection of the overlying aquitard is difficult to assess. While there maybe some wells that are in poor condition and their presence do increase the vulnerability of the aquifer, it is likely that most of the former wells would not fall into this category.~~

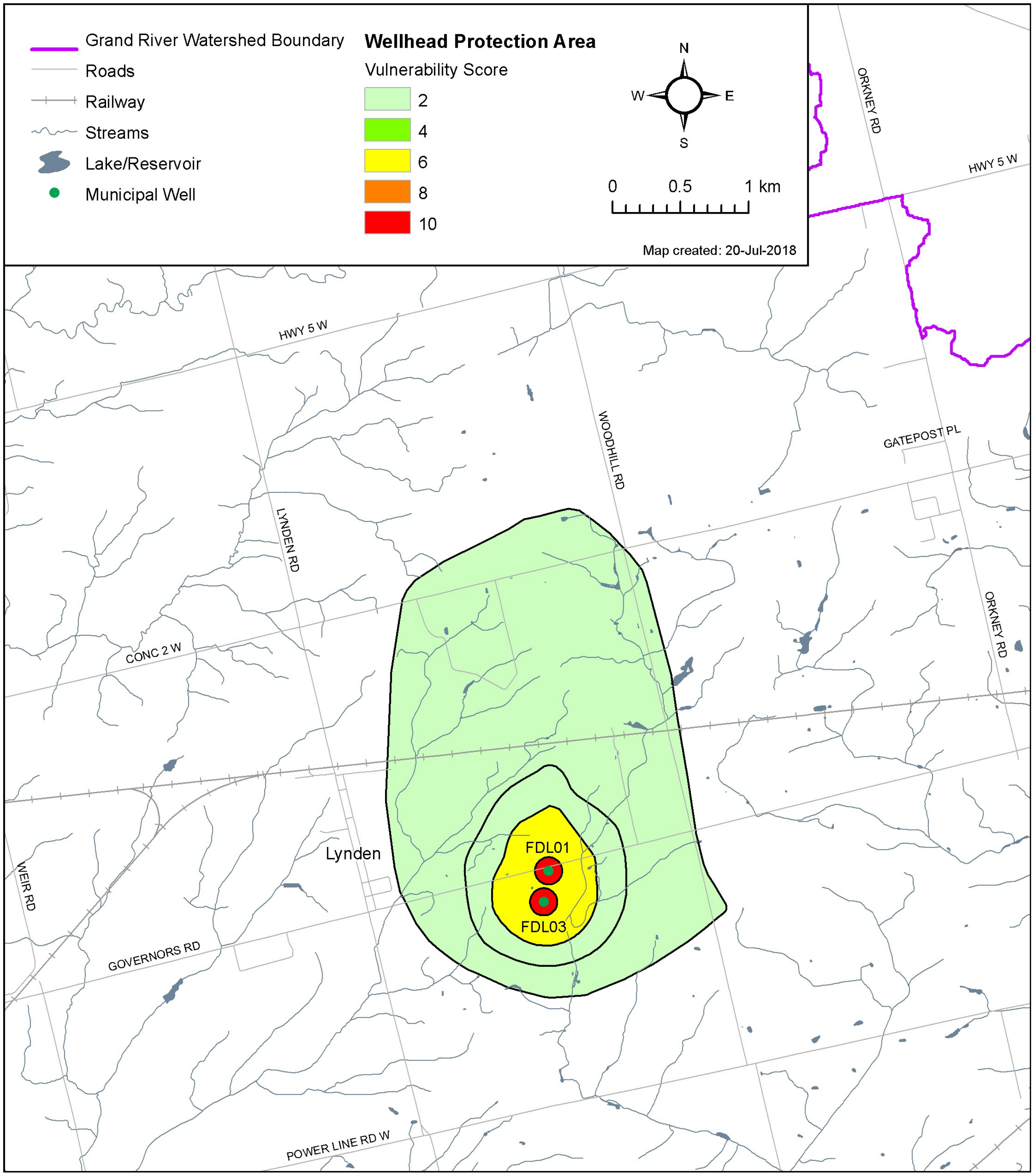
~~The identified data gap is the confirmation of the presence/absence of transport pathways on the identified properties. To fill this gap, site specific information could be obtained through site visits or surveys. The resulting data should be used to update the Transport Pathway map, and the Final Vulnerability Scoring Map, if necessary.~~

Based on the discussion above, the uncertainty associated with the vulnerability assessment is deemed “High”, as defined by the Technical Rules.

Map 12-3 Lynden Communal Well System Wellhead Protection Area ~~Initial~~ Intrinsic Vulnerability



Map 12-4: Lynden Communal Well System Wellhead Protection Area ~~Adjusted~~ Vulnerability



Managed Lands within the Lynden Wellhead Protection Area

~~Under the Technical Rules Part II, Rule 16 (9), the location and percentage of managed lands within the delineated WHPAs must be identified.~~ The Percent Managed Land Area analysis identifies lands to which nutrients are applied ~~(e.g., agricultural source material (ASM), fertilizer, non-agricultural source material (NASM))~~. The analysis categorizes managed lands into two groups: agricultural managed lands and non-agricultural managed lands. Agricultural managed lands include areas of cropland, fallow, and improved pasture that may receive nutrients. Non-agricultural managed lands include golf courses, sports fields, lawns and other built-up areas that may have received nutrients ~~(primarily~~such as commercial fertilizers~~)~~. ~~The methodology followed is based on the Ministry of the Environment Technical Bulletin, dated November 2009, describing the proposed methodology for calculating managed lands and livestock density. The Technical Bulletin requires the portion of a parcel that falls within the vulnerable area to be factored into the calculation. Calculations were completed only on areas where vulnerability is considered high enough for a threat to be present. This includes scores of 6 or higher for groundwater. Consequently, Wellhead Protection Areas C and D are excluded from the analysis since they exhibit scores below this threshold.~~The assessment of managed lands is only necessary for areas within a WHPA that have a vulnerability score of 6 or greater.~~areas of which some portion has been assigned a vulnerability score greater than or equal to 6.~~

~~Assessment parcels and MPAC property codes are used to identify parcels that belong to the agricultural managed lands category. Next, satellite imagery interpretation is used to adjust this area to exclude features within each parcel not considered managed lands, such as buildings, driveways, and forests.~~

~~Using a similar approach, features belonging to the non-agricultural managed lands category are delineated, such as residential lawns. The percent managed land area within a subset of a vulnerable area (e.g. WHPA-A / Score 10) is computed by summing the total area of agricultural managed land and non-agricultural managed land, dividing by the total land area within the area, and multiplying by 100.~~ The percentages of managed lands in the Lynden WHPA is high given the rural location of the wellfield. Managed lands were completed using the methodology outlined in Chapter ~~The~~ 3, with results of the managed lands calculations ~~are~~ presented in **Table 12-4** and **Map 12-5**.

Table 12-4: Percent Managed Lands in the Lynden Wellhead Protection Areas

Wellhead Protection Area	**Lynden FDL01**	**Lynden FDL03**
A	76%	100%
B	91%	
C	94%	
D	76%	

~~**Table 12-5: Percent Managed Lands in the Lynden Wellhead Protection Areas**~~

~~**Wellhead Protection Area**~~	~~**Total Area (Acres)**~~	~~**Agriculture Managed Lands**~~		~~**Non-Agriculture Managed Lands**~~		~~**Total Managed Lands**~~	
		~~**Area (Acres)**~~	~~**Percent**~~	~~**Area (Acres)**~~	~~**Percent**~~	~~**Area (Acres)**~~	~~**Percent**~~
~~WHPA-A~~	~~7.7~~	~~3.9~~	~~50.1%~~	~~1.9~~	~~24.0%~~	~~5.7~~	~~74.1%~~

~~WHPA-B~~	~~465.3~~	~~359.7~~	~~77.3%~~	~~15.0~~	~~3.2%~~	~~374.7~~	~~80.5%~~
~~WHPA-C~~	~~n/a~~	~~n/a~~	~~n/a~~	~~n/a~~	~~n/a~~	~~n/a~~	~~n/a~~
~~WHPA-D~~	~~n/a~~	~~n/a~~	~~n/a~~	~~n/a~~	~~n/a~~	~~n/a~~	~~n/a~~

Livestock Density within the Lynden Wellhead Protection Area

The Livestock Density analysis determines the intensity of livestock animals and is ~~the~~ a surrogate measure of the potential for gathering, storing and applying ~~ASM~~ agricultural source materials (ASM) as a ~~source of~~ nutrients source within ~~the~~ vulnerable areas. ~~Assessment parcels and MPAC property codes are initially used to identify parcels that have the potential to house farm animals in barns. Next, the confirmation of the presence and type of livestock was accomplished through a windshield survey, also noting the location of grazing land. The size of the buildings (with potential to house animals) and grazing yard is measured through satellite imagery interpretation. This measurement is then converted to a nutrient unit (NU) estimate using the Barn/Nutrient Relationship Table provided in the Technical Bulletin. The conversion table provides an average sq. m/nutrient unit ratio for each animal type. Next, the number of nutrient units is adjusted to reflect the requirements of the Technical Bulletin. In the case where a portion of the farm unit falls within a vulnerable area the NUs generated on the entire parcel of land should be factored into the calculations rather than the NUs generated within the portion of land that falls within the vulnerable area.This is accomplished by estimating nutrient units for the entire lot (or grazing land area) and then multiplying it by its proportion within the vulnerable area. Livestock density for land application of nutrients is expressed in nutrients per acre by summing the total nutrient units for all categories of poultry and livestock, divided by the total area of agricultural managed lands for the vulnerable area.~~

Based on ~~the~~ a windshield survey within the Lynden WHPA, it was determined that 'livestock density for grazing and pasture land' ~~is~~was not applicable to this analysis. This conclusion ~~i~~was based an interpretation of the windshield survey results ~~observed situations during the survey that~~ that suggested ~~that~~ most of the livestock permanently dwell in barns, and only occasionally use their grazing lands. Furthermore, the area of grazing lands appeared~~s~~ too small to serve as ~~a~~ permanent livestock dwelling areas. A summary of the calculated livestock density is presented in **Table 12-5** and **Map 12-6**.

Confirmation of the actual situations would require ~~a~~ site visits and interviews with property owners.

Table 12-5: Livestock Density (NU/Acre) in the Lynden ~~Wellhead Protection Areas~~WHPA

Wellhead Protection Area	Livestock Density (NU/Acre)	
	~~Application of Nutrients~~FDL01	~~Livestock Grazing or Pasturing~~FDL03
WHPA-A	0.2~~30~~	~~N/A~~0.0
WHPA-B	0.25~~7~~ ~~N/A~~	
WHPA-C	0.33~~00~~ ~~N/A~~	
WHPA-D	0.11~~00~~ ~~N/A~~	

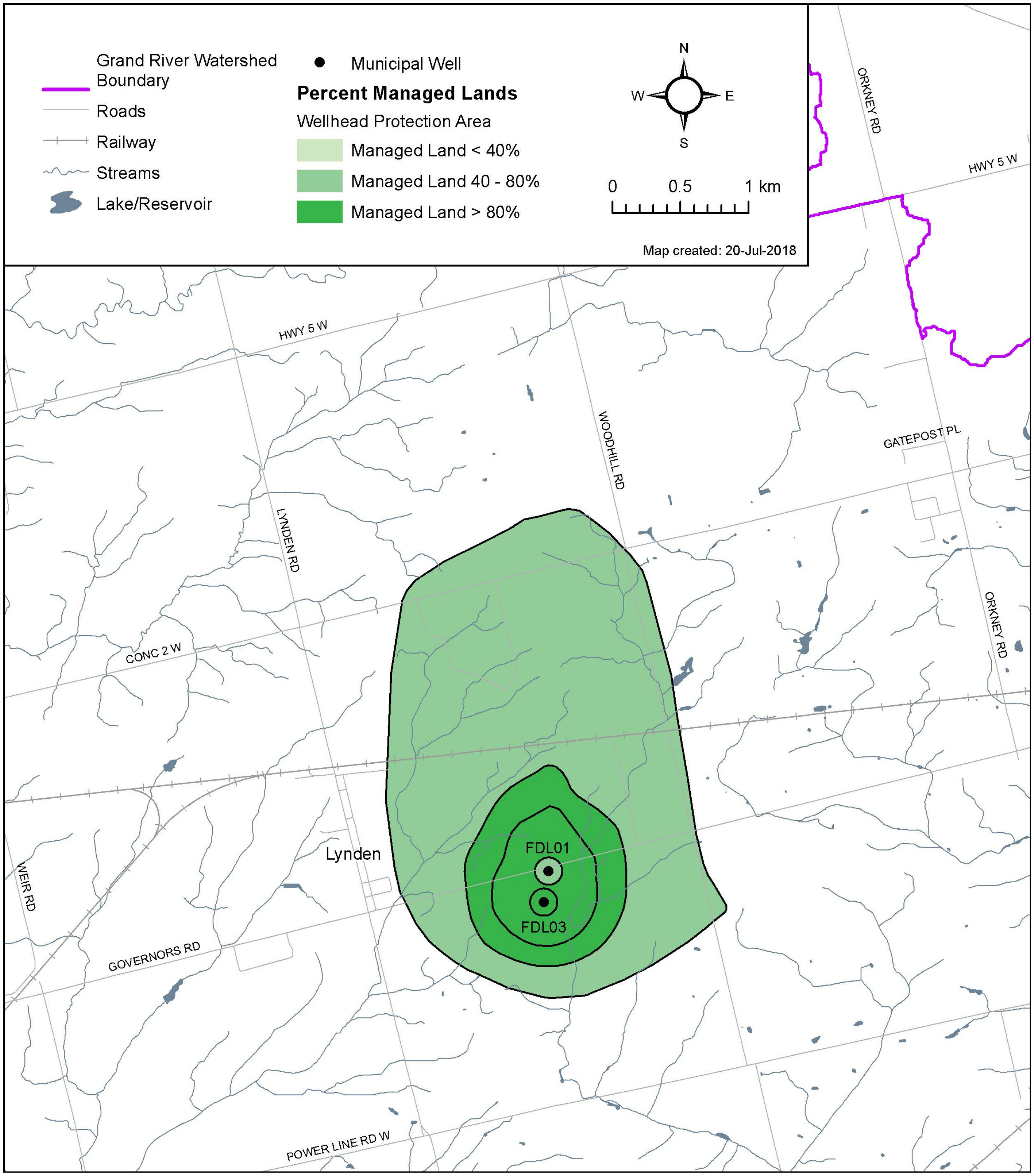
Percentage of Impervious Surface Area within the Lynden Wellhead Protection Areas

The Technical Rules 16(11) and 17 require the calculation and mapping of the percentage of total impervious surface area where road salt can be applied per square kilometre in each of the vulnerable areas. The resulting ~~is~~ impervious surface area maps ~~mapping is~~are ~~to be~~ used in the ~~MOE MECP~~water quality risk scoring and the assessment of threat circumstances relating to road salt application. Total impervious surface area is defined in the Technical Rules as the surface area of all highways and other impervious land surfaces used for vehicular traffic and parking, and all pedestrian paths. The method used to calculate impervious surfaces for the Lynden WHPAs is the 1x1 km grid and detailed in Section 3 of the Assessment Report.

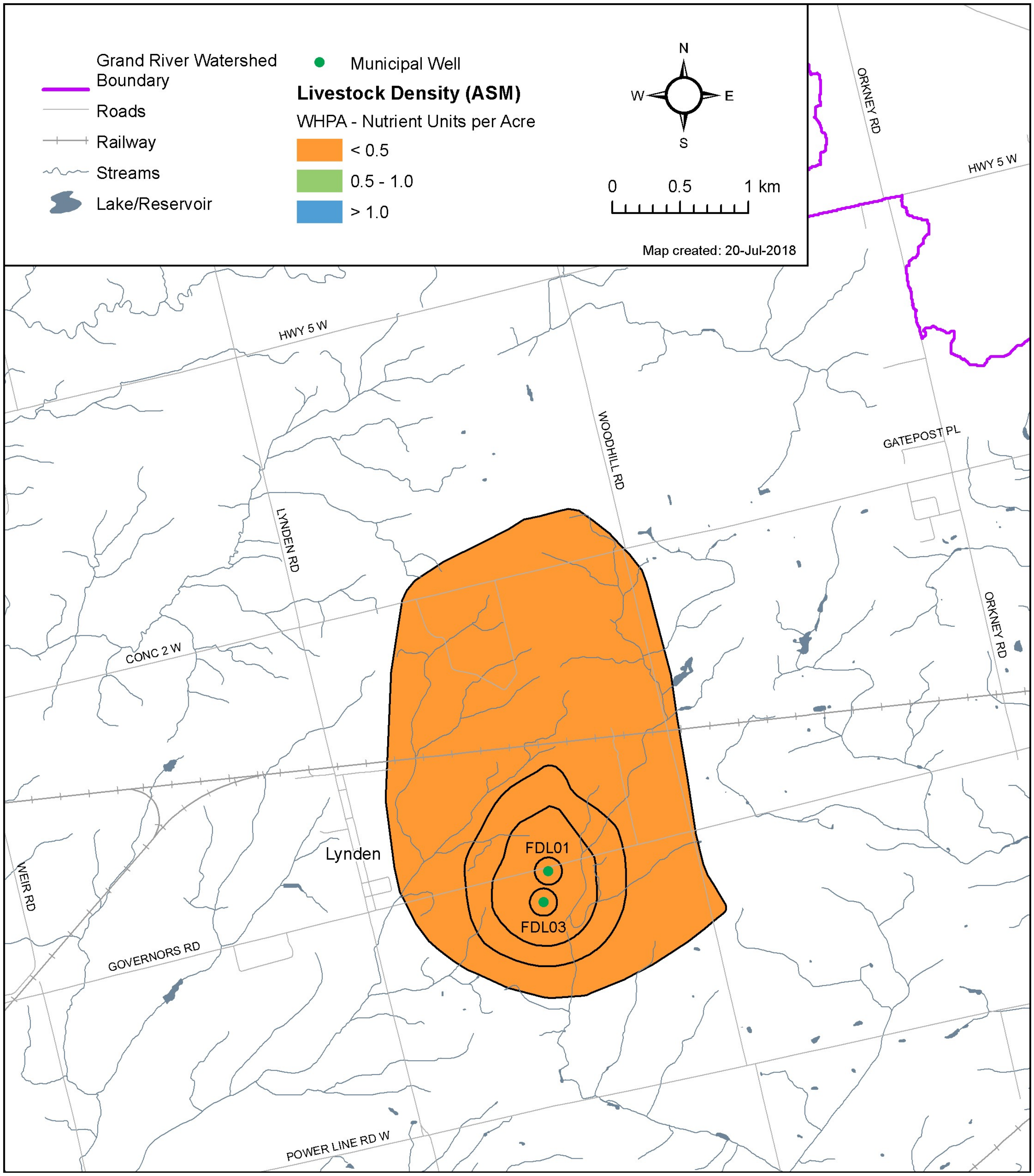
The results of the assessment are presented ~~in~~ on **Map 12-7.** The~~ and where~~ percent impervious surface area ~~range from 0are~~is a combination of the '<1%' and '1% to <8%' classification categories ~~(~~within the WHPAs~~all Wellhead Protection Areas) to 3.6% in WHPA-C~~.~~,~~ A thin area on the outer western edge of the WHPA-D is classified as '8% to <80%' percent impervious surface.

Overall, the error associated with the analysis is deemed low since the lands are predominantly agricultural in use with ~~little~~ few impervious surface features~~ expected~~.

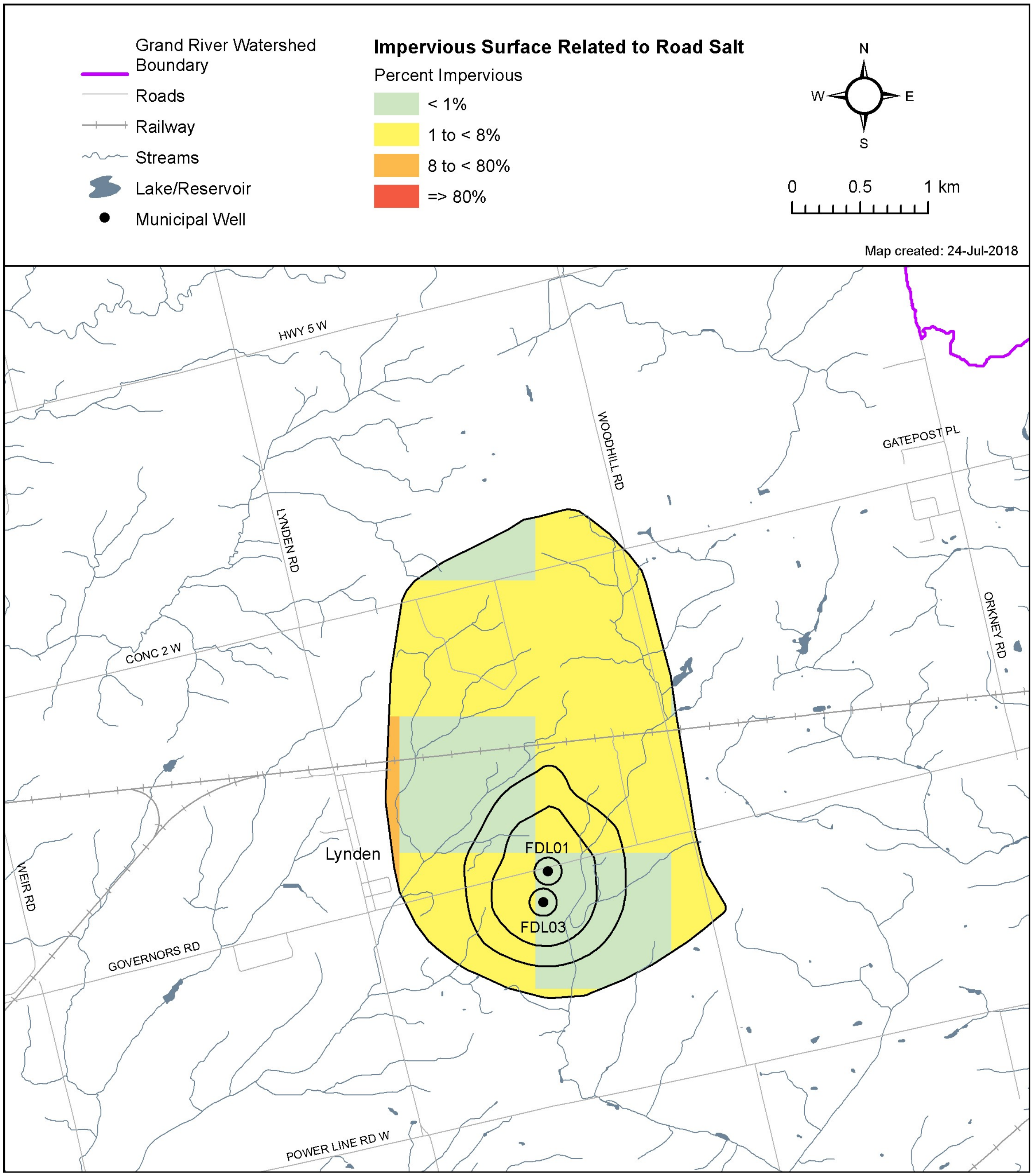
Map 12-5: Lynden Communal Well System Percent Managed Lands



Map 12-6: Lynden Communal Well System Livestock Density



Map 12-7: **Lynden Communal Well System Percent Impervious Surfaces**



~~12.1.3~~12.1.2 Lynden Drinking Water Quality Threats Assessment

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."

~~The Technical Rules (MOE, 2009) 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).~~

~~*Activities that Are or Would be Drinking Water Quality Threats in the Wellhead Protection Areas*~~

~~Ontario Regulation 287/07, pursuant to the *Clean Water Act*, provides a list of Prescribed Drinking Water Quality Threats that could constitute a threat to drinking water sources. **Table 13-7** lists the activities that are prescribed as water quality related prescribed drinking water threats. Listed beside the prescribed drinking water threats are the typical land use activities that are associated with the threat.~~

~~In addition, there is one local threat that has been identified in the Lake Erie Source Protection Region: the transportation of oil and fuel products through a pipeline.~~

~~A spill of oil and fuel products could result in the presence of petroleum hydrocarbons or BTEX in groundwater. The conveyance of oil by way of an underground pipeline that would be designated as transmitting or distributing "liquid hydrocarbons", including "crude oil", "condensate", or "liquid petroleum products", and not including "natural gas liquids" or "liquefied petroleum gas", within the meaning of Ontario Regulation 210/01 under the *Technical Standards and Safety Act* or is subject to the *National Energy Board Act,* was approved as a local threat. The letter of approval from the Director of the Source Protection Programs Branch and table of hazard ratings is found in **Appendix D**.~~

~~**Table 12-7: Drinking Water Quality Threats**~~

~~**Prescribed Drinking Water Quality Threat**~~ ~~Ontario Regulation 287/07 s.1.1.(1)~~		~~**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~~

~~Table 12-7: Drinking Water Quality Threats~~

~~Prescribed Drinking Water Quality Threat~~ ~~Ontario Regulation 287/07 s.1.1.(1)~~		**~~Land Use / Activity~~**
~~2~~	~~The establishment, operation or maintenance of a system that collects, stores, transmits, treats or disposes of sewage.~~	~~Sewage Infrastructures~~ ~~Septic Systems, etc.~~
~~3~~	~~The application of agricultural source material to land.~~	~~e.g. manure, whey, etc.~~
~~4~~	~~The storage of agricultural source material.~~	~~e.g. manure, whey, etc.~~
~~5~~	~~The management of agricultural source material.~~	~~aquaculture~~
~~6~~	~~The application of non-agricultural source material to land.~~	~~Organic Soil Conditioning~~ ~~Biosolids~~
~~7~~	~~The handling and storage of non-agricultural source material.~~	~~Organic Soil Conditioning~~ ~~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~~
~~Local Drinking Water Threat~~		**~~Land Use / Activity~~**
~~The conveyance of oil by way of an underground pipeline that would be designated as transmitting or distributing "liquid hydrocarbons", including "crude oil", "condensate", or "liquid petroleum products", and not including "natural gas liquids" or "liquefied petroleum gas", within the meaning of the Ontario Regulation 210/01 under the *Technical Standards and Safety Act* or is subject to the *National Energy Board Act*.~~ [1]		~~Oil pipeline~~

~~1: As confirmed by the letter from the Director of the Source Protection Programs Branch in Appendix D.~~

Identification of Significant, Moderate and Low Drinking Water Quality Threats for the Lynden Communal Well System

Table 12-6 provides a summary of the threat levels possible in the ~~Dundalk~~Lynden WHPAs ~~Well Supply~~ for Chemicals, ~~,~~ Dense Non-Aqueous Phase Liquids (DNAPLs)~~,~~ and Pathogens. A checkmark indicates possible ~~that~~ the threat classification level ~~is possible f~~for the indicated threat type under the corresponding vulnerable area / vulnerable score; a blank cell indicates that it is not. The colours shown for each vulnerability score correspond to those shown in **Map 12-4.**

~~The identification of a land use activity as a significant, moderate, or low drinking water threat depends on its risk score, determined by considering the circumstances of the activity and the type and vulnerability score of any underlying protection zones, as set out in the Tables of Drinking Water Threats available through www.sourcewater.ca. Information on drinking water threats is also accessible through the Source Water Protection Threats Tool: http://swpip.ca. For local threats, the risk score is calculated as per the Director's Approval Letter, as shown in **Appendix C**. The information above can be used with the vulnerability scores shown in **Map 13-7** to help the public determine where certain activities are or would be significant, moderate and low drinking water threats.~~

~~**Table 13-8** provides a summary of the threat levels possible in the Lynden Well System for Chemical, Dense Non-Aqueous Phase Liquid (DNAPL), Pathogen, and Local Threats (Oil Pipelines). A checkmark indicates that the threat classification level is possible for the indicated threat type under the corresponding vulnerable area / vulnerable score; a blank cell indicates that it is not. The colours shown for each vulnerability score correspond to those shown in **Map 13-7**.~~

Table 12-6: Identification of Drinking Water Quality Threats in the Lynden Wellhead Protection Areas

Threat Type	Vulnerable Area	Vulnerability Score	Threat Classification Level		
			Significant 80+	Moderate 60 to <80	Low >40 to <60
Chemicals	WHPA-A	10	✓	✓	✓
	WHPA-B	6		✓	✓
	WHPA-C/D	2			
Handling / Storage of DNAPLs	WHPA-A/B/C	Any Score	✓		
	WHPA-D	2			
Pathogens	WHPA-A	10	✓	✓	
	WHPA-B	6			✓
	WHPA-C/D	Any Score			

Enumeration of Significant Drinking Water Quality Threats for the Lynden Communal Well System

The number of significant Prescribed Drinking Water Threats identified by EarthFX (2018) are tabulated in **Error! Reference source not found.**. A total of 26 significant threats, 5 moderate and 33 low level threats were identified within the Lynden WHPA. Significant threats were primarily associated with agricultural activities in the area, the use of septic systems and handling, and storage of fuel associated with residential dwellings.

Table 12-7: Significant Drinking Water Quality Threats for the Lynden Communal Well System (current to the year 2018)

PDWT[1] #	Threat Subcategory[2]	Number of Activities	Vulnerable Area
2	Sewage System Or Sewage Works – Onsite Sewage Systems	5	WHPA-A
3	Application Of Agricultural Source Material (ASM) To Land	6	WHPA-A
9	Storage Of Commercial Fertilizer	2	WHPA-A
10	Application Of Pesticide To Land	6	WHPA-A
15	Handling and Storage Of Fuel	6	WHPA-A
21	The use of land as livestock grazing or pasturing land, an outdoor confinement area or farm –animal yard. O. Reg.385/08, s. 3.	1	WHPA-A
Total Number of Activities		**26**	
Total Number of Properties		**7**	

1: Prescribed Drinking Water Quality Threat Number refers to the prescribed drinking water threat listed in O.Reg 287/07 s.1.1.(1).

2: Where applicable, waste, sewage, and livestock threat numbers are reported by sub-threat; fuel and DNAPL by Prescribed Drinking Water Threat category

Note: Storm sewer piping is not considered to be part of a storm water management facility.

~~12.1.4 Conditions Evaluation~~

~~Conditions are contamination that already exist and are a result of past activities that could affect the quality of drinking water. To identify a Condition, Part XI.3, Rule 126 of the Technical Rules lists the following two criteria for groundwater sources:~~

- ~~The presence of a non-aqueous phase liquid in groundwater in a highly vulnerable aquifer, significant groundwater recharge area or wellhead protection area.~~
- ~~The presence of a contaminant in groundwater in a highly vulnerable area, significant groundwater recharge area or a wellhead protection area, if the contaminant is listed in Table 2 of the Soil, Groundwater and Sediment Standards and is present at a concentration that exceeds the potable groundwater standard set out for the contaminant in that Table.~~

~~The above listed criteria were used to evaluate potentially contaminated sites within the WHPAs to determine if such a Condition was present at a given site.~~

Conditions Evaluation for the Lynden Communal Well Supply

After review of several databases and a discussion with municipal staff, there is no evidence of a Condition for the Lynden Communal Well Supply. It is possible that condition-related drinking water threats do exist; however, no data is available to either confirm or refute this possibility.

Limitations and Uncertainty of the Enumeration of Significant Drinking Water Quality Threats for the Lynden Communal Well System

No significant data gaps were encountered during the identification of significant drinking water threats. There was a general lack of information on the presence/absence of contamination associated with historical land uses. As a result, no condition-related drinking water threats (if present) were identified. In addition, the type and amounts of chemicals stored/used/applied at the agricultural operations within the wellhead protection areas is unknown. In the absence of site-specific information, a conservative approach was taken, namely the assumption that all chemicals/materials that are commonly used in a given land use type are present.

The level of uncertainty associated with the threats asessment was classified as high (Earthfx, 2018). The level of uncertainty could be reduced by contacting the owners of the properties within the WHPA to confirm storage and application quantities and to identify any mitigation or containment measures that may be in place to reduce potential impacts to drinking water quality.

~~12.1.5 Drinking Water Quality Issues Evaluation~~

~~The objective of the Issues evaluation is to identify drinking water Issues where the existing or trending concentration of a parameter or pathogen at an intake, well or monitoring well would result in the deterioration of the quality of water for use as a source of drinking water. The parameter or pathogen must be listed in Schedule 1, 2 or 3 of the Ontario Drinking Water Quality Standards (ODWQS) or Table 4 of the Technical Support Document for Ontario Drinking Water Standards, Objectives and Guidelines (Technical Rules XI.1 (114 – 117)).~~

~~Once 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 and manage these threats appropriately. If at this time the Issue Contributing Area can not be identified or the Issue can not be linked to threats then a work plan must be provided to assess the possible link.~~

~~If an Issue is identified for an intake, well or monitoring well, then all threats related to a particular Issue within the Issue Contributing Areas are as significant drinking water threats, regardless of the vulnerability.~~

~~12.1.6~~12.1.3 Water Quality Issues Evaluation for the Lynden Communal Well Supply

The Issues evaluation focused on the water quality parameter groupings outlined in the Ontario Drinking Water Quality Standards (ODWQS). These include: a) Pathogens, b) Schedule 1 parameters, c) Schedule 2 and 3 parameters and, d) Table 4 parameters. In addition to these parameters, the Source Protection Committee may identify other parameters that are to be evaluated; however, to date, no additional parameters have been selected.

~~Assessment of the possible Issues related to the raw water quality at the municipal water system, was conducted following a two-step screening and evaluation process. This process involved the comparison of available water quality information to water quality benchmarks and other comparison criteria. The first step was a screening evaluation, where parameters were flagged for further scrutiny based largely on their concentration relative to the ODWQS and whether the operator identifies the parameter as a concern. Flagged parameters were then further evaluated relative to degree, duration and frequency of ODWQS exceedances, water treatment capacity, and opinion of operating authority.~~

~~Numerous sources of data have been used for this analysis, where available, to review the current and historical water quality for the well system in question. Available Annual Drinking Water System Reports (2003-2008) and quarterly reports (2009) for the Lynden Well Supply were reviewed and scrutinized. These reports summarize the results of testing completed during the reporting year for the municipal system. Reported parameters include Schedules 1, 2 and, 3 and Table 4 parameters, along with other parameters that may be individually important to a specific well. Additional information, such as treatment method, system improvements and any breakdowns in the treatment equipment are also available in the annual reports.~~

Drinking water issues were evaluated for the Lynden Communal Well System by reviewing the available water quality data (EarthFX, 2018). ~~The reviewed information consists of the following:~~

No known pathogens ~~have been~~were detected based on ~~the~~ available test results for the Lynden Communal Well System.

No Schedule 2 or 3 parameters were ~~have been noted~~identified as potential or actual Issues based on a review of the available raw water quality information.

It should be noted~~, however,~~ that the City of Hamilton has reported ~~that~~the detection of lead ~~has been detected~~ a number of times within the Lynden distribution system ~~in Lynden~~. The operator ~~has~~ reported that "*Turbidity is caused by colloidal sulphur, a byproduct of the reaction between hydrogen sulfide and chlorine. The colloidal sulfur acts as a scavenger and concentrates very low levels (close to non~~e~~-detect) of lead in the raw water. The sulphur precipitate therefore contains significant levels of lead. So long as the precipitate stays at the bottom of the tank it does not cause problem in the distribution system*." Since the concentration of lead is a by-product of the treatment and not a parameter of the raw water, lead has not been identified as an Issue under Technical Rule 114.

Between the period of 2003 and ~~2008~~2017, there were ~~313~~ 756 reported raw water samples collected and analyzed for *E.coli*, total coliforms, and background colonies. There were no instances of *E.coli* and ~~no instances of~~ or total coliforms in any of the reported raw water samples.

Since 2005, there have been multiple reported water samples ~~that contain~~with sodium concentrations greater than ~~above~~ the 20 mg/L Medical Officer of Health notification level. None of these ~~reports~~ samples exceeded the 200 mg/L ODWQS aesthetic objective. Concentrations reported at greater than 20 mg/L occurred in in 2005 and again between 2007 and 2017. ~~The m~~Maximum reported sodium concentrations ~~(~~of 67 mg/L~~)~~ ~~was~~ occurred in 2005 and again in 2007. ~~Concentrations have been reported at greater than 20 mg/L in 2005 and 2007-200179.~~ Data ~~for~~between the years of 2007~~-~~ and 2017~~09~~ is only available as a range. Both the upper and lower bounds of the sodium concentration range exceeded 20 mg/L. Sodium is deemed to be naturally occurring in the groundwater and is not classified as an Issue under Technical Rule 114.

Based on ~~the~~ historical data ~~from~~dating from 2005 to 2008, ~~the~~ raw water turbidity for the Lynden ~~well~~ system ranges between 0.26 and 3.77 NTU. More recent raw water turbidity for the Lynden ~~well~~system ranges between 0.07 to 0.66 NTU, with one maximum value in 2015 of 2.30 NTU. The maximum reported values for the ranges reported between 2003 and ~~2005~~ 2017 never exceeded the aesthetic objective of 5 NTU (as measured at point of consumption). ~~Since the data is only available as a range, no trend can be determined at this time.~~ The higher reported values prior to 2006 may be related to reporting protocol at the time that required reporting of all turbidity spikes including those noted during well startup. This parameter should continue to be monitored, as there is no filtration incorporated in this water system, and increasing turbidity can possibly hinder the disinfection process.

Summary of Water Quality Issues Evaluation of the Lynden Communal Well System

There are no identified Issues for the Lynden Communal Well Supply.

Sodium concentrations regularly exceeded the local Medical Officer of Health notification level of 20 mg/L but have not been reported to be above 50% of the ODWQS MAC. The sodium present in the Lynden Communal Well System is deemed to be naturally occurring in the groundwater and is not identified as an Issue.

Turbidity has ~~also~~ been noted as a concern for continued monitoring. ~~Like~~ Similar to sodium, turbidity is classified as likely having a natural source.

The City of Hamilton has reported the presence of ~~that~~ lead ~~has been detected~~ within the distribution system, ~~. The cause of the lead~~which is ~~reported to be~~ a by-product of the treatment process where lead-containing sulphur precipitate ~~(containing lead)~~ has become~~s~~ mobilized. It ~~is~~was reported that as long as the precipitate ~~stays~~remains at the bottom of the treatment tank, there is no problem in the distribution system. Since the ~~concentration~~presence of lead is a by-product of the water treatment process, rather than ~~being present at elevated concentrations~~ within the raw water, it is not identified as an Issue under Technical Rule 114. Furthermore there are plans for a new treatment and pumping station to be built in order to replace the existing one and to service the two wells (FDL-01 and FDL-03) (WSP, 2017).

Limitations and Uncertainty of the Water Quality Issues Evaluation

The results of this assessment are based on the review of ~~the available~~ data available at the time of the assessment (EarthFX, 2018). This was~~, which is~~ generally limited to water system annual reports. Overall, the number of tested parameters for raw water quality is limited. Since sampling and analysis is not part of this review, the analysis and conclusions drawn herein can only be based on previous data obtained by others. This analysis can also not comment on the method by which these samples were obtained or as to the laboratories used in the analysis. Any errors in data reporting or analysis associated with the referenced reports will be unknowingly carried forward through this analysis.

Data for the years between 2003 and ~~2008~~ 2017 were reviewed. Therfore the analysis of any ~~, and the potential to review any~~ trends in the data ~~is~~was limited to this time span. Nevertheless, the reviewed data ~~i~~was deemed adequate for the purpose of this assessment, and no significant data gaps ~~are~~were identified.

~~12.1.7 Enumeration of Significant Drinking Water Threats~~

~~While any of the activities in **Table 13-7** could pose a threat to drinking water, the MOE recognizes that these prescribed activities would only pose a threat under certain circumstances. Therefore, elaboration regarding the specifics of these Prescribed Drinking Water Threats (PDWT) has been provided in Tables 1 & 2 of the MOE Technical Rules (November, 2009). Tables 1 & 2 list detailed circumstances set forth for each PDWT that may result in the threat being classified as posing a low, moderate or significant risk, based on the vulnerability scores of the area in which they occur (columns 4, 5, and 6, respectively). The~~

~~circumstances often involve factors associated with the type of contaminant, its volume and consideration of the likelihood of release.~~

~~*Data Sources for the Enumeration of Significant Drinking Water Quality Threats*~~

~~Windshield surveys were conducted to gain information on current land uses and to confirm the land use and location of potential drinking water threats identified from other data sources. The survey was conducted in the Fall of 2009 and the Spring of 2010, and involved viewing land parcels from public thoroughfares to visually identify potential threats. Windshield surveys were the main source of data for identification of threats related to agriculture (manure, fertilizer and pesticide use), type of farm, cemeteries and storm water management ponds. For agriculture land uses, farmsteads were highlighted as potential areas for fuel, pesticide, fertilizer and/or manure storage.~~

~~Information on historic and existing land uses that involved the storage of potential contaminants were obtained primarily from Provincial, Federal and commercial databases listed below. These databases were provided through a third-party vendor, EcoLog ERIS.~~

~~*Government Databases*~~

- ~~Federal Contaminated Sites: June 2000-Sept 2002~~
- ~~MOE Spills Database (Occurrence Reports)~~
- ~~Ontario Inventory of PCB Storage Sites~~
- ~~O. Reg 347 - Waste Generators Summary~~
- ~~O. Reg 347 - Waste Receivers Summary~~
- ~~Private Fuel Storage Tanks (TSSA)~~
- ~~Inventory of Coal Gasification Plants (MOE)~~
- ~~Pesticide Register (MOE)~~
- ~~Wastewater Discharger Registration Database (MOE)~~
- ~~Sewage Treatment Plants (MOE)~~
- ~~Certificates of Approval (MOE)~~
- ~~Waste Disposal Site Inventory (MOE)~~
- ~~DataHounds (MOE)~~
- ~~Record of Site Condition Registry (MOE)~~

~~*Commercial Databases*~~

- ~~Retail Fuel Storage Tanks~~
- ~~Anderson's Waste Disposal Sites~~
- ~~Scott's Manufacturing Directory~~
- ~~Automobile Wrecking & Supplies~~

~~***Limitations and Uncertainty of the Enumeration of Significant Drinking Water Quality Threats for the Lynden Communal Well System***~~

~~No significant data gaps were encountered during the identification of significant drinking water threats. There was a general lack of information on the presence/absence of contamination associated with historical land uses. As a result, no condition-related drinking water threats (if present) were identified. In addition, the type and amounts of chemicals stored/used/applied at the agricultural operations within the wellhead protection areas is unknown. In the absence of site-specific information, a conservative approach was taken, namely the assumption that all~~

~~chemicals/materials that are commonly used in a given land use type are present. Only through site visits and interviews with the property owners could the type and quantity of chemicals/ pathogen containing materials be confirmed.~~

~~The level of uncertainty associated with the threats asessment has been classified as high (Earthfx, 2018). The level of uncertainty could be reduced by contacting the owners of the properties within the WHPA to confirm storage and application quantities and to identify any mitigation or containment measures that may be in place to reduce potential impacts to drinking water quality.~~

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13.0 CITY OF HAMILTON – LYNDEN RURAL SETTLEMENT AREA

The following City of Hamilton- Lynden Rural Settlement Area Source Protection Plan policies apply to the Lynden Communal Well System as presented in Schedule A. Policies which apply to the City of Hamilton outside of the Grand River Watershed can be found in the Halton-Hamilton and Niagara Peninsula Source Protection Plans.

13.1 Definitions

General definitions are provided in Volume I of the Source Protection Plan or in the *Clean Water Act, 2006.* Defined terms are intended to capture both the singular and plural forms of these terms.

The following definitions shall apply to the City of Hamilton (Lynden Rural Settlement Area) Source Protection Policies.

Existing Threat – means an activity that commenced or has been engaged in at a location in a vulnerable area within ten (10) years prior to the Source Protection Plan taking effect where there would be a drinking water threat. It includes any expansion of the activity only on the same parcel of land.

Future Threat – means any activity in a vulnerable area where there could be a drinking water threat that is not defined as an existing threat within this Source Protection Plan.

13.2 City Of Hamilton – Lynden Rural Settlement Area Source Protection Plan Policies

Policy Number	Source Protection Plan Policies within Lynden Rural Settlement Area
Implementation Timing Policies	
CH-CW-1.1 *Implement. & Timing*	Except as set out below, the policies contained in this Source Protection Plan shall take effect on the date set out by the Minister. a. For Section 58 of the *Clean Water Act*, *2006,* if an activity was engaged in at a particular location before this Source Protection Plan took effect and the Risk Management Official gives notice to a person who is engaged in the activity at that location that, in the opinion of the Risk Management Official, policies regarding regulated activities should apply to the person who engages in the activity at that location on and after a date specified in the notice that is at least 120 days after the date of the notice; b. For Section 59 of the *Clean Water Act*, *2006,* policies regarding restricted land uses shall take effect the same day the Source Protection Plan takes effect; c. Where the Source Protection Policies require the City of Hamilton to develop and implement education and outreach programs as the primary tool for managing or eliminating a particular significant threat, such programs shall be developed and implemented within five (5) years from the date the Source Protection Plan takes effect; d. For Sections 43 of the *Clean Water Act, 2006,* if an activity was engaged in at a particular location before this Source Protection Plan took effect, amendments to Prescribed Instruments shall be completed within three (3) years from the date the Source Protection Plan takes effect; and, e. For Section 40(2) and 42 of the *Clean Water Act*, *2006,* the Official Plan

Policy Number	Source Protection Plan Policies within Lynden Rural Settlement Area
	and Zoning By-Laws must be amended to conform with the significant threat policies and adopted by municipal council by the next five (5) year Official Plan update as required under subsection 26(1) of the *Planning Act* or within five (5) years from the date the Source Protection Plan takes effect.
Uses and Areas Designated as Restricted Land Uses	
CH-CW-1.2 *Part IV- RLU*	In accordance with Section 59 of the *Clean Water Act*, *2006,* all land uses, unless identified specifically within a policy, where significant drinking water threat activities have been designated for the purpose of Section 57 or 58 of the *Clean Water Act, 2006* are hereby designated as Restricted Land Uses and a written notice from the Risk Management Official shall be required prior to approval of any Building Permit, *Planning Act* or *Condominium Act* Application.
Land Use Planning	
CH-MC-1.3 *Future Land Use Planning*	The City of Hamilton shall amend their Official Plan and/ or Zoning By-Laws to: a. Identify the vulnerable areas in which drinking water threats prescribed under the *Clean Water Act, 2006* would be significant; b. Indicate that within the areas identified, any use or activity that is, or would be, a significant drinking water threat is required to conform with all applicable Source Protection Plan policies and, as such, may be prohibited, restricted or otherwise regulated by those policies; c. Incorporate any other amendments required to conform to the threat specific land use policies identified in this Source Protection Plan.
Annual Reporting	
CH-CW-1.4 *Monitoring*	The City of Hamilton shall provide a report to the Source Protection Authority, by February 1st of each year, summarizing the actions taken to implement the Source Protection Plan policies.
CH-CW-1.5 *Monitoring*	Where the City of Hamilton is required to amend their Official Plan and/or Zoning By-law to bring their planning documents into conformity with the Source Protection Plan, the City of Hamilton shall provide proof of compliance to the Source Protection Authority and shall provide a copy of such compliance within 30 days of final adoption of the amendment(s).
CH-CW-1.6 *Monitoring*	The Risk Management Official shall provide a report to the Source Protection Authority, by February 1st of each year, summarizing the actions taken by the Risk Management Official to implement the Source Protection Policies, in accordance with the *Clean Water Act, 2006* and associated regulations.
CH-CW-1.7 *Monitoring*	Where the Source Protection Plan policies require a provincial ministry to amend a Prescribed Instrument or issue a new Prescribed Instrument, the applicable Ministry shall provide a summary of any actions taken and/or conditions imposed. The applicable ministry shall provide a written report summarizing this information to the Source Protection Authority by February 1st of each year.
CH-CW-1.8 *Monitoring*	Where the Source Protection Plan policies require a provincial ministry to deny a Prescribed Instrument, the applicable Ministry shall summarize the actions taken the previous year to implement the policies and provide a written report summarizing this information to the Source Protection Authority by February 1st of each year.

Policy Number	**Source Protection Plan Policies within Lynden Rural Settlement Area**
~~Local Threat: The Conveyance of Oil by way of Underground Pipelines~~	
~~CH-NB-1.9~~ ~~*Future*~~ ~~*Specify Action*~~ ~~*WHPA-A-v.10*~~ ~~*Monitoring*~~	~~To reduce the risk due to the conveyance of oil by way of underground pipes within the meaning of O. Reg. 210/01 under the *Technical Safety and Standards Act* or that is subject to the *National Energy Board Act,* where this activity would be a significant drinking water threat, the pipeline proponent, the National Energy Board and the Ontario Energy Board are encouraged to provide the Source Protection Authority and the City the location of any new proposed pipeline within the City and/or Source Protection Area.~~ ~~The Source Protection Authority shall document in the annual report the number of new pipelines proposed within vulnerable areas~~
Strategic Action	
Spill Prevention, Spill Contingency or Emergency Response Plans	
CH-NB-1.10 *Future* *Specify Action*	To ensure the protection of drinking water sources with respect to spills that occur within a wellhead protection area along highways, railway lines, or shipping lanes, the City of Hamilton and the ~~Ministry of the Environment~~ Ministry of the Environment, Conservation and Parks are encouraged to incorporate the Wellhead Protection Area mapping into their Emergency Response Plan and Spills Action Centre mapping, respectively.
CH-NB-1.11 *Future* *Specify Action*	The City of Hamilton is requested to implement an education and outreach program to encourage all transportation businesses that ship goods through wellhead protection areas to prepare spill prevention plans and spill contingency plans, to review these plans annually, and to update them, as required.
Transport Pathways	
CH-NB-1.12 *Existing/Future* *Specify Action*	To achieve the intent of the *Clean Water Act*, *2006* that drinking water threats identified in the vicinity of a transport pathway cease to be or do not become a significant threat, and that a pathway ceases to endanger the source water of a municipal water supply, the following policies apply: a. The City of Hamilton is requested to use best management practices to protect the quantity and quality of groundwater sources during the installation of new municipal infrastructure in proximity to municipal water wells. b. The City of Hamilton is requested to incorporate conditions of approval for development applications to ensure private wells that are no longer in use are decommissioned in accordance with O. Reg. 903. c. The ~~Ministry of the Environment~~ Ministry of the Environment, Conservation and Parks and the municipalities responsible for water services are requested to provide ongoing funding for incentive programs focused on the decommissioning of wells, and for education and outreach programs regarding the decommissioning of wells. d. If funding is provided by the ~~Ministry of the Environment~~ Ministry of the Environment, Conservation and Parks through the Ontario Drinking Water Stewardship Program, the Conservation Authority shall implement an incentive program to decommission unused wells. e. The City of Hamilton is requested to develop a program to facilitate, where possible and appropriate, the connection to municipal water services of

Policy Number	Source Protection Plan Policies within Lynden Rural Settlement Area
	current private well users within the urban boundary. The users should be required to decommission the unused wells in accordance with O. Reg. 903. f. The City of Hamilton is requested to prohibit the construction of new wells and ~~septic~~onsite sewage systems within the urban area where municipal water and wastewater services are available. g. The City of Hamilton is requested to prepare bylaws/procedures/ processes that ensure the construction of closed loop, earth energy systems will not result in the establishment of transport pathways.
Interpretation	
CH-CW-1.13 *Interpretation of Source Protection Plan*	The Source Protection Plan provides policies to meet the objectives of the *Clean Water Act, 2006*. The Source Protection Plan consists of the written policy text and Schedules. a. The Schedules in the Source Protection Plan identify the areas where the policies of the Source Protection Plan apply. The boundaries for the circumstances shown on the Plan Schedules are general. More detailed interpretation of the boundaries relies on the mapping in the approved Assessment Report and the Specific Circumstances found in the Tables of Drinking Water Threats, *Clean Water Act, 2006*. b. Where any Act or portion of an Act of the Ontario Government or Canadian Government is referenced in this Plan, such reference shall be interpreted to refer to any subsequent renaming of sections in the Act as well as any subsequent amendments to the Act, or successor thereof. This provision is also applicable to any policy statement, regulation or guideline issued by the Province or the municipality.

13.3 Policies Addressing Prescribed Drinking Water Threats

Policy Number	Policies Addressing Prescribed Drinking Water Threats within the City of Hamilton- Lynden Rural Settlement Area
1. Establishment, Operation or Maintenance of a Waste Disposal Site, within the Meaning of Part V of the *Environmental Protection Act*	
CH-MC-2.1 *Future* *Prescribed Instr.* *WHPA-A-v.10*	To ensure the future establishment of waste disposal sites never becomes a significant drinking water threat, where such an activity would be a significant drinking water threat, as defined within the meaning of Part V of the *Environmental Protection Act*, the ~~Ministry of the Environment~~ Ministry of the Environment, Conservation and Parks shall prohibit these activities within the Environmental Compliance Approvals process for such waste disposal sites on lands located within identified vulnerable areas.
CH-CW-2.2 *Future* *Education & Outreach* *WHPA-A-v.10*	To ensure the disposal of hazardous materials at waste disposal sites never becomes a significant drinking water threat, where such an activity would be a significant drinking water threat, the City of Hamilton shall continue their established education and outreach programs on hazardous waste disposal and reduction of waste. The programs shall include messaging consistent with source water protection and the diligent use and disposal of substances.
CH-MC-2.3 *Future*	To ensure the establishment of waste disposal sites within the meaning of Part V of the *Environmental Protection Act*, never become significant drinking water threats, where such activities would be significant drinking water threats, the City

Policy Number	**Policies Addressing Prescribed Drinking Water Threats within the City of Hamilton- Lynden Rural Settlement Area**
Land Use Planning *WHPA-A-v.10*	of Hamilton shall prohibit through amendments to *Planning Act* tools the establishment of waste disposal sites and the specific land uses.
2. Establishment, Operation or Maintenance of a System That Collects, Stores, Transmits, Treats or Disposes of Sewage	
Sewage System or Sewage Works- Onsite Sewage~~ptic~~ System Sewage System or Sewage Works- Onsite Sewage~~ptic~~ System Holding Tank	
CH-MC-3.1 *Existing/Future* *Prescribed Instr.* *WHPA-A-v.10*	To ensure any existing or future ~~septic~~onsite sewage systems and ~~holding tanks~~onsite sewage system holding tanks regulated under the *Ontario Water Resources Act* ceases to be or never becomes a significant drinking water threat, where such an activity would be a significant drinking water threat, the ~~Ministry of the Environment~~ Ministry of the Environment, Conservation and Parks shall ensure that Environmental Compliance Approvals required for these ~~septic~~onsite sewage systems are prepared to incorporate terms and conditions that, when implemented, will ensure that they do not become a risk to drinking water. The terms and conditions may include, as appropriate: i. mandatory monitoring of groundwater impacts; ii. contingencies in the event that the quality of sources of drinking water is adversely affected; iii. regular and ongoing compliance monitoring; iv. mandatory system inspections at least every five years; v. upgrading of these ~~septic~~onsite sewage systems to current standards, if necessary; and vi. annual reporting to the Source Protection Authority of any monitoring and inspection programs required and their results.
CH-MC-3.2 *Future* *Land Use Planning* *WHPA-A-v.10*	To ensure the establishment of new ~~septic~~onsite sewage systems and ~~holding tanks~~onsite sewage system holding tanks regulated under the *Ontario Water Resources Act* never become significant drinking water threats, where such activities would be significant drinking water threats, the City of Hamilton, in consideration of site plan approval for properties located partially within vulnerable areas, shall require the applicants to locate the ~~septic~~onsite sewage systems outside of vulnerable areas.
CH-MC-3.3 *Future* *Land Use Planning* *WHPA-A-v.10*	To ensure future ~~septic~~onsite sewage systems and ~~holding tanks~~onsite sewage system holding tanks regulated under the Ontario *Building Code Act* never become significant drinking water threats, where such activities would be significant drinking water threats, the City of Hamilton shall require through amendments to *Planning Act* tools that future lot sizes be sufficient to accommodate the systems. Where possible, the municipal planning authority shall require the applicants to locate the ~~septic~~onsite sewage systems outside of a vulnerable area.
CH-CW-3.4 *Existing* *Education & Outreach* *WHPA-A-v.10*	To increase awareness about best practices to protect drinking water sources for users of ~~septic~~onsite sewage systems and ~~holding tanks~~onsite sewage system holding tanks located within vulnerable areas where their use is or would be a significant drinking water threat, within five (5) years of the date the Source Protection Plan comes into effect, the City of Hamilton, in collaboration with the Conservation Authority, is requested to continue and broaden education and outreach programs. The programs should inform landowners about the proper disposal of toxic

Policy Number	Policies Addressing Prescribed Drinking Water Threats within the City of Hamilton- Lynden Rural Settlement Area
	chemicals, the operation and maintenance of sewage systems, and the benefits of installing effluent filters, performing tank inspections, and having tanks regularly pumped out.
CH-CW-3.5 *Existing/Future* *Specify Action* *WHPA-A-v.10*	To ensure existing and future ~~septic~~onsite sewage systems cease to be, or never become, significant drinking water threats, where this activity is, or would be, a significant drinking water threat, the City of Hamilton shall implement an ~~septic~~onsite sewage system maintenance inspection program subject to the requirements of the *Ontario Building Code* within vulnerable areas.
CH-NB-3.6 *Existing* *Incentive Program* *WHPA-A-v.10*	To assist landowners in reducing the risks to drinking water sources where existing ~~septic~~onsite sewage systems and ~~holding tanks~~onsite sewage system holding tanks are significant threats, the ~~Ministry of the Environment~~ Ministry of the Environment, Conservation and Parks is requested to provide ongoing funding through the Ontario Drinking Water Stewardship Program or a similar program for ~~septic~~onsite sewage system upgrades, replacements, decommissioning of unused systems, and for connection to municipal systems. If funding is provided, the Conservation Authority shall implement the incentive program.
CH-CW-3.7 *Existing* *Incentive Program* *WHPA-A-v.10*	To assist landowners with improvements to ~~septic~~onsite sewage systems and ~~holding tanks~~onsite sewage system holding tanks required under the ~~septic~~onsite sewage systems maintenance inspection program implemented where ~~septic~~onsite sewage systems are significant threats and in accordance with the Ontario *Building Code Act*, the City of Hamilton shall consider the creation of a financial assistance program designed in a manner that allows the work to be completed as required, and the landowner to repay the cost over time.
Sewage System or Sewage Works- Sanitary Sewers and Related Pipes	
CH-MC-3.8 *Existing/Future* *Prescribed Instr.* *WHPA-A-v.10*	To ensure any existing or new sanitary sewer and pipes cease to be or never become significant drinking water threats, where such an activity is, or would be, a significant drinking water threat, the ~~Ministry of the Environment~~ Ministry of the Environment, Conservation and Parks shall ensure that Environmental Compliance Approvals required for sanitary sewers and pipes are prepared/amended to incorporate conditions that, when implemented, will ensure that they do not become a risk to drinking water. The conditions may include requirements for the proponent/applicant to undertake regular maintenance and inspections.
Sewage System or Sewage Works- Sewage Works Storage ~~of Sewage (e.g., t~~- Treatment ~~plant~~ or Holding T~~t~~anks~~)~~ Sewage System or Sewage Works- Sewage Treatment Plant Effluent Discharges~~ (includes lagoons)~~	
CH-MC-3.9 *Existing/Future* *Prescribed Instr.* *WHPA-A-v.10*	To ensure existing or future sewage treatment plants effluent discharges, bypasses, or the storage of sewage, cease to be or never become significant drinking water threats, the ~~Ministry of the Environment~~ Ministry of the Environment, Conservation and Parks shall prepare/ amend the environmental compliance approvals to incorporate conditions that, when implemented, will ensure they do not become a risk to drinking water. The conditions may include strict criteria for effluent quality, appropriate sizing to reduce bypasses, in addition to inspections and proactive maintenance of the works to prevent leaks.

Policy Number	**Policies Addressing Prescribed Drinking Water Threats within the City of Hamilton- Lynden Rural Settlement Area**
Sewage System or Sewage Works- Discharge ~~of Stormwater~~ from a Stormwater Management Facility	
CH-MC-3.10 *Future* *Prescribed Instr.* *WHPA-A-v.10*	To ensure the future discharge of stormwater from a stormwater management facility never becomes a significant drinking water threat the ~~Ministry of the Environment~~ Ministry of the Environment, Conservation and Parks shall prepare/ amend the environmental compliance approvals to incorporate conditions that, when implemented, will ensure they do not become a risk to drinking water. The conditions may include the requirement for regular maintenance, periodic removal of accumulated sediment, lining of the pond where warranted, the use of an oil/water separator, and other requirements to address site conditions.
CH-MC-3.11 *Future* *Land Use Planning* *WHPA-A-v.10*	To ensure the discharge of storm water effluent from a storm water management facility never becomes a significant drinking water threat, where such an activity would be a significant drinking water threat, where possible, the City of Hamilton, in consideration of *Planning Act* applications for the development of stormwater management facilities, shall require the applicant to locate future stormwater management facilities outside of the vulnerable area.
3. The Application of Agricultural Source Material to Land **4. The Storage of Agricultural Source Material**	
CH-CW-4.1 *Existing/Future* *Part IV-RMP* *WHPA-A-v.10*	To ensure the existing and future application and storage of agriculture source material ceases to be or never becomes a significant drinking water threat, where such an activity is, or would be, a significant drinking water threat, these activities shall be designated for the purpose of Section 58 of the *Clean Water Act, 2006* and a Risk Management Plan shall be required. The content shall be based upon, but not limited to, the regulatory requirements of a nutrient management plan and strategy under the *Nutrient Management Act* and scoped to address these specific threats.
6. The Application of Non-Agricultural Source Material (NASM) to Land **7. The Handling and Storage of Non-Agricultural Source Material (NASM)**	
CH-MC-5.1 *Future* *Prescribed Instr.* *WHPA-A-v.10* *Policy only applies to the application of NASM containing materials from sewage works or meat plant*	To ensure the future application, handling and storage of non-agricultural source material never become significant drinking water threats, where such activities are, or would be, significant drinking water threats, the Ministry of Agriculture, Food and Rural Affairs and/or the ~~Ministry of the Environment~~ Ministry of the Environment, Conservation and Parks shall revoke or not approve any Non-Agricultural Source Material (NASM) Plan, in accordance with the *Nutrient Management Act,* or within the Environmental Compliance Approval process that allows, or would permit these activities within vulnerable areas where it would be a significant drinking water threat.
8. The Application of Commercial Fertilizer to Land **9. The Handling and Storage of Commercial Fertilizer**	
CH-CW-6.1 *Existing/Future* *Part IV-RMP* *WHPA-A-v.10* *Does currently not apply to the application of commercial fertilizer due to percent*	To ensure the existing and future application, handling and storage of commercial fertilizer ceases to be or never becomes a significant drinking water threat, where such an activity is, or would be, a significant drinking water threat, the activity shall be designated for the purpose of Section 58 of the *Clean Water Act, 2006* and a Risk Management Plan shall be required.

Policy Number	**Policies Addressing Prescribed Drinking Water Threats within the City of Hamilton- Lynden Rural Settlement Area**
managed land and livestock density calculation	
10. The Application of Pesticide to Land **11. The Handling and Storage of Pesticides**	
CH-CW-7.1 *Existing/Future* *Part IV-RMP* *WHPA-A-v.10*	To ensure the existing and future application of pesticide and the handling and storage of pesticide, cease to be or never become significant drinking water threats, these activities are designated for the purposes of Section 58 of the *Clean Water Act, 2006* and a Risk Management Plan is required.
CH-CW-7.2 *Future* *Education & Outreach* *WHPA-A-v.10*	To ensure the future application, handling or storage of pesticides never become a significant drinking water threat, where the activity is a significant drinking water threat, the City of Hamilton, in collaboration with the Conservation Authority is requested to undertake an education and outreach program on pesticide use and storage methods and their potential impacts on drinking water sources. The program should consider including wellhead protection area mapping and target pesticide applicators, exterminators and farmers.
13. The Handling and Storage of Road Salt	
CH-MC-8.1 *Future* *Land Use Planning* *WHPA-A-10*	Where the future handling and storage of greater than 5,000 tonnes of road salt would be a significant drinking water threat, the City of Hamilton shall prohibit through *Planning Act* tools salt storage and handling facilities with more than this capacity.
14. The Storage of Snow	
CH-MC-9.1 *Future* *Land Use Planning* *WHPA-A-v.10*	To ensure the future storage of snow never becomes a significant drinking water threat, where such an activity would be a significant drinking water threat, the City of Hamilton shall prohibit this land use through *Planning Act* tools.
15. The Handling and Storage of Fuel	
CH-CW-10.1 *Existing/Future* *Part IV-RMP* *WHPA-A-v.10*	To ensure the existing and future handling and storage of fuel ceases to be or never becomes a significant drinking water threat, where such an activity is, or would be, a significant drinking water threat, this activity shall be designated for the purpose of Section 58 of the *Clean Water Act*, 2006 and a Risk Management Plan shall be required. The Risk Management Plan shall include, as a minimum, the requirements for all storage tanks to comply with the requirements of the *Technical Standards and Safety Act* and its regulations, for all owners/operators to have an emergency response plan with emergency contact information of the municipality responsible for water services and the Spills Action Centre.
CH-MC-10.2 *Future* *Land Use Planning* *WHPA-A-v.10*	To ensure the future handling and storage of fuel never becomes a significant drinking water threat, where such an activity would be a significant drinking water threat; the City of Hamilton shall prohibit gas stations through *Planning Act* tools.
CH-CW-10.3 *Existing/Future* *Education & Outreach* *WHPA-A-v.10*	To ensure the existing and future handling and storage of fuel ceases to be or never becomes a significant drinking water threat, where such an activity is, or would be, a significant drinking water threat, within five (5) years of the date that the Source Protection Plan comes into effect, the City of Hamilton shall develop and implement an education and outreach program for homeowners with home fuel oil tanks, regarding spill response and the method and timing for contacting

Policy Number	Policies Addressing Prescribed Drinking Water Threats within the City of Hamilton- Lynden Rural Settlement Area
	the Spills Action Centre
16. The Handling and Storage of a Dense Non-Aqueous Phase Liquid (DNAPL)	
CH-CW-11.1 *Existing/Future* *Part IV-RMP* *WHPA-A/B/C*	To ensure the existing and future handling and storage of dense non-aqueous phase liquids ceases to be or never becomes a significant drinking water threat, where such an activity is, or would be, a significant drinking water threat, this activity shall be designated for the purpose of Section 58 of the *Clean Water Act*, 2006 and a Risk Management Plan shall be required.
17. The Handling and Storage of an Organic Solvent	
CH-CW-12.1 *Existing/Future* *Part IV-RMP* *WHPA-A-v.10*	To ensure the existing and future handling and storage of an organic solvent ceases to be or never becomes a significant drinking water threat, where such an activity is, or would be, a significant drinking water threat, this activity shall be designated for the purpose of Section 58 of the *Clean Water Act*, 2006 and a Risk Management Plan shall be required.
18. The Management of Runoff that Contains Chemicals Used in De-icing of Aircraft	
CH-NB-13.1 *Future* *Specify Action* *WHPA-A-v.10* *Monitoring*	To ensure the management of runoff containing chemicals used in the de-icing of aircraft where such an activity would be a significant drinking water threat, never becomes a significant drinking water threat, the relevant airport authorities and operators, in their consideration of any future airport facilities where the activity would be a significant drinking water threat, are requested to include appropriate design standards and management practices to prevent the runoff from airport de-icing facilities from becoming a significant drinking water threat. The City of Hamilton shall report to the Source Protection Authority if an application has been made for a new airport facility within the vulnerable areas by February 1 of each year.
21. The Use of Land as Livestock Grazing or Pasturing Land, an Outdoor Confinement Area or Farm Animal Yard	
CH-CW-14.1 *Existing/Future* *Part IV-RMP* *WHPA-A-v.10*	To ensure the risks to drinking water from the existing or potential future use of land as an outdoor confinement area or farm-animal yard on farms not phased-in under the *Nutrient Management Act*, or from the use of land for livestock grazing or pasturing on all farms, ceases to be or never becomes a significant drinking water threat, where these activities are, or would be, a significant drinking water threat, these activities shall be designated for the purpose of Section 58 of the *Clean Water Act*, 2006 and a Risk Management Plan shall be required. The Risk Management Plan shall be based upon the regulatory requirements of a nutrient management strategy under the *Nutrient Management Act* and incorporate the best management practices for livestock grazing and pasturing land.
CH-MC-14.2 *Existing/Future* *Prescribed Instr.* *WHPA-A-v.10*	Where the existing and potential future use of land as an outdoor confinement area or farm-animal yard is, or would be, a significant drinking water threat and is managed by nutrient management strategies prepared under the *Nutrient Management Act*, the Ministry of Agriculture, Food and Rural Affairs shall ensure that all existing and future nutrient management strategies incorporate measures to protect drinking water sources that, when implemented, ensure that the activity ceases to be or never becomes a significant drinking water threat.
22. The Establishment and Operation of a Liquid Hydrocarbon Pipeline	

Policy Number	Policies Addressing Prescribed Drinking Water Threats within the City of Hamilton- Lynden Rural Settlement Area
CH-NB-15.1 *Future* *Specify Action* *WHPA-A-v.10* *Monitoring*	To reduce the risk due to the conveyance of oil by way of underground pipes within the meaning of O. Reg. 210/01 under the *Technical Safety and Standards Act* or that is subject to the *National Energy Board Act,* where this activity would be a significant drinking water threat, the pipeline proponent, the National Energy Board and the Ontario Energy Board are encouraged to provide the Source Protection Authority and the City the location of any new proposed pipeline within the City and/or Source Protection Area. The Source Protection Authority shall document in the annual report the number of new pipelines proposed within vulnerable areas

13.4 Appendix A: List of Policies as per Section 34 of Regulation 287/07

LIST A

Title: Significant threat policies that affect decisions under the *Planning Act* and *Condominium Act*, 1998

Opening Statement: “Clause 39 (1)(a), subsections 39 (2), (4) and (6), and sections 40 and 42 of the *Clean Water Act*, 2006 apply to the following policies:”

Content: CH-CW-1.1, CH-CW-1.2, CH-CW-1.3, CH-MC-2.3, CH-MC-3.2, CH-MC-3.3, CH-MC-3.11, CH-MC-8.1, CH-MC-9.1, CH-MC-10.2

LIST B

Title: Moderate and low threat policies that affect decisions under the *Planning Act* and *Condominium Act*, 1998

Opening Statement: “Subsection 39 (1) (b) of the *Clean Water Act*, 2006 applies to the following policies:”

Content: No Applicable Policies

LIST C

Title: Significant threat policies that affect Prescribed Instrument decisions

Opening Statement: “Subsection 39 (6), clause 39 (7) (a), section 43 and subsection 44 (1) of the *Clean Water Act*, 2006 apply to the following policies:”

Content: CH-CW-1.1, CH-MC-2.1, CH-MC-3.1, CH-MC-3.8, CH-MC-3.9, CH-MC-3.10, CH-MC-5.1, CH-MC-14.2

LIST D

Title: Moderate and low threat policies that affect Prescribed Instrument decisions

Opening Statement: “Clause 39 (7) (b) of the *Clean Water Act*, 2006 applies to the following policies:”

Content: No Applicable Policies

LIST E

Title: Significant threat policies that impose obligations on municipalities, source protection authorities and local boards

Opening Statement: “Section 38 and subsection 39 (6) of the *Clean Water Act*, 2006 applies to the following policies:”

Content: CH-CW-1.1, CH-CW-1.13, CH-CW-2.2, CH-CW-3.4, CH-CW-3.5, CH-CW-3.7, CH-CW-7.2, CH-CW-10.3

LIST F

Title: Monitoring policies referred to in subsection 22 (2) of the *Clean Water Act*, 2006

Opening Statement: “Section 45 of the Clean Water Act, 2006 applies to the following policies:”

Content: CH-CW-1.4, CH-CW-1.5, CH-CW-1.6, CH-CW-1.7, CH-CW-1.8, CH-NB-15.1~~1.9~~, CH-NB-13.1

LIST G
Title: Policies related to section 57 of the *Clean Water Act*, 2006

Opening Statement: “The following policies relate to section 57 (prohibition) of the Clean Water Act, 2006.”

Content: No Applicable Policies

LIST H
Title: Policies related to section 58 of the *Clean Water Act*, 2006

Opening Statement: “The following policies relate to section 58 (Risk Management Plans) of the Clean Water Act, 2006.”

Content: CH-CW-1.1, CH-CW-4.1, CH-CW-6.1, CH-CW-7.1, CH-CW-10.1, CH-CW-11.1, CH-CW-12.1, CH-CW-14.1

LIST I
Title: Policies related to section 59 of the *Clean Water Act*, 2006

Opening Statement: “The following policies relate to section 59 (restricted land uses) of the *Clean Water Act, 2006*.”

Content: **CH-CW-1.1,** CH-CW-1.2

LIST J
Title: Strategic Action policies

Opening Statement: For the purposes of section 33 of O. Reg. 287/07, the following policies are identified as strategic action policies:

Content: CH-NB-1.10, CH-NB-1.11, CH-NB-1.12

LIST K
Title: Significant threat policies targeted to bodies other than municipalities, local board or source protection authorities for implementation

Opening Statement: The following policies are identified as non-legally binding policies:

Content: CH-NB-15.1~~1.9~~, CH-NB-3.6, CH-NB-13.1

13.5 Appendix B: Prescribed Instruments and Policy Summary Tables

Table 1: Prescribed instruments which apply to source protection plan policies in Lists C and D above (s.34(4) of O. Reg. 287/07)

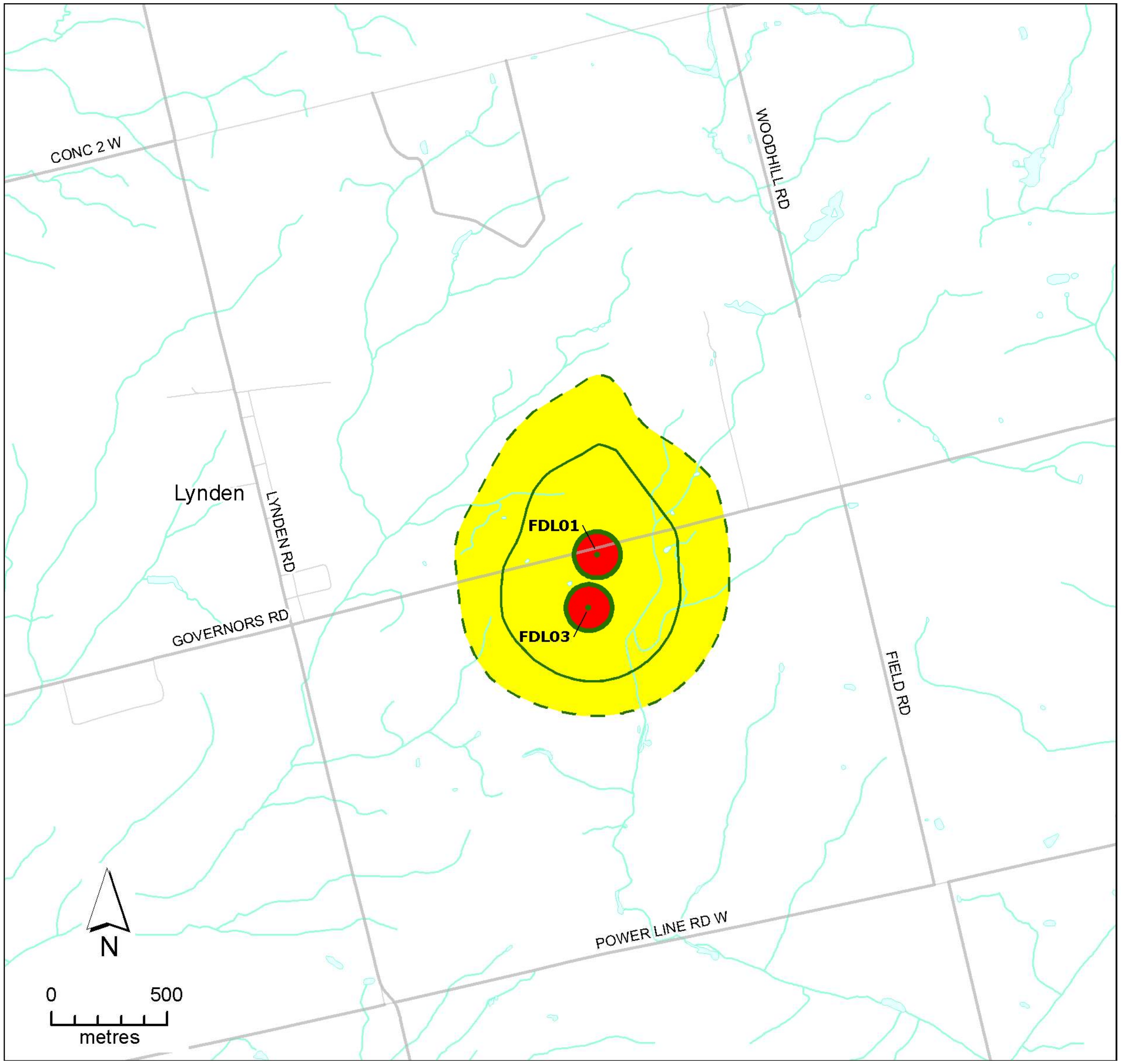
Policy #	Legal Effect	Environmental Protection Act	Nutrient Management Act	Ontario Water Resources Act
CH-CW-1.1	Comply With	X	X	X
CH-MC-2.1	Must Conform	X		X
CH-MC-3.1	Must Conform	X		X
CH-MC-3.8	Must Conform	X		X
CH-MC-3.9	Must Conform	X		X
CH-MC-3.10	Must Conform	X		X
CH-MC-5.1	Must Conform	X	X	
CH-MC-14.2	Must Conform		X	

Table 2: Policy Summary Matrix

Policy ID#	Legal Effect (conform with, have regard to, non-binding)	Policy affects decisions under the Planning Act and Condominium Act, 1998 (Lists A and B)	Policy affects Prescribed Instrument decisions (Lists C and D)	Significant threat policies that impose obligations on municipalities, source protection authorities and local boards (List E)	Monitoring policies referred to in s.22(2) of the CWA (List F)	Part IV Policies - Significant threat policies that are designated in the plan as requiring a Risk Management Plan, are prohibited under s. 57, or to which s. 59 of the CWA applies (Lists G, H, and I)	Strategic Action Policies (List J)	Significant threat policies which designate a body other than a municipality, source protection authority or local board as responsible for implementing the policy (List K)
CH-CW-1.1	Comply With	X	X	X		X		
CH-CW-1.2	Comply With	X				X		
CH-CW-1.3	Comply With	X						
CH-MC-2.3	Must Conform	X						
CH-MC-3.2	Must conform	X						
CH-MC-3.3	Must conform	X						
CH-MC-3.11	Must conform	X						
CH-MC-8.1	Must conform							
CH-MC-9.1	Must conform	X						
CH-MC-10.2	Must conform	X						
CH-MC-2.1	Must conform		X					
CH-MC-3.1	Must conform		X					
CH-MC-3.8	Must conform		X					
CH-MC-3.9	Must conform		X					
CH-MC-3.10	Must conform		X					
CH-MC-5.1	Must conform		X					
CH-MC-14.2	Must conform		X					
CH-CW-1.13	Comply With			X				
CH-CW-2.2	Comply With			X				

Policy ID#	Legal Effect (conform with, have regard to, non-binding)	Policy affects decisions under the Planning Act and Condominium Act, 1998 (Lists A and B)	Policy affects Prescribed Instrument decisions (Lists C and D)	Significant threat policies that impose obligations on municipalities, source protection authorities and local boards (List E)	Monitoring policies referred to in s.22(2) of the CWA (List F)	Part IV Policies - Significant threat policies that are designated in the plan as requiring a Risk Management Plan, are prohibited under s. 57, or to which s. 59 of the CWA applies (Lists G, H, and I)	Strategic Action Policies (List J)	Significant threat policies which designate a body other than a municipality, source protection authority or local board as responsible for implementing the policy (List K)
CH-CW-3.4	Comply With			X				
CH-CW-3.5	Comply With			X				
CH-CW-3.7	Comply With			X				
CH-CW-7.2	Comply With			X				
CH-CW-10.3	Comply With			X				
CH-CW-1.4	Comply With				X			
CH-CW-1.5	Comply With				X			
CH-CW-1.6	Comply With				X			
CH-CW-1.7	Comply With				X			
CH-CW-1.8	Comply With				X			
CH-CW-4.1	Comply With					X		
CH-CW-6.1	Comply With					X		
CH-CW-7.1	Comply With					X		
CH-CW-10.1	Comply With					X		
CH-CW-11.1	Comply With					X		
CH-CW-12.1	Comply With					X		
CH-CW-14.1	Comply With					X		
CH-NB-1.10	Non- binding						X	
CH-NB-1.11	Non- binding						X	
CH-NB-1.12	Non- binding						X	
~~CH-NB-1.9~~	~~Non- binding~~				~~X~~			~~X~~
CH-NB-3.6	Non- binding							X
CH-NB-13.1	Non- binding				X			X
CH-NB-15.1	Non- binding				X			X

13.6 Schedule A: City of Hamilton, Lynden Rural Settlement Area- Communal Well Supply



Significant Drinking Water Threat Policy Applicability

Significant Drinking Water Threat Policy Categories		Vulnerability Scores on Map		
		10	8	2,4,6
1.	Waste Disposal	🟥	🟧	
2.	Sewage Systems	🟥	🟧	
3, 4.	Agricultural Source Material	🟥		
6, 7.	Non-Agricultural Source Material*	🟥		
8, 9.	Commercial Fertilizer*	🟥		
10, 11.	Pesticide	🟥		
12, 13.	Road Salt*	🟥		
14.	Storage of Snow	🟥		
15.	Fuel	🟥		
16.	DNAPLs	🟥	🟧	🟨
17.	Organic Solvents	🟥		
18.	Aircraft De-icing	🟥		
21.	Livestock Area	🟥		
Local Threat	Oil Pipelines	🟥		

Note: This table provides a summary of the activities listed in the Clean Water Act (2006) that apply as Prescribed Drinking Water Threats (PDWT) within the Non-GUDI Wellhead Protection Zones shown on this map. For details refer to the text of the Source Protection Plan and the Ministry of the Environment Drinking Water Threats Tables.

*Application of Commercial Fertilizer, Non-Agricultural Source Material, and Road Salt may not be a significant drinking water threat in some areas due to the % managed land, livestock density, and/or % impervious surface calculations for these areas. See the text of the plan for further details.

● Well
Road
Minor River
Lake / Main River

Wellhead Protection Zones:
WHPA-A
WHPA-B
WHPA-C

1. Updated July 20, 2018
2. Larger scale mapping of some map layers, including roads and vulnerability scores, is available at www.sourcewater.ca.
3. This map is for illustrative purposes only. Information contained hereon is not a substitute for professional review or a site survey and is subject to change without notice. The Grand River Conservation Authority takes no responsibility for, nor guarantees, the accuracy of the information contained on this map. Any interpretations or conclusions drawn from this map are the sole responsibility of the user.

LAKE ERIE REGION SOURCE PROTECTION COMMITTEE

REPORT NO. SPC-18-10-09 **DATE:** October 4, 2018

TO: Members of the Lake Erie Region Source Protection Committee

SUBJECT: **Draft Updated Grant River Assessment Report and Source Protection Plan: Non-municipal Sections**

RECOMMENDATION:

THAT the Lake Erie Region Source Protection Committee receives report SPC-18-10-09 – Draft Updated Grand River Assessment Report and Source Protection Plan: Non-municipal Sections – for information.

REPORT:

Updates to the Assessment Report

Section 1 – Introduction

The draft updated Section 1 (Introduction) of the Grand River Assessment Report primarily includes content, brevity and added clarity updates. Information from section 1.8 (Overview of Source Protection Risk Assessment Process) was removed from this section and updated to flow into section 3 (Water Quality Threat Assessment Methodology) of the Assessment Report. Section 3 is currently undergoing major revisions and will be presented at the December 6, 2018 Source Protection Committee meeting.

Section 2 – Physical Characterization

The draft updated Section 2 (Physical Characterization) of the Grand River Assessment Report has undergone major revisions in addition to content, brevity and added clarity updates. The major revisions include:

- Population statistics, including projections, population density and population of municipally serviced residents were updated to reflect 2016 Statistics Canada Census data within the Grand River Watershed.
- Bedrock geology text and maps were updated to include the most recent available information from the Ontario Geological Survey (OGS)
- Hydrogeology text and maps were updated with data and knowledge gained from the Tier 2 Water Budget of the Grad River watershed.
- Significant groundwater recharge areas and highly vulnerable aquifer text and maps were moved into the Physical Characterization section.
- Groundwater and surface water quality across the Grand River watershed was modified to reflect current water quality challenges specific to the watershed (i.e. road salts and nitrates).
- Climate, forests and wetlands in the Grand River watershed text and maps were updated

to reflect the most recent data available.

- Surface water characterization text and figures were updated with the most recent surface water flow data.
- Watershed characterization data gaps were revised to include progress made on addressing data gaps.
- A summary of the Watershed Characterization (section 2) was added to the end of the section.

Section18 – Tier 2 Water Budget Results

The draft updated Section 18 (Tier 2 Water Budget Results) of the Grand River Assessment Report primarily includes content, brevity and added clarity updates. Out of date and irrelevant content was removed pertaining to Tier 2 methodology and results.

Please see **Appendix A** for sections 1 and 2 and **Appendix B** for section 18.

Prepared by:

Emily Hayman

Emily Hayman, P.Geo.
Source Protection Program Assistant

Approved by:

Martin Keller, M. Sc.
Source Protection Program Manager

Appendix A

Draft Updated Grand River Assessment Report
Section 1 – Introduction
Section 2 – Watershed Characterization

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1.0 INTRODUCTION

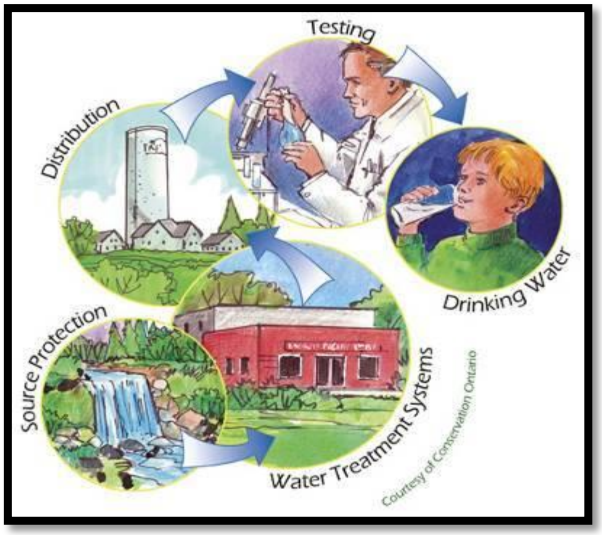
Following the public inquiry into the Walkerton drinking water crisis in May 2000, Justice Dennis O'Connor released a report in 2002 containing 121 recommendations for the protection of drinking water in Ontario. Since the release of the recommendations, the Government of Ontario has introduced legislation 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~~ies~~ of the Environment, Conservation and Parks (M~~O~~ECP), Ministry of ~~and~~ Natural Resources and Forestry (MNRF), and other stakeholders to facilitate the update ~~development~~ of local, science based source protection plans.

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 https://www.ontario.ca/page/ministry-environment-conservation-parks~~www.ontario.ca/ministry-environment-and-climate-change~~ or call 1-800-565-4923.

1.1 Source Protection Planning Process

The key objectives of this process are the completion of science-based Assessment Reports that identify the risks to municipal drinking water sources, and locally-developed Source Protection Plans that put policies in place to reduce the risks to protect current and future sources of drinking water.

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 Grand River Source Protection Area (watershed area).

The Amended Assessment Report was submitted to the Ministry of the Environment for approval on April 30, 2012. Opportunities for public review and input have been available on the Draft Assessment Report (August – September 2010), the Proposed Assessment Report (October – November 2010) and again on the Draft Amended Assessment Report (April 15 to May 21, 2011). For details on the public comments submitted and the responses made by the Source Protection Committee, please see **Appendix A**. The Amended Assessment Report was officially approved by the Ministry of the Environment on August 16, 2012.

In 2014, further studies were undertaken to better delineate the wellhead protection areas for wells located in the Bethel wellfield and a new section characterizing a municipal drinking water system serving the Town of Shelburne but located in the Township of Melancthon was added. The Updated Assessment Report was posted for a 40-day public consultation period starting on March 16, 2015. 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 Grand River Source Protection Authority submitted the Updated Grand River Assessment Report to the Minister on July 6~~June 26~~, 2015.

Following the July 2015 submission, additional comments were addressed and the Assessment Report was re-submitted for approval on November 13, 2015. The Ministry of the Environment and Climate Change approved the Updated Grand River Assessment Report on November 26, 2015.

New information has since been added to the Approved Grand River Assessment Report. These updates include Tier 3 Water Budget ~~and Local Area Risk Assessments~~Studies and Wellhead Protection Area (WHPA) updates.

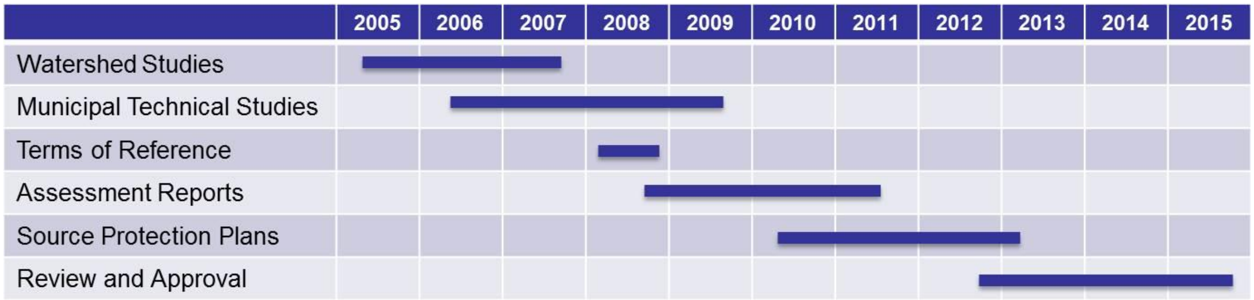
The Source Protection Plan is a document that contains policies to protect sources of drinking water against threats identified in the Assessment Report. The Plan sets out:

- 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.

~~As illustrated in **Figure 1-1**, the Source Protection Plan was submitted to the Minister of the Environment on January 25, 2013 for approval. Revisions to the Source Protection Plan as a result of Ministry review comments received were consulted on together with changes to this Updated Assessment Report.~~

Following ~~After approval of the~~ Source Protection Plan approval, annual progress~~monitoring~~ reports ~~and progress reports~~ on implementation are~~will be~~ required. Implementation of the Source Protection Plan~~,~~ is ~~once it has been approved by the Minister of the Environment, will be~~ 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 ~~will be able to~~ use a range of voluntary and regulatory programs and tools, including outreach and education; 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~~will be~~ mandatory, since the *Clean Water Act, 2006* requires that all identified significant threats cease to be significant.



~~**Figure 1-1: Source Protection Timeline**~~

1.2 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 Grand River watershed is called the Grand River 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 Grand River Source Protection Authority is partnered with the Catfish Creek Source Protection Authority, Kettle Creek Source Protection Authority and Long Point Region 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.

1.3 Source Protection Committee

In the Grand River Source Protection Area, the Source Protection Planning process is being led by a multi-stakeholder steering committee called the Lake Erie Region Source Protection Committee. The Committee was formed in November 2007, and met monthly until the Proposed Grand River Source Protection Plan was submitted to the Ministry of the Environment in January 2013. Since then the Committee has continued to meet on a quarterly basis. The Committee is responsible for directing the development and update of the Assessment Reports and Source Protection Plans for each of the four Source Protection Areas in the Lake Erie Region. The list of current and past members is summarized in **Table** 1-1**.**

Table 1-1: Current and Past Members of the Lake Erie Region Source Protection Committee

Name	Seat Held	Appointment	Joined	Resigned
Wendy Wright-Cascaden	~~Acting~~ Chair	~~Lake Erie Region Source Protection Committee~~Minister of the Environment and Climate Change	Nov~~September~~, 2016~~5~~	-
Wendy Wright-Cascaden	Acting Chair	Lake Erie Region Source Protection Committee	Sep, 2015	Nov, 2016
Craig Ashbaugh	Chair	Minister of the Environment	Nov, 2007	Jul~~y~~, 2015
Brad Carberry	Agriculture	Agricultural Community	Aug, 2017	-
Peter Busatto	Municipal	City of Guelph	Nov, 2012	Sep, 2013
Marguerite Ceschi-Smith	Public Interest	Grand River Source Protection Authority	Nov, 2007	Sep, 2014
Howard Cornwell	Municipal	Perth, Oxford	Nov, 2007	-
Alan Dale	Public Interest	Grand River Source Protection Authority	Jan, 2012	-
Paul Emerson	Municipal	Brant, Brantford, Hamilton	Sep, 2018	-
Paul General	First Nations	Six Nations of the Grand River	Nov, 2007	-
Mark Goldberg	Public Interest	Grand River Source Protection Authority	Nov, 2007	Nov, 2011
Roy Haggart	Municipal	Brant, Brantford, Hamilton	Nov, 2007	Aug 2018~~-~~
John Harrison	Public Interest	Grand River Source Protection Authority	Nov, 2007	Jun, 2012
Andrew Henry	Public Interest	Elgin Area Primary Water Board	Nov, 2007	-
Carl Hill	First Nations	Six Nations of the Grand River	Feb, 2012	Mar, 2012
Darryl Hill	First Nations	Six Nations of the Grand River	Apr, 2012	Nov, 2015~~-~~
Carl Hill	First Nations	Six Nations of the Grand River	May, 2016	-
Eric Hodgins	Municipal	Grand River Source Protection Authority	May, 2016	-
Ken Hunsberger	Agriculture	Agricultural Community	Nov, 2007	-
Cathie Jamieson	First Nations	Mississaugas of the New Credit	Sep, 2018	-
Robert E. Johnson	First Nations	Six Nations of the Grand River	Mar, 2011	Apr, 2011
Casey Jonathan	First Nations	Mississaugas of the New Credit	Feb, 2016	Dec, 2017
Jim Kirchin	Public Interest	Grand River Source Protection Authority	Feb, 2015	-
Ralph Krueger	Business and Industry	Grand River Source Protection Authority	Nov, 2007	-
Clynt King	First Nations	Mississaugas of the New Credit	Mar, 2011	Dec, 2015~~-~~
Bryan LaForme	First Nations	Mississaugas of the New Credit	Nov, 2007	Mar, 2011
Janet Laird	Municipal	City of Guelph	Nov, 2007	Nov, 2012
Ian MacDonald	Business and	Grand River Source Protection Authority	Nov, 2007	-

Table 1-1: Current and Past Members of the Lake Erie Region Source Protection Committee

Name	Seat Held	Appointment	Joined	Resigned
	Industry			
Chris Martin	First Nations	Six Nations of the Grand River	Nov, 2007	Nov, 2010
George Montour	First Nations	Six Nations of the Grand River	Apr, 2011	Jan, 2012
Dale Murray	Municipal	Grey, Dufferin, Halton, Wellington	Nov, 2007	Jul, 2016~~-~~
Thomas Nevills	Public Interest	Grand River Source Protection Authority	May, 2017	-
Jim Oliver	Municipal	Haldimand, Norfolk	Nov, 2007	Jun, 2018~~-~~
David Parker	Agriculture	Agricultural Community	Nov, 2007	Mar, 2016~~-~~
Lloyd Perrin	Municipal	Elgin, Middlesex, London	Nov, 2007	-
Geoff Rae	Public Interest	Nanticoke Grand Valley Water Supply	Nov, 2007	Jul, 2010
Peter Rider	Municipal	Guelph	Oct, 2013	-
Phil Wilson	Public Interest	Nanticoke Grand Valley Water Supply	Nov, 2007	-
~~Richard Seibel~~	~~Aggregate Industry~~	~~Ontario Stone, Sand & Gravel Assoc.~~	~~Nov, 2007~~	~~Aug, 2011~~
Thomas Schmidt	Municipal	Waterloo Region	Nov, 2007	Mar, 2016~~-~~
George Schneider	Aggregate Industry	Ontario Stone, Sand & Gravel Assoc.	Oct, 2011	-
Richard Seibel	Aggregate Industry	Ontario Stone, Sand & Gravel Assoc.	Nov, 2007	Aug, 2011
John Sepulis	Municipal	Grey, Dufferin, Halton, Wellington	Nov, 2017	-
Bill Strauss	Public Interest	Grand River Source Protection Authority	Jul, 2012	-
Bill Ungar	Business and Industry	Grand River Source Protection Authority	Nov, 2007	-
Mark Wales	Agriculture	Agricultural Community	Nov, 2007	-
Don Woolcott	Public Interest	Grand River Source Protection Authority	Nov, 2007	-
Wendy Wright-Cascaden	Public Interest	Grand River Source Protection Authority	Nov, 2007	Sep, 2015~~-~~

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.

In December 2008, the Committee submitted to the Minister of the Environment their Terms of Reference for the Grand River Source Protection Area Assessment Report and Source Protection Plan. 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 Grand River Source Protection Area Terms of Reference can be found at: www.sourcewater.ca.

1.4 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.

~~Under the stewardship program, current funding from the Ministry of the Environment provides grants to undertake early actions that protect municipal sources of drinking water. The grants are directed to landowners within close proximity to municipal wells or surface water intakes to undertake projects that reduce existing potential contamination sources. In addition, funding has been available for communications and outreach efforts to persons and businesses in these areas. The program currently has funding through 2013 to provide grants to undertake Early Response Programs to address significant drinking water threats identified in the Grand River Source Protection Area Assessment Report, in advance of approved Source Protection Plans. The Lake Erie Region Source Protection Committee will continue to request that the province funds the program beyond 2013 in order to provide financial assistance to property owners affected by new policies and risk reduction strategies that may result from approved source protection plans.~~

1.5 Framework of the Assessment Report

The Grand River 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* ~~(November 2009)~~ under O. Reg. 287/07. The technical work was undertaken by municipalities and the Grand River Conservation Authority. Funding to complete the technical studies for the Assessment Report was provided by the Province of Ontario.

Within the Grand River Source Protection Area (SPA), there are 39 upper and lower tier municipalities and two First Nations communities. At present, there are 46~~8~~ municipal residential drinking water systems, including two integrated groundwater/inland river systems and one inland river system. In addition, one Lake Erie intake located outside of the source protection area (Nanticoke) and one pipeline system from Lake Ontario also supply water to residents in the Grand River SPA.

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 additional non-municipal systems. To date, no municipalities in the Grand River Source Protection Area have designated non-municipal drinking water supplies under the *Clean Water Act, 2006*. The Minister of the Environment~~ has~~ included the Ohsweken Water Treatment Plant: a non-municipal system that serves a major residential development on the reserve of the Six Nations of the Grand River.

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 Budget and Water Quantity Stress Assessment;~~ Water Quality Risk Assessment (including groundwater vulnerability, and sections dedicated to each municipality's Wellhead Protection Areas and Intake Protection Zones); Water Budget Framework, Tier 2 Water Budget, Tier 3 Water Budgets, 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 at www.sourcewater.ca.

1.6 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 the 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.

1.7 Public Consultation

Throughout the development of the Grand River 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.ca website and hard copies were also available at the conservation authority and municipal administrative offices. A series of public meetings were also held during each public consultation period. **Table 1-2** below provides details regarding each of the public consultation periods held regarding the Grand River Assessment Report.

Table 1-2: Grand River Assessment Report – Public Consultation Periods

Document / Notice	Notification Date:	Consultation Period:	Public Meeting Date(s)	Meeting Location
Draft Assessment Report	July 16, 2010	July 16, 2010 – Sept 24, 2010	September 8, 2010	Grand Valley Community Centre
			September 9, 2010	Waterloo Region Emergency Services Training and Research Complex
			September 13, 2010	Grand River Conservation Authority
			September 14, 2010	Italian Canadian Club, Guelph
			September 15, 2010	Tranquility Hall, Brantford
Proposed Assessment Report	Nov 9, 2010	Nov 5, 2010 – Dec 6, 2010	N/A *	N/A *
Draft Amended Assessment Report	Apr 18, 2011	Apr 15, 2011– May 21, 2011	N/A *	N/A *
Updated Assessment Report:	March 16, 2015	March 16, 2015 - April 24, 2015	March 31, 2015	Amaranth Recreation Hall
			March 31, 2015	Fergus SportsPlex
			April 8, 2015	T.J Costini Community Centre, Brantford
			April 9, 2015	City Hall, Guelph
			April 9, 2015	Waterloo Region Emergency Services Training and Research

				Complex
			April 15, 2015	Grand River Conservation Authority
			April 15, 2015	Dunnville Optimist Hall
			April 16, 2015	County of Brant SportsPlex
Draft Updated Assessment Report (Grey, Hamilton, Brant, S.34)	To Be Determined	February 14 – March 20, 2019	To Be Determined	To Be Determined
Draft Updated Assessment Report (Grand River, S.34)	To Be Determined	April 8 – May 21, 2019	To Be Determined	To Be Determined

* 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.

All comments received by the Source Protection Committee during periods of public consultation are included in **Appendix A**.

The Draft Updated Assessment Report [specified S.34 update title to be entered] will be posted for a 30-day public consultation period between [dates to be entered]. The public is invited to review the Assessment Report on www.sourcewater.ca, during public open houses, or at the Grand River Region Conservation Authority where hard copies will be made available.

The public can submit comments on the Assessment Report at public open houses, by email (comments@sourcewater.ca), or by regular mail to:

Martin Keller, M.Sc.
Source Protection Program Manager
Lake Erie Source Protection Region
c/o Grand River Conservation Authority
400 Clyde Road, Box 729, Cambridge ON N1R 5W6

All comments received during this comment period will be forwarded to the Ontario Ministry of the Environment, Conservation and Parks with the submission of the Grand River Assessment Report.

~~1.8 Overview of Source Protection Risk Assessment Process~~

~~Source Protection Area Assessment Reports are summaries of technical studies that have the objective ofidentify:~~

- ~~Mapping areas surrounding municipal drinking water sources in which land use activities could impact the water quality or quantity of a municipal water supply. These are termed Wellhead Protection Areas (WHPAs) and Intake Protection Zones (IPZs). The vulnerable areas around municipal-residential drinking water sources~~
- ~~Ranking areas within WHPAs and IPZs that have an increased potential or vulnerability for impacting the municipal supply.How “vulnerable” the vulnerable areas are~~
- ~~IdentifyingWhere potential water quality and quantity threats to the municipal supply within the WHPAs and IPZs.water quality and quantity can be found in each vulnerable area~~

- ~~IdentifyingThe activities that pose the largestbiggest potential threat to the quality or quantity of the municipal supply.human health~~
- ~~How significant the risk of the threat is of contaminating or depleting the water supply~~

~~1.8.1 Vulnerable Areas~~

~~What are vulnerable areas?~~

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

- ~~Wellhead Protection Areas (WHPA)~~
- ~~Intake Protection Zones (IPZ)~~
- ~~Highly Vulnerable Aquifer (HVA) areas~~
- ~~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 Aquifers areas, Significant Groundwater Recharge Areas and Wellhead Protection Areas are delineatedtermined through complex qualitative and quantitative assessmentsmodeling of the geology and groundwater flow in an area., as well as the permeability of surface material above the groundwater (aquifers). The Intake Protection Zones are determined by assessinggenerated through the assessment of surface water the flow of surface water in the watercourseriver or lake where a municipal intake is located.~~

~~Wellhead Protection Areas and Intake Protection Zones are developed specifically around for municipal groundwater and surface 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 an existing municipal drinking water system.~~

~~What is vulnerability?~~

~~The word “Vvulnerability” describes how easily athe sensitivity of a drinking water source such as an aquifer or surface water feature to negative water quality impacts from anthropogenically derived materials. source of water (aquifer, river or lake) can become polluted with a dangerous material. The vulnerability of an area is applied as a score,can range from 1 to 10, with 10 being the most vulnerable. The process for assessingmeasuring vulnerability differs betweenis different for aquifers and surface water, rivers and lakes.~~

~~AquiferGroundwater Vulnerability~~

~~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 movesspeed depends on the characteristics of the soil and bedrock in the area and the pumping rate of the 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 consideredquestion 1 had to be answered:~~

~~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 naturecharacteristics of the soil and bedrock in the area.~~

~~This answer to this question was used to delineatedetermine where the Highly Vulnerable Aquifers within the Grand River areas are.~~

~~To determine the vulnerability score of areas near a municipal well, question 2 had to be answered, and combined with the answers to question 1.~~

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

~~This information was used to draw Wellhead Protection Areas around each municipal groundwater well. WHPAs are divided into rings called Time-of-Travel zones. The innermost zone is a 100-metre circle around the well. The other zones are set at times-of-travel of 2 years, 5 years (or 10 years) and 25 years.~~

~~To obtainget the vulnerability score for a WHPA, both the rates of vertical and horizontal movement of water through the ground arewere used and a scoring matrix is applied according to the Director's Technical Rules. Generally, the scores are highest immediately around the well and lower further away. Because of the proximity to the well, the 100-metre zone around the well was given a vulnerability score of 10, as required by the Ministry of the Environment *Assessment Report Technical Rules (MOE, 2009b)*. Usually, the most vulnerable areas in a WHPA (score of 8 to 10) are in the 2 year time-of-travel zone. For some wells, land may still be highly vulnerable in the 5 year time-of-travel zone.~~

~~Surface Water Vulnerability~~

~~IRiver 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 beforewhile 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 59 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 6.3.5 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 10/7~~

~~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 96.3.~~

~~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.~~

~~1.8.2 Municipal Drinking Water Threats~~

~~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 things like 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 migrateove 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?*~~

~~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 will be 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 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 to the public 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~~
~~(Risks with scores lower than 40 do not have to be dealt with under the *Clean Water Act, 2006*.)~~	

~~*This information is available online to the public at: http://swpip.ca.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 score 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 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 score 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 score 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 45 to 16 and 19 and 20 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.of this report to determine whether your property is in a vulnerable area with a score of 8 to 10. Publicly available Web-GIS mapping of vulnerable areas including vulnerability scores is available at https://maps.grandriver.ca. If your property is located in a wellhead protection area or intake protection zone with a score of 8 to 10, then you can use the Tables of Drinking Water Threats compiled by the Ministry of the Environment to determine whether any activities on your property might be considered a significant threat. These tables are available online at www.sourcewater.ca.~~

~~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 impact 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~~

~~The Province of Ontario has made funding available under the Ontario Drinking Water Stewardship Program to help landowners undertake some of these actions and more. To learn more, go to www.sourcewater.ca and look under Stewardship Program, or contact your local Conservation Authority. As of 2014 this funding is no longer available.~~

~~**Conservation Authority**~~	~~**Contact**~~	~~**Phone**~~	~~**E-mail**~~
~~Grand River Conservation~~	~~Louise Heyming, Supervisor of~~	~~519-621-2761 x2279~~	~~Lheyming@grandriver.ca~~

~~Authority~~	~~Conservation Outreach~~		
~~Long Point Region Conservation Authority~~	~~Paul Gagnon, Land and Waters Supervisor~~	~~1-888-231-5408~~	~~watercare@lprca.on.ca~~
~~Catfish Creek Conservation Authority~~	~~Peter Dragunas, Water Management Technician~~	~~519-773-9037~~	~~water@catfishcreek.ca~~
~~Kettle Creek Conservation Authority~~	~~Betsy McClure, Stewardship Coordinator~~	~~519-631-1270~~	~~betsy@kettlecreekconservation.on.ca~~

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2.0 WATERSHED CHARACTERIZATION

Understanding the human and physical characteristics of the watershed is important to protecting and managing water. Interactions between surface water, groundwater and potential sources of contamination 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 overall health of the ecosystem. The following sections are intended to provide information on the physical and human characteristics of the Grand River watershed.

2.1 Lake Erie Source Protection Region

In an effort to share knowledge and resources for the purposes 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 shows the territory covered by the Lake Erie 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.

Combined, the 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 Dundalk. The area includes, in whole or in part, ~~49~~ 39 upper, lower and single tier municipalities, as well as two First Nations communities (Glauser et al., 2008).

2.2 Grand River Source Protection Area

The Grand River watershed covers an area of approximately 6,800 square kilometres in south-central Ontario, and contains 39 upper-, lower- and single-tier municipalities, as listed in **Table** 2-1, and two First Nations bands, as listed in **Table** 2-2. The watershed contributes about ten percent of the drainage to Lake Erie. The length of the Grand River itself is 300 kilometres, while the average width of the watershed is 36 kilometres. **Map** 2-2 shows the boundaries of the Grand River watershed, along with subwatersheds (**Map 2-3**) and the municipalities it contains.

Surface elevation in the watershed ranges from 173 metres above sea level at the mouth of the Grand River on Lake Erie, to 535 metres above sea level in the northern headwaters. The major tributaries of the Grand River include: the Conestogo and Nith, draining the western half of the watershed; and the Speed, which drains the north-east. Several smaller tributaries drain the southern half of the watershed. The largest of these include the Fairchild, Whitemans and McKenzie creeks.

The Grand River watershed has a long history of settlement that has drastically altered the landscape and impacted surface water and groundwater quality and quantity. Settlement areas of the Grand River watershed are shown in **Map 2-4.**

Table 2-1: Municipalities in the Grand River Source Protection Area

Upper/Single Tier Municipality	Lower Tier Municipality
Grey County	Township of Southgate
Dufferin County	Township of Melancthon
	Township of Amaranth
	T~~ownship of East Luther-Grand Valley~~he Town of Grand Valley
	Township of East Garafraxa
Wellington County	Township of Wellington North
	Township of Mapleton
	Township of Centre Wellington
	Township of Guelph-Eramosa
	Town of Erin
	Township of Puslinch
City of Guelph	
Region of Waterloo	Township of Woolwich
	Township of Wellesley
	Township of Wilmot
	City of Waterloo
	City of Kitchener
	City of Cambridge
	Township of North Dumfries
Region of Halton	Town of Milton
	Town of Halton Hills
County of Perth	Township of North Perth
	Township of Perth East
County of Oxford	Township of East Zorra-Tavistock
	Township of Blandford-Blenheim
	City of Woodstock
	Township of Norwich
City of Hamilton	
County of Brant	
City of Brantford	
County of Norfolk	
County of Haldimand	

Table 2-2: First Nations Reserves in the Grand River Source Protection Area

First Nation	Reserve
Six Nations of the Grand River Territory	Reserve No. 40
Mississaugas of the New Credit First Nation	Reserve No. 40A

2.3 Population, Population Density and Future Projections

According to the ~~2006~~ 2016 Statistics Canada Census, the Grand River Source Protection Area had a population of approximately 994,000 ~~898,525~~ people. **Table** 2-3 shows the breakdown of the population in each municipality for the area that falls within the Grand River Source Protection Area boundaries. The Counties of Grey, Dufferin, Wellington, Perth, Oxford, and the Regions of Halton and Waterloo have been left off of this table because the populations are broken down into the lower tiers. **Table** 2-3 also summarizes the ~~2026~~ 2041 and ~~2056~~ 2066 population projections by municipality. The ~~2026~~ 2041 projections are based on municipal population projection estimates from municipal official plans, master servicing plans or other municipal documents, where ~~. The~~applicable. The same growth rates and assumptions used for the ~~2026~~ 2041 projections were applied for the period up to ~~2056~~ 2066 to estimate the ~~2056~~ 2066 projections. Where updated projections were not available, the growth rate from the 2010 Population Forecasts report (GSP, 2010) were applied to the 2016 population and extrapolated to the years 2041 and 2066. A detailed summary of population and population projections in the Grand River Source Protection Area is provided in the ~~report~~ technical memorandum entitled ~~*Grand River, Long Point Region, Catfish Creek and Kettle Creek Watershed Areas: Population Forecasts*~~*Summary of Population Statistics for the Grand River Watershed*, ~~*January 2010*~~*August 2018*~~, available online at www.sourcewater.ca.~~.

Table 2-3: Population and Population Projections in the Grand River Source Protection Area

Municipality/First Nation	~~2006~~ 2016 Population*	~~2026~~ 2041 Projection*	~~2056~~ 2066 Projection*
Township of Southgate	1,754~~3,754~~	4,078~~2,778~~	6,453~~3,710~~
Township of Melancthon	1,306~~1,286~~	1,493~~1,625~~	1,718~~2,134~~
Township of Amaranth	3,058~~2,759~~	4,860~~3,239~~	5,610~~3,958~~
Town of ~~ship of East Luther~~Grand Valley	3,045~~2,844~~	7,694~~7,257~~	**7,694~~13,876~~
Township of East Garafraxa	1,833~~1,739~~	2,194~~2,141~~	2,594~~2,745~~
Township of Wellington North	5,294~~5,868~~	7,118~~6,451~~	8,148~~7,378~~
Township of Mapleton	10,518~~9,541~~	13,710~~11,144~~	16,960~~13,661~~
Township of Centre Wellington	29,037~~26,050~~	52,310~~36,650~~	74,735~~52,890~~
Township of Guelph-Eramosa	13,240~~12,070~~	14,575~~14,420~~	15,750~~17,110~~
Township of Puslinch	6,041~~4,844~~	7,724~~6,511~~	9,574~~9,055~~
Town of Erin	4,033~~3,567~~	*4,801~~4,182~~	5,569 ~~5,139~~
City of Guelph	135,748~~115,000~~	193,733~~158,900~~	255,683~~223,000~~
Township of Woolwich	25,756~~20,050~~	43,060~~29,600~~	59,460~~44,950~~
Township of Wilmot	21,120~~17250~~	32,820~~27,100~~	43,620~~42,750~~
City of Waterloo	126,083~~114,900~~	155,320~~143,300~~	193,620~~185,100~~
City of Kitchener	240,219~~213,500~~	361,500~~292,600~~	466,500~~409,500~~
City of Cambridge	133,818~~122,100~~	196,840~~165,500~~	248,940~~231,900~~
Township of Wellesley	11,598~~10,100~~	13,460~~12,400~~	15,860~~15,900~~
Township of North Dumfries	10,521~~9,350~~	18,720~~13,950~~	25,520~~20,650~~
Town of Halton Hills	280~~467~~	*467~~467~~	467~~467~~
Town of Milton	1,383~~1,423~~	*1,423~~1,423~~	1,423~~1,423~~
Township of North Perth	73~~66~~	*71~~66~~	71~~75~~
Township of Perth East	5,762~~3,847~~	*6,554~~4,481~~	7,346~~5,464~~
Township of East Zorra-Tavistock	265~~211~~	275~~251~~	315~~299~~
Township of Blandford-Blenheim	7,020~~6,928~~	7,889~~8,516~~	8,694~~10,888~~
Township of Norwich	1,060~~987~~	1,385~~1,228~~	1,647~~1,542~~
City of Woodstock	595~~230~~	*683~~318~~	788~~445~~
City of Hamilton	16,605~~19,404~~	*16,946~~20,426~~	17,771~~21,417~~
County of Brant	35,387~~37,040~~	*46,381~~45,744~~	58,406~~60,184~~
City of Brantford	100,421~~90,190~~	158,786~~113,970~~	220,086~~151,950~~
Six Nations of the Grand River / Mississaugas of the New Credit	13,687~~11,167~~	*15,363~~12,875~~	17,438~~15,399~~
Norfolk County	1,781~~1,957~~	*2,164~~2,264~~	2,547~~2,864~~
Haldimand County	28,254~~28,036~~	41,520~~33,427~~	68,846~~41,107~~

Total	994,000~~898525~~	1,435,917~~1185204~~	1,869,853~~1618930~~

Source: Statistics Canada Census, 2016~~06~~; ~~GSP Group Inc., 2010.~~Summary of Population Statistics for Grand River Watershed, GRCA, August 2018.
*~~Total population and projected population within Grand River watershed boundary by municipality~~where Municipal plans have not been updated, growth rate from the previous report was applied to the 2016 population to estimate 2041 population
** no growth estimates beyond current capacity of water supply system

Map 2-5 and **Table** 2-4 illustrate the population density by Municipality/First Nation within the Grand River watershed area. The Counties of Grey, Dufferin, Wellington, Perth, Oxford, and the Regions of Halton and Waterloo have been left off of this table because the population densities are broken down into the lower tiers. As indicated, the central portion of the watershed is the most densely populated area with the Cities of Waterloo, Kitchener, Cambridge, Guelph and Brantford. The remaining areas in the watershed are mainly rural agricultural areas, and, as such, have lower population density.

Table 2-4: Population Density in the Grand River Source Protection Area

Municipality/First Nation	~~2006~~ 2016 Population Density (people/km^2)*	~~2026~~ 2041 Projected Population Density (people /km^2)*	~~2056 Projected Population Density (people /km^2)*~~
Township of Southgate	38.31~~81.99~~	89.06~~60.67~~	~~81.03~~
Township of Melancthon	7.64~~7.52~~	8.73~~9.50~~	~~12.48~~
Township of Amaranth	14.01~~12.64~~	22.26~~14.84~~	~~18.13~~
Town~~ship of East Luther~~ of Grand Valley	18.71~~17.48~~	47.29~~44.60~~	~~85.28~~
Township of East Garafraxa	13.06~~12.38~~	15.62~~15.25~~	~~19.55~~
Township of Wellington North	15.97~~17.70~~	21.47~~19.46~~	~~22.26~~
Township of Mapleton	20.47~~18.57~~	26.69~~21.69~~	~~26.59~~
Township of Centre Wellington	69.83~~62.64~~	125.79~~88.13~~	~~127.18~~
Township of Guelph-Eramosa	44.68~~40.73~~	49.19~~48.66~~	~~57.74~~
Township of Puslinch	35.22~~28.46~~	45.04~~38.26~~	~~53.20~~
Town of Erin	24.82~~22.12~~	29.54~~25.94~~	~~31.87~~
City of Guelph	1543.99~~1307.93~~	2203.51~~1807.22~~	~~2536.26~~
Township of Woolwich	78.21~~60.88~~	130.76~~89.88~~	~~136.50~~
Township of Wilmot	79.35~~64.81~~	123.31~~101.82~~	~~160.62~~
City of Waterloo	1932.02~~1760.72~~	2380.02~~2195.91~~	~~2836.45~~
City of Kitchener	1736.94~~1543.70~~	2613.88~~2115.62~~	~~2960.86~~
City of Cambridge	1156.49~~1055.24~~	1701.15~~1430.32~~	~~2004.18~~
Township of Wellesley	41.64~~36.26~~	48.33~~44.52~~	~~57.09~~
Township of North Dumfries	55.43~~49.26~~	98.62~~73.49~~	~~108.79~~
Town of Halton Hills	53.57~~93.91~~	89.29~~93.91~~	~~93.91~~
Town of Milton	24.36~~25.22~~	25.06~~25.22~~	~~25.22~~
Township of North Perth	10.52~~9.64~~	10.22~~9.64~~	~~10.96~~
Township of Perth East	19.13~~12.97~~	21.76~~15.11~~	~~18.42~~
Township of East Zorra-Tavistock	9.09~~7.25~~	9.44~~8.62~~	~~10.27~~
Township of Blandford-Blenheim	20.13~~19.86~~	22.62~~24.42~~	~~31.22~~
Township of Norwich	19.79~~17.78~~	25.86~~22.12~~	~~27.78~~
City of Woodstock	143.46~~105.07~~	164.58~~145.27~~	~~203.29~~
City of Hamilton	55.39~~65.03~~	56.53~~68.46~~	~~71.78~~
County of Brant	51.64~~51.97~~	67.68~~64.19~~	~~84.45~~
City of Brantford	980.00~~1201.57~~	1549.59~~1518.38~~	~~2024.37~~
Six Nations of the Grand River / Mississaugas of the New Credit	64.14~~52.33~~	71.99~~60.34~~	~~72.17~~
Norfolk County	22.66~~24.90~~	27.54~~28.81~~	~~36.45~~
Haldimand County	54.00~~53.76~~	79.35~~64.10~~	~~78.82~~

Source: Statistics Canada Census, ~~2006~~2016; Summary of Population Statistics for Grand River Watershed, GRCA, August

2018.~~GSP Group Inc., 2010.~~
*Prorated to the area of the municipality that falls within the Grand River watershed.

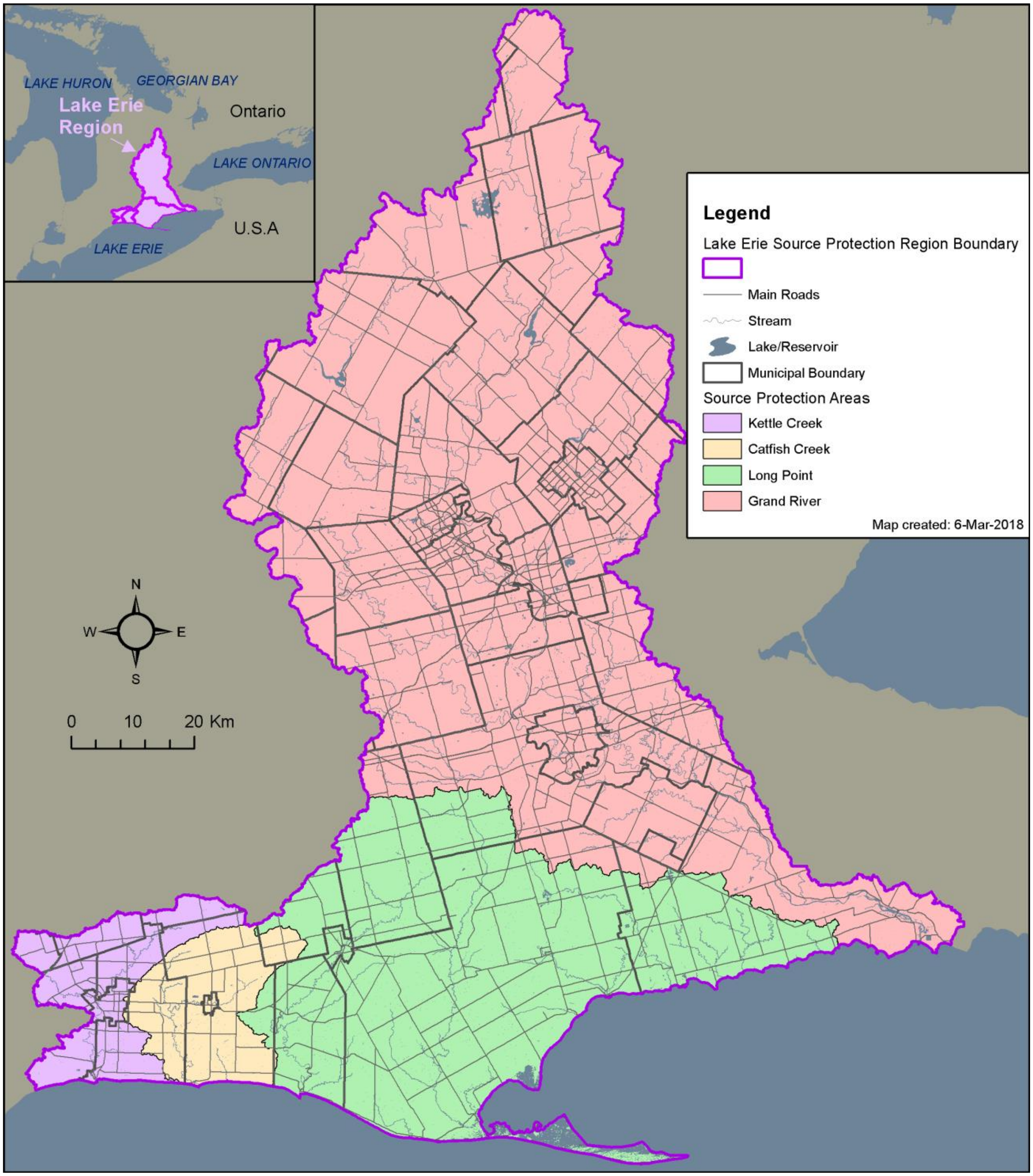
The population of the watershed that receives municipal water supplies is ~~767~~865,~~558~~538. All groundwater and surface water municipal and First Nation supply systems are shown on **Map 2-6.** **Table** 2-5 provides a breakdown of the serviced population by Municipality/First Nation for ~~2006~~2016. As indicated, approximately ~~86~~ 87 percent of the total population in the watershed is serviced by municipal water supplies.

Table 2-5: ~~2006~~ 2016 Serviced Population by Municipality/First Nation in the Grand River Source Protection Area

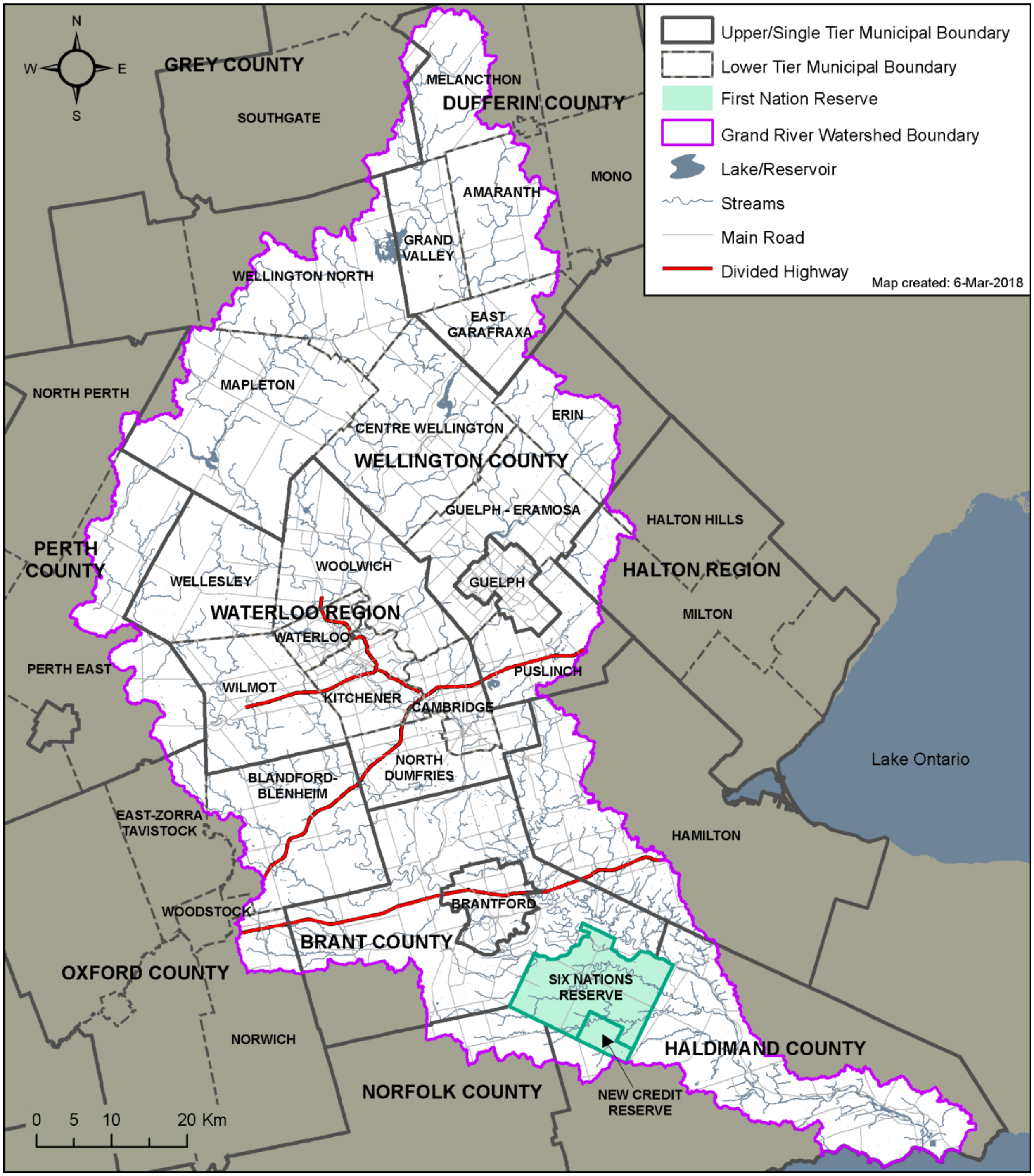
Municipality/First Nation	~~2006~~ 2016 Population*
Township of Southgate	1,794~~2,143~~
Township of Melancthon	0~~0~~
Township of Amaranth	536~~537~~
Township of East Luther-Grand Valley	2,228~~1,942~~
Township of East Garafraxa	93~~436~~
Township of Wellington North	2,333~~2,320~~
Township of Mapleton	2,430~~2,180~~
Township of Centre Wellington	19,300~~19,160~~
Township of Guelph-Eramosa	4,561~~4,107~~
Township of Puslinch	0~~0~~
Town of Erin	0~~0~~
City of Guelph	132,000~~115,000~~
Township of Woolwich	14,798~~15,388~~
Township of Wilmot	15,096~~13,797~~
City of Waterloo	138,464~~114,900~~
City of Kitchener	240,669~~213,500~~
City of Cambridge	134,403~~122,100~~
Township of Wellesley	5,451~~4,860~~
Township of North Dumfries	5,598~~4,290~~
Town of Halton Hills	0~~0~~
Town of Milton	0~~0~~
Township of North Perth	0~~0~~
Township of Perth East	1,872~~1,824~~
Township of East Zorra-Tavistock	0~~0~~
Township of Blandford-Blenheim	3,482~~2,664~~
Township of Norwich	0~~0~~
City of Woodstock	0~~0~~
City of Hamilton	**8,234~~500~~
County of Brant	18,763~~15,995~~
City of Brantford	96,000~~90,190~~
Six Nations of the Grand River / Mississaugas of the New Credit	2,000~~2,000~~
Norfolk County	0~~0~~
Haldimand County	15,433~~17,725~~
Total	865,538~~767558~~

Source: Statistics Canada Census, 2016~~06~~; Summary of Population Statistics for Grand River Watershed, GRCA, August 2018.~~GSP Group Inc., 2010.~~
*Population receiving municipality serviced drinking water within the Grand River watershed boundary by municipality.
**Population includes part of the Town of Ancaster within the City of Hamilton. This population is within the Grand River watershed but is serviced by water from outside of the watershed. The community of Lynden (population 380) is entirely within the Grand River watershed.

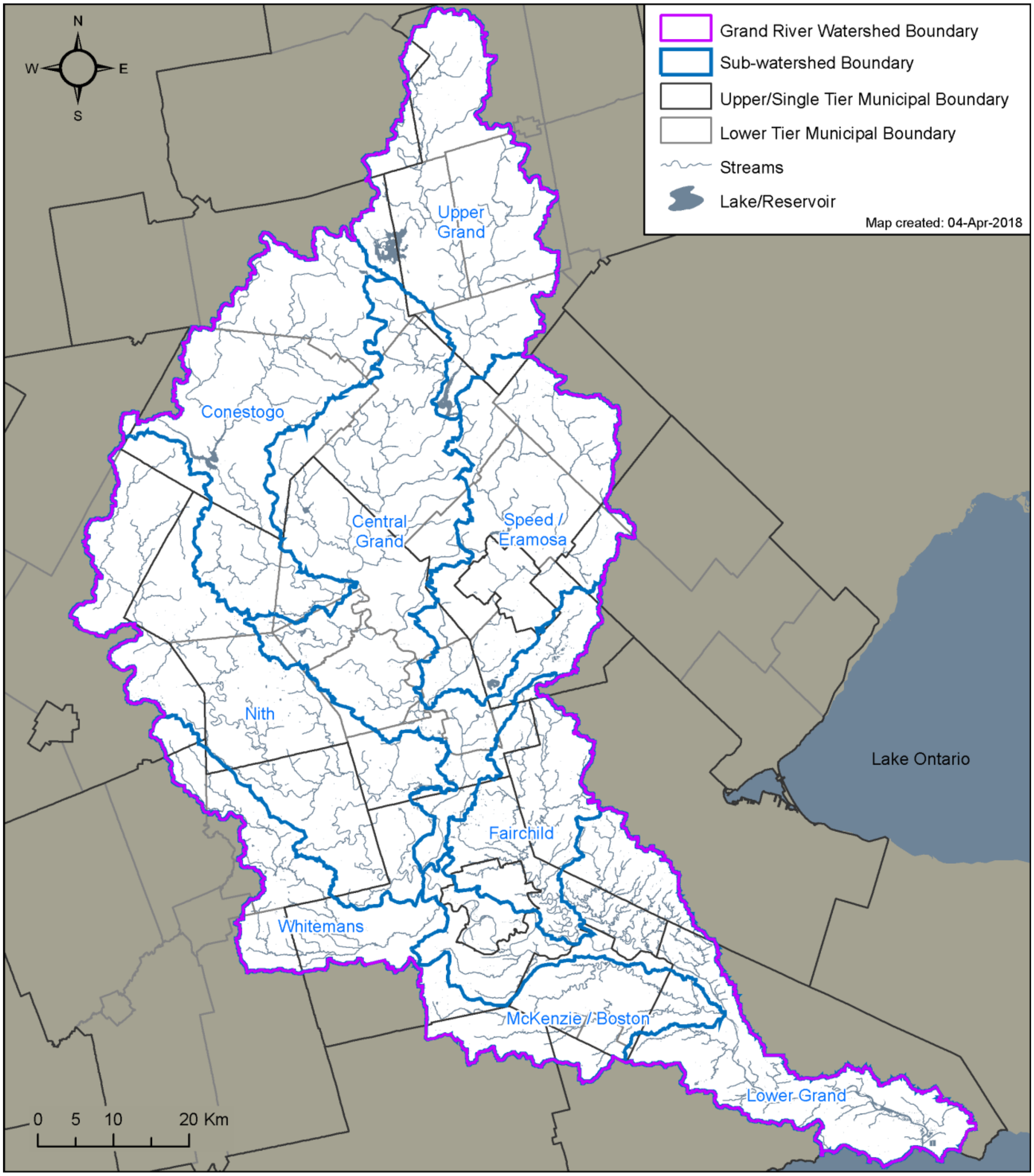
Map 2-1: Lake Erie Source Protection Region Boundary



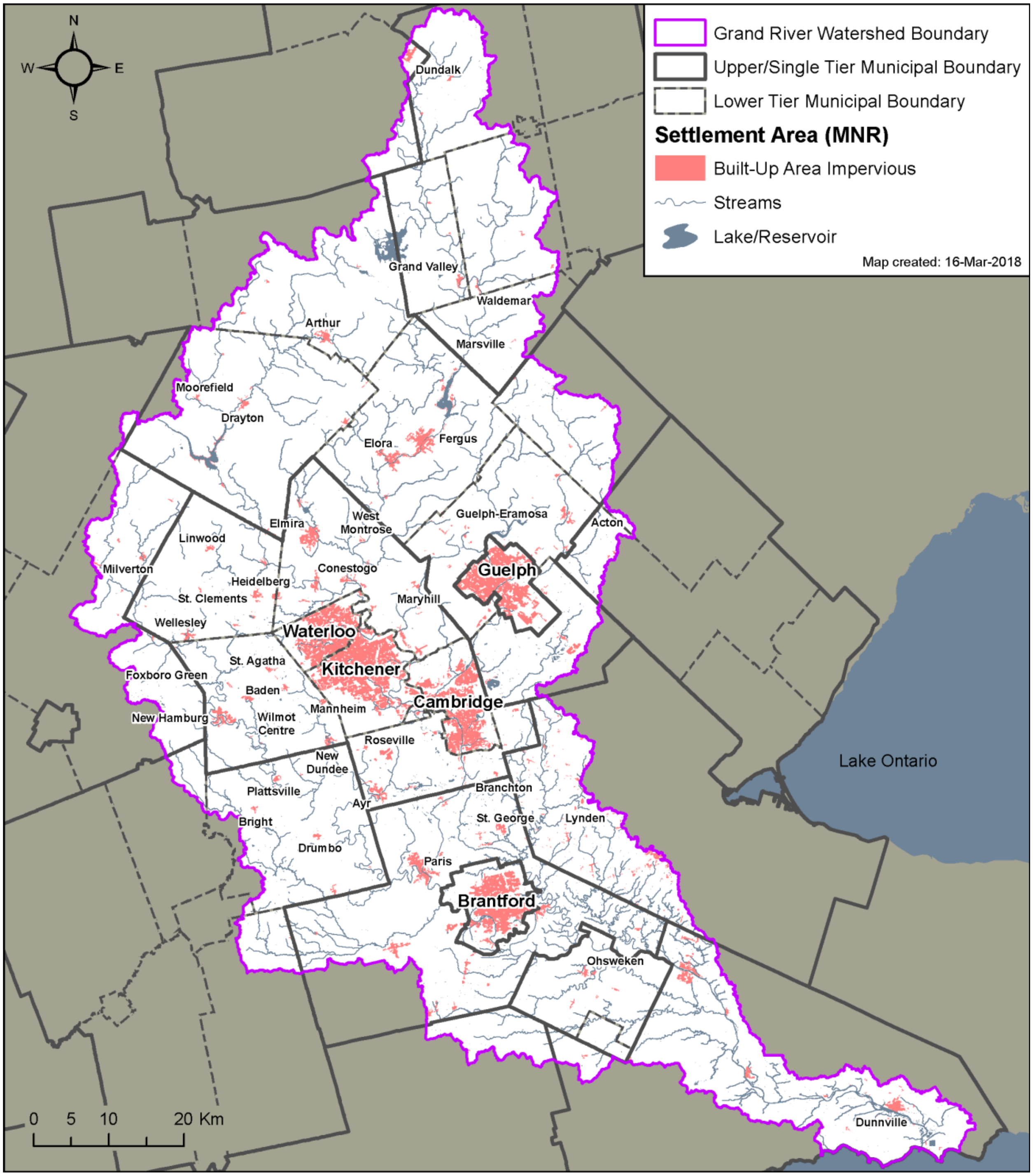
Map 2-2: Grand River Watershed Boundary



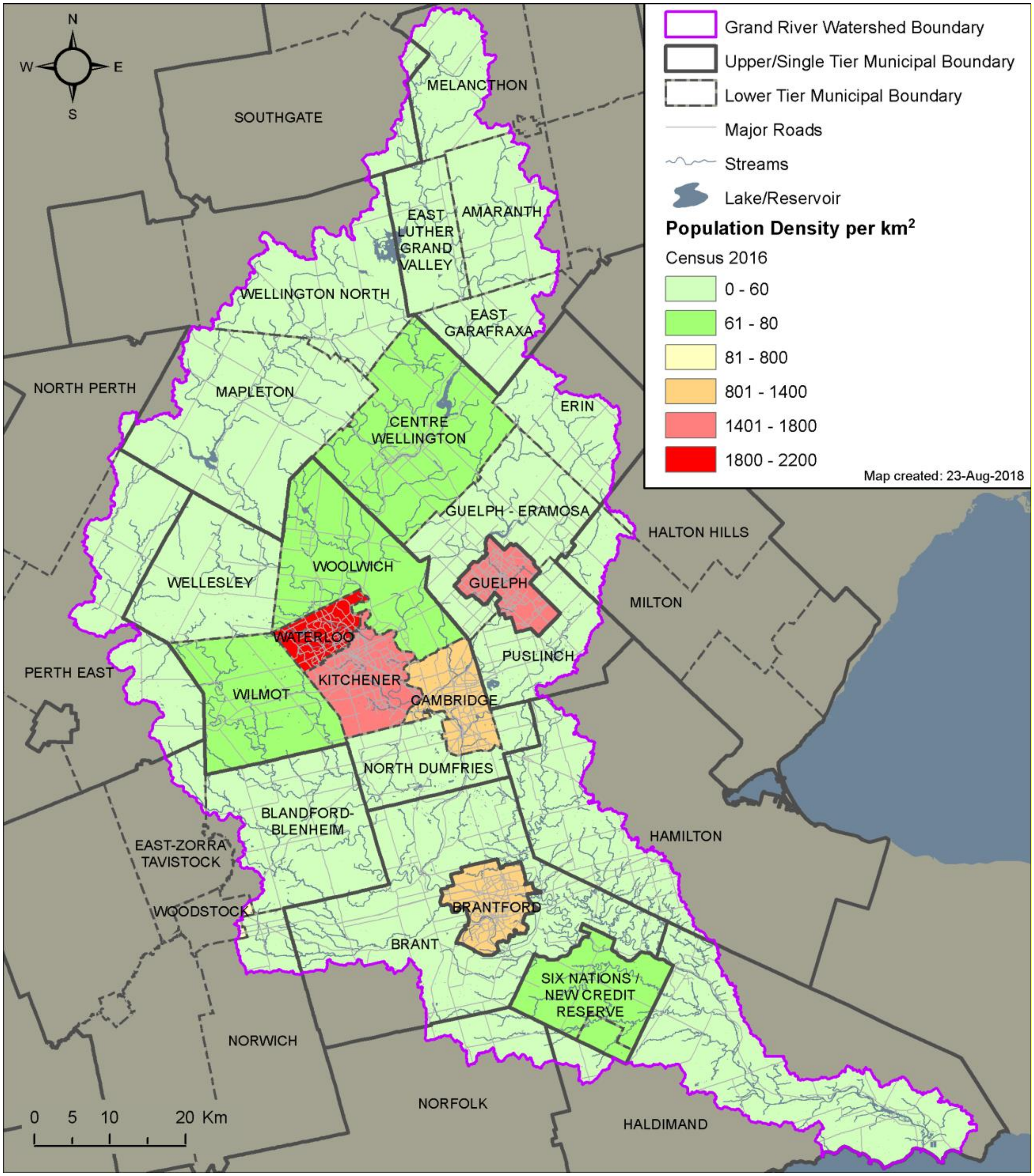
Map 2-3: Grand River Subwatershed Boundaries



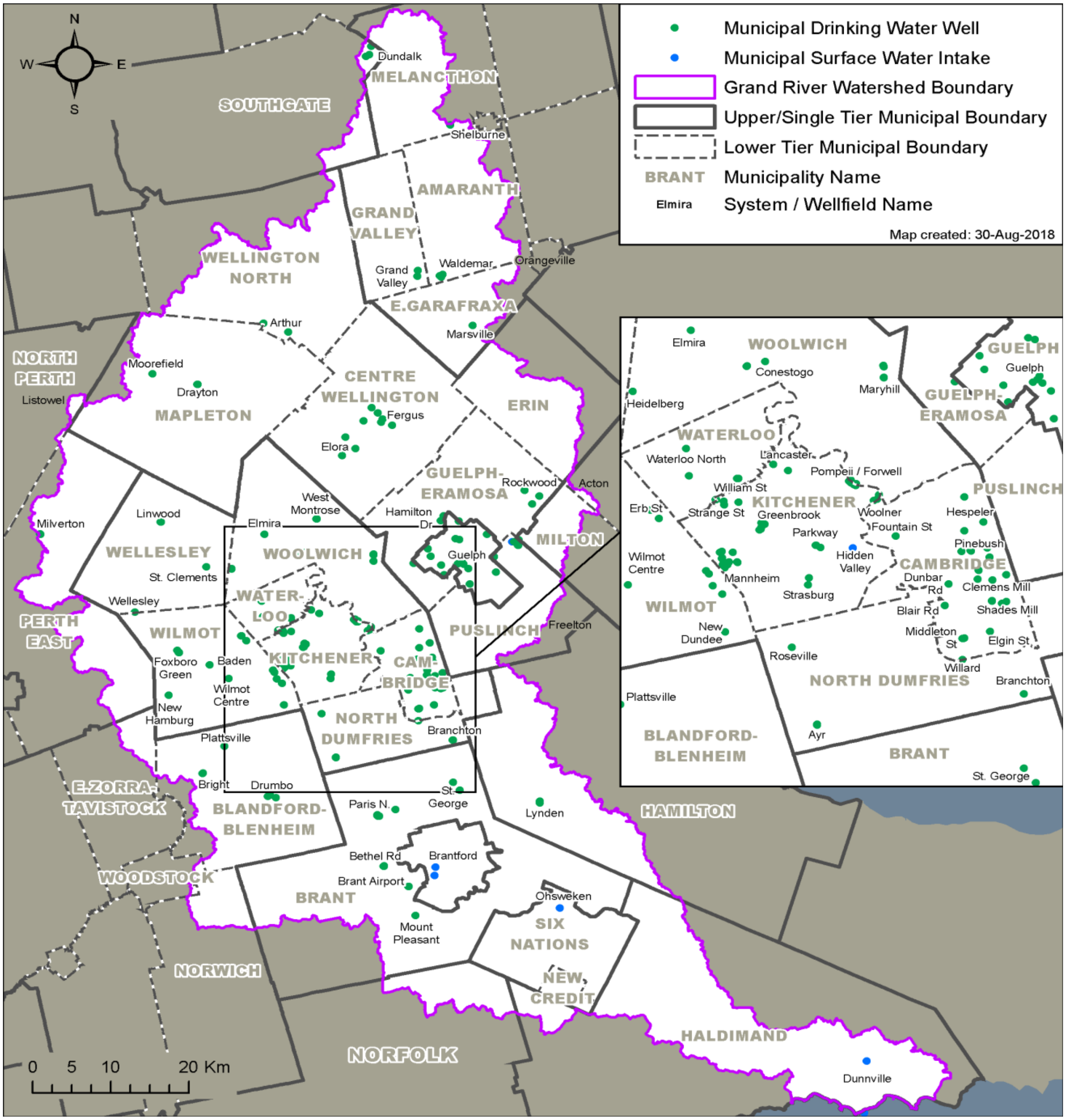
Map 2-4: Grand River Watershed Areas of Settlement



Map 2-5: **Population and Population Density in Watershed by Municipality and Reserve in the Grand River Watershed**



Map 2-6: Groundwater and Surface Water Supply Systems in the Grand River Watershed



2.4 Physiography

Physiography plays an important role in the hydrologic and hydrogeologic systems within the Grand River watershed. In total, there are 11 physiographic regions within the Grand River watershed, which are described by Chapman and Putnam (1984). The regions are described below, from north to south, and shown in **Map** 2-7**.**

2.4.1 Dundalk Till Plain

The Dundalk Till Plain, generally located north of County Road 109, is a major headwater area for the Grand and Conestogo Rivers. It includes most of Dufferin County and portions of the Townships of Wellington North and Mapleton.

The till plain is gently undulating and consists of a mix of clay, gravel, and boulders deposited by retreating glaciers. Elevations within the till plain range from 425 metres above sea level (m asl) to 530 m asl.

The till plain supports extensive wetland complexes, wet meadows, and agricultural land in four major source areas: Dundalk, Melancthon, Amaranth, and Keldon. An extensive network of agricultural drains and small watercourses which link the numerous wetlands drain the till plain.

Two large eskers and a series of small drumlins, which are located at the northwest boundary of the watershed, add considerable diversity to the habitat of the till plain. The western esker runs through the Keldon Swamp southeasterly to the north bog at Luther Marsh Wildlife Management Area.

Luther Marsh is a 5,679 ha complex of bog, marsh, mixed deciduous-coniferous swamp, upland deciduous forest, plantation, meadow and agricultural fields. The Luther Dam has created a lake-wetland area of about 2,000 ha.

The well-vegetated Horseshoe Moraine and Niagara Escarpment physiographic regions border the till plain on its east side. There is a noticeable transition from scarce natural vegetative cover along the west side of the till plain to extensive cover in the east.

2.4.2 Stratford Till Plain

The Stratford Till Plain is located to the south of the Dundalk Till Plain and includes parts of Dufferin County, Wellington County, Waterloo Region, and Perth County. This flat clay plain is wedge-shaped with its broadest sector in the west, between New Hamburg, Millbank, and County Road 109. The point is in the east, between Belwood and County Road 109. The terrain, which is generally level and often poorly drained, is characterized by silty, clay-rich soils. Artificial drainage has made this a rich and productive agricultural region and, as a consequence, only a small portion of the land remains in woodlot, marsh, or rough pasture.

Natural vegetative cover is more extensive in the east. The valleys of the Conestogo, Irvine, and Grand Rivers are deeply cut through the till plain. The headwater area of the Nith River, in the western sector, is very open and there is little wildlife habitat. Slightly better, covered drainage ditches and small watercourses are located to the east, in the northerly source area for the Speed River.

Conestogo Lake and the river’s valley lands in the Drayton area have the most extensive habitat. Between Glen Allen and Wallenstein, along the Conestogo River, there is a diverse valley forest accompanied by floodplain meadows.

2.4.3 Hillsburg Sandhills

In the Township of East Garafraxa and the Town of Erin, the Hillsburg Sandhills form a natural boundary on the southeastern flank of the Dundalk and Stratford Till Plains. The sandhills have a minimum elevation of 425 masl with some ridges reaching elevations of 490 masl.

This region is characterized by rough topography, sandy soils and swampy valleys. Agricultural use is limited due to topographical and drainage factors. The region is approximately 30% forested and much of the forest is composed of provincially significant swamps located in the valleys between the hills.

2.4.4 Guelph Drumlin Field

The watersheds of the Speed and Eramosa Rivers lie within the Guelph Drumlin Field which also includes the City of Guelph and parts of Wellington County and Waterloo Region. In this region there are approximately 300 drumlins, which are characterized as broad, oval shaped hills with low slopes.

The general landform pattern in the Guelph Drumlin Field consists of drumlins or groups of drumlins fringed by gravel terraces and separated by swampy valleys. Tributaries of the Grand River flow through these valleys. The dominant soil materials are the stony tills of the drumlins and deep gravel terraces.

This region has the most extensive network of forest habitat in the watershed. Large forests typically cover the valleys between the numerous hills and drumlins. The areas of lowest elevation are swamp and floodplain.

At the northwest corner of the drumlin field, in the Lutteral Creek watershed, there is swamp-upland forest known as the Speedside Forest. The Ariss woods are located on a significant esker and have importance due to size and botanical features. The Eramosa River Valley follows a lengthy glacial spillway from Brisbane to Guelph. The Brisbane Swamp, which is a major headwater area for the river, and the upper river valley, above Ospringe, are within the drumlin field. From Ospringe, the Eramosa River flows through the Horseshoe Moraine physiographic region to its confluence with the Speed River.

2.4.5 Horseshoe Moraines

As the name suggests, the Horseshoe Moraines region consists of a series of moraines surrounding much of southwestern Ontario. The “toe” of the horseshoe is at the north, near Georgian Bay. The moraines run roughly parallel to the Lake Huron shoreline on the west, Georgian Bay along the north, and the Niagara Escarpment to the east.

The eastern leg of the horseshoe runs along the eastern boundary and through the central part of the Grand River Watershed, from the Town of Erin in the north, past Guelph and Cambridge to Paris and Brantford in the south.

Some of this region is very hilly, often with steep irregular slopes and small enclosed basins which contain water in the spring and early summer, often referred to as kettles.

Two large moraines dominate the Horseshoe Moraines region: the Paris and Galt moraines (**Map** 2-8).

The Paris Moraine runs from Erin to Paris and then through the southwestern part of Brant County. South of Paris, the surface is sandy and to the north it consists of loose bouldery loam. Broad gravel terraces, often at one or more levels, with swampy stretches in the lowest one, can be traced along the length of the Paris Moraine. For part of its length, the moraine provides a channel for the Eramosa River.

The Galt Moraine runs parallel to and east of the Paris Moraine, never more than a few kilometres away and touching it in some places, such as near the City of Guelph. The soils are quite similar to the Paris Moraine as well: sandier in the region south of Brantford, and loose loamy till north of Brantford.

The Horseshoe Moraines region of the Grand River watershed has large sand and gravel deposits with many extraction operations in southern Wellington County, southern Waterloo Region, and northern Brant County.

The Horseshoe Moraines region is a very dynamic area and provides extensive habitat, including 5,000 ha of wetlands. Approximately 30% of the moraine region is forested, field sizes are slightly smaller, and fencerow vegetation is often very well developed. The region hosts a number of cold-water watercourses, including the Eramosa River and Mill Creek, which receive groundwater discharge. Groundwater discharge also feeds the Grand River itself, between Cambridge and Paris, providing a significant portion of its flow during summer months.

Groundwater discharge also affects soil formation and initiates wetland development on steep slopes.

2.4.6 Waterloo Hills

The Waterloo Hills region is located within the centre of the watershed, mostly within the Regional Municipality of Waterloo. This area is characterized by sand hills, gravel terraces, and many swampy valleys. The soils of the hilly areas are rich and well drained.

Water from precipitation infiltrates in the sand hills and discharges as groundwater to the headwater wetlands and source areas of the streams, creating fens, bogs, kettle lakes, swamps, marshes, and baseflow in streams.

The Grand River has cut its valley in a north-south direction through the eastern half of the region, and two of its major tributaries, the Conestogo and Speed, converge on the Grand in this area.

2.4.7 Flamborough Plain

The western side of the former Township of Beverly (now part of the City of Hamilton) lies within the Flamborough Plain. Shallow soils over bedrock in the Sheffield-Rockton area create areas of swamps, marshes, and bedrock outcrops. Soils are either wet or stony and shallow. The west end of the Beverly Swamp and the headwater area of Fairchild Creek are located in this region.

The 2000 ha Beverly Swamp is the third largest remaining interior wetland in Southern Ontario. There are relatively flat exposed bedrock plains in the Kirkwall-Rockton area.

2.4.8 Norfolk Sand Plain

The portion of the Norfolk Sand Plain in the Grand River watershed covers parts of Brant and Oxford Counties. The sands and silts of this region were deposited as a delta of the ancient Grand River when water from melting glaciers made its way south.

There are two parts in this plain region, one being west of the southern Horseshoe Moraine region, the other to the east.

The western portion covers the watershed from Ayr to Princeton and southerly to the watershed boundary in the vicinity of Scotland and Oakland. The western leg of the sand plain is drained by Whitemans Creek, which joins the Grand River near Brantford. There are also large wetlands near Falkland, Oakland and Burford. The headwaters of McKenzie Creek and Boston Creek are in this region.

Fairchild Creek and Big Creek drain the eastern portion of the Norfolk Sand Plain region, in the Peter's Corners, Ancaster, and Cainsville area. Wetlands in the Fairchild Creek watershed complex are important to this region. Most natural areas are small, fragmented, and narrowly sinuous along streams and steep slopes.

2.4.9 Oxford Till Plain

The Oxford Till Plain is located in the Plattsville, Drumbo, Princeton, and Woodstock area and is a source area for Black Creek and Whiteman-Horner Creek.

All of the blocks of natural habitat of any significant size are wetlands in this region. The Black Creek complex drains to the Nith River. The upper Whitemans Creek complex has a number of wetlands within it which are provincially significant. They include Chesney Bog, Pine Pond, Lockart Pond, Buchanan Lake, and Benwall Swamp. Soils and drainage in this region are considered to be good.

2.4.10 Mount Elgin Ridges

The Kenny Creek watershed is located in this northeastern tip of the Mount Elgin Ridges region which covers parts of Oxford and Brant Counties within the Grand River Watershed. The landscape is dominated by a succession of ridges composed of imperfectly drained clay or silty clay and hollows supporting alluvial swamps, along with deposits of sand and silt. The wetlands of the Kenny Creek watershed, which are mainly riparian swamps, are provincially significant and the creek supports a warm water fishery.

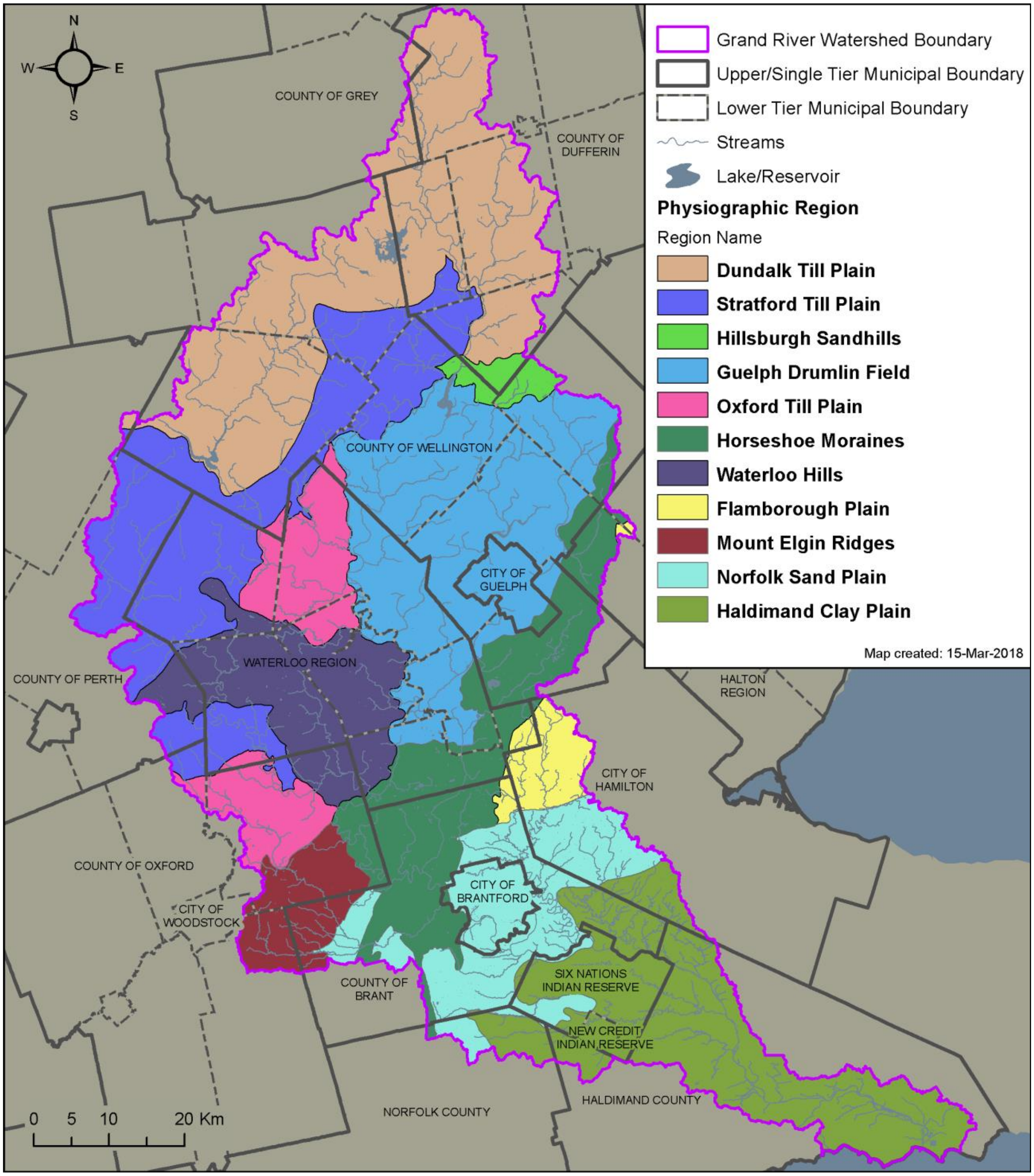
2.4.11 Haldimand Clay Plain

The lower Grand River watershed, southeast of a line through Alberton, Onondaga, and Bealton, is within the Haldimand Clay Plain region. The Grand River has cut a deep valley into the clay and silt below Brantford. Soils tend to be clay-rich and are poorly drained in places. There are however, some siltier and better drained soils in the Caledonia area and south of the Grand River.

The river corridor is well developed with extensive marshes, floodplain meadows, oak savannahs, woodlands, and willow lined riverbanks, between the roads that parallel the river.

The Six Nations and New Credit Reserves have almost 50% forest cover. Other large forested areas of importance are the North Cayuga slough forest, the Oriskany Sandstone woodland and Dry Lake wetland complex, the Taquanyah wetland complex, the lower Grand River marshes, the Dunnville northwest woodland and wetland complex, and the Mount Healy woods.

Map 2-7: Physiography of Grand River Watershed



2.5 Ground Surface Topography

Map 2-9 shows the topography of the Grand River watershed. The ground surface elevation ranges from a high of more than 500 m above sea level (asl) near Dundalk to a low of approximately 175 m ~~above sea level~~asl at the Lake Erie shoreline. Significant topographic features within the watershed include the moraine features, clay/till plains, drumlin fields, and incised river valleys. The moraine features shown on **Map** 2-8 (Waterloo, Orangeville, etc.) create topographic ridges on the landscape as formed through the last glaciation. Clay and till plains (Haldimand Clay Plain and Stratford Till Plain) result in large flat regions which are particularly prevalent throughout the southern and western extents of the watershed. Drumlin fields create a series of elongated hills on the landscape, with the elongation in the direction of glacial ice movement. The river valleys throughout the watershed are also dominant features on the landscape and have created well-recognized features such as the Elora Gorge.

2.5.1 Bedrock ~~Topography~~Surface

The bedrock surface is displayed in ~~Bedrock topography, shown on~~ **Map** 2-10 using information from the Ontario Geological Survey (OGS) (Gao *et al*., 2006).

~~, has a regional slope from approximately 525 m AMSL at the most northern extent of the watershed to 135 m AMSL where the Grand River enters Lake Erie.~~

The highest elevation, located in the northern portion of the watershed, is coincident with the 'Dundalk Dome' at approximately 525 m asl, which is also one of the highest elevations in southern Ontario. The bedrock slopes uniformly to the south where it becomes obscured by Lake Erie at approximately 173 m asl. However, the lowest bedrock elevation within the Grand River Watershed is found within the Dundas Buried Valley near Copetown. A borehole was drilled here by the OGS during an investigation of the sediments filling the Dundas Buried Valley. Bedrock was not intersected, but drilling reached depths of 30 m asl (44 m below the surface of nearby Lake Ontario) and geotechnical borings to the east, on the Burlington bar, suggest this valley reaches depths well below sea level (Karrow, 1987; Bajc *et al*., 2009).

The bedrock surface, and in particular areas of low elevation, can be very important from a hydrogeological perspective. If these depressions are partially infilled with either coarse grained material, or fine grained material with sufficiently high transmissivity, they can behave as high-yielding aquifers. Buried-bedrock valleys (thalwegs) have been interpreted as large linear depressions formed through glacial and subglacial meltwater erosion and are displayed in Map 2-10 (Gao, 2011). They are an important hydrogeological feature within the Grand River watershed as they provide targets for municipal groundwater exploration and also serve as conduits or transport paths for groundwater between sub-watersheds and surrounding watersheds.

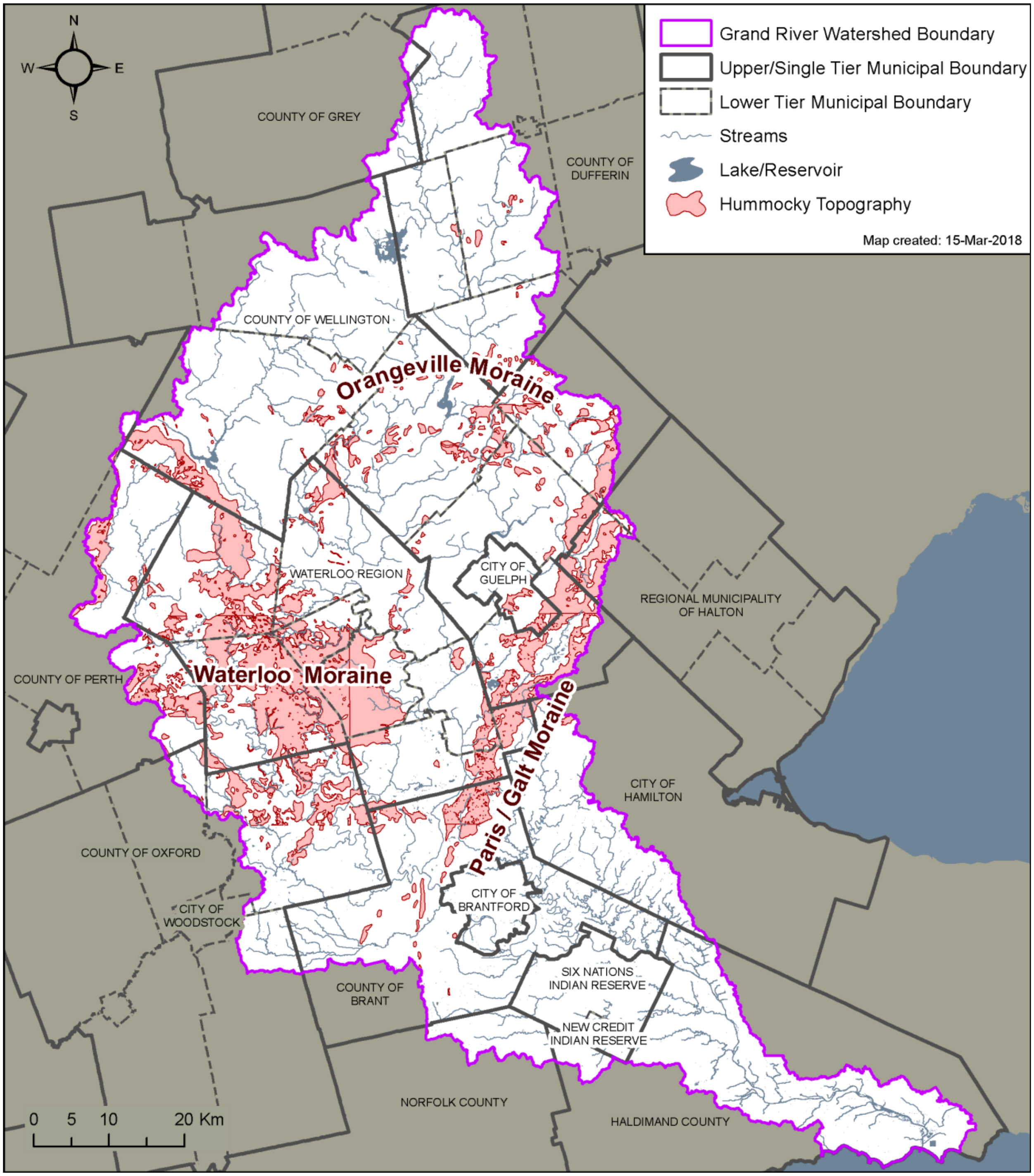
Bedrock surface features within the Grand River Watershed include the Dundas, Rockwood, and Elora Buried Valleys, along with several other buried and re-entrant valleys surrounding the watershed, with some even crossing through the watershed boundaries. The buried valleys in the Grand River watershed are thought to have formed through glacial and subglacial drainage carving out the underlying bedrock prior to the deposition of sediments (Gao, 2011). The Dundas Valley, aside from having the lowest bedrock surface elevation in the watershed, is a buried bedrock valley with little to no surface expression as it has been infilled with glacially-derived sediments. The valley is the deepest at Copetown because it is thought to be a knickpoint (a sudden drop in the slope of a river) for the drainage system, creating a deeply incised, narrow channel below a large waterfall, very much like Niagara Falls today (Marich *et al*., 2011). From Copetown, the Dundas Valley channel trends west and northwest within the Guelph and Salina Formations, displaying a dendritic drainage network with limited valley incision that is controlled by the elevation of the knickpoint (Marich *et al*., 2011). The channel then continues northwest through Wellesley and the Onondaga Escarpment as it once again returns to a linear, deeply incised, bedrock depression known as the Milverton Buried Valley (Marich *et al*., 2011).

The Rockwood Valley is also a buried bedrock valley system with no surface expression which trends southwest to northeast from the Rockwood area past the town of Erin bisecting the Niagara Escarpment at the Credit River Valley (Burt *et al*., 2011).

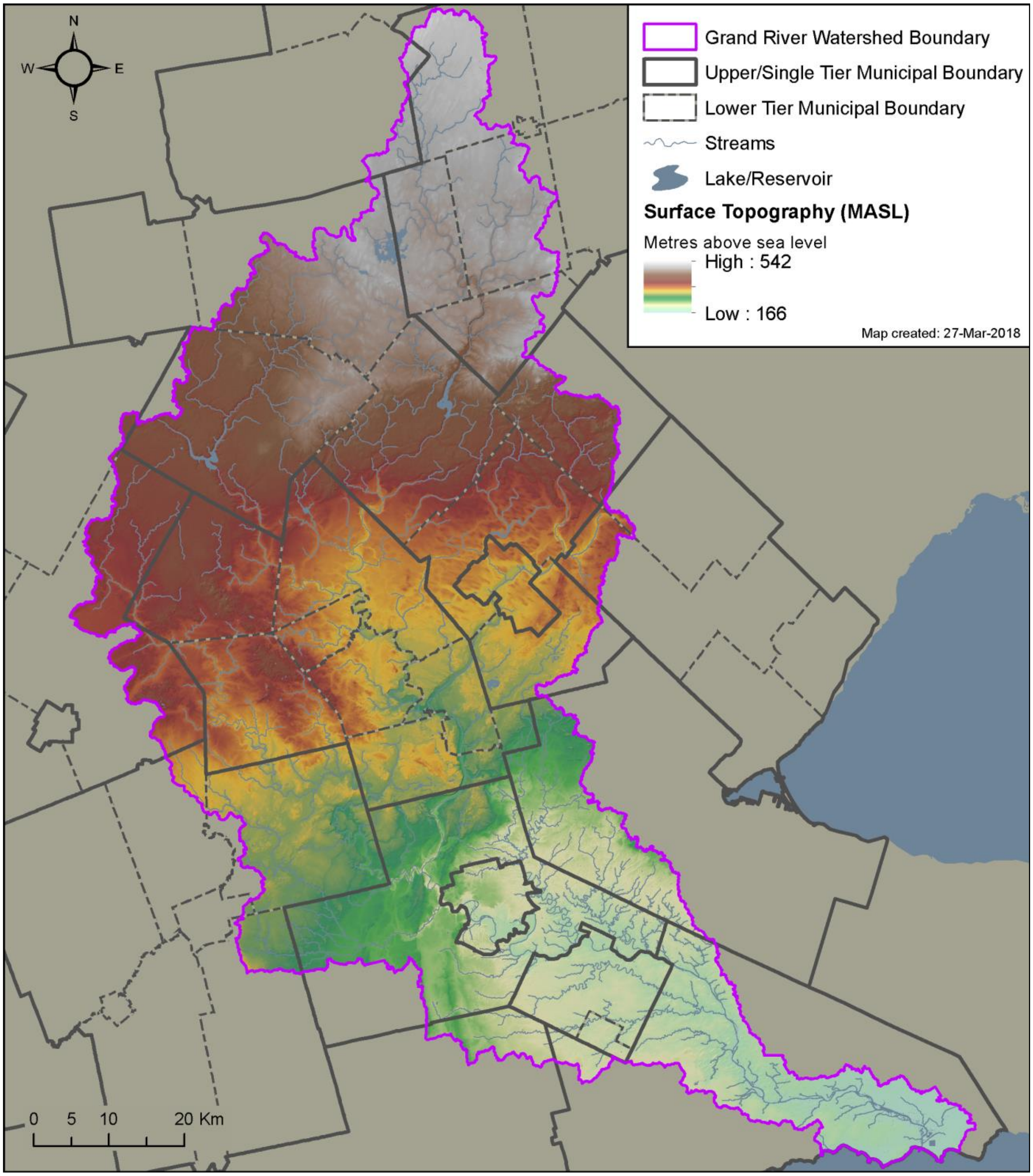
The Elora Buried Valley is discontinuous, beginning north of Fergus, and trending toward the south, and east of Belwood Reservoir. The valley then disappears for several kilometers before re-appearing on the west side of Belwood Reservoir suggesting that water flowed in an underground conduit, as is a common occurrence in karst landscapes (Burt *et al*., 2011). This interpretation was inferred through water well and geophysical records and has not been confirmed by drilling.

~~Important bedrock features within the GRCA watershed include the Dundas Valley, the Rockwood Valley and the Onondaga Escarpment. The Dundas Valley is a buried bedrock valley (no surface expression) that trends east-west from Hamilton Harbour toward Brantford before trending north within the Salina Formation. The valley again trends west through Wellesley from the north Waterloo area. The Rockwood Valley is a buried bedrock valley (no surface expression) that trends northeast-southwest from the Rockwood area to the northeastern portion Guelph, emerging within the Eramosa River Valley. The Onondaga Escarpment extends from Buffalo, running along the north side of Lake Erie and trending north along the west side of the Grand River Watershed, south of Brantford.~~

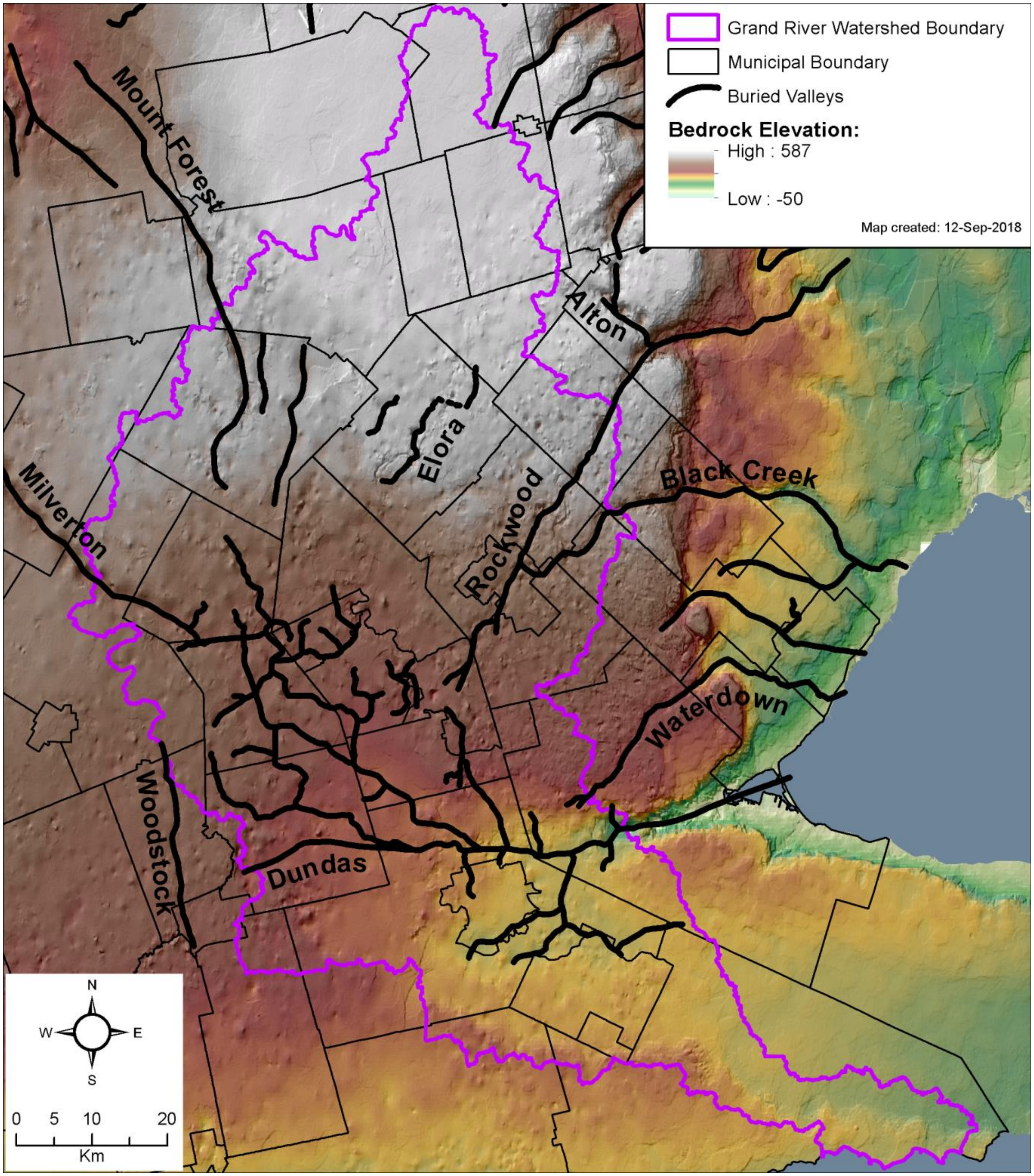
Map 2-8: Hummocky Topography in the Grand River Watershed



Map 2-9: Ground Surface Topography in the Grand River Watershed



Map 2-10: Bedrock Topography in the Grand River Watershed



2.6 Geology

~~In a general sense, t~~The geology of the Grand River watershed varies widely across the region. The entire watershed is underlain by carbonate bedrock formations which form north to south trending bands. Unconsolidated sediments, or overburden, deposited in relation to the movement of glaciers across the landscape over time overlay the bedrock formations. The overburden sediments are classified into three common groupings within the north, central and southern portions of the watershed. ~~can be classified into three types of unconsolidated sedimentary material overlying bedrock.~~ Overburden within the northern part of the watershed are commonly tills and till-related materials. The central portion of the watershed contains a series of complex moraine systems, ice-contact, and outwash deposits, whereas the southern portion of the watershed is comprised of fine-grained glaciolacustrine, or clay-rich, sediment.

~~**The northern portion of the watershed is comprised of till and related materials, the central portion of the watershed is comprised of a series of northeast-southwest trending, typically coarse-grained, moraine sediments, and the southern portion of the watershed is comprised of fine-grained glaciolacustrine sediments. Each of these categories of unconsolidated sediments is unconformably underlain by sedimentary bedrock.**~~

2.6.1 Bedrock Geology

Three main bedrock structures, shown in **Map 2-11**, define the sedimentary bedrock sequences underlying the Grand River Watershed (Janzen, 2018):

- the Niagara Escarpment cuesta,
- the Onondaga Escarpment cuesta, and
- the Algonquin arch forebulge.

A cuesta is defined as a ridge that contains a gentle slope on one side and a scarp on the other. A forebulge is a flexural bulge in the lithosphere (earth's crust) caused by a load depressing a tectonic plate.

The Alleghanian orogeny, which occurred approximately 325 million to 260 million years ago (Ma), was an orogenic (or mountain building) event that occurred to the east of Southern Ontario. This orogenic event was responsible for the bedrock expressions found in Southern Ontario (Root and Onasch, 1999). Mountains are created through the collision of tectonic plates. The area behind the newly formed mountain range is folded and faulted creating a network of bedrock highs (arches) and basinal foreland lows, such as the Algonquin arch to the west of the Grand River watershed and the associated bedrock lows of the Michigan foreland basin to the west of the Algonquin arch and the Appalachian foreland basin to the east.

As shown in **Map 2-11**, the Grand River watershed is situated adjacent to the southeastern edge of the Algonquin Arch, within the westernmost part of the Appalachian foreland basin. Bedrock formations within the Grand River watershed consists of upper Ordovician, Silurian, and lower Devonian-aged marine sediments that straddle the broad northeastern oriented basement high of the Algonquin Arch. Proterozoic sedimentary rocks were deposited into the Grand River watershed area between 458 to 393 Ma (Thurston *et al.*, 1992; Armstrong and Carter, 2010; Sun, 2018). The sedimentary bedrock contains shales, sandstones, limestones, dolostones, and evaporites with varying degrees of disconformable (erosion has removed a part of the record due to low sea levels) and conformable (continuous deposition of sediments) surfaces. The type of sedimentary rock is highly dependent on the geologic setting that existed during deposition. The rise and fall of sea levels determined the type and characteristics of the rock deposited. The bedrock formations generally subcrop in long parallel bands of varying width generally aligned in a north-west to south-east direction.

The Niagara Escarpment cuesta is east and nearly parallel, at a distance of approximately 10 to 20 km, to the eastern boundary of the Grand River watershed from Dundalk, south to Hamilton. There are multiple re-entrant bedrock valleys that cut perpendicular through the rock face and many areas above the Niagara escarpment that have been subjected to karstification.

The Onondaga Escarpment cuesta trends east-west near the Lake Erie shoreline from the Niagara Region to South Cayuga before turning northwest to the Woodstock area, then trending approximately south-north to the County of Bruce. The Grand River cuts through the Onondaga escarpment to its terminus at Port Maitland on Lake Erie but the southern and southwestern boundary of the watershed trend along this escarpment from South Cayuga, northwest, to the area east of Listowel.

The Algonquin Arch is a northeast to southwest trending forebulge zone separating the Michigan and Appalachian Basins. The Algonquin Arch trends from the Chatham area, through Dundalk and out past the Niagara escarpment. The western edge of the Grand River watershed divide appears to follow this trend from the Woodstock area, where the Onondaga Escarpment meets the Algonquin Arch, and follows it to the northeast where it meets Dundalk. The bedrock structures shown in Map 2-11 display the importance of bedrock structures in shaping the Grand River watershed.

Bedrock outcrops are most commonly found in two areas; along the eastern boundary of the watershed from near the town of Erin, south to Hamilton; and along the southern boundary of the watershed from Port Maitland/Dunnville west to Hagaersville. The eastern area outcrops are commonly found along river valleys, road cuts, and quarries. They consist of, in ascending order, the Gasport, Goat Island, Eramosa, and Guelph Formations (Brunton, 2009; Brunton *et al*., 2009). The southern watershed outcrops are commonly found along the Onondaga Escarpment and associated river valleys and quarries. The stratigraphy of the southern outcrops commonly consist of the Bertie, Bass Island, Oriskany, Bois Blanc, and Onondaga/Amherstburg Formations (Armstrong and Carter, 2010; Sun, 2018). The outcropping or subcropping bedrock formations within the Grand River watershed were originally deposited horizontally. The bedrock strata in southwestern Ontario now dip shallowly as a result of subsequent structural deformation. Regional dip generally increases with depth and distance away from the crest of the Algonquin Arch. Along the arch crest, the dip is 3 to 6 m/km to the southwest, increasing to 3.5 to 12 m/km down the flank of the arch into the Appalachian basin (Armstrong and Carter, 2010).

~~*Bedrock underlying the Grand River Watershed is part of the Michigan and Appalachian Basins, transitioning between the basins in the Brantford area at what is known as the Algonquin Arch. The bedrock consists of Devonian, Silurian, and Ordovician aged marine sediments deposited in a sea that once inundated this area between 345 to 370 million years ago (Sibul et al., 1980). The sedimentary bedrock mainly consists of interbedded limestone and dolostone carbonate materials, and shale of the Ordovician (oldest) to Devonian (youngest) age. The bedrock formations generally outcrop or subcrop in long parallel bands of varying width, aligned in a north-west to south-east direction.*~~

~~*Bedrock outcrops are most commonly found in the central-eastern and southern areas of the watershed. Within the central-eastern area, outcrops, which are commonly found along river valleys, generally consist of the Guelph and Gasport (former Amabel) Formations. In the southern part of the watershed, outcrops are generally associated with the Onondaga Escarpment and consist of the Bass Island-Bertie, and Bois Blanc Formations (Karrow, 1973).*~~

~~***The bedrock formations outcropping or subcropping within the Grand River watershed were deposited horizontally but now regionally dip approximately 2 degrees to the west as a result of subsequent structural deformation. Map 2-11Map 2-10 shows the bedrock formations of the Grand River Watershed.***~~

~~***The following provides a brief description of the bedrock formations within the watershed. Note that these descriptions are consistent with the proposed revised stratigraphy of the Silurian carbonate along the Niagara Escarpment currently being undertaken by the Ontario Geological Survey (Brunton, 2009).***~~

Queenston Formation

~~The Queenston Formation, which is also commonly known as the Queenston Shale, is the oldest Paleozoic bedrock formation within the watershed and forms the uppermost bedrock formation in a small area in the Dundas Valley in the vicinity of Copetown. It was formed during the Upper Ordovician period (458 to 443 million years ago), generally consists of red shale interbedded with limestone and siltstone, and ranges in thickness from 135 m to 335 m. (Telford, 1976).~~The Queenston Formation, commonly known as the Queenston Shale, was formed during the Upper Ordovician period, 458 to 443 Ma, and is the oldest Paleozoic bedrock formation within the watershed. It underlies all of southwestern Ontario and outcrops, within the Grand River watershed along the Niagara Escarpment in a small area of the Dundas Valley, in the vicinity of Copetown. It is a noncalcareaous to calcareaous red (maroon) shale with subordinate amounts of green shale, siltstone, sandstone, and limestone (Armstrong and Carter, 2010). The thickness ranges from 275 m beneath Lake Erie to 50 m in the Bruce Peninsula (Sanford, 1961).

Clinton–Cataract Group

The Clinton-Cataract Group is represented by a narrow band on Map 2-11 that overlies the Queenston Formation. The Clinton-Cataract Group subcrops in the Dundas Valley area of the Grand River Watershed, and is comprised of several different bedrock formations, including the Whirlpool, Manitoulin, Cabot Head, Merritton, Rockway, and Irondequoit Formations. These formations however have not been differentiated on Map 2-11 and are mapped as the Clinton-Cataract Group. This group, which is exposed along the face of the Niagara Escarpment, was deposited during the Lower to Middle Silurian period, 444 to 430 Ma, and generally consists of grey to dark grey shale, sandstone, limestone and dolostone (Telford, 1979). Additional information on the individual formations is found in Janzen (2018).~~The Clinton-Cataract Group overlies the Queenston Formation. From **Map** 2-11**Map 2-10**, a narrow band representing the Clinton-Cataract Group subcrops in an area surrounding the Queenston Formation in the Dundas Valley area. The Clinton-Cataract Group is comprised of several different bedrock formations (including Cabot Head, Merritton, Rockway, Irondequoit, and Rochester), however these formations have not been differentiated on **Map** 2-11**Map 2-10**. This group, which is exposed along the face of the Niagara Escarpment, was deposited during the Lower to Middle Silurian period, 443 to 428 million years ago and overall, generally consists of grey to dark grey shale, sandstone, limestone and dolostone (Telford, 1979).~~

Gasport Formation

The Gasport Formation consists of thick- to massive-bedded, fine- to coarse-grained, blue-grey to white to pinkish grey dolostone and dolomitic limestone (Armstrong and Carter, 2010). There are two members to the Gasport Formation; the basal Gothic Hill member and the upper Pekin member. The basal Gothic hill member is a light pinkish-grey, cross-bedded grainstone to packstone containing microbial–crinoidal reef mound lithofacies changing upward to rhynchonellid brachiopod–bryozoan–bivalve coquinas (Brett *et al.*, 1995; Brunton, 2009). The upper Pekin member is a dark olive-gray, argillaceous, fine- to medium-grained, thin- to medium-bedded dolomicrite with coral-stromatoporoid framestone bioherms up to 6 m high and dark grey, coarse, rubbly dolorudite representing biohermal flank debris (Brett *et al*., 1995; Brunton, 2009). Bioherms extend from the top of the Gothic Hill member grainstones into the Pekin member and occasionally into the overlying Goat Island Formation.

The Gasport Formation outcrops in the Grand River watershed at three points along the eastern boundary of the watershed: i) in Amaranth Township near Laurel; ii) in a relatively large area surrounding the town of Rockwood; and, iii) in a band surrounding the Dundas Valley.

The thickness of the Gasport Formation changes due to an increase in accommodation space during deposition. This results in thicker development of the microbial–crinoidal–bryozoan–coral reef mound complexes of the lower Gothic Hill member (Brunton, 2009). In some areas, the reef mounds form multiple stacked cycles that range in thickness from 25 m to more than 70 m (Brunton, 2009). The relative thickness of the Gothic Hill member of the Gasport Formation controls the relationship with the overlying strata. This results in the upper Pekin member being absent north of Hamilton, from Guelph to the southern Bruce Peninsula. Furthermore, if the Gasport Formation lithofacies is thicker, then the stratigraphic unit that rests disconformably on the sequence boundary will be younger. For example, when the younger Guelph Formation rests disconformably on a sufficiently thick Gasport Formation, the Goat Island and Eramosa Formations (which stratigraphically overlie the Gasport Formation but underlie the Guelph Formation) are absent. Additionally, there is no evidence to suggest that the Goat Island and Eramosa Formations were ever deposited at these locations prior to the deposition of the Guelph Formation (Brunton, 2009). The upper contact of the Gasport Formation is typically characterized by a sharp disconformable contact that can be stylolitic and is erosional in many places (Brett *et al*., 1995). The Gasport Formation is also susceptible to karstification where the Gothic Hill member reef mounds are overlain by the Guelph Formation lithofacies (Brunton, 2009). There are large cavernous pores created by karstification of the subterranean Gasport Formation beneath the city of Guelph (Cole *et al*., 2009). The Gothic Hill member reef mounds make up the key hydrogeologic units in the Guelph–Cambridge region (Brunton, 2009).

Goat Island Formation

The basal contact of the Goat Island Formation with the underlying Gasport Formation is truncated by the variable thickness of the Gasport Formation reef mounds (Brett *et al*., 1995). The Goat Island Formation is not always present due to the variably thick lower Gasport Formation.

The Goat Island Formation consists of the lower Niagara Falls member and the upper Ancaster member. The Niagara Falls member is a crinoidal grainstone (brachiopod bearing) that contains a distinctive pin-striped appearance, is finely crystalline, tight, and cross laminated with incipient small reef mounds (Brunton, 2009). This member can be distinguished from the underlying encrinitic Gasport Formation by the finer grained and thinner bedded nature of the Niagara Falls member (Brett *et al*., 1995; Armstrong and Carter, 2010). The upper Ancaster member is a chert-rich, finely crystalline dolostone that is medium to ash grey in colour, thin to medium bedded and bioturbated (Brunton, 2009). Near Hamilton and among various other locales, it contains abundant chert nodules and lenses within the basal beds. These are informally referred to as the Ancaster chert beds (Armstrong and Carter, 2010). There is also a shaly interval near the top of the member east of Hamilton (Bolton, 1957; Armstrong and Carter, 2010). This is the cap rock of much of the Niagara Escarpment between Hamilton and Niagara Falls but due to the variably thick Gasport Formation north of Hamilton, the Niagara Falls and Ancaster members of the Goat Island Formation become an interfingered hybrid rock unit (Brunton, 2009). North of Hamilton, the hybridized members of the Goat Island Formation occur when the Gasport Formation is 30 to 50 m thick. The Goat Island Formation may even be absent if the Gasport is sufficiently thick (*i.e*. where significant relief is caused by Gasport Formation reef mounds) (Brunton, 2009). Where the Gasport Formation is less than 20 to 25 m thick, the Niagara Falls member may be up to 10 m thick and the Ancaster member up to 6 m thick (Brunton, 2009).

Eramosa Formation

The Eramosa Formation is comprised of three members; the basal Vinemount member, the middle Reformatory Quarry member, and the upper Stone Road member.

The basal Vinemount member is a black (fresh) to light grey (weathered), thinly bedded, fine-crystalline, and cyclic horizontally bioturbated dolostone with interbedded partially silicified brachiopods and digitate tabulate corals, and has a distinctive petroliferous odour when broken (Brunton, 2009). It is most shaly west of Hamilton becoming less shaly to the north.

The middle and upper Reformatory Quarry and Stone Road members are lithologically similar units. The Reformatory Quarry member is a light brown to cream coloured thick bedded, coarsely crystalline and coral-stromatoporoid biostromal lithofacies dolomite (Brunton, 2009). It also contains a strongly deformed pseudonodular interval, interpreted as a seismite (earthquake-deformed) bed, that varies in thickness from <30 cm to 1.6 m regionally (Brunton, 2009).

The Stone Road member is the upper cream-coloured pseudonodular facies dolomite of the Eramosa Formation (Brunton *et al*., 2012).

Guelph Formation

The Guelph Formation is the uppermost bedrock stratum for a large portion of the watershed, stretching in a 30 km wide swath from Dundalk to the Hamilton International Airport. This formation is a platformal and reefal dolostone with biostromal and biohermal reef complexes (Armstrong and Carter, 2010; Brintnell, 2012). There are two members of the Guelph Formation; the basal Wellington member and the upper Hanlon member.

The Wellington member is a carbonate reef mound-bearing and open-marine medium to thickly bedded, cross-stratified, crinoidal grainstone to wackestone-dominated facies (Brunton, 2009; Brunton *et al.*, 2012).

The Hanlon member is a mid-shelf, open marine to lagoonal dolostone that is a thinly-bedded megalodont–gastropod-dominated wackestone and packstone facies (Brunton, 2009; Brunton *et al.*, 2012).

The Guelph Formation is typically 15 to 22 m thick in the Cambridge through Guelph area and thickens to more than 100 m in the Luther Lake region (Brunton, 2009; Brintnell, 2012; Brunton *et al*., 2012). Areas with exposed sections of the Guelph Formation include the Guelph Dolime Quarry (approximately 16 m of strata) and the Irvine Gorge in Elora (figure 5) (Brunton *et al*., 2012).

There are large, interconnected, cavernous, karstic pores associated with the Guelph Formation, located at an average depth of ~60 m, which have been identified using downhole geophysical logs, video logs, and hydraulic testing (Cole *et al*., 2009). The karst in the Guelph Formation is extremely important to the hydraulic characteristics of the watershed~~ (see section 2.2)~~.

Salina ~~Formation~~Group

The ~~Salina Formation~~Salina Group overlays the Guelph Formation and, similar to the Guelph Formation, it also underlies a large portion of the Grand River Watershed, stretching from Drayton to Dunnville. The group, which was deposited during the Upper Silurian period, approximately 420 million years ago, is comprised of several sub-members, four of which can be found in the watershed. From east to west, these sub-members are labelled A, C, E, and F. Similar to the main geological formations, the sub-members are aligned in long parallel bands, with the geology of each sub-member differing slightly. The A sub-member of the Salina abuts the Guelph Formation and consists of tan dolomite and grey mudstone. Immediately west is the C member, consisting of grey and olive green shale containing lenses of anhydrite and gypsum. The E member generally consists of tan dolomite with lenses of anhydrite or gypsum. Finally, the westernmost F member is made up of grey and red shale containing lenses of anhydrite or gypsum (Sanford, 1969). The gypsum mines present in the Caledonia area are set within the ~~Salina Formation~~Salina Group. Generally, the ~~Salina Formation~~Salina Group has poor water quality, forcing many municipal systems in the western portion of the watershed to rely on overburden aquifers for drinking water supplies.

Bertie - Bass Islands Formation

The Bass Island and Bertie Formations are considered to be laterally equivalent. The Bertie Formation is considered an Appalachian basin Formation in the Niagara Peninsula and the Bass Island Formation is considered a Michigan basin Formation (Johnson *et al*., 1992; Armstrong and Carter, 2010).

The Bertie Formation consists of cyclic successions of dark brown to light grey-tan, very fine- to fine-crystalline, variably laminated and massive, argillaceous or bituminous dolostones and minor shales (Armstrong and Carter, 2010; Sun, 2018).

The Bass Island Formation contains a 2-cm thick shale layer at its base, overlying the Bertie Formation (Sun, 2018). The formation is a dark brown to light grey, variably laminated, mottled, argillaceous or bituminous, very fine- to fine-crystalline and sucrosic dolostone. Intraclastic breccias, evaporite interbeds, and blue-grey mottling are common (Armstrong and Carter, 2010; Sun, 2018).

The Bertie and Bass Island formations may comprise a succession from 10 to 90 m thick with local intervals up to 150 m; however, in the Grand River watershed the Bass Island Formation is 5 m thick and overlies the 16 to 18 m thick Bertie Formation (Sanford, 1969; Armstrong and Carter, 2010; Sun, 2018).

Bois Blanc Formation

The Bois Blanc Formation unconformably overlies the Bass Islands-Bertie Formation to the west. The formation subcrops in a band roughly paralleling the western boundary of the watershed from approximately Conestogo Lake south. This unit was deposited during the Lower Devonian period, 418 to 394 million years before present, and primarily consists of grey and grayish-brown dolomite, limestone and nodular chert (Sanford, 1969).

Oriskany Formation

In the Grand River watershed, the Oriskany Formation overlies the Bass Island Formation by a sharp and irregular erosional surface (Sun, 2018). The Oriskany Formation is the oldest Devonian deposit in southwestern Ontario and has been assigned a Pragian age of 410 to 407 Ma (Sun, 2018). The Oriskany Formation consists of grey to yellowish white, well-rounded to sub-angular, well-sorted, medium to coarse grained, loosely cemented, thick- to massive-bedded, calcareous quartzose sandstone with fossiliferous horizons (Armstrong and Carter, 2010; Sun, 2018).

In Southern Ontario, the Oriskany Formation is discontinuous, thins from east to west, and eventually pinches out west of the Hagarsville area (Sun, 2018). In the Grand River watershed, the Oriskany Formation underlies an area of roughly 6 km^2.

Onondaga – Amherstburg Formation

The Onondaga-Amherstburg Formation is the youngest and westernmost bedrock formation which is present in the watershed at two locations: in the County of Perth and along the western boundary of the watershed west of Dunnville. The Onondaga-Amherstburg Formation was deposited during the Middle Devonian period, 394 to 382 million years ago. The formation is primarily composed of fossiliferous limestone, which is variably cherty and includes some shale (Telford and Tarrant, 1975).

2.6.3 Quaternary Geology

The understanding and interpretation of the Quaternary geology of the Grand River watershed is largely confined to the Late Wisconsinan time period, which began around 25,000 years ago. Prior to this time the geological record within the watershed is vague; however, it is known that Early and Middle Wisconsinan sediments and even pre-Wisconsinan sediments might underlie parts of the watershed.

The most recent glacial history of southern Ontario can be summarized as three episodes of glaciation, the Nissouri, Port Bruce, and Port Huron Stadial events, separated by three ice-free periods, the Erie, Mackinaw and the current interstadial events. Numerous surficial landforms were deposited within the Grand River Watershed with each stadial and interstadial event.

The first widely recognized Late Wisconsinan event is associated with the Nissouri Stadial ice advance about 20,000 years ago (Karrow, 1993). Catfish Creek Till, which is believed to generally underlie the entire Grand River Watershed, is representative of the Nissouri Stadial. It is often used as a stratigraphic marker bed as a result of its overall consistency in composition (Barnett, 1992). During the Nissouri Stadial, thick ice spread over the entire southwestern Ontario area and into the northern United States as far south as Ohio. The ice advance was quite strong and was believed to have progressed unimpeded by any of the subtle topographical features in southern Ontario. Approximately 18,000 years ago, the ice began to retreat from Ohio, and 16,000 years ago the glacier covering southern Ontario was believed to have split along a line from the Kitchener-Waterloo area to northeast of Orangeville (Sibul et al., 1980). Where the ice lobes broke apart, the low areas between the separating ice lobes became the focus for sediment-laden meltwaters. Over time, as the meltwaters flowed into these low areas, large deposits of sands and gravels built up and subsequently formed interlobate moraines. Upon full retreat of the ice, these deposits remained behind as topographical highs. Initial deposition of the Waterloo and Orangeville interlobate moraine complexes were thought to have taken place at this time (Sibul et al., 1980). As the ice retreated, meltwaters flowed across the area, resulting in extensive glaciofluvial deposits and numerous small lakes and ponds were formed on the surface of the Catfish Creek till.

Within the Grand River watershed, subsequent glaciation and the resulting sediment deposition occurred as a result of the advance of three ice lobes: the Georgian Bay lobe, the Huron lobe, and the Lake Erie-Ontario lobe. The lobes were centered in the lows provided by the Great Lake basins and advanced out of, and retreated back into these basins. A strong re-advancement of ice during the Port Bruce Stadial, about 15, 000 years ago, resulted in the deposition of the Maryhill Till and later the Port Stanley Till by the Erie-Ontario lobe which advanced from the south. The Guelph Drumlin field was also formed at this time. At the same time, the Huron-Georgian Bay lobe advanced from the north and deposited the Stirton Till followed by the Tavistock Till. Local short-lived re-advancements of the retreating Huron and Georgian Bay lobes resulted in the deposition of the Mornington Till, the Stratford Till, and the Wartburg Till. A stronger re-advancement about 14,500 years ago, resulted in the deposition of the Elma Till (Sibul et al., 1980).

Retreat of the ice during the late Port Bruce Stadial resulted in extensive kame and outwash deposits throughout the central parts of the watershed. The Waterloo, Elmira, Easthope and Orangeville Moraine complexes were either further built upon or created at this time. Meltwaters flowing to the south created a complex of outwash channels, now occupied by many present day streams. These channels are commonly filled with coarser grained sediments. A series of terminal moraines (and associated kame and outwash deposits) are found to the southwest of Brantford marking the retreat of the Lake Ontario/Erie ice lobe. At the time of the Mackinaw Interstadial, about 13,300 years ago, the entire Grand River Watershed was ice free.

The Port Huron Stadial, which began approximately 13,000 years ago, marked an advancement of ice back into the Grand River Watershed, however at this time, ice only advanced from the Lake Ontario/Erie lobe. The Wentworth Till was deposited at this time as the ice advanced to the Paris Moraine. During the recession of the Port Huron ice, ice contact sediments were again laid down, further building the Paris and Galt Moraine systems.

With the final retreat of ice from the Grand River Watershed, Lake Whittlesey was created. A series of large glacial lakes continued to occupy the Lake Erie basin until about 12,000 years ago, when the present day drainage system was created. In the Brantford and Paris areas, shallow water deltaic sediments were deposited closer to the shoreline of Lake Whittlesey. In contrast, the deep water clay and silt sediments south and east of Brantford, were deposited in the basin at the time of the deeper Lake Warren II. At this time, Halton ice advanced out of the Lake Ontario basin (east of the watershed) thus preventing the escape of meltwaters from the Lake Erie basin.

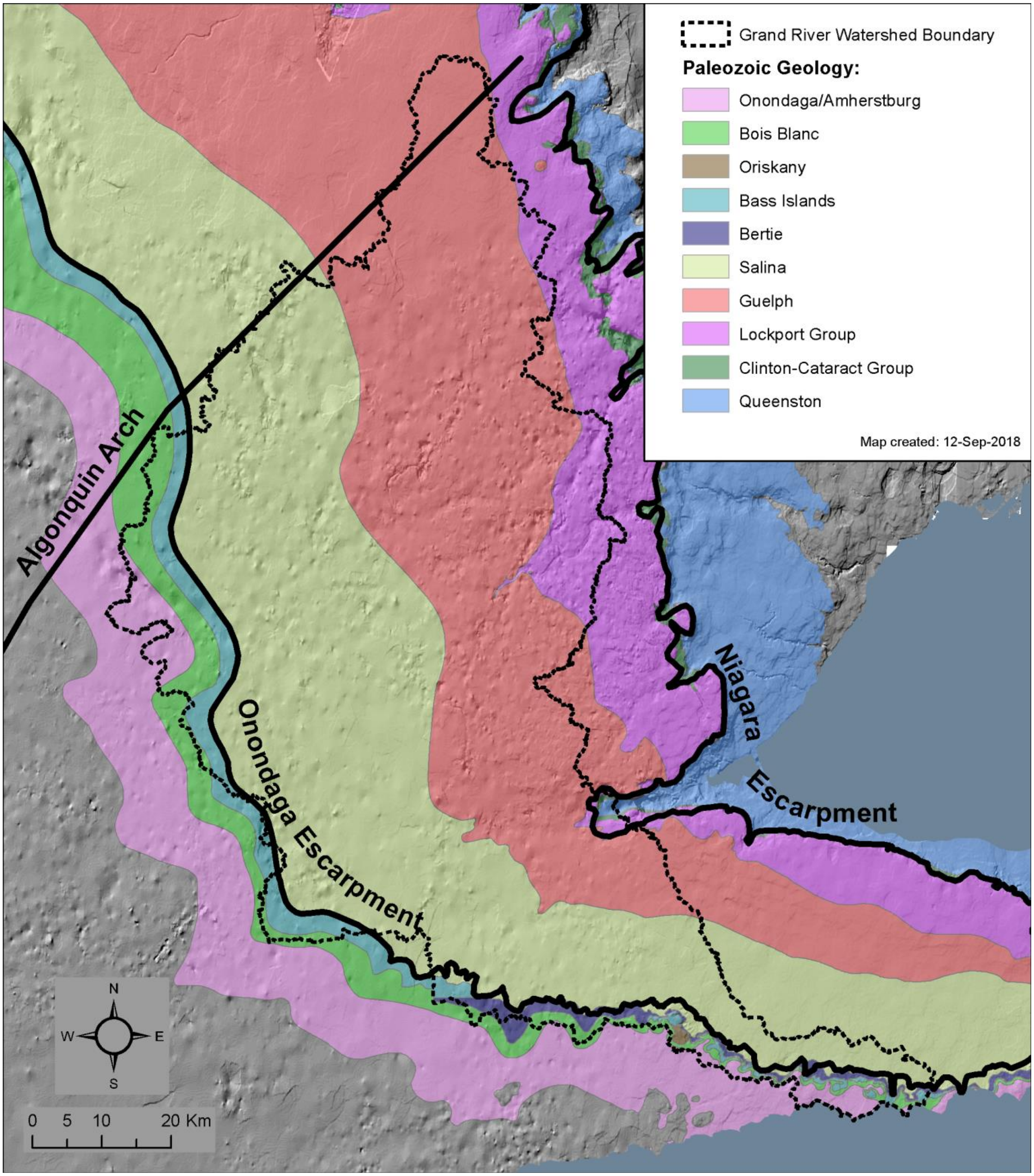
Since the final glacial retreat from southwestern Ontario, the present day stream system has eroded through the pre-existing surficial geology to create the current landscape. The retreat also resulted in the formation of major moraines within the Grand River Watershed.

Map 2-12 shows the Quaternary geology of the watershed. Although the Quaternary geology of the watershed is relatively complex, it can be generally divided into three broad areas:

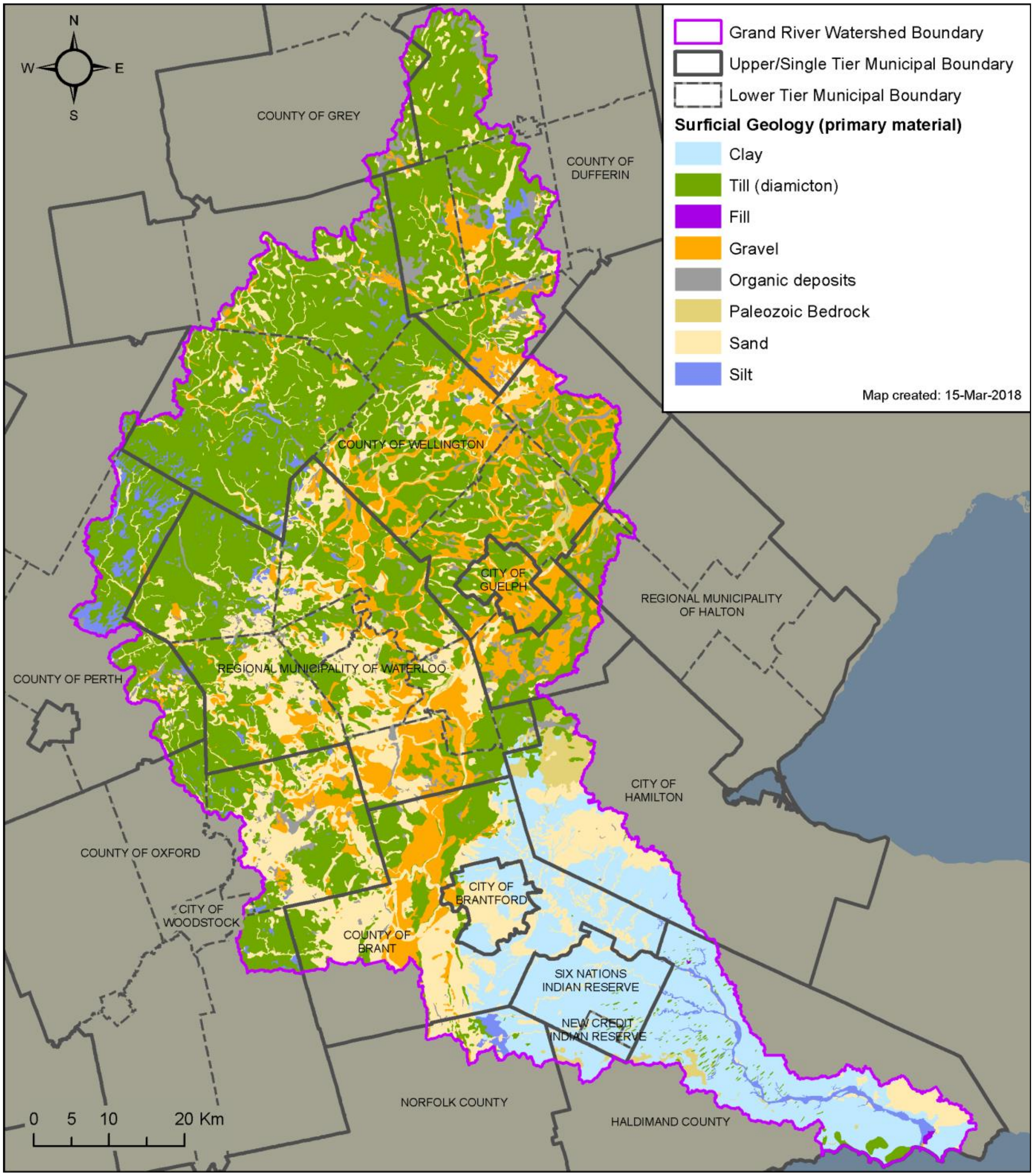
- The northern till plains, with varying relief and lower permeability;
- The central sand and gravel kame moraines and recessional moraines, with moderately high relief and higher permeability;
- The southern lacustrine clay plains, with lower permeability and low relief.

Map 2-13 shows the Overburden Thickness of the watershed.

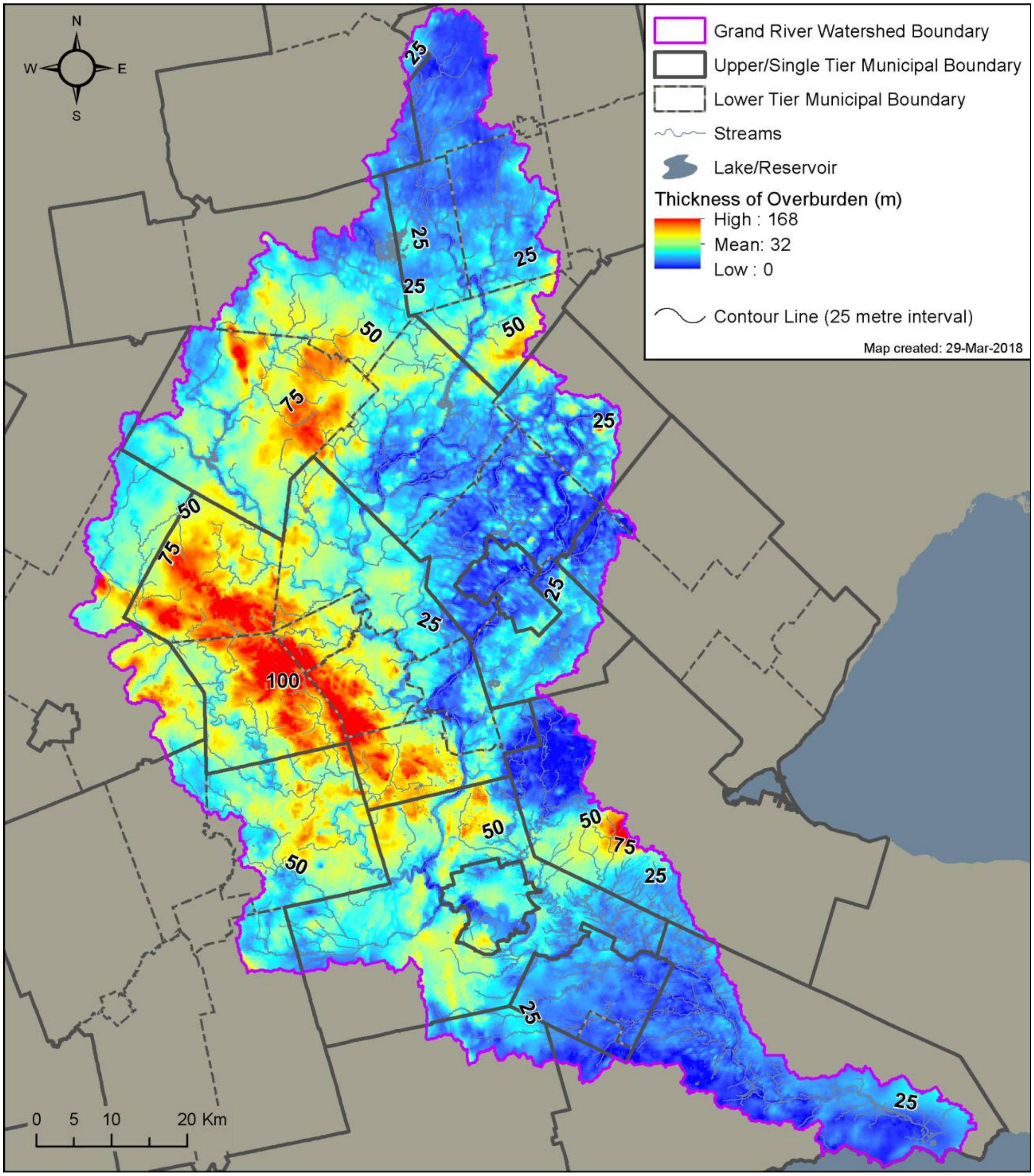
Map 2-11: Bedrock Geology in the Grand River Watershed



Map 2-12: ~~Map~~ Quar~~r~~ternary (Surficial) Geology in the Grand River Watershed



Map 2-13: Overburden Thickness in the Grand River Watershed



2.7 Groundwater

2.7.1 Hydrogeology

~~Approximately 82%~~The majority of the population of the Grand River watershed relies on groundwater as a clean, safe, ~~domestic~~ drinking water supply. In addition to providing ~~the Grand River Watershed's population with~~ a safe source of drinking water, groundwater is used in agriculture, ~~,~~ commercial, and industrial applications.~~y, and commercial production of bottled water for export.~~ Groundwater also plays a pivotal role in sustaining sensitive natural features and aquatic habitats such as streams and wetlands. It has long been recognized that groundwater ~~within the Grand River Watershedalso~~ has a vital role in the hydrologic function of the watershed. Groundwater provides critical baseflow to many parts of the watershed, thereby supporting ~~many of the watershed's~~ aquatic and wetland ecosystems.

Numerous municipalities and communities within the watershed are dependent on groundwater as their principal drinking water source. Groundwater resources are found within both bedrock and overburden aquifers as summarized in the following sections~~ below~~.~~.~~ ~~Both the quality and quantity of groundwater are strongly influenced by the bedrock and overburden geology within the watershed.~~

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 watershed's aquifers (water bearing units) and aquitards (confining units) as well as the location of significant recharge areas.

The most recent regional characterization and quantification of groundwater resources in the Grand River watershed has been through the completion of the Grand River Tier 2 Integrated Water Budget (AquaResource, 2009). Since the completion of the Tier 2 water budget, areas of the watershed have been locally refined and further characterized through Tier 3 water budgets. To date, Tier 3 studies have been initiated within the Region of Waterloo, the City of Guelph / Township of Guelph Eramosa, the Whitemans Creek subwatershed, and the Township of Centre Wellington. Summaries of these water budget studies are included in this assessment report.

Regional ~~Bedrock~~ Aquifers

The Grand River watershed contains extensive aquifers within its bedrock formations and overburden deposits. Groundwater within the aquifers provides for municipal and private water takings, and also supports cold water surface water features through the provision of baseflow from groundwater discharge.

The northern portion of the watershed contains primarily till deposits, which do not to contain extensive or significant aquifer units. Communities such as Dundalk, Grand Valley, Waldemar, Marsville, Fergus, Elora, Guelph-Eramosa, and the City of Guelph rely on groundwater obtained from the Guelph, Goat Island, and Gasport Formations for municipal supply. Communities in Wellington North, such as Arthur, Moorefield, and Drayton obtain municipal water from aquifer units located in the overburden.

Several major moraine systems which support aquifers within the overburden ~~–~~are found in the Grand River Watershed. These~~,~~ include~~ing~~ the Orangeville and Waterloo interlobate moraines, and the Paris and Galt recessional moraines. These moraines, made up of extensive sand and gravel units, provide significant amounts of groundwater for municipal and private use across the watershed. **Map** 2-8 shows the location of moraines in the watershed. ~~Additional significant groundwater resources are found within the Norfolk Sand Plain, which is located to the southwest of the City of Brantford.~~

The Orangeville interlobate moraine, located in the northern portion of the Grand River Watershed, is situated on the east side of Belwood Lake, and extends up to the west side of Orangeville. ~~Groundwater maps produced for areas throughout the Orangeville Moraine have shown that a~~A high water table elevation is generally associated with the feature. A portion of the groundwater within the moraine tends to flow to the northwest towards the Grand River, while the remainder flows to the southwest towards the Credit River Watershed~~ (Burnside, 2001d)~~. Although not used for municipal supply within the Grand River watershed~~ies~~, the Orangeville Moraine is a highly permeable feature and has been identified as an area of significant recharge (AquaResource, 2009a, AquaResource, 2011).

Located to the south of the Orangeville Moraine, the Waterloo Moraine is one of the largest moraines within the Grand River ~~W~~watershed. A number of aquifers situated within the moraine are used by the Region of Waterloo for drinking water supply. The moraine is situated within the west-central part of Waterloo Region in the central portion of the watershed. There are three major overburden aquifer units found within the Waterloo Moraine and they supply 50% of the municipal groundwater supplies for the Region of Waterloo (AquaResource, 2009a). Groundwater discharge from aquifers within the moraine also provides baseflow to numerous surface water features located on the flanks of the moraine.

In the St. George area, just north of Brantford, the Galt Moraine yields two local aquifers; a deeper aquifer which consists of 3 to 5 m of gravel deposits and a shallow sand and gravel aquifer (AquaResource, 2009a).

Located in the southwest portion of the watershed, the Norfolk Sand Plain is a significant source of groundwater within the overburden sediments. ~~Another significant groundwater resource is within the Norfolk Sand Plain, located in the southwest portion of the Grand River watershed.~~ The sand plain is comprised of coarse-grained glaciolacustrine sand and silt deposits laid down as a delta in glacial Lakes Whittlesey and Warren (Waterloo Hydrogeologic, 2003b). The deposits consist of fine- to medium-grained, cross-bedded sand up to 25 m thick. The permeable sand and gravel deposits associated with the Norfolk Sand Plain yield good water supplies; however, they are particularly vulnerable to impacts from land use activities. Groundwater from the aquifers located within the sand plain is used as a drinking water resource, and also relied heavily upon for crop irrigation and to meet agricultural water needs. Water from the aquifers also provide critical baseflow to Whitemans Creek which supports cold-water fisheries.

~~Within the Grand River watershed, several bedrock units have the ability to transmit significant quantities of groundwater making them potentially important for municipal or private use. These units, shown on **Map 2-10** include the Gasport Formation (formerly called the Amabel Formation), the Guelph Formation, and the Salina Formation.~~

~~The Gasport Formation underlies the Guelph Formation throughout the Grand River Watershed with the exception of where it subcrops in the far eastern extents of the watershed. The formation, which is predominantly comprised of limestone and dolostone, ranges in thickness from 10 to 45 metres. Portions of the Gasport Formation have been subjected to varying degrees of solution enhancement (karstification), resulting in areas of higher porosity, which have enhanced the ability of the rock to transmit groundwater. A key example has been documented through recent work in the City of Guelph (Golder, 2006a). Here, the Gasport Formation is a highly productive aquifer where significant~~

~~groundwater yields are derived from the middle section of the Formation, which is often termed the 'Production Zone'. The Production Zone exhibits a higher secondary porosity relative to the less fractured upper and lower zones. To date, the exact lateral extents of the production zone are unknown.~~

~~In the vicinity of the Production Zone and near the community of Rockwood, the Gasport Formation is overlain by the Eramosa Formation. The Eramosa Formation, which can be up to 20 m thick, is characterized by its black, shale-rich nature, and behaves as an aquitard. As a result, in areas where the Eramosa Formation is present, the Gasport Formation is not highly influenced by shallow groundwater recharge and discharge.~~

~~Overlying the Gasport Formation, the Guelph Formation, which generally consists of brown or tan dolostone, has a maximum thickness of 55 m to the west and forms a moderately productive aquifer. The largest groundwater yields from this formation are from the upper portion of the bedrock which exhibits a higher secondary porosity (typically more weathered and fractured) than lower sections of the Formation.~~

~~The Salina Formation, which consists of evaporites (salts, gypsum, anhydrite), shales, and interbeds of carbonate rock, overlies the Guelph Formation in the western and southern portion of the watershed. This formation is considered a moderately productive regional aquifer, supplying groundwater for both municipal and private use. Higher transmissivity values are a result of mineral dissolution and fractures which have developed in the upper bedrock. As a groundwater resource however, many wells are not completed in this aquifer because of water quality concerns, as water quality is often poor.~~

~~Overburden Aquifers~~

2.7.2 Regional Groundwater ~~Static Water Levels and~~ Flow Directions

As a part of the regional Tier 2 water budget study, hydraulic heads were simulated for the water table and contact zone (weathered bedrock) across the Grand River watershed (AquaResource, 2009). **Map 2-14** and **Map 2-15** show the hydraulic head distribution throughout the watershed for the water table and contact zone aquifer. These maps were based on a regional numerical groundwater flow model developed for the entire Grand River watershed that was completed as a part of the Tier 2 study.

Both maps illustrate the flow from the upper reaches of the watershed where there is a topographic high, to the south toward Lake Erie. The maps also exhibit the influence of primary surface water features; this influence is greater on the water table than on deeper groundwater. The irregularity of the water table shown on **Map 2-14** reflects both the heterogeneity of the hydraulic conductivity values applied to the overburden layers within the groundwater flow model, and the strong local influences of the surface water features.

In contrast, the hydraulic conductivity within the contact zone aquifer is relatively uniform, resulting in a smoother contour distribution. Additionally, the direct influence of surface water features decreases for deeper hydrogeologic units.

~~The Grand River Conservation Authority has produced two static water level surfaces using the Ministry of the Environment's water well database; one surface was developed using deeper wells, and a second water table surface was created using shallower wells. The mapping of static water~~

~~levels on a regional scale does not follow aquifer units and the resulting surfaces are therefore not considered to be locally representative, however these surfaces can be used to represent regional groundwater flow conditions.~~

~~On a watershed scale, groundwater flow directions can be interpreted from potentiometric surfaces that have been developed from static groundwater levels. In the case of the Grand River watershed, a 'deep' potentiometric surface was developed from hydraulic head values collected from wells greater than 40 m deep. These values were then interpolated to develop a continuous potentiometric surface as shown on **Map 2-14**. The direction of groundwater flow within the bedrock and deep overburden sediments can then be inferred from the potentiometric surface. From **Map 2-14**, the highest potentiometric elevations are found in the northern part of the watershed, whereas lower hydraulic head values are found in the southern part of the watershed; this implies a general north to south flow direction, as might be expected. The major river systems, as well as the Dundas Valley, are observed to influence groundwater movement in the deeper subsurface units within the watershed.~~

~~The regional water table surface, shown on **Map 2-13**, was developed from an interpolation of the reported static water levels in wells less than 25 m deep. In general, from this map, groundwater is interpreted to flow from the topographically higher elevations in the north towards the topographically lower elevations in the south. It can be observed from **Map 2-13** that the present day Grand River and the most significant tributaries have an influence on shallow groundwater movement across the watershed. Also illustrated on **Map 2-13** is the interpreted water table divide across the watershed. Where the interpreted water table divide is located inside the boundaries of the surface watershed, the Grand River watershed is likely losing water via shallow groundwater movement to the adjacent watershed. However, where the water table divide is located outside the surface watershed, it is likely that the Grand River watershed is receiving via shallow groundwater movement from the adjoining watershed.~~

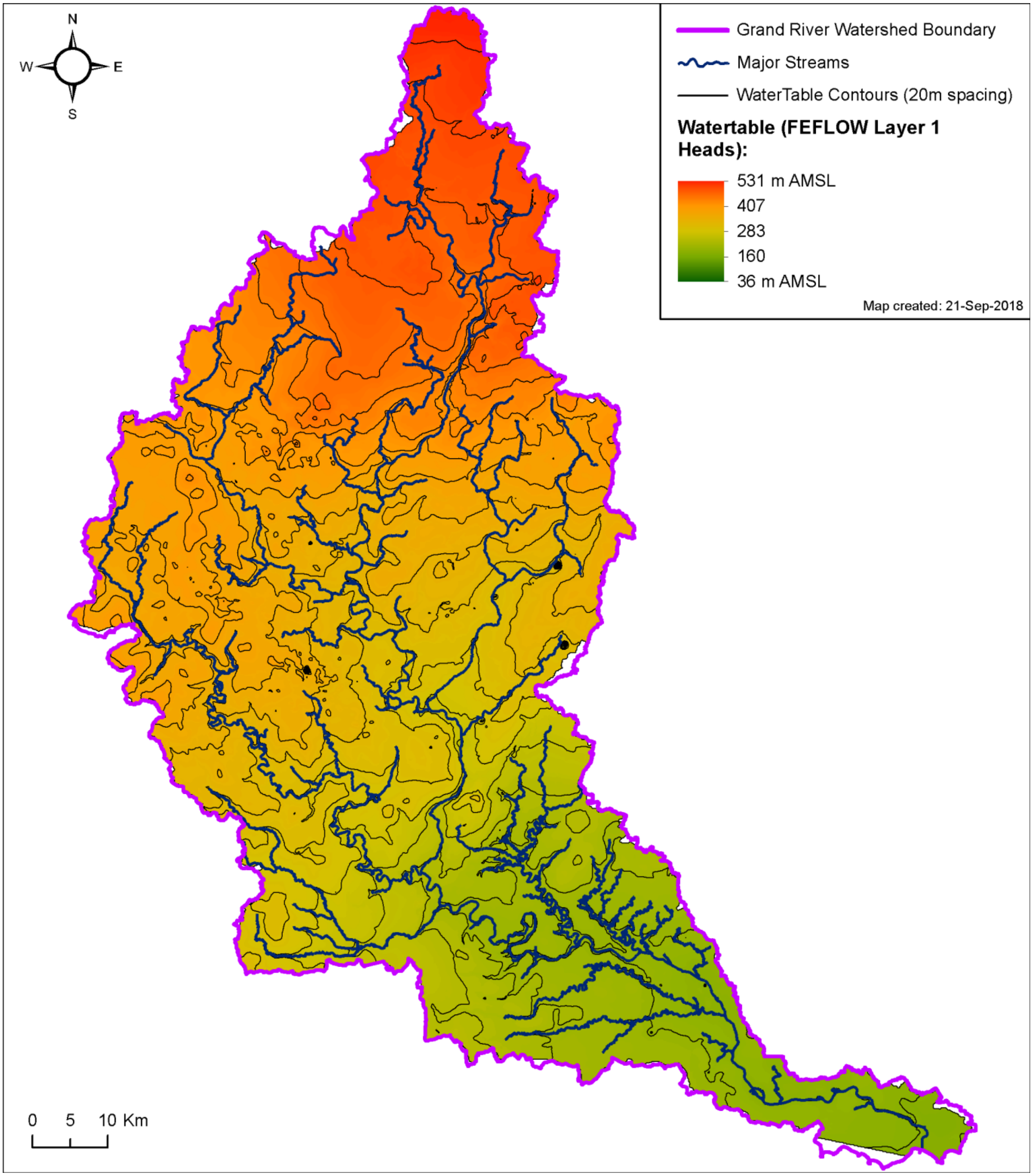
~~2.7.3 Specific Capacity~~

~~The specific capacity of a well is defined as its yield of groundwater per unit of drawdown. It is a function of the properties of the aquifer, pumping time, and well construction characteristics and is calculated by dividing the pumping rate by the water level drawdown that occurred in the water well. This measure therefore provides an estimate of the productivity of the aquifer in which the well is completed. In general, high specific capacities in water wells are indicative of high transmissivities and consequently, high productivity in the associated aquifer. However, the results may be skewed to indicate the aquifer is more productive than it really is, as wells with low productivity are immediately abandoned.~~

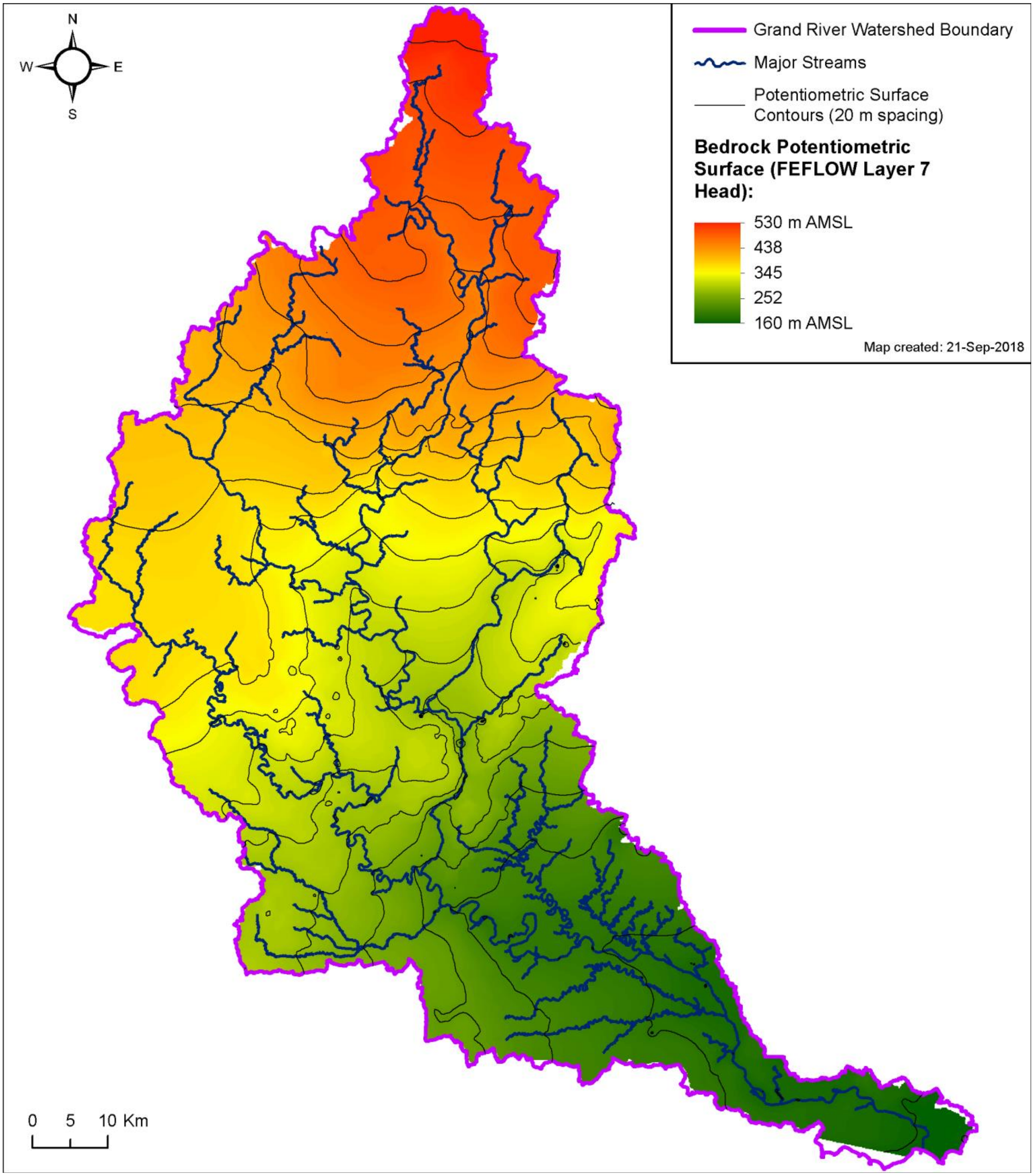
~~The greatest concentration of high specific capacity wells are found in the eastern half of the watershed, generally coincident with the Gasport Formation. High specific capacity wells are also found to be coincident with the Guelph Formation, which is also known to be a highly productive aquifer. High capacity wells occur in the western half of the watershed less frequently. Other bedrock aquifers that show limited high specific capacity include the Salina Formation in the vicinity of Caledonia, and the Bois Blanc Formation near Drayton in the northwest of the watershed (Holysh et al., 2001).~~

~~Overburden wells with a high specific capacity are generally found throughout the central portion of the watershed. In particular, wells with a high specific capacity tend to coincide with the Paris and Galt Moraines as well as the Waterloo Moraine. In addition, high specific capacity wells are located within the Norfolk sand plain where many irrigation wells have high specific capacity values (Holysh et al., 2001).~~

Map 2-14: ~~Water Table Surface of the~~Calibrated Water Table for the Grand River Watershed



Map 2-15: **Calibrated Potentiometric Surface ~~of~~ (Contact Zone) for the Grand River Watershed**



~~2.7.4~~2.7.3 Major Groundwater Recharge Areas

The recharge of surface water to the groundwater system occurs throughout the Grand River watershed. The rate of recharge is dependent on slope of the ground surface, soil moisture, grain size, and stratification.

Significant Groundwater Recharge Areas (SGRAs) are defined as a specific type of vulnerable area that may be protected under the *Clean Water Act*, 2006. The role of SGRAs is to support the protection of drinking water across the broader landscape. SGRAs were delineated using the methodology described in Chapter 3.

Map 2-16 shows the SGRAs mapped with isolated areas of less than 1 km^2 removed. All of the SGRAs mapped within the Grand River Source Protection Area are considered hydrologically connected to groundwater sources used for drinking water because of the extensive cover of domestic overburden wells in the watershed.

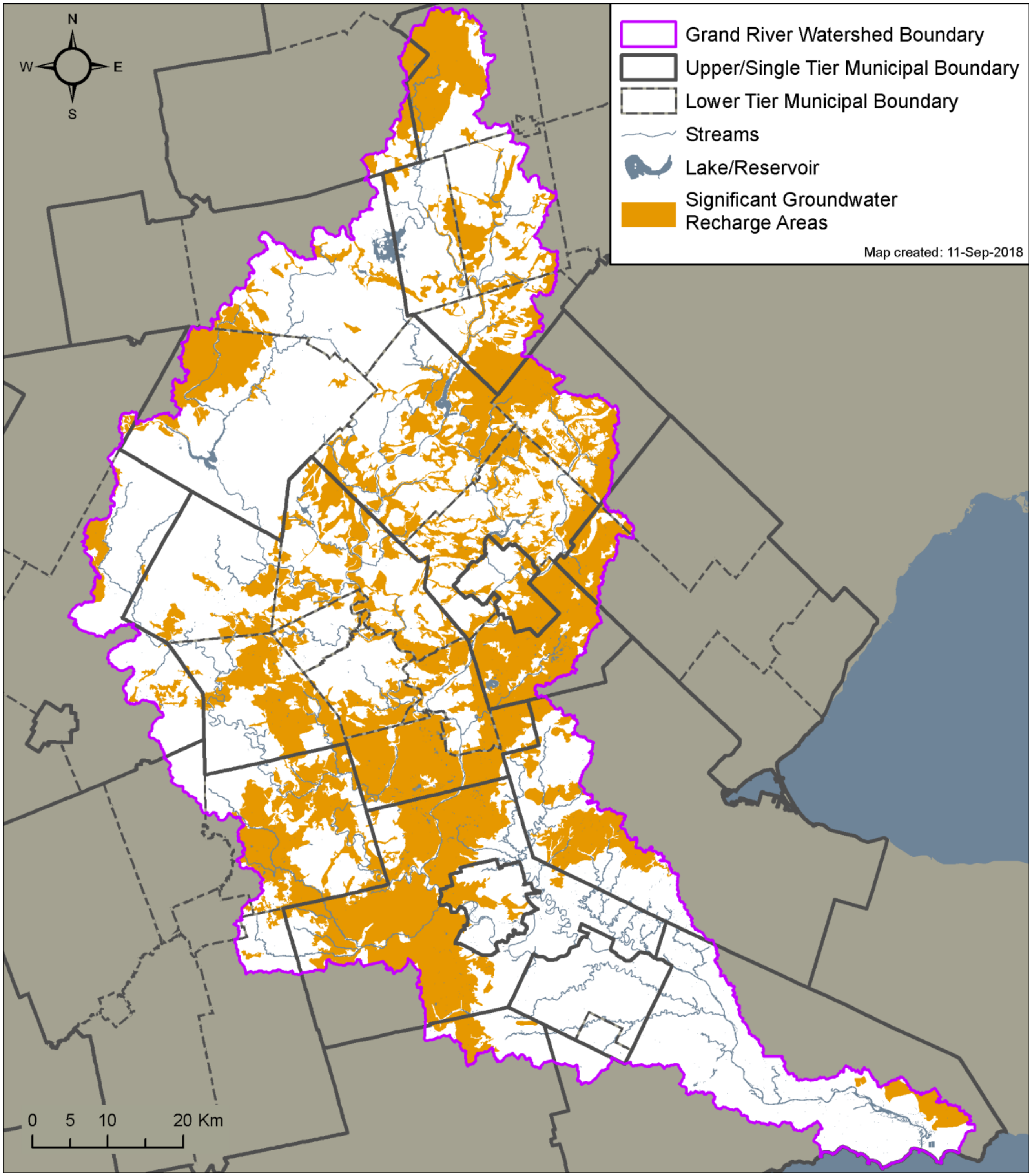
The areas of highest recharge tend to coincide with the moraine features within the watershed (shown on **Map** 2-7 and **Map** 2-8). These include the Galt, Paris, and Waterloo Moraines in the central portion of the watershed and the Orangeville Moraine located in the northern portion of the watershed. These moraines are commonly comprised of permeable, coarse-grained deposits and hummocky topography (disconnected drainage), allowing for extensive infiltration and recharge. These moraine areas represent very significant recharge zones for the watershed’s major aquifers.

Where recharge in the areas of the Galt, Paris, and Waterloo Moraines contributes to the groundwater system in the overburden deposits, the Orangeville Moraine is a major recharge area that contributes to the bedrock aquifers in the region. In addition to the moraine features, areas within the Upper Grand watershed contain isolated, interspersed pockets of coarse-grained glaciofluvial outwash deposits which allow for high recharge rates.

To the southwest, the Norfolk Sand Plain is an area characterized by thick deposits of highly permeable, coarse-grained sands. High recharge supports an extensive unconfined overburden aquifer throughout the Norfolk Sand Plain. ~~Potentially, a large quantity of recharge from this area leaves the watershed as subsurface flow across the watershed boundary.~~

The northern portions of the watershed, including the Upper Conestogo River, Upper Nith River, and the Irvine River, generally consist of consolidated till deposits with low permeability that inhibit water movement through to the subsurface. Towards the south of the watershed, the fine-grained clay-rich deposits characteristic of the Halidmand Clay Plain inhibit recharge in this area.

Map 2-16: Significant Groundwater Recharge Areas



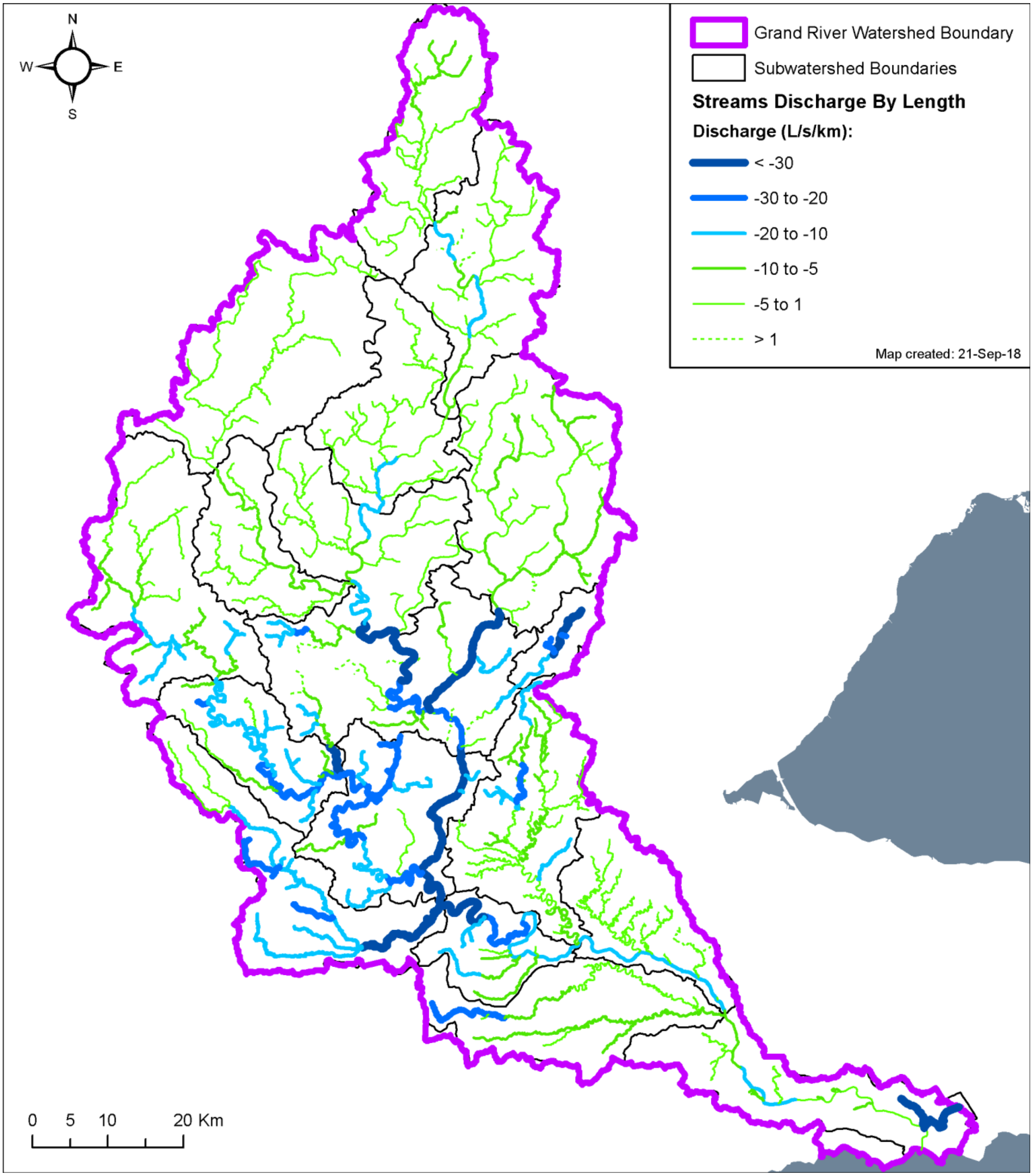
~~2.7.5~~2.7.4 Major Groundwater Discharge Areas

Major discharge areas within the Grand River watershed are associated with the major river corridors, especially along the lower Nith River and the Grand River south of Cambridge ~~(Waterloo Hydrogeologic Inc., 2005a)~~. In addition, Luther Marsh, Belwood Lake and the Orangeville Reservoir are examples of significant wetland areas that are indicated as being groundwater discharge areas ~~(Holysh et al., 2001)~~. Groundwater discharge areas within the watershed have resulted in significant ecological habitat for numerous cold water aquatic species.~~, such as rainbow trout~~. Particularly, the stretch of the main Grand River from Paris to Brantford is known for significant groundwater discharge, and has spurred resurgence in trout populations within the last decade as water quality has improved.

Simulated groundwater discharge at a watershed scale is shown on **Map** 2-17 (AquaResource, 2009). This information is presented as groundwater discharge per kilometer of stream.~~,~~ Groundwater discharge was calculated by delineating stream reaches into shorter lengths (i.e. 2-5 km), calculating total amount of groundwater discharge into each reach, and then dividing the total groundwater discharge by the length of the reach. On the figure, reaches of highest groundwater discharge are shown as thicker dark blue lines. Thin light blue lines indicate that the headwater regions primarily receive smaller discharge volumes. The highest groundwater discharge rates occur in major stream reaches in low lying areas, such as between Cambridge and Paris. These results provide an initial regional-scale visualization of groundwater / surface water interactions.

~~Of additional note, the clay plain located in the southern portion of the watershed is a very limited discharge area due to the low permeability of the sediments in the area.~~

Map 2-17: Simulated Groundwater Discharge



~~2.7.6~~2.7.5 Surface and Groundwater Interactions

Interactions between groundwater and surface water systems in the Grand River ~~Watershed~~ watershed are ~~very important~~critical to the maintenance of the water cycle within the watershed. Groundwater discharge sustains many watercourses through dry periods resulting in significant ecological habitat and improved water quality. On the other hand, recharge from surface waters supports groundwater aquifers which are a significant source of drinking water in the watershed.

Within the Grand River Watershed, groundwater recharge occurs over much of the landscape. However the rate at which recharge occurs is dependent on the nature of the overburden material, where highest rates of recharge occur on coarse-grained ~~moraine~~ deposits and areas with disconnected drainage. Groundwater discharge occurs in many of the watercourses in the watershed where stream beds intersect the water table or upward hydrologic gradients drive water through permeable material. This is shown by sustained baseflows in many watercourses and the abundance of cold water aquatic ecosystems. Areas that have been identified with high rates of groundwater discharge include the middle portions of the Grand River, in particular the reach between Cambridge and Brantford, the Nith River below New Hamburg, the Lower Eramosa River including Blue Springs Creek, the Speed River below Guelph, and Whitemans Creek.

Major areas of potential discharge to the Grand River include the reach between Legatt and Shand Dam, the reach below Elora through Kitchener, and the reach from Cambridge to Brantford (AquaResource, 2009a). The massive discharge zone downstream of Cambridge is most likely produced from a combination of the Galt Moraine to the east and the presence of large overburden aquifers to the west. Discharge in this area adds as much flow to the river as either the Shand or Conestogo dams, allowing water quality to recover after large urban influences upstream.

The lower Nith River and some of its tributaries including Cedar Creek receive large quantities of groundwater discharge from moraines and other coarse-grained deposits. This area of the Nith River sub~~-~~watershed is characterized by thick deposits of coarse-grained sand and gravel which support extensive overburden aquifers. Both local and regional groundwater flow systems may contribute to groundwater discharges through this subwatershed.

The lower Eramosa River including Blue Springs Creek and the Speed River below Guelph pass though areas receiving groundwater discharge. The Lower Eramosa River receives discharge from both bedrock aquifers and overburden sediments (Gartner Lee, 2004). Unconfined aquifers are located along much of the river's length in this area. Groundwater discharge contributes to healthy cold water aquatic ecosystems in this subwatershed.

Whitemans Creek flows through a large groundwater discharge zone. Springs and seeps can be found along parts of the creek, which also supports a cold water fishery. Whitemans Creek flows through the upper part of the Norfolk Sand Plain, an area characterized by thick deposits of coarse-grained and highly permeable sand. High recharge in this subwatershed supports an unconfined overburden aquifer, which in turn discharges to the creek.

There are also areas with little groundwater - surface water interaction. These areas often are characterized by fine-grained, silt- and clay-rich surficial deposits which results in a decreased permeability that inhibits water movement between the surface and sub-surface systems. Areas within the Grand River Watershed with these characteristics include the Haldimand Clay Plain in the south and tight, consolidated tills in the north.

2.8 Groundwater Quality Across the Watershed

Groundwater within the Grand River watershed is used extensively as a drinking water source, for both municipal and private supplies. As such, monitoring and managing the quality of the groundwater supply is of critical importance.

The chemical characteristics of groundwater within the Grand River watershed are derived from two sources: (1) the ambient chemistry, where the composition of the groundwater reflects its relative residence time in the aquifer and the nature of the substrate through which it flows, and (2) anthropogenic impacts to the quality of the groundwater through various land use activities such as road salting, fertilizer and manure applications to agricultural fields, and industrial chemical use.

In some groundwater, parameters such as fluoride and arsenic can be elevated to greater than the maximum allowable concentration (MAC) as specified in the Ontario Drinking Water Quality Standards (ODWQS). Other non-health related parameters such as hardness, iron, and manganese can be elevated as well. Parameters such as these are reflective of the substrate the groundwater has flowed through and the relative residence time of the groundwater in the flow system. Recently recharged groundwater tends to be less mineralized and more bicarbonate-rich. As groundwater moves through the flow system, and depending on the nature of material (i.e., bedrock versus sands or gravel) it comes in contact with, the water becomes increasingly mineralized along its flow path.

The second class of controls which influence the quality of groundwater are related to land use activities. In the Grand River watershed, three distinctive land use activities have impacted groundwater quality: road salting, the application of manures/fertilizer, and the use of dense non-aqueous phase liquids (DNAPLS).

Road Salt

The application of road salt (sodium chloride) is a common activity across the watershed given winter road conditions. Chloride is soluble and highly mobile in water. It can impair the taste of drinking water, and at high concentrations can be toxic to aquatic vegetation and species. Sodium can be a health concern for people on low sodium diets. If left unmanaged, chloride and sodium from road salt can infiltrate into the ground, and potentially recharge into the groundwater flow system. Once in the groundwater, chloride is not readily removed through treatment.

Through the source protection program, elevated concentrations of chloride have been identified and classified as drinking water issues for 11 municipal wellfields in the Grand River watershed. Four municipal wellfields have had sodium identified as a drinking water issue. To mitigate the impact of road salt to the groundwater system a number of measures can be applied. Road salt storage and application can be managed through: source protection plan policies within WHPAs, municipal programs such as the Region of Waterloo's Smart About Salt program, and public outreach and education.

Nitrate

Approximately 70% of the Grand River watershed's land use is classified as rural agricultural. As such, nitrate is applied directly to agricultural lands in the form of fertilizer. Excess nitrate not removed from the soil by plants can either run off into surface water bodies, or infiltrate into the ground, eventually making its way to the groundwater system. Elevated concentrations of nitrate in drinking water can be harmful to young infants or young livestock. Excessive nitrate in the body can result in the restriction of oxygen transport in the bloodstream. Infants under the age of 4 months lack the enzyme necessary to correct this condition; this is referred to as 'blue baby syndrome'.

Nitrate has been identified as a drinking water issue through the source protection program at 11 municipal wellfields, where nitrate has been monitored at concentrations greater than 5 mg/L or one half of the nitrate MAC (10 mg/L). Although nitrate can be removed from drinking water through treatment, it can be an expensive process and not always feasible. Similar to road salt, nitrate application and the storage and handling of manure and fertilizer can be managed through source protection policies within WHPAs, in addition to public education and outreach strategies.

Industrial Chemicals

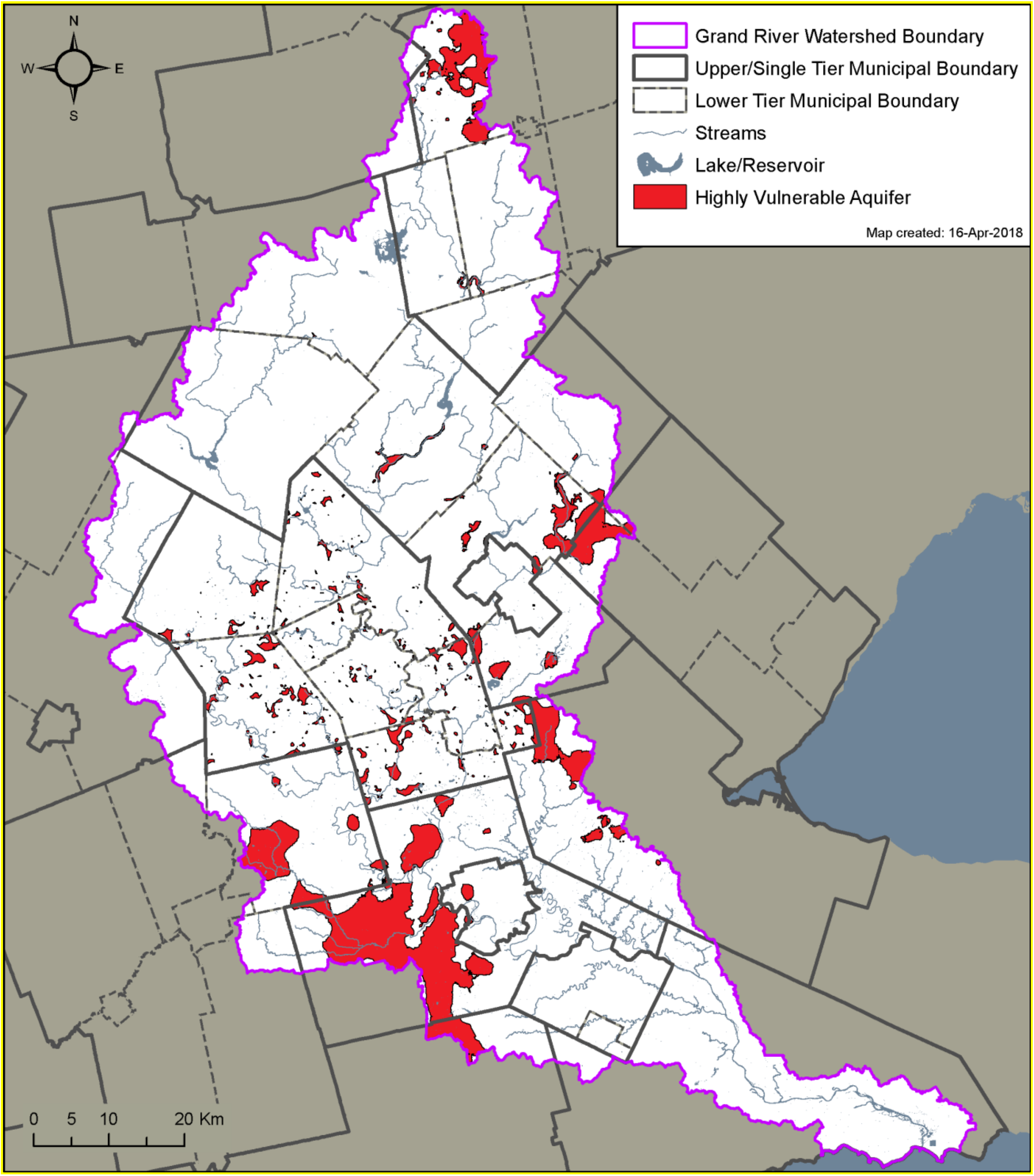
The use of industrial chemicals, such as trichloroethylene (TCE), is prevalent in the watershed. Chemicals such as TCE are classified as dense non-aqueous phase liquids, or DNAPLs. When these compounds enter the groundwater system, they are only slightly soluble in water, and therefore persist in aquifers, forming pools and plumes. DNAPLs, even at low levels, can present human health and ecological risks. When present in groundwater, DNAPLs are removed from the aquifer using such technologies as pump-and-treat;~~,~~ however, these can be lengthy treatment processes due to the complexity and migration of the DNAPL plume. In the Grand River watershed, TCE was identified as a drinking water issue at 6 municipal wellfields.

2.9 Highly Vulnerable Aquifers

All aquifers are susceptible to impacts from surficial land use activities, such as those described in Section 2.8. The vulnerability of municipal supply aquifers to contaminants introduced at ground surface was calculated across the watershed and is presented in **Map 2-18**. The methodology used to map highly vulnerable aquifers (HVAs) is described in Chapter 3.

Areas of highly vulnerable aquifers generally correspond to shallow and/or unconfined aquifers across the Norfolk sand plain to the southwest and through the Waterloo Moraine across the central portion of the watershed.

Map 2-18: Highly Vulnerable Aquifers



2.10 Climate in the Grand River Watershed

The climate of the Grand River watershed is reflective of its position at the heart of southwestern Ontario. The watershed covers a large area where proximity to different Great Lakes and topographic relief result in a variable climate across the watershed. Climate is changing worldwide. Both the historic and recent climate is important in the understanding of water movement and availability in the Grand River watershed.

Precipitation and temperature averages were calculated from observed data collected at Grand River Conservation Authority (GRCA) manual weather stations and from Environment and Climate Change Canada (ECCC) climate stations across the watershed. A thirty year average period, 1986 to 2016, was used to calculate average precipitation and temperature on an annual and monthly basis. This length of time was recommended by the World Meteorological Organization to be long enough to filter out year to year variability, but short enough to observe changes with time.

Over the 30 year period, the Grand River watershed had an average temperature of 7.2 degrees. **Map 2-19** shows the annual average temperature across the watershed. Temperatures follow an increasing trend from north to south. The warmest temperatures were in the south with an average of 9.0 degrees near Lake Erie. The coolest temperatures were in the north with an average of 6.1 degrees near Grand Valley. Observed data shows an increase in average temperatures of about 0.5 degrees over the last half century with the winter months having the highest increase at approximately 1.0 degrees.

The watershed has an average annual precipitation of 921 mm with 16% of total precipitation falling as snow. Precipitation is highly variable within the watershed, **Map 2-20**. The northern part of the watershed had the highest annual precipitation at over 1000 mm, while the lowest annual precipitation occurred near Brantford at 850 mm. Summer precipitation is mainly from convective storms, which can be highly localized and represent a large percentage of the total summer precipitation, ~~. W~~while the northern tip of the watershed can receive heavy snowfall coming off of Lake Huron. These factors have contributed to some local areas of low precipitation surrounded by areas of high precipitation. Total precipitation amounts have not changed significantly over the last half century, but the portion of winter precipitation falling as snow has decreased.

Figure 1 shows the watershed average precipitation and temperature on a monthly basis. Across the watershed, July is the warmest month with an average of 20 degrees. It is also the wettest month with an average of 91 mm. The driest month is February, with only 57 mm of precipitation. February and January are the coldest months with a daily average temperature of -6.4 degrees. These were also the snowiest months with approximately 55% of precipitation across the watershed falling as snow. At the northern stations, snow accounted for about 65% of the total precipitation during the months of January and February, while at the most southern stations it only accounted for about 35%.

~~The climate of the Grand River watershed is reflective of its position at the heart of southwestern Ontario. Weather patterns in both regions consist of 4 seasons, including winters that see the majority of the precipitation in the form of snow, and summers which are hot and humid. Precipitation is fairly evenly distributed throughout the year. However, in any given month the amount of rain and snow varies greatly and a dry month will cause noticeably lower streamflows, while a month of rainy weather will saturate the soil and raise river levels. A winter with little snow accumulation will lead to moderate spring flows, whereas cold winters with heavy snow can lead to heavy spring runoff and floods.~~

~~The four distinct seasons have transitional periods between them which results in noticeable variations in weather patterns across the watershed and can give unpredictable weather. This region is affected by lake effects from the Great Lakes, jet streams, high and low pressure cells and weather coming from the Arctic and the Gulf of Mexico.~~

~~Since the Grand River watershed covers such a large stretch of southwestern Ontario, the Grand River watershed from north to south can be subdivided into several climatic zones (**Map 2-16**). These climatic regions show slight differences in temperature and precipitation and onset of the seasons. Average monthly temperatures are coldest (-0.2^{0}C) in January in the north and warmest (21^{0}C) further south in the month of July. Extreme temperatures can reach as low as -35^{0}C in the winter and up to 40^{0}C in the summer and temperatures in the urban regions tend to be slightly higher than their surrounding regions. **Figure 2-1** shows the differences in average temperatures and precipitation in the Grand River watershed. There are large differences in average winter temperatures between Monticello in the north and Hagersville in the south of almost 5^{0}C. July is the hottest month throughout the watershed, with an average temperature difference of less than 3^{0}C from the headwaters to the mouth.~~

~~The Grand River watershed's three climate regions, from north to south, include the Dundalk Uplands, the Huron and South Slopes and the Lake Erie Counties.~~

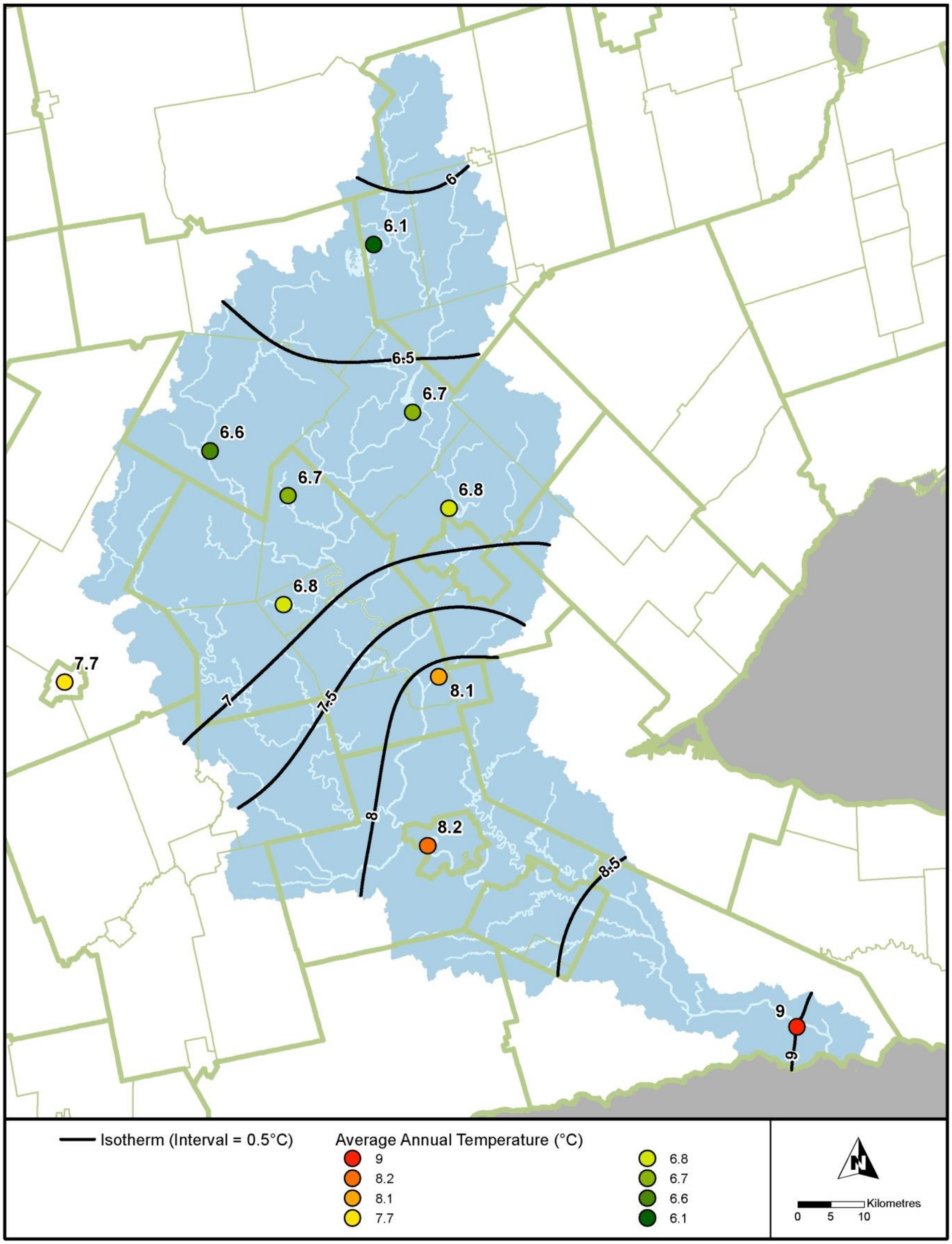
~~2.10.1 Dundalk Uplands~~

~~The Dundalk Uplands include Dufferin County, Grey County and northern Wellington County. Here, the higher altitude produces a cooler climate. Winters are colder and the snow stays longer in the spring. The winter months are generally indicated by temperatures below 0^{0}C, while temperatures over 20^{0}C could be considered summer. With this classification, the Dundalk Uplands experiences winters that last 6 months, summers of 3 months, the month of May is spring and fall occurs during September and October. Any moisture left in the winds after they pass over the Huron Slopes is dropped on this tableland as snow or rain. The average annual temperature in this region is about 5^{0}C to 6^{0}C. Average annual rainfall is about 950 to 1000 mm.~~

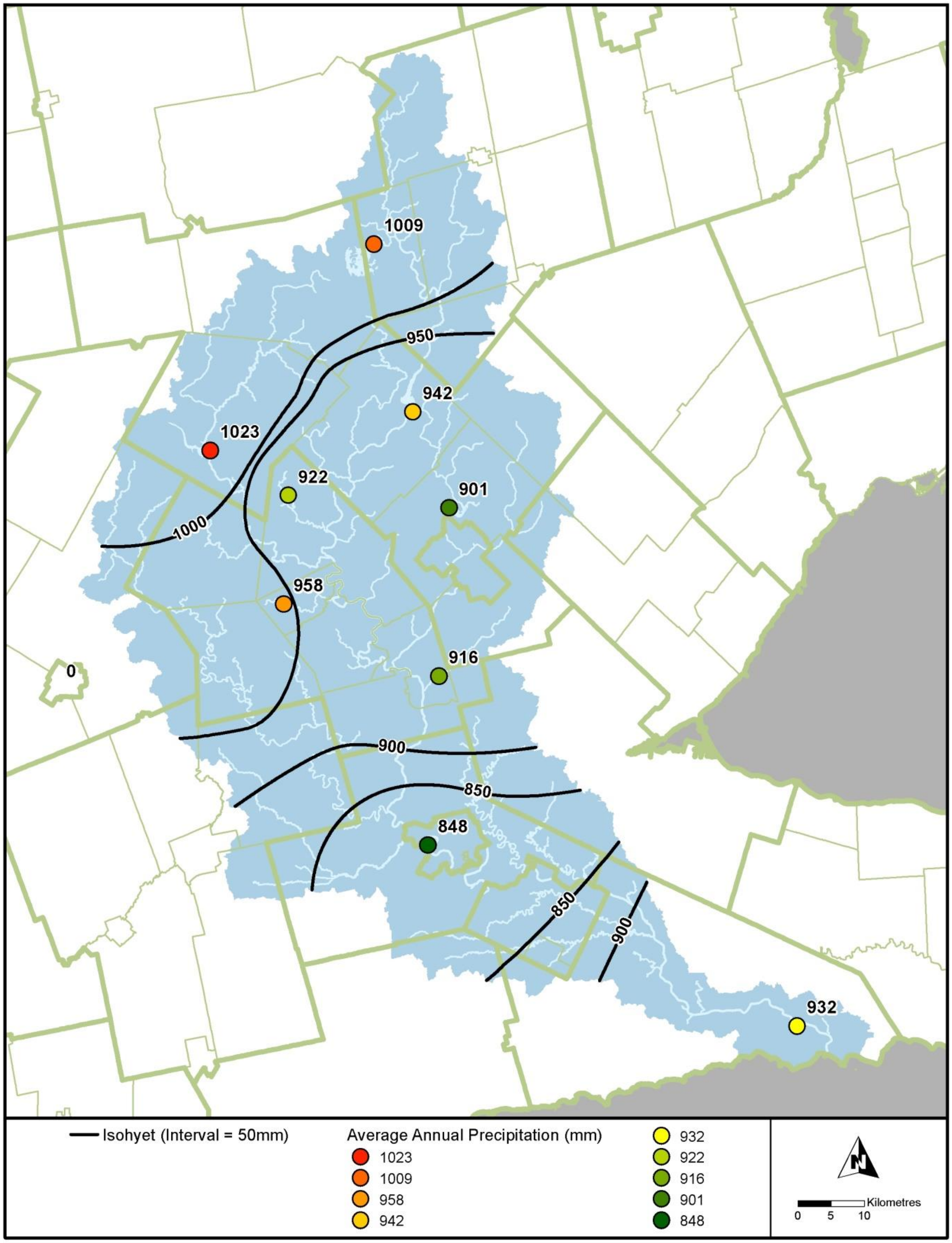
~~2.10.2 Huron and South Slopes~~

~~These two areas – the Huron Slopes and the South Slopes -- rise from the plains bordering Lakes Erie and Huron and include the central portion of the watershed: Waterloo Region, most of Wellington, Perth, Oxford and northern Brant. Moisture, picked up by winds blowing over Lake Huron, condenses as snow or rain on the slopes. This creates a "snow belt" area on the west side of the Grand River watershed between Arthur and Stratford, with a higher than average rainfall and snow accumulation. Across the Huron and South Slopes regions, the average annual temperature is about 6^{0}C to 7^{0}C. Winter lasts 5 months from November to March, summer is June to September, spring is April to May and fall is October. Average annual precipitation ranges from 850 mm to 950 mm.~~

Map 2-19: Average Annual Temperatures (1986 to 2016) in the Grand River Watershed



Map 2-20: Average Annual Precipitation (1986 to 2016) in the Grand River Watershed



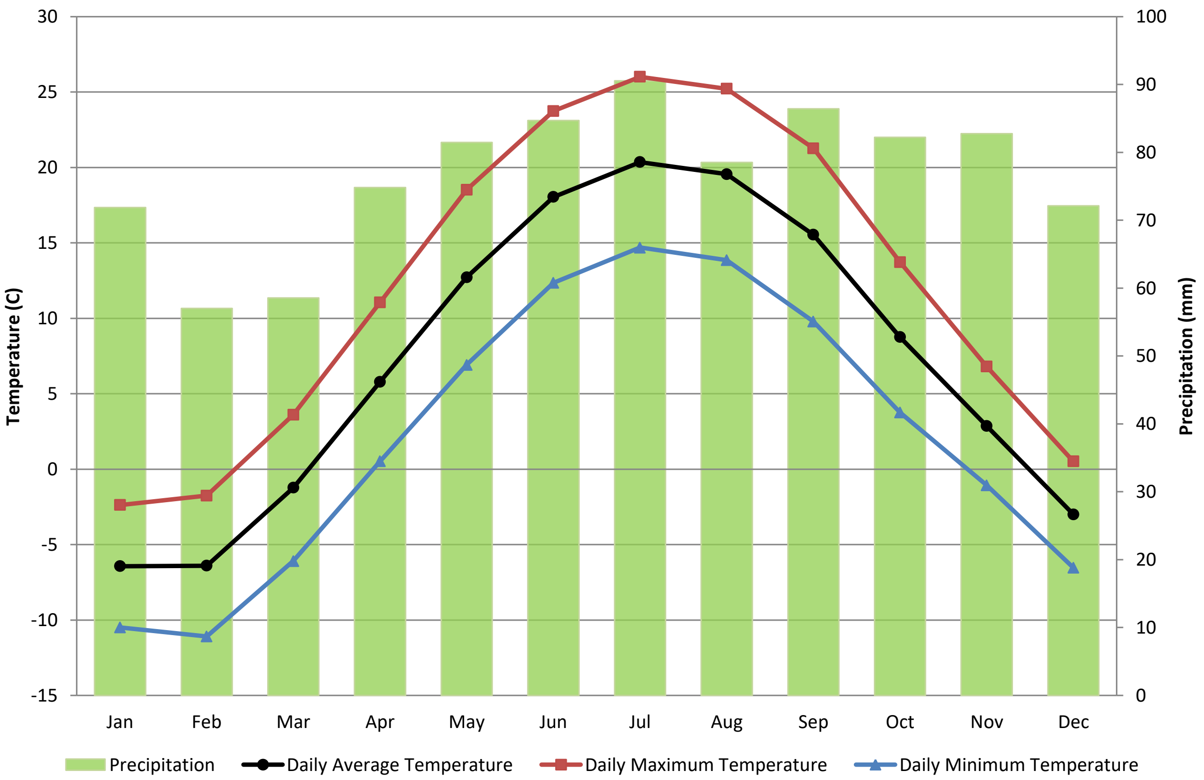


Figure 1: Watershed average monthly precipitation and temperature (1986-2016)

~~2.10.3 Lake Erie Counties~~

~~In the Lake Erie Counties zone, from Brantford to the Lake Erie shore, winds passing over the lake are warmed in winter and cooled in summer. This produces a warmer climate with a longer frost-free growing season in the lowland plains from the mouth of the Grand River northwards to Brantford. The Lake Erie counties in the southern Grand watershed are the most fortunate with seasonal weather with only 4 months of winter (December to March), 4 months of summer (June to September), and spring and fall both 2 months in length (Sanderson, 1998). The average annual temperature is about 7^{0}C to 7.5^{0}C. Average annual precipitation ranges from 850 mm to 900 mm.~~

~~**Figure 2-1: Long term monthly average temperature and precipitation for 3 stations in the Grand River watershed.**~~

~~2.10.4 Precipitation Trends~~

~~Precipitation in the Grand River watershed ranges from 800mm to 1025mm per year (climate normals between 1971-2000; Environment Canada, 2005a). Precipitation patterns in the watershed show a slight north to south trend, but the general precipitation patterns of south-western Ontario show slightly decreasing depths moving eastward. **Figure 2-1** shows the pattern of precipitation across the Grand River watershed.~~

~~Precipitation is fairly uniform throughout the year, as opposed to wet and dry seasons as seen in other regions such as the tropics. Although it seems that winter and spring have the majority of the precipitation, it is actually August that has the highest average precipitation in this region (see **Figure 2-1**). The warmer temperatures in the summer months enable the air to hold more moisture than in the winter months, giving us more precipitation. Following on this rule across the watershed, the driest months are February and January.~~

~~Precipitation characteristics in the Grand River watershed are quite varied, including short intense rainfalls and thunderstorms in the summer due to convection, to steady gentle rainfalls in the autumn, to heavy snowfalls that can last for days in the winter, and flashy spring downpours.~~

~~Snowfall generally becomes part of the precipitation pattern starting in October or November and ending around April, though traces of snow sometimes occur in May and September. As previously mentioned, there are differences in the duration of the winter season from the headwaters to the mouth of the watershed at Lake Erie. Snowfall in the Grand River watershed has a trend of decreasing as you move southeast from the northwest. Lake Huron, to the west of the watershed, provides much moisture and the northwestern edge of the watershed is influenced by lake effects snow. The Dundalk Uplands will also have snow later into the spring and earlier in the fall than the southern portion due to the higher altitude.~~

~~2.10.5 Extreme Weather~~

~~Extreme weather is not uncommon in the Grand River watershed. This region experiences, hurricanes, tornadoes, extreme snow days, droughts and other unpredictable weather events. Droughts in the Grand River watershed are due to both meteorological reasons and high water use through human consumption. Summer is the time when most droughts occur because of the high water demands and high evapotranspiration rates. The summer can also see extreme thunderstorms due to convection or weather fronts, which can result in high amounts of rainfall in short durations, and thus it is not uncommon that the summer experiences short stints of heavy rainfall followed by longer stretches of little to no rainfall. The winter months contend with various kinds of precipitation from rain to snow, including sleet, freezing rain, heavy wet snow, blizzards with extreme wind storms and ice conditions.~~

~~In summary, climatic patterns in the Grand River watershed, as well as the rest of southern Ontario, are constantly changing. The four seasons experienced here have typical weather patterns but are also coupled with unpredictable weather patterns due to its geographic location. Many things influence the weather from wind patterns bringing in Arctic cold from the north, or Gulf of Mexico weather from the south, to jet streams bringing weather patterns eastward across the continent from the Pacific. Daily weather within each of the seasons could be typical of the current season, or of the previous or following season, such as having a snowy day in October followed the next week by an Indian summer heat wave.~~

2.11 Land Cover in the Grand River Watershed

2.11.1 Forest and Vegetation Cover

Forest and vegetation cover are important factors in overall watershed health. In particular, increased forest and vegetation cover greatly reduces soil erosion and surface water runoff, which are often significant sources of contamination in streams, rivers and lakes. These areas contribute to improved water quality and quantity by slowing erosion and runoff, increasing evapotranspiration, increasing groundwater infiltration and uptake of nutrients and other contaminants. Reduced erosion and runoff translates into fewer contaminants and sediments entering surface waters. **Map 2-21** illustrates forest cover within the Grand River watershed.

The Grand River watershed straddles two distinct forest regions: the Great Lakes-St. Lawrence Forest Region to the north and the Deciduous Forest Region, also known as the Carolinian Zone, in the south. The forests of both regions share many of their dominant tree species including: sugar and silver maple, beech, ash species, basswood, white elm, red and bur oak, bitternut hickory and black cherry. In the Great Lakes - St. Lawrence Region conifer species, including white pine, eastern hemlock and eastern white cedar, make up a greater percentage of the forest composition, while the Carolinian zone is more dominated by deciduous species including a greater number of oak and hickory species. The Carolinian zone is also home to a number of tree species that are at the northern edges of their natural ranges including pignut, giant shellbark and shagbark hickory, black, Chinquapin and northern pin oak, sycamore, tulip tree, sassafras and American chestnut.

Forests currently cover approximately 16% of the Grand River watershed, below the 30% cover suggested by Environment Canada as the level required to sustain a healthy watershed. Forest cover levels are highest in the McKenzie Creek (26%) and Speed River (24%) subwatersheds and lowest in the agriculturally dominated Conestogo (11%) and Upper Middle Grand (12%) subwatersheds **(Map 2-21).**

Through most of the watershed, forest patches tend to be small and fragmented. In agricultural areas the historic practice of leaving a small woodlot at the back of the farm lots resulted in narrow forest bands that provide some forest connectivity across the landscape. Large blocks or high concentrations of forest in the watershed are often associated with poorly drained areas and wetlands. Large forest blocks and interior forest are uncommon and therefore where present they are especially valuable to sensitive woodland species that require a more secluded woodland habitat.

For more detailed description and history of the forests of the Grand River watershed, see *A Watershed Forest Plan for the Grand River* (2004).

~~Forest and vegetation cover are important factors in overall watershed health. In particular, increased forest and vegetation cover greatly reduces soil erosion and surface water runoff, which are often significant sources of contamination in streams, rivers and lakes. These areas contribute to improved water quality and quantity by slowing erosion and runoff, increasing evapotranspiration, increasing groundwater infiltration and uptake of nutrients and other contaminants. Reduced erosion and runoff translates into fewer contaminants and sediments entering surface waters (**Map 2-17**).~~

~~As determined from **Map 2-18**, forested areas in the Grand River watershed make up approximately 19 percent of the total land cover. A minimum forest cover of 30 percent is advocated by Environment Canada to be necessary to sustain the health of a watershed.~~

~~The Carolinian Forest type reaches its northern limit in the Grand River watershed in the area of the City of Cambridge. In general, this forest type is dominated by sugar maple and beech along with basswood, silver maple, and several species of oak. Other less prominent species include several species of elm, ash and hickory, black cherry, and yellow birch. Numerous characteristic plants and animals, having a broad distribution southward, reach their northern limit in the southern half of the watershed. Among these are several trees, including the hickories, sycamore, sassafras, black oak, Chinquapin and dwarf Chinquapin oaks, and (formerly) American chestnut (Grand River Conservation Authority, 2004).~~

~~In the northern half of the watershed, the Great Lakes–St. Lawrence Forest predominates, containing eastern hemlock, white pine and eastern white cedar. In addition, balsam fir, white spruce and white birches reach their southern limit in this zone. In some of the upper reaches of the~~

~~watershed, cool hollows of wetland vegetation similar to the muskeg of the Boreal forest can be found. The characteristic tree species of these sites is black spruce (Grand River Conservation Authority, 2004).~~

~~In the watershed, there are no known examples of large areas untouched by human activities. There are, however, many areas where the trees are older than 100 years.~~

~~Recent studies have discovered several eastern white cedars over 400 years old on the cliffs of Elora, Rockwood and Everton, and some over 500 years old, representing the oldest known trees in the watershed.~~

~~There are many woodlands that exhibit old growth characteristics in the watershed, but with the possible exception of the cliffs, there are probably no 'virgin' forests. In addition, only a handful of forests in the watershed are larger than the 400 hectares deemed necessary for significant interior habitat. Throughout the watershed many stands of trees, wetlands and other natural landscape features have been converted for housing, industry, agriculture and recreation. Summer logging, land grading, and artificial land drainage have impacted remaining woodlots (Grand River Conservation Authority, 1998).~~

~~There is currently a high edge-to-interior ratio in forests of the Grand watershed. Conditions are far from ideal in most parts of the landscape for species that require forest interior habitat.~~

~~Some of the main issues threatening forests in the watershed include invasive species and disease; urbanization; climate change; and pollution. As part of the Grand Strategy, the GRCA, in partnership with local stakeholders and the public, completed a forest management plan in 2004 entitled *A Watershed Forest Plan for the Grand River* to help develop a plan to deal with these issues on a watershed scale.~~

~~Recent trends indicate that forest cover is improving in many parts of the watershed. Historical practices such as pasturing in woodlands is virtually non-existent today, and during the past three decades many floodplain pastures have been abandoned and reforested, or now offer opportunities for forest restoration. This general trend away from livestock grazing in forests and floodplains may in fact be one of the most far-reaching influences on the current state of the watershed landscape.~~

~~This progress will translate into continued and expanding protection of water quality in streams, rivers and wetlands by providing a natural buffer that reduces contaminants from entering the water courses. Reduction in common pollutants associated with urban and rural runoff, including phosphorus, nitrogen and suspended sediments will improve the quality of both surface and groundwater drinking water sources.~~

2.11.2 Wetlands

Wetlands are a significant landscape feature in terms of providing habitat to a diverse range of species, as well as providing moderation to surface water flow by absorbing surface water runoff and releasing it slowly. This process acts as a filter and can reduce contamination reaching downstream surface and groundwater sources, thereby improving water quality and drinking water sources.

Wetlands often contribute to groundwater recharge, especially in areas of permeable soils (gravel, sand or loam). Where groundwater is used for drinking water or other uses, these wetland recharge areas can play a significant role in enhancing groundwater resources. However, contamination of the wetlands and upstream water can lead to contamination of groundwater sources, as wetlands recharging groundwater provide a direct conduit to aquifers.

Wetlands can also be areas of groundwater discharge, where aquifers located close to the surface release water. These are significant areas for habitat creation and species diversity, and can moderate surface water flow conditions and temperatures of streams and rivers that drain wetlands.

Within the Grand River watershed, over 65 percent of historical wetlands have been lost. In some areas of the watershed this exceeds 85 percent. A minimum of ten percent wetland coverage within a watershed is thought to be required to indicate a healthy watershed. Overall wetland coverage in the Grand River watershed meets this goal. However, in over half of the subwatersheds the percentage of existing wetlands is significantly lower, indicating considerable regional variation in wetland loss from one sub-watershed to another.

Wetland cover meets or exceeds the federal target in the following subwatersheds: Upper Grand (18%), Speed (17%), Whitemans (13%), Middle Grand (11%), and Fairchild (11%). Wetland cover is below the federal target in the following subwatersheds: Upper Middle Grand (7%), Nith (6%), Lower Grand (5%), Conestoga (5%), Lower Middle Grand (4%), McKenzie Creek (4%).

Map 2-23 shows the distribution of wetlands throughout the Grand River watershed.

Despite the historical loss of these areas, there are many significant wetland complexes found throughout the watershed, including:

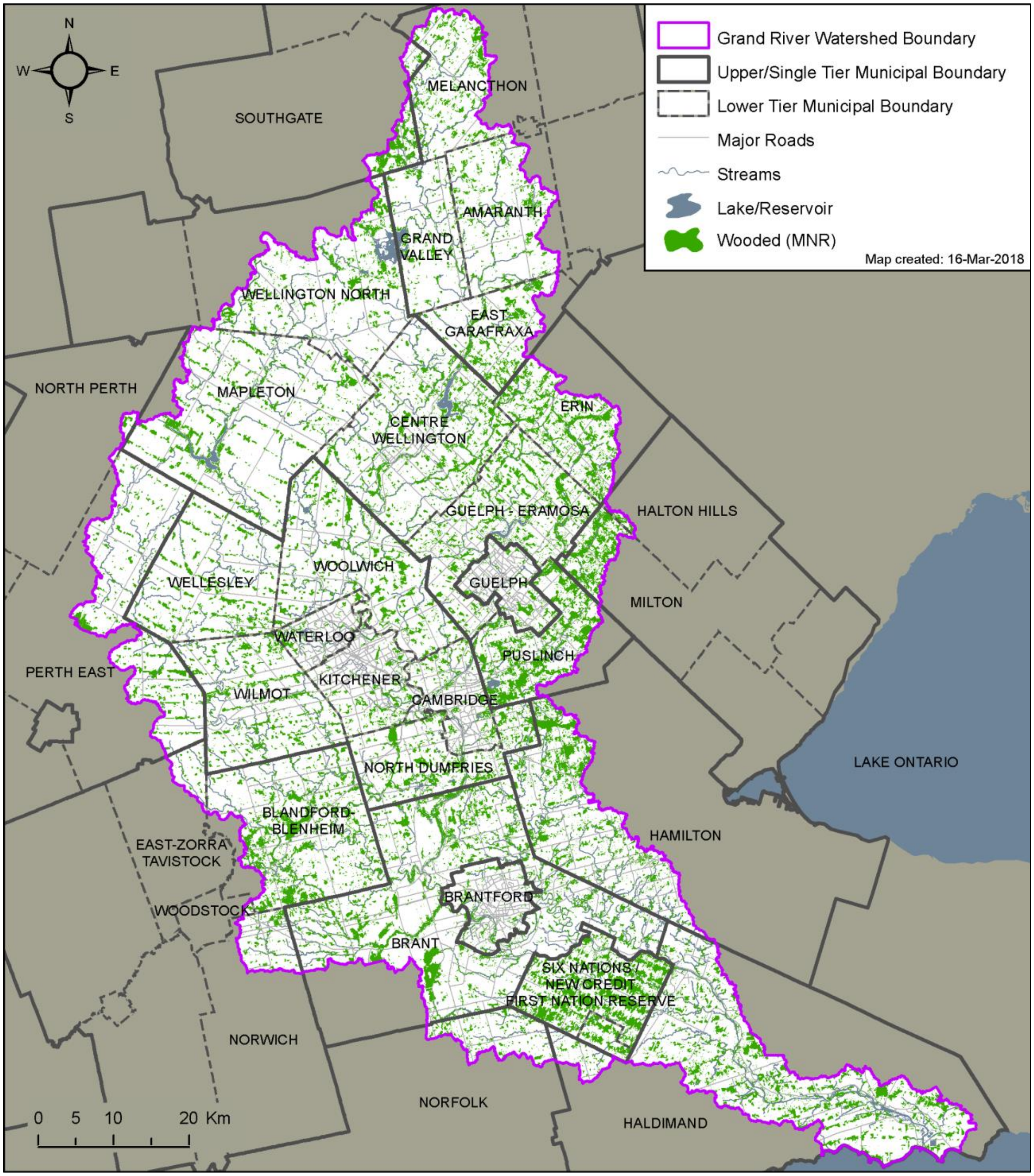
- Luther Marsh – covering approximately 4029 hectares in the Dundalk Till Plain at the headwaters of the Grand River;
- Brisbane Swamp – a major headwater for the Eramosa River in the Guelph Drumlin Field; not in our watershed; perhaps highlight the Eramosa-Blue Springs PSW Complex (3089 ha) as an important headwater wetland;
- Horseshoe Moraine – over 5,000 hectares of groundwater fed wetlands; comprises several wetland complexes, including the Mill Creek PSW Complex (1804 ha), Spottiswood-Pinehurst Lake PSW Complex (100 ha), many small kettle wetlands that are internally drained (i.e. no surface water outlet);
- Beverly Swamp – at approximately 2,000 hectares, it is the third largest remaining interior wetland in Southern Ontario in the southeast portion of the watershed;
- Keldon Swamp in the north, approximately 920 hectares;
- Amaranth Source Area in Dufferin County; (Melanchton Swamp PSW Complex is the largest (approx. 2800 hectares);
- Roseville Swamp in North Dumfries Township, (approx. 630 hectares);
- Several provincially-significant wetlands in the Oxford Till Plain draining into Whitemans Creek; Whitemans Creek-Horner Creek PSW Complex (3492 ha) and Whitemans Creek-Kenny Creek PSW Complex (2082 ha) are the 2 largest complexes but these span several physiographic regions;
- Provincially-significant alluvial and riparian swamps in the southwest portion of the watershed in the Mount Elgin Ridges Region, providing warm water fishery habitat. Several smaller and more isolated wetlands remain unevaluated but provide flood storage and groundwater recharge functions; and,

- At approximately 5700 hectares and located on the Guelph Drumlin Field, the Speed-Lutteral-Swan Creek PSW Complex is the largest evaluated wetland in our watershed. ~~Luther Marsh – covering approximately 3,000 hectares in the Dundalk Till Plain at the headwaters of the Grand River;~~
- ~~Brisbane Swamp – a major headwater for the Eramosa River in the Guelph Drumlin Field;~~
- ~~Horseshoe Moraine – over 5,000 hectares of groundwater fed wetlands;~~
- ~~Beverly Swamp – at approximately 2,000 hectares, it is the third largest remaining interior wetland in Southern Ontario in the southeast portion of the watershed;~~
- ~~Keldon Source Area in the north;~~
- ~~Amaranth Source Area in Dufferin County;~~
- ~~Roseville Swamp in North Dumfries Township;~~
- ~~Several provincially-significant wetlands in the Oxford Till Plain draining into Whitemans Creek; and~~
- ~~Provincially-significant alluvial and riparian swamps in the southwest portion of the watershed in the Mount Elgin Ridges Region, providing warm water fishery habitat.~~

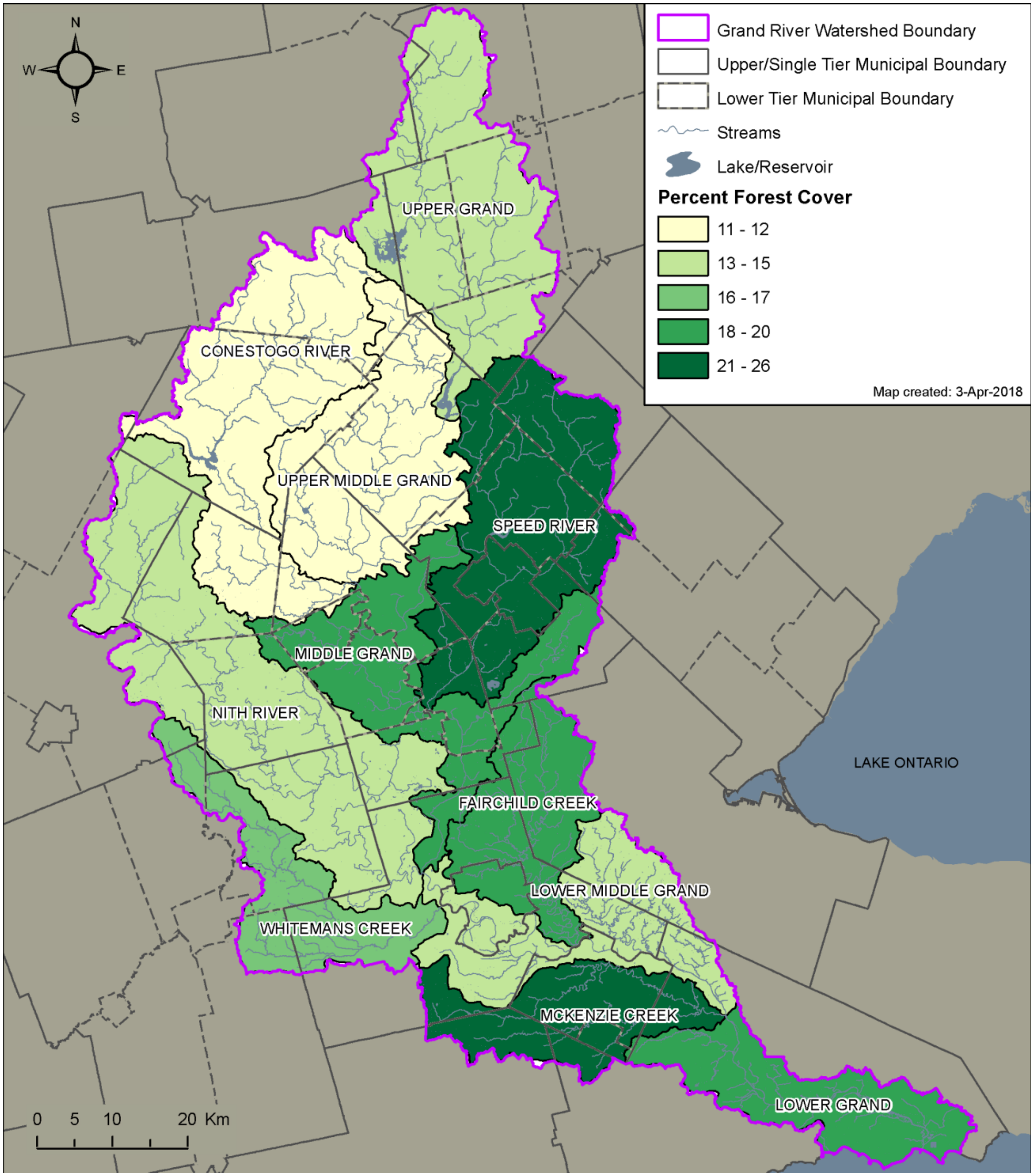
The highest concentrations of wetlands are located in the eastern portion of the watershed, in the Speed and Eramosa subwatersheds, as well as in Puslinch Township. The northern most portion of the watershed, near the towns of Dundalk, Grand Valley and Damascus, also holds significant wetland complexes. The wetlands and wet meadows in the poorly drained till plains and clay and gravel soils in the north are very significant source areas for the headwaters of the Grand, Nith and Conestogo Rivers.

Although wetlands were drastically reduced throughout the watershed during the period of European settlement, and more recently through the processes of agricultural drainage and urbanization, they continue to play a significant role in water quality improvement and surface water flow regulation, as well as providing habitat for a diverse range of species.

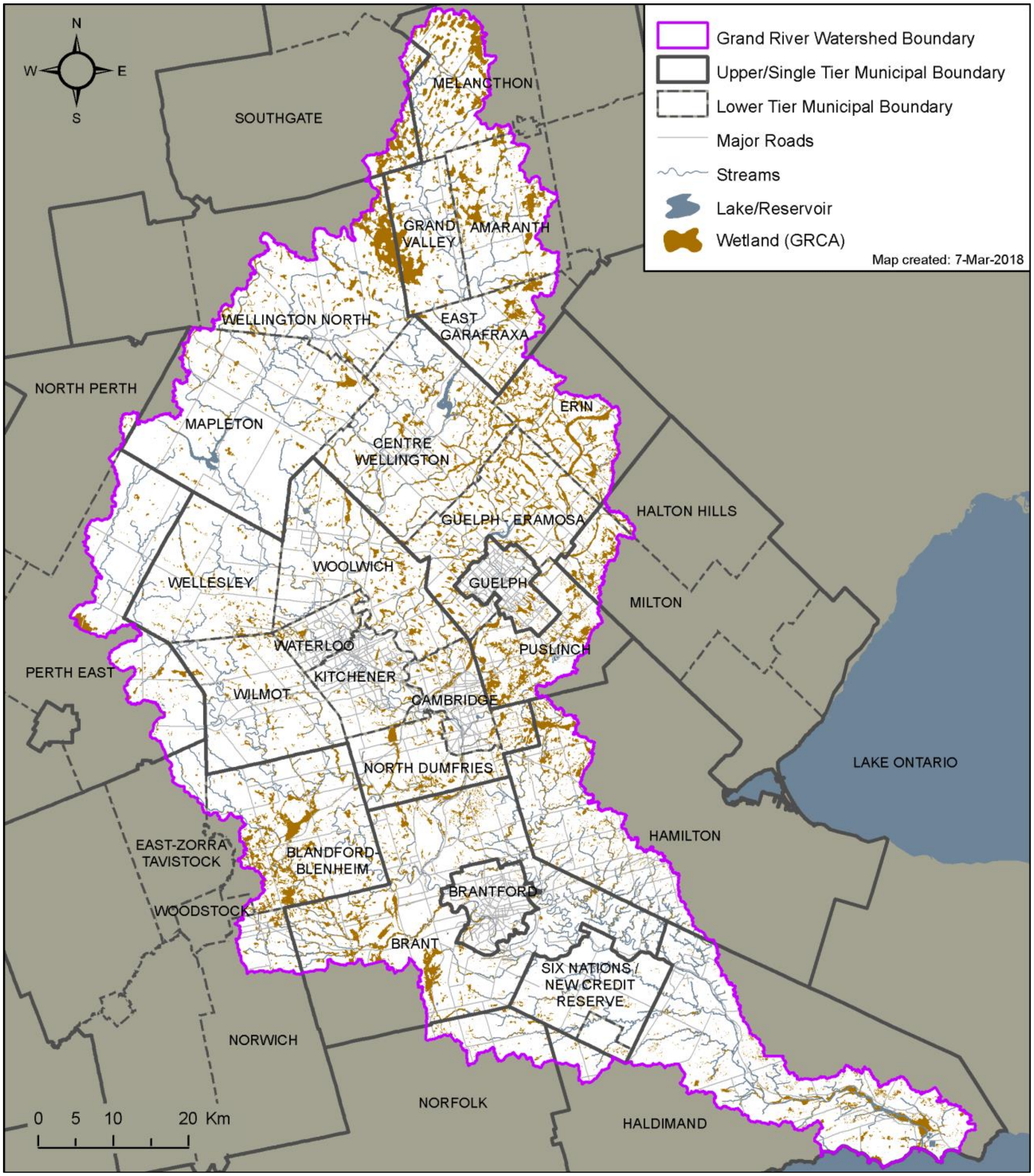
Map 2-21: Forest Cover in the Grand River Watershed



Map 2-22: Percent Forest Cover by Watershed



Map 2-23: Distribution of Wetlands in the Grand River Watershed



~~Surface Water~~

2.12 Surface Water Characterization

The Grand River drains approximately 6,800 square kilometres from its headwaters in the Dundalk Highlands to where it empties into Lake Erie at Port Maitland. Total elevation change along its 300 kilometres length is approximately 180 metres. The major tributaries of the Grand River include: the Conestogo and Nith Rivers, draining the western half of the watershed; and the Speed and Eramosa Rivers, which drains the north-east. Several smaller tributaries drain the southern half of the watershed. The largest of these include Fairchild, Whitemans and McKenzie creeks.

The Grand River is a managed river system where reservoir operations, water supply and wastewater management were designed as an integrated system on a watershed basis. The surface water system can be characterized with three regions: the northern till plains, the central moraines, and the southern clay plain. Water is managed primarily through a system of multi-purpose reservoirs and an extensive monitoring system of stream flow gauges.

~~The Grand River drains approximately 6,800 square kilometres from its headwaters in the Dundalk Highlands to where it empties into Lake Erie at Port Maitland. Total elevation change along its 300 kilometres length is approximately 180 metres. The major tributaries of the Grand River include: the Conestogo and Nith Rivers, draining the western half of the watershed; and the Speed and Eramosa Rivers, which drains the north-east. Several smaller tributaries drain the southern half of the watershed. The largest of these include Fairchild, Whitemans and McKenzie creeks. Portions of the Grand River and some of its tributaries are regulated for flood control and low flow augmentation using several water control structures and an extensive stream gauge network.~~

2.12.1 ~~Surface Water Monitoring~~Multi-Purpose Reservoirs

The Grand River Conservation Authority operates seven dams and reservoirs that have the dual purpose of flood damage reduction and low flow augmentation. The four largest reservoirs, Shand, Luther, Conestogo and Guelph, are operated as a system to provide flow augmentation and flood control for the main Grand River and the lower portion of the Speed River.

The reservoirs are managed to provide maximum flood storage during the spring, to handle spring snow melt, and the fall, to deal with remnants of tropical hurricanes. During periods of high flow, water is taken into storage at the reservoirs and downstream peak flows are reduced. During dry periods, water is released from storage to maintain minimum flows in the river system. Low flow augmentation is critical to the operation of municipal wastewater treatment plants to assist with assimilating wastewater effluent and to provide sufficient supplies for municipal drinking water systems in Waterloo Region, Brantford and Ohsweken.

2.12.2 Northern Till Plains

The northern till plains cover most of the headwaters of the Grand, Conestogo, Speed and Nith Rivers. This region is characterized by high surface runoff that results in high flood flows, but little to no flow in watercourses during sustained dry periods. Watercourses are well defined and much of the land is tile drained for agriculture. Flow distribution from the Leggatt gauge (**Figure 2-1**) shows both high flows during the spring freshet period and low flows during the summer months. This flow distribution is fairly typical of watercourses in this region.

The multi-purpose reservoirs were built on the fringe of these till plains to manage high surface runoff. Some watercourses downstream of the reservoirs are influenced by reservoir operations, but most watercourses in this region are unregulated.

2.12.3 Central Moraines and Sand Plains

The central portion of the watershed contains most of the watershed's moraines and sand/gravel deposits left by glaciation. The drainage network is not well defined and stream flows are maintained by groundwater discharge and/or flow augmentation from upstream reservoirs. Urbanization in this part of the watershed has led to an increase in surface runoff from impervious area and localized flooding issues.

There are three main types of watercourses in this region. The main Grand River and the lower Speed River are regulated by upstream reservoirs that add significant flow augmentation during the summer dry period and decrease flood peaks. An example is the flow distribution at the Galt gauge on the Grand River in Cambridge (**Figure 2-2**) where the summer months have a very consistent median flow. The second types are unregulated rural watercourses, such as the Nith River (**Figure 2-3**). Although there is no flow augmentation on the Nith River, summer flows are maintained by groundwater discharge from the Waterloo moraine. The final types are the urban watercourses. These watercourses react quickly during storm events since they are a major receiver of urban storm water runoff. Low flow conditions are variable depending on the condition of the watercourse and design of local storm water retention ponds.

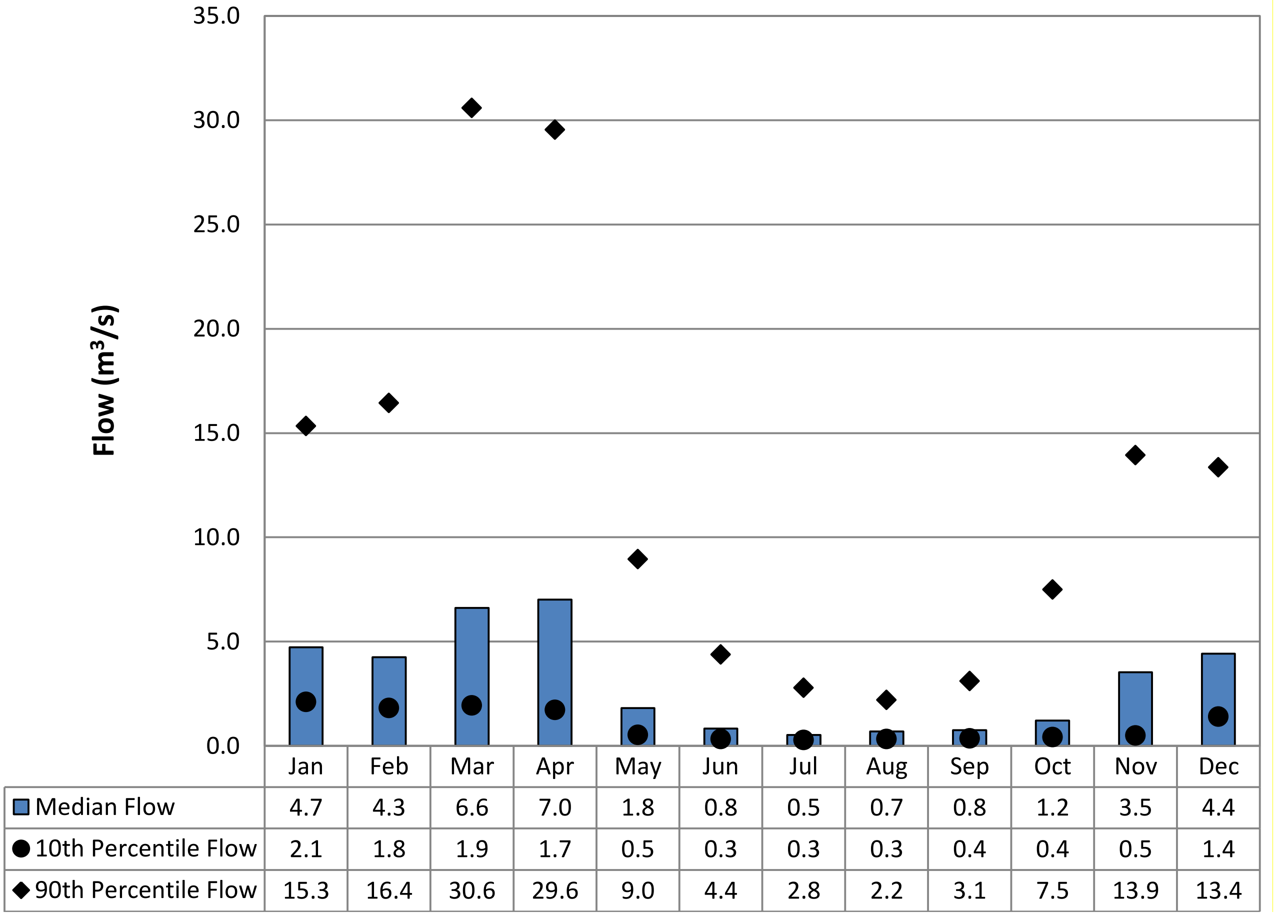
2.12.4 Southern Clay Plain

The southern portion of the watershed is dominated by the Haldimand Clay Plain. The landscape produces extremely high surface runoff and has a dense drainage network. There are few stream gauges monitoring the smaller tributaries in this reach and the few that do exist monitor flows in watercourses with headwaters in the central moraines. An example is McKenzie Creek, **Figure 2-4**, which has a flow distribution that is similar to the distribution in the northern till plain. On the other hand, flows in the Grand River are sustained by upstream flow augmentation and groundwater discharge. **Figure 2-5** shows the flows at the York gauge on the Grand River with high and consistent flows during the summer months.

2.12.5 Surface Water Monitoring

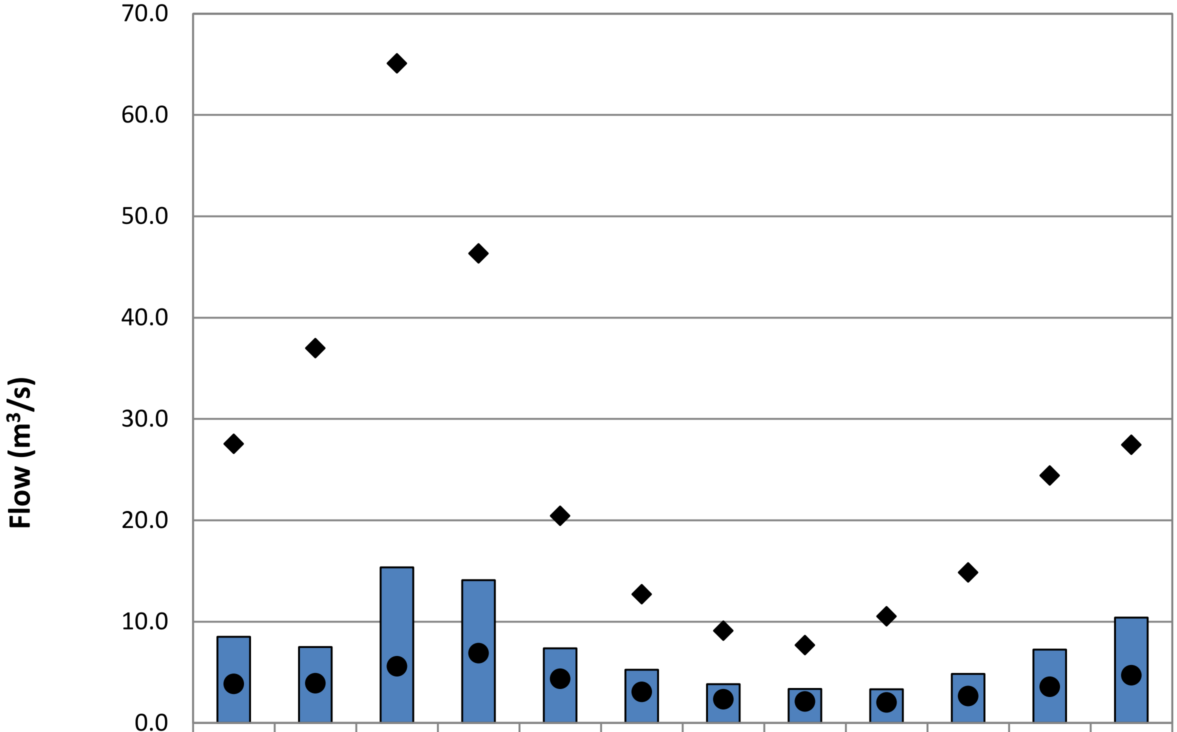
The flow monitoring network in the Grand River watershed consists of a dense network of stream gauges funded under the Federal/Provincial cost share agreement, gauges operated solely by the GRCA, and gauges operated in partnership between the GRCA and its member municipalities. The gauge network has been designed to support a number of water management activities such as flood management, low flow augmentation, water quality analysis, low water response, subwatershed planning, and basin reporting.

There are over 65 stream flow and level gauges currently in operation in the watershed, shown in **Map 2-24**. The gauge network covers both the regulated and the unregulated portions of the watershed, as well as inflow to major reservoirs and outflow from major dams. Many of the gauges record sub-hourly flow, with flow data available in real-time. Some gauges are operated seasonally for specific purposes, while others are operated continuously for various water management activities. Flow records in the Grand River Watershed date back to 1913 for some of the oldest gauges, predating the major dams and reservoirs.



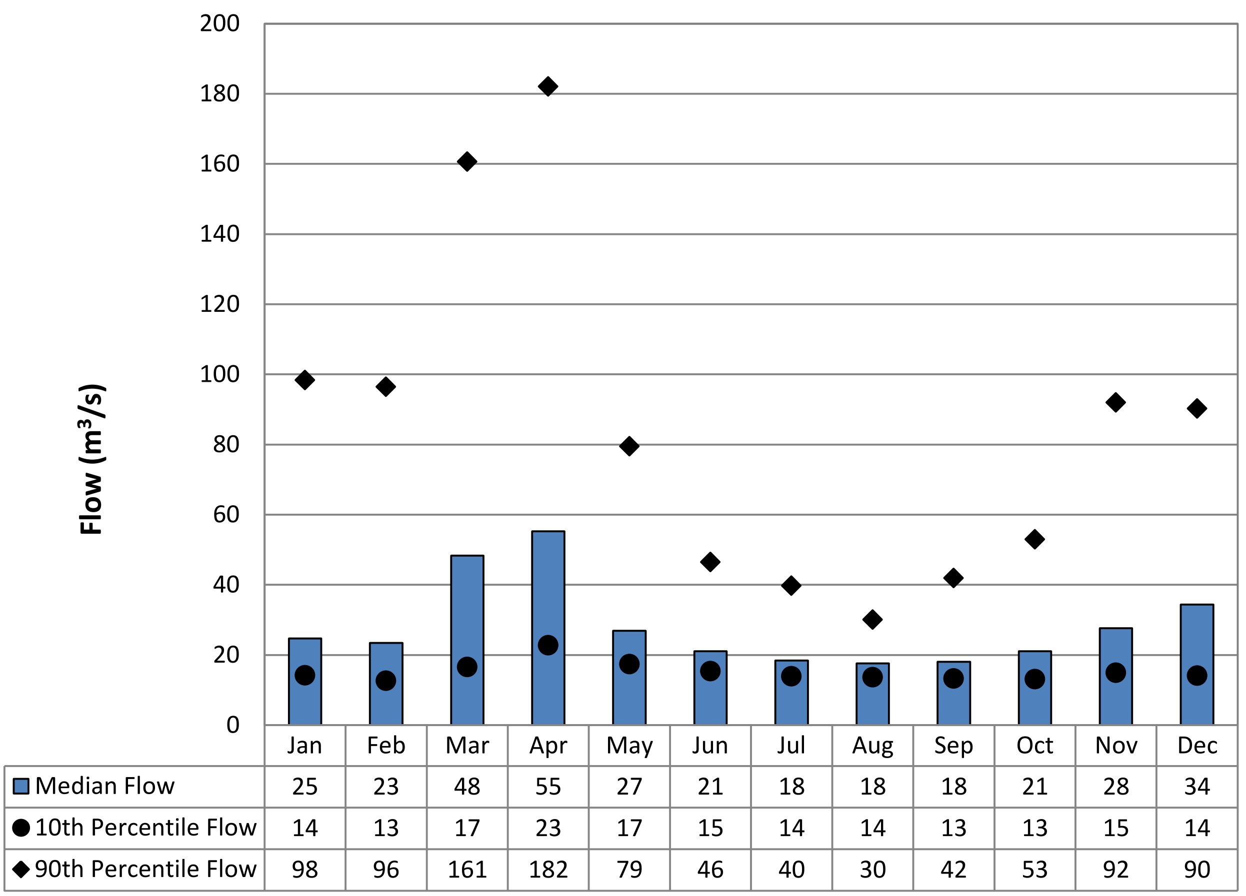
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
■ Median Flow	4.7	4.3	6.6	7.0	1.8	0.8	0.5	0.7	0.8	1.2	3.5	4.4
● 10th Percentile Flow	2.1	1.8	1.9	1.7	0.5	0.3	0.3	0.3	0.4	0.4	0.5	1.4
◆ 90th Percentile Flow	15.3	16.4	30.6	29.6	9.0	4.4	2.8	2.2	3.1	7.5	13.9	13.4

Figure 2-1: Flow Distribution for the Grand River at Leggatt



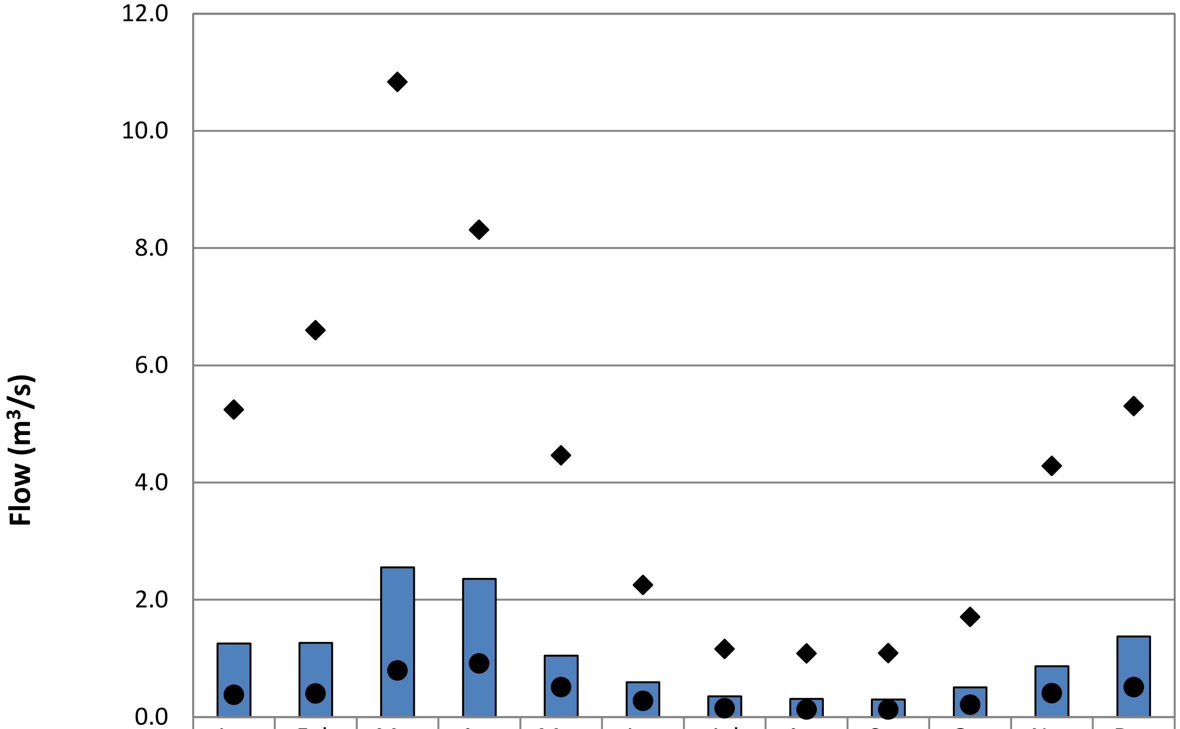
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
🟦 Median Flow	8.5	7.5	15.4	14.1	7.4	5.3	3.8	3.4	3.3	4.8	7.3	10.4
● 10th Percentile Flow	3.8	3.9	5.6	6.9	4.3	3.0	2.3	2.1	2.0	2.7	3.6	4.7
◆ 90th Percentile Flow	27.5	37.0	65.1	46.3	20.4	12.7	9.1	7.7	10.5	14.8	24.4	27.4

Figure 2-2: Flow Distribution for the Nith River at Canning



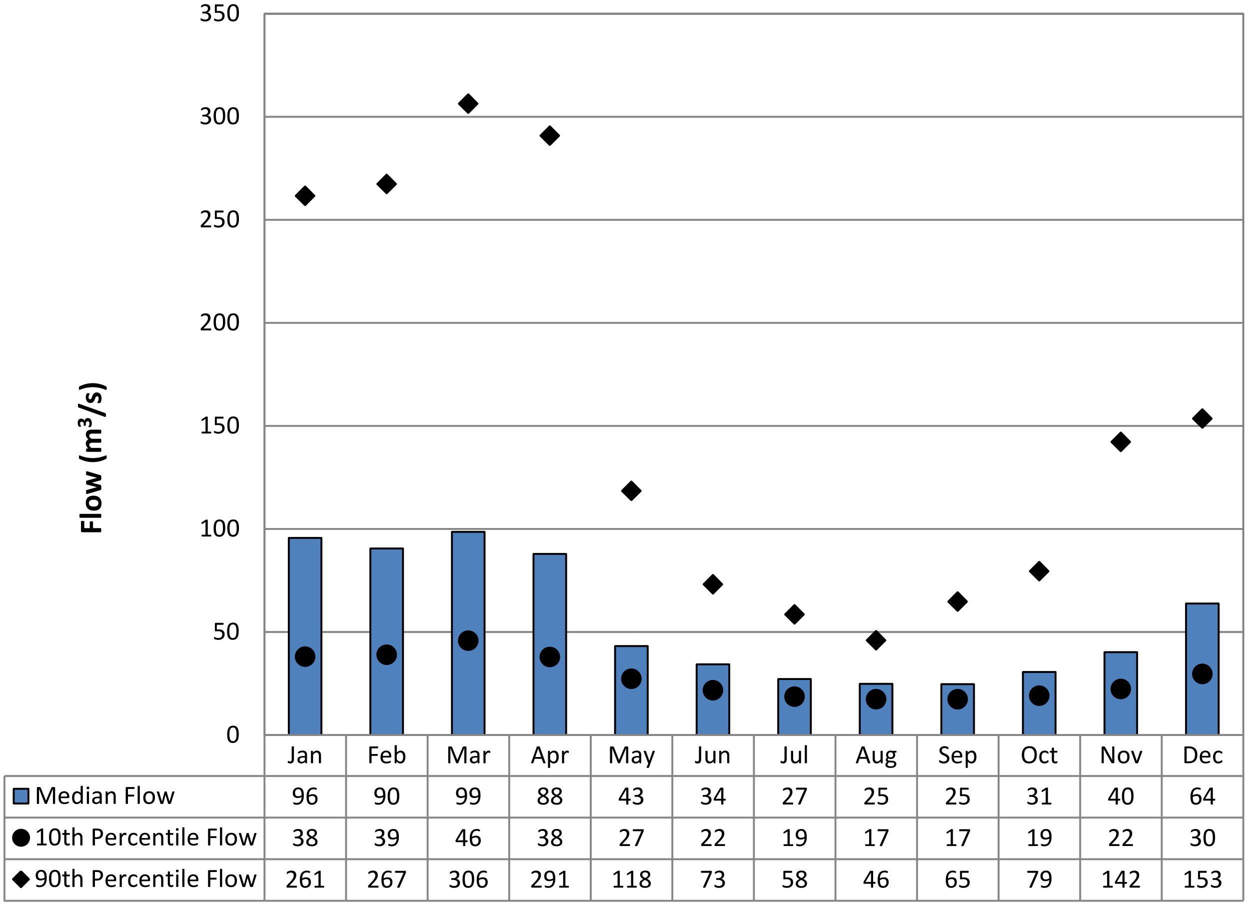
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
■ Median Flow	25	23	48	55	27	21	18	18	18	21	28	34
● 10th Percentile Flow	14	13	17	23	17	15	14	14	13	13	15	14
◆ 90th Percentile Flow	98	96	161	182	79	46	40	30	42	53	92	90

Figure 2-3: Flow Distribution for the Grand River at Galt



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
■ Median Flow	1.26	1.27	2.56	2.36	1.05	0.59	0.35	0.31	0.30	0.51	0.87	1.38
● 10th Percentile Flow	0.38	0.40	0.79	0.91	0.51	0.27	0.15	0.13	0.12	0.21	0.40	0.51
◆ 90th Percentile Flow	5.24	6.60	10.83	8.31	4.46	2.25	1.16	1.08	1.09	1.70	4.28	5.30

Figure 2-4: Flow Distribution for McKenzie Creek



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
■ Median Flow	96	90	99	88	43	34	27	25	25	31	40	64
● 10th Percentile Flow	38	39	46	38	27	22	19	17	17	19	22	30
◆ 90th Percentile Flow	261	267	306	291	118	73	58	46	65	79	142	153

Figure 2-5: Flow Distribution for the Grand River at York

~~The flow monitoring network in the Grand River watershed consists of a dense network of stream gauges funded under the Federal/Provincial cost share agreement, gauges operated solely by the GRCA, and gauges operated in partnership between the GRCA and its member municipalities. The gauge network has been designed to support a number of water management activities such as flood management, low flow augmentation, water quality analysis, low water response, subwatershed planning, and basin reporting.~~

~~There are over 45 stream flow and level gauges currently in operation in the watershed. The gauge network covers both the regulated and the unregulated portions of the watershed, as well as inflow to major reservoirs and outflow from major dams. Many of the gauges record hourly flow, with flow data available in real-time. Some gauges are operated seasonally for specific purposes, while others are operated continuously for various water management activities. Flow records in the Grand River Watershed date back to 1913 for some of the oldest gauges, predating the major dams and reservoirs.~~

~~The flow monitoring network continues to expand as water management activities require. Major stream flow gauge network evaluations were undertaken in 1991 and 2002.~~

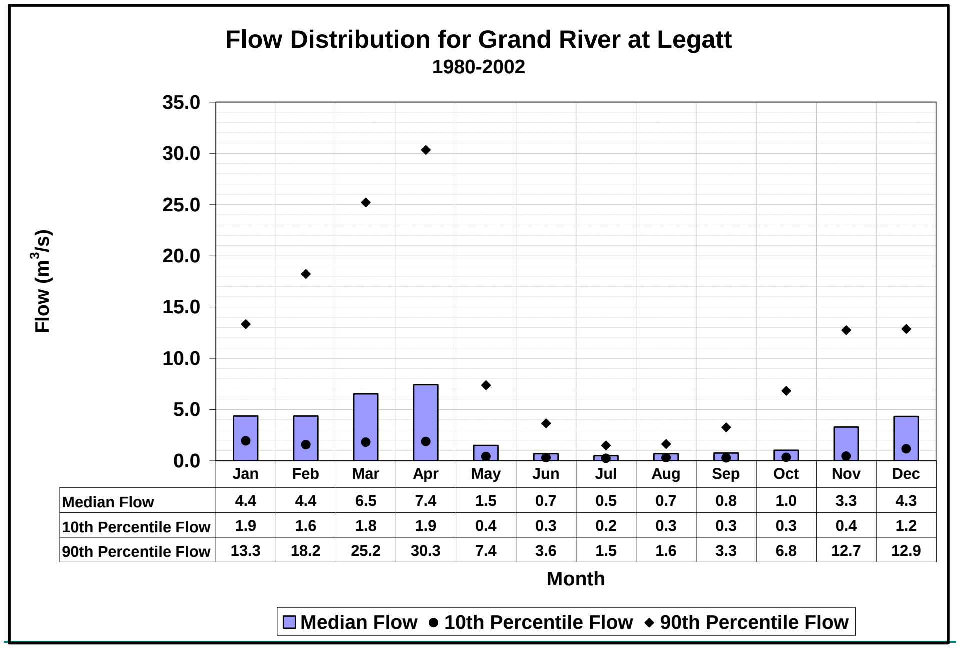
~~The flow regime for selected gauges is included in the following sections that describe the hydrology of various parts of the watershed.~~

~~2.12.6 Upper Grand River~~

~~The Upper Grand River watershed from the headwaters to the Conestogo River largely consists of Tavistock Till Plain, characterized by high surface runoff and low soil infiltration. The river valley is distinct through the region, with well-defined banks and floodplains. Through part of its length the river has cut a steep sided gorge through exposed bedrock.~~

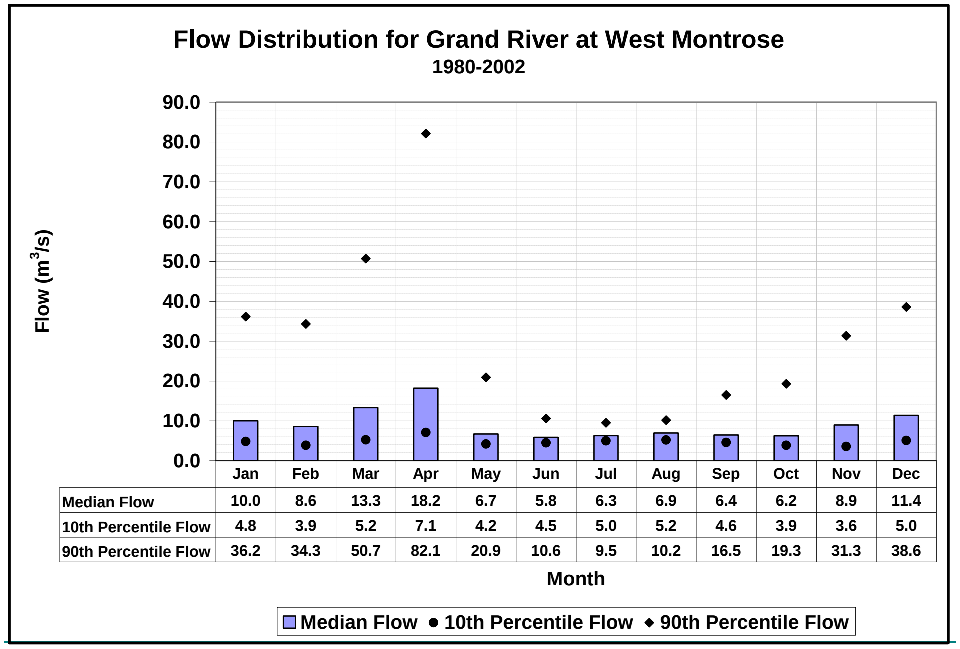
~~Upstream of the Belwood Lake (Shand Dam) Reservoir, the river is runoff dominated as shown by the flow distribution for the stream gauge at Legatt, **Figure 2-2**.~~

~~Spring snowmelt is used to fill the large reservoirs, Luther Marsh and Belwood Lake, in the Upper Grand watershed to mitigate flooding and provide flow augmentation during low flow conditions. Downstream of the Shand Dam, the flow regime is modified by reservoir operations. Peak flows are smaller and base flows more stable as seen in the flow distribution for the stream gauge at West Montrose, **Figure 2-3**.~~



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Median Flow	4.4	4.4	6.5	7.4	1.5	0.7	0.5	0.7	0.8	1.0	3.3	4.3
10th Percentile Flow	1.9	1.6	1.8	1.9	0.4	0.3	0.2	0.3	0.3	0.3	0.4	1.2
90th Percentile Flow	13.3	18.2	25.2	30.3	7.4	3.6	1.5	1.6	3.3	6.8	12.7	12.9

~~**Figure 2-2: Flow Distribution for the Grand River at Legatt gauge showing median, 10th and 90th percentile flows**~~

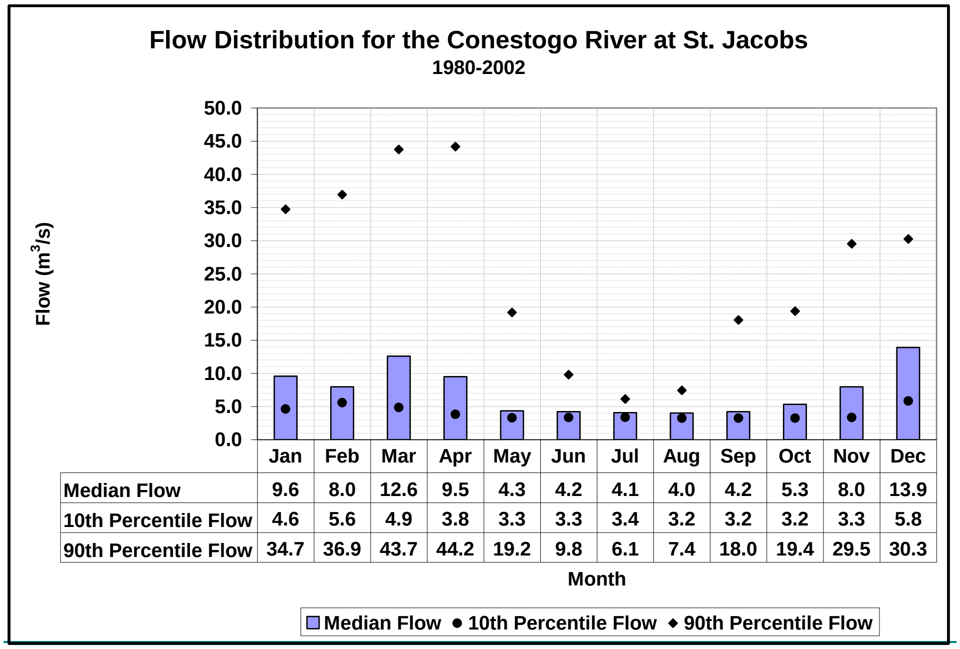


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Median Flow	10.0	8.6	13.3	18.2	6.7	5.8	6.3	6.9	6.4	6.2	8.9	11.4
10th Percentile Flow	4.8	3.9	5.2	7.1	4.2	4.5	5.0	5.2	4.6	3.9	3.6	5.0
90th Percentile Flow	36.2	34.3	50.7	82.1	20.9	10.6	9.5	10.2	16.5	19.3	31.3	38.6

~~**Figure 2-3: Flow Distribution for the Grand River at West Montrose gauge showing median, 10th and 90th percentile flows**~~

~~2.12.7 Conestogo River~~

~~The Conestogo River Watershed drains approximately 820 square kilometres. The watershed is a runoff dominated system, largely comprised of Tavistock Till Plain. The system generates extremely high runoff, however due to the efficient drainage system, peak flows rarely last long. The watershed contains one large reservoir, Conestogo Lake, which is used for flood control and low flow augmentation. Flow above Conestogo Dam during summer periods is quite low, with virtually no flow during extreme dry periods. Stream flow in the lower portion of the river is controlled by discharges from Conestogo Dam. The dam controls flooding through the lower Conestogo and middle and lower Grand River, and adds significant flow augmentation during the summer dry period as shown in Figure 2-4. While the lower Conestogo does pick up some groundwater discharge from the northern flank of the Waterloo Moraine, most of the summer flows are solely from reservoir augmentation.~~

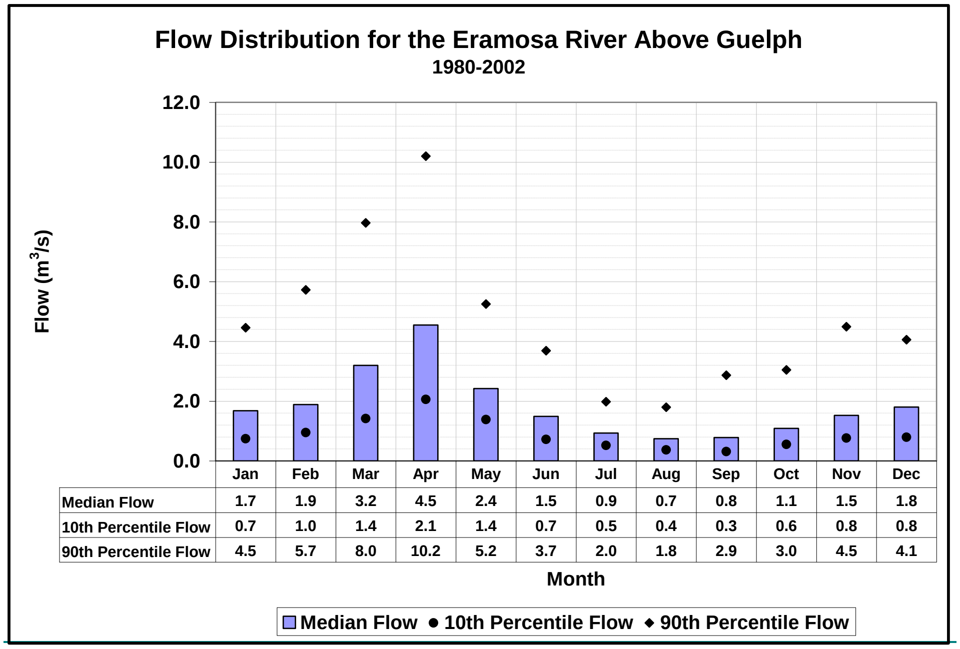


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Median Flow	9.6	8.0	12.6	9.5	4.3	4.2	4.1	4.0	4.2	5.3	8.0	13.9
10th Percentile Flow	4.6	5.6	4.9	3.8	3.3	3.3	3.4	3.2	3.2	3.2	3.3	5.8
90th Percentile Flow	34.7	36.9	43.7	44.2	19.2	9.8	6.1	7.4	18.0	19.4	29.5	30.3

~~Figure 2-4: Flow Distribution for the Conestogo River at St. Jacobs gauge showing median, 10th and 90th percentile flows~~

~~2.12.8 Speed and Eramosa Rivers~~

~~The Speed River, along with its tributary the Eramosa River, drains an area of approximately 780 square kilometres. The Eramosa River watershed is largely within the Galt/Paris moraines. It is characterized by low surface runoff, high soil infiltration, and disconnected drainage. The watershed also has a high percentage of forest cover. Because the drainage area includes a significant portion of moraines, the topography is also described as hummocky. In these areas, runoff, unable to reach a watercourse, collects in large scale depressions, and either evaporates or infiltrates. With pervious material, significant forest cover and hummocky topography, this watershed has very reliable baseflow as shown in~~ **~~Figure 2-5.~~** ~~The Eramosa River joins the Speed River in the City of Guelph below Guelph Dam.~~

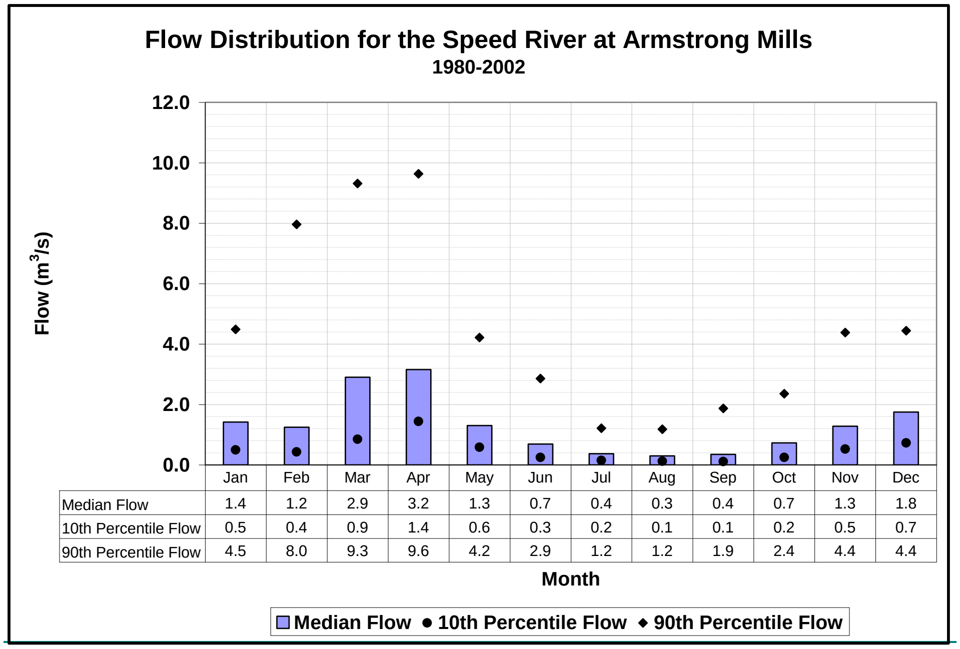


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Median Flow	1.7	1.9	3.2	4.5	2.4	1.5	0.9	0.7	0.8	1.1	1.5	1.8
10th Percentile Flow	0.7	1.0	1.4	2.1	1.4	0.7	0.5	0.4	0.3	0.6	0.8	0.8
90th Percentile Flow	4.5	5.7	8.0	10.2	5.2	3.7	2.0	1.8	2.9	3.0	4.5	4.1

~~Figure 2-5: Flow Distribution for the Eramosa River above Guelph gauge showing median, 10th and 90th percentile flows~~

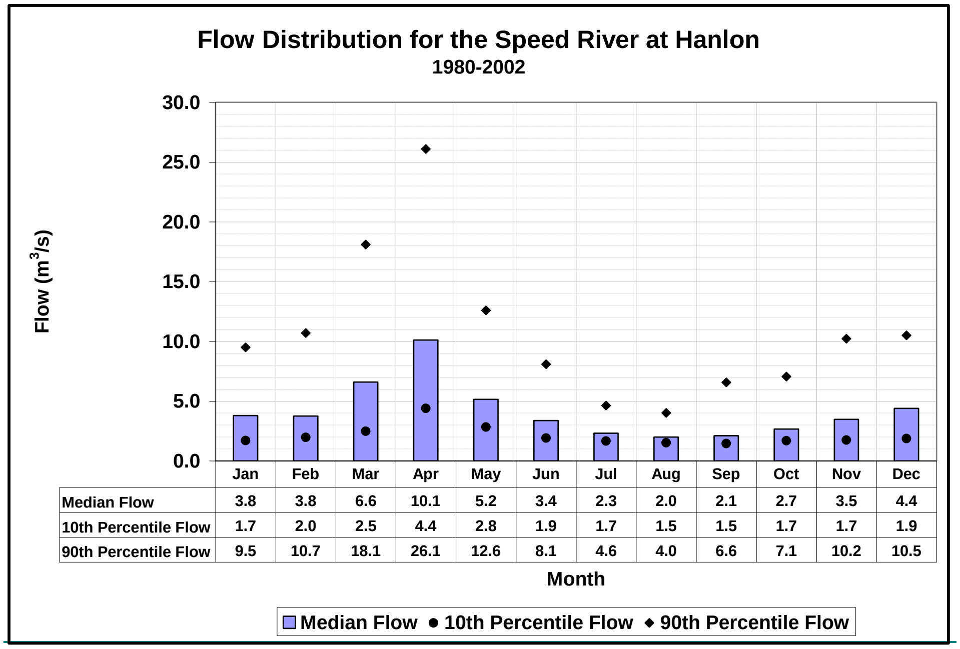
~~The Upper Speed Watershed is mainly within the Orangeville Moraine. Due to the eroded nature of the Orangeville Moraine the area has a well-defined drainage network and therefore does not produce as much groundwater recharge as the Eramosa River Watershed. This results in a more variable and often lower, groundwater discharge component of the flow regime as shown in~~ **~~Figure 2-6~~**~~.~~

~~Guelph Dam was built for flood control and low flow augmentation. The Lower portions of the Speed River are regulated with discharge from Guelph Dam to augment low flow for waste assimilation purposes and to control flooding in the City of Guelph. The modifying effects of the dam and the contribution of the Eramosa River can be seen in the flow distribution for the Speed River at Hanlon gauge,~~ **~~Figure 2-7~~**~~. The Speed River joins the Grand River in the City of Cambridge.~~



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Median Flow	1.4	1.2	2.9	3.2	1.3	0.7	0.4	0.3	0.4	0.7	1.3	1.8
10th Percentile Flow	0.5	0.4	0.9	1.4	0.6	0.3	0.2	0.1	0.1	0.2	0.5	0.7
90th Percentile Flow	4.5	8.0	9.3	9.6	4.2	2.9	1.2	1.2	1.9	2.4	4.4	4.4

~~Figure 2-6: Flow Distribution for the Speed River at Armstrong Mills (above Guelph Dam) gauge showing median, 10th and 90th percentile flows~~



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Median Flow	3.8	3.8	6.6	10.1	5.2	3.4	2.3	2.0	2.1	2.7	3.5	4.4
10th Percentile Flow	1.7	2.0	2.5	4.4	2.8	1.9	1.7	1.5	1.5	1.7	1.7	1.9
90th Percentile Flow	9.5	10.7	18.1	26.1	12.6	8.1	4.6	4.0	6.6	7.1	10.2	10.5

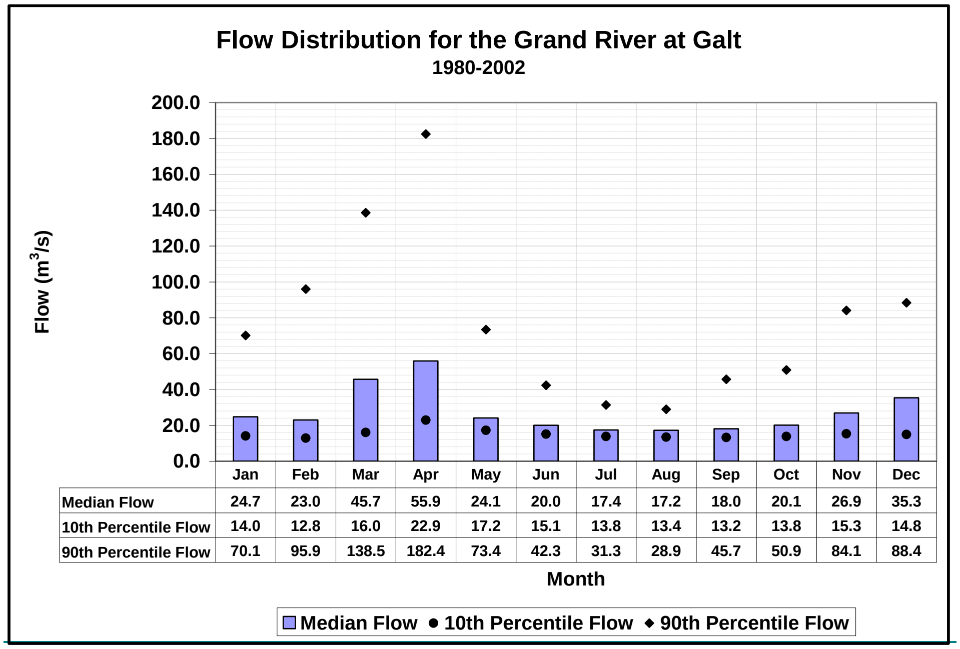
~~Figure 2-7: Flow Distribution for the Speed River at Hanlon gauge showing median, 10th and 90th percentile flows~~

~~2.12.9 Central Grand~~

~~The central portion of the Grand River, from the confluence of the Conestogo River to the Nith River, is the most urbanized part of the watershed. It contains the Cities of Kitchener, Waterloo, and Cambridge. The natural river channel has been altered in places and increased impervious areas in the urban areas have led to some localized flooding. Within this central portion, the Grand is joined by the Speed River in Cambridge. There are also two reservoirs located in this section, Laurel Creek and Shades Mill.~~

~~Laurel Creek Reservoir is on Laurel Creek, a small creek that drains approximately 74 square kilometres. Upstream of the reservoir the watershed is largely agricultural on the Waterloo Moraine, while downstream the creek passes through the City of Waterloo. This makes for a variety of watercourse conditions including concrete channels, natural streams within wooded areas, regulated flow, and urban runoff. Shades Mill Reservoir is on Mill Creek, a small watercourse, draining 83 square kilometres, within Puslinch Township. Mill Creek flows through Cambridge before entering the Grand River, just upstream of the Grand at Galt gauge. Mill Creek flows through a glacial outwash, which is sandwiched between the Galt and Paris moraines. Due to the high amounts of hummocky topography in the moraines, and significant deposits of gravel within the outwash areas, the watercourse is a known coldwater stream, seeing considerable groundwater discharge and very little surface runoff. The largest anthropogenic impact along Mill Creek is the presence of numerous aggregate pits, many of which are extracting below the water table.~~

~~Flow is regulated through the central portion of the Grand River from upstream reservoirs. Spring flows are greatly reduced by the reservoirs which capture the spring snow melt. In combination with local dyke systems, this has reduced average annual flood damages through the urban centers in Waterloo, Kitchener, and Cambridge by 75 percent. Flows in the summer are augmented by the reservoirs to maintain flow for municipal water supply withdrawals and wastewater assimilation as shown in the flow distribution for the Galt gauge,~~ ~~**Figure 2-8**~~~~. South of Cambridge, the Grand River passes through a massive groundwater discharge zone, which adds as much flow as either Shand or Conestogo dams. This large amount of groundwater discharge allows the Grand River to recover downstream of the large urban and intensive agricultural regions of the upper watershed.~~



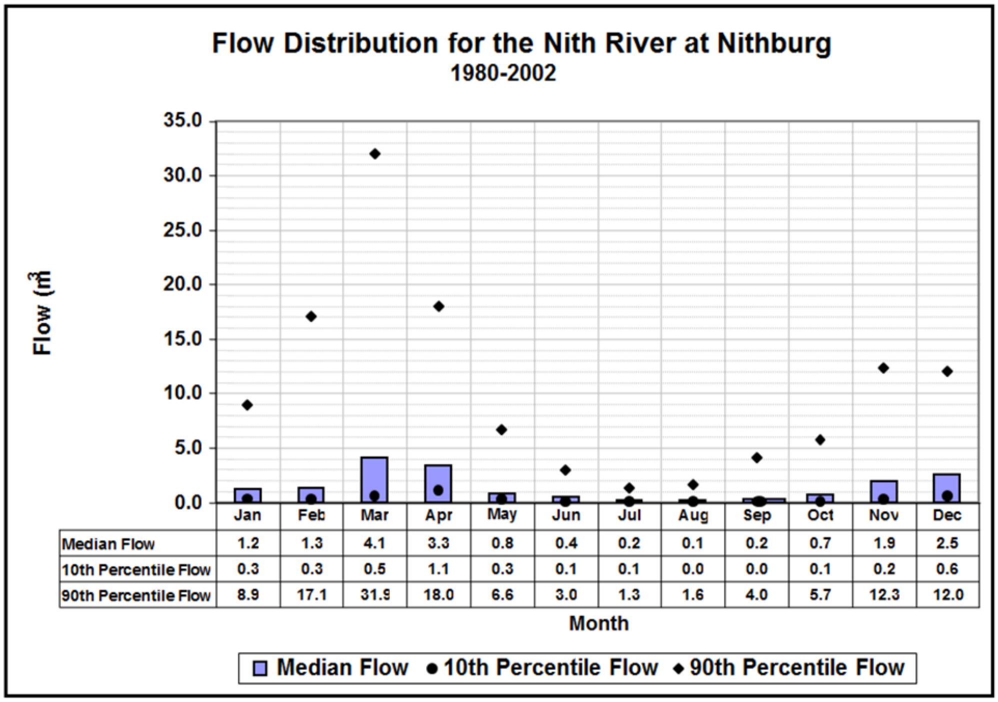
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Median Flow	24.7	23.0	45.7	55.9	24.1	20.0	17.4	17.2	18.0	20.1	26.9	35.3
10th Percentile Flow	14.0	12.8	16.0	22.9	17.2	15.1	13.8	13.4	13.2	13.8	15.3	14.8
90th Percentile Flow	70.1	95.9	138.5	182.4	73.4	42.3	31.3	28.9	45.7	50.9	84.1	88.4

~~**Figure 2-8: Flow Distribution for the Grand River at Galt gauge showing median, 10th and 90th percentile flows**~~

~~2.12.10 Nith River~~

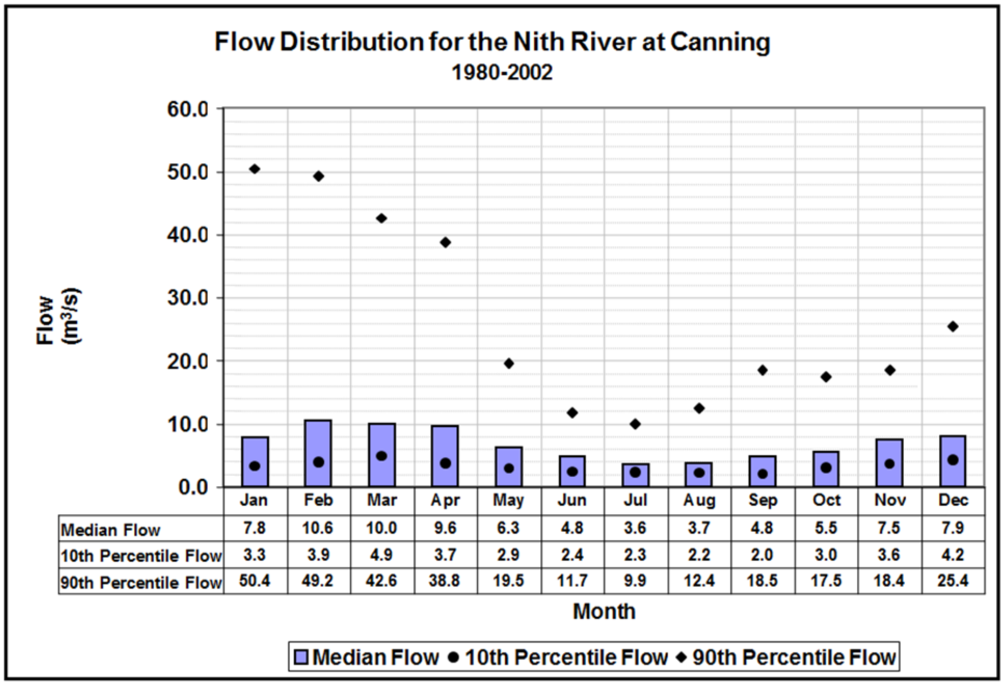
~~The Nith River drains approximately 1,030 square kilometres of the western portion of the watershed, and is the largest uncontrolled tributary in the Grand River Watershed. It drains two vastly different portions of the watershed. The Upper Nith River drains the same geologic unit as the Upper Conestogo, and hence reacts similarly. The tight Tavistock Till generates large volumes of runoff, but very little infiltration, leading to little or no summer flows as shown in **Figure 2-9**.~~

~~As the Nith flows southward downstream of New Hamburg, it passes by the western and then southern flank of the Waterloo Moraine. In this area, the Nith River picks up substantial groundwater discharge, improving base flows as shown in the flow distribution for the gauge at Canning, **Figure 2-10**. In addition to the moraine, the geology changes in the southern portion of the watershed to more pervious materials, that produce large quantities of groundwater recharge. While there are significant groundwater takings occurring within the Nith River Basin, surface water takings are relatively insignificant. The Nith River joins the Grand River in the Town of Paris in Brant County.~~



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Median Flow	1.2	1.3	4.1	3.3	0.8	0.4	0.2	0.1	0.2	0.7	1.9	2.5
10th Percentile Flow	0.3	0.3	0.5	1.1	0.3	0.1	0.1	0.0	0.0	0.1	0.2	0.6
90th Percentile Flow	8.9	17.1	31.9	18.0	6.6	3.0	1.3	1.6	4.0	5.7	12.3	12.0

~~Figure 2-9: Flow Distribution for the Nith River at Nithburg gauge showing median, 10th and 90th percentile flows~~

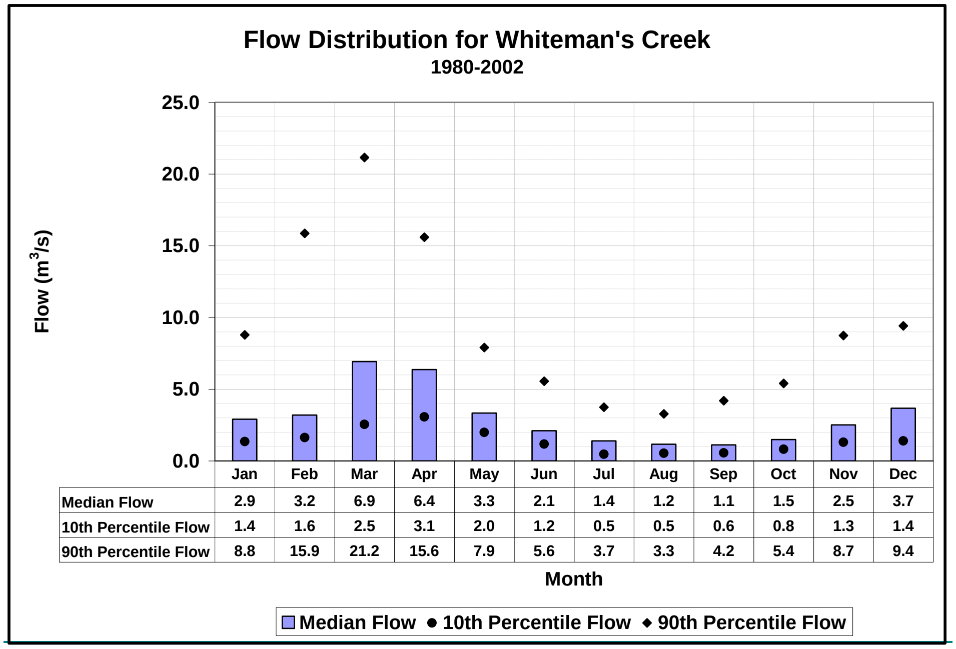


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Median Flow	7.8	10.6	10.0	9.6	6.3	4.8	3.6	3.7	4.8	5.5	7.5	7.9
10th Percentile Flow	3.3	3.9	4.9	3.7	2.9	2.4	2.3	2.2	2.0	3.0	3.6	4.2
90th Percentile Flow	50.4	49.2	42.6	38.8	19.5	11.7	9.9	12.4	18.5	17.5	18.4	25.4

~~Figure 2-10: Flow Distribution for the Nith River at Canning gauge showing median, 10th and 90th percentile flows~~

~~2.12.11 Whitemans, Fairchild and McKenzie Creeks~~

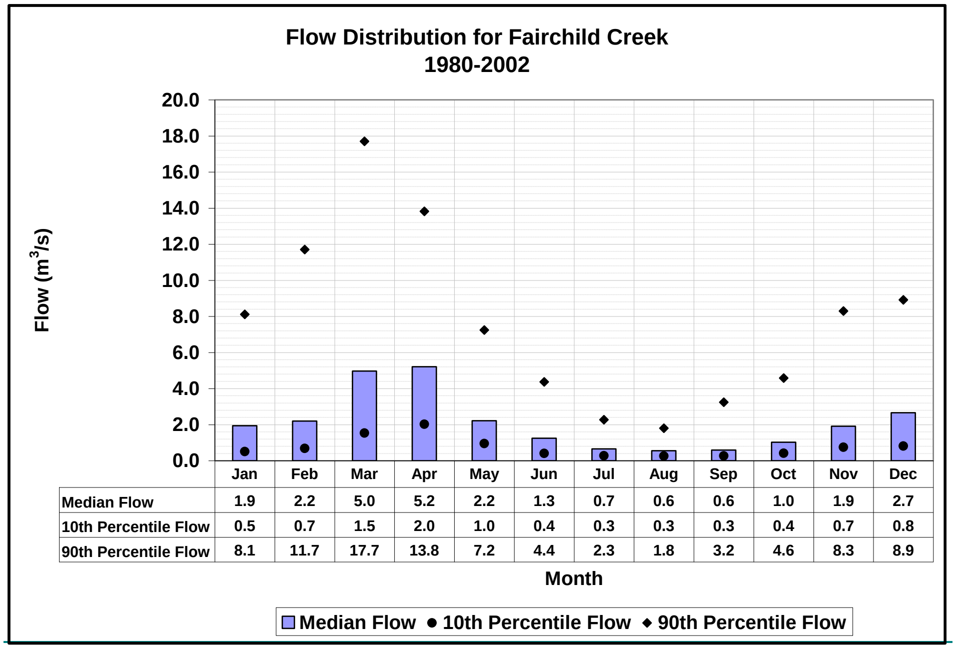
~~The watershed of Whitemans Creek lies adjacent to the Nith River and has two main tributaries, Horner and Kenny creeks. Much like the Nith River, Whitemans Creek has two distinct geologic areas. Furthest upstream, Horner Creek flows over the Tavistock Till Plain, then as it flows south, drains an area characterized by granular, more pervious material. The watershed of Kenny Creek is dominated by Port Stanley Till, another relatively impervious material. At the Kenny and Horner confluence, where Whitemans Creek is formed, the watershed becomes largely comprised of Norfolk Sand Plain. The sands of the area produce large amounts of groundwater recharge (**Figure 2-11**), although because of the well drained nature of the area, substantial irrigation is required to sustain viable crops. Water takings for irrigation can affect the flow series lowering summer base flows, which can impact the creek's cold water fishery. Whitemans Creek flows into the Grand River just upstream of Brantford.~~



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Median Flow	2.9	3.2	6.9	6.4	3.3	2.1	1.4	1.2	1.1	1.5	2.5	3.7
10th Percentile Flow	1.4	1.6	2.5	3.1	2.0	1.2	0.5	0.5	0.6	0.8	1.3	1.4
90th Percentile Flow	8.8	15.9	21.2	15.6	7.9	5.6	3.7	3.3	4.2	5.4	8.7	9.4

~~**Figure 2-11: Flow Distribution for Whitemans Creek showing median, 10th and 90th percentile flows**~~

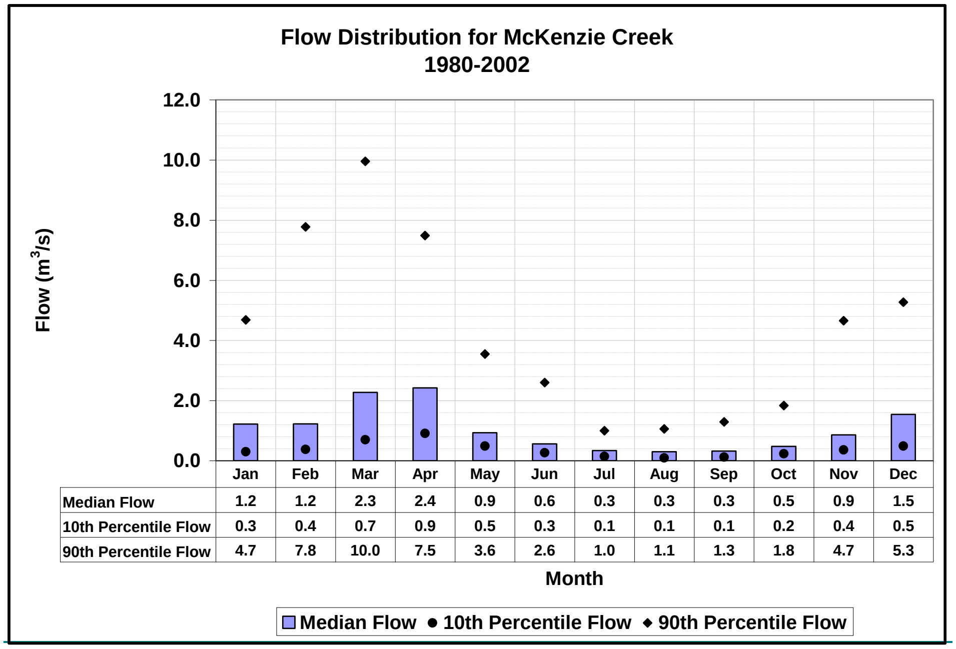
~~Fairchild Creek drains an area of approximately 360 square kilometres just west of the City of Brantford, and enters into the Grand River near the community of Onondaga. The watershed's geology is a mixture of Haldimand Clay, Rockton Bedrock Plain, Norfolk Sand Plain, and portions of the Paris Moraine. Due to the influence of the sand deposits and the Paris Moraine, this watershed can have a substantial low flow component. The drainage density in this portion of the Grand River watershed is extremely high in comparison to other areas, pointing to very high runoff rates, and low groundwater recharge (**Figure 2-12**).~~



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Median Flow	1.9	2.2	5.0	5.2	2.2	1.3	0.7	0.6	0.6	1.0	1.9	2.7
10th Percentile Flow	0.5	0.7	1.5	2.0	1.0	0.4	0.3	0.3	0.3	0.4	0.7	0.8
90th Percentile Flow	8.1	11.7	17.7	13.8	7.2	4.4	2.3	1.8	3.2	4.6	8.3	8.9

~~Figure 2-12: Flow Distribution for the Fairchild Creek gauge showing median, 10th and 90th percentile flows~~

~~McKenzie Creek drains 171 square kilometres, including portions of the Six Nations Territory and Haldimand County. The watershed is largely comprised of Haldimand Clay, with the upper portion draining an area of the Norfolk Sand Plain. With the majority of the watershed being clay, this is, predictably, a runoff dominated system (**Figure 2-13**). The upper portions of the watershed can produce a reliable low flow component; however, irrigation within the Norfolk Sand Plain causes this to be variable.~~



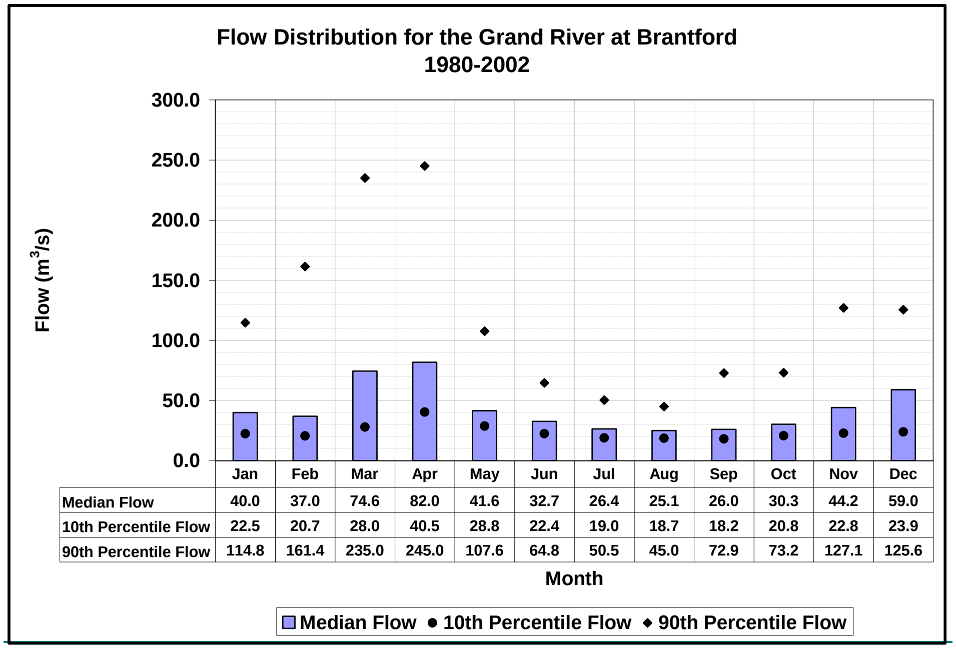
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Median Flow	1.2	1.2	2.3	2.4	0.9	0.6	0.3	0.3	0.3	0.5	0.9	1.5
10th Percentile Flow	0.3	0.4	0.7	0.9	0.5	0.3	0.1	0.1	0.1	0.2	0.4	0.5
90th Percentile Flow	4.7	7.8	10.0	7.5	3.6	2.6	1.0	1.1	1.3	1.8	4.7	5.3

~~Figure 2-13: Flow Distribution for the McKenzie Creek gauge showing median, 10th and 90th percentile flows~~

~~2.12.12 Lower Grand River~~

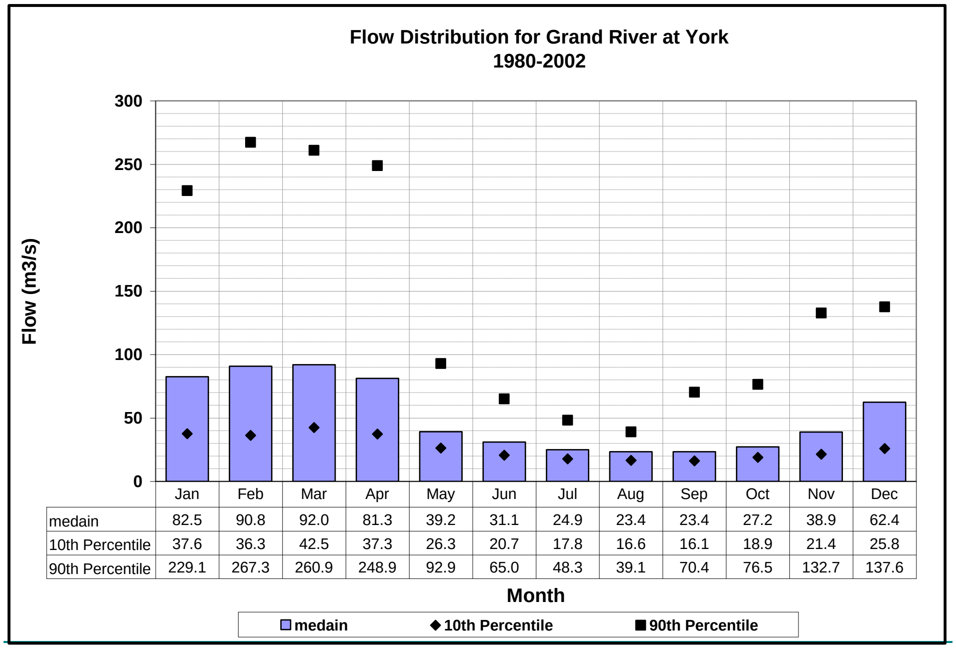
~~The Lower Grand River from the Nith River confluence to Lake Erie is largely influenced by upstream flow conditions. Contributions to the flow regime from Whitemans, Fairchild and McKenzie creeks have little influence on the flow regime of the Grand River compared to the watershed upstream of the Nith River confluence. At Brantford the flow distribution,~~ ~~**Figure 2-14**~~~~, shows a stable base flow component which is influenced by both upstream reservoir operations and groundwater discharge upstream of the gauge. Peak flows occur in April, a reflection of the influence of the later snowmelt in the northern portion of the watershed on this flow distribution.~~

~~Downstream of Brantford the watershed is fairly flat and comprised of Haldimand Clay Plain. The drainage area produces high runoff and little groundwater recharge. Tributaries in this area form a dense drainage network that quickly conveys water to the river. The main river channel itself is very wide and it meanders as it travels south to Lake Erie. Water is slow moving, but flow rates can be significant. The last stream gauge on the Grand River is at the community of York. The York gauge is operated by the GRCA and its flow distribution is given in~~ ~~**Figure 2-15**~~~~. Following York the Grand River continues its southward path past the communities of Cayuga and Dunnville before it joins Lake Erie at Port Maitland.~~



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Median Flow	40.0	37.0	74.6	82.0	41.6	32.7	26.4	25.1	26.0	30.3	44.2	59.0
10th Percentile Flow	22.5	20.7	28.0	40.5	28.8	22.4	19.0	18.7	18.2	20.8	22.8	23.9
90th Percentile Flow	114.8	161.4	235.0	245.0	107.6	64.8	50.5	45.0	72.9	73.2	127.1	125.6

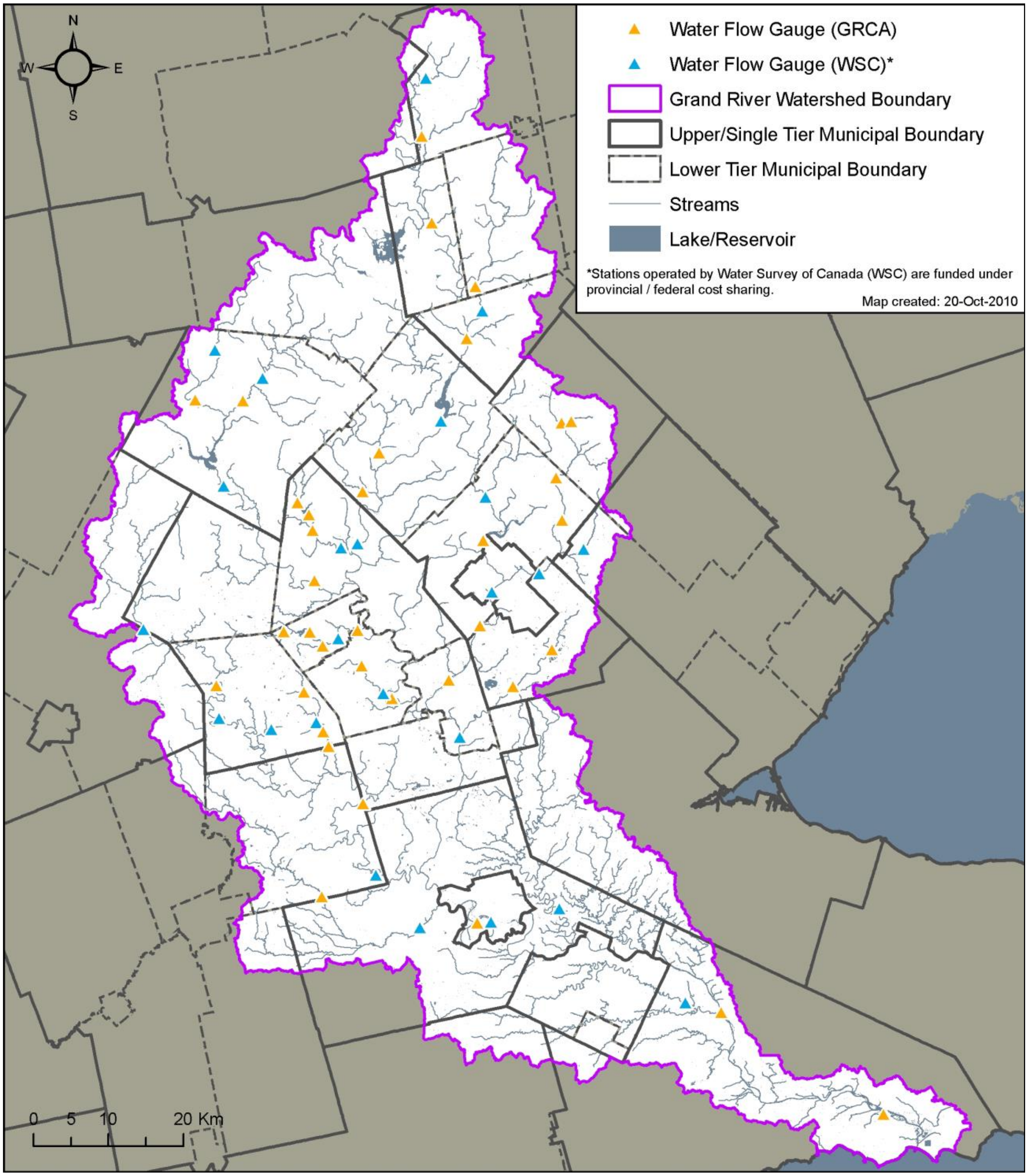
~~**Figure 2-14: Flow Distribution for the Grand River at Brantford gauge showing median, 10th and 90th percentile flows**~~



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
medain	82.5	90.8	92.0	81.3	39.2	31.1	24.9	23.4	23.4	27.2	38.9	62.4
10th Percentile	37.6	36.3	42.5	37.3	26.3	20.7	17.8	16.6	16.1	18.9	21.4	25.8
90th Percentile	229.1	267.3	260.9	248.9	92.9	65.0	48.3	39.1	70.4	76.5	132.7	137.6

~~**Figure 2-15: Flow Distribution for the Grand River at York gauge showing median, 10th and 90th percentile flows**~~

Map 2-24: Water Flow Gauges in the Grand River Watershed



*Stations operated by Water Survey of Canada (WSC) are funded under provincial / federal cost sharing.

Map created: 20-Oct-2010

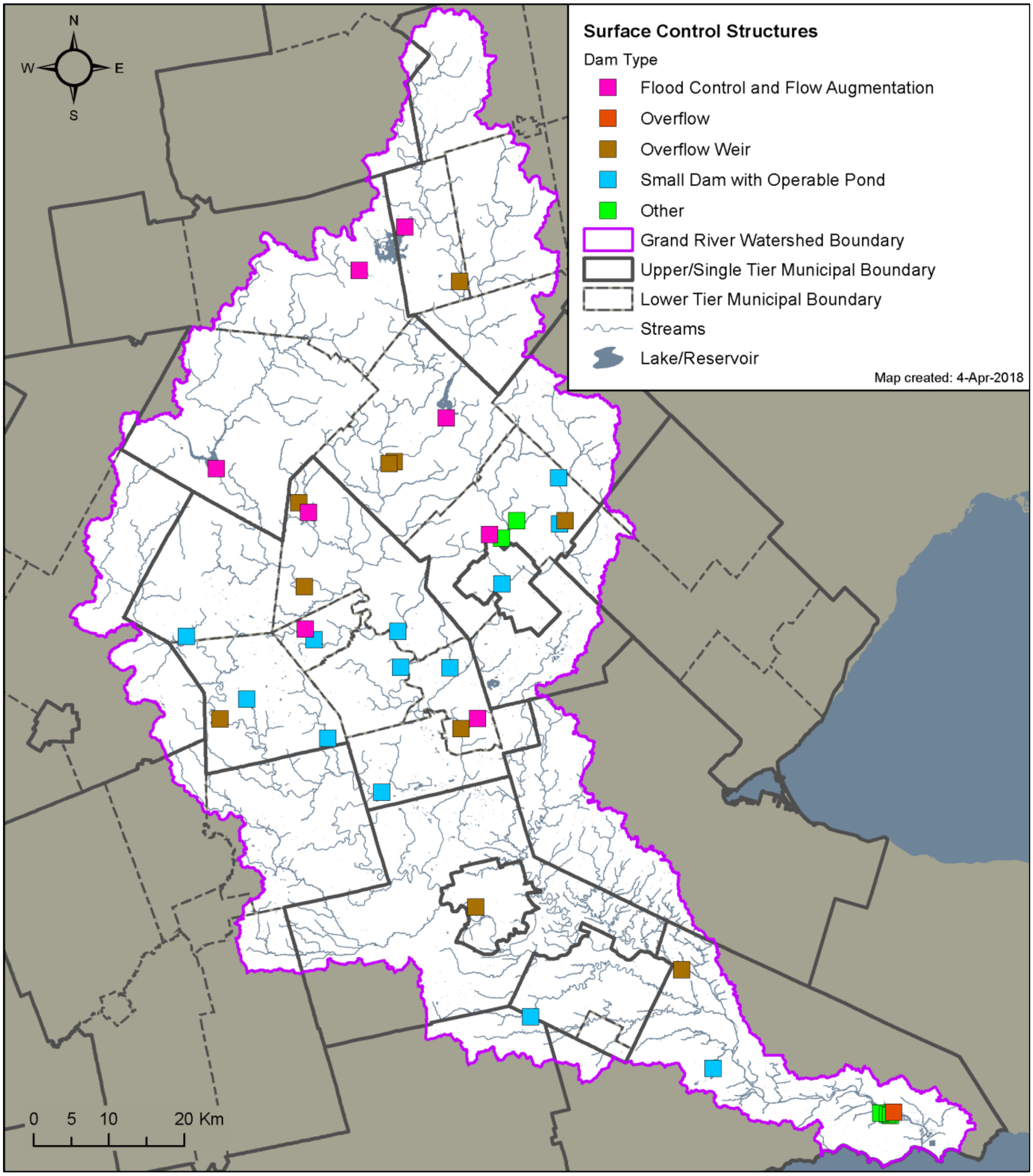
~~2.12.13~~2.12.6 Water Control Structures

There are approximately thirty-four water control structures operated by the Grand River Conservation Authority throughout the watershed. These structures range from simple overflow weirs to large multi-purpose dams and reservoirs. **Map** 2-25 shows the location of GRCA control structures throughout the watershed.

There are also approximately 103 private and municipally-owned dams located throughout the watershed. Small mill ponds and overflow weirs are remnants of the valley's early industrial heritage. These structures are often a community focal point and recreational area. While they back water up and deepen the river channel locally, they do not provide flood control or improve river flow. A dam inventory ~~listing~~ describing what is known about all ~~known~~ dams in the watershed is maintained by the GRCA. ~~The inventory describes what is known about the dams, and is available to the public.~~

A series of multi-purpose reservoirs were constructed in the mid-20^{th} century to control flooding and for low flow augmentation. There are seven significant water control structures that are used for active river management by the GRCA. The current operating procedure for the large dams (Shand, Conestogo, Guelph, and Luther) was established as a recommendation of the 1982 Grand River Basin Water Management Study. At that time, reservoir system operation was optimized to meet downstream flow targets for the dual purpose of waste assimilation and drinking water takings, while still providing an adequate level of protection for flood control. The reservoirs are filled during the spring snowmelt, the most active flooding season, and then gradually drawn down over the summer and early fall, thereby supplying more flow in the river than would normally be. The current operating procedures for the reservoir system were modified in 2004 to provide more flexibility to respond to warmer winters and less accumulation of snow. The reservoir system has a very significant effect on the flows in the Grand, Conestogo, and Speed Rivers.

Map 2-25: Surface Water Control Structures in the Grand River Watershed



2.13 Surface Water Quality

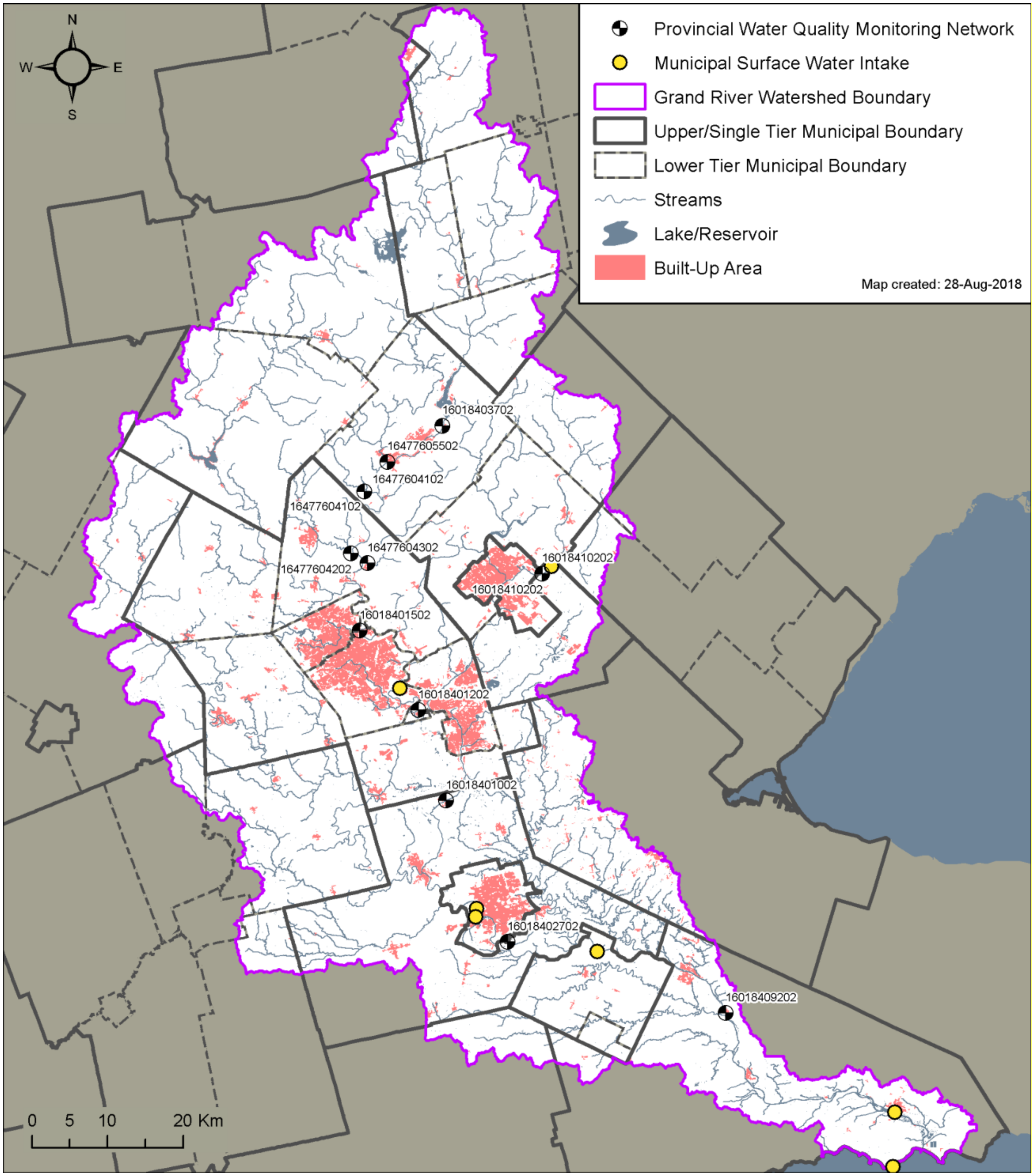
~~The following summary is adapted from Loomer and Cooke (draft) *Water Quality in the Grand River Watershed: Current Conditions and Trends (2003-2008)*. The subwatersheds of the Grand River watershed are shown on **Map 2-3.** Water quality in the Grand River watershed is monitored at 36 long-term monitoring sites as part of the Provincial Water Quality Monitoring Network (**Map 2-22**). The monitoring is completed in partnership with the Ministry of the Environment. Water quality data collected at each of these sites between 2003 and 2008 is summarized in **Table 2-7**.~~

Historic characterization of the water quality in the Grand River watershed can be found in the following reports: Loomer and Cooke (2011) Water Quality in the Grand River Watershed: Current Conditions and Trends (2003-2008).

There are 37 long-term water quality monitoring sites that are sampled roughly 9-10 times per year during the open water season (March – November). These sites are sampled in partnership with the Ministry of Environment, Conservation and Parks through their Provincial Long Term Monitoring Network (PWQMN).

The following describes the ambient water quality in the Grand River above and below surface water intakes. The parameters characterized including chloride, sodium and nitrates are likely of interest for municipal drinking water suppl~~y~~ies~~ including chloride, sodium and nitrates~~. **Map 2-26** shows the long term water quality monitoring sites in the vicinity of municipal drinking water intakes in the Grand River watershed.

Map 2-26: Water Quality Monitoring Sites in the Grand River Watershed



2.14 Grand River

The Grand River flows through the central region from the Shand Dam to Brantford. Above the Mannheim drinking water intake, it collects surface water from the Conestogo River and the Irvine, Canagagigue, Laurel creeks. The Grand River continues to flow downstream and collects surface water from other major tributaries including the Speed and Nith rivers and Whitemans Creek before it reaches the Brantford drinking water intake at Wilks Dam.

In addition to surface water, groundwater discharges into the Grand River downstream of Cambridge as well as into many smaller tributaries draining the Waterloo and Paris-Galt moraines.

Water quality is reflective of both the geology and land use in the watershed however, within the central Grand River region, land use plays a significant role. Agricultural production tends to be much more intense in the Conestogo River basin and Canagagigue Creek and can significantly influence water quality in the Grand River especially during the spring freshet and following major rainfall events. The urban area is quite hydrologically dynamic and can also impact the river especially following intense rainfall events.

There are a number of small wastewater treatment plants that discharge treated effluent into the Grand River and its tributaries prior to reaching Bridgeport. Specifically, the Waterloo wastewater treatment plant is a large plant that discharges into the river approximately 17 km upstream of the Mannheim drinking water intake.

The Grand and Speed rivers then collect treated effluent from the Kitchener, Preston, Galt, Paris, Guelph and Hespeler wastewater treatment plants prior to surface water reaching the Brantford intake. Ongoing upgrades to wastewater treatment plants in the Region of Waterloo are improving the ambient river quality (GRCA Board Report, February 2017).

Descriptive statistics for chloride, sodium and nitrates are listed in **Table 2-6**.

Table 2-6: Descriptive statistics for chloride, nitrate and sodium at select water quality monitoring sites in the Grand and Eramosa Rivers for the open water season (March – November)

Chloride concentrations reflect the influence of urban point and non-point sources but levels in the Grand River do not exceed the aesthetics guideline for drinking water supplies of 250 mg/L. Levels do, however, approach the guideline for the protection of aquatic life (150 mg/L) albeit occasionally, usually during the spring freshet. Levels in the smaller urban tributaries such as Schneider's Creek and Laurel Creek are routinely above this benchmark, primarily due to the use of road salt. Previous unpublished studies have illustrated increasing trends in chloride (GRCA, unpublished). Further, chloride levels in the Speed River ~~do~~ appear to contribute substantially to the overall chloride levels found in the Grand River below the urban area at Glen Morris (Loomer and Cooke, 2011).

Sodium levels in drinking water supplies are flagged for those people who are on a sodium restricted diet. Levels in the Grand River are ~~far~~substantially below the Canadian Drinking water guideline of 200 mg/L yet are above the levels required for reporting to local medical officer of health (20 mg/L), particularly in the Grand River near Brantford.

Elevated nitrate concentrations are found in the Grand River upstream of Bridgeport during the winter months. Research in the watershed indicated that shallow tile drainage may have an important role in the elevated nitrate concentrations seen in the upper central Grand River area (see **Table 2-7).** Nitrate levels above 10 mg/L, the drinking water quality guideline for treated water, may cause concern for municipal supplies. The 75th percentile in winter sampling ranged from 2.0 mg/L in the Grand River below the Shand Dam to 7.2 mg/L in the Canagagigue Creek. The maximum concentration seen during the sampling program was 9.2 mg/L in the Canagagigue Creek in February 2013. Nitrate is a conservative parameter and treatment to remove this chemical is costly. The GRCA has installed a continuous monitoring probe for nitrate at the Bridgeport Water Quality Station for near-real time surveillance of nitrate during the winter.

Eramosa River

Water quality in the Eramosa River is of relatively high quality for all uses. Chloride, sodium and nitrate levels are far below the guidelines for both drinking water and for the protection of aquatic life.

~~Table 2-7: Water Quality Summary (2003 – 2008) for the Grand River Watershed~~

~~Site ID~~	~~Statistic~~	~~Total Ammonia Nitrogen (mg N/L)~~	~~Nitrate+Nitrite (mg N/L)~~	~~Total Kjeldahl Nitrogen (mg N/L)~~	~~Total Phosphorus (mg/L)~~	~~Phosphate (mg P/L)~~	~~Chloride (mg/L)~~	~~Total Suspended Solids (mg/L)~~
~~16018400902~~	~~Min~~	~~0.002~~	~~1.7~~	~~0.20~~	~~0.008~~	~~0.0005~~	~~8.9~~	~~1~~
-	~~Median~~	~~0.015~~	~~3.32~~	~~0.59~~	~~0.0265~~	~~0.0023~~	~~40.75~~	~~8.5~~
-	~~Max~~	~~0.958~~	~~8~~	~~4.88~~	~~1.66~~	~~0.233~~	~~96~~	~~1470~~
~~16018401002~~	~~Min~~	~~0.002~~	~~1.42~~	~~0.65~~	~~0.025~~	~~0.0008~~	~~23.3~~	~~1~~
-	~~Median~~	~~0.069~~	~~3.29~~	~~0.85~~	~~0.058~~	~~0.02~~	~~97.25~~	~~7.2~~
-	~~Max~~	~~4.16~~	~~5.69~~	~~4.98~~	~~0.625~~	~~0.261~~	~~294~~	~~209~~
~~16018401202~~	~~Min~~	~~0.009~~	~~1.5~~	~~0.69~~	~~0.024~~	~~0.0013~~	~~25.5~~	~~1~~
-	~~Median~~	~~0.333~~	~~3.3~~	~~1.34~~	~~0.074~~	~~0.0244~~	~~81~~	~~6.25~~
-	~~Max~~	~~5.56~~	~~7.02~~	~~7.53~~	~~0.714~~	~~0.295~~	~~296~~	~~252~~
~~16018401502~~	~~Min~~	~~0.002~~	~~0.347~~	~~0.58~~	~~0.016~~	~~<0.0005~~	~~17.4~~	~~1~~
-	~~Median~~	~~0.0205~~	~~2.29~~	~~0.76~~	~~0.029~~	~~0.0041~~	~~29~~	~~6.1~~
-	~~Max~~	~~0.49~~	~~5.93~~	~~3.20~~	~~0.728~~	~~0.206~~	~~67.2~~	~~325~~
~~16018401602~~	~~Min~~	~~0.002~~	~~1.59~~	~~0.70~~	~~0.034~~	~~0.003~~	~~26.3~~	~~1~~
-	~~Median~~	~~0.113~~	~~4.34~~	~~1.18~~	~~0.114~~	~~0.0345~~	~~78.8~~	~~10.85~~
-	~~Max~~	~~1.07~~	~~15~~	~~2.37~~	~~0.549~~	~~0.206~~	~~191~~	~~222~~
~~16018402702~~	~~Min~~	~~0.002~~	~~1.83~~	~~0.29~~	~~0.015~~	~~0.0005~~	~~20.3~~	~~2.5~~
-	~~Median~~	~~0.024~~	~~2.81~~	~~0.70~~	~~0.058~~	~~0.00575~~	~~72.8~~	~~19.4~~
-	~~Max~~	~~0.832~~	~~8.5~~	~~2.55~~	~~0.8~~	~~0.189~~	~~115~~	~~380~~
~~16018402902~~	~~Min~~	~~0.002~~	~~0.228~~	~~0.55~~	~~0.018~~	~~<0.0005~~	~~18~~	~~1~~
-	~~Median~~	~~0.022~~	~~3.08~~	~~0.77~~	~~0.038~~	~~0.0084~~	~~25.2~~	~~7.3~~
-	~~Max~~	~~0.53~~	~~11~~	~~2.50~~	~~0.65~~	~~0.32~~	~~83.2~~	~~210~~
~~16018403002~~	~~Min~~	~~0.002~~	~~0.391~~	~~0.47~~	~~0.023~~	~~0.0011~~	~~79.4~~	~~2.9~~
-	~~Median~~	~~0.075~~	~~0.9055~~	~~0.83~~	~~0.0695~~	~~0.0104~~	~~204~~	~~14.25~~
-	~~Max~~	~~0.281~~	~~1.46~~	~~1.86~~	~~0.398~~	~~0.0747~~	~~468~~	~~268~~
~~16018403202~~	~~Min~~	~~0.002~~	~~0.411~~	~~0.50~~	~~0.03~~	~~0.0005~~	~~11.2~~	~~4.8~~
-	~~Median~~	~~0.0455~~	~~3.48~~	~~0.93~~	~~0.0935~~	~~0.0148~~	~~39.8~~	~~27.75~~
-	~~Max~~	~~0.879~~	~~12.2~~	~~4.39~~	~~0.81~~	~~0.38~~	~~78.8~~	~~339~~
~~16018403302~~	~~Min~~	~~0.002~~	~~2.27~~	~~0.41~~	~~0.018~~	~~0.0005~~	~~11.4~~	~~2.6~~
-	~~Median~~	~~0.013~~	~~3.57~~	~~0.72~~	~~0.035~~	~~0.0035~~	~~41.1~~	~~6.6~~
-	~~Max~~	~~0.485~~	~~6.39~~	~~2.27~~	~~0.493~~	~~0.225~~	~~52.8~~	~~273~~

~~Table 2-7: Water Quality Summary (2003 – 2008) for the Grand River Watershed~~

~~Site ID~~	~~Statistic~~	~~Total Ammonia Nitrogen (mg N/L)~~	~~Nitrate+Nitrite (mg N/L)~~	~~Total Kjeldahl Nitrogen (mg N/L)~~	~~Total Phosphorus (mg/L)~~	~~Phosphate (mg P/L)~~	~~Chloride (mg/L)~~	~~Total Suspended Solids (mg/L)~~
~~16018403402~~	~~Min~~	~~0.01~~	~~0.424~~	~~0.53~~	~~0.015~~	~~0.0005~~	~~27.3~~	~~3~~
-	~~Median~~	~~0.041~~	~~1.08~~	~~0.63~~	~~0.026~~	~~0.0015~~	~~38.2~~	~~6.2~~
-	~~Max~~	~~0.16~~	~~3~~	~~2.20~~	~~0.12~~	~~0.01~~	~~66~~	~~52~~
~~16018403502~~	~~Min~~	~~0.002~~	~~0.263~~	~~0.36~~	~~0.027~~	~~0.0008~~	~~6.1~~	~~2~~
-	~~Median~~	~~0.136~~	~~2.86~~	~~1.01~~	~~0.107~~	~~0.0159~~	~~76.35~~	~~41.6~~
-	~~Max~~	~~1.41~~	~~7.14~~	~~2.65~~	~~0.282~~	~~0.12~~	~~285~~	~~142~~
~~16018403602~~	~~Min~~	~~0.006~~	~~0.101~~	~~0.02~~	~~0.002~~	~~0.0005~~	~~41.3~~	~~1~~
-	~~Median~~	~~0.053~~	~~3.74~~	~~0.71~~	~~0.045~~	~~0.01~~	~~106~~	~~7.1~~
-	~~Max~~	~~0.259~~	~~9.58~~	~~1.50~~	~~0.095~~	~~0.0447~~	~~236~~	~~29.4~~
~~16018403702~~	~~Min~~	~~0.008~~	~~0.015~~	~~0.60~~	~~0.008~~	~~0.0005~~	~~10.5~~	~~1.4~~
-	~~Median~~	~~0.085~~	~~0.879~~	~~0.80~~	~~0.032~~	~~0.0038~~	~~14.6~~	~~4.7~~
-	~~Max~~	~~0.398~~	~~3.68~~	~~1.20~~	~~0.101~~	~~0.0388~~	~~22.9~~	~~18.8~~
~~16018404102~~	~~Min~~	~~0.002~~	~~1.2~~	~~0.67~~	~~0.018~~	~~0.0005~~	~~22.3~~	~~2.1~~
-	~~Median~~	~~0.068~~	~~2.25~~	~~0.90~~	~~0.033~~	~~0.0046~~	~~51.05~~	~~8.15~~
-	~~Max~~	~~0.39~~	~~5.29~~	~~2.72~~	~~0.595~~	~~0.221~~	~~84.3~~	~~275~~
~~16018405102~~	~~Min~~	~~0.018~~	~~0.112~~	~~0.76~~	~~0.006~~	~~0.0005~~	~~14.8~~	~~1~~
-	~~Median~~	~~0.31~~	~~2.75~~	~~1.58~~	~~0.118~~	~~0.014~~	~~25~~	~~18.6~~
-	~~Max~~	~~0.982~~	~~9.88~~	~~2.66~~	~~0.404~~	~~0.226~~	~~45.7~~	~~76.4~~
~~16018405202~~	~~Min~~	~~0.046~~	~~2.73~~	~~0.79~~	~~0.063~~	~~0.0089~~	~~17.6~~	~~7~~
-	~~Median~~	~~0.2~~	~~4.37~~	~~1.02~~	~~0.122~~	~~0.0236~~	~~25.5~~	~~22.7~~
-	~~Max~~	~~1.74~~	~~9.57~~	~~3.76~~	~~0.545~~	~~0.287~~	~~31.9~~	~~131~~
~~16018406702~~	~~Min~~	~~0.006~~	~~0.054~~	~~0.68~~	~~0.008~~	~~0.0005~~	~~8.1~~	~~1.5~~
-	~~Median~~	~~0.026~~	~~0.578~~	~~0.84~~	~~0.03~~	~~0.00175~~	~~12.2~~	~~5.2~~
-	~~Max~~	~~0.185~~	~~4.7~~	~~1.34~~	~~0.17~~	~~0.0393~~	~~20.7~~	~~69~~
~~16018407402~~	~~Min~~	~~0.002~~	~~0.035~~	~~0.50~~	~~0.024~~	~~<0.0005~~	~~7.4~~	~~3.1~~
-	~~Median~~	~~0.035~~	~~3.745~~	~~0.88~~	~~0.0805~~	~~0.0171~~	~~23.5~~	~~19.1~~
-	~~Max~~	~~0.562~~	~~7.26~~	~~2.35~~	~~0.652~~	~~0.317~~	~~39.8~~	~~260~~
~~16018407502~~	~~Min~~	~~0.002~~	~~0.011~~	~~0.55~~	~~0.012~~	~~0.0005~~	~~11.7~~	~~2.4~~
-	~~Median~~	~~0.028~~	~~2.67~~	~~0.80~~	~~0.035~~	~~0.0032~~	~~26.6~~	~~11.6~~
-	~~Max~~	~~0.289~~	~~4.7~~	~~1.63~~	~~0.283~~	~~0.0919~~	~~37.5~~	~~113~~

~~Table 2-7: Water Quality Summary (2003 – 2008) for the Grand River Watershed~~

~~Site ID~~	~~Statistic~~	~~Total Ammonia Nitrogen (mg N/L)~~	~~Nitrate+Nitrite (mg N/L)~~	~~Total Kjeldahl Nitrogen (mg N/L)~~	~~Total Phosphorus (mg/L)~~	~~Phosphate (mg P/L)~~	~~Chloride (mg/L)~~	~~Total Suspended Solids (mg/L)~~
~~16018407702~~	~~Min~~	~~0.002~~	~~0.488~~	~~0.60~~	~~0.024~~	~~0.0005~~	~~13.6~~	~~1~~
	~~Median~~	~~0.064~~	~~3.3~~	~~0.78~~	~~0.058~~	~~0.0189~~	~~18.8~~	~~9.4~~
	~~Max~~	~~0.339~~	~~6.15~~	~~1.41~~	~~0.253~~	~~0.134~~	~~71.2~~	~~83.4~~
~~16018409002~~	~~Min~~	~~0.005~~	~~0.021~~	~~0.63~~	~~0.01~~	~~0.0005~~	~~2.4~~	~~1.2~~
	~~Median~~	~~0.023~~	~~0.267~~	~~0.79~~	~~0.031~~	~~0.0016~~	~~7.2~~	~~5.1~~
	~~Max~~	~~0.055~~	~~1.25~~	~~1.13~~	~~0.114~~	~~0.0206~~	~~17.6~~	~~39.3~~
~~16018409102~~	~~Min~~	~~0.002~~	~~0.005~~	~~0.51~~	~~0.013~~	~~<0.0005~~	~~10.5~~	~~1~~
	~~Median~~	~~0.024~~	~~3.15~~	~~0.72~~	~~0.039~~	~~0.0051~~	~~22.9~~	~~4.6~~
	~~Max~~	~~0.281~~	~~8.28~~	~~1.36~~	~~0.232~~	~~0.172~~	~~81~~	~~40.3~~
~~16018409202~~	~~Min~~	~~0.004~~	~~1.63~~	~~0.58~~	~~0.014~~	~~0.001~~	~~22.9~~	~~2.1~~
	~~Median~~	~~0.061~~	~~3.26~~	~~0.83~~	~~0.0645~~	~~0.0126~~	~~82.05~~	~~23.6~~
	~~Max~~	~~2.11~~	~~7.4~~	~~2.95~~	~~0.662~~	~~0.161~~	~~241~~	~~380~~
~~16018409302~~	~~Min~~	~~0.002~~	~~0.618~~	~~0.46~~	~~0.04~~	~~0.0068~~	~~25.1~~	~~9.6~~
	~~Median~~	~~0.052~~	~~1.47~~	~~0.80~~	~~0.116~~	~~0.03535~~	~~54.9~~	~~51~~
	~~Max~~	~~0.703~~	~~4.93~~	~~2.43~~	~~0.41~~	~~0.159~~	~~326~~	~~320~~
~~16018409902~~	~~Min~~	~~0.002~~	~~0.654~~	~~0.42~~	~~0.006~~	~~0.0005~~	~~15.1~~	~~0.5~~
	~~Median~~	~~0.014~~	~~1.73~~	~~0.62~~	~~0.018~~	~~0.0009~~	~~25.1~~	~~4.7~~
	~~Max~~	~~0.404~~	~~5.23~~	~~2.30~~	~~0.485~~	~~0.0785~~	~~42.1~~	~~297~~
~~16018410102~~	~~Min~~	~~0.002~~	~~0.241~~	~~0.60~~	~~0.017~~	~~0.002~~	~~29.4~~	~~1~~
	~~Median~~	~~0.051~~	~~3.15~~	~~0.75~~	~~0.051~~	~~0.01395~~	~~107~~	~~8.9~~
	~~Max~~	~~0.664~~	~~7.83~~	~~2.50~~	~~0.277~~	~~0.127~~	~~299~~	~~85~~
~~16018410202~~	~~Min~~	~~0.003~~	~~0.386~~	~~0.28~~	~~0.003~~	~~<0.0005~~	~~24.5~~	~~1~~
	~~Median~~	~~0.022~~	~~1.52~~	~~0.50~~	~~0.015~~	~~0.0008~~	~~35.1~~	~~4.6~~
	~~Max~~	~~0.133~~	~~2.9~~	~~0.84~~	~~0.051~~	~~0.0111~~	~~40.9~~	~~18.4~~
~~16018410302~~	~~Min~~	~~0.002~~	~~0.317~~	~~0.58~~	~~0.008~~	~~<0.0005~~	~~14.9~~	~~1~~
	~~Median~~	~~0.014~~	~~1.72~~	~~0.74~~	~~0.021~~	~~0.0017~~	~~23.4~~	~~4.2~~
	~~Max~~	~~0.198~~	~~4.61~~	~~1.23~~	~~0.162~~	~~0.0584~~	~~31.4~~	~~61.1~~
~~16018410402~~	~~Min~~	~~0.002~~	~~0.872~~	~~0.45~~	~~0.005~~	~~<0.0005~~	~~12.1~~	~~0.8~~
	~~Median~~	~~0.019~~	~~2.91~~	~~0.73~~	~~0.02~~	~~0.0008~~	~~26~~	~~2.7~~
	~~Max~~	~~0.285~~	~~9.2~~	~~1.38~~	~~0.213~~	~~0.104~~	~~33~~	~~200~~

~~Table 2-7: Water Quality Summary (2003 – 2008) for the Grand River Watershed~~

~~Site ID~~	~~Statistic~~	~~Total Ammonia Nitrogen (mg N/L)~~	~~Nitrate+Nitrite (mg N/L)~~	~~Total Kjeldahl Nitrogen (mg N/L)~~	~~Total Phosphorus (mg/L)~~	~~Phosphate (mg P/L)~~	~~Chloride (mg/L)~~	~~Total Suspended Solids (mg/L)~~
~~16018410602~~	~~Min~~	~~0.002~~	~~2.2~~	~~0.27~~	~~0.007~~	~~0.0005~~	~~19~~	~~1~~
~~-~~	~~Median~~	~~0.015~~	~~3.9~~	~~0.60~~	~~0.028~~	~~0.0061~~	~~37~~	~~3.6~~
~~-~~	~~Max~~	~~0.632~~	~~8.2~~	~~2.17~~	~~0.31~~	~~0.121~~	~~86.7~~	~~87.7~~
~~16018411702~~	~~Min~~	~~0.002~~	~~0.434~~	~~0.37~~	~~0.006~~	~~0.0005~~	~~33.6~~	~~0.6~~
~~-~~	~~Median~~	~~0.0285~~	~~0.988~~	~~0.63~~	~~0.041~~	~~0.0054~~	~~183.5~~	~~7.05~~
~~-~~	~~Max~~	~~0.37~~	~~2.84~~	~~1.47~~	~~0.377~~	~~0.0702~~	~~507~~	~~249~~
~~16018412602~~	~~Min~~	~~0.011~~	~~0.039~~	~~0.50~~	~~0.011~~	~~<0.0005~~	~~21.3~~	~~1.7~~
~~-~~	~~Median~~	~~0.0505~~	~~0.6765~~	~~0.70~~	~~0.02~~	~~0.00115~~	~~24.95~~	~~3.75~~
~~-~~	~~Max~~	~~0.154~~	~~2.68~~	~~1.13~~	~~0.046~~	~~0.0037~~	~~29.3~~	~~15.3~~
~~16018412702~~	~~Min~~	~~0.01~~	~~0.708~~	~~0.86~~	~~0.035~~	~~0.0034~~	~~16.2~~	~~3.8~~
~~-~~	~~Median~~	~~0.048~~	~~2.97~~	~~0.96~~	~~0.1035~~	~~0.04625~~	~~38.45~~	~~13~~
~~-~~	~~Max~~	~~0.28~~	~~6.54~~	~~1.48~~	~~0.58~~	~~0.473~~	~~46.8~~	~~32.4~~
~~16018412802~~	~~Min~~	~~0.002~~	~~0.023~~	~~0.68~~	~~0.047~~	~~0.0059~~	~~32.9~~	~~7.6~~
~~-~~	~~Median~~	~~0.05~~	~~1.935~~	~~0.82~~	~~0.071~~	~~0.0189~~	~~82.95~~	~~18.65~~
~~-~~	~~Max~~	~~0.184~~	~~4.8~~	~~1.58~~	~~0.502~~	~~0.201~~	~~108~~	~~275~~
~~16018412902~~	~~Min~~	~~0.002~~	~~0.005~~	~~0.40~~	~~0.038~~	~~0.0031~~	~~13.9~~	~~7.3~~
~~-~~	~~Median~~	~~0.02~~	~~0.449~~	~~0.76~~	~~0.097~~	~~0.0201~~	~~36.3~~	~~27.2~~
~~-~~	~~Max~~	~~0.281~~	~~3.9~~	~~1.86~~	~~0.35~~	~~0.141~~	~~303~~	~~247~~
~~16018413102~~	~~Min~~	~~0.002~~	~~0.392~~	~~0.24~~	~~0.005~~	~~<0.0005~~	~~33.7~~	~~0.8~~
~~-~~	~~Median~~	~~0.0075~~	~~0.8255~~	~~0.47~~	~~0.0165~~	~~0.0014~~	~~52.9~~	~~4.7~~
~~-~~	~~Max~~	~~0.098~~	~~1.23~~	~~0.94~~	~~0.069~~	~~0.0154~~	~~56~~	~~15~~

Table 2-6: Descriptive statistics for chloride, nitrate and sodium at select water quality monitoring sites in the Grand and Eramosa Rivers for the open water season (March – November)

River	Site Description	Site No.	Minimum Chloride (mg/L)	Average Chloride (mg/L)	Median Chloride (mg/L)	75th percentile Chloride (mg/L)	95th percentile Chloride (mg/L)	Maximum Chloride (mg/L)
Eramosa River	Wellington Country Rd. 41, Arkell	16018410202	13.8	33.6	33.8	35.6	41.7	42.3
Grand River	Bridgeport Bridge	16018401502	16.2	32.9	31.0	35.6	45.9	68.0
Grand River	Blair Bridge	16018401202	0.2	69.4	72.9	87.7	110.0	118.0
Grand River	Glen Morris Bridge	16018401002	20.5	84.3	90.8	107.3	130.2	145.0
Grand River	Cockshutts Bridge, Brantford	16018402702	0.2	73.5	82.9	92.7	110.5	117.0
Grand River	Bridge, York	16018409202	22.1	77.5	83.2	96.7	111.8	132.0

River	Site Description	Site No.	Minimum Nitrates (mg/L)	Average Nitrates (mg/L)	Median Nitrates (mg/L)	75th percentile Nitrates (mg/L)	95th percentile Nitrates (mg/L)	Maximum Nitrates (mg/L)
Eramosa River	Wellington Country Rd. 41, Arkell	16018410202	0.53	0.99	0.98	1.18	1.42	1.76
Grand River	Bridgeport Bridge	16018401502	0.46	3.50	2.84	4.80	7.65	8.10
Grand River	Blair Bridge	16018401202	1.15	3.09	2.98	3.86	4.67	6.63
Grand River	Glen Morris Bridge	16018401002	1.17	3.41	3.43	3.89	4.99	6.56
Grand River	Cockshutts Bridge, Brantford	16018402702	1.93	3.31	3.22	3.84	4.88	6.74
Grand River	Bridge, York	16018409202	1.50	3.16	3.02	3.58	4.85	5.83

River	Site Description	Site No.	Minimum Sodium (mg/L)	Average Sodium (mg/L)	Median Sodium (mg/L)	75th percentile Sodium (mg/L)	95th percentile Sodium (mg/L)	Maximum Sodium (mg/L)

Eramosa River	**Wellington Country Rd. 41, Arkell**	16018410202	--	--	--	--	--	--
Grand River	**Bridgeport Bridge**	16018401502	9.6	17.3	17.1	19.1	24.0	31.7
Grand River	**Blair Bridge**	16018401202	12.6	41.5	43.6	54.1	66.9	69.6
Grand River	**Glen Morris Bridge**	16018401002	12.2	50.9	53.3	64.4	80.5	88.1
Grand River	**Cockshutts Bridge, Brantford**	16018402702	11.6	44.3	48.5	57.4	67.5	72.2
Grand River	**Bridge, York**	16018409202	--	--	--	--	--	--

Table 2-7: Nitrate concentrations at select monitoring sites in the central Grand River region during winter months (January – March) between 2011-2015

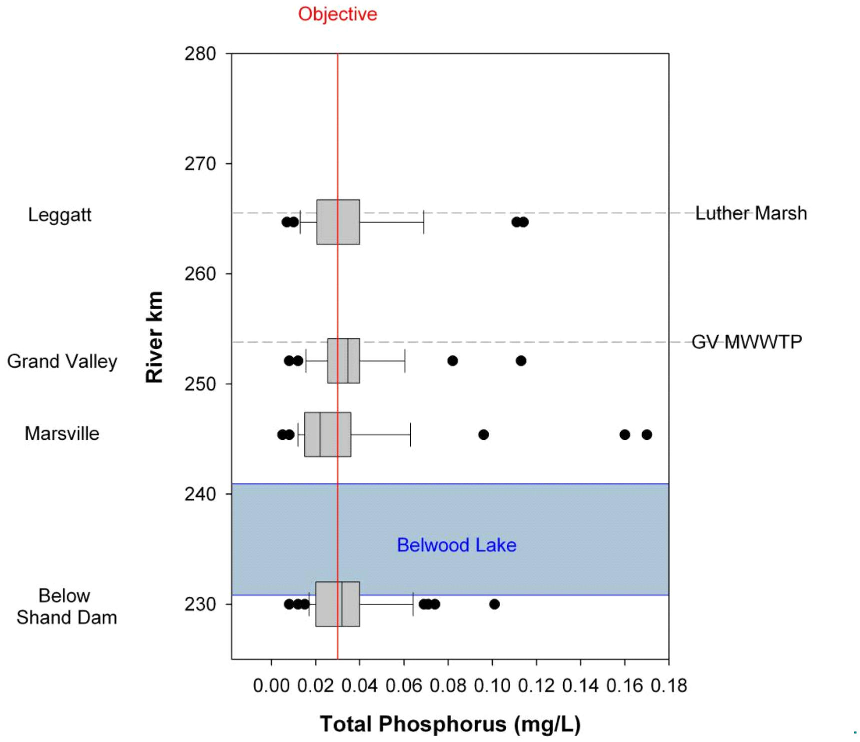
River	Site Description	Site No.	Minimum Nitrates (mg/L)	Average Nitrates (mg/L)	Median Nitrates (mg/L)	75th Percentile Nitrates (mg/L)	95th Percentile Nitrates (mg/L)	Maximum Nitrates (mg/L)
Grand River	**First Conc. d/s of Bellwood Lake**	16018403702	1.30	1.80	1.77	2.00	2.62	2.70
Irvine Creek	**Upstream of confluence**	16477605502	3.30	4.27	4.00	4.65	5.97	6.30
Carroll Creek	**Middlebrook Rd, Pilkington 5-6**	16477604102	4.80	5.58	5.59	5.73	6.58	6.80
Swan Creek	**Wellington Rd 21, Inverhaugh**	16018412102	3.46	4.11	4.19	4.41	4.62	5.10
Cox Creek	**Waterloo Rd 23, Winterbourne**	16477604302	4.27	5.42	4.92	6.30	7.34	7.90
Canagagigue Creek	**Woolwich Twp Rd 46**	16477604202	5.24	6.65	6.40	7.18	8.83	9.20
Conestogo River	**at Glasgow Street, Conestogo Village**	16018413402	3.40	5.02	4.73	5.90	7.24	7.80
Grand River	**Bridgeport Bridge**	16018401502	2.90	4.15	4.04	4.58	5.78	6.60

~~2.14.1 Upper Grand River~~

~~The upper Grand River sub-basin drains about 783 km^2. River water quality is generally fair to good and reflective of the general geology and land use of this area. Soils in this sub-basin are dominated by a tightly packed Tavistock till, which facilitates high surface run-off. While the most of the area drains agricultural lands, the intensity of the agricultural production tends to be less than other areas of the watershed.~~

~~Flow regimes in this watershed consist of high spring flows and low summer flows, which are influenced by the Luther Marsh reservoir that discharges to the Grand River upstream of Leggatt. High spring flows generate very high phosphorus and suspended solids concentrations in the river (i.e. 3 to 5 times higher than the PWQO) that are delivered to and retained in Belwood Lake (**Figure 2-16**). Nitrate and chloride levels in the river tend to be well below provincial objectives or benchmarks.~~

~~Belwood Lake is a reservoir that is managed to reduce the risk of flooding to downstream communities and augment summer low flows in the Grand River, as well as providing local recreational activities. Belwood Lake is classified as eutrophic as phosphorus levels are high enough to support substantial algae growth, including blue-green algae, throughout the summer and early fall. Although the largest phosphorus loads to Belwood Lake occur during the spring, summer water column stratification in the lake also facilitates the release of phosphorus from the sediments which also likely contributing to the blue-green algae blooms in the fall (Guildford 2006).~~



~~Figure 2-16: Box and whisker plots of total phosphorus concentrations in the Upper Grand River sub-basin.~~

~~Central Grand River~~

~~The Grand River flows through the central region from the Shand Dam to Brantford. It collects surface water from three major tributaries: the Conestogo; the Speed; and the Nith River, as well as many minor tributaries including the Irvine Creek, Canagagigue Creek, Laurel Creek, Schneiders Creek and Mill Creek. In addition to surface water, groundwater is also discharged directly to the central Grand River and into many smaller tributaries draining the Waterloo and Paris-Galt moraines.~~

~~Water quality is reflective of both the geology and land use in this sub-basin. Agricultural production tends to be much more intense throughout this region while most of the urban land use is focused in this region as well. Furthermore, the complex geology, such as the moraines, has a significant influence on the general water quality of the river in specific reaches.~~

~~Generally, levels of phosphorus, nitrogen and chloride progressively increase as the Grand River flows from the Shand Dam to Brantford (**Figure 2-17**, **Figure 2-18** and **Figure 2-19**).~~

~~Although non-point sources are largely driving elevated nutrient levels seen in the Grand River above Bridgeport, especially during the spring, point sources become a significant contributor of phosphorus and ammonia-nitrogen during the summer. Of note, however, are the observed high nitrate concentrations in the Grand River upstream of Bridgeport, especially in the winter months. Groundwater may have an important role in the elevated nitrate concentrations seen in the upper central Grand River area.~~

~~Chloride concentrations reflect the influence of urban point and non-point sources but levels in the Grand River do not exceed the water quality benchmark of 150 mg/L. Levels in the smaller urban tributaries such as Schneider's Creek and Laurel Creek are routinely above the benchmark, primarily due to the use of road salt.~~

~~Given the numerous point source discharges to the Grand River through the central Grand River, and significant aquatic plant and algae growth through this region, dissolved oxygen in the river is a concern. Although dissolved oxygen tends to be above the provincial objective of 4.0 mg/L in the Grand River at Bridgeport, it tends to drop below the objective frequently in the Grand River at Blair. Dissolved oxygen levels tend to recover and, for the most part, remain above the provincial objective at Glen Morris which is likely due to the significant groundwater being discharged into the Grand River below Galt.~~

~~Flows in the central Grand River are sustained by the discharge from Belwood Reservoir combined with flows from the major tributaries including the Conestogo, Speed, and Nith Rivers. The Canagagigue Creek and Irvine Creek also contribute to the flows in the Grand River, though their annualized contributions are relatively minor compared to the other major tributaries.~~

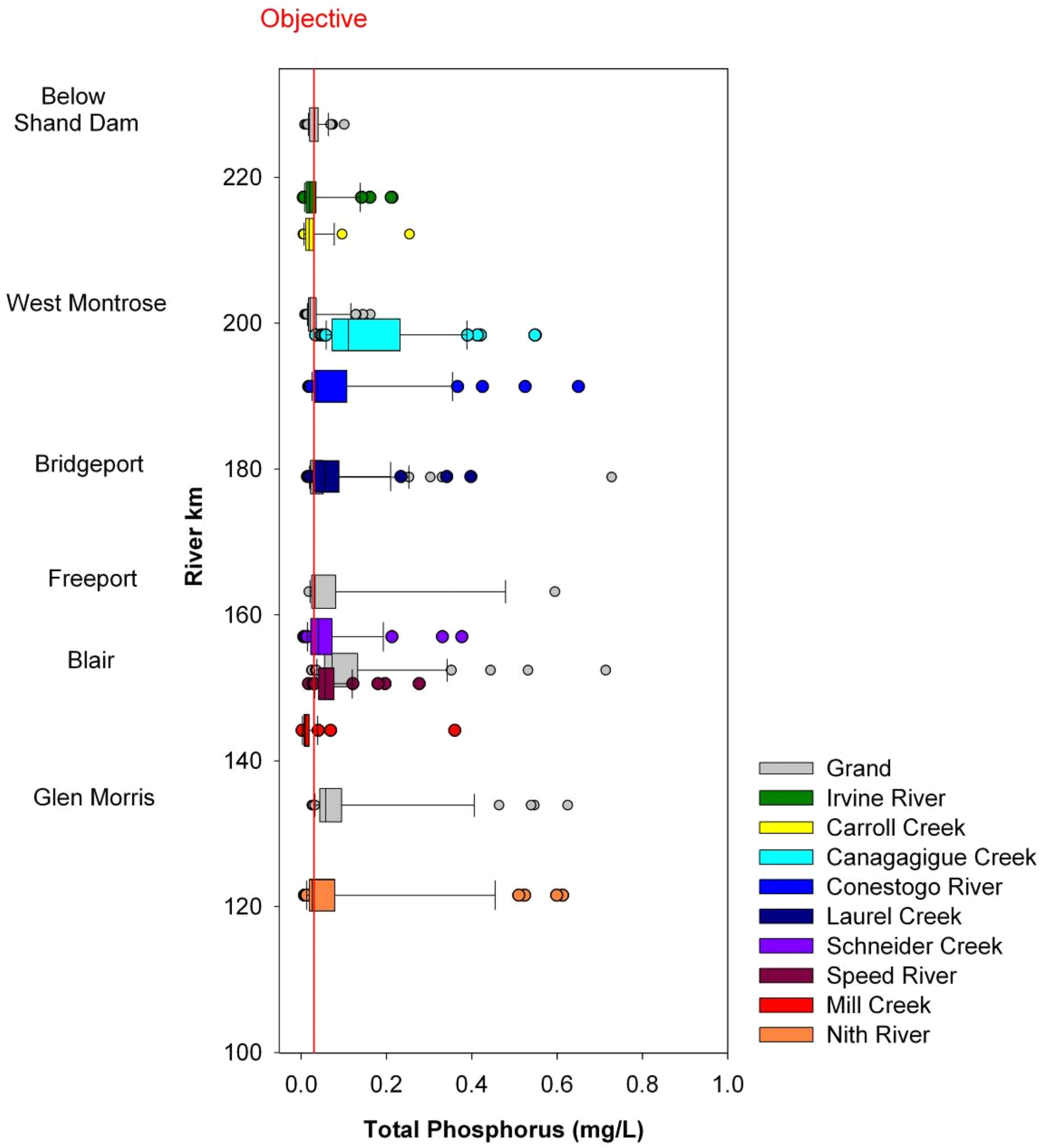
~~The water quality at the mouths of the Conestogo, Irvine and Canagagigue Creeks is highly variable across seasons. Higher total phosphorus concentrations during spring runoff are obvious and are characteristic of the strong influence of non-point sources such as runoff from rural land use activities. Nitrate concentrations in the Canagagigue Creek and Conestogo and Irvine rivers tend to be 2 to 3 times higher than those found in the Grand River suggesting that these areas contribute substantially to the overall nitrate load to the Grand River above Bridgeport.~~

~~The Canagagigue Creek drains some of the most intensive agricultural lands in the watershed. Nutrient levels in the Canagagigue Creek are among the highest in the watershed. The Woolwich reservoir, built to protect the town of Elmira from flooding and to ensure flows during the summer, is highly eutrophic. This is a result of the extremely high levels of both total phosphorus and nitrate in~~

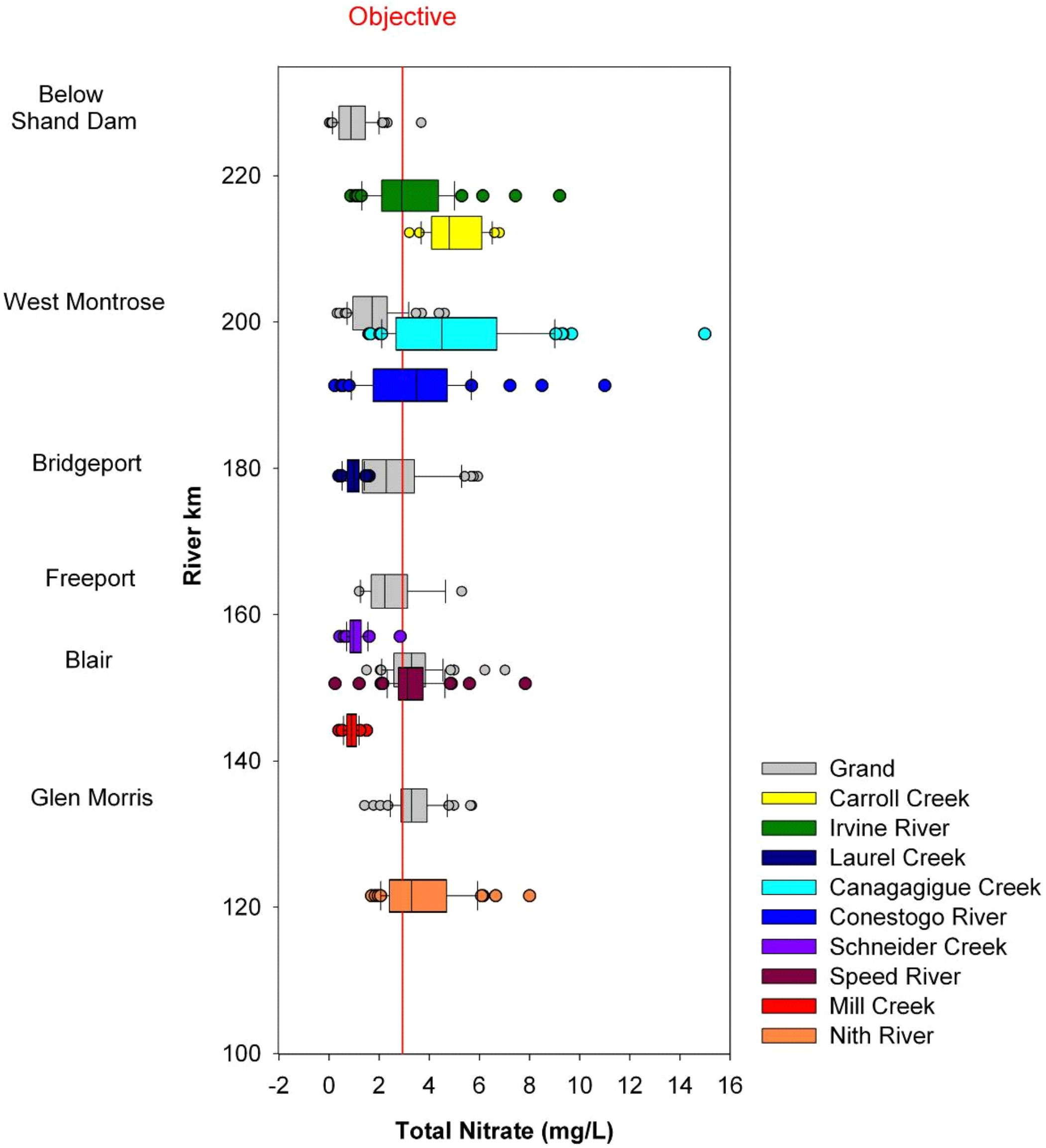
~~the creek that flows into the reservoir. Canagagigue Creek below the town of Elmira is influenced by the wastewater treatment plant discharge as is evident by the three-fold increase in chloride levels when compared to upstream concentrations.~~

~~As the Grand River flows through the urban area of the central region, it accumulates both non-point urban runoff and numerous point source discharges. The Speed River flows into the Grand in Cambridge and although the Speed River is a large tributary, it does not contribute significantly to the phosphorus levels already in the Grand River. However, the Speed River does appear to contribute substantially to the overall chloride levels found in the Grand River below the urban area at Glen Morris.~~

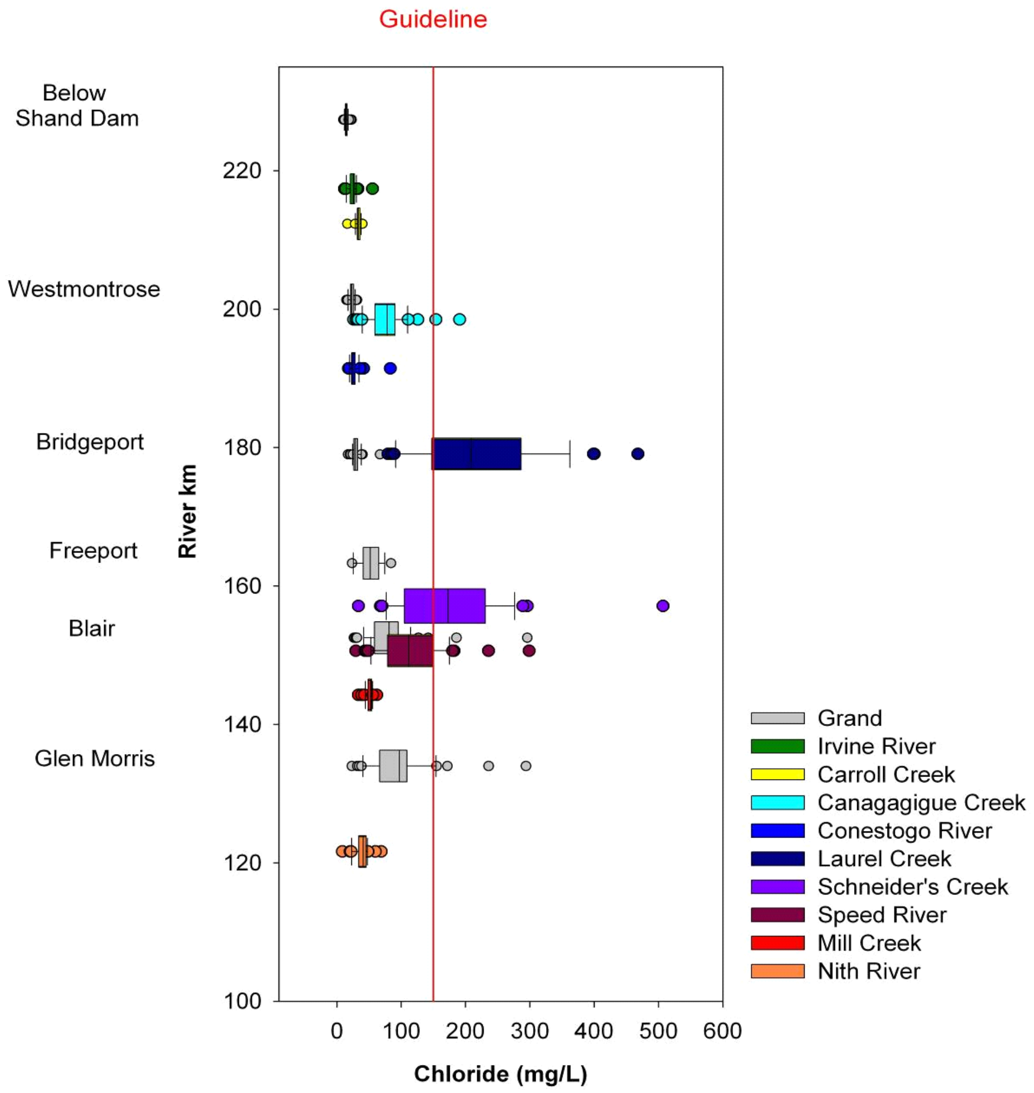
~~The Nith River drains mostly rural lands with very intensive agricultural production. Phosphorus levels tend to be high and variable, especially during the spring. Nitrate levels at the mouth of the Nith River are also high as the lower Nith River tends to be heavily influenced by groundwater discharges, likely high in nitrate, from the Waterloo and Paris-Galt moraines. Chloride levels are generally low and do not contribute substantially to the levels found in the Grand River at Brantford.~~



~~**Figure 2-17: Box and whisker plots of total phosphorus in the central Grand River sub-basin**~~



~~**Figure 2-18: Box and whisker plots of nitrate & nitrite concentrations in the Central Grand River sub-basin**~~



~~Figure 2-19: Box and whisker plots of chloride concentrations observed at water quality monitoring sites in the Central Grand River sub-basin~~

~~2.14.2 Conestogo River~~

~~The Conestogo River drains an area of 819 km^2. The sub-basin consists of two head water streams: Moorefield Creek and the upper Conestogo River. These headwater rivers drain into the Conestogo Reservoir in the middle of the watershed. Below the reservoir the river joins with a few smaller tributaries, the most notable being Boomer Creek, before discharging to the Grand River above Bridgeport.~~

~~Most of the upper subbasin drains the Tavistock till which generates high quantities of surface run-off during rain and melt events resulting in very 'flashy' streamflows. Streams in this sub-basin are described as~~ *~~intermittent warm~~* ~~and are not strongly supported by ground water discharges (Grand River Fisheries Management Plan Implementation Committee 2005). High surface run-off that produces flooding and extreme summer low flow conditions that are experienced in the upper sub-basin, are regulated in the lower portion of the sub-basin by the Conestogo Reservoir. The Conestogo reservoir is eutrophic with elevated phosphorus levels that can sustain algae growth throughout the summer and fall. The management of flows from the Conestogo Reservoir also helps to regulate flows in the Grand River.~~

~~Eutrophic conditions characterized by elevated nitrate/nitrite and total phosphorus concentrations are the dominant water quality concerns in the Conestogo River. Concentrations are elevated both above and below the reservoir and show similar seasonal trends of elevated nitrate concentrations throughout the sub-basin and total phosphorus concentrations that correlate with suspended solid concentrations during high flows. Boomer Creek, a major tributary to the lower Conestogo River, has the highest phosphorus concentrations in the Grand River watershed. Total phosphorus levels average an order of magnitude higher than the water quality objective of 0.03 mg/L. These trends reflect the loading of nutrients from non-point sources across the sub-basin, particularly during spring melt.~~

~~2.14.3 Speed River~~

~~Water quality in the upper Speed River is of relatively high quality. Phosphorus and nitrogen levels in the Eramosa River are among the lowest in the Grand River watershed. Water quality in the Speed River below the City of Guelph, however, shows the influence of the urban centre, specifically the municipal wastewater treatment plant, with elevated phosphorus, nitrate and chloride concentrations. Phosphorus and nitrate levels in the Speed River continue to be elevated through Cambridge just before the river flows into the Grand River.~~

~~Dissolved oxygen is a parameter of concern in the Speed River given the influence of the municipal wastewater treatment plant; however, continuous monitoring of dissolved oxygen in the Speed River both above and below the wastewater plant demonstrates significant diurnal fluctuations of dissolved oxygen that rarely falls below the provincial objective of 4.0 mg/L.~~

~~Guelph Lake is a multipurpose reservoir built to reduce flood risks, as well as provide recreational activities. The reservoir is meso-eutrophic with elevated phosphorus levels that sustain algae growth throughout the summer and fall. Dissolved nutrient concentrations (ammonia, nitrate, and phosphate) are different above and below the Guelph Lake reservoir. These changes may reflect transformation and retention of nutrients in the reservoir (reviewed in Jarvie et al., 2006; Bosch, 2008).~~

~~2.14.4 Nith River~~

~~The Nith River sub-basin drains an area of 1130 km^2. The upper Nith River sub-basin drains the Tavistock tills which generate significant runoff, while the lower Nith River sub-basin drains portions~~

~~of the Waterloo Moraine (Grand River Fisheries Management Plan Implementation Committee, 2005). The resulting ground water discharges in the lower Nith River sub-basin are reflected by the annual flow distribution showing more sustained summer base flows in this sub-basin (Lake Erie Source Protection Region Technical Team, 2008).~~

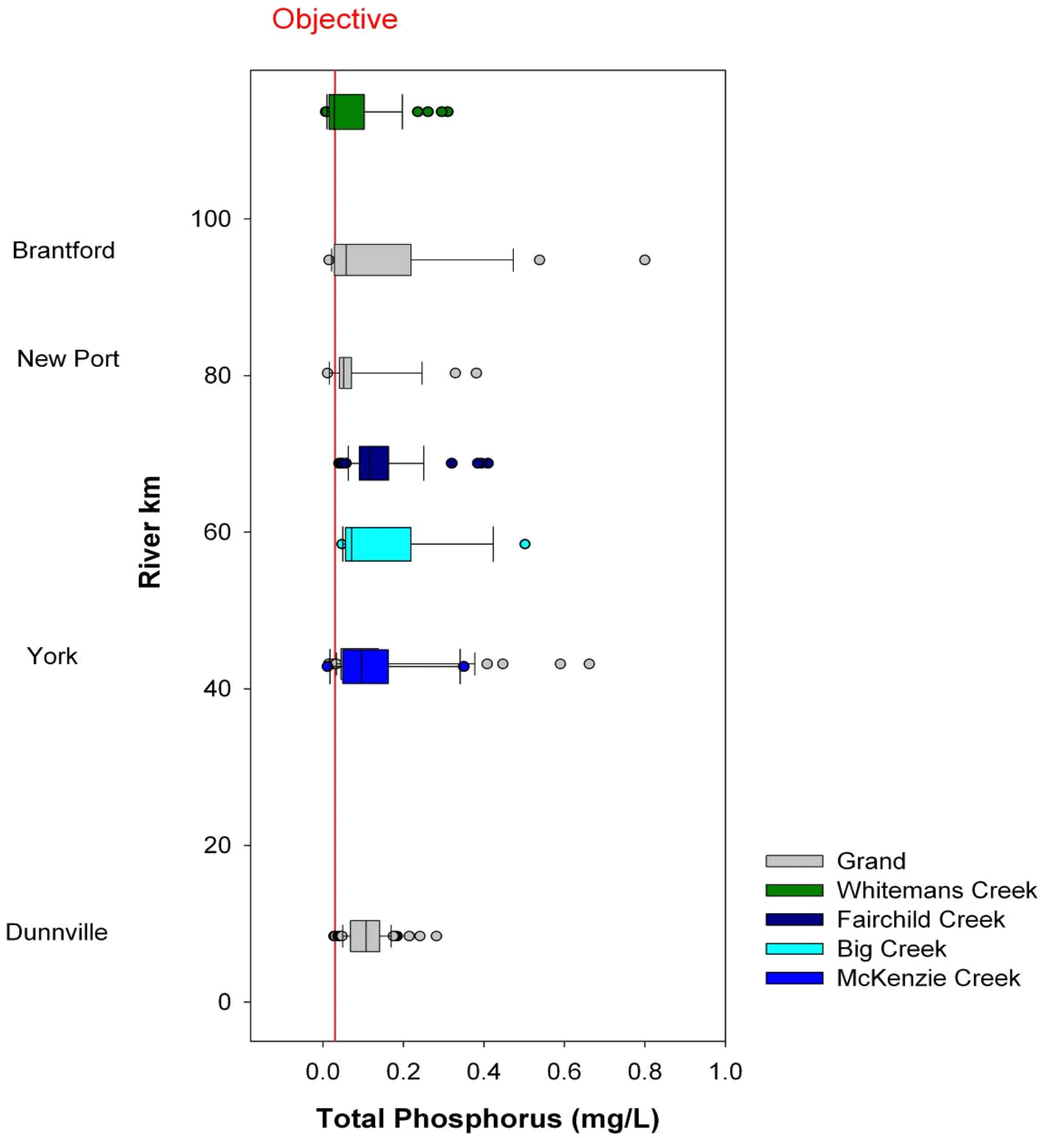
~~Water quality in the upper Nith River sub-basin is characterized by high total phosphorus and suspended solids levels while the lower Nith River sub-basin is characterized by higher nitrate levels. The difference between the upper and lower sub-basins is likely the strong influence of the geology (e.g. higher spring runoff from the tills) and predominant land use (e.g. agriculture) in the upper sub-basin while the significant groundwater discharges, likely high in nitrates, to the lower Nith River likely drives the elevated nitrate levels seen in the river below Ayr and in Paris. Across all monitoring sites, total phosphorus and total ammonia concentrations were significantly lower at Paris where it discharges to the Grand River relative to sites in the upper region indicating an improvement in water quality from upstream to downstream sites.~~

~~2.15 Lower Grand River~~

~~As the Grand River flows through Brantford toward York, Dunnville and Lake Erie, it becomes a large seventh order river which flows through the Haldimand Clay plain. Consequently, the quality of the lower Grand River sub-basin is reflective of the cumulative influence of numerous point source discharges and runoff from both urban and rural land uses which are mostly located in the central Grand River region. This is reflected in the very high phosphorus levels seen in the Grand River throughout the lower reach from Brantford to Dunnville (**Figure 2-20**). However, the influence of the local geology in this region is readily apparent as the river becomes more turbid, carrying a lot of suspended sediments and clay particles, once it flows over the clay plain.~~

~~Within the lower Grand River sub-basin, Whitemans, Fairchild, MacKenzie, and Big creeks all drain into the Grand River. The north-western portion of Whitemans Creek drains various tills while the eastern portion of the sub-basin, closer to where it discharges to the Grand River, flows through the northern part of the Norfolk sand plain. In contrast to the clay plain, there is considerable infiltration in the sand plain that recharges shallow groundwater. Consequently, there is significant groundwater discharge to Whitemans Creek and the other small creeks which drain the Norfolk sand plain. The water quality in Whitemans Creek reflects the strong influence of groundwater with elevated nitrate concentrations particularly during the winter season when baseflows sustain much of the flow in the river. Generally, suspended sediments and total phosphorus levels tend to be low in Whitemans Creek. In contrast, although upper Fairchild Creek drains part of the Paris-Galt moraine, the lower sub-basin drains the clay plain which is similar to MacKenzie Creek. Again, the water quality at the mouth of Fairchild and MacKenzie creeks is reflective of the clay plain and rural agricultural activities with high concentrations of both phosphorus and suspended sediments.~~

~~Overall, high total phosphorus and suspended sediment concentrations in the Grand River in Dunnville are the major water quality concerns as the river discharges to Lake Erie. The high phosphorus concentrations have been hypothesized to be one of many causative factors in the observed increased Cladophora growth and distribution within the nearshore region of Lake Erie.~~



~~**Figure 2-20: Box and whisker plots of total phosphorus concentrations at water quality monitoring sites in the lower Grand River sub-basin (2003-2008).**~~

~~2.16~~2.15 Aquatic Habitat

~~2.16.1~~2.15.1 Upper Grand River Subwatershed~~-basin~~

The Upper Grand River is considered as that part of the Grand River watershed that drains into the Grand River upstream of Belwood Lake. The Upper Grand is dominated by till/clay plains and till moraines with small, localized areas of gravel and sand deposits. Much of the upper watershed was once composed of wetlands. The dense soils permit little infiltration, and flows are highly variable, with low summer and winter base flows. Most streams support coolwater fish communities, while the main stem of the Grand also contains warmwater fisheries. Downstream of Grand Valley, the river enters a narrow gravel spillway with some groundwater influences, and a sandy plain exists southeast of Grand Valley, which supports coldwater fisheries.

~~2.16.2~~2.15.2 Lower Middle Grand River Sub~~-basin~~watershed

The subwatershed includes a stretch of the Grand River from the mouth of the Nith River just north of Paris to York, and comprises portions of Brant County, the southeast quadrant of the City of Brantford, rural portions of the City of Hamilton, and small sections of Haldimand County, and Six Nations of the Grand River.

The subwatershed can be characterized as largely agricultural with a small section of urban land use in the City of Brantford. Natural areas include a wide variety of habitat types such as open water areas with shallow marsh, grasslands, meadows, and mix of deciduous and coniferous forests and swamps.

Coldwater tributaries sustained by groundwater discharge include Mount Pleasant Creek and D’Aubigny Creek, which provide suitable habitat for cold water species such as brook trout as well as cool and warm water species. Mixed water (warm to cool) tributaries, such as Big Creek, are sustained primarily by overland surface runoff but also provide suitable habitat for a diverse fish community consisting of top predators such as northern pike and largemouth bass. A total of 65 fish species representing 40 genera have been recorded in the Lower Middle Grand River and its tributaries. Sport fishes include non-indigenous rainbow trout and brown trout, which were deliberately introduced, as well as indigenous brook trout, channel catfish, northern pike, rock bass, smallmouth bass, largemouth bass, black and white crappie, walleye, and yellow perch (GRCA Natural Heritage, 2017).

~~The area from below Belwood Lake downstream to Brantford is considered the Middle Grand River watershed. The physiography of the Middle Grand is complex, with kame and till moraines and extensive out-wash areas of gravels and sands, intermixed with various tills. The hydrology of this zone is also complex. The main river channels have numerous areas of active groundwater discharge, generating thermal refuges for various fish species.~~

~~The Grand River Tailwater Fishery - the part of the river downstream of the Shand Dam to West Montrose - has grown into one of the best-recognized brown trout fisheries in North America. In 1999 work was initiated by the Ontario Ministry of Natural Resources, the Grand River Conservation Authority and the Friends of the Grand River to develop a management plan. The tailwater management plan highlights the biological, social and economic developments of this fishery and the issues that it faces.~~

~~The Exceptional Waters area of the Grand River between Paris and Brantford is simply that "exceptional". The river in this reach has the potential to provide world-class fishing, in a high quality river environment. From the scenery, to the diversity of life, both in the river and along its banks, this area is truly spectacular and is home to smallmouth bass and steelhead.~~

Major Tributaries of the Lower Middle Grand River sub-basin

Some of the tributaries that are associated with physiographic features composed of coarse parent materials receive significant base flow, and contain coldwater fish communities. Others receive little groundwater and experience warm summer temperatures. Fish communities range from coldwater to warmwater. Many of the major tributaries enter the main stem of the Grand River within the Middle watershed area (i.e. Conestogo River, Nith River, Speed River, Whitemans Creek).

Conestogo River

The upper sections were historically associated with swamp wetlands which have since been converted to primarily agricultural lands. Adjacent lands generally contain tight soils with poor to extremely poor infiltration and high runoff, which results in very flashy flows and very low base flows. Water in these streams tends to be turbid because of the clay and silty soils and resuspension of sediment. High rates of nutrient loading have led to the proliferation of algae and high bacterial levels (GRCA Natural Heritage, *In progress* 2018).

Flows in the lower main channel are heavily regulated by the Conestogo Dam. Conestogo Reservoir is subject to periodic outbreaks of blue-green algae owing to nutrient loading and seasonably warm temperatures. The poor water quality can be harmful to aquatic organisms as well as people and their pets. The reservoir experiences frequent fish kills during spring, a condition associated with Columnaris Disease. This disease affects brown bullheads as waters warm up in spring. The disease is not considered a threat to humans (Conestogo Lake Conservation Area Fish Die off Response Protocol, July 2011, M. Anderson, GRCA).

~~Land use in the Conestogo River subwatershed is predominately agricultural and dominated by drains rather than natural stream channels. As a result of this, significant runoff of nutrients and sediments from farm fields creates a highly productive and turbid system. A general lack of riparian zones and low channel stability results in poor habitat quality. A warmwater fishery exists in most of the watershed, though a coldwater fishery is supported in the tailwater below Conestogo Lake.~~

A “Tailwater Fishery” was established below Conestogo Dam downstream to Hawksville following an Environmental Assessment to assess potential. ~~The Conestoga River Tailwater project – the part of the river downstream of the Conestogo Dam – is being developed as one of 42 “Best Bets” identified in the Grand River Fisheries Management Plan. In 2003, an Environmental Assessment (EA) was completed to examine the feasibility of introducing a trout species to the Conestogo River between the Conestogo Dam and St. Jacobs. From the The EA process it was determined that the water temperatures and habitat available may produce a fishery that rivals many other trout fishing destinations in Ontario and northeastern North America.~~ Since the spring of 2004 many volunteers, neighboring landowners, municipal politicians, representatives from the Ministry of Natural Resources, and the Grand River Conservation Authority have been stocking brown trout into this reach of river. In order to maintain this fishery, the province stocks 17,000 – 20,000 fish annually.

Top predators and sport fishes typically include species adapted to warm or cool water such as Northern Pike, Largemouth Bass, and Smallmouth Bass.

Nith River

Heavy agricultural use, particularly in the upper watershed, reduces riparian zones and results in increased sediment and nutrient runoff into the river, impacting the aquatic habitat. As the river moves downstream groundwater discharges and healthier riparian zones help to restore the habitat. Fish communities range from coldwater fisheries in some tributaries, to warmwater fisheries.

Speed River

Large portions of the upper Speed River subwatershed remain forested and as such the aquatic habitat is less impacted here. In addition, the geology of the area is such that groundwater discharge is significant in certain tributaries and sections of the main stem. These conditions allow coldwater fisheries to exist in the upper watershed. Moving downstream through Guelph, the river transitions into a warmwater fish community.

~~2.16.3~~2.15.3 Southern Grand River Sub-basin

The southern watershed is a region of geologically recent glacial lake deposits or silts overlying older clay/till deposits, giving the river a natural increase in turbidity. Many of the tributaries are highly productive, with large drainage areas, deep pools and extensive littoral zones. Unlike most of the upstream watershed where macrophytes dominate the primary production, in the Southern Grand phytoplankton can account for the majority of the primary production, as increased turbidity quickly filters light out of the water column. This creates a shift from a benthic dominated to a more pelagic system. The Southern Grand also features extensive wetlands which can provide significant habitat for many aquatic organisms, and potentially acting as a nursery ground for juvenile fish.

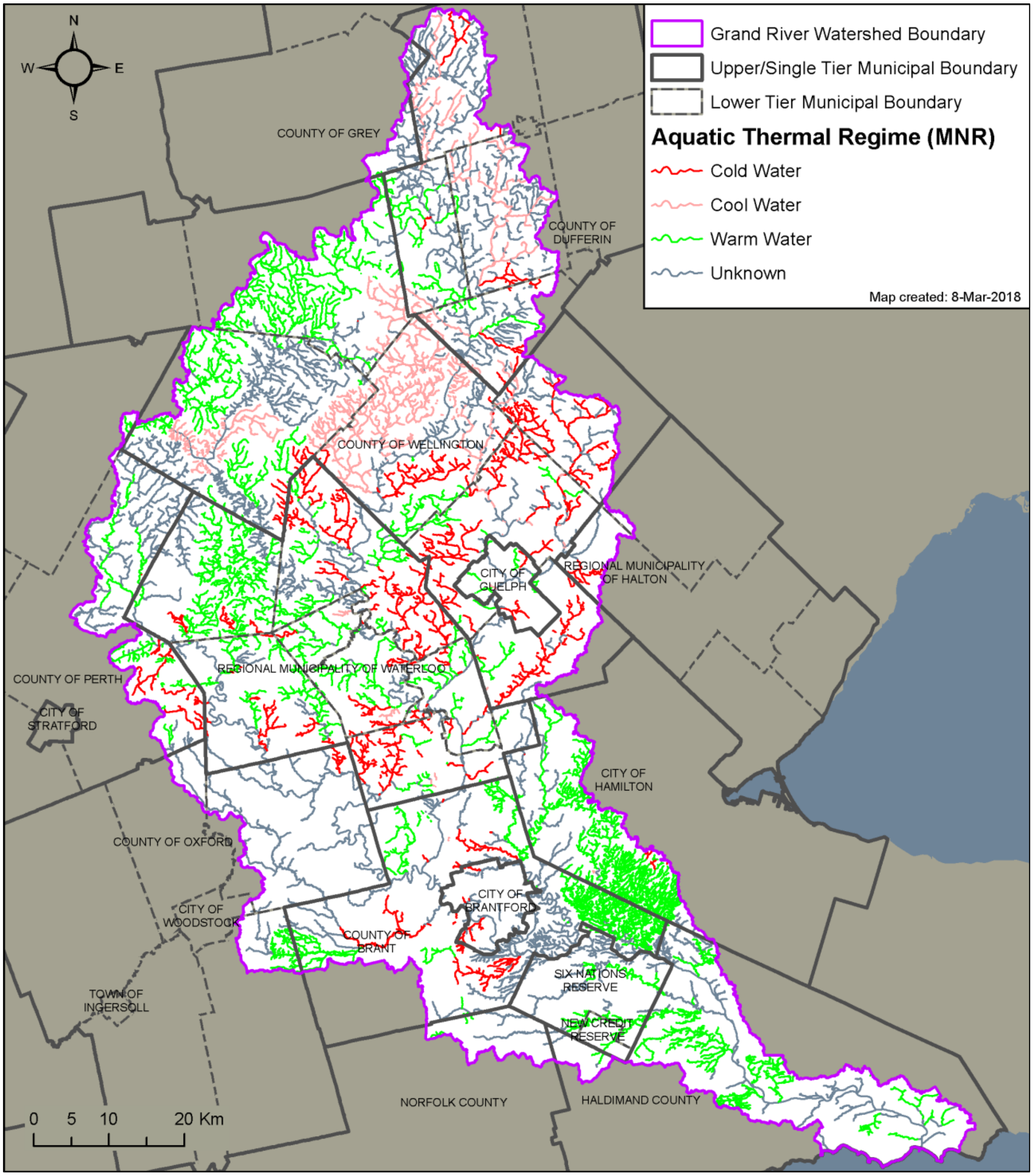
The fish communities in this area range from coolwater to warmwater, with a select few coldwater tributaries. Additionally the fish assemblage in this area is influenced by the close proximity of the Lake Erie, creating a very diverse fish community.

~~2.16.4~~2.15.4 Major Tributary of the Southern Grand River sub-basin

Whitemans Creek

This subwatershed has a high concentration of agricultural water taking activity during the summer months, which is not sustainable from an ecological perspective (Wong and Boyd, 2014). Low flows caused by low precipitation and water takings for large scale agricultural irrigation is a recurring problem. This can have economic impacts on the human users of the creek as well as adverse impacts on fish and wildlife that depend on the creek for survival. The majority of irrigation water is sourced from groundwater (Wong, 2011). However, because of the close connection between groundwater aquifers and surface water features such as creeks and wetlands, additional stress is often placed on these natural features during the summer months, when creek flows and water levels in wetlands are at their lowest. ~~Significant groundwater discharge, particularly in the lower reach, is an important influence on the aquatic community in Whitemans Creek. This provides a steady base flow for the creek while keeping water temperatures down. The Creek supports both a resident coldwater fishery as well as a migratory coldwater fishery.~~ In spite of the ongoing agriculture and high water use, lower portions of Whitemans Creek downstream of Burford support a recreational fishery consisting of Brown Trout, Brook Trout, and Smallmouth Bass (GRCA Natural Heritage, 2017).

Map 2-27: Aquatic Habitat in the Grand River Watershed



~~2.17~~2.16 Species at Risk

A complete list of species of animals and plants known to be at risk, rare or endangered in the Grand River Watershed is included in **Table** 2-8

Table 2-8: List of Species at Risk in the Grand River Watershed

Taxonomy	Common Name	Scientific Name	OMNR Status	Notes
Amphibians	Jefferson Salamander	Ambystoma jeffersonianum	Threatened	
Amphibians	Fowler's Toad	Anaxyrus fowleri	Threatened	
Birds	Henslow's Sparrow	Ammodramus henslowii	Endangered	
Birds	Short-eared Owl	Asio flammeus	Special Concern	
Birds	Whip-poor-will	Caprimlugus vociferus	Threatened	
Birds	Chimney swift	Chaetura pelagica	Threatened	
Birds	Black Tern	Chlidonias niger	Special Concern	
Birds	Common nighthawk	Chordeiles minor	Special Concern	
Birds	Northern Bobwhite	Colinus virginianus	Endangered	
Birds	Cerulean Warbler	Cendroica cerulea	Special Concern	
Birds	Acadian Flycatcher	Empidonax virescens	Endangered	
Birds	Bald Eagle	Haliaeetus leucocephalus	Special Concern	
Birds	Yellow-breasted Chat	Icteria virens	Special Concern	
Birds	Least Bittern	Ixobrychus exilis	Threatened	
Birds	Red-headed Woodpecker	Melanerpes erythrocephalus	Special Concern	
Birds	King Rail	Rallus elegans	Endangered	
Birds	Louisiana Waterthrush	Seiurus motacilla	Special Concern	
Birds	Barn Owl	Tyto alba	Endangered	
Birds	Canada warbler	Wilsonia canadensis	Special Concern	
Birds	Hooded Warbler	Wilsonia citrina	Special Concern	
Fish	Eastern Sand Darter	Ammocrypta pellucida	Endangered	Member of the perch family. Found in the main stem of the Grand River from of Dunnville to Brantford.
Fish	Redside Dace	Clinostromus elongatus	Endangered	Inhabit part of the Irvine Creek. Only known population on north shore of Lake Erie. Limited due to its

Table 2-8: List of Species at Risk in the Grand River Watershed

Taxonomy	Common Name	Scientific Name	OMNR Status	Notes
				preference for cool headwater streams.
Fish	Northern Brook Lamprey	Ichthyomyzon fossor	Special Concern	
Fish	River Redhorse	Moxostoma carinatum	Special Concern	Found from the mouth of the Grand River up to Caledonia. Requires moderate to large sized, fast flowing rivers, low silt substrates and clear water.
Fish	Black Redhorse	Moxostoma duquesnei	Threatened	Inhabits moderate to large rivers; is limited to the main stem of the Grand River and ilarger tributaries such as the Nith River. Water quality at capture sites in Ontario can be characterized as well oxygenated and relatively fertile.
Fish	Bigmouth Buffalo	Ictiobus cyprinellus	Special Concern	Found only downstream of Dunnville. Documented to inhabit areas where the current is slow. Will tolerate high turbidity and prefer waters that are warm and highly eutrophic.
Fish	Silver Shiner	Notropis photogenis	Special Concern	Distributed in various locations including the main Grand River, the Nith River, the Conestogo River,

Table 2-8: List of Species at Risk in the Grand River Watershed

Taxonomy	Common Name	Scientific Name	OMNR Status	Notes
				Whitemans Creek, Schneider Creek, Rogers Creek and McKenzie Creek.
Insects	Monarch	Danaus plexippus	Special Concern	
Mammals	Woodland Vole	Microtus pinetorum	Special Concern	
Mammals	American Badger	Taxidea taxus	Endangered	
Mammals	Grey Fox	Urocyon cinereoargenteus	Threatened	
Molluscs	Kidneyshell	Ptychobranchus fasciolaris	Endangered	Historically located in southern portion of the main stem of the Grand River. Populations in the Grand River watershed likely extirpated due to the combined effects.
Molluscs	Wavy-Rayed Lampmussel	Lampsilis fasciola	Endangered	Found in Southern sections of the Grand River, in Branford area Township of Woolwich and in some areas of the main stem of the Nith River.
Molluscs	Round Pigtoe	Pleurobema sintoxia	Endangered	Found in the main stem of the Southern Grand River. High loadings of sediment, nutrients and toxic compounds originating from urban and agricultural sources are potential threats.
Molluscs	Mapleleaf Mussel	Quadrula quadrula	Endangered	
Molluscs	Fawnsfoot	Truncilla donaciformis	Endangered	
Molluscs	Rainbow Mussel	Villosa iris	Threatened	
Molluscs	Pygmy Pocket Moss	Fissidens exilis	Special	

Table 2-8: List of Species at Risk in the Grand River Watershed

Taxonomy	Common Name	Scientific Name	OMNR Status	Notes
			Concern	
Plants	Gattinger's Agalinis	Agalinis gattingeri	Endangered	
Plants	Green Dragon	Arisaema dracontium	Special Concern	
Plants	American Chestnut	Castanea dentata	Endangered	
Plants	American Columbo	Frasera caroliniensis	Endangered	
Plants	Goldenseal	Hydratis canadensis	Threatened	
Plants	Large Whorled Pogonia	Isotria verticillata	Endangered	
Plants	Butternut	Juglans cinerea	Endangered	
Plants	American Water-willow	Justicia americana	Threatened	
Plants	American Ginseng	Panax quinquefolius	Endangered	
Plants	Broad Beech Fern	Phegopteris hexagonoptera	Special Concern	
Plants	Hill's Pondweed	Potamogeton hillii	Special Concern	
Plants	Common Hoptree	Ptelea trifoliata	Threatened	
Plants	Bird's-foot Violet	Viola pedata	Endangered	
Reptiles	Spiny Softshell	Apalone spinifera	Threatened	
Reptiles	Snapping Turtle	Chelydra serpentina	Special Concern	
Reptiles	Blanding's Turtle	Emydoidea blandingii	Threatened	
Reptiles	Wood Turtle	Glyptemys insculpta	Endangered	
Reptiles	Northern Map Turtle	Graptemys geographica	Special Concern	
Reptiles	Eastern Hog-nosed Snake	Heterodon platirhinos	Threatened	
Reptiles	Milksnake	Lampropeltis triangulum	Special Concern	
Reptiles	Eastern Foxsnake (Carolinian population)	Pantherophis gloydi	Endangered	
Reptiles	Gray Rattlesnake (Carolinian population)	Pantherophis spiloides	Endangered	
Reptiles	Queensnake	Regina septemvittata	Threatened	
Reptiles	Eastern Musk Turtle	Sternotherus odoratus	Threatened	
Reptiles	Butler's Gartersnake	Thamnophis butleri	Threatened	
Reptiles	Eastern Ribbonsnake	Thamnophis sauritus	Special Concern	

~~2.18~~2.17 Interactions Between Human and Physical Geography

Some land uses in the watershed can pose an increased threat to drinking water sources depending on the geology of the area. The geology of the Grand River watershed varies significantly. Deposits of clay and till found in the northern and southern portions of the watershed, form relatively impermeable barriers to the infiltration of water. As a result, runoff to nearby watercourses is increased. Glacial moraines and drumlins, located in the central portion of the watershed, can allow for higher levels of infiltration through permeable sand and gravel deposits.

The northern and southern portions of the watershed are predominantly rural, with agriculture as the main land use. Runoff of precipitation over the tight till and clay deposits can quickly move soils, nutrients (manure and fertilizer) and other contaminants into nearby watercourses. Tile drainage of farm fields and wetlands, and removal of riparian buffers, fence lines and forest cover to increase tillable acreage has increased runoff, and subsequently increased contamination of surface water over the decades. However, recent trends to adopt more environmentally friendly farming practices have increased riparian buffers and tree cover throughout the watershed.

The permeable sand and gravel deposits of the moraines and drumlins in the central portion of the watershed are overlain by both intense agriculture and densely populated urban areas. Much of the population in this area obtains their drinking water from the rich groundwater sources, characteristic of the middle watershed. In permeable areas, where aquifers don’t have additional shallow or deep aquitards, there is an increased potential for spills and runoff from both urban and rural areas to infiltrate into the ground and contaminate groundwater resources.

~~2.19~~2.18 Watershed Characterization Data Gaps

The following data gaps have been identified in the Watershed Characterization component of the Grand River Source Protection Area Assessment Report.

Data	Plan to Address Data Gap	~~Plan to~~Progress to Address Data Gap
Location of federal lands in the watershed	As new information is released, it will be included in an updated Assessment Report.	Data on the location of federal lands is not currently available as of October 2018~~.~~
List of non-municipal drinking water systems	Working with the public health units and the Ministry of the Environment to improve the available data on non-municipal drinking water systems. This information will be included in an updated Assessment Report.	This item remains as a data gap as efforts are still being made to fully characterize existing non-municipal drinking water systems.
Location of monitoring wells related to drinking water systems	Working with municipalities to improve the available data on municipal drinking water monitors. This information will be included in an updated 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 less sensitive to the errors in geologic characterizations, local flow systems are more sensitive to such errors. To reduce uncertainty associated with local studies, it is recommended that additional effort be expended on accurately characterizing the local subsurface, including interpreting cross sections and drilling additional boreholes (LESPR, 2010).	Four Tier 3 water budget studies have been implemented within the Grand River Watershed; Whitemans Creek, Centre Wellington, Region of Waterloo, and Guelph-Guelph Eramosa. As a part of each of these studies, a detailed assessment of the local groundwater regime was completed by way of review of municipal wells, monitoring wells, and all local high quality borehole data. The studies also included the development of numerical groundwater flow models. With the exception of Centre Wellington, a field component was incorporated into each of the studies. In the Region of Waterloo and Guelph-Guelph Eramosa studies, extensive drilling and monitoring well installations were completed to better understand the local groundwater flow system. As a part of the Whitemans study, water levels in local wetlands were monitored to improve the understanding of local groundwater/surface water interactions.

~~2.20~~2.19 Watershed Characterization Section Summary

- The Grand River watershed covers an area of approximately 6,800 square kilometres in south-central Ontario, and contains 39 upper-, lower- and single-tier municipalities and two First Nations bands.

- The length of the Grand River is 300 kilometres. The major tributaries of the Grand River include: the Conestogo and Nith, draining the western half of the watershed; and the Speed, which drains the north-east. Several smaller tributaries drain the southern half of the watershed. The largest of these include the Fairchild, Whitemans and McKenzie creeks.

- The Grand River Source Protection Area had a population of approximately 994,000 people, with approximately 87% serviced by municipal water supplies.

- The majority of the population of the Grand River watershed relies on groundwater as a clean, safe, drinking water supply. In addition to providing a safe source of drinking water, groundwater is used in agriculture, commercial, and industrial applications.

- The Grand River is a managed river system where reservoir operations, water supply and wastewater management were designed as an integrated system on a watershed basis. Water is managed primarily through a system of multi-purpose reservoirs and an extensive monitoring system of stream flow gauges.

- The Grand River Watershed is comprised of eleven physiographic regions: Dundalk Till Plains, Stratford Till Plains, Hillsburgh Sandhills, Guelph Drumlin Field, Oxford Till Plain, Horseshoe Moraines, Waterloo Hills, Flamborough Plain, Mount Elgin Ridges, Norfolk Sand Plain, and Haldimand Clay Plain.

- The entire watershed is underlain by carbonate bedrock formations which form north to south trending bands. Unconsolidated sediments overlay the bedrock formations and were deposited by the movement of glaciers across the landscape.

- Groundwater resources are found within both bedrock and overburden aquifers, with regional groundwater flow from the upper reaches of the watershed where there is a topographic high, to the south toward Lake Erie.

- Groundwater within the aquifers provides for municipal and private water takings, and also supports cold water surface water features through the provision of baseflow from groundwater discharge.

- Groundwater quality in the Grand River watershed is influenced by both natural and anthropogenic impacts. In the Grand River watershed, three distinctive land use activities have impacted groundwater quality: road salting, the application of manures/fertilizer, and the use of dense non-aqueous phase liquids (DNAPLS).

- Annual average precipitation from the years 1986 to 2016 is 921 mm, which is highly variable within the watershed. The northern part of the watershed had the highest annual precipitation at over 1000 mm, while the lowest annual precipitation occurred near Brantford at 850 mm.

- Over the 30 year period of 1986 to 2016, the Grand River watershed had an average temperature of 7.2 degrees with the coolest temperatures in the north of the watershed.

- Observed data shows an increase in average temperatures of about 0.5 degrees over the last half century with the winter months having the highest increase at approximately 1.0 degrees.

- The Grand River watershed straddles two distinct forest regions: the Great Lakes-St. Lawrence Forest Region to the north and the Deciduous Forest Region, also known as the Carolinian Zone, in the south.

- The Grand River watershed straddles two distinct forest regions: the Great Lakes-St. Lawrence Forest Region to the north and the Deciduous Forest Region, also known as the Carolinian Zone, in the south. Forests currently cover approximately 16% of the Grand River watershed.

- The highest concentrations of wetlands are located in the eastern portion of the watershed, in the Speed and Eramosa subwatersheds, as well as in Puslinch Township. The northern most portion of the watershed, near the towns of Dundalk, Grand Valley and Damascus, also holds significant wetland complexes.

- Surface water quality is reflective of both the geology and land use in the watershed. The parameters of interest for municipal drinking water supply including chloride, sodium and nitrates.

- The Grand River watershed supports a combination of coldwater, cool water and warm water fisheries with a variety of aquatic species.

- As of 2009, there are 64 species at risk found in the Grand River watershed area, including 15 reptiles and amphibians, 19 birds and insects, 14 fish and mollusks, 13 plants and 3 mammals.

- Progress to address data gaps identified in the Grand River watershed characterization report have been made and include; detailed Tier 3 water budget studies which contain updated local geologic and groundwater flow data determined through detailed field investigations and modeling.

Appendix B

Draft Updated Grand River Assessment Report
Section 18 – Tier 2 Water Budget Results

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18.0 TIER 2 WATER BUDGET RESULTS

The Tier 2 Water Budget and Water Quantity Stress Assessment reports were completed to increase the understanding of water quantity and availability in the Grand River watershed (AquaResource 2009a, 2009b).

The Integrated Water Budget was completed using numerical hydrologic and groundwater flow models. A continuous hydrologic model for the Grand River watershed was developed using a GAWSER (Guelph all-weather storm-event runoff) model to simulate surface water flows and the partitioning of precipitation (Schroeter & Associates, 2004). Groundwater flows were simulated by the development of a regional-scale numerical groundwater flow model using the FEFLOW software package. The regional groundwater flow model was designed to represent average annual groundwater flow conditions, with a particular focus on volumetric flow from one subwatershed to another. When used together, these modelling tools provided a physical means of quantifying flow through the system to determine available water resources in the Grand River watershed.

~~Water Budget modelling activities have been conducted in the Grand River watershed for more than 20 years. The Tier 2 Water Budget and Water Quantity Stress Assessment were completed by AquaResource Inc. and built on a greater body of work that had been completed in the Grand River watershed to increase the understanding of water pathways in the watershed.~~ ~~**Table** 18-1 provides a summary of the relevant reports and tools which comprise the larger suite of studies that document the Grand River watershed Water Budget as given in this Assessment Report.~~

~~**Table 18-1: Reports and Tools Documenting the Water Budget**~~

~~**Report/Tool**~~	~~**Content**~~
~~Integrated Water Budget Report: Grand River Watershed (AquaResource, 2009a)~~	~~Conceptual water budget, integrated water budget including quantity and movement of water within and across subwatersheds~~
~~Tier 2 Water Quantity Stress Assessment Report: Grand River Watershed (AquaResource, 2009b)~~	~~Water quantity stress assessment~~
~~Water Use in the Grand River Watershed (GRCA, 2005)~~	~~Water Use~~
~~Grand River Watershed Characterization Report (LESPR Technical Team, 2008)~~	~~Describe the physical and human characteristics of the watershed~~
~~Grand River Watershed Geological and Hydrogeological Model Report (WHI, 2005a)~~	~~Groundwater quantity and flow assessment and water levels~~

~~The Integrated Water Budget Report was completed using a set of water budget tools (groundwater flow and hydrologic numerical models). To simulate surface water flows and partitioning of precipitation, a continuous hydrologic model built using GAWSER (Guelph All-Weather Storm-Event Runoff) was used. Hydrologic modelling is able to simulate streamflows that reflect seasonal hydrologic processes. To simulate groundwater flows, a regional-scale groundwater flow model was developed and calibrated to available water level and streamflow data using FEFLOW (Finite Element subsurface Flow system). The regional groundwater flow model was designed to represent average annual groundwater flow conditions, with particular focus on volumetric flow from one subwatershed to another. Together these modelling tools provide a physical means of quantifying flows through the system for determining available water resources in the Grand River watershed.~~

~~Significant efforts were undertaken to better quantify and characterize the consumptive water demand. The water demand characterization completed in this study included efforts to verify Permit To Take Water (PTTW) information, gathering "actual pumping" data, estimating agricultural demand based on discussions with the farming community, validating actual use information through calibration of the surface water model, and gathering relevant information contained within Ministry of the Environment's Permit To Take Water paper files.~~

~~The Tier 2 Water Quantity Stress Assessment (AquaResource, 2009b) was prepared as a structured means of evaluating the degree of potential water quantity stress throughout an area by comparing the volume of water demand to that which is practically available for use.~~ The results of ~~streamflow and groundwater flow modelling and water demand estimates from~~ the Integrated Water Budget, were then incorporated into the Tier 2 Water Quantity Stress Assessment (AquaResource, 2009b). The objective of the Tier 2 Water Quantity Stress Assessment was to evaluate the degree of potential water quantity stress throughout an area by comparing the volume of water demand to that which was practically available for use.

The Water Budget was calculated based on 18 subwatersheds as shown in Error! Reference source not found.~~**Map 18-1**~~ and listed~~given~~ in ~~**Table 18-2**~~ **Table 18-1.** These same 18 subwatersheds were used for the surface water stress assessment. For the groundwater stress assessment, 19 subwatersheds that were different from the surface subwatersheds were used to better represent groundwater demand and aquifer systems within the watershed. ~~The groundwater assessment areas are described in more detail in **Section 18.8**.~~

Table 18-1: Integrated Water Budget Surface Water Subwatersheds

Watershed	Subwatershed	Drainage Area (km^2)
Upper Grand River	Grand Above Legatt	365
	Grand Above Shand To Legatt	426
	Grand Above Conestogo To Shand	640
Conestogo River	Conestogo Above Dam	566
	Conestogo Below Dam	254
Central Grand River	Grand Above Doon To Conestogo	248
	Grand Above Brantford To Doon	274
	Mill Creek	82
Speed and Eramosa Rivers	Eramosa Above Guelph	230
	Speed Above Dam	242
	Speed Above Grand To Armstrong	308
Nith River	Nith Above New Hamburg	545

Table 18-1: Integrated Water Budget Surface Water Subwatersheds

Watershed	Subwatershed	Drainage Area (km^2)
	Nith Above Grand To New Hamburg	583
Whitemans and McKenzie Creeks	Whitemans Creek	404
	McKenzie Creek	368
Lower Grand River	Fairchild Creek	401
	Grand Above York To Brantford	476
	Grand Above Dunnville To York	356

~~18.1 Water Use~~

~~Water use is expressed in two ways: the amount of water pumped and the amount of water consumed. Consumed water is the amount of water pumped and not returned to the source from which it was pumped.~~

~~The amount of water pumped was determined by contacting municipalities for information on public water supplies, surveying non-agricultural Permit-To-Take-Water holders, utilizing Statistics Canada data to estimate rural domestic and agricultural water use, reviewing Permit-To-Take-Water information from the Ministry of the Environment including the Permit-To-Take-Water database and Permit-To-Take-Water paper records at the Ministry of the Environment offices, and running an irrigation demand model. The seasonality of a water taking sector was considered when estimating the annual volume of extracted water.~~

~~The amount of water consumed was determined by applying a consumptive factor to each taking based on the specific purpose of the taking, while taking into account the source of water and the return of waste water. Specific consumptive use factors are based on work by AquaResource (2005) with modifications to agricultural water use based on Isidoro et al. (2003) and comments from the peer review committee.~~

~~**Table** 18-3 shows the top consumptive water use sectors active in the Grand River Source Protection Area.~~

~~Table 18-3: Top Consumptive Water Use Sectors in the Grand River Watershed~~

~~Rank~~	~~Purpose~~	~~Consumptive Takings (1000 m^3/year)~~	~~Percentage of Total Consumed within the Watershed~~

~~1~~	~~Municipal Water Supply~~	~~81,615~~	~~53%~~
~~2~~	~~Dewatering~~	~~13,860~~	~~9%~~
~~2~~	~~Commercial~~	~~13,860~~	~~9%~~
~~4~~	~~Industrial~~	~~12,320~~	~~8%~~
~~5~~	~~Agricultural Irrigation~~	~~10,780~~	~~7%~~
~~6~~	~~Livestock Watering/Rural Domestic~~	~~7,700~~	~~5%~~
~~7~~	~~Private Water Supply~~	~~6,160~~	~~4%~~
~~8~~	~~Remediation~~	~~4,620~~	~~3%~~
~~9~~	~~Miscellaneous~~	~~1,540~~	~~1%~~
~~Total~~		**~~152,455~~**	**~~100%~~**

~~18.1.1 Municipal and First Nations Systems~~

~~There are 49 municipal residential drinking water systems, including two integrated groundwater/inland river systems, one inland river intake and one Lake Erie intake. As well, the Ohsweken Water Treatment Plant serves the Six Nations of the Grand River First Nations Reserve. There is also one pipeline system from Lake Ontario that supplies residents in the watershed.~~

~~The systems are owned and operated by upper, lower, and single tier municipalities, and First Nations. Municipal water demand within the watershed is estimated at approximately 100 million m3/yr, and this volume services approximately 770,000 residents. Although most of the water pumped for municipal water supply is returned to the Grand River watershed, the majority comes from groundwater systems and is therefore considered consumptive as it is returned to the surface water system. The location of the municipal water wells and surface water intakes in the Grand River watershed area are illustrated on~~ **~~Map~~** ~~18-2, and~~ **~~Map~~** ~~18-3 respectively.~~

~~Dundalk~~

~~The community of Dundalk has an estimated serviced population of 1,500 people. The Dundalk water supply system (DWS 220001753) consists of two bedrock wells (Wells D3 and D4) located within the Town of Dundalk. The wells feed into a common distribution system.~~

~~Waldemar~~

~~Three wells (PW1, PW2 and PW3) supply groundwater to the Waldemar Heights water supply system (DWS 220013553). The wells are completed in bedrock and draw water from the locally confined Guelph – Gasport aquifer (Burnside and Waterloo Hydrogeologic Inc., 2001). The population serviced is approximately 342 residents.~~

~~Grand Valley~~

~~Grand Valley is serviced by four wells (PW1, PW2, PW3 and PW4). All four wells are bedrock and are completed in the Guelph-Gasport formation (DWS 220007016). Wells PW1 and PW2 are located east of the Grand River in the flood plain and obtain water from a leaky confined bedrock aquifer. Wells PW3 and PW4 are west of the Grand River. The bedrock in the area of PW3 and PW4 is protected by over 24 m of fine-grained overburden. The population serviced by the Grand Valley municipal system is approximately 1,600 people.~~

~~Marsville~~

~~The Marsville Water Supply System (DWS 210002183) consists of two municipal groundwater supply wells (PW1 and PW2) located at the northeast end of Grand Crescent in a public park~~

~~and provides water for the Thunderbird Estates Subdivision located within the Hamlet of Marsville. The system distributes to 33 homes, which services approximately 130 people. The well, which taps the locally confined Guelph – Gasport aquifer, draws water from the upper weathered and competent middle portion of the bedrock aquifer. Overburden in the vicinity of the Marsville well is approximately 62 m in thickness.~~

~~*Arthur*~~

~~Within the Township of Wellington North, the community of Arthur's municipal water supply system (DWS 220000040) consists of 3 overburden wells (Wells 7B and 8A/8B). The municipal system supplies water to approximately 2,770 people within the community. The upper surficial Quaternary geology has been mapped as a clayey silt to silt till (Tavistock Till) which covers a large part of the area surrounding Arthur.~~

~~*Drayton*~~

~~Two municipal wells completed in the Salina Formation supply the community of Drayton (DWS 220004054). Both wells are completed as open hole in the upper portion of the dolostone bedrock aquifer which is overlain by about 58m of fine-grained overburden. The wells service an estimated population of 1,500 people (Drinking Water System Regulation 170/03, 2008a).~~

~~*Moorefield*~~

~~The Moorefield Water Supply has two pumping wells (DWS 260069732). Water in the wells comes from an extremely permeable portion of the dolomite bedrock aquifer at a depth of 82m. The aquifer is described as a confined aquifer with little to no leakage. Overburden sediments consist of primarily fine grained silt and clay till. The Moorefield Water Supply services a population of approximately 550 residents (Burnside, 2010d).~~

~~*Centre Wellington (Fergus-Elora)*~~

~~Within the Township of Centre Wellington, the communities of Fergus and Elora are supplied by an integrated municipal groundwater system (DWS 220000086). Both Elora and Fergus obtain their water supply from municipal groundwater supply systems located within the village and town, respectively. Together the water systems are referred to as the Centre Wellington Supply System which serves 12,893 residents in Fergus and 5,202 residents in Elora.~~

~~The water supply system for Elora consists of three bedrock wells referred to as E1, E3 and E4. The water supply system for Fergus consists of six bedrock wells referred to as F1, F2, F4, F5, F6 and F7, although F2 is not in use. The uppermost bedrock unit within the two communities is the Guelph Formation. The Eramosa Member underlies the Guelph Formation and behaves as an aquitard. The Gasport Formation, located beneath the Eramosa Member, forms the aquifer for the Fergus and Elora municipal wells.~~

~~*Rockwood*~~

~~The Rockwood Water Supply System (DWS 220005599) services a population of approximately 3,970 people (2008) in the Village of Rockwood and consists of three municipal groundwater wells and two pumphouses: the Station Street Pumphouse and the Bernardi Pumphouse. A fourth well is not currently online but has been identified as a future municipal supply well.~~

~~Rockwood Wells 1 and 2 are both inside the Station Street Pumphouse located west of Main Street and south of the Canadian National Railway Line. Rockwood Well 2 (also known as TW#1-67) was constructed in 1967 as a municipal source for the village. A second well, Well 1 (also known as TW#1-76), was constructed in 1976. The overburden is approximately 6 m thick~~

~~at both wells and consists of stony gravel with some clay. The bedrock is part of the heterogeneous, layered and fractured Gasport aquifer.~~

~~Rockwood Well 3, also known as the Bernardi Well, is located approximately 5 m to the north of the Bernardi Pumphouse. The Bernardi Pumphouse is located southeast of the Eramosa River and adjacent to the Town boundary. Well 3 was drilled in 2002 as a 150 mm diameter test well and was reconstructed to a diameter of 250 mm in 2004 so it could be used as a supply well.~~

~~Rockwood Well 4 is not currently online, but has been identified as a future municipal supply well. Well 4 (also known as TW2/03) is located northeast of Highway 7, northeast of the Eramosa River and adjacent to the Town boundary. The well was constructed at the same time as Well 3 when the Village was looking for future water supply wells. Both wells were tested and Well 3 was chosen for development, however, plans to use Well 4 for future supply remain in place.~~

~~Wells 1 and 2 are approximately 60 m deep and completed in bedrock. The bedrock is part of the heterogeneous, layered and fractured Gasport aquifer and is overlain by approximately 6 m of stoney gravel overburden. Well 3 is located sourthest of the Eramosa River and is completed in bedrock. Water is drawn from depths of approximately 45 to 49m.~~

~~*Hamilton Drive*~~

~~The Hamilton Drive Water Supply System (DWS 220009194) services a population of approximately 653 people (2008) in a community located just north of the City of Guelph. The system services the geographical area bounded by Victoria Road to the east, Conservation Road to the north, Highway 6 to the west and the Speed River to the south. The Hamilton Drive Water Supply System consists of two municipal groundwater wells located at two pumphouses: the Cross Creek Pumphouse and the Huntington Pumphouse.~~

~~The Cross Creek Well also known as Cross Creek PW3 was drilled in 1990. The well was completed as a 250 mm diameter well with a steel casing to 21.3 m and a 200 mm steel casing to 39.6 metres. The well is an open bedrock hole from 39.62 m to a depth of 99 m. The bedrock is overlain by 21.3 m of clay overburden.~~

~~The Huntington Well also known as Huntington Estates PW1 was drilled in 1986 and is a 200 mm well with an open bedrock interval from 12.5 to 71.9 m below grade. The well is completed in the Guelph Gasport aquifer which is overlain by 3 m of till.~~

~~*Guelph*~~

~~The City of Guelph has a population of approximately 115,000 in 2006. The groundwater supply system comprises of 23 groundwater supply wells and one shallow groundwater collector system (DWS 220000095). Currently 19 wells are in service, with the four wells out of service due to quality and maintenance concerns. The wells that supply the City's water are completed within both overburden sediments (1 well), and the underlying Guelph and/or Gasport Formations (22 wells).~~

~~At Arkell, which is located just outside the City, the groundwater supply is supplemented by an artificial recharge system. Surface water from the Eramosa River is used to recharge and enhance the flow of the Arkell Springs Collection System. The amount of water that can be taken from the Eramosa River is regulated by the City of Guelph's permit to take water. The water taken from the Eramosa River is pumped into an infiltration trench of which approximately~~

~~50% of the water is recovered by the Arkell Springs Collection System and the balance either recharges bedrock aquifers, underflows the collector or is lost to the River.~~

~~*Region of Waterloo Integrated Urban System (IUS)*~~

~~The Integrated Urban System (IUS) is a complex network of water sources, treatment, storage and delivery systems serving Cambridge, Kitchener, Waterloo, parts of Elmira and St. Jacobs in the Township of Woolwich, and parts of Wilmot Township (approximately 325,000 persons). The IUS system is comprised of 76 wells (from seven drinking water systems – DWS 220000166; DWS 220003092; DWS 260002668; DWS 260002707; DWS 220000157 and the Lancaster wells), completed in both overburden and bedrock, the Hidden Valley surface water intake on the Grand River, and an aquifer storage and recovery system (ASR). During periods of high demand treated surface water is introduced to the IUS in Kitchener and combined with treated water from a variety of groundwater sources. During the seasons of lower demand, treated surface water is injected via ASR wells for storage and pumped out for use during high demand periods.~~

~~*Ayr*~~

~~The water supply for the Ayr well field is obtained from production wells A1, A2 and A3 (DWS 220004199). Wells A1 and A2 are the primary production wells at this well field. All of the production wells are screened from approximately 43 to 51 m below ground surface within the deep overburden aquifer, which is overlain by an aquitard and aquifer sequence including the shallow overburden aquifer. The Ayr water supply system supplies water to approximately 4,000 people.~~

~~*Baden*~~

~~The water supply for the Baden well field is obtained from production wells B1 and B2 (no DWS number identified). The production wells are screened in the shallow overburden aquifer at depths ranging from 35 m 42 m below ground surface. This aquifer typically behaves as a confined to semi-confined aquifer system as it is overlain by clayey silt till.~~

~~*Branchton Meadows*~~

~~The water supply for the Branchton Meadows well field is obtained from production wells BM1 and BM2 (DWS 260002538). All of the production wells are screened within the bedrock aquifer at depths ranging from approximately 29 m 34 m below ground surface. A vertically extensive surficial aquitard is present near these production wells, with an aquifer unit directly overlying bedrock. The Branchton Meadows system supplies water to approximately 125 people.~~

~~*Conestogo*~~

~~The water supply for the Conestogo well field is obtained from production wells C3, C4, C5 and C6. Production wells C2, C5 and C6 are referred to as the Conestogo Golf well field (DWS 260001994), while wells C3 and C4 are collectively referred to as the Conestogo Plains well field (DWS 260002772). These two well fields are found on opposite sides of the river from each other. All of the production wells are screened at depths ranging from 15 m BGS to 33 m BGS within the Deep Overburden Aquifer, which is a confined aquifer system separated from surface and the overlying Shallow Overburden Aquifer by an extensive aquitard unit corresponding to the Maryhill and Catfish Creek Tills.~~

~~The Conestogo Golf well field serves a population of 411 people, while the Conestogo Plains well field serves a population of 367 people (RMOW, 2007).~~

~~*Elmira*~~

~~The water supply for the Elmira well field is obtained from production well E10 (no DWS number identified). The production well is completed at a depth of approximately 53 m below ground surface within the deep overburden aquifer, which overlies bedrock.~~

~~*Foxboro Green*~~

~~The water supply for the Foxboro Green well field is obtained from production wells FG1, FG2, and FG4 (DWS 220009210). All of the production wells are screened at depths ranging from 47 m BGS to 67 m below ground surface within the bedrock aquifer, which is overlain by units consistent with the deep overburden aquifer, Catfish Creek, the Maryhill Tills and the shallow overburden aquifer present near ground surface. The Foxboro water supply serves a population of approximately 398.~~

~~*Heidelberg*~~

~~The water supply for the Heidelberg well field is obtained from production wells HD01 and HD02, with the highest pumping rates at well HD1 (DWS 220007310). All of the production wells are screened at depths ranging from approximately 54 m to 60 m below ground surface within the deep overburden aquifer, which is overlain by stratigraphic units consistent with the Catfish Creek and Maryhill Tills and the shallow overburden aquifer near ground surface. The Heidelberg water supply system serves a population of approximately 1,060.~~

~~*Linwood*~~

~~The water supply for the Linwood well field is obtained from production wells L01A and L02, with the highest pumping rates at well L01A (DWS 220000102). All of the production wells are screened within the bedrock aquifer at depths ranging from 64 m to 80 m below ground surface. The Linwood wells draw water from the Salina Formation, the uppermost bedrock formation in the area (Conestoga-Rovers & Assoc., 2002). It supplies water to approximately 814 people.~~

~~*Maryhill*~~

~~The water supply for the Maryhill well field is comprised of two municipal residential drinking water systems. Groundwater is obtained from production wells MH01, MH02 (known as the Maryhill Water Supply, DWS 220004171), and production wells MH03 and MH04 (known as Maryhill Village Heights Water Supply, DWS 260007413). MH04 is not currently used for water supply with wells MH1 and MH2 acting as the primary production wells. All of the production wells are screened within sand and gravel in the deep overburden aquifer at depths ranging from 18 m to 45 m below ground surface. The Maryhill water supply system serves a population of approximately 315.~~

~~*New Dundee*~~

~~The water supply for the New Dundee well field is obtained from Production Wells ND04 and ND05 (DWS 220004180). The production wells are screened at depths ranging from 14 m BGS to 16 m BGS within the Shallow Overburden Aquifer, which lies below a surficial aquitard unit, and overlies the Maryhill Till. The New Dundee water supply system serves a population of approximately 1,132.~~

~~*New Hamburg*~~

~~The water supply for the New Hamburg well field is obtained from Production Well NH03 (DWS 220000111). The production well is screened from approximately 57 to 76 m BGS within the Bedrock Aquifer, with overlying material corresponding to Catfish Creek Till and pre-Catfish~~

~~Creek aquifer deposits. A small portion of the WHPA-D extends into the Township of Perth East.~~

~~*Roseville*~~

~~The water supply for the Roseville well field is obtained from production wells R05 and R06 (DWS 220007301). The production wells have screen depths ranging from 48 to 52 m below ground surface within the deep overburden aquifer, and are overlain by the Catfish Creek and Maryhill Till units, with the shallow overburden aquifer identified near ground surface. The Roseville system supplies water to approximately 295 people.~~

~~*St. Agatha*~~

~~A water supply pipeline has been constructed from Waterloo to replace three water supply systems in St. Agatha in accordance with the St. Agatha Water Supply System Study completed in March 2005. The systems include the St. Agatha system, the St. Agatha – Swartzentruber system and the St. Agatha – Sararas system. As part of this project the existing water supply wells have been decommissioned. These well systems have been removed from the Source Protection Program, as per the Regional council resolution included in Section 9.5.14.~~

~~*St. Clements*~~

~~The water supply for the St. Clements well field is obtained from production wells SC02 and SC03 (DWS 220005811). All of the production wells are screened over depths ranging from 15 m to 20 m below ground surface within the shallow overburden aquifer, which is underlain by the Maryhill Till. The St. Clements water supply system serves a population of approximately 1,410.~~

~~*Wellesley*~~

~~The water supply for the Wellesley well field is obtained from Production Wells WY01 and WY05 (DWS 220004215). The highest pumping rates are observed at well WY01 during most years. The production wells are screened within a sand and gravel unit corresponding to the Deep Overburden Aquifer from 45 m BGS to 54 m BGS. The Wellesley water supply system serves a population of approximately 2,150.~~

~~*West Montrose*~~

~~The West Montrose well field contains production wells WM01, WM02, WM03, and WM04 (DWS 220007007), screened from approximately 3 to 4 m below ground surface within the Uppermost Significant Aquifer, consisting of Grand River Valley outwash deposits. The only production well currently used for supply at the West Montrose Well Field is well WM04. The West Montrose well field is located approximately 19 m from the Grand River within the GRCA Regulatory floodplain. The production wells at this well field are classified as infiltration wells under the Certificate of Approval (CofA). The West Montrose system serves a population of 180.~~

~~*Wilmot Centre*~~

~~The water supply for the Wilmot Centre well field is obtained from Production Wells K50 and K51 with the highest pumping rates observed at well K50. These wells are part of the Integrated Urban System for the Region of Waterloo. All of the production wells are screened within the Shallow Overburden Aquifer at depths ranging from 30 m BGS to 40 m BGS. This aquifer behaves as a confined to semi-confined aquifer system as it is overlain by a clayey silt till.~~

~~Milverton~~

~~The Milverton municipal wells are located in the Village of Milverton in the Township of Perth East. The drinking water system consists of two bedrock wells: Well 4 and Well 6 (DWS 220000503). Both wells are completed in the Amherstburg Formation. The bedrock is reached at a depth of approximately 40 m. The drinking water system supplies a population of approximately 1,750 people.~~

~~Bright~~

~~The Bright water system is currently supplied by two wells, referred to as Well 4 and Well 4A, located at a site in the west part of the village (DWS 220009050). Both wells draw water from an intermediate aquifer and are screened at 21 to 25m below ground surface. Two other supply wells, the Bright Baird wells, are not currently in use. The Bright water system serves a population of approximately 366.~~

~~Drumbo~~

~~The Drumbo water system is supplied by two production wells (Well 2A and Well 3) (DWS 220007515). These two wells tap a deep, semi-confined, overburden aquifer.~~

~~In Drumbo, Well 2A is located on the east side of the village on the north side of County Road 29 (Drumbo Road). Well 3 is located in the northwest part of the village. A third well (Well 1), not yet part of the water supply system, is located on the east side of County Road 3 in the north part of Drumbo.~~

~~The water system services an estimated population of 510 people (Drinking Water Systems Regulation O. Reg. 170/03, 2004). The County is in the process of building a new system that would include servicing of the entire village of Princeton with municipal water from an expanded Drumbo water system.~~

~~Plattsville~~

~~Within the community of Plattsville, two wells (DWS 210001291) service an estimated population of 1,146 people (Drinking Water Systems Regulation O. Reg. 170/03, 2004). Both wells, completed at depths ranging from 12 to 15 m below ground surface, tap an unconfined, shallow overburden aquifer (Golder Associates, 2001). Within the Plattsville area, the shallow overburden aquifer is underlain by 20 to 30 m of silt and clay sediments which are underlain by bedrock (Golder Associates, 2001).~~

~~Airport~~

~~The municipal groundwater supply system for the Airport area is located on the north side of Colborne Street (DWS 220002743). The system includes one municipal production well, referred to as the Airport Well. The Airport well is completed in an unconfined sand and gravel aquifer. At the production site, the aquifer is approximately 25 m thick and contains a significant component of coarse sand and gravel. Lotowater (2005) suggested that this aquifer is laterally continuous in the vicinity of the Airport well and can be correlated with the aquifer that exists at the Mount Pleasant well site.~~

~~The County indicates that there were 214 residential connections and 22 commercial connections in 2008 serving an estimated population of 601 people.~~

~~*Mount Pleasant*~~

~~The municipal groundwater supply system for Mount Pleasant is located on Ellis Avenue, approximately 1.4 km west of the village (DWS 210000069). There are two production wells at the site, referred to as Well 1 and Well 2. Each well is located in a separate pump house, approximately 13 m apart. The overburden thickness in the vicinity of the Mount Pleasant production wells ranges from approximately 50 to 70 m (Golder, 2010f).~~

~~The County indicates that there were 508 residential connections and 22 commercial connections in 2008 serving an estimated population of 1,427 people (Golder, 2010f).~~

~~*St. George*~~

~~The St. George municipal groundwater supply system is located near the centre of the village (DWS 220002734). The system includes three production wells located inside a single pump house. The two end wells, which were constructed in 1970, are referred to as Well 1 and Well 2, and are separated by a distance of approximately 5 m. The middle well (Well 3) appears to have been the original test well for the site that was constructed in 1968. The wells are constructed in the overburden aquifer system and would flow under non-pumping conditions.~~

~~The County indicates that there were 1,153 residential connections and 105 commercial connections in 2008 serving an estimated population of 3,239 people (Golder, 2010f).~~

~~*Town of Paris*~~

~~The four wellfields in the Paris service area include the Gilbert, Telfer, Fairview Heights and Bethel wellfields (DWS 220002752).~~

~~The Gilbert wellfield contains eight active production wells and is located in a low-lying area to the east of Grand River Street North and south of Watt's Pond Road. Wells P28 and P29 were constructed in 1990 and 1991, respectively, and are completed in the upper bedrock aquifer. Wells P210, P211, P212, P213, P214 and P215, also located at the Gilbert Well Field, were constructed in 2001 and are completed in the upper overburden aquifer (sand/gravel). Wells P214 and P215 were brought on-line in 2001 and wells P210, P211, P212 and P213 were connected to the municipal supply system in 2008. These overburden wells at the Gilbert Well Field are considered groundwater under the direct influence of surface water (GUDI) with effective filtration due to the unconfined nature of the aquifer. The wells are considered GUDI only during a regional storm event.~~

~~The Telfer Well Field is located adjacent to West River Road (approximately 300 m west of the Grand River) and includes two active production wells (P31, P32). Well P31 (constructed in 1965) is completed in the deep overburden sediments and P32 (constructed in 1974) is completed in the upper bedrock aquifer. An additional well referred to as P36 was constructed in 1996, but is currently not connected to the municipal system. The well is completed in the deep overburden sediments. Previous testing at P36 indicated that high nitrate concentrations were observed at the well and that blending with P31 and P32 would be required to reduce the high concentrations.~~

~~The Fairview Heights Well (previously referred to as TW4/92 and located in the Scott Pumphouse) is located in a residential area in the northwest part of Paris. The well was constructed in 1992 and is completed in the upper bedrock aquifer. The well is not currently in production because the water quality exceeds certain aesthetic objectives. The County has indicated that treatment for the well is included in the future plans for the water supply.~~

~~The Bethel Road wellfield contains three active production wells (TW1/05, PW1/12, and PW2/12) and is located along Bethel Road west of the intersection with Rest Acres Road, south of Paris. The County of Brant is also in the process of bringing a fourth municipal well, PW4/12, on-line as a part of the Bethel Road wells field. The four wells are completed in intermediate to deep overburden sediments and are considered GUDI with effective filtration due to the unconfined nature of the aquifer (International Water Consultants, 2008).~~

~~Lynden~~

~~The Lynden well supplies municipal water to approximately 400 people (DWS 250001830). The water supply system is comprised of the single well which draws water from a confined gravel aquifer that is situated directly on the bedrock surface.~~

~~Six Nations (Ohsweken)~~

~~Six Nations uses the Grand River as a source of water for a communal water system at Ohsweken. This water system is a First Nations system, and was brought into the Grand River Assessment Report after a regulation was made by the Lieutenant Governor of Ontario. The water treatment plant has a design capacity of 1,040 m^3/day and serves a population of approximately 2,000 (no DWS number identified).~~

~~Holmedale (Brantford)~~

~~The Holmedale Water Treatment Plant is owned and operated by the City of Brantford and treats water from the Grand River via the Holmedale Canal (DWS 220003564). The Brantford Water Treatment Plant is a conventional treatment plant servicing the City of Brantford and the Village of Cainsville with a population of approximately 95,000. This plant has a rated capacity of 100,000 m^3/day. The raw water access to the Holmedale Canal is located approximately 1.5 km upstream of the water treatment plant.~~

~~Dunnville~~

~~The Dunnville Water System, operated by the Corporation of Haldimand County, is situated on the shore of Lake Erie at the mouth of the Grand River (DWS 220003555). Raw water is collected from a pumping station 10km away in Port Maitland through an intake pipe located in Lake Erie approximately 460m offshore. The pumping station has a design capacity of 26,400 m^3/day and supplies both the Dunnville Water Treatment Plant and the Port Maitland industrial area. The Dunnville plant has a design capacity of 14,500 m^3/day and serves a population of approximately 11,300.~~

~~18.1.2 Municipal and First Nations Systems outside of the Grand River Watershed which service Grand River Watershed residents~~

~~Hamilton (Woodward) Water Supply – Caledonia, York, Cayuga~~

~~The Hamilton Water Supply System, which supplies drinking water to the communities of Caledonia and Cayuga and the hamlet of York within the Grand River watershed, is owned and operated by the city of Hamilton. The intake for this system is in Lake Ontario and is outside of the Grand River Watershed.~~

~~Nanticoke Intake~~

~~The Nanticoke water system is owned by the Corporation of Haldimand County. The treatment plant is located southwest of the Hamlet of Nanticoke in Lake Erie and treated water is supplied to the communities of Hagersville, Jarvis and Townsend within Long Point Region Source Water Protection Area and the Mississaugas of the Credit in the Grand River Watershed. The~~

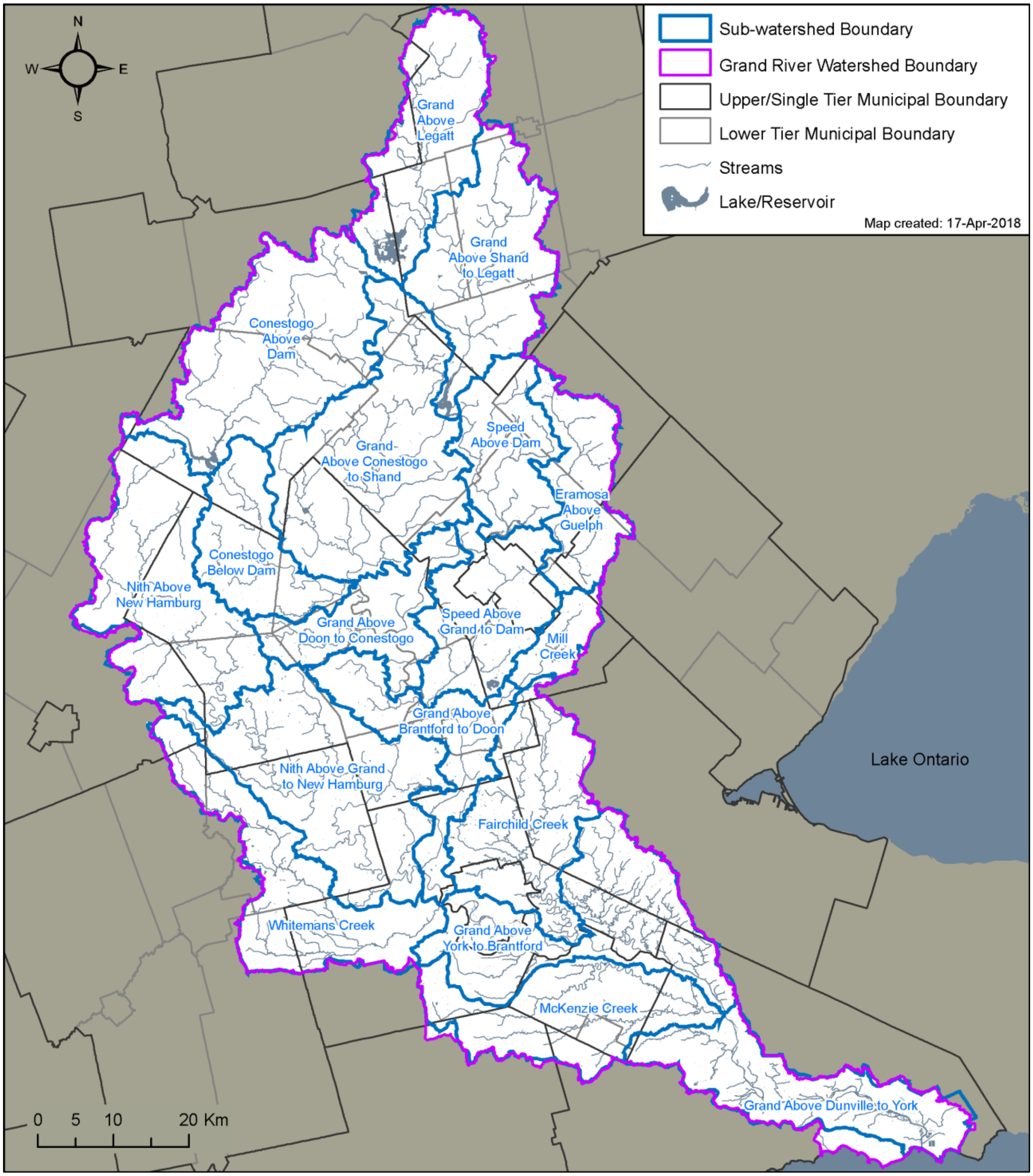
~~water treatment plant has a rated capacity of 300,000 m~~^{3}~~/day. Two intakes are located approximately 465m apart from one another and 530m from shore at a depth of 9m of water. Water is transported by gravity from the intakes to a forebay at the Ontario Power Generation Nanticoke Plant where it is then pumped to the water treatment plant via an intake pipe at the western end of the forebay. Additional details on this water system can be found in the Long Point Region Source Protection Area Approved Updated Assessment Report – February 27, 2012.~~

~~18.1.3 Municipal and First Nations Systems inside the Grand River Watershed which service other watersheds~~

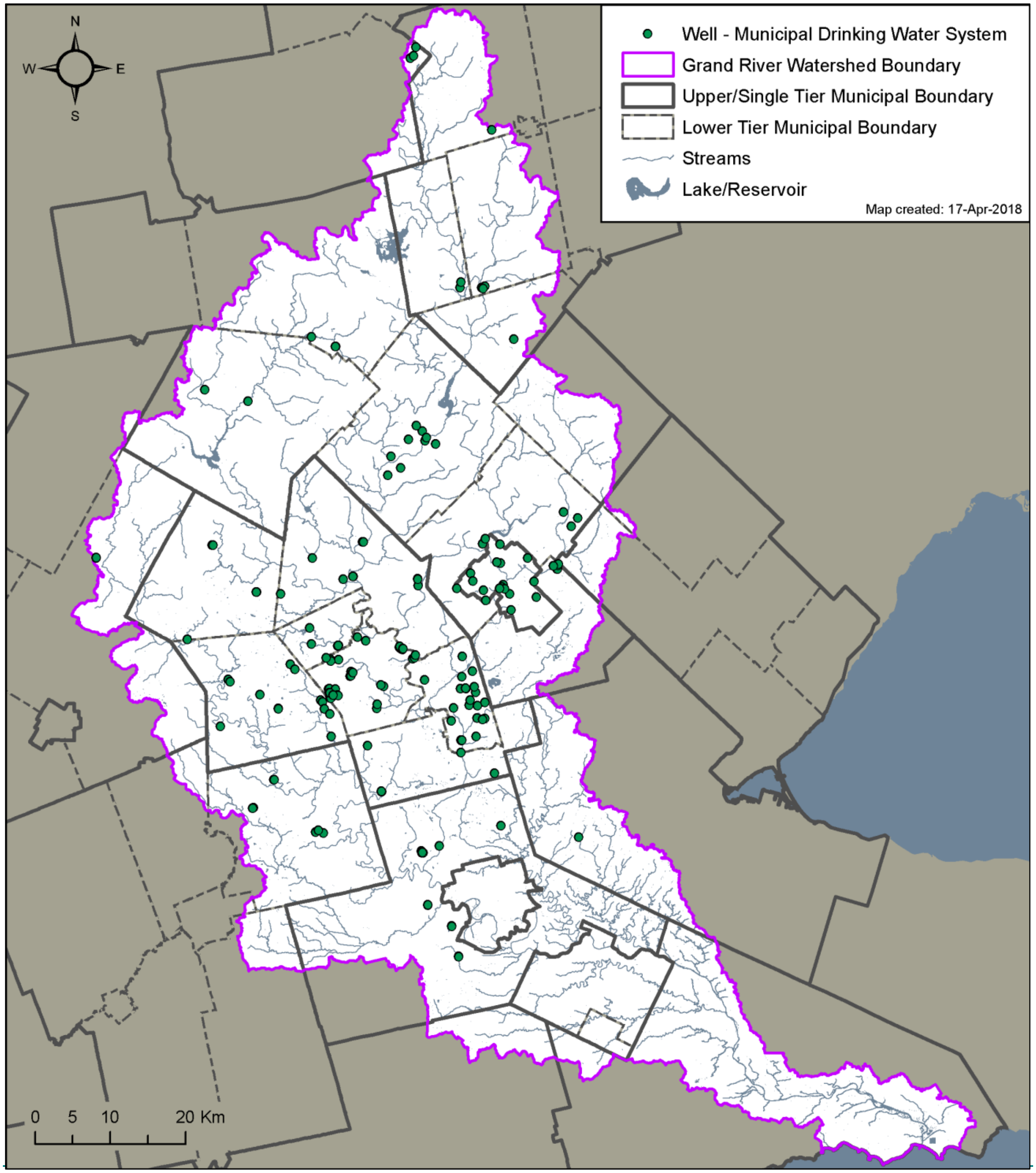
~~Township of Melancthon – Town of Shelburne~~

~~The Town of Shelburne water supply well PW7 is located in the Township of Melancthon within the Grand River watershed but provides municipal water to the Town of Shelburne, located outside of the Grand River watershed. PW7 is a 305 mm diameter well drilled to a depth of 86.6 mbgs (meters below ground surface) which draws water from the Gasport aquifer unit, which is considered to have more desirable formation water chemistry than the shallower Guelph aquifer (EarthFX, 2015). The well is permitted to pump 1135L/min and serves a population of approximately 6900.~~

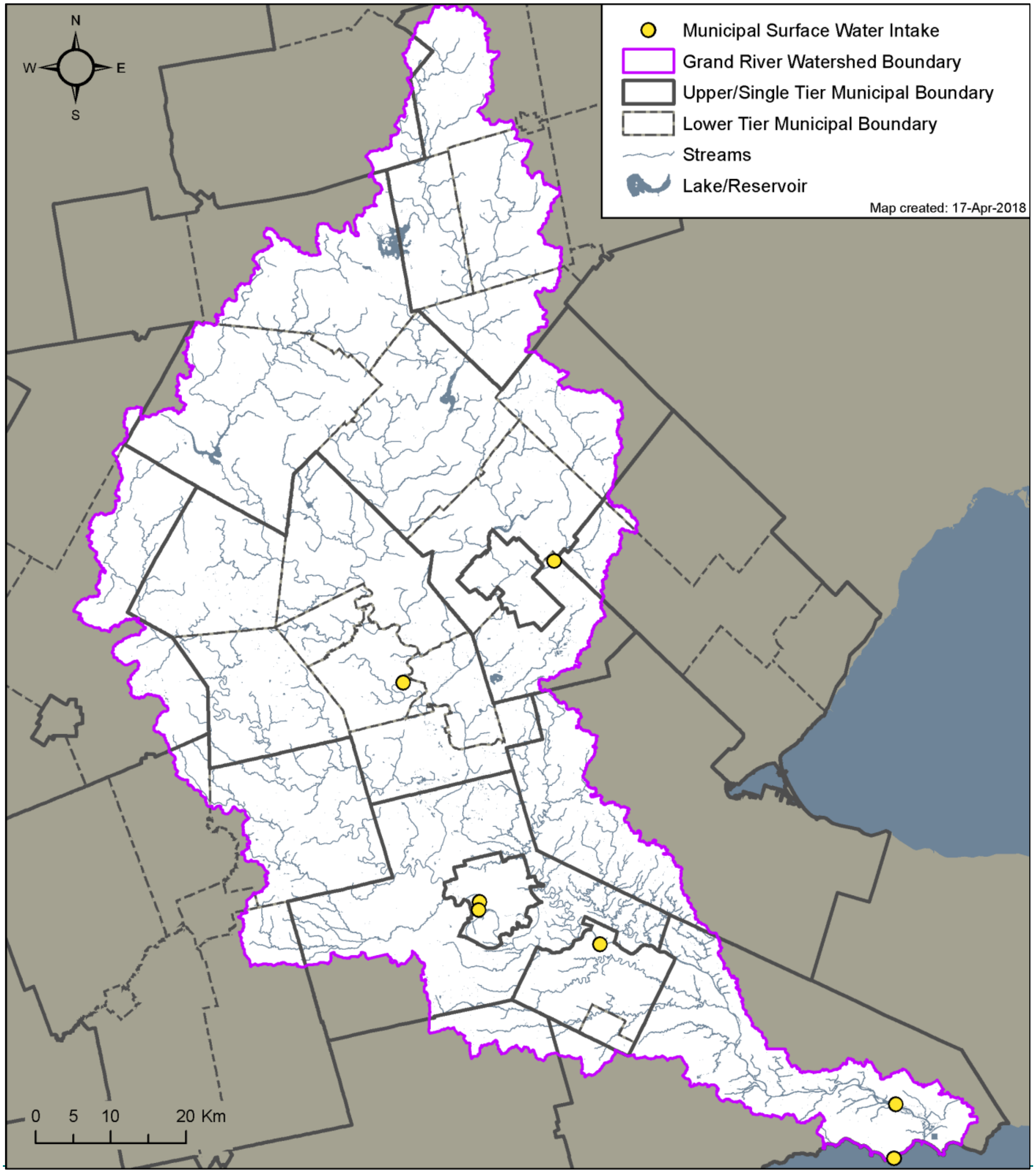
Map 18-1: Grand River Integrated Water Budget Subwatershed Boundaries



~~**Map 18-2: Municipal Water Wells in the Grand River Watershed**~~



~~Map 18-3: Surface Water Intakes in the Grand River Watershed~~



~~18.1.4 Private Drinking Water Supplies~~

~~An estimate of approximately 23,000 domestic wells exist in the Grand River watershed, with approximately 13,250 (60%) of these wells being classified as bedrock wells and 9,775 (40%) as overburden wells. Bedrock wells for domestic use are located throughout the watershed. Domestic overburden wells are also found throughout the watershed but there are clusters that correspond to the moraine features. Domestic bedrock and overburden wells as given in the Ministry of the Environment's Water Well Information System (WWIS) are illustrated on **Map** 18-4 and **Map** 18-5, respectively.~~

~~The GRCA Water Use Study (GRCA, 2005) estimated the amount of water taken for un-serviced domestic use by combining Census of Population data for areas known not to be serviced by a municipal system, and a per capita water use rate of 160 L/d. A per capita rate of 160 L/d was estimated by Vandierendonck and Mitchell (1997), and is consistent with the MOE Groundwater Studies Technical Terms of Reference (2001), which suggests an un-serviced per capita rate of 175 L/d. The estimates were pro-rated by area to the subwatershed areas and are included in **Table** 18-4.~~

~~18.1.5~~

~~Table 18-4: Un-serviced Domestic Water Use~~

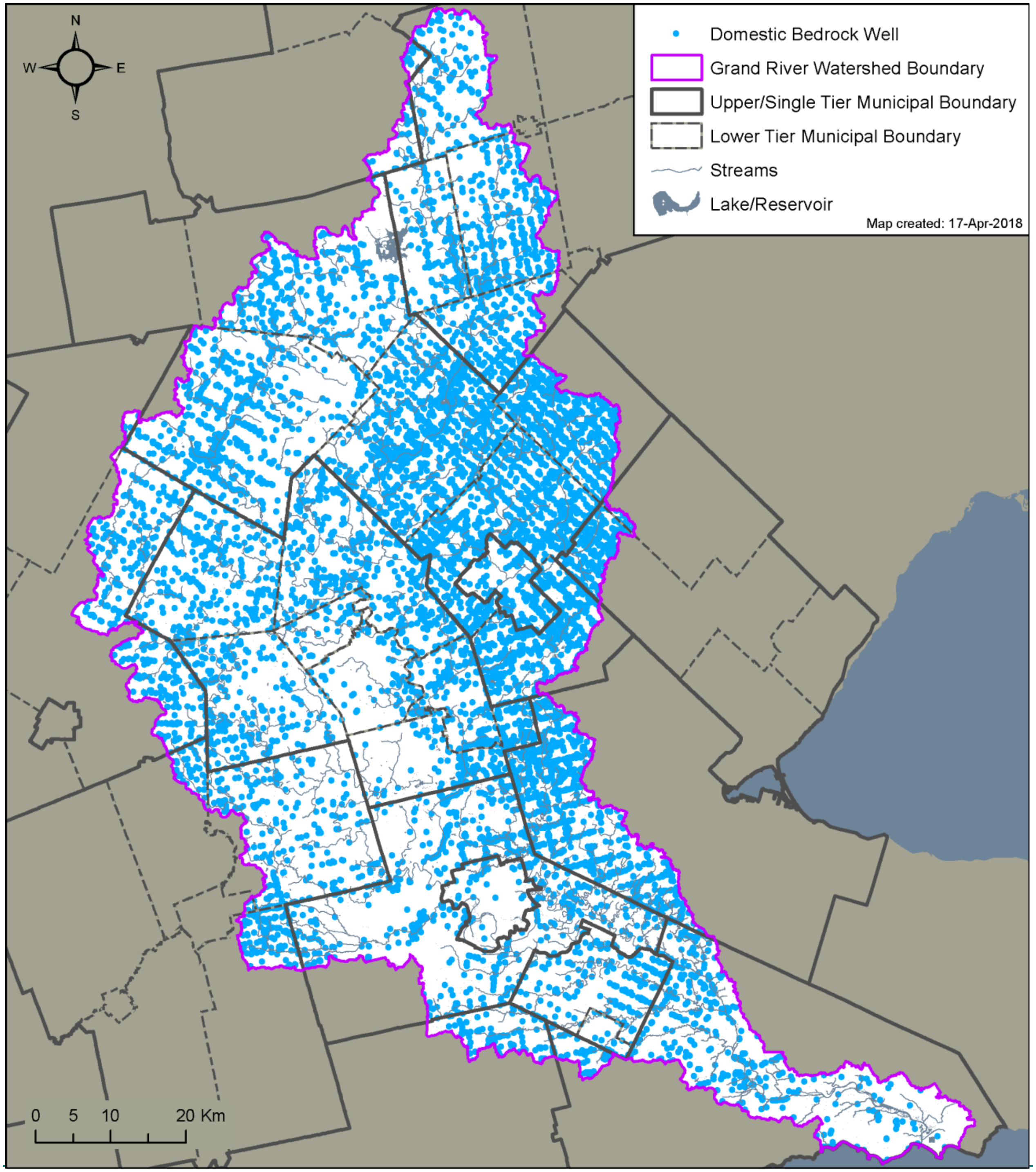
~~**Subwatershed**~~	~~**Rural Domestic Demand (L/s)**~~
~~Grand Above Legatt~~	~~4~~
~~Grand Above Shand To Legatt~~	~~9~~
~~Grand Above Conestogo To Shand~~	~~22~~
~~Conestogo Above Dam~~	~~11~~
~~Conestogo Below Dam~~	~~14~~
~~Grand Above Doon To Conestogo~~	~~7~~
~~Grand Above Brantford To Doon~~	~~7~~
~~Mill Creek~~	~~3~~
~~Eramosa Above Guelph~~	~~10~~
~~Speed Above Dam~~	~~8~~
~~Speed Above Grand To Armstrong~~	~~11~~
~~Nith Above New Hamburg~~	~~15~~
~~Nith Above Grand To New Hamburg~~	~~21~~
~~Whitemans Creek~~	~~15~~

~~McKenzie Creek~~	~~9~~
~~Fairchild Creek~~	~~17~~
~~Grand Above York To Brantford~~	~~17~~
~~Grand Above Dunnville To York~~	~~11~~

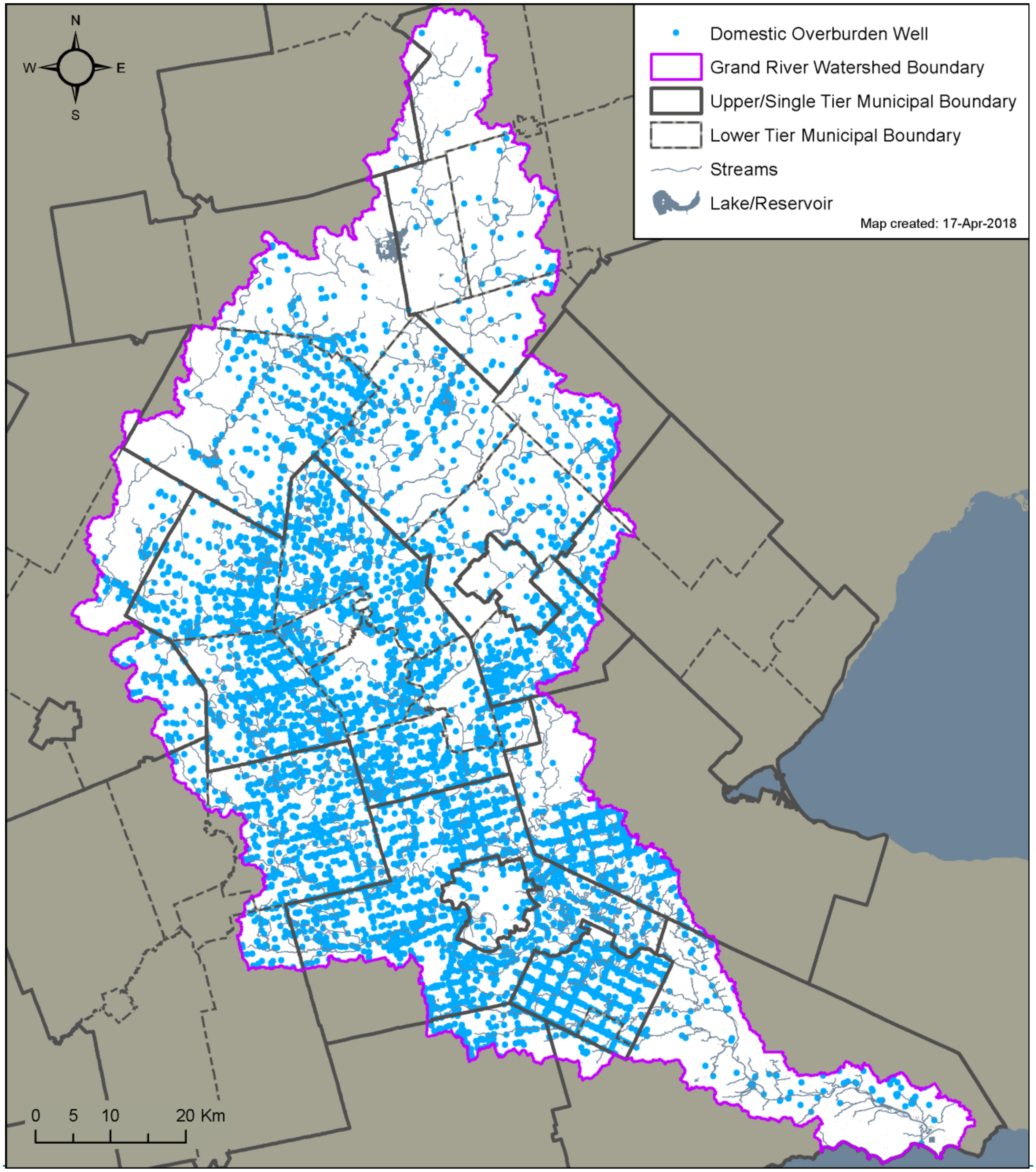
~~18.1.6~~

~~Due to concerns about poor water quality, this unserviced domestic demand is almost exclusively obtained from groundwater. Therefore, it is assumed that all unserviced domestic demand draws water from groundwater supplies. Consistent with the water consumption ratios for other Water Supply categories, the consumptive ratio is assumed to be 0.2. For domestic water wells, this assumption implies that 80% of pumped water is returned to groundwater through septic systems.~~

~~Map 18-4: Domestic Bedrock Wells in the Grand River Watershed~~



~~Map 18-5: Domestic Overburden Wells in the Grand River Watershed~~



~~18.1.7 Non Drinking Water Use~~

~~The Grand River Watershed has approximately 750 individual permits to take water, extracting water from approximately 1,200 different sources. Permits are focused on the central urban part of the watershed, with a large number of agricultural permits in the Norfolk Sand Plain region as illustrated on **Map** 18-6. Approximately 80% of the permitted sources withdraw water from groundwater and 20% from surface water bodies.~~

~~18.1.8 Permitted Rate~~

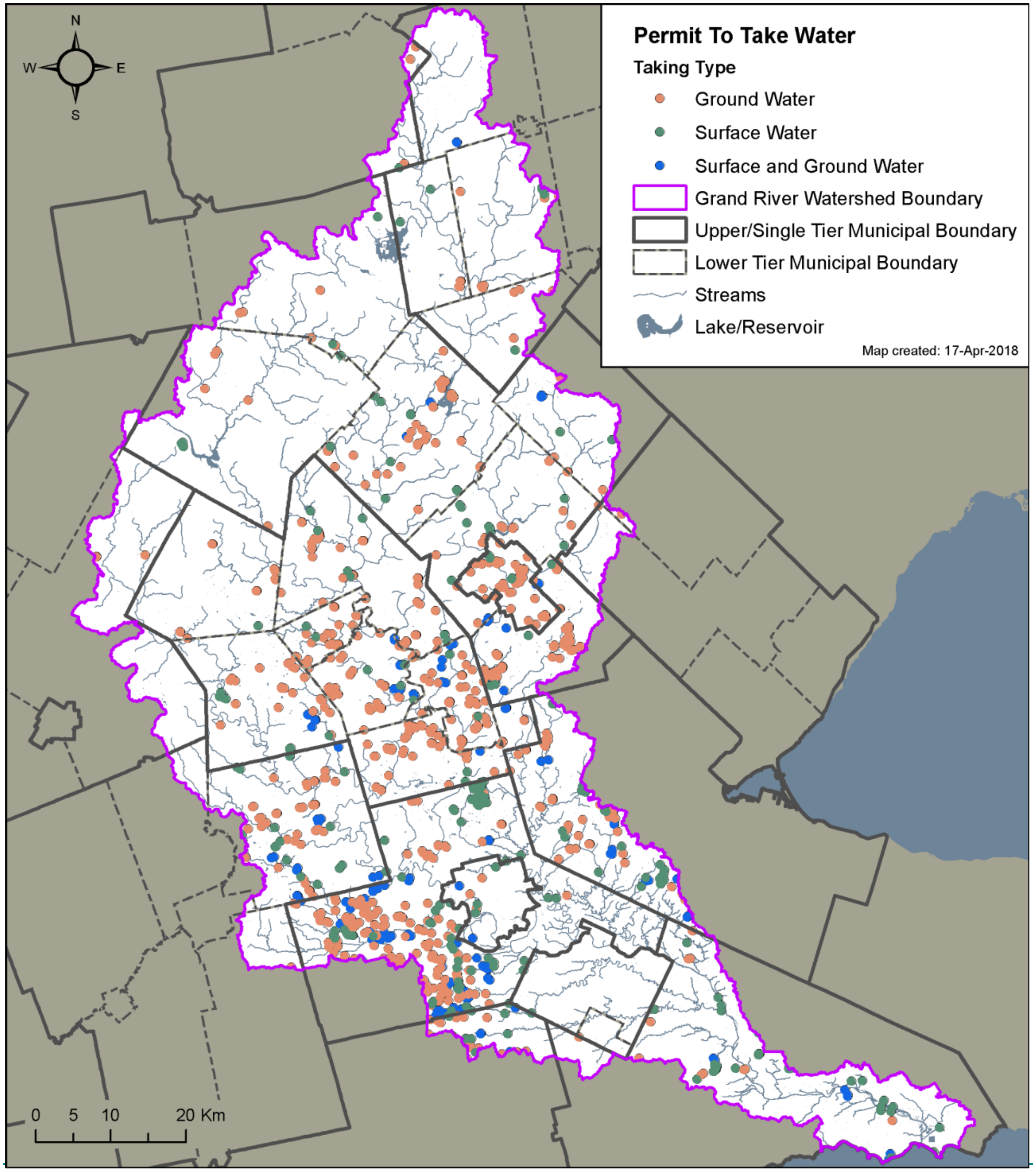
~~Permitted rates were obtained from the Ministry of the Environment Permit-To-Take-Water database. **Table** 18-5 shows the total permitted rate of active permitted water takings categorized by subwatershed and source. Only active permits, or permits representing a sustained water taking, were included in this analysis. Temporary permits, such as pipeline testing or pumping tests, were not included. A total of 27,600 L/s of groundwater, and 27,300 L/s of surface water, are permitted to be withdrawn within the watershed, for a total of 54,900 L/s or 55 m^3/s.~~

~~Table 18-5: Permitted Rate~~

~~**Subwatershed**~~	~~**Total Permitted Rate (L/s)**~~	
	~~**Groundwater**~~	~~**Surface Water**~~
~~Grand Above Legatt~~	~~50~~	~~54~~
~~Grand Above Shand To Legatt~~	~~276~~	~~0~~
~~Grand Above Conestogo To Shand~~	~~1,639~~	~~8,412~~
~~Conestogo Above Dam~~	~~213~~	~~500~~
~~Conestogo Below Dam~~	~~312~~	~~0~~
~~Grand Above Doon To Conestogo~~	~~1,918~~	~~3,044~~
~~Grand Above Brantford To Doon~~	~~5,865~~	~~510~~
~~Mill Creek~~	~~850~~	~~0~~
~~Eramosa Above Guelph~~	~~1,601~~	~~689~~
~~Speed Above Dam~~	~~142~~	~~2,021~~
~~Speed Above Grand To Armstrong~~	~~1,921~~	~~491~~
~~Nith Above New Hamburg~~	~~182~~	~~52~~
~~Nith Above Grand To New Hamburg~~	~~3,293~~	~~409~~
~~Whitemans Creek~~	~~3,543~~	~~1,304~~

~~McKenzie Creek~~	~~1,715~~	~~1,085~~
~~Fairchild Creek~~	~~580~~	~~311~~
~~Grand Above York To Brantford~~	~~1,784~~	~~7,947~~
~~Grand Above Dunnville To York~~	~~418~~	~~308~~
~~Total~~	~~26,303~~	~~27,137~~

~~Map 18-6: Permits to Take Water in the Grand River Watershed~~



~~18.1.9 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 (GRCA, 2005).~~

~~For agricultural permits, pumping rates were determined 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. The results show that irrigation is required, on average, 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 use, the GRCA developed a methodology to quantify non-permitted agricultural water use as part of the Grand River Water Use Study (GRCA, 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**~~ ~~18-6 pro-rates these watershed-based estimates for each subwatershed by area.~~

~~Table 18-6: Non-Permitted Agricultural Water Use~~

~~**Subwatershed**~~	~~**Non-Permitted Agricultural Demand (L/s)**~~
~~Grand Above Legatt~~	~~3~~
~~Grand Above Shand To Legatt~~	~~5~~
~~Grand Above Conestogo To Shand~~	~~28~~
~~Conestogo Above Dam~~	~~19~~
~~Conestogo Below Dam~~	~~25~~
~~Grand Above Doon To Conestogo~~	~~7~~
~~Grand Above Brantford To Doon~~	~~5~~
~~Mill Creek~~	~~1~~
~~Eramosa Above Guelph~~	~~8~~
~~Speed Above Dam~~	~~7~~
~~Speed Above Grand To Armstrong~~	~~5~~

~~Nith Above New Hamburg~~	~~14~~
~~Nith Above Grand To New Hamburg~~	~~14~~
~~Whitemans Creek~~	~~8~~
~~McKenzie Creek~~	~~3~~
~~Fairchild Creek~~	~~17~~
~~Grand Above York To Brantford~~	~~11~~
~~Grand Above Dunnville To York~~	~~3~~

~~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** 18-7 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 25 m^3/s pumped on an annual average basis, compared to 53 m^3/s that is permitted.~~

~~Table 18-7: Pumped Rate~~

~~**Subwatershed**~~	~~**Average Pumped Rate (L/s)**~~	
	~~**Groundwater**~~	~~**Surface Water**~~
~~Grand Above Legatt~~	~~28~~	~~55~~
~~Grand Above Shand To Legatt~~	~~152~~	~~3~~
~~Grand Above Conestogo To Shand~~	~~272~~	~~8,402~~
~~Conestogo Above Dam~~	~~46~~	~~509~~
~~Conestogo Below Dam~~	~~99~~	~~13~~
~~Grand Above Doon To Conestogo~~	~~511~~	~~635~~
~~Grand Above Brantford To Doon~~	~~1,283~~	~~361~~
~~Mill Creek~~	~~339~~	~~1~~
~~Eramosa Above Guelph~~	~~294~~	~~315~~

~~Speed Above Dam~~	~~34~~	~~2,022~~
~~Speed Above Grand To Armstrong~~	~~876~~	~~164~~
~~Nith Above New Hamburg~~	~~75~~	~~13~~
~~Nith Above Grand To New Hamburg~~	~~950~~	~~129~~
~~Whitemans Creek~~	~~165~~	~~51~~
~~McKenzie Creek~~	~~76~~	~~369~~
~~Fairchild Creek~~	~~115~~	~~132~~
~~Grand Above York To Brantford~~	~~364~~	~~4,886~~
~~Grand Above Dunnville To York~~	~~260~~	~~21~~
~~Total~~	~~5,939~~	~~18,080~~

~~18.1.10 Consumptive Use~~

~~The consumptive nature 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.~~ ~~**Table 18-8**~~ ~~summarizes the estimated consumptive demand (source scale) within each subwatershed. The table shows the maximum and minimum monthly and average annual demand for both surface water and groundwater sources. On an average annual basis, 4.3 m^3/s of water is estimated to be consumed from aquifers and 0.59 m^3/s is consumed from rivers and creeks.~~

~~Table 18-8: Consumptive Demand (By Hydrologic Source Unit)~~

~~Subwatershed~~	**~~Groundwater Demand (L/s)~~**			**~~Surface Water Demand (L/s)~~**		
	~~Maximum Monthly~~	**~~Minimum Monthly~~**	**~~Average Annual~~**	**~~Maximum Monthly~~**	**~~Minimum Monthly~~**	**~~Average Annual~~**
~~Grand Above Legatt~~	~~27~~	~~23~~	~~25~~	~~2~~	~~2~~	~~2~~
~~Grand Above Shand To Legatt~~	~~77~~	~~59~~	~~69~~	~~3~~	~~3~~	~~3~~
~~Grand Above Conestogo To Shand~~	~~267~~	~~235~~	~~250~~	~~35~~	~~22~~	~~26~~
~~Conestogo Above Dam~~	~~40~~	~~35~~	~~37~~	~~12~~	~~12~~	~~12~~
~~Conestogo Below Dam~~	~~54~~	~~39~~	~~46~~	~~13~~	~~13~~	~~13~~
~~Grand Above Doon To Conestogo~~	~~542~~	~~405~~	~~459~~	~~133~~	~~102~~	~~117~~
~~Grand Above Brantford To Doon~~	~~1207~~	~~911~~	~~1027~~	~~62~~	~~4~~	~~26~~
~~Mill Creek~~	~~114~~	~~46~~	~~82~~	~~1~~	~~1~~	~~1~~
~~Eramosa Above Guelph~~	~~354~~	~~229~~	~~286~~	~~101~~	~~5~~	~~45~~
~~Speed Above Dam~~	~~62~~	~~11~~	~~27~~	~~17~~	~~14~~	~~15~~
~~Speed Above Grand To Armstrong~~	~~907~~	~~723~~	~~831~~	~~56~~	~~17~~	~~28~~
~~Nith Above New Hamburg~~	~~71~~	~~59~~	~~62~~	~~13~~	~~7~~	~~9~~
~~Nith Above Grand To New Hamburg~~	~~681~~	~~378~~	~~513~~	~~71~~	~~16~~	~~29~~
~~Whitemans Creek~~	~~465~~	~~9~~	~~117~~	~~218~~	~~4~~	~~51~~
~~McKenzie Creek~~	~~223~~	~~3~~	~~53~~	~~108~~	~~3~~	~~29~~
~~Fairchild Creek~~	~~117~~	~~83~~	~~92~~	~~59~~	~~9~~	~~22~~
~~Grand Above York To Brantford~~	~~412~~	~~156~~	~~227~~	~~245~~	~~105~~	~~145~~
~~Grand Above Dunnville To York~~	~~116~~	~~74~~	~~91~~	~~70~~	~~2~~	~~21~~
~~Total~~			**~~4,295~~**			**~~588~~**

~~18.1.12~~

~~The main unit consumptive water use sector in the watershed is municipal water supply, accounting for 53% of the total average annual unit consumptive water demand. The commercial sector and dewatering each use 9% of the watershed's total average annual unit consumptive water demand, while the industrial sector uses 8%. Agricultural use accounts for~~

~~7% of total average annual unit consumptive water demand, while livestock/rural domestic uses account for 5% of total average annual unit consumptive water demand. Private water uses account for 4%, remediation accounts for another 3% of the total average annual unit consumptive demand, and a final 1% is attributed to miscellaneous uses. Summing the watershed totals for all reported categories shows that 58% of the total unit consumptive demand for the Grand River Watershed has been generated based on reported water use values. The fact that the majority of the unit consumptive demand estimates have been generated through use of reported (actual) pumping rates increases the certainty of the unit consumptive demand estimates.~~

~~18.2~~18.1 Surface Water ~~Budget~~

~~18.2.1~~18.1.1 Surface Water ~~Model~~ Budget

The Grand River Watershed continuous surface water model was built using the ~~Guelph All-Weather Sequential-Events Runoff (~~GAWSER~~)~~ model program. This modelling software is a physically-based deterministic hydrologic model that is used to predict the total streamflow resulting from inputs of rainfall and/or snowmelt. The infiltration routine used~~s~~ the Green-Ampt equation to partition precipitation into runoff and infiltrated water (recharge). Potential evapotranspiration was~~is~~ calculated using the Linacre model. Evapotranspiration was~~is~~ then calculated by removing available water from depression storage and the soil layers until wilting point was~~is~~ reached. Modelling procedures were~~are fully~~ documented in the GAWSER Training Guide and Reference Manual (Schroeter & Associates, 2004). Runoff, recharge and evapotranspiration were then aggregated to the subwatershed scale.~~ for the water budget.~~

~~The Grand River Watershed hydrologic model originally developed in the late 1980s for flood forecasting purposes and it has remained in a continuous improvement process. The event based model was converted to a continuous hydrologic model in the late 1990s at which time a substantial calibration/verification exercise was carried out. The current model represents in excess of 15 years of continuous improvement. The watershed is modeled with 136 catchments, ranging in size from 3 km^2 to 154 km^2, with the average being 50 km^2.~~

~~Each catchment was assigned to one of 13 Zones of Uniform Meteorology (ZUMs) for climate data input. Missing precipitation and temperature data was filled in using data from nearby stations based on a process described by Schroeter et al. (2000). Climate data for the period November 1960 to November 1999 was used for this study.~~

~~Hydrologic Response Units (HRUs) were delineated by overlaying quaternary geology mapping with land cover information. Land cover information was taken from the 1992 MNR land cover (MNR, 1995) to be consistent with the 1990-2000 calibration period. By grouping hydrologically similar land covers and geology, the overlain datasets resulted in 18 HRUs, as given in **Table 18-9**, which were further categorized as hummocky or non-hummocky. The top eight pervious HRUs, by drainage area, and one impervious HRU are selected to represent the hydrologic response of a particular catchment. The remaining HRUs, often less then 10% area, are prorated across the top eight.~~

~~Table 18-9: Hydrologic Response Units for Western Watersheds~~

~~HRU~~	~~Description~~	~~Groundwater Reservoir~~
~~1~~	~~Impervious Surfaces~~	~~NA~~
~~2~~	~~Wetlands~~	~~Fast~~
~~3~~	~~Clay Till Low Vegetation~~	~~Fast~~
~~4~~	~~Clay Till Medium Vegetation~~	~~Fast~~
~~5~~	~~Clay Till High Vegetation~~	~~Slow~~
~~6~~	~~Silt Till Low Vegetation~~	~~Fast~~
~~7~~	~~Silt Till Medium Vegetation~~	~~Fast~~
~~8~~	~~Silt Till High Vegetation~~	~~Slow~~
~~9~~	~~Sand Till Low Vegetation~~	~~Fast~~
~~10~~	~~Sand Till Medium Vegetation~~	~~Fast~~
~~11~~	~~Sans Till High Vegetation~~	~~Slow~~
~~12~~	~~Sand Gravel Low Vegetation~~	~~Slow~~
~~13~~	~~Sand Gravel Medium Vegetation~~	~~Slow~~
~~14~~	~~Sans Gravel High Vegetation~~	~~Slow~~
~~15~~	~~Urban Clay~~	~~Fast~~
~~16~~	~~Urban Silt~~	~~Fast~~
~~17~~	~~Urban Sand~~	~~Slow~~
~~18~~	~~Urban Sand Gravel~~	~~Slow~~

~~Contributions from human sources were also modeled by including wastewater treatment plant outflow. Wastewater treatment plant outflows from 26 facilities in the Grand River Watershed were added as part of the baseflow from the catchment in which the outfall is located.~~

~~The model has undergone extensive calibration throughout its development. Most recently it was paired with the groundwater model and initial feedback indicated that the hydrologic model was producing insufficient recharge to sustain flows during the low flow period. Calibration/verification was revisited to determine if recharge rates could be increased while maintaining the models acceptable calibration to higher flows. By focusing on hydrologic processes and seasonal parameters, mostly during the transition months, calibration was improved to match both the high and low flows throughout the watershed.~~

The surface water budget components – precipitation, evapotranspiration, runoff and recharge - ~~are~~ were determined from the hydrologic model ~~(precipitation, evapotranspiration, runoff and recharge)~~ and from the ~~w~~Water ~~u~~Use ~~s~~Study for surface water takings (AquaResource, 2009a). The ~~Surface water budget components have significant temporal variability. R~~results presented below~~are~~ are based on average annual conditions for the 1980-1999 period; ~~and~~ it is recognized that these results may vary significantly based on climate conditions. The analysis d~~oes~~id not account for changes in water storage that would occur from one time period to the next.

As shown on Table 18-2: , the average annual precipitation for the watershed is approximately 933 mm/year. The hydrologic model ~~has~~ estimated average annual evapotranspiration to be 491 mm/year. The average runoff rate across the watershed is 266 mm/year, with an average groundwater recharge rate of 176 mm/year. Water taken from watercourses, that is not immediately returned to the surface water system, is approximately 0.59 m^3/s, or 2.7 mm/year. While precipitation and evapotranspiration rates had~~ve~~ some degree of spatial variability, runoff and recharge rates had~~ve~~ the most significant spatial variability due to changing soils, surficial geology, and land cover.

Table 18-2: Average Annual Water Budget (Surface Water)

Water Budget Parameter	**Value (m^3/s)**	**Value (mm/year)**
Precipitation	200	933
Evapotranspiration	105	491
Runoff	57	266
Recharge	38	176
SW Taking	0.59	2.7

Table 18-3 and **Table 18-4** summarize the water budget components for each of the subwatersheds in mm and m^3/s, respectively.

Table 18-3: Surface Water Budget (mm/year)

Subwatershed	**Area (km^2)**	**Precip**	**ET**	**Runoff**	**Recharge**	**SW Taking**
Grand Above Legatt	365	988	469	345	174	0.2
Grand Above Shand To Legatt	426	988	464	356	168	0.2
Grand Above Conestogo To Shand	640	925	487	282	156	1.3
Conestogo Above Dam	566	936	485	327	123	0.7
Conestogo Below Dam	254	968	487	365	117	1.6
Grand Above Doon To Conestogo	248	897	500	197	199	14.9
Grand Above Brantford To Doon	274	896	495	163	238	3.0

Table 18-3: Surface Water Budget (mm/year)

Subwatershed	Area (km^2)	Precip	ET	Runoff	Recharge	SW Taking
Mill Creek	82	888	507	89	292	0.4
Eramosa Above Guelph	230	892	506	142	244	6.2
Speed Above Dam	242	894	529	123	242	2.0
Speed Above Grand To Armstrong	308	889	510	156	223	2.9
Nith Above New Hamburg	545	992	503	346	144	0.5
Nith Above Grand To New Hamburg	583	945	508	154	284	1.6
Whitemans Creek	404	945	512	176	257	4.0
McKenzie Creek	368	945	481	337	127	2.5
Fairchild Creek	401	866	468	263	135	1.7
Grand Above York To Brantford	476	896	495	284	118	9.6
Grand Above Dunnville To York	356	945	465	392	89	1.9
Total Area	**6,769**	**933**	**491**	**266**	**176**	**2.7**

Table 18-4: Surface Water Budget (m3/s)

Subwatershed	Area (km^2)	Precip	ET	Runoff	Recharge	SW Taking
Grand Above Legatt	365	11.43	5.42	3.99	2.02	0.002
Grand Above Shand To Legatt	426	13.36	6.27	4.81	2.28	0.003
Grand Above Conestogo To Shand	640	18.77	9.88	5.72	3.17	0.026
Conestogo Above Dam	566	16.80	8.71	5.88	2.21	0.012
Conestogo Below Dam	254	7.79	3.92	2.94	0.94	0.013
Grand Above Doon To Conestogo	248	7.05	3.93	1.55	1.57	0.117
Grand Above Brantford To Doon	274	7.79	4.30	1.42	2.07	0.026
Mill Creek	82	2.32	1.32	0.23	0.76	0.001
Eramosa Above Guelph	230	6.51	3.70	1.04	1.78	0.045
Speed Above Dam	242	6.87	4.06	0.95	1.86	0.015
Speed Above Grand To Armstrong	308	8.69	4.98	1.52	2.18	0.028
Nith Above New Hamburg	545	17.15	8.68	5.97	2.49	0.009
Nith Above Grand To New Hamburg	583	17.47	9.39	2.84	5.25	0.029
Whitemans Creek	404	12.11	6.56	2.26	3.29	0.051
McKenzie Creek	368	11.04	5.62	3.94	1.48	0.029
Fairchild Creek	401	11.01	5.95	3.34	1.72	0.022
Grand Above York To Brantford	476	13.52	7.46	4.28	1.78	0.145
Grand Above Dunnville To York	356	10.67	5.25	4.42	1.00	0.021
Total Area	**6,769**	**200.4**	**105.4**	**57.1**	**37.8**	**0.588**

Uncertainty in the Surface Water Model

Many elements of the water budget modelling process using the hydrologic model are subject to uncertainty. Although the calibration process ~~is~~ was performed in an attempt to reduce uncertainty, the model results and water budgets reflect the uncertainty in the input parameters as well as limitations in the modelling approach. The model ~~is~~ was designed to reflect general characteristics of each catchment relating to land cover, climate, soils and vegetation, and stream and river hydraulics. Calibration is limited to the available stream flow data.

~~18.3~~18.2 Groundwater ~~Water Budget~~

~~18.3.1~~18.2.1 Groundwater ~~Model~~ Budget

The steady-state groundwater flow model developed for the Grand River Watershed was developed using FEFLOW and~~. The model~~ builds upon earlier work completed by WHI (2005a). ~~The calibration of the model was further refined by AquaResource (2005).~~ The groundwater model is a regional numerical flow model which encompasses~~ing~~ an area of approximately 6,800 km^2~~ with 18 subwatersheds~~. ~~It~~The model has 13 primary hydrostratigraphic units which are represented ~~by~~ a separate layers within the model~~ each~~. ~~In addition t~~The shallow subsurface was further~~is~~ subdivided into two layers to provide a more detailed calculation at the groundwater/surface water interface.

~~Enhancements to the previous model structure included the division of the Guelph and Gasport Formations, and the inclusion of the Eramosa Member as separate model layers. The addition of these two model layers provides the flexibility to incorporate the Eramosa Member as an aquitard that potentially separates the Guelph and Gasport Formations; this provides a more physical representation of these important bedrock aquifers. With these additional layers the model contains over three million elements and almost two million nodes.~~

~~Recharge estimates were taken from the hydrologic model and applied to the groundwater model to provide a connection between the surface and groundwater numerical models. Streams and rivers within the groundwater model were given specified head values. Stream stage was taken from the available Digital Elevation Model. To determine appropriate lateral boundary conditions for the model, water level trends around the perimeter of the model were carefully reviewed. Where water level trends suggested that natural flow boundaries exist (groundwater divides), a no-flow boundary was applied. In other areas where water level trends indicated cross-boundary flow, fixed water level boundary conditions equivalent to the equipotential heads in those layers were applied. The review process also included evaluation of all cross-boundary flows to ensure that the direction and magnitude of cross-boundary flows were reasonable.~~

~~The best available data was used to determine the location, screened interval and pumping rate for wells. Reported "actual" pumping rates were used where available (municipal pumping wells and through surveys). For other permits to take water, the consumptive use estimate for the source was applied. Non-permitted water takings are not represented within the model. A total of 721 wells are incorporated within the model with a total demand of approximately 4 m^3/s.~~

~~Initial overburden hydraulic conductivity estimates were derived based on borehole lithology records within each model layer and the distribution used in the hydrologic model for the surficial model layers. All bedrock model layers, except for the Eramosa Member, were assigned uniform hydraulic properties representative of the bedrock materials. Special care was taken in specifying the hydraulic conductivity within the Eramosa Member. For that unit, a low~~

~~conductivity was only specified within the sub-crop zone and was focused within the Guelph-Puslinch area, extending north toward Fergus, where it is also known to exist as an aquitard. In areas further west, it was treated as having a hydraulic conductivity similar to the Guelph Formation, as has been observed in Cambridge and the northwest part of Guelph. Initial estimates of hydraulic conductivity were subsequently modified through the model calibration process. Layer thicknesses, however, were not modified during model calibration. As a result, the calibration of the ability of the groundwater system to transmit flow was primarily accomplished by varying hydraulic conductivity.~~

~~Observed groundwater levels (head) and groundwater discharge (portion of stream baseflow) were used as calibration targets for the groundwater model. Water levels selected for use in calibration included those with high location reliability and with static water levels observed in the period 1980-2000 (7,953 well water levels) from the Ministry of the Environment water well information system. Additional water levels used in the Guelph-Puslinch Groundwater Study (Golder, 2005) and wells currently being used by the Region of Waterloo were also included as calibration targets. In addition to the water level calibration targets used, baseflow discharge estimates at 28 locations throughout the model domain for the 1980-2000 period were also used as calibration targets.~~

Table 18-5 summarizes the average annual groundwater budget for the Grand River watershed. It is linked to the surface water budget by the recharge rate. Water taken from aquifers~~,~~ that is not immediately returned to the groundwater system~~,~~ is approximately 4 m^3/s, or 18 mm/year. The groundwater model estimates average annual groundwater discharge to surface water features to be 33 m^3/s. A~~dditionally, a~~ net flow of approximately 2 m^3/s flows out of the watershed.

Table 18-5: Average Annual Water Budget Summary (Groundwater)

Water Budget Parameter	Value (m^3/s)	Value (mm/year)
Recharge	37.8	176
Net Flow Out of Watershed	1.8	8
Net Discharge to Surface Water Features	32.6	152
GW Taking	4.0	18

Table 18-6 and **Table 18-7** summarize the water budget components for each of the subwatersheds in mm and m^3/s, respectively.

Table 18-6: Groundwater Budget (mm/year)

Subwatershed	Area (km^2)	Recharge	External Boundary	Discharge	GW Taking
Grand Above Legatt	365	173	0	-155	-1
Grand Above Shand To Legatt	426	168	-2	-163	-4
Grand Above Conestogo To Shand	640	157	0	-125	-12
Conestogo Above Dam	566	124	-31	-70	-2
Conestogo Below Dam	254	118	0	-211	-4
Grand Above Doon To Conestogo	248	202	0	-203	-32
Grand Above Brantford To Doon	274	240	0	-219	-121

Table 18-6: Groundwater Budget (mm/year)

Subwatershed	Area (km^2)	Recharge	External Boundary	Discharge	GW Taking
Mill Creek	82	287	0	-208	-40
Eramosa Above Guelph	230	243	-15	-246	-27
Speed Above Dam	242	245	0	-235	-1
Speed Above Grand To Armstrong	308	224	0	-174	-75
Nith Above New Hamburg	545	143	-28	-81	-2
Nith Above Grand To New Hamburg	583	282	0	-216	-32
Whitemans Creek	404	254	-29	-211	-14
McKenzie Creek	368	126	3	-94	-11
Fairchild Creek	401	137	2	-134	-7
Grand Above York To Brantford	476	117	-27	-127	-10
Grand Above Dunnville To York	356	88	9	-86	-5
Total Watershed	**6,769**	**176**	**-8**	**-152**	**-18**

Positive values represent flow into the groundwater system and negative values represent flow out of the groundwater system.

Table 18-7: Groundwater Budget (m^3/s)

Subwatershed	Area (km^2)	Recharge	External Boundary	Discharge	GW Taking
Grand Above Legatt	365	2.01	0.00	-1.80	-0.01
Grand Above Shand To Legatt	426	2.27	-0.02	-2.19	-0.06
Grand Above Conestogo To Shand	640	3.18	0.00	-2.54	-0.24
Conestogo Above Dam	566	2.22	-0.55	-1.26	-0.03
Conestogo Below Dam	254	0.95	0.00	-1.70	-0.03
Grand Above Doon To Conestogo	248	1.59	0.00	-1.60	-0.25
Grand Above Brantford To Doon	274	2.08	0.00	-1.91	-1.05
Mill Creek	82	0.75	0.00	-0.54	-0.10
Eramosa Above Guelph	230	1.77	-0.11	-1.80	-0.20
Speed Above Dam	242	1.88	0.00	-1.81	-0.01
Speed Above Grand To Armstrong	308	2.19	0.00	-1.70	-0.73
Nith Above New Hamburg	545	2.47	-0.48	-1.40	-0.04
Nith Above Grand To New Hamburg	583	5.22	0.00	-4.00	-0.59
Whitemans Creek	404	3.26	-0.37	-2.70	-0.18
McKenzie Creek	368	1.47	0.03	-1.10	-0.13
Fairchild Creek	401	1.74	0.03	-1.70	-0.09
Grand Above York To Brantford	476	1.77	-0.41	-1.91	-0.16
Grand Above Dunnville To York	356	0.99	0.10	-0.97	-0.06
Total Watershed	**6,769**	**37.8**	**-1.8**	**-32.6**	**-4.0**

Positive values represent flow into the groundwater system and negative values represent flow out of the groundwater system.

Uncertainty in the Groundwater Model

Any model developed to represent a natural system is inherently a simplification of that system. Most of the scientific approach involves representing physical conditions observed using approximations of larger scale functionality: hydraulic conductivity is an example of this. The Grand River groundwater flow model is designed to incorporate key hydrogeologic features for each subwatershed and their characteristics. The implication is that features at a smaller scale may not be adequately represented to support more local assessments. There is also uncertainty in the model from a lack of available subsurface data. The quality and availability of subsurface data varies throughout the watershed resulting in greater uncertainty in some areas compared to others.

~~18.4~~18.3 ~~Interactions Between Groundwater and Surface WaterIntegrated Water Budget~~ Integrated Water Budget Results

This section presents the integrated water budget for the Grand River Watershed. This integrated water budget considers average annual estimates of key hydrologic parameters relating to both surface water and groundwater resources, and the integration between the two.

The ~~V~~values reported are based on annual averages~~,~~ and may exhibit significant seasonal variation. Due to the regional perspective of this analysis, the subwatershed descriptions may lack local details that may have local hydrologic significance. In addition, local scale interpretation and/or models may provide differing results than those presented here when averaged spatially and temporally. Table 18-8 and Table 18-9 summarize the water budget components for each of the subwatersheds in mm and m^3/s, respectively. Table 18-10, describes the components of the water budget.

Following Table 18-10 is a summary of the integrated water budget for each of the subwatersheds based on the information provided in the tables below.

Table 18-8: Integrated Water Budget (mm/yr)

		Surface Water					Groundwater				
Subwatershed	**Area (km^2)**	**Precip**	**ET**	**Runoff**	**Recharge**	**SW Taking**	**External Boundary**	**Discharge to Lakes**	**Discharge to Streams**	**GW Taking**	**Inter Basin**
Grand Above Legatt	365	988	469	345	174	0.2	0	-5	-150	-1	-17
Grand Above Shand To Legatt	426	988	464	356	168	0.2	-2	-27	-136	-4	0
Grand Above Conestogo To Shand	640	925	487	282	156	1.3	0	-2	-123	-12	-20
Conestogo Above Dam	566	936	485	327	123	0.7	-31	-14	-56	-2	-21
Conestogo Below Dam	254	968	487	365	117	1.6	0	0	-211	-4	98
Grand Above Doon To Conestogo	248	897	500	197	199	14.9	0	-6	-197	-32	34
Grand Above Brantford To Doon	274	896	495	163	238	3.0	0	-1	-218	-121	101
Mill Creek	82	888	507	89	292	0.4	0	0	-208	-40	-39
Eramosa Above Guelph	230	892	506	142	244	6.2	-15	0	-246	-27	46
Speed Above Dam	242	894	529	123	242	2.0	0	-10	-225	-1	-9
Speed Above Grand To Armstrong	308	889	510	156	223	2.9	0	0	-174	-75	25
Nith Above New Hamburg	545	992	503	346	144	0.5	-28	0	-81	-2	-31
Nith Above Grand To New Hamburg	583	945	508	154	284	1.6	0	0	-216	-32	-34
Whitemans Creek	404	945	512	176	257	4.0	-29	0	-211	-14	-1
McKenzie Creek	368	945	481	337	127	2.5	3	0	-94	-11	-23
Fairchild Creek	401	866	468	263	135	1.7	2	0	-134	-7	2
Grand Above York To Brantford	476	896	495	284	118	9.6	-27	0	-127	-10	47
Grand Above Dunnville To York	356	945	465	392	89	1.9	9	-4	-82	-5	-5
Total Watershed	**6769**	**933**	**491**	**266**	**176**	**2.7**	**-8**	**-4**	**-148**	**-18**	**0**

Positive values represent flow into the groundwater system and negative values represent flow out of the groundwater system.

Table 18-9: Integrated Water Budget (m^3/s)

		Surface Water					Groundwater				
Subwatershed	**Area (km^2)**	**Precip**	**ET**	**Runoff**	**Recharge**	**SW Taking**	**External Boundary**	**Discharge to Lakes**	**Discharge to Streams**	**GW Taking**	**Inter Basin**
Grand Above Legatt	365	11.43	5.42	3.99	2.02	0.002	0.00	-0.06	-1.74	-0.01	-0.20
Grand Above Shand To Legatt	426	13.36	6.27	4.81	2.28	0.003	-0.02	-0.36	-1.83	-0.06	0.00
Grand Above Conestogo To Shand	640	18.77	9.88	5.72	3.17	0.026	0.00	-0.04	-2.50	-0.24	-0.40
Conestogo Above Dam	566	16.80	8.71	5.88	2.21	0.012	-0.55	-0.26	-1.00	-0.03	-0.38
Conestogo Below Dam	254	7.79	3.92	2.94	0.94	0.013	0.00	0.00	-1.70	-0.03	0.79
Grand Above Doon To Conestogo	248	7.05	3.93	1.55	1.57	0.117	0.00	-0.05	-1.55	-0.25	0.26
Grand Above Brantford To Doon	274	7.79	4.30	1.42	2.07	0.026	0.00	-0.01	-1.90	-1.05	0.88
Mill Creek	82	2.32	1.32	0.23	0.76	0.001	0.00	0.00	-0.54	-0.10	-0.10
Eramosa Above Guelph	230	6.51	3.70	1.04	1.78	0.045	-0.11	0.00	-1.80	-0.20	0.34
Speed Above Dam	242	6.87	4.06	0.95	1.86	0.015	0.00	-0.08	-1.73	-0.01	-0.07
Speed Above Grand To Armstrong	308	8.69	4.98	1.52	2.18	0.028	0.00	0.00	-1.70	-0.73	0.24
Nith Above New Hamburg	545	17.15	8.68	5.97	2.49	0.009	-0.48	0.00	-1.40	-0.04	-0.54
Nith Above Grand To New Hamburg	583	17.47	9.39	2.84	5.25	0.029	0.00	0.00	-4.00	-0.59	-0.63
Whitemans Creek	404	12.11	6.56	2.26	3.29	0.051	-0.37	0.00	-2.70	-0.18	-0.01
McKenzie Creek	368	11.04	5.62	3.94	1.48	0.029	0.03	0.00	-1.10	-0.13	-0.27
Fairchild Creek	401	11.01	5.95	3.34	1.72	0.022	0.03	0.00	-1.70	-0.09	0.02
Grand Above York To Brantford	476	13.52	7.46	4.28	1.78	0.145	-0.41	0.00	-1.91	-0.16	0.70
Grand Above Dunnville To York	356	10.67	5.25	4.42	1.00	0.021	0.10	-0.04	-0.93	-0.06	-0.06
Total Watershed	**6,769**	**200.4**	**105.4**	**57.1**	**37.8**	**0.588**	**-1.8**	**-0.9**	**-31.7**	**-4.0**	**0.0**

Positive values represent flow into the groundwater system and negative values represent flow out of the groundwater system.

Table 18-10: Summary of Water Budget Components

Parameter	Source	Description
Precipitation	Climate Monitoring Data	Climate data used to represent the precipitation over each of the subwatersheds is summarized by the hydrologic model.
Evapotranspiration	GAWSER	Using potential evapotranspiration rates the hydrologic model estimates actual evapotranspiration by determining the amount of water available.
Surface Water Runoff	GAWSER	When the precipitation exceeds the infiltration capacity of a soil, overland runoff is created. Subwatersheds with tighter surficial materials tend to have a higher proportion of runoff.
Groundwater Recharge	GAWSER	By calculating the amount of infiltration, net of evapotranspiration, the hydrologic model estimates the amount of groundwater recharge for a particular HRU. Subwatersheds with more pervious materials have a higher proportion of recharge.
Surface Water Taking	Water Use Estimates	The amount of water taken from a surface water source and not immediately returned to that source. Includes estimates from permits as well as rural domestic and permit-exempt agricultural use.
Groundwater Taking	FEFLOW	This parameter refers to the flux of groundwater removed from pumping wells as reported in the actual water use estimates.
External Boundary	FEFLOW	This component identifies groundwater flow through the boundaries of the groundwater flow model. This is representative of groundwater flow out of, or into, the Grand River Watershed. Negative flows indicate water leaving the basin; positive flows indicate water entering the basin.
Groundwater Discharge to Lakes	FEFLOW	This parameter quantifies the groundwater flux into or out of lakes. Negative values indicate that flow is leaving the groundwater system to the lakes.
Groundwater Discharge to Rivers	FEFLOW	This parameter quantifies the groundwater flux to rivers and streams in the particular subwatershed. Negative values indicate that flow is leaving the groundwater system to the surface water system
Inter-Basin Flow	FEFLOW	This parameter is the amount of groundwater flow to another subwatershed within the Grand River Watershed. Positive values indicate that the subwatershed is experiencing a net increase of groundwater flow from adjacent subwatersheds. Negative values indicate that the subwatershed is experiencing a net loss of groundwater flow to adjacent subwatersheds.

Grand Above Legatt Subwatershed

The Grand Above Legatt subwatershed is the most northern subwatershed and is characterized by having a mixture of low to medium permeability surficial materials. Catfish Creek Till and Tavistock Till dominate the subwatershed, with isolated glaciofluvial outwash deposits. The topography is generally flat, with no hummocky features. Some areas within the subwatershed receive more precipitation (988 mm/y) than the watershed average (933 mm/y) due primarily to lake effect snowfall. The spatial distribution of lake effect snowfall, however, may not be well represented due to a lack of long term climate stations. The subwatershed experiences more surface runoff (345 mm/y) than the Watershed average (266 mm/y). Groundwater recharge (173 mm/y) is close to the average groundwater recharge rates (176 mm/y), and is highest within the pervious Catfish Creek Till and glaciofluvial deposits.

Significant overburden aquifers within the subwatershed are confined to pockets of pervious deposits, and the bedrock (Guelph/Gasport) contributes to the regional groundwater flow system. An estimated 1.8 m^3/s of groundwater discharge occurs, with most of the groundwater discharge predicted to occur in the upper reaches of the subwatershed, where Catfish Creek Till is dominant.

Consumptive water use in this subwatershed is low, with the estimated average annual consumptive groundwater demand of 25 L/s and the estimated average annual surface water demand of 2 L/s.

For the Grand Dundalk gauge, simulated baseflow estimates are higher than the range of estimated baseflow. Additionally, the hydrologic model over-predicts surface water flow. Additional model calibration would be recommended if using the models for future hydrologic or hydrogeological studies.

Grand Above Shand To Legatt Subwatershed

The Grand Above Shand to Legatt subwatershed is mainly composed of the clayey soils (57%) of Tavistock Till, with glaciofluvial deposits over 30% of the area. There are some hummocky features where portions of the Orangeville Moraine extend into the southern portions of this subwatershed. The subwatershed’s average annual precipitation (988 mm/y) is similar to the Grand Above Legatt subwatershed, with similar uncertainty relating to the lake effect snow. The simulated hydrological response is very similar to that observed in the Grand Above Legatt subwatershed. Evapotranspiration is estimated to be 464 mm/y. Surface runoff is estimated to be 356 mm/y, which is higher than the watershed average (266 mm/y) due to the areas of clayey soils. The average groundwater recharge rate in the subwatershed is 168 mm/y. Higher amounts of runoff would be observed in areas with surficial materials of Tavistock Till, where the majority of the groundwater recharge occurring in the pervious glaciofluvial deposits.

Overburden aquifers in this subwatershed include the shallow glaciofluvial deposits and a lower overburden aquifer below the Tavistock Till. The primary bedrock aquifer is the Guelph/Gasport bedrock formation. Higher rates of groundwater discharge are predicted to occur along the Grand River throughout this subwatershed.

Estimated consumptive water use within the subwatershed is relatively low and a small proportion of the total water budget. Average annual groundwater demand is approximately 69 L/s and the average annual consumptive surface water demand is approximately 3 L/s.

Grand Above Conestogo To Shand Subwatershed

The Grand Above Conestogo to Shand subwatershed is the largest in the Grand River watershed. The subwatershed is predominately Tavistock Till in the north and northwest sections (particularly the Irvine Creek). The central areas of the subwatershed contain extensive deposits of outwash gravels, interspersed with Tavistock and Port Stanley Tills, and transitioning to Port Stanley Till in the southeast portion. Approximately 6% of the subwatershed is has hummocky topography. The average annual precipitation in the subwatershed receives is 925 mm/y, which is close to the watershed average of 933 mm/y. Evapotranspiration is estimated to be 487 mm/y. Surface runoff and groundwater recharge are estimated to be 282 mm/y and 156 mm/y, respectively.

The most significant aquifer in this subwatershed is the Guelph/Gasport Formation bedrock aquifer, which supplies most of the municipal systems in the area. Overburden aquifers are generally confined to isolated patches of granular material, with more continuous overburden aquifers located near Elmira. Other areas where productive lower overburden aquifers can be found include the villages of Conestoga, Winterbourne, and Floradale. Higher groundwater discharge rates are predicted into the Grand River where it passes through the Elora Gorge and West Montrose, and again immediately upstream of the Conestogo/Grand confluence.

Estimated consumptive water use within the subwatershed is moderate. The largest water demands include municipal supplies for Elora and Fergus, as well as permits for aquaculture and groundwater remediation. Average annual groundwater demand is approximately 250 L/s and the average annual consumptive surface water demand is approximately 26 L/s.

The surface water and groundwater models are reasonably calibrated to the hydrologic and hydrogeologic processes in the subwatershed; however, groundwater supplies in the area are critical for the communities of Fergus and Elora in Centre Wellington. Further calibration and conceptualization would be beneficial to better understand the regional groundwater system with respect to those communities and validate the model's predictions of groundwater discharge in the area.

Conestogo Above Dam Subwatershed

The Conestogo Above Dam subwatershed is characterized by having a large proportion of clayey soils belonging to the Tavistock Till as the primary surficial material. Elma Till is also present in the western portion of the Subwatershed, which is drained by Moorefield Creek. Granular glaciofluvial deposits are sparse and generally discontinuous. The annual average precipitation is 936 mm/y. Lake effect snowfall may have an influence on total precipitation in certain areas of the subwatershed; however, this cannot be characterized well with the available long term climate stations. Evapotranspiration is estimated to be 485 mm/y. As a result of the abundant low permeability soils, surface runoff is approximately 327 mm/y, which is significantly higher than the watershed average. Correspondingly, estimated groundwater recharge is relatively low and estimated to be 123 mm/y.

With the exception of an esker in the Damascus area, most upper overburden aquifers are localized. Deeper overburden aquifers are present over the subwatershed, typically below the Tavistock Till deposit. The Salina formation forms the uppermost bedrock formation over much of the subwatershed, and the Guelph/Gasport Formation remains the primary bedrock aquifer in the extreme eastern portions of the subwatershed. Typical of being a headwaters subwatershed, the groundwater flow model predicts a net groundwater outflow into adjacent subwatersheds (i.e., Inter-Basin Flow) equal to 0.38 m^3/s. Furthermore, an additional 0.55 m^3/s of groundwater flow leaves the Grand River watershed and flows to the west from this subwatershed. There are no significant reaches of groundwater discharge.

Permitted water use within the Conestogo Above Dam subwatershed is relatively low, with estimated average annual groundwater demand of 37 L/s and estimated average annual consumptive surface water demand of 12 L/s.

Conestogo Below Dam Subwatershed

Much like the Upper Conestogo subwatershed, the surficial materials of the Conestoga Below Dam Subwatershed are primarily composed of low permeability materials (Mornington and Tavistock Tills).

There are some deposits of ice-contact sands and gravels in the lower portions of the subwatershed; however, the less permeable tills dominate the surficial geology. In the lower portions of the subwatershed there are large areas with hummocky terrain. These areas include portions of the Waterloo, Elmira and Macton Moraine. The subwatershed receives approximately 968 mm/y of precipitation per year, which is higher than the Watershed average of 933 mm/y. The hydrologic response of the Conestogo Below Dam subwatershed is very similar to the upstream Conestogo Above Dam subwatershed. Surface runoff is estimated to be 365 mm/y, which is higher than the watershed average of 266 mm/y. With the predominant low permeability soils, the average groundwater recharge rate is estimated to be 117 mm/y, which is lower than the watershed average of 176 mm/y. The highest groundwater recharge rates are predicted in the lower portions of the subwatershed where pervious deposits are present.

Significant overburden aquifers are not expected where the upper areas of the subwatershed are dominated by Tavistock and Mornington Tills. In the lower portions of the subwatershed, which intersect the northern flank of the Waterloo Moraine and the southern portions of the Elmira Moraine, there are isolated areas with upper and lower overburden aquifers near Wellesley and Crosshill. An extension of the buried Dundas Valley also extends through this subwatershed, and may contain a productive lower aquifer. The Salina Formation is the uppermost bedrock in this subwatershed and may form a weak aquifer.

The Conestoga River within the subwatershed may receive higher rates of groundwater discharge than would be expected from the lower recharge rates in the subwatershed. This is potentially a result of groundwater inflow from adjacent subwatersheds as simulated by the groundwater flow model. It is estimated that 0.8 m^3/s of groundwater flow is entering this subwatershed as Inter-Basin Flow. The large amount of groundwater inflow supports the groundwater discharge zone predicted along the lower Conestogo River.

Water use within the Conestogo Below Dam subwatershed is relatively low, with estimated average annual groundwater demand of 46 L/s and estimated average annual consumptive surface water demand of 13 L/s.

Grand Above Doon To Conestogo Subwatershed

The surficial geology of the Grand Above Doon to Conestogo subwatershed is highly variable. There are extensive ice-contact stratified drift and Maryhill Till deposits associated with the Waterloo Moraine, as well as Port Stanley Till, as mapped on the eastern portion of the subwatershed. The Waterloo Moraine is the most predominant physiographic feature, and contributes a large portion (24%) of hummocky area. Approximately 18% of the subwatershed is urbanized. The average annual precipitation is 897 mm/y. Surface water runoff is estimated to be approximately 197 mm/y, which is lower than the watershed average due to the high percentage of pervious materials. Similarly, groundwater recharge is 199 mm/y, which is higher than the watershed average.

In the western areas of the subwatershed there are extensive upper and lower overburden aquifers. Upper overburden aquifers include surficial outwash and ice-contact deposits in the Erbsville, Homer-Watson, and Forwell areas, as well as deposits near the Grand River. Lower overburden aquifers include the Greenbrook, Parkway and Strasburg aquifers. In the eastern areas of the subwatershed, there are local outwash deposits that may represent upper overburden aquifer, particularly around the Ariss area. High groundwater discharge rates into the Grand River are found in this area.

Consumptive water demand in the subwatershed is relatively high due to municipal demands. Average annual groundwater demand is 459 L/s, which represents nearly one-third of the recharge in the subwatershed. Estimated consumptive surface water demand is 117 L/s. The Region of Waterloo's Mannheim surface water intake is located within this subwatershed.

Water resources within this subwatershed are critical to municipal drinking water supplies. The hydrogeological conditions within the watershed tend to be very complex, particularly in the vicinity of the Waterloo Moraine. The Grand River watershed steady-state groundwater-flow model is not calibrated to municipal observation well data, and as a result, the model may not be fully representative of hydrogeology in or near wellfields. Further calibration and conceptualization would be beneficial to better understand the regional groundwater system, and significant hydrologic processes in the subwatershed.

Grand Above Brantford To Doon Subwatershed

The Grand Above Brantford To Doon subwatershed is situated in the centre of the watershed, and contains the urban areas of Kitchener and Cambridge. The surficial materials are predominantly icecontact stratified drift and outwash deposits. This subwatershed includes parts of both the Waterloo Moraine and the Galt/Paris Moraines and has a very high proportion of hummocky topography (42%). Annual precipitation for the subwatershed is 896 mm/y, which is lower than the watershed average of 933 mm/y. Although it is heavily urbanized (25%), the high permeability soils result in low runoff (163 mm/y) and high recharge (238 mm/y).

Upper overburden aquifers are located in the vast deposits of outwash materials, and ice-contact drift. Lower overburden aquifers exist in interconnected pockets throughout the area. The primary bedrock aquifer in the eastern portion of the subwatershed is found within the Guelph formation, whereas in the western portion of the subwatershed the Salina formation is the main bedrock aquifer. The subwatershed receives approximately 0.88 m^3/s of groundwater flow from adjacent subwatersheds as part of a deeper regional groundwater flow system. The calibrated groundwater flow model identifies significant groundwater discharge rates along the entire reach of the Grand River.

Municipal groundwater consumption within the subwatershed is relatively high. Estimated average annual groundwater demand is 1,027 L/s. Other significant groundwater use sectors include aggregate washing and golf course irrigation. Estimated average annual consumptive surface water demand is 26 L/s.

Similar to the Grand Above Doon to Conestoga subwatershed, water resources within this subwatershed are critical to municipal drinking water supplies. The hydrogeological conditions within the watershed tend to be very complex, particularly in the vicinity of the Waterloo Moraine. The Grand River watershed steady-state groundwater-flow model is not calibrated to municipal observation well data, and as a result, the model may not be fully representative of hydrogeology in or near wellfields. Further calibration and conceptualization would be beneficial to better understand the regional groundwater system, and significant hydrologic processes in the subwatershed.

Mill Creek Subwatershed

The Mill Creek subwatershed is situated between the Galt and Paris Moraines on the western edge of the Grand River watershed. The subwatershed's surficial materials include high permeability outwash deposits, and medium permeability Wentworth Till. Fifty percent of the watershed is classified as having hummocky topography associated with the moraines. Precipitation for this subwatershed is 888 mm/y, which is slightly below the watershed average (933 mm/y). Estimated runoff is much lower (89 mm/y) than the watershed average (266 mm/y). Similarly, groundwater recharge (292 mm/y) is higher than the watershed average (176 mm/y).

The most significant overburden aquifers in the subwatershed are contained within the large outwash deposits located between the Moraines. The Guelph/Gasport Formation bedrock is a significant regional aquifer within this subwatershed. Relatively high rates of groundwater discharge are predicted to occur along Mill Creek, which is consistent with the creek being identified as an important coldwater aquatic resource.

Permitted groundwater water demand is very high due to many aggregate washing operations in the subwatershed. 850 L/s of total groundwater pumping and no surface water withdrawals are permitted. Actual consumption rates for aggregate operations are much lower than permitted pumping rates. While it is estimated that the average annual pumping rate is approximately 339 L/s in the watershed, only an estimated 82 L/s of this water is being consumed and is not returned to its original source.

The calibrated groundwater levels appear to be higher on average than observed, however, the simulated groundwater discharge is within the estimated baseflow range. Currently, the hydrologic model is consistently under-predicting streamflow in comparison to the measured conditions. This may be due to the model's simplification of groundwater storage and baseflow, the effect of which is clearly demonstrated for a small subwatershed. Further work is warranted to better understand the hydrology of the watershed, and the potential interactions with the regional system.

The greatest water demands placed on the subwatershed are by the aggregate resources industry, and the cumulative effects of these activities are poorly understood. Given the importance of maintaining groundwater and surface water interactions, additional surface water and groundwater characterization and modelling is recommended to improve the understand of the hydrologic processes, and aid in assessing potential future impacts. Integrated groundwater and surface water modelling may be beneficial for this subwatershed.

Eramosa Above Guelph Subwatershed

The Eramosa Above Guelph subwatershed has a highly variable geologic composition. Extensive deposits of glaciofluvial ice-contact deposits are distributed throughout area, in addition to Port Stanley and Wentworth Tills. Due to the presence of the Galt and Paris Moraines, hummocky topography is extensive, comprising 36% of the subwatershed. Average annual precipitation in the subwatershed is 892 mm/y, which is lower than the watershed average of 933 mm/y. Due to the pervious soils and high percentage of hummocky topography, runoff (142 mm/y) is much lower than the watershed average and similarly, groundwater recharge (244 mm/y) is higher than the watershed average. The highest groundwater recharge rates would occur where pervious materials are deposited, or where hummocky topography increases the potential for groundwater recharge on the Galt and Paris Moraines.

There are generally no significant overburden aquifers in the subwatershed. The primary aquifer for this area is the Guelph/Gasport bedrock aquifer. Higher groundwater discharge rates are focused in the lower reaches of the Eramosa River, Blue Springs Creek and the headwaters of the Eramosa River. These results are consistent with the area supporting significant coldwater aquatic systems.

Consumptive water use in the subwatershed is relatively high due primarily to municipal demands. Average annual groundwater demand is approximately 286 L/s and average annual consumptive surface water demand is 45 L/s. Maximum monthly surface water demand is higher as a result of the City of Guelph's Eramosa River water supply intake.

Hydrological and hydrogeological conditions in the Eramosa Above Guelph subwatershed are complex due to the variable complex surficial and bedrock hydrogeology. The predicted groundwater discharge rate is within the estimated baseflow range, but further work is warranted to better understand groundwater/surface water interactions, groundwater flow through the bedrock system, and the City of Guelph's water supply. Water resources within this Subwatershed are critical to municipal drinking water supplies. The Grand River watershed steady-state groundwater-flow model is not calibrated to municipal observation well data, and as a result, the model should not be used for local or well-field scale assessments. Further calibration and conceptualization would be beneficial to better understand the regional groundwater system, and significant hydrologic processes in the subwatershed.

Speed Above Dam Subwatershed

The Speed Above Dam subwatershed is primarily composed of ice-contact stratified drift, and outwash deposits, mixed with Port Stanley Till. Orangeville Moraine deposits cover a large part of this subwatershed; however, the moraine is eroded and only 14% of the subwatershed is classified as hummocky. Precipitation for this subwatershed is 894 mm/y, which is slightly less than the watershed average of 933 mm/y. Due to the high amount of pervious materials, runoff is estimated to be 123 mm/y, which is lower than the watershed average (266 mm/y). Similarly, groundwater recharge (242 mm/y) is higher than the watershed average (176 mm/y).

Because of the extensive deposits of ice-contact and outwash deposits, upper overburden aquifers are distributed through the subwatershed. The uppermost bedrock unit in the area is the Guelph/Gasport Formation, and it is the primary aquifer for the area. Groundwater discharge is most significant in the Lutteral Creek area, a tributary of the Upper Speed River. This creek is recognized as a significant groundwater-fed coldwater stream. Other more isolated areas of groundwater discharge are found on the eastern branch of the Upper Speed River.

Consumptive water demand in the Speed Above Dam subwatershed is low. Average annual groundwater demand is 27 L/s and average annual consumptive surface water demand is 15 L/s.

Speed Above Grand to Armstrong Subwatershed

The Speed Above Grand to Armstrong subwatershed, similar to the upstream Speed Above Dam subwatershed, is primarily composed of ice-contact and outwash deposits, mixed with Port Stanley Till. Ten percent of the subwatershed is classified as hummocky. Annual precipitation for the Speed Above Grand to Dam is 889 mm/y, which is lower than the Watershed average of 933 mm/y. Due to the pervious materials and moderate level hummocky topography, runoff (156 mm/y) is much lower than the watershed average (266 mm/y) and groundwater recharge (223 mm/y) is much higher than the watershed average (176 mm/y).

Overburden aquifers are generally limited to areas of ice-contact and outwash deposits, with no significant lower overburden aquifers identified. As with other subwatersheds in this area, the primary water supply aquifer is the Guelph/Gasport bedrock aquifer. High groundwater discharge rates shown along the main Speed River, with the highest rates being predicted in the lower areas of the subwatershed.

Consumptive water use in the watershed is high due primarily to municipal water demands. Average annual groundwater demand is 831 L/s and average annual consumptive surface water demand is 28

L/s. In addition to municipal demands, other significant water users include the aggregate industry and golf courses (irrigation).

In general, the groundwater levels appear to be well calibrated. This calibration, however, does not include municipal observation wells. The Speed River is regulated by the Guelph Dam, and it is therefore difficult to develop an accurate estimate of groundwater discharge without having a series of instream baseflow measurements. The hydrogeology of the bedrock aquifer in the City of Guelph is complex, and the Grand River watershed groundwater flow model may not be fully representative of hydrogeology in or near wellfields.

Nith Above New Hamburg Subwatershed

The Nith Above New Hamburg subwatershed is similar to the Conestogo Below Dam subwatershed, in that the surficial materials are primarily Mornington Till, interspersed with ice-contact deposits. Stratford Till is also present in the southwestern portion of the subwatershed. The subwatershed encompasses the northwestern flank of the Waterloo Moraine, as well as portions of the Milverton, Macton and Easthope Moraines. As a result of these moraine deposits, a large portion of the subwatershed is classified as hummocky (27%). However, the primary surficial material over most of the hummocky areas is low permeability Mornington Till, which inhibits groundwater recharge. Precipitation for this subwatershed is 992 mm/y, which is higher than the watershed average (933 mm/y). Due to the low permeability materials present in the subwatershed, runoff (346 mm/y) is higher than the watershed average (266 mm/y) and groundwater recharge (144 mm/y) is lower than the watershed average (176 mm/y).

There are no significant upper overburden aquifers over most of the subwatershed; however more continuous deposits of surficial sands and gravels are found in the southeastern portion of the subwatershed within the Waterloo Moraine. An extension of the Dundas Valley is located within the Nith Above New Hamburg, and may also support a lower overburden aquifer. The primary bedrock aquifer is found within the Salina formation. The Nith Above New Hamburg Subwatershed has an estimated net groundwater outflow (Inter-Basin Flow) of 0.54 m^3/s to adjacent subwatersheds, and a net external groundwater outflow of 0.48 m3/s to areas beyond the Grand River watershed boundary. Groundwater discharge is generally restricted to the lower reaches of the Nith River within the subwatershed, closer to the western flank of the Waterloo Moraine.

Permitted water demands within the Nith Above New Hamburg are relatively low. Estimated average annual groundwater demand is 62 L/s and average annual consumptive surface water demand is 9 L/s.

Calibrated water levels appear to be reasonable across the subwatershed, although there are local areas within the subwatershed showing a trend of higher than observed water levels. Simulated groundwater discharge rates, however, are at the low end of the estimated baseflow range at several gauges. The result of this may be that the Inter-Basin Flow, or the amount of groundwater flow out of the watershed, is over-estimated. Since groundwater and surface water demands in the subwatershed are very small, the benefit of refining the conceptual model and calibration may not be significant.

Nith Above Grand To New Hamburg Subwatershed

The Nith Above Grand to New Hamburg subwatershed is primarily composed of outwash and ice-contact materials, mixed with lower permeability materials such as Port Stanley, Maryhill and Tavistock Tills. The subwatershed contains a large portion of the Waterloo Moraine, and therefore has 29% of the area being classified as having hummocky features. Annual precipitation for the subwatershed is 945 mm/y, consistent with the average watershed precipitation of 933 mm/y. Due to the extensive deposits of pervious materials and hummocky features, runoff (154 mm/y) is much less than the watershed average (266 mm/y), and the average groundwater recharge (284 mm/y) is much higher than the watershed average (176 mm/y).

Areas of very high groundwater recharge can be found in pervious areas containing hummocky topography on the southern flank of the Waterloo Moraine. Hummocky areas with granular materials, which drain the less permeable Maryhill Till cap, can provide estimated average annual groundwater recharge rates as high as 500 mm/y. To confirm these estimated high groundwater recharge rates, the Alder Creek groundwater study (CH2M Hill and S.S. Papadopulous, 2003) mapped localized depressions, infilled with granular material, which drain significant areas of Maryhill Till and have no drainage outlet. Very high recharge rates were estimated within these localized depressions.

Extensive upper overburden aquifers are located in this subwatershed, coinciding with the pervious surficial materials. There are also significant lower overburden aquifers in the area, particularly in the eastern portion of the subwatershed, located in the Ayr/Roseville area. The primary bedrock aquifer in the subwatershed is found within the Salina formation. Groundwater modelling results suggest a very significant net outflow of groundwater, estimated to be 0.63 m^3/s, from the Nith Above Grand to New Hamburg subwatershed. This water likely flows to the east, and partially contributes to groundwater discharge found in the Cambridge to Paris reach of the Grand River. Groundwater discharge is predicted to occur throughout the subwatershed, with particularly high discharge areas occurring along the Nith River immediately upstream of Plattsville, the lower reaches of Alder Creek, the Nith River near Ayr, Cedar Creek, and the lower Nith River near Paris.

Water demand is high in this subwatershed, with the largest water users including municipal supplies, aggregate washing, golf course and agricultural irrigation. Estimated average annual groundwater pumping is 513 L/s and average annual consumptive surface water demand is 29 L/s.

Whitemans Creek Subwatershed

The Whitemans Creek subwatershed is highly variable in terms of surficial materials, with Tavistock and Port Stanley Tills in the headwaters, and outwash and glaciolacustrine shallow water deposits in the lower reaches of the subwatershed. Topography is generally flat, with 7% of the subwatershed area containing hummocky features. Average annual precipitation for this subwatershed is 945 mm/y. Due to the high permeability materials in the middle and lower reaches of the subwatershed, runoff (176 mm/y) is much lower than the watershed average (266 mm/y) and groundwater recharge (257 mm/y) is greater than the watershed average (176 mm/y). Due to the highly variable surficial materials, hydrologic conditions are variable across the subwatershed, with the headwaters being runoff dominated and the lower subwatershed having higher amounts of groundwater recharge.

There is an extensive unconfined overburden aquifer throughout much of the lower subwatershed, where the Norfolk Sand Plain is present. In areas composed of Tavistock and Port Stanley Till, there are no significant overburden aquifers. Bedrock aquifers range from the Salina formation in the eastern portions of the subwatershed, to Bass Island/Bertie Formation in the western portions. Groundwater discharge is most significant in the lower sections of Whitemans Creek, downstream of Burford, and the middle reach of Horner Creek, immediately upstream of Princeton.

Water use within Whitemans' Creek is high, with maximum permitted groundwater takings equal to 3,543 L/s and maximum permitted surface water takings equal to 1,304 L/s. The main water use in Whitemans Creek is agricultural irrigation, and therefore water taking is seasonal in nature. Estimated maximum and average annual groundwater pumping is 465 L/s and 117 L/s, respectively. Similarly, maximum monthly and average annual consumptive surface water demand is 218 L/s and 51 L/s, respectively.

Calibrated water levels appear reasonable in the Norfolk Sand Plain portion of the watershed, however simulated water levels are higher than observed in the till areas, The predicted groundwater discharge rate is within the estimated baseflow range. Any future local-scale impact assessments may require refinements to the conceptual model and consideration of seasonal/transient groundwater flow conditions. An integrated surface water and groundwater flow model may be beneficial.

McKenzie Creek Subwatershed

Similar to the Grand Above York to Brantford subwatershed, the McKenzie Creek subwatershed is characterized by the low permeability surficial materials of the Haldimand Clay plain. In the upper reaches of McKenzie Creek there are sand deposits associated with the Norfolk Sand Plain. There are no areas within McKenzie Creek that are classified as hummocky topography. Precipitation for this subwatershed is 945 mm/y, which is similar to the average watershed precipitation of 933 mm/y. Due to the prevalence of low permeability materials over the majority of the subwatershed, runoff is estimated to be 337 mm/y, which is higher than the watershed average (266 mm/y) and groundwater recharge (127 mm/y) is lower than the watershed average (176 mm/y). Groundwater recharge rates for pervious areas in the upper reaches are higher.

Overburden aquifers are limited to the upper reaches of the subwatershed, where the Norfolk Sand Plain forms an unconfined overburden aquifer. Bedrock aquifers are the main source of groundwater for this area, with the Guelph Formation forming the main bedrock aquifer in the east, and the Salina Formation forming the bedrock aquifer in the west. Higher groundwater discharge rates are simulated in the upper reaches of McKenzie Creek, where pervious materials are most prevalent.

Similar to Whitemans Creek Subwatershed, water demand is relatively high and seasonally variable, mostly due to agriculture demands. Estimated maximum monthly and average annual groundwater pumping is 223 L/s and 53 L/s, respectively. Maximum monthly and average annual consumptive surface water demand is 108 L/s and 29 L/s, respectively.

Calibrated water levels appear to be reasonable, and simulated groundwater discharge matches well with observed baseflow estimates. The results indicate that the water demands are relatively high in relation to water supply in this subwatershed. In addition, there are historical observations of hydrologic stress due to low streamflow. Due to the seasonal water use sectors active in the subwatershed, any future local-scale impact assessments may need to consider seasonal/transient groundwater in consideration of the shallow system and seasonal groundwater discharge variability. Furthermore, an integrated groundwater/surface water flow model may be useful in better representing the hydrology and hydrogeology of this subwatershed.

Fairchild Creek Subwatershed

The Fairchild Creek subwatershed is composed primarily of low permeability materials associated with the Haldimand Clay plain, exposed bedrock in the Rockton Bedrock Plain, and veneers of shallow water glaciolacustrine deposits. In the upper reaches of the subwatershed, Fairchild Creek has some areas of Wentworth Till and hummocky topography where the Galt Moraine intersects the subwatershed. Precipitation for this subwatershed is 866 mm/y, which lower than the average watershed precipitation of 933 mm/y. Runoff is estimated to be 263 mm/y, which is similar to the watershed average (266 mm/y) and groundwater recharge (135 mm/y) is lower than the Watershed average (176 mm/y). These results are expected given the amount of low permeability soils in the subwatershed.

There are no significant upper overburden aquifers in the subwatershed. While localized, unconfined aquifers exist in pervious deposits, they are no regionally significant. Bedrock aquifers (Guelph

Formation) are the primary groundwater sources. Simulated groundwater discharge rates show higher groundwater discharge in the headwaters of the creek.

Consumptive water demand in the subwatershed is relatively low. Estimated average annual groundwater demand is 92 L/s and average annual surface water consumptive demand is 22 L/s.

Grand Above York To Brantford Subwatershed

The Grand Above York to Brantford subwatershed is characterized by the low permeability soils of the Haldimand clay plain and the sand deposits associated with the Norfolk Sand Plain in the upper reaches. Precipitation for this subwatershed is 896 mm/y, which is below average watershed precipitation of 933 mm/y. Due to the prevalence of low permeability materials over the majority of the subwatershed, runoff (284 mm/y) is higher than the watershed average (266 mm/y) and groundwater recharge (118 mm/y) is lower than the watershed average (176 mm/y). Areas in the upstream reaches of the subwatershed containing granular materials, such as Mt. Pleasant Creek, are estimated to have groundwater recharge rates higher than the subwatershed average.

There are limited overburden aquifers with the majority of the subwatershed being composed of a massive laminated lacustrine deposit. Unconfined aquifers would be found in the areas in the upper reaches having pervious surficial materials. The bedrock aquifer is the primary water bearing unit for much of the subwatershed, with the Guelph formation being predominant in the eastern portions, and the Salina formation in the west. The Grand Above York to Brantford subwatershed receives a net groundwater inflow (Inter-Basin Flow) of approximately 0.70 m^3/s from adjacent subwatersheds as part of the regional groundwater flow system. Highest groundwater discharge rates are located in the upstream reaches of the subwatershed.

Water use in the Grand Above York to Brantford subwatershed is relatively high. Major water users include municipal supplies, aggregate washing, and agricultural irrigation. Average annual groundwater pumping is approximately 227 L/s and average annual surface water consumptive demand is 145 L/s. The Brantford and Six Nations municipal surface intakes are located in the subwatershed and represent the largest surface water demands.

Grand Above Dunnville To York Subwatershed

The Grand Above Dunnville to York subwatershed is characterized by the low permeability surficial materials of the Haldimand Clay plain. There is also a thin localized deposit of outwash sands located near Dunnville. Average annual precipitation is 945 mm/y and evapotranspiration is 465 mm. Due to the amount of low permeability materials over the subwatershed, average annual runoff is estimated to be 392 mm/y, which is much higher than the watershed average (266 mm/y). Similarly, groundwater recharge (89 mm/y) is much lower than the watershed average (176 mm/y).

There are no significant overburden aquifers expected within the Grand Above Dunnville to York subwatershed. Many of the current domestic wells are completed within the Salina bedrock formation.

Water use is relatively low in the Grand Above Dunnville to York subwatershed. Average annual groundwater demand is 91 L/s and average annual consumptive surface water demand is 21 L/s. There are no local baseflow estimates to compare against calibrated values; however, the impact of groundwater discharge to baseflow in the Grand River is considered to be minor in this subwatershed.

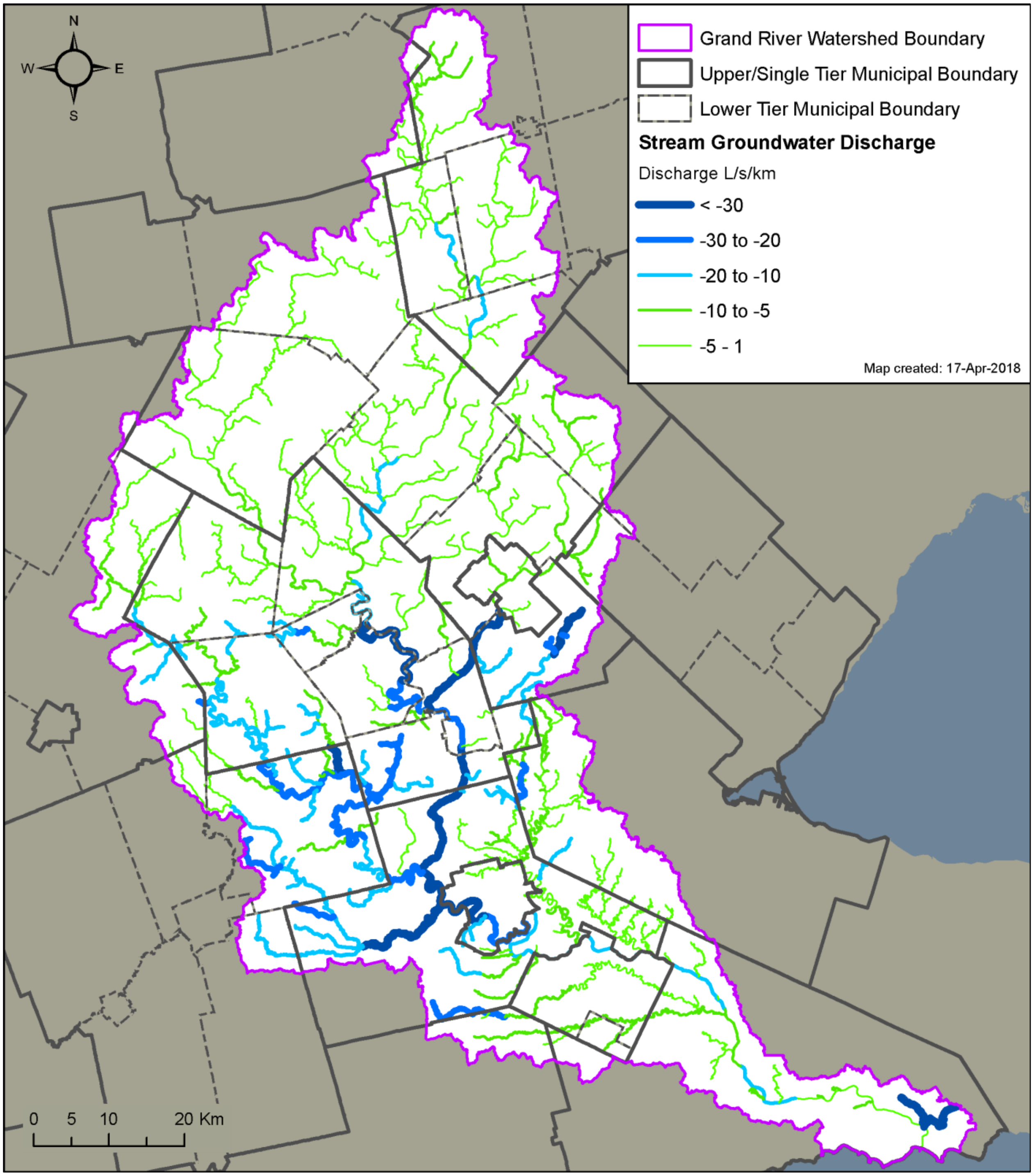
Calibrated groundwater levels tend to be higher than observed; however, due to groundwater and surface water demands being relatively low in the watershed, further calibration and conceptualization may not be warranted.

Interactions between Groundwater and Surface Water

The calibrated groundwater model provided~~s~~ a synthesis of available information that ~~can be~~was used to increase the understanding about the groundwater flow system and its interaction with the surface water system. Map 18-2 presents the simulated distribution of groundwater discharge flux to the higher order streams and rivers throughout the Grand River Watershed.

The headwater regions primarily receive smaller discharge volumes than other parts of the watershed. The highest groundwater discharge rates occur in major stream reaches in low lying areas through the middle of the watershed, such as between Cambridge and Paris. These areas of discharge aid in allowing the stream to recover after impacts from the large urban parts of the watershed. Groundwater discharge is low through the tight soils of the Haldimand Clay Plain in the lower part of the watershed although the main river may still be gaining water from groundwater discharge. The results from the calibrated groundwater model are similar to the delineation of cold and cool water streams which are another ~~way~~ method of identifying groundwater discharge on a regional scale.

Map 18-2: Groundwater Discharge Map in the Grand River Watershed



~~18.5~~18.4 Tier 2 Water Quantity Stress Assessment

All subwatersheds within the Grand River watershed were evaluated at the Tier 2 level for water quantity potential stress for both groundwater and surface water using the percent water demand calculation given below. Subwatersheds with either a '*moderate'* or '*significant'* potential for stress and a municipal drinking water system are recommended to have a Tier 3 Water Quantity Risk Assessment completed.

$$\textit{Percent Water Demand} = \frac{Q_{DEMAND}}{Q_{SUPPLY} - Q_{RESERVE}} \times 100\%$$

A *Moderate* or *Significant* potential for stress for a subwatershed does not necessarily imply that the subwatershed is experiencing local hydrologic or ecologic stress. This classification indicates where additional information is required to understand local water supply sustainability and potential cumulative impacts of water withdrawals.

Surface Water Stress Assessment

~~All Grand River Source Protection Area subwatersheds were evaluated at the Tier 2 level for water quantity potential stress for both groundwater and surface water using the percent water demand calculation given below. Subwatersheds with either a 'moderate' or 'significant' potential for stress and a municipal drinking water system would then be recommended to have a Tier 3 Water Quantity Risk Assessment conducted.~~

~~$\textit{Percent Water Demand} = \frac{Q_{DEMAND}}{Q_{SUPPLY} - Q_{RESERVE}} \times 100\%$~~

~~Being classified as having a Moderate or Significant potential for stress does not necessarily imply that a subwatershed is experiencing local hydrologic or ecologic stress. This classification indicates where additional information is required to understand local water supply sustainability and potential cumulative impacts of water withdrawals.~~

~~18.6 Section SummarySurface Water Stress Assessment~~

~~For surface water systems, the percent water demand equation is carried out using monthly estimates. The maximum Percent Water Demand for all months is then used to categorize the surface water quantity potential for stress into one of three levels; Significant, Moderate or Low (see **Table** 18-19).~~

~~Table 18-19: Surface Water Potential Stress Thresholds~~

~~Surface Water Potential Stress Level Assignment~~	**~~Maximum Monthly % Water Demand~~**
~~Significant~~	~~> 50%~~
~~Moderate~~	~~20% - 50%~~
~~Low~~	~~<20 %~~

~~18.6.1 Existing Conditions Percent Water Demand~~

~~The monthly unit consumptive surface water demand estimates are shown in **Table** 18-20 for each subwatershed and were calculated as described in the Water Use Section. The total consumptive demand for each subwatershed is calculated from a combination of reported and estimated pumping rates.~~

~~Table 18-20: Surface Water Unit Consumptive Demands (L/s)~~

~~Subwatershed~~		~~Jan~~	~~Feb~~	~~Mar~~	~~Apr~~	~~May~~	~~Jun~~	~~Jul~~	~~Aug~~	~~Sep~~	~~Oct~~	~~Nov~~	~~Dec~~
~~Grand Above Legatt~~	~~Reported~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~
	~~Estimated~~	~~2~~	~~2~~	~~2~~	~~2~~	~~2~~	~~2~~	~~2~~	~~2~~	~~2~~	~~2~~	~~2~~	~~2~~
	~~Total~~	~~2~~	~~2~~	~~2~~	~~2~~	~~2~~	~~2~~	~~2~~	~~2~~	~~2~~	~~2~~	~~2~~	~~2~~
~~Grand Above Shand to Legatt~~	~~Reported~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~
	~~Estimated~~	~~3~~	~~3~~	~~3~~	~~3~~	~~3~~	~~3~~	~~3~~	~~3~~	~~3~~	~~3~~	~~3~~	~~3~~
	~~Total~~	~~3~~	~~3~~	~~3~~	~~3~~	~~3~~	~~3~~	~~3~~	~~3~~	~~3~~	~~3~~	~~3~~	~~3~~
~~Grand Above Conestogo to Shand~~	~~Reported~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~
	~~Estimated~~	~~22~~	~~22~~	~~22~~	~~22~~	~~22~~	~~34~~	~~35~~	~~34~~	~~33~~	~~22~~	~~22~~	~~22~~
	~~Total~~	~~22~~	~~22~~	~~22~~	~~22~~	~~22~~	~~34~~	~~35~~	~~34~~	~~33~~	~~22~~	~~22~~	~~22~~
~~Conestogo Above Dam~~	~~Reported~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~
	~~Estimated~~	~~12~~	~~12~~	~~12~~	~~12~~	~~12~~	~~12~~	~~12~~	~~12~~	~~12~~	~~12~~	~~12~~	~~12~~
	~~Total~~	~~12~~	~~12~~	~~12~~	~~12~~	~~12~~	~~12~~	~~12~~	~~12~~	~~12~~	~~12~~	~~12~~	~~12~~
~~Conestogo Below Dam~~	~~Reported~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~
	~~Estimated~~	~~13~~	~~13~~	~~13~~	~~13~~	~~13~~	~~13~~	~~13~~	~~13~~	~~13~~	~~13~~	~~13~~	~~13~~
	~~Total~~	~~13~~	~~13~~	~~13~~	~~13~~	~~13~~	~~13~~	~~13~~	~~13~~	~~13~~	~~13~~	~~13~~	~~13~~
~~Grand Above Doon to Conestogo~~	~~Reported~~	~~111~~	~~102~~	~~107~~	~~99~~	~~119~~	~~118~~	~~107~~	~~112~~	~~112~~	~~109~~	~~106~~	~~109~~
	~~Estimated~~	~~4~~	~~4~~	~~4~~	~~4~~	~~4~~	~~15~~	~~15~~	~~15~~	~~15~~	~~4~~	~~4~~	~~4~~
	~~Total~~	~~115~~	~~106~~	~~111~~	~~102~~	~~123~~	~~133~~	~~122~~	~~127~~	~~126~~	~~113~~	~~110~~	~~113~~
~~Eramosa Above Guelph~~	~~Reported~~	~~0~~	~~0~~	~~0~~	~~28~~	~~55~~	~~71~~	~~62~~	~~55~~	~~54~~	~~51~~	~~6~~	~~0~~
	~~Estimated~~	~~5~~	~~5~~	~~5~~	~~5~~	~~5~~	~~30~~	~~31~~	~~30~~	~~30~~	~~5~~	~~5~~	~~5~~
	~~Total~~	~~5~~	~~5~~	~~5~~	~~33~~	~~60~~	~~101~~	~~93~~	~~85~~	~~83~~	~~56~~	~~12~~	~~5~~
~~Speed Above Dam~~	~~Reported~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~
	~~Estimated~~	~~14~~	~~14~~	~~14~~	~~14~~	~~14~~	~~17~~	~~17~~	~~17~~	~~17~~	~~14~~	~~14~~	~~14~~
	~~Total~~	~~14~~	~~14~~	~~14~~	~~14~~	~~14~~	~~17~~	~~17~~	~~17~~	~~17~~	~~14~~	~~14~~	~~14~~
~~Speed Above Grand to Dam~~	~~Reported~~	~~0~~	~~0~~	~~0~~	~~1~~	~~10~~	~~23~~	~~24~~	~~18~~	~~9~~	~~1~~	~~0~~	~~0~~
	~~Estimated~~	~~17~~	~~17~~	~~17~~	~~17~~	~~17~~	~~27~~	~~31~~	~~27~~	~~23~~	~~17~~	~~17~~	~~17~~
	~~Total~~	~~17~~	~~17~~	~~17~~	~~18~~	~~28~~	~~50~~	~~55~~	~~45~~	~~32~~	~~19~~	~~17~~	~~17~~
~~Mill Creek~~	~~Reported~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~
	~~Estimated~~	~~1~~	~~1~~	~~1~~	~~1~~	~~1~~	~~1~~	~~1~~	~~1~~	~~1~~	~~1~~	~~1~~	~~1~~
	~~Total~~	~~1~~	~~1~~	~~1~~	~~1~~	~~1~~	~~1~~	~~1~~	~~1~~	~~1~~	~~1~~	~~1~~	~~1~~
~~Grand Above Brantford to Doon~~	~~Reported~~	~~0~~	~~0~~	~~0~~	~~0~~	~~4~~	~~8~~	~~4~~	~~4~~	~~5~~	~~0~~	~~0~~	~~0~~
	~~Estimated~~	~~4~~	~~4~~	~~4~~	~~4~~	~~14~~	~~55~~	~~55~~	~~55~~	~~55~~	~~14~~	~~14~~	~~4~~
	~~Total~~	~~4~~	~~4~~	~~4~~	~~4~~	~~18~~	~~63~~	~~60~~	~~60~~	~~59~~	~~14~~	~~14~~	~~4~~
~~Nith Above New Hamburg~~	~~Reported~~	~~0~~	~~0~~	~~0~~	~~0~~	~~2~~	~~4~~	~~3~~	~~3~~	~~2~~	~~0~~	~~0~~	~~0~~
	~~Estimated~~	~~7~~	~~7~~	~~7~~	~~7~~	~~7~~	~~8~~	~~9~~	~~8~~	~~8~~	~~7~~	~~7~~	~~7~~
	~~Total~~	~~7~~	~~7~~	~~7~~	~~7~~	~~9~~	~~13~~	~~12~~	~~11~~	~~10~~	~~7~~	~~7~~	~~7~~
~~Nith Above Grand to New Hamburg~~	~~Reported~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~
	~~Estimated~~	~~16~~	~~16~~	~~16~~	~~16~~	~~16~~	~~55~~	~~71~~	~~55~~	~~38~~	~~16~~	~~16~~	~~16~~
	~~Total~~	~~16~~	~~16~~	~~16~~	~~16~~	~~16~~	~~55~~	~~71~~	~~55~~	~~38~~	~~16~~	~~16~~	~~16~~
~~Whitemans Creek~~	~~Reported~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~1~~	~~8~~	~~3~~	~~0~~	~~0~~	~~0~~	~~0~~
	~~Estimated~~	~~4~~	~~4~~	~~4~~	~~4~~	~~4~~	~~141~~	~~210~~	~~141~~	~~73~~	~~4~~	~~4~~	~~4~~
	~~Total~~	~~4~~	~~4~~	~~4~~	~~4~~	~~4~~	~~142~~	~~218~~	~~144~~	~~73~~	~~4~~	~~4~~	~~4~~
~~Grand Above York to Brantford~~	~~Reported~~	~~102~~	~~102~~	~~100~~	~~110~~	~~114~~	~~135~~	~~137~~	~~128~~	~~113~~	~~113~~	~~104~~	~~100~~
	~~Estimated~~	~~6~~	~~6~~	~~6~~	~~6~~	~~6~~	~~84~~	~~108~~	~~84~~	~~60~~	~~6~~	~~6~~	~~6~~
	~~Total~~	~~108~~	~~108~~	~~105~~	~~115~~	~~120~~	~~219~~	~~245~~	~~212~~	~~173~~	~~118~~	~~109~~	~~105~~
~~Fairchild Creek~~	~~Reported~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~
	~~Estimated~~	~~9~~	~~9~~	~~9~~	~~9~~	~~9~~	~~46~~	~~56~~	~~46~~	~~36~~	~~9~~	~~9~~	~~9~~
	~~Total~~	~~9~~	~~9~~	~~9~~	~~9~~	~~9~~	~~46~~	~~56~~	~~46~~	~~36~~	~~9~~	~~9~~	~~9~~
~~McKenzie Creek~~	~~Reported~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~3~~	~~5~~	~~3~~	~~1~~	~~0~~	~~0~~	~~0~~
	~~Estimated~~	~~3~~	~~3~~	~~3~~	~~3~~	~~3~~	~~73~~	~~103~~	~~73~~	~~43~~	~~3~~	~~3~~	~~3~~
	~~Total~~	~~3~~	~~3~~	~~3~~	~~3~~	~~3~~	~~76~~	~~108~~	~~76~~	~~44~~	~~3~~	~~3~~	~~3~~
~~Grand Above Dunnville to York~~	~~Reported~~	~~0~~	~~0~~	~~0~~	~~0~~	~~10~~	~~34~~	~~34~~	~~34~~	~~30~~	~~0~~	~~0~~	~~0~~
	~~Estimated~~	~~2~~	~~2~~	~~2~~	~~2~~	~~2~~	~~24~~	~~36~~	~~24~~	~~13~~	~~2~~	~~2~~	~~2~~
	~~Total~~	~~2~~	~~2~~	~~2~~	~~2~~	~~11~~	~~58~~	~~70~~	~~58~~	~~42~~	~~2~~	~~2~~	~~2~~

~~The monthly Q_{SUPPLY} (Median Flow) and $Q_{RESERVE}$ (90th percentile flow) were calculated using hydrologic model predicted streamflow at the outfall of each subwatershed for the period 1980-1999. This time period was selected because reservoir operating procedures prior to 1980 were different than they are now, and therefore the flow regime may not represent current conditions.~~ ~~**Table** 18-23 shows the supply and reserve terms, in addition to their difference, used in the Stress Assessment equation (Q_{SUPPLY} - $Q_{RESERVE}$).~~

~~Table 18-21: Surface Water Supply Flows (L/s)~~

~~Subwatershed~~	~~Term~~	~~Jan~~	~~Feb~~	~~Mar~~	~~Apr~~	~~May~~	~~Jun~~	~~Jul~~	~~Aug~~	~~Sep~~	~~Oct~~	~~Nov~~	~~Dec~~
~~Grand Above Legatt~~	~~Q_{SUPPLY}~~	~~2,620~~	~~2,050~~	~~3,660~~	~~6,860~~	~~3,560~~	~~2,420~~	~~1,250~~	~~1,010~~	~~1,290~~	~~3,910~~	~~5,010~~	~~3,570~~
	~~$Q_{RESERVE}$~~	~~1,730~~	~~1,230~~	~~1,790~~	~~3,160~~	~~2,300~~	~~1,170~~	~~810~~	~~660~~	~~590~~	~~910~~	~~2,640~~	~~2,680~~
	~~Difference~~	~~890~~	~~820~~	~~1,870~~	~~3,700~~	~~1,260~~	~~1,250~~	~~440~~	~~350~~	~~700~~	~~3,000~~	~~2,370~~	~~890~~
~~Grand Above Shand to Legatt~~	~~Q_{SUPPLY}~~	~~4,100~~	~~3,230~~	~~7,290~~	~~15,860~~	~~5,470~~	~~4,020~~	~~2,050~~	~~1,550~~	~~2,240~~	~~6,700~~	~~9,400~~	~~5,540~~
	~~$Q_{RESERVE}$~~	~~2,840~~	~~2,000~~	~~2,880~~	~~4,760~~	~~3,580~~	~~2,000~~	~~1,180~~	~~870~~	~~800~~	~~1,670~~	~~4,140~~	~~4,140~~
	~~Difference~~	~~1,260~~	~~1,230~~	~~4,410~~	~~11,100~~	~~1,890~~	~~2,020~~	~~870~~	~~680~~	~~1,440~~	~~5,030~~	~~5,260~~	~~1,400~~
~~Grand Above Conestogo to Shand~~	~~Q_{SUPPLY}~~	~~11,520~~	~~8,990~~	~~16,320~~	~~19,800~~	~~8,960~~	~~7,400~~	~~6,290~~	~~6,260~~	~~6,180~~	~~9,350~~	~~14,470~~	~~13,560~~
	~~$Q_{RESERVE}$~~	~~6,550~~	~~5,070~~	~~7,030~~	~~9,250~~	~~6,540~~	~~5,500~~	~~5,160~~	~~4,590~~	~~4,330~~	~~4,070~~	~~5,540~~	~~7,190~~
	~~Difference~~	~~4,970~~	~~3,920~~	~~9,290~~	~~10,550~~	~~2,420~~	~~1,900~~	~~1,130~~	~~1,670~~	~~1,850~~	~~5,280~~	~~8,930~~	~~6,370~~
~~Conestogo Above Dam~~	~~Q_{SUPPLY}~~	~~2,610~~	~~2,050~~	~~5,400~~	~~6,920~~	~~2,990~~	~~1,700~~	~~590~~	~~380~~	~~500~~	~~2,950~~	~~4,530~~	~~3,410~~
	~~$Q_{RESERVE}$~~	~~1,500~~	~~1,190~~	~~1,870~~	~~2,610~~	~~1,180~~	~~320~~	~~180~~	~~100~~	~~80~~	~~90~~	~~510~~	~~1,930~~
	~~Difference~~	~~1,110~~	~~860~~	~~3,530~~	~~4,310~~	~~1,810~~	~~1,380~~	~~410~~	~~280~~	~~420~~	~~2,860~~	~~4,020~~	~~1,480~~
~~Conestogo Below Dam~~	~~Q_{SUPPLY}~~	~~5,830~~	~~4,180~~	~~10,150~~	~~9,950~~	~~4,520~~	~~4,580~~	~~4,380~~	~~4,910~~	~~4,690~~	~~6,150~~	~~11,830~~	~~12,350~~
	~~$Q_{RESERVE}$~~	~~2,600~~	~~1,360~~	~~2,550~~	~~3,860~~	~~3,480~~	~~3,350~~	~~3,540~~	~~3,610~~	~~3,340~~	~~3,420~~	~~4,300~~	~~5,540~~
	~~Difference~~	~~3,230~~	~~2,820~~	~~7,600~~	~~6,090~~	~~1,040~~	~~1,230~~	~~840~~	~~1,300~~	~~1,350~~	~~2,730~~	~~7,530~~	~~6,810~~
~~Grand Above Doon to Conestogo~~	~~Q_{SUPPLY}~~	~~20,600~~	~~16,330~~	~~31,700~~	~~35,920~~	~~16,810~~	~~14,800~~	~~12,860~~	~~13,580~~	~~13,480~~	~~17,120~~	~~30,940~~	~~29,090~~
	~~$Q_{RESERVE}$~~	~~11,120~~	~~8,830~~	~~12,790~~	~~16,500~~	~~13,030~~	~~11,150~~	~~11,010~~	~~10,930~~	~~9,800~~	~~10,050~~	~~12,850~~	~~17,550~~
	~~Difference~~	~~9,480~~	~~7,500~~	~~18,910~~	~~19,420~~	~~3,780~~	~~3,650~~	~~1,850~~	~~2,650~~	~~3,680~~	~~7,070~~	~~18,090~~	~~11,540~~
~~Eramosa Above Guelph~~	~~Q_{SUPPLY}~~	~~2,350~~	~~2,060~~	~~2,660~~	~~2,960~~	~~2,500~~	~~1,780~~	~~1,120~~	~~830~~	~~780~~	~~1,250~~	~~2,430~~	~~2,440~~
	~~$Q_{RESERVE}$~~	~~1,280~~	~~1,140~~	~~1,750~~	~~2,090~~	~~1,650~~	~~880~~	~~610~~	~~490~~	~~430~~	~~440~~	~~750~~	~~1,210~~
	~~Difference~~	~~1,070~~	~~920~~	~~910~~	~~870~~	~~850~~	~~900~~	~~510~~	~~340~~	~~350~~	~~810~~	~~1,680~~	~~1,230~~
~~Speed Above Dam~~	~~Q_{SUPPLY}~~	~~2,430~~	~~2,080~~	~~2,410~~	~~2,840~~	~~2,360~~	~~1,420~~	~~690~~	~~450~~	~~400~~	~~1,070~~	~~2,680~~	~~2,830~~
	~~$Q_{RESERVE}$~~	~~1,160~~	~~1,090~~	~~1,620~~	~~2,140~~	~~1,320~~	~~560~~	~~330~~	~~260~~	~~200~~	~~190~~	~~410~~	~~940~~
	~~Difference~~	~~1,270~~	~~990~~	~~790~~	~~700~~	~~1,040~~	~~860~~	~~360~~	~~190~~	~~200~~	~~880~~	~~2,270~~	~~1,890~~
~~Speed Above Grand to Dam~~	~~Q_{SUPPLY}~~	~~7,900~~	~~6,620~~	~~9,190~~	~~11,640~~	~~7,590~~	~~5,490~~	~~3,700~~	~~3,090~~	~~3,330~~	~~4,530~~	~~7,450~~	~~7,910~~
	~~$Q_{RESERVE}$~~	~~4,260~~	~~4,090~~	~~5,160~~	~~6,940~~	~~4,700~~	~~3,220~~	~~2,630~~	~~2,430~~	~~2,380~~	~~2,250~~	~~2,780~~	~~4,330~~
	~~Difference~~	~~3,640~~	~~2,530~~	~~4,030~~	~~4,700~~	~~2,890~~	~~2,270~~	~~1,070~~	~~660~~	~~950~~	~~2,280~~	~~4,670~~	~~3,580~~
~~Mill Creek~~	~~Q_{SUPPLY}~~	~~900~~	~~870~~	~~1,070~~	~~1,310~~	~~1,160~~	~~710~~	~~310~~	~~160~~	~~150~~	~~330~~	~~710~~	~~950~~
	~~$Q_{RESERVE}$~~	~~450~~	~~360~~	~~630~~	~~820~~	~~610~~	~~240~~	~~110~~	~~50~~	~~30~~	~~30~~	~~90~~	~~400~~
	~~Difference~~	~~450~~	~~510~~	~~440~~	~~490~~	~~550~~	~~470~~	~~200~~	~~110~~	~~120~~	~~300~~	~~620~~	~~550~~
~~Grand Above Brantford to Doon~~	~~Q_{SUPPLY}~~	~~45,410~~	~~39,890~~	~~70,670~~	~~79,260~~	~~41,850~~	~~32,570~~	~~25,100~~	~~24,110~~	~~25,130~~	~~35,690~~	~~58,340~~	~~59,760~~
	~~$Q_{RESERVE}$~~	~~28,080~~	~~22,990~~	~~32,980~~	~~40,640~~	~~29,880~~	~~21,590~~	~~19,920~~	~~19,770~~	~~17,690~~	~~17,920~~	~~23,300~~	~~38,380~~
	~~Difference~~	~~17,330~~	~~16,900~~	~~37,690~~	~~38,620~~	~~11,970~~	~~10,980~~	~~5,180~~	~~4,340~~	~~7,440~~	~~17,770~~	~~35,040~~	~~21,380~~
~~Nith Above New Hamburg~~	~~Q_{SUPPLY}~~	~~3,180~~	~~2,510~~	~~8,110~~	~~9,170~~	~~3,130~~	~~1,290~~	~~550~~	~~260~~	~~360~~	~~2,810~~	~~4,770~~	~~4,110~~
	~~$Q_{RESERVE}$~~	~~2,400~~	~~1,830~~	~~2,420~~	~~2,810~~	~~1,460~~	~~530~~	~~210~~	~~90~~	~~60~~	~~80~~	~~500~~	~~3,040~~
	~~Difference~~	~~780~~	~~680~~	~~5,690~~	~~6,360~~	~~1,670~~	~~760~~	~~340~~	~~170~~	~~300~~	~~2,730~~	~~4,270~~	~~1,070~~
~~Nith Above Grand to New Hamburg~~	~~Q_{SUPPLY}~~	~~9,480~~	~~8,400~~	~~16,530~~	~~17,970~~	~~9,200~~	~~5,460~~	~~3,570~~	~~3,400~~	~~3,610~~	~~6,730~~	~~12,200~~	~~11,980~~
	~~$Q_{RESERVE}$~~	~~7,000~~	~~5,980~~	~~7,720~~	~~8,700~~	~~5,650~~	~~3,240~~	~~2,600~~	~~2,370~~	~~2,280~~	~~2,400~~	~~3,230~~	~~8,590~~

~~Table 18-21: Surface Water Supply Flows (L/s)~~

~~**Subwatershed**~~	~~**Term**~~	~~**Jan**~~	~~**Feb**~~	~~**Mar**~~	~~**Apr**~~	~~**May**~~	~~**Jun**~~	~~**Jul**~~	~~**Aug**~~	~~**Sep**~~	~~**Oct**~~	~~**Nov**~~	~~**Dec**~~
	~~Difference~~	~~2,480~~	~~2,420~~	~~8,810~~	~~9,270~~	~~3,550~~	~~2,220~~	~~970~~	~~1,030~~	~~1,330~~	~~4,330~~	~~8,970~~	~~3,390~~
~~Whitemans Creek~~	~~Q_{SUPPLY}~~	~~4,870~~	~~4,160~~	~~5,490~~	~~5,940~~	~~4,470~~	~~1,870~~	~~790~~	~~930~~	~~1,060~~	~~2,380~~	~~4,870~~	~~5,490~~
	~~$Q_{RESERVE}$~~	~~2,730~~	~~2,190~~	~~3,530~~	~~3,660~~	~~2,020~~	~~540~~	~~210~~	~~110~~	~~70~~	~~120~~	~~620~~	~~3,480~~
	~~Difference~~	~~2,140~~	~~1,970~~	~~1,960~~	~~2,280~~	~~2,450~~	~~1,330~~	~~580~~	~~820~~	~~990~~	~~2,260~~	~~4,250~~	~~2,010~~
~~Grand Above York to Brantford~~	~~Q_{SUPPLY}~~	~~58,160~~	~~51,270~~	~~90,900~~	~~102,280~~	~~52,780~~	~~39,490~~	~~29,940~~	~~28,980~~	~~29,620~~	~~43,120~~	~~70,810~~	~~77,620~~
	~~$Q_{RESERVE}$~~	~~35,520~~	~~31,130~~	~~43,640~~	~~51,840~~	~~35,700~~	~~24,680~~	~~21,710~~	~~21,780~~	~~19,450~~	~~19,340~~	~~27,390~~	~~49,010~~
	~~Difference~~	~~22,640~~	~~20,140~~	~~47,260~~	~~50,440~~	~~17,080~~	~~14,810~~	~~8,230~~	~~7,200~~	~~10,170~~	~~23,780~~	~~43,420~~	~~28,610~~
~~Fairchild Creek~~	~~Q_{SUPPLY}~~	~~2,830~~	~~2,710~~	~~5,040~~	~~3,760~~	~~2,410~~	~~1,330~~	~~900~~	~~1,130~~	~~1,140~~	~~2,180~~	~~2,970~~	~~3,730~~
	~~$Q_{RESERVE}$~~	~~1,410~~	~~1,360~~	~~2,190~~	~~2,220~~	~~870~~	~~130~~	~~60~~	~~70~~	~~100~~	~~140~~	~~350~~	~~1,660~~
	~~Difference~~	~~1,420~~	~~1,350~~	~~2,850~~	~~1,540~~	~~1,540~~	~~1,200~~	~~840~~	~~1,060~~	~~1,040~~	~~2,040~~	~~2,620~~	~~2,070~~
~~McKenzie Creek~~	~~Q_{SUPPLY}~~	~~2,260~~	~~2,240~~	~~4,510~~	~~3,660~~	~~1,760~~	~~1,010~~	~~500~~	~~380~~	~~470~~	~~1,500~~	~~4,160~~	~~3,750~~
	~~$Q_{RESERVE}$~~	~~1,400~~	~~1,280~~	~~1,690~~	~~1,690~~	~~840~~	~~250~~	~~90~~	~~50~~	~~40~~	~~100~~	~~1,090~~	~~1,540~~
	~~Difference~~	~~860~~	~~960~~	~~2,820~~	~~1,970~~	~~920~~	~~760~~	~~410~~	~~330~~	~~430~~	~~1,400~~	~~3,070~~	~~2,210~~
~~Grand Above Dunnville to York~~	~~Q_{SUPPLY}~~	~~64,440~~	~~56,820~~	~~101,100~~	~~117,220~~	~~56,770~~	~~43,330~~	~~33,720~~	~~31,160~~	~~31,750~~	~~47,910~~	~~83,030~~	~~90,710~~
	~~$Q_{RESERVE}$~~	~~39,860~~	~~35,040~~	~~48,810~~	~~56,670~~	~~39,050~~	~~26,010~~	~~23,270~~	~~22,580~~	~~20,280~~	~~20,140~~	~~30,230~~	~~55,360~~
	~~Difference~~	~~24,580~~	~~21,780~~	~~52,290~~	~~60,550~~	~~17,720~~	~~17,320~~	~~10,450~~	~~8,580~~	~~11,470~~	~~27,770~~	~~52,800~~	~~35,350~~

~~Monthly Percent Water Demand for surface water is calculated using the Percent Water Demand equation, as well as the values shown in **Table** 18-20 and **Table** 18-23. The results of this calculation are included in **Table** 18-22.~~

~~Table 18-22: Percent Water Demand Estimate (Surface Water)~~

~~Subwatershed~~	~~Jan~~	~~Feb~~	~~Mar~~	~~Apr~~	~~May~~	~~Jun~~	~~Jul~~	~~Aug~~	~~Sep~~	~~Oct~~	~~Nov~~	~~Dec~~	~~Max~~
~~Grand Above Legatt~~	~~0%~~	~~0%~~	~~0%~~	~~0%~~	~~0%~~	~~0%~~	~~0%~~	~~0%~~	~~0%~~	~~0%~~	~~0%~~	~~0%~~	~~0%~~
~~Grand Above Shand To Legatt~~	~~0%~~	~~0%~~	~~0%~~	~~0%~~	~~0%~~	~~0%~~	~~0%~~	~~0%~~	~~0%~~	~~0%~~	~~0%~~	~~0%~~	~~0%~~
~~Grand Above Conestogo To Shand~~	~~0%~~	~~1%~~	~~0%~~	~~0%~~	~~1%~~	~~2%~~	~~3%~~	~~2%~~	~~2%~~	~~0%~~	~~0%~~	~~0%~~	~~3%~~
~~Conestogo Above Dam~~	~~1%~~	~~1%~~	~~0%~~	~~0%~~	~~1%~~	~~1%~~	~~3%~~	~~4%~~	~~3%~~	~~0%~~	~~0%~~	~~1%~~	~~4%~~
~~Conestogo Below Dam~~	~~0%~~	~~0%~~	~~0%~~	~~0%~~	~~1%~~	~~1%~~	~~2%~~	~~1%~~	~~1%~~	~~0%~~	~~0%~~	~~0%~~	~~2%~~
~~Grand Above Doon To Conestogo~~	~~1%~~	~~1%~~	~~1%~~	~~1%~~	~~3%~~	~~4%~~	~~7%~~	~~5%~~	~~3%~~	~~2%~~	~~1%~~	~~1%~~	~~7%~~
~~Eramosa Above Guelph~~	~~0%~~	~~1%~~	~~1%~~	~~4%~~	~~7%~~	~~11%~~	~~18%~~	~~25%~~	~~24%~~	~~7%~~	~~1%~~	~~0%~~	~~25%~~
~~Speed Above Dam~~	~~1%~~	~~1%~~	~~2%~~	~~2%~~	~~1%~~	~~2%~~	~~5%~~	~~9%~~	~~8%~~	~~2%~~	~~1%~~	~~1%~~	~~9%~~
~~Speed Above Grand To Dam~~	~~0%~~	~~1%~~	~~0%~~	~~0%~~	~~1%~~	~~2%~~	~~5%~~	~~7%~~	~~3%~~	~~1%~~	~~0%~~	~~0%~~	~~7%~~
~~Mill Creek~~	~~0%~~	~~0%~~	~~0%~~	~~0%~~	~~0%~~	~~0%~~	~~0%~~	~~0%~~	~~0%~~	~~0%~~	~~0%~~	~~0%~~	~~0%~~
~~Grand Above Brantford To Doon~~	~~0%~~	~~0%~~	~~0%~~	~~0%~~	~~0%~~	~~1%~~	~~1%~~	~~1%~~	~~1%~~	~~0%~~	~~0%~~	~~0%~~	~~1%~~
~~Nith Above New Hamburg~~	~~1%~~	~~1%~~	~~0%~~	~~0%~~	~~1%~~	~~2%~~	~~4%~~	~~6%~~	~~3%~~	~~0%~~	~~0%~~	~~1%~~	~~6%~~
~~Nith Above Grand To New Hamburg~~	~~1%~~	~~1%~~	~~0%~~	~~0%~~	~~0%~~	~~2%~~	~~7%~~	~~5%~~	~~3%~~	~~0%~~	~~0%~~	~~0%~~	~~7%~~
~~Whitemans Creek~~	~~0%~~	~~0%~~	~~0%~~	~~0%~~	~~0%~~	~~11%~~	~~38%~~	~~18%~~	~~7%~~	~~0%~~	~~0%~~	~~0%~~	~~38%~~
~~Grand Above York To Brantford~~	~~0%~~	~~1%~~	~~0%~~	~~0%~~	~~1%~~	~~1%~~	~~3%~~	~~3%~~	~~2%~~	~~0%~~	~~0%~~	~~0%~~	~~3%~~
~~Fairchild Creek~~	~~1%~~	~~1%~~	~~0%~~	~~1%~~	~~1%~~	~~4%~~	~~7%~~	~~4%~~	~~3%~~	~~0%~~	~~0%~~	~~0%~~	~~7%~~
~~Mckenzie Creek~~	~~0%~~	~~0%~~	~~0%~~	~~0%~~	~~0%~~	~~10%~~	~~26%~~	~~23%~~	~~10%~~	~~0%~~	~~0%~~	~~0%~~	~~26%~~
~~Grand Above Dunnville To York~~	~~0%~~	~~0%~~	~~0%~~	~~0%~~	~~0%~~	~~0%~~	~~1%~~	~~1%~~	~~0%~~	~~0%~~	~~0%~~	~~0%~~	~~1%~~

~~Note: **Shaded** cells have Percent Water Demand greater than the Moderate Stress Threshold (20%)~~

~~The potential for stress classification is determined based on the thresholds presented in **Table** 18-19.~~ The results of the surface water stress classification for each of the s~~three s~~ubwatersheds is summarized in **Table 18-11**. ~~. As shown in **Table** 18-23, t~~The Eramosa Above Guelph, Whitemans Creek, and McKenzie Creek Subwatersheds were~~are~~ classified as having a *Moderate* surface water potential for stress.

Table 18-11: Subwatershed Surface Water Potential for Stress Classification

Subwatershed	Potential Stress Classification	Municipal Water Supply (Surface Water)
Grand Above Legatt	Low	None
Grand Above Shand To Legatt	Low	None
Grand Above Conestogo To Shand	Low	None
Conestogo Above Dam	Low	None
Conestogo Below Dam	Low	None
Grand Above Doon To Conestogo	Low	RMOW Mannheim Intake
Eramosa Above Guelph	**Moderate**	**Guelph Eramosa/Arkell Intake**
Speed Above Dam	Low	None
Speed Above Grand To Dam	Low	None
Mill Creek	Low	None
Grand Above Brantford To Doon	Low	None
Nith Above New Hamburg	Low	None
Nith Above Grand To New Hamburg	Low	None
Whitemans Creek	Moderate	None
Grand Above York To Brantford	Low	Brantford, Ohsweken
Fairchild Creek	Low	None
McKenzie Creek	Moderate	None
Grand Above Dunnville To York	Low	None

~~18.6.2 Planned Condition Percent Water Demand~~

~~The ‘Planned Systems’ scenario is not evaluated within this Tier 2 Subwatershed Stress Assessment. The purpose of the ‘Planned System’ scenario under the Technical Rules is to evaluate planned municipal water systems that are not included within the Current Demand scenario. Planned Systems were not adequately characterized at the time this report was prepared. The municipalities do not currently have any “planned systems” and there is no requirement to evaluate this scenario under the Technical Rules.~~

~~18.6.3 Future Conditions Percent Water Demand~~

~~The future demand scenario is completed to estimate the potential effect of estimated future (25-year) demands on the subwatershed stress classifications. This analysis only considers increased municipal demand in the estimation of future demand and does not consider the impact of increased or reduced non-municipal demand on subwatershed stress.~~

~~Future Demand~~

~~Three municipalities in the Grand River Watershed rely on surface water for some or all of their municipal drinking supply. The City of Guelph Eramosa River intake and the Regional Municipality of Waterloo Mannheim intake are used to supplement larger groundwater-based supplies. The City of Brantford’s Holmedale intake meets all of Brantford’s drinking water demands.~~

~~For the majority of municipal water supply systems, future water demand was estimated by the GRCA, and is documented within "Status Report on Municipal Long Term Water Supply Strategies" (Shifflett, 2007). The GRCA estimated future water demand rates by taking current average daily per capita water use and multiplying it by the future population for each municipal water system. Future population was based on municipal official plans current to 2006, while current water use data was collected from water system owners and operators. For municipalities with Long Term Water Supply Plans, the GRCA~~

~~obtained future water demands directly from approved plans. All future water demands were projected to 2031. Further explanation of future water demand calculations can be found within Shifflett (2007). Future municipal water demands for the Regional Municipality of Waterloo were taken from *Region of Waterloo Water Supply Strategy Report* (XCG, 2007).~~

~~Future municipal water demand increases for surface water systems are summarized in **Table** 18-24. For this assessment, the estimates for future water demand need to be allocated to surface water sources or groundwater sources. **Table** 18-24 also contains the amount of future water demand that will be obtained from surface water sources.~~

~~Table 18-24: Future Municipal Demand Estimates for Systems Served by Surface Water Sources~~

~~Municipal System with Surface Water Intake~~	~~Assessment Area~~	~~Estimated Average Day Municipal Water Demand Increase (L/s)~~	~~Future Demand Sourced from Surface Water (L/s)~~
~~City of Guelph – Eramosa Intake~~	~~Eramosa Above Guelph~~	~~200~~	~~13 (Apr-Nov)~~
~~Region of Waterloo – Mannheim~~	~~Grand Above Doon to Conestogo~~	~~600~~	~~200~~
~~City of Brantford - Holmedale~~	~~Grand Above York to Brantford~~	~~280~~	~~280~~

~~*Future Stress Assessment*~~

~~The estimated future municipal supply required by the City of Guelph is approximately 200 L/s. The Eramosa River Intake currently supplies 87 L/s during the April to November period, and has sufficient capacity to pump a total of 100 L/s (Earth Tech, 2006), an increase of 13 L/s over current pumping rates. This stress assessment assumes that all of this additional capacity will contribute to meeting future demands, with remaining future demand to be met by additional groundwater resources. Because the Eramosa Above Guelph subwatershed was already identified as having a *Moderate* potential for stress under current conditions, the Technical Rules (MOE, 2009b) do not require that the Percent Water Demand for the future scenario be evaluated for this subwatershed. The Eramosa Above Guelph subwatershed is not considered further in this future scenario.~~

~~For this assessment, future municipal water demand estimates are based on future population projections. In this assessment, it is assumed that future landuse changes will not have a significant effect on streamflow within the regulated Grand River, which is the water supply for both the Regional Municipality of Waterloo and City of Brantford's water takings. Information regarding the potential spatial location or extent of land use changes in the watershed for the next 25 years was unavailable for this assessment. In general, however, current development patterns in the watershed focus on re-development and intensification within existing urban areas instead of green field development. This type of development should have a minimal impact on Grand River flows. In addition it is recognized that discharge from upstream reservoirs (Shand, Conestogo and Guelph Dams) is the dominant process with respect to streamflow within the regulated Grand River, and development upstream of the reservoirs is expected to be negligible. As a result, it is assumed that these patterns of development will not result in a significant impact to water supplies and that the existing water supply will be representative of future supplies.~~

~~Consumptive demand calculations were applied to the surface water future municipal takings for Brantford and the Region of Waterloo, as the water is returned to surface water sources in the same subwatershed via wastewater treatment plant effluent. The future Percent Water Demand estimates for~~

~~both the Grand Above Doon to Conestogo and the Grand Above York to Brantford subwatersheds are less than 20% and as a result, both subwatersheds remain classified as having a *Low* potential for stress under the future demand scenario.~~

~~The Future % Water Demand in **Table** 18-25 is an estimate of the 25-year Percent Water Demand for each subwatershed with surface water demand increases.~~

~~Table 18-25: Future Demand And Percent Water Demand Analysis (L/s)~~

	~~Jan~~	~~Feb~~	~~Mar~~	~~Apr~~	~~May~~	~~Jun~~	~~Jul~~	~~Aug~~	~~Sep~~	~~Oct~~	~~Nov~~	~~Dec~~
~~Grand Above Doon to Conestogo~~												
~~Supply~~	~~20,602~~	~~16,335~~	~~31,700~~	~~35,918~~	~~16,808~~	~~14,796~~	~~12,865~~	~~13,581~~	~~13,478~~	~~17,115~~	~~30,941~~	~~29,085~~
~~Reserve~~	~~11,122~~	~~8,830~~	~~12,789~~	~~16,500~~	~~13,026~~	~~11,151~~	~~11,014~~	~~10,931~~	~~9,796~~	~~10,050~~	~~12,849~~	~~17,546~~
~~Current Municipal Demand~~	~~111~~	~~102~~	~~107~~	~~98~~	~~119~~	~~117~~	~~107~~	~~112~~	~~111~~	~~108~~	~~105~~	~~109~~
~~Additional Future Municipal Demand~~	~~49~~	~~58~~	~~53~~	~~62~~	~~41~~	~~43~~	~~53~~	~~49~~	~~49~~	~~52~~	~~55~~	~~51~~
~~Total Municipal Future Demand~~	~~160~~	~~160~~	~~160~~	~~160~~	~~160~~	~~160~~	~~160~~	~~160~~	~~160~~	~~160~~	~~160~~	~~160~~
~~Other Consumptive Water Uses~~	~~4~~	~~4~~	~~4~~	~~4~~	~~4~~	~~15~~	~~15~~	~~16~~	~~15~~	~~5~~	~~4~~	~~4~~
~~Total Future Demand~~	~~164~~	~~164~~	~~164~~	~~164~~	~~164~~	~~175~~	~~175~~	~~176~~	~~175~~	~~165~~	~~164~~	~~164~~
~~Future % Water Demand~~	~~2%~~	~~2%~~	~~1%~~	~~1%~~	~~4%~~	~~5%~~	~~9%~~	~~7%~~	~~5%~~	~~2%~~	~~1%~~	~~1%~~
~~Grand Above York to Brantford~~												
~~Supply~~	~~58,163~~	~~51,267~~	~~90,899~~	~~102,278~~	~~52,782~~	~~39,488~~	~~29,941~~	~~28,977~~	~~29,620~~	~~43,120~~	~~70,815~~	~~77,615~~
~~Reserve~~	~~35,525~~	~~31,127~~	~~43,642~~	~~51,844~~	~~35,705~~	~~24,678~~	~~21,708~~	~~21,777~~	~~19,446~~	~~19,336~~	~~27,393~~	~~49,014~~
~~Current Municipal Demand~~	~~102~~	~~102~~	~~100~~	~~110~~	~~114~~	~~115~~	~~122~~	~~119~~	~~113~~	~~113~~	~~104~~	~~100~~
~~Additional Future Municipal Demand~~	~~56~~	~~56~~	~~56~~	~~56~~	~~56~~	~~56~~	~~56~~	~~56~~	~~56~~	~~56~~	~~56~~	~~56~~
~~Total Municipal Future Demand~~	~~158~~	~~158~~	~~156~~	~~166~~	~~170~~	~~171~~	~~178~~	~~175~~	~~169~~	~~169~~	~~160~~	~~156~~
~~Other Consumptive Water Uses~~	~~6~~	~~6~~	~~6~~	~~6~~	~~6~~	~~104~~	~~123~~	~~94~~	~~61~~	~~6~~	~~6~~	~~6~~
~~Total Future Demand~~	~~164~~	~~164~~	~~161~~	~~171~~	~~176~~	~~275~~	~~301~~	~~268~~	~~229~~	~~174~~	~~165~~	~~161~~
~~Future % Water Demand~~	~~1%~~	~~1%~~	~~0%~~	~~0%~~	~~1%~~	~~2%~~	~~4%~~	~~4%~~	~~2%~~	~~1%~~	~~0%~~	~~1%~~

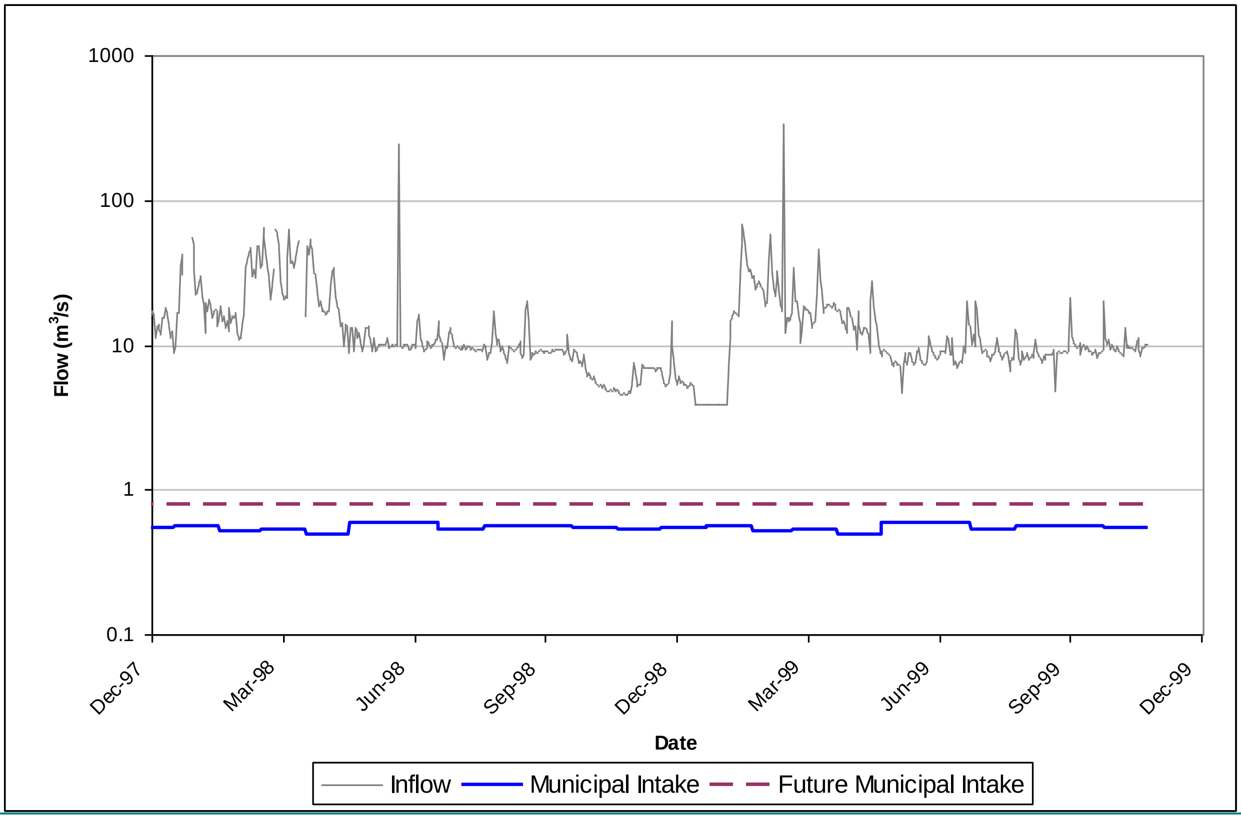
~~18.6.4 Drought Scenario~~

~~The drought analysis is to be completed only for municipal surface water intakes located in subwatersheds that have not previously been identified as having a Moderate or Significant potential for stress. The Eramosa Above Guelph subwatershed has previously been identified as having a *Moderate* potential for stress under current demand conditions. Due to this, the Technical Rules do not require this subwatershed to be analyzed in the Drought Scenario. Only the Mannheim and Holmedale Intakes were looked at in further detail for this scenario.~~

~~*Drought Scenario for Current Demand*~~

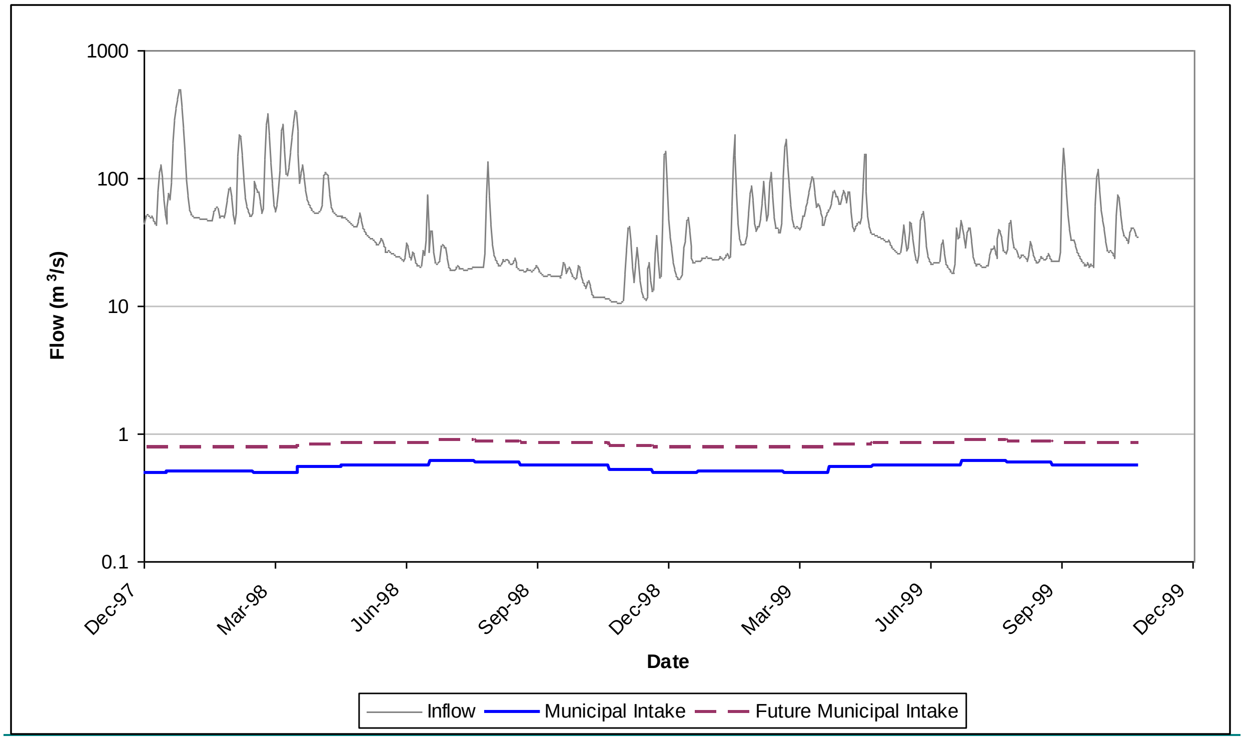
~~The Eramosa Above Guelph subwatershed has previously been identified as having a *Moderate* potential for stress under current demand conditions. Due to this, the Technical Rules (MOE, 2009b) do not require this subwatershed to be analyzed in the Drought Scenario. Only the Mannheim and Holmedale Intakes will be looked at in further detail for this scenario.~~

~~Both the Mannheim and Holmedale Grand River intakes are located upstream of small dam structures that produce a backwater effect, keeping the intake below the water surface at all times. **Figure 18-1** compares the average daily pumping rate and the future pumping rate at the Mannheim Intake to the flow in the Grand River. The figure shows that the flow in the Grand River is much greater than the municipal pumping rates during the drought period of 1998 and 1999.~~



~~**Figure 18-1: Municipal Intake and River Flow at Mannheim Intake**~~

~~**Figure 18-2** shows the river flow and historical and future municipal demand at the City of Brantford's Holmedale intake. The Holmedale intake is protected by a downstream dam structure that maintains the water surface above the intake as long as streamflow exceeds the pumping rate. The figure shows that the flow in the Grand River is an order of magnitude greater than the municipal pumping rates during the drought period of 1998 and 1999.~~



~~**Figure 18-2: Municipal Intake and River Flow at Holmedale Intake**~~

~~The drought scenarios indicate that there would not be a cessation of normal intake operations at the Mannheim and Holmedale Intakes due to drought conditions. As a result, the stress classifications would not be changed to *Moderate* due to the drought scenario.~~

~~***Drought Scenario for Future Demand***~~

~~Similar to the previous section, where the existing demand was compared to streamflow under drought conditions, the Technical Rules (MOE, 2009b) also require an evaluation of the future demand of planned systems using the same method. As discussed in **Section 18.6.3**, **Table** 18-24 summarizes potential increased future water demands at the Region of Waterloo's Mannheim Intake and at Brantford's Holmedale Intake. **Figure 18-1** and **Figure 18-2** show estimated future demands, calculated by combining historical pumping rates with potential future increases. Similar to the current conditions, river flow at these two intakes remains significantly higher than the rates needed to sustain the potential future water demands.~~

~~This assessment indicates that there would not be an increased stress at the Mannheim and Holmedale Intakes due to drought conditions. As a result, the stress classifications would not change due to future water demands and the drought scenario.~~

~~18.6.5 Uncertainty in Stress Classifications~~

~~The Technical Rules indicate that each subwatershed should be labeled as having a "Low" or "High" uncertainty in regards to the Stress Assessment classification assigned to each subwatershed. **Table** 18-26 summarizes the results of the sensitivity analysis for surface water. The Percent Water Demand for maximum monthly demand is presented for the four surface water sensitivity scenarios.~~

~~The sensitivity analysis does not change the final stress assessment classifications. For the three assessment areas classified as having a *Moderate* potential for stress in **Table** 18-26 (i.e. Eramosa~~

~~Above Guelph, Whitemans Creek and McKenzie Creek), the sensitivity analyses resulted in the Percent Water Demand being greater than the 20% threshold value for all scenarios for these three subwatersheds. When considering the uncertainty of the water budget parameters, a high level of confidence exists that these subwatersheds will be classified as having at least a *Moderate* potential for stress using the thresholds and methodology required by the Technical Rules.~~

~~Table 18-26: Surface Water Sensitivity Analysis~~

~~Subwatershed~~	~~Results Under Current Conditions~~	~~(1) Agricultural Surface Water Demand x 75%~~	~~(2) Agricultural Surface Water Demand x 125%~~	~~(3) Supply x 75%~~	~~(4) Supply x 125%~~
	~~% Water Demand~~	~~% Water Demand~~	~~% Water Demand~~	~~% Water Demand~~	~~% Water Demand~~
	~~Max Month~~	~~Max Month~~	~~Max Month~~	~~Max Month~~	~~Max Month~~
~~Grand Above Legatt~~	~~0%~~	~~0%~~	~~1%~~	~~1%~~	~~0%~~
~~Grand Above Shand To Legatt~~	~~0%~~	~~0%~~	~~0%~~	~~0%~~	~~0%~~
~~Grand Above Conestogo To Shand~~	~~3%~~	~~2%~~	~~4%~~	~~4%~~	~~2%~~
~~Conestogo Above Dam~~	~~4%~~	~~3%~~	~~5%~~	~~6%~~	~~3%~~
~~Conestogo Below Dam~~	~~2%~~	~~1%~~	~~2%~~	~~2%~~	~~1%~~
~~Grand Above Doon To Conestogo~~	~~7%~~	~~5%~~	~~8%~~	~~9%~~	~~5%~~
~~Eramosa Above Guelph~~	~~**25%**~~	~~**23%**~~	~~**27%**~~	~~**34%**~~	~~**20%**~~
~~Speed Above Dam~~	~~9%~~	~~7%~~	~~11%~~	~~12%~~	~~7%~~
~~Speed Above Grand To Dam~~	~~7%~~	~~6%~~	~~8%~~	~~9%~~	~~5%~~
~~Mill Creek~~	~~0%~~	~~0%~~	~~1%~~	~~1%~~	~~0%~~
~~Grand Above Brantford To Doon~~	~~1%~~	~~1%~~	~~2%~~	~~2%~~	~~1%~~
~~Nith Above New Hamburg~~	~~6%~~	~~5%~~	~~8%~~	~~9%~~	~~5%~~
~~Nith Above Grand To New Hamburg~~	~~7%~~	~~5%~~	~~9%~~	~~10%~~	~~6%~~
~~Whitemans Creek~~	~~**38%**~~	~~**29%**~~	~~**47%**~~	~~**50%**~~	~~**30%**~~
~~Grand Above York To Brantford~~	~~3%~~	~~2%~~	~~4%~~	~~4%~~	~~2%~~
~~Fairchild Creek~~	~~7%~~	~~5%~~	~~8%~~	~~9%~~	~~5%~~
~~McKenzie Creek~~	~~**26%**~~	~~**20%**~~	~~**32%**~~	~~**35%**~~	~~**21%**~~
~~Grand Above Dunnville To York~~	~~1%~~	~~1%~~	~~1%~~	~~1%~~	~~1%~~

~~Note: **Shaded** cells have Percent Water Demand greater than the Moderate Stress Threshold (20%)~~

~~**Table** 18-27 summarizes the results of the sensitivity analysis and the final uncertainty levels. Those subwatersheds which were originally identified as having a *Moderate* or *Significant* potential for stress and retained that classification for all sensitivity scenarios, are assigned an Uncertainty Classification of *Low*. Likewise, those subwatersheds originally identified as having a *Low* potential for stress, and retained this classification for all sensitivity scenarios were assigned an Uncertainty Classification of *Low*.~~

~~Table 18-27: Uncertainty Levels~~

~~Subwatershed~~	~~Low or High Uncertainty~~
~~Grand Above Legatt~~	~~Low~~
~~Grand Above Shand To Legatt~~	~~Low~~
~~Grand Above Conestogo To Shand~~	~~Low~~
~~Conestogo Above Dam~~	~~Low~~
~~Conestogo Below Dam~~	~~Low~~

~~**Table 18-27: Uncertainty Levels**~~

~~**Subwatershed**~~	~~**Low or High Uncertainty**~~
~~Grand Above Doon To Conestogo~~	~~Low~~
~~Eramosa Above Guelph~~	~~Low~~
~~Speed Above Dam~~	~~Low~~
~~Speed Above Grand To Dam~~	~~Low~~
~~Mill Creek~~	~~Low~~
~~Grand Above Brantford To Doon~~	~~Low~~
~~Nith Above New Hamburg~~	~~Low~~
~~Nith Above Grand To New Hamburg~~	~~Low~~
~~Whitemans Creek~~	~~Low~~
~~Grand Above York To Brantford~~	~~Low~~
~~Fairchild Creek~~	~~Low~~
~~McKenzie Creek~~	~~Low~~
~~Grand Above Dunnville To York~~	~~Low~~

~~18.6.6 Uncertainty Assessment~~

~~As per the Technical Rules (MOE, 2009b), subwatersheds that are not identified as being under a Moderate or Significant potential for stress may be assigned a classification of Moderate potential for stress if all the following are true (Technical Rule 34(2)(f)):~~

1. ~~The maximum monthly Percent Water Demand is between 18% and 20%;~~
2. ~~The uncertainty associated with the Percent Water Demand calculations, when evaluated to be either “Low” or “High” is High; and~~
3. ~~When an uncertainty analysis using appropriate error bounds suggests that the potential for stress could be Moderate.~~

~~As presented in **Table** 18-23, there are no subwatersheds meeting the first criteria. Additionally, presented in **Table** 18-27, none of the subwatersheds have a *High* uncertainty regarding the stress classification. No additional subwatersheds are classified as having a *Moderate* potential for stress due to this uncertainty assessment.~~

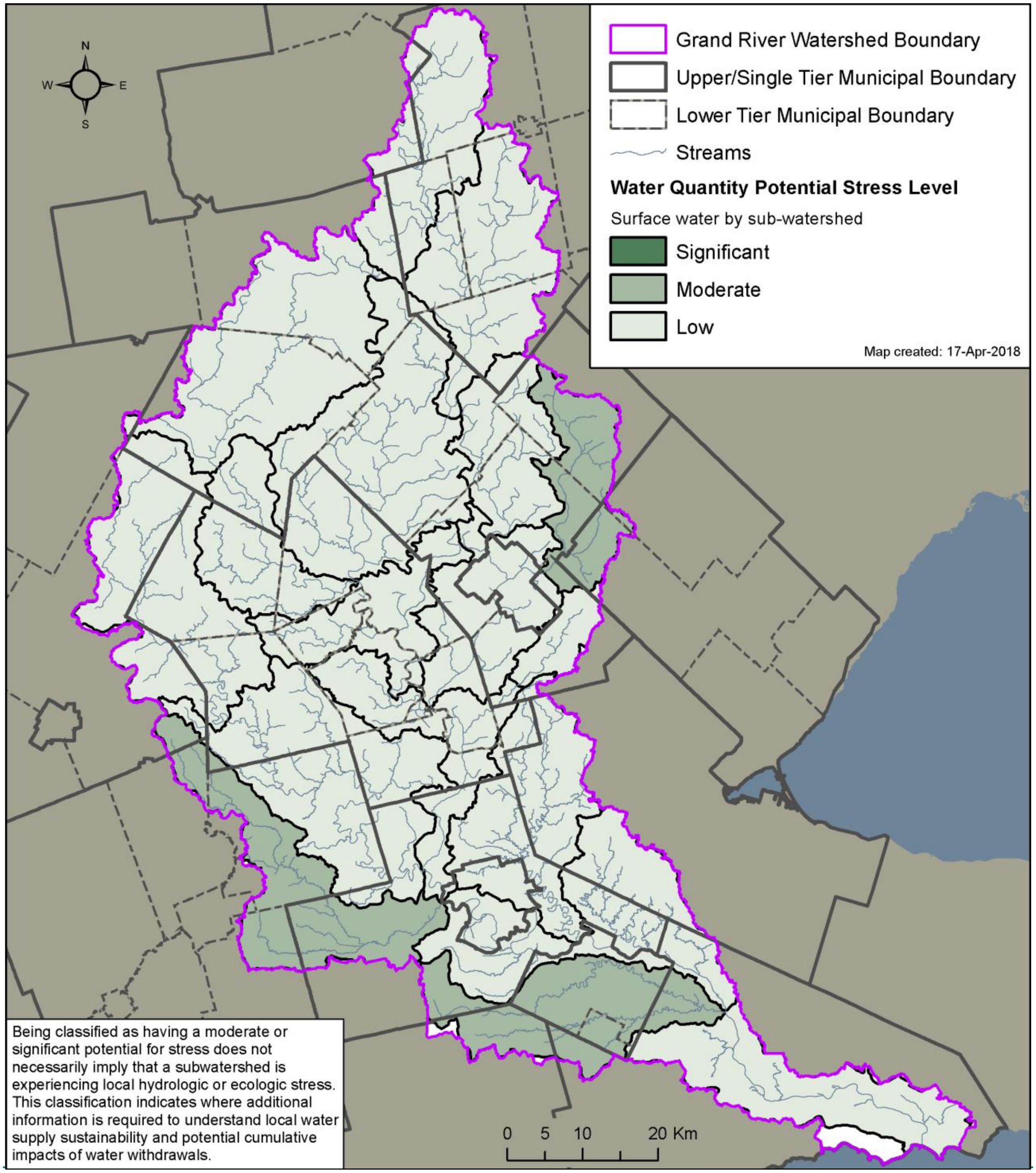
~~18.6.7 Surface Water Stress Assessment Results~~

~~The Surface Water Subwatershed Stress Assessment described in this section classifies the following subwatersheds as having a *Moderate* potential for stress:~~

- ~~Eramosa Above Guelph subwatershed;~~
- ~~Whitemans Creek subwatershed; and~~
- ~~McKenzie Creek subwatershed.~~

~~These subwatersheds had also been previously identified as Areas of Special Concern by the GRCA as part of its Low Water Response program. **Map** 18-8 shows these areas in the Grand River watershed. It is anticipated that water supply problems may occur at times in these identified areas.~~

~~**Map 18-8: Tier 2 Surface Water Stress Assessment in the Grand River Watershed**~~



Map created: 17-Apr-2018

Being classified as having a moderate or significant potential for stress does not necessarily imply that a subwatershed is experiencing local hydrologic or ecologic stress. This classification indicates where additional information is required to understand local water supply sustainability and potential cumulative impacts of water withdrawals.

~~All other subwatersheds in the Grand River Watershed are classified as having a *Low* potential for surface water stress, including some of those containing municipal surface water intakes. Drought conditions do not modify the classification of any subwatersheds containing municipal drinking water intakes. The sensitivity scenarios completed for all subwatersheds, indicated that the stress classification was not sensitive to changes of +/- 25% for either water supply or estimated consumptive water demand.~~

This section provides additional discussion relating to the three ~~assessment~~ subwatersheds~~areas~~ classified as having a *Moderate* potential for stress.

Eramosa Above Guelph Subwatershed

The Eramosa River is northeast of Guelph and joins the Speed River in the City of Guelph. The headwaters are in the northwest portion of Erin Township. Blue Springs Creek, a major tributary of the Eramosa River, joins the Eramosa River in Halton Region. In addition to the municipal intake, at the time of the study, there ~~are~~were 10 known permitted surface water takings within this subwatershed; these included one agricultural use permit, three commercial use permits, three recreational use permits, and two miscellaneous use permits. The stress assessment completed for the Eramosa Above Guelph subwatershed classifie~~s~~d the subwatershed as having a ***Moderate*** potential for stress under current water demand conditions. The subwatershed's maximum monthly Percent Water Demand is estimated to be 25% during the month of August. The subwatershed contains the City of Guelph's Eramosa River drinking water intake.

The City of Guelph has been found to meet the requirements set out by the Technical Rules (MOE, 2009b) to complete a Tier 3 Water Quantity Risk Assessment for the Eramosa River Intake. The Eramosa Above Guelph subwatershed was~~is~~ classified as having a ***Moderate*** potential for stress for surface water. The objective of the Tier 3 Water Quantity Risk Assessment ~~is~~ was then to estimate the potential ~~that~~for the City of Guelph ~~would~~to not be able to obtain its permitted water pumping rates at this intake.

Whitemans Creek Subwatershed

Whitemans Creek, located in the western portion of the County of Brant near Burford, enters the Grand River just upstream of Brantford. This creek has two main tributaries, Kenny Creek (in Norwich Township) and Horner Creek (in Blandford-Blenheim Township). At the time of the study, ~~T~~there ~~are~~were 55 identified permitted agricultural surface water takings within the Whitemans Creek subwatershed. The only additional water demand estimated for the subwatershed is the unpermitted agricultural (livestock) surface water demand, estimated to be 4 L/s throughout the year.

The stress assessment completed for Whitemans Creek assessment area classified~~s~~ the subwatershed as having a ***Moderate*** potential for stress under current water demand conditions. There are no planned municipal systems in this assessment area and, therefore, the future demand and drought scenarios were not evaluated for this subwatershed. Without having a municipal surface water intake in the subwatershed, there is not a requirement for the completion of a Tier 3 Water Quantity Risk Assessment as a result of the ***Moderate*** classification.

McKenzie Creek Subwatershed

McKenzie Creek, including Boston Creek, is a tributary of the Grand River in the southern portion of the Grand River watershed. The headwaters of both creeks begin in Brant County, where the shallow Norfolk Sand Plain aquifer supplies groundwater baseflow~~s~~. The subwatershed is primarily rural land use. Similar to the Whitemans Creek~~- assessment area~~subwatershed, agricultural irrigation is a major water use in the summer months, especially in the Norfolk sand plain area. At the time of the study, t~~T~~here ~~are~~were 35 identified surface water permits-to-take-water in the subwatershed, mostly for irrigation.

The stress assessment classifies the McKenzie Creek subwatershed as having a ***Moderate*** potential for stress under current water demand conditions. There are no planned municipal systems in this assessment area and, therefore, the future water demand and drought scenarios were not evaluated for this subwatershed. Without having a municipal surface water intake in this subwatershed, there are no requirements for the completion of a Tier 3 Water Quantity Risk Assessment as a result of the ***Moderate*** classification.

Groundwater Stress Assessment

~~Under the requirements of the Technical Rules (MOE, 2009b), the Water Quantity Stress Assessment is carried out on a subwatershed basis.~~ For the preliminary groundwater stress assessments, the 18 surface water-based subwatersheds were used. While these delineated subwatersheds reflected surface water demands and hydrology well, they did not adequately reflect the major aquifer systems in the watershed, existing municipal wells systems and capture zones for those systems. The surface-water based subwatersheds subdivided several of the large aquifers and wellfields into separate assessment areas, and this resulted in groundwater demand from the same aquifer being split into separate subwatersheds.

Map 18-3 illustrates a new set of 19 groundwater assessment areas delineated to better represent water demand and aquifer systems. The new groundwater boundaries were developed to encompass groundwater demand systems from the same aquifer in a single assessment area. These areas are listed in Table 18-12 with a description of how these boundaries were derived.

Map 18-3: Groundwater Assessment Area Boundaries in the Grand River Watershed

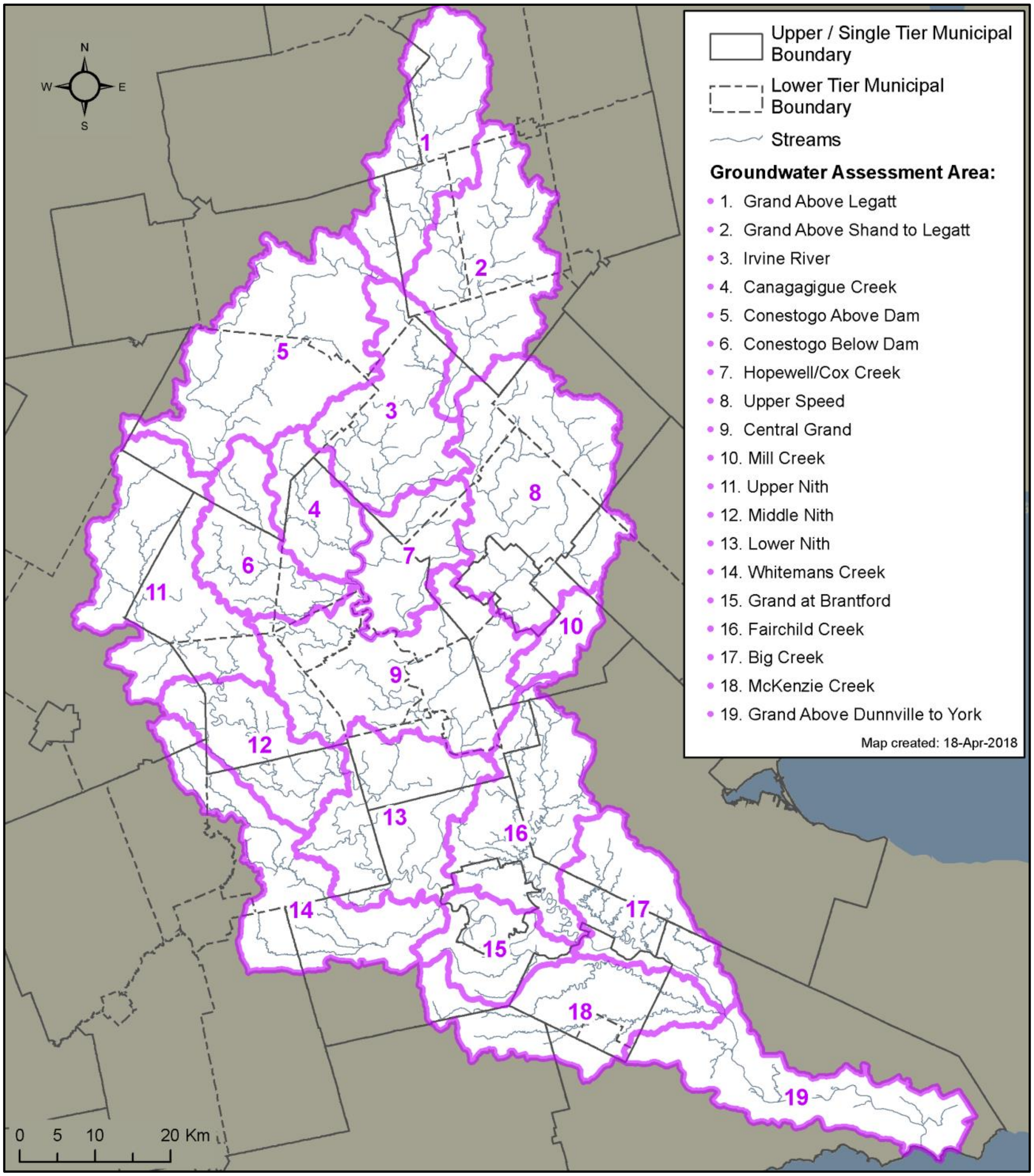


Table 18-12: Groundwater Assessment Areas

Groundwater Assessment Area	Area (km^2)	Description of Boundary Modification
Grand Above Legatt	365	No Change from Surface Water Subwatershed
Grand Above Shand to Legatt	426	No Change from Surface Water Subwatershed
Irvine River	359	Delineated as the upper portion of the Grand Above Conestogo to Shand Subwatershed
Canagagigue Creek	177	Delineated as the southwest portion of the Grand Above Conestogo to Shand Subwatershed
Conestogo Above Dam	566	No Change from Surface Water Subwatershed
Conestogo Below Dam	254	No Change from Surface Water Subwatershed
Hopewell/Cox Creek	208	Delineated as the southeast portion of the Grand Above Conestogo to Shand Subwatershed joined with the northeast portion of the Grand Above Doon to Conestogo Subwatershed
Upper Speed	614	Delineating by combining the Eramosa River, Speed Above Dam, and upper portion of the Speed Above Grand to Dam Subwatersheds. This area encompasses the City of Guelph drinking water systems and capture zones.
Central Grand	562	Delineated by combining portions of the Nith Above Grand To New Hamburg, Grand Above Doon to Conestogo, Speed Above Grand to Dam, and Grand Above Brantford to Doon Subwatersheds. This area encompasses most of the Region of Waterloo's municipal wells.
Mill Creek	82	No Change from Surface Water Subwatershed
Upper Nith	496	Delineated as the original Nith Above New Hamburg Subwatershed, subtracting the small lower portion of the subwatershed
Middle Nith	259	Delineated as the lower portion of the original Nith Above New Hamburg Subwatershed joined with an upper portion of the Nith Above Grand to New Hamburg Subwatershed
Lower Nith	395	Delineated as the lower portion of the Nith Above Grand to New Hamburg Subwatershed combined with the lower portion of the Grand Above Brantford to Doon Subwatershed
Whitemans Creek	404	No Change from Surface Water Subwatershed
Grand at Brantford	181	Delineated as the western portion of the Grand Above York to Brantford Subwatershed
Fairchild Creek	401	No Change from Surface Water Subwatershed
Big Creek	295	Delineated as the eastern portion of the Grand Above York to Brantford Subwatershed
McKenzie Creek	368	No Change from Surface Water Subwatershed
Grand Above Dunnville To York	356	No Change from Surface Water Subwatershed

For groundwater systems, the Stress Assessment calculation wa~~i~~s carried out for the average annual demand conditions and for the monthly maximum demand conditions; groundwater supply is considered constant. The stress level for groundwater systems is categorized into three levels (Significant, Moderate or Low) according to the thresholds listed in Table 18-13.

Table 18-13: Groundwater Potential Stress Thresholds

Groundwater Potential Stress Level Assignment	Average Annual	Monthly Maximum
Significant	> 25%	> 50%
Moderate	> 10%	> 25%
Low	0 – 10%	0 – 25%

~~18.6.9 Existing Conditions Percent Water Demand~~

~~**Table** 18-30 contains the monthly estimates of unit consumptive groundwater demands calculated for each assessment area. The annual average and maximum monthly demands are shown in the table; they are used to estimate assessment area potential stress in the groundwater stress assessment. **Table** 18-30 also includes the amount of total water demand that is derived from reported values (*Rep*), versus the amount of water that is estimated from the Permit To Take Water database (*Est*).~~

~~Table 18-30: Groundwater Unit Consumptive Demands (L/s)~~

~~Groundwater Assessment Area~~		~~Jan~~	~~Feb~~	~~Mar~~	~~Apr~~	~~May~~	~~Jun~~	~~Jul~~	~~Aug~~	~~Sep~~	~~Oct~~	~~Nov~~	~~Dec~~	~~Avg~~	~~Max~~
~~Grand Above Legatt~~	~~Rep~~	~~8~~	~~8~~	~~8~~	~~8~~	~~8~~	~~8~~	~~8~~	~~8~~	~~8~~	~~8~~	~~8~~	~~8~~		
	~~Est~~	~~16~~	~~16~~	~~16~~	~~16~~	~~20~~	~~20~~	~~20~~	~~20~~	~~20~~	~~16~~	~~16~~	~~16~~		
	~~Total~~	~~23~~	~~23~~	~~23~~	~~23~~	~~27~~	~~27~~	~~27~~	~~27~~	~~27~~	~~23~~	~~23~~	~~23~~	~~25~~	~~27~~
~~Grand Above Shand to Legatt~~	~~Rep~~	~~7~~	~~7~~	~~7~~	~~7~~	~~7~~	~~9~~	~~10~~	~~8~~	~~8~~	~~7~~	~~7~~	~~7~~		
	~~Est~~	~~53~~	~~53~~	~~53~~	~~53~~	~~67~~	~~67~~	~~67~~	~~67~~	~~67~~	~~67~~	~~67~~	~~53~~		
	~~Total~~	~~60~~	~~60~~	~~59~~	~~59~~	~~75~~	~~76~~	~~77~~	~~76~~	~~75~~	~~74~~	~~74~~	~~60~~	~~69~~	~~77~~
~~Irvine River~~	~~Rep~~	~~55~~	~~58~~	~~56~~	~~54~~	~~59~~	~~57~~	~~63~~	~~56~~	~~59~~	~~61~~	~~53~~	~~56~~		
	~~Est~~	~~18~~	~~18~~	~~18~~	~~19~~	~~23~~	~~26~~	~~26~~	~~25~~	~~23~~	~~21~~	~~20~~	~~18~~		
	~~Total~~	~~73~~	~~76~~	~~74~~	~~74~~	~~82~~	~~83~~	~~89~~	~~81~~	~~82~~	~~82~~	~~73~~	~~74~~	~~79~~	~~89~~
~~Canagagigue Creek~~	~~Rep~~	~~103~~	~~106~~	~~105~~	~~109~~	~~112~~	~~114~~	~~112~~	~~103~~	~~115~~	~~114~~	~~130~~	~~109~~		
	~~Est~~	~~53~~	~~53~~	~~53~~	~~53~~	~~53~~	~~53~~	~~53~~	~~53~~	~~53~~	~~53~~	~~53~~	~~53~~		
	~~Total~~	~~156~~	~~160~~	~~159~~	~~162~~	~~166~~	~~167~~	~~165~~	~~156~~	~~169~~	~~168~~	~~183~~	~~163~~	~~164~~	~~183~~
~~Conestogo Above Dam~~	~~Rep~~	~~22~~	~~23~~	~~22~~	~~22~~	~~22~~	~~25~~	~~23~~	~~23~~	~~24~~	~~23~~	~~24~~	~~24~~		
	~~Est~~	~~13~~	~~13~~	~~13~~	~~13~~	~~15~~	~~15~~	~~15~~	~~15~~	~~15~~	~~13~~	~~13~~	~~13~~		
	~~Total~~	~~35~~	~~36~~	~~36~~	~~35~~	~~38~~	~~40~~	~~39~~	~~38~~	~~39~~	~~37~~	~~37~~	~~37~~	~~37~~	~~40~~
~~Conestogo Below Dam~~	~~Rep~~	~~8~~	~~8~~	~~8~~	~~12~~	~~20~~	~~22~~	~~22~~	~~21~~	~~14~~	~~12~~	~~13~~	~~11~~		
	~~Est~~	~~32~~	~~32~~	~~32~~	~~32~~	~~32~~	~~32~~	~~32~~	~~32~~	~~32~~	~~32~~	~~32~~	~~32~~		
	~~Total~~	~~39~~	~~40~~	~~40~~	~~43~~	~~52~~	~~54~~	~~53~~	~~53~~	~~45~~	~~44~~	~~44~~	~~43~~	~~46~~	~~54~~
~~Hopewell/Cox Creek~~	~~Rep~~	~~3~~	~~3~~	~~2~~	~~3~~	~~3~~	~~4~~	~~4~~	~~4~~	~~3~~	~~3~~	~~2~~	~~3~~		
	~~Est~~	~~70~~	~~70~~	~~70~~	~~70~~	~~70~~	~~104~~	~~104~~	~~104~~	~~104~~	~~70~~	~~70~~	~~70~~		
	~~Total~~	~~72~~	~~73~~	~~72~~	~~72~~	~~73~~	~~108~~	~~108~~	~~108~~	~~107~~	~~72~~	~~72~~	~~72~~	~~84~~	~~108~~
~~Upper Speed~~	~~Rep~~	~~772~~	~~785~~	~~839~~	~~728~~	~~865~~	~~838~~	~~840~~	~~884~~	~~859~~	~~895~~	~~855~~	~~838~~		
	~~Est~~	~~66~~	~~66~~	~~66~~	~~66~~	~~66~~	~~148~~	~~154~~	~~148~~	~~141~~	~~66~~	~~66~~	~~66~~		
	~~Total~~	~~838~~	~~851~~	~~905~~	~~794~~	~~931~~	~~985~~	~~994~~	~~1,032~~	~~1,000~~	~~960~~	~~921~~	~~904~~	~~926~~	~~1,032~~

~~Table 18-30: Groundwater Unit Consumptive Demands (L/s)~~

~~Groundwater Assessment Area~~		~~Jan~~	~~Feb~~	~~Mar~~	~~Apr~~	~~May~~	~~Jun~~	~~Jul~~	~~Aug~~	~~Sep~~	~~Oct~~	~~Nov~~	~~Dec~~	~~Avg~~	~~Max~~
~~Central Grand~~	~~Rep~~	~~1,345~~	~~1,389~~	~~1,380~~	~~1,399~~	~~1,409~~	~~1,616~~	~~1,525~~	~~1,491~~	~~1,423~~	~~1,400~~	~~1,377~~	~~1,295~~		
	~~Est~~	~~384~~	~~384~~	~~352~~	~~352~~	~~365~~	~~580~~	~~584~~	~~580~~	~~576~~	~~361~~	~~361~~	~~384~~		
	~~Total~~	~~1,729~~	~~1,773~~	~~1,732~~	~~1,750~~	~~1,775~~	~~2,197~~	~~2,109~~	~~2,071~~	~~1,999~~	~~1,761~~	~~1,738~~	~~1,679~~	~~1,859~~	~~2,197~~
~~Mill Creek~~	~~Rep~~	~~32~~	~~29~~	~~28~~	~~37~~	~~43~~	~~47~~	~~47~~	~~45~~	~~40~~	~~37~~	~~43~~	~~32~~		
	~~Est~~	~~18~~	~~18~~	~~18~~	~~18~~	~~59~~	~~67~~	~~68~~	~~67~~	~~67~~	~~55~~	~~55~~	~~18~~		
	~~Total~~	~~50~~	~~46~~	~~46~~	~~55~~	~~102~~	~~114~~	~~114~~	~~112~~	~~107~~	~~91~~	~~98~~	~~50~~	~~82~~	~~114~~
~~Upper Nith~~	~~Rep~~	~~15~~	~~15~~	~~15~~	~~16~~	~~16~~	~~24~~	~~24~~	~~16~~	~~15~~	~~16~~	~~15~~	~~16~~		
	~~Est~~	~~17~~	~~17~~	~~17~~	~~17~~	~~17~~	~~17~~	~~17~~	~~17~~	~~17~~	~~17~~	~~17~~	~~17~~		
	~~Total~~	~~32~~	~~32~~	~~32~~	~~32~~	~~33~~	~~41~~	~~41~~	~~32~~	~~32~~	~~32~~	~~32~~	~~32~~	~~34~~	~~41~~
~~Middle Nith~~	~~Rep~~	~~131~~	~~84~~	~~96~~	~~112~~	~~116~~	~~123~~	~~106~~	~~117~~	~~112~~	~~112~~	~~120~~	~~112~~		
	~~Est~~	~~11~~	~~11~~	~~11~~	~~11~~	~~11~~	~~11~~	~~11~~	~~11~~	~~11~~	~~11~~	~~11~~	~~11~~		
	~~Total~~	~~142~~	~~95~~	~~107~~	~~123~~	~~127~~	~~134~~	~~117~~	~~128~~	~~123~~	~~123~~	~~131~~	~~123~~	~~123~~	~~142~~
~~Lower Nith~~	~~Rep~~	~~77~~	~~78~~	~~155~~	~~136~~	~~90~~	~~143~~	~~149~~	~~95~~	~~82~~	~~171~~	~~79~~	~~77~~		
	~~Est~~	~~49~~	~~49~~	~~49~~	~~49~~	~~63~~	~~111~~	~~121~~	~~111~~	~~101~~	~~63~~	~~63~~	~~49~~		
	~~Total~~	~~126~~	~~126~~	~~203~~	~~185~~	~~153~~	~~254~~	~~271~~	~~207~~	~~183~~	~~234~~	~~141~~	~~126~~	~~184~~	~~271~~
~~Whitemans Creek~~	~~Rep~~	~~1~~	~~1~~	~~1~~	~~8~~	~~16~~	~~47~~	~~52~~	~~45~~	~~43~~	~~11~~	~~1~~	~~1~~		
	~~Est~~	~~9~~	~~9~~	~~9~~	~~9~~	~~9~~	~~278~~	~~412~~	~~278~~	~~143~~	~~9~~	~~9~~	~~9~~		
	~~Total~~	~~10~~	~~10~~	~~10~~	~~16~~	~~24~~	~~325~~	~~465~~	~~323~~	~~186~~	~~20~~	~~9~~	~~9~~	~~117~~	~~465~~
~~Grand at Brantford~~	~~Rep~~	~~15~~	~~15~~	~~15~~	~~19~~	~~17~~	~~19~~	~~25~~	~~21~~	~~15~~	~~15~~	~~15~~	~~15~~		
	~~Est~~	~~10~~	~~10~~	~~10~~	~~10~~	~~17~~	~~143~~	~~186~~	~~143~~	~~100~~	~~17~~	~~17~~	~~10~~		
	~~Total~~	~~26~~	~~26~~	~~26~~	~~30~~	~~34~~	~~162~~	~~211~~	~~163~~	~~115~~	~~33~~	~~33~~	~~26~~	~~74~~	~~211~~
~~Fairchild Creek~~	~~Rep~~	~~12~~	~~11~~	~~12~~	~~12~~	~~14~~	~~22~~	~~23~~	~~19~~	~~18~~	~~17~~	~~12~~	~~12~~		
	~~Est~~	~~71~~	~~71~~	~~71~~	~~71~~	~~72~~	~~87~~	~~94~~	~~87~~	~~80~~	~~71~~	~~71~~	~~71~~		
	~~Total~~	~~83~~	~~83~~	~~83~~	~~83~~	~~86~~	~~109~~	~~117~~	~~106~~	~~98~~	~~88~~	~~83~~	~~83~~	~~92~~	~~117~~
~~Big Creek~~	~~Rep~~	~~3~~	~~3~~	~~3~~	~~4~~	~~10~~	~~13~~	~~22~~	~~16~~	~~13~~	~~4~~	~~4~~	~~3~~		
	~~Est~~	~~17~~	~~17~~	~~17~~	~~17~~	~~22~~	~~45~~	~~44~~	~~44~~	~~44~~	~~17~~	~~17~~	~~17~~		
	~~Total~~	~~20~~	~~20~~	~~20~~	~~21~~	~~32~~	~~58~~	~~66~~	~~60~~	~~57~~	~~21~~	~~21~~	~~20~~	~~35~~	~~66~~
~~McKenzie Creek~~	~~Rep~~	~~0~~	~~0~~	~~0~~	~~0~~	~~1~~	~~1~~	~~2~~	~~2~~	~~0~~	~~0~~	~~0~~	~~6~~		
	~~Est~~	~~3~~	~~3~~	~~3~~	~~3~~	~~3~~	~~148~~	~~221~~	~~148~~	~~76~~	~~3~~	~~3~~	~~3~~		
	~~Total~~	~~3~~	~~3~~	~~3~~	~~3~~	~~4~~	~~149~~	~~223~~	~~150~~	~~76~~	~~3~~	~~3~~	~~9~~	~~53~~	~~223~~
~~Grand Above Dunnville to York~~	~~Rep~~	~~50~~	~~34~~	~~30~~	~~17~~	~~21~~	~~8~~	~~9~~	~~10~~	~~17~~	~~59~~	~~43~~	~~36~~		
	~~Est~~	~~57~~	~~57~~	~~57~~	~~57~~	~~57~~	~~77~~	~~79~~	~~77~~	~~75~~	~~57~~	~~57~~	~~57~~		
	~~Total~~	~~106~~	~~91~~	~~87~~	~~74~~	~~78~~	~~86~~	~~88~~	~~87~~	~~93~~	~~116~~	~~99~~	~~93~~	~~91~~	~~116~~

~~Groundwater supply is calculated as the sum of the average annual recharge and the total amount of groundwater flowing laterally into each assessment area. The GAWSER continuous streamflow-generation modelling results predicted groundwater recharge and the FEFLOW steady-state groundwater-flow model estimated the groundwater flowing laterally into each assessment area. Both the GAWSER continuous streamflow-generation model and the FEFLOW steady-state groundwater-flow model are discussed in the Integrated Water Budget Report (AquaResource, 2009a). The groundwater Flow In for each assessment area is calculated from the model results as the sum of all positive flow vectors into each area.~~

~~Groundwater reserve is calculated as 10% of the estimated groundwater discharge to surface water streams in each assessment area. The purpose of the groundwater reserve is to introduce a measure~~

~~of conservativeness into the Percent Water Demand equation and to represent a portion of groundwater discharge needed to sustain ecological function. An estimate of 10% of groundwater discharge for the reserve is suggested in the Technical Rules (MOE, 2009b). It is noted that the total amount of groundwater discharge needed to maintain ecological functions is greater than this amount; however, the need to maintain current groundwater discharge rates is built into the stress assessment thresholds, which effectively require that groundwater demand is well below 10% of groundwater supply to maintain a '*Low*' stress level.~~

~~The groundwater reserve for each assessment area is given in **Table** 18-31.~~

~~18.6.10~~

~~Table 18-31: Groundwater Stress Assessment~~

~~Assessment Area~~	**~~Groundwater Supply (L/s)~~**			**~~Groundwater Reserve (L/s)~~**	**~~Demand (L/s)~~**		**~~Percent Water Demand~~**	
	~~Recharge~~	**~~Flow In~~**	**~~Supply~~**		**~~Average Annual~~**	**~~Maximum Monthly~~**	**~~Average Annual~~**	**~~Max Monthly~~**
~~Grand Above Legatt~~	~~2,046~~	~~0~~	~~2,046~~	~~183~~	~~25~~	~~27~~	~~1%~~	~~1%~~
~~Grand Above Shand to Legatt~~	~~2,286~~	~~157~~	~~2,443~~	~~217~~	~~69~~	~~77~~	~~3%~~	~~3%~~
~~Irvine River~~	~~1,595~~	~~58~~	~~1,653~~	~~125~~	~~79~~	~~89~~	~~5%~~	~~6%~~
~~Canagagigue Creek~~	~~905~~	~~157~~	~~1,063~~	~~66~~	~~164~~	~~183~~	**~~16%~~**	~~18%~~
~~Conestogo Above Dam~~	~~2,245~~	~~42~~	~~2,287~~	~~124~~	~~37~~	~~40~~	~~2%~~	~~2%~~
~~Conestogo Below Dam~~	~~944~~	~~789~~	~~1,734~~	~~168~~	~~46~~	~~54~~	~~3%~~	~~3%~~
~~Hopewell/Cox Creek~~	~~1,376~~	~~181~~	~~1,557~~	~~130~~	~~84~~	~~108~~	~~6%~~	~~8%~~
~~Upper Speed~~	~~4,652~~	~~480~~	~~5,132~~	~~425~~	~~926~~	~~1,032~~	**~~20%~~**	~~22%~~
~~Central Grand~~	~~4,132~~	~~456~~	~~4,588~~	~~259~~	~~1,859~~	~~2,197~~	**~~43%~~**	**~~51%~~**
~~Mill Creek~~	~~764~~	~~0~~	~~764~~	~~54~~	~~82~~	~~114~~	**~~12%~~**	~~16%~~
~~Upper Nith~~	~~2,163~~	~~133~~	~~2,296~~	~~98~~	~~34~~	~~41~~	~~2%~~	~~2%~~
~~Middle Nith~~	~~1,815~~	~~517~~	~~2,332~~	~~196~~	~~123~~	~~142~~	~~6%~~	~~7%~~
~~Lower Nith~~	~~3,807~~	~~234~~	~~4,041~~	~~361~~	~~184~~	~~271~~	~~5%~~	~~7%~~
~~Whitemans Creek~~	~~3,274~~	~~120~~	~~3,395~~	~~271~~	~~117~~	~~465~~	~~4%~~	~~15%~~
~~Grand at Brantford~~	~~1,023~~	~~438~~	~~1,461~~	~~133~~	~~74~~	~~211~~	~~6%~~	~~16%~~

~~Table 18-31: Groundwater Stress Assessment~~

~~**Assessment Area**~~	~~**Groundwater Supply (L/s)**~~			~~**Groundwater Reserve (L/s)**~~	~~**Demand (L/s)**~~		~~**Percent Water Demand**~~	
	~~**Recharge**~~	~~**Flow In**~~	~~**Supply**~~		~~**Average Annual**~~	~~**Maximum Monthly**~~	~~**Average Annual**~~	~~**Max Monthly**~~
~~Fairchild Creek~~	~~1,735~~	~~203~~	~~1,938~~	~~167~~	~~92~~	~~117~~	~~5%~~	~~7%~~
~~Big Creek~~	~~777~~	~~198~~	~~975~~	~~52~~	~~35~~	~~66~~	~~4%~~	~~7%~~
~~McKenzie Creek~~	~~1,471~~	~~119~~	~~1,590~~	~~108~~	~~53~~	~~223~~	~~4%~~	~~15%~~
~~Grand Above Dunnville To York~~	~~1,019~~	~~54~~	~~1,073~~	~~92~~	~~91~~	~~116~~	~~9%~~	~~12%~~

~~Note: Assessment areas with **Highlighted** Percent Water Demand are above Moderate Stress Threshold~~

~~Assessment area with ***Highlighted*** Percent Water Demand Estimates are above Significant Stress Threshold~~

Table 18-14: Groundwater Stress Classification (Current Demand)

Assessment Area	Potential Stress (Average Demand)	Potential Stress (Maximum Monthly Demand)	Municipal Water Supply
Grand Above Legatt	Low	Low	Dundalk
Grand Above Shand To Legatt	Low	Low	Grand Valley, Waldemar Marsville
Irvine River	Low	Low	Elora, Fergus
Canagagigue Creek	Moderate	Low	West Montrose, Conestogo, Elmira
Conestogo Above Dam	Low	Low	Arthur, Drayton, Moorefield
Conestogo Below Dam	Low	Low	Integrated Urban System Villages
Hopewell/Cox Creek	Low	Low	Maryhill
Upper Speed	Moderate	Low	City of Guelph, Guelph/Eramosa, Rockwood
Central Grand	Significant	Significant	Integrated Urban System
Mill Creek	Moderate	Low	Puslinch Mini-Lakes (communal)
Upper Nith	Low	Low	Milverton, Wellesley (Integrated Urban System)
Middle Nith	Low	Low	Integrated Urban System, Plattsville
Lower Nith	Low	Low	Integrated Urban System, Drumbo, Paris
Whitemans Creek	Low	Low	Bright
Grand at Brantford	Low	Low	Airport, Mt Pleasant
Fairchild Creek	Low	Low	St. George
Big Creek	Moderate	Low	Lynden
McKenzie Creek	Low	Low	None
Above Dunnville To York	Low	Low	None

The results of the Groundwater Stress Assessment are shown in Table 18-14 which contains the estimated potential for hydrologic stress. The table also lists the municipal groundwater supplies in each of the assessment areas.

~~18.6.11 Planned Condition Percent Water Demand~~

~~Planned Systems were not fully characterized at the time this report was prepared and therefore were not evaluated within this Tier 2 Groundwater Stress Assessment. The purpose of the 'Planned System' scenario under the Technical Rules is to evaluate planned municipal water systems that are not included within the Current Demand scenario.~~

~~18.6.12 Future Conditions Percent Water Demand~~

~~The Water Quantity Stress Assessment evaluates the impact of increased future municipal demand on the potential for assessment area stress. Future non-municipal water demand is assumed equal to current non-municipal water demand.~~

~~**Table** 18-33 lists the estimated future water demand requirements for each municipal groundwater supply system. As described in Section 3.8.3, these values are derived from GRCA's summary report "Status Report on Municipal Long Term Water Supply Strategies" (Shifflett, 2007), as well as the "Region of Waterloo Water Supply Strategy Report" (XCG, 2007). Where the municipal system relies upon both groundwater and surface water, the total future demand requirement was split between sources as described in Section 3.8.3.~~

~~Table 18-33: Future Groundwater Municipal Demand Increases~~

~~**GW Assessment Area**~~	~~**Municipal Water Supply System**~~	~~**Est. 2031 Population**~~	~~**Total Increase in Municipal Demand (m^3/d)**~~	~~**Increase Supplied by Additional Groundwater Sources**~~	
				~~**(m^3/d)**~~	~~**(L/s)**~~
~~Grand Above~~	~~*Dundalk*~~	~~2,995~~	~~316~~	~~316~~	~~4~~
~~Grand Above Shand to Legatt~~	~~*Grand Valley*~~	~~3,650~~	~~533~~	~~533~~	
	~~*Waldemar*~~	~~425~~	~~45~~	~~45~~	
	~~*Marsville*~~	~~143~~	~~9~~	~~9~~	
~~Irvine River~~	~~*Fergus-Elora*~~	~~3,650~~	~~5,530~~	~~5,530~~	
~~Canagagigue Creek~~	~~*West Montrose*~~	~~185~~	~~*n/a*~~	~~*n/a*~~	~~*n/a*~~
	~~*Conestogo Plains*~~	~~370~~	~~*n/a*~~	~~*n/a*~~	~~*n/a*~~
~~Conestogo Above Dam~~	~~*Arthur*~~	~~3,275~~	~~616~~	~~616~~	
	~~*Drayton*~~	~~3,780~~	~~776~~	~~776~~	
	~~*Moorefield*~~	~~855~~	~~*n/a*~~	~~*n/a*~~	~~*n/a*~~
~~Conestogo Below Dam~~	~~*Heidelberg*~~	~~1,065~~	~~*n/a*~~	~~*n/a*~~	~~*n/a*~~
	~~*Linwood*~~	~~807~~	~~*n/a*~~	~~*n/a*~~	~~*n/a*~~
	~~*St. Clements*~~	~~1,580~~	~~40~~	~~40~~	
~~Hopewell/Cox Creek~~	~~*Conestogo Golf*~~	~~491~~	~~54~~	~~54~~	
	~~*Maryhill*~~	~~160~~	~~*n/a*~~	~~*n/a*~~	~~*n/a*~~
	~~*Maryhill Heights*~~	~~127~~	~~*n/a*~~	~~*n/a*~~	
~~Upper Speed~~	~~*Rockwood*~~	~~2,995~~	~~1,276~~	~~1,276~~	
	~~*Hamilton Drive*~~	~~1,001~~	~~*n/a*~~	~~*n/a*~~	~~*n/a*~~

~~Table 18-33: Future Groundwater Municipal Demand Increases~~

~~GW Assessment Area~~	**~~Municipal Water Supply System~~**	**~~Est. 2031 Population~~**	**~~Total Increase in Municipal Demand (m^3/d)~~**	**~~Increase Supplied by Additional Groundwater Sources~~**	
				~~(m^3/d)~~	**~~(L/s)~~**
	~~Guelph~~	~~166,750~~	~~17,280~~	~~16,156~~	~~187~~
~~Central Grand~~	*~~Tri-City (Kitchener, Waterloo, Cambridge, Elmira, St. Jacobs, Breslau, Brown Subdivision)~~*	~~662,542~~	~~51,840~~	~~34,560~~	~~400~~
	~~New Dundee~~	~~1,136~~	*~~n/a~~*	*~~n/a~~*	*~~n/a~~*
~~Mill Creek~~	*~~No municipal systems~~*	*~~n/a~~*	*~~n/a~~*	*~~n/a~~*	*~~n/a~~*
~~Upper Nith~~	*~~Wellesley~~*	~~4,150~~	~~349~~	~~349~~	~~4~~
	~~Milverton~~	~~2,485~~	~~203~~	~~203~~	
~~Middle Nith~~	*~~New Hamburg/Baden~~*	~~17,850~~	~~2,272~~	~~2,272~~	
	~~Plattsville~~	~~2,175~~	~~686~~	~~686~~	
	~~Foxboro~~	*~~397~~*	*~~n/a~~*	*~~n/a~~*	*~~n/a~~*
~~Lower Nith~~	*~~Ayr~~*	~~7,800~~	~~1,413~~	~~1,413~~	~~16~~
	~~Branchton~~	*~~125~~*	*~~n/a~~*	*~~n/a~~*	*~~n/a~~*
	~~Drumbo~~	~~797~~	~~86~~	~~86~~	
	~~Paris~~	~~11,000~~	~~922~~	~~922~~	
	~~Roseville~~	*~~277~~*	*~~n/a~~*	*~~n/a~~*	
~~Whitemans~~	*~~Bright~~*	~~454~~	~~26~~	~~26~~	
~~Grand at Brantford~~	*~~Mount Pleasant~~*	~~1,790~~	~~273~~	~~273~~	
	~~Airport~~	~~597~~	~~24~~	~~24~~	
~~Fairchild Creek~~	*~~St George~~*	~~5237~~	~~1,304~~	~~1,304~~	
~~Big Creek~~	*~~Lynden~~*	~~495~~	~~34~~	~~34~~	
~~McKenzie Creek~~	*~~No municipal systems~~*	*~~n/a~~*	*~~n/a~~*	*~~n/a~~*	*~~n/a~~*
~~Grand Above Dunnville To York~~	*~~No municipal systems~~*	*~~n/a~~*	*~~n/a~~*	*~~n/a~~*	*~~n/a~~*

~~Notes: n/a – no projected increased municipal water demand.~~

~~**Table** 18-34 contains estimated average annual and maximum monthly future water demands calculated by adding the future increased municipal water demand (**Table** 18-33) to the current water demand. Future non-municipal water demand estimates are assumed equal to current estimates. With these estimated future demands, the Percent Water Demand is calculated using the same approach as followed for current conditions (**Table** 18-30).~~

~~18.6.13~~

~~Table 18-34: Groundwater Stress Assessment Components with Future Demand Estimates~~

~~**Assessment area**~~	~~**Groundwater Supply (L/s)**~~			~~**GW Reserve**~~	~~**Future Water Demand (L/s)**~~		~~**Percent Water Demand**~~	
	~~**Recharge**~~	~~**Flow In**~~	~~**Total Supply**~~		~~**Average Annual**~~	~~**Maximum Monthly**~~	~~**Average Annual**~~	~~**Maximum Monthly**~~
~~Grand Above Legatt~~	~~2,046~~	~~0~~	~~2,046~~	~~183~~	~~29~~	~~31~~	~~2%~~	~~2%~~
~~Grand Above Shand to Legatt~~	~~2,286~~	~~157~~	~~2,443~~	~~217~~	~~76~~	~~84~~	~~3%~~	~~4%~~
~~Irvine River~~	~~1,595~~	~~58~~	~~1,653~~	~~125~~	~~146~~	~~167~~	~~9%~~	~~11%~~
~~Canagagigue Creek~~	~~905~~	~~157~~	~~1,063~~	~~66~~	~~164~~	~~183~~	~~**16%**~~	~~18%~~
~~Conestogo Above Dam~~	~~2,245~~	~~42~~	~~2,287~~	~~124~~	~~53~~	~~56~~	~~2%~~	~~3%~~
~~Conestogo Below Dam~~	~~944~~	~~789~~	~~1,734~~	~~168~~	~~46~~	~~54~~	~~3%~~	~~3%~~
~~Hopewell/Cox Creek~~	~~1,376~~	~~181~~	~~1,557~~	~~130~~	~~85~~	~~109~~	~~6%~~	~~8%~~
~~Upper Speed~~	~~4,652~~	~~480~~	~~5,132~~	~~425~~	~~1,128~~	~~1,234~~	~~**24%**~~	~~**26%**~~
~~Central Grand~~	~~4,132~~	~~456~~	~~4,588~~	~~259~~	~~2,259~~	~~2,597~~	~~**52%**~~	~~**60%**~~
~~Mill Creek~~	~~764~~	~~0~~	~~764~~	~~54~~	~~82~~	~~114~~	~~**12%**~~	~~16%~~
~~Upper Nith~~	~~2,163~~	~~133~~	~~2,296~~	~~98~~	~~40~~	~~48~~	~~2%~~	~~2%~~
~~Middle Nith~~	~~1,815~~	~~517~~	~~2,332~~	~~196~~	~~157~~	~~177~~	~~7%~~	~~8%~~
~~Lower Nith~~	~~3,807~~	~~234~~	~~4,041~~	~~361~~	~~212~~	~~299~~	~~6%~~	~~8%~~
~~Whitemans Creek~~	~~3,274~~	~~120~~	~~3,395~~	~~271~~	~~117~~	~~465~~	~~4%~~	~~15%~~
~~Grand at Brantford~~	~~1,023~~	~~438~~	~~1,461~~	~~133~~	~~77~~	~~214~~	~~6%~~	~~16%~~
~~Fairchild Creek~~	~~1,735~~	~~203~~	~~1,938~~	~~167~~	~~107~~	~~132~~	~~6%~~	~~7%~~
~~Big Creek~~	~~777~~	~~198~~	~~975~~	~~52~~	~~35~~	~~66~~	~~4%~~	~~7%~~

~~Table 18-34: Groundwater Stress Assessment Components with Future Demand Estimates~~

~~Assessment area~~	~~Groundwater Supply (L/s)~~			~~GW Reserve~~	~~Future Water Demand (L/s)~~		~~Percent Water Demand~~	
	~~Recharge~~	~~Flow In~~	~~Total Supply~~		~~Average Annual~~	~~Maximum Monthly~~	~~Average Annual~~	~~Maximum Monthly~~
~~McKenzie Creek~~	~~1,471~~	~~119~~	~~1,590~~	~~108~~	~~53~~	~~223~~	~~4%~~	~~15%~~
~~Grand Above Dunnville To York~~	~~1,019~~	~~54~~	~~1,073~~	~~92~~	~~91~~	~~116~~	~~9%~~	~~12%~~

~~Note: Assessment areas with **Highlighted** Percent Water Demand are above Moderate Stress Threshold~~

~~Assessment area with ***Highlighted*** Percent Water Demand Estimates are above Significant Stress Threshold~~

~~**Table** 18-35 lists the stress classifications for the future water demand estimates.~~

~~Table 18-35: Groundwater Area Stress Classifications with Future Demand Estimates~~

~~**Assessment Area**~~	~~**Average Percent Water Demand**~~	~~**Maximum Monthly Percent Water Demand**~~	~~**Municipal Water Supply**~~
~~Grand Above Legatt~~	~~Low~~	~~Low~~	~~Dundalk~~
~~Grand Above Shand To Legatt~~	~~Low~~	~~Low~~	~~Grand Valley, Waldemar Marsville~~
~~Irvine River~~	~~Low~~	~~Low~~	~~Elora, Fergus~~
~~Canagagigue Creek~~	~~**Moderate**~~	~~Low~~	~~West Montrose, Conestogo, Elmira~~
~~Conestogo Above Dam~~	~~Low~~	~~Low~~	~~Arthur, Drayton, Moorefield~~
~~Conestogo Below Dam~~	~~Low~~	~~Low~~	~~RMOW Villages~~
~~Hopewell/Cox Creek~~	~~Low~~	~~Low~~	~~Maryhill~~
~~Upper Speed~~	~~**Moderate**~~	~~**Moderate**~~	~~City of Guelph, Guelph/Eramosa, Rockwood~~
~~Central Grand~~	~~**Significant**~~	~~**Significant**~~	~~RMOW~~
~~Mill Creek~~	~~**Moderate**~~	~~Low~~	~~Puslinch Mini-Lakes (communal)~~
~~Upper Nith~~	~~Low~~	~~Low~~	~~Milverton, Wellesley (RMOW)~~
~~Middle Nith~~	~~Low~~	~~Low~~	~~RMOW, Plattsville~~
~~Lower Nith~~	~~Low~~	~~Low~~	~~RMOW Villages, Drumbo, Paris~~
~~Whitemans Creek~~	~~Low~~	~~Low~~	~~Bright, Princeton~~
~~Grand at Brantford~~	~~Low~~	~~Low~~	~~County of Brant (Airport & Mt Pleasant)~~
~~Fairchild Creek~~	~~Low~~	~~Low~~	~~St. George~~
~~Big Creek~~	~~Low~~	~~Low~~	~~Lynden~~
~~McKenzie Creek~~	~~Low~~	~~Low~~	~~None~~
~~Grand Above Dunnville To York~~	~~Low~~	~~Low~~	~~None~~

~~18.6.14 Drought Scenario~~

~~The Technical Rules specify both a two year and a ten year drought scenario. The two year scenario is specified as a simulated two year period with no groundwater recharge. The ten year scenario means the continuous ten year period for which precipitation records exist with the lowest mean annual precipitation. Furthermore, the scenarios need to be assessed for both existing and planned systems. The two year period is intended as a screening scenario where the ten year scenario would be considered only if the two year scenario resulted in groundwater declines that would result in problems at a well.~~

~~Instead of completing the two-year drought scenario, this study proceeded directly with 10-year drought scenario using the monthly groundwater recharge rates estimated by GAWSER for the 1960-2000 climate period. Information relating to planned pumping rates for municipal wells was not available and therefore the drought assessment is only carried out for existing pumping rates.~~

~~In general, the results of the drought scenario are consistent with expectations. Shallow wells tend to have water levels that fluctuate more than those for deeper wells. However, the Grand River groundwater flow model has not been calibrated to any wellfield conditions. Hydrogeologic parameters near wellfields including specific storage, hydraulic conductivity, and aquifer thickness each have a role in the simulation of transient water levels and without having these values calibrated there cannot be a high level of confidence in predicted values. However, the results of the 1960-1999 simulation are useful to identify wellfields where there is a potential for drought impacts and then to focus additional effort on those areas.~~

~~The objective of the drought assessment is to identify any additional assessment areas that should be classified as having a *Moderate* potential for stress due to the drought scenario. Since the model is not calibrated to wellfield conditions, the results of this drought assessment should only be used as a screening tool to identify areas where there is a potential for drought impacts and therefore to collect more information. Wells located in assessment areas already classified as having a *Moderate* or *Significant* potential for stress under the Percent Water Demand assessment are not evaluated in the drought scenario. **Table** 18-36 lists the municipal wells having a simulated drawdown greater than 3 m during the drought scenario.~~

~~Table 18-36: Wells with Simulated Water Level Decreases Greater than 3 metres in Assessment Areas with Low Potential for Stress~~

~~Municipality~~	~~Municipal System~~	~~Assessment Area~~	~~Well Name~~	~~Maximum Water Level Decrease Below Initial Condition (m)~~	~~Maximum Water Level Increase Above Initial Condition (m)~~	~~Absolute Variability in Water Level Fluctuations (m)~~	~~Available Draw-down (m)~~
~~County of Brant~~	~~Airport Well~~	~~Grand at Brantford~~	~~Airport Well~~	~~-3.8~~	~~+0.7~~	~~4.5~~	~~11~~

~~Table 18-36: Wells with Simulated Water Level Decreases Greater than 3 metres in Assessment Areas with Low Potential for Stress~~

~~Municipality~~	~~Municipal System~~	~~Assessment Area~~	~~Well Name~~	~~Maximum Water Level Decrease Below Initial Condition (m)~~	~~Maximum Water Level Increase Above Initial Condition (m)~~	~~Absolute Variability in Water Level Fluctuations (m)~~	~~Available Draw-down (m)~~
	~~Supply~~						
~~County of Oxford~~	~~Bright~~	~~Whitemans Creek~~	~~Well_4~~	~~-7.0~~	~~+7.6~~	~~14.6~~	~~6.7~~
~~RMOW~~	~~Roseville~~	~~Lower Nith~~	~~R6~~	~~-3.0~~	~~+0.1~~	~~3.1~~	~~32~~
~~RMOW~~	~~Heidelberg~~	~~Conestogo Below Dam~~	~~HD1~~	~~-3.1~~	~~+0.2~~	~~3~~	~~27~~
			~~HD2~~	~~-3.5~~	~~+0.2~~	~~3~~	~~27~~
~~RMOW~~	~~Foxboro Green~~	~~Middle Nith~~	~~FG_1~~	~~-3.8~~	~~+0.9~~	~~4.7~~	~~25~~
		~~Middle Nith~~	~~FG_2~~	~~-3.8~~	~~+1.0~~	~~4.8~~	~~12~~
~~Centre Wellington~~	~~Fergus~~	~~Irvine River~~	~~Fergus_6~~	~~-3.6~~	~~+2.3~~	~~5.9~~	~~30~~
	~~Elora~~	~~Irvine River~~	~~Elora_E1~~	~~-4.3~~	~~+0.1~~	~~4.4~~	~~17~~

~~18.6.15~~

~~Based on this additional information, as well as the results of the drought assessment, the Whitemans Creek Assessment Area is classified with a *Moderate* stress level due to drought conditions at Bright Well #4.~~

~~Uncertainty in Stress Classifications~~

~~**Table** 18-37 summarizes the results of the sensitivity analysis for groundwater under current water demand (**Table** 18-37**a**) and future water demand (**Table** 18-38**b**). The Percent Water Demand for average annual demand and maximum monthly demand is presented for the groundwater sensitivity analysis.~~

~~Table 18-37a: Groundwater Sensitivity Analysis (Current Water Demand)~~

~~Assessment Area~~	**~~(1) Estimated Water Demand x 125 %~~**		**~~(2) Estimated Water Demand x 75 %~~**		**~~(3) Recharge x 125%~~**		**~~(4) Recharge x 75%~~**	
	~~Average Annual~~	**~~Max Monthly~~**	**~~Average Annual~~**	**~~Max Monthly~~**	**~~Average Annual~~**	**~~Max Monthly~~**	**~~Average Annual~~**	**~~Max Monthly~~**
~~Grand Above Legatt~~	~~2%~~	~~2%~~	~~1%~~	~~1%~~	~~1%~~	~~1%~~	~~2%~~	~~2%~~
~~Grand Above Shand to Legatt~~	~~4%~~	~~4%~~	~~2%~~	~~3%~~	~~2%~~	~~3%~~	~~4%~~	~~5%~~
~~Irvine River~~	~~5%~~	~~6%~~	~~5%~~	~~6%~~	~~4%~~	~~5%~~	~~7%~~	~~8%~~
~~Canagagigue Creek~~	**~~18%~~**	~~20%~~	**~~15%~~**	~~17%~~	**~~13%~~**	~~15%~~	**~~22%~~**	~~24%~~
~~Conestogo Above Dam~~	~~2%~~	~~2%~~	~~2%~~	~~2%~~	~~1%~~	~~1%~~	~~2%~~	~~2%~~
~~Conestogo Below Dam~~	~~3%~~	~~4%~~	~~2%~~	~~3%~~	~~2%~~	~~3%~~	~~4%~~	~~5%~~
~~Hopewell/Cox Creek~~	~~7%~~	~~9%~~	~~4%~~	~~6%~~	~~5%~~	~~6%~~	~~8%~~	~~10%~~
~~Upper Speed~~	**~~20%~~**	~~23%~~	**~~19%~~**	~~21%~~	**~~16%~~**	~~18%~~	***~~26%~~***	**~~29%~~**
~~Central Grand~~	***~~45%~~***	***~~54%~~***	***~~40%~~***	**~~47%~~**	***~~34%~~***	**~~41%~~**	***~~57%~~***	***~~68%~~***
~~Mill Creek~~	**~~13%~~**	~~19%~~	**~~10%~~**	~~14%~~	~~9%~~	~~13%~~	**~~15%~~**	~~22%~~
~~Upper Nith~~	~~2%~~	~~2%~~	~~1%~~	~~2%~~	~~1%~~	~~1%~~	~~2%~~	~~2%~~
~~Middle Nith~~	~~6%~~	~~7%~~	~~6%~~	~~7%~~	~~5%~~	~~5%~~	~~8%~~	~~9%~~
~~Lower Nith~~	~~5%~~	~~8%~~	~~5%~~	~~7%~~	~~4%~~	~~6%~~	~~7%~~	~~10%~~
~~Whitemans Creek~~	~~5%~~	~~18%~~	~~3%~~	~~12%~~	~~3%~~	~~12%~~	~~5%~~	~~20%~~
~~Grand at Brantford~~	~~7%~~	~~19%~~	~~4%~~	~~12%~~	~~4%~~	~~13%~~	~~7%~~	~~21%~~
~~Fairchild Creek~~	~~6%~~	~~8%~~	~~4%~~	~~5%~~	~~4%~~	~~5%~~	~~7%~~	~~9%~~
~~Big Creek~~	~~4%~~	~~6%~~	~~2%~~	~~4%~~	~~3%~~	~~6%~~	~~5%~~	~~9%~~
~~McKenzie Creek~~	~~4%~~	~~19%~~	~~3%~~	~~11%~~	~~3%~~	~~12%~~	~~5%~~	~~20%~~
~~Grand Above Dunnville To York~~	**~~11%~~**	~~13%~~	~~8%~~	~~10%~~	~~7%~~	~~9%~~	**~~12%~~**	~~16%~~

~~Table 18-37a: Groundwater Sensitivity Analysis (Current Water Demand)~~

~~**Assessment Area**~~	~~**(1) Estimated Water Demand x 125 %**~~		~~**(2) Estimated Water Demand x 75 %**~~		~~**(3) Recharge x 125%**~~		~~**(4) Recharge x 75%**~~	
	~~**Average Annual**~~	~~**Max Monthly**~~	~~**Average Annual**~~	~~**Max Monthly**~~	~~**Average Annual**~~	~~**Max Monthly**~~	~~**Average Annual**~~	~~**Max Monthly**~~

~~Table 18-38b: Groundwater Sensitivity Analysis (Future Water Demand)~~

~~**Assessment Area**~~	~~**(1) Future Water Demand x 125 %**~~		~~**(2) Future Water Demand x 75 %**~~		~~**(3) Recharge x 125%**~~		~~**(4) Recharge x 75%**~~	
	~~**Average Annual**~~	~~**Max Monthly**~~	~~**Average Annual**~~	~~**Max Monthly**~~	~~**Average Annual**~~	~~**Max Monthly**~~	~~**Average Annual**~~	~~**Max Monthly**~~
~~Irvine River~~	~~**10%**~~	~~11%~~	~~8%~~	~~8%~~	~~7%~~	~~9%~~	~~**13%**~~	~~15%~~

~~Note: Assessment areas with **Highlighted** Percent Water Demand are above Moderate Stress Threshold~~

~~Assessment area with ***Highlighted*** Percent Water Demand Estimates are above Significant Stress Threshold~~

~~18.6.16~~

~~For the current water demand assessment areas originally classified as having a *Low* potential for stress, there is only one assessment area (Grand Above Dunnville to York) whose classification was shown to change due to the sensitivity calculations. If recharge decreased by 25% or demand increased by 25%, this assessment area may move to a *Moderate* potential for stress classification.~~

~~The four current water demand assessment areas identified as having either a *Moderate* or *Significant* potential for stress in the Groundwater Stress Assessment in **Table** 18-32 (i.e. Canagagigue Creek, Upper Speed, Central Grand, and Mill Creek) maintain estimated Percent Water Demands consistent with their original classification. The only exception to this is Mill Creek. When recharge is increased by 25%, Mill Creek is classified as having a *Low* potential for stress under average and maximum monthly conditions.~~

~~For the future water demand assessment areas originally classified as having a *Low* potential for stress, there is only one assessment area (Irvine River) whose classification was shown to change due to the sensitivity calculations. If recharge decreased by 25% or demand increased by 25%, this assessment area may move to a *Moderate* potential for stress classification.~~

~~Despite large changes to demand and supply parameters, the sensitivity analysis shows that the Stress Assessment results for most assessment areas are not sensitive to uncertainty associated with water demand and groundwater recharge estimates. This confirmation of the stress classification provides additional confidence in the classification.~~

~~**Table** 18-39 summarizes the results of the sensitivity analysis. Those assessment areas which were originally identified as having a *Moderate* or *Significant* potential for stress and retained that classification for all sensitivity scenarios, were assigned an Uncertainty Classification of *Low*. Likewise, those assessment areas originally identified as having a *Low* potential for stress and retained that identification for all sensitivity scenarios, were assigned an Uncertainty Classification of *Low*. An~~

~~uncertainty classification of *High* is assigned to assessment areas whose potential for stress was shown to change for at least one of the sensitivity scenarios.~~

~~18.6.17~~

~~Table 18-39: Low or High Uncertainty based on Sensitivity Analysis~~

~~**Assessment Area**~~	~~**Low or High Uncertainty**~~
~~Grand Above Legatt~~	~~Low~~
~~Grand Above Shand to Legatt~~	~~Low~~
~~Irvine River~~	~~**High**~~
~~Canagagigue Creek~~	~~Low~~
~~Conestogo Above Dam~~	~~Low~~
~~Conestogo Below Dam~~	~~Low~~
~~Hopewell/Cox Creek~~	~~Low~~
~~Upper Speed~~	~~Low~~
~~Central Grand~~	~~Low~~
~~Mill Creek~~	~~**High**~~
~~Upper Nith~~	~~Low~~
~~Middle Nith~~	~~Low~~
~~Lower Nith~~	~~Low~~
~~Whitemans Creek~~	~~**High**~~
~~Grand at Brantford~~	~~Low~~
~~Fairchild Creek~~	~~Low~~
~~Big Creek~~	~~Low~~
~~McKenzie Creek~~	~~Low~~
~~Grand Above Dunnville To York~~	~~**High**~~

~~18.6.18 Uncertainty Assessment~~

~~The only current water demand assessment area that meets the first criteria is Grand Above Dunnville to York, seen in **Table** 18-31. This assessment area also meets the second criteria, as it was labeled as having a *High* uncertainty in regards to its classification in **Table** 18-39. The Groundwater Sensitivity~~

~~Analysis in **Table** 18-37 suggests that Grand Above Dunnville to York could have a *Moderate* potential for stress under two different sensitivity scenarios.~~

~~Because all the criteria for the uncertainty assessment are met for the Grand Above Dunnville to York Assessment Area, a *Moderate* potential for stress should be assigned to this assessment area. However, since the Grand Above Dunnville to York Assessment Area does not contain any municipal groundwater supplies, a *Moderate* stress classification has no implication on the requirement for future work under the Clean Water Act.~~

~~The only future water demand assessment area that meets the first criteria is Irvine River, seen in **Table** 18-31. This assessment area also meets the second criteria, as it was labeled as having a *High* uncertainty in regards to its classification in **Table** 18-39. The Groundwater Sensitivity Analysis in **Table** 18-37 suggests that Irvine River could have a *Moderate* potential for stress under two different sensitivity scenarios.~~

~~Because all the criteria for the uncertainty assessment are met for the Irvine River Assessment Area, a *Moderate* potential for stress should be assigned to this assessment area. Current and future percent water demand values are below the threshold for moderate potential for stress, but the future average annual percent water demand is very close to the 10% threshold. Percent water demand calculations are slightly sensitive to future water use, but are more sensitive to changes in recharge estimates. A reduction in recharge or a large increase in future water use would bring values above the threshold triggering a need for a Tier 3 Risk Assessment work on the Fergus-Elora municipal drinking water systems under the *Clean Water Act, 2006*. The Tier 3 Risk Assessment for the Fergus-Elora municipal drinking water system is currently deferred based on this uncertainty assessment.~~

~~18.6.19 Groundwater Stress Assessment Results~~

~~Based on the Percent Water Demand calculations for current and future demand conditions, and the results of the Drought Scenario, the groundwater stress classifications are included in **Table** 18-40 below.~~

~~18.6.20~~

~~Table 18-40: Groundwater Area Stress Classifications with Future Demand Estimates~~

~~**Assessment Area**~~	~~**Average Percent Water Demand**~~	~~**Maximum Monthly Percent Water Demand**~~	~~**Drought Conditions**~~	~~**Municipal Water Supply**~~
~~Grand Above Legatt~~	~~Low~~	~~Low~~	~~Low~~	~~Dundalk~~
~~Grand Above Shand To Legatt~~	~~Low~~	~~Low~~	~~Low~~	~~Grand Valley, Waldemar Marsville~~
~~Irvine River~~	~~**Moderate**~~	~~Low~~	~~Low~~	~~Elora, Fergus~~
~~Canagagigue Creek~~	~~**Moderate**~~	~~Low~~	~~Low~~	~~West Montrose, Conestogo, Elmira~~
~~Conestogo Above Dam~~	~~Low~~	~~Low~~	~~Low~~	~~Arthur, Drayton, Moorefield~~

~~Table 18-40: Groundwater Area Stress Classifications with Future Demand Estimates~~

~~Assessment Area~~	**~~Average Percent Water Demand~~**	**~~Maximum Monthly Percent Water Demand~~**	**~~Drought Conditions~~**	**~~Municipal Water Supply~~**
~~Conestogo Below Dam~~	~~Low~~	~~Low~~	~~Low~~	~~RMOW Villages~~
~~Hopewell/Cox Creek~~	~~Low~~	~~Low~~	~~Low~~	~~Maryhill~~
~~Upper Speed~~	**~~Moderate~~**	**~~Moderate~~**	~~Low~~	~~City of Guelph, Guelph/Eramosa, Rockwood~~
~~Central Grand~~	**~~Significant~~**	**~~Significant~~**	~~Low~~	~~RMOW~~
~~Mill Creek~~	**~~Moderate~~**	~~Low~~	~~Low~~	~~Puslinch Mini-Lakes (communal)~~
~~Upper Nith~~	~~Low~~	~~Low~~	~~Low~~	~~Milverton, Wellesley (RMOW)~~
~~Middle Nith~~	~~Low~~	~~Low~~	~~Low~~	~~RMOW, Plattsville~~
~~Lower Nith~~	~~Low~~	~~Low~~	~~Low~~	~~RMOW Villages, Drumbo, Paris~~
~~Whitemans Creek~~	~~Low~~	~~Low~~	**~~Moderate~~**	~~Bright, Princeton~~
~~Grand at Brantford~~	~~Low~~	~~Low~~	~~Low~~	~~County of Brant (Airport & Mt Pleasant)~~
~~Fairchild Creek~~	~~Low~~	~~Low~~	~~Low~~	~~St. George~~
~~Big Creek~~	~~Low~~	~~Low~~	~~Low~~	~~Lynden~~
~~McKenzie Creek~~	~~Low~~	~~Low~~	~~Low~~	~~None~~
~~Grand Above Dunnville To York~~	~~Low~~	~~Low~~	~~Low~~	~~None~~

~~18.6.21~~

~~The following sections summarize the subwatersheds classified as having a **Moderate** or **Significant** potential for stress under existing and future demand conditions. The hydrologic factors influencing the classification are discussed, and municipal supplies located within the assessment area are identified. The results of the Tier 2 Groundwater Stress Assessment are illustrated on **Map** 18-10. To facilitate the discussion of the driving factors that result in the relative levels of potential for stress for each assessment area, **Table** 18-41 presents a breakdown of the consumptive water demand by sector.~~

~~Table 18-41: Breakdown of Consumptive Groundwater Demand, By Sector~~

~~Groundwater Assessment Area~~	**~~Total Demand~~**		**~~Consumptive Water Demand Breakdown By Sector~~**										
	~~Demand (L/s)~~	**~~Average % Water Demand~~**	**~~Com-mercial~~**	**~~Dewat-ering~~**	**~~Ind-ustrial~~**	**~~Instit-utional~~**	**~~Rec-reation~~**	**~~Remed.~~**	**~~Private Water Supply~~**	**~~Misc.~~**	**~~Agric. Irrigation~~**	**~~Livestock & Rural Domestic~~**	**~~Munic. Water Supply~~**
~~Grand Above Legatt~~	~~25~~	~~1%~~	~~53%~~	~~0%~~	~~0%~~	~~0%~~	~~0%~~	~~0%~~	~~7%~~	~~0%~~	~~0%~~	~~9%~~	~~30%~~
~~Grand Above Shand to Legatt~~	~~69~~	~~3%~~	~~0%~~	~~0%~~	~~12%~~	~~0%~~	~~0%~~	~~0%~~	~~66%~~	~~5%~~	~~0%~~	~~6%~~	~~11%~~
~~Irvine River~~	~~79~~	~~5%~~	~~1%~~	~~0%~~	~~4%~~	~~0%~~	~~0%~~	~~0%~~	~~0%~~	~~0%~~	~~0%~~	~~22%~~	~~73%~~
~~Canagagigue Creek~~	~~164~~	**~~16%~~**	~~61%~~	~~11%~~	~~2%~~	~~0%~~	~~0%~~	~~21%~~	~~0%~~	~~0%~~	~~0%~~	~~3%~~	~~1%~~
~~Conestogo Above Dam~~	~~37~~	~~2%~~	~~0%~~	~~0%~~	~~9%~~	~~0%~~	~~0%~~	~~0%~~	~~6%~~	~~0%~~	~~0%~~	~~31%~~	~~53%~~
~~Conestogo Below Dam~~	~~46~~	~~3%~~	~~0%~~	~~0%~~	~~33%~~	~~0%~~	~~0%~~	~~0%~~	~~15%~~	~~0%~~	~~0%~~	~~33%~~	~~19%~~
~~Hopewell/Cox Creek~~	~~84~~	~~6%~~	~~13%~~	~~75%~~	~~0%~~	~~0%~~	~~0%~~	~~0%~~	~~2%~~	~~0%~~	~~0%~~	~~6%~~	~~4%~~
~~Upper Speed~~	~~926~~	**~~20%~~**	~~5%~~	~~17%~~	~~3%~~	~~0%~~	~~0%~~	~~0%~~	~~0%~~	~~2%~~	~~0%~~	~~1%~~	~~71%~~
~~Central Grand~~	~~1,859~~	***~~43%~~***	~~6%~~	~~1%~~	~~12%~~	~~0%~~	~~0%~~	~~4%~~	~~6%~~	~~0%~~	~~0%~~	~~1%~~	~~71%~~
~~Mill Creek~~	~~82~~	**~~12%~~**	~~37%~~	~~0%~~	~~42%~~	~~0%~~	~~0%~~	~~0%~~	~~19%~~	~~1%~~	~~0%~~	~~1%~~	~~0%~~
~~Upper Nith~~	~~34~~	~~2%~~	~~0%~~	~~0%~~	~~21%~~	~~0%~~	~~0%~~	~~0%~~	~~2%~~	~~0%~~	~~4%~~	~~27%~~	~~46%~~
~~Middle Nith~~	~~123~~	~~6%~~	~~3%~~	~~0%~~	~~2%~~	~~0%~~	~~0%~~	~~0%~~	~~3%~~	~~0%~~	~~0%~~	~~4%~~	~~88%~~
~~Lower Nith~~	~~184~~	~~5%~~	~~6%~~	~~0%~~	~~24%~~	~~0%~~	~~0%~~	~~0%~~	~~5%~~	~~0%~~	~~4%~~	~~4%~~	~~58%~~
~~Whitemans Creek~~	~~117~~	~~4%~~	~~2%~~	~~0%~~	~~0%~~	~~0%~~	~~0%~~	~~0%~~	~~0%~~	~~0%~~	~~91%~~	~~6%~~	~~1%~~
~~Grand at Brantford~~	~~74~~	~~6%~~	~~21%~~	~~0%~~	~~12%~~	~~0%~~	~~0%~~	~~0%~~	~~0%~~	~~0%~~	~~42%~~	~~5%~~	~~21%~~
~~Fairchild Creek~~	~~92~~	~~5%~~	~~26%~~	~~0%~~	~~12%~~	~~0%~~	~~0%~~	~~3%~~	~~27%~~	~~0%~~	~~5%~~	~~13%~~	~~15%~~
~~Big Creek~~	~~35~~	~~4%~~	~~11%~~	~~66%~~	~~15%~~	~~0%~~	~~0%~~	~~0%~~	~~2%~~	~~0%~~	~~3%~~	~~4%~~	~~1%~~
~~McKenzie Creek~~	~~53~~	~~4%~~	~~0%~~	~~0%~~	~~0%~~	~~0%~~	~~0%~~	~~0%~~	~~0%~~	~~0%~~	~~94%~~	~~6%~~	~~0%~~
~~Grand Above Dunnville to York~~	~~91~~	~~9%~~	~~6%~~	~~89%~~	~~0%~~	~~0%~~	~~0%~~	~~0%~~	~~0%~~	~~0%~~	~~1%~~	~~4%~~	~~0%~~
~~Grand Total~~	**~~4,295~~**	~~-~~	~~9%~~	~~10%~~	~~10%~~	~~0%~~	~~0%~~	~~3%~~	~~5%~~	~~0%~~	~~5%~~	~~3%~~	~~55%~~

~~18.6.23~~18.4.3 Groundwater Water Budget Results

Canagagigue Creek Assessment Area

The Canagagigue Creek Assessment is a relatively small assessment area with an estimated Percent Water Demand of 16% under average demand conditions and 18% under maximum demand conditions. These estimates result in the area being classified as having a ***Moderate*** potential for stress under average demand conditions and a *Low* potential for stress under maximum demand conditions. Estimated future demands do not change these classifications.

Most of the estimated consumptive demand for this area is related to a combination of commercial (61%) and remediation (21%) water uses. The estimated commercial demand is based on PTTWs for aquaculture and golf course irrigation and most of this estimate is supported by reported pumping rates. All of the groundwater demand relating to groundwater remediation is based on reported pumping rates from the PTTW database. There are very few estimated demands in this assessment area, therefore there is high certainty regarding the classification of Canagagigue Creek having a ***Moderate*** potential for stress.

The municipal groundwater supplies for Elmira, West Montrose, and Conestogo Plains are located within this assessment area. These municipal demands represent only 1% of the total estimated consumptive water demand but, according to the Technical Rules, this assessment area meets the requirements for a Tier 3 Water Quantity Risk Assessment.

Upper Speed Assessment Area

The Upper Speed assessment area has an estimated Percent Water Demand of 20% under average demand conditions and 22% under maximum demand conditions. These estimates result in the Assessment Area being classified as having a ***Moderate*** potential for stress under average demand conditions and a *Low* potential for stress under maximum demand conditions. When accounting for estimated future municipal demands, the Percent Water Demand increases to 24% under average conditions and to 26% under maximum monthly conditions. These Percent Water Demands produce a classification of *Moderate* potential for stress under average demand conditions and a ***Moderate*** potential for stress under maximum demand conditions.

The largest water use sector in the assessment area is municipal water supply which represents 71% of the average annual consumptive water demand. Quarry dewatering is responsible for 17% of the estimated demand. Other water uses include commercial use (i.e. golf course irrigation, aquaculture, and bottled water), industrial use (i.e. brewing and soft drinks, cooling water), institutional use, miscellaneous use (i.e. heat pumps), remediation use, and agriculture. Out of the total groundwater demand in the assessment area, 90% of the estimated demand is calculated using reported pumping rates which increases the confidence of the values.

The City of Guelph is the largest groundwater user in the Upper Speed Assessment Area. The City maintains an aquifer monitoring program to ensure that the City's groundwater supplies are sustainable and do not cause adverse impacts to other users. In addition, monitoring is required as part of the Permits to Take Water issued by the Ontario Ministry of the Environment for the groundwater supply system.

The City's ongoing groundwater monitoring results show that the City continuously meets the requirements of its Permits to Take Water and that it is managing the groundwater resource in a responsible manner. Groundwater levels in the city do not show any significant downwards trends, indicating that current pumping rates can be maintained in the future.

The stress assessment results for the Upper Speed Assessment Area should not be interpreted as an indication of the sustainability of drinking water supplies. Rather, the stress assessment identifies a need for further work under the requirements of the Clean Water Act, and the need for this work is consistent with the value of the groundwater resource in the area.

The Upper Speed assessment area meets the requirements for a Tier 3 Water Quantity Risk Assessment. The municipal systems affected by the Tier 3 study include:

- City of Guelph;
- Rockwood; and
- Guelph/Eramosa (Hamilton Drive).

A Tier 3 Water Quantity Risk Assessment is currently underway for the City of Guelph as a pilot project for the Ministry of Natural Resources; however, this Tier 3 Assessment does not currently include the Rockwood or Hamilton Drive wells. Results of the Tier 3 Assessment for the City of Guelph waterworks system will be included in a future update of the Grand River Assessment Report.

Central Grand Assessment Area

The estimated Percent Water Demand for the Central Grand assessment area is 43% under average demand conditions and 51% under maximum conditions. Based on these estimates, the Central Grand assessment area is classified as having a ***Significant*** potential for stress under average demand conditions, and a *Significant* potential for stress under maximum demand conditions. After accounting for future water demands into account, the Percent Water Demand for this assessment area is 56% under average demand estimates and 64% under maximum conditions. These estimates classify the area as having a ***Significant*** potential for stress under both average and maximum future demand conditions.

The Central Grand Assessment Area contains the urban areas of Kitchener, Waterloo and Cambridge and includes a wide variety of water users, including municipal supply, commercial use, groundwater remediation and other industrial purposes. Municipal demands represent 71% the total demand. Approximately 76% of the total consumptive demand is calculated from reported pumping rates, which indicates a relatively high level of confidence in estimated demand.

The Regional Municipality of Waterloo is the largest groundwater user in the Central Grand Assessment Area. Approximately 75% of the Region’s water supply is provided by groundwater, the remaining 25% by surface water. In 1994, the Region began implementing a comprehensive Water Resources Protection Strategy (WRPS) to ensure that the Region’s groundwater supplies are sustainable and do not cause adverse impacts to other users. Groundwater level monitoring is an integral component of the WRPS. In addition, monitoring is required as part of the Permits to Take Water issued by the Ontario Ministry of the Environment for the groundwater supply system.

The Region’s ongoing groundwater monitoring results show that the Region continuously meets the requirements of its Permits to Take Water and that it is managing the groundwater resource in a responsible manner. Groundwater levels in the aquifers do not show any significant downwards trends, indicating that current pumping rates can be maintained in the future.

The stress assessment results for the Central Grand Assessment Area should not be interpreted as an indication of the sustainability of drinking water supplies. Rather, the stress assessment identifies a need for further work under the requirements of the Clean Water Act, and the need for this work is consistent with the value of the groundwater resource in the area.

Municipal groundwater supplies within this assessment area meet the requirements for completing a Tier 3 Water Quantity Risk Assessment, as follows:

- Regional Municipality of Waterloo Integrated Urban System Supply Wells

A Tier 3 Water Quantity Risk Assessment is currently underway for the Regional Municipality of Waterloo Integrated Urban Supply Wells as a pilot project for the Ministry of Natural Resources. Results of the Tier 3 Water Quantity Risk Assessment for the Regional Municipality of Waterloo will be included in a future update of the Grand River Assessment Report.

Mill Creek Assessment Area

The Mill Creek Assessment Area is located between the Galt and Paris Moraines, east of the City of Cambridge and South of the City of Guelph. The estimated Percent Water Demand for this assessment area is 12% and 16% under average and maximum demand conditions, respectively. These Percent Water Demands result in the classification of a ***Moderate*** potential for stress under average demand conditions and a *Low* potential for stress under maximum demand conditions. Major water use sectors in the Mill Creek area are the commercial (i.e. bottled water and golf course irrigation) and industrial (i.e. aggregate washing and manufacturing) sectors. Other groundwater demands include some agricultural uses, some miscellaneous uses (i.e. heat pumps), communal water supply, and unpermitted agricultural demand. Industrial uses account for 42% of the total groundwater demand. The commercial water use forms 37% of total demand in the Mill Creek area. A further 19% is associated with communal water supply uses.

Approximately 47% of the total demand is from reported water taking rates. While there are reported pumping rates for a number of the aggregate operations, a large portion of the estimated consumptive demand is a reflection of the consumptive factor applied to those pumping rates. Due to the uncertainty associated with aggregate washing consumptive use factors, there is a relatively high uncertainty in the estimated consumptive demand for these uses. As a result the Percent Water Demand for the assessment area may be over-estimated.

There are no municipal groundwater supplies within this assessment area.

Irvine River Assessment Area

The Irvine River assessment area contains the municipal groundwater supplies for Elora and Fergus in the Municipality of Centre Wellington. The assessment area is classified as having a *Low* potential for stress, with a Percent Water Demand of 5% under average conditions and 6% under maximum demand conditions. Estimated future municipal demands increase the Percent Water Demand to 9% which would still classify the area as having a *Low* potential for stress.

However, the future average annual percent water demand is very close to the 10% threshold. Percent water demand calculations are slightly sensitive to future water use, but are more sensitive to changes in recharge estimates giving the Irvine River Assessment Area a ***High*** level of uncertainty and a ***Moderate*** potential for stress using future demand estimates. A reduction in recharge or a large increase is future water use would bring values above the threshold triggering a need for a Tier 3 Risk Assessment.

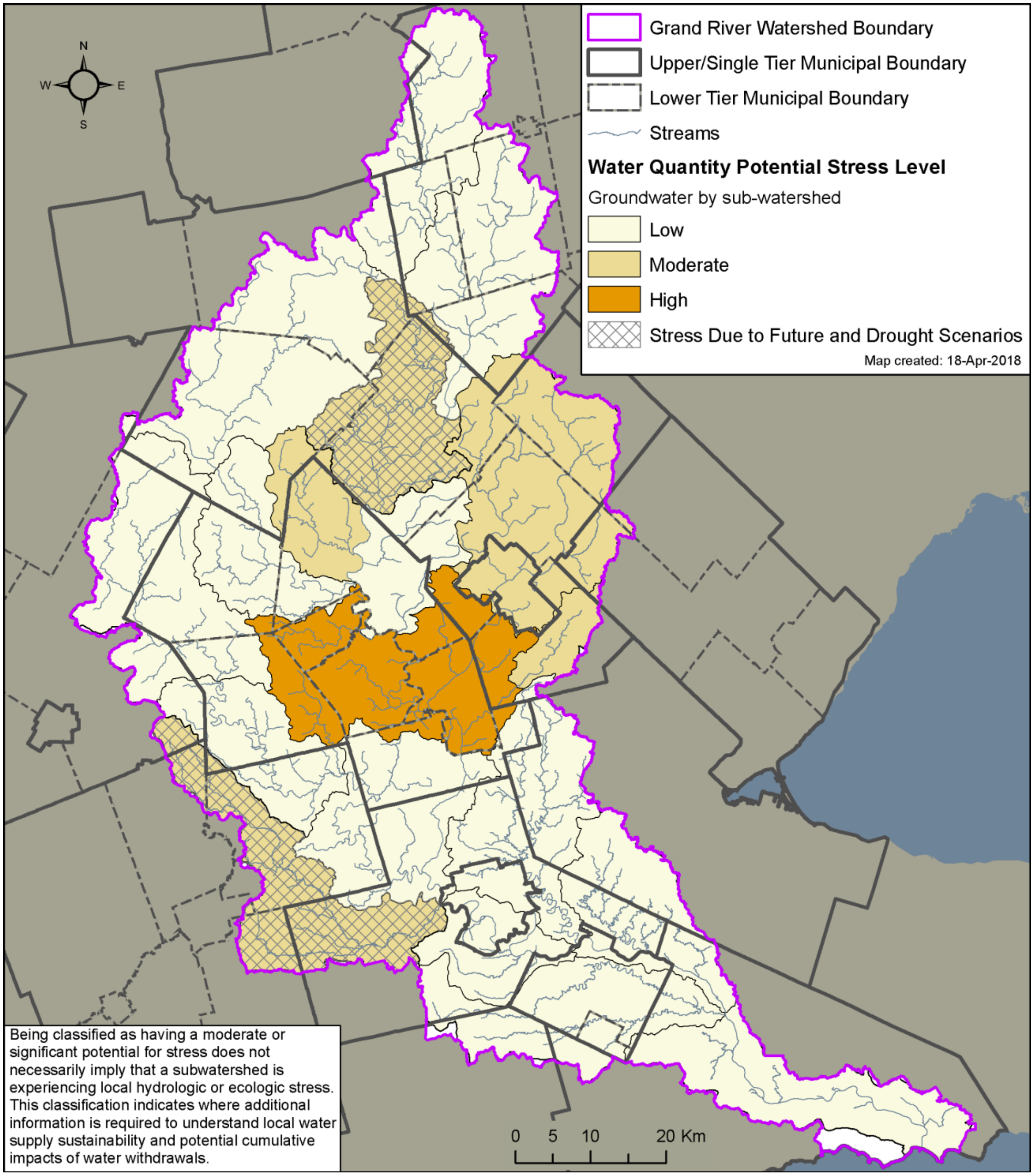
Therefore, due to the uncertainty of the future water demand scenario, the ~~Elora and Fergus.~~ Centre Wellington Tier 3 study has been deferred until new future municipal water use estimates are available from the municipality to confirm if the ***Moderate*** stress threshold is exceeded under future use scenarios. Additional studies of water demand and availability in this assessment area should focus on recharge and connections between surface recharge and the bedrock aquifer, where most of the water for the municipal supply is drawn from.

Whitemans Creek Assessment Area

The Whitemans Creek assessment area contains the municipal water supply system for the village of Bright. The assessment area was classified as having a *Low* potential for stress under existing conditions, both for annual average pumping conditions (4%) and monthly maximum demand (15%). The impact of drought conditions on the Bright supply was considered using transient output from the regional groundwater flow model. This analysis indicated that there may not be a sufficient depth of water within the #4 Bright well to accommodate simulated water level fluctuations caused by drought. Following consultation with County of Oxford hydrogeological support staff, and as per the Technical Rules, the Whitemans Creek assessment area was assigned a classification of having a ***Moderate*** potential for stress under Drought Conditions.

Based on this classification, the Bright system meets the requirement for a Tier 3 Water Quantity Risk Assessment. The Tier 3 Water Quantity Risk Assessment for the Whitemans Creek Assessment Area began in 2014. Once the project is completed the results will be included in a future update of the Grand River Assessment Report.

Map 18-4: Water Quantity Stress Levels by Groundwater Assessment Area within the Grand River Watershed



Map created: 18-Apr-2018

Being classified as having a moderate or significant potential for stress does not necessarily imply that a subwatershed is experiencing local hydrologic or ecologic stress. This classification indicates where additional information is required to understand local water supply sustainability and potential cumulative impacts of water withdrawals.

~~18.7~~18.5 Uncertainty/Limitations

All water budget calculations contain inherent uncertainty due to incomplete data, data inaccuracies, and imperfect estimation and simulation tools. ~~Many of the sources of uncertainty have been documented throughout the Water Budget sections.~~ It is important to consider the regional-scale nature of the analysis and interpretation presented. The methods used and the amount of data available were suitable for regional water budgeting purposes.

Any model developed to represent a natural system is inherently a simplification of that natural system. T~~Part of the reason for this is that t~~he complexities of the physical system can never be known well enough to incorporate all details into a numerical context. In reality, most of the scientific approach involves representing physical conditions observed using approximations of larger-scale functionality; hydraulic conductivity is an example of this. This approximation does not negate the ability of scientists and practitioners to utilize numerical models as tools to help understand and manage natural systems; however, there is a need to recognize the limitations of such tools when interpreting model results.

Every effort was made to minimize uncertainty in the Water Quantity Risk Assessment: data was cross checked with additional sources, models were calibrated to the highest quality of monitoring data available, and an external peer review team was consulted.

~~18.8 Orangeville and Amaranth Tier Three Water Quantity Risk Assessment~~

~~Under the requirements of the *Clean Water Act, 2006* the municipalities of Orangeville and Amaranth were required to complete a Tier Three Water Budget and Local Area Risk Assessment (Tier Three Assessment) to assess the ability of their municipal water sources to meet committed and planned water demands.~~

~~In 2007 the MNR entered into a contract with AquaResource Inc. (2011) to complete a pilot project to conduct a Tier Three Assessment for the Town of Orangeville and the Township of Amaranth. This project was completed as a pilot to assess the technical Tier Three Assessment framework, be available as a reference for future Tier Three Assessments taking place in the province, and be used to complete an updated Source Protection Assessment Report. Although the Town of Orangeville in not within the Grand River watershed, the model domain for the project includes portions of the Townships of Amaranth and East Garafraxa which are within the watershed.~~

~~The Final Report, submitted in January 2011, details the Tier Three Water Budget and Local Area Risk Assessment carried out for the Town of Orangeville and Mono, and the Township of Amaranth. The report summarizes background information relating to the geology and hydrogeology of the area, current and planned water demands, and the process and results of the Local Area Risk Assessment.~~

~~18.8.1 Tier Three Approach~~

~~The Tier Two Water Quantity Stress Assessment completed for the Credit River Watershed in 2009 by AquaResource Inc., identified the Headwaters Subwatershed (Subwatershed 19) as having a "Moderate" groundwater stress level. The identification of a moderate stress level lead to the requirement of a Tier Three Assessment for the Town of Orangeville and the Township of Amaranth as most of their municipal wells are located within this subwatershed. To date Orangeville, Mono and Amaranth have not had any issues meeting their water quantity requirements.~~

~~The numerical models used within the Tier Two Assessment were used as the basis from which to develop the Tier Three models. The HSP-F surface water model was refined from that used for the Tier Two Assessment. The watershed-scale FEFLOW groundwater flow model that was used in the Tier Two Assessment was considered too broad in scale to be used in the Tier Three Assessment to~~

~~adequately assess impacts at a wellfield scale. As such, a new groundwater flow model using the MODFLOW-2000 code was developed.~~

~~Specific updates undertaken in the Tier Three Assessment included the interpretation of local-scale cross-sections across the study area to refine the subsurface geology, and the assignment of hydrogeologic parameters consistent with local hydraulic testing results within the subwatershed and surrounding areas. The groundwater flow model was calibrated to a finer level of detail with close attention to observations at high quality monitoring wells. The Tier Three model was calibrated at the municipal wellfield-scale to both steady state (long term average) and transient (time-varying) conditions. It was also verified using long term (15 years) monitoring data to further increase the confidence in the model and its ability to simulate the groundwater flow system within the Study Area which included approximately 55 km2 within the Grand River watershed.~~

~~The study included an in-depth compilation of current and historical groundwater pumping and monitoring data. This assessment of monitoring data indicated that the nine Town of Orangeville wells and the one Township of Amaranth well with capture zones extending into the Grand River watershed have never experienced problems pumping the allocated quantities of water from their respective municipal pumping wells. The Town of Orangeville has implemented very effective water conservation measures resulting in reduced maximum day demands and per-capita average day demands.~~

~~This report (AquaResource, 2011) describes the development of a three-dimensional hydrogeological conceptual model of the study area. This conceptual model was based on the interpretation of both high quality boreholes and domestic water well records throughout the area. An estimated 133 domestic water wells and two non-municipal permits for heat pumps are situated on rural lands within the GRCA portion of the model domain.~~

~~Following the development of the conceptual model, a continuous surface water flow model and three-dimensional groundwater flow model were developed to assess the water budget components in the area and to complete the Water Quantity Risk Assessment scenarios. The report (AquaResource, 2011) shows that these models were calibrated to observed steady state and transient water levels and flows and can be considered as reliable tools for water budget estimation.~~

~~A detailed water budget for the Headwaters Subwatershed was developed and approximately 890 mm/yr of precipitation falls within the subwatershed (measured as average annual precipitation at the MOE Orangeville climate station). Of this, approximately 63% leaves the subwatershed as evapotranspiration, 39% leaves as streamflow, and 6% leaves the subwatershed flowing into the Nottawasaga Valley Watershed to the northeast. Recharge along the Grand River – Credit Valley watershed divide is quite high at 320 mm/yr due to the situation of the divide atop the Orangeville Moraine.~~

~~Groundwater modelling results indicate that groundwater flow into Subwatershed 19 across the subwatershed boundaries is significant with approximately 5,000 m^3/d flowing into the subwatershed from the Grand River Watershed, representing approximately 3% of the overall water balance. Much of the cross-boundary flow from the Grand River is influenced by municipal pumping.~~

~~Four distinct Local Areas were delineated surrounding the municipal supply wells in the Study Area including Local Area A **(Map** 18-11). This area was delineated following the Province's Technical Rules (MOE, 2009b) based on a combination of the cone of influence of each municipal well as well as land areas where recharge has the potential to have a measurable impact on the municipal wells.~~

~~A series of Risk Assessment scenarios were derived to represent the municipal allocated quantity of water (existing plus committed plus planned pumping rates); and current and planned land uses. The calibrated surface water and groundwater flow models were used to estimate both the changes in water levels in the municipal supply aquifer and the impacts to groundwater discharge and baseflow under average and drought climate conditions.~~

~~18.8.2 Risk Assessment Results~~

~~Based on the results of the Risk Assessment modelling scenarios, Local Area A was classified as having a “Significant” Risk Level. Local Area A includes many of the Town of Orangeville’s municipal supply wells located in the western half of Subwatershed 19, as well as the Town of Mono’s Cardinal Woods Wells and Amaranth’s Pullen Well (**Map** 18-11). Local Area A was classified as having a significant water quantity risk level due to a combination of factors including the impacts of pumping the allocated quantity of water (Existing plus Committed plus Planned) and groundwater recharge reductions under both average recharge and drought conditions. Increased pumping within this Local Area also resulted in reductions to groundwater discharge in coldwater streams that exceeded the Province’s thresholds.~~

~~While the Tier Three Assessment scenarios resulted in a Significant Water Quantity Risk Level for Local Area A, the Town of Orangeville has never had problems pumping their municipal wells, even during periods of higher water demand prior to the implementation of water conservation measures. The Water Quantity Risk Level categories do not indicate a problem associated with current municipal wells and their current pumping rates; rather, they reflect a need to manage the drinking water resources in the Local Areas as future stresses arise. Furthermore, the results indicate a need to manage the drinking water as a regional resource shared by the Town of Orangeville and Township of Amaranth.~~

~~Following the Technical Rules, all consumptive water users and reductions to groundwater recharge within Local Area A are classified as significant water quantity threats. These consumptive water users include the permitted water demands (e.g., municipal pumping) and non-permitted water demands (e.g., domestic water wells). The only consumptive uses within the Grand River watershed portion of Local Area A are approximately 44 domestic water wells (**Map** 18-11). Almost half of these domestic wells are located within designated areas of land use change in the Township of Amaranth’s Official Plan~~

~~As part of their earlier Water Supply Strategy, the Town of Orangeville identified several areas near the Town to investigate the potential to provide future groundwater drinking supplies. Several of these areas, including one test well with in the Grand River watershed, were studied under an extension of this Tier Three Assessment. This preliminary investigation suggested that these areas would not be suitable for supporting wells of sufficient capacity to meet municipal requirements; however, this study should not be considered as an exhaustive investigation of future drinking water supply.~~

~~The potential groundwater discharge reductions associated with recharge reductions in Local Areas A vary from “Moderate” (between 10% and 20%) to “Significant” (greater than 20%). The model scenarios did not consider the influence of stormwater best management practices, and the groundwater recharge was reduced proportionally to the imperviousness assumed for areas where land use changes are expected to occur. The only lands within the Grand River watershed portion of Local Area A with identified groundwater recharge reduction activities are designated for commercial/industrial/ residential activities in the Township of Amaranth’s Official Plan.~~

~~While these scenarios are conservative, they indicate where groundwater discharge is most sensitive to land use change, and where the Town of Orangeville and the Grand River Conservation Authority may wish to direct efforts to maintain groundwater recharge in the future.~~

~~18.8.3 Tier Three Assessment SGRAs~~

~~The Technical Rules require that Significant Groundwater Recharge Areas (SGRAs) be delineated for each source protection area. SGRAs are one of four types of vulnerable areas that are used in water quality vulnerability assessments; the other vulnerable areas are wellhead protection areas, intake protection zones, and highly vulnerable aquifers.~~

~~SGRAs were delineated in the Tier Two Assessment (AquaResource, 2009c) across the Credit River Watershed using a peer reviewed methodology. The average annual recharge across the entire Credit River Watershed was calculated to be 200 mm/yr; consequently, the SGRA threshold was calculated to be 230 mm/yr. The SGRAs cover a large portion of Subwatershed 19, and are noticeably absent in the urban areas and in areas designated as lakes, ponds or large wetlands.~~

~~The recharge distribution calculated in the Tier Three Assessment for Subwatershed 19 was refined from that established in the Tier Two Assessment; as such the SGRA mapping for Subwatershed 19 was updated. The SGRA threshold established in the Tier Two Assessment for the Credit River Watershed (of 230 mm/yr) was used again in this assessment as SGRAs aim to protect groundwater recharge areas across the broader watershed. To account for uncertainty associated with the HSP-F recharge results in the Tier Three Assessment, recharge rates greater than 225 mm/yr were used to delineate the SGRAs for the Tier Three Assessment. Professional judgment was used to remove potential groundwater discharge areas (areas where the model simulated water table is less than 2 m below ground surface) from the SGRA mapping.~~

~~Due to changes in methodologies and varying geologic characteristics from one watershed to the next, it is expected that there will be edge matching issues at watershed divides. Therefore, the SGRAs in the Grand River portion of this assessment will not be consistent with Lake Erie Source Protection mapping. It is recommended that modeling and mapping staff from the two source protection regions get together to address edge matching issues.~~

~~18.8.4 Uncertainty~~

~~During the Tier 3 Assessment, some knowledge and data gaps were encountered, however the approach undertaken in the study was conservative, and as such, addressing these uncertainties is not considered necessary for protecting or managing the water resources within the subwatershed. The Risk Level for the Orangeville water supply wells was classified as “Significant”, which is appropriate considering the uncertainties associated with urban infiltration and the impact of enhanced recharge through subsurface infrastructure.~~

~~**Map 18-11: Orangeville Tier Three Water Budget and Local Area Risk Assessment**~~