

Preface

Source Protection Committee Commitment

The CTC Source Protection Committee (SPC) is a multi-stakeholder committee selected to represent municipalities, economic sectors, and the general public interests. The Committee has legislated responsibilities to protect drinking water sources across the CTC Source Protection Region.

The SPC's ultimate role is to develop a Source Protection Plan that, when implemented by the responsible parties (including municipalities), eliminates, reduces, or manages threats to drinking water sources, both now and in the future.

About This Document

This *Updated Assessment Report: Toronto and Region Source Protection Area (TRSPA)* contains new information about municipal drinking water threats. The text with new information in this report is highlighted in yellow. The document also includes the previous information about threats, but the document has been reorganized within each chapter. The *Proposed Assessment Report: Toronto and Region Source Protection Area (TRSPA)* was submitted previously to the Ministry of the Environment for approval on December 21, 2010, after public consultation.

The *Updated Assessment Report: TRSPA* identifies the location and nature of threats to sources of municipal drinking water supplies. These threats include activities that are impacting or could adversely impact drinking water quality or quantity from groundwater and/or surface water sources. New information is included that identifies water quantity threats, additional groundwater quality threats and threats to surface water quality in Lake Ontario.

The completion of an Assessment Report is a requirement of the *Clean Water Act, 2006* (CWA) and Ontario Regulation (O. Reg.) 287/07, both of which came into effect on July 3, 2007. It has been developed in accordance with these regulations, the *Director's Technical Rules* (MOE, 2009) and the *Terms of Reference: TRSPA* (TRCA, 2009) as approved by the Minister of the Environment (MOE).

Acknowledgements

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Toronto and Region Conservation Authority (TRCA)

Deborah Martin-Downs, Project Director
Don Ford, Project Lead and Hydrogeologist
Sylvia Waters, Administrative Assistant
Gary Bowen, Lake Ontario water quality
Jehan Zeb, hydrogeology
Sameer Dhalla, hydrology
Jamie Duncan, hydrology and water use
Rita Lucero, water use
Tim VanSeters and Angela Wallace, surface water quality
Scott Jarvie, monitoring
Dena Lewis, terrestrial ecology
Christine Tu and David Lawrie, aquatic ecology
David Burnett, human characterization
Dean Young and Sonya Meek, watershed plan integration
Ming Guo, database management
Rick Wilson and Daniela MacLeod, geographic information systems

CTC Source Protection Region

Beverley Thorpe, CTC Project Manager
Andréa Dubé-Goss, CTC Project Lead
Megan Price, CTC Communications Supervisor
Sylvia Waters, CTC Administrative Coordinator

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Technical Advisor

Rick Gerber, Conservation Authorities Moraine Coalition

Region of Peel

Rodney Bouchard
Luis Lasso

Region of York

Wendy Kemp
Tammy Silverstone
Tom Bradley

Region of Durham

Beata Golas
James Partridge

City of Toronto

William Snodgrass

EXECUTIVE SUMMARY

Why should you read this document?

This *Updated Assessment Report: Toronto and Region Source Protection Area (TRSPA)* has been prepared under the direction of the CTC Source Protection Region Source Protection Committee, one of 19 such committees across Ontario (**Figure ES: 1**). This report is a requirement of the *Clean Water Act, 2006 (CWA)* and Ontario Regulation (O. Reg.) 287/07 as amended by O. Reg. 59/10. The Report has been developed in accordance with the regulations, the *Technical Rules: Assessment Report* (MOE, 2009) and the *Terms of Reference: TRSPA*, as approved by the Minister of the Environment.

This report contains new information about municipal drinking water threats. The document also includes the previous information about threats, but the document has been reorganized within each chapter. The *Proposed Assessment Report: Toronto and Region Source Protection Area (TRSPA)* was submitted previously to the Ministry of the Environment for approval on December 21, 2010, after public consultation.

The *Updated Assessment Report: TRSPA* identifies the location and nature of threats to sources of municipal drinking water supplies. These threats include activities that are impacting or could adversely impact drinking water quality or quantity from groundwater and/or surface water sources. New information is included identifying water quantity threats, additional groundwater quality threats and threats to surface water quality in Lake Ontario.

This *Updated Assessment Report: TRSPA* identifies the location and nature of potential threats to sources of municipal drinking water. These threats include activities that are adversely impacting, or could impact, drinking water quality or quantity from groundwater and/or surface water sources.

Source Protection Committees determine threats to drinking water sources by delineating and applying vulnerability scores where needed to the different types of vulnerable areas, where they exist, within each Source Protection Area, as discussed in the legislation. These areas are:

- intake protection zones (IPZs);
- highly vulnerable aquifers (HVAs);
- significant groundwater recharge areas (SGRAs);
- wellhead protection areas (WHPAs);
- issue contributing areas (ICAs - none within the TRSPA); and
- water quantity vulnerable areas (Local Areas - not yet identified within the TRSPA).

Detailed information about how these vulnerable areas were delineated and scored can be found in **Chapters 3, 4 and 5**. This report identifies and describes each of these types of vulnerable areas within the TRSPA, per the *Technical Rules, 2009*. Below are maps showing the vulnerable areas for TRSPA. Descriptions, scoring, and documentation on the analyses performed to arrive at these delineations are all contained in the body of this report or in the referenced technical appendices. Work is still ongoing to delineate water quantity vulnerable areas around wells in Whitchurch-Stouffville and Uxville as part of Tier 3 water budget studies. This work may also result in changes to the areas delineated as wellhead protection areas. This work will also result in refinements to the mapping of significant groundwater recharge areas. When the updated information is available it will be made available for public review and comment.

In the TRSPA, there are ten municipal drinking water system intakes which are sourced from Lake Ontario. These intakes supply drinking water to over 3,250,000 people within the TRSPA and beyond. The IPZ-1 and IPZ-2 map (**Figure ES: 2**) indicates areas near a drinking water intake where a contaminant spill could reach the intake before a plant operator is able to respond.

The IPZ-1 is based on drawing a 1 kilometre radius around each intake. The IPZ-2 is based on the estimation of the distance a contaminant might move in a two hour time of travel to the intake, and is made up of two parts – the in-lake portion, and the landward extent. The delineation of the in-lake portion is based on hydrodynamic modelling, while the delineation of the landward extent is based on estimated travel times in the storm sewers and contributory watercourses. The upland component considers various setbacks, transport pathways such as tile drainage with the residual time of travel onto the land as a limiting factor. Details on this work can be found in **Chapter 4** of this report.

The **IPZ-3 maps** shows a number of spill scenarios which were modelled as part of the Lake Ontario Collaborative to determine if certain land-based sources activities could pose a potential drinking water threat to these intakes. Any scenario that identifies conditions under which a contaminant could exceed a threshold in the raw water is identified as a significant drinking threat. The delineated IPZ-3 is shown as a line between the source of the spill and the intake following the flow direction predicted by the model. More details about this work can be found in **Chapter 5** of this report.

Details on this IPZ-3 work can be found in **Chapter 5** of this report, along with detailed maps for each of the Lake Ontario systems. The maps shows the shortest path that a modelled spill which has been identified a significant drinking water could take to reach the intakes within the TRSPA, or that could be affected by activities within the TRSPA.

Figure 5.33: Lorne Park WTP Intake

Figure 5.34: Lakeview WTP Intake

Figure 5.35: R.L. Clark Intake

Figure 5.36: Toronto Island Intakes

Figure 5.37: R.C. Harris Intake

Figure 5.38: F.J. Horgan Intake

Figure 5.39: Ajax Intake

Figure 5.40: Whitby Intake

Figure 5.41: Oshawa Intake

The SGRA map (**Figure ES: 3**) indicates areas where a high percentage of rain or snow seeps down into the groundwater system and is used for drinking water (including both municipal and other users). These areas are delineated according to the methodology provided in **Chapter 4** using the recharge results from the water budget process described in **Chapter 3** of this report. Under the CWA, 2006 the CTC Source Protection Committee (SPC) may choose to develop policies to protect SGRAs within TRSPA.

The HVA map (**Figure ES: 4**) indicates areas where one or more aquifers have been determined to be highly vulnerable to contamination from surface activities. HVAs are more extensive than SGRAs because they are not dependent on the 150 mm/yr recharge threshold. Extra caution should be taken when constructing wells in vulnerable aquifers. Water well construction standards are set out in O. Reg. 903 under the *Ontario Water Resource Act*. Under the CWA, the CTC SPC may choose to develop policies to protect HVAs within TRSPA.

The WHPA map (**Figure ES: 5**) indicates areas around municipal groundwater systems where certain activities are more likely to negatively impact a drinking water source. **Chapter 4** of this report provides detailed maps for each of the municipal groundwater systems within the TRSPA.

Figure 4.4: Caledon East WHPAs

Figure 4.5: Palgrave WHPAs

Figure 4.6: Nobleton WHPAs

Figure 4.7: Kleinburg WHPAs

Figure 4.8: King City WHPAs

Figure 4.9: Whitchurch-Stouffville WHPAs

Figure 4.10: Uxville WHPAs

Where there is evidence of contamination levels increasing within the water reaching a municipal well, Issue Contributing Areas (ICA) are delineated. These areas are where activities could release the contaminant of concern and thereby contribute to the rising contaminant levels. However, as detailed in **Chapter 5** of this report, no such areas have been identified within the TRSPA.

Where Tier 3 water budget studies are undertaken, water quantity vulnerable areas are delineated around wells or groups of wells where they interact with one another, called Local Areas. **Chapter 3** of this report describes how these areas are delineated, although none have yet been confirmed within the TRSPA. When Tier 3 water budget studies are completed for the wells in Whitchurch-Stouffville and Uxville, Local Areas may be delineated around these wells.

The Source Protection Plan (SPP) will identify the actions required to reduce, manage, or eliminate current threats to municipal drinking water sources, as well as to prevent future potential threats. The SPP will also set out requirements for the regular monitoring and reporting on the implementation of the SPP. Public consultation will be an important part of developing the SPP, starting in early 2012. The SPP must be submitted to the Minister of the Environment for approval in August 2012. When the SPP is approved, the Minister of the Environment will set the date by which the SPP must be reviewed and updated, as necessary.

What does all this mean?

This *Updated Assessment Report: TRSPA* describes the physical features and water resources within the Toronto and Region Source Protection Area (TRSPA) jurisdiction. Using approved provincial methodologies it delineates vulnerable areas and assesses specific activities on the landscape within these vulnerable areas as potential drinking water threats. It should be noted that municipal drinking water supplies for the TRSPA jurisdiction come from both groundwater and surface water sources.

The analyses of the Watershed Characterization component in **Chapter 2** of this *Updated Assessment Report: TRSPA* show that groundwater quality across the TRSPA is generally high. In the deeper groundwater formations there are naturally elevated iron, manganese, and hardness levels. Surface water quality in the streams discharging into Lake Ontario shows some elevated chlorides and phosphorus levels as compared against ecosystem and aquatic life standards (Canadian Water Quality Guidelines). These contaminants are thought to be associated with the impact of urbanization within the TRSPA. The surface water in these streams is not used as a drinking water supply. Water quality in Lake Ontario in the vicinity of intakes is generally very good. Occasionally higher levels of some contaminants are found after significant rainfall. The currents in the near shore area of the western end of Lake Ontario are complex. Contaminants released from a spill can be transported in both easterly and westerly directions along the shore, as well as moving from the surface to lower depths.

The water budget analysis in **Chapter 3** of this *Updated Assessment Report: TRSPA* assesses potential water quantity stress in both surface water (not including Lake Ontario) and groundwater. Groundwater sources in TRSPA are used for drinking water supplies for both municipal and private wells, and to support ecosystem functions. The surface water in streams in the study area is important for supporting the ecosystem, and is also used for irrigation and other non-drinking-water purposes.

Based on the Tier 2 water budget analysis the TRSPA has determined that five subwatersheds were found to have moderate or significant groundwater stress levels and 17 subwatersheds have moderate or significant surface water stress levels during summer months. Of these potentially stressed watersheds only two are associated with a municipal drinking water source and will be assessed at the Tier 3 level. Work is still underway on the Tier 3 water budget for the areas around the Whitchurch-Stouffville and Uxville wells. When updated information is

available, it will be released for public review and comment before it is submitted to the Ministry of the Environment for approval. All other catchments in the study area have low stress levels for both groundwater and surface water. Since the *Technical Rules, 2009* exclude consideration of Great Lakes in water budget “stress” assessments, Lake Ontario was not included in the water budget studies.

Chapter 4 assesses and scores vulnerability in all vulnerable areas in TRSPA (IPZs, HVAs, SGRAs and WHPAs). The IPZs for the study area (IPZ-1s and IPZ-2s) were all ranked as having low vulnerability. The results of the TRSPA HVA and SGRA vulnerability analyses reflect the presence of many shallow aquifers that are naturally vulnerable. WHPA delineation and scoring has been completed for every municipal groundwater system within the TRSPA, identifying areas where certain types of activities may pose drinking water threats.

In **Chapter 5**, vulnerability is considered together with provincial hazard scores outlined in the Table of Drinking Water Threats (*Technical Rules*, MOE, 2009) for the various activities and their associated chemicals and pathogens to determine a risk score. Using both the natural vulnerability and hazard scores, potential drinking water threats are ranked as significant, moderate, or low in the vulnerable areas (IPZ-1s and IPZ-2s, HVAs, SGRAs, and WHPAs). In certain vulnerable areas (ICAs and Local Areas determined to have a significant risk level) all the relevant activities are deemed to be significant drinking water threats. In the case of the IPZ-3s for intakes in the Lake Ontario, the determination of whether a threat is significant was determined through spill scenario modelling to assess the impact of a particular spill scenario on individual intakes.

Significant threats must be identified and located in the assessment report and addressed in the Source Protection Plan. In the absence of field verification, the SPC took a conservative approach in identifying threats, assuming that a threat activity could exist based on current land use and other available information. However, source protection plan policies will only apply to activities which actually exist or are planned. If the activity does not exist or ceases to exist on a property where it could pose a drinking water threat, any policies directed at the activity would not apply.

If the activity is categorized as a moderate or low-level threat, the province requires only the identification of all of the circumstances that could pose a threat to drinking water by reference to the Provincial Tables of Circumstances:

http://www.ene.gov.on.ca/environment/en/legislation/clean_water_act/STDPROD_081301

It should be noted that these moderate and low threats may not actually exist within the vulnerable areas discussed. Low and moderate threats do not require mandatory action.

A number of spill scenarios were modelled as part of the Lake Ontario Collaborative (LOC) project to determine if certain land-based activities could pose a potential drinking water threat to these intakes. Any scenario that identifies conditions under which a contaminant could exceed a threshold in the raw water is identified as a significant drinking water threat. The scenarios considered included:

Based on the criteria above, the following list of preliminary scenarios was modelled:

- Disinfection failure at each Lake Ontario WWTP to evaluate the potential effects to nearby WTPs;
- Release of *E coli* from an industrial processing facility into the Credit River (this does impact any CLOSPA intake);
- Combined sewer overflow (CSO) release in the City of Toronto to evaluate the potential effects to the Toronto WTPs, (this does impact any CLOSPA intake);

- Sanitary trunk sewer (STS) break within the Toronto creeks;
- Release of gasoline from a bulk petroleum fuel storage facility in the Keele/Finch area of Toronto (this does not impact any CLOSPA intake)
- Spill of gasoline/refined product from large pipelines located under major tributaries to Lake Ontario (e.g. Lynde Creek, Oshawa Creek etc.)
- Discharge of tritium from nuclear generating plants at Pickering or Darlington.

The Technical Rules, 2009 require an IPZ-3 is to be delineated if modelling demonstrates that contaminants may be transported to an intake and result in deterioration of the raw water quality of a drinking water supply above a specific threshold, based on the ODWS.

The selected LOC spill scenarios were based on “real” events that have occurred in the past, and were not based on extreme weather condition events at the time of the spill. The IPZ-3 for each threat activity was delineated by drawing a line from the location of the threat activity on shore where the contaminant is released to the affected intake along the shortest path within the area where concentrations were modelled to exceed the threshold for that contaminant.

With respect to surface water, **18** significant water quality threats related to Lake Ontario intakes have been identified in the TRSPA. In addition, **10** significant drinking water quantity threats from activities within the TRSPA have been identified for four Lake Ontario intakes outside the TRSPA.

With respect to groundwater, **465** significant drinking water quality threats have been identified in this Assessment Report. Additional work underway in the Tier 3 water budget for Whitchurch-Stouffville may identify significant drinking water quantity threats for the study area.

No drinking water quality or quantity issues were identified in WHPAs of municipal wells within the TRSPA.

You may request more information by writing to:

sourcewater@trca.on.ca,

or by regular mail to:

Chair, CTC Source Protection Committee
c/o Toronto and Region Conservation Authority
5 Shoreham Drive
Downsview, ON M3N 1S4

or by fax to: 416-661-6898 - Attention Chair, CTC Source Protection Committee

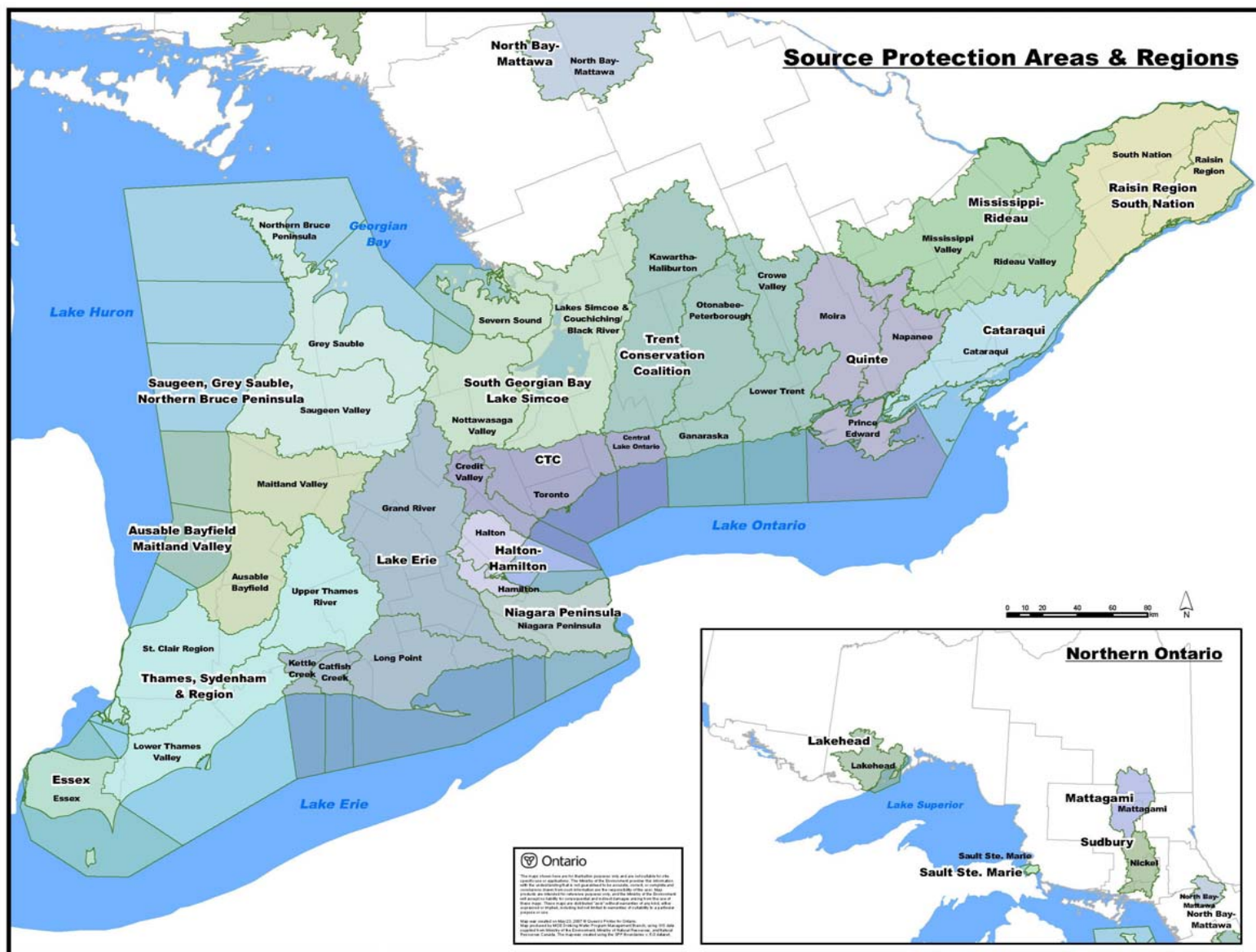


Figure ES: 1: Source Protection Areas and Regions

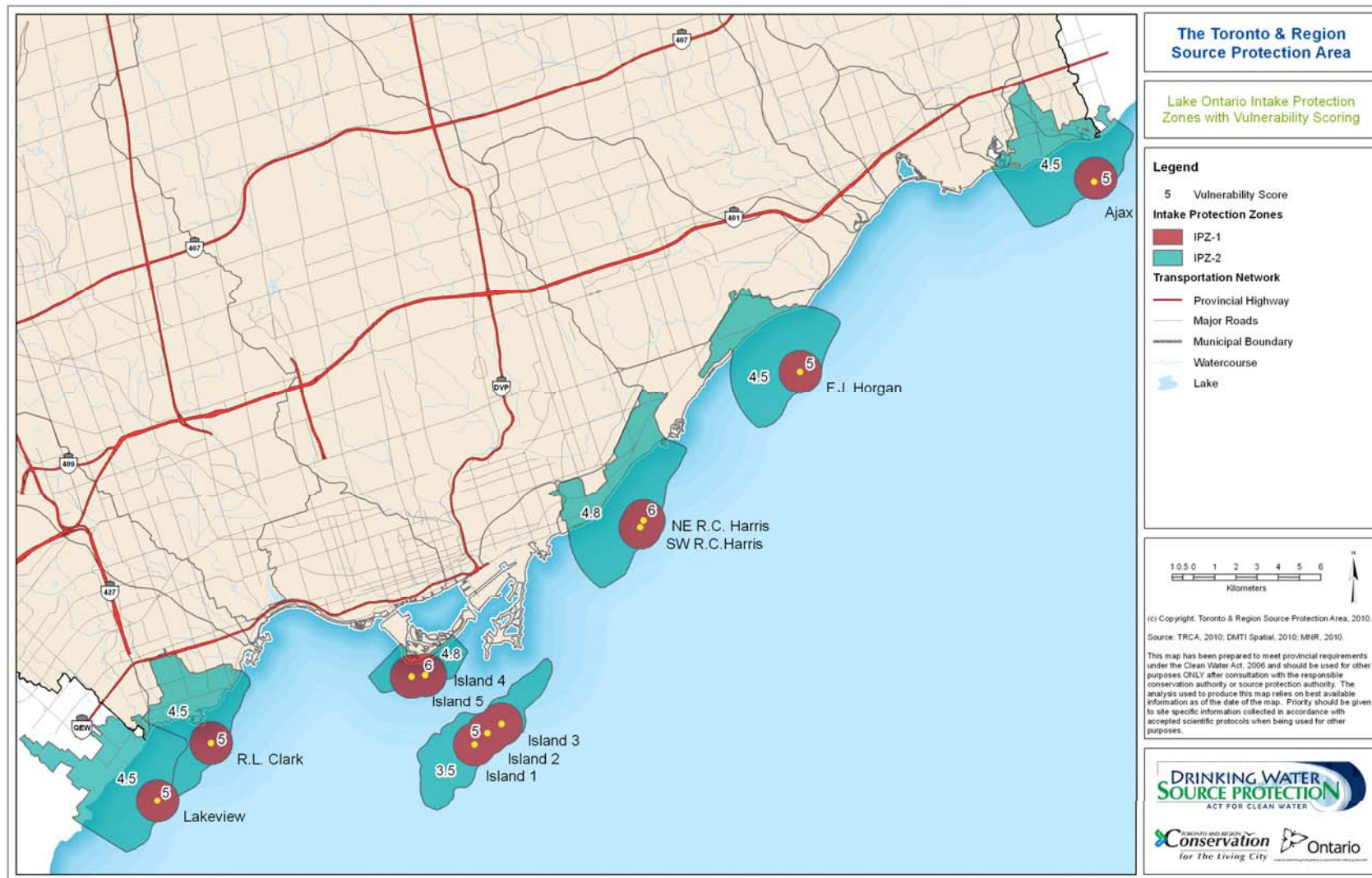


Figure ES: 2: Lake Ontario Intake Protection Zones with Vulnerability Scoring

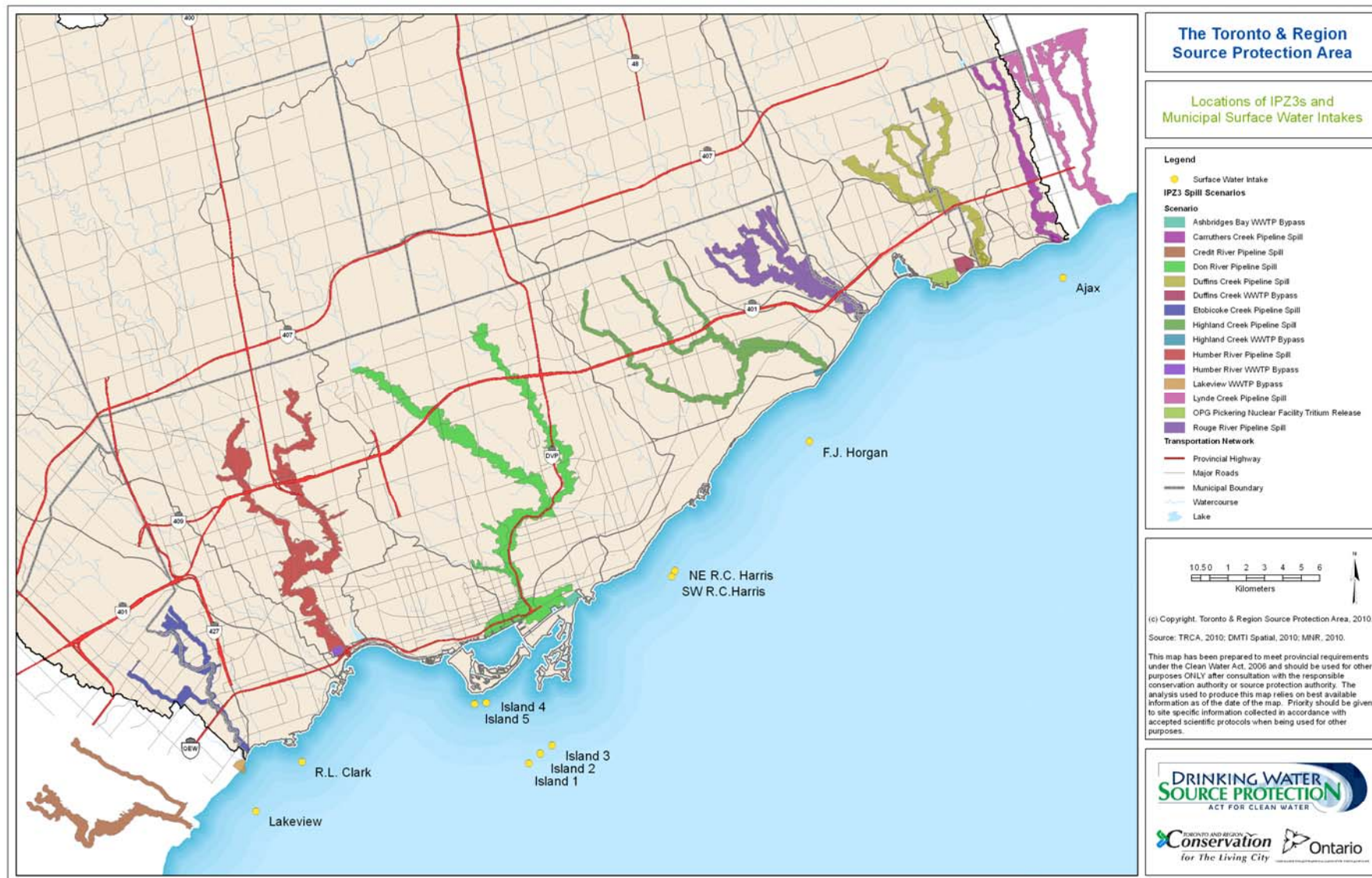


Figure ES: 3: Locations of IPZ-3s and Municipal Surface Water Intakes

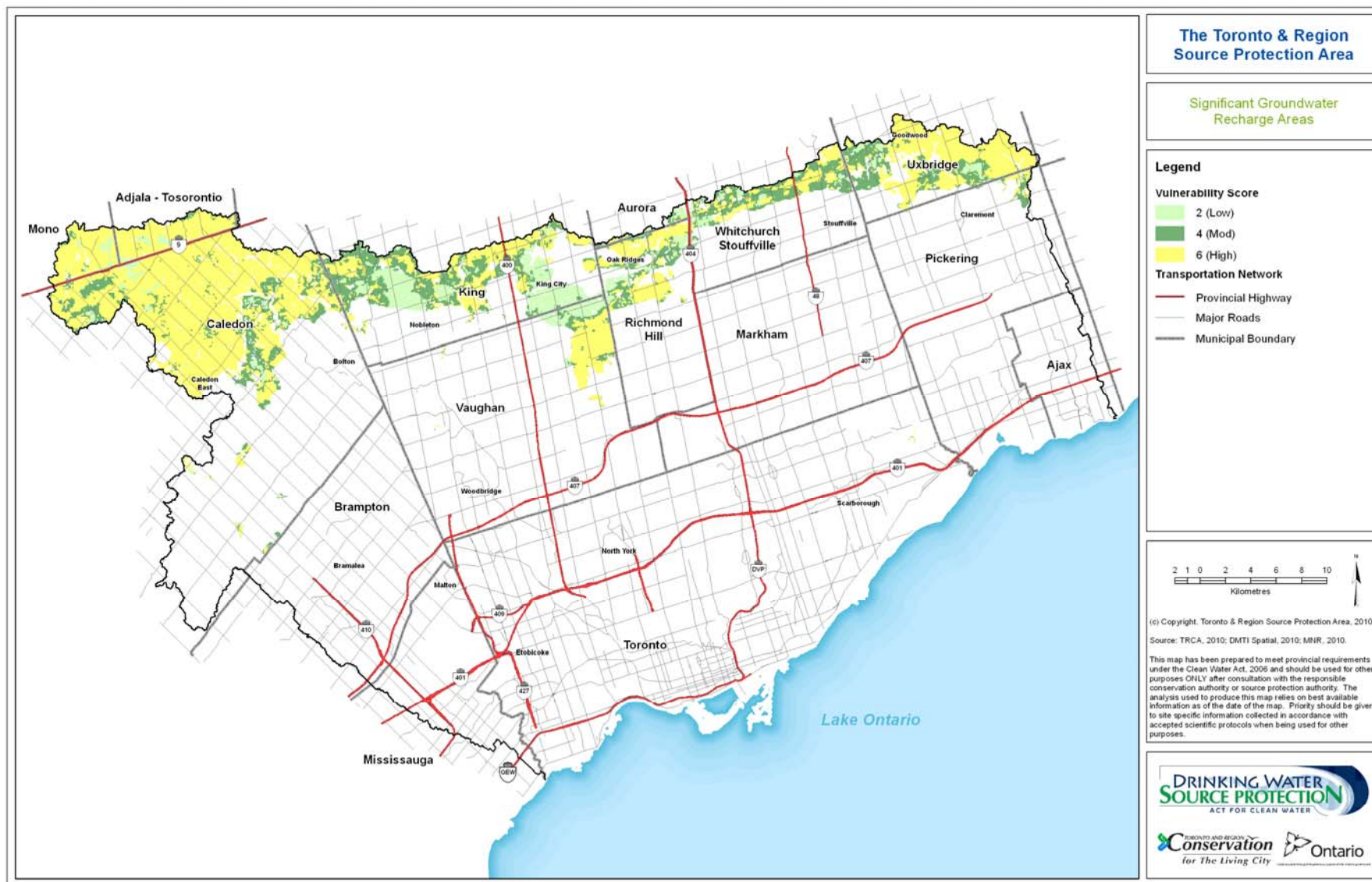


Figure ES: 4: Significant Groundwater Recharge Areas

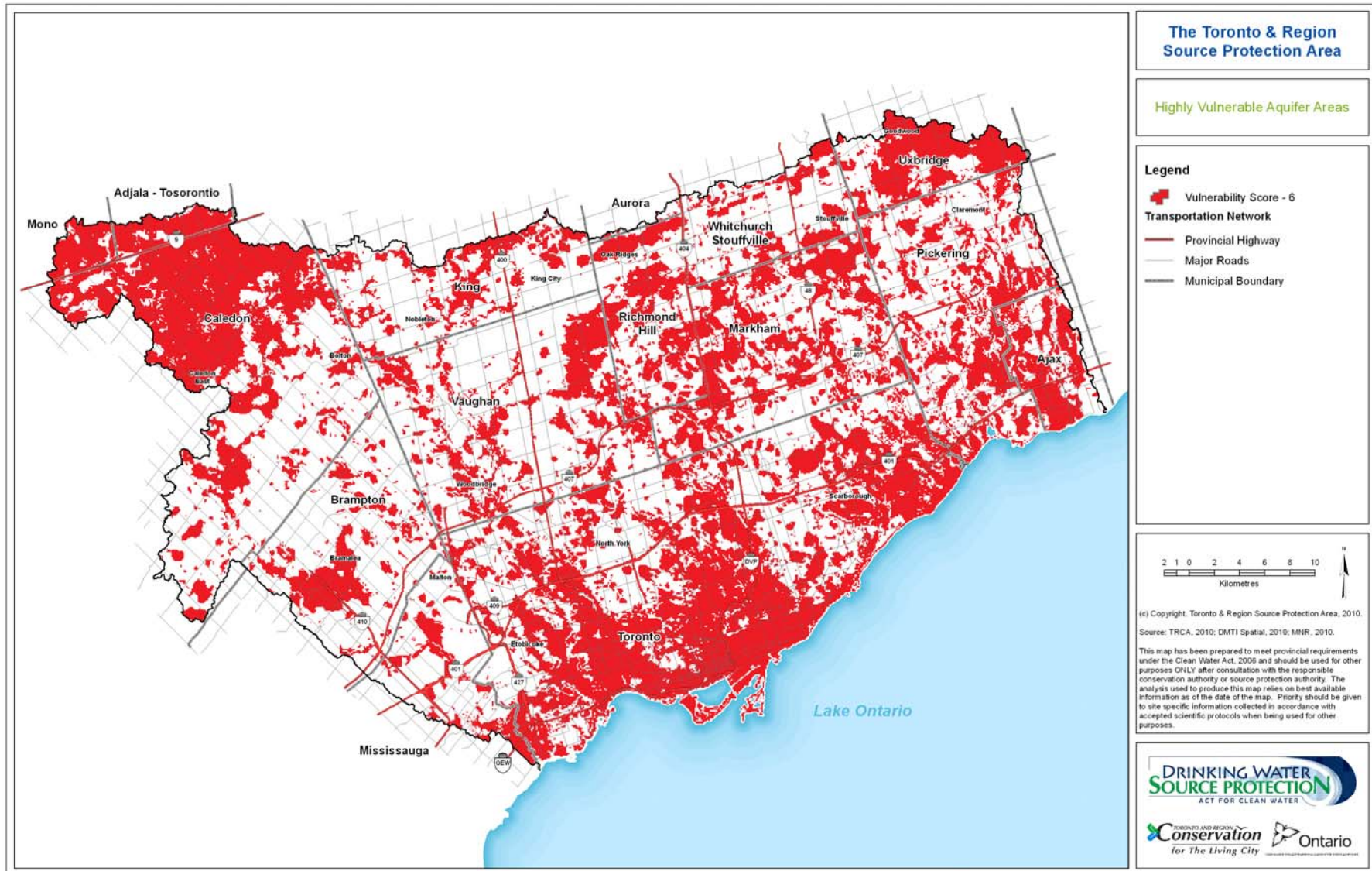


Figure ES: 5: Highly Vulnerable Aquifers Areas

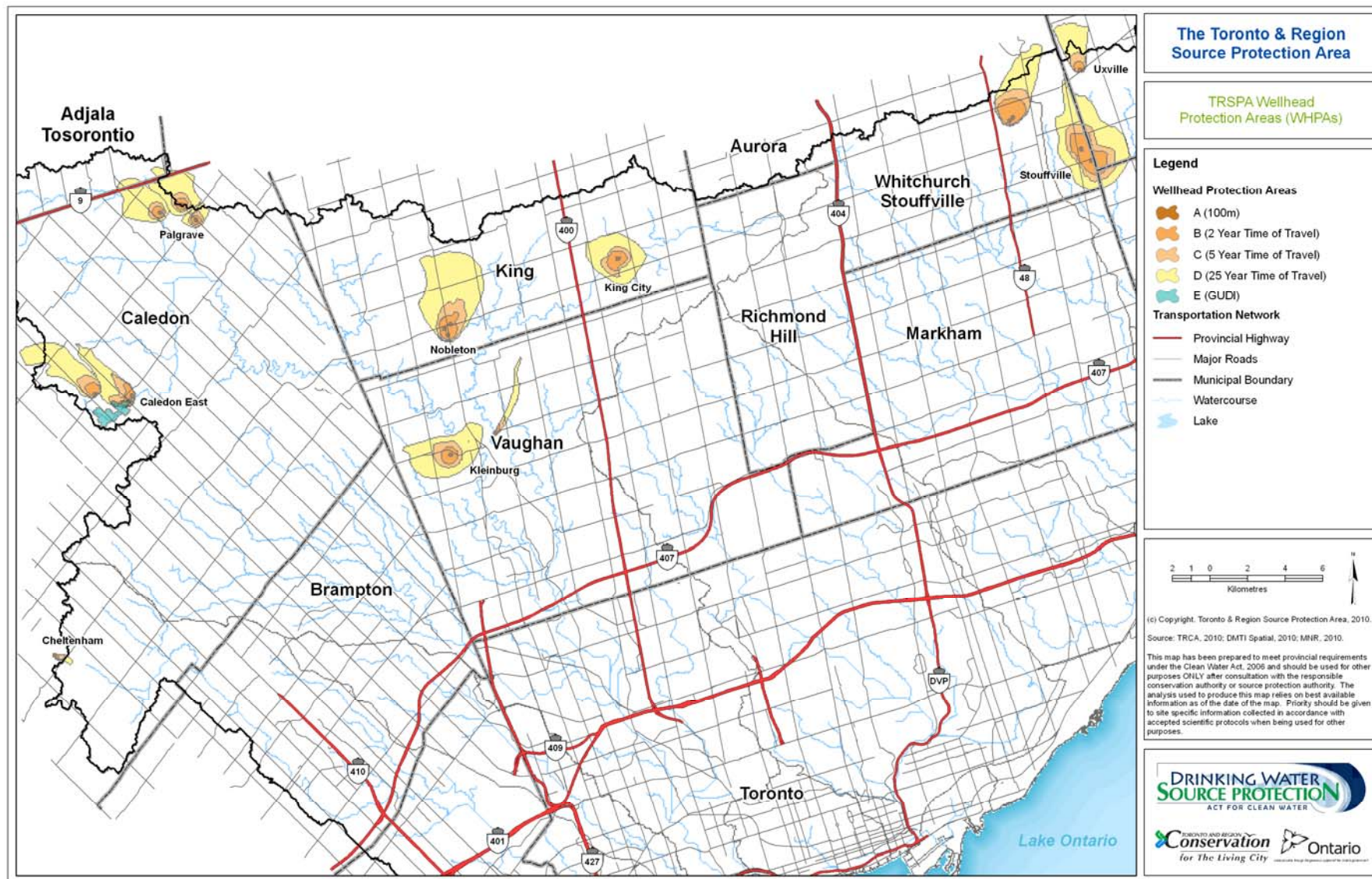


Figure ES: 6: TRSPA Wellhead Protection Areas (WHPA)

Glossary

Below are some terms, scientific and non-scientific, related to Drinking Water Source Protection. Note that some of these terms are derived from draft documents, and as such may be subject to change. They are provided here for information purposes, not as official legal definitions.

Abandoned Well: A well that is deserted because it is dry, contains non-potable water, was discontinued before completion, is not being properly maintained, was constructed poorly, or for which it has been determined that natural gas may pose a hazard.

Abiotic: Not relating to living things.

Activity: One or a series of related processes, natural or anthropogenic that occur within a geographical area and may be related to a particular land use.

Aggregate Risks: Multiple risks in a municipal water supply protection area that are considered together relative to the overall risk to drinking water sources.

Agro-ecosystem: Any agricultural system, which incorporates a natural community of plants and animals within a particular physical environment, on land where domestic animals are raised or crops grown.

Ambient water: Natural concentration of water quality constituents prior to mixing of either point or non-point source load of contaminants.

Aquatic: Growing or living in water.

Aquiclude: A saturated geologic unit that is incapable of transmitting significant quantities of water under ordinary conditions.

Aquifer: An underground area of porous, permeable soil or rock that contains a sufficient amount of water to support a domestic well. Shallow aquifers exist in the overburden, the sedimentary rock and soil above bedrock, whereas bedrock aquifers are found in the bedrock itself, beneath whatever overburden is present.

Aquifer Vulnerability Index (AVI): A numerical indicator of an aquifer intrinsic or inherent vulnerability susceptibility to contamination expressed as a function of the thickness and permeability of overlying layers.

Aquitard: The layer of geological material that prevents or inhibits the transmission of water in a confined aquifer.

Attenuation (Flow): Flow that is lessened or weakened or the severity reduced.

Average Maximum Water Velocity: The average highest speed of a surface water body.

Bank Stability: The ability of a stream bank to resist change.

Baseflow: The water that flows into a stream through the subsurface.

Bedrock: The solid rock underlying unconsolidated surface material.

Bedrock Geology: The study of the solid rock underlying unconsolidated surface material. Also refers to description of bedrock types.

Benthic: Occurring at the base of bodies of water: lakes, oceans and seas.

Benthic Invertebrates: Small aquatic organisms that live in stream sediments and are a good indicator of water quality and stream health.

Biochemical Oxygen Demand: A measurement used to assess the rate at which water is deoxygenated. High BOD general corresponds to water containing high amounts of organic pollution.

Bioengineering: The application of biological science to engineering principles. The use of living or organic plant material to achieve engineering solutions.

Biogeochemistry: The study of the cycles of chemical elements, such as carbon and nitrogen, and their interactions with and incorporation into living things.

Biological Diversity: The variability among organisms and the ecological complexes of which they are a part.

Biomass: The amount of living matter, usually measured per unit area or volume of habitat.

Biotic: Relating to, produced by, or caused by living organisms

Bog: A wetland ecosystem characterized by high acidity, low nutrient levels, and accumulation of peat and mosses, chiefly *Sphagnum*. The water table is at or near the surface in spring, and slightly below during the remainder of the year. The bog surface is often raised; if flat or level with the surrounding wetlands, it is virtually isolated from mineral soil waters. Peat is usually formed in situ under closed drainage and oxygen saturation is very low. Bogs are rare across the Toronto and Region Source Protection Area (TRSPA).

Broader Landscape: The watershed or drinking water source protection study area. Applies to regional rather than local aquifer vulnerability assessments usually using an indices method of vulnerability assessment.

Campylobacter Bacteria: Bacteria commonly found in the intestines of humans and animals. Some types of *Campylobacter* can cause serious illness in humans.

Carbon Sequestration: Process by which carbon is removed from the environment and held within, for example, a wetland.

Catchment: The groundwater and surface water drainage area from which a woodland, wetland, or watercourse derives its water.

Chemical: A substance used in conjunction with, or associated with, a land use activity or a particular entity, and with the potential to adversely affect water quality.

Climate: The average weather conditions of a place or region throughout the seasons.

Cold water: Water with a temperature of approximately 14 C. This thermal habitat is typically considered ideal for brook and brown trout.

Conceptual Water Budget: A written description of the overall flow system dynamics for each watershed in the Source Protection Area taking into consideration surface water and groundwater features, land cover (e.g., proportion of urban vs. rural uses), human-made structures (e.g., dams, channel diversions, water crossings), and water takings.

Conductivity: The quality or power of conducting or transmitting.

Confined Aquifers: An aquifer that is bounded above and perhaps below by layers of geological material that do not transmit water readily.

Conservation: The protection of natural or man-made resources and landscapes for later use.

Consumptive Use: Water use that diminishes the source and is not available for other and future uses.

Contaminant: Chemicals and pathogens.

Contaminant of Concern: A chemical or pathogen that is or may become a drinking water threat.

Contamination: The mixing of harmful elements, compounds or microorganisms with surface or groundwater. Contamination can occur naturally (e.g., an aquifer flowing through mineral deposits that contain heavy metals) or through human activity (e.g., sewer water flowing into a river). Nutrients, such as nitrogen and phosphorus, can also cause water contamination when they are present in excessive amounts.

Contiguous: Having contact with, or touching along a boundary or point.

Cumulative (water quality) Effects: The consequence of multiple threats sources, in space and time, which affect the quality of drinking water sources.

Cumulative (water quantity) Effects: The consequence of multiple threats sources, in space and time, which affect the quantity of drinking water sources.

Data Gaps: The lack of raw information for a specific geological area and/or specific type of information.

Decommissioned Wells: Capped, plugged and sealed in compliance with regulatory requirements (O. Reg. 903) established by the Ministry of the Environment.

Dense Non-Aqueous Phase Liquids (DNAPLs): a group of chemicals that is insoluble and denser than water.

Designated System: A drinking water system that is included in a terms of reference, pursuant to resolution passed by a municipal council under subsection 8(3) of the proposed *Clean Water Act*, 2005.

Developed / Developable: Reference to the useable portion of a parcel of land that meets the regulatory zoning provisions, particularly those pertaining to defining the area of occupation for buildings, structures, facilities and infrastructure.

Discharge Area: An area where water leaves the saturated zone across the water table surface.

Drainage Density: Length of watercourse per unit drainage area.

Drainage System (under the Drainage Act): A drain constructed by any means, including works necessary to regulate the water table or water level. This broad definition allows for features to be included in drainage systems to restore wetlands while still protecting the agricultural interests of the private landowners.

Drained: A condition in which the level or volume of groundwater or surface water has been reduced or eliminated from an area by artificial means.

Drinking Water Concern: A purported drinking water issue that has not been substantiated by monitoring, or other verification methods; will be identified through consultations with the public, stakeholder groups, and technical experts (e.g., water treatment plant operators).

Drinking Water Threat: An existing activity, possible future activity or existing condition that results from a past activity, (a) 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, or (b) that results in or has the potential to result in the raw water supply of an existing or planned drinking-water system failing to meet any standards prescribed by the regulations respecting the quality or quantity of water, and includes an activity or condition that is prescribed by the regulations as a drinking water threat.

Drinking Water Issue: A substantiated condition relating to the quality or quantity of water that interferes or is anticipated to soon interfere with the use of a drinking water source by a municipal residential system or designated system.

Ecological: Relating to the totality or pattern relations between organisms and their environment.

Ecosystem: A natural community of plants and animals within a particular physical environment, which is linked by a flow of materials throughout the non-living (abiotic) as well as the living (biotic) section of the system.

Elevation: The height of a portion of the Earth's surface in relation to its surroundings.

Empirical: Information gained by means of observation, experience, or experiment.

Enhancement: To add to, or to make greater; for example, to add additional water to a wetland, in order to make greater its environmental functionality.

Entity: One or a series of related objects, natural or anthropogenic, that may be related to a specific process. Examples: Storage Tank, Bird Colony, Abandoned Well, Mine Tailing, Natural Radiation Source.

Entrain: To draw in and transport through water.

Episodic: Made up of separate loosely connected episodes.

Erosion: The wearing away of the land by the action of water, wind or glacial ice.

***Escherichia coli (E. coli)*:** A type of coliform bacteria found in human and animal waste. Their presence in water indicates fecal contamination.

Event: Occurrence of an incident (isolated or frequent) with the potential to promote the introduction of a threat into the environment. An event can be intentional, as in the case of licensed discharge or accidental, as in the case of a spill.

Existing Drinking Water Source: The aquifer or surface water body from which municipal residential systems or other designated systems currently obtain their drinking water. This includes the aquifer or surface water body from which back-up wells or intakes for municipal residential systems or other designated systems obtain their drinking water when their current source is unavailable or an emergency occurs.

Exposure: The extent to which a contaminant or pathogen reaches a water resource. Exposure, like a drinking water threat, can be quantified based on the intensity, frequency, duration and scale. The degree of exposure will differ from that of a drinking water threat dependent on the nature of the pathway or barrier between the source (threat) and the target (receptor) and is largely dependent on the vulnerability of the resource.

Extirpated: A species that still exists somewhere in the world, but is no longer found in the study area.

Fen: Fens are peatlands characterized by surface layers of poorly to moderately decomposed peat, often with well-decomposed peat near the base. The waters and peat in fens are less acid

than in bogs, and often are relatively nutrient rich and minerotrophic since they receive water through groundwater discharge from adjacent uplands. Fens usually develop in situations of restricted drainage where oxygen saturation is relatively low and mineral supply is restricted. Usually very slow internal drainage occurs through seepage down very low gradient slopes, although sheet surface flow may occur during spring melt or periods of heavy precipitation or if a major local or regional aquifer discharges into the wetland. Some fen wetlands develop directly on limestone rock where minerotrophic waters are emerging through constant groundwater discharge. Fens are rare across the Toronto and Region Source Protection Area (TRSPA).

Flood Pulse: The peak flow during a flooding event.

Floodplain: A plain bordering a river, which has been formed from deposits of sediment carried down the river. When a river rises and overflows its banks, the water spreads over the floodplain.

Flow Regime: The pattern of how water levels change in a stream.

Flow Stability: Determined by measuring the ratio of surface discharge to groundwater discharge on an annual basis.

Fluvial: Relating to a stream or river.

Forest Cover: The percentage of the watershed that is forested.

Forest Interior: The portion of a woodlot which remains when a 100 metre buffer is removed from the inside perimeter (e.g., 100 metres in from the outside edge).

Function: An ecological role for human benefit.

Future Municipal Water Supply Areas: An area corresponding to a wellhead protection area or a surface water intake protection zone, or an aquifer or groundwater area identified for future municipal water supply infrastructure (either a well or a surface water intake pipe).

Geology: The science of the composition, structure and history of the Earth. It thus includes the study of the material of which the Earth is made, the forces which act upon these materials and the resulting structures.

Geomorphology: The scientific study of the origin of land, riverine and ocean features on the Earth surface.

Glaciation: The covering of an area or the action on that area, by an ice sheet or by glaciers.

Goals: High level achievements to aim for with respect to source protection (e.g., to protect drinking water sources). Provides an opportunity to add value statements. Not measurable through numeric means.

Gradient: The rate or regular graded ascent or descent.

Granular: Having a texture composed of small particles.

Great Lakes: The five (large) lakes located in Canada and United States: Lake Ontario, Lake Superior, Lake Huron, Lake Erie, and Lake Michigan.

Great Lakes Connecting Channels: The large rivers that connect the Great Lakes (e.g., St. Clair River, St. Lawrence River).

Groundwater: Subsurface water that occurs beneath the water table in soils and geological formations that are fully saturated.

Groundwater Discharge: The function of a wetland to accept subsurface water and hold it for release over long periods of time.

Groundwater Recharge Area: The area where an aquifer is replenished from (a) natural processes, such as the infiltration of rainfall and snowmelt and the seepage of surface water from lakes, streams and wetlands, (b) from human interventions, such as the use of storm water management systems, and (c) whose recharge rate exceeds a specified threshold.

Groundwater Table: The meeting point between the groundwater and the unsaturated layer above it.

GUDI: Groundwater Under the Direct Influence of surface water.

Habitat: The environment of an organism; the place where it is usually found.

Hazard: A contaminant and/or pathogen threat.

Hazard Rating: The numeric value which represents the relative potential for a contaminant of concern to impact drinking water sources at concentrations significant enough to cause human illness.

Highly Vulnerable Aquifer (HVA): An aquifer that can be easily changed or affected by contamination from both human activities and natural processes as a result of (a) its intrinsic susceptibility, as a function of the thickness and permeability of overlaying layers, or (b) by preferential pathways to the aquifer.

Hydraulic Gradient: A measure of the change in groundwater head over a given distance. Maximum flow will normally be in the direction of the maximum fall in head per unit of vertical distance.

Hydric Soil: A soil that is saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions that favour the growth and regeneration of hydrophytic vegetation.

Hydrogeology: Hydrogeology is the study of the movement and interactions of groundwater in geological materials.

Hydrologic Cycle: The continuous movement of water on, above, and below the surface of the earth.

Hydrologic Function: The functions of the hydrological cycle that include the occurrence, circulation, distribution, and chemical and physical properties of water on the surface of the land, in the soil and underlying rocks, and in the atmosphere, and water's interaction with the environment including its relation to living things.

Hydrology: The study of the Earth's water, particularly of water on and under the ground before it reaches the ocean or before it evaporates into the air.

Hydro-period: The seasonal pattern of the water level of a wetland that is a hydrologic signature of each wetland type. It defines the rise and fall of a wetland surface and subsurface water.

Hydrophytic Plants: Vegetation adapted to growing in water or in hydric soils.

Imminent Threat to Health: A contaminant of concern that can affect human health in a short period of time.

Index of Biotic Integrity (IBI): Indicator of overall stream health.

Infiltration: The movement of water into soil pores from the ground surface.

Inland Lake: An inland body of standing water, usually fresh water, larger than a pool or pond or a body of water filling a depression in the earth surface.

Inland Rivers: A creek, stream, brook and any similar watercourse inland from the Great Lakes that is not a connecting channel between two Great Lakes

Intermittent: Stopping and beginning again, pausing at intervals. An intermittent stream is a watercourse that does not flow permanently year-round.

Intrinsic Vulnerability: The potential for the movement of a contaminant(s) through the subsurface based on the properties of natural geological materials.

Invertebrates: Animals lacking a spinal column.

Impact: Often considered the consequence or effect, the impact should be measurable and based on an agreed set of indicators. In the case of drinking water source protection, the parameters may be an acceptable list of standards which identify a maximum raw water levels of contaminants and pathogens of concern. In the case of water quantity, the levels may relate to a minimum annual flow, piezometric head or lake level.

Knowledge Gaps: Lack of referenced materials or expertise to assess certain characteristics of the specific watershed that can be adequately described without tabular or spatial data.

Landform: Defines the physical shape of the landscape and the materials based on how the geologic material was deposited by glaciers.

Land Use: A particular use of space at or near the earth surface with associated activities, substances and events related to the particular land use designation.

Liaising: Business act to refine logistics around gathering data and information

Local Discharge: Discharge to a watercourse that originates nearby. The water moves through the upper layers of the groundwater system.

Low flow: The flows that exist in a stream channel in dry conditions.

Macroinvertebrates: Animals lacking a spinal column that are visible with the unaided eye.

Marsh: Wetlands frequently or continually inundated with water, characterized by emergent soft-stemmed vegetation adapted to saturated soil conditions (e.g., cattails).

Meandering: A curve in the course of a river which continually swings from side to side.

Meltwater Channel: The path of drainage and leftover sedimentary deposits usually from the ice margin of an alpine or continental glacier.

Model: An assembly of concepts in the form of mathematical equations or statistical terms that portrays a behaviour of an object, process or natural phenomenon.

Model Calibration: The process for generating information over the life cycle of the project that helps to determine whether a model and its analytical results are of a quality sufficient to serve as the basis of a decision.

Model Evaluation: A comparison of model results with numerical data independently derived from experiments or observations of the environment.

Model Validation: A test of a model with known input and output information that is used to adjust or estimate factors for which data are not available.

Model Verification: The examination (normally performed by the model developers) of the numerical technique in the computer code to ascertain that it truly represents the conceptual model and that there are no inherent numerical problems with obtaining a solution.

Monitoring: Periodic evaluation of a site to determine success in achieving goals.

Moraine: The debris or rock fragments brought down with the movement of a glacier.

Municipal Residential System: All municipal drinking-water systems that serve or are planned to serve a major residential development (i.e., six or more private residences).

Naturalize: To make a part of the physical environment natural, free from conventional characteristics.

Natural Heritage: The legacy of natural objects and attributes encompassing the countryside and natural environment, including plants and animals.

Naturally Occurring Processes: Processes that occur in nature and that are the result of human activity. For example, erosion along a stream that provides a source of drinking water or the leaching of naturally occurring metals found in bedrock into groundwater.

Non-Aqueous Phase Liquid (NAPL): a group of chemicals that is insoluble in water, including light and dense NAPLs.

Nonconsumptive Water Use: Water use that does not diminish the source or impair future water use.

Non-Point Source: A source of pollutants from a wide geographic area, such as manure runoff, stream bank erosion, and storm water runoff, which threatens the quality of surface and groundwater sources of drinking water.

Non-Renewable Resources: A resource that is not capable of being replaced by natural ecological cycles or sound management practices within the timeframe of a human life.

Nutrient: Something that nourishes and promotes growth. It is possible to have too many nutrients in an ecosystem, which can result in an unhealthy imbalance or overgrowth of certain species.

ODWS: Ontario Drinking Water Standards. The primary purpose of the Ontario Drinking Water Standards, Objectives and Guidelines is to provide information for the protection of public health through the provision of safe drinking water.

Ontario Ministry of the Environment (Ministry of the Environment, MOE): The provincial ministry that is spearheading Drinking Water Source Protection in Ontario. The *Clean Water Act* was passed in 2006 and proclaimed into full effect in July of 2007, and ensures that communities are able to identify potential risks to their supply of drinking water, and take action to reduce or eliminate these risks. Under the Act, municipalities, Conservation Authorities acting as Source Protection Authorities (SPAUs), landowners, farmers, industry, community groups, First Nations, health, Province of Ontario ministries and the public are working together to meet common goals. For more information on the Ontario Ministry of the Environment (MOE) and the *Clean Water Act*, visit www.ene.gov.on.ca.

Organic Matter: Of, relating to, or derived from living organisms.

Overburden: Unconsolidated geologic material above the bedrock.

Parcel Level: A parcel is a conveyable property, in accordance with the provisions of the Land Titles Act. The parcel is the smallest geographic scale at which risk assessment and risk management are conducted.

Pathogen: A disease-causing organism.

Percolation: The downward movement of water in the ground through porous soil and cracked or loosely-packed rock.

Permeability: The quality of having pores or openings that allow liquids to pass through.

Phosphorus: A non-toxic pollutant that is an essential nutrient. In excessive amounts it leads to eutrophication of a water system. Phosphorus accumulates along the entire length of a river from a variety of point and non-point sources.

Physiography: The study or description of landforms.

Planned Drinking Water Source: The drinking water source (i.e., aquifer or surface water body) from which planned municipal residential systems or other planned designated systems are projected to obtain their drinking water from in the future and for which specific wellhead protection areas and surface water intake protection zones have been identified.

Point Source: A source of pollutants from a municipal treatment plant or an industrial facility, often by way of a pipe.

Poorly Drained: Soils that are saturated at or near the surface during a sufficient part of the year such that field crops cannot be grown without drainage.

Precipitation: The deposits of water in either liquid or solid form which reach the Earth from the atmosphere. It includes rain, sleet, snow and hail.

Preferential Pathways: Any structure of land alteration or condition resulting from a naturally occurring process or human activity which would increase the probability of a contaminant reaching a drinking water source.

Productivity: Rate of production, especially of food or solar energy by producer organisms.

Raw Water: Water that is in a drinking-water system or in plumbing that has not been treated in accordance with, (a) the prescribed standards and requirements that apply to the system, or (b) such additional treatment requirements that are imposed by the license or approval for the system.

Raw Water Supply: Water outside a drinking-water system that is a source of water for the system.

Recharge Area: An area where water enters a saturated zone at the water table surface.

Regional Discharge: Water that has traveled deep beneath the ground through the saturated zone and resurfaces at the water table.

Regulated Areas: Those areas for which Conservation Authorities delineate and restrict land uses by making regulations under subsection 28(1) of the Conservation Authority Act. This subsection applies to watercourses, streams, lakes, valleys, flood plains, and wetlands in Ontario. Provincially approved standards and methodologies for delineating Regulated Areas are outlined in draft guidance documents prepared by Conservation Ontario in cooperation with the Ontario Ministry of the Natural Resources (MNR).

Renewable Resources: Resources that are capable of being replaced through ecological processes or sound management practices.

Reserve Amounts: Minimum flows in streams that are required for the maintenance of the ecology of the ecosystem.

Restoration: Changing existing function and structure of wetland habitat so that it is similar to historical conditions.

Return Period: The frequency in which a flow event in a stream is likely to repeat itself.

Receptor: The exposed target in danger of incurring a potential impact. An example would be any aquifer or surface water body used for drinking water consumption.

Response Factor: Typical factors affecting the response include dilution, rate of discharge, absorption, and degradation of the contaminant or pathogen in question. Because of the nature of the water resource, certain contaminants and pathogens may not have an impact (see definition), great enough to warrant concern or responsive action. The level of impact may not effectively degrade the water resource and therefore would not require a mitigative action.

Riffle/Pool System: A riverine system that alternates cycles of shallow broken water (riffle) and deeper still water (pool).

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

Risk: The likelihood of a drinking water threat (a) rendering an existing or planned drinking water source impaired, unusable or unsustainable, or (b) compromising the effectiveness of a drinking water treatment process, resulting in the potential for adverse human health effects.

Riverine: Relating to or resembling a river.

Runoff: Water that moves over land rather than being absorbed into the ground. Runoff is greatest after heavy rains or snowmelts, and can pick up and transport contaminants from landfills, farms, sewers, industry and other sources.

Saturated Soil: Soil that is full of moisture.

Scale: A graduated series or scheme of rank or order.

Security of well or intake infrastructure: An evaluation of structures/measures that are in place or are needed to protect a municipal groundwater supply well or surface water intake from potential contamination from external sources.

Sediment: Material deposited by water, wind or glaciers.

Sedimentary Bedrock: Rock formed of mechanical, chemical or organic sediment such as rock formed from sediment transported from elsewhere, by chemical precipitation from solution or from inorganic remains of living organisms.

Semi-Quantitative: Describes an approach or methodology that uses measurable or ranked data, derived from both quantitative and qualitative assessments, to produce numerical values to articulate results.

Sensitivity Analysis: Sensitivity analysis evaluates the effect of changes in input values or assumptions on a model results.

Severity: The degree to which an impact is measured compared to an idealized value of some indicator of concern. In the case of water quality, the severity may relate to degree of measurable exceedance of some contaminant or pathogen. In the case of water quantity, deviation from some measurable indicator (e.g., minimum annual flow, piezometric head or lake level) must also be established.

Significant Hydrologic Features: (a) A permanent or intermittent stream, (b) wetlands, (c) kettle lakes and their surface catchment areas, (d) seepage areas and springs, and (e) aquifers and recharge areas that have been identified as significant by the Ministry of Natural Resources, using evaluation procedures established by that Ministry, as amended from time to time.

Sinkhole: Any depression in the surface of the ground, with or without collapse of the surrounding soil or rock, which provides a means through which surface water can enter the ground and therefore come in contact with groundwater. Sinkholes often allow this contact to occur quite rapidly and do little to filter any contaminants the surface water may contain.

Site-level: The most refined scale at which technical assessment of hydrological and hydrogeological conditions can be conducted. These assessments may contribute to water budgets, vulnerability assessments, and issues evaluation.

Slope: Ground that forms a natural or artificial incline.

Source Protection (Drinking Water Source Protection): Protecting surface water sources such as lakes, rivers and streams, and groundwater sources from contamination or overuse, particularly through the planning process under the *Clean Water Act, 2006*. It is the first step in the multi-barrier approach to protecting drinking water. Other barriers include water testing and monitoring, reliable water treatment and distribution systems and training of water managers and staff. At this time, the emphasis of the project is to identify and address existing or potential threats to municipal water supplies by concentrating on zones immediately surrounding municipal wellheads and surface water intake zones in Lake Huron. See the About Source Protection tab for more details.

Source Protection Planning: The creation of local, watershed-based plans for the protection of the quality and quantity of drinking water sources, now and in the future. Plans will be created by local stakeholders on Source Protection Committees (SPCs); this process will be facilitated by conservation authorities, who will ensure that SPCs have the technical knowledge to ensure that plans are science-based. See the About Source Water Protection and Our Project tabs for more details.

Spawn: To produce or prevent eggs in the reproductive process (particularly in aquatic animals).

Spillway: The valley that results when glacial meltwater cuts into the landscape. Spillways are often composed of sand and gravel.

Stratigraphy: Geology that deals with the origin, composition, distribution and succession of layers of the Earth.

Stream: A body of running water flowing on the surface of the Earth.

Substrate: The base on which an organism lives.

Subwatershed: An area that is drained by an individual tributary into the main watercourse of a watershed.

Successional Areas: Ecosystems undergoing the gradual process of change that results from one community gradually replacing another.

Surface Water: Water occurring in lakes, rivers, and streams that may be used as a source of drinking water. As water moves in a cycle (hydrologic cycle), groundwater and surface water interact; this may cause contaminants to move between groundwater and surface water systems.

Surface to Aquifer Advection Time (SAAT): The average time required by a water particle to travel from a point at the surface to the aquifer of concern. The SAAT is approximated by using the vertical component of the advective velocity integrated over the vertical distance and the average porosity.

Surface to Well Advection Time (SWAT): The average time required by a water particle to travel from a point at the ground surface to the well, including both vertical and horizontal movement.

Surface Water Intake Protection Zone (IPZ): The contiguous area of land and water immediately surrounding a surface water intake, which includes:

- 1) The distance from the intake.
- 2) The minimum travel time of the water associated with the intake of a municipal residential system or other designated system, based on the minimum response time for the water treatment plant operator to respond to adverse conditions or an emergency. And
- 3) The remaining watershed area upstream of the minimum travel time area (also referred to as the Total Water Contributing Area) is applicable to inland water courses and inland lakes only.

Surficial Geology: Deals with the study and description of the forms on the outer layer of the Earth.

Swamp: Any wetland dominated by woody plants such as trees and shrubs. This is generally considered as 25% or more cover of trees or tall shrubs. Standing to gently flowing waters occur seasonally or persist for long periods on the surface. Many swamps are characteristically flooded in spring, with dry relict pools apparent later in the season.

Targets: In the context of technical guidance documents, these are detailed goals that are often expressed as numeric goals (e.g., to reduce contaminant X in this aquifer by 10 per cent by 2009).

Ten-year storm wind conditions: The maximum sustained wind speed coming from a single direction likely to occur once every ten years.

Terrestrial: Living on or growing on land.

Thermal Regime: The characteristic behaviour and pattern of temperature.

Till: A tough unstratified clay loaded with stones originating from finely ground rock particles that were deposited by glacial activity.

Time of Travel (TOT): An estimate of the time required for a particle of water to move in the saturated zone from a specific point in an aquifer into the well intake.

Tolerance of a Water Supply System: A measure of the ability to sustain required pumping levels even during exposure events.

Topography: A detailed description or representation of the features, both natural and artificial, or an area. Also the physical and natural features of an area, and their structural relationships.

Transport Pathway: A man-made or natural feature on the landscape that may promote quicker travel of contaminants to the water bearing rock material, than would otherwise occur in the surrounding landscape. Where Transport Pathways occur the vulnerability score maybe increased.

Uncertainty Analysis: Uncertainty analysis investigates the effects of lack of knowledge and other potential sources of error in the model

Uncertainty Score: Uncertainty addresses known gaps in data/information about, or deficiencies in methods of assessment for, threats and/or vulnerability. It reflects the degree of confidence in the semi-quantitative data used to calculate risk.

Unconfined Aquifer: An aquifer whose upper boundary is the water table.

Unsaturated Zone Advection Time (UZAT): Estimated time for water to flow vertically from ground surface through to the water table.

Valley: A long, narrow depression on the Earth surface, usually with a fairly regular downward slope. A river or stream usually flows through it.

Valuation of the Supply: An evaluation of the importance of a particular municipal well or intake to the whole municipal drinking water supply. For example, where there are multiple supplies, value may be smaller, versus a single supply where value may be greater.

Vernal Pools: Temporary pools of water that are usually devoid of fish, and thus allow the safe development of natal amphibian and insect species.

WTP: Water Treatment Plant. A facility that provides municipal drinking water.

WWTP: Waste Water Treatment Plant. A facility that treats to sanitary sewage

WWIS: Water Well Information System – a database of water wells from across Ontario that includes a summary of the characteristics of the well and soil for each well.

Water Balance: Use of a water budget to mitigate changes to the hydrological cycle following urbanization, typically by increasing infiltration and evaporation and decreasing runoff.

Water Budget: The movement of water within the hydrologic cycle can be described through a water budget or water balance. It is a tool that when used properly allows the user to determine the source and quantity of water flowing through a system. From a groundwater perspective the key components of a water budget are: infiltration, contribution to baseflow, deeper groundwater flow outside the study area and groundwater taking.

Water Control Structure: An engineered structure designed to hold back water and mimic a natural water regime that promotes wetland restoration, without affecting adjacent agricultural practices.

Watercourse: An identifiable depression in the ground in which a flow of water regularly or continuously occurs (*Conservation Authorities Act*, Section 28(1), Regulations by the Minister of Natural Resources, May 2006).

Water Cycle: The continuous movement of water from the oceans to the atmosphere (by evaporation), from the atmosphere to the land by condensation and precipitation, and from the land back to the sea (via stream flow).

Watershed: An area where many sources of surface water drain into the same place.

Water Quality Indicator: An entity that provides information on the condition and quality of water through its life cycle patterns. Water quality can also be determined through non-living sources, like chemical sampling.

Water Table: The surface below which the soil is saturated with water.

Water Wells: A hole in the Earth surface used to obtain water from an aquifer. For a bored well, an earth auger is used to bore a hole carry earth to the surface. The casing is usually steel, concrete or plastic pipe. Modern dug wells are dug by power equipment and typically are lined with concrete tile. Dug and bored wells have a large diameter and expose a large area to the aquifer. These wells are able to obtain water from less-permeable materials such as very fine sand, silt, or clay. Drilled wells are constructed by either percussion or rotary-drilling machines. Drilled wells that penetrate unconsolidated material require installation of casing and a screen to prevent inflow of sediment and collapse. A flowing, or Artesian, well is completed in a confined aquifer that has a water level higher than the ground surface at the location of the well. This causes water to flow out of the well.

Weathering: The disintegration of the Earth crust by exposure to the atmosphere, most importantly, rain.

Well Capture Zone: The area in the aquifer that will contribute water to a well in a certain time period. Often measured in days and years. Area at the ground surface is also included if the time period chosen is longer than the travel time for water in the aquifer and the groundwater recharge area is incorporated.

Wellhead Protection Area (WHPA): The surface and underground area surrounding a water well or well field that supplies a municipal residential system or other designated system through which contaminants are reasonably likely to move so as to eventually reach the water well or wells.

Wetland: Land that is seasonally or permanently covered by shallow water, as well as land where the water table is close to or at the surface. In either case, the presence of abundant water has caused the formation of hydric soils and has favoured the dominance of either hydrophytic plants or water tolerant plants. The four major types of wetlands are swamps, marshes, bogs, and fens. Periodically soaked or wet lands being used for agricultural purposes, which no longer exhibit wetland characteristics, are not considered to be wetlands for the purposes of this definition (*Provincial Policy Statement, 2005*).

Wetland Values: Wetland processes or attributes which are beneficial to society.

Woodland: A treed area that provides environmental and economic benefits to both the private landowner and the public, such as erosion prevention, hydrological and nutrient cycling, clean air and long-term storage of carbon, wildlife habitat, outdoor recreational opportunities, and the sustainable harvest of a wide range of woodland products. Woodlands include treed areas, woodlots, or forested areas and vary in their level of significance at local, regional, and provincial levels (*Provincial Policy Statement, 2005*).