DRINKING WATER
SOURCE PROTECTION
Our Actions Matter
CTC Source Protection Region

Credit Valley SPA Assessment Report

NOTICE OF AMENDMENTS

Currently proposed amendments to this document, made under Ontario Regulation 287/07, Section 34, are summarized in the table below. Page references are to those of the pdf. The proposed amendments to the document are highlighted in yellow.

DATE PROPOSED AMENDMENTS POSTED: Monday June 5, 2023

Table: Summary of Anticipated Section 34 Amendments to the Assessment Report for the Credit Valley Source Protection Area

PDF Page No.	Section, Figure and/ or Table	Brief Description of Anticipated Amendment	Estimated Timing to Submit Proposed Amendment to Ministry of the Environment, Conservation, and Parks
3-4, all pages	Cover page, footers	Update to proposed version number; date of approval and effective dates	September 2023
5	Version Control	Summary of proposed amendment version	September 2023
6	Executive Summary	Add version number and Director's Technical Rules documentation	September 2023
7	Executive Summary	Update significant drinking water quality threats count.	September 2023
9	Executive Summary. Figure ES: 4:	Update to include updated IPZ collector lines from new Ashbridges Bay Treatment Plant	September 2023
12	Executive Summary. Figure ES: 7:	Update to include new WHPA delineation for Caledon Village wells 3, 3B, and 4.	September 2023
13-27	Glossary	Updates to glossary terms	September 2023
28	Introduction	Add version number and Director's Technical Rules documentation	September 2023
31	Table 1.1	Update table to include new version of assessment report.	September 2023
32-34	Section 2.3.2	Update number of active wells to include Caledon Village Well 3B	September 2023
33	Table 2.6	Update number of wells and max pumping rate for Caledon Village	September 2023
35	Section 4.1.4	Amendments to text on Transport Pathways methodology adopted in the CVSPA.	September 2023

36	Section 4.2	Update well numbers	September 2023
38	Section 4.2.2	Amendments to text on Transport Pathways methodology adopted in the CV SPA.	September 2023
42	Figure 4.4	Update Figure to include new WHPA delineation for Caledon Village wells 3, 3B, and 4.	September 2023
43-76	Section 4.8	Update text, figures and tables to reflect refinements made to the groundwater flow model, capture zone delineation, and WHPAs for the Caledon Village wells 3, 3B, and 4; including uncertainty assessment and adopted Transport Pathways methodology work.	September 2023
78-80	Section 5.1.2; Tables 5.1-5.3	Update text and tables to reflect where threats can exist under different version of Director's Technical Rules	September 2023
82	Section 5.2.7	Update the text on impervious surface methodology used for the Caledon Village Wellfield.	September 2023
83	Section 5.5; Table 5.12	Update number of wells and significant threat and parcel counts	September 2023
85-88	Section 5.5.6; Table 5.25	Update number of wells and significant threat counts	September 2023
89-94	Figures 5.37-5.39	Update chemical, pathogen and DNAPL threat area figures for Caledon Village wells 3, 3B, and 4.	September 2023
97-98	Table 5.40 & 5.41	Updated surface water spill scenario locations and significant threats for new Ashbridges Bay outfall	September 2023
104-113	Figures 5.51-5.57	Updates IPZ collector lines to include new Ashbridges Bay outfall significant threat	September 2023
115-116	Section 5.9, Table 5.44	Update significant threat and affected parcel counts	September 2023
117-121	Section 6, Table 6.1, Table 6.2	Update text and tables on Director's Technical Rules version, transport pathways methodology, and significant threat and parcel counts. Remove transport pathways knowledge gap.	September 2023
122-131	Section 7	Update references	September 2023

DRINKING WATER SOURCE PROTECTION
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CTC Source Protection Region

Proposed Amended~~Approved~~ Assessment Report: Credit Valley Source Protection Area

Prepared by: CTC Source Protection Committee
Approved: ~~December 3, 2019~~TBD
Effective Date: ~~December 5, 2019~~TBD
Version ~~4~~5.0 (Proposed June 5, 2023)

Proposed Amended~~Approved~~ Assessment Report:

Credit Valley Source Protection Area

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

Version Control

Version Number	Approval Date	Effective Date	Description of Amendment
1.0	July 22, 2015	December 31, 2015	N/A
	n/a	n/a	Section 51: Review and update for consistency between chapters, as well as with the Toronto and Region and Central Lake Ontario Assessment Reports. Section 51: Update wording for Tables of Drinking Water Threats to direct readers to http://swpip.ca/. Date amendment posted: June 5, 2018
2.0	March 11, 2019	March 25, 2019	Section 34: Addition of Wellhead Protection Areas, Vulnerability Assessment and Threats Enumeration for Inglewood Drinking Water System.
3.0	December 3, 2019	December 5, 2019	Section 34: Addition of Wellhead Protection Areas, Vulnerability Assessment and Threats Enumeration for Alton Well 4A, Caledon Village – Alton Drinking Water System.
4.0	n/a	n/a	Section 51: Amendments to correct clerical, grammatical or typographical errors; to make changes referencing a name, title, location, or address that has changed; to incorporate Phase I Director Technical Rule 2017 amendments; and to account for the discontinuation of the use of Inglewood Well 2 in the Inglewood Drinking Water System. Date amendment posted: May 20, 2022.
5.0	TBD	TBD	Section 34: Addition of Wellhead Protection Areas, Vulnerability Assessment and Threats Enumeration for Caledon Village – Alton Drinking Water System.

EXECUTIVE SUMMARY

Why should you read this document?

The *Approved Amended Assessment Report: Credit Valley Source Protection Area* (Assessment Report) has been prepared under the direction of the CTC Source Protection Committee (SPC), one of 19 such committees across Ontario **(Figure ES: 1)**. It is a requirement of the *Clean Water Act, 2006* (*CWA*) and Ontario Regulation (O. Reg.) 287/07 as amended by O. Reg. 59/10 and has been developed in accordance with the regulations, the *Technical Rules*: A*ssessment Report* (MOE, 2009) and the *Terms of Reference: CVSPA*, as approved by the Minister of the Environment. Amendments to the Credit Valley Assessment Report resulting in versions 2.0, 3.0 and 4.0 were made using the 2017 Director's Technical Rules and Tables of Drinking Water Threats. Further amendments resulting in version 5.0 were made using the 2021 Director's tTechnical Rules. Sections of the Assessment Report that were not updated as part of those amendments refer to the 2009 edition of the Director's Technical Rules and Tables of Drinking Water Threats.

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

This Assessment Report 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 vulnerable areas and applying vulnerability scores to these 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 for water quality (WHPAs);
- Issue contributing areas (ICAs); and
- Wellhead protection areas for water quantity (WHPA-Q1/Q2).

Detailed information about how these vulnerable areas were delineated and scored can be found in **Chapters 3, 4** (regarding vulnerability), and **5** (regarding Intake Protection Zone-3)**.** This Assessment Report identifies and describes per the *Technical Rules (2009)* each of these types of vulnerable areas within the Credit Valley Source Protection Area (CVSPA). Descriptions, scoring, and documentation on the analyses performed to arrive at these delineations are all contained in the body of this Assessment Report or in the referenced technical appendices.

Work has been undertaken to delineate water quantity vulnerable areas around wells in Amaranth, Mono, Orangeville, Acton, and Georgetown as part of Tier 3 Water Budget study (**Figure ES:2**). This work also resulted in changes to the areas delineated as wellhead protection areas, and issue contributing areas around these wells. Refinements to the mapping of significant groundwater recharge areas were also completed through this work.

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 was delineated for activities in the tributary using the required setbacks from the contaminant point of release to a point representing the maximum landward extent of the IPZ-2. A dashed line is also drawn from the point of entry at the lake to the affected intake. This line is termed the "spill collector" and represents the shortest transport path between the shoreline and the affected intakes. An IPZ-3 that falls in the lake such as a spill at a WWTP is represented by a spill collector dashed line only. The spill collector line represents the shortest path to the intake within the area where concentrations were modelled to exceed the threshold for the contaminant. Once a contaminant is modelled to reach an intake at a level that is identified as a significant drinking water threat, an Event Based Area (EBA) within the IPZ-1, 2 or 3 was delineated, using the required setbacks, from the point of its release in the tributary to a point representing the maximum landward extent of the IPZ-2. The EBA is the spatial component of the IPZ-1, 2 or 3 required for database and policy application purposes.

With respect to surface water, three significant drinking water quality threat locations have been identified in CVSPA. With respect to groundwater, 9,5~~53~~61 significant drinking water quality threats have been identified in this Assessment Report.

Drinking water issues relating to sodium (Na) and chloride (Cl) were identified in WHPAs of municipal wells servicing the Towns of Orangeville, and issues related to chloride were identified for municipal supply wells for the Town of Georgetown. Issues relating to Nitrates (NO_3) were found in municipal wells servicing the Town of Acton. These are areas in the middle and upper zones where sizeable populations receive municipal water supplies sourced from the ground. The Tier 3 work has also identified 392 significant drinking water quantity threats at Orangeville, Mono, Amaranth, and Acton.

You may request more information by writing to:

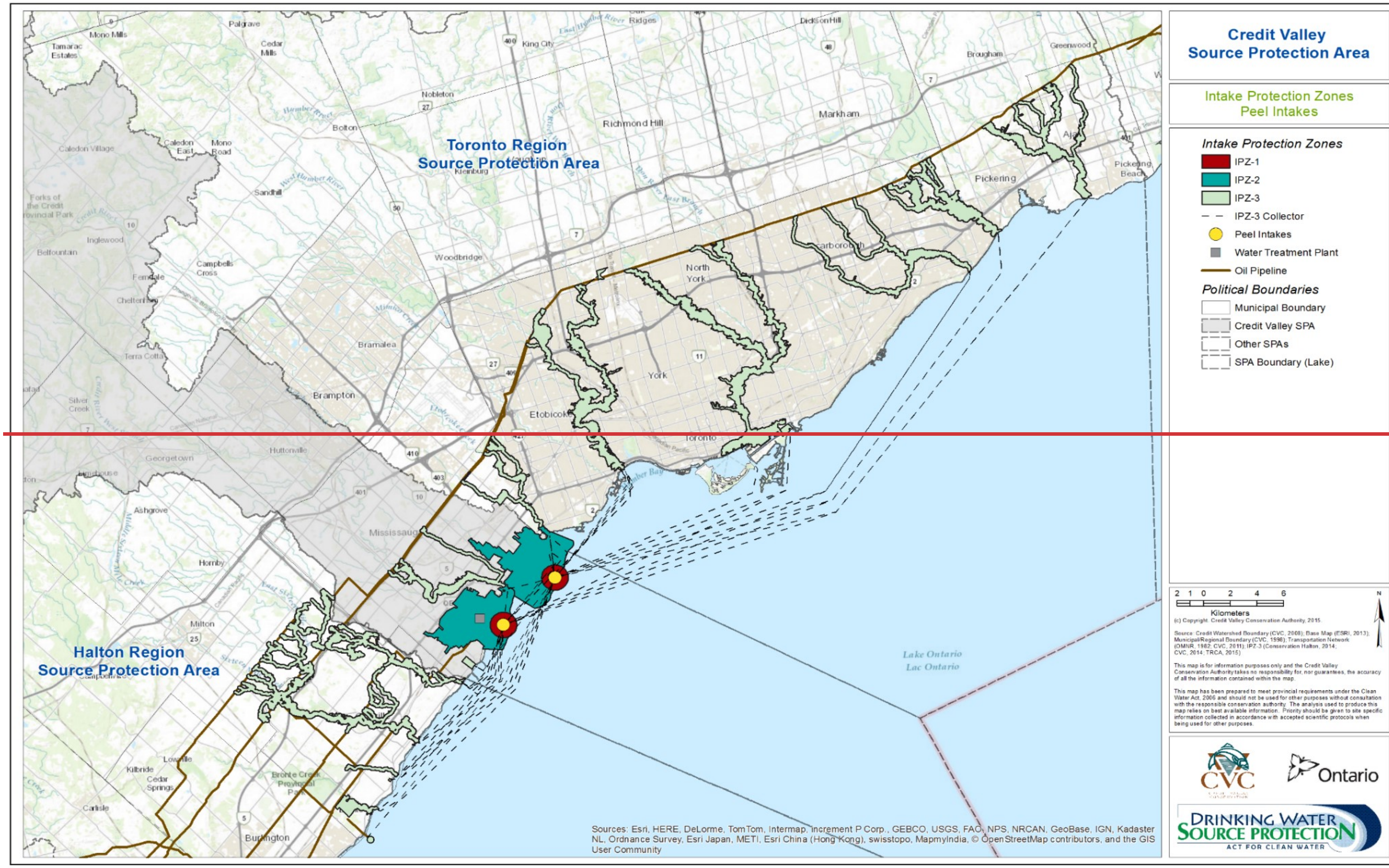
ctcswp@cvc.ca

or by regular mail to:

Chair, CTC Source Protection Committee

c/o Credit Valley Conservation

1255 Old Derry Road, Mississau~~a~~ga, ON L5N 6R4


Credit Valley Source Protection Area
Intake Protection Zones
Peel Intakes
Intake Protection Zones
IPZ-1
IPZ-2
IPZ-3
IPZ-3 Collector
Peel Intakes
Water Treatment Plant
Oil Pipeline
Political Boundaries
Municipal Boundary
Credit Valley SPA
Other SPAs
SPA Boundary (Lake)
Toronto Region Source Protection Area
Halton Region Source Protection Area
Lake Ontario
Lac Ontario
Kilometers
Sources: Esri, HERE, DeLorme, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community
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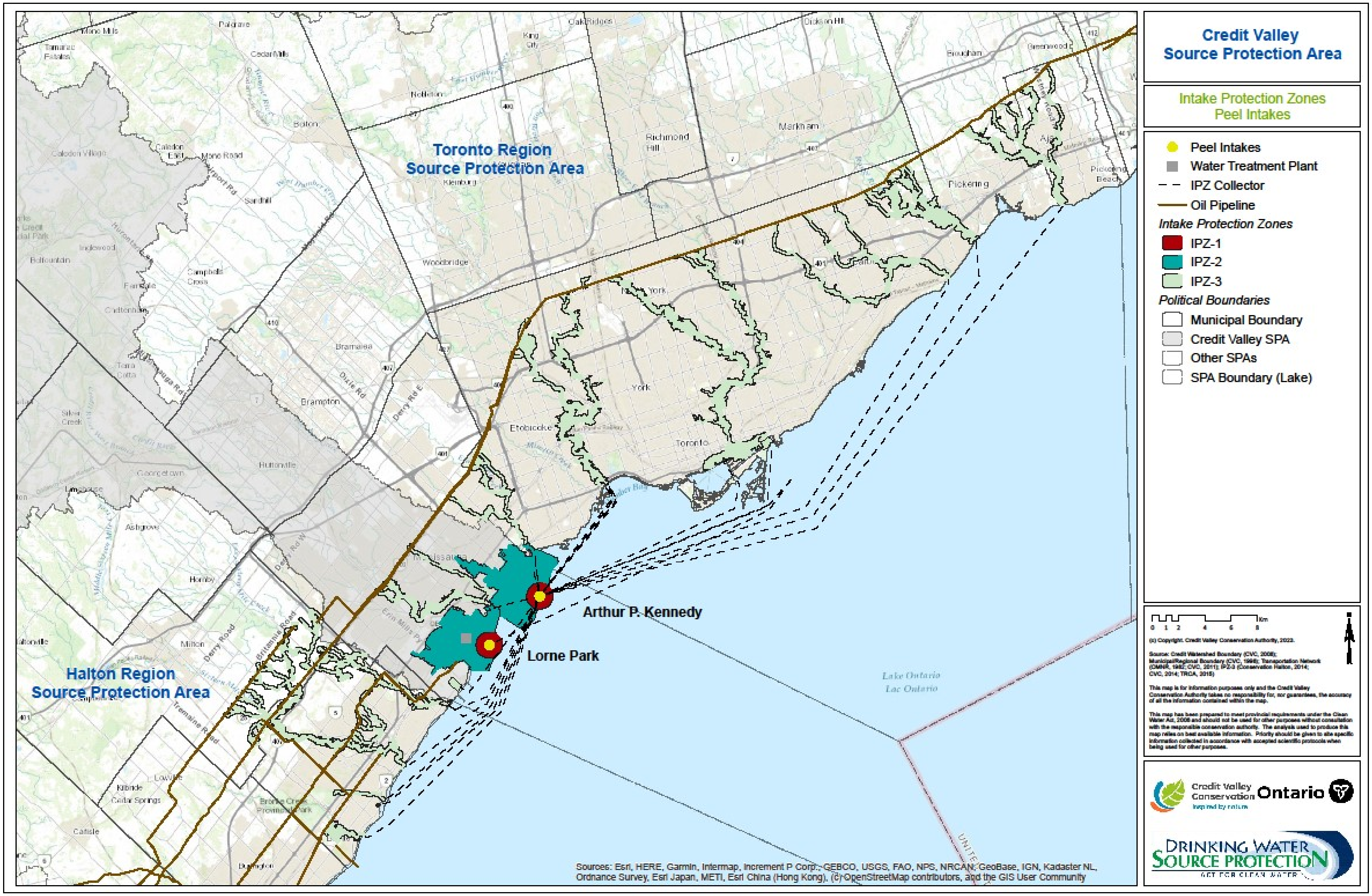
Credit Valley
Source Protection Area
Intake Protection Zones
Peel Intakes
Peel Intakes
Water Treatment Plant
IPZ Collector
Oil Pipeline
Intake Protection Zones
IPZ-1
IPZ-2
IPZ-3
Political Boundaries
Municipal Boundary
Credit Valley SPA
Other SPAs
SPA Boundary (Lake)
Toronto Region
Source Protection Area
Halton Region
Source Protection Area
Arthur P. Kennedy
Lorne Park
Lake Ontario
Lac Ontario
Markham
Richmond Hill
Pickering
Brampton
Etobicoke
Toronto
York
Woodbridge
Bolton
Georgetown
Milton
Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community
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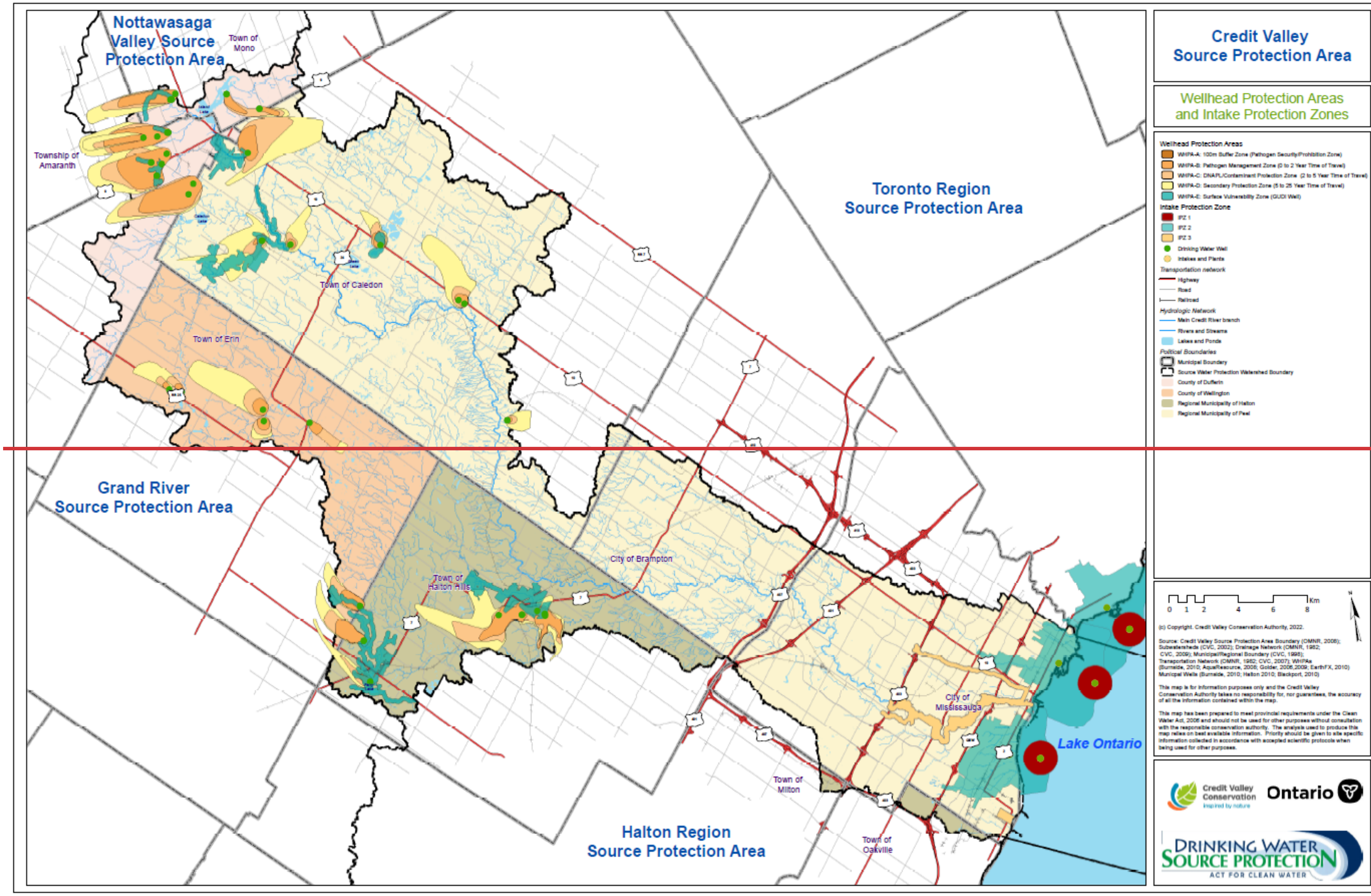
DRINKING WATER SOURCE PROTECTION

Figure ES: 4: Location of Intake Protection Zones and Municipal Surface Water Intakes


Credit Valley
Source Protection Area
Wellhead Protection Areas
and Intake Protection Zones
Wellhead Protection Areas
WHPA-A: 100m Buffer Zone (Pathogen Security/Prohibition Zone)
WHPA-B: Pathogen Management Zone (0 to 2 Year Time of Travel)
WHPA-C: DNAPL/Contaminant Protection Zone (2 to 5 Year Time of Travel)
WHPA-D: Secondary Protection Zone (5 to 25 Year Time of Travel)
WHPA-E: Surface Vulnerability Zone (GUDI Well)
Intake Protection Zone
IPZ 1
IPZ 2
IPZ 3
Drinking Water Well
Intakes and Plants
Transportation network
Highway
Road
Railroad
Hydrologic Network
Main Credit River branch
Rivers and Streams
Lakes and Ponds
Political Boundaries
Municipal Boundary
Source Water Protection Watershed Boundary
County of Dufferin
County of Wellington
Regional Municipality of Halton
Regional Municipality of Peel
Nottawasaga Valley Source Protection Area
Town of Mono
Township of Amaranth
Town of Caledon
Town of Erin
Toronto Region Source Protection Area
Grand River Source Protection Area
Town of Halton Hills
City of Brampton
City of Mississauga
Lake Ontario
Town of Milton
Town of Oakville
Halton Region Source Protection Area
Km
0 1 2 4 6 8
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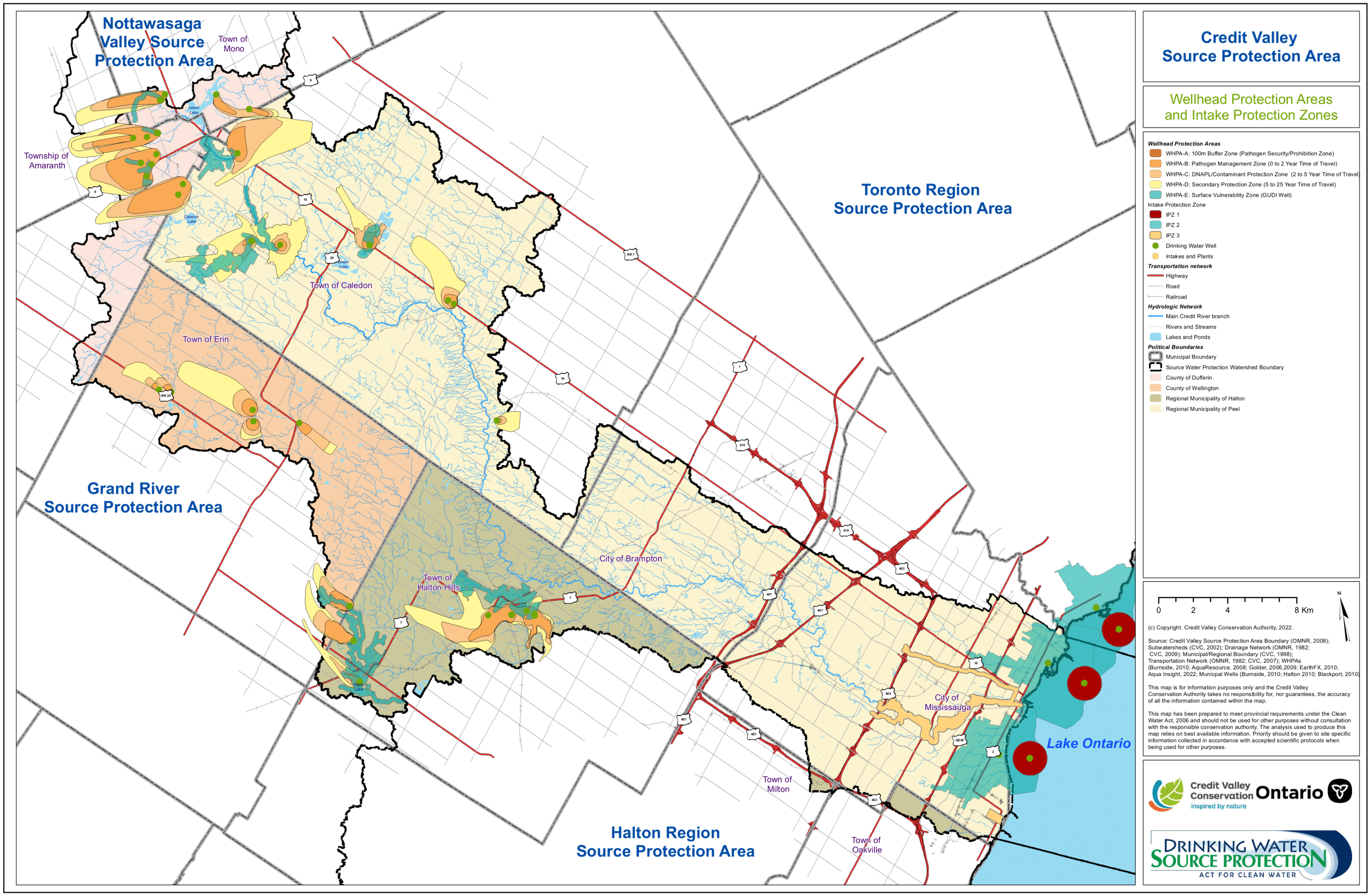


Figure ES: 7: Wellhead Protection Areas, Intake Protection Zones, and Issue Contributing Area

Glossary

Below are some terms, both 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 occurs 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 layer of water-bearing sediments (e.g., sand, gravel) or permeable rock from which groundwater can be usefully extracted via a water well.~~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's 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.

Artesian: Groundwater under sufficient pressure to rise above the top of the aquifer containing it.

~~**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 sustained component of flow in a watercourse (i.e., stream, river) which continues even through dry weather periods. It is normally regarded as the sum of groundwater flow and delayed throughflow.~~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 (BOD): A measurement used to assess the rate at which water is deoxygenated. High BOD generally 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.~~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 Credit Valley Source Protection Area (CVSPA).~~

~~**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.~~

Cone of Influence: For one or more wells that draw water from an aquifer, this is the area within the depression created in the water table or potentiometric surface when the wells are pumped at a rate equivalent to their allocated plus planned quantities of water.

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: To permanently fill in and seal a well to eliminate the well as a source of water, or as a potential physical hazard and to prevent movement of water within well.

~~Capped, plugged and sealed in compliance with regulatory requirements (O. Reg. 903) established by the Ministry of the Environment and Climate Change.~~

Dense Non-Aqueous Phase Liquids (DNAPLs): A group of chemicals that is insoluble and denser than the water portion of the shallowest aquifer. ~~a group of chemicals that are insoluble and denser than water.~~

Designated System: A drinking water system that is included in a Terms of Reference for developing source protection plans, pursuant to resolution passed by a municipal council under subsection 8(3) of the *Clean Water Act, 2006* or added by the Minister.~~, 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.

Dissemination Areas (Da): the smallest standard geographic area for which all census data are disseminated (Census Canada).

Drainage Density: Length of watercourse per unit drainage area.

Drainage System (under the Drainage Act): A drain constructed by any means, including the improving of a natural watercourse, and includes works necessary to regulate the water table or water level within or on any lands or to regulate the level of the waters of a drain, reservoir, lake or pond, and includes a dam, embankment, wall, protective works or any combination thereof. Physically, a municipal drain is simply a drainage system. Under the Drainage Act, municipalities are legislated to maintain, and repair drains and to respond to petitions for new drainage systems. Municipal drains are generally watercourses as defined under the Conservation Authorities Act and are therefore regulated by Conservation Authorities.

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. Drinking water concerns 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 of 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.

Downgradient: A downward hydrologic slope that causes groundwater to move toward lower elevations.

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*) and *Campylobacter: A type of coliform bacteria found in human and animal feces. Their presence in surface and groundwater indicates fecal contamination. Some types of *E. coli* can cause serious illness for humans.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: Nutrient-rich, peat-forming wetland that receives water from surface water or groundwater flow. They are usually less acidic than bogs.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.

Flood Pulse: The peak flow during a flooding event.

Floodplain: The flat, low-lying area along a stream channel that is subjected to recurrent flooding. It is formed when the stream overflows its channel during times of high flow. When the water recedes, alluvial deposits generally are deposited along the plain bordering the stream.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: Process associated with rivers and the deposits and landforms they create.~~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 perimeter of the forest (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, including riverine and ocean features on the Earth's 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 interconnected freshwater) lakes located along the border of Canada and the United States: Lake Ontario, Lake Superior, Lake Huron, Lake Erie, and Lake Michigan.

Great Lakes Connecting Channels: The 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: An area in which there are upward components of hydraulic head in the aquifer. Groundwater is flowing toward the surface in a discharge area and may escape as a spring, seep, or baseflow; or by evaporation and transpiration.~~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 surface in an unconfined aquifer or confining bed at which the pore water pressure is atmospheric. It can be measured by installing shallow wells extending a few metres into the zone of saturation and then measuring the water level in those wells.~~The meeting point between the groundwater and the unsaturated layer above it.~~

Groundwater Under the Direct Influence of Surface Water (GUDI): Raw groundwater supply obtained from a water well and where there is an interaction between the surface water and groundwater supply that may impact the water quality at the well.

Groundwater supply sources that have a direct hydrological connection to surface water sources (rivers, streams, ponds, etc.), and are therefore vulnerable to contamination from the surface.

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.

Headwaters: Area of a watershed where a major river system originates.

High Water Mark: The usual or average level to which a body of water rises at its highest point and remains for sufficient time so as to change the characteristics of the land. Under the director's technical rules, this term is consistent with the definition of 'ordinary high water mark' as defined by Fisheries and Ocean Canada as described in DFOs Fish Habitat Fact Sheet #T-6.

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 downward entry of water through the soil surface into the soil.The movement of water into soil pores from the grounds 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 Stream: 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 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: The management and modification of the natural environment for 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:** Bends in the course of a river which continually curves 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 the 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: Marginal glacial deposits (lateral, medial, terminal, ground) of unsorted and stratified material.~~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 residencies).

~~**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 not 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): An organic liquid that is insoluble in water (hydrophobic), such as oil, gasoline, and other petroleum products.~~A group of chemicals that are 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.

Ontario Drinking Water Standards (ODWS): Water quality standards through which the Provincial Government of Ontario regulates drinking water quality. Standards contain maximum allowable concentrations (MAC) for major inorganic and organic parameters in water.~~means Ontario Regulation 169/03 (Ontario Drinking Water Quality Standards) made under the *Safe Drinking Water Act,* 2002.~~

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 ability of a material to transmit a fluid, a measure of how quickly fluid will flow through the rock or sediment.~~The quality of having pores or openings that allows 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 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's 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.

~~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.~~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 occurs 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 term applied to a mixture of unstratified grain sizes ranging from clay to boulders deposited directly by glacial activity.~~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 may be 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.~~

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

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

Water Well Information System (WWIS): A Government of Ontario database of water wells installed across Ontario.~~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: A watershed is the area of land where all of the water that is under it or drains off of it goes into the same place. Its boundaries are defined by ridges of high land.~~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 to 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 then 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.

~~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 wetlands 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).~~

safe and clean air, land, and water. In particular, the ministry provides funding and guidance with respect to Wellhead Protection Area (WHPA) delineation and drinking water systems.

The Ministry of Natural Resources (MNR) is committed to protecting and managing the province's natural resources, or its "natural capital," and making the interest from that capital available for individuals, communities, and economies that depend on it. In doing so, the ministry contributes to the environmental, social, and economic well-being of the people of Ontario, meeting not only today's needs, but also ensuring these resources are available for future generations. In support of this mission, the MNR is responsible for providing funding and guidance for water budgets aimed at source protection planning.

Note: The Ministry of Environment, Conservation and Parks has undergone several name changes throughout the years. It was called the Ministry of Environment (MOE) in the early 2000's. In June 2014, the name was changed to the Ministry of the Environment and Climate Change (MOECC). In June 2018, the name was changed yet again, to the Ministry of the Environment, Conservation and Parks (MECP), as it is currently known.

In June 2014, the Ministry of Natural Resources (MNR) changed its name to the Ministry of Natural Resources and Forestry (MNRF). In 2021, the Ministry of Natural Resources and Forestry changed its name to Ministry of Northern Development, Mines, Natural Resources and Forestry.

The recent and past names of both Ministries are used within this document.

1.2.2 Regulations

The CWA and its regulations can be found at www.e-laws.gov.on.ca. The four regulations under the *CWA* are:

- O. Reg. 231/07 (Service of Documents);
- O. Reg. 284/07 (Definitions of Source Protection Areas and Regions);
- O. Reg. 288/07 (Source Protection Committee Names and Structure); and
- O. Reg. 287/07 (General).

O. Reg. 287/07 provides the framework for the terms of reference, for the SPCs, the assessment report, and the source protection plan, including the required public consultation.

1.2.3 Technical Rules

The *Technical Rules* outline the legislated content for assessment reports across Ontario. The *Technical Rules* report was posted on the MOECC's website in December 2008 and further amended in November 2009. The 2017 version of the document can be found at: https://www.ontario.ca/page/2017-technical-rules-under-clean-water-act.

Amendments to the Credit Valley Assessment Report resulting in versions 2.0, 3.0, and 4.0 were made using the 2017 Director's Technical Rules and Tables of Drinking Water Threats. Amendments to the Credit Valley Assessment Report resulting in version 5.0, -were made using the 2021 ~~2021~~ Director's Technical Rules and Tables of Drinking Water Threats. Sections of the Assessment Report that were not updated as part of those amendments refer to the 2009 edition of the Director's Technical Rules and Tables of Drinking Water Threats. The *Technical Rules* contain definitions of key terms, as well as 143 specific requirements or rules for the content of an assessment report. The rules are organized by chapter and include key aspects of the methodologies used in the underlying analysis. The amended rules guide the development of this assessment report. As part of the *Technical Rules,* the Province has also provided provincial Tables of Drinking Water Threats that establish the risk score for the different combinations of municipal drinking water threat activities and the corresponding vulnerable area types and scores. There are also standards to be used in preparing maps so that the symbology is consistent from one source protection area to another.

1.2.4 Provincial Technical Bulletins

In addition to the legislated, regulatory requirements and the *Technical Rules*, the province provided a series of technical bulletins to assure accuracy and consistency with other source protection authorities across the province. The guidance and bulletins advised staff with additional direction on how to complete the analyses required, and outlined the technical work required to comply with legal requirements. Detailed guidance materials outlining how to conduct the various technical studies included in an assessment report were developed between 2005 and 2008 by the MOECC. Subsequently, a series of technical bulletins was issued by the MOECC interpreting the *Technical Rules*. In the case of a conflict between the Technical Bulletins and the *Technical Rules*, the rules govern the requirements.

1.3 OBJECTIVES

The objectives of drinking water source protection are to identify areas where municipal drinking water sources may be at risk from quantity or quality threats, to assess the level of risk, and to put in place measures to eliminate or manage the threats. To do so, the flow systems in the study area associated with drinking water sources (both groundwater and surface water) must be understood. These systems are described in this Assessment Report in support of the delineated vulnerable areas around wells and intakes. Vulnerability of these sources must also be assessed to determine the threat presented by the activities that occur on the land. Both vulnerability and threat are presented in this Assessment Report.

The Source Protection Plan (SPP) for the Credit Valley Source Protection Authority (CVSPA) was developed by the CTC SPC and outlines measures, by way of policies, to protect against the current and future potential risks associated with municipal drinking water sources. Drinking water threats that are identified as potentially significant must be addressed by policies in the SPP. The SPC has the option to include policies to address, some or all potentially, low and moderate drinking water threats, or to address these at a later time.

1.4 SOURCE PROTECTION PROCESS AND STUDY PARTNERS

The source protection planning process is directed by a group of 21 local stakeholders and a Chair, referred to in regulation as the CTC SPC. The committee members (https://www.ctcswp.ca/who-we-are/ctc-source-protection-committee/) are municipal, business, and public representatives who act as a Board of Directors, and are responsible for the development of the terms of reference (work plan), assessment report (technical assessment to identify vulnerable areas and drinking water threats), and the SPP (policies and identification of who is responsible for implementation) for each of the three source protection areas within the CTC Source Protection Region. The CTC SPC Chair is appointed by the MOECC. Members of the CTC SPC are appointed by the lead source protection authority for the CTC.

For the purposes of assessment report and SPP development, the CVSPA partners with the Central Lake Ontario Source Protection Authority (CLOSPA) and the Toronto Region Source Protection Authority (TRSPA). A Memorandum of Agreement among the three partners source protection authorities sets out the responsibilities and operating arrangements. Under *Ontario Regulation 288/07* the TRSPA was assigned the lead responsibility in the CTC Source Protection Region and was responsible to support and ensure that the SPC fulfills its responsibilities to prepare the terms of reference, assessment reports and a

Appendix C documents the methodologies employed in the development of understanding the water supply and demand across the CVSPA. **Appendix D** provides additional documentation of the vulnerable areas assessment process including the MOECC Technical Bulletins on vulnerability. **Appendix E** includes the MOECC Technical Bulletin for the threat assessment process as well as output from the South Georgian Bay Lake Simcoe conformance exercise on the enumeration of threats, summaries of the municipal threat assessment reports prepared for municipalities and a summary of the work completed for the Lake Ontario Collaborative for the assessment of threats to Lake Ontario drinking water intakes.

1.6.2 Source Protection Plan

The Source Protection Plan (SPP) is a document that sets out the policies to protect source water against drinking water threats identified in the CTC Assessment Reports. The SPP identifies how drinking water threats will be reduced, eliminated, or monitored, who is responsible for taking action, timelines, and how progress will be measured.

Different regulatory bodies or agencies or persons are identified by the CTC SPC to implement different policies within the SPP. For example, if the policy requires changing a provincially issued approval, a provincial ministry would be identified as the responsible party to take the necessary steps to implement the policy. Municipalities would be responsible for implementation if the SPP policy requires new zoning by-laws, or amendments to the Official Plans.

The SPC must develop policies in its SPP to address the significant drinking water quality and quantity threats identified in this Assessment Report. The Source Protection Committee may choose to develop policies in the SPP that addresses the moderate and low level threats identified in this Assessment Report.

Implementation actions will be mandatory for significant drinking water threat policies. If the SPP includes policies for low or moderate drinking water threats, the responsible party is to "have regard" for the policy in making decisions.

The SPP must include polices to require annual reporting by implementing bodies to the lead Source Protection Authority on actions taken to implement significant threat policies. The lead authority is responsible for preparing and submitting a public annual report to the Minister of the Environment and Climate Change, summarizing implementation of the policies developed under the SPP.

1.7 CONSULTATION

Consultation has been integral to the development of this Assessment Report **(Table 1.1).** Prior to any technical work being incorporated into this Report, the public has been given the opportunity to comment and provide feedback on new or revised technical material. Consultation periods have lasted for a minimum duration of 30 days.

Table 1.1: Public Consultation Record

Version of Assessment Report	Timeline	Focus of Public Consultation
Draft Proposed Assessment Report (Version 0.1)	2010, 2011	Technical content – Watershed Characterization, Water Budget, Vulnerability Assessment, and Threats Enumeration Chapters
Draft Proposed Updated Assessment Report (Version 0.3)	Spring 2012	Region of Halton (Acton, Georgetown) – Water Quality Vulnerability Assessment
Updated Approved Assessment Report (Version 0.4)	Fall 2013	Water Quantity Risk Assessment and Tier 3 Water Budget (Halton Hills)
Approved Amended Assessment Report (Version 2.0)	Fall 2018	Region of Peel (Inglewood) – Water Quality Vulnerability Assessment
Approved Amended Assessment Report (Version 3.0)	Summer 2019	Region of Peel (Alton) – Water Quality Vulnerability Assessment
Approved Amended Assessment Report (Version 54.0)	Summer 2023	Region of Peel (Caledon Village) – Water Quality Vulnerability Assessment

Note: The Credit Valley Assessment Report was approved by the Minister of the Environment, Conservation and Parks in January 2012 (with knowledge that additional technical work would be required) (Version 0.2) and then again in July 2015 (Version 1.0).

In 2009, construction began to enlarge the plant's capacity to 500 million litres to ensure an adequate supply of safe drinking water to an increasing population. The upgrades to the plant include installation of modern, state of the art, membrane filtration and an ultraviolet (UV) light treatment system to inactivate pathogens and control taste and odours that are sometimes found in our water supply.

The resulting water quality at Arthur P. Kennedy and Lorne Park WTPs meets the ODWS criteria and is suitable for human consumption.

2.3.2 Municipal Groundwater Systems

Groundwater-based municipal water systems provide about 11% of CVSPA's drinking water supply, and service communities in the middle and northern zones of the CVSPA **(Figure 2.6)**. There are nine systems, comprising 4~~4~~3 active wells, providing drinking water to residents in the towns of Orangeville, Mono, Erin, Halton Hills, and Caledon. In addition, there are two other systems that are not currently operational.

An overview of the municipal service boundaries of water systems servicing residents in the CVSPA is shown in **Table 2.6**. Information pertaining to each water system and associated monitoring infrastructure is shown below, and also at a more local level in **Chapter 4**.

Table 2.6 shows the maximum annual abstraction rates for each system. This data reflects the maximum allowable abstraction per the Permit to Take Water (PTTW) issued by the MOECC. Average monthly and annual pump rates for each system are reported in **Appendix B 1.4**. Monthly rates reflect average daily pumping rates, and show seasonal variation in demand, while average annual rates report average daily pumping rates for the year.

Table 2.6: Municipal Groundwater Systems Serving the Population of the CVSPA

Drinking Water System Name & System Type	Drinking Water System MOECC Ref No.	Municipality (Town/ Township)	Number of Wells	Max. Annual Pump Rate (m^3/day)	Population Served*
Orangeville Well Supply, Type I	220003252	Orangeville	12	17,175	26,875
Island lake Supply, Type I			2	2,786	
Coles Subdivision, Type I	220008523	Mono	2 (alternates)	655	822
Cardinal Wood Subdivision, Type 1			3	3,142	888
Amaranth Pullen Well - Type I	designated	Amaranth	1-off-line	Never pumped	
Bel-Erin Subdivision, Type I	260003006	Erin	2 -off-line	Off since 2002	
Town of Erin, Type I	220000013	Erin	2	4,943	2,500
Town of Hillsburgh, Type I	220007285	Erin	2	1,637	810
Acton Well Supply, Type I	220001673	Halton Hills	5	8,355	9,779
Georgetown Well Supply, Type I	220001655	Halton Hills	7	44,513	39,373
Alton Well Supply Type I Caledon Village, Type I	220004000	Caledon	2 ~~2~~3	1,046 ~~5,237~~6,546	1,544 2,914
Cheltenham, Type I	260002590	Caledon	2	1,469	816
Inglewood, Type 1	220004037	Caledon	2	2,590	1,223

* Based on 2010 numbers reported by municipalities, and thus may not correlate exactly with census population data for the SPA, which was calculated using census data from 2006.

Municipal Residential Groundwater Systems

Town of Orangeville – Orangeville Water System

The municipal system consists of twelve supply wells, two grade-level water storage reservoirs, one elevated water storage reservoir, and 112 km of water main. Three of the wells are located outside of its municipal boundary – one within the Township of Amaranth and two in the Town of Caledon. Average daily municipal demand stands at approximately 8,600 m^3/d.

The town has a monitoring network comprising of over 60 sentry wells (wells used for monitoring water levels and water quality within WHPAs) and conducts an intensive monitoring program in compliance with PTTW requirements and for the general management of the groundwater resources.

Since January 2008, enhanced water treatment facilities have been implemented at nine of the wells. Liquid sodium hypochlorite is used for disinfection at the other three wells. Liquid sodium silicate is also used at two wells for iron sequestration. The resulting water quality at Orangeville water system meets

The Region also has a monitoring network comprised of at least 60 sentry wells and conducts an intensive monitoring program for their wells. The Acton and Georgetown water systems service average day demand of about 3,170 and 10,240 m^3/d (Region of Halton, 2009), respectively.

At Acton, all wells use ultraviolet (UV) light for primary disinfection with chlorine for secondary disinfection. Fluoride is added to the water from all three sources. The Prospect Park facility is equipped with greensand filters for the removal of manganese and iron from the water. Water from the three sources is pumped to the Churchill Reservoir, and then flows into the distribution system.

At Georgetown, the following treatment is implemented:

- Cedarvale – greensand filters for the removal of manganese and iron from the water, fluoridisation and disinfection using UV light;
- Princess Anne – disinfection with chlorine, and fluoride is added; and
- Lindsay Court - disinfection with chlorine, and fluoride is added.

The resulting water quality at the Acton and Georgetown water systems meets the Ontario Drinking Water Standards (ODWS) criteria and is suitable for human consumption.

Town of Caledon - Caledon Village – Alton Drinking Water System, Cheltenham & Inglewood Drinking Water Systems

The Town of Caledon is comprised of the Villages of Alton, Cheltenham, Inglewood, and Caledon Village. The Regional Municipality of Peel provides municipal water through three drinking water systems comprising nine wells.

In 2007, the Caledon Village – Alton Drinking Water Supplies were connected and began to operate as a single water system (one drinking water system number) in March 2008. It services an average day demand of about 1,007 m^3/d (Region of Peel, 2009).

The Alton municipal supply consists of two wells (Alton Wells 3 and 4A), which draw water from an unconfined sand and gravel aquifer. Alton Well 4A replaced previous supply well Alton Well 4, which operated until December 2015, and was subsequently decommissioned in May 2019. This well was installed in close proximity to the location of former Well 4.

Sodium hypochlorite is added for primary and secondary disinfection. Ultraviolet light is used to supplement the primary disinfection process. The treated water travels through a chlorine contact chamber before entering the water distribution system.

The Caledon Village supply comprises ~~two~~three wells (Wells 3, 3B, and 4) that draw supply from unconfined sand and ~~un~~semi-confined sand ~~and gravel~~ aquifers. Wells 3 and 4 have been in operation since the mid-1980's, while Well 3B was commissioned and added to the system in 2014. Sodium hypochlorite is added for primary and secondary disinfection, and ultraviolet light disinfection is included to meet the primary disinfection requirements. Additionally, greensand filters are used at Well 4 to remove iron.

The resulting water quality at the Caledon Village – Alton Drinking Water System meets the ODWS criteria and is suitable for human consumption.

The Inglewood Drinking Water System consists of two wells Inglewood Well 3 (ING-3) and Inglewood Well 4 (ING-4)). Both are relatively deep wells located in coarse-grained overburden sediments within a buried bedrock valley (Matrix, 2017). The system services an average daily demand of about 405 m^3/d.

4.1.4 Transport Pathways

Under the *CWA,* man-made structures such as improperly maintained or abandoned wells, aggregate pits, quarries, and storm water ponds may affect the natural vulnerability in a system and are termed "transport pathways." There are several such structures and features within the CVSPA that could increase the vulnerability of the various aquifers where they circumvent the natural protection that the overlying materials provide. There are private water wells that may be improperly maintained or left abandoned, quarries that may remove protective material, and horizontal structures, such as trunk sewers, that may provide a shorter pathway for potential contaminants to travel to drinking water sources.

While the *Technical Rules* provide a general framework for the assessment of transport pathways, they are not prescriptive on the methodology to be applied in the analyses. Earlier work was completed by various consultants employing differing assumptions, data sources, and methodologies.

To improve upon the consistency and standardization across the CTC SPR, a transport pathway adjustment study was undertaken by the Central Lake Ontario Source ProtectionConservation Authority and is documented The methodology followed to determine whether a vulnerability score increase is warranted due to transport pathways is described in more detail in **Appendix D4** of this Assessment Report. The *Technical Rules* indicate that a SPC may conclude that the data available may be insufficient or of too poor quality to justify an increase in vulnerability. Several datasets for pathway features were reviewed in an attempt to assess transport pathways within the CTC Source Protection Region, including the CVSPA jurisdiction. Only the data for pits and quarries were sufficient to adjust the vulnerability within the HVAs. This adjustment for pits and quarries was done consistently with the previous WHPAs vulnerability assessment.

While subsurface utilities, aggregate operations, and water wells were all considered, uncertainties associated with the water well database and the unknown depth of municipal linear infrastructure limited the analysis. The *Technical Rules* indicate that a SPC may conclude that the data available may be insufficient or of too poor quality to justify an increase in vulnerability. Given this, the adjustment studythat study recommended the consideration of pathways resulting only from aggregate pits and quarries for adjustments to vulnerability scores in WHPAs.

Over the last decade, the coverage and accuracy of the water well and borehole data, and of infrastructure databases have been improved significantly, primarily through work completed by the Oak Ridges Moraine Groundwater Program, municipalities, and other partner agencies. This has allowed for refinement in the location and depth of potential transport pathways on the landscape, as reflected in recent work completed in 2022 for municipalities within the CVSPA (Credit Valley Conservation, 2022).

As of 2023In early 2023, Conservation Ontario (CO) released a Transport Pathways Guidance Document (CO, 2023), to provide a standardized technical methodology with a recommended set of criteria for the completion of such studies in the future.

The CTC SPC recommends that additional data be collected on pathways to re-visit the vulnerability assessment in a future iteration of this Assessment Report. The conservatism built into the current assessment provides assurance that vulnerability of the aquifers is sufficient at this time. Pits and quarries as transport pathways resulted in a 0.34% change (increase) in the area identified as HVAs.

4.1.5 Uncertainty Assessment

Confidence with the AVI depends on the density of data, the accuracy and currency of the surface geology mapping, and interpretations and assumptions made in the development of three-dimensional models. Over the last decade, the Oak Ridges Groundwater Moraine Program (ORGMP) has made significant advances in its understanding of the hydrogeologic system, adding new high integrity data sources, refining existing data, and developing cutting edge tools and products. As well, there is a relatively high density of data for the area of the CTC watershed region compared to other source protection regions.

The delineation of the SGRA mapping was based on a complex surface water model linked to a complex, three-dimensional groundwater flow model, and both models were calibrated to the satisfaction of external peer reviewers.

Together, these factors result in a high level of confidence in the results of the groundwater vulnerability analyses for the CTC Region. Therefore, the level of uncertainty is considered to be low. The reader is cautioned, however, that there is always a certain level of uncertainty, particularly in studies involving the subsurface, which cannot be observed directly. These studies are also regional in nature; site-specific information should always be used where available to determine local vulnerability. Data (quality and quantity) and knowledge gaps are complex.

Additional details on uncertainty factors surrounding HVA and SGRA analyses are provided in **Appendix D2**. Specific drinking water threats associated with all HVAs must be identified. Activities that pose a threat to the source water in these zones are listed in the Provincial Tables of Circumstances (*Technical Rules, Tables 10, 11, 17 and 18*) and discussed in **Chapter 5** of this document.

~~**GUDI Well:** Groundwater Under the Direct Influence of Surface Water. The Drinking Water Systems Regulations (Ont. Reg. 170/03) under the *Safe Drinking Water Act, 2002* defines specific circumstances under which a groundwater supply is considered to be GUDI. These wells are more susceptible to contamination than non-GUDI wells because they can be affected by short-term water quality issues associated with surface water sources.~~

~~**Porosity:** The percent of open spaces or voids occurring between mineral grains or in fractures of bedrock. It is a measure of the potential volume of water that can be stored in the geologic material.~~

~~**Permeability:** The ability of a material to transmit a fluid, a measure of how quickly fluid will flow through the rock or sediment. This is determined by the size of open spaces and degree to which they are connected.~~

4.2 GROUNDWATER VULNERABILITY - WELLHEAD PROTECTION AREA (WHPA)

The groundwater-based municipal supplies in the CVSPA are currently delivered through nine active water systems which have a total of 467 wells, 434 of which are in active use.

A wellhead is the physical structure of the well above the ground. A wellhead protection area is the area that surrounds the well through which contaminants are reasonably likely to move toward or reach the well. The size of the area is determined by using a computer model that estimates the time it takes groundwater to travel within the aquifer to the well based on the rate the water is pumped out of the well, the type of geological materials around the well and the speed that groundwater travels. Pollutants from a variety of activities can seep into the ground and move toward a well. The following four WHPAs have been determined for each groundwater well listed in the *CVSPA Terms of Reference*:

- WHPA-A: the area within 100 m radius of the well - The area where the risk to the well is highest and the greatest care should be taken in handling any potential contaminant.

- WHPA-B: the area where groundwater is estimated to take up to 2 years to reach the well from within the aquifer. This second ring is important to protect from bacteria and viruses from human and animal waste as well as hazardous chemicals.
- WHPA-C: the area where groundwater is estimated to take up to 5 years to reach the well from within the aquifer. Although biological contaminants are less of a concern in the third ring, chemical pollutants remain a concern.
- WHPA-D: the area where groundwater is estimated to take up to 25 years to reach the well from within the aquifer. In this outer ring, the most persistent and hazardous pollutants remain a concern.

~~**Backward particle tracking analysis:** A modelling technique where water particles are released at the wellhead and tracked back to their point of origin. The times-of-travel for particles are assigned based on the location of the originating cell.~~

~~**Steady state:** To determine steady-state capture, every particle is traced back to the location it entered the groundwater system. This represents the complete capture of the well.~~

Two other WHPA (WHPA-E and WHPA-F) are delineated to include the area in and around the surface water body that is influencing a *GUDI well*. WHPA-E is delineated the same way as the IPZ-2 for a surface water intake (see **Section 4.9)** from the point of interaction between the aquifer and the surface water body. If the point of interaction is not known, the WHPA-E is delineated from the point of interaction between the aquifer and the surface water body that is nearest to the well. WHPA-F zones are only delineated where an issue has been confirmed for a GUDI well.

Mapping of WHPAs has been completed by consultants working for the respective municipalities and then peer reviewed by consultants under the direction of the CTC SPC. The WHPAs have been mapped for all of the following 46 municipal wells in the CVSPA watersheds:

WHPAs A to D were delineated per *Technical Rule 47 (1*) to *(4)* and *Technical Rule 48 (3)*, using three-dimensional flow modelling. This involved the creation of numerical models, as done for the Tier 2 water budget study (see **Chapter 3**). The modelling packages used for the analysis varied amongst the municipalities. Most groundwater consultants used three-dimensional MODular FLOW (MODFLOW) modelling system, while others used the Finite Element FLOW (FeFLOW) model.

WHPAs A-D for all wells in the CVSPA were delineated through a time of travel assessment, using *backward particle tracking* analysis. Forward particle tracking analysis was used to cross-check the WHPA delineation.

The WHPAs were delineated by pumping each well to *steady state* at rates determined to be the maximum future average annual groundwater demand that can be sustained by the wells. The rates were chosen through consultation with individual municipalities.

4.2.1 WHPA Vulnerability Assessment

In the municipal-sourced aquifers of CVSPA, vulnerability analyses were conducted by consultants, who applied the AVI, SWAT or ISI methodology listed in **Chapter 4.1**. Each method produces a numerical index representing the relative vulnerability of an aquifer to sources of contamination at or near the surface, and through a translation process, categorizes vulnerability as high, medium, or low, as shown on **Table 4.2.** Since many municipal wells are located in deeper aquifers, they are less vulnerable because of the protection provided by overlying materials (aquifers and aquitards).

Vulnerability scoring of the WHPAs B – D is obtained by overlaying each delineated WHPA on the groundwater vulnerability developed for the area around the related wellhead. The groundwater vulnerability is then translated into a vulnerability score (per *Technical Rules 82-85*), and this score provides the ultimate expression of the groundwater vulnerability in the WHPAs. All WHPA-A areas are given a vulnerability score of 10, without considering the geological setting.

The scoring within the WHPAs B–D, based upon the vulnerability using the AVI, ISI and SWAT methodologies, respectively, are presented in **Table 4.2**.

Table 4.2: Range of Vulnerability Scores in WHPAs A–D

WHPA Zone	Vulnerability Score by SWAT Methodology			Vulnerability Score by ISI & AVI Methodology		
	Low (>25 yrs)	Medium (5-25 yrs)	High (< 5 yrs)	Low (>80)	Medium (30-80)	High (<30)
Zone A	10	10	10	10	10	10
Zone B	6	8	10	6	8	10
Zone C	2	6	8	4	6	8
Zone D	2	4	6	2	4	6

Vulnerability within WHPA-Es is also assessed using the *Technical Rules* relevant to the IPZ-2. The range of applicable vulnerability scores within the WHPA-E is shown in **Table 4.3.**

Table 4.3: Summary of Vulnerability Scores within WHPA-E

WHPA-E	Range of Vulnerability Scores
Inland Lakes	5.6, 6.3, 6.4, 7.0, 7.2, 8.0, 8.1, 9.0
Inland Rivers & Streams	6.3, 7.0, 7.2, 8.0, 8.1, 9.0

4.2.2 Transport Pathways

The *Technical Rules* allow for adjustments to the vulnerability scoring to account for the presence of transport pathways. Examples of potential pathways include subsurface utilities, aggregate operations, and clusters of private water wells. Adjustments to the vulnerability to account for the presence of transport pathways were considered.

Subsurface Utilities

Information on the location of sewers and other subsurface utilities was reviewed. Where a utility was thought to represent a possibility of becoming a transport pathway the vulnerability rating of the underlying aquifer was increased to the next category.

Aggregate Operations

Information on the locations, and status of aggregate operations was reviewed. Aggregate operations may create or enhance a transport pathway to groundwater increasing the vulnerability of the aquifer.

Water Wells

Domestic water wells are the most common transport pathway in rural areas. Improper construction can potentially introduce a cumulative impact to drinking water sources especially when the casing deteriorates. If the well is no longer in use.~~, i~~Improper abandonment also provides a pathway for a contaminant to impact a drinking water source.

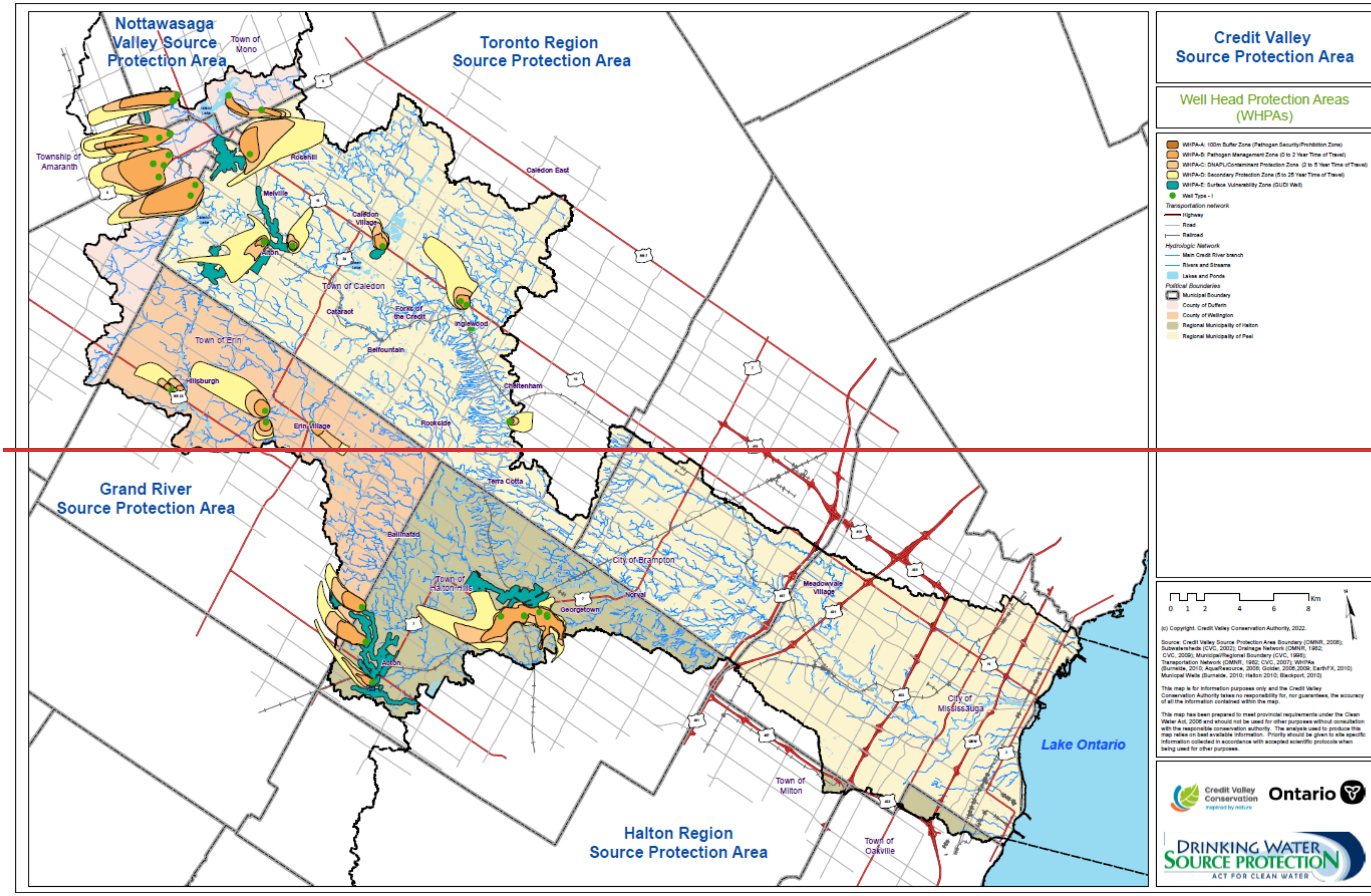
~~A~~ Prior review of the MOECC WWIS was undertaken to identify older~~, unused~~ domestic wells and boreholes. However, as many ~~are~~ records were decades old, it ~~is~~ was not known if their status had~~s~~ been updated in the ~~WWIS since being drilled~~database, if they still existed, or if they were~~have been~~ decommissioned. ~~Also, the *Technical Rules* do not provide guidance on how they should be considered. As a result, different consultants have applied a wide range of assumptions and standards in their assessments. Based on this~~Given the ~~analysis~~uncertainty, the CTC SPC opted against the inclusion of such pathways since the unreliability of the database ~~used and~~ implied that staff would not be able ~~the high uncertainty associated with the analyses were too high~~ to defend the location and status of the water wells ~~work~~ in a reasonable manner.

Over the last decade~~ however~~, the coverage and accuracy of the water well and borehole database has~~ve~~ been significantly improved~~ significantly~~, primarily through work completed by the Oak Ridges Moraine Groundwater Program and its partner agencies. This has allowed for refinement in the location and depth of potential transport pathways on the landscape and is reflected in the ~~more~~ recent work completed for municipalities within the CVSPA (Credit Valley Conservation, 2022).

~~An analysis was applied to assess the effect of clusters of water wells as transport pathways. The methodology that was applied is described in **Appendix D4**.~~

Specific drinking water threats associated with large quantities of contaminants within all WHPAs must be identified. These analyses are done where the vulnerability score is 6 or higher for groundwater (WHPAs A to D) and 4.4 or higher for surface water (and WHPAs E). Activities that may pose a potential threat to the source water in these zones are listed in the Provincial Tables of Circumstances (*Technical Rules, Nov. 2009, Tables 10, 11, 17 and 18*) and discussed in **Chapter 5** of this document.

WHPAs for municipal wells in the CVSPA are shown in **Figure 4.4.**


Credit Valley Source Protection Area
Well Head Protection Areas (WHPAs)
WHPA-A: 100m Buffer Zone (Pathogen Security/Prohibition Zone)
WHPA-B: Pathogen Management Zone (0 to 2 Year Time of Travel)
WHPA-C: DNAPL/Contaminant Protection Zone (2 to 5 Year Time of Travel)
WHPA-D: Secondary Protection Zone (5 to 25 Year Time of Travel)
WHPA-E: Surface Vulnerability Zone (GUDI Well)
Well Type - I
Transportation network
Highway
Road
Railroad
Hydrologic Network
Main Credit River branch
Rivers and Streams
Lakes and Ponds
Political Boundaries
Municipal Boundary
County of Dufferin
County of Wellington
Regional Municipality of Halton
Regional Municipality of Peel
Nottawasaga Valley Source Protection Area
Toronto Region Source Protection Area
Grand River Source Protection Area
Halton Region Source Protection Area
Lake Ontario
Town of Mono
Township of Amaranth
Caledon East
Town of Caledon
Town of Erin
Town of Halton Hills
City of Brampton
City of Mississauga
Town of Milton
Town of Oakville
Georgetown
Acton
Erin Village
Hillsburgh
Cataract
Belfountain
Inglewood
Cheltenham
Terra Cotta
Ballinafad
Norval
Meadowvale Village
Melville
Alton
Caledon Village
Rockside
Forks of the Credit
(c) Copyright, Credit Valley Conservation Authority, 2022.
Credit Valley Conservation
Ontario
DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER

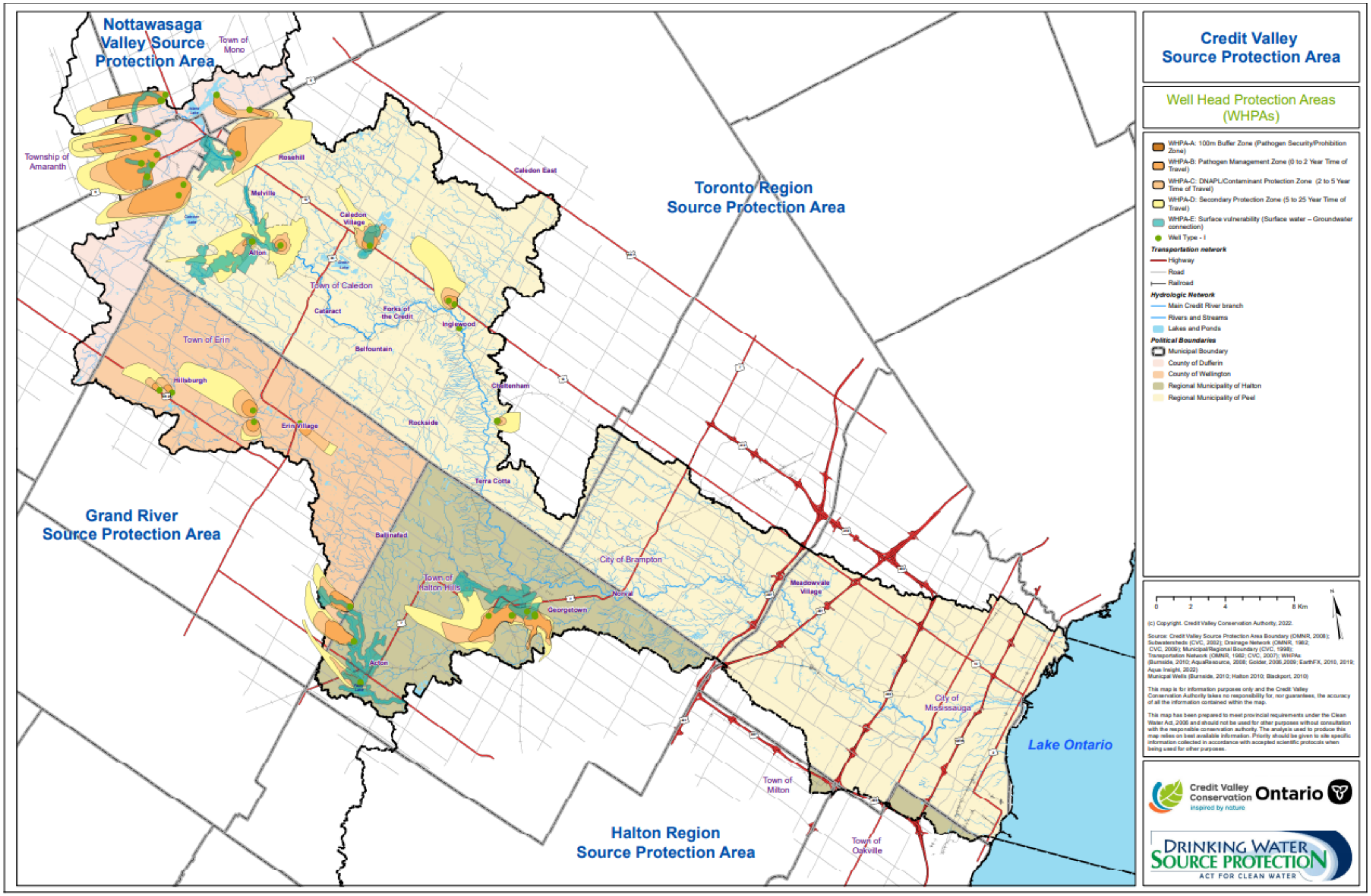


Figure 4.4: Wellhead Protection Areas (WHPAs)

4.8 REGIONAL MUNICIPALITY OF PEEL - TOWN OF CALEDON

The Town of Caledon is situated in the north eastern portion of the Credit River Watershed. Municipal water is supplied to the town by the Region of Peel through the following drinking water systems:

- Caledon Village – Alton (Alton Wells 3 and 4A; Caledon Village Wells 3, 3B and 4);
- Inglewood – Wells 3 and 4; and
- Cheltenham – Wells 1 and 2.

4.8.1 Geological Setting

Alton Wells 3 and 4A are in an unconfined sand and gravel aquifer, 15-25 metres below ground.

Caledon Village Well 4 (61-75 metres below ground surface) is screened within a semi-confined sand aquifer that underlies the modern-day Credit River associated within a in a confined gravel aquifer (buried bedrock valley (northwest to southeast trending and perpendicular to the Credit River). infill) that forms part of a melt water channel running between Orangeville and Halton Hills, while Caledon Village Well 3 and 3B (29-35 and -26-32 metres below ground surface, respectively) isare screened within an unconfined sand aquifer associated with the Caledon Meltwater Channel (southwest to northwest trending glacial meltwater channel lying west of the Niagara Escarpment brow). coarse-grained in an unconfined and semi-confined sand, and gravel aquifer associated with the Caledon Meltwater Channel.

The Village of Inglewood obtains its water from two municipal wells; Inglewood Wells 3 and 4. These wells are completed to depths of approximately 50-55 metres below ground in a buried valley aquifer.

Cheltenham Wells 1 and 2 are located in the Peel Plain, 45 to 55 metres below ground within a bedrock valley underlying the meltwater channel and the Halton Till deposits.

A summary of well depths and associated geological setting of Caledon's municipal wellfields is presented in **Appendix D2 (Table D-28)**.

4.8.2 Data Sources and Study Methodology

The WHPA delineations and vulnerability assessment are detailed in the following foundation reports:

- Region of Peel WHPA Study for Municipal Residential Groundwater Systems located within the Credit River Watershed, AquaResource Inc., 2007;
- Wellhead Protection Area Delineations and Vulnerability Assessments for Alton 1-2 Standy by Wells, Cheltenham PW1/PW2 Amended PTTW, and Caledon Village Proposed Well 5 (TW2-05), AquaResources Inc., April 2008;
- Surface to Aquifer and Surface to Well Advection Time Wellhead Protection Areas in Credit Valley Watershed Caledon Village Wells 3 and 4, Inglewood Wells 1/2 and 3, Cheltenham PW1/ PW2, & Alton Wells 3 and 4, AquaResources Inc., April 2008;
- Transport Pathways Update to Vulnerability, Region of Peel, R.J. Burnside and Associates Ltd., May 2010;
- Inglewood Wellhead Protection Area Delineation Wells ING3 and ING4, Peel Region, Matrix Solutions Inc., February 2017;

- Vulnerability Assessment and Vulnerability Scoring for Inglewood Well 4, Region of Peel, Matrix Solutions Inc., August 2018; ~~and~~
- Phase 1: Alton Wellhead Protection Area Delineation, Peel Water Resources Management Model, Region of Peel, Earthfx and GeoKamp Ltd., June 2019; and
- Source Protection Updates for the Communities of Palgrave, Caledon East, and Caledon Village, Regional Municipality of Peel, Aqua Insight Inc., August 2022

Documents published prior to 2015 were subjected to extensive peer review by municipal staff, the CVC, and private consultants, prior to acceptance by the CTC SPC, and inclusion in this Assessment Report. Additionally, the base models upon which the studies are premised, were also subject to independent peer review during previous (to source protection) studies for which they were initially developed. These reports contain the foundation technical data and information upon which this Assessment Report has been based. Reports prepared after 2015 to amend the Assessment Report to reflect wells being brought on-line were, at a minimum, prepared and/or reviewed by a qualified professional.

WHPA delineation was undertaken through computer-based three-dimensional groundwater flow modelling, using the FEFLOW (Finite Element Flow - WASY, 2006) code. The model was built upon data from previous initiatives (regional water budget studies; WHI 2002; WHI 2004), and the Tier 2 Water Budget, Aqua Resource Inc. (2009) (**Chapter 3**).

In 2019, a regional-scale numerical model of groundwater and surface water flow systems in Peel Region was initiated. Given the breadth of a study of this magnitude, there are multiple phases. Phase 1 includes the development of a steady-state groundwater flow model for Peel Region. The first application of the model is to delineate wellhead protection areas (WHPA) for the Alton Wellfield, using the USGS MODFLOW-NWT code. Eventually, this model will allow the vulnerable areas around all municipal wellfields to be refined.

The most current groundwater flow model (Aqua Insight Inc., 2022) corresponds to the Peel Water Resources Management Model 2021; PWRMM21,~~)~~ which builds upon a previous groundwater flow model (PWRMM19) ~~earlier work~~ completed for Peel Region ~~: the PWRMM19 groundwater flow model which was developed by Earthfx~~ (Earthfx and GeoKamp, 2020). The model was developed for the entire Region of Peel and Credit River~~Valley Conservation~~ watershed ~~area~~ as part of a previous modelling study.

The PWRMM19 model was calibrated at the regional scale and represents ~~the~~ key aquifers and aquitards across Peel Region and the surrounding area. The model was created in MODFLOW using a uniform 90 m grid cell spacing. The PWRMM19 model was parsed for the communities of Palgrave, Caledon East, and Caledon Village and transferred from MODFLOW to FEFLOW in 2022 by Aqua Insight Inc. to locally refine the grid (mesh) around the municipal wells, and the hydrogeologic parameters such as the layers, hydraulic conductivity values and boundary conditions that represent lakes, rivers, and wetlands. ~~; t~~This revised and updated version of the model is termed herein as PWRMM21. The steady-state version of the PWRMM19 model ~~(Earthfx and GeoKamp, 2020)~~ formed the basis for this study and ~~it~~ was updated locally within five kilometers of the municipal water supply wells in Palgrave, Caledon East, and Caledon Village. The groundwater flow model consists of ten numerical model layers with each numerical model layer representing a specific hydrogeologic unit.

To ensure that the model represents conditions at the local scale required that the regional model grid used for the Tier 2 water budget study be refined within the vicinity of the wellheads. A finer grid cell size provides for a more accurate representation of aquifer and stream properties, as well as the drawdown simulation near pumping wells.

The model was calibrated to steady state using water level and baseflow measurements within the modelled area. Calibration was done by systematically adjusting the model parameters and boundary conditions to match field observations within an acceptable range.

A schematic of the flow modelling process is shown in **Figure 3.18**, and technical details on the model construction and calibration are summarized in **Appendix D2**, and described in detail in the foundation reports cited above.

4.8.3 WHPA A-D Delineation and Vulnerability Scoring

WHPAs B-D were delineated using backward and forward particle tracking analysis (**Chapter 4.3**), by pumping each well field to steady state, at its maximum permitted rate (**Appendix D2, Table D-30**). Rate selection considered future demand and growth projections for the Town of Caledon. The WHPAs for the Caledon Village-Alton, Inglewood and Cheltenham Drinking Water Systems are shown in

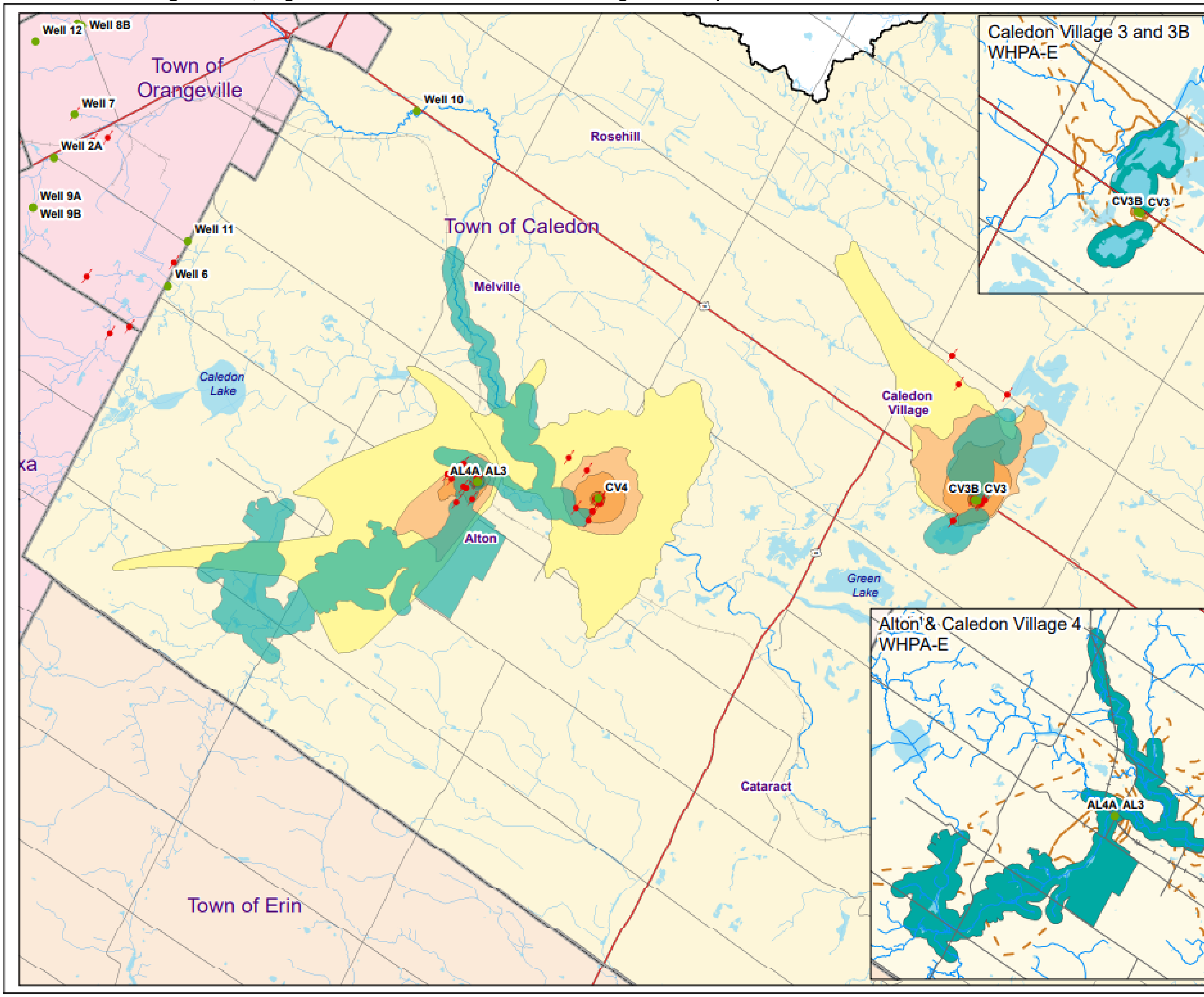
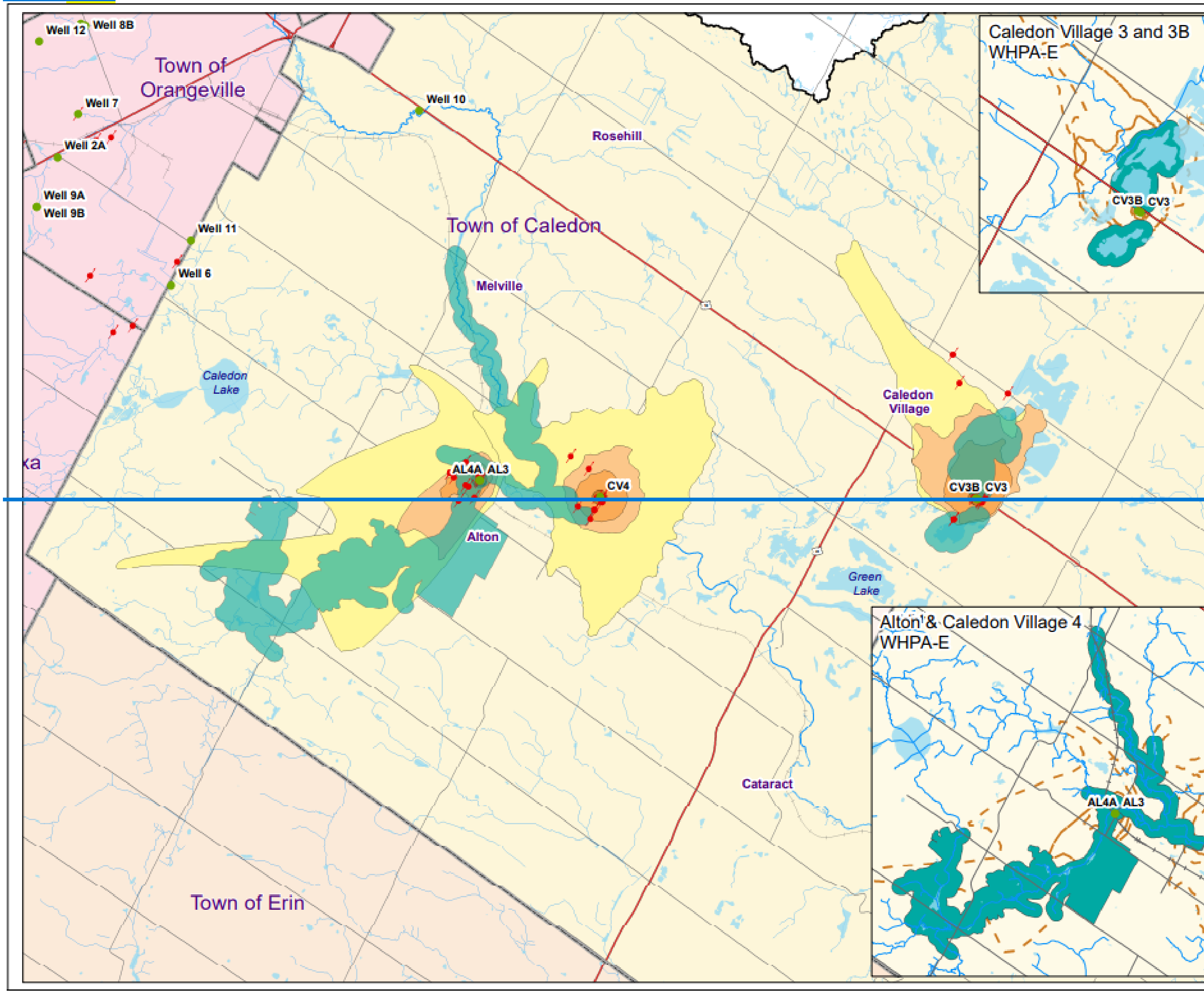


Figure 4.31


Well 12
Well 8B
Town of Orangeville
Well 7
Well 2A
Well 9A
Well 9B
Well 11
Well 6
Well 10
Rosehill
Town of Caledon
Melville
Caledon Lake
AL4A
AL3
CV4
Alton
Caledon Village
CV3B
CV3
Green Lake
Cataract
Town of Erin
Caledon Village 3 and 3B WHPA-E
Alton & Caledon Village 4 WHPA-E

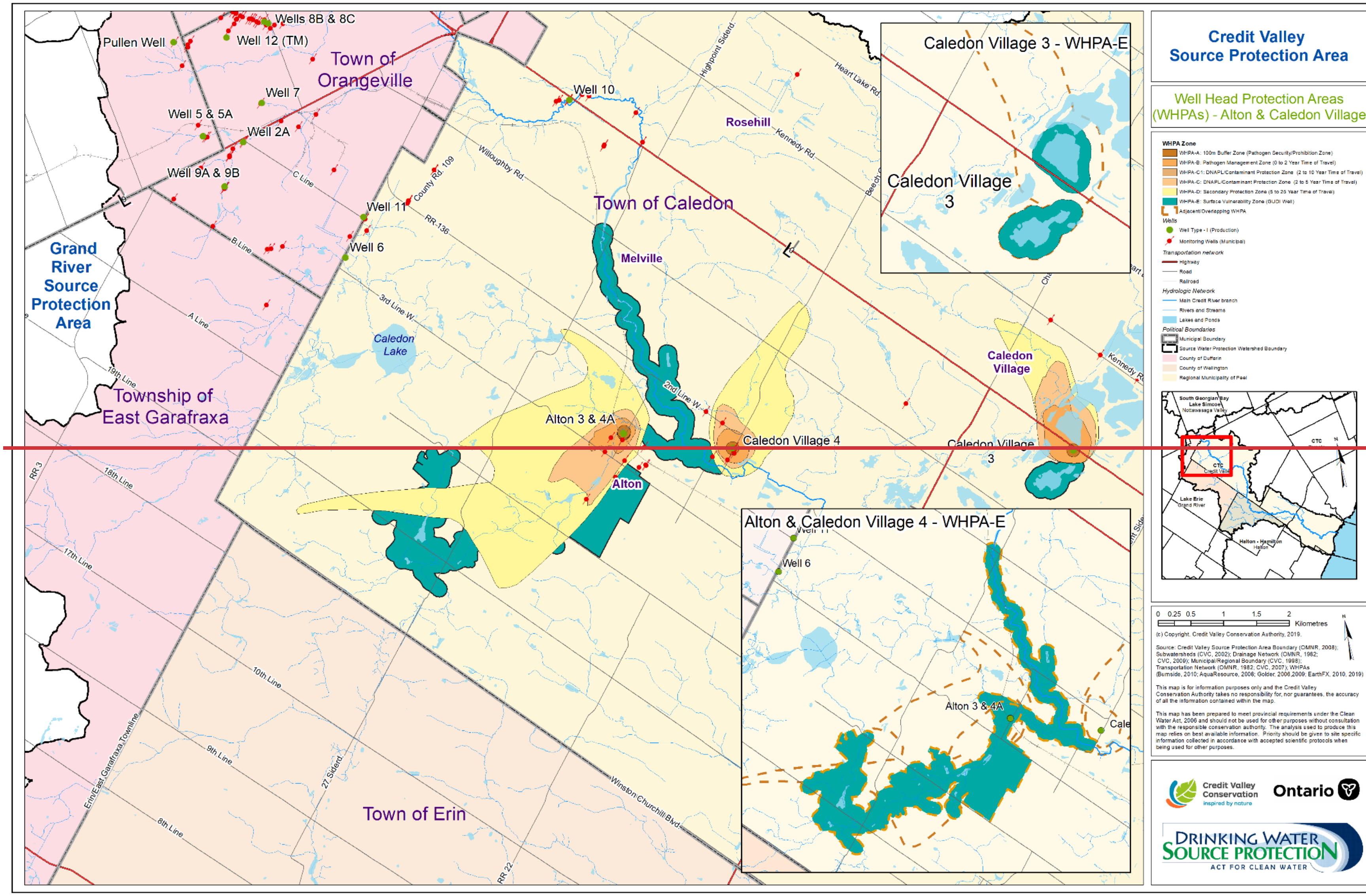
recharge rates, hydraulic conductivity values, and effective porosity values between the two models also led to increases in the WHPA size and shape.

Additional detail on the model development and refinements pertaining to Caledon Village Wells 3, 3B, and 4 is presented in **Appendix D2**, and in the foundation document:, Source Protection Updates for the Communities of Palgrave, Caledon East, and Caledon Village, Regional Municipality of Peel, Aqua Insight Inc., August 2022 cited above.

Groundwater vulnerability was assessed using the Surface to Well Advection Time (SWAT) method, which calculates travel time separately through the unsaturated zone (ground surface to the water table - UZAT), and the saturated zone (water table to the well screen - WWAT), then sums them. The SWAT methodology was selected since it is numerically consistent with the model used to delineate the WHPAs (i.e., it used the FEFLOW model for calculating travel times in the saturated zone).

Forward particle tracking was used to determine the saturated zone travel time (WWAT), while the unsaturated zone travel times (UZAT) were calculated independently within a GIS using modelled recharge rates, estimates of mobile water content and the thickness of the unsaturated zone.

The travel time through the unsaturated zone in the immediate vicinity of the wells are very low and assumed as zero. As such, the WWAT component of the SWAT was chosen to form the basis of the analysis. A letter from the Director, MOECC granting permission for this approach can be found in **Appendix D3**. The WWAT approach considers only the movement of water particles within the aquifer and assumes that the contaminant is introduced within this zone bypassing the unsaturated zone. It is therefore regarded as a conservative indicator of vulnerability.


Credit Valley
Source Protection Area
Well Head Protection Areas
(WHPAs) - Alton & Caledon Village
Caledon Village 3 - WHPA-E
Alton & Caledon Village 4 - WHPA-E
Town of Orangeville
Town of Caledon
Township of East Garafraxa
Town of Erin
Grand River Source Protection Area
Wells 8B & 8C
Well 12 (TM)
Pullen Well
Well 7
Well 5 & 5A
Well 2A
Well 9A & 9B
Well 10
Well 11
Well 6
Rosehill
Melville
Caledon Lake
Caledon Village
Alton 3 & 4A
Alton
Caledon Village 4
Caledon Village 3
Ontario
Credit Valley Conservation
Drinking Water Source Protection
ACT FOR CLEAN WATER

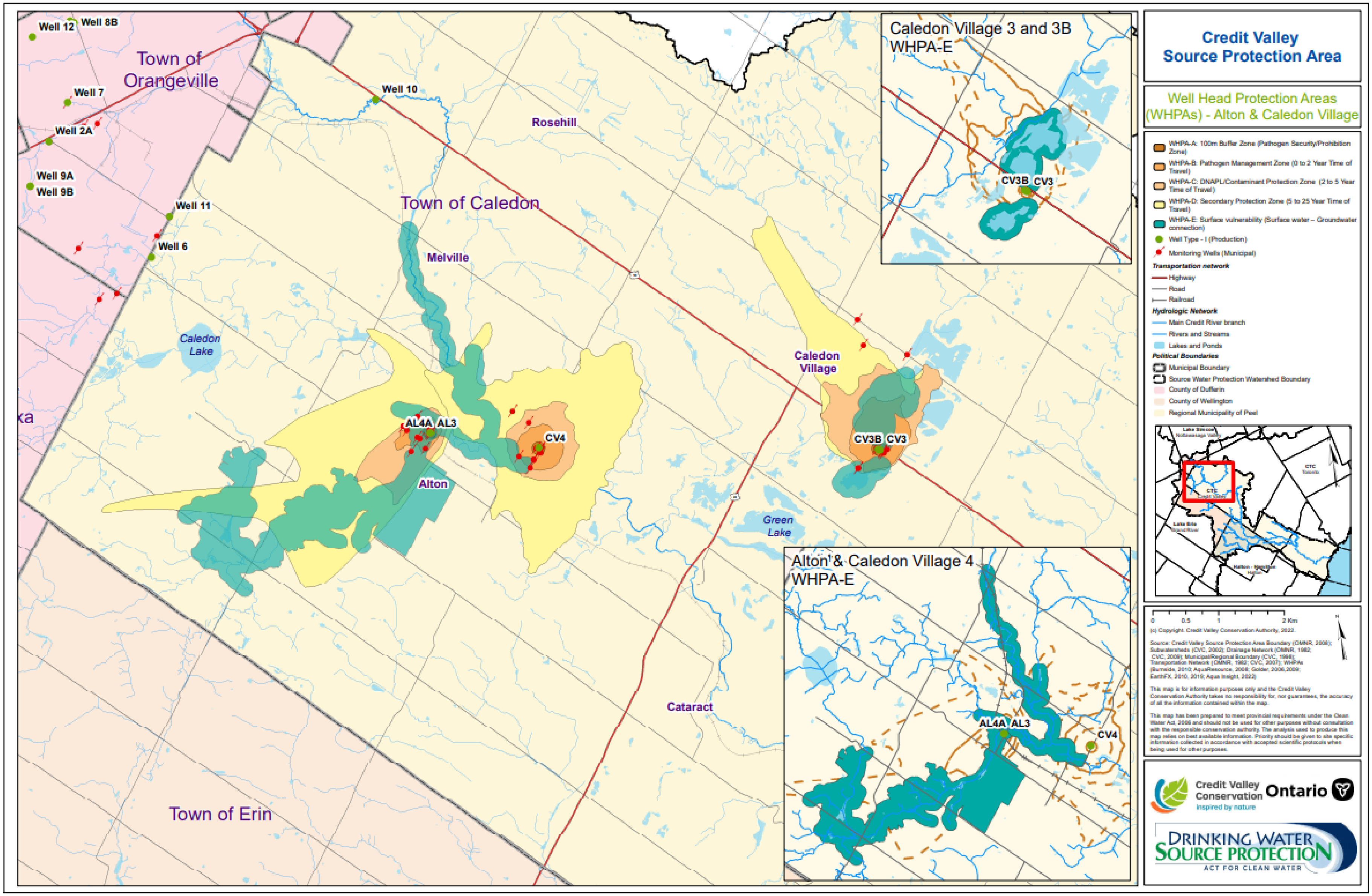

Credit Valley Source Protection Area
Well Head Protection Areas (WHPAs) - Alton & Caledon Village
WHPA-A: 100m Buffer Zone (Pathogen Security/Prohibition Zone)
WHPA-B: Pathogen Management Zone (0 to 2 Year Time of Travel)
WHPA-C: DNAPL/Contaminant Protection Zone (2 to 5 Year Time of Travel)
WHPA-D: Secondary Protection Zone (5 to 25 Year Time of Travel)
WHPA-E: Surface vulnerability (Surface water – Groundwater connection)
Well Type - I (Production)
Monitoring Wells (Municipal)
Transportation network
Highway
Road
Railroad
Hydrologic Network
Main Credit River branch
Rivers and Streams
Lakes and Ponds
Political Boundaries
Municipal Boundary
Source Water Protection Watershed Boundary
County of Dufferin
County of Wellington
Regional Municipality of Peel
Caledon Village 3 and 3B WHPA-E
Alton & Caledon Village 4 WHPA-E
Town of Orangeville
Town of Caledon
Town of Erin
Well 12
Well 8B
Well 7
Well 2A
Well 9A
Well 9B
Well 10
Well 11
Well 6
Rosehill
Melville
Caledon Lake
Caledon Village
Alton
AL4A
AL3
CV4
CV3B
CV3
Green Lake
Cataract
(c) Copyright: Credit Valley Conservation Authority, 2022.
Credit Valley Conservation inspired by nature
Ontario
Drinking Water Source Protection
Act for Clean Water

Figure 4.31: Wellhead Protection Areas (WHPAs) – Caledon Village – Alton

Groundwater vulnerability was assessed as being high, medium or low, in keeping with *Technical Rule* 38 (2). The groundwater vulnerability in the vicinity of the Caledon Village - Alton, Inglewood and Cheltenham WHPAs is shown on

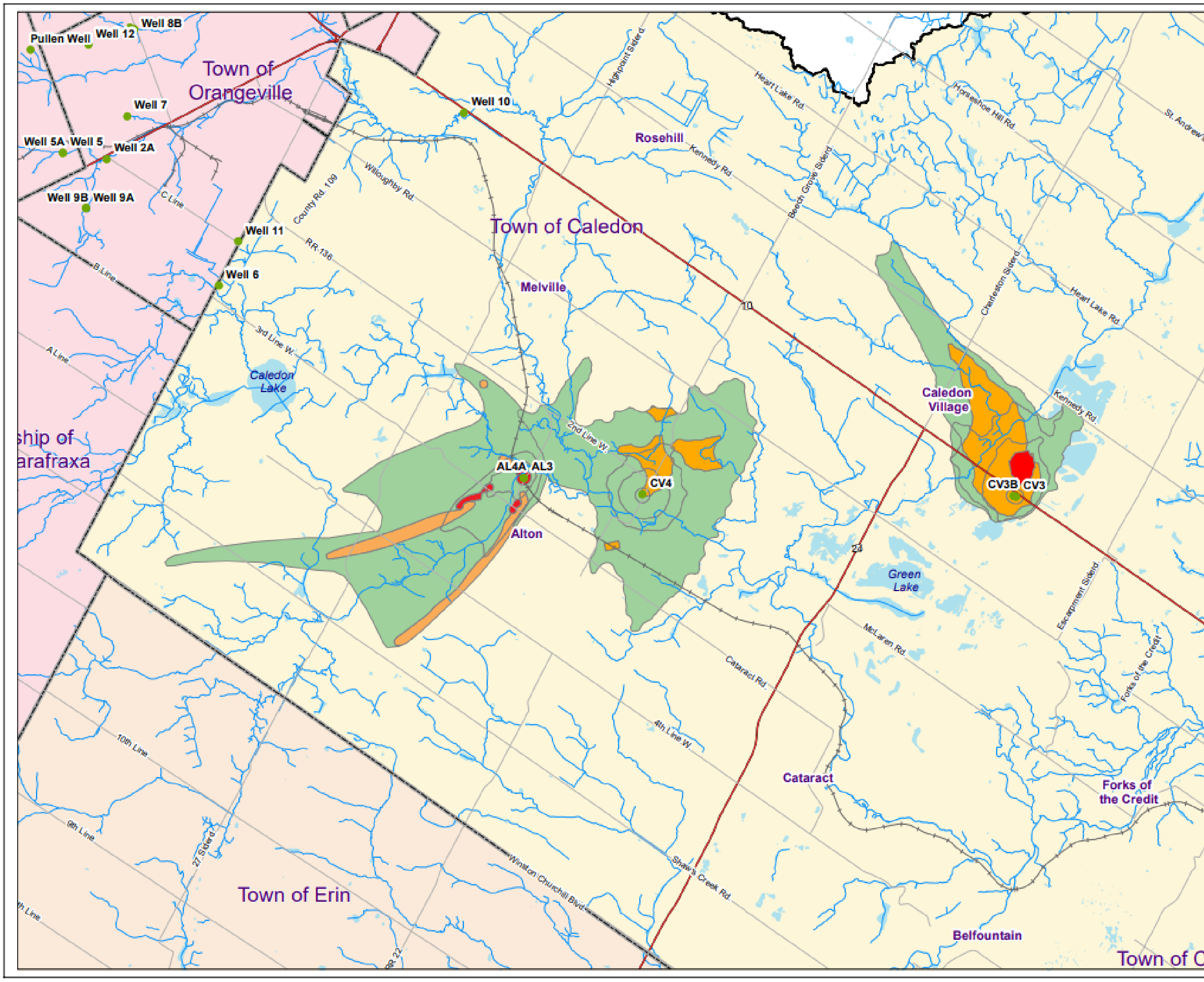
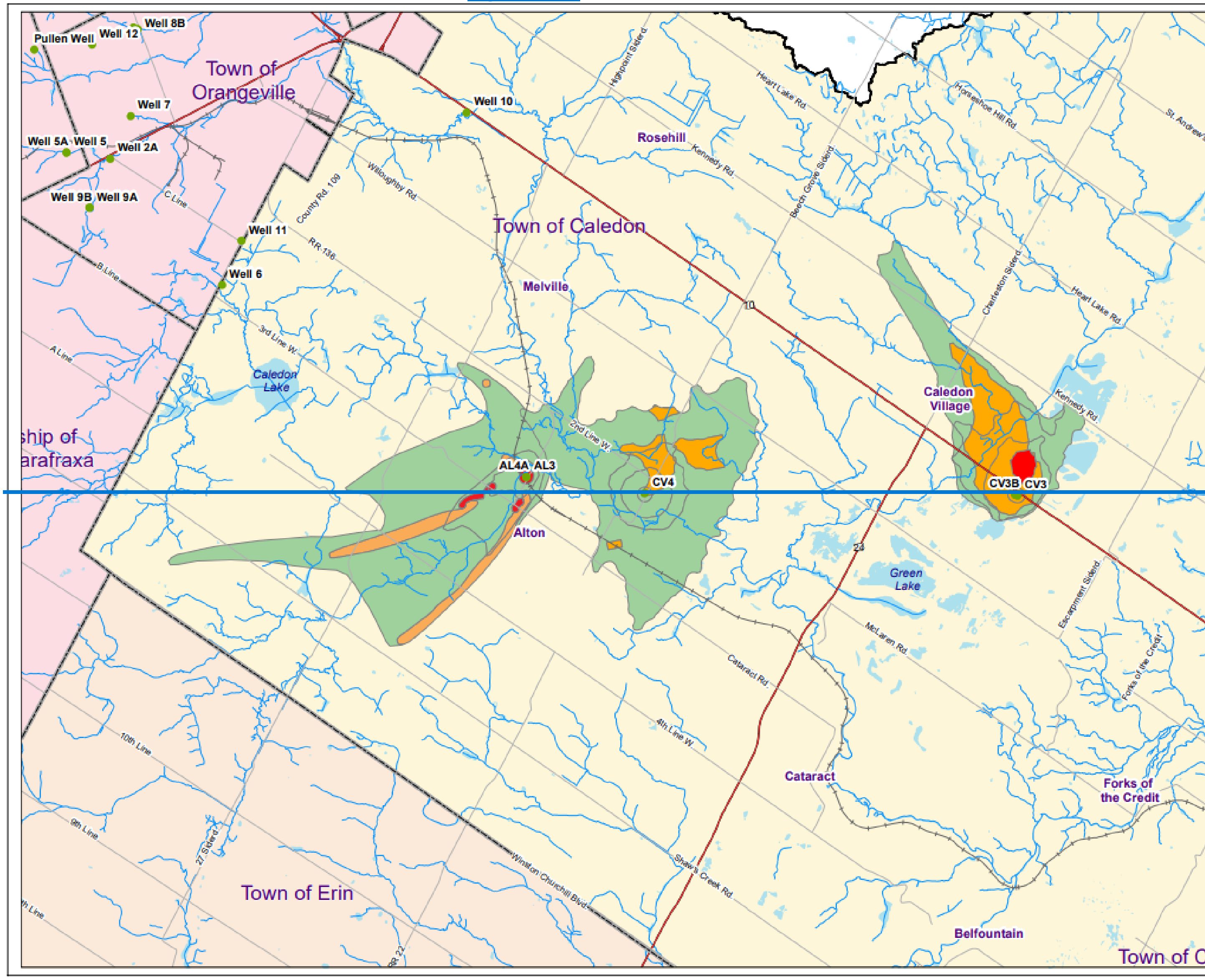


Figure 4.34


Town of Orangeville
Town of Caledon
Town of Erin
Pullen Well
Well 12
Well 8B
Well 7
Well 5A
Well 5
Well 2A
Well 9B
Well 9A
Well 10
Well 11
Well 6
Rosehill
Melville
Caledon Lake
Caledon Village
AL4A
AL3
CV4
CV3B
CV3
Alton
Green Lake
Cataract
Forks of the Credit
Belfountain

The vulnerability scores developed for the WHPAs are shown in

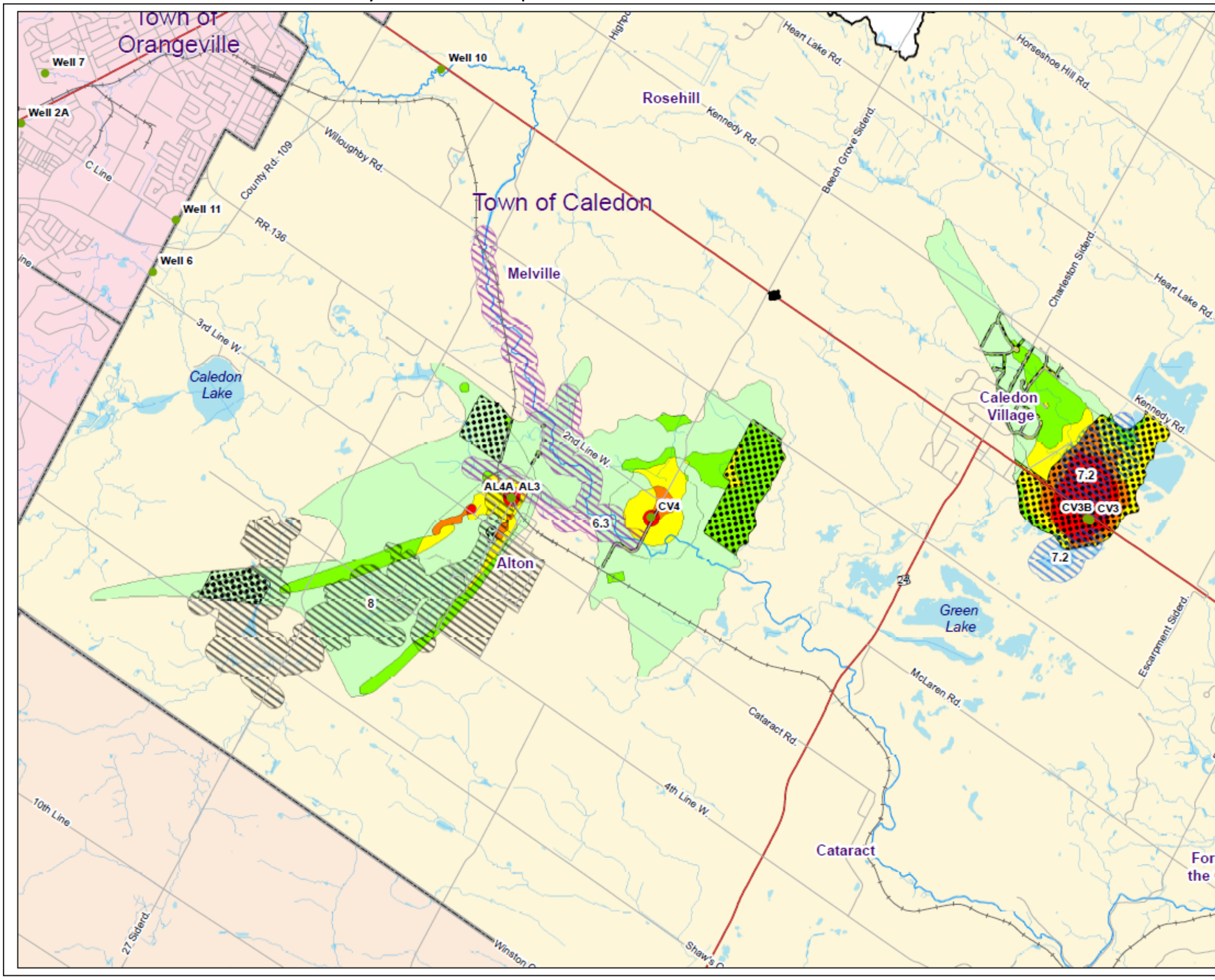


Figure 4.37

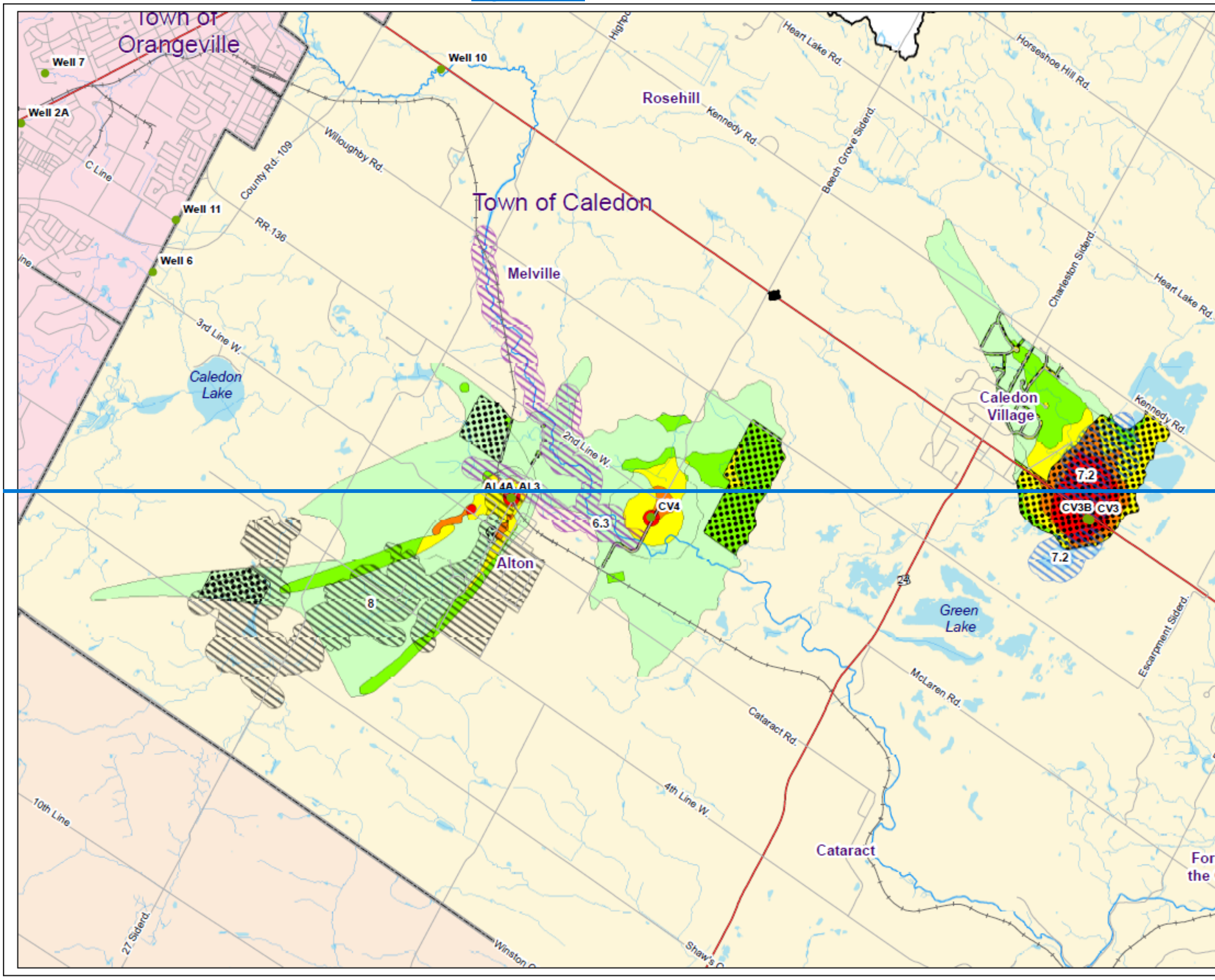
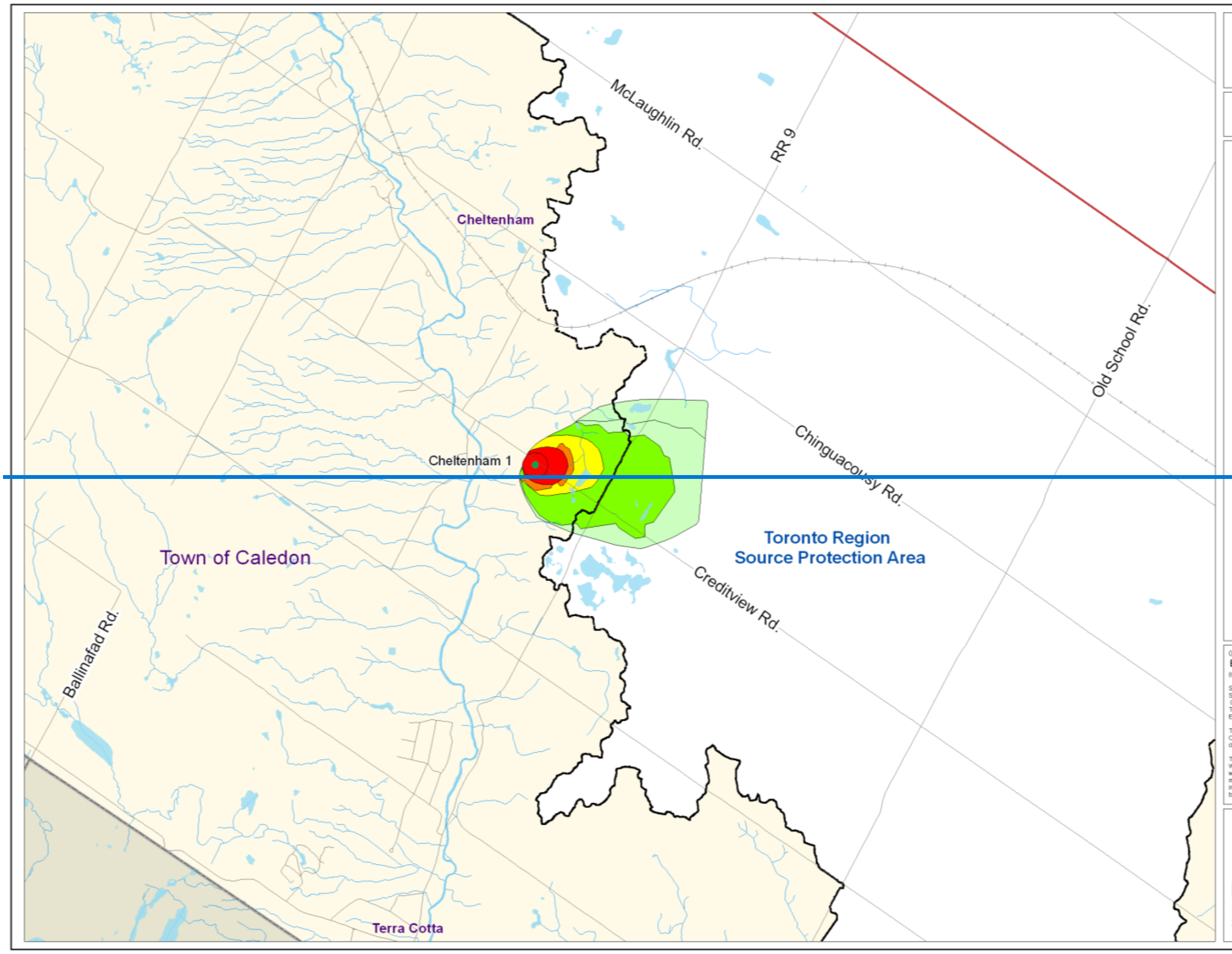

Town of Orangeville
Well 7
Well 2A
Well 10
Well 11
Well 6
Town of Caledon
Rosehill
Melville
Caledon Lake
Caledon Village
AL4A
AL3
CV4
6.3
Alton
8
7.2
CV3B
CV3
Green Lake
Cataract
Heart Lake Rd.
Horseshoe Hill Rd.
Kennedy Rd.
Beech Grove Siderd.
Willoughby Rd.
County Rd. 109
C Line
RR 136
3rd Line W.
2nd Line W.
Charleston Siderd.
McLaren Rd.
Cataract Rd.
4th Line W.
Escarpment Siderd.
10th Line
27 Siderd.

Figure 4.39



~~Figure 4.39~~Figure 4.39~~, and 4.40~~ respectively. The scoring for Caledon Village WHPAs reflect localized increases in vulnerability rating due to the identification of transport pathways, as described in Section 4.8.5.

4.8.4 WHPA-E Delineation and Vulnerability Scoring

~~The majority of~~Most WHPA-E delineations are described in the document "Transport Pathways Update to Vulnerability, Region of Peel" (R.J. Burnside and Associates Ltd., May 2010). For Alton Wells 3 and 4A, the WHPA-E delineation is outlined in Earthfx and GeoCamp (2019), with additional details provided in **Appendix D**. The methodology used to delineate the WHPA-E is consistent with the approach used for an IPZ-2 (surface water intake) delineation.

The WHPA-E delineation~~zones~~ associated with Caledon Village Wells 3 and 3B~~s CV3 and /3B wereas also~~were previously delineated by Burnside (2010) as the 120 m setback away from the closest aggregate ponds. Through the most recent study (Aqua Insight Inc., 20212), refinements to the model were made, as the aggregate ponds have changed shape since the last assessment was completed and new WHPA-E zones were delineated around the aggregate ponds located close to Wells 3 and/ 3B. The most recent Ontario Hydrologic Network "water bodies" polygon was downloaded from the Land Information Ontario and used alongside current air photos to define the aggregate ponds in the area, and these areas were buffered by 120 m to delineate the WHPA-E.

The WHPA-E zone for Caledon Village Well 4 was previously defined (Burnside 2010) using a HEC-RAS hydraulic model, which estimated stream velocities and calculated the two-hour travel time upstream of the groundwater well. Laterally, regulation limits defined by CVC and 120 m offsets from the channel were used. Re-delineation of the WHPA-E was not deemed necessary (nor completed) as the data and modelling previously used to delineate the WHPA-E were considered suitable. As such, the WHPA-E zone for Caledon Village Well 4 remains the same as those as previously delineatedcompleted previously by ((Burnside, 2010)., (2010).

A brief overview of the methodology used in delineating a WHPA-E is provided in **Chapter 4.2**. Since the exact point of interaction was not defined for any of the wells, the closest surface water body to the wells were used as the starting point for the delineation.

The WHPA-E zones associated with Wells CV3/3B were also previously delineated by Burnside (2010) as the 120 m setback away from the closest aggregate ponds. Through the most recent study (AquaInsight, 2021), refinements to the model were made, as the aggregate ponds have changed shape since the last assessment was completed and new WHPA-E zones were delineated around the aggregate ponds located close to Wells 3/3B. The most recent Ontario Hydrologic Network "water bodies" polygon was downloaded from the Land Information Ontario and used alongside current air photos to define the aggregate ponds in the area, and these areas were buffered by 120 m to delineate the WHPA-E

The WHPA-E zone for Caledon Village Well 4 was previously defined (Burnside 2010) using a HEC-RAS hydraulic model, which estimated stream velocities and calculate the two-hour travel time upstream of the groundwater well. Laterally, regulation limits defined by CVC and 120 m offsets from the channel were used. Re-delineation of the WHPAE was not deemed necessary (nor completed) as the data and modelling previously used to delineate the WHPA were considered suitable. As such the WHPA-E zone for Caledon Village Well 4 remains the same as those completed previously (Burnside, 2010).

Details on the calculation procedures, design assumptions and vulnerability scoring used in the derivation of the WHPA-Es are summarized in **Appendix D2**. The WHPA-Es delineatedfound atfor the

Caledon Village-Alton Drinking Water System areis shown in

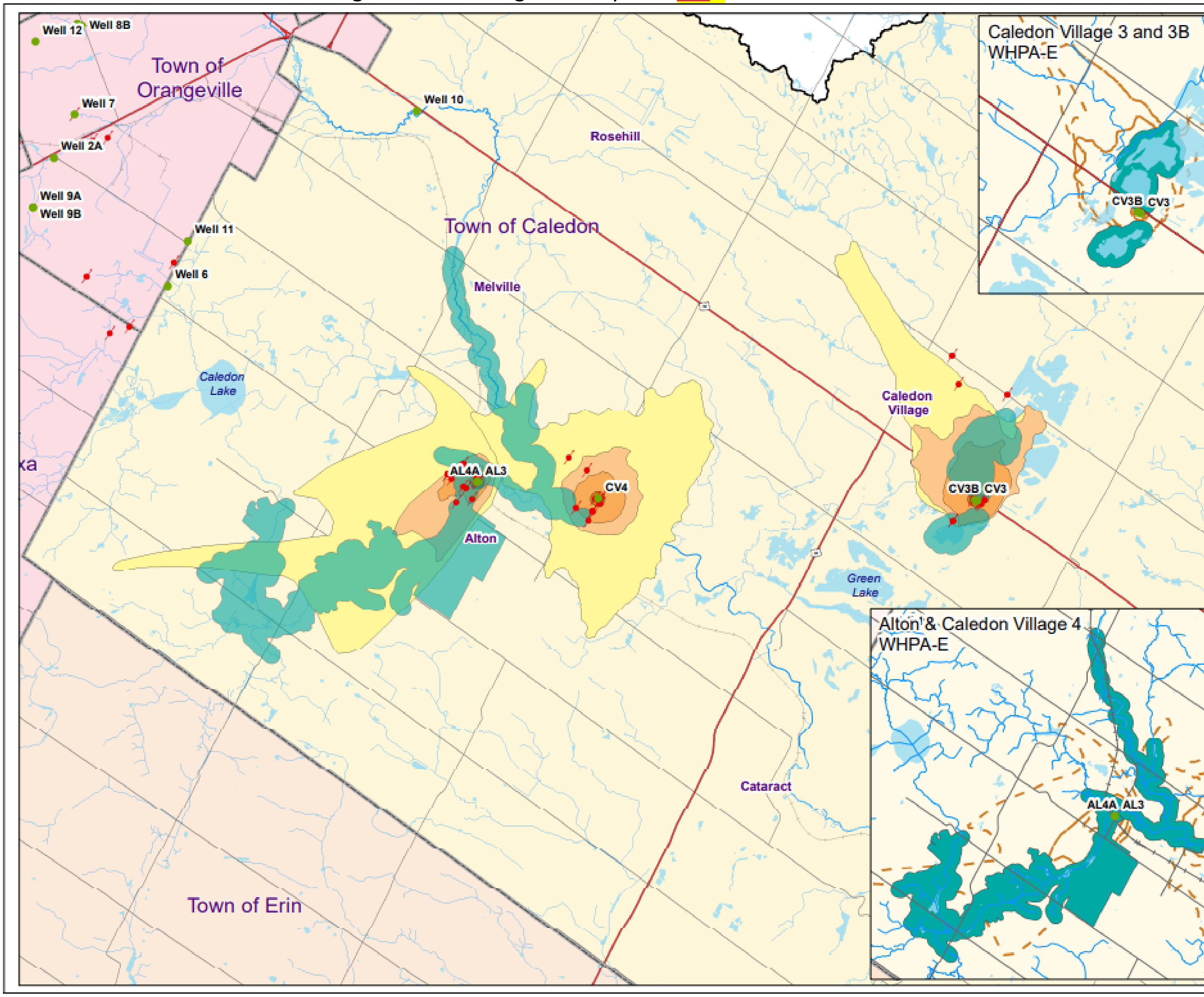
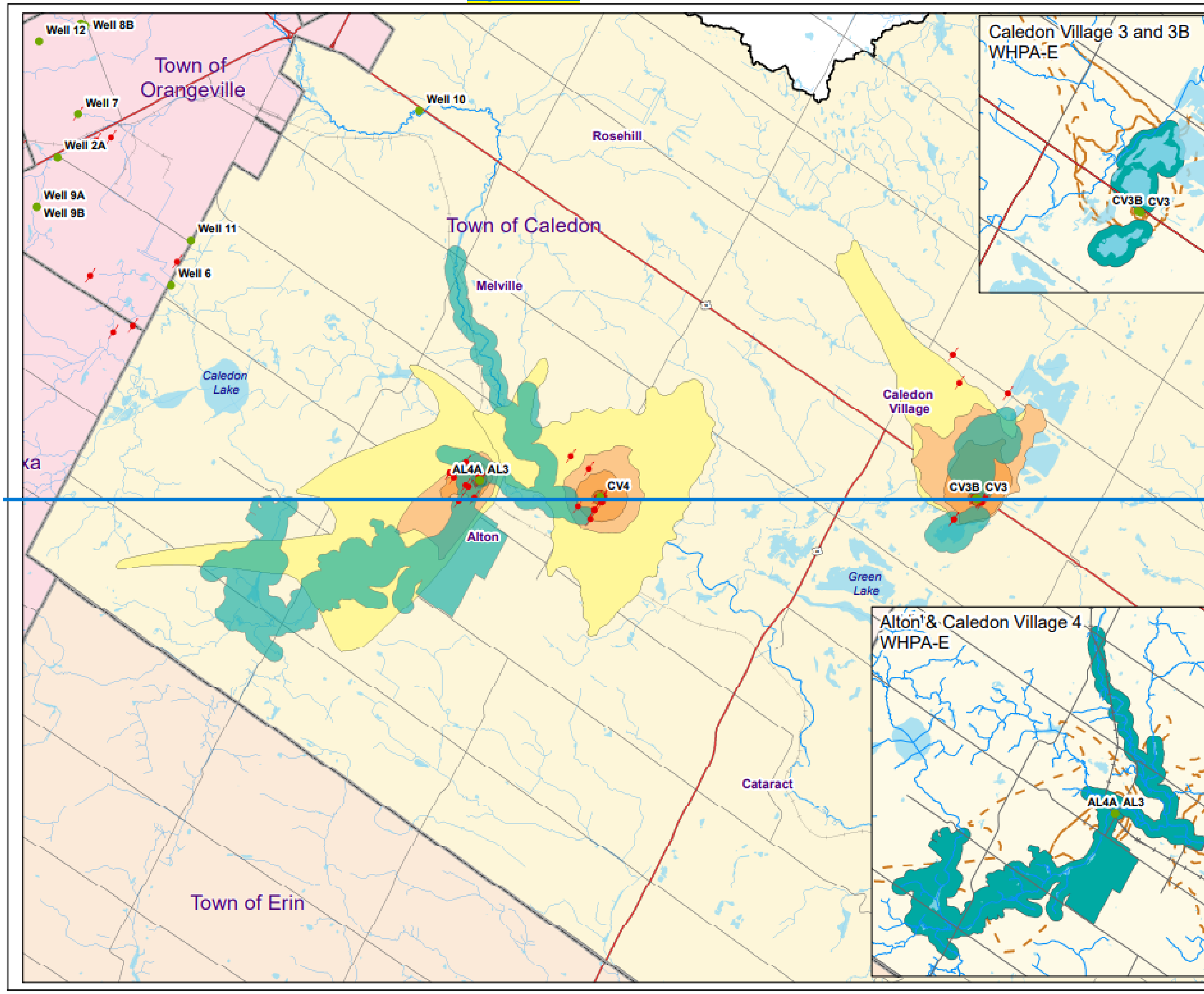


Figure 4.31


Well 12
Well 8B
Town of Orangeville
Well 7
Well 2A
Well 9A
Well 9B
Well 11
Well 6
Well 10
Rosehill
Town of Caledon
Melville
Caledon Lake
AL4A
AL3
CV4
Alton
Caledon Village
CV3B
CV3
Green Lake
Cataract
Town of Erin
Caledon Village 3 and 3B WHPA-E
Alton & Caledon Village 4 WHPA-E

~~Figure 4.31~~Figure 4.31. Vulnerability scores were assigned per the *Technical Rules* as the product of the area vulnerability factor and the source vulnerability factor. WHPA-E vulnerability scores are provided in

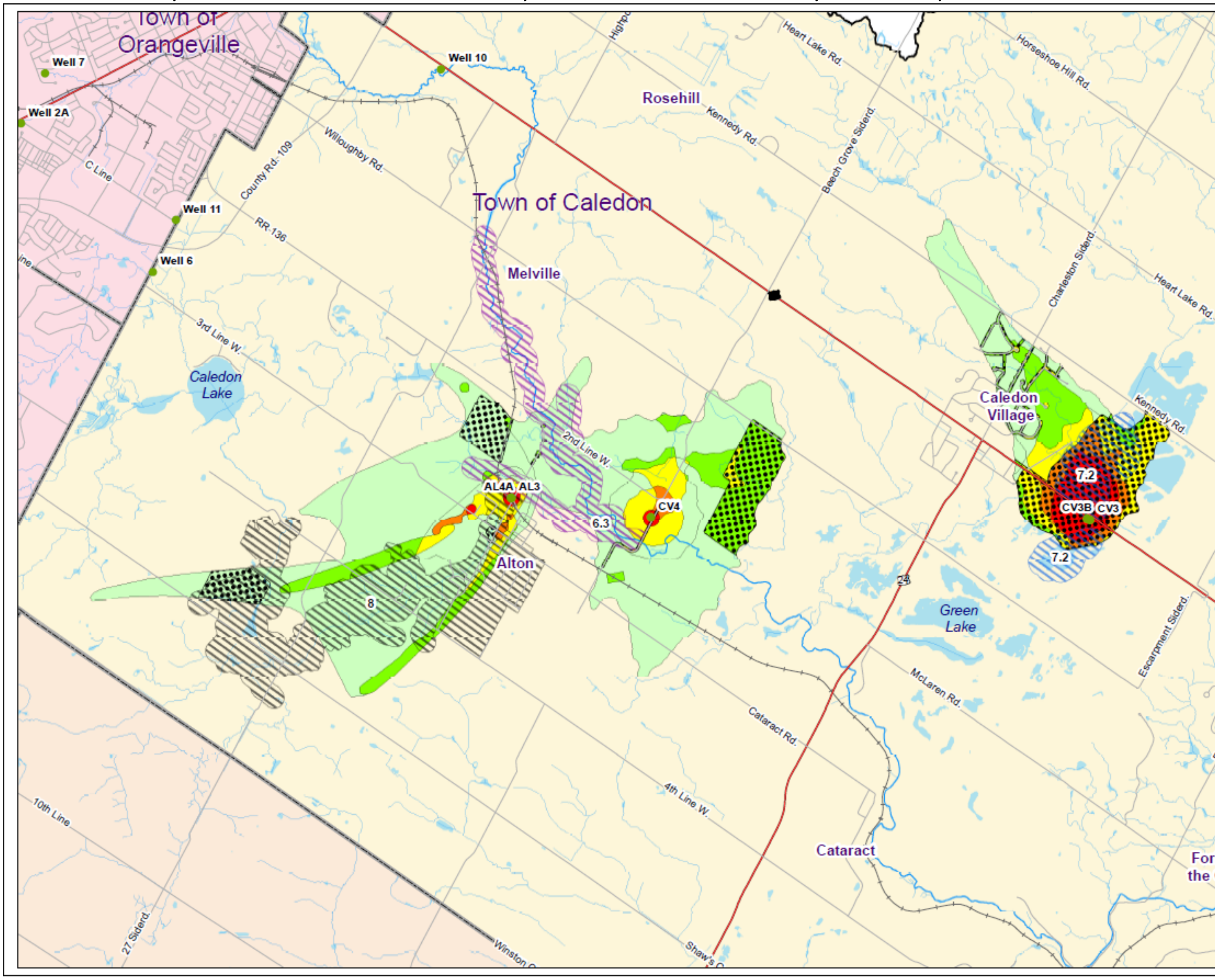
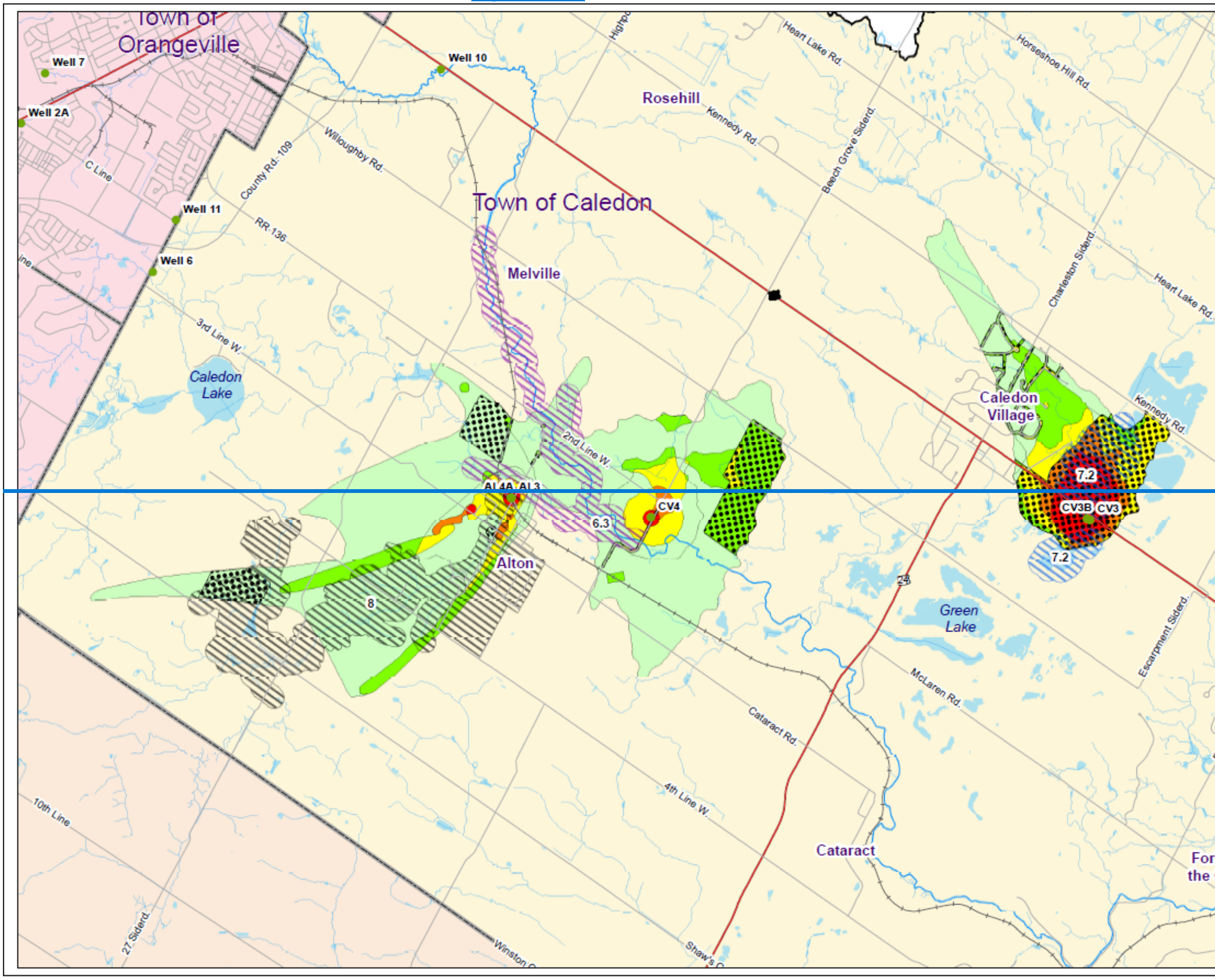


Figure 4.37



~~Figure 4.37Figure 4.37~~.

4.8.5 Transport Pathways

Transport pathways can be created through abandoned or improperly maintained wells, pits, and quarries that breach the confining layer~~,~~; underground infrastructures such as storm sewers and sanitary sewers, pipelines, road ditches, and other drainage systems. The presence of these features has the potential of increasing the vulnerability of an aquifer as they allow surficial sources of contamination to move quickly from ground surface to underlying aquifers. To account for these features, the *Technical Rules* allows for the vulnerability rating to be increased in areas where these pathways have been identified.

The assessment of transport pathways was completed in accordance with guidelines and criteria proposed by the CVC through research and technical work completed in recent years. Theis methodology applied to the analyses are described in the report "Credit Valley Source Protection Area Transport Pathway Assessment Technical Report", which was endorsed as guidance for municipalities, by the CTC SPC in December 2022. The report assesses various anthropogenic features on the landscape within WHPAs, and providesoffers recommendations on the criteria to be applied to the analysis of each feature.

In early 2023, Conservation Ontario (CO) released a Transport Pathways Guidance Document (CO, 2023), to provide a standardized technical methodology with a recommended set of criteria for the completion of such studies in the future.

The features studied within the context of this analysis are outlined in **Chapter 4.2**transport pathways that were identified through this study are discussed below. In keeping with recommendations of the *Technical Rules* and CVSPA's study, the vulnerability classification was increased from low to moderate or moderate to high for the identified pathways.

Per the recommendation of the study, clusters of six or more boreholes or wells drilled prior to 1990 which that are located within a 100 m radius of one another were identified. Municipal pumping, sentry, and monitoring wells were omitted from the cluster analysis. Where the bottom of three or more boreholes or wells in the cluster were within 3 m of the top of the municipal aquifer, each of the wells were buffered by 100 m and the vulnerability rating was increased.

boreholes or wells in the cluster were within three metres of the top of the municipal aquifer, each of the wells were buffered by 100 m and the vulnerability rating was increased.

Stormwater management ponds, aggregate extraction areas (active and inactive), and clusters of boreholes were also considered as potential transport pathways. Where a stormwater management pond or landfill (private or public) lie within athe WHPA of a municipal well that is screened in an unconfined or semi-confined aquifer, the stormwater management pond or landfill wasere buffered by 15 m and 30 m respectively, and the vulnerability rating was increased. The vulnerability rating was also increased in WHPAs wheren aggregate extraction properties were located within WHPAs by buffering the property by 30 m.

respectively, and the vulnerability rating was increased. The vulnerability rating was also increased on aggregate extraction properties located within WHPAs by buffering the property by 30 m.

Geothermal systems, sewage lagoons and pipelines were not identified in any of the WHPAs in this study.

Watermains, sanitary sewers and sewer mains have the potential to increase the vulnerability of shallow unconfined and semi-confined aquifers. The vulnerability classification was increased where the base of the infrastructure (assumed to be 5 m deep) lies in unconfined material within 3 m of the water table or top of the municipal aquifer. For linear features that met this depth criteria, the linear feature was buffered by 15 m and the vulnerability was increased by one rating category.

Gravel Pits/Aggregate OperationsLinear Infrastructure, including Sanitary, Storm and Watermains

The interpreted depth of a watermain (5 m) was found to intercept or come within 3 m of the water table in the WHPAs for Caledon Village Well 3 and /3B, and Caledon Village Well 4 so the vulnerability classification was increased in these areas.

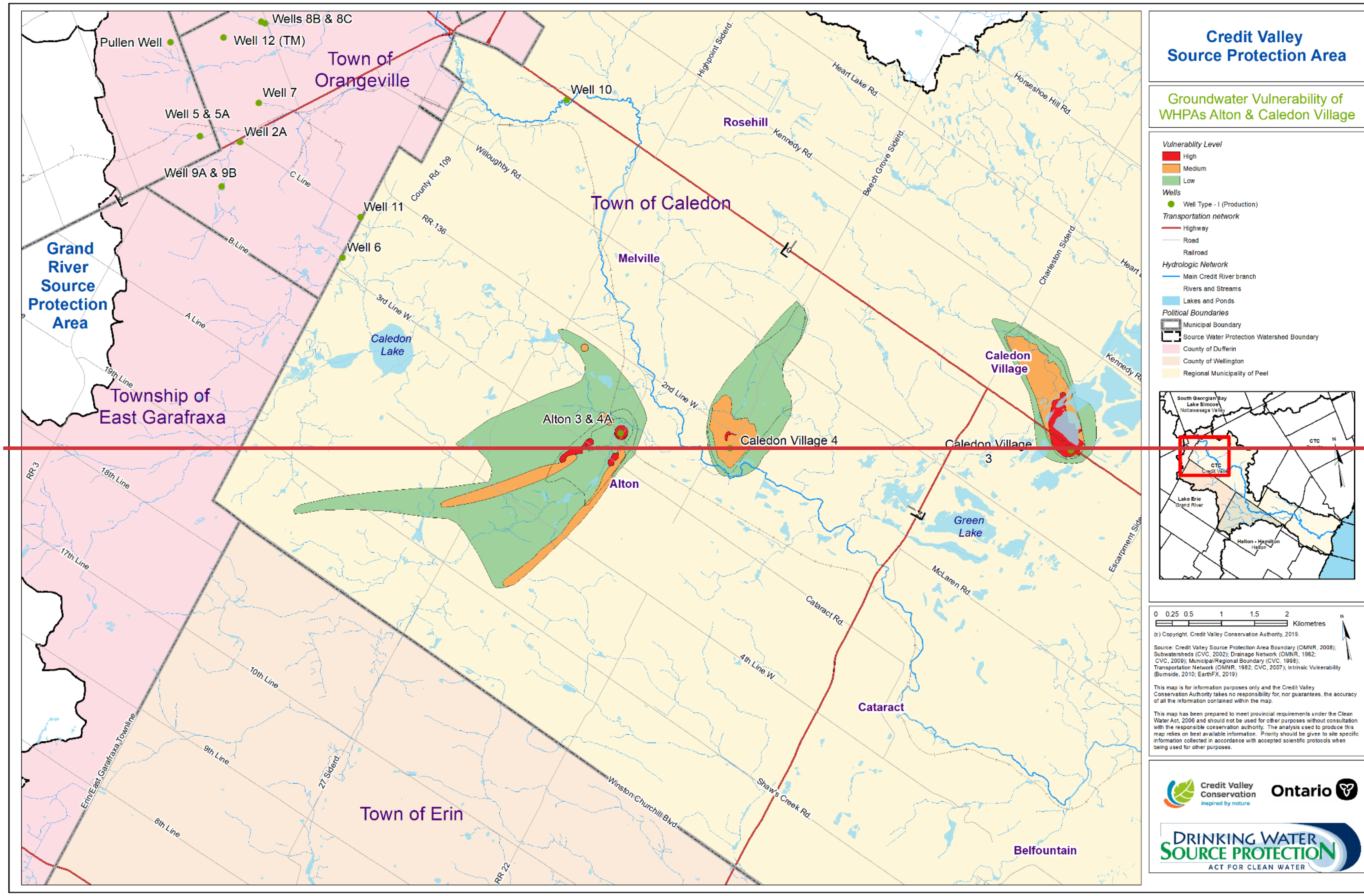
Aggregate Extraction Properties

There are several existing and closed aggregate extraction operations in the Caledon Village area that led to increased vulnerability ratings). These include the aggregate operations on the west and east sides of Highway 10 near Wells 3 and/ 3B, and two active operations in the eastern portion of the Well 4the CV4 WHPAs, southwest of Willoughby Road.

Closed Landfill located northwest of Caledon Village Well CV4

There is a former landfill mapped near Porterfield Road, north of Alton that lies within the WHPA-D offor Caledon Village Well CV4. The vulnerability- category was increased in this polygon.

The identified transport pathways, and their associated areas of influence (buffer zones) are presented in **Figure 4.40Figure 4.40Figure 4.40Figure 4.3740**.
vulnerability category rating was increased in this polygonAn aggregate operation was identified in the WHPAs associated with Caledon Village Well 3. This aggregate operation consists of several pits that extend below the water table, covering an area of approximately 20 hectares. Within the footprint of the sand and gravel pits, the entire overburden layer has been removed, resulting in the loss of the protective layers overlying the aquifer. Therefore, the vulnerability score in the area where the gravel pits are located was increased from medium to high for Caledon Village Well 3.


Credit Valley
Source Protection Area
Groundwater Vulnerability of
WHPAs Alton & Caledon Village
Vulnerablity Level
High
Medium
Low
Wells
Well Type - I (Production)
Transportation network
Highway
Road
Railroad
Hydrologic Network
Main Credit River branch
Rivers and Streams
Lakes and Ponds
Political Boundaries
Municipal Boundary
Source Water Protection Watershed Boundary
County of Dufferin
County of Wellington
Regional Municipality of Peel
Kilometres
Town of Orangeville
Town of Caledon
Township of East Garafraxa
Town of Erin
Grand River Source Protection Area
Pullen Well
Wells 8B & 8C
Well 12 (TM)
Well 7
Well 5 & 5A
Well 2A
Well 9A & 9B
Well 10
Well 11
Well 6
Alton 3 & 4A
Caledon Village 4
Caledon Village 3
Rosehill
Melville
Caledon Village
Caledon Lake
Alton
Green Lake
Cataract
Belfountain
Credit Valley Conservation
Ontario
Drinking Water Source Protection
ACT FOR CLEAN WATER

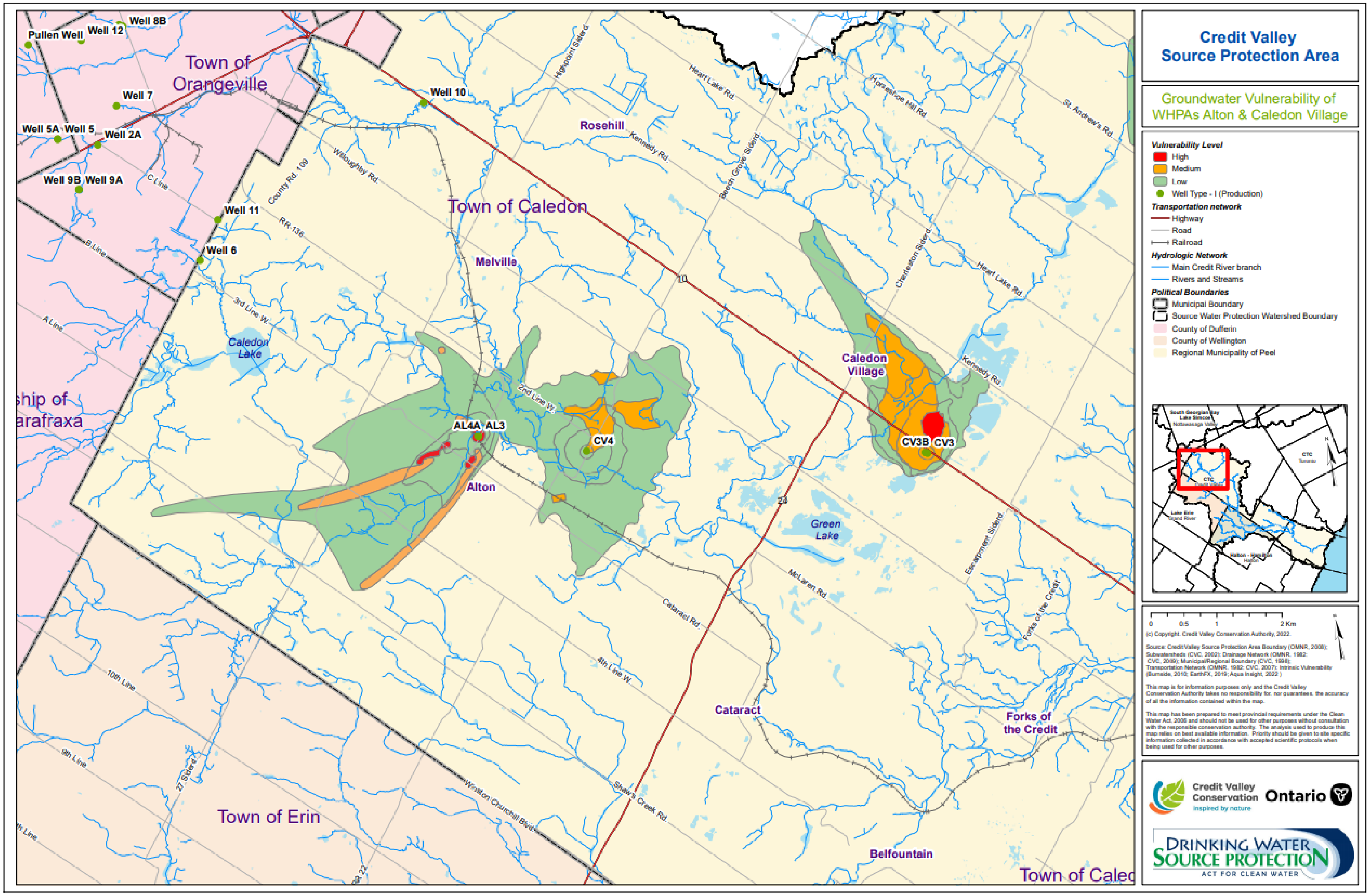
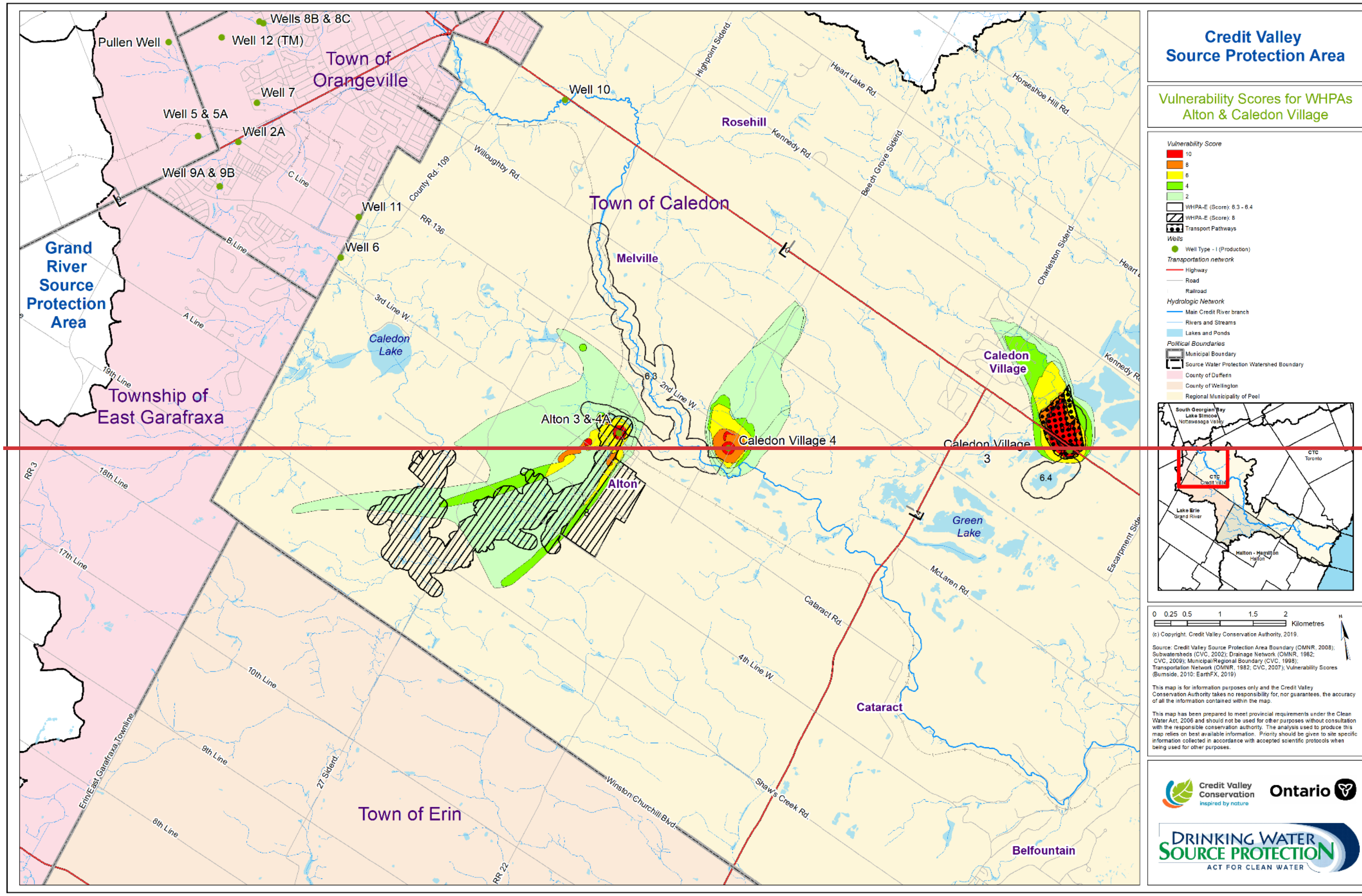
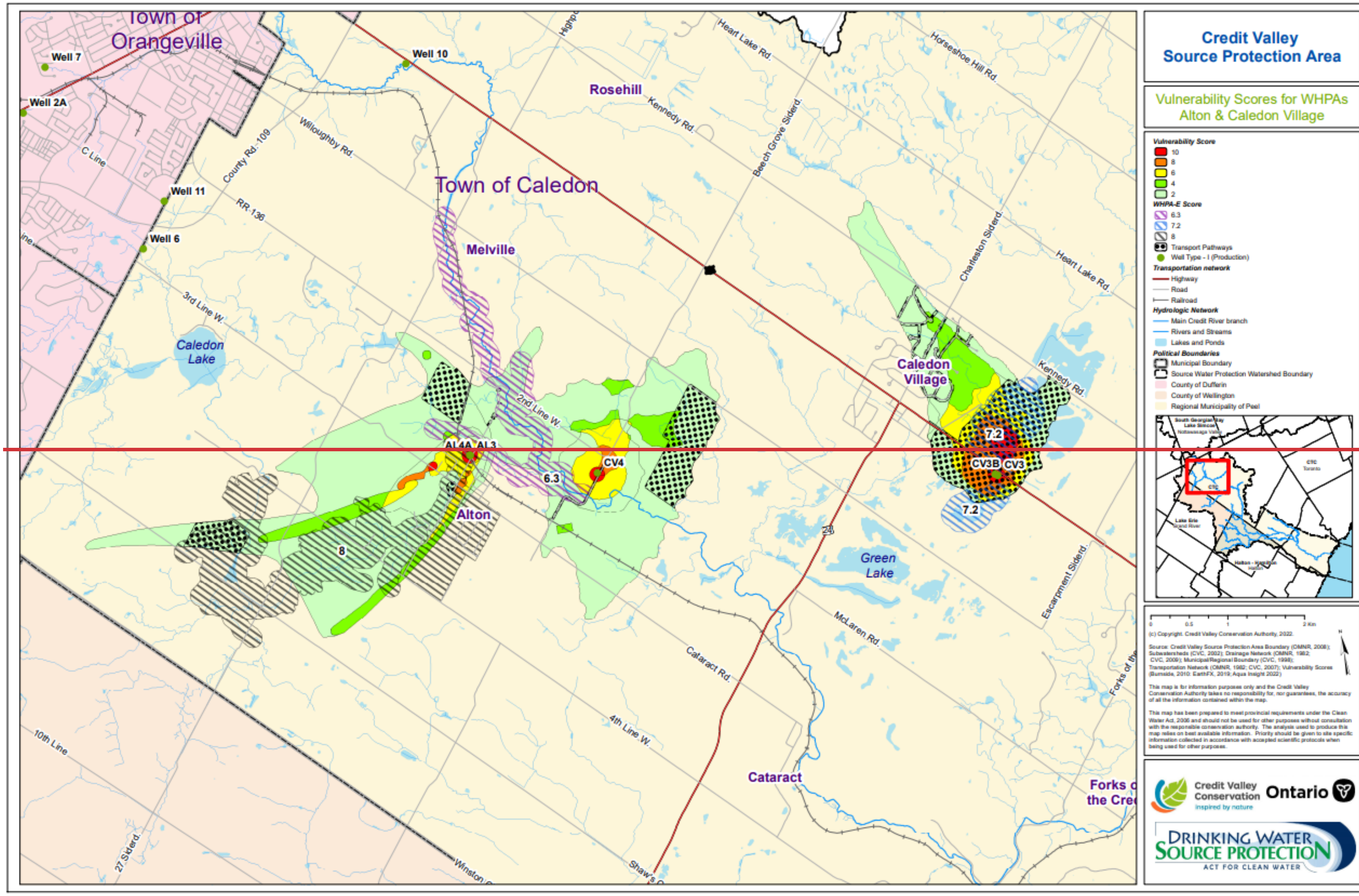
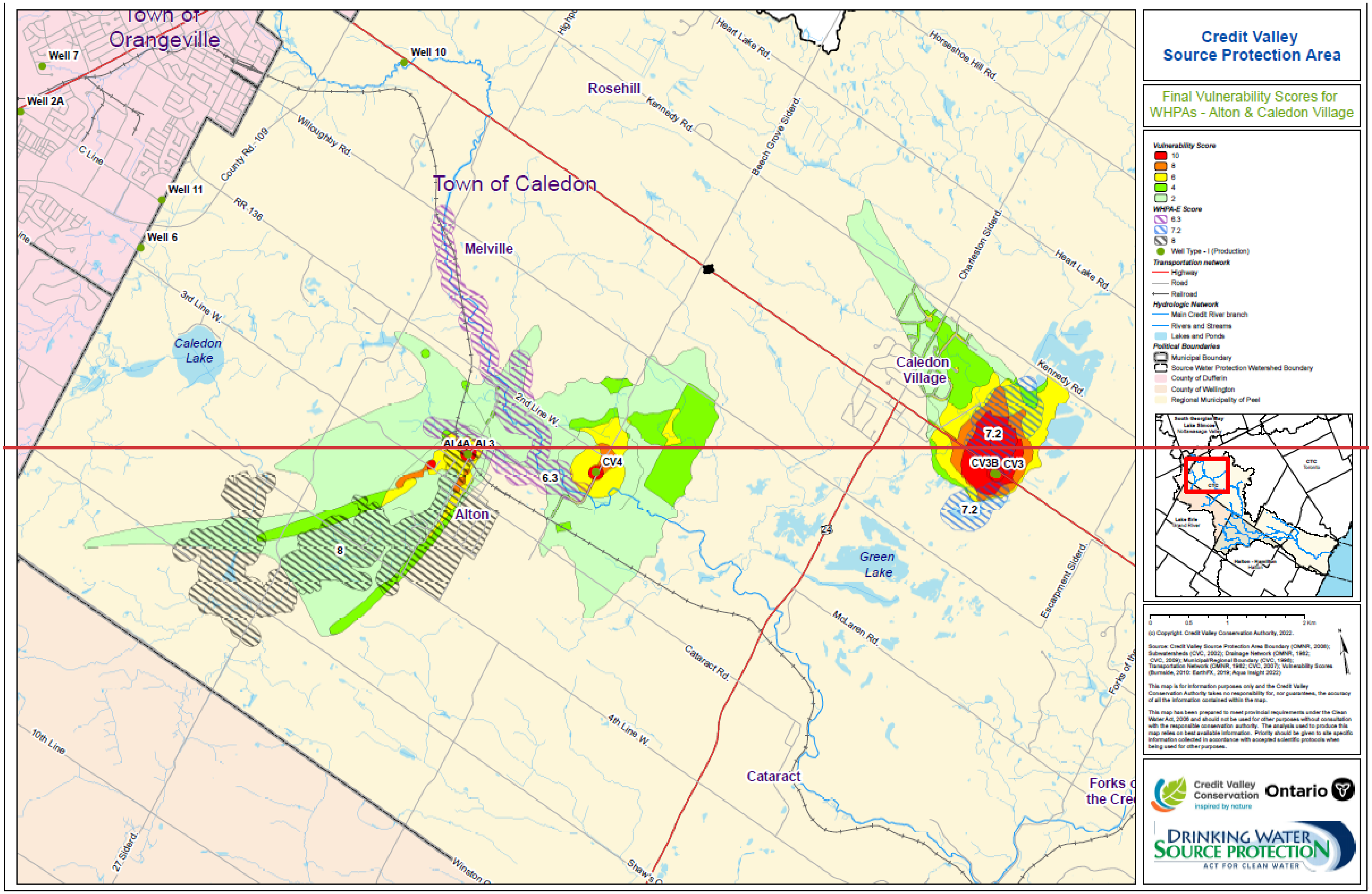

Credit Valley Source Protection Area
Groundwater Vulnerability of WHPAs Alton & Caledon Village
Vulnerability Level
High
Medium
Low
Well Type - I (Production)
Transportation network
Highway
Road
Railroad
Hydrologic Network
Main Credit River branch
Rivers and Streams
Political Boundaries
Municipal Boundary
Source Water Protection Watershed Boundary
County of Dufferin
County of Wellington
Regional Municipality of Peel
Town of Orangeville
Town of Caledon
Town of Erin
Melville
Rosehill
Caledon Village
Alton
Cataract
Forks of the Credit
Belfountain
Caledon Lake
Green Lake
AL4A
AL3
CV4
CV3B
CV3
Well 8B
Pullen Well
Well 12
Well 7
Well 10
Well 5A
Well 5
Well 2A
Well 9B
Well 9A
Well 11
Well 6
(c) Copyright. Credit Valley Conservation Authority, 2022.
Credit Valley Conservation
Ontario
Drinking Water Source Protection
Act for Clean Water

Figure 4.34: Groundwater Vulnerability of WHPAs— Caledon Village – Alton


Credit Valley
Source Protection Area
Vulnerability Scores for WHPAs
Alton & Caledon Village
Vulnerability Score
10
8
6
4
2
WHPA-E (Score): 6.3 - 6.4
WHPA-E (Score): 8
Transport Pathways
Wells
Well Type - I (Production)
Transportation network
Highway
Road
Railroad
Hydrologic Network
Main Credit River branch
Rivers and Streams
Lakes and Ponds
Political Boundaries
Municipal Boundary
Source Water Protection Watershed Boundary
County of Dufferin
County of Wellington
Regional Municipality of Peel
0 0.25 0.5 1 1.5 2 Kilometres
(c) Copyright. Credit Valley Conservation Authority, 2019.
Source: Credit Valley Source Protection Area Boundary (OMNR, 2008); Subwatersheds (CVC, 2002); Drainage Network (OMNR, 1982; CVC, 2009); Municipal/Regional Boundary (CVC, 1998); Transportation Network (OMNR, 1982; CVC, 2007); Vulnerability Scores (Burnside, 2010; EarthFX, 2019)
This map is for information purposes only and the Credit Valley Conservation Authority takes no responsibility for, nor guarantees, the accuracy of all the information contained within the map.
This map has been prepared to meet provincial requirements under the Clean Water Act, 2006 and should not be used for other purposes without consultation with the responsible conservation authority. The analysis used to produce this map relies on best available information. Priority should be given to site specific information collected in accordance with accepted scientific protocols when being used for other purposes.
Town of Orangeville
Town of Caledon
Township of East Garafraxa
Town of Erin
Grand River Source Protection Area
Wells 8B & 8C
Well 12 (TM)
Pullen Well
Well 7
Well 5 & 5A
Well 2A
Well 9A & 9B
Well 11
Well 6
Well 10
Alton 3 & 4A
Caledon Village 4
Caledon Village 3
Caledon Village
Caledon Lake
Green Lake
Rosehill
Melville
Alton
Cataract
Belfountain
6.3
6.4


Credit Valley Source Protection Area
Vulnerability Scores for WHPAs Alton & Caledon Village
Town of Orangeville
Town of Caledon
Well 7
Well 2A
Well 10
Well 11
Well 6
Rosehill
Melville
Caledon Lake
Caledon Village
Alton
AL4A
AL3
CV4
CV3B
CV3
6.3
7.2
8
Green Lake
Cataract
Forks of the Credit
Credit Valley Conservation
Ontario
Drinking Water Source Protection
ACT FOR CLEAN WATER


Credit Valley
Source Protection Area
Final Vulnerability Scores for
WHPAs - Alton & Caledon Village
Vulnerability Score
10
8
6
4
2
WHPA-E Score
6.3
7.2
8
Well Type - I (Production)
Transportation network
Highway
Road
Railroad
Hydrologic Network
Main Credit River branch
Rivers and Streams
Lakes and Ponds
Political Boundaries
Municipal Boundary
Source Water Protection Watershed Boundary
County of Dufferin
County of Wellington
Regional Municipality of Peel
0
0.5
1
2 Km
(c) Copyright. Credit Valley Conservation Authority, 2022.
Town of Orangeville
Well 7
Well 2A
Well 10
Well 11
Well 6
Town of Caledon
Rosehill
Melville
Caledon Lake
Caledon Village
AL4A
AL3
CV4
6.3
Alton
8
CV3B
CV3
7.2
7.2
Green Lake
Cataract
Forks of the Credit
Willoughby Rd.
County Rd. 109
RR 136
C Line
3rd Line W.
2nd Line W.
Kennedy Rd.
Beech Grove Siderd.
Heart Lake Rd.
Horseshoe Hill Rd.
Charleston Siderd.
McLaren Rd.
Cataract Rd.
4th Line W.
10th Line
27 Siderd.
Escarpment Siderd.
24
Credit Valley Conservation
inspired by nature
Ontario
DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER

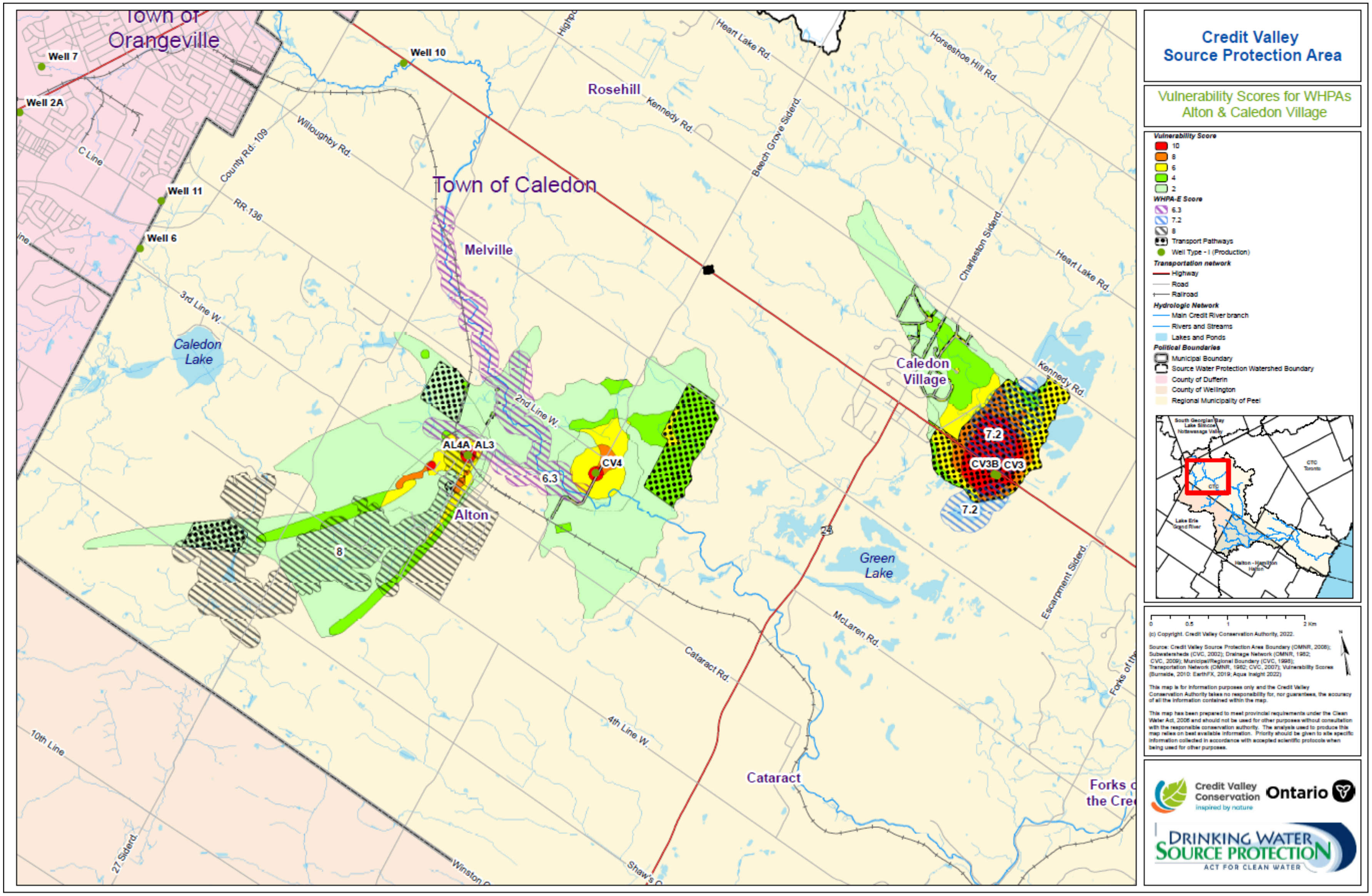
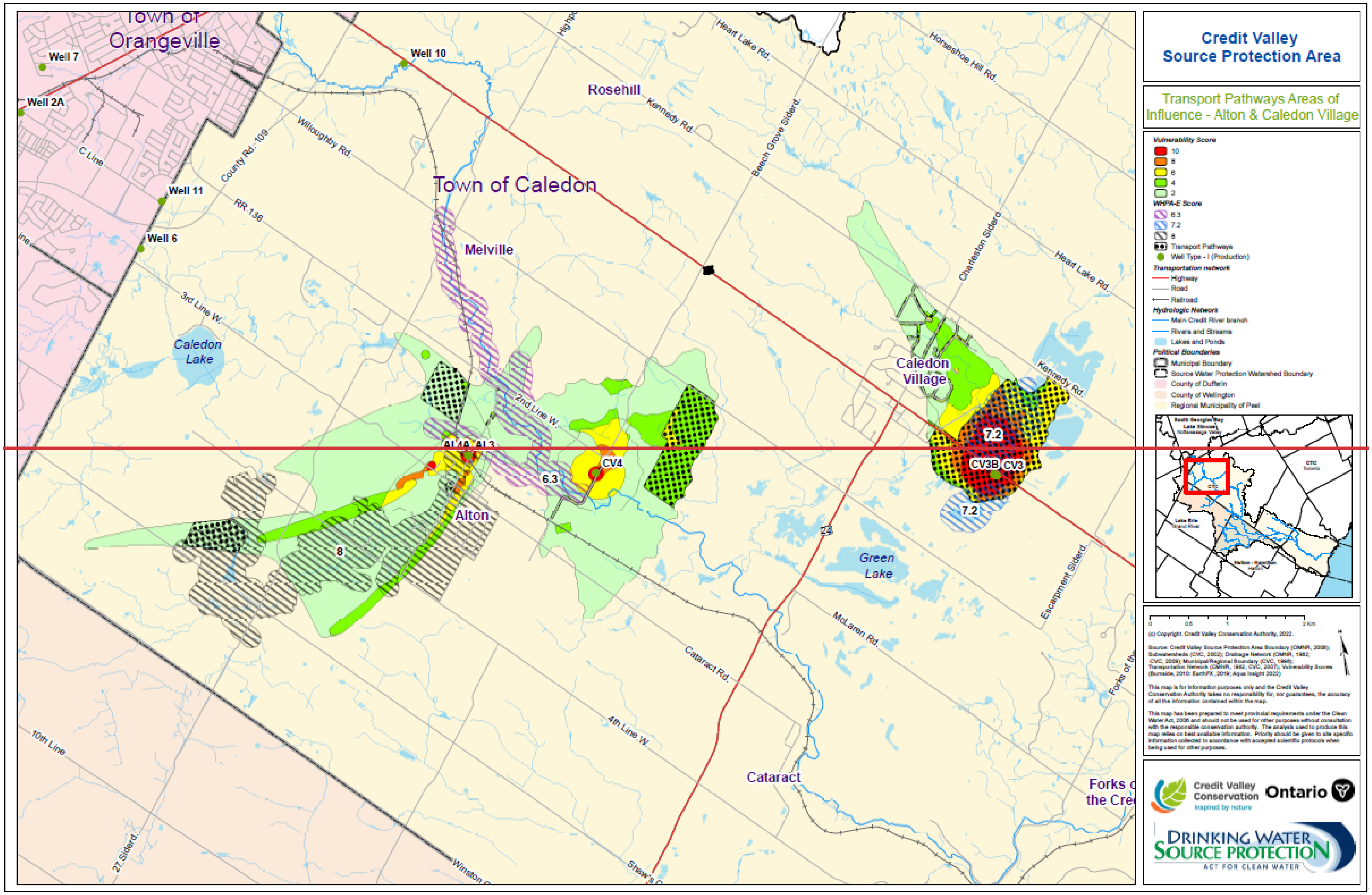
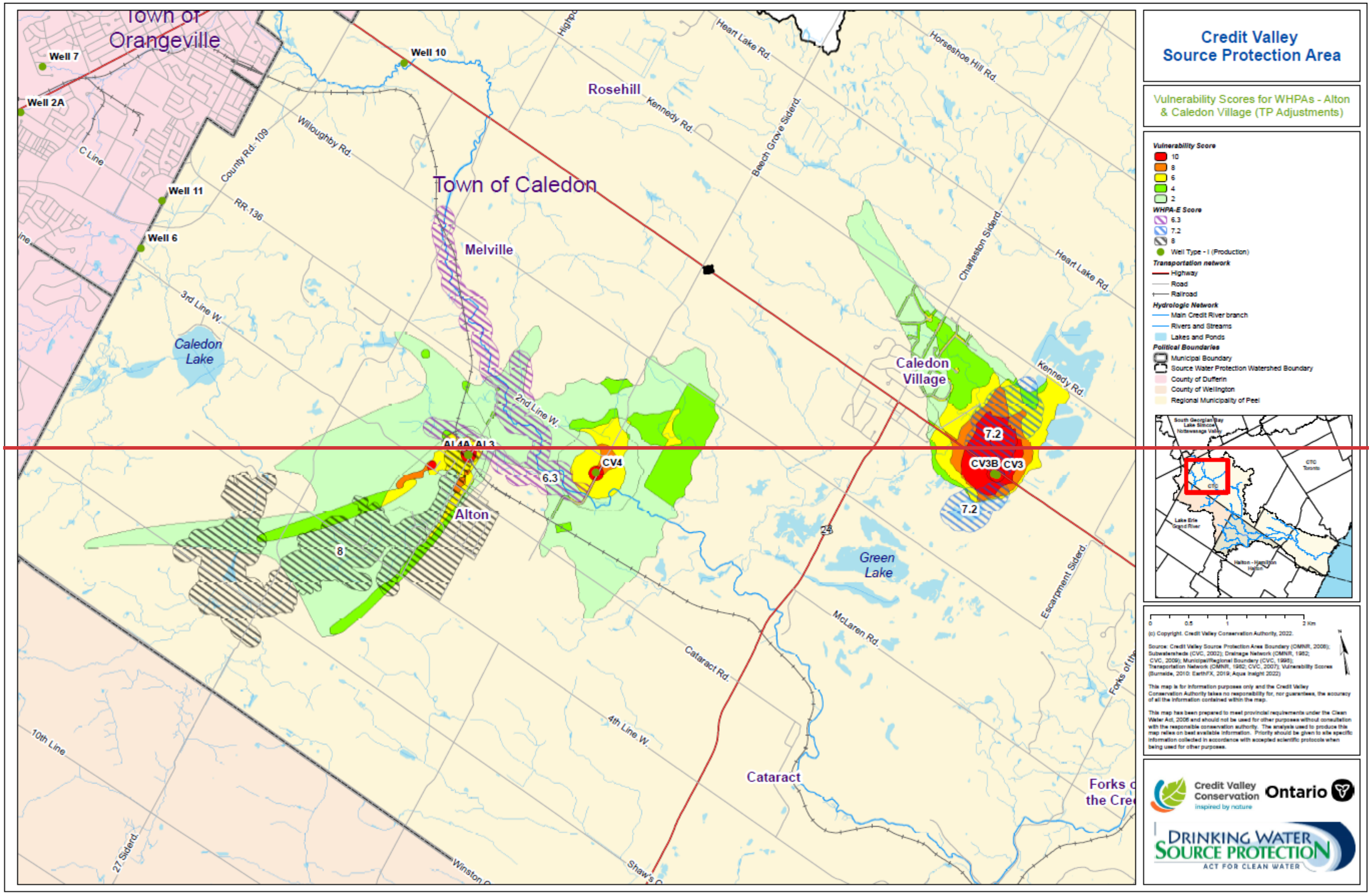


Figure 4.37: Vulnerability Scores for WHPAs - Caledon Village - Alton


Credit Valley
Source Protection Area
Transport Pathways Areas of Influence - Alton & Caledon Village
Town of Orangeville
Town of Caledon
Well 7
Well 2A
Well 10
Well 11
Well 6
Rosehill
Melville
Caledon Lake
Caledon Village
Alton
Green Lake
Cataract
AL4A
AL3
CV4
CV3B
CV3
6.3
7.2
8
Willoughby Rd.
County Rd. 109
RR 136
C Line
3rd Line W.
2nd Line W.
4th Line W.
10th Line
27 Sideroad
Heart Lake Rd.
Horseshoe Hill Rd.
Kennedy Rd.
Beech Grove Siderd.
Charleston Siderd.
McLaren Rd.
Cataract Rd.
Escarpment Siderd.
Vulnerability Score
WHPA-E Score
Transport Pathways
Well Type - I (Production)
Transportation network
Highway
Road
Railroad
Hydrologic Network
Main Credit River branch
Rivers and Streams
Lakes and Ponds
Political Boundaries
Municipal Boundary
Source Water Protection Watershed Boundary
County of Dufferin
County of Wellington
Regional Municipality of Peel
Credit Valley Conservation
inspired by nature
Ontario
Drinking Water Source Protection
ACT FOR CLEAN WATER


Credit Valley
Source Protection Area
Vulnerability Scores for WHPAs - Alton & Caledon Village (TP Adjustments)
Vulnerability Score
10
8
6
4
2
WHPA-E Score
6.3
7.2
8
Well Type - I (Production)
Transportation network
Highway
Road
Railroad
Hydrologic Network
Main Credit River branch
Rivers and Streams
Lakes and Ponds
Political Boundaries
Municipal Boundary
Source Water Protection Watershed Boundary
County of Dufferin
County of Wellington
Regional Municipality of Peel
0 0.5 1 2 Km
(c) Copyright. Credit Valley Conservation Authority, 2022.
Source: Credit Valley Source Protection Area Boundary (OMNR, 2006); Subwatersheds (CVC, 2002); Drainage Network (OMNR, 1982; CVC, 2009); Municipal/Regional Boundary (CVC, 1998); Transportation Network (OMNR, 1982; CVC, 2007); Vulnerability Scores (Burnside, 2010: EarthFX, 2019; Aqua Insight 2022)
This map is for information purposes only and the Credit Valley Conservation Authority takes no responsibility for, nor guarantees, the accuracy of all the information contained within the map.
This map has been prepared to meet provincial requirements under the Clean Water Act, 2006 and should not be used for other purposes without consultation with the responsible conservation authority. The analysis used to produce this map relies on best available information. Priority should be given to site specific information collected in accordance with accepted scientific protocols when being used for other purposes.
Town of Orangeville
Town of Caledon
Well 7
Well 2A
Well 10
Well 11
Well 6
Rosehill
Melville
Caledon Lake
Caledon Village
Alton
AL4A
AL3
CV4
CV3B
CV3
6.3
7.2
8
Green Lake
Cataract
Forks of the Credit
C Line
County Rd. 109
Willoughby Rd.
RR 136
3rd Line W.
2nd Line W.
4th Line W.
10th Line
27 Siderd.
Heart Lake Rd.
Kennedy Rd.
Beech Grove Siderd.
Horseshoe Hill Rd.
Charleston Siderd.
Escarpment Siderd.
McLaren Rd.
Cataract Rd.
24

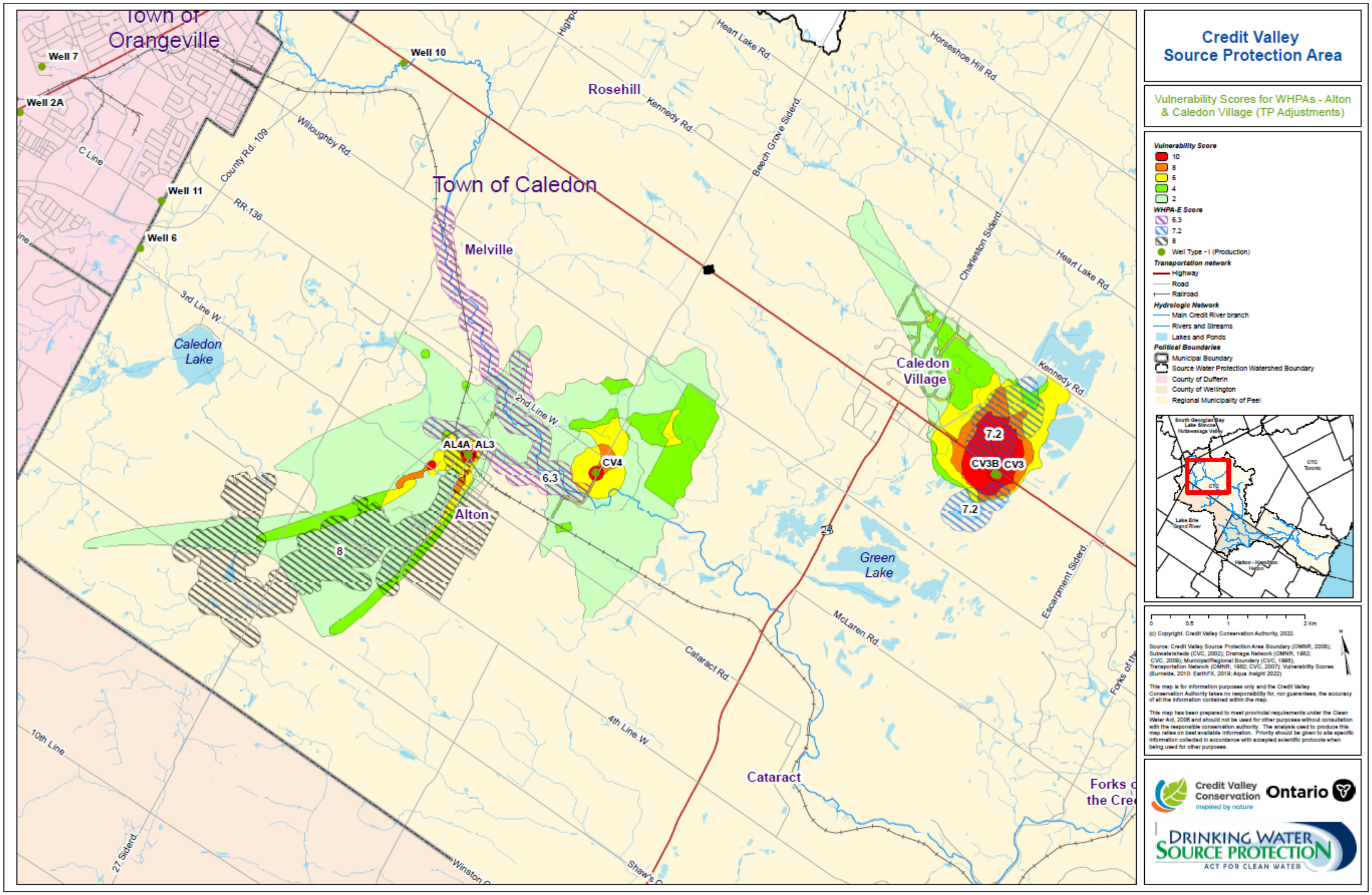


Figure 4.40: Transport Pathways Areas of Influence - Caledon Village - Alton

4.8.6 Uncertainty Assessment

Alton and Cheltenham Wells

When the initial WHPA delineations (circa 2007) were completed for incorporation into this Assessment Report, some peer reviewers highlighted concerns regarding the WHPA delineations and vulnerability assessment prepared for the Cheltenham wells. These concerns were associated with the variations in the shapes and size of the WHPAs compared to previous delineations (circa 2000), as well as the orientation of the Cheltenham WHPAs. Based upon comments obtained through the peer review of the foundation reports and of the base models, Peel Region accepted the initial WHPA delineations, and in 2009 recommended that they be included in the Official Plan for the Town of Caledon. The Region was mindful of the concerns brought forward by these reviewers and recommended that the WHPAs be accepted for the time being pending further refinement of the groundwater flow model through the inclusion of additional data.

To assist with the collection of additional data, the Region initiated independent water quality monitoring programs with extensive data collection. These programs are described below:

- Re-evaluation of Early Warning Wells (EWW) Monitoring Program – installation of additional early warning wells to improve the resolution of the EWW network, including some in the vicinity of the Cheltenham and Alton municipal wells. This program commenced in early 2011; and
- Development of a Nitrate Management Plan for Alton which included the installation of boreholes and monitoring wells. This Program was initiated in Fall 2010.

The data generated from these programs will be used when refining the geologic/hydrogeologic interpretations near the municipal wells and updating the groundwater flow model used to delineate the WHPAs. With the inclusion of improved data sets, there is the potential for alterations in the shape and size of the WHPAs.

General WHPA Delineation and Vulnerability Assessment

The dimensions of WHPA-~~A~~E and the vulnerability scoring assigned, are outlined in the *Technical Rules* (MOE, 2009, 2017, 2021). With WHPAs~~-~~-B through E there is an intrinsic level of uncertainty in the analysis, given the complexity of the study area and the paucity of data in certain instances. The vulnerability assessment also has a certain level of uncertainty associated with it.

The vulnerability assessment is a combination of several components each with their own uncertainty associated to them. These components include:

- The time of travel zones are based on the calibration match and the response of the capture zones within the sensitivity scenarios;
- The quality of the data used to calculate the vulnerability; and
- The vulnerability rating, which is often due to uncertainty associated with the understanding and conceptualization of the hydrostratigraphic groundwater system.

In some areas, the hydrostratigraphy is well understood, and therefore the resulting vulnerability mapping may be clear, leading to low uncertainty. In contrast, hydrogeologically complex areas may result in higher uncertainty. **Table 4.11** outlines the uncertainty estimated for each factor, at each municipal wellhead.

Uncertainty for the Peel Region WHPAs is summarized as follows:

- The WHPAs were delineated using a multiple scenario sensitivity analysis to account for variation in multiple parameters. The resulting WHPAs are conservative in nature with good calibration results therefore, the uncertainty can be considered low with the exception of Alton Wells 3 and 4A, and Cheltenham Wells.
- WWAT uncertainty was determined based on the groundwater model used to delineate the WHPAs and that these zones cannot be field verified.
- Although the delineation of the WHPA-E for Alton Well 4A includes a significant amount of stream flow data (8 years), parameter values used to complete Mannings equation (flow volume, channel slope and section geometry) introduced some uncertainty. Given that each segment of the WHPA-E was not field verified, a high uncertainty rating was assigned to both the WHPA delineation and the vulnerability assessment.
- The uncertainty in the delineation of the WHPA-E for Caledon Village Well 4 was considered low, as it was mapped to extend to the Melville Pond along the ~~c~~Credit River in the north, and the travel time in Shaw's Creek was calculated using ~~-~~a hydraulic model. The WHPA-E areas associated with Caledon Village Wells 3 and~~/~~ 3B were delineated by drawing a buffer around the current extent of the aggregate ponds in Caledon Village, which produces a low uncertainty. The extent of the aggregate ponds may change in the future, but the current delineation is considered to have a low uncertainty. ~~nso this~~
- The uncertainty in transport pathways is associated with the quality of GIS data available and the assumptions made. The vulnerability associated with private or public landfills and closed aggregate extraction areas was increased from Low to Moderate or Moderate to High when the feature lies within a WHPA of an unconfined or semi-confined aquifer. The vulnerability rating was uniformly increased by one level in the presence of these features. The linear infrastructure pieces were mapped by Peel Region, as such these features were considered to have low uncertainty.

Table 4.11: Uncertainty Assessment—Town of Caledon

	Uncertainty Type	WHPA-A	WHPA-B	WHPA-C	WHPA-D	WHPA-E
Alton Well 3	Delineation of WHPA	Low	High	High	High	Low
	Vulnerability assessment	Low	High	High	Low	Low
	Overall – Vulnerability Scores	**Low**	**High**	**High**	**Low**	**Low**
Alton Well 4A	Delineation of WHPA	Low	High	High	High	High
	Vulnerability assessment	Low	High	High	High	High
	Overall – Vulnerability Scores	**Low**	**High**	**High**	**High**	**High**
Caledon Village Well 3 & 3B	Delineation of WHPA	Low	Low	Low	Low	—
	Vulnerability assessment	Low	~~High~~Low	~~High~~Low	Low	—
	Transport pathways	Low	Low	Low	Low	–
	Overall – Vulnerability Scores	**Low**	**~~High~~Low**	**~~High~~Low**	**Low**	—
Caledon Village Well 4	Delineation of WHPA	Low	Low	Low	Low	—
	Vulnerability assessment	Low	~~High~~Low	Low	Low	—
	Transport pathways	Low	Low	Low	Low	–
	Overall – Vulnerability Scores	**Low**	**~~High~~Low**	**Low**	**Low**	**—**

	Uncertainty Type	WHPA-A	WHPA-B	WHPA-C	WHPA-D	WHPA-E
Inglewood Well 3	Delineation of WHPA	Low	Low	Low	Low	—
	Vulnerability assessment	Low	High	Low	Low	—
	Overall – Vulnerability Scores	**Low**	**High**	**Low**	**Low**	—
Inglewood Well 4	Delineation of WHPA	Low	Low	Low	Low	—
	Vulnerability assessment	Low	High	Low	Low	—
	Overall – Vulnerability Scores	**Low**	**High**	**Low**	**Low**	—
Cheltenham	Delineation of WHPA	Low	High	High	High	—
	Vulnerability assessment	Low	High	High	Low	—
	Overall – Vulnerability Scores	**Low**	**High**	**High**	**Low**	

5.0 DRINKING WATER THREATS ASSESSMENT

5.1 OVERVIEW

5.1.1 Threats to Drinking Water Quantity

The majority of the technical work on threat identification and enumeration was based on the 2009 version of the Director's Technical Rules, but amendments to the Credit Valley Assessment Report, resulting in versions 2.0, 3.0 and 4.0, were made using the 2017 Director's Technical Rules and Tables of Drinking Water Threats. These amendments were completed for groundwater-based water systems in Peel Region.

~~**Stressed**: A subwatershed is identified as stressed when the estimated water use is greater than 10% of the available groundwater or surface water supply.~~

~~**Subwatershed:** A portion of a watershed separated out for stress assessment calculations.~~

The *Technical Rules* require that a Water Quantity Risk Assessment be completed for municipal drinking water supplies if they are considered *stressed* according to the water budget calculations described in **Chapter 3** of this Assessment Report. In the Credit Valley Source Protection Area (CVSPA), municipal water supplies are sourced from groundwater, and from Lake Ontario (**Chapter 2**). No municipal supplies are sourced from the Credit River. Stresses to water quantity have been identified for three municipal groundwater systems in Orangeville, Mono, Amaranth, Acton, and Georgetown (**Chapter 3**).

Note that the *Technical Rules* exempt Great Lakes sources from the water quantity threat assessment process, and that no municipal supplies within the CVSPA are sourced from the rivers or streams

A Tier 2 Water Budget was completed for the CVSPA, as per *Technical Rules (19–24)*. The screening results calculated groundwater and/or surface water *stresses* in 22 *subwatersheds,* but the only additional work necessary under the *Clean Water Act, 2006* (*CWA),* was a Tier 3 water budget for the Orangeville, Acton, and Georgetown water supplies, as discussed in **Chapter 3**. Under other programs within the conservation authority and municipalities, additional work is planned to examine the potential effects to the ecosystem in the other stressed subwatersheds. The CTC Source Protection Committee (SPC) has recommended to the conservation authority and municipality that additional work to assess the potential stresses to the ecosystem in these watersheds should be undertaken.

5.1.2 Threats to Drinking Water Quality

Site-specific verification of drinking water threats was not conducted as part of the original studies informing the 2012 Approved Assessment Report. Since 2012 however, preliminary effort aimed at the ground-truthing of significant threats in vulnerable zones around municipal wells has been undertaken. The findings of this work have been used to update the threats enumeration around the wells. Despite this, it is possible that threats identified in this document do not actually exist, and it is also possible that a non-documented threat exists that has not been enumerated. If a significant threat has been enumerated but does not exist, policies in a Source Protection Plan would not apply. Conversely, if a significant threat has not been enumerated but does exist, such policies would apply. A key implementation activity for the municipalities will be to confirm the existence of significant drinking water threats at the site scale.

In the Water Quality Risk Assessment process, the hazard rating and the vulnerability score are multiplied to produce a risk score. In place of having to complete these calculations for all threats, *Part XI* (*Rule 118*) of the *Technical Rules* under the *CWA* allows reference to activities in the Tables of

Drinking Water Threats that may pose a potential threat to the quality and/or quantity of drinking water within each vulnerable area. The size and complexity of the Table of Drinking Water Threats precludes efficient reference and analysis. Therefore, in March 2010 the Ministry of the Environment and Climate Change (MOECC) developed a series of 76 Provincial Tables of Circumstances each of which lists every circumstance that makes an activity a low, moderate, or significant drinking water threat, as per the the 2009 Director's Technical Rules. The Director's Technical Rules have been subsequently updated three times in 2013, 2017 and 2021. The Tables of Drinking Water Threats and Circumstances for three subsequent updates can be viewed in the Provinces Source Water Protection Threat Tool, http://swpip.ca. ~~The Director's Technical Rules 2009, 2013, 2017, and 2021 Table of Drinking Water Threats and Associated CircumstancesThProvincial Tables of Circumstances that apply in the CVSPA are listed in **Table 5.1**.~~

The identification of threats to municipal drinking water sourced from Lake Ontario follows a different process, using event based modelling as described in **Section 5.7.6**.

No conditions were identified in the CVSPA, as per *Rule (126)* (conditions).

Tables 5.1a, 5.1b, and 5.1c summarize where significant, moderate or low water quality threats can occur based on Vulnerable Area and Vulnerability Score under each of four versions of the Director's Technical Rules (2009, 2013, 2017, and 2021). For additional information, refer to Section 5.2 Threats Assessment Methodology for further information on Table 5.1a; to Section 5.7 Surface Water Quality Threats for Table 5.1b, and Section 5.4 Groundwater Quality Threats in Highly Vulnerable Aquifers for Table 5.1c.

Table 5.1~~-~~a: Identification of Drinking Water Quality Threats in WHPA-A/B/C/D using 2009, 2013, 2017 and 2021 Director's Technical Rules ~~Provincial Tables of Circumstances (2010)~~

Threat Type	Vulnerable Area and Score	Threat Classification Level: Significant 2009 / 2013 / 2017 / 2021 DTR's	Moderate 2009 / 2013 / 2017 DTR's	Moderate 2021 DTR's	Low 2009 / 2013 / 2017 / 2021 DTR's
Chemicals	WHPA-A/B (VS = 10)	✓	✓	✓	✓
	WHPA-B/C (VS = 8)	✓	✓	✓	✓
	WHPA-B/C/D (VS = 6)		✓	✓	✓
Handling / Storage of DNAPLs	WHPA-A/B/C (VS = Any Score)	✓			
	WHPA-D (VS = 6)		✓		✓
Pathogens	WHPA-A/B (VS = 10)	✓	✓	✓	
	WHPA-B (VS = 8)		✓	✓	✓
	WHPA-B (VS = 6)				✓

DTR's refers to Director's Technical Rules
VS = Vulnerability Score

Table 5.21b: Identification of Drinking Water Quality Threats in WHPA-E and IPZ's using 2009, 2013, 2017 and 2021 Director's Technical Rules

Threat Type	Vulnerable Area and Score	Threat Classification Level				
		Significant		Moderate	Low	
		2009 / 2013 / 2017 DTR's	2021 DTR's	2009 / 2013 / 2017 / 2021 DTR's	2009 / 2013 / 2017 DTR's	2021 DTR's
Chemicals	IPZ/WHPA-E (VS = 9)	✓	✓	✓	✓	✓
	IPZ/WHPA-E (VS = 8 to 8.1)	✓	✓	✓	✓	✓
	IPZ/WHPA-E (VS = 6 to 7.2)			✓	✓	✓
	IPZ/WHPA-E (VS = 4.2 to 5.6)				✓	✓
Handling / Storage of DNAPLs	IPZ/WHPA-E (VS = 9)		✓	✓		
	IPZ/WHPA-E (VS = 7 to 8.1)			✓	✓	✓
	IPZ/WHPA-E (VS = 4.8 to 6.4)				✓	✓
	IPZ/WHPA-E (VS = 4.5)					✓
Pathogens	IPZ/WHPA-E (VS = 9)	✓	✓	✓	✓	✓
	IPZ/WHPA-E (VS = 8 to 8.1)	✓	✓	✓	✓	✓
	IPZ/WHPA-E (VS = 6 to 7.2)			✓	✓	✓
	IPZ/WHPA-E (VS = 4.2 to 5.6)				✓	✓

DTR's refers to Director's Technical Rules
VS = Vulnerability Score

Table 5.31c: Identification of Drinking Water Quality Threats in HVA's using 2009, 2013, 2017 and 2021 Director's Technical Rules

Threat Type	Vulnerable Area and Score	Threat Classification Level			
		Significant	Moderate		Low
		2009 / 2013 /2017 / 2021 DTR's	2009 / 2013 / 2017 DTR's	2021 DTR's	2009 / 2013 /2017 / 2021 DTR's
Chemicals	HVA (VS = 6)		✓	✓	✓
Handling / Storage of DNAPLs	HVA (VS = 6)		✓		✓

Pathogens	HVA (VS = 6)				

DTR's refers to Director's Technical Rules
VS = Vulnerability Score

Threat Type	Vulnerability Area	Vulnerability Score	Threat Classification and Provincial Table Reference Code		
			Significant	Moderate	Low
Chemical*	WHPA A,B,C,D	10	1(CW10S)	3(CW10M)	6(CW10L)
		8	2(CW8S)	4(CW8M)	7(CW8L)
		6	n/a	5(CW6M)	8(CW6L)
	WHPA-E, IPZ	7.2	n/a	27(CIPZWE7.2M)	35(CIPZWE7.2L)
		6	n/a	75(CIPZWEM6)	76(CIPZWEL6)
		5.4	n/a	n/a	40(CIPZWE5.4L)
		5	n/a	n/a	74(CIPZWEL5)
		4.8	n/a	n/a	42(CIPZWE4.8L)
		4.5	n/a	n/a	43(CIPZWE4.5L)
	SGRA, HVA	6	n/a	17(CSGRAHVA6M)	18(CSGRAHVA6L)
DNAPL	WHPA A,B,C	all	9(DWAS)	n/a	n/a
	WHPA-D, SGRA, HVA	6	n/a	10(DW6M)	11(DW6L)
Pathogen	WHPA A,B	10	12(PW10S)	13(PW10M)	n/a
		8	n/a	14(PW8M)	15(PW8L)
		6	n/a	n/a	16(PW6L)
	WHPA-E, IPZ	7.2	n/a	53(PIPZWE7.2M)	62(PIPZWE7.2L)
		6	n/a	57(PIPZ6M)	66(PIPZ6L)
		5.4	n/a	n/a	68(PIPZWE5.4L)
		5	n/a	n/a	69(PIPZ5L)
		4.8	n/a	n/a	71(PIPZWE4.8)
		4.5	n/a	n/a	72(PIPZWE4.5L)

Only Tables of Circumstances that apply within the CVSPA are included

n/a: does not apply

** In some Tables of Circumstances, both chemicals and DNAPLs are listed*

Current information that appears in the Provincial Tables of Circumstances can be generated by searching the Source Water Protection Threats Tool, accessible via http://swpip.ca/

For land application of ASMs, high livestock density suggests an increased potential for over-application of ASMs because the land base may not be large enough to properly utilize all the material; conversely, an area with low livestock density is more likely to have enough land base to properly utilize materials. It should be noted that there may be provincial legislation, agricultural/industrial standards, or other instruments that control the application of these materials that would reduce the actual threat, and that ground truthing was not conducted. This analysis does not consider whether or not such instruments are in place. This matter will be evaluated when the Source Protection Plan policies are developed by the SPC.

Growers will likely use commercial fertilizers to compensate for any undersupply of ASM based nutrients; however, the amounts applied will be limited. The rationale is that growers will want to minimize the use of commercial fertilizers and not exceed crop requirements, as they are a purchased crop input that increases the cost of crop production.

The livestock density was calculated using the methodology recommended by the MOECC, outlined in the *Draft Technical Bulletin: Proposed Methodology for Calculating Percentage of Managed Lands and Livestock Density for Land Application of Agricultural Source of Material, Non-Agricultural Source of Material and Commercial Fertilizers, November 2009* (see **Appendix E1**).

To evaluate the threat of over-application of ASMs, the thresholds are defined as follows:

- If livestock density in the vulnerable area has a value of less than 0.5 NUs/acre, the area has a low potential for nutrient application that exceeds crop requirements;
- If livestock density in the vulnerable area is greater than 0.5 and less than 1.0 NU/acre, the area has a moderate potential for nutrient application that exceeds crop requirements; and
- If livestock density in the vulnerable areas is greater than 1.0 NU/acre, the area has a high potential for nutrient application that exceeds crop requirements.

Where agricultural facilities were found within HVAs or SGRAs, the building footprints of structures within those facilities were digitized to calculate the area occupied by the structure. The Farm Operation Code based on the MPAC data was used to determine farm operation type and calculate its Nutrient Unit per acre (NU/ acre). All agricultural managed lands associated with an agricultural facility were added together and associated NU factor applied.

Livestock densities are considered with the natural vulnerability to determine the level of threat to drinking water sources. In HVAs with a vulnerability score of 6, no significant or moderate threats can be identified; only low threat scores are possible.

5.2.7 Impervious Surfaces

Impervious surfaces are defined by the *CWA* as the surface area of all highways and other impervious land surfaces used for vehicular traffic and parking, and all pedestrian paths. As per subsection 16 (11) in Part II of the *CWA*, for each vulnerable area, one or more maps of the percentage of the impervious surface area where road salt can be applied per square kilometre in the vulnerable area is required. This calculation is required in order to assist in determining the threat level associated with the application of road salt within each vulnerable area within the CVSPA jurisdiction.

The impervious surface analyses for the CVSPA study area were completed for HVAs, SGRAs, WHPAs, and IPZ-1s and IPZ-2s where they extend onto land. The analyses include all on-land areas where the vulnerability exceeds a score of 6 in HVAs and WHPAs, and 4.4 in IPZs. The impervious surfaces evaluation followed the steps outlined below.

The data sources required to complete the impervious area calculations, included the CVSPA HVA, SGRA, WHPA and IPZ delineations with their associated vulnerability scoring (**Chapter 4** and **Appendix D**), and mapping of the road network across the CVSPA. The information from these data sources was overlain so that the vulnerability mapping and road networks were presented on a single figure. Notably absent from the dataset were parking lots, driveways, or pedestrian pathways, which could receive salt application and thus, were NOT included in this assessment. Specific to the Caledon Village Wellfield, the area associated with publicly accessible parking lots (as defined by OpenStreets mapping) were included in the impervious area calculations.

Credit Valley Conservation (CVC) staff developed and used a 1 km^2 grid net to perform the analysis. The percent impervious area within each grid was determined by calculating the total impervious surface area and dividing by the total area of the grid. For each road, the road width was determined using the following road conversion widths supplied by Genivar (2007):

- Arterial Road – 15 m;
- Collector Road – 12 m;
- Expressway/Highway – 12 m;
- Freeway – 25 m;
- Local Road – 10 m;
- Ramp/Service Road – 5 m; and
- Resource/Recreation Road – 8 m.

According to *Technical Rule 16 (11),* the percent impervious area calculated within each grid is grouped according to the following divisions:

- 1% to 8%;
- Greater than 8% but less than 80%; and
- Greater than or equal to 80%.

Applicable to only the Caledon Village Wellfield, as outlined in the Technical Rules (MECP 2021), the percent impervious area calculated within each grid cell within a WHPA-A to D polygon is classified into one of the following groups:

- Less than 8%
- 8% to 30%
- Greater than 30%

For WHPA-E zones, the thresholds are as follows:

- Less than 6%
- 6% to 8%
- Greater than 8%.

5.2.8 Uncertainty Assessment

Technical Rules (13), (14) and (15) require a discussion of uncertainty as it relates to the delineation of vulnerable areas and the calculation of the vulnerability scores. Uncertainty, as defined by the *Technical Rules*, has been discussed for each of the vulnerable areas in **Chapter 4**. The CTC SPC, however,

5.5 GROUNDWATER QUALITY THREATS AND ISSUES IN WELLHEAD PROTECTION AREAS (WHPA)

Threats assessments have been completed by consultants working for each municipality except for wells in the Township of Amaranth and the Region of Halton, where the consultants were under the direction of CVC staff. Threats have been assessed for all municipal wells in the CVSPA as described in the following sections organized by municipality. Groundwater based municipal supplies in the CVSPA are currently delivered through nine active water systems plus two water systems that are currently off-line (**Table 2.6**). There are a total of 47~~6~~ municipal drinking water wells in the CVSPA.

Table 5.10 shows the summary of the number significant drinking water threats identified within these WHPAs.

Table 5.12~~10~~: Summary of Drinking Water Threats (Quality and Quantity) for the Credit Valley Source Protection Area

Municipality	Wells	Significant Drinking Water Threats	Total # of Parcels with Significant Drinking Water Threats
Town of Orangeville	Wells 2A, 5, 5A, 6, 7, 8B, 8C, 9A, 9B, 10, 11 and 12	2,728	2,495
Town of Mono	Cardinal Woods Wells 1, 3 and 4, Island Lake Wells TW1 and PW1, and Coles Wells 1 and 2	66	40
Township of Amaranth	Pullen Well	41	30
Town of Erin	Erin Wells 7 and 8	28	10
	Hillsburgh Wells H2 and H3	39	19
	Bel Erin Wells 1 and 2	223	104
Region of Halton	Acton 4th Line Well, Davidson Wells 1 and 2, and Prospect Park Wells 1 and 2	651	346
	Georgetown Lindsay Court Well 9, Princess Anne Wells 5 and 6, and Cedarvale Wells 1a, 3a, 4 and 4a	6,135	4,046
Region of Peel	Alton Wells 3 and 4A	13	12
	Caledon Village Wells 3, 3B and 4	~~2~~10	~~1~~7
	Inglewood Wells 3 and 4	3	3
	Cheltenham Wells 1 and 2	16	6
	Total	**9,9~~45~~53**	**7,11~~2~~8**

Note that since the Pullen Well (Amaranth) and its WHPAs lie within the WHPAs for Orangeville Wells 8B, 8C and Well 12, a number of the threats and affected properties around the Pullen Well are also included in the threats count for Orangeville. Similar overlap occurs within Orangeville (WHPA & ICA), and between Mono's Coles wells and Orangeville Well 10 WHPAs. Given this, the total threat and parcel counts do not represent direct summations of the data shown for the individual municipalities.

To reduce inconsistencies in the approaches used by the various consultants undertaking the threats assessment work, staff in the CTC Source Protection Region participated, along with their consultants, in a series of meetings led by the South Georgian Bay Lake Simcoe Source Protection Region (SGBLS SPR), to develop a common approach to interpreting the provincial direction. The agreements emerging from this process are documented in the report *Reducing Inconsistencies in Threat Subcategory Enumeration* (May 2010), reproduced in **Appendix E2**, and referred to as the *SGBLS Accord*. The SGBLS Accord opted to apply a single threat for handling and storage of fuel in each WHPA with a vulnerability score of 10, unless there was a high probability that natural gas was the primary source of heating fuel. However, the CTC SPC requested that a single threat for handling and storage of fuel oil be assigned to each individual property, unless it could be shown that the property is not using fuel oil.

Prior to 2012, the analyses of threats were mainly restricted to desktop studies with limited field verification of significant threats through windshield surveys. Since then, initial effort aimed at the ground truthing of significant threats in vulnerable zones around municipal wells has been undertaken. The *Technical Rules* require the enumeration (counting, locating) of all significant threats to the quality of the water used as a source of drinking water, in a given vulnerable area. The location and number of moderate and low threats do not have to be reported; only referencing to the provincial tables is required. The *Technical Rules* require that each significant threat within the vulnerable areas be enumerated (identified and counted). As such, drinking water threats were analyzed within the WHPAs, as follows:

- Chemical threats—located within WHPA-A to WHPA-E;
- DNAPL threats—located in WHPA-A, WHPA-B, or WHPA-C/C1 regardless of the risk score, and in WHPA-D, where there is a vulnerability score of 6; and
- Pathogen threats—located within WHPA-A, WHPA-B, and WHPA-E.

5.5.1 County of Dufferin - Town of Orangeville

The Town of Orangeville has a municipal supply comprised of 12 wells. The WHPA delineation and vulnerability assessment processes around these wells are described in **Chapter 4.2**.

The original issues evaluation and threats identification for the town's wells are detailed in the report "Issues Evaluation and Threats Assessment, Town of Orangeville" (R.J. Burnside & Associates Limited, June 2010). This report was subjected to extensive peer review by municipal staff and by the CVC prior to acceptance by the CTC SPC, and inclusion in the Assessment Report. This document contains the foundation technical data and information upon which the summary below has been based.

Since the WHPAs of Orangeville's wells also traverse the land areas of Amaranth, East Garafraxa, Mono, and Caledon. Official Plan land-use maps for these municipalities were also consulted to evaluate the existing and planned land uses within them. Historical aerial photographs from 1951 and 1976 were reviewed to identify land-use changes and potential high-risk activities such as waste disposal sites within the well-capture zones. Aerial photography available to the Town of Orangeville based on 2002 and 2006 Ministry of Natural Resources and Forestry (MNRF) ortho-imagery was also utilized as part of this study.

Threats and Issues

The threats inventory was compiled using the data and information sources outlined in **Appendix E2**. Site-specific verification of drinking water threats was not conducted as part of the original study

- Storage of NASM;
- Application of untreated septage to land;
- Management or handling of agricultural source material (ASM);
- Sewage system or sewage works—septic systems;
- Storage of ASM;
- Storage of commercial fertilizer;
- Storage of snow;
- Waste disposal; and
- The use of land as livestock grazing or pasturing land, an outdoor confinement area, or a farm-animal yard.

The CTC SPC is required to develop policies in the Source Protection Plan to reduce or avoid the threat from such activities if they occur in an ICA for nitrate.

5.5.6 Regional Municipality of Peel - Town of Caledon

The Region of Peel provides municipal water to Caledon through nineeight wells located at Alton, Caledon Village, Inglewood, and Cheltenham. The WHPA delineation and vulnerability assessment processes around the municipal wells are described in **Chapter 4.2**.

The issues evaluation and threats identification exercise originally undertaken within the WHPAs of the wells are detailed in the report "Issues Evaluation and Threats Assessment, Region of Peel" (R.J. Burnside & Associates Limited, May 2010). This report was subjected to extensive peer review by municipal and CVC staff prior to acceptance by the CTC SPC, and inclusion in this Assessment Report. Tables 5.25, 5.26 and 5.27 summarize the technical data and information provided in Burnside and Associates Limited (2010). In preparation for Inglewood Well 4 to be brought on-line in 2019, a desktop exercise to identify existing significant drinking water threats associated with the new drinking water well, was completed. This exercise involved a review of MPAC classification and aerial photography. This exercise added to the number of significant drinking water threats at the Inglewood Drinking Water System.

In July 2019, a desktop exercise was carried out to evaluate the existing significant drinking water threats in the WHPAs delineated for Alton Well 4A. This exercise primarily involved reviewing aerial photography to determine whether a property was residential, commercial/institutional, or agricultural. A list of potential existing significant drinking water threats was generated for use in carrying out a field verification exercise. During the public consultation period which took place between July 25 and September 11, 2019, Region of Peel staff contacted property owners to confirm whether particular activities were actively taking place.

Threats and Issues

The threats inventory was compiled using the data and information sources outlined in **Appendix E1**. Site specific verification of drinking water threats was not conducted as part of the original study by R.J. Burnside & Associates Limited, May 2010. Since 2012, the Region of Peel has undertaken work aimed at ground truthing significant drinking water threats in vulnerable areas around its municipal wells. This work has been detailed in the report "Region of Peel – Verification of Significant Drinking Water Quality Threats (Groundwater)" (R.J. Burnside & Associates Limited, August 2012) and the findings have been used to refine the threat counts in this Assessment Report.

Table 5.24 to **Table 5.27** summarizes the number of significant threats around Peel's wellheads. Details of the evaluation of managed land threats are found in **Appendix E3**.

The areas where threats are or would be low, moderate, or significant for chemicals, DNAPLs and pathogens are shown on **Figure 5.40** through **Figure 5.48**.

- Alton – A total of thirteen significant threats have been identified, which are linked to the handling and storage of DNAPLs (1), sewage disposal systems (3), the application of agricultural source material (5), and livestock grazing/pasturing (4).
- Caledon Village—A total of ~~two~~ten significant threats have been identified, which are linked to the establishment, operation or maintenance of a system that collects, stores, transmits, treats or disposes of sewage (2), the handling and storage of DNAPLs (4~~1~~), and the handling and storage of fuel (4~~1~~).
- Inglewood—A total of 3 significant threats have been identified, and are linked to sewage (1), DNAPLs (1), and the handling and storage of fuel (1).
- Cheltenham—A total of 16 significant threats have been identified, and are linked to agricultural activities (10), waste disposal (2), and the handling and storage of fuel (4).

Septic systems are assumed to be used at all rural homes and buildings outside of the serviced areas of Inglewood. Septic systems that are not properly maintained can contribute to pathogen and chemical contamination in surface and groundwater. MPAC data were used to identify properties that had a building and were not municipally serviced. These parcels were assumed to have a septic system.

Septic effluent disposal systems may contribute nitrate to the groundwater. Many houses in the area may have water softeners due to the hardness of the groundwater. Backwashing softeners during maintenance can introduce high amounts of sodium chloride into septic systems that can also potentially contaminate the groundwater.

No record of status or inspections information for septic systems is available from the municipal records. It is known that septic systems are more likely to deteriorate in performance with age. In the absence of information on the status of these systems, it is assumed that water quality data from the area is indicative of the impact of these sources on the water supply.

The available water quality data (from 1982) were reviewed to assess whether contaminants are impacting or have the potential to impact the quality of water used as the source of the Region's municipal supply. A review of water quality data and information at Peel's wellheads has been presented in **Chapter 2.4**.

Although not identified as an issue under the *Clean Water Act, 2006,* a review of water quality data at the Alton Wells 3 and 4 (decommissioned in 2019) show that sodium (Na) and chloride (Cl) concentrations are generally elevated with respect to the ODWS, suggesting impacts from road salt in the aquifer (**Figure 2.31** and **Figure 2.32**). There is, however, no identifiable increasing trend that would suggest that the concentrations may threaten the use of the wells for water supply in the future. The trends are thought to be reflective of seasonal variations in concentrations.

Conditions

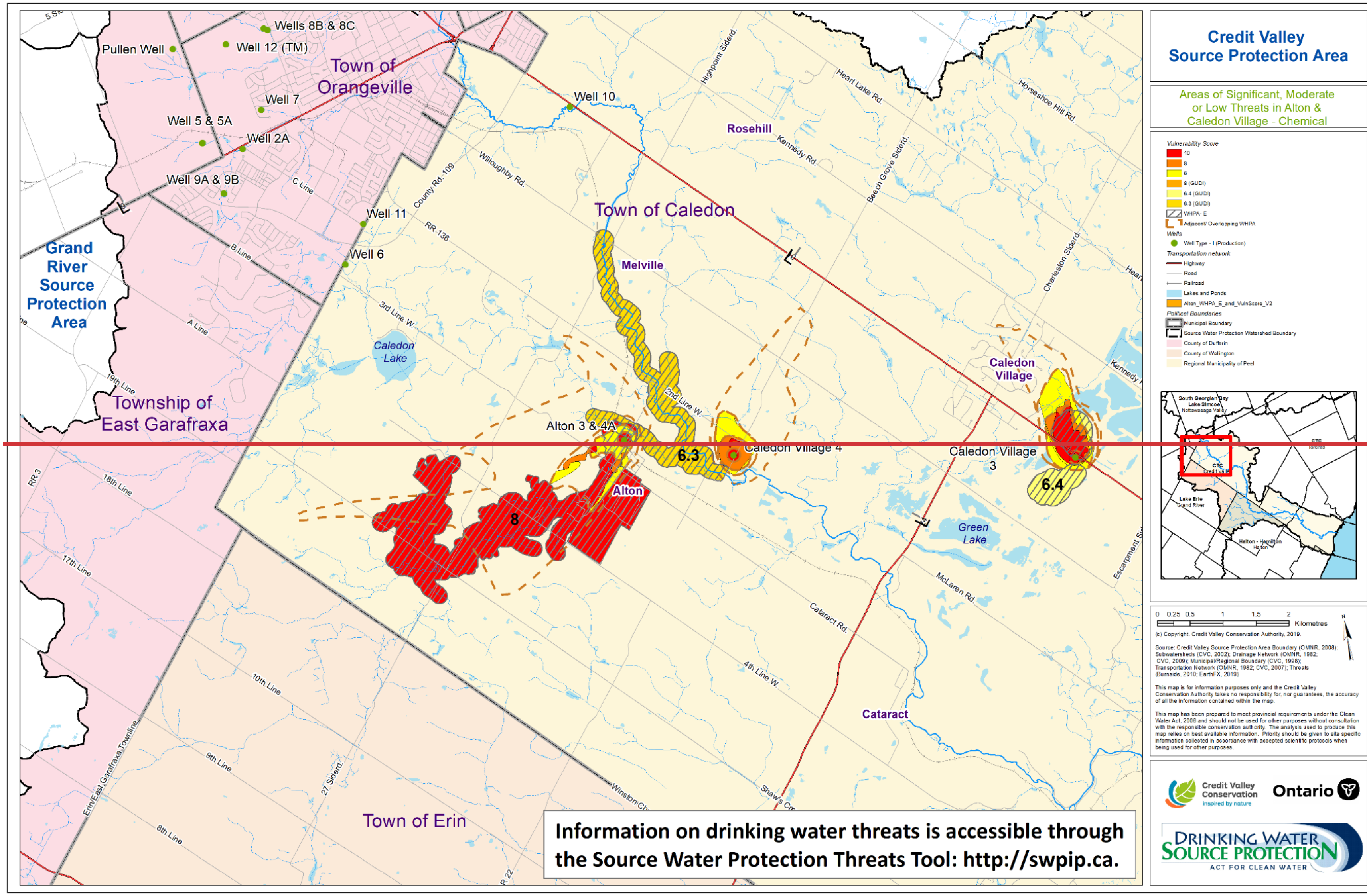
A review of available data and documents was conducted on potential contamination associated with past activities within the WHPAs of Alton, Caledon Village, Inglewood, and Cheltenham. Data available included databases from the Ecolog ERIS results such as Record of Site Condition, MOECC Spills Database and Occurrence Reporting Information System, and MOECC Historical Waste Disposal Sites.

Based on this review, no conditions have been identified within the Peel Region WHPAs.

Table 5.27~~25~~: Town of Caledon (Caledon Village Wellfield)—Enumerated Significant Drinking Water Threats

Activity (or Threat Type)	Threats			
	Significant	Moderate	Low	Total
1) The establishment, operation, or maintenance of a system that collects, stores, transmits, treats or disposes of sewage	0	n/a	n/a	n/a
2) The establishment, operation, or maintenance of a waste disposal site within the meaning of Part V of the *Environmental Protection Act*	2~~0~~	n/a	n/a	n/a
3) The application of agricultural source material to land	0	n/a	n/a	n/a
4) The storage of agricultural source material	0	n/a	n/a	n/a
5) The management of agricultural source material to land		n/a	n/a	n/a
6) The application of non-agricultural source material (NASM) to land	0	n/a	n/a	n/a
7) The handling and storage of non-agricultural source material NASM	0	n/a	n/a	n/a
8) The application of commercial fertilizer	0	n/a	n/a	n/a
9) The handling and storage of commercial fertilizer	0	n/a	n/a	n/a
10) The application of pesticide to land	0	n/a	n/a	n/a
11) The handling and storage of pesticide	0	n/a	n/a	n/a
12) The application of road salt	0	n/a	n/a	n/a
13) The handling and storage of road salt	0	n/a	n/a	n/a
14) The storage of snow	0	n/a	n/a	n/a
15) The handling and storage of fuel	4~~1~~	n/a	n/a	n/a
16) The handling and storage of a dense non-aqueous phase liquid	4~~1~~	n/a	n/a	n/a
17) The handling and storage of an organic solvent	0	n/a	n/a	n/a
18) The management of runoff that contains chemicals used in the de-icing of aircraft	0	n/a	n/a	n/a
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	n/a	n/a	n/a	n/a
20) An activity that reduces the recharge of an aquifer	n/a	n/a	n/a	n/a
21) The use of land as livestock grazing or pasturing land, an outdoor confinement area, or a farm-animal yard.	0	n/a	n/a	n/a
Total Threats	**10~~2~~**	**n/a**	**n/a**	**n/a**
Total Parcels	**7~~1~~**	**n/a**	**n/a**	**n/a**

n/a - not required by the MOECC


Credit Valley
Source Protection Area
Areas of Significant, Moderate or Low Threats in Alton & Caledon Village - Chemical
Town of Orangeville
Town of Caledon
Grand River Source Protection Area
Township of East Garafraxa
Town of Erin
Wells 8B & 8C
Well 12 (TM)
Pullen Well
Well 7
Well 5 & 5A
Well 2A
Well 9A & 9B
Well 11
Well 6
Well 10
Rosehill
Melville
Caledon Lake
Alton 3 & 4A
Alton
Caledon Village 4
Caledon Village 3
Caledon Village
Green Lake
Cataract
6.3
6.4
8
Information on drinking water threats is accessible through the Source Water Protection Threats Tool: http://swpip.ca.
Credit Valley Conservation
Ontario
Drinking Water Source Protection
Act for Clean Water

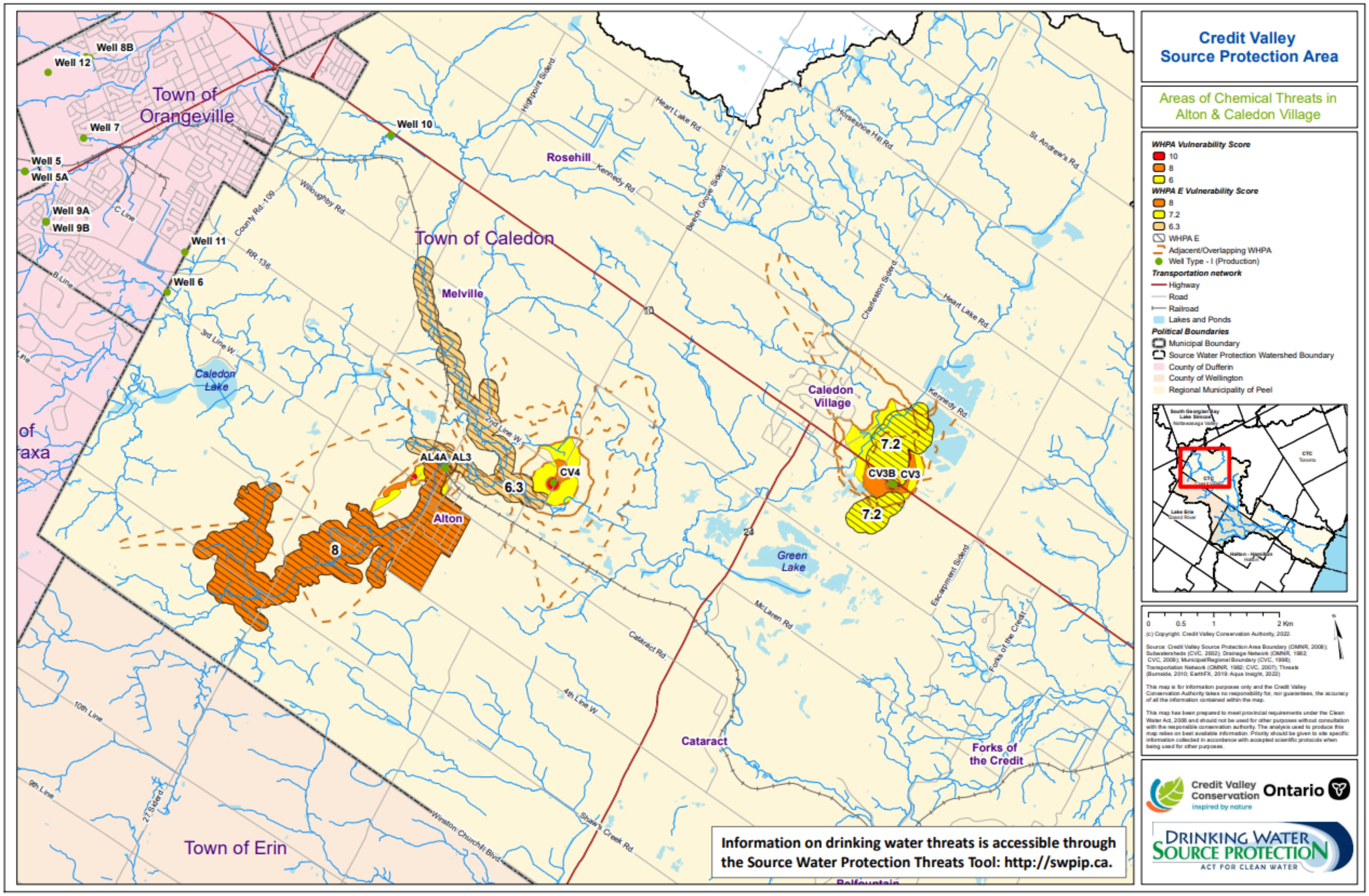
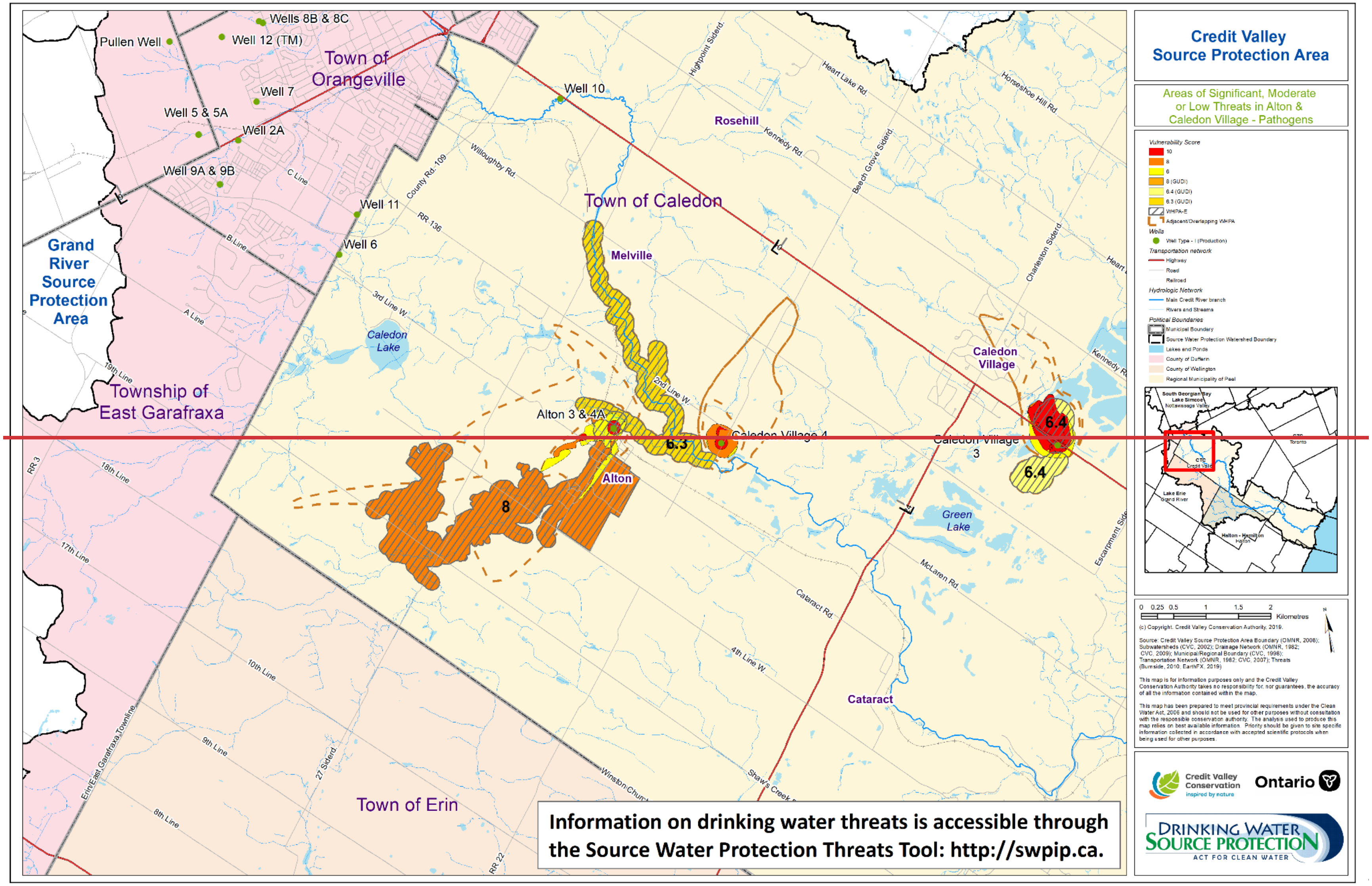


Figure 5.37: Areas of Significant, Moderate or Low Threats at Caledon Village – Alton Drinking Water Systems – Chemicals

The current Provincial Table of Drinking Water Threats can be accessed at http://swpip.ca/


Credit Valley Source Protection Area
Areas of Significant, Moderate or Low Threats in Alton & Caledon Village - Pathogens
Town of Orangeville
Town of Caledon
Township of East Garafraxa
Town of Erin
Grand River Source Protection Area
Wells 8B & 8C
Well 12 (TM)
Pullen Well
Well 7
Well 5 & 5A
Well 2A
Well 9A & 9B
Well 10
Well 11
Well 6
Alton 3 & 4A
Caledon Village 4
Caledon Village 3
Rosehill
Melville
Alton
Caledon Village
Cataract
Caledon Lake
Green Lake
6.4
6.3
8
Information on drinking water threats is accessible through the Source Water Protection Threats Tool: http://swpip.ca.
Kilometres
Ontario
DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER
Credit Valley Conservation

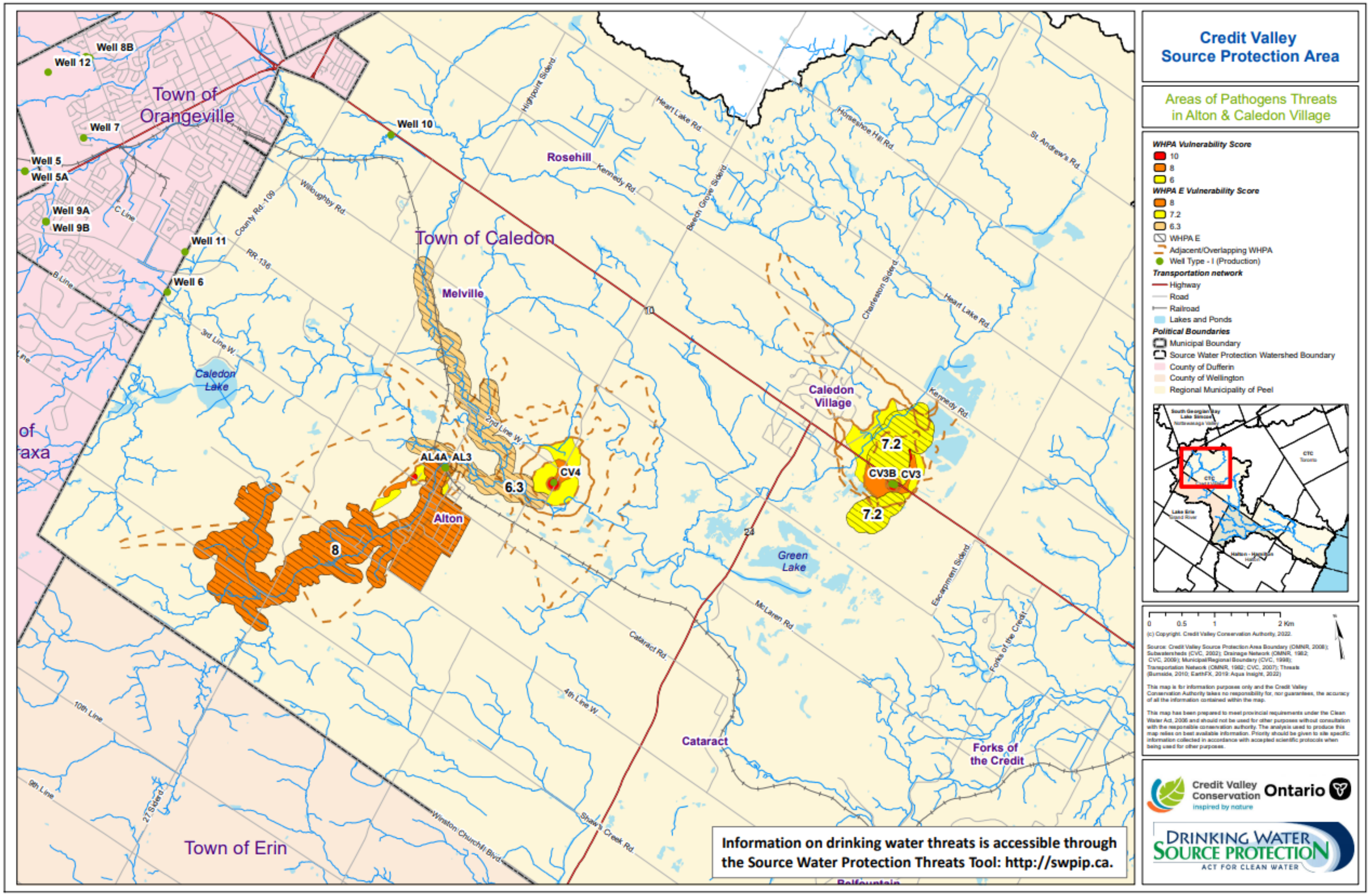
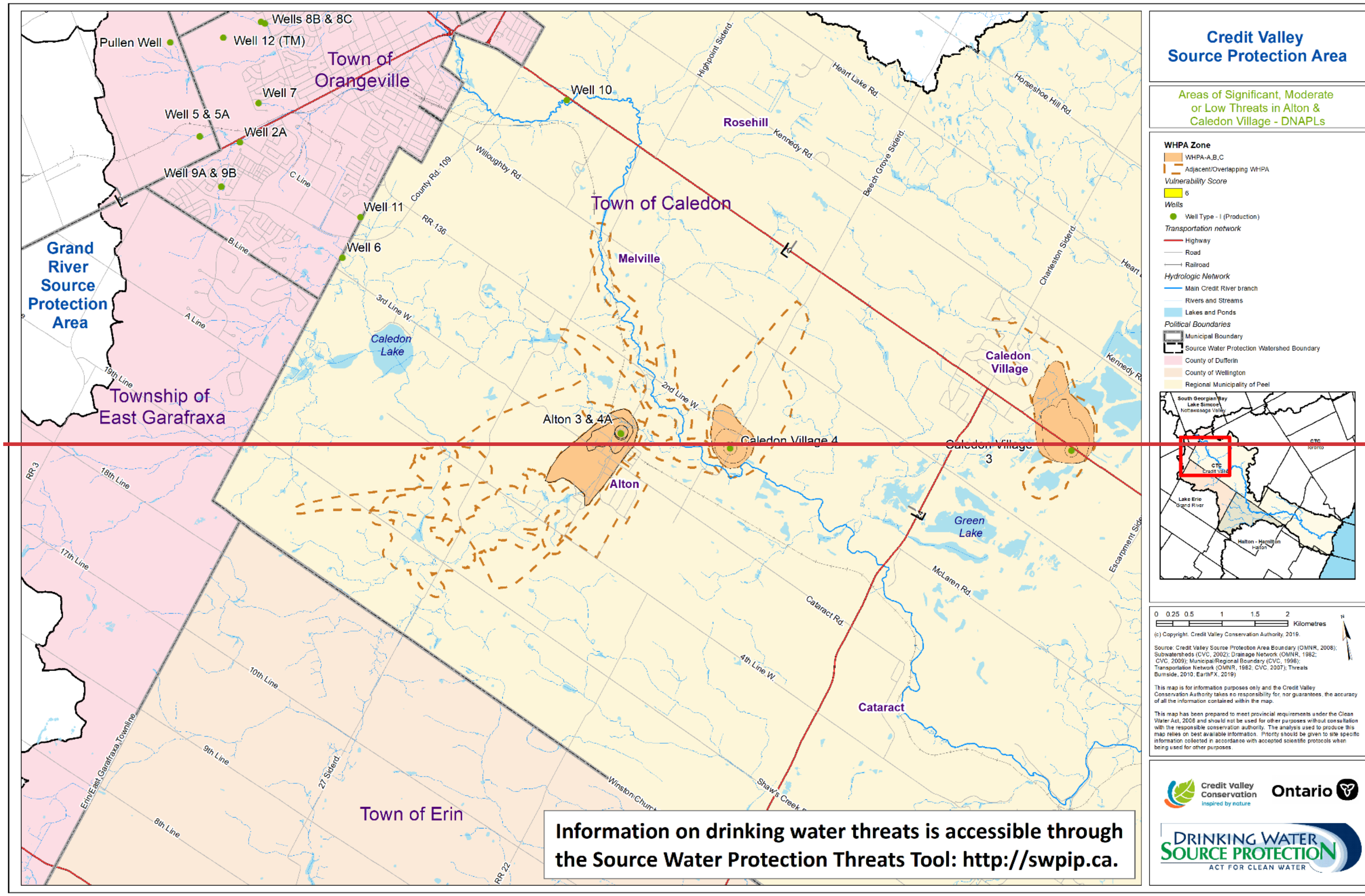


Figure 5.38: Areas of Significant, Moderate or Low Threats at Caledon Village - Alton Drinking Water Systems – Pathogens

The current Provincial Table of Drinking Water Threats can be accessed at http://swpip.ca/


Credit Valley Source Protection Area
Areas of Significant, Moderate or Low Threats in Alton & Caledon Village - DNAPLs
Town of Orangeville
Town of Caledon
Township of East Garafraxa
Town of Erin
Grand River Source Protection Area
Alton 3 & 4A
Caledon Village 4
Caledon Village 3
Well 10
Well 11
Well 6
Information on drinking water threats is accessible through the Source Water Protection Threats Tool: http://swpip.ca.

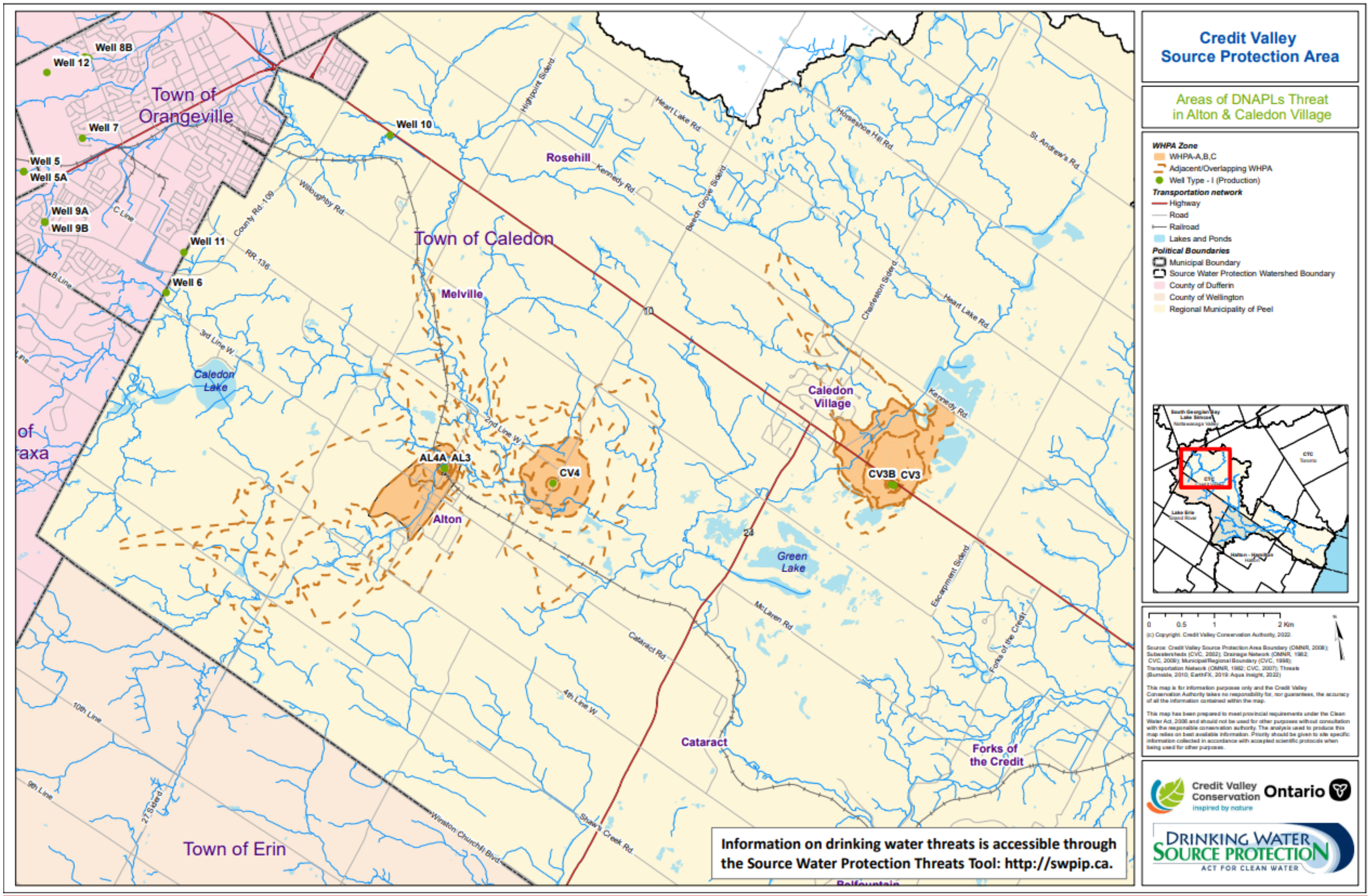


Figure 5.39: Areas of Significant, Moderate or Low Threats at Caledon Village – Alton Drinking Water Systems – DNAPLs

The current Provincial Table of Drinking Water Threats can be accessed at http://swpip.ca/

5.7.6 Threats from Activities in Intake Protection Zones

Threshold: A contaminant concentration above which the raw water quality could be considered to be impaired. A description of the individual thresholds that were used is provided in **Appendix E7**.

The *Technical Rules* stipulate that event based modelling can be used to identify whether spills from existing facilities, such as bulk petroleum storage facilities, wastewater treatment plants (WWTP), and industrial chemical facilities, are significant threats to nearby WTP intakes.

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 *Technical Rules* require an IPZ-3 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. The key *Technical Rules* and the *MOECC's Technical Bulletin: Delineation of Intake Protection Zone 3 Using Event Based Approach (EBA)*, dated July 2009, describes the process for delineating the IPZ-3. These are described below:

- *Rule (68)*: If … modelling or other methods demonstrate that contaminants … may be transported to a Type A intake … an area known as IPZ-3 shall be delineated;
- *Rule (69)*: the area delineated shall not exceed the area that may contribute water during or as a result of an extreme event;
- *Rule (130)*: An activity is or would be a significant drinking water threat in an IPZ, if modelling demonstrates that a release of a chemical parameter or pathogen would be transported to the intake and result in deterioration of the water as a drinking water source;
- Guidance from the MOE identified that *Rule (68)* prescribes that an IPZ-3 must be delineated if a spill may result in deterioration of the water supply; and
- The intent of *Rules (68)* and (*130)* was to identify the location and type of activity of concern and based on an understanding of that type of activity, contaminants of concern, and potential spill volume. This was referred to as an Events Based Approach, which may be used to determine whether or not an IPZ-3 should be delineated.

Modelling Approach

The LOC developed a list of existing land use activities near and along the shoreline of Lake Ontario that were of concern if a spill from each location were to occur. The spill characteristics for each modelling scenario (volume, release mechanism, release rate, concentration, and other variables) were determined by the LOC modelling team with input from industry and municipal representatives.

Where concentrations predicted at an intake exceeded the threshold, the land use activity was identified as a significant threat and an IPZ-3 was delineated to identify the contaminant travel path to the intake.

If spill scenario modelling results indicate that a spill/release from an existing facility has the potential to impact a WTP (basically reach an intake) at a level that a WTP needs to shut down, then that facility is automatically identified as a significant drinking water threat activity. There is no limitation based on the time of travel within the event based modelling methodology.

A list of proposed spill scenario simulations for existing facilities was developed in concurrence with municipal partners, source protection committees, and MOECC. The following criteria were used:

- The location and possible materials released under normal operation and spill scenarios;
- Conditions under which contaminants could reach drinking water intakes;
- Predicted concentration of key parameters at the intake*;* and
- Evaluation of historical raw water analyses at drinking water plants to assess whether there are observed elevations of parameters that may be linked to storm events or past spill or weather conditions

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;
- Combined Sewer Overflow (CSO) release in the City of Toronto to evaluate the potential effects to the Toronto WTPs (this did not impact any CVSPA intakes);
- Sanitary Trunk Sewer (STS) breaks within Toronto area creeks;
- Spill of gasoline/refined product from large pipelines located under major tributaries to Lake Ontario (e.g., Credit River, Humber River, etc.);
- Release of gasoline from a bulk petroleum fuel storage and handling facilities in the Keele/Finch area of Toronto and in the Mississauga – Oakville area; and
- Discharge of tritium from nuclear generating plants at Pickering and Darlington (this did not impact any CVSPA intakes).

The selected LOC spill scenarios are based on real events that have occurred in the past and, as such, are not representative of extreme events. For example, the pipeline spill scenario events used for the LOC is based on the Enbridge pipeline rupture event that occurred near Kalamazoo, Michigan during the summer of 2010. Details on the spill scenario characteristics and how the model (MIKE-3) was calibrated and validated are provided in **Appendix E5**. The MIKE-3 model uses the full three-dimensional representation of water motion. It simulates the seasonal temperature conditions and summer stratification that affects the circulation pattern in Lake Ontario, which is required for accurate predictions of water currents.

The identification of significant threats did not consider any regulated risk management requirements. Current risk management measures and the adequacy of existing regulatory requirements will be considered in the development of the Source Protection Plan. Source protection plans are required to reduce or eliminate threats to drinking water.

The spill scenarios that were modelled for the Lake Ontario intakes are summarized in **Table 5.38** below and described in the text following the table. **Table 5.39** presents all of the scenarios that were modelled for the CTC Source Protection Region.

Table 5.4038: Lake Ontario Model Spill Scenarios

Spill Scenario Details			Contaminant of Concern
Type	**Location**	**Volume and Duration of Spill**	
Disinfection Failure at WWTP	Mid-Halton WWTP S.W. Halton WWTP S. E. Halton WWTP Clarkson WWTP G.E. Booth WWTP Humber WWTP Ashbridges Bay WWTP1 Ashbridges Bay WWTP2* Highland Creek WWTP Duffins Creek WWTP Wellington WWTP Corbett Creek WWTP Harmony Creek WWTP Courtice WWTP	Disinfection failure at the plant, leading to a release of *E. coli* at a level of 5,000,000/100mL for a two-day period between April and August.	*E. coli*
Sanitary Trunk Sewer (STS) Breaks	Sanitary trunk sewer breaks from pipes located within 120 meters or regulated limit of the main tributaries along the Toronto Waterfront (Etobicoke Creek, Humber River, Highland Creek and Don River) up to and including location of first lateral sewer connection upriver from the mouth	Actual density of *E. coli* (1,000,000 CU/100ml) measured downstream of the Aug. 19, 2005 event in Highland Creek was used to model impact. Simulated spills to each of the other tributaries assumed release of 50% of their design flow at an *E. coli* density of 5,000,000 CFU/100ml; all simulated for 24-hour spill duration.	*E. coli*
Combined sewer overflow (CSO)	Toronto Inner Harbour	Continuous simulation of actual conditions April 1, 2007 to October 31, 2008.	*E. coli*
Lagoon Spill	Industrial Processing Facility on the Credit River	52,800$m^{3,}$ with *E. coli* concentration at 5,000, 000/100mL, 24-hour duration.	*E. coli*
Petroleum (gasoline) Pipeline Break	16 Mile Creek Joshua Creek Credit River Etobicoke Creek Humber River Don River Highland Creek Rouge River Petticoat Creek Duffins Creek Carruthers Creek Lynde Creek Oshawa Creek Bowmanville Creek Wilmot Creek Graham Creek Ganaraska River Cobourg Creek	Spill of 2,700 m^3 of gasoline containing 1% benzene, 6-hour duration.	Benzene

Spill Scenario Details			Contaminant of Concern
Type	Location	Volume and Duration of Spill	
Bulk Petroleum (gasoline) Release	Bulk petroleum storage and handling facilities in Oakville and North York	260,000 litre benzene spill under easterly and westerly wind conditions, 6 hour duration. Three, 15-minute spills, volume ranging from 200 to 1000 litres of benzene under a variety of meteorological conditions.	Benzene
Tritium Release	Pickering Nuclear Facility	2900 kg of tritiated water discharged over a period of 6 hours at a concentration of 7.9 $x10^{11}$ Bq/L (i.e., the estimated total amount of tritium activity released was $2.3x10^{15}$ Bq).	Tritium
Tritium Release	Darlington Nuclear Facility	2900 kg of tritiated water discharged over a period of 6 hours at a concentration of 7.9 $x10^{11}$ Bq/L (i.e., the estimated total amount of tritium activity released was $2.3x10^{15}$ Bq).	Tritium

*New outfall modelled to select intakes only (from Toronto Background Brief 2022)

Wastewater Treatment Plant Disinfection Failure

Modelling scenarios were undertaken to determine if disinfection failures at wastewater treatment plants would cause deterioration of the quality of raw water for drinking water purposes for the CVSPA WTPs. The modelled parameter of concern for these scenarios was *E. coli* and the recreational standard for *E. coli* of 100 CFU/100ml was used as the threshold to assess deterioration of the quality of water. Normally the measured *E. coli* levels in the raw water in the vicinity of these intakes is less than 1 CFU/100 ml. The simulation date for this modelling was April 25 to August 31, 2008, using wind data from the Pearson Airport. Note that these weather conditions were not extreme event conditions, but daily conditions that occurred within the simulation period window. Each WWTP was simulated at the Certificate of Approval flow rate, and *E. coli* levels within the discharge were set constant at 5,000,000 CFU/100 ml. The decay of *E. coli* was taken into consideration for the modelling. The Lake Ontario version of MIKE-3 was used to model the contaminant pathway within Lake Ontario and determine the concentrations of the contaminant at the intakes.

Sanitary Trunk Sewer Breaks

A series of scenarios were modelled to determine if simultaneous trunk sewer breaks near Lake Ontario across the Toronto shoreline would cause deterioration of the quality of water at the CVSPA intakes. Although there are trunk sewers near Lake Ontario in other municipalities within the CTC that may be threats, these have not been assessed to date.

Four trunk sewer break locations were modelled during this exercise. The sewer breaks were considered to occur where the trunk sewer was located within the tributary valley out to the greater of the regulated limit, or 120 metres of the top of bank and between the WWTP upriver to the first lateral connection to the trunk sewer. Within this area, the maximum amount of wastewater would be present in the pipe and the time of travel to the lake would be less than two hours. The trunk sewer flow was estimated at 50% of the design flow of each WWTP.

in the lake are complex and not one-directional. Further details regarding these points are included in **Appendix E5**.

The modelling results for the event-based modelling are summarized below. **Table 5.39** shows all of the modelled scenarios that result in significant drinking water threats to the CVSPA intakes, as well as spill scenarios located in CVSPA that result in significant drinking water threats in adjacent source protection areas. Further details are provided in the **Appendix E5**. **Table 5.38** outlines the results where the model scenarios predict that an activity will be a significant drinking water threat, including:

- Threats located within the CVSPA that are a significant threat to intakes located within the CVSPA (three unique threats to two intakes); and
- Threats located outside of the CVSPA that are a significant threat to intakes located within the CVSPA (eighteen unique threats to two intakes).

Table 5.4139: Modelling Results Identifying Significant Drinking Water Threats Affecting CVSPA

SPR/SPA	WTP	Spill Model Scenario	Spill Location	Parameter of Concern	Water Quality Threshold	Concentration at the Intake	Significant Threat
Halton-Hamilton/ Halton SPA	Burlington	Clarkson WWTP Disinfection failure	IPZ-3 CVSPA	*E. coli*	100 cfu/100 mL	623	yes
	Burloak	Clarkson WWTP Disinfection failure	IPZ-3 CVSPA	*E. coli*	100 cfu/100 mL	889	yes
		G.E. Booth WWTP disinfection failure	IPZ-2 CVSPA	*E. coli*		1,000	yes
	Oakville	Clarkson WWTP Disinfection failure	IPZ-3 CVSPA	*E. coli*	100 cfu/100 mL	9950	yes
		G.E. Booth WWTP disinfection failure	IPZ-2 CVSPA	*E. coli*		3,070	yes
CTC/CVSPA	Lorne Park	S.W. Halton WWTP disinfection failure	IPZ-2 HSPA	*E. coli*	100 cfu/100 mL	216	yes
		Mid-Halton WWTP disinfection failure	IPZ-2 HSPA	*E. coli*		248	yes
		S.E. Halton WWTP Disinfection failure	IPZ-2 HHSPA	*E. coli*		539	yes
		Clarkson WWTP Disinfection failure	IPZ-3 CVSPA	*E. coli*		5600	yes
		G.E. Booth WWTP disinfection failure	IPZ-2 CVSPA	*E. coli*		38,000	yes
		Humber River WWTP disinfection failure	IPZ-3 TRSPA	*E. coli*		734	yes
		Ashbridges Bay WWTP1 disinfection failure	IPZ-3 TRSPA	*E. coli*		756	yes
		Ashbridges Bay WWTP2 disinfection failure	IPZ-3 TRSPA	*E. coli*		†	yes
		Etobicoke Creek STS break	IPZ-3 TRSPA	*E. coli*	100 cfu/100 mL	367	yes
		16 Mile Creek pipeline break	IPZ-3 HSPA	Benzene	0.005 mg/L	0.42	yes

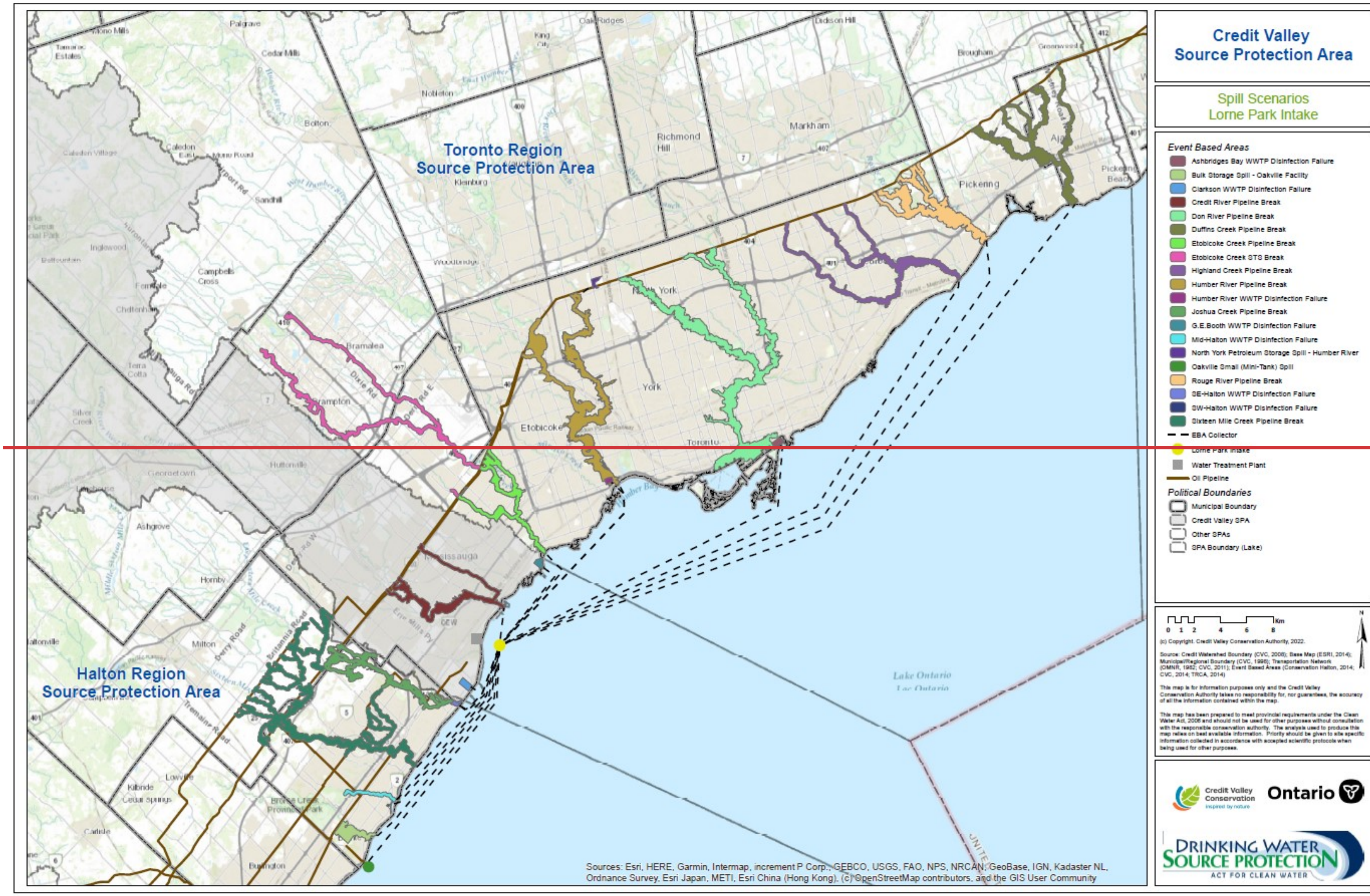
SPR/SPA	WTP	Spill Model Scenario	Spill Location	Parameter of Concern	Water Quality Threshold	Concentration at the Intake	Significant Threat
CTC/CVSPA	Lorne Park	Joshua Creek pipeline break	IPZ-3 HSPA	Benzene	0.005 mg/L	0.065	yes
		Credit River pipeline break	IPZ-3 CVSPA	Benzene		2.4	yes
		Etobicoke Creek pipeline break	IPZ-3 TRSPA	Benzene		0.006	yes
		Humber River pipeline break	IPZ-3 TRSPA	Benzene		0.15	yes
		Don River pipeline break	IPZ-3 TRSPA	Benzene		0.014	yes
		Highland Creek pipeline break	IPZ-3 TRSPA	Benzene		0.01	yes
		Rouge River pipeline break	IPZ-3 TRSPA	Benzene		0.008	yes
		Duffins Creek pipeline break	IPZ-3 TRSPA	Benzene		0.009	yes
		Bulk storage spill, Oakville facility*	IPZ-2 HSPA	Benzene		1.25	yes
		Small (mini tank) Spills -15 min duration	IPZ-2 HSPA	Benzene		0.0068	yes
		North York Petroleum Storage Spill via Humber River	IPZ-3 TRSPA	Benzene		0.078	yes

SPR/SPA	WTP	Spill Model Scenario	Spill Location	Parameter of Concern	Water Quality Threshold	Concentration at the Intake	Significant Threat
CTC/CVSPA	Arthur P. Kennedy	Clarkson WWTP Disinfection failure	IPZ-3 CVSPA	*E. coli*	100 cfu/100 mL	1,426	yes
		G.E. Booth WWTP disinfection failure	IPZ-2 CVSPA	*E. coli*		83,800	yes
		Humber River WWTP disinfection failure	IPZ-3 TRSPA	*E. coli*		2,906	yes
		Ashbridges Bay WWTP1 1disinfection failure	IPZ-3 TRSPA	*E. coli*		780	yes
		Ashbridges Bay WWTP2 disinfection failure	IPZ-3 TRSPA	*E. coli*		†	yes
		Etobicoke Creek STS break	IPZ-3 TRSPA	*E. coli*		183	yes
		Humber River STS break	IPZ-3 TRSPA	*E. coli*		110	yes
		16 Mile Creek pipeline break	IPZ-3 HSPA	Benzene	0.005 mg/L	0.146	yes
		Joshua Creek pipeline break	IPZ-3 HSPA	Benzene		0.007	yes
		Credit River pipeline break	IPZ-3 CVSPA	Benzene		0.37	yes
		Etobicoke Creek pipeline break	IPZ-3 TRSPA	Benzene		0.0057	yes
		Humber River pipeline break	IPZ-3 TRSPA	Benzene		0.30	yes
		Don River pipeline break	IPZ-3 TRSPA	Benzene		0.023	yes
		Highland Creek pipeline break	IPZ-3 TRSPA	Benzene		0.012	yes
		Rouge River pipeline break	IPZ-3 TRSPA	Benzene		0.009	yes
		Duffins Creek pipeline break	IPZ-3 TRSPA	Benzene		0.011	yes
		Bulk storage spill, Oakville facility*	IPZ-2 HSPA	Benzene		0.5	yes
		North York Petroleum Storage Spill via Humber River	IPZ-3 TRSPA	Benzene		0.31	yes

SPR/SPA	WTP	Spill Model Scenario	Spill Location	Parameter of Concern	Water Quality Threshold	Concentration at the Intake	Significant Threat
CTC/TRSPA	R.L. Clark	G.E. Booth WWTP disinfection failure	IPZ-2 CVSPA	*E. coli*	100 cfu/100 mL	55,600	yes
		Clarkson WWTP Disinfection failure	IPZ-3 CVSPA	*E. coli*		1,400	yes
		Credit River Pipeline Break	IPZ-3 CVSPA	Benzene	0.005 mg/L	0.15	yes
	R.C. Harris	G.E. Booth WWTP disinfection failure	IPZ-2 CVSPA	*E. coli*	100 cfu/100 mL	110	yes

**The modelling scenario for the Oakville bulk fuel storage assumed that the spill would reach Lake Ontario via Bronte Creek. The Halton-Hamilton Source Protection Committee has determined that a spill may take another route to reach the lake. Further assessment will be undertaken in the future when funding is available, but it is most likely that modelled results would still be a significant drinking water threat.*

†The City of Toronto is building a new Ashbridges Bay Treatment Plant (ABTP) outfall (WWTP2) that is further from the lakeshore than the current outfall~~, the current intake~~ with increased capacity and greater diffusion capability~~ further from the lakeshore~~ (note that the current outfall~~intake~~ will be maintained for emergency use). The existing outfall was assessed as being a significant drinking water threat to the Lorne Park and Arthur P. Kennedy Intakes through the initial Lake Ontario lake-wide modelling work for the 2015 Assessment Report. A focused lake modelling study was conducted for this new ABTP outfall and the results indicate that E. ~~C~~coli densities at the Lorne Park and Arthur P. Kennedy Intakes are similar to those assessed for the existing ABTP outfall, so therefore no changes are required to the existing results.


Credit Valley Source Protection Area
Spill Scenarios Lorne Park Intake
Toronto Region Source Protection Area
Halton Region Source Protection Area
Lake Ontario
Event Based Areas
Ashbridges Bay WWTP Disinfection Failure
Bulk Storage Spill - Oakville Facility
Clarkson WWTP Disinfection Failure
Credit River Pipeline Break
Don River Pipeline Break
Duffins Creek Pipeline Break
Etobicoke Creek Pipeline Break
Etobicoke Creek STS Break
Highland Creek Pipeline Break
Humber River Pipeline Break
Humber River WWTP Disinfection Failure
Joshua Creek Pipeline Break
G.E.Booth WWTP Disinfection Failure
Mid-Halton WWTP Disinfection Failure
North York Petroleum Storage Spill - Humber River
Oakville Small (Mini-Tank) Spill
Rouge River Pipeline Break
SE-Halton WWTP Disinfection Failure
SW-Halton WWTP Disinfection Failure
Sixteen Mile Creek Pipeline Break
EBA Collector
Lorne Park Intake
Water Treatment Plant
Oil Pipeline
Political Boundaries
Municipal Boundary
Credit Valley SPA
Other SPAs
SPA Boundary (Lake)
Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community
Ontario
DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER

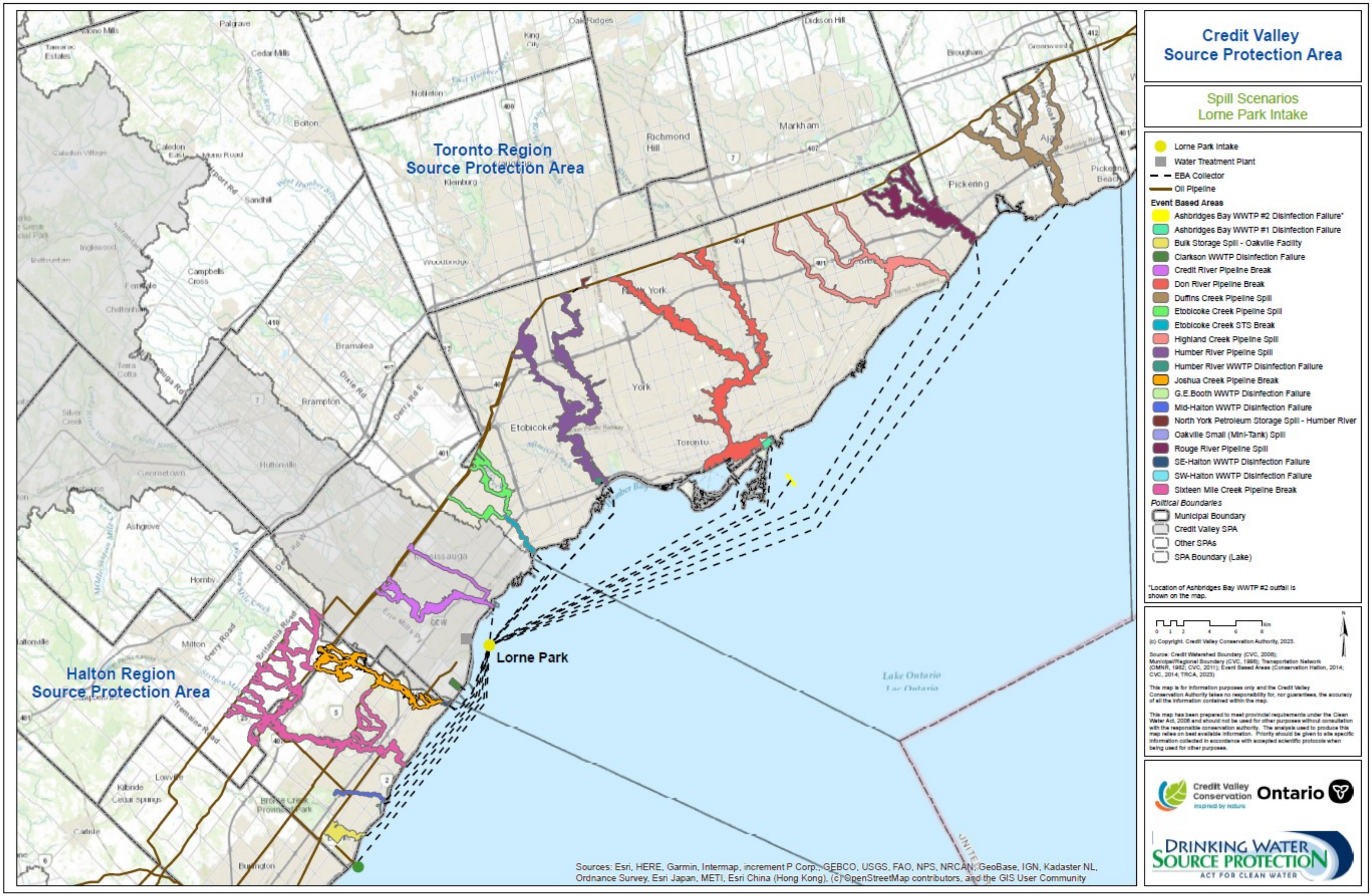
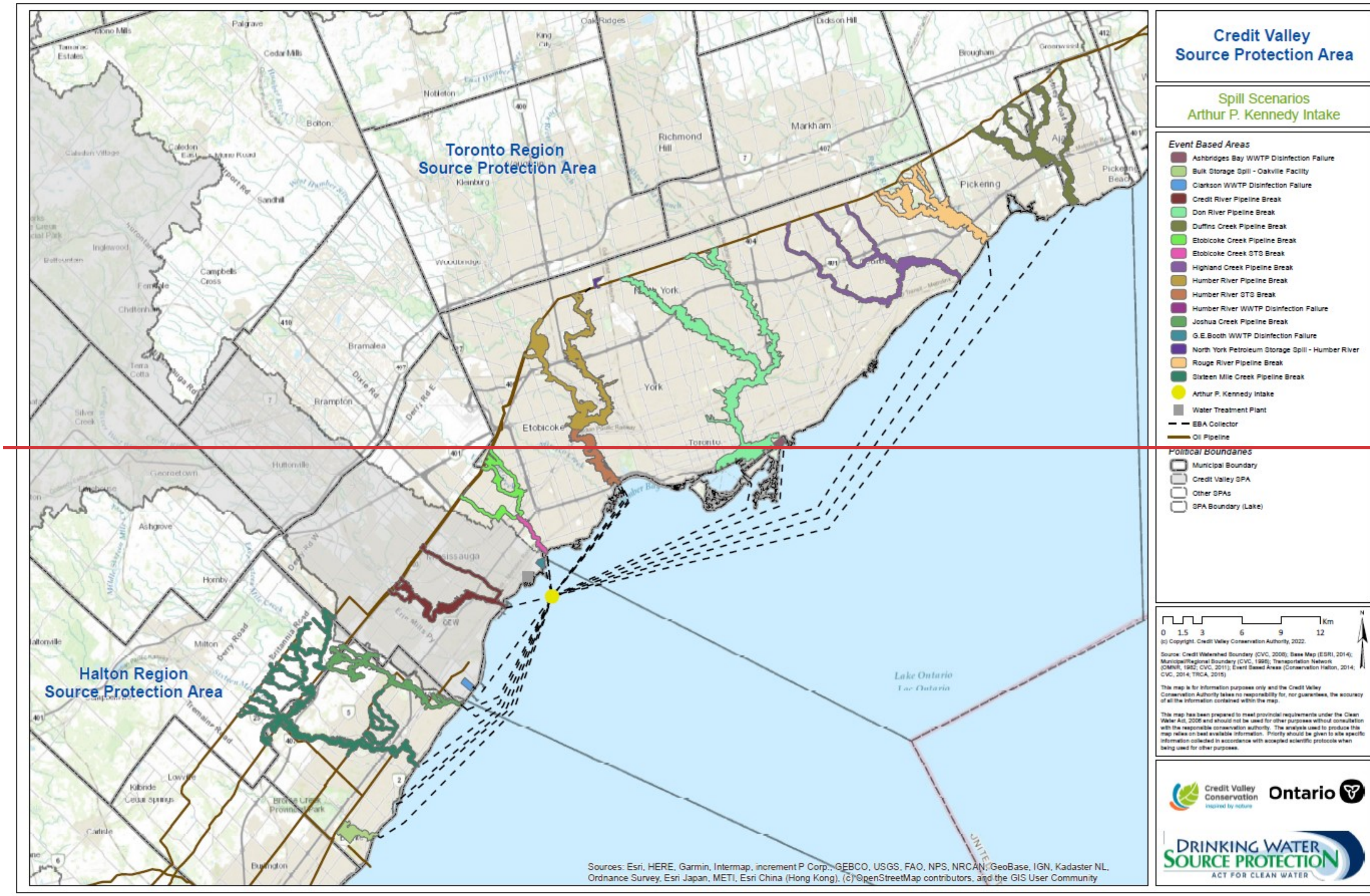


Figure 5.51: Spill Scenarios Lorne Park Intake


Credit Valley Source Protection Area
Spill Scenarios
Arthur P. Kennedy Intake
Event Based Areas
Ashbridges Bay WWTP Disinfection Failure
Bulk Storage Spill - Oakville Facility
Clarkson WWTP Disinfection Failure
Credit River Pipeline Break
Don River Pipeline Break
Duffins Creek Pipeline Break
Etobicoke Creek Pipeline Break
Etobicoke Creek STS Break
Highland Creek Pipeline Break
Humber River Pipeline Break
Humber River STS Break
Humber River WWTP Disinfection Failure
Joshua Creek Pipeline Break
G.E.Booth WWTP Disinfection Failure
North York Petroleum Storage Spill - Humber River
Rouge River Pipeline Break
Sixteen Mile Creek Pipeline Break
Arthur P. Kennedy Intake
Water Treatment Plant
EBA Collector
Oil Pipeline
Political Boundaries
Municipal Boundary
Credit Valley SPA
Other SPAs
SPA Boundary (Lake)
Toronto Region
Source Protection Area
Halton Region
Source Protection Area
Lake Ontario
Markham
Pickering
Richmond Hill
Etobicoke
Toronto
York
Brampton
Mississauga
Milton
Burlington
Km
0 1.5 3 6 9 12
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Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community
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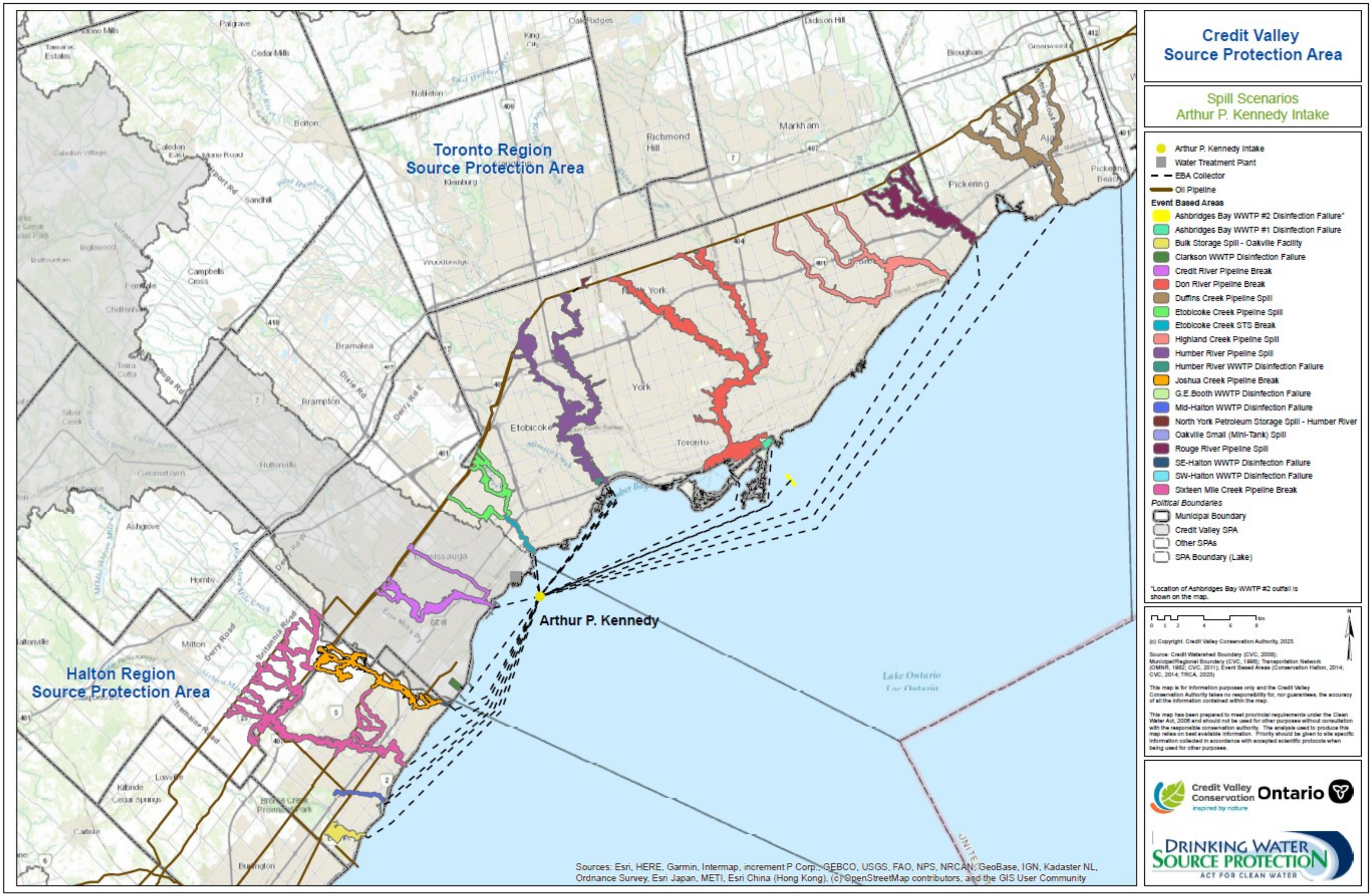
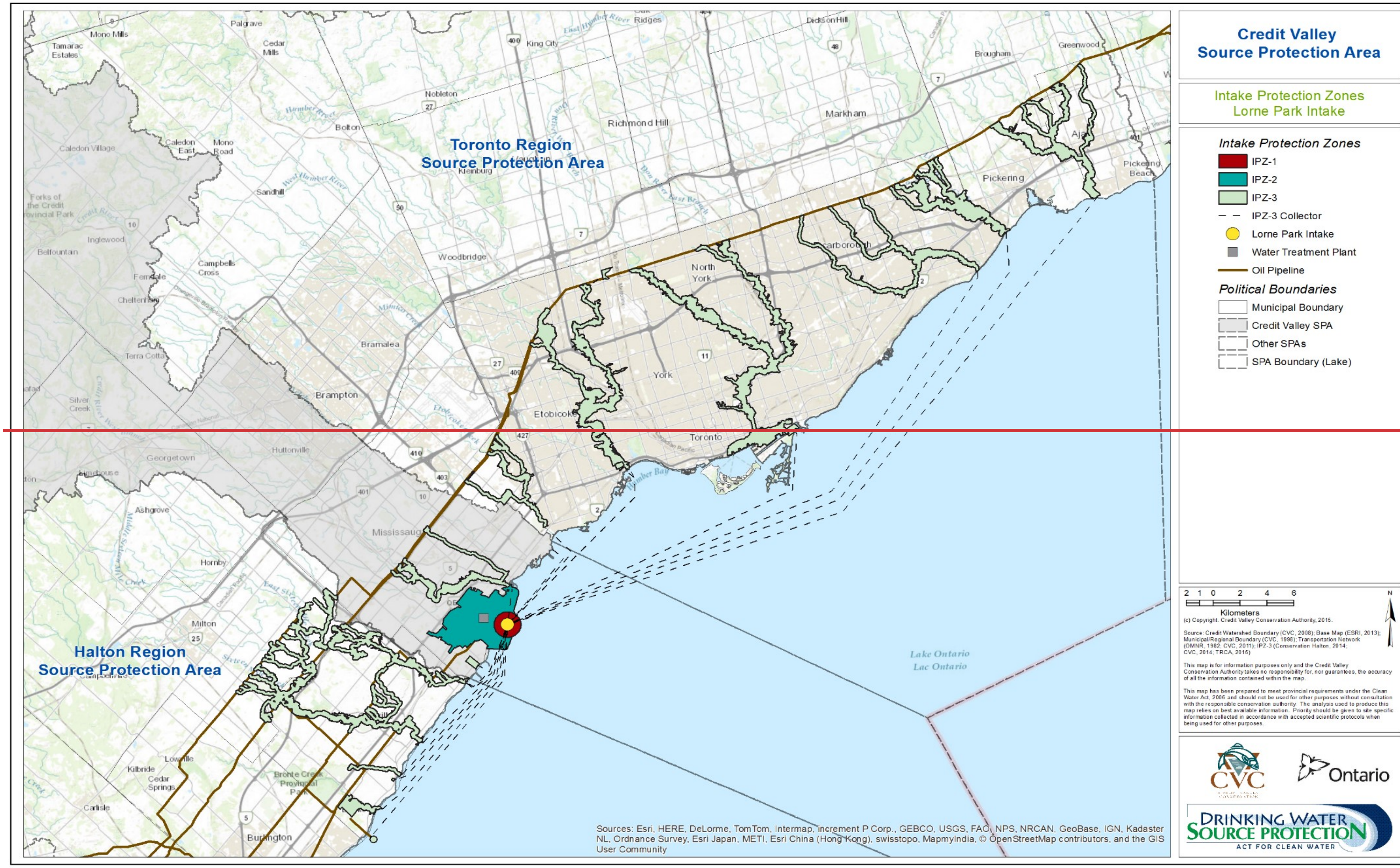


Figure 5.52: Spill Scenarios Arthur P. Kennedy (formerly Lakeview) Intake


Credit Valley
Source Protection Area
Intake Protection Zones
Lorne Park Intake
Intake Protection Zones
IPZ-1
IPZ-2
IPZ-3
IPZ-3 Collector
Lorne Park Intake
Water Treatment Plant
Oil Pipeline
Political Boundaries
Municipal Boundary
Credit Valley SPA
Other SPAs
SPA Boundary (Lake)
Kilometers
Toronto Region
Source Protection Area
Halton Region
Source Protection Area
Lake Ontario
Lac Ontario
Toronto
Mississauga
Brampton
Etobicoke
North York
York
Scarborough
Markham
Richmond Hill
Pickering
Woodbridge
Bramalea
Milton
Burlington
Georgetown
Sources: Esri, HERE, DeLorme, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community
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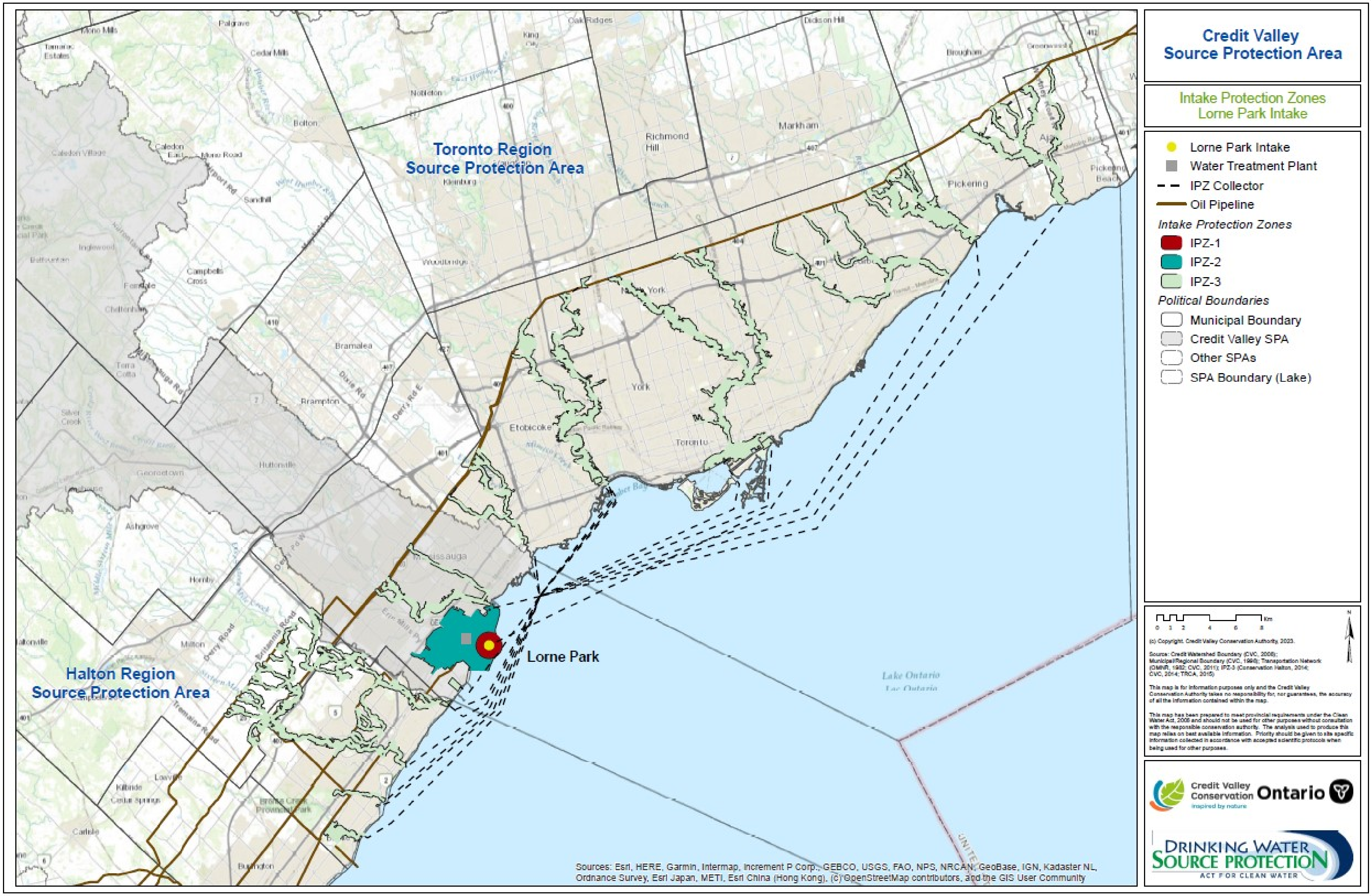
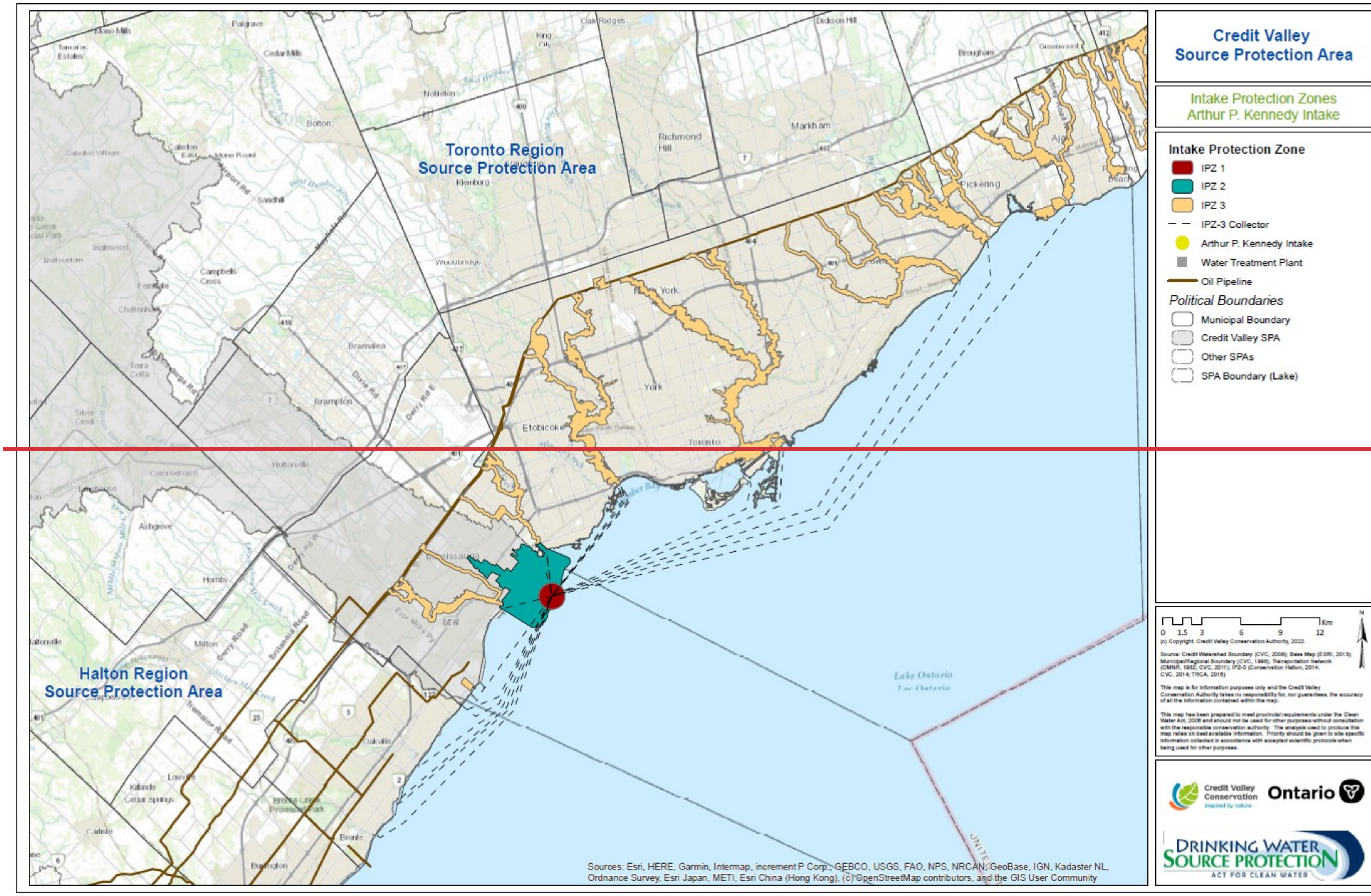


Figure 5.55: Intake Protection Zone Lorne Park Intake


Credit Valley
Source Protection Area
Intake Protection Zones
Arthur P. Kennedy Intake
Intake Protection Zone
IPZ 1
IPZ 2
IPZ 3
IPZ-3 Collector
Arthur P. Kennedy Intake
Water Treatment Plant
Oil Pipeline
Political Boundaries
Municipal Boundary
Credit Valley SPA
Other SPAs
SPA Boundary (Lake)
Toronto Region
Source Protection Area
Halton Region
Source Protection Area
Lake Ontario
Km
0 1.5 3 6 9 12
Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community
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SOURCE PROTECTION
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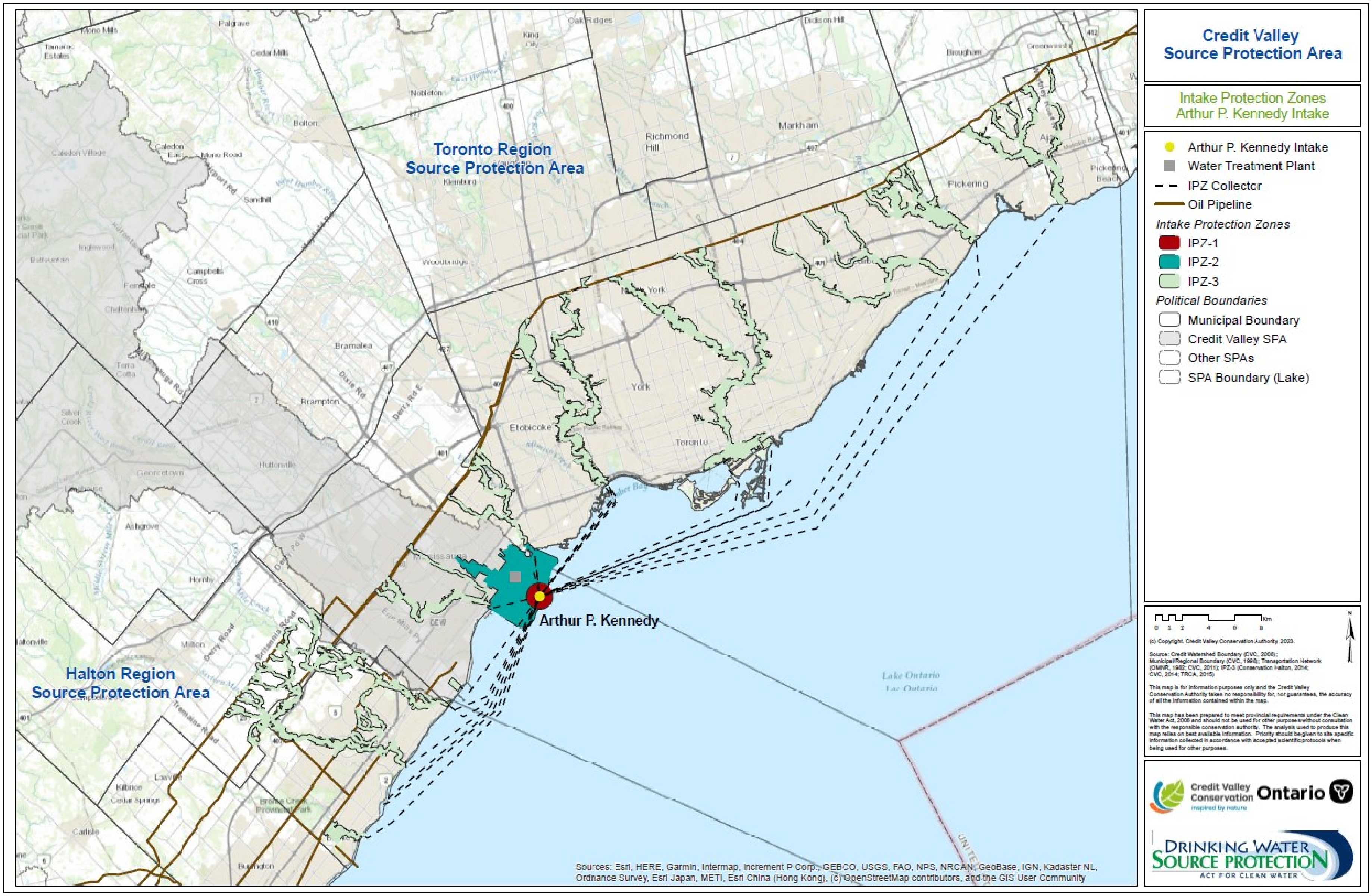
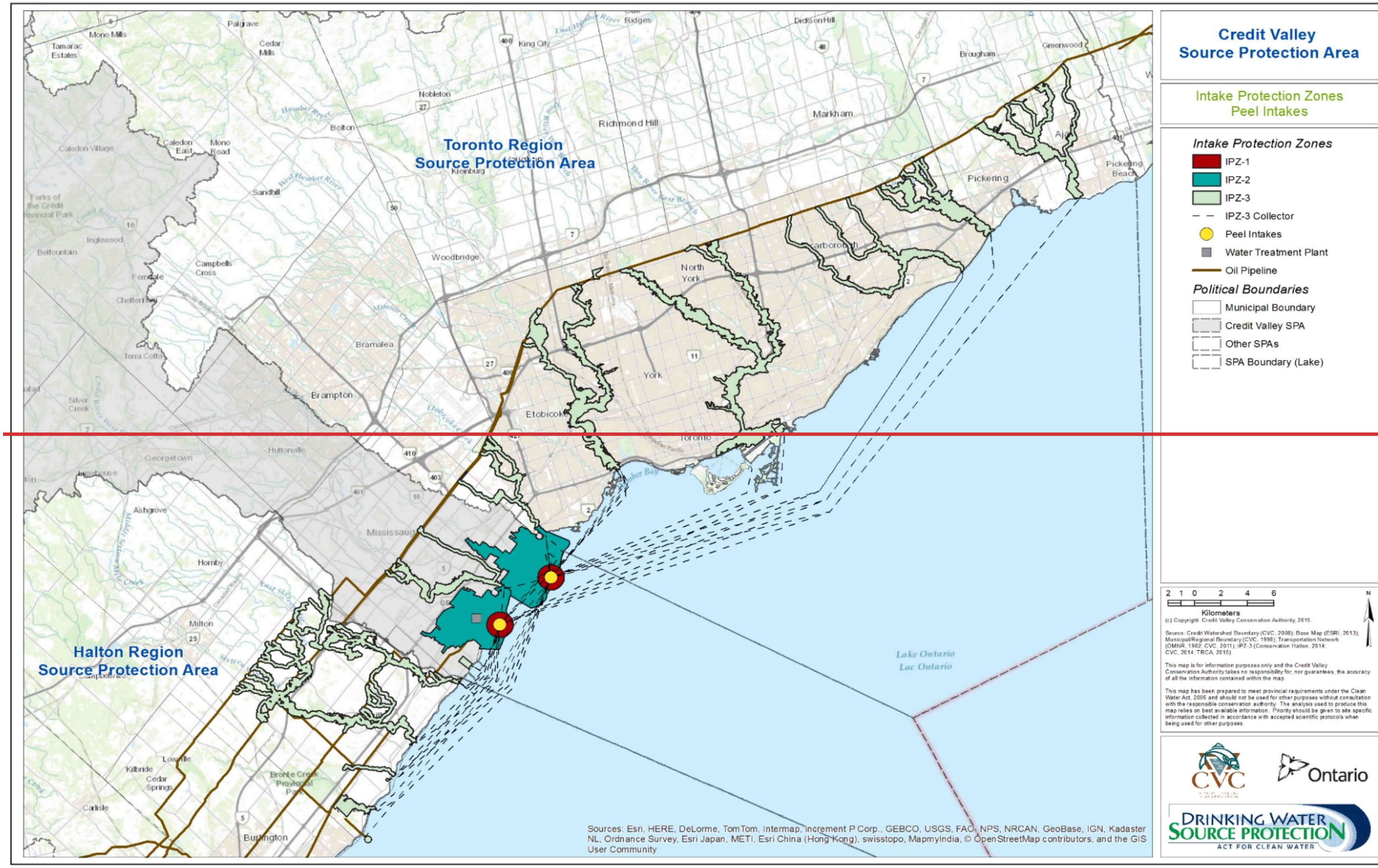


Figure 5.56: Intake Protection Zone Arthur P. Kennedy Intake


Credit Valley
Source Protection Area
Intake Protection Zones
Peel Intakes
Intake Protection Zones
IPZ-1
IPZ-2
IPZ-3
IPZ-3 Collector
Peel Intakes
Water Treatment Plant
Oil Pipeline
Political Boundaries
Municipal Boundary
Credit Valley SPA
Other SPAs
SPA Boundary (Lake)
Kilometers
Toronto Region
Source Protection Area
Halton Region
Source Protection Area
Lake Ontario
Lac Ontario
Brampton
Mississauga
Etobicoke
Toronto
North York
York
Markham
Pickering
Richmond Hill
Woodbridge
Bramalea
Milton
Burlington
Ontario
DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER
Sources: Esri, HERE, DeLorme, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

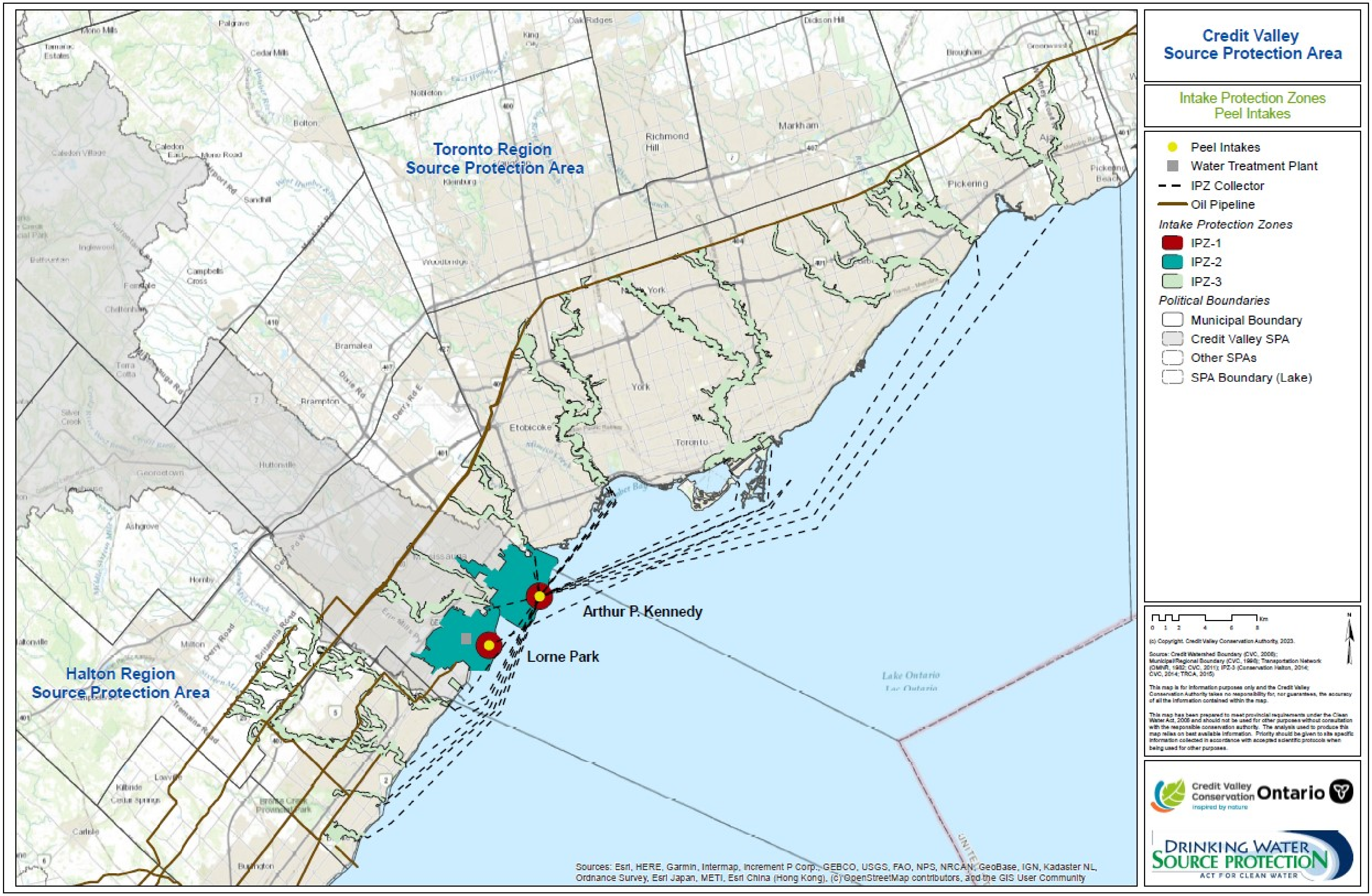


Figure 5.57: Intake Protection Zones Peel Intakes

The case study did not consider impacts from land development or increased water demand. There are currently no municipal surface water takings in Subwatershed 19; therefore, climate change impacts were not completed for the Credit River.

5.9 SUMMARY

The *Technical Rules* require a risk assessment of certain prescribed activities (of both water quantity and water quality threats) that occur in the other vulnerable areas (HVAs, SGRAs, WHPAs, and IPZs) surrounding municipal water supply abstraction points. These threats may be associated with activities, conditions (past activities), or issues. The threats present in these areas are assessed using a combination of the area's natural vulnerability ranking and a hazard score for the activity per the Provincial Tables of Circumstances. Significant threats must be identified and counted in the Assessment Report and addressed in the Source Protection Plan. The SPC may also choose to address moderate and low threats within the Source Protection Plan. The SPC is not aware of any current conditions or issues affecting any groundwater or surface water drinking water source in the CVSPA study area.

Threats to Water Quantity

Under the *Technical Rules*, water quantity threats are associated with municipal groundwater and inland surface water systems. These threats are defined and assessed through the water budget process. The Great Lakes are exempt from such assessment, and there are no surface water intakes on the Credit River.

With respect to municipal groundwater-based systems (wells), a Tier 3 Water Budget study completed for the municipalities of Orangeville, Mono and Amaranth has identified 305 significant water quantity threats related to consumptive usage and to recharge reduction.

A Tier 3 Water Budget study completed for the municipalities of Acton and Georgetown has similarly identified 87 significant water quantity threats related to consumptive usage.

Threats to Water Quality – Surface Water

Under the *Technical Rules*, water quality issues, conditions, and threats must be defined and assessed through approved methodologies. The analysis for the CVSPA resulted in no significant water quality issues, conditions, or threats being identified in any of the HVAs, SGRAs, or IPZs to date.

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:

- Disinfection failure at each Lake Ontario Wastewater Treatment Plant to evaluate the potential effects to nearby Water Treatment Plants;
- Release of *E. coli* from an industrial processing facility into the Credit River;
- Combined sewer overflow release in the City of Toronto to evaluate the potential effects of the Toronto WTPs (this did not impact any CVSPA intakes);
- Sanitary Trunk Sewer breaks within Toronto area creeks;
- Spill of gasoline/refined product from large pipelines located under major tributaries to Lake Ontario (e.g., Credit River, Humber River, etc.);

- Release of gasoline from a bulk petroleum fuel storage facility in the Oakville area and in the Keele/Finch Area of Toronto; and
- Discharge of tritium from nuclear generating facilities at Pickering and Darlington (this did not impact any CVSPA intakes).

The Technical Rules 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.

The identification of significant threats does not consider any risk management measures that may be in place. Source Protection Plan policies when implemented are intended to reduce or eliminate threats to drinking water. The Lake Ontario modelling identified three locations of significant drinking water quality threats for Lake Ontario intakes within the CVSPA. The Source Protection Plan for CTC SPR must have policies to address these significant drinking water threats that are located within the source protection area.

In addition, CVSPA has identified significant drinking water threats located outside of the CVSPA. These activities, although not enumerated in this Assessment Report, affect water treatment plants located in CVSPA, and must be addressed through source protection plan policies developed in adjacent source protection areas. CVSPA staff has brought this information to the attention of the source protection staff of the neighbouring source protection areas to ensure that policies are developed for them.

Threats to Water Quality – Groundwater

With respect to the groundwater, water quality issues relating to sodium (Na) and chloride (Cl) were identified in WHPAs of several municipal wells servicing the Town of Orangeville; issues relating to chloride (Cl) were identified for municipal wells servicing Georgetown; and issues relating to Nitrates ($N0_3$) were identified in one municipal well servicing Acton. No conditions were identified in any of the WHPAs of municipal wells within the CVSPA. A total of ~~9,553~~9,561 significant threats related to water quality have been identified in WHPAs in the CVSPA. They are located on ~~6,725~~6,731 parcels of land as shown in **Table 5.44**.

Most of the significant threats in the CVSPA are related to issues identified in municipal wells serving the most populated urban centres: Acton, Georgetown, and Orangeville. These are areas in the middle and upper zones of the Credit River watershed where sizeable populations receive municipal water supplies sourced solely from groundwater.

Table 5.4644: Significant Water Quality Threats Count in the CVSPA

Municipality	Wells	Significant Drinking Water Threats	Total # of Parcels with Significant Drinking Water Threats
Town of Orangeville	Wells 2A, 5, 5A, 6, 7, 8B, 8C, 9A, 9B, 10, 11 and 12	2,501	2,268
Town of Mono	Cardinal Woods Wells 1, 3 and 4, Island Lake Wells TW1 and PW1, and Coles Wells 1 and 2	17	8
Township of Amaranth	Pullen Well	12	2
Town of Erin	Erin Wells 7 and 8	28	10
	Hillsburgh Wells H2 and H3	39	19
	Bel Erin Wells 1 and 2	223	104
Region of Halton	Acton 4th Line Well, Davidson Wells 1 and 2, and Prospect Park Wells 1 and 2	564	246
	Georgetown Lindsay Court Well 9, Princess Anne Wells 5 and 6, and Cedarvale Wells 1a, 3a, 4 and 4a	6,135	4,046
Region of Peel	Alton Wells 3 and 4A	13	12
	Caledon Village Wells 3, 3B and 4	~~2~~10	~~1~~7
	Inglewood Wells 3 and 4	3	3
	Cheltenham Wells 1 and 2	16	6
	Total	**9,5~~53~~61**	**6,7~~25~~31**

Note that since the Pullen Well (Amaranth) and its WHPAs lie within the WHPAs for Orangeville Wells 8B, 8C and Well 12, a number of the threats and affected properties enumerated around the Pullen Well are also included in the threats count for Orangeville. Similar overlap occurs within Orangeville (WHPA & ICA), and between Mono's Coles wells and Orangeville Well 10 WHPAs. Given this, the total threat and parcel counts do not represent direct summations of the data shown for the individual municipalities.

6.0 SUMMARY, CONCLUSIONS AND NEXT STEPS

6.1 SUMMARY AND CONCLUSIONS

The *Clean Water Act, 2006 (CWA)* and regulations aim to protect drinking water supplies in Ontario. The Act requires that we assess risks to all drinking water sources by completing an assessment report. This Assessment Report describes the physical features and water resources within the CVSPA 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.

The *Technical Rules* outline the legislated content for assessment reports across Ontario. The *Technical Rules* report was posted on the MOECC's website in December 2008 and further amended in November 2009, December 2013, March 2017 and again in December 2021. The ~~2017~~ 2021 version of the document can be found at: https://www.ontario.ca/page/2021-technical-rules-under-clean-water-act. The 2017 version can be found at: https://www.ontario.ca/page/2017-technical-rules-under-clean-water-act; while the 2013 version can be found at: https://www.ontario.ca/page/2013-technical-rules-under-the-clean-water-act. Older versions of the *Technical Rules* can be obtained from the CTC Source Protection Region. ~~2017~~ ~~https://www.ontario.ca/page/2017-technical-rules-under-clean-water-act.~~

Amendments to the Credit Valley Assessment Report resulting in versions 2.0, 3.0 and 4.0 were made using the 2017 Director's Technical Rules and Tables of Drinking Water Threats. Amendments to the Credit Valley Assessment Report resulting in version 5.0 were made using the 2021 Director's Technical Rules and Tables of Drinking Water Threats. Sections of the Assessment Report that were not updated as part of those amendments refer to the 2009 edition of the Director's Technical Rules and Tables of Drinking Water Threats.

The various chapters in this Assessment Report have been completed to meet provincial requirements in the determination of any potential risk to drinking water supplies. Based on these discussions, the status and sustainability of drinking water can be determined, as required under the *CWA, 2006*. The vulnerable areas and threats identified in this Assessment Report are the focus of the source protection plan policies.

Municipal drinking water supplies in the CVSPA originate from both Lake Ontario and groundwater aquifers. The *Lake Ontario Collaborative Intakes Protection Zone Studies* (2009), assessed raw water quality data for the two municipal intakes in Lake Ontario that serve as drinking water sources for the lower zone of the CVSPA. Municipal driven wellhead protection area studies (2010 - 2019), assessed raw water quality data for the municipal wells that serve as drinking water sources for the middle and upper zones of the CVSPA. In general, both the Lake Ontario and groundwater sourced water for the CVSPA were assessed as being of high quality and suitable for use as sources of municipal supplies.

The analyses of the Watershed Characterization component of the Assessment Report revealed some interesting trends in the quality of water used as a source for municipal supplies. In general, parameter concentrations remain comfortably below the Ontario Drinking Water Standards, indicating that both surface water and groundwater used as municipal drinking water sources tend to be of high quality. Several supply wells, however, have shown increases in sodium and chloride over time, which are thought to be associated with the application of road salt. Increasing nitrate levels were also observed in several wells, and thought to be linked to septic systems, pesticide and fertilizer application.

Surface water quality in the streams discharging into Lake Ontario show some elevated levels of chlorides, phosphorus, copper and nitrates as compared against ecosystem and aquatic life standards (*Canadian Water Quality Guidelines*). These contaminants are thought to be associated with the impact of urbanization and agricultural activities. With the exception of chlorides which are still below the provincial standards, the other parameters showed decreasing or no trend. The surface water in these streams is not used as a drinking water supply.

The Water Budget analysis in this Assessment Report assessed potential water quantity stress in both surface water (not including Lake Ontario) and groundwater. Tier 2 Water Budget analyses were undertaken for both surface water and groundwater resources. Groundwater sources provide approximately 11% of CVSPA's drinking water and supports vital ecosystem functions. The surface water in streams is important for supporting the ecosystem and is also used for irrigation and other non-drinking water purposes.

With respect to surface water, the vast majority of subwatersheds were found to be experiencing low stresses, with Fletcher's Creek (Subwatershed 15) being the only exception and identified as having a moderate surface water stress level. Given that the stress does not impact municipal drinking water supplies - the focus of the *CWA* additional investigation and management will take place under the conservation authority's watershed protection programs.

With respect to groundwater, the majority of sub-watersheds were also found to be experiencing low stresses, with the exception of Black Creek (subwatershed 10), Silver Creek (subwatershed 11), and Orangeville (subwatershed 19) subwatersheds, which were each identified as having moderate groundwater stress level. Since these subwatersheds support municipal groundwater supplies, they each were required to undergo additional study at the Tier 3 level, per the provisions of the *CWA.* This work was completed, and the findings incorporated in **Chapter 3** of this Assessment Report.

Vulnerability was assessed and scored in the following vulnerable areas in CVSPA – Highly Vulnerable Aquifers (HVAs), Wellhead Protection Areas (WHPAs) and Intake Protection Zones (IPZs) following the *Technical Rules*. The Intake Protection Zones (IPZ-1s and IPZ-2s) were all ranked as having low vulnerability. The resulting HVA and SGRA analyses reflect the presence of many shallow aquifers that are naturally vulnerable. The vulnerability in the WHPAs was found to be highest in close proximity to municipal wellheads, decreasing with distance from the wellheads.

Transport pathway analyses were undertaken within the WHPAs only, and were premised on the occurrence of vertical components such as ~~subsurface utilities~~boreholes , wells, SWM ponds, quarries and pits that extend below the water table as well as horizontal components such as water mains. ~~quarries and pits that extend below the water table~~.

Vulnerability is considered together with provincial hazard scores outlined in the Provincial Tables of Circumstances 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 HVAs, WHPAs and IPZs. Significant threats must be addressed in the source protection plan and moderate and low threats may be addressed.

A threat is defined 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 province through the *Technical Rules.* The methodology outlined in the *Technical Rules* directs what types of activities can be considered potential threats. The Provincial Tables of Circumstances assigns the level of drinking water threat to a specific circumstance. The circumstance includes the specific characteristic of the prescribed drinking water threat activity, the type of vulnerable area, and its vulnerability score. There was limited field verification of potential threat activities during the initial threats assessment. Verification of threat activities has taken place during the development and implementation of the source protection plan.

In addition to identifying potential drinking water threat activities, existing water quality problems or increasing trends that suggest a future water quality problem must be evaluated – and may be labeled as "issues". The requirements to identify an issue are set out in *Technical Rules 114 - 117*. According to *Technical Rule 114.1* (a & b), issues may exist only in vulnerable areas associated with a municipal drinking water system.

The analyses identified no significant drinking water conditions, issues or threats related to quality of water in the HVAs or SGRAs.

With respect to the WHPAs, water quality issues relating to sodium (Na) were identified in WHPAs of municipal wells servicing the Town of Orangeville; issues relating to chloride (Cl) were identified in WHPAs of municipal wells servicing the Towns of Orangeville and Georgetown. A water quality issue related to nitrate (NO^3) was identified in WHPAs of the Davidson wellfield of Acton. All threats related to issues were elevated to significant threats in the Issue Contributing Areas with the exception of septic systems governed under the *Building Code Act* only in Issue Contributing Areas for sodium or chloride.

With respect to drinking water supplies sourced from Lake Ontario**,** event based modelling studies undertaken in the vulnerable area surrounding Lake Ontario intakes, resulted in the identification of three unique significant drinking water quality threats to the two intakes located in the CVSPA.

Under the *Technical Rules*, water quantity threats must be assessed through the water budget process. The Great Lakes are exempt and there are no surface water intakes on the Credit River.

For municipal groundwater-based systems, the Tier 3 Water Budget completed for the municipalities of Orangeville, Mono and Amaranth identified 305 significant water quantity threats related to consumptive usage and to recharge reduction. A Tier 3 Water Budget completed for the municipalities of Acton and Georgetown has similarly identified 87 significant water quantity threats related to consumptive usage.

A total of **9,9~~45~~53** significant groundwater quality and quantity threats have been identified around municipal wellheads in the CVSPA. They were located on **7,11~~2~~8** parcels of land as shown in **Table 6.1** below.

Table 6.1: Significant Groundwater Threat (Quality and Quantity) Count in the CVSPA

Municipality	Wells	Significant Drinking Water Threats	Total # of Parcels with Significant Drinking Water Threats
Town of Orangeville	Wells 2A, 5, 5A, 6, 7, 8B, 8C, 9A, 9B, 10, 11 and 12	2,728	2,495
Town of Mono	Cardinal Woods Wells 1, 3 and 4, Island Lake Wells TW1 and PW1, and Coles Wells 1 and 2	66	40
Township of Amaranth	Pullen Well	41	30
Town of Erin	Erin Wells 7 and 8	28	10
	Hillsburgh Wells H2 and H3	39	19
	Bel Erin Wells 1 and 2	223	104
Region of Halton	Acton 4th Line Well, Davidson Wells 1 and 2, and Prospect Park Wells 1 and 2	651	346
	Georgetown Lindsay Court Well 9, Princess Anne Wells 5 and 6, and Cedarvale Wells 1a, 3a, 4 and 4a	6,135	4,046
Region of Peel	Alton Wells 3 and 4A	13	12
	Caledon Village Wells 3, 3B and 4	~~2~~10	~~1~~7
	Inglewood Wells 3 and 4	3	3
	Cheltenham Wells 1 and 2	16	6
	Total	**9,9~~45~~53**	**7,11~~2~~8**

Table 6.2: Approved Assessment Report Data and Knowledge Gaps

Identified Data and Knowledge Gaps			
Knowledge Gaps			
Need to develop methodology and tools to provide analysis of spills response, which will involve all pathways, including overland flow, stream travel, and groundwater flow, including the unsaturated zone transport			
~~Need more detailed consideration of potential transport pathways~~			
Need more detailed scrutiny of SGRAs as they relate to drinking water systems			
Need more detailed scrutiny of HVAs, specifically shallow aquifer deposits			
Threats, Conditions, and Issues			
Component	**Data Set Name or Source**	**Data Gap Problem**	**Comment**
Threats in WHPAs	Significant threats	Lack of field verification	Additional field verification to further reduce inaccuracy
Knowledge Gaps			
Need updated ecological land classification and MPAC data			
Need for additional work to identify source of the issue at Orangeville Well 10			
Need for additional monitoring of Nitrate ($N0_3$) at the Davidson Wellfield			
Additional field verification to confirm land use activities			
Uncertainty regarding the number of animals and types of animals that a farm unit may hold			

6.3 NEXT STEPS

The CTC SPC has used the findings of this Assessment Report, to develop the CTC Source Protection Plan (CTC SPP) which addresses existing and potential future significant drinking water threats identified in CVSPA. In developing the CTC SPP, the CTC Source Protection Committee consulted broadly within the CVSPA and with various sectors as well as neighbouring source protection areas and regions. Policies contained in the CTC SPP address the three significant drinking water quality threats from activities impacting Lake Ontario surface water intakes (located within the CVSPA), in addition to the 9,561~~53~~ significant drinking water quality threats and 392 significant drinking water quantity threats identified with the potential to affect municipal groundwater wells.

The CTC SPC also chose to develop policies in the CTC SPP that address moderate and low threats as a result of the application of road salt, as well as the handling and storage of DNAPLs and organic solvents.

Since May 2018, the Credit Valley Source Protection Authority has reported on the progress of implementing the CTC SPP to the Minister of the Environment, Conservation and Parks.

On July 22, 2019, pursuant to Section 36 (1) of the *CWA, 2006* the Minister of the Environment, Conservation and Parks amended the Order established in July 2015 governing the content and timeframes for the review of updates to this Assessment Report and to the CTC SPP. Over the next several years, this Assessment Report will be updated to reflect new or revised data and knowledge.

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