



Considering Climate Change in Drinking Water Source Protection

Chitra Gowda, M.A.Sc. (Env. Eng.)

Source Water Protection Lead

Conservation Ontario

Training Sessions - January and February 2020



Overview

- Welcome
- Climate Change and Impacts
- The Clean Water Act: Source Protection Program and Technical Rules
- Considering Climate Change in Source Water Quality Risk Assessments



DRINKING WATER
SOURCE PROTECTION
Our Actions Matter



Conservation
ONTARIO
Natural Champions

Welcome



Climate Change Vulnerability Assessment Tool for Drinking Water Source Quality: Training Sessions January 2020

Conservation Ontario (CO) is pleased to invite you to training sessions across Ontario, on the use of a climate change vulnerability assessment tool for water quality of drinking water sources.

This semi-quantitative, Excel-based tool and its guidance document were developed through a multi-stakeholder, collaborative project coordinated by CO under the Drinking Water Source Protection program. Training sessions are being held as follows:

- **Jan. 16 at the Laurentian University, Executive Learning Centre, Sudbury**
- **Jan. 24 at the Upper Thames River Conservation Authority, London**
- **Jan. 29 at the Cataraqui Region Conservation Authority, Kingston**
- **Jan. 30 at the Toronto and Region Conservation Authority, Vaughan**



Conservation
ONTARIO
Natural Champions

Welcome



Climate Change Vulnerability Assessment Tool for Drinking Water Source Quality: Webinar Sessions – February 2020

Conservation Ontario (CO) is pleased to invite you to webinar sessions to introduce you to the Climate Change Vulnerability Assessment Tool for water quality of drinking water sources.

This tool applies a climate change lens to drinking water source protection. It is a semi-quantitative, Excel-based tool developed through a multi-stakeholder, collaborative project coordinated by CO under the Drinking Water Source Protection program. The webinar sessions are being held as follows:

- **Feb. 13, 2020 (2:00-3:30pm) – Groundwater Systems**
- **Feb. 19, 2020 (2:00-3:30pm) – Surface water Systems**
- **Feb. 24, 2020 (2:00-3:30pm) – Groundwater Systems**
- **Feb. 27, 2020 (10:00-11:30am) – Surface water Systems**



Conservation
ONTARIO
Natural Champions

Conservation Ontario: Who We are

Non-profit corporation that represents the network of Ontario's 36 Conservation Authorities. Governed by member Conservation Authorities. Funded by members, some agreements and contracts.

Key Areas

- Policy and Program Development
- Business Development and Partnerships
- Communications
- Education and Training
- Collective Corporate Services
- Government Relations
- Information Management and Research.



Project coordinator of the source water quality - Climate Change Vulnerability Assessment project, funded by the **Province of Ontario**.

Project management of the **Infrastructure Ontario** Flood Resilience Analysis project with Ontario Climate Consortium.



Conservation
ONTARIO
Natural Champions

Climate Change

Climate change: a change in the state of the climate that can be identified by changes in weather and atmospheric conditions that persist for an extended period, typically decades or longer (from IPCC 2007, IPCC 2012a).

Climate emergencies are being declared across Ontario by municipalities including Ottawa, Sudbury, Meaford, Barrie, King, Toronto, Halton Hills, Waterloo, Burlington, London, Windsor, and many more. *Check out this world map of climate emergency declarations:* <https://bit.ly/2MY327g>





Conservation
ONTARIO
Natural Champions

Climate Change

Local climate change **impacts** include:

- Increased flood and erosion due to more extreme rainfall
- More drought conditions and frequent severe weather due to rising temperatures and changing precipitation patterns.
- Water quality changes, including an increased likelihood of impacting the quality of drinking water sources
- Impacts to water supply
- Public health impacts
- Reduced wetlands
- Degraded biodiversity.

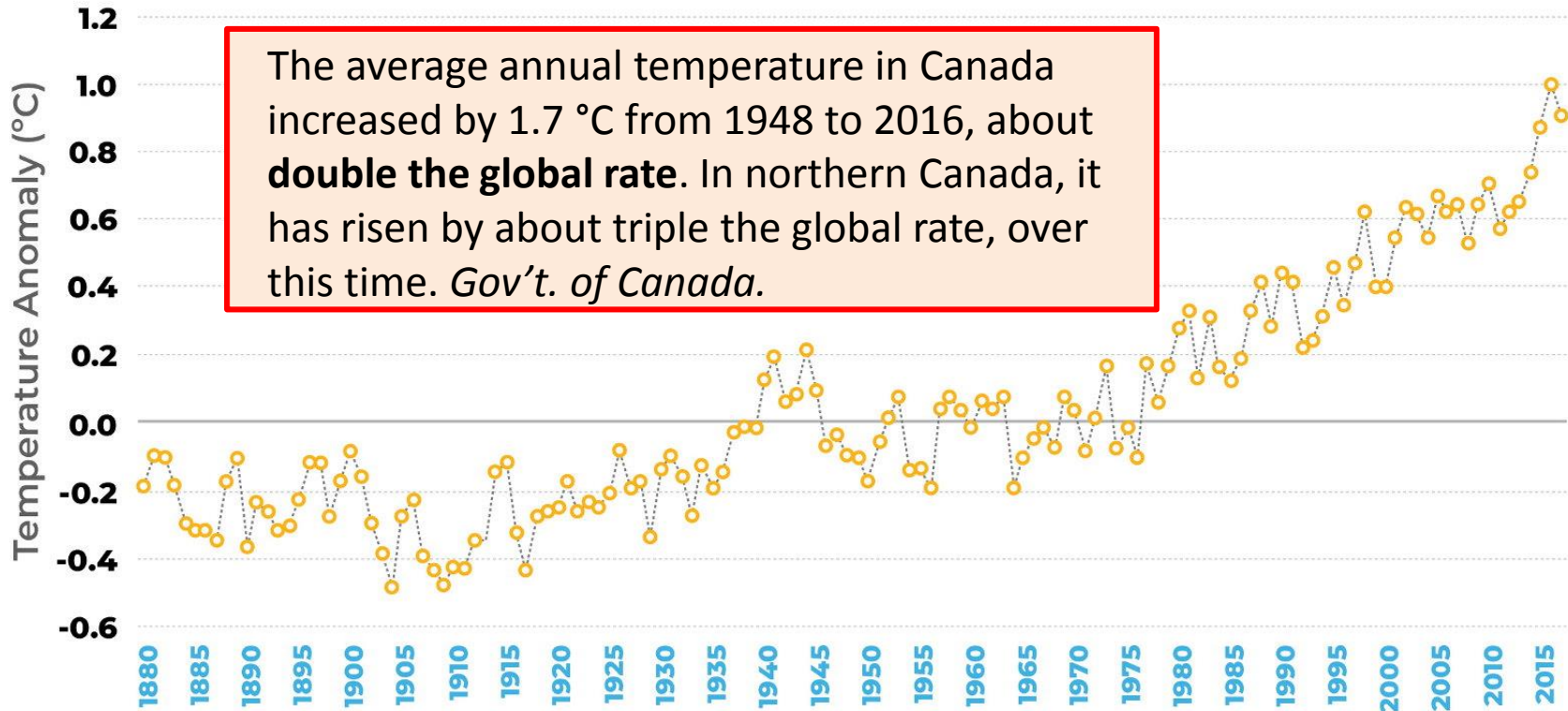




Conservation
ONTARIO
Natural Champions

Climate Change

Global Temperature, 1880 to 2017








Prairie
Climate Centre

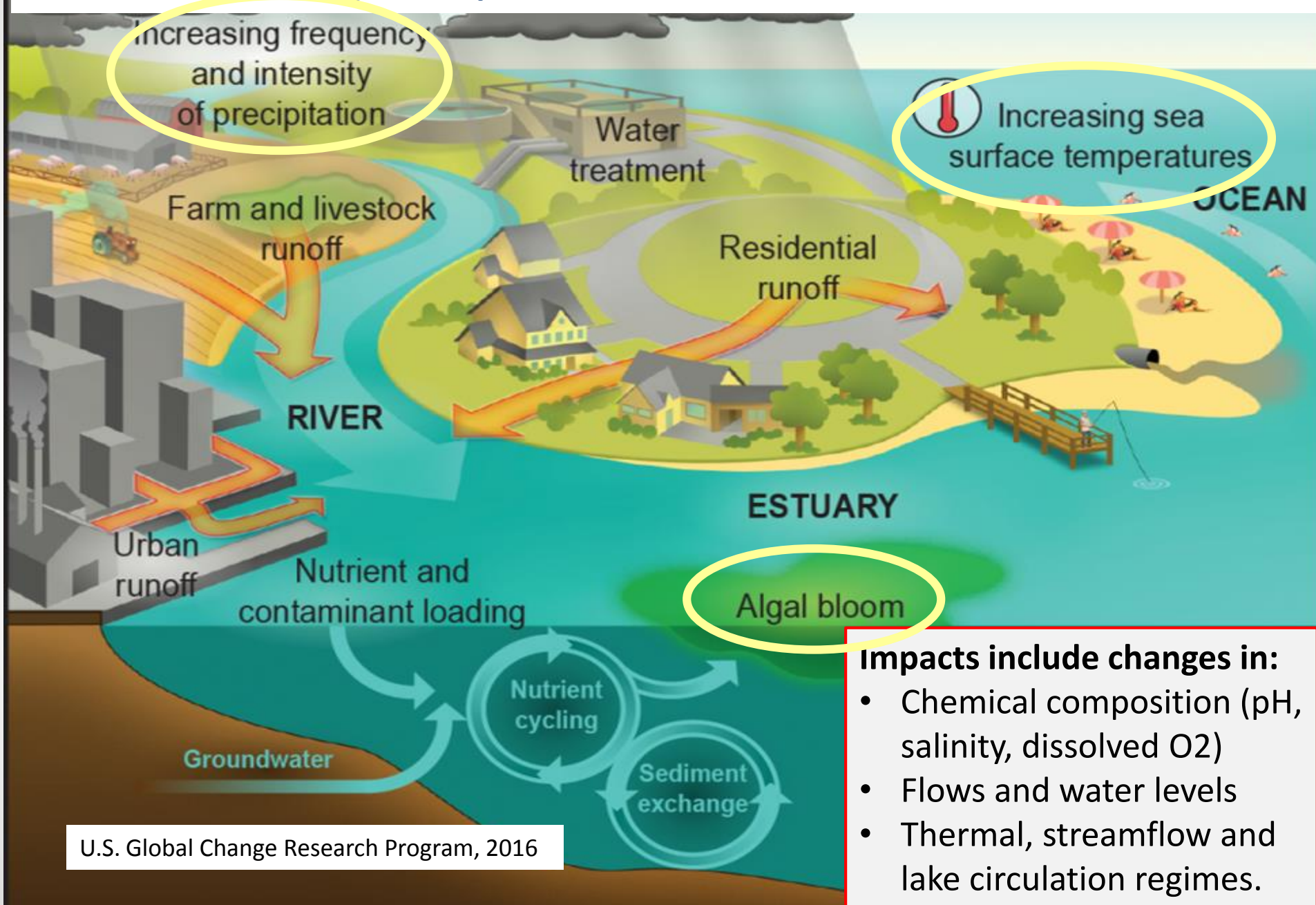
© 2018, Prairie Climate Centre

Global estimates of mean annual land and ocean surface temperature from 1880 to 2017. Values are displayed as departures from a 1951-1980 baseline period. Source: NASA
<https://data.giss.nasa.gov/gistemp/graphs/>

Climate change projections for the Great Lakes Basin

| Theme | General projections | Trend | Data Confidence |
|------------------------|---|-------|---|
| Air temperature | <ul style="list-style-type: none"> • 1.5°C-7°C increase by 2080s depending on climate scenario and model used • Greater increases in the winter • Increased frost-free period and growing season | ↑ |  <p>High evidence High agreement</p> |
| Precipitation | <ul style="list-style-type: none"> • 20% increase in annual precipitation across the Great Lakes Basin by 2080s under the highest emission scenario • Increases in rainfall, decreases in snowfall • Increased spring precipitation, decreased summer precipitation • More frequent extreme rain events | ↑ |  <p>High evidence Medium agreement</p> |
| Drought | <ul style="list-style-type: none"> • Projected increases in frequency and extent of drought | ↑ |  <p>Low evidence High agreement</p> |
| Wind | <ul style="list-style-type: none"> • Increased wind gust events | ↑ |  <p>Low evidence Low agreement</p> |
| Ice storms | <ul style="list-style-type: none"> • Greater frequency of freezing rain events | ↑ |  <p>Low evidence Low agreement</p> |

Climate Change Impacts on Surface Water Sources



Impacts include changes in:

- Chemical composition (pH, salinity, dissolved O₂)
- Flows and water levels
- Thermal, streamflow and lake circulation regimes.



Conservation
ONTARIO
Natural Champions

Goderich Water Treatment Plant – Lake Huron

Town of Goderich to spend more than \$1 million for stone wall to protect town's drinking water treatment plant... municipal officials are concerned about increasing erosion and rising lake levels. (CBC, Dec. 31, 2019)



Photos taken in Nov. 2019 by
Veolia staff.





Climate Change Impacts on Groundwater Sources

- Shallow and unconfined aquifers are affected the most.
- Reduced groundwater levels during hot, dry summers potentially leading to reduced discharge rates that supply base flow and cold water inputs to surface water systems, lakes, and wetlands
- Potential contamination due to increased precipitation intensity and frequency; more runoff to infiltrate into groundwater sources.



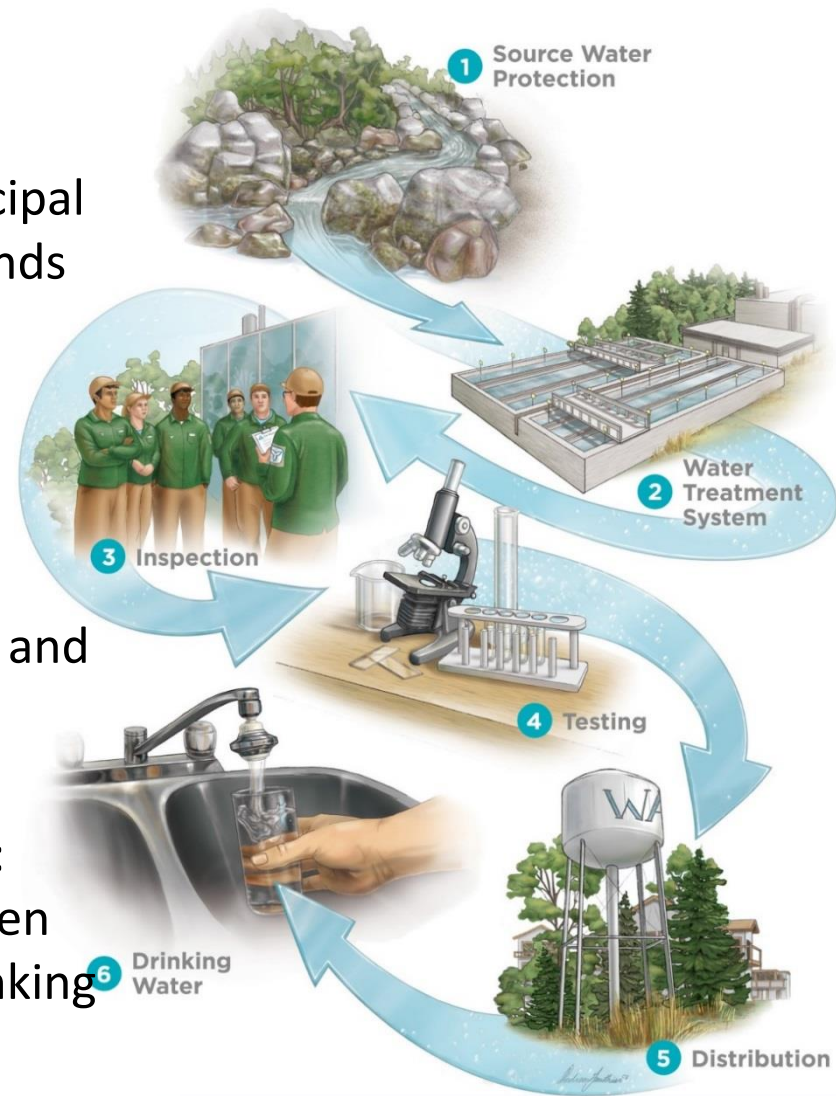
The Clean Water Act

The History

- Bacterial contamination of Walkerton municipal water supply in 2000. Seven deaths; thousands left with severe, long term illnesses.
- Justice O’Conner’s Inquiry in 2002: recommendations to protect sources.

The Clean Water Act (2006)

- The purpose of the Act is to protect existing and future sources of drinking water from contamination or depletion.
- **Drinking Water Source Protection Program:** multi-stakeholder, collaborative, locally-driven process to protect municipal residential drinking water sources.
- Municipalities may also bring in other systems (private, non-residential). First Nations have the option to join.



*Multi-barrier approach:
Protecting from Source to Tap*



Conservation
ONTARIO
Natural Champions

The Clean Water Act - Technical Rules

- The Clean Water Act (2006) - Technical Rules prescribe technical methods to: delineate vulnerable areas around drinking water sources; determine their vulnerability to contamination; identify threat activities and assess risk levels.
- These Technical Rules allow the consideration of climate change impacts on the quality and quantity of drinking water sources.
- There are no clearly defined Technical Rules on how to consider climate change impacts on source water quality.





Considering Climate Change Impacts in Source Water Quality Risk Assessments

- Stakeholders asked the Ministry of the Environment, Conservation and Parks (MECP) for a means to determine **how climate change may impact the quality of drinking water sources.**
- Therefore, MECP initiated a project in early 2018, retaining Conservation Ontario as the coordinator.
- In 2019, MECP proposed enabling amendments to the Technical Rules to consider climate change into source water quality risk assessments.
- MECP proposes that the Rules will specify the information required (data source, approach, findings, impacts) for climate change risk assessment to be incorporated into the assessment report.



Conservation
ONTARIO
Natural Champions

Climate Change Vulnerability Assessment Project

- The project was made possible through the Government of Ontario's Drinking Water Source Protection program.
- Conservation Ontario coordinated a comprehensive, multi-stakeholder process from Jan. 2018 – present.
- Stakeholder engagement sessions were held across Ontario in fall 2018. Three pilot studies were conducted in 2019.
- This process resulted in the development of a science based **Climate Change Vulnerability Assessment Tool** and accompanying guidance, to enable the consideration of climate change into source water quality risk assessments under the Clean Water Act.



Conservation
ONTARIO
Natural Champions

Project Collaborations



Supported by Toronto and Region Conservation Authority

This project has received funding support from the Government of Ontario. Such support does not indicate endorsement by the Government of Ontario of the contents of this material.



Project Collaborations: Pilot studies led by Conservation Ontario

1. Burlington Intake



2. Seaforth Wells





Conservation
ONTARIO
Natural Champions

Project Collaborations: Pilot studies led by Conservation Ontario

3. Carleton Place Intake



4. City of Timmins Intake



Province of Ontario and Climate Change: Recent News and Environmental Plan Commitments

Building Resilience

- On November 7, 2019, Ontario issued a procurement to undertake its first-ever climate change impact assessment as a key part of the Made-in-Ontario Environment Plan, 2018.
- The assessment will help the province better understand where and how climate change is likely to affect communities, critical infrastructure, economies and the natural environment.
- The results from this assessment will help the province, municipalities, Indigenous communities and other local decision-makers to make more informed and timely decisions to keep communities and people healthy and safe. (Timeline: 2020-2022).
- The Province introduced a Climate Change Advisory Panel (Nov. 2019) and outlined how they will provide expert advice on the implementation of the province's climate change actions - especially how Ontarians can prepare for the costs and impacts of climate change.

A Made-in-Ontario Environment Plan





Province of Ontario and Climate Change: Recent News and Environmental Plan Commitments

Building Resilience

- Ontario's Environment Plan also commits to the development of a user-friendly on-line tool that would support the sharing of information by making practical climate change impact information available. This tool will help a range of users understand the potential impacts of climate change in their communities.
- The Ontario's Special Advisor on Flooding Report (2019) provides 66 recommendations including:
 - the consideration of climate change in the Provincial Policy Statement, Ontario's flood management programs, and asset management plans;
 - ensuring that strategies are developed with local CAs to address climate change impacts in certain areas in south-western Ontario;
 - supporting municipalities and CAs on green infrastructure to mitigate flood impacts.

Climate Change Mitigation

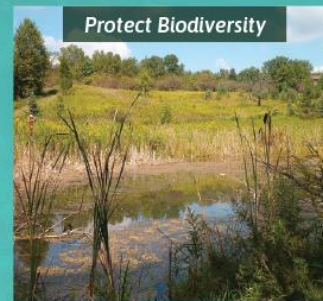
- Ontario's Environment Plan also considers the province's specific priorities, challenges and opportunities, and commits to reducing GHG emissions to 30% below 2005 levels by 2030.
- Minister Yurek issued a statement (Dec. 2019) upon return from 25th Conference of the Parties to the United Nations' Framework Convention on Climate Change (COP 25), reiterating the GHG emission reduction target, collaborations, and innovative solutions to support a healthy environment and strong economy in Ontario.

Conservation Authorities

Unique to Ontario, Conservation Authorities (CAs) are local watershed management agencies that deliver services and programs to protect and manage water and other natural resources in partnership with many organizations.

- CAs are creatures of statute, legislated under the *Conservation Authorities Act, 1946*. **95% of Ontario's population lives in a watershed managed by a CA.**
- CAs have identified and are responding to local climate change impacts through their programs and services such as: watershed planning, monitoring, flood management, tree planting, low impact development and green infrastructure.

Conservation Authorities



Thank you.

Chitra Gowda

Source Water Protection Lead

Conservation Ontario

Email: cgowda@conservationontario.ca

**Conservation Ontario is the
network of all 36 conservation
authorities in Ontario.**

DRINKING WATER
SOURCE PROTECTION
Our Actions Matter



References

- Intergovernmental Panel on Climate Change, IPCC. 2007. Working Group I Contribution to the IPCC Fourth Assessment Report on Climate Change 2007: The Physical Science Basis. Available Online: http://www.ipcc.ch/publications_and_data/ar4/wg1/en/contents.html
- Intergovernmental Panel on Climate Change, IPCC. 2012a. “Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change.” http://ipccg2.gov/SREX/images/uploads/SREX-All_FINAL.pdf
- World map of climate emergency declarations: <https://bit.ly/2MY327g>. Details at: <https://www.cedamia.org/global/>
- https://www.torontoenvironment.org/toronto_city_council_voted_yes_to_declare_a_climate_emergency_and_accelerate_climate_action
- National Aeronautics and Space Administration <https://data.giss.nasa.gov/gistemp/graphs/>
- Government of Canada: <https://www.canada.ca/en/environment-climate-change/services/climate-change/canadian-centre-climate-services/basics/trends-projections/changes-temperature.html>
- McDermid, JL, S.K Dickin, C.L. Winsborough, H. Switzman, S. Barr, JA Gleeson, G Krantzberg, PA Gray. 2015. State of Climate Change Science in the Great Lakes Basin: A Focus on Climatological, Hydrological and Ecological Effects. Prepared Jointly by the Ontario Climate Consortium and Ontario Ministry of Natural Resources and Forestry to advise Annex 9 – Climate Change Impacts under the Great Lakes Water Quality Agreement. October 2015.
- U.S. Global Change Research Program, USGCRP. (2016). The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment. Crimmins, A. J. Balbus, J.L. Gamble, C.B. Beard, J.E. Bell, D. Dodgen, R.J. Eisen, N. Fann, M.D. Hawkins, S.C. Herring, L. Jantarasami, D.M. Mills, S. Saha, M.C. Sarofim, J. Trtanj, and L. Ziska, Eds. U.S. Global Change Research Program, Washington, DC, 312 pp. <http://dx.doi.org/10.7930/JOR49NQX>
- <https://www.cbc.ca/news/canada/london/we-had-no-choice-goderich-moves-to-protect-water-treatment-plant-from-rising-lake-levels-1.5410851>
- Tu, C. Milner, G. Lawrie, D. Shrestha, N. Hazen, S. (2017). Natural Systems Vulnerability to Climate Change in the Region of Peel. Toronto, Ontario: Toronto and Region Conservation Authority and Ontario Climate Consortium Secretariat. Available Online: <https://climateconnections.ca/wp-content/uploads/2012/03/Final-Natural-Systems-VA.pdf>
- <https://www.ontario.ca/page/made-in-ontario-environment-plan>
- <https://news.ontario.ca/ene/en/2019/11/ontario-appoints-advisory-panel-on-climate-change.html>
- <https://news.ontario.ca/ene/en/2019/12/statement-from-minister-yurek-following-the-united-nations-climate-change-conference.html>
- <https://news.ontario.ca/mnr/en/2019/11/ontario-releases-report-from-special-advisor-on-flooding.html>
- <https://conservationontario.ca/conservation-authorities/about-conservation-authorities/>



Climate Change Vulnerability Assessment Tool for Drinking Water Source Protection - Quality

Chitra Gowda, M.A.Sc. (Env. Eng.)

Source Water Protection Lead, Conservation Ontario

Training Sessions - January and February 2020



Overview

- Key Terms
- Climate Change Data: The Three Ss: Sources, Stations, Statistical analysis
- Overview of the Assessment Tool and its Guidance
- Explore the Pilot Studies:
 - Burlington Water Intake
 - Seaforth Well Supply



DRINKING WATER
SOURCE PROTECTION
Our Actions Matter



Key Terms

Climate

- An area's long-term weather patterns, such as precipitation type and timing, wind speeds and directions

Climate Change

- Change in the state of the climate, typically identified through statistical analysis

Climate Normal

- A period used for calculating average conditions, typically 30 years

General Circulation Models (GCM)

- Mathematical models for climate condition projections. An average of GCMs is an “Ensemble”

Representative Concentration Pathways (RCP)

- Represent future human emissions of GHGs from all sources; modelled RCP scenarios: 2.6, 4.5, 6.0, 8.5



Key Terms

Exposure

- The inventory of elements in an area in which hazard events may occur (IPCC, 2012b). In other words, the nature and degree to which a system (people, assets, ecosystems) is subject to significant climate variations.

Sensitivity

- The degree to which a system is affected by climatic stresses, adversely or beneficially, by climate stimuli (IPCC, 2007).

Impact

- The consequences of climate change on systems (IPCC, 2014b).

Adaptive Capacity

- The ability of a system to adjust to climate change, to moderate potential damages, to take advantage of opportunities, or to cope with the consequences (IPCC, 2007).

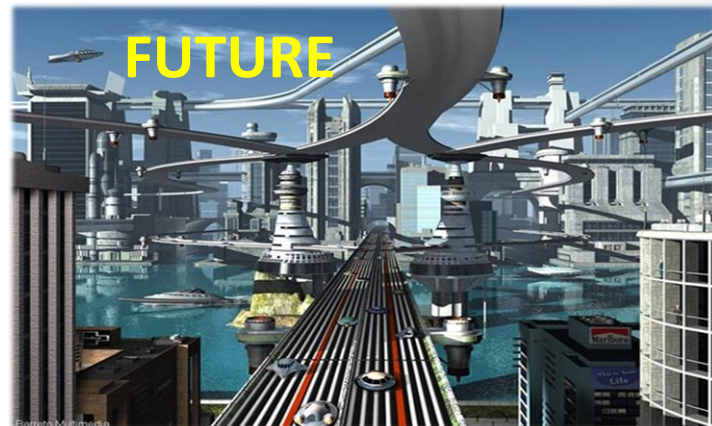
Vulnerability

- The propensity or predisposition [of a system, place, or human being] to be adversely affected [by climate change]. It is a function of exposure, sensitivity, and adaptive capacity (IPCC, 2012b).



Climate Data: Sources

| No. | Climate Variable (Indicator) | Historical Data (actual *, modelled**, both***) | Future Data (modelled) |
|-----|---|---|---|
| 1 | Min. Temp. (°C) | Environment and Climate Change Canada (ECCC)*, Climate Atlas of Canada*** | Climate Atlas of Canada |
| 2 | Max. Temp. (°C) | ECCC*, Climate Atlas of Canada*** | Climate Atlas of Canada |
| 3 | Precipitation (mm) | ECCC*, Climate Atlas of Canada*** | Climate Atlas of Canada |
| 4 | Heavy Precipitation (mm) | Climatedata.ca** | Climatedata.ca |
| 5 | Very Hot Days of +30°C (no. of days) | ECCC*, Climate Atlas of Canada*** | Climate Atlas of Canada |
| 6 | Freeze-Thaw Cycle (no. of days) | ECCC*, Climate Atlas of Canada*** | Climate Atlas of Canada |
| 7 | Frost-Free Season (no. of days) | ECCC*, Climate Atlas of Canada*** | Climate Atlas of Canada |
| 8 | Max. Length of Dry Spell (max. no. of consecutive days) | Ontario Climate Data Portal (OCDP)** | Ontario Climate Data Portal (OCDP) |
| 9 | Rainfall (mm) | ECCC (data)*, Environmental Commissioner of Ontario, 2018 (summary info)* | Price, D.T., et. al., 2011 (summary info) |
| 10 | Snowfall (cm) | ECCC (data)*, Environmental Commissioner of Ontario, 2018 (summary info)* | Price, D.T. et. al., 2011 (summary info) |



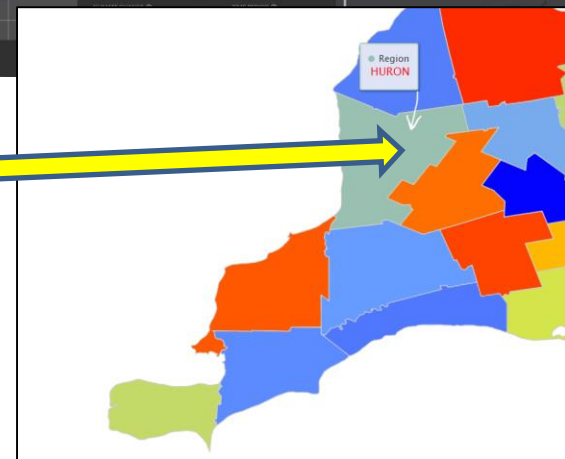
- Historical period e.g.: 1980-2010; future e.g.: 2011-2040.
- Annual data available for all climate variables; while seasonal data is available for some of the variables.
- Modelled data is typically available for all 4 RCP scenarios.
- RCP 8.5 is the highest emissions scenario: we continue to emit large amounts of CO₂ from burning fossil fuels (business as usual).
- Historical data can be actual or modelled, so check the data description to be sure. ECCC data is actual data.
- Review actual and modelled historical data, to check for differences. Modelled historical data is easy to analyze and compare against modelled future data.

Climate Data: Stations

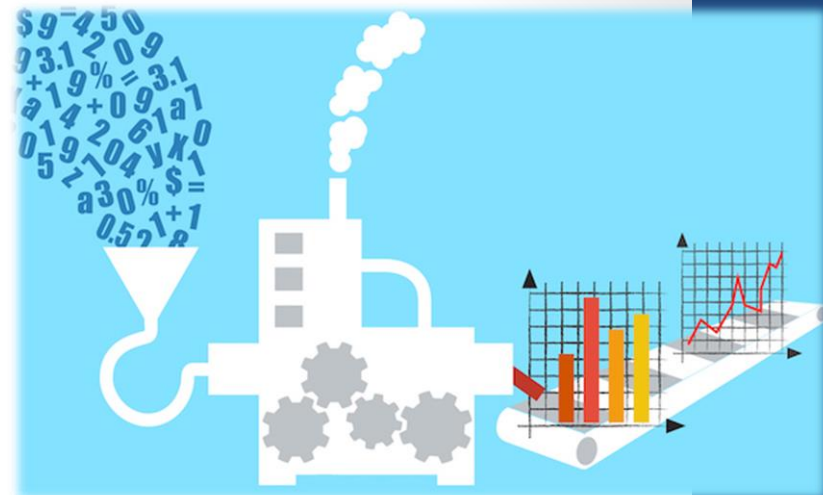
Climate data can be available for specific stations or based on regional aggregations. Some data sources offer both.

Let's look at the Seaforth Well Supply pilot - climate data example

- ✓ Historical data: ECCC – “Blyth” weather station (ID: 6120819).
- ✓ Future data (most climate variables): Climate Atlas Canada - “Kitchener Grid Box”.
- ✓ Future data (dry spell variable): Ontario Climate Data Portal - “Huron Region”
- ✓ Future data (rainfall and snowfall): McDermid et al, 2015.



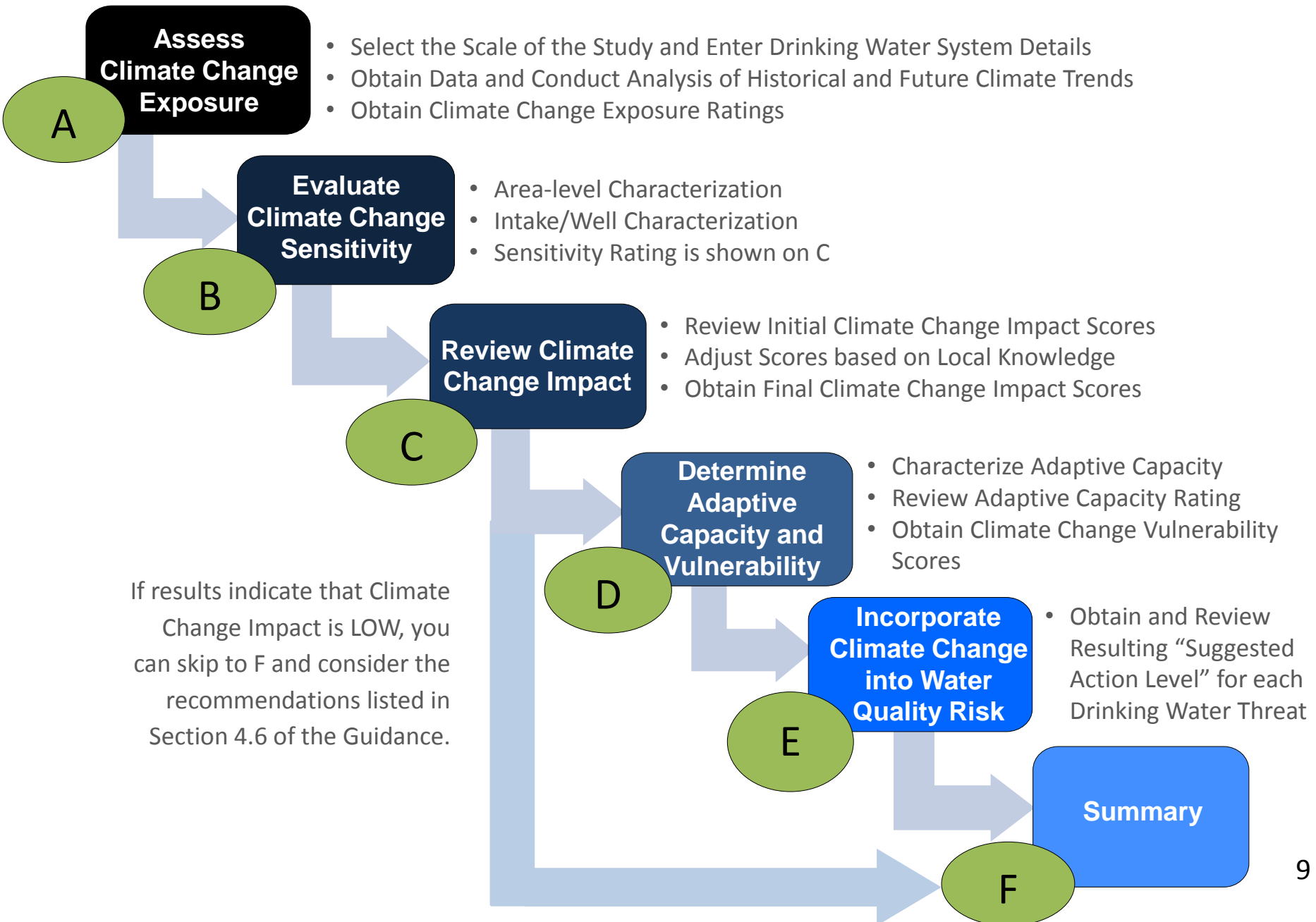
Climate Data: Statistical Analysis



Statistics was your favourite subject in school, right? Great!

- ✓ The DWSP - climate change assessment tool contains step by step instructions for downloading climate data.
- ✓ The tool also contains instructions for developing time-series graphs in Microsoft Excel for each climate variable.
- ✓ Trends of: “change” (i.e. increase or decrease) or “no change” are confirmed by applying a simple statistical analysis within Excel.
- ✓ These trends are determined for each climate variable and for both historical and future periods/normals.

Overview of the Assessment Tool





A: Scale of Study for Climate Change Exposure

- The climate change exposure assessment is considered at an “area” scale that is larger than the drinking water system.
- Select the scale of the area in order to capture the broader context that may increase or decrease the vulnerability of the intake or well/well field :
 - source protection area
 - predetermined climate zone
 - area with distinct geological composition
 - Watershed
 - Subwatershed
 - Groundwatershed (a subsurface catchment area defined by geologic and hydraulic conditions of the rock and sediment through which the water is flowing toward the well).



Conservation
ONTARIO
Natural Champions

A: Exposure

The nature and degree to which a system (people, assets, ecosystems) is subject to significant climate variations.

Example: Potential for a drinking water source well/intake to be exposed to an increased number of rain events and flooding.



Worksheet A provides information on climate data sources, and shows the user how to download data and make use of automated statistical analysis in Microsoft Excel. This process confirms climate trends, which are then entered into the tool to obtain climate change exposure ratings.



Conservation
ONTARIO
Natural Champions

B: Sensitivity

The degree to which a system is affected by climatic stresses, adversely or beneficially, by climate stimuli (IPCC, 2007).

Examples: Area characteristics such as % of floodplains. Well/intake characteristics such as number and depth of wells/intakes, history of water quality issues due to rain events.



Worksheet B seeks information from the user to describe attributes relevant to the drinking water system, at both the area and well/intake scale. The tool evaluates climate change sensitivity at both scales. The score at the well/intake scale is twice as important as the area scale.

C: Impact

The consequences of climate change on systems. Without considering adaptation, this is the product of climate exposure and sensitivity (IPCC, 2014b).

Examples: A shallow intake closer to the shore could become severely impacted by more intense rain events. Shallow, unconfined wells will be more responsive to climate change.



Worksheet C provides climate change impact scores based on the exposure and sensitive ratings from A and B. The user has the opportunity to review and adjust the impact scores and must provide a rationale for any adjustments made.



Conservation
ONTARIO
Natural Champions

D: Adaptive Capacity

The ability of a system to adjust to climate change, to moderate potential damages, to take advantage of opportunities, or to cope with the consequences (from IPCC, 2007).

Example: The water treatment plant is capable of handling a further deterioration in source water quality.

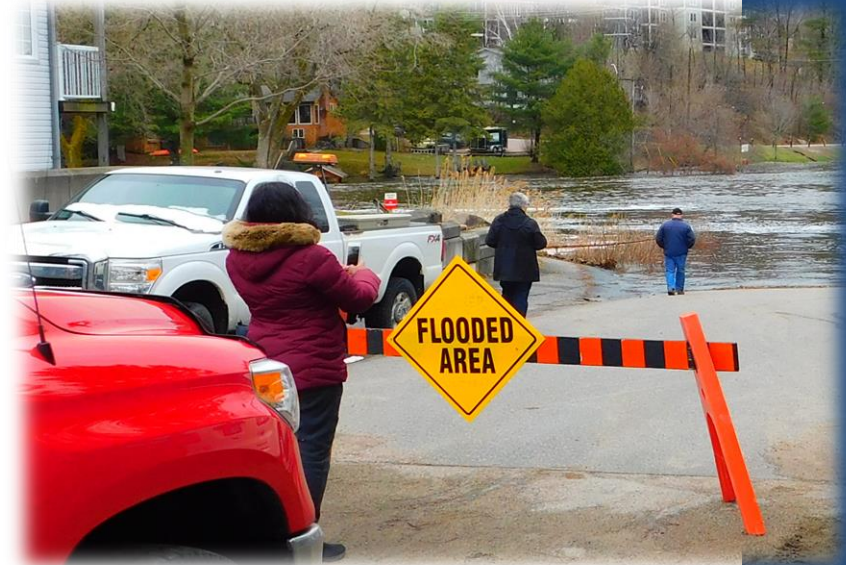


Worksheet D seeks information from the user to describe attributes relevant to the drinking water system, at both the area and well/intake scale. The tool evaluates adaptive capacity at both scales. The score at the well/intake scale is twice as important as the area scale.

D: Climate Change Vulnerability

The propensity or predisposition of a system, place, or human being to be adversely affected by climate change.

It is a function of exposure, sensitivity, and adaptive capacity (IPCC, 2012b).



$$\text{Climate Change Vulnerability} = \frac{\text{Exposure} \times \text{Sensitivity}}{\text{Adaptive Capacity}}$$

Worksheet D provides the overall climate change vulnerability score based on impact scores from C and adaptive capacity from D. Impact is based on exposure and sensitivity.

E: Applying A Climate Change Lens to Drinking Water Threats

Table 1. Incorporating Climate Change Vulnerability of the Intake into Existing Source Water Quality Risk Assessment

| # | Prescribed/ Local Threat | Existing/ Future Threat | Existing Highest Threat Risk Level in IPZ | Climate Change Vulnerability Rating | Suggested Action Level | Local Knowledge (Optional), e.g. policies or actions already in place | Are Additional Actions Potentially Needed to Address Threat? |
|----|---|-------------------------|---|-------------------------------------|------------------------|---|--|
| 1 | The establishment, operation or maintenance of a waste disposal site within the meaning of Part V of the Environmental Protection Act | | | | | | |
| 1a | Storage, Treatment And Discharge Of Tailings From Mines | | | | | | |
| 1b | Waste Disposal Site - Landfarming Of Petroleum Refining Waste | | | | | | |
| 1c | Waste Disposal Site - Landfilling (Hazardous Waste) | | | | | | |
| 1d | Waste Disposal Site - Landfilling (Municipal Waste) | | | | | | |
| | Waste Disposal Site - | | | | | | |

Worksheet E seeks information from the user on: drinking water threat activities (from source protection plan), and knowledge of factors like policies, measures, flooding potential.

E: Applying A Climate Change Lens to Drinking Water Threats



| | | | | |
|--|-------------|--|--------------------------|--------------------------|
| Drinking Water Threat Risk Level (Current) | Significant | Suggested Action Level 2 | Suggested Action Level 3 | Suggested Action Level 3 |
| | Moderate | Suggested Action Level 1 | Suggested Action Level 2 | Suggested Action Level 3 |
| | Low | Suggested Action Level 1 | Suggested Action Level 1 | Suggested Action Level 2 |
| | | Low | Medium | High |
| | | Climate Change Vulnerability Rating (From Worksheet D) | | |

The tool does not change the risk level calculated under the *Clean Water Act*. Rather, **Worksheet E** provides a suggested “action level” based on a matrix of threat risk level and the overall vulnerability score.

Local source protection authorities and committees can discuss how to address the suggested action level. The MECP will provide guidance for considering the outcome of the assessment tool.

F: Summary

- Print-friendly summary of the assessment results
- Compiles all results from each worksheet:
 - Climate Change Exposure
 - Climate Change Sensitivity
 - Climate Change Impact
 - Adaptive Capacity
 - Climate Change Vulnerability
 - Number of threats where actions may be appropriate.

Let's Explore the Pilot Studies

- Burlington water intake
- Seaforth well supply



The climate change assessment tool was developed by a multi-disciplinary team. We thank you in advance for your patience, where we may need to seek input from our project partners outside of the training sessions to address queries. Please email your questions to help expedite the process (contact information is on the next slide).

Thank you.

Chitra Gowda

Source Water Protection Lead

Conservation Ontario

Email: cgowda@conservationontario.ca

Conservation Ontario is the network of all 36 conservation authorities in Ontario.

DRINKING WATER
SOURCE PROTECTION
Our Actions Matter



References

- Intergovernmental Panel on Climate Change, IPCC. 2007. Working Group I Contribution to the IPCC Fourth Assessment Report on Climate Change 2007: The Physical Science Basis. Available Online: http://www.ipcc.ch/publications_and_data/ar4/wg1/en/contents.html
- Intergovernmental Panel on Climate Change, IPCC. 2012b. Glossary of terms. In: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation [Field, C.B. V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)]. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change (IPCC). Cambridge University Press, Cambridge, UK, and New York, NY, USA, pp. 555-564. https://www.ipcc.ch/pdf/special-reports/srex/SREX-Annex_Glossary.pdf
- Intergovernmental Panel on Climate Change, IPCC. 2014b. Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Edenhofer, O. R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
- Environmental Commissioner of Ontario. 2018. Climate Action in Ontario: What's Next? 2018 Greenhouse Gas Progress Report.
- Price, D.T.; McKenney, D.W. ; Joyce, L.A. ; Siltanen, R.M.; Papadopol, P. ; Lawrence, K. 2011. *High-Resolution Interpolation of Climate Scenarios for Canada Derived from General Circulation Model Simulations*. Nat. Resour. Can., Can. For. Serv., North. For. Cent., Edmonton, AB. Inf. Rep. NOR-X-421.



Climate Change – Science and Assessments 101

Chitra Gowda, M.A.Sc. (Env. Eng.)

Source Water Protection Lead, Conservation Ontario

Reading Materials for

*Training Session on: Climate Change Vulnerability Assessment Tool
January and February 2020*



Overview

- Key Terms, Definitions and Descriptions
- Climate Change Science
- Climate Change Risk Assessment Frameworks



Climate Science: Key Terms

Climate

- An area's long-term weather patterns. The simplest way to describe climate is to look at average conditions (e.g., temperature, precipitation, etc.) over time. (IPCC 2012a, IPCC 2012b)

Climate Change

- A long-term shift in weather conditions measured by changes in temperature, precipitation, wind, snow cover, and other indicators. <https://www.canada.ca/en/environment-climate-change/services/climate-change/frequently-asked-questions.html>

Climate Variability

- Variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all spatial and temporal scales beyond that of individual weather events (IPCC 2014b).

Weather

- The mix of events that happen each day in our atmosphere. *Though they are closely related, weather and climate aren't the same thing. Climate is what you expect. Weather is what actually happens.* <https://www.ncei.noaa.gov/news/weather-vs-climate>

Extreme Event

- An event that is rare at a particular place and time of year. It would normally be as rare as or rarer than the 10th or 90th percentile of a probability density function estimated from observations (IPCC 2014b).

WEATHER

Tells you what to wear each day



CLIMATE

Tells you what types of clothes to have in your closet





Climate Science: Key Terms

Climate Normal

- Arithmetic calculations based on observed climate values for a given location over a specified time period and are used to describe the climatic characteristics of that location (ECCC, 2017).
- A 30-year period is typically used to smooth out extremes.

Climate Projections

- Simulated response of the climate system to a scenario of future emission or concentration of greenhouse gases (GHGs) and aerosols, generally derived using climate models (IPCC, 2014b).

General Circulation/Global Climate Models (GCM)

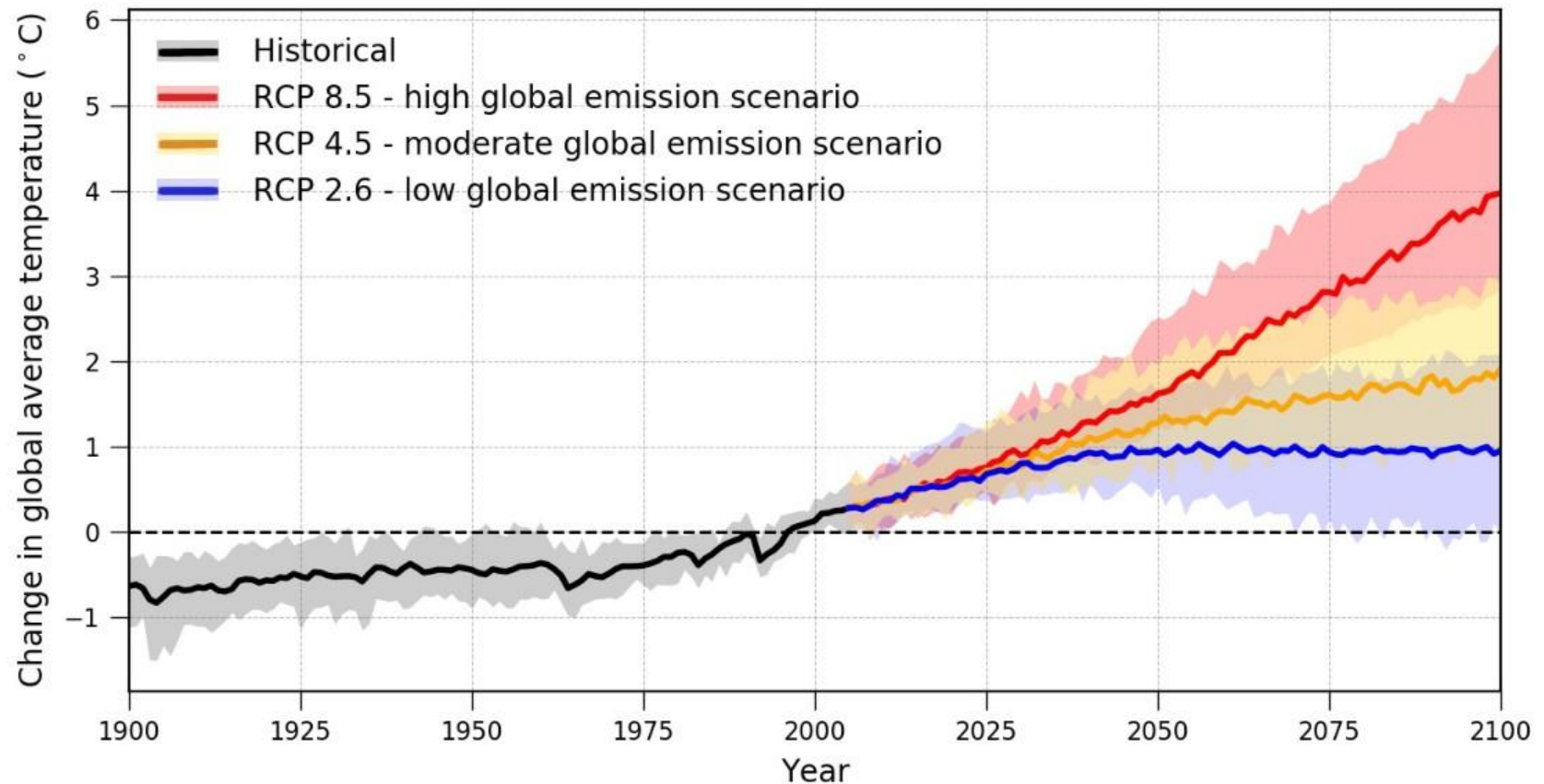
- Mathematical models for climate condition projections. Based on widely accepted, well known physical processes to simulate the transfer of energy and materials through a climate system.
<https://www.climate.gov/maps-data/primer/climate-models>.
- An average of GCMs is an “Ensemble”

Representative Concentration Pathways (RCP)

- A set of scenarios that focus on the level of GHGs in the atmosphere in 2100. Each RCP indicates the amount of radiative forcing, expressed in Watts per square meter, that would result from GHGs in the atmosphere in 2100. The rate and trajectory of the forcing is the pathway. RCPs: 2.6, 4.5, 6.0, 8.5.



RCP Emission Scenarios and Climate Projections



This figure shows **changes in global average temperature**, relative to the 1986 to 2005 reference period, simulated by 29 global climate models from the Coupled Model Intercomparison Project, Phase 5 (CMIP5).



Conservation
ONTARIO
Natural Champions

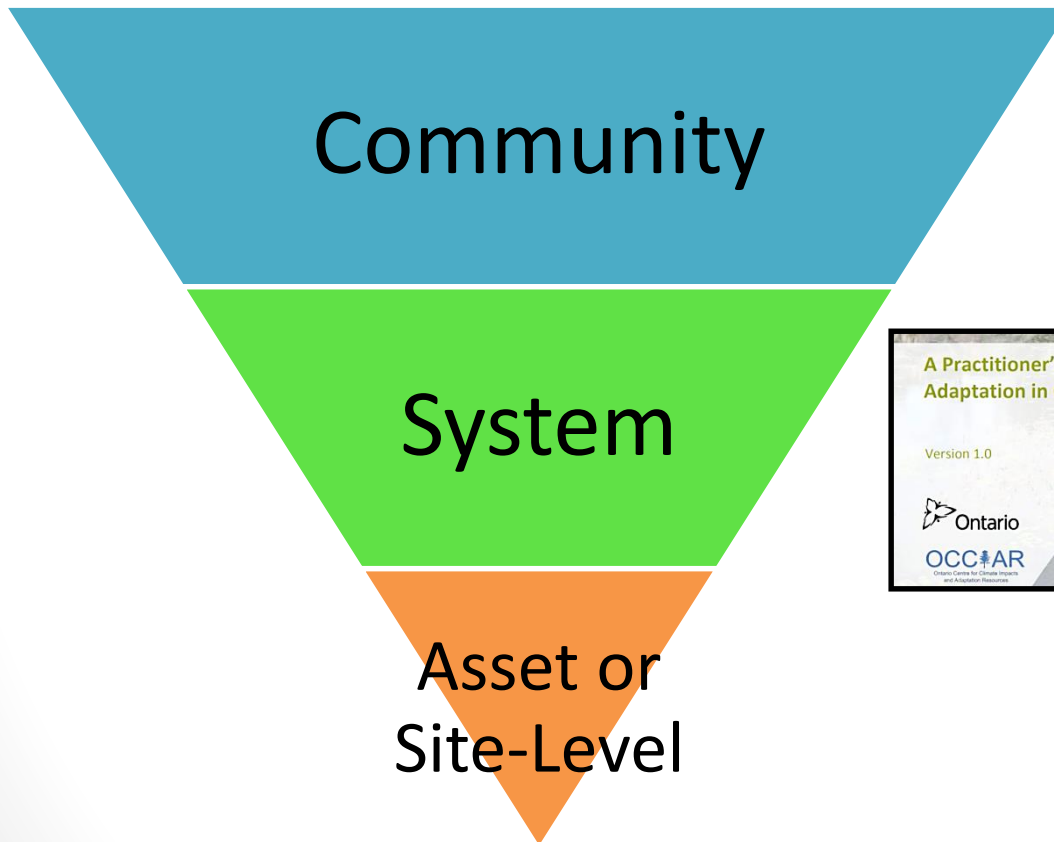
Risk Assessment Frameworks - Elements

- **Scoping:** Setting the context, establishing a team and assessment objectives
- **Set-up:** Characterizing the System and hazards (e.g., extreme heat or extreme rain, or tornado).
- **Risk Analysis:** Estimating, characterizing and comparing the vulnerabilities. Characterizing likelihoods of things happened and consequences associated with them.
- **Risk Treatment:** Determining risk, researching, evaluating and selecting alternatives to manage risk or strategies to increase resilience.

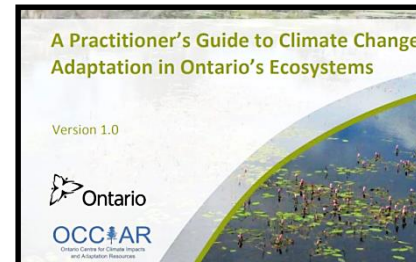


Risk Assessment Frameworks - Scale

Scales



Examples

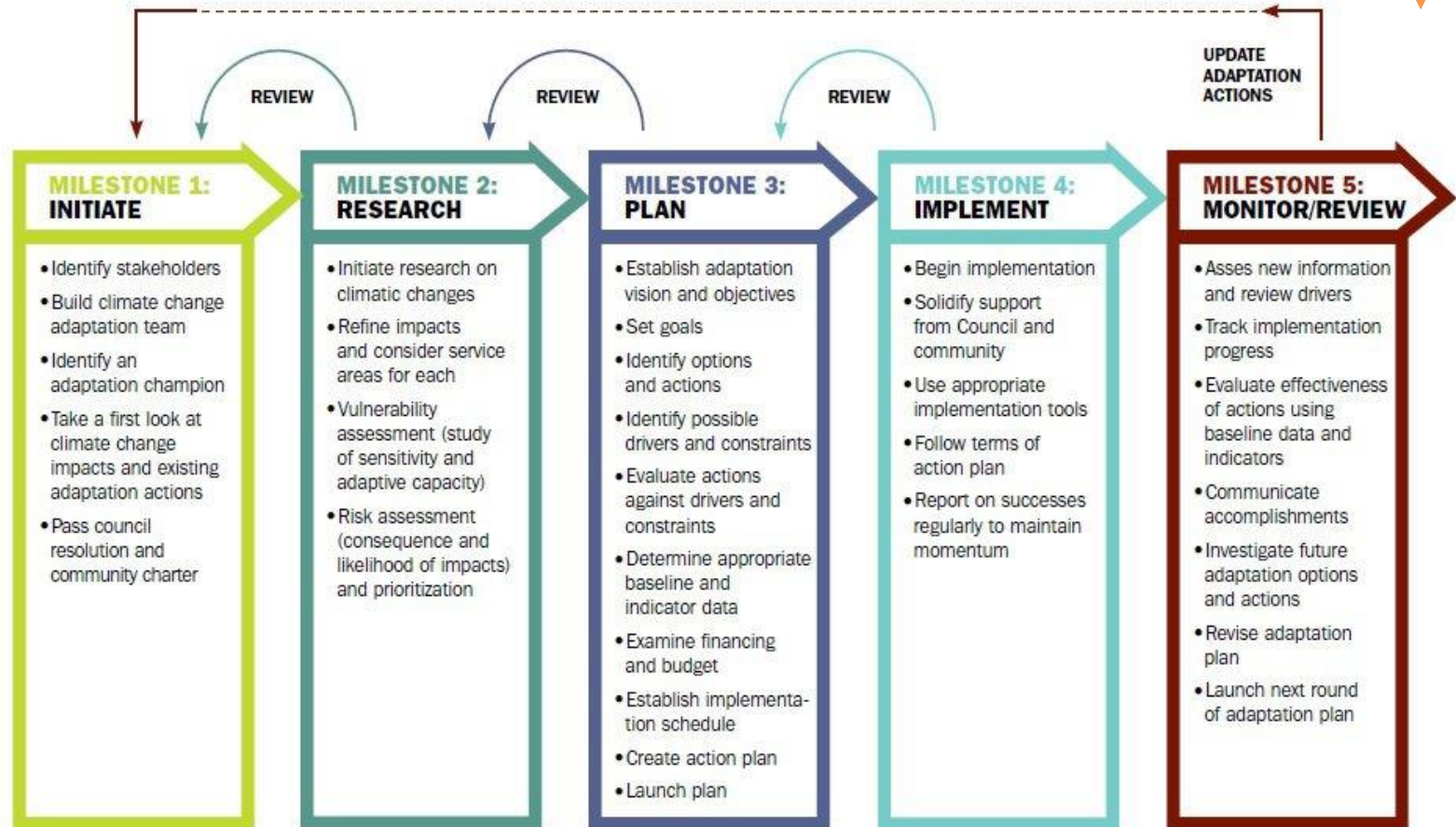




Conservation
ONTARIO
Natural Champions

Building Adaptive Resilient Communities (BARC- ICLEI) Framework

ICLEI
Local
Governments
for Sustainability



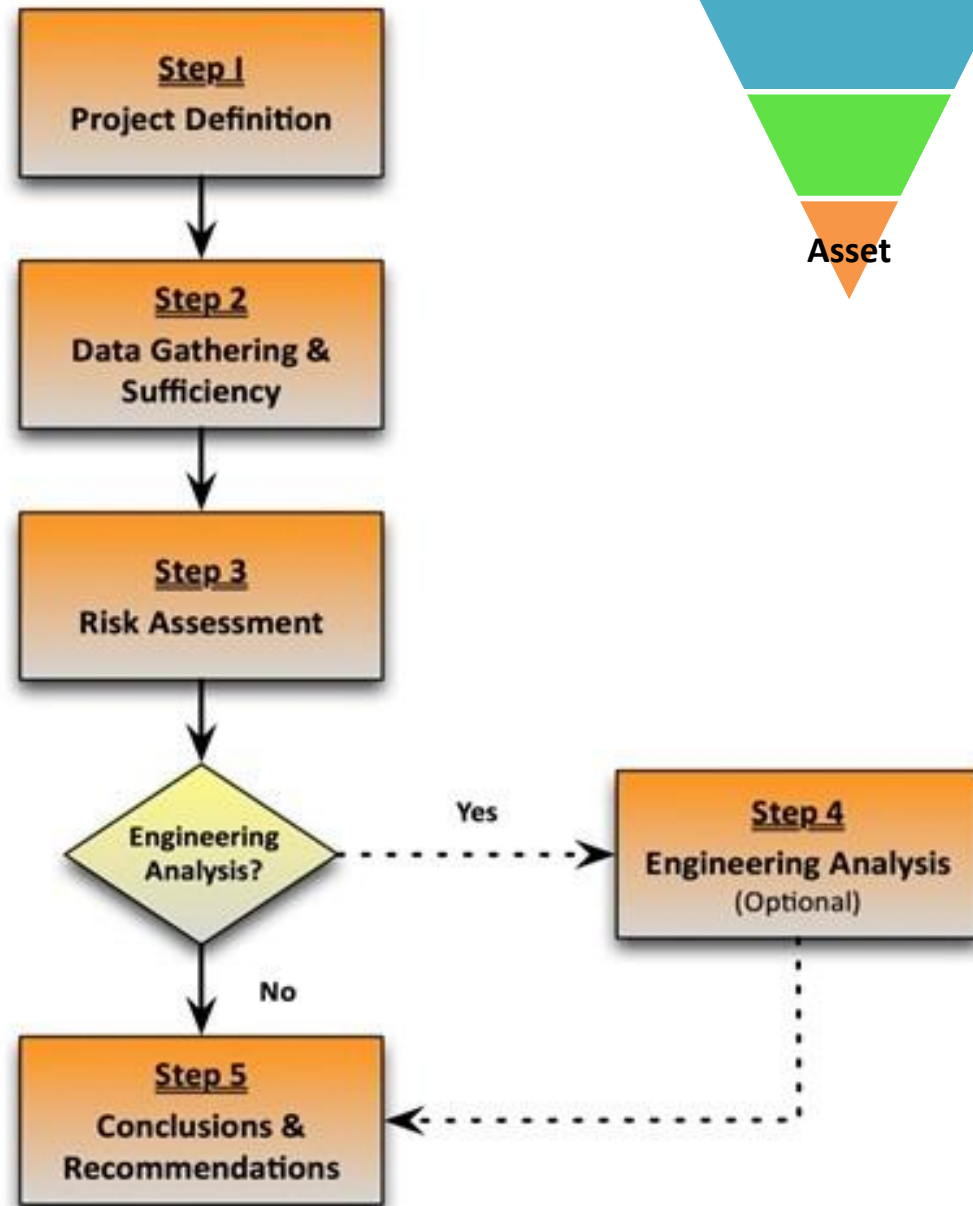
A Practitioner's Guide to Climate Change Adaptation in Ontario's Ecosystems (MNRF, 2011)

System



ITERATIVE PROCESS

The protocol is a five step process to analyze the engineering vulnerability of an individual infrastructure e.g. a building or an infrastructure system e.g. a potable water treatment and supply system to current and future climate parameters such as extreme heat or extreme rainfall. It is not a spatial risk assessment tool to identify areas of high, medium or low risk.





Vulnerability Assessments: Key Terms

Exposure

- The inventory of elements in an area in which hazard events may occur (IPCC, 2012). In other words, the nature and degree to which a system (people, assets, ecosystems) is subject to significant climate variations.

Sensitivity

- The degree to which a system is affected by climatic stresses, adversely or beneficially, by climate stimuli (IPCC, 2007).

Impact

- The consequences of climate change on systems (IPCC, 2014).

Adaptive Capacity

- The ability of a system to adjust to climate change, to moderate potential damages, to take advantage of opportunities, or to cope with the consequences (IPCC, 2007).

Vulnerability

- The propensity or predisposition [of a system, place, or human being] to be adversely affected [by climate change]. It is a function of exposure, sensitivity, and adaptive capacity (IPCC, 2012).

Exposure

The nature and degree to which a system (people, assets, ecosystems) is subject to significant climate variations.

Example: Potential for a drinking water source well/intake to be exposed to an increased number of rain events and flooding.

Analogy:

Living in an area where you are exposed to pollen.





Conservation
ONTARIO
Natural Champions

Sensitivity

The degree to which a system is affected by climatic stresses, adversely or beneficially, by climate stimuli (IPCC, 2007).

Examples: Area characteristics such as % of floodplains. Well/intake characteristics such as number and depth of wells/intakes, history of water quality issues due to rain events.

Analogy:
Being allergic (sensitive) to pollen, or not.





Conservation
ONTARIO
Natural Champions

Impact

The consequences of climate change on systems. Without considering adaptation, this is the product of climate exposure and sensitivity (IPCC, 2014).

Examples: A shallow intake closer to the shore could become severely impacted by more intense rain events. Shallow, unconfined wells will be more responsive to climate change.

Analogy:
Missing work due to allergies.





Conservation
ONTARIO
Natural Champions

Adaptive Capacity

The ability of a system to adjust to climate change, to moderate potential damages, to take advantage of opportunities, or to cope with the consequences (from IPCC, 2007).

Example: The water treatment plant is capable of handling a further deterioration in source water quality.

Analogy:

Using an inhaler to cope with allergies, while being exposed to pollen.



Climate Change Vulnerability

The propensity or predisposition of a system, place, or human being to be adversely affected by climate change.

It is a function of exposure, sensitivity, and adaptive capacity (IPCC, 2012).

$$\text{Climate Change Vulnerability} = \frac{\text{Exposure} \times \text{Sensitivity}}{\text{Adaptive Capacity}}$$

Thank you.

Chitra Gowda

Source Water Protection Lead

Conservation Ontario

Email: cgowda@conservationontario.ca

Conservation Ontario is the network of all 36 conservation authorities in Ontario.

DRINKING WATER
SOURCE PROTECTION
Our Actions Matter



References

- Intergovernmental Panel on Climate Change, IPCC. 2007. Working Group I Contribution to the IPCC Fourth Assessment Report on Climate Change 2007: The Physical Science Basis. Available Online: http://www.ipcc.ch/publications_and_data/ar4/wg1/en/contents.html
- Intergovernmental Panel on Climate Change, IPCC. 2012a. “Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change.” http://ipccg2.gov/SREX/images/uploads/SREX-All_FINAL.pdf
- Intergovernmental Panel on Climate Change, IPCC. 2012b. Glossary of terms. In: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation [Field, C.B. V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)]. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change (IPCC). Cambridge University Press, Cambridge, UK, and New York, NY, USA, pp. 555-564. https://www.ipcc.ch/pdf/special-reports/srex/SREX-Annex_Glossary.pdf
- Intergovernmental Panel on Climate Change, IPCC. 2014b.: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Edenhofer, O. R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
- Environmental Commissioner of Ontario. 2018. Climate Action in Ontario: What’s Next? 2018 Greenhouse Gas Progress Report.
- Price, D.T.; McKenney, D.W. ; Joyce, L.A. ; Siltanen, R.M.; Papadopol, P. ; Lawrence, K. 2011. *High-Resolution Interpolation of Climate Scenarios for Canada Derived from General Circulation Model Simulations*. Nat. Resour. Can., Can. For. Serv., North. For. Cent., Edmonton, AB. Inf. Rep. NOR-X-421.



The Ontario Drinking Water Source Protection Program

Chitra Gowda, M.A.Sc. (Env. Eng.)

Source Water Protection Lead, Conservation Ontario

*Reading Materials for
Training Session on: Climate Change Vulnerability Assessment Tool
January and February 2020*



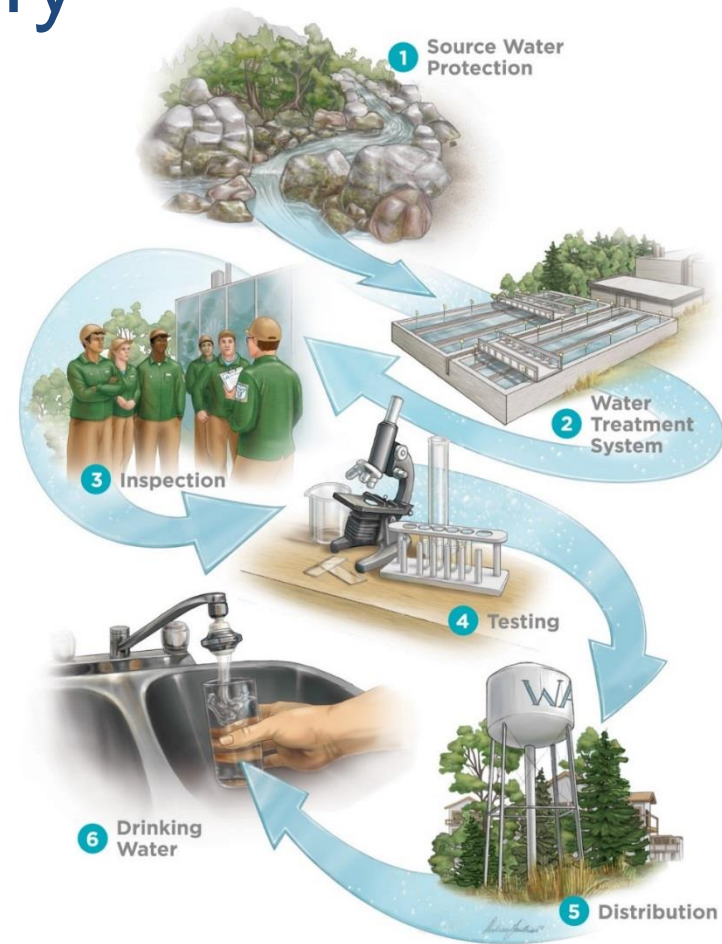
Overview

1. The Clean Water Act (2006)
2. Conservation Authorities
3. Drinking Water Source Protection Program
 - Key Elements and Partners
 - The Science: Assessment Reports
 - The Policies: Source Protection Plans



The Clean Water Act - History

- Tragic events occurred in Walkerton in May 2000 where the town's drinking water became contaminated with E.coli. Seven people died and hundreds were made ill, many with lifetime health impacts.
- Justice O'Connor led an inquiry into the contamination of the Walkerton water supply and the safety of Ontario's drinking water. Final reports issued in 2002.
- In response, Ontario's multi-barrier approach was developed, focusing on prevention.
- **Source-to-tap focus**, strong legislative framework, health-based standards, regular testing, licensing, operator certification, and compliance support.
- Includes the ***Clean Water Act, 2006*** and its regulations.



*Multi-barrier approach:
Protecting from Source to Tap*

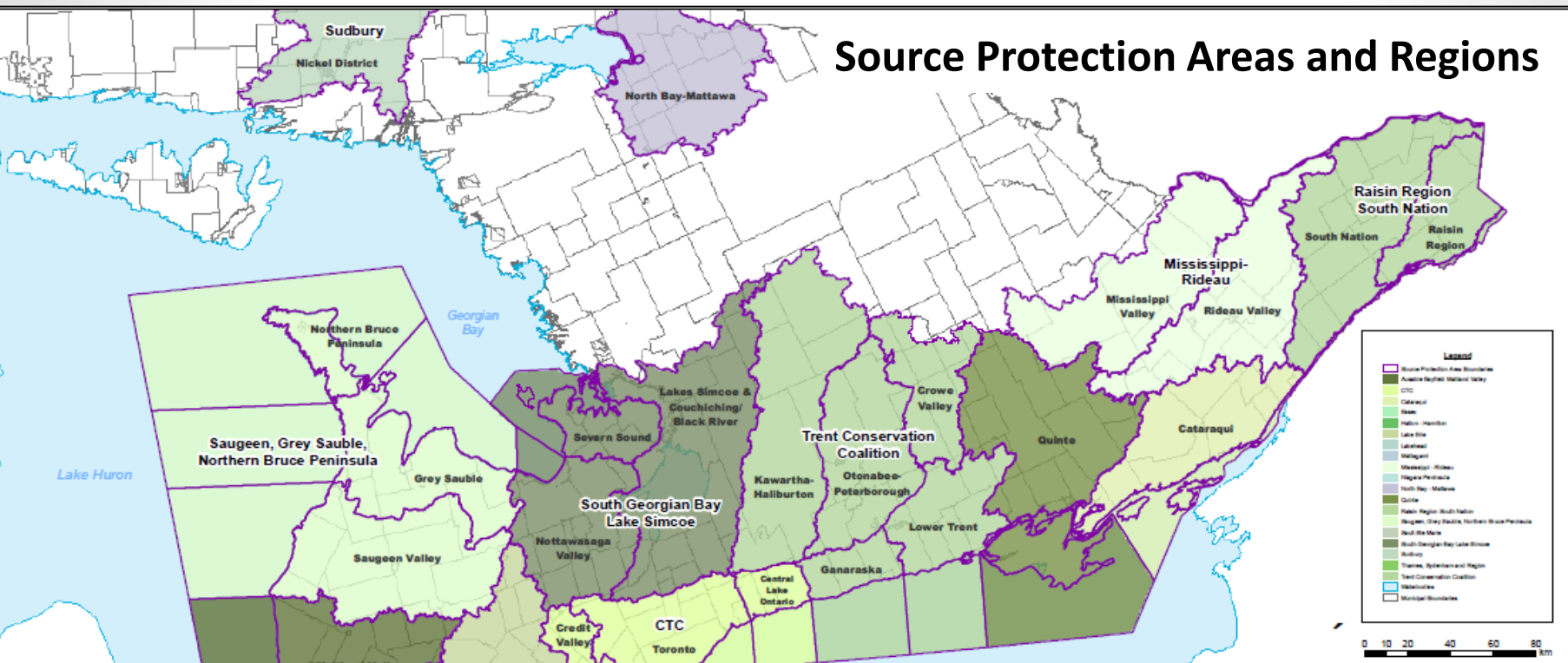
The Clean Water Act - Purpose

- The purpose of the Act is to protect existing and future sources of municipal, residential drinking water from contamination or depletion.
- Municipalities may also bring in other systems (private, non-residential). First Nations have the option to join.
- The Act manages activities that could be a risk to sources of drinking water in Ontario. It also relies on existing legislation, regulations, and processes to manage or eliminate risks.
- The Act does not extend the powers of existing legislation and regulations. Where there is a conflict between pieces of legislation – the most protective of drinking water applies.

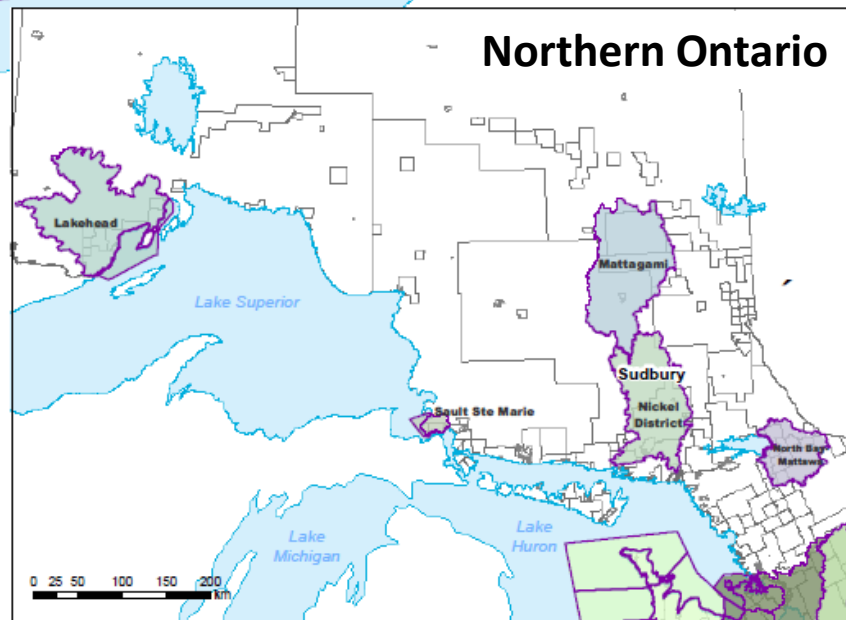
The Clean Water Act – Jurisdiction

- The Clean Water Act is the **legal foundation** for the Ontario Drinking Water Source Protection Program, a multi-stakeholder, collaborative, locally-driven, science-based process within established **source protection areas**.
- The Clean Water Act established **38 watershed-based source protection areas**, grouped into 19 unique units. See the map on the next slide.
- Each source protection area has a **source protection authority (SPA)**.
- 36 SPAs are based on **Conservation Authorities** and 2 SPAs are based on the Municipality of Northern Bruce Peninsula and Severn Sound Environmental Association.

Source Protection Areas and Regions



Northern Ontario



The maps shown here are for information purposes only and are not suitable for site-specific water quality assessments. The Ministry of the Environment and Conservation will be undertaking field work to determine, correct, or complete all information shown here, and will be responsible for the use of the data. All products are intended for reference purposes only, and the Ministry of the Environment will not be held liable for any consequences, damages or losses from the use of this map. These maps are distributed "as is" without warranty, in any form, either expressed or implied, including but not limited to warranties of merchantability, fitness for purpose, or use.

Map was created on November 20, 2008 © Queen's Printer for Ontario.
 Map produced by MCE Source Protection Program Branch, Source Protection Planning Unit & MCE's 22 Protection Regions of Southern Ontario and MCE's 10 Protection Regions of Northern Ontario. Additional data provided by various municipal governments and water users provided to Ministry of Municipal Affairs & Housing and Ministry of Natural Resources respectively.

Conservation Authorities

- Unique to Ontario, **Conservation Authorities** are local watershed management agencies that deliver services and programs to protect and manage impacts on water and other natural resources in partnership with all levels of government, landowners and many other organizations.
- CAs are creatures of statute, legislated under the *Conservation Authorities Act, 1946*. **95% of Ontario's population lives in a watershed managed by a CA.**
- Conservation Authorities promote an integrated watershed management approach balancing human, environmental and economic needs. Conservation Authorities are organized on a watershed basis. The network of Conservation Authorities is represented by **Conservation Ontario**, which is a nonprofit association.

Key Elements of the Source Protection Program

Ministry of the Environment, Conservation and Parks

- Maintain legislative/regulatory foundation and scientific framework. Collaborate across ministries.
- The Minister's roles include: approving revisions to source protection plans and issuing orders for reviews and updates, as well as appointing source protection committee chairs.
- The Minister has other powers under the Legislation such as the power to make regulations, to require Official Plans to come into conformity with source protection plans, to require hearings or to require changes to be made.

Source Protection Authority (SPA)

- Maintain source protection committees and provide admin, technical and scientific support to committee.
- Develop amendments to source protection plans.
- Undertake annual reporting and maintain access to data and information.
- Support municipalities in fulfilling their implementation responsibilities, and undertake other functions related to SPA role (provide advice and technical services to municipalities, businesses, land owners and others about plan policies and source protection program).

Source Protection Committee

- Responsible for preparing local assessment reports and source protection plans, and reviewing and updating them in accordance with Minister's orders.
- Chair appointed by Minister.
- Members appointed by source protection authority – 1/3 municipal, 1/3 economic (agricultural, commercial, business/industrial), 1/3 other (environment, health, public).
- Ministry rep sits on committee.
- 12 have additional seats dedicated to First Nation representatives.
- Meets ~ 4x year.

Source Protection Plan

- Action plan that addresses risks to sources of drinking water within vulnerable areas around municipal residential drinking water systems.
- Includes the **Assessment Report** which sets out the technical (science-based) information related to drinking water systems and their vulnerable areas, risk assessments, maps and activities that pose a threat to source water.

Implementing Bodies

- Province, municipalities, conservation authorities.
- Responsible for undertaking the actions directed by the source protection plan

Source: Ministry of Environment, Conservation and Parks

Key Partners Roles, Responsibilities

Municipalities

- Participated in the development of the terms of reference, assessment report, and source protection plans.
- Implementers and enforcers of the majority (60%) of actions in the plans to address identified risks to sources municipal drinking water.
- Determine the inclusion of other drinking water systems within their jurisdiction (e.g. private well clusters, non-municipal) in plans.

First Nations

- The Clean Water Act, 2006, enables First Nations drinking water systems to be included in source protection plans if their reserves are located within a source protection area.
 - First Nations with reserves in source protection areas can participate in the source protection planning process by sitting on the local source protection committee.
 - Consulting on source protection planning documents.
 - Including their drinking water systems in local plans to address off-reserve risks to their drinking water sources.
- Three communities have included their drinking water systems: Chippewas of Rama; Six Nations of the Grand River; Chippewas of Kettle and Stony Point.

Key Partners Roles, Responsibilities

Other Provincial Ministries:

- Implement plan policies that rely on provincial instruments prescribed in Clean Water Act regulations (e.g. permits, approvals, licences etc.).
- Consider, support and/or implement other plan policies (e.g. specified actions, research, education and outreach etc.).
- Report on implementation progress.
- Key ministries are: Environment, Conservation and Parks; Agriculture, Food and Rural Affairs; Natural Resources and Forestry; Municipal Affairs and Housing; Transportation; Government and Consumer Services (incl. TSSA); Energy, Northern Development and Mines.

The Science: Assessment Reports

Vulnerability Analysis

- Water quality vulnerability analysis assesses how vulnerable **groundwater** and **surface water** sources are to contamination
- Water quantity vulnerability analysis uses **water budgets** to assess the sustainability of the drinking water sources

Vulnerable Areas

Through these analyses, four types of vulnerable areas have been delineated:

1. Intake Protection Zone (IPZ) (Quality & Quantity)*
2. Well Head Protection Area (WHPA) (Quality & Quantity)*
3. Significant Groundwater Recharge Area (SGRA)(Quantity)
4. Highly Vulnerable Aquifer (HVA) (Quality)

** areas where significant risks, to drinking water sources, can occur*



The Science: Assessment Reports

Vulnerable Area Scoring (Water Quality only)

Each vulnerable area is assessed to determine how vulnerable it is to contamination. The **factors** considered for assigning scores are:

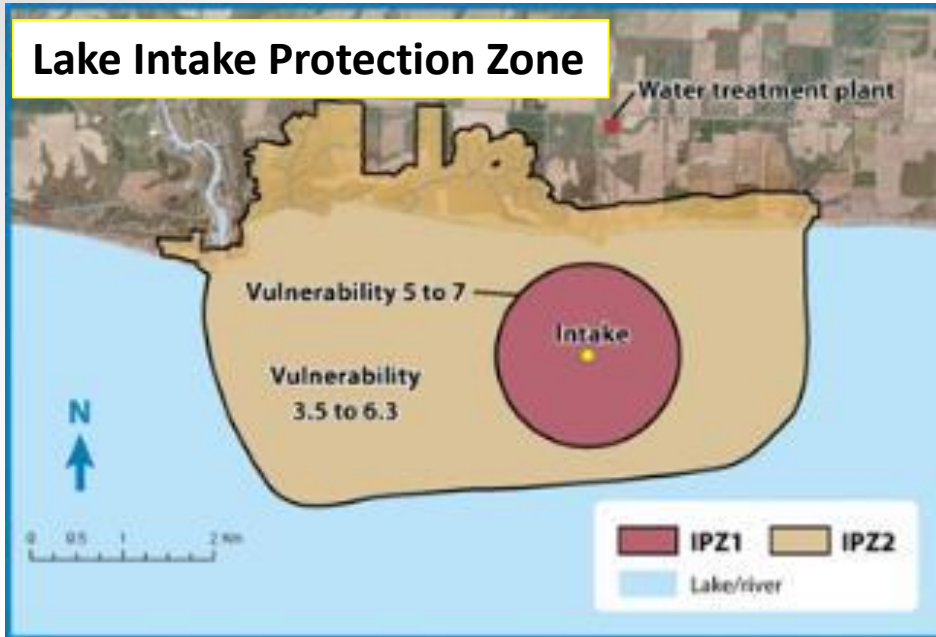
Surface water sources:

- Area Characteristics: Land percentage, land cover, soil type, permeability, slope, rainfall, transport pathways, etc.
- Intake Characteristics: depth of intake, length of intake from shore, history of water quality concerns.

Groundwater sources:

- Flow characteristics: vertical and horizontal groundwater flow.
- Aquifer characteristics: depth of aquifer, types of soils.
- Time of travel to the well.

Lake Intake Protection Zone



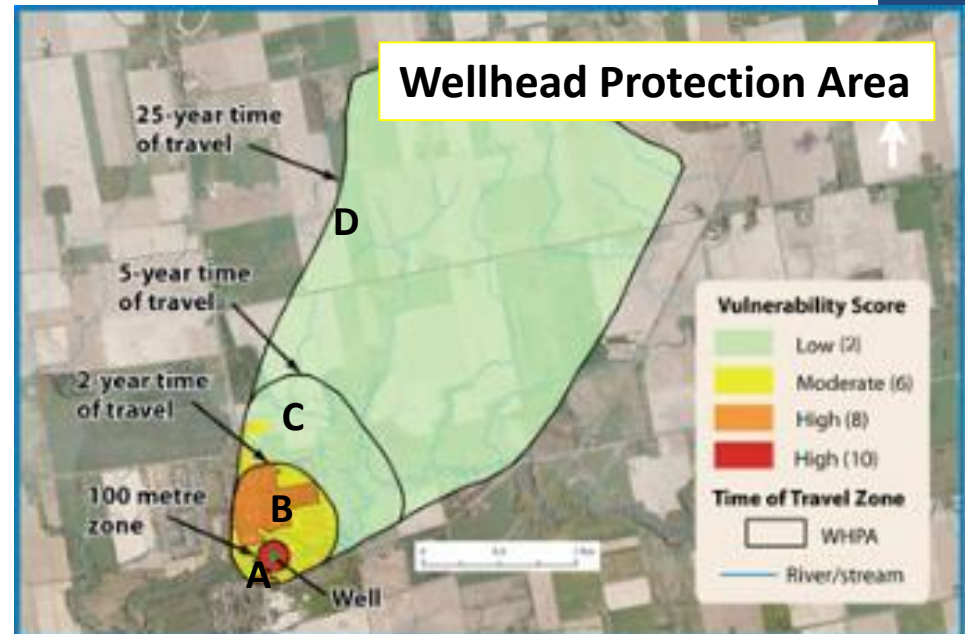
The vulnerability scores are used to determine whether activities pose a risk to the source of drinking water.

Vulnerability Score Range: 1 (lowest) to 10 (highest)

Depending on the score, risks posed by the activities can be identified as

- **Significant**
- **Moderate**
- **Low**

Wellhead Protection Area



The Science: Assessment Reports

Transport Pathways

- For Surface Water:
Works or any other thing that reduces the time it takes for a contaminant to reach a surface water intake (e.g. storm sewers, discharge pipes, utility trenches, ditches, swales, drainage works or any other types of drains)
- For Ground Water:
Anthropogenic pathways may short-circuit the natural infiltration of water from the surface to the aquifer (e.g. improperly abandoned well(s), aggregate pit/quarry).

The Science: Assessment Reports

Threat Activities

1 – **waste disposal**

2 – **sewage**

Agriculture

3 – application of Agricultural Source Materials
4 – storage of Agricultural Source Materials
5 – management of Agricultural Source Materials

6 – application of Non Agricultural Source Materials
7 – handling and storage of Non Agricultural Source Materials

8 – application of commercial fertilizer
9 – handling and storage of commercial fertilizer

10 – application of pesticide
11 – handling and storage of pesticide

21 – livestock grazing and pasturing

12 – application of **road salt**
13 – handling and storage of **road salt**

14 – storage of **snow**

Industrial

15 – handling and storage of **fuel**

16 – handling and storage of dense non-aqueous phase liquid (**DNAPL**)

17 – handling and storage of an **organic solvent**

22 - establishment and operation of a **liquid hydrocarbon pipeline**

18 – chemicals used in the de-icing of aircraft

Water Quantity

19 – consumptive water taking

20 – activity that reduces the recharge of an aquifer

Clean Water Act (General Reg. 287/07)

Source: Ministry of Environment, Conservation and Parks

The Science: Assessment Reports

Current Water Quality Risk Assessment

(I) Vulnerability Scoring Approach

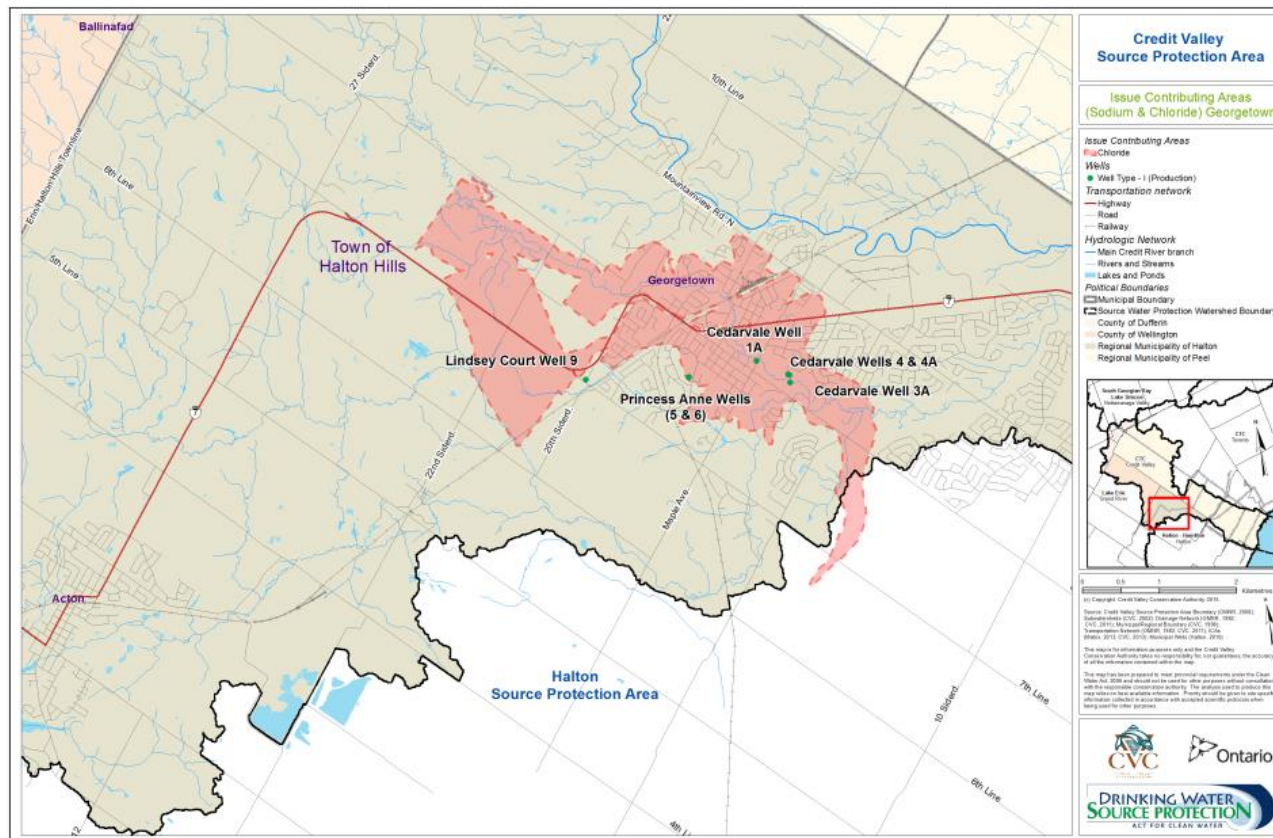
- Risk scores are the basis for identifying the level of risk of threat activities in vulnerable areas.

$$\text{RISK SCORE} = \text{VULNERABILITY SCORE} \times \text{HAZARD SCORE}$$

- Vulnerability scores are determined for each vulnerable area.
- Hazard scores are determined for each threat activity based on:
 - Environmental fate, Toxicity
 - Quantity released to the environment, and
 - Likelihood of contaminant to may be released to the environment
- Risk for each threat activity is assessed as:
 - Significant \rightarrow risk score ≥ 80
 - Moderate \rightarrow risk score $\geq 60 - 80$
 - Low \rightarrow risk score $\geq 40 - 60$

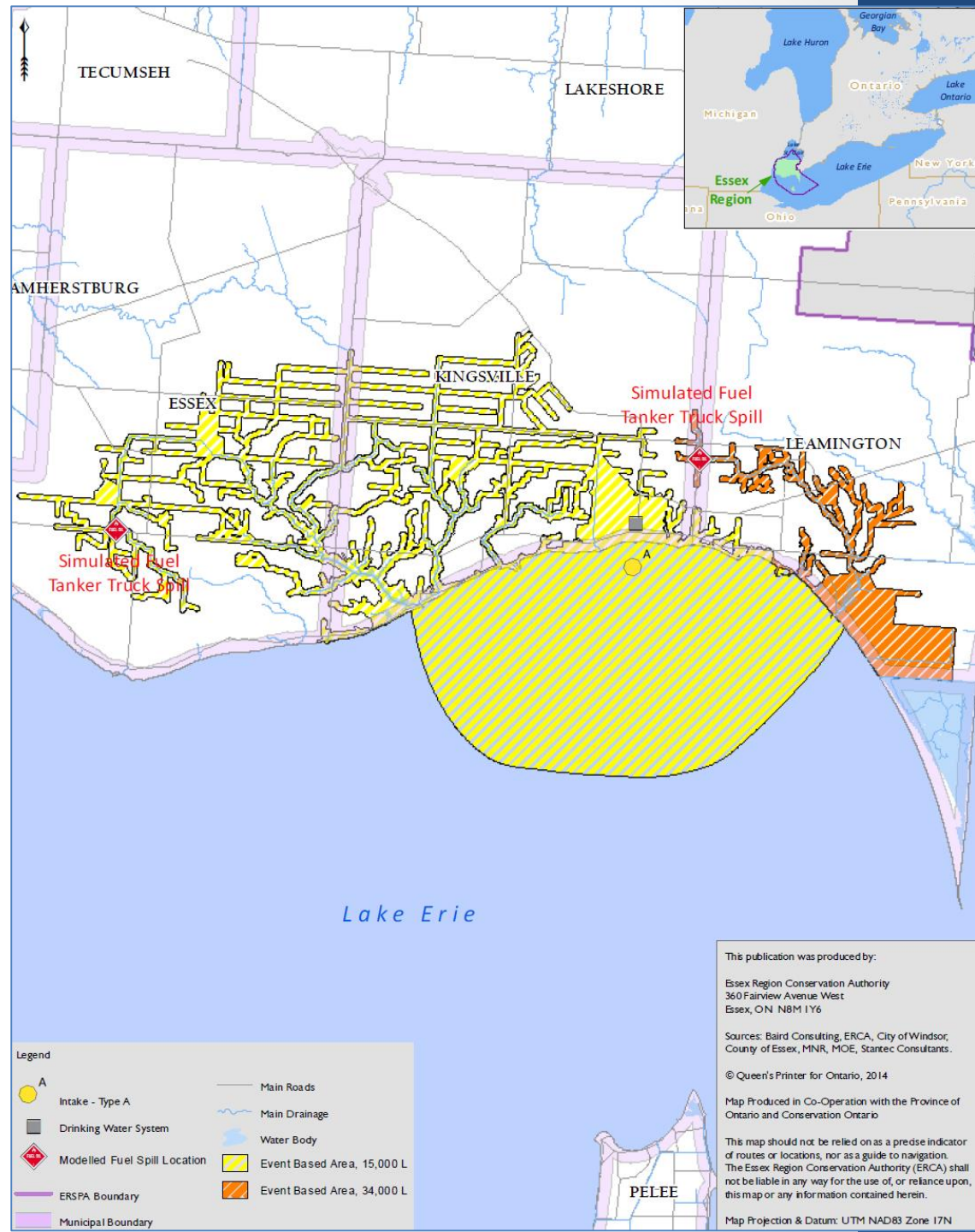
(II) Water Quality Issues Approach

- Water Quality Issue is a known contaminant at the intake or well that may cause a deterioration to the water quality of the drinking water source (anthropogenic).
- Where an issue is identified, a geographical Issue Contributing Area is delineated within existing vulnerable areas where threats activities and past activities may contribute to the issue (e.g. chloride).



(III) Event Based Areas Approach

- These areas within existing IPZs are delineated where the release and transport of contaminants to an intake under extreme weather events pose a risk to a source.
- Can be used where the vulnerability scoring approach did not adequately address the risk of spills in IPZs.
- Applicable to large surface water bodies only (e.g. Great Lakes).



The Policies: Source Protection Plans

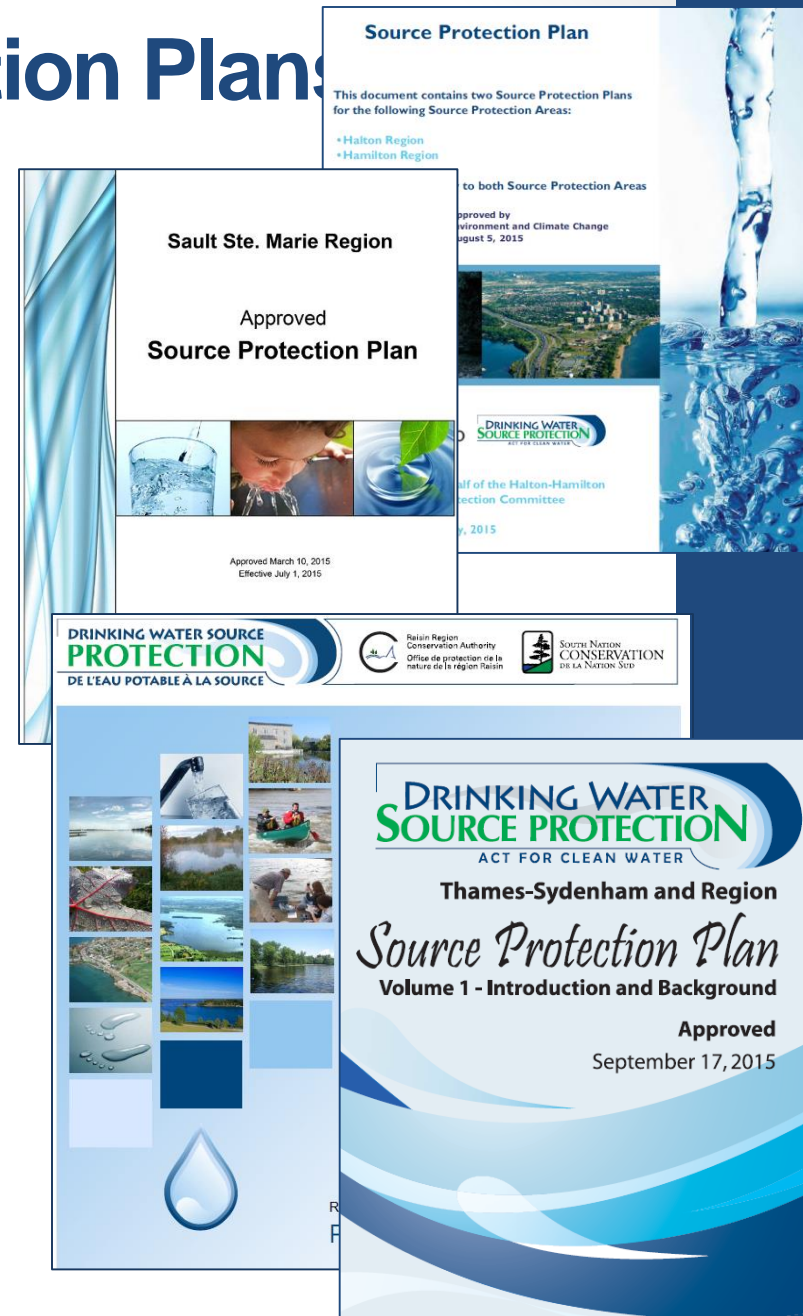


Policies are **mandatory** for activities that pose a significant level risk:

- Areas with water quality risk = or > than 80.
- Issue contributing areas.
- Modelled event based areas.

The Policies: Source Protection Plans

- As of 2017, source protection plans are being implemented for all source protection areas.
- The source protection plans cover ~440 municipal residential drinking water systems, where the majority of Ontario's population get their drinking water.
- Progress is reported annually to the Ministry and summarized in the Minister's Annual Report on Drinking Water.



The Policies: Source Protection Plans

Climate Change Policy Example

From the Halton-Hamilton Source Protection Plan

3.3.2 Climate Data (*This policy requests that the collection of data necessary for assessing long term trends in the local climate be continued and the data be shared*)

O-2-S To ensure that data on the climate conditions in the Source Protection Area are gathered on an ongoing basis, the following policies apply:

- a.** The municipalities, the conservation authorities, the Ministries of the Environment and Natural Resources, and Environment Canada are supported and encouraged in their efforts to collect and/or interpret the hydrogeological, hydrological, and climate data for the Source Protection Areas and are requested to share the data as appropriate in a timely manner.
- b.** The Ministry of the Environment and Climate Change is requested, in collaboration with Environment Canada, to install best practical instrumentation to provide monitoring of current speed and direction and water chemistry of Lake Ontario in the nearshore source water.
- c.** Environment Canada is requested to review its monitoring network to ensure appropriate locations are utilized for climate stations, and that data for all necessary parameters, including solar radiation, used to monitor climate change are being collected.
- d.** The Ministry of the Environment and Climate Change, in collaboration with the conservation authorities, is requested to review its monitoring networks for groundwater and surface water to ensure appropriate locations and adequate construction of monitoring wells and stations are utilized, and that data for all necessary parameters that could be used to monitor climate change are being collected.

<http://www.protectingwater.ca/docandmaps.cfm?smocid=1372>

Thank you.



Chitra Gowda
Source Water Protection Lead
Conservation Ontario
E: cgowda@conservationontario.ca

DRINKING WATER
SOURCE PROTECTION
Our Actions Matter

