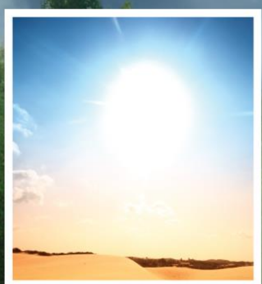
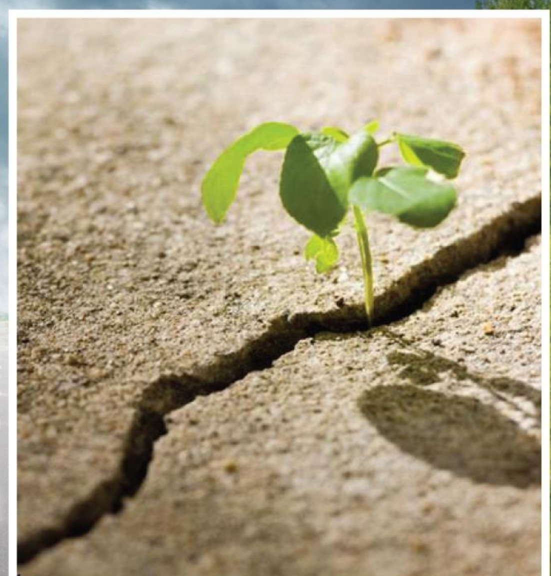
A CHANGING CLIMATE

Assessing health impacts and vulnerabilities due to climate change within Simcoe Muskoka





simcoe muskoka
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Executive Summary

Background

Climate change is impacting the health of Canadians,[1] and is expected to have a significant effect on public health throughout the twenty-first century.[2] Potential health impacts are varied and widespread, and have been identified as direct (increased range and transmission of infectious diseases; health impacts of air pollution and temperature stress; reduced access to safe water; injuries related to extreme weather events; food insecurity) and indirect (psycho-social impacts; population displacement).[3,4] While the impact of these health effects occur at global, national, provincial and local levels, understanding the potential local impacts of climate change is particularly important for public health units who can act as key players in reducing climate-related health impacts within their communities.

In 2014, the Simcoe Muskoka District Health Unit (SMDHU) identified climate change as an issue of public health importance for the organization; an action plan was created in 2015 that supports the reduction of climate-related health impacts. A key deliverable of the action plan was the completion of a climate change and health vulnerability assessment. The purpose of the assessment was three fold:

1) To identify potential climate-sensitive health outcomes expected to occur due to climate change within Simcoe Muskoka.
2) To determine populations vulnerable to these climate-sensitive health outcomes within Simcoe Muskoka.
3) To identify policies and actions to help mitigate the impact of climate change on climate-sensitive health outcomes in Simcoe Muskoka.

This report highlights the findings from the SMDHU climate change and health vulnerability assessment. Climate projections (including temperature and precipitation) for the near-term (2020s), short-term (2050s), and long-term future (2080s) are provided. It examines the expected health impacts due to climate change for six climate-sensitive categories, including:

- temperature extremes;
- extreme weather events and natural hazards;
- air quality;
- contamination and availability of food and water;
- infectious disease transmission by insects and ticks; and
- exposure to ultraviolet radiation.

Additionally, the report provides information on projected climate change impacts for the region based on exposure (the probability of an individual or community being exposed to a climate-related health issue), sensitivity (the degree to which individuals or communities are affected by the health impacts of climate change), and adaptive capacity (the ability of an individual or community to adapt to the changing environment). Results from stakeholder engagement surrounding climate change mitigation and adaptation strategies are also presented. When possible, data is presented within a Northern and Southern region context, to identify any differences due to geographical regions within Simcoe County and the District of Muskoka. Information within the assessment will be utilized to support planning for Phase II of the SMDHU Climate Change Action Plan, which aims to increase community engagement and awareness surrounding climate change within Simcoe Muskoka.

Climate Change in Simcoe Muskoka – Report Findings

Climate projections identify that climate change will alter future temperature and precipitation patterns within Simcoe Muskoka. Specifically:

- annual mean temperatures are expected to rise by approximately 1°C (2020s), 3.5°C (2050s) and 5.7°C (2080s) above baseline temperatures (1990s);
- the largest mean temperature increases above baseline (1990s) are expected to occur within winter (expected increase of 2°C (2020s), 5°C (2050s) and 7.5°C (2080s)) and summer (expected increase of 1°C (2020s), 3°C (2050s), and 5°C (2080s));
- annual precipitation levels are expected to increase, with the largest increases occurring during the winter and spring months;
- summer precipitation levels are expected to decrease, leading to potential drought during these warmer, dryer months; and
- precipitation events are projected to occur less frequently, but as more extreme downpours when precipitation events occur.

These projected alterations to temperature and precipitation patterns have the potential to influence multiple health outcomes of Simcoe Muskoka residents. While some variation exists as to the sensitivity of individuals with respect to climate-related health outcomes, individuals such as children, seniors, individuals living in low income, the homeless and precariously housed, and individuals with pre-existing chronic conditions tend to be most sensitive to climate-related health outcomes. In addition, specific vulnerable populations related to each of the climate sensitive health impacts are highlighted in the key considerations below.

Extreme Temperatures

- An increase in the number of extreme heat events is expected within Simcoe Muskoka, thus increasing potential for heat-related illness.
- Urban heat island (UHI) effect will increase exposure in urban centres. Urban heat island will become more prominent as areas within Simcoe Muskoka are developed and urbanized.
- Access to home cooling/air conditioning, a strategy to adapt to extreme temperatures, is highest among Simcoe Muskoka residents who own their own home. Tenants or individuals in the lowest income category have the least access to home air conditioning.
- Individuals attending mass gathering and special events during the summer months, as well as outdoor workers, are at increased risk of exposure to extreme heat.
- Pregnant women and newborns have increased sensitivity to extreme heat events.
- While average winter temperatures are projected to become milder, there is the potential for extreme cold events to impact populations due to a decreased acclimatization to winter weather.
- Rates of cold exposure-related hospital visits among Simcoe Muskoka residents are highest among males, aged 15 to 24.

Extreme Weather

- An increase in the number and intensity of extreme precipitation events, and associated flooding, is expected by 2080.
- Increase in thunderstorms has the potential to increase the number of forest fires caused by lightning.
- Winter storms will become more prevalent, with increases in precipitation in the form of snow or rain.
- Within the summer there will be increased drought periods due to decreases in summer precipitation levels.
- Individuals with mobility issues, mental illness and those who are socially isolated, may have increased sensitivity to associated health impacts arising from extreme weather events.

Air Quality

- While air quality has been increasing across the province, climate change has the potential to increase levels of important air pollutants, such as ozone, within Simcoe Muskoka.
- Climate change is expected to impact on the volume, timing, and distribution of pollens and moulds within the environment; increases in aeroallergens are expected due to increased productivity of plants and prolonged growing periods.

Contamination and Availability of Food and Water

- Increased temperatures may lead to increased foodborne illnesses, due to an enhanced ability for pathogens to survive, and a rise in human activities during warmer months that increase risk of food contamination (i.e. barbeques).
- Impacts to food access can be expected, as climate change weather events (temperature, flooding, drought, extreme storms) interrupt local and global food production systems.
- Water quality throughout the region will be impacted through both increased potential for contamination by bacteriological agents, as well as increases in blue-green algae blooms.
- Individuals living in low income will have the highest rates of household food insecurity due to these changes, with increased food pricing due to changes in food production globally.

Vector-Borne Disease

- Increased risk of West Nile virus is anticipated, due to an enhanced ability of vectors to propagate, as well as increasing viral proliferation in warmer temperatures.
- Climate change will support an increased range within Ontario and Simcoe Muskoka of blacklegged ticks, the vector responsible for transmitting the bacteria which causes Lyme disease.

Exposure to UV Radiation

- Temperature increases, as well as behavioral variables, are expected to impact levels of ultraviolet radiation exposure, increasing rates of non-melanoma skin cancers.
- Basal cell carcinomas are projected to increase by 7.8% (2050s) and 13.1% (2080s) due to climate change; squamous cell carcinomas are projected to increase by 14.8% (2050s) and 24.8% (2080s).

Mitigation and Adaptation

- Many mitigation and adaptation strategies are currently implemented across each department of the SMDHU.
- Community partners are also implementing climate change mitigation and adaptation strategies throughout the region, which supports programming offered by public health.
- Future prioritization of climate change programming that supports vulnerable populations will enhance adaptive capacity among those most greatly affected by climate change.

Recommendations and Next steps

- Develop and implement a stakeholder engagement plan that aligns with Phase II (Stakeholder Engagement) of the SMDHU Climate Change Action Plan.

- Develop priorities and actions, including health promotion and community education and engagement plans by utilizing information from the vulnerability assessment. Prioritize based on current and future climate change conditions.
- Review MOECC's Climate Change Action Plan and ensure alignment with SMDHU activities.
- Review updated OPHS standards (when available) and ensure alignment with SMDHU Climate Change Action Plan.
- Develop a knowledge translation plan to share the results of this vulnerability assessment with other public health units, municipalities and other agencies.
- Launch and promote the SMDHU interactive climate change GIS tool.
- Participate with municipalities and other community agencies in local climate change planning processes.
- Develop a review process for further iterations of the vulnerability assessment, including reporting timelines and indicators.
- Support the creation of an information sharing network that will help to enhance local climate change mitigation and adaptation activities.
- Create resources for community members to increase knowledge of local climate change impacts.
- Review the actions of the SMDHU Environmentally Sustainable Business Practices program to enhance internal mitigation activities.

Glossary of Terms

Cold Days

The number of days in a given period (year), where the five-day averaged daily maximum temperature is lower than the 10th percentile of experienced temperatures at baseline.

Cold Nights

The number of nights in a given period (year), where the five-day averaged daily maximum temperature is lower than the 10^{th} percentile of experienced temperatures at baseline.

Consecutive Dry Days

The maximum number of consecutive days with daily precipitation of <1 mm.

Consecutive Wet Days

The maximum number of consecutive days with daily precipitation of ≥1 mm.

Extremely Wet Days

The total number of days when the amount of precipitation is greater than the 95^{th} percentile of the baseline period.

Frost Days

Annual count of days when the daily minimum temperature is < 0°C.

Ground Water

Includes water located in subsurface aquifer(s).

Heat Wave Duration Index

The maximum period for the year of at least five consecutive days with the maximum temperature at least 5°C warmer than the baseline period.

Heavy Precipitation Days

Count of days with a daily precipitation of ≥10 mm.

Icing Days

Annual count of days when the daily maximum temperature is < 0°C.

Intensity, Duration and Frequency Curve

A graphical representation of projected precipitation patterns expected to occur over a 5, 10, 25, 50, and 100-year span, based on the intensity of rainfall (mm/hr) within a specific time duration (minutes to hours).

Outbreak

An unexpected increase of disease occurring within a specific population at a given time and place.

Monthly Maximum One-Day Precipitation

The maximum one-day value of the daily precipitation in a given month (mm).

Summer Days

Annual count of days when the daily maximum temperature is > 25°C.

Surface Water

Water found within surface water bodies including lakes, rivers and ponds.

Tropical Nights

Annual count of days when the daily minimum temperature is > 20°C.

Key Resources

Within this section a variety of key climate change resources are summarized. While some of these resources represent evidence from a global or federal perspective, others were created locally and provide a perspective which is specific to a changing climate within the Simcoe Muskoka region. While this list provides an overview of climate change literature, it is by no way exhaustive, but helps to identify how climate change will impact on Canada and Simcoe Muskoka specifically, identifies vulnerabilities to climate change impacts, and also highlights adaptive strategies to support resiliency to climate change.

A Climate of Concern: Climate Change and Health Strategy for Toronto 2015 (Toronto Public Health, 2015)

A strategy for addressing climate change and health impacts within the City of Toronto. This report identifies the impacts of climate change on extreme temperatures (heat and cold); severe weather; air quality; built environment; vector-borne disease; impacts to water; and food systems safety and security.

Assessment of Vulnerability to the Health Impacts of Climate Change in Middlesex-London (Middlesex-London Health Unit, 2014)

An assessment looking at the vulnerability of the Middlesex-London community to health risks due to climate change. The report highlights impacts due to extreme weather events and natural disasters; air quality; vector-borne disease; and waterborne illnesses, foodborne illnesses and food security. It also highlights adaptive capacity solutions at community and individual levels, and the effectiveness of current adaptations.

Canada in a Changing Climate: Sector Perspectives on Impacts and Adaptation (Natural Resources Canada, 2014)

An updated assessment of the expected impacts of climate change, vulnerabilities to climate change across Canada, and potential adaptation strategies. It provides an overview of the changing climate in Canada, links adaptation research to practice, and also examines the impacts of climate change on specific topics (natural resources; food production; industry; biodiversity and protected areas; human health; and water and transportation infrastructure).

Cities Adapt to Extreme Heat: Celebrating Local Leadership (Institute for Catastrophic Loss Reduction, Health Canada, 2016)

Report prepared by the ICLR and Health Canada outlining 20 case studies which provide examples of extreme heat adaptation strategies being implemented by local and regional governments across the country. While the communities highlighted within the report provide a comprehensive strategy to address heat health risks, this report showcases a key element from each of the represented communities. It also highlights lessons learned when dealing with extreme heat within a Canadian context.

City of Barrie Adaptation Strategy (City of Barrie, 2017)

The City of Barrie is has created a climate change adaptation strategy which aims to increase resiliency and adaptive capacity to changing climate. The adaptation strategy identifies climate projections for the city, physical, social, ecological and economic impacts of climate change, and outlines the process the city took to identify priority actions they will be implementing to increase community resiliency to climate change.

Climate Change 2014: Impact, Adaptation, and Vulnerability, contributions of Working Group II to the Fifth Assessment Report (Intergovernmental Panel on Climate Change, 2014)

The impact, adaptation and vulnerability report takes a broad examination of the expected impacts due to climate change on a global scale. It examines the impacts on natural and managed resources and their systems; human settlements, industry and infrastructure; human health, well-being and security; adaptation; and multi-sector impacts, risks, vulnerabilities, and opportunities. It also examines regional changes due to climate change which are projected to occur across the globe.

Climate Change Action Plan (Ministry of the Environment and Climate Change, 2016)

The Climate Change Action Plan lays out the Provincial actions which will support mitigating climate change through transitioning to a low-carbon economy. Areas of action include transportation; buildings and homes; land-use planning; industry and business; collaboration with Indigenous communities; research and development; government; and agriculture, forests and lands.

Climate Change Adaptation and Health Equity Background Report (Toronto Public Health, 2011)

While all individuals can be impacted by climate change, certain populations will be more vulnerable to these impacts. The adaptation and health equity report from Toronto Public Health identifies populations which are more vulnerable to climate-related impacts, and identifies features of climate-resilient cities to support adaptation to climate change.

Facing Climate Change: Greenhouse Gas Progress Report 2016 (Environmental Commissioner of Ontario, 2016)

The Environmental Commissioner of Ontario is the environmental watchdog for the province of Ontario. The 2016 greenhouse gas progress report reviews Ontario's current carbon dioxide footprint, identifies impacts of other greenhouse gases such as methane and black carbon, identifies the emissions of Ontarians from a per capita basis, examines the cap and trade program, and reviews the province's Climate Change Action Plan.

Human Health in a Changing Climate: A Canadian Assessment of Vulnerabilities and Adaptive Capacity (Health Canada, 2008)

A review of climate change vulnerabilities which will impact the health of Canadians, as well as actions which can help to increase adaptive capacity of communities to deal with these impacts. Specific topics discussed include vulnerabilities to natural hazards and extreme weather; air quality, climate change and health; impacts to food, water, and vector-borne disease; regional impacts due to climate change in Quebec; health impacts due to climate change in Canada's North; and adaptive capacity to climate change within Canada.

Lake Simcoe Climate Change Adaptation Strategy (Ministry of the Environment and Climate Change, 2017)

This strategy provides an overview of the actions being taken within the Lake Simcoe watershed to adapt to a changing climate, including strategies to reduce phosphorus loading of the Lake, agricultural water use assessments, modeling programs, and aquatic life monitoring programs. It showcases successes within the watershed and identifies how the strategy was developed.

NVCA Climate Change Strategy and Action Plan 2016-2018: Milestone 2 – Research (Nottawasaga Valley Conservation Authority, 2016)

A local assessment of projected climate impacts for the Nottawasaga Valley watershed. Projected temperature and precipitation levels, as well as changes to temperature within local streams are discussed.

Ontario Climate Change and Health Toolkit (Ministry of Health and Long-Term Care, 2016)

A three-pronged toolkit which supports the completion of climate change and health vulnerability assessments within Ontario public health units. The toolkit includes a technical document which describes and outlines the process for completing a vulnerability assessment; a workbook which provides step by step processes and worksheets to complete the vulnerability assessment; and a climate change and health modelling study report which provides projections on the expected impacts on health due to climate change in the 2050s and 2080s.

Planning for Climate Change in Muskoka (Muskoka Watershed Council, 2016)

The Planning for Climate Change in Muskoka report identifies projected impacts due to climate change for the District of Muskoka. It provides a snapshot of what the climate of Muskoka may look like mid-century, and examines impacts to aquatic environments (lakes, rivers, streams, and wetlands), forests, and lifestyle (recreation, infrastructure and health).

Report on Health Vulnerability to Climate Change: Assessing Exposure, Sensitivity, and Adaptive Capacity in the Region of Peel (Peel Public Health, 2012)

An assessment looking at the vulnerability of the Region of Peel to health risks associated with climate change. The report highlights impacts due to extreme heat; air quality; extreme weather and natural disasters/hazards; contamination of food and water; and vector-borne disease. It examines all of these factors in the context of exposure, sensitivity, and adaptive capacity.

Federation of Canadian Municipalities

Federation of Canadian Municipalities (FCM) offers a variety of resources to assist municipalities as they address climate change such as case studies, webinars, interviews with successful innovators and alternate funding mechanisms. FCM also coordinates the Partners for Climate Protection program.

World Health Organization

World Health Organization (WHO) is an agency that works in more than 150 countries with local governments to direct and coordinate international health within the United Nations' system. The climate change and human health program provides a variety of climate change policies, resources, publications and projects.

1.0 Introduction

Climate change is impacting the health of Canadians,[1,5] and is expected to have a significant effect on public health throughout the twenty-first century.[2] Potential health impacts are varied and widespread, and have been identified as direct (increased range and transmission of infectious diseases; health effects of air pollution and temperature stress; reduced access to safe water; injuries related to extreme weather events; food insecurity) and indirect (psycho-social impacts; population displacement).[3,4] While the impact of these health effects occurs at global, national, provincial, and local levels, understanding the potential local impacts of climate change is particularly important for public health units. However, accessing data on climate change and health can be challenging, with data often unavailable at the local level.

To combat climate change, governments are focusing efforts on greenhouse gas mitigation and adaptation. Both strategies are essential in order for communities to decrease green-house gas emissions, reduce potential impacts from climate change, and support communities to effectively manage changes that cannot be alleviated.

Climate change mitigation is defined as the reducing, stabilizing, and/or sequestering of green-house gas emissions.[4] A number of public health activities support mitigation. Such activities include supporting the creation of well-designed communities to decrease the need for cars; advocating for active transportation infrastructure and effective public transportation; and supporting the preservation of local agricultural lands and green space. Within the context of this report, mitigation refers to actions that help to decrease carbon emissions and/or carbon footprint. As an approach to decrease the carbon footprint of the agency and support climate change mitigation, the Simcoe Muskoka District Health Unit (SMDHU) has implemented actions outlined in the Environmentally Sustainable Business Practices report (2009). More details related to these actions are provided in Section 4.0.

Adaptation, another key and equally necessary component associated with climate change, is defined as the preparing for and adapting to environmental changes as a result of climate change.[6] Adaptation ensures policies, programs, and infrastructure are in place so communities can cope with climate change impacts that cannot be mitigated. Being resilient and able to adapt to this change will help to reduce health burdens caused by a changing climate.[7] Public health has many avenues for aiding in the climate change adaptation process including planning for extreme weather events, performing surveillance to track and identify changing disease trends, and working with community partners to create adaptation plans. Within the context of this report, adaptation refers to policies and/or programs that help individuals and communities increase resiliency to the impacts of climate change.

While there are a number of future climate projections available, based on differing carbon emission scenarios, this report is based on Representative Concentration Pathway (RCP) 8.5,[i] which represents the current temperature trajectory, without interventions or policies that may decrease global carbon emission levels. In discussion with Health Canada and in consideration of the climate projection data available, RCP8.5 was selected as the scenario for SMDHU analysis in this assessment. A further discussion of climate projections and emission scenarios can be found in subsection 5.2.4.

In Simcoe Muskoka, historic climate data have shown that mean summer temperatures have increased. Predictive models suggest an additional increase of up to 5°C by the 2080s, based on the RCP8.5 emissions scenario.[9] This increase in temperature has been projected to have widespread impacts globally, including an increased frequency and severity of extreme weather events; increased range and transmission of vector-borne diseases; changes in the ability to produce food; and decreased recreational and drinking water quality.[10] While climate change has the potential to affect all residents across Simcoe Muskoka, some individuals, such as children, the elderly, those living with low income, and those with chronic diseases, may be more vulnerable to climate risks.[1] In addition to these health impacts, it has also been identified that climate change will exert other socioeconomic pressures. Such pressures include: impacts to local nature-based tourism and agricultural economies; impacts on local community infrastructure, such as water treatment and transportation facilities; and damage to residential property and housing.[11-13] Because of the growing concerns surrounding climate change and its resultant health impacts, SMDHU identified climate change as an issue of public health concern for the agency. As a result, a climate change action plan which supports climate change mitigation and adaptation activities, is currently being implemented across the agency.

The following climate change and health vulnerability assessment has been completed as part of the larger agency action plan to address climate change. The vulnerability assessment will be used to support the identification of climate-related health outcomes, populations that are vulnerable to the changing climate, and actions that can help to mitigate and adapt to climate-related health impacts across the region. Many initiatives related to climate change are currently happening at the federal, provincial, and municipal level. As such, this document is not intended to identify all the actions occurring across governments or community organizations, nor is it intended to be a fulsome review of the climate change and health literature. The assessment is intended to assist the health unit and community partners as they move forward with climate change actions.

A full definition of climate change and health vulnerability assessments, as well as methodology utilized to complete the assessment, can be found in the following sections.

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i The Representative Concentration Pathway (RCP) 8.5, is the highest emission scenario used by the Intergovernmental Panel on Climate Change. The RCP8.5 corresponds to very high global greenhouse gas emissions scenario; this scenario is considered a baseline scenario, and does not take into account any potential climate change policies which may decrease carbon emissions.8

2.0 Climate Change and Health Vulnerability Assessments

Vulnerability assessments are tools used to identify and understand the impacts that a changing climate will have on the health of a population. They aid in the identification of risks associated with climate change and the populations most vulnerable to those risks. Vulnerability assessments enhance adaptive capacity through the identification of mitigative and adaptive measures to decrease health impacts of those risks. Climate change health vulnerability assessments can be used to:

- improve evidence and understanding of the link between climate and health outcomes;
- provide information on severity and patterns of current and future health risks;
- identify opportunities to incorporate climate change concerns into existing policies and programs;
- provide a baseline analysis for future change; and
- facilitate cross-sectoral collaboration to improve health outcomes.[14]

While climate change has the potential to impact all residents across Simcoe Muskoka, some individuals will be more vulnerable to climate risks, while others may have a greater capacity to cope with these changing climates.[1] The purpose of completing a climate change and health vulnerability assessment for the Simcoe Muskoka region is three-fold:

1) to identify potential climate-sensitive health outcomes expected to occur due to climate change within Simcoe Muskoka;
2) to determine populations vulnerable to these climate-sensitive health outcomes within Simcoe Muskoka; and
3) to identify policies and actions to help mitigate the impact of climate change on climate-sensitive health outcomes in Simcoe Muskoka.

Within Ontario, few climate change and health vulnerability assessments have been completed. Currently only two Ontario health units, Peel Public Health[15] and Middlesex-London Health Unit,[16] have completed climate change and health vulnerability assessments. The City of Toronto[17] has also included health in its climate change planning, through the creation of the city's climate change and health strategy in 2015. However, in 2016, the Ministry of Health and Long-term Care (MOHLTC) released the Ontario Climate Change and Health Toolkit to further increase capacity across the province related to climate change and public health. The toolkit provides a technical document,[14] workbook,[18] and report[19] to support health units in completing an assessment. Simcoe Muskoka District Health Unit and Hamilton Public Health were identified in 2015 as pilot sites for the MOHLTC Climate Change Toolkit; SMDHU has utilized components of the assessment guidelines outlined within the toolkit to support the completion of this assessment. Through the completion of a vulnerability assessment, the SMDHU will be able to identify vulnerable populations, mobilize resources and policies, and maximize proposed internal climate change mitigation and adaptation actions. Additionally, it is expected that the vulnerability assessment can be used as a tool to provide information on vulnerable populations and expected climate-related impacts to support community and municipal partners during their climate change mitigation and adaptation planning processes.

3.0 Climate Change: Knowledge and Perceived Impacts in Simcoe Muskoka

The Ontario Public Health Standards requires health units to conduct surveillance and use surveillance data to communicate risks to relevant audiences. Health units are also required to make surveillance data available to key stakeholders and the general public. To accomplish these tasks, the SMDHU utilizes the Rapid Risk Factor Surveillance System (RRFSS), a key source of health-related behaviour data among Ontario adults 18 years of age and over.

Rapid Risk Factor Surveillance System conducts a series of surveys across the province each year to provide data that supports health units in planning and evaluating local programs and services, and supporting education, awareness and advocacy surrounding health behaviours. Every month, a random sample of between 60 and 100 adults, aged 18 years and older, in each participating health unit area are interviewed via landline regarding awareness, knowledge, attitudes and behaviours about topics and issues of importance to public health.

In 2014, between May and December, the health unit participated in a RRFSS survey that examined the knowledge and perceived impacts of climate change among approximately 500 randomly selected adults (18+) in Simcoe Muskoka. This was in follow-up to a similar survey conducted in 2010. Among the 2014 participants, nearly three-quarters (72%) strongly agreed that the world's climate is changing, a result that was significantly higher than the 60% that strongly agreed in 2010 (Figure 3.1). The vast majority of participants were either very concerned (42%) or somewhat concerned (50%) about climate change.

Respondents were also asked how likely climate change was to result in increases of several health-related natural phenomena in their community. Approximately half of Simcoe Muskoka adults said that climate change was very likely to cause more extreme weather (52%), heat waves (48%) and smog advisories (48%) in their community. In addition, approximately one-third (32%) of respondents said that climate change was very likely to result in more disease-carrying insects in their community (Figure 3.2).

The results of this survey are important for this vulnerability assessment for two reasons. First, it identifies that knowledge of and concern surrounding climate change has increased recently, with the residents of Simcoe Muskoka being more aware of the potential impacts due to climate for our region. Second, it identifies the perceived risk by residents across the region of the health-related implications of extreme weather, heat, air quality and vector-borne disease. This information is important to consider when identifying potential impacts and strategies to educate and adapt to our changing climate.

Figure 3.1: Number of Simcoe Muskoka adults (18+) who agree the world's climate is changing, 2010 vs 2014.

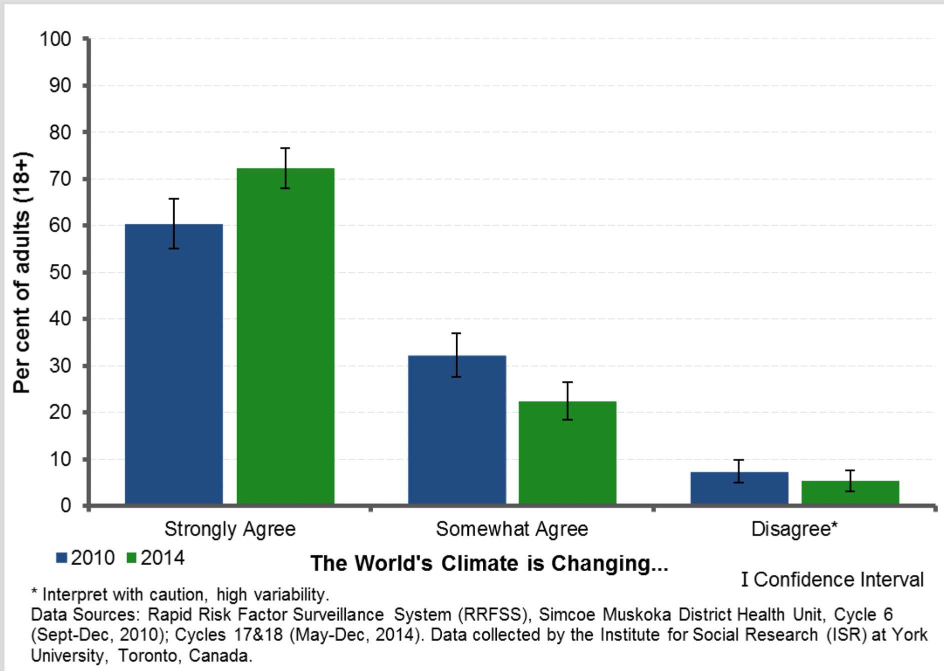
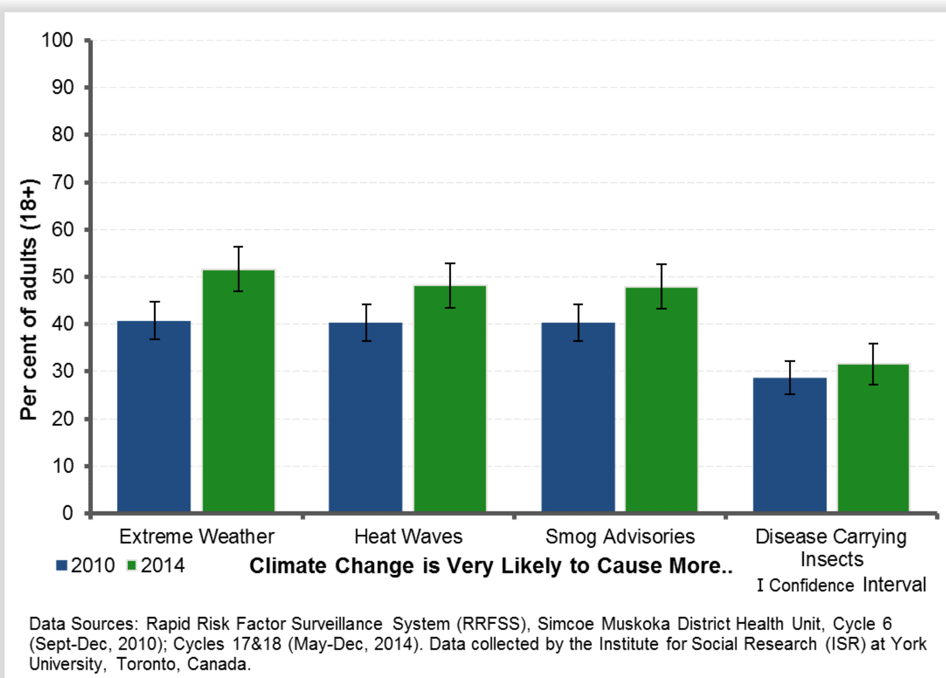


Figure 3.2: Number of Simcoe Muskoka adults (18+) who perceive that climate change is likely to cause more environmental impacts, 2010 vs 2014.



4.0 Mitigation at the Simcoe Muskoka District Health Unit

According to the Ontario Ministry of Environment and Climate Change (MOECC) and the Environmental Commissioner of Ontario, climate change is already impacting our environment, and it is critical that greenhouse gas emissions (GHGs) are dramatically decreased.[20,21] The health unit recognized climate change mitigation as an important action within the agency in 2009 when the *Environmentally Sustainable Business Practices* report was received and endorsed by its Board of Health and Executive Committee. The purpose of the report was to provide background information about sustainability and recommend actions for the health unit to reduce its carbon footprint and environmental impact. The report provided ideas and recommendations to create a more “environmentally friendly” organization and included actions related to the reduction of GHGs. Progress has been made on a significant number of mitigation efforts identified in the report:

- implementation of the four-stream waste diversion program in five of eight health unit offices, with over 70% of office waste diverted into recycling and organics programs;
- identification of “Office Sustainability Champions” in six of the health unit’s seven offices to support sustainable practices;
- inclusion of sustainability language in procurement policies;
- annual collection and analysis of Sustainability Indicators. Highlights include:
    - 49% reduction in paper purchase between 2007 and 2015;
    - 26% reduction in km driven by staff between 2007 and 2014;
    - 25% reduction in km driven/FTE within the agency between 2007 and 2014.
- installation of low-flush toilets (approximate savings of 2100 litres of water/day) and motion sensor lighting;
- creation of four designated carpooling spots installed at the 15 Sperling Drive, Barrie office location;
- fleet changes that include the provision of more fuel-efficient vehicles for staff and the purchase of hybrid vehicles;
- technology supports that increase teleconferencing and telecommuting; and
- reduction of the office footprint of a number of health unit offices and clinic spaces.

In addition to the positive changes outlined above, there are many sustainable business activities that occur as components of health unit programs. These activities, both mitigative and adaptive, can be found in the adaptive capacity sections of the chapters within this assessment.

5.0 Methodology

5.1 Assessment Process

5.1.1 Assessment Team

The completion of the climate change and health vulnerability assessment was supported by the SMDHU Climate Change Steering Committee, a cross-departmental committee with representation across all departments and staffing levels. Three members of the steering committee (Program Manager of Health Hazards/Vector-Borne Disease; Public Health Promoter; Epidemiologist) formed an internal workgroup to support the development of a vulnerability assessment framework, which provided scope and local context to the assessment. This workgroup was also responsible for the completion of the full assessment, with support and guidance provided by the larger steering committee.

In addition, an external review panel supported the completion of the vulnerability assessment by providing consultation and review of the assessment results. This review panel was comprised of representatives from the local, provincial, and federal level, and included individuals from Health Canada, Public Health Ontario, the Public Health Agency of Canada, Environment and Climate Change Canada, the City of Barrie, the District of Muskoka, the Muskoka Watershed Council, and the Nottawasaga Valley Conservation Authority.

5.1.2 Assessment Process

The vulnerability assessment was completed over two years. Its formulation was guided by the Ontario MOHLTC Climate Change and Health Vulnerability and Adaptation Assessment Guidelines for Ontario,[14] and through direct consultation with Health Canada. The guidelines identify six steps that were followed throughout the completion of the SMDHU assessment.

- **Frame/Scope the Assessment:** Aims to identify parameters, including identification of timeframe and resources; health risks from climate change; future time periods for assessing risks; future adaptation needs based on risks; how the assessment will be managed; and communication plans for informing decision makers, stakeholders, and the public of the progress and results of the assessment.
- **Describe Current Health Risks**: Helps to identify and describe exposures, vulnerabilities, and adaptive capacity of vulnerable populations. It also helps to identify where modifications to current programming can occur to reduce impacts of climate change.

- **Project Future Health Risks:** Aims to identify how health burdens could be altered due to our future changing climate. Time frames for future risks (e.g., 2020s, 2050s, 2080s) need to be defined to determine risks.
- **Identify Current and Potential Policies and Programs:** Once potential risks of climate change have been identified, the identification of specific policies and programs that support adaptation or mitigation must be completed. These policies must be able to support decreased impacts for current vulnerabilities, while also be flexible so as to decrease vulnerability and increase resiliency as the climate changes. This step supports action planning and the actions needed to protect health.
- **Establish an Iterative Process for Managing and Monitoring Health Risks:** Once initial assessments are completed, a process for managing and monitoring health risks must be identified, including identifying when future vulnerability assessments need to be completed, tracking indicators, and documenting and sharing lessons learned throughout the vulnerability assessment.
- **Examine the Potential Health Benefits/Co-Harms of Adaptation and Mitigation Options Implemented in Other Sectors:** Climate change mitigation and adaptation strategies are occurring within many sectors, not just public health. Options need to be considered in terms of their potential co-benefits or harms. Co-benefits occur when an action also provides an additional positive impact (i.e. active transportation reduces GHG emissions and also improves cardiovascular health). Co-harms occur if there is a secondary adverse side effect.[22] These actions may impact on the health of the local community; therefore, communications with local stakeholders needs to occur to identify synergies among other mitigation and adaptation strategies.

In addition to following the MOHLTC Climate Change and Health Vulnerability and Adaptation Assessment Guidelines, the two previously completed Ontario vulnerability assessments (Region of Peel[15] and Middlesex-London Health Unit[16]) were also reviewed to determine whether other steps and inclusions of health variables within the SMDHU assessment needed to be considered. Consultations with vulnerability assessment leads from Peel Public Health and Middlesex-London Health Unit were also completed, which aided in identifying potential challenges and barriers to completing a vulnerability assessment prior to initiation.

5.2 Assessment Scope

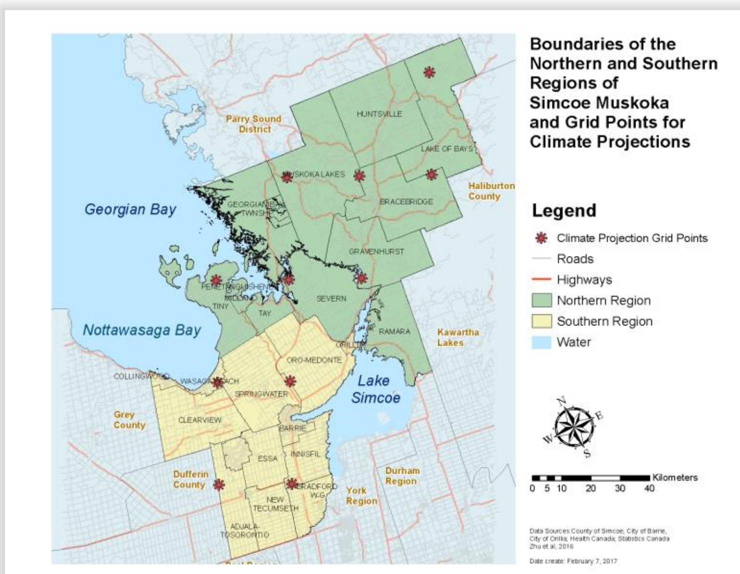
5.2.1 Geography (Northern and Southern Regions)

Assessing potential climate change impacts for each individual municipality in Simcoe and Muskoka would be beneficial to identify all expected climate change impacts to health and vulnerable populations. However, the resources required to complete this assessment would be significant, require more time than outlined for the project, and require data that may not be available on an individual municipal level. Additionally, the sensitivity of the data may not be sufficient to provide differences in potential outcomes based on individual municipalities across the region.

There is a resultant need to offset the resources required for the vulnerability assessment, while also ensuring the assessment is useful for identifying potential mitigation and adaptation strategies related to climate change within differing geographical areas across the region. The assessment, therefore, outlines information for climate-sensitive health outcomes for two geographic locations (when available):

- The Northern Region (includes the northern region of the County of Simcoe and the District of Muskoka); and
- The Southern Region (includes the southern and central regions of the County of Simcoe) (Figure 5.1).

Figure 5.1: Geographic locations of Southern and Northern Region grid points used as reference points for analysis.



These general boundaries provide data that represents the differing geographical regions within the SMDHU catchment area, and were determined based on the availability of downscaled projection model data grid points from MOECC temperature and precipitation data. It is expected that examining the data based on these two regions, where available, will aid in identifying differences in vulnerabilities based on population and climate variations found throughout our region, while also supporting the overall objectives of the vulnerability assessment. For more information on the climate projection data, see subsection 5.2.4.

5.2.2 Timeframe (Baseline, 2020s, 2050s, 2080s)

Examining the immediate, short-term, and long-term changes to our climate (defined as the average of weather variations over a 30-year period) is essential to determining appropriate mitigation and adaptation strategies for the SMDHU Climate Change Action Plan. The MOHLTC toolkit provides data that models the impacts of climate change for a variety of potential climate sensitive outcomes (e.g. heat stress; cold alerts; West Nile virus and vector-borne disease exposure), and are based on climate projections for the 2050s, and 2080s. As such, SMDHU framed the assessment based on these projections, which supports both goals of piloting the MOHLTC vulnerability assessment guidelines and highlighting short-term, medium-term and long-term adaptation strategies for our health unit and its populations.

Throughout the assessment, the following dates are used, when available, to examine local climate projection data:

- Baseline: 1990s (average of 1971 – 2010)
- Near future: 2020s (average of 2011 – 2040)
- Short term: 2050s (average of 2041 – 2070)
- Long term: 2080s (average of 2071 – 2100)

5.2.3 Climate Related Health Outcomes

Climate-related health outcomes within Canada vary depending on the geographic location, environmental factors, and the populations living in an area. In 2008, Health Canada identified a list of health impact categories that can be expected across the county due to climate change. These are associated with the following hazards: temperature extremes; extreme weather events and natural hazards; air quality; contamination of food and water; infectious disease transmitted by insects, ticks and rodents; and stratospheric-ozone depletion.[1]

After reviewing these health impact categories due to climate change, as well as those issues identified by other vulnerability assessments completed in Ontario, SMDHU determined that the vulnerability assessment would include six climate-sensitive categories that have the potential to impact health within Simcoe Muskoka.

These categories include:

- temperature extremes;
- extreme weather events and natural hazards;
- air quality;
- contamination of food and water;
- infectious disease transmission by insects and ticks; and
- exposure to UV radiation.

5.2.4 Climate Projections

Projections of future anthropogenic greenhouse gas emissions are based on a variety of factors, including projected population size, economic activity, lifestyle, energy use, land use, technology, and climate policies.[2] A variety of projection scenarios describe potential anthropogenic emissions levels based on these factors, identified as a Representative Concentration Pathway (RCP). These scenarios provide projections that take into account stringent mitigation activities (RCP2.6); intermediate levels of mitigation (RCP4.5 and 6.0); and a scenario of very high emission levels (RCP8.5).[2] The RCP8.5 scenario is considered the baseline, "business as usual" scenario, and does not take into account potential climate change policies or mitigation strategies that may decrease global carbon emissions.[8] While the RCP8.5 scenario is the highest emission scenario utilized by the Intergovernmental Panel on Climate Change (IPCC), it corresponds to the current trajectory of emissions expected globally, anticipating atmospheric carbon concentration to rise to a level of 936 parts per million (ppm) by 2100.[8] Current atmospheric carbon concentrations have exceeded the 400 ppm threshold,[23] a level which is the highest in human history, and one which would take decades to fall below even if carbon emissions were halted.

For the purpose of this assessment, the RCP8.5 emission scenario was utilized for climate projections. Data were accessed through the Ontario Climate Change Projections data portal (OCCP) hosted by York University.[9] Data from the OCCP utilizes an ensemble of 37 climate data projections, and includes a range of variables related to projected temperature and precipitation levels for our region. The data was provided by the OCCP as percentiles, and this report will present the median (50th percentile) as a measure of central tendency of the projected values, and the 5th and 95th percentiles as plausible ranges of future climates.

For projections of Intensity-Duration-Frequency (IDF) curves – an engineering tool for describing extreme precipitation events, described in further detail below – baseline (1960-1990) and projected (2015-2045; 2035-2065; 2065-2095) IDF curves were obtained from the Ontario Climate Change Data Portal,[24] based on the A1B emission scenario, and projections produced for the IPCC Fourth Assessment Report (AR4) using a PRECIS ensemble.[25] The A1B emission scenario represents a moderate emission scenario, based on a balanced emphasis on fossil and non-fossil energy scenarios.[26] At the time of this report, IDF curve projections were not available under the RCP8.5 emission scenario.

Within the Simcoe Muskoka region, 11 data grid points were used in the projection of temperature and precipitation data for the area, as evidenced in Figure 5.1 above.

5.3 Exposure, Sensitivity, and Adaptive Capacity

Vulnerability to climate change can be defined as the degree to which communities are prone to the impacts of climate change due to an increased exposure. It also takes into account the composition of individuals within the community that may be more susceptible to health impacts due to these changes.[10] Each of the climate-sensitive health outcomes outlined above will be examined through the lens of key health vulnerability concepts, which include exposure, sensitivity and adaptive capacity.

Exposure refers to the probability of a climate-related health hazard, such as an extreme weather event or vector-borne disease, occurring to an individual or population.[27] This may be due to a specific geographic location being more susceptible to a changing climate (i.e. flood-prone area), or due to the fact that a large population is located in an area (i.e. high-density urban environment vs rural community). Within the context of this report, exposure refers to the geographic and temporal conditions (where and when) that allow exposure to climate-related impacts to occur.

Sensitivity to climate change refers to the degree to which individuals or a population are affected by the health impacts of climate change.[14] Within the context of this report, sensitivity refers to the physiological and social attributes that affect the impacts that climate change will have on health, such as age, gender, chronic conditions, or other socioeconomic vulnerabilities.

Adaptive capacity is the ability of an individual or community to adapt to the changing environment due to climate change,[16] mitigate potential damages, and take advantage of opportunities or cope with the consequences.[1] This capacity can be due to individual resources, abilities and knowledge, or from programming and supports provided at the community level. This report will examine activities currently offered by the health unit, as well as provide examples offered throughout the region, that increase the ability to adapt to our changing climate.

Adaptive capacity is a crucial factor related to effective climate change adaptation. It is influenced by economic resources, education, institutional strength, state of infrastructure, population health status, access to technology and political will of the system.[1,28] Canada has the capacity to adapt given its high national income per capita, highly skilled and educated human resources, effective and efficient public organizations and institutions, strong private sector and access to technology.[29] Overall, Canadians experience very good health status and a high level of health and social services, which supports adaptive resiliency. However, people living with poor health, precarious living conditions and limited economic resources generally have more difficulty coping with environmental stresses.[1] According to Natural Resources Canada in 2007, adaptive capacity in Canada is generally high, but is unevenly distributed between and within regions and population.[29]

Income is an important constraint on adaptive capacity for individuals. Increasing income expands the type and number of adaptive responses that can be considered and implemented. Differences in funding at various levels of government can impose important and relevant constraints on adaptive capacity.[28] Socially and economically disadvantaged populations are likely to have less adaptive capacity than the population as a whole. Community characteristics such as social networks, volunteerism, and economic and income diversification, contribute to adaptive capacity and resilience.[30] Determinants that are important for managing health risk and contributing to adaptive capacity include economic resources, technology, information and skills, institutions, infrastructure, equity and existing burden of illness.[1]

Health Canada has identified that small communities often lack the capacity to cope with extreme weather events or health emergencies, as they have fewer available resources and more limited services. These communities are less likely to have completed vulnerability assessments or implemented adaptation measures that could increase their risk of adverse impacts. Lack of resources is a particular concern for small cities and communities in terms of adaptation measures.[1]

Adaptation efforts can also be constrained by technological challenges, environmental concerns related to a proposed action (e.g. storm wall construction), economic costs and political will. Investments and efforts to mitigate impacts from natural hazards often occur only after a disaster has taken place in an attempt to reduce the risks of similar impacts in the future.[1]

Public health's role is to prevent disease and illness as well as protect and promote health across a wide range of programs and services. Healthy people, homes and communities are less likely to suffer disaster-related morbidity or mortality and are more disaster resilient.[4] Public health is uniquely placed at the community level to help build human resilience to climate-related disasters.[4] This is a clear co-benefit for public health to support adaptation and adaptive resiliency initiatives.

Public health will need to assess which of its programs can be enhanced to address the anticipated health burdens. Additionally, public health must assess the effectiveness of current interventions, the health burden associated with climate change projections, and the feasibility of implementing strategies. Since the rate of change is likely to increase over the next several decades, adaptation strategies and policies need to be effective today, yet flexible as more knowledge becomes known.[31]

The adaptation literature increasingly focuses on the importance of 'mainstreaming' climate change adaptation measures into existing decision-making processes rather than creating new frameworks.[1] This would entail incorporating adaptation measures and interventions, as well as mitigation efforts, into existing programs and policies to reduce health risks. Mainstreaming climate change adaptation can involve considering opportunities within the key public health functions as outlined in the Ontario Public Health Standards;[32] these functions include: population health assessment; surveillance; health promotion and policy development; and health protection, disease and injury prevention. In addition, a crucial underpinning to strong public health programs is stakeholder partnership and collaboration. This collaboration will aid in supporting the implementation of both community and public health mitigation and adaptation programming.

Population health assessment includes measuring, monitoring, and reporting on the status of a population's health, including determinants of health and health inequities. Population health assessment provides the information necessary to understand the health of populations through the collaborative development and ongoing maintenance of population health profiles, identification of challenges and opportunities, and monitoring of the health impacts of public health practice.[32]

Surveillance is the systematic and ongoing collection, collation, and analysis of health-related information, communicated in a timely manner to all who need to know, so that action can be taken. Surveillance contributes to effective public health program planning, delivery, and management. Dissemination of surveillance analyses may take the form of reports, advisories, healthy public policy recommendations, alerts, or warnings.[32]

Health promotion is the process of enabling people to increase control over, and to improve, their health. It moves beyond a focus on individual behaviour towards a wide range of social and environmental interventions.[33] Key elements of health promotion include policy and legislative development to create supportive health environments, advocacy for healthier individuals and communities, and public education and communication to build personal skills and mobilize communities.

Health protection, disease and injury prevention programs and practices are intended to reduce or prevent the burden of illness and injury. This is achieved through implementing health protective practices and programs related to preventing injury, and reducing or eliminating exposure to infectious diseases and other hazardous agents.

For the purposes of this vulnerability assessment, public health adaptive capacities have been identified, and are categorized within the four key functions identified in the Ontario Public Health Standards. The adaptive capacities for each of the health outcomes are considered in terms of existing health unit programs related to that potential health outcome and whether future program activities need to be considered. This information was gathered during internal program focus groups and through the expertise of the steering committee. Given the crucial importance of mitigation efforts to reduce the impacts of climate change, the adaptive capacity charts found at the end of each chapter also indicate whether there is a mitigation co-benefit associated with the activities and programs.

In addition, stakeholder engagement (details in subsection 5.4) was completed to identify current and future actions being implemented by municipal and community partners which support adaptive capacity throughout the region. These actions have been identified as examples in Section 14.0, which examines activities supporting both climate change mitigation and adaptation. However, it is understood that these examples would not represent a complete or exhaustive list of adaptive capacity within our municipalities and community agencies.

While climate change will have an impact on all residents of Simcoe Muskoka, there may be some populations that are more vulnerable to the impacts of climate change, while others have a greater capacity to cope.[1] By identifying vulnerable populations, resources and policies can be mobilized to maximize the co-benefits of climate change mitigation and adaptation policies, address health disparities and reduce health risks at the local level.[34]

5.4 Stakeholder Engagement

Supplementary to the review of quantitative data on the climate-related health outcomes, stakeholder engagement occurred in the form of key informant interviews and focus groups to support greater understanding of the current activities in Simcoe Muskoka that support climate change mitigation and adaptation strategies. The goals of the stakeholder engagement were five-fold:

- increase understanding of the impacts of climate change within our region, and the current actions being taken by partners to mitigate and/or adapt to climate change in Simcoe Muskoka;
- understand partners' expectations of SMDHU and public health in creating community resiliency to climate change;
- identify potential actions/collaborations with community partners related to climate change mitigation and adaptation;
- identify current knowledge of SMDHU staff of the connections between climate change and health and existing programs; and
- identify key areas for future climate actions within existing SMDHU programs.

The key informant interviews were held with a broad range of community stakeholders, including governments, educational institutions, conservation authorities, environmental organizations, and community-based agencies. These interviews were integral in increasing our knowledge of the adaptive capacity of our communities through identifying current and future actions and priorities for climate change. A list of identified actions and goals surrounding climate change from these interviews can be found in Section 14.0.

In addition, further identification of health unit programming that supports climate change mitigation and adaptation efforts occurred through internal focus groups with staff, management, and the Board of Health. These focus groups also identified staff knowledge of climate change for future education purposes. Program teams across the health unit were consulted throughout this process. Internal actions that support climate change adaptation can be found within the adaptive capacity section of each outcome.

5.5 Limitations

Climate change is a broad and complex subject. There is a scarcity of published vulnerability assessment literature available that specifically addresses vulnerability assessment results and methods from a local public health unit perspective. This vulnerability assessment was not intended to be a comprehensive review of the climate change and health literature; it was intended, rather, as a general overview of vulnerability from a public health perspective, highlighting local data and impacts for Simcoe Muskoka.

Previous approaches to vulnerability assessments completed by the Middlesex-London Health Unit and Peel Public Health have influenced this assessment. In addition, representatives from Health Canada and the MOHLTC were consulted throughout the assessment process. The information collected from key informant interviews and SMDHU focus groups provided more substantive insights into the existing and potential role of public health related to climate change. However, the key informant interviews were completed with 15 individuals across the region, and were not intended to identify all actions currently being undertaken to support climate change mitigation or adaptation.

This assessment was completed with a public health lens; primary health care assessments related to climate change were not included in the scope of this assessment. It must be noted that the science and best practice around climate change and health are constantly evolving, and this assessment was completed with the research and data available at the time. While there is some discussion in the assessment related to climate change mitigation, the focus of this report is themed towards adaptation. Greenhouse gas emissions and inventories, cap and trade or carbon market strategies were not included in the scope of this assessment. While adaptive capacity actions are highlighted within the assessment, the prioritization of future actions will be considered in the next phase of the health unit’s Climate Change Action Plan.

Data

The climate change projection data used within this assessment is based on modelling and, as such, has some inherent limitations. Projection data was limited to only a few variables, such as temperature and precipitation. The ability of models to produce climate projections is inherently tied to the ability to provide adequate baseline measures. This is influenced by the completeness of the historic climate record, both through geographic representativeness and through completeness of the station observation records. Missing or incomplete data can impact especially on threshold-based climate indices, such as heavy precipitation days (≥10mm) or the number of tropical nights. Challenges also arise in combining data at different geographic scales (e.g. point data collected at weather stations and global circulation systems such as the Walker cell), analysing them at a regional scale and then downscaling them to represent local climates. Further discussions of the methods used to produce these climate projections and the various challenges associated with such climate simulations are available elsewhere.[35,36] It is also important to note that although there are anticipated changes, it is not known whether these changes will be gradual and continuous, abrupt, or some combination of the two.

The PRECIS modelling approach was used to produce precipitation projections in order to build Intensity-Duration-Frequency (IDF) Curves to describe future extreme precipitation events. This approach involves using dynamic downscaling to produce local information from global and regional climate models. The PRECIS model is a powerful and widely used approach, and has been reported as performing well.[37]

The climate projections used in this report represent the best available information we have to predict the future climate, based on scientific understanding of the inputs, outputs, and interactions across various climate models. The projected climate values used in this report are simplifications of potential future conditions, derived from climate models which themselves are simplifications of a complex global climate system. The probable ranges of climatic variables expressed here reflect both uncertainty within individual models, and the combined uncertainty of the ensemble. In addition, this report was initiated as a pilot for the Ontario Climate Change and Health Toolkit. As such, direction and advice was sought from representatives of the MOHLTC and MOECC with regards to data access and availability for climate projections for Ontario. We acknowledge that data used for this modelling may not accurately represent the breadth of uncertainty inherent in climate change projection models; however, the scope of this report is to identify vulnerabilities rather than to quantitatively estimate impacts.

Climate data was analyzed based on the availability of downscaled projections, and thus did not align with established municipal boundaries within Simcoe Muskoka. Also, due to availability of resources, data is not presented based on municipality, and is generalised for the geographic area based on the downscaled models.

Data drawn from divergent sources and for different purposes is collected and reported on different scales and over different time periods. For example, population projections are not provided over the same period as the climate projection data; historical climate data is available from individual weather stations, while health data is aggregated across census boundaries. The ability to identify current and future vulnerabilities associated with changing climate is limited by the availability of data to measure or report; for example, underreporting of infectious disease cases in the community may lead to underestimation of the potential impact of climate on infectious disease.

Stakeholder Engagement

Stakeholder engagement occurred through key informant interviews with external partners and focus groups among SMDHU staff and Board of Health. The individuals selected for the key informant interviews were selected using a maximum variation strategy; therefore, bias may have been introduced into the interview data through selection bias. In addition, bias may also have occurred as an unintended effect of the interviewer's clarification of questions, leading an informant's response. Therefore, the ability to generalize the information to the general public, and/or other health units, may not be possible. However, by utilizing a maximum variation strategy, the intent was to garner a wide range of opinions and actions to better inform the prioritization of actions within Phase II of the SMDHU Climate Change Action Plan.

In addition, some of the responses from key informants may have been from the informant's perspective as a professional expert, and may not be representative of his or her respective agency position. A data collection plan was completed that outlines the process and limitations related to the key informant interviews, which can be viewed upon request.

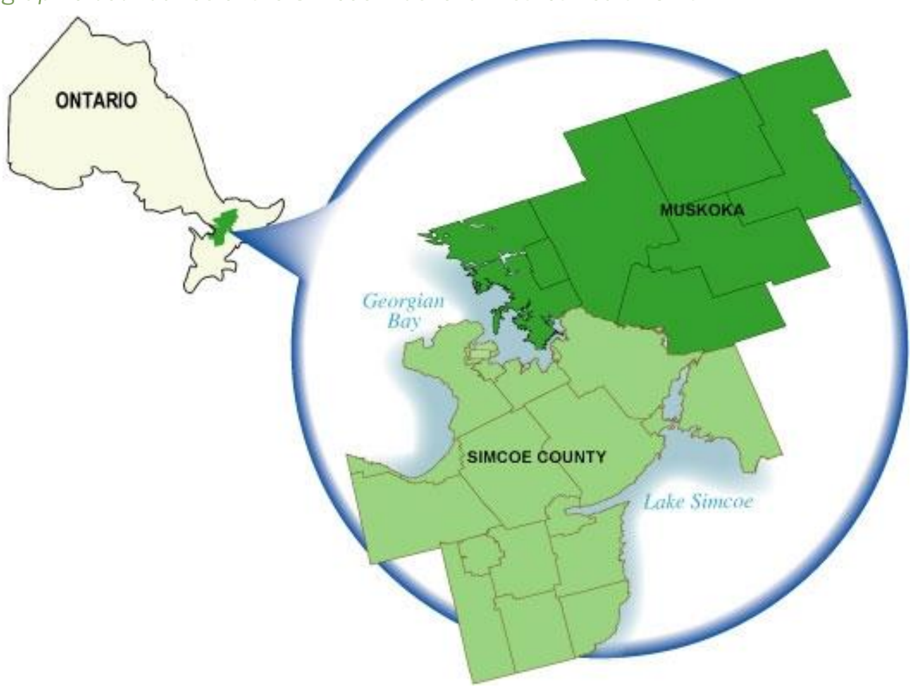
Focus groups were conducted within program team meetings. As such, there is the potential that participants may have had a decreased willingness to respond due to lack of anonymity. As well, due to a lack of knowledge of the impacts of climate change by some staff, there is the potential that not all actions and impacts connecting programming to climate change were identified within the focus groups. Focus groups were time-limited sessions; in some instances there may not have been sufficient time to completely explore the connections between climate change and health from a program perspective.

6.0 The Simcoe Muskoka Region

6.1 Geographic Distribution

The Simcoe Muskoka District Health Unit is responsible for the health of populations within a large geographic area. From the southern border of the County of Simcoe, to the northern border of the District of Muskoka, the territory covers a total area of 8,736 square kilometres (Figure 6.1). The area comprises two upper tier (County of Simcoe; District of Muskoka), two single tier (City of Barrie; City of Orillia); and 22 lower tier municipalities (16 in Simcoe; six in Muskoka), with urban and rural communities throughout. There are four First Nations communities in Simcoe Muskoka including Beausoleil Island (Chippewa) First Nation (located on Christian Island), Chippewas of Rama First Nation (formerly known as Mnjikaning First Nation), Wahta Mohawk First Nation and Moose Deer Point First Nation.

Figure 6.1: Geographic boundaries of the Simcoe Muskoka District Health Unit.



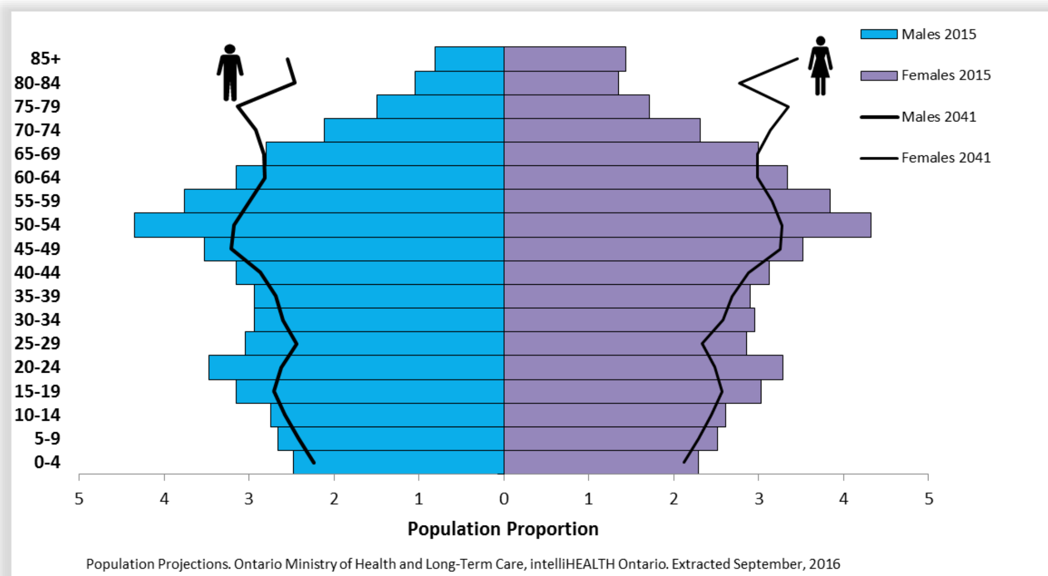
6.2 Population

A total of 540,249 people reside within Simcoe Muskoka; the majority of the population (479,650) resides in Simcoe County, with the remaining population (60,599) residing within the District of Muskoka.[38] The City of Barrie is the largest urban area within the region, with a total of 145,614 residents,[38] with 31,128 individuals also residing within the City of Orillia.[38] During the summer months the population of Muskoka increases greatly with the influx of tourists for the cottage season. In 2012, the estimated population for Muskoka increased by 83,200, for an approximate population of 143,000 when seasonal populations are taken into account.[39] While increases in tourist population also occur across Simcoe County, approximate population increases are not currently available.

6.2.1 Population Demographics

The population pyramid below (Figure 6.2) depicts the age and sex distribution of the resident population of Simcoe Muskoka for the years 2015 and 2041.

Figure 6.2: Population distribution by age and sex, Simcoe Muskoka, 2015 and 2041.



In 2015, children (ages 0 to 9 years) made up a total of 10% (54,593) of Simcoe Muskoka's population, representing 8.2% of the population of Muskoka and 10.2% of the population of Simcoe County. By 2041, this number is expected to increase to 67,000, and the proportion of the population is expected to decrease slightly, to 9% (Population Projections, Ontario Ministry of Health and Long-Term Care, intelliHealth Ontario. Extracted September 2016).

In 2015, just over 99,100 seniors (ages 65 years and older) resided within Simcoe Muskoka, totaling 18% of the population. However, by 2041 this age group is expected to comprise 30% of the total population, surpassing 218,800. Other age groups, are expected to decrease to from 6.2% in 2015 to 5.3% in 2041 among 15 to 19 year olds, and from 15.7% in 2015 to 12.9% in 2041 for individuals aged 45 to 54, indicating an aging population within Simcoe Muskoka.

6.2.2 Population Growth

The population across Simcoe Muskoka has been steadily growing; from 2011 to 2016, growth in Simcoe occurred at a rate of 7.5%, and with growth occurring at 4.5% within Muskoka.[38] The growth rate of the population served by the health unit is expected to continue to exceed that of the province over the next 25 years. By 2041, Simcoe Muskoka's population is projected to reach 740,073. Whereas all age groups are expected to increase by 2041, the senior population is expected to increase at the largest rate, projected to surpass 218,800, more than double the number of seniors from 2011.[38]

6.2.3 Cultural Characteristics

The majority of individuals living in Simcoe Muskoka can speak one or both of Canada's official languages, including English only (92%), French only (0.1%) and English and French bilingual (7%) (Statistics Canada, 2006). Additionally, the majority of individuals (97% or 491,090) speak English most often at home.[40]

According to the National Household Survey (2011), 11% of the population, or 54,800 people living in Simcoe Muskoka are immigrants to Canada, much lower than the rate of 29% within the Province of Ontario. Among immigrants residing in Simcoe Muskoka, most are from the United Kingdom (29% or 15,830), Germany (7% or 3,770), and Italy (6% or 3,355).

While 38% (or 188,330 individuals) report English as their ethnic origin, followed by Canadian (34% or 166,925), there are a few geographic areas in Simcoe Muskoka in which certain ethnicities are more commonly reported when compared to the overall rates of Simcoe Muskoka.[40] These areas include:

- French: 40% of those living in Penetanguishene, 24% of those living in Tiny and Tay, 23% of those living in Midland and 13% of those living in Barrie identify as French origin.
- Italian: 15% of those living in Bradford West Gwillimbury, 8% of those living in Innisfil and Wasaga Beach, and 6% of those living in Barrie, identify as Italian origin.
- Portuguese: 10% of those living in Bradford West Gwillimbury, and 2% of those who live in Barrie, identify as Portuguese origin.

Additionally, according to the 2011 National Household Survey, 4% (19,240) of the Simcoe Muskoka population reported identifying themselves with at least one Aboriginal group. Of these, just over 10,000 reported a First Nations (North American Indian) identity only, just over 8,600 reported a Métis identity only, about 130 reported an Inuk (Inuit) identity only, 160 reported having more than one aboriginal identity and 260 reported other Aboriginal identities. In comparison, 2% (301,430) of Ontarian residents reported having an Aboriginal identity.[41]

6.2.4 Socioeconomic Characteristics

According to the Low-Income Measure After Tax (LIM-AT), the percentage of people living with low income in Simcoe Muskoka remained relatively unchanged at 12% from 2006 to 2012, representing just over 59,000 people in Simcoe Muskoka in 2012. Similarly, the number of Ontarians living with low income has remained stable, around 15% of the population, representing just over 1,970,000 people in 2012.[42]

Among Simcoe Muskoka residents 15 years and older, 267,800 were part of the labour force in 2011.[40] Of those individuals who are part of the labour force, 8%, or just over 22,000, were unemployed, similar to the 8% unemployment rate for Ontario.

7.0 How to Read this Report

The following sections of this report examine six climate-related outcomes which have the potential to impact health:

- Extreme Temperatures;
- Extreme Weather;
- Air Quality;
- Contamination and Availability of Food and Water;
- Vector-Borne Disease; and
- Exposure to Ultraviolet Radiation.

For each climate-related outcome, current impact and health burden are presented for the Simcoe Muskoka region. In addition, each impact is examined based on potential exposure, sensitivity, and adaptive capacity from a public health perspective. Where possible and relevant, climate projections for the 2020s, 2050s and 2080s are utilized to determine potential changes to our climate, and thus expected climate-related health outcomes for our region. In addition, current and future community-level mitigation and adaptive capacity actions are also outlined within Section 14.0 of this assessment.

Where possible, information is presented with respect to Northern or Southern Regions, as previously identified. However, some data were not available for both regions, and as such, may be presented for one geographical area (either Simcoe or Muskoka).

Throughout the report a variety of terminology is utilized to describe climate projections and/or health outcomes. While definitions may not be identified within the report, all terms have been defined within the glossary at the beginning of this assessment.

8.0 Extreme Temperatures

Key Considerations:

- Annual mean temperatures within both the Northern and Southern Regions are expected to rise above baseline (1990s) temperatures of 5.6°C in the Northern region and 6.4°C in the Southern Region by approximately 1°C (2020s), 3.5°C (2050s) and 5.7°C (2080s).
- Mean winter temperatures within both the Northern and Southern Region are expected to rise above baseline (1990s) temperatures of -7°C in the Northern Region and -6°C in the Southern Region by approximately 2°C (2020s), 5°C (2050s) and 7.5°C (2080s).
- Mean summer temperatures within both the Northern and the Southern Region are expected to rise above baseline (1990s) temperatures of 18°C for the Northern and Southern Regions by approximately 1°C (2020s), 3°C (2050s), and 5°C (2080s).
- The number of warm, tropical nights is expected to rise from two in baseline (1990s) to 41 by 2080 in the Northern Region; Southern Region tropical nights are projected to increase from three (1990s) to 46 (2080s). If these changes occur it will have a serious impact on vulnerable populations.
- Individuals who live in urban centres, work outdoors, attend outdoor events, or live with low income may be more highly exposed to extreme temperatures.
- The young, the elderly, and those with chronic illnesses may be more sensitive to the impacts of extreme temperatures.
- Senior populations are expected to comprise 30% of the Simcoe Muskoka population by 2041 (totalling 218,800), which will significantly increase the number of individuals vulnerable to heat-related illness within Simcoe Muskoka.
- Within Simcoe Muskoka, prevalence of at-home air conditioning, an adaptive capacity measure, is associated with higher household incomes as well as home ownership, with individuals in the lowest income category and/or tenants being less likely to have air conditioning access.
- 40% of cold exposure hospital visits can be attributed to factors such as mental health or substance abuse disorders, injury, sports activity or work activities.

As the global climate changes, weather patterns, including the number of extreme heat and cold events, are expected to alter. Temperatures across Canada increased by an average of 1.6°C over the period of 1948 and 2013, a rate of warming that is higher than most other regions around the globe.[43] Temperatures are expected to continue to increase in the future, providing milder winters and higher temperatures during the summer months.

The following section describes mean temperature projections and reviews the impact of climate change on extreme temperatures in Simcoe Muskoka, associated health-burden for extremes of both heat and cold, and identifies individuals most sensitive to extreme temperature events in our region. In addition, measures to support adaptive capacity with respect to extreme temperature events are presented.

How to interpret the temperature charts – Each chart below describes the median (50th percentile) range of projected ambient temperature increases for both the Northern and Southern Regions. The bottom dot represents the median projected minimum temperature, the middle dot represents the median projected mean temperature, and the top dot represents the median projected maximum temperature. Temperature changes described throughout this report are based on mean temperature projections, unless otherwise specified. All charts present data from 1990s (baseline), 2020s, 2050s and 2080s.

8.1 Future Climate Projections for the Simcoe Muskoka Region

Across Canada an increase in the average annual temperature has been observed. While there are variations in the projected minimum, mean, and maximum temperatures expected to occur throughout the Simcoe Muskoka region, all geographic areas across the region can expect rising temperatures, with longer summer periods and warmer winters.

8.1.1 Annual Temperature Projections

Figure 8.1 and Table 8.1 below illustrate projected minimum, mean, and maximum annual temperatures[ii] for the Northern and Southern Regions[iii], from 1990s (baseline) to the 2020s, 2050s, and 2080s. A general warming is expected, with annual temperatures projected to increase by approximately 5.8°C from baseline to the 2080s (Northern Region) and 5.7°C from baseline to the 2080s (Southern Region).

ii Temperature projections were calculated using the Downscaled IPCC AR5 RCP8.5 Projections (very high greenhouse gas emission scenario). Data was downloaded from York University (occp.lamps.yorku.ca/node/217/41607).

iii For map of Northern and Southern Regions, please refer to Figure 5.1.

Figure 8.1: Projected annual average temperature range (°C) for the Northern and Southern Regions of Simcoe Muskoka.

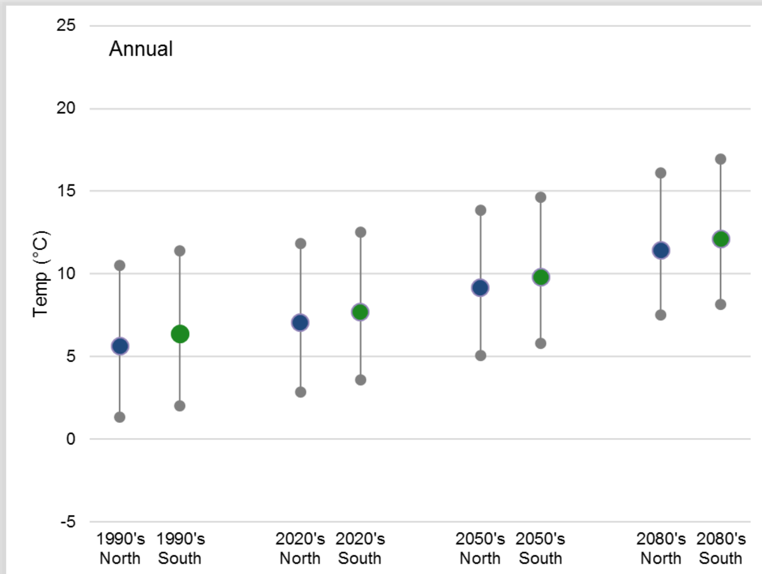


Table 8.1: Annual average temperature change (°C) from baseline (1990s).

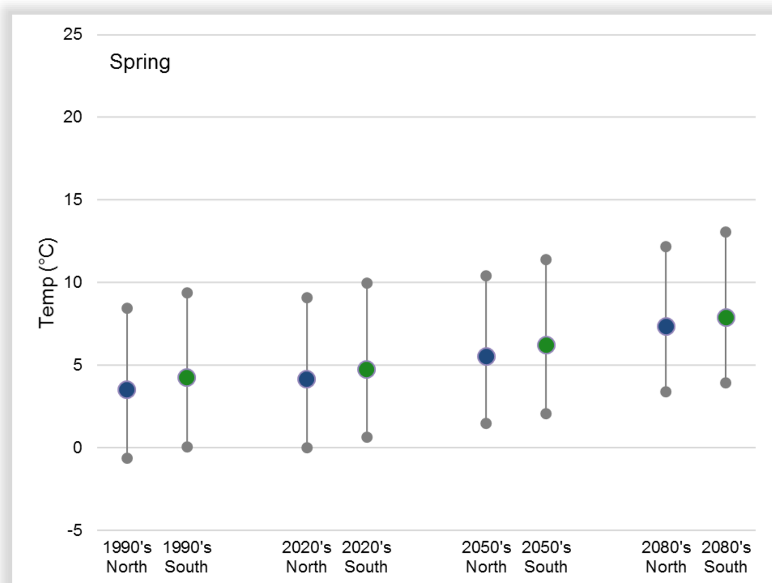
	2020s		2050s		2080s	
	Median	Range	Median	Range	Median	Range
Northern Region	1.4°C	(-)[iv]0.3 – 3.8°C	3.5°C	1.5 – 6.4°C	5.8°C	3.7 – 9.3°C
Southern Region	1.3°C	(-)0.5 – 3.8 °C	3.4°C	1.3 – 6.2	5.7°C	3.6 – 9.2°C

iv Note: Within this document, the (-) in a temperature change table denotes that the bottom range of the temperature change is below that of the median baseline temperature.

8.1.2 Seasonal Temperature Projections

Figures 8.2–8.5 show the mean seasonal temperature projections for the Northern and Southern Regions. While all seasons are expected to have increases in temperature, there will be variations in the amount of those increases that occur across each season, ranging from an average of approximately 4°C in the mean spring temperatures, to approximately 7.5°C increase within the mean winter temperatures for both the Northern and Southern Regions. In addition to warmer winter months, mean autumn temperatures will also increase by just over 7°C, extending the warm weather from summer into the autumn. The number of summer days[v] are projected to increase dramatically between the 1990s and 2080s (Figure 8.6 and 8.7), extending from 48 days and 56 days in the 1990s, to 104 and 107 days by the 2080s, for the Northern and Southern Regions respectively. Seasonal temperature projections from baseline (1990s) for the Northern Region (Table 8.2) and Southern Region (Table 8.3) can be found below.

Figure 8.2: Projected average spring temperature range (°C) for the Northern and Southern Regions of Simcoe Muskoka.



v Summer days are defined as the annual count of days when the daily maximum temperature is greater than 25°C.

Figure 8.3: Projected average summer temperature range (°C) for the Northern and Southern Regions of Simcoe Muskoka.

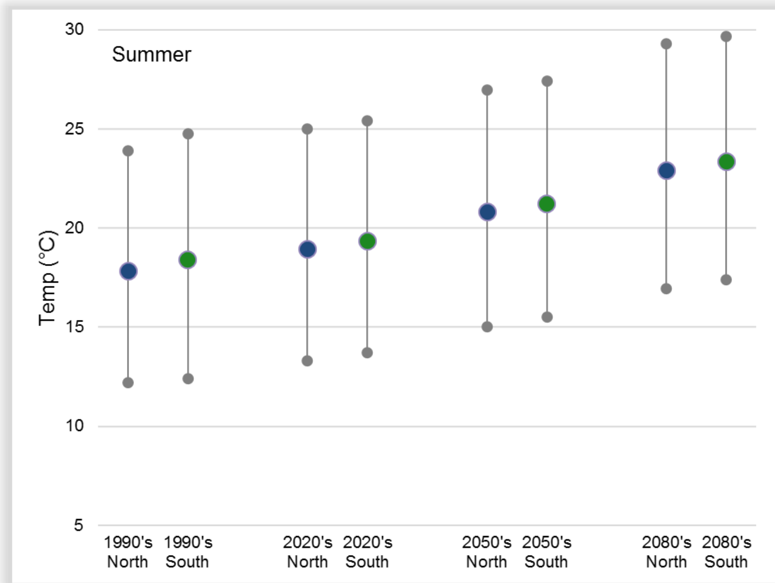


Figure 8.4: Projected average autumn temperature range (°C) for the Northern and Southern Regions of Simcoe Muskoka.

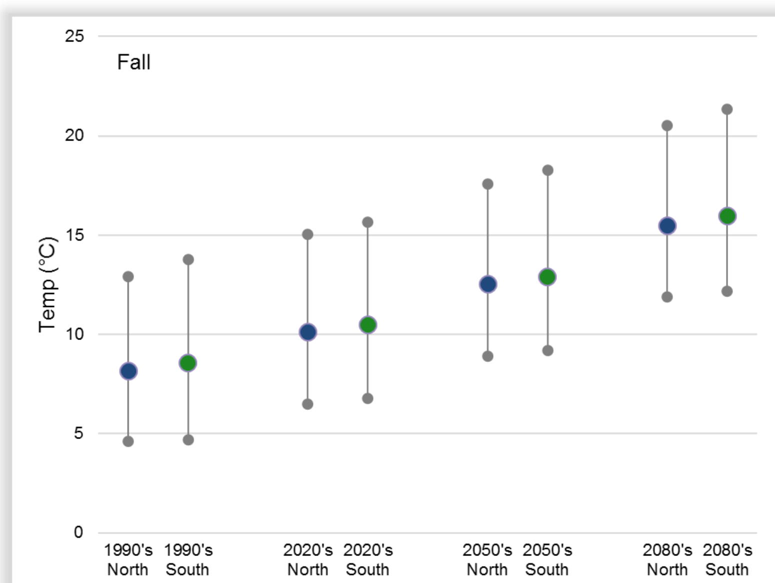


Figure 8.5: Projected average winter temperature range (°C) for the Northern and Southern Regions of Simcoe Muskoka.

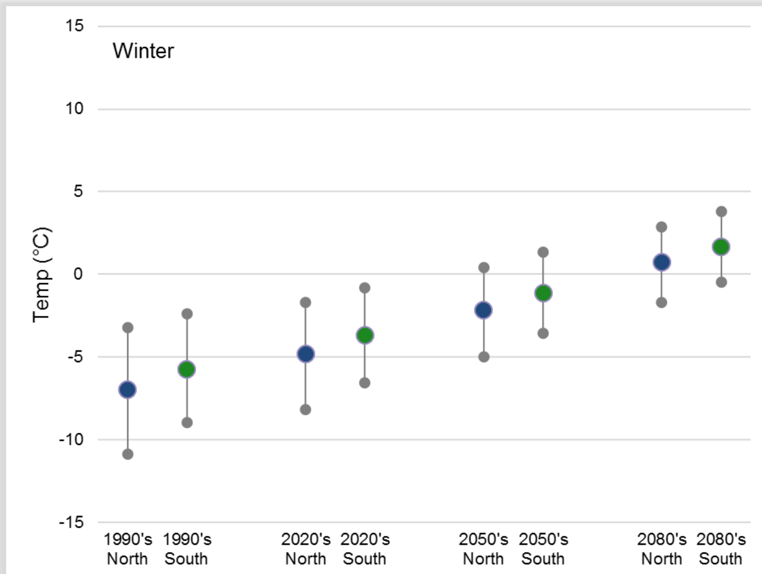


Figure 8.6: Number of projected summer days within the Northern Region.

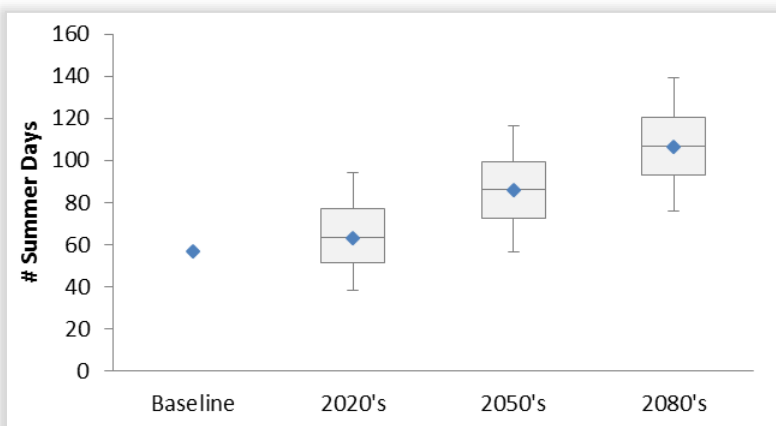


Figure 8.7: Number of projected summer days within the Southern Region.

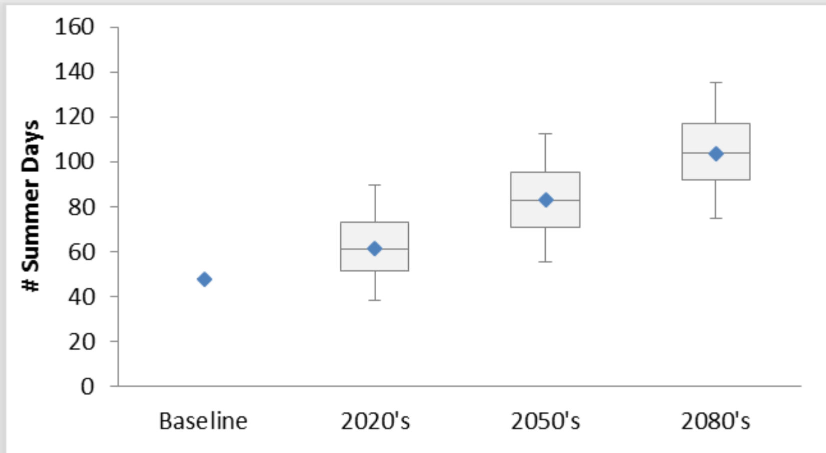


Table 8.2: Seasonal average temperature change (°C) from baseline (1990s) for the Northern Region.

	2020s		2050s		2080s	
	Median	Range	Median	Range	Median	Range
Spring	0.6°C	(-)2 – 4 °C	2°C	(-)1.2 – 6°C	3.8°C	(-)1.1 – 8.8°C
Summer	1.1°C	(-)0.7 – 3.6°C	3°C	0.8 – 6.1°C	5.0°C	2.3 – 9.1°C
Autumn	2°C	(-)0.2 – 5.2°C	4.4°C	1.7 – 9.3°C	7.3°C	3.7 – 14.1°C
Winter	2.1°C	(-)1.5 – 6.5°C	4.8°C	0.7 – 9.4°C	7.7°C	3.5 – 12.4°C

Table 8.3: Seasonal average temperature change (°C) from baseline (1990s) for the Southern Region.

	2020s		2050s		2080s	
	Median	Range	Median	Range	Median	Range
Spring	0.6°C	(-)2.2 – 3.8°C	2°C	(-)1.4 – 5.9°C	3.7°C	(-)1.4 – 8.6°C
Summer	0.9°C	(-)0.9 – 3.7°C	2.9°C	0.5 – 6.1°C	5.0°C	2.1 – 9.3°C
Autumn	1.9°C	(-)0.3 – 5.3°C	4.4°C	1.7 – 9.6°C	7.4°C	3.8 – 14.6°C
Winter	2.1°C	(-)1.5 – 6.2°C	4.6°C	0.6 – 9°C	7.4°C	3.4 – 11.9°C

8.2 Extreme Heat

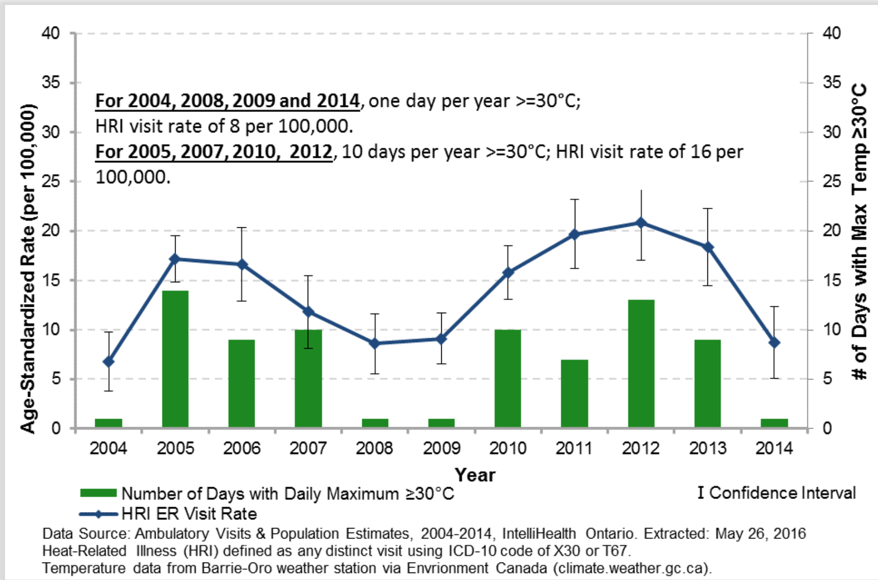
In addition to a general warming trend throughout our region and the increased number of summer days, climate change is also expected to increase the number of extreme heat events experienced both in the Northern and Southern areas of our region. Extreme heat events are defined as a period of temperatures and/or humidex values that are unusually higher than the typical temperature/humidex values for an area.[44] To support awareness and decrease the impacts of extreme heat events, Environment and Climate Change Canada (ECCC) issues heat warnings when temperatures reach specific criteria for heat and/or humidity within a region. These criteria were created taking into consideration heat health impacts, and aim to protect the health of the public during extreme heat conditions. Currently, heat warnings for Simcoe Muskoka are issued by ECCC when the daytime temperatures are expected to reach 31°C or greater and are not expected to dip below 20°C during the night. A heat warning will also be issued if the humidex is expected to rise to 40°C or greater.[45] These conditions must be expected to occur for a minimum of two days or more for a heat warning to be issued by ECCC. In 2016, the year ranked as the warmest year on record globally to date,[46] ECCC issued seven heat warnings for parts or all of Simcoe Muskoka, five of which lasted for three or more days.

Heat related mortality in the United States has been associated with increased intensity (temperature), duration (number of days), and timing in the season (earlier in the season when individuals are not yet acclimatized to the heat).[47] Canadian research suggests that heat-related mortality risk is not linear, and the risk of heat related mortality increases as temperatures rise from the mid to late 20s upwards.[48] As temperatures increase within Simcoe Muskoka, increased heat-related morbidity and mortality may be observed, especially if these episodes of extreme heat coincide with other emergency management situations, such as power brownouts, outages or extreme weather events (e.g. severe thunderstorms or tornadoes).

Current Burden of Heat-Related Illness

Within Simcoe Muskoka, the number of heat-related visits to hospital emergency departments has been higher (16 per 100,000 population) during years when the daily temperature reaches 30°C or greater on 10 or more days, versus years where the temperature only reaches 30°C or greater on one day or less (Figure 8.8). As our summers warm, and the number of days above 30°C increases in the future, it is expected that the number of individuals seeking treatment for heat-related illness may also increase.

Figure 8.8: Heat-related illness emergency room visit rate (per, 100,000) & days >30°C, Simcoe Muskoka, 2004–2014.



8.2.1 Exposure to Extreme Heat

As temperatures within Simcoe Muskoka increase in the future, all residents will be exposed to an increased risk of heat-related illnesses without further adaptation. As stated previously, the average summer temperatures are projected to increase by approximately 5°C by the 2080s, with the number of summer days increasing to more than 100 days per year across the region. In addition to these increases, the number of tropical nights[vi] experienced, and the "heat wave duration" are also expected to rise, which could also have potential impacts on health.

Daily minimum night-time temperatures are an important factor in the potential for health-related outcomes, as warm, tropical nights do not allow for a respite from the heat for vulnerable populations who may not have access to cooling mechanisms. Within the Northern Region, the mean number of tropical nights is expected to rise from an average of two at baseline (1990s), to a potential 41 by the 2080s (Figure 8.9); within the Southern Region an increase from three in the 1990s to 46 by the 2080s can be expected (Figure 8.10).

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vi Tropical nights are defined as the annual count of days when the daily minimum temperature is greater than 20°C.

Figure 8.9: Projected number of tropical nights for the Northern Region.

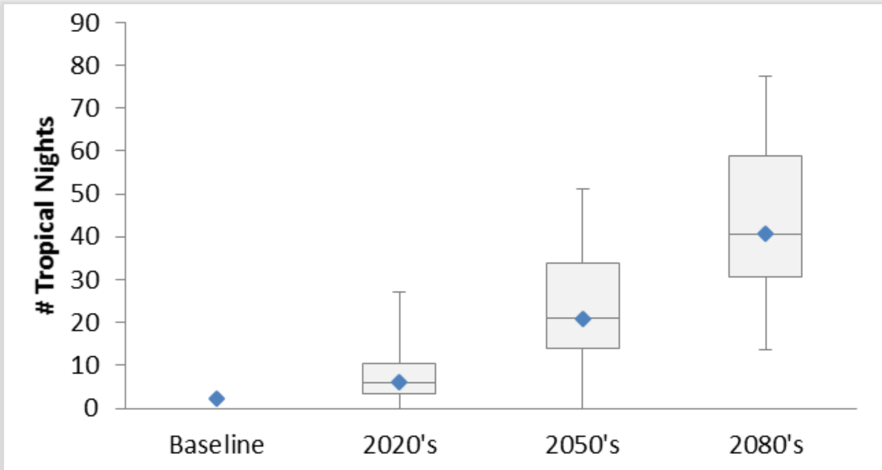
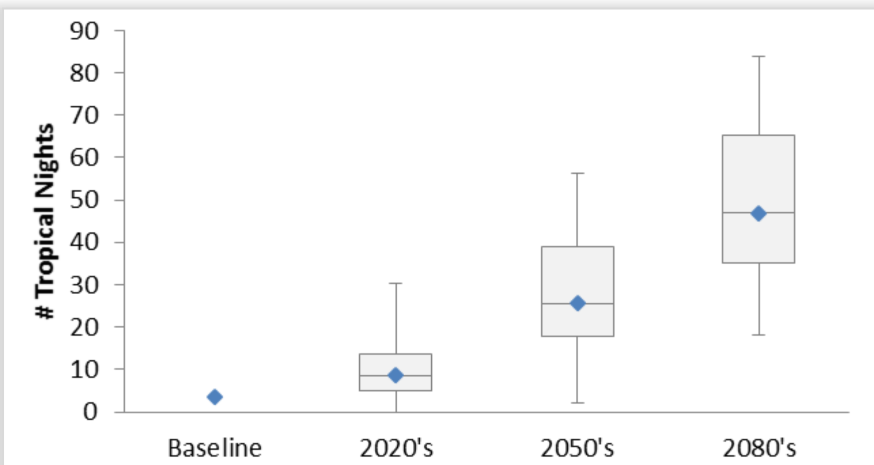


Figure 8.10: Projected number of tropical nights for the Southern Region.



The Heat Wave Duration Index (HWDI) is defined as five consecutive days where the maximum temperature is at least 5°C warmer than the average maximum temperature, relative to 1961–1990 baseline averages.[49] With rising temperatures, it is projected that the number of days associated with HWDI would increase from 12 and 13 for the Northern and Southern Regions respectively, to approximately 118 days by the 2080s for both regions relative to baseline 1961–1990 temperatures. This represents a significant increase in possible exposure to extreme temperatures in all areas in Simcoe Muskoka.

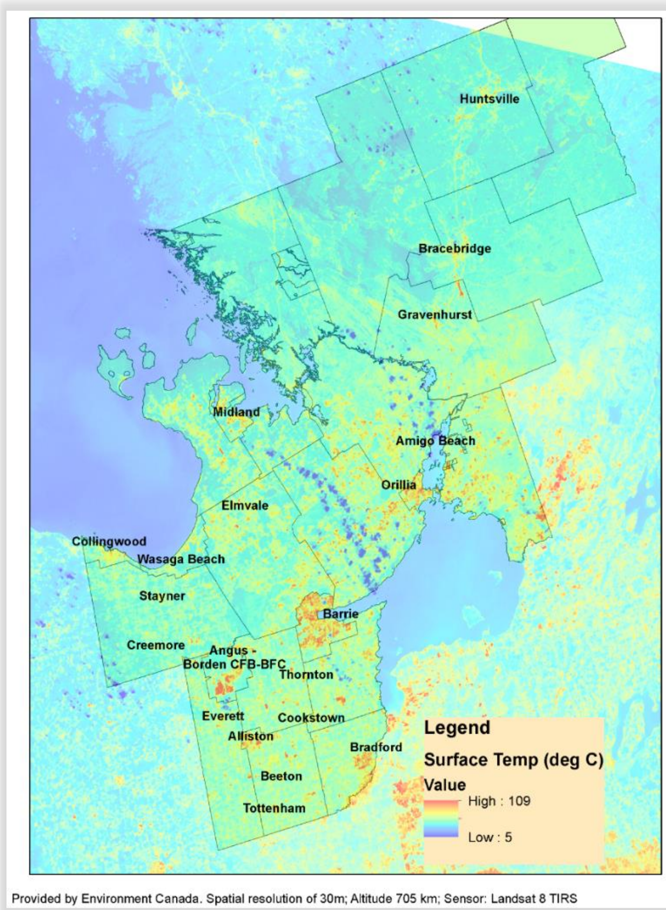
Urban Heat Island Effect

Community design, including the amount of impervious surfaces (i.e. roads, parking lots) and reduced green space or tree-canopy cover, contributes to the Urban Heat Island (UHI) effect, a phenomenon that describes the temperature differences between more built-up urban areas and their surrounding rural counterparts.[50,51] Urban Heat Islands can exacerbate extreme heat conditions and associated health impacts within urban areas; temperature differences due to UHIs can be up to 1 to 3°C during the daytime, with nighttime temperature differences reaching up to 12°C.[52]

While the Simcoe Muskoka region is generally composed of rural municipalities consisting of areas with a low percentage of impervious surfaces and increased greenspace, there are urban areas within Simcoe Muskoka that will experience more extreme heat due to building density and road surface area. Figure 8.11 below illustrates the impact that UHIs had on the urban areas across the region on a summer day in 2013. A UHI map helps to visually identify urban areas where the observed temperatures tend to be higher than the surrounding rural areas. Note that the figure illustrates surface temperature, and does not equate to the ambient air temperatures for the area.[vii] The highest surface temperatures viewed in Figure 8.11, up to 109°C, are observed within urban centres, including the municipalities of Barrie, Orillia, Bradford West-Gwillimbury, and New Tecumseth; cooler surface temperatures are illustrated by a blue to green colour in the surrounding rural areas. The urban areas house a large percentage of the population within Simcoe Muskoka, and this map illustrates the number of individuals potentially exposed to the UHI and extreme heat conditions. As urban growth continues to occur throughout Simcoe Muskoka, increases in the areas that are affected by UHIs can be expected.

vii A similar analysis based on surface temperature was performed by the City of Windsor to identify urban heat islands. Within Windsor's assessment, temperature observed in the Landsat images showed pockets of temperature within the urban environment that were more than twice what was reported by Environment Canada weather stations for ambient air temperatures.[53]

Figure 8.11: Observed surface temperatures across Simcoe Muskoka, July 15, 2013 at 12:05pm.



Mass Gatherings and Special Events

Across Simcoe Muskoka, a number of mass gatherings draw visitors to our region. The Simcoe Muskoka District Health Unit defines a mass gathering as "a pre-planned event that is held for a limited time period and generally has an attendance of greater than 25,000 people." In 2016, two large events - the WayHome Music and Arts Festival, and the Boots & Hearts Music Festival - occurred at the Burl's Creek Event Grounds in Oro-Medonte. Each event brought a total of between 35,000 and 40,000 attendees to the event grounds for multiple days. These events occur during the summer months of July and August, thus increasing the potential exposure to heat events for individuals attending either festival due to long hours outdoors, limited access to shade in festival areas, and the potential for extreme heat events to occur during the summer months. In addition, many other special events held throughout Simcoe Muskoka, including but not limited to Kempenfest in Barrie, the Collingwood Elvis Festival, and the Mariposa Folk Festival in Orillia, all draw large crowds to the region during the summer months. These events increase the potential for exposure and heat-related illnesses to occur on a large scale if an extreme heat event coincides with these gatherings.

Outdoor Workers and other Occupational Groups

The work environment of some occupational groups can increase risk of exposure to extreme heat, and thus risk of heat-related illness. Exposure to heat is increased for certain outdoor occupations, including agriculture, construction, mining, and forestry.[44] For example, the County of Simcoe and the District of Muskoka have 2189 and 175 farms respectively within their jurisdictions.[54] According to the 2011 National Household Survey, 4395 people, or 1.2% of the labour force in Simcoe County, identified that they were employed within natural resources, agriculture and related production occupations[55]; a total of 730 people, or 2.5% of the total labour force within Muskoka, identified as working within these same sectors. In addition, there are a number of migrant farm workers who live and work within Simcoe County during the summer planting and harvest season, who also have increased exposure to heat.

Other occupational exposures, such as those working in indoor environments with limited air conditioning, have increased risk of heat-related illness due to occupational exposure. Substantial heat exposure can occur in a variety of workplaces such as bakeries and commercial kitchens, foundries, and chemical plants. To ensure the health and safety of workers, the Ministry of Labour recommends the use of Threshold Limit Values for heat stress and strain outlined by the American Conference of Governmental Industrial Hygienists, to prevent the core body temperature of workers from rising above 38°C.[56]

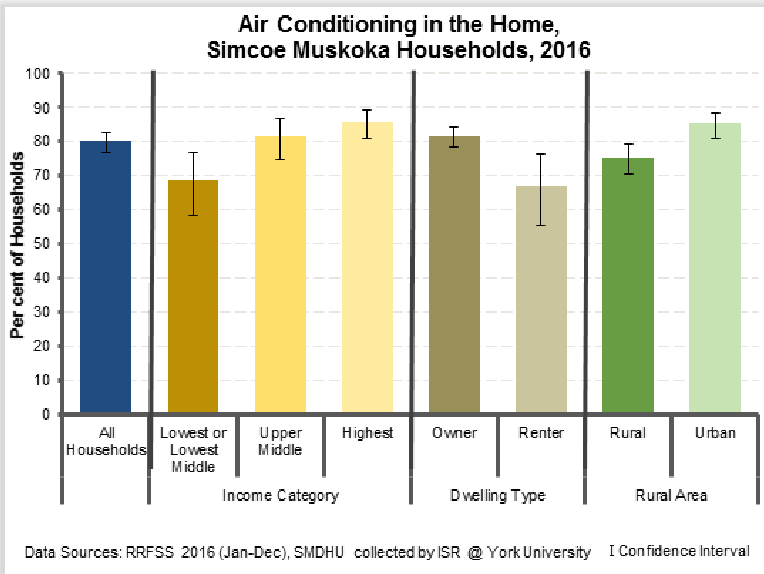
Data on the total number of individuals employed within occupational environments where exposure to extreme heat occurs are not readily available for the Simcoe Muskoka region.

Home Cooling and Air Conditioning

Lack of access to cool, air-conditioned spaces is another factor that may increase exposure to extreme heat events, especially as the number of warm, tropical nights increase and provide a decreased respite from the warm days. In a survey conducted by RRFSS, approximately 80% of Simcoe Muskoka households reported having air conditioning in their homes (Figure 8.12); prevalence of air conditioning was associated with higher household incomes, as well as home ownership. Individuals who were in the lowest income category, and/or who rented their housing accommodations, were less likely to have access to in-home air conditioning. In addition, it must be noted that while access to air conditioning is a factor, cost of operating air conditioning may limit individuals’ access to in-home air conditioning. For those with a strong reliance on air conditioning as an adaptive strategy, there could be an even greater potential for heat exposure and associated illness in the event of a power outage.

However, it must be acknowledged that utilizing air conditioning may contribute to climate change depending on the source of power and whether it creates greenhouse gases; thus using air conditioning may contribute to further heat events in the future. To combat the negative contribution that air-conditioning has on climate change, while still supporting cool home environments that decrease the exposure to extreme heat, passive climate control - including actions such as solar shading, ventilation, different levels of insulation, passive cooling from waterbodies, etc. – can be examined as an adaptive method of keeping residential and commercial environments cool without requiring additional energy inputs.[57]

Figure 8.12: Percent of households with access to air conditioning, based on household income, type, and geography, Simcoe Muskoka, 2016.



8.2.2 Sensitivity to Extreme Heat

Extreme heat events can cause a variety of health issues along a spectrum of severity, from heat cramps and rashes to the more serious heat exhaustion and heat stroke.[44] While extreme heat can impact everyone within a community, specific populations will be more sensitive to heat impacts. These populations include:

- children;
- seniors;
- pregnant women and newborns;
- individuals who have chronic conditions or are on certain medications; and
- individual living in low income.

Children

There are various factors that influence children's sensitivity to extreme heat. Children (0 to 9 years of age) have a greater surface-area-to-body weight ratio, which causes a faster heat gain from the environment when temperatures rise; metabolic rates are also higher among children, which can increase their body temperature quickly. While children tend to exert a lower level of intensity during physical activity than adults, they tend to often be more active overall, which if performed during extreme heat events can cause heat-related illness. Temperature also plays a role in the potential for Sudden Infant Death Syndrome (SIDS), with overheating being identified as a risk factor for SIDS.[58,59] In addition, children have a dependence on their caregivers for recognition of the impact of heat and their associated health outcomes, increasing their sensitivity.[60] Children with underlying health conditions, such as asthma, gastrointestinal illnesses, and autoimmune disorders, are at higher risk of heat-related illness compared to healthy children.[61]

Within Simcoe Muskoka in 2011, children made up 11% of the population (53,330), with the largest proportion residing in the City of Barrie. While the number of children is expected to increase to 73,000 by 2036, the proportion of children among the population will decrease slightly to 10%.[40]

Seniors

Seniors (age 65 years or older) are more sensitive to extreme heat due to physiological impacts such as a decreased ability to sweat, decreased blood flow, and a reduced thirst sensitivity.[60] In addition, lack of social support networks or access to resources can further compound these physiological impacts.[62]

In 2011, nearly 82,500 seniors 65 or older resided in Simcoe Muskoka - however, this number is projected to grow substantially by 2041, when the senior population is expected to surpass 218,800 people, significantly increasing the number of individuals that may be impacted by our changing climate in the future.

Pregnant Women and Newborn Infants

Pregnant women are vulnerable to temperature extremes and are especially susceptible to dehydration. Dehydration early in pregnancy can affect the baby's growth and later in pregnancy can be responsible for the release of labor-inducing hormones, leading to pre-term birth. Extreme heat events are also associated with adverse birth outcomes, such as low birth weight and infant mortality. Newborns are especially sensitive to ambient temperature extremes because their capacity for regulating body temperature is limited.[63]

In 2011, 4,817 babies were born to Simcoe Muskoka mothers, a slight decrease from 4845 in 2010. Since 2005, the number of babies born in Simcoe Muskoka has remained relatively stable while the crude live birth rate[viii] has continued to decrease. This decrease is due, in part, to people waiting longer to have children and not having as many children as in the past.[64]

Individuals with Chronic Conditions

Individuals with certain chronic conditions, such as cardiovascular illness, diabetes mellitus, chronic kidney disease and some neurological illnesses, may be at higher risk for health outcomes when exposed to extreme heat, due to the physiological changes created by these illnesses.[62] Additionally, certain medications can exacerbate the effects of extreme heat,[44,65] reduce heat tolerance and impair the ability to thermoregulate.[62]

Socioeconomic Status

The socioeconomic status (SES) of an individual can influence the level of exposure to heat through a variety of factors, including inadequate or unstable housing and homelessness; and lack of access to adaptive resources,[60] such as lack of access to and/or use of air conditioning, which have been associated with increased risk of heat-related health outcomes.[66]

In addition, Kravchenko and colleagues[62] found that within the United States, low SES individuals who identify with ethnic groups were more likely to reside in urban areas of higher density with reduced green space, resulting in greater heat exposure; subsequently a higher heat-related morbidity was reported among African Americans. Marginalized individuals may also not attend public cooling shelters, whether due to availability or cost of transportation to these stations, or a feeling of being unwelcome in these public spaces.[44]

Within Simcoe Muskoka, 11.3% of the population (approximately 57,760 individuals) lived with low income (after tax) in 2014, slightly lower than the provincial average of 15.1%. Those living with low income in Simcoe Muskoka include 15.6% of children 17 years of age and younger (18,230) and 12.3% of adults between the ages of 18 and 64 (38,430). While the proportion of the population living with low income is higher among children (17 years of age and younger) and adults (18 to 65), the average rate of those living with low income within Simcoe Muskoka is decreased due to the percentage of individuals over the age of 65 who live in low income (2.9%). This decrease may be due in part to the Old Age Security pension (an income supplement) that is available to seniors aged 65 and older (Table 8.4).[42]

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viii The crude birth rate is the number of live births per 1000 people in the population per year. This rate is influenced by the age structure of the population and will be higher among populations with more women of childbearing age.

Prevalence of low income varies throughout the region, from as low as 0.9% within certain geographical dissemination areasix, to as high as 59.6% in other areas. An interactive map that identifies the areas of low income across Simcoe Muskoka can be viewed at the SMDHU's Health Stats page www.simcoemuskokahealthstats.org.

Table 8.4: Low-income measure – after tax for Simcoe Muskoka and Ontario, 2014 (Source: Statistics Canada, 2016).

	Simcoe Muskoka (%)	Simcoe Muskoka (Count)	Ontario (%)	Ontario (Count)
Couple Families [x]	5.4	7,010	9.7	308,320
Lone Parent Families	29.7	6,680	30.4	169,080
Non Family Persons [xi]	23.5	18,230	27.6	575,650
17 years and under	15.6	16,650	18.8	513,850
18 to 64 years	12.3	38,430	15.9	1,307,750
65 years and over	2.9	2,680	6.8	141,630
All persons	11.3	57,760	15.1	1,963,230

8.3 Extreme Cold

8.3.1 Exposure to Extreme Cold

Temperatures during the winter months in Simcoe Muskoka have historically been cold, with potential for extreme cold events and large amounts of snowfall. However, as the temperatures rise, average winter temperatures are expected to increase by more than 7°C in both the Northern and Southern region. In the baseline period, a total of approximately 33 cold nights[xii] and cold days were observed; by the 2080s, this number decreases to 9.9 and 3.7

ix Dissemination areas (DA) are a standard geography with populations of approximately 400 to 700 people. Dissemination Areas are used within the low income interactive map to show the variation in the prevalence of low income (after tax).

x Includes families that contain a married or common-law couple (either with or without children).

xi Non-family persons include persons living alone and persons living in a household but are not part of a couple family or lone-parent family.

xii Definitions of terminology for extreme cold can be found within the glossary at the beginning of this report.

cold nights for the Northern and Southern Regions respectively, and 3.67 and 0.2 cold days for the Northern and Southern regions respectively. In addition, the number of frost days is projected to decrease from 152 and 150 in the Northern and Southern Regions in the baseline period to 101 and 98 in the Northern and Southern Regions by the 2080s; the number of icing days is also set to decrease from 79 to 38 (Northern) and 73 to and 31 (Southern) days per year by the 2080s.

Increases in temperature within the winter months will aid in decreasing exposure to extreme cold events for the residents of Simcoe Muskoka in the future. However, while the temperature increases will provide overall milder winter weather, there is a potential for extreme cold events to be more severe on individuals when they do occur, due to lack of acclimatization to the colder weather, as is currently observed during cold events in regions which generally experience milder winter temperatures.[67] In addition, research has identified that even exposure to moderate cold temperatures can increase cold-related health outcomes and cold-related mortality.[68] Exposure to cold is associated with an increase in cardiovascular mortality, due to increases in blood pressure, cholesterol, fibrinogen and erythrocyte counts.[67]

Between the 2003–2004 and 2014–2015 winter season, 728 residents of Simcoe Muskoka sought treatment at a hospital emergency room or were hospitalized for cold exposures.[69] A cold exposure, for the purpose of the analysis, was defined as a new emergency department visit or hospitalization to a Simcoe Muskoka resident that was determined to have occurred between November 1 to March 31 of a given winter season. Only one case per season was counted for an individual to ensure repeated visits for the same cold exposure were not counted more than once. Causes were for any diagnosis with the given code, and not necessarily the main problem or most responsible diagnosis. Cold exposure events included the following causes:

- frostbite (ICD10-CA: T33-T35);
- hypothermia (ICD10-CA: T68); and
- exposure to excessive natural cold (ICD10-CA: X31)

The highest number of cold exposures treatments (118) occurred in the 2014–2015 winter season. Within this time period, rates of cold exposure were approximately twice as high in males (16.7 per 100,000) as they were in females (7.3 per 100,000). Rates of exposure were highest among those aged 15 to 24 years (21.6 per 100,000) compared to all other age groups combined (10.5 per 100,000).[69] Any cold exposures for Simcoe Muskoka residents that occurred outside of Simcoe Muskoka (e.g. other locations where residents were visiting or vacationing) or cases of cold exposure that were not reported or counted because individuals did not seek medical care, are not included in the above cold exposure data.

While 60% (435) of cold exposure hospital visits events had no obvious risk factors, 40% (293) have been attributed to factors such as mental health or substance abuse disorders, injury or other medical events, sports activity or work activities. Of those exposures that could be attributed to a risk factor, 10 were suspected to be related to homelessness. However, it must be noted that this is likely an underestimate.

8.3.2 Sensitivity to Extreme Cold

Exposure to extreme cold can cause a variety of serious and/or life-threatening health outcomes, including frostbite and hypothermia.[70] Certain individuals are more susceptible to the health impacts of extreme cold, including:

- infants under the age of one year;
- seniors over the age of 65 years; and
- those who are homeless or under-housed.

While the increasing temperature will help to decrease some exposure to extreme cold in the future, our increasing and aging population will mean a growing number of individuals may be sensitive to extreme cold.

8.4 Adaptive Capacity to Extreme Temperatures

Adaptive capacity is the ability of an individual or community to adapt to the changing environment due to climate change.[16] This capacity can be due to individual resources, abilities and knowledge, or from programming and supports provided at the community level. For more detail on adaptive capacity, see subsection 5.3.

Table 8.5 below highlights current and potential actions, key partners, and mitigation co-benefits related to extreme weather adaptive capacity for which the health unit has a role. For information on a sample of adaptive capacity measures completed by local municipalities, conservation authorities, and community organizations, see Section 14.0.

Table 8.5: Current and potential actions taken by the Simcoe Muskoka District Health Unit to support adaptive capacity to extreme temperatures.

Public Health Role	Type of Action (current/for consideration)	Activities	Key Partners	Mitigation Co-Benefit
hePopulation Assessment	Current	Identify populations and communities at risk.		
		Create extreme temperature morbidity/mortality reports.	Acute care facilities	
	For Consideration		Municipal planners Parks & Recreation staff	
Surveillance	Current	Monitor heat and cold weather surveillance of Environment and Climate Change Canada temperature alerts.	Environment and Climate Change Canada	
		Monitor and analyze acute care emergency room and admission data.	Acute care facilities	
	For Consideration			
Health Promotion (Policy Development, Advocacy & Public Education)	Current	Participate in municipal emergency response planning.	Community EMCs Community agencies Health care providers	
		Participate in vulnerable population planning.	Community EMCs Community agencies Health care providers	
		Provide education and recommendations for precautions surrounding extreme temperatures and sun safety within childcare centres and public recreation centres.	Childcare providers Simcoe County Childcare Committee MOHLTC Ministry of Education Municipalities	
		Provide public education via social media, media interviews.	Media	
		Participate in Official Plan reviews; provide policy statements related to trees, shade, energy conservation.	Municipal planners	✓

Public Health Role	Type of Action (current/for consideration)	Activities	Key Partners	Mitigation Co-Benefit
		Provide information re: temperature, hydration and sun safety through website and in-person interactions.	Public	
		Provide Health Connection telephone service for public re: health information (supports those without internet and those with mobility and/or transportation issues).	Public	
		Support of naturalized outdoor play areas.	School boards	
		Support policy development related to planting shade trees, tree management strategies, increasing green spaces, installing reflective/cool/green roofs, energy conservation and heat resilient buildings, provision of water fountains and bottle filling stations in public areas.	Municipal planners Infrastructure & Engineering Environmental services Parks & Recreation	✓
	For Consideration	Assess municipal and community agency capacity to provide interventions (i.e. cooling centres, transit passes).	Community EMCs Community agencies Municipal partners	
		Support policy development related to provision of water fountains and bottle filling stations in public areas.	Municipal planners Infrastructure & Engineering Environmental services	✓
		Increase targeted messaging to specific groups (i.e., outdoor enthusiasts, male youth).	Recreation Departments Special interest groups Community agencies	
		Develop messages to public to reduce temperatures around home by planting bushes and trees, and other passive cooling strategies.	Landscape/horticultural experts	
		Develop messaging to encourage the use of economical heat mitigation measures for individuals living with low income (i.e. using blinds to decrease heat exposure).		

Public Health Role	Type of Action (current/for consideration)	Activities	Key Partners	Mitigation Co-Benefit
		Include extreme temperatures messaging as a component of personal preparedness.	Community EMCs Media	
		Support advocacy for vulnerable populations without air conditioning, including: ensuring no utility service cancellations during extreme temperature warnings; provision of transportation/transit to cooling centres; working with landlords to provide 'cooling rooms'.	Municipalities Community & Social Service agencies	
		Support advocacy to support funding for the creation of cool areas (i.e. planted trees, splash-pads).	Municipal staff	
		Support advocacy to ensure access to drinking water for homeless/under-housed individuals, checking outdoor spaces for homeless/at risk individuals during extreme temperature events.	Municipalities Community & Social Service agencies	
		Develop strong messages re: use of internal fossil fuel heat sources during extreme cold events and power outages.		
		Develop public messages and alerts in languages other than English, as needs dictate.		
Health Protection (disease and injury)	Current	Continued implementation of Temperature Notification Process to provide advance warning of extreme temperature events.	Community EMCs	
		Continued implementation of MOH recommendations for action in extreme temperature events.	Community EMCs	
		Consider extreme temperature as a component of mass gathering events.	Community EMCs Special event planners Municipalities	
	For consideration	Explore mitigation and adaptation actions by agencies and individuals as a result of extreme temperature notification.	Community & Social Service agencies	

Public Health Role	Type of Action (current/for consideration)	Activities	Key Partners	Mitigation Co-Benefit
		Regular review of best practice interventions for extreme temperature events.		
		Assessment of non-traumatic deaths in conjunction with temperature to examine associated mortality.		
		Promote use of Ministry of Labour heat guidelines for workers and maintain awareness of updates to guidelines.	Ministry of Labour	
		Develop Extreme Temperature & Power Outage emergency response exercise.	Community EMCs	
		Support identification of land in proximity of waterbodies to be preserved for public access as heat adaptation strategy (i.e. for long-term care facilities, location of emergency shelter buildings, etc.).	Community EMCs Municipal Partners	

9.0 Extreme Weather

Key Considerations:

- Current precipitation patterns have identified a decrease in overall precipitation in both the Northern and Southern Regions. The greatest precipitation decrease has been observed in the late summer (August and September).
- Projection models anticipate an overall annual increase in precipitation in the future, with the increase anticipated in the winter months, and a continued decrease expected during the summer.
- An increase in the number and intensity of extreme precipitation events, and associated flooding, is expected by 2080.
- Increases in thunderstorms has the potential to increase the number of forest fires caused by lightning. Increases in 'super cell thunderstorms' may also impact on the number of tornados which will occur.
- Winter storms will become more prevalent, with increases in precipitation in the form of snow, freezing rain or rain.
- Within the summer there will be increased drought periods due to decreases in summer precipitation levels.
- Individuals with mobility issues, mental illness and those who are socially isolated, may have increased sensitivity to associated health impacts arising from extreme weather events.
- Individuals with chronic illnesses related to respiratory disease (asthma, COPD) may be especially impacted by forest fires. Within Simcoe Muskoka, COPD rates are highest among those with lower levels of education and income, which increases vulnerability risk.

Changes in climate alter traditional evaporation and precipitation cycles, with higher temperatures increasing the atmosphere's ability to hold moisture globally.[71] Within Canada, weather stations have identified an increase in the amount of precipitation across the country, with increases occurring primarily in the spring and autumn.[71] These changes in the atmosphere's capacity can have profound impact on the intensity of precipitation events in the future.

Traditionally, Simcoe Muskoka has experienced varied weather patterns, with strong winter storms, heavy snowfall, and increased precipitation due to the presence of large water bodies within the region, including Georgian Bay and Lake Simcoe. As temperatures increase, it is predicted that the weather patterns across all of Canada will change, with more frequent and intense precipitation events expected. The following sections discuss trends in historical precipitation data, projected precipitation for Simcoe Muskoka, as well as changes to other extreme weather events resulting from climate change. These events include: flooding, drought, tornadoes, forest fires, and winter storms, which may impact the health of individuals across Simcoe Muskoka.

9.1 Historical Precipitation Variability in Simcoe Muskoka

To examine observed shifts to precipitation changes within Simcoe Muskoka, historic precipitation data from four weather stations were obtained from Environment Canada's Historic Climate Data,[xiii] including Barrie and Egbert in the Southern Region and Muskoka Airport and Beatrice in the Northern Region.[xiv] Utilizing this data, trends in precipitation from the years 1971 to 2000 (historical period) were compared[xv] with precipitation trends from 2001 to 2015 (recent period), for both the Northern (Table 9.1 and Figure 9.1) and Southern (Table 9.2 and Figure 9.2) Regions. Both mean monthly precipitation trends and mean difference between the baseline and recent precipitation amounts are reported in the tables below.

From the historical period to the recent period, an overall decrease in monthly precipitation is observed. This decrease is greatest in the Northern Region, with an average decrease of 27 mm of rainfall per month over the year compared to 8 mm in the Southern Region. Across the year, a decrease in total monthly precipitation was most evident in late summer in the Northern Region. There is a less obvious change in the precipitation patterns evident in the Southern Region, with increases in precipitation observed in some months, despite an overall decreasing trend.

Weather stations in Simcoe Muskoka provide information on overall precipitation, but do not consistently report on rainfall and snowfall separately; as such we are unable to describe specific changes in these types of precipitation. The completeness of the historical precipitation record varies across weather stations and between the two time periods, with 1.5% (Northern Region) to 6.9% (Southern Region) of records missing precipitation data from the baseline series, and 5.7% (Southern Region) up to 21.2% (Northern Region) missing data from

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xiii Climate data accessed from http://climate.weather.gc.ca/historical_data/search_historic_data_e.html on 9 November 2016.

xiv Historical precipitation information was produced by combining historical data from nearby weather stations due to an incomplete time series for both the Barrie and Egbert weather stations (for Barrie data were combined with the Shanty Bay weather station; for Egbert, data were combined from Egbert, Essa and Cookstown).

xv Similar comparison techniques for precipitation have been included within the Middlesex-London Health Unit Climate Change and Health Vulnerability Assessment,16 and have also been observed in Binita and colleagues.72

the 2001 to 2015 series. The latter series is derived from daily precipitation records provided by Environment Canada, whereas the former is from monthly data.

Table 9.1: Total mean monthly precipitation (mm) for historical (1971–2000) and recent (2001–2015) periods, and the difference, for the Northern Region.

Month	Total precipitation (mm) (1971–2000)	Total precipitation (mm) (2001–2015)	Difference (mm)
January	111.5	81.8	-29.7
February	69.2	67.1	-2.1
March	74.3	70.4	-3.9
April	76.9	65.6	-11.3
May	90.7	59.6	-31.1
June	111.5	62.3	-49.1
July	94.6	45.1	-49.5
August	92.8	51.3	-41.5
September	111.5	50.9	-60.6
October	107.6	77.0	-30.5
November	118.0	104.6	-13.4
December	110.3	106.3	-4.0

Figure 9.1: Precipitation (mm) trend for historical (1971–2000) and recent (2001–2015) periods, and the difference, for the Northern Region.

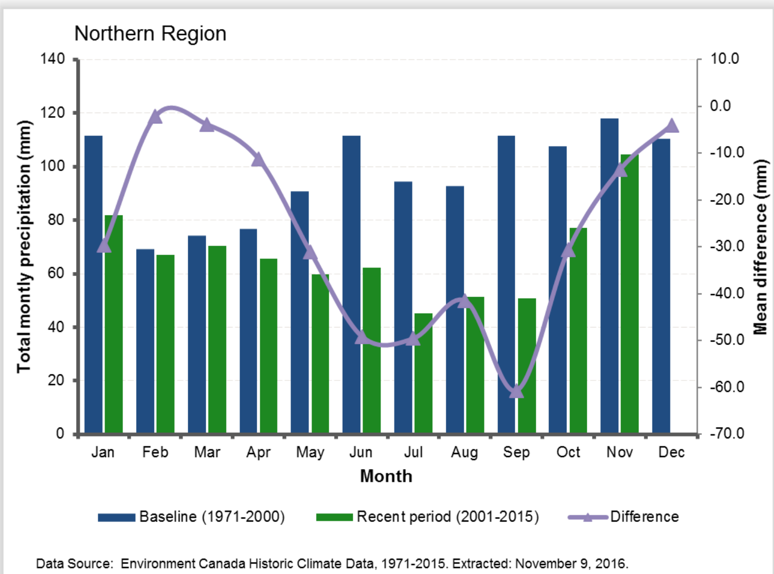
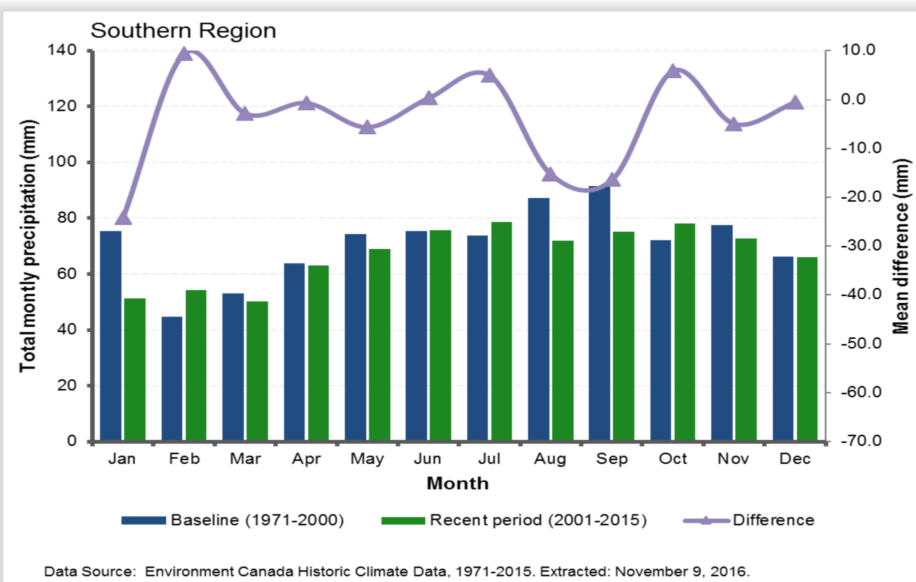


Table 9.2 Total mean monthly precipitation (mm) for historical (1971–2000) and recent (2001–2015) periods, and the difference, for the Southern Region.

Month	Total precipitation (mm) (1971–2000)	Total precipitation (mm) (2001–2015)	Difference (mm)
January	81.6	51.2	-30.4
February	51.0	54.4	+3.3
March	56.9	50.3	-6.6
April	62.9	63.1	+0.1
May	72.8	68.9	-3.9
June	81.6	75.7	-6.0
July	73.8	78.6	+4.8
August	90.8	71.9	-18.9
September	93.9	75.0	-18.9
October	73.7	78.1	+4.4
November	83.8	72.7	-11.1
December	77.3	65.9	-11.3

Figure 9.2: Precipitation (mm) trend for historical (1971–2000) and recent (2001–2015) periods, and the difference, for the Southern Region.



9.2 Future Precipitation Variability in Simcoe Muskoka

9.2.1 Precipitation Models for Simcoe Muskoka

Climate projection models for the Simcoe Muskoka area have identified changes in the pattern and volume of precipitation expected to occur across the region by the 2080s (for full data, see Appendix G & H).

Tables 9.3 and 9.4 present the total seasonal and annual precipitation (mm) measured at baseline (1990s), and projected across the 2020s, 2050s, and 2080s, as well as the 5th to 95th percentile range (identified as range in charts) for these projections. There is a wide range of uncertainty around future precipitation patterns, and we can expect to see increased variability overall, reflected in the width of the 90th percentile projected range. Generally, while recent precipitation has shown a decrease in winter precipitation (9.1 & 9.2 above), projections identify a slight increasing trend in precipitation, driven largely by increases in winter precipitation. Increased winter precipitation (e.g. as snow) can lead to increased spring runoff, which can increase risks of localized flooding. In the summer, especially in the North, we can expect to see decreasing summer precipitation, which can have impacts on crops and contribute to drought and drying.

Table 9.3: Mean total seasonal and annual precipitation (mm) for the Northern Region for baseline (1990s), 2020s, 2050s, and 2080s.

Northern Region	Baseline (1990s)	2020s Estimated Total	2020s Range	2050s Estimated Total	2050s Range	2080s Estimated Total	2080s Range
Winter	276.1	304.7	235.2 – 393	321.8	239.9 – 416.3	341.3	251 – 440.7
Spring	219.0	199.6	126.8 – 290.9	215.9	130.5 – 311.5	232.2	144.7 – 335.4
Summer	256.8	236.4	145.1 – 341.2	236.4	151.5 – 347.1	237.1	138.1 – 349
Autumn	304.9	302.1	210.6 – 404.8	304.7	212.2 – 423.8	303.1	204.2 – 441.3
Annual	1057.1	1049.7	876.5 – 1238.7	1090.2	894.3 – 1294.7	1128.4	911 – 1354.4

Table 9.4: Mean total seasonal and annual precipitation (mm) for the Southern Region for baseline (1990s), 2020s, 2050s, and 2080s.

Southern Region	Baseline (1990s)	2020s Estimated Total	2020s Range	2050s Estimated Total	2050s Range	2080s Estimated Total	2080s Range
Winter	211.7	237.7	184.1 – 307.7	249.6	189 – 330.4	268.8	196.1 – 345.6
Spring	199.8	186.3	120.7 – 279	201.8	125.7 – 296.6	218.5	136.9 – 319.9
Summer	245.9	225.9	143.7 – 324.2	227.4	149.1 – 330.9	229.3	134.3 – 339.3
Autumn	257.0	260.0	173.4 – 355	260.6	173.7 – 370.7	258.4	167.9 – 385.7
Annual	914.6	917.8	764.6 – 1099.1	952.8	783.1 – 1141.8	982.1	788.7 – 1200.9

Slight increases in consecutive wet (Figure 9.3) and dry (Figure 9.4) days from baseline are expected to occur between baseline (1990s) and the 2080s. Of note is that these increases are not statistically significant, with the greatest increases occurring within the range of uncertainty, which is highlighted by the increasing bars on either side of the mean.

Figure 9.3: Projected annual average consecutive wet days, Northern and Southern Regions, for baseline (1990s), 2020s, 2050s, and 2080s.

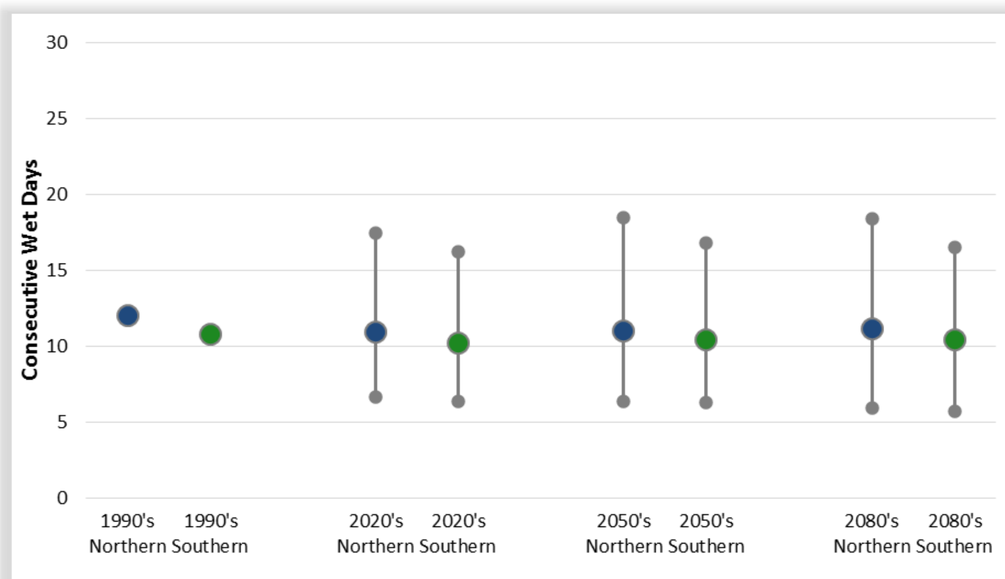
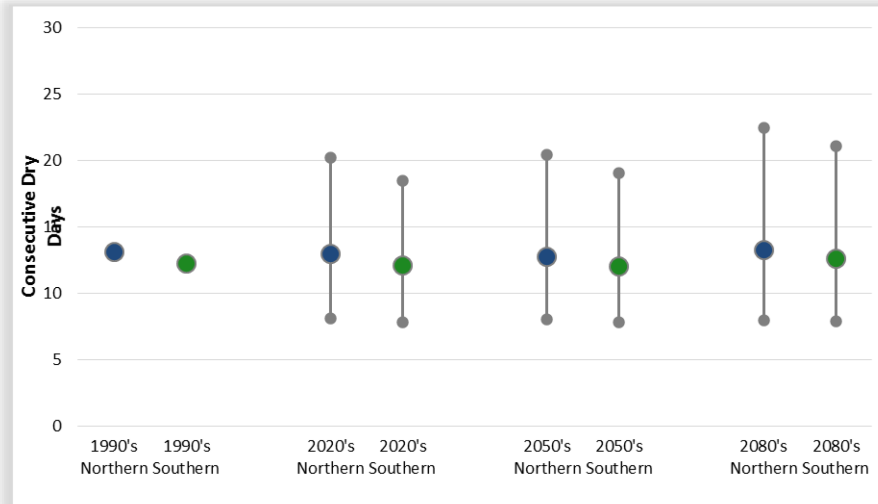


Figure 9.4: Projected annual average consecutive dry days, Northern and Southern Regions, baseline (1990s), 2020s, 2050s and 2080s.



In addition to changes in the patterns of when precipitation will occur, projected climate changes also indicate an increase in the volume of precipitation that will fall during any one day or event, as illustrated by the number of extremely wet days (EWD), heavy precipitation days (HPD), and monthly maximum one-day precipitation (MMP) (Table 9.5). These changes in precipitation amounts during events may affect ground saturation, and the ability of natural areas and waste-water systems to deal with rain runoff and resultant overland flows. High intensity precipitation events are more likely to apply increased stress on infrastructure and ecosystems and increase risk to human health.[5,73]

Table 9.5: Projected precipitation volume changes for baseline (1990s), 2020s, 2050s and 2080s, for the Northern and Southern Regions, presented as median, and 5th to 95th percentile range.[9]

		Baseline (1990s)	2020s		2050s		2080s	
			Median	Range	Median	Range	Median	Range
Northern Region	EWD (# days)	8.7	11.76	6.97–17.17	12.93	7.61–19.19	14.19	8.07–20.47
	HPD (# days)	30.33	36.44	27.36–46.46	37.83	28.49–48.3	39.04	29.4–49.8
	MMP (mm)	38.01	41	27.83–63.53	43.57	28.74–67.56	46.73	30.8–73.59
Southern Region	EWD (# days)	8.78	10.13	5.78–15.38	11.35	6.38–17.35	12.25	7–18.43
	HPD (# days)	29.23	31.55	23.05–41.05	32.85	24.25–42.4	34.05	24.88–44.15
	MMP (mm)	39.33	42.45	28.2–65.65	44.23	29.23–69	46.55	69–72.78

By the 2080s, it is anticipated that the number of extremely wet days will increase by 5.5 days in the Northern Region, and by 3.5 days in the Southern Region compared to the 1990 baseline (8.7 and 8.8 days respectively). In addition, the number of days with heavy precipitation is also expected to increase, by approximately nine days within the Northern Region, and roughly seven days for the Southern Region, by the 2080s.

Lastly, the monthly maximum one-day precipitation, defined as the maximum one-day value of the daily precipitation (mm) within a month, is also projected to increase from baseline to the 2080s, by 8.72 mm in the Northern Region, and 7.22 mm in the Southern Region. These impacts – increases in extremely wet days, heavy precipitation days, and the monthly maximum precipitation, with an increasing number of consecutive dry days – highlight the changing type of precipitation that we can anticipate for our region. We can expect more days without precipitation, while experiencing heavy or intense downpours when precipitation does occur.

9.2.2 Local Intensity, Duration, Frequency Curves

To prepare for extreme weather events, infrastructure and engineering departments use Intensity-Duration-Frequency (IDF) curves, which provide information on the expected levels of precipitation for events based on historical rainfall amounts.[74]

IDF curves outline the intensity of storms, in the form of amount of precipitation (mm) per hour, as well as the duration, or length of time this amount of precipitation occurs in; usually in the form of minutes or hours. Frequency is identified by the probability that a storm of that duration and intensity will occur (i.e. a low level duration and intensity storm might happen every year or every two years, while one of high intensity may only be predicted to occur once in every 50 years). As our climate changes, so do the frequency and intensity of precipitation events, and so too do the IDF curves for an area.

E.g. within the baseline (1960-1990) IDF curve for the Southern region, a precipitation event with 15 mm of rainfall accumulating over an hour is expected to happen approximately once every two years; however, a precipitation event (rain storm) where 16 mm of rain accumulates in only 10 minutes is expected to happen only once in every 25 years.

In Ontario, the Ontario Climate Change Data Portal (CCDP) provides projected IDF curves.[xvi] While other projection data in this assessment has used the RCP8.5 emission scenario, these curves are based on an A1B emissions scenario[xvii] as this was the only data available which supported the use of local IDF data. The curves are dynamically downscaled to 25 km grid patterns, and are accessible free of charge to support climate change impact assessments across the province. Among the families of emissions scenarios presented by the Intergovernmental Panel on Climate Change (IPCC), the A1B scenario falls somewhere in the middle of projected future emissions, projecting a lower level of carbon emissions than the RCP8.5 emissions scenario used elsewhere in this report. Additionally, while the CCDP has averaged data over 30 year time periods to represent baseline and projection dates, the years utilized in this analysis are slightly altered from those used for other projection data highlighted in this assessment. For IDF curves, the following dates are used to represent local projections:

- Baseline (1960-1990)
- 2020s (2015 – 2045)
- 2050s (2035 – 2065)
- 2080s (2065 – 2095)

IDF curve projections can be accessed at www.ontarioccdp.ca.[24]

Although IDF curve information was available for many data points in the Northern and Southern Regions; due to the size of the regions, a centralized point was identified to access IDF curve information from the CCDP database for that specific geographic location. To represent the Southern Region, a central 25 km^2 grid point which captured the City of Barrie region was accessed; for the Northern Region, a central 25 km^2 grid point which captured the Town of Huntsville was accessed.

Below, IDF curve information is presented for one-hour durations, with baseline and projections for the 2080s highlighted (for full IDF curves for the Northern and Southern Regions, see Appendix I & J). Within the Northern Region, it is projected that events currently occurring on a frequency of once every 50 years (~50 mm/hr) can be expected to occur at a frequency of once every 25 years (Figure 9.5).

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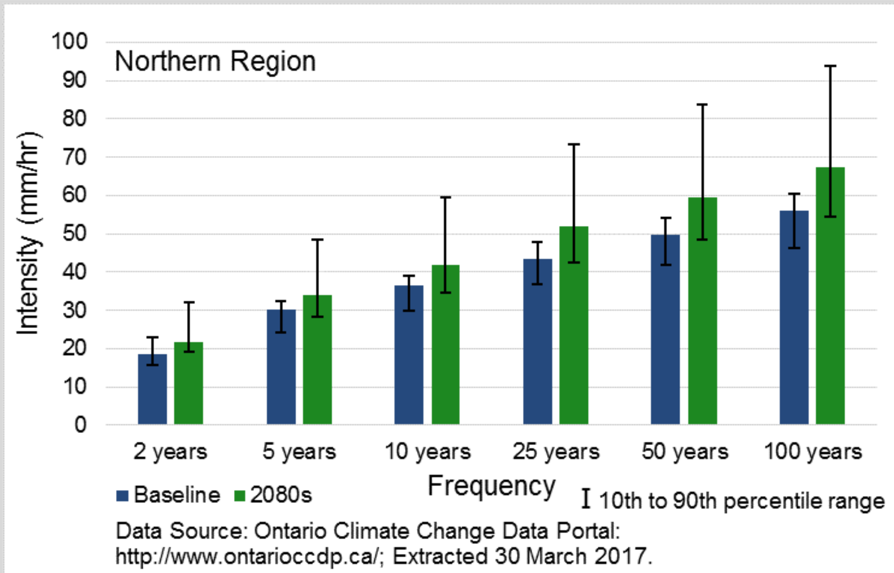
xvi Information on the validation of IDF curves access through the CCDP can be examined within a paper by Wang and colleagues.[75]

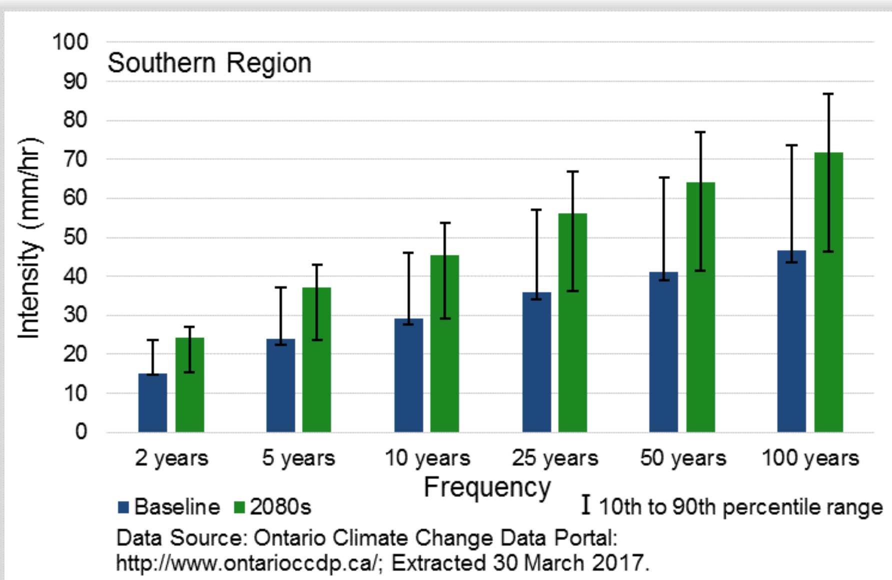
xvii The A1B emission scenario describes fast future economic growth, with a global population peak then decline, and a rapid introduction of new and efficient technologies. It also assumes a balance across all energy sources, where there is not reliance on any one energy source (IPCC, 2000). For further emission scenario information, see section 5.2.4.

Figure 9.5: Precipitation, intensity and frequency projections of baseline vs 2080s for a one-hour rain interval, for the Northern Region.[24]



For the Southern Region, projections show that local one-hour precipitation events are likely to change so that events currently occurring on a frequency of once every 50 years (~40 mm/hr) can be expected to occur at a frequency of once every 10 years (Figure 9.6)

Figure 9.6: Precipitation, intensity and frequency projections at baseline vs 2080s for a one-hour rain interval, for the Southern Region.[24]



9.3 Exposure to Extreme Weather Events

Climate change has already influenced the type and number of extreme weather events experienced across the globe.[1] As the climate of Simcoe Muskoka changes, the frequency, intensity and type of weather events experienced across the region is projected to be altered. This may include severe storms, heavy rain events with associated flooding, thunderstorms, tornadoes and windstorms occurring more often. Existing and aging infrastructure that was designed to deal with weather events of the past may not have the capacity to cope with these changing patterns. In addition, the frequency and type of winter storm events are also expected to be altered, with change in storms due to increasing precipitation during winter months, decreases in ice cover allowing for lake-effect snow, and more ice events as average winter temperatures near the freezing mark. While changes in storm patterns have been observed, current climate change models are not able to accurately predict changes to flooding, rates of tornadoes, and other extreme storm events, making predictions on related health impacts difficult.[76]

Health impacts related to extreme weather can be both immediate, occurring within hours of the weather event, and prolonged, occurring after the event has subsided. Impacts can also be direct, including injury and death as a result of the event, or indirect, including issues such as insufficient infrastructure, health impacts related to mould, and food or water contamination from flooding and waterborne disease outbreaks.[77] In addition, there can be mental health impacts associated with emergency situations, flooding, and drought.[78-80]

9.3.1 Flooding

Flood events are some of the most frequently reported and economically damaging natural events in Canada. The most notable flooding event in Ontario occurred in October 1954 with Hurricane Hazel, when 210 mm of precipitation fell over two days.[81] This event caused major flooding throughout Southern Ontario including Simcoe Muskoka, and resulted in the deaths of 81 individuals, left thousands homeless, and caused infrastructure damage.[81]

There are three categories of floods: flash floods, slow rise floods, and storm surge floods, each with potential for causing human health impacts. A flash flood is caused by local storms with heavy rainfalls that quickly saturate the earth resulting in substantial run-off and unusually high peak flows in waterways; they can happen quickly, often with little time to prepare. These floods occur most frequently during the peak thunderstorm season of the summer and can cause massive erosion and undermine infrastructure such as roads and bridges, cause sewer backups into buildings, flooding on roadways, and may disrupt power supplies.[1] Characteristics of a municipality (impervious surfaces, age and capacity of infrastructure) can hamper the capacity of watersheds to cope with the increased storm runoff due to climate change.[82] A flood's severity is largely determined by topography, the infrastructure of the flooded area and the potential for flood waters to spread over a wide area.[83]

Slow rise flooding can result from a quick thaw following a winter with deep snow and ice cover.[84] This flooding usually occurs along large, flat river basins with gentle slopes and results in large peak flows of slowly moving water. The run-off melt water inundates wide areas that tend to remain flooded for a long time due to slow water drainage.[1] Exposure to such flooding events has occurred frequently within the watershed of the Black River in the Ramara and Severn areas, as well as in the municipalities of Huntsville, Gravenhurst and Bracebridge. The potential increase of lake effect snow within the area due to warmer temperatures and waterways with reduced ice cover could impact on the amount of snow accumulation, and thus flooding risk, in the future.[13]

Other flood events have occurred in Simcoe Muskoka. In the City of Barrie, five precipitation events exceeding the five-year storm interval have occurred since 2005, including the flooding of Kidd's Creek on June 9, 2005, which exceeded the 100-year storm interval, and caused major flooding within the city's downtown core.[85] Other notable storm events within Simcoe Muskoka include: yearly flooding between 1998–2008 of the Big East River within the Huntsville area, including a 100-year flood event in 2008; flooding of the Lake St. John and the Black River within Ramara and Severn (2008); severe flooding within the Coldwater area (2004); and flooding within Angus (2008). Of note, the flooding event of 2008 within the Huntsville area was classified as a 100-year storm event. The alteration of frequency and severity of storm events due to climate change is compounded by population growth, which will increase the amount of impervious surfaces throughout Simcoe Muskoka. The combined effect has the potential to increase exposure of populations to flooding in the future.

9.3.2 Tornadoes

In Canada, tornadoes are most common in southern Ontario and Quebec, southeastern Manitoba, southern Saskatchewan and southern and central Alberta.[1] Eisen reported in 2000 that there is a trend toward an increasing number of tornadoes in Canada, although the trend may be a result of improved reporting and more intensive news media coverage.[1] This trend has not been directly linked to climate change, although more intense storm events are anticipated with a changing climate. However, if the number of tornadoes is actually increasing, given the growth of communities in southern Canada, the Canadian population could be exposed to increasing risks from tornadoes.[1]

Tornadoes usually develop during intense thunderstorms classified as "super cell thunderstorms" and are among some of the most destructive weather phenomena. Due to their quick occurrence, tornadoes often leave little time for warning or for populations to seek appropriate shelter.[83] Within Canada, tornado activity peaks in July, with the majority of events (85%) occurring between 1 p.m.

and 8 p.m.[86] Between 1912 and 2005, 31 disasters[xviii] were caused by tornadoes in Canada, resulting in 142 deaths, injuring 1930 people and requiring evacuation of nearly 6500 individuals.[1] Simcoe Muskoka is located in an area with a high probability of tornadoes, due to the influence of lake-breeze circulations generated by Lakes Erie, Huron, and Ontario.[88] Between 1980 and 2009 there have been a total of 36 tornadoes in our area.[89] Three notable tornadoes—1985 Barrie, 2010 Midland, and 2014 Angus—have had the greatest health and economic impacts (Table 9.6).

Table 9.6: Large impact tornadoes in Simcoe Muskoka.[89,90]

Location	Date	Event Information	Fatalities	Injuries	Estimated Cost	Insurance Payments
Barrie	May 31, 1985	Occurring from Hopeville to Barrie ON, causing multiple fatalities and injuries, with 800 homeless. More than 100 buildings and 150 farms were damaged, and 300 houses destroyed. Occurred with hail, severe thunderstorms and power outages.	12	500	$83,992,000	$83,992,000
Midland	June 23, 2010	F2 tornado destroyed approximately 50 homes and caused extensive damages. Wind speeds between 180 and 240 km/h were reached.	0	12	$16,000,000	$15,000,000
Angus	June 17, 2014	EF2 tornado resulting from a storm that caused many strong-to-severe thunderstorms across Ontario. The storm featured winds between 200 and 220 km/h, with a width of 300m at its widest point and tracked over 20 km.	0	3 (minor injuries)	n/a	$30,000,000 (estimated)

xviii A disaster must meet one or more of the following criteria: ≥10 people killed; ≥100 people affected/injured/infected/evacuated or homeless; an appeal for national/international assistance; historical significance; and significant damage/interruptions of normal processes such that the community affected cannot recover on its own.[87]

9.3.3 Forest Fires

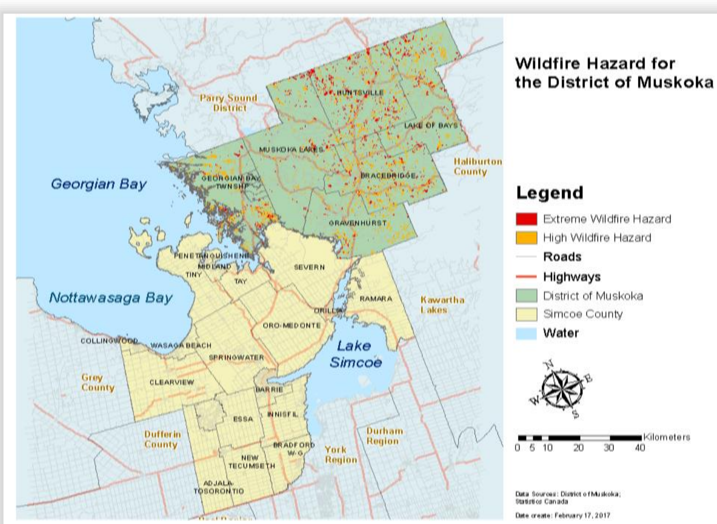
Fires are a natural and essential component of nature, and are a function of the availability of fuel, lightning strikes, temperature, wind, precipitation rates, rates of humidity, and other anthropogenic factors.[91] In Canada, the frequency of forest fire activity is projected to increase by 25% by 2030 and up to 75% by the end of the century. It must be noted that there will be regional variability based on the above mentioned factors and rates of heat and precipitation.[73] This increase is due, in part, to an increased frequency of lightning strikes expected during more frequent severe storms.[92]

In Ontario, there is a 10-year average of just under 1000 forest fires per year, with a total average burn area of approximately 111,000 hectares.[93] Natural Resources Canada estimates that slightly less than half of all fires in Canada are caused by lightning, with the remaining attributed to human causes.[94]

Percentage of forested areas varies across the region. Within the County of Simcoe, there are two broadly categorized geographic zones, each with a varying level of forest cover. The Simcoe Uplands includes the areas along the eastern edge of Georgian Bay and the Oro Moraine, and has a forest cover of 51%. The Simcoe Lowlands contains a forest cover of 27%.[95,96] A total of 166,935 hectares of forested lands can be found within Simcoe County, 7.6% of which is owned by the Simcoe County Forests.[95,96]

The District of Muskoka has identified areas that are wildfire hazard risk within the District, including high or extreme wildfire risk (see Figure 9.7). As temperatures and occurrence of severe thunderstorms increase and precipitation decreases, areas of wildfire risk may intensify. Of note, while there may be areas of wildfire risk within the County of Simcoe, data on these sites is not currently available.

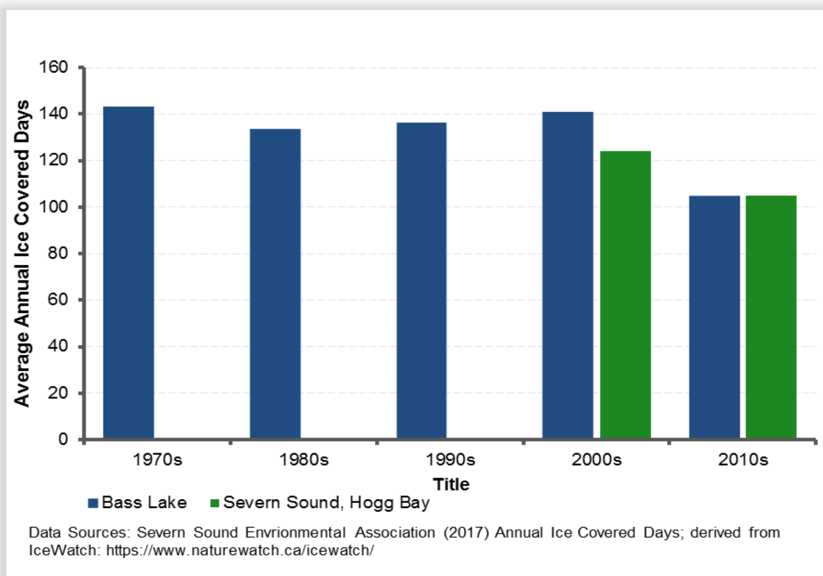
Figure 9.7: Areas of wildfire hazard within the District of Muskoka



9.3.4 Winter Storms

Changes to climate and precipitation patterns are expected to alter the frequency and intensity of winter storms across the region. There are multiple reasons for changing intensity of storm events. Primarily, projected increasing annual precipitation for the region is expected to occur generally between November and April.[13,97] In addition, warming temperatures will decrease the amount of ice cover on the Great Lakes, including Georgian Bay and Lake Huron, as well as other lakes within the region. This availability of open water will allow for higher rates of evapotranspiration to occur later in the year, providing increased lake-effect precipitation as either rain or snow-squalls.[13] Changes in ice cover have already been recorded in some regions of Simcoe Muskoka (Figure 9.8), with slight decreases being observed on Bass Lake and Hogg Bay, Severn Sound through observations by the Severn Sound Environmental Association. Warming temperatures will also impact on the number of winter ice storms, as increasing temperatures rise above freezing throughout the winter months (see Section 8.0 for temperature data).

Figure 9.8: Average annual ice covered days at Bass Lake and Severn Sound, Hogg Bay, per decade, 1970s – 2010.[xix]



xix Ice cover data was provided by the SSEA and derived from data sets provided by IceWatch, citizen observations, Canadian Ice Service, Wye Heritage Marina, and Bayport Marina. While every effort has been made to accurately depict the ice cover data, errors may exist. Any party relying on this information does so at their own risk.

9.3.5 Drought

Changes in precipitation patterns and increases in overall temperature can lead to drying and drought.[98] Drought conditions can affect ecosystems, watersheds, agricultural production, and impact on the quality and quantity of available drinking water.

Parts of Ontario, including Simcoe Muskoka, are currently experiencing abnormally dry drought conditions arising from lower than average precipitation levels and reduced water levels in watersheds.[99] Although projections indicate that annual precipitation rates are expected to increase, these increases in precipitation will occur generally within the winter months, with dryer than usual conditions during the summer months.[13,97] In addition, increased evaporation rates due to increasing temperatures will decrease the amount of water available to infiltrate and recharge ground water supplies.[100]

Projected increases in temperature (Table 8.1) and changes in precipitation patterns (Table 9.3 & 9.4) increase the likelihood of more frequent, longer duration, and more intense drought conditions in the future.

9.4 Sensitivity to Extreme Weather Events

The health impacts from extreme weather events are varied. Impacts can be acute and primarily linked to the extreme event, such as injuries and/or death; while other, more secondary impacts, such as mental health impacts attributed to experiencing an extreme weather event, can also occur.[101] Similar to other climate-related health outcomes, the young and the elderly are more susceptible to the impacts of extreme weather events due to the presence of pre-existing conditions and a reliance on caregivers.[102] Other groups who have demonstrated sensitivity to extreme weather events include those with previously diagnosed illnesses, individuals living in low income, those who are under-housed, individuals who are socially isolated, and individuals with mobility issues.[102]

Additionally, power outages caused by extreme weather events can greatly increase the risk of health impacts for individuals who rely on electricity for medical reasons, such as individuals reliant on electronic medical devices. Power outages and reliance on electricity will also impact on food safety and security. Decreased ability to safely store food products during power outages, will result in food products becoming unsafe/unusable for consumption without proper refrigeration.

9.4.1 Flooding

The health impacts due to flooding are varied, and are influenced by both flood type and the vulnerability of the population.[78] Increased rates of morbidity and mortality are found during flash-floods, in which there is little time to prepare for the event.[78] Floods can contribute significantly to morbidity due to injuries such as lacerations, puncture wounds and electrocution.[83,103] In addition, buildings can stay damp after flood waters have receded, creating a perfect environment for moulds and fungi that impair indoor air quality. Breathing spores from mould and fungi can cause allergic reactions and respiratory issues.[104] Other health impacts that have been linked to flooding include the increased risk of food- and waterborne illness and vector-borne diseases.[78,103] Flooding associated with heavy precipitation events can affect water availability, quality or access, and create a threat to human health. Exposure to pathogens occurs through ingestion of contaminated drinking water, or secondarily through food contaminated with unsafe water,[105] with the elderly, children, and individuals with compromised immune function most sensitive to these impacts.[103] A further discussion of the impacts of water and foodborne pathogens on human health can be found in Section 11.0.

Research has also identified links between flooding events and mental health outcomes, including anxiety and depression.[78,101,103] While risks for mental impacts have been documented in all individuals, flood exposure is linked to a significant increase in depression risk for those who had depressive tendencies prior to the flood, and for those from lower socioeconomic groups.[78]

The elderly, children, those with medical issues and persons with physical mobility limitations may also be sensitive to the impacts of flooding,[106] as they are less likely or less able to leave their homes for safety during a flood event.[5] Patients and residents of institutional settings, such as long-term care facilities, will also be vulnerable to the impacts of flooding, due to potential displacement and health service interruptions.[106] Tenants of rental units have also been identified as being less prepared for flooding emergencies and thus are more sensitive to the impacts of flooding events.[5] In addition, the health of individuals living with low income and poor housing conditions may be further impacted by flooding. For example, risks may arise from impacts to drinking water sources or from mould growth associated with flooding due to a lack of resources to support proper restoration post-flood.[5]

9.4.2 Tornadoes

Similar to flooding, health impacts of tornadoes can be direct—such as injuries, trauma, and death—and indirect—including decreased access to services, power outages, and infections.[79]

Most tornado-related fatalities occur at the scene, and tend to happen either with individuals caught out in exposed areas or in mobile homes, which have reduced capacity to deal with extreme winds compared to other more permanent structures. The serious injury rate during tornadoes for occupants of mobile homes has been calculated at 85.1 per 1000 as compared to 3 per 1000 for standard construction homes.[107] In 2011, there were a total of 2210 mobile dwellings in Simcoe Muskoka, 525 within the Northern Region and 1685 within the Southern Region.[55]

Most serious injuries and deaths are the result of either persons or solid objects becoming airborne, or structural collapse. Risk factors for injuries include poor building anchorage, occupant location other than the basement, high wind strength, and occupant age over 70 years.[83] The elderly may be less likely to receive warning messages or take effective protective actions, and co-morbid medical conditions can contribute to slowed reaction and increased risk of morbidity or mortality.[107]

9.4.3 Forest Fires

Fire smoke carries large amounts of fine particles that exacerbate cardiac and respiratory problems.[83] Fine particles in the air can result in potentially severe impacts on respiratory illness, particularly for people with pre-existing conditions.[4,92] Exposure to smoke and ash can result in acute health impacts including hyperthermia and dehydration, eye irritation, and respiratory irritation leading to bronchitis. Fires can also result in physical and mental exhaustion, direct physical risks of burns in persons unable to leave the site of a fire, stress-related hypertension, and post-traumatic stress disorder in both the responders and the affected populations.[1] Mental health impacts may also be felt by individuals whose homes are destroyed by the fires, or who are evacuated due to safety concerns out of their communities.[65]

While all individuals exposed to smoke and particulate matter from forest fires will be impacted, certain groups, such as children, elderly, and those with pre-existing health conditions will be more sensitive to the by-products of forest fires.[108] One group with an increased sensitivity to the impacts of forest fires includes those individuals with pre-existing cardio-respiratory illnesses, such as asthma and chronic obstructive pulmonary disorder (COPD).[4]

In 2011, nearly 80,000 residents of Simcoe Muskoka were living with asthma, an age-standardized prevalence rate of 15.82 persons per 1000;[109] rates of asthma between 1996 and 2011 were higher among females than males. Between 2009 and 2014, 5.5% of Simcoe Muskoka residents (aged ≥35 years) reported having COPD, which was significantly higher than the self-reported prevalence of 4% for all of Ontario.[110] Important to highlight is that within Simcoe Muskoka, COPD prevalence is highest among those with lower levels of education and income, with the highest prevalence among those with a high school diploma or less, and those living in a household in the bottom 20% of income.[110] This combined prevalence of COPD with lower income levels may increase vulnerability if exposed to forest fires, due to associated health outcomes and reduced financial resources to cope with other fire related outcomes.

9.4.4 Winter Storms

Severe winter storms can place a large amount of stress on community infrastructure, causing health impacts due to loss of power, heat, and isolation. These impacts were seen within the 1998 ice storm in the northeastern United States and Eastern Canada. The ice storm caused electrical failures, injuries and fatalities due to icy road conditions, and fatalities from carbon monoxide poisoning due to the indoor use of combustible heating sources such as propane heaters.[65] While all residents of a community will be impacted due to loss of infrastructure during winter storms, individuals who rely on power for medical devices, the elderly, children, and those who are socially isolated may be most at risk.

Additionally, increased precipitation during the winter months can also impact on the amount of injuries related to slips, trips, and falls for those walking in outdoor environments. Toronto Public Health conducted a burden of illness report that identified a total of 30,000 emergency department visits and 2,800 hospitalizations between 2006 and 2015 due to ice and snow, costing the provincial health care system approximately $4,000,000 within Toronto alone.[111] Furthermore, the presence of snow on sidewalks and walkways can limit the ability of individuals to manoeuvre during the winter months, increasing the risk of related chronic illnesses due to decreased activity and social isolation for individuals who do not have other means of transportation other than walking. A study in Toronto identified 56% of older participants had trouble moving around outdoors in the winter, with 47% of those identifying sidewalks as their major area of concern.[112] Individuals who utilize assistive devices or those who use strollers may also be impacted by the effects of snow and ice on walkways.

9.4.5 Drought

While annual precipitation amounts are expected to increase, summer precipitation is expected to decrease within Simcoe Muskoka,[13,97] leading to the potential for increased seasonal drought. Drought conditions can have a major impact on ecosystems and available resources, such as decreased water quality, wetland loss, habitat destruction and soil erosion.[113] Drought has also been associated with periods of extreme heat, increasing impacts of heat stress on vulnerable populations such as children, the elderly, pregnant women, and those with pre-existing conditions.[113] Drought has been associated with an increased prevalence of forest fires, increasing the potential for health risks previously discussed.[65,113] In addition, drought conditions can be accompanied by an increase in dry, dusty conditions, which can impact health through irritation of the nasal passages and respiratory systems, and increasing in coughing.[113]

Drought conditions can also influence crop yields and livestock production, decreasing the availability of food and associated economic losses. Degrading environmental conditions, as well as the social strains related to economic hardship across a community, can lead to many health outcomes, including respiratory illnesses, exhaustion, and mental health impacts such as depression or suicide.[65,113] Decreases in agricultural production due to drought can also increase food prices, increasing stress related to food access for those with reduced economic resources.[113] A further discussion of the impacts of climate change on food and water is explored in Section 11.0.

Additionally, increases in infectious diseases can be a direct consequence of drought conditions.[114] Pathogens can pollute both ground water and surface water when rainfall decreases. Individuals who get their drinking water from private wells may be at higher risk for drought-related infectious diseases. Other groups also at increased risk include those who have underlying chronic conditions, infants and children, the elderly, and those living in low income.[113] Droughts clearly have links to the contamination and availability of food and water; this concept is pursued more thoroughly in Section 11.0.

9.5 Adaptive Capacity to Extreme Weather

Table 9.7 below highlights current and potential actions, key partners, and mitigation co-benefits surrounding extreme weather adaptive capacity within the health unit's jurisdiction. For information on a sample of adaptive capacity measures occurring within the community by municipalities, conservation authorities and community organizations, see Section 14.0.

Table 9.7: Current and potential actions taken by the Simcoe Muskoka District Health Unit to support adaptive capacity to extreme weather.

Public Health Role	Type of Action (current/ for consideration)	Activities	Key Partners	Mitigation Co-Benefit
Population Assessment	Current	Identify populations and communities at risk.		
		Create transportation fund for transit to health unit clinics in adverse weather.		
	For Consideration	Identify areas and populations at greatest risk for flooding and develop a voluntary registry of vulnerable individuals.	Conservation authorities Watershed organizations Community & Social Service agencies	
		Complete a gap analysis to explore actions and outreach by agencies and individuals as a result of monitoring and notification.	Community & Social Service agencies	
Surveillance	Current	Monitor Extreme Weather events forecasted and issued by Environment and Climate Change Canada.	Environment and Climate Change Canada	
		Monitor and analyze acute care emergency room and admission data.	Acute care facilities	
	For Consideration	Develop early monitoring system of health outcomes from extreme weather events.	Public Health Ontario acute care facilities	
Health Promotion (Policy Development, Advocacy &	Current	Provide Health Connection telephone access for public re: health information (supports those without internet and those with mobility and/or transportation issues).		
		Participate in municipal emergency response planning.	Community EMCs	

Public Health Role	Type of Action (current/ for consideration)	Activities	Key Partners	Mitigation Co-Benefit
Public Education)		Participate in vulnerable population planning.	Community EMCs Community & Social Service agencies	
		Provide public education via social media, media interviews.	Media	
		Participate in Official Plan reviews with policy statements related to: greenspace creation and preservation, energy and water conservation, infrastructure assessment, storm water management strategies (permeable landscapes & materials).	Municipal planners Infrastructure & Engineering Environmental services Parks & Recreation	✓
		Provide breastfeeding support to ensure food supply for infants.		
		Provide public education re: personal and neighbourhood preparedness.	Environmental services Conservation authorities Environmental organizations	
		Develop public messages and alerts in languages other than English, as required.		
	For Consideration	Provide 72-hour emergency kits for low income individuals/families. Adapt existing kit to contain lower cost items.	Parks & Recreation	
		Develop strong messages re: use of internal fossil fuel heat sources during extreme cold events and power outage.	Fire & Emergency services	
		Support advocacy for critical infrastructure assessments to minimize impacts of extreme weather events.	Municipal planners Infrastructure & Engineering Environmental services Parks & Recreation	✓
		Support advocacy for a cost-sharing mechanism (i.e. Insurance) for compensation to reduce post-event mental and economic stress.	Community & Social Service agencies Insurance Industry	

Public Health Role	Type of Action (current/ for consideration)	Activities	Key Partners	Mitigation Co-Benefit
		Support work for current identification of floodplains.	Conservation authorities Watershed organizations	
		Implement actions related to support for agricultural/food security.	OMAFRA Ontario Federation of Agriculture	✓
		Support policy development to support vulnerable populations impacted by extreme weather events.	Municipalities Community & Social Service agencies	
Health Protection (Disease and Injury Prevention)	Current	Participate in vulnerable populations planning and notification process.	Community EMCs Community & Social Service agencies	
		Participate in emergency response management planning and exercises.	Community EMCs Community & Social Service agencies	
		Participate in municipal Hazard Identification and Risk Assessment (HIRA).	Community EMCs	
		Implement internal Tornado Response Protocol.		
		Develop Business Continuity Plan.		
		Regular review of best practice interventions for extreme weather events.		
	For Consideration	Support policy development to support vulnerable populations impacted by extreme weather event.	Community & Social Service Agencies Insurance industry	
		Consider impact of severe wildfire as an emergency response.		

10.0 Air Quality

Key Considerations:

- While air quality has been increasing across the province, climate change has the potential to increase levels of important air pollutants, such as ozone, within Simcoe Muskoka.
- Climate change is expected to impact on the volume, timing, and distribution of pollens and moulds within the environment; increases in aeroallergens are expected due to increased productivity of plants and prolonged growing periods.
- There is a strong correlation between rates of asthma-related ER visits and moderate to high-risk AQHI readings in both the Northern and Southern regions.

Air quality is affected by a variety of factors, including pollutant emission rates, regulations and programs that support decreased emissions, and local weather pattern elements such as temperature, precipitation, and wind speed and direction.[115,116] The elimination of coal electricity generation and other home-based energy conservation programs have supported the reduction of energy use and associated emissions across the province.[117] However, while overall air quality has improved within recent years, traffic-related emissions still act as a main contributor to air pollution in Ontario.[118] Climate change has the potential to impact a variety of factors relating to local air quality levels, impacts that can potentially be mitigated through further reduction of air pollutant emissions.[5]

The following sections describe current air pollution levels and associated health burden; reviews the impact of climate change on air quality in Simcoe Muskoka; and identifies individuals most sensitive to poor air quality in our region. Impacts due to pollution (particulate matter, ground-level ozone, traffic-related emissions) and aeroallergens (plant pollen) are discussed. In addition, the Air Quality Health Index (AQHI), a tool for monitoring the potential health impacts of air quality in Ontario, is described.

10.1 Air Quality Monitoring and Health in Ontario

Across Ontario, the Ministry of the Environment and Climate Change (MOECC) conducts daily monitoring of a variety of air pollutants; some of these pollutants, specifically ground level ozone (O_3), fine particulate matter ($PM_{2.5}$) and nitrogen dioxide (NO_2), are used in the calculation of the AQHI. The AQHI is a tool that can be used to monitor the risk of negative health outcomes related to local air quality, based on current air quality levels and considering an individual's level of risk such as chronic respiratory conditions.[119] In Simcoe Muskoka, air quality monitoring occurs at two geographic locations: the City of Barrie in the south and the community of Dorset in the north. These two locations will be used as indicator sites for air quality monitoring for the Southern and Northern Regions for this report.

The AQHI is designed to help the public make decisions about their level of outdoor activity based on current air quality levels. It is calculated on a one through 10+ scale, with various levels of health risk determined by air quality. A rating of 1 to 3 indicates low risk, 4 to 6 indicates moderate risk, 7 to 10 indicates high risk, and 10+ indicates a very high risk due to current pollutant levels. Health messages are provided based on the rating level, as well as by population type (general or at-risk).[119] This tool helps individuals modify outdoor activity level based on their health conditions and the ambient air quality. Further information on the AQHI can be accessed through the MOECC Air Quality Ontario website www.airqualityontario.com

Within Simcoe Muskoka, air quality is monitored and commonly reported to be within the 'low risk' category, and does not often reach levels that would qualify it as high or very high risk. Although most of the air quality monitoring[xx] falls within the 'low risk' category according to the AQHI, there is a slightly higher proportion of moderate risk exposures recorded in the Southern Region. Moderate risk exposures have decreased over time[xxi].[120] For a full list of historical AQHI readings for the Northern and Southern Regions, see Figure 10.1.

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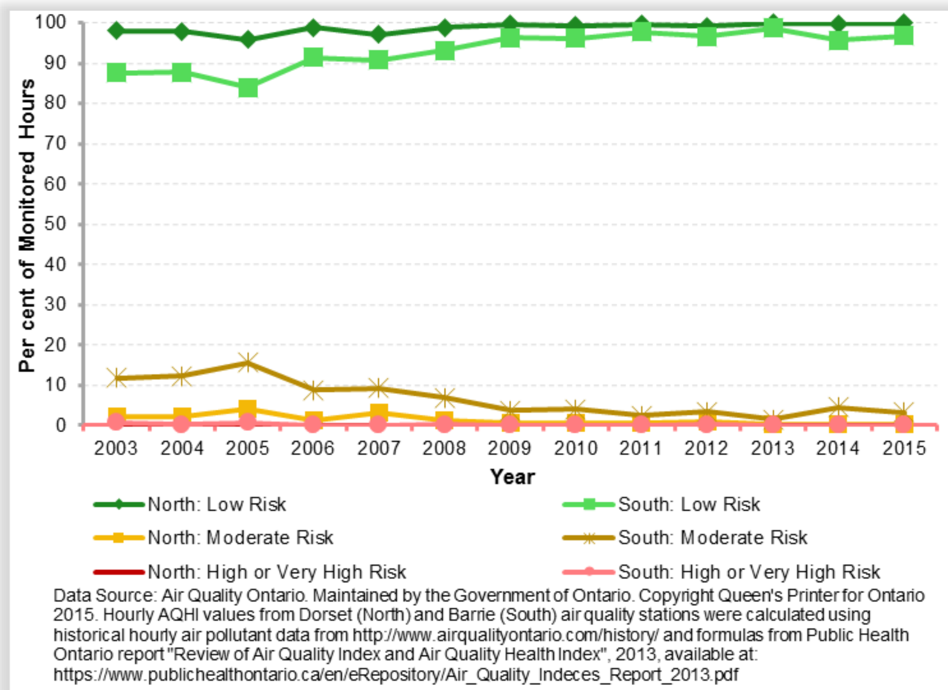
xx Air quality is monitored 24 hours a day by the MOECC air quality monitoring stations. Monitored hours are the number of hours that fall within a low, moderate or high-risk category for air quality.

xxi Air pollution data for the Southern Region was accessed from the Barrie MOECC air quality monitoring station. Air pollution data for the Northern Region was accessed from the Dorset MOECC air quality monitoring station. Historic AQHI was calculated using historical hourly air pollutant data from www.airqualityontario.com/history/ and formulas from the Public Health Ontario report. "Review of Air Quality Index and Air Quality Health Index, 2013, available at: www.publichealthontario.ca/en/eRepository/Air_Quality_Indices_Report_2013.pdf.

Figure 10.1: Air Quality Health Index (AQHI) readings for the Northern and Southern Regions, 2003 to 2015.



10.2 Current Burden of Illness

Numerous studies show that poor air quality contributes to a variety of health issues, including: cardiovascular disease, cancer, stroke, respiratory illnesses including asthma, and premature death.[121] It is estimated that between 290 and 900 new cancer cases are attributed each year to $PM_{2.5}$ in Ontario in addition to various other cardiovascular and respiratory illnesses.[122]

While health outcomes due to poor air quality vary (see subsection 10.3 below) within Simcoe Muskoka the current burden of illness due to air quality can be examined by observing the number of asthma-related emergency room (ER) visits that occur during moderate or high risk AQHI periods (Figure 10.2).[xxii] Asthma-related ER visits were observed to be higher in the Northern Region compared to the Southern Region, despite the higher number of moderate hours in the low-risk air quality category in the Northern Region. Reasons for the variation in asthma rates between the Northern and Southern Region are not known at this time.

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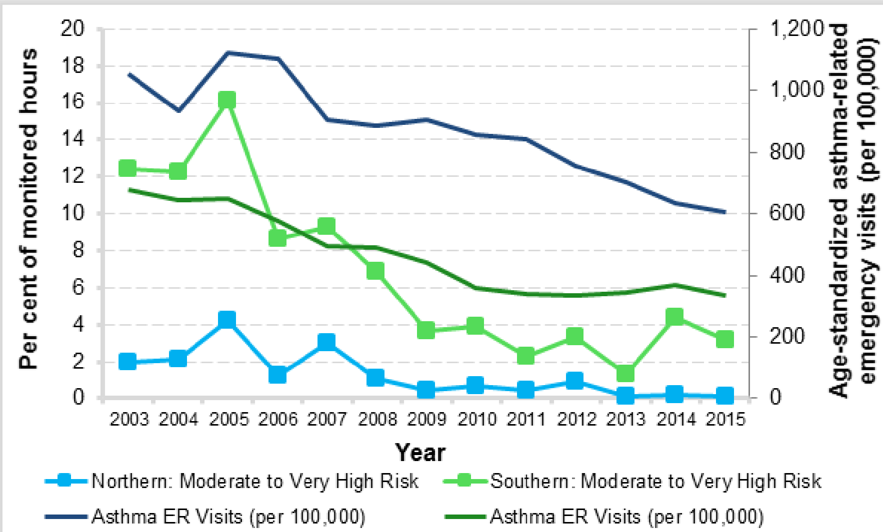
xxii Air quality data for the Northern Region was calculated from the Dorset MOECC air quality monitoring station, and does not include NO2 (one of the three measures used to calculate AQHI). This has some impact on the comparability of the two AQHI series, as NO2, PM2.5 and O3 do not necessarily fluctuate together. Thus, the Northern Region series could be missing “high risk” days that would be captured based on NO2 concentrations.

Further assessment is needed to determine the cause of these variations, including access to services and barriers to receiving care.

When examining rates of asthma-related ER visits in correlation to moderate or high-risk AQHI readings, there is a strong correlation between the per cent of monitored hours in the moderate to very high risk AQHI readings and asthma ER visits in both the Northern Region (R^2=0.72) and the Southern Region (R^2=0.94). It is important to note that, as the trend for moderate, high, and very high risk AQHI readings decreased over time, a similar decrease in the rates of asthma ER visits was also observed, in both the Northern and Southern Regions.

Figure 10.2: AQHI readings (moderate or high risk) & asthma-related ER visits in Simcoe Muskoka, 2003 – 2015.



AQHI Data: Air Quality Ontario. Maintained by the Government of Ontario. Copyright Queen's Printer for Ontario 2015. Hourly AQHI values were calculated using historical hourly air pollutant data from Dorset (North) and Barrie (South) weather stationsfrom http://www.airqualityontario.com/history/ and formulas from Public Health Ontario report "Review of Air Quality Index and Air Quality Health Index", 2013, available at: https://www.publichealthontario.ca/en/eRepository/Air_Quality_Indeces_Report_2013.pdf. **Asthma Data**: Ambulatory Visits (2003-2015), Ontario Ministry of Health and Long-Term Care. IntelliHealth Ontario. Date Extracted: [November 2016] ICD-10 Codes: J45:J46

10.3 Exposure

10.3.1 Ground-level Ozone

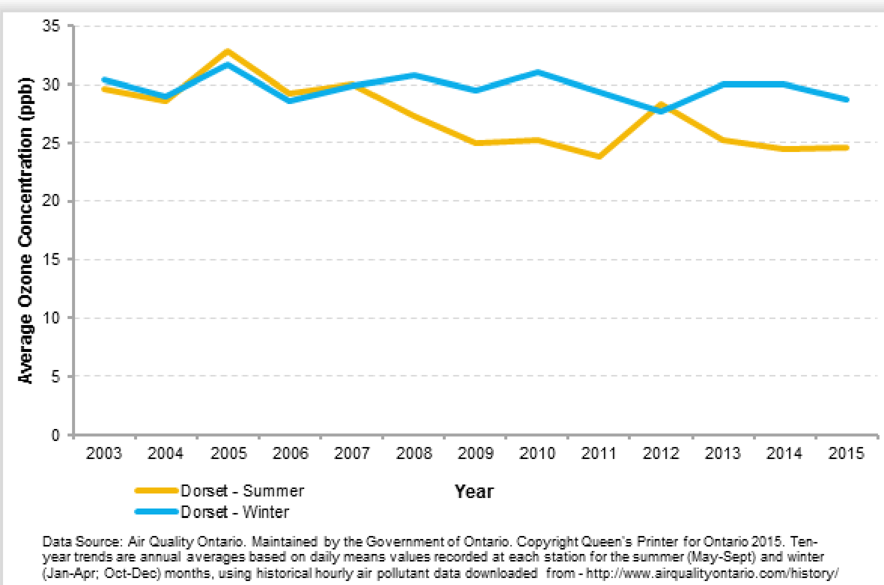
Ground-level ozone is a main air pollutant that impacts health.[123] Ozone is created when certain compounds (nitrogen oxides, carbon monoxide, methane, volatile organic compounds) react with sunlight under elevated temperatures.[10] As such, levels of ozone tend to be greatest during the warmer summer months,[10,123] a trend that has been observed across Ontario.[116] Ozone is generally lower in urban areas, where it tends to react with nitric oxides from vehicle pollutants and combustion sources, creating nitrogen dioxide.[116] Alternatively, ozone levels tend to be higher in suburban and rural areas, as ozone precursor pollutants that originate from urban areas are able to react in sunlight during transport by wind away from their pollution source.[124]

Ozone causes an inflammatory response within the respiratory system; short and long-term exposure to high levels of ozone have been linked to asthma and asthma-like symptoms.[125] Long-term impacts include impaired respiratory function, increased airway reactivity, decreased ability to exert energy, and lung inflammation.[115] Evidence has also linked ozone exposure to premature deaths.[5]

According to the Air Quality in Ontario 2014 Report,[116] overall provincial ozone annual means have increased by 3% from 2005 to 2014; however, ozone summer means have decreased by 8% over the same period. Generally, provincial summer ozone levels have decreased due to the reduction of nitrogen oxide emissions within Ontario and trans-border emissions from the United States. However, winter means have increased due to rising overall background ozone concentrations.[116] Background ozone concentrations are levels of ozone that cannot be decreased through local emission controls; these concentrations can be influenced by natural ozone production (soil emissions, lightning strikes and forest fires) and by other intercontinental emissions that cannot be ameliorated through local emission controls.[126]

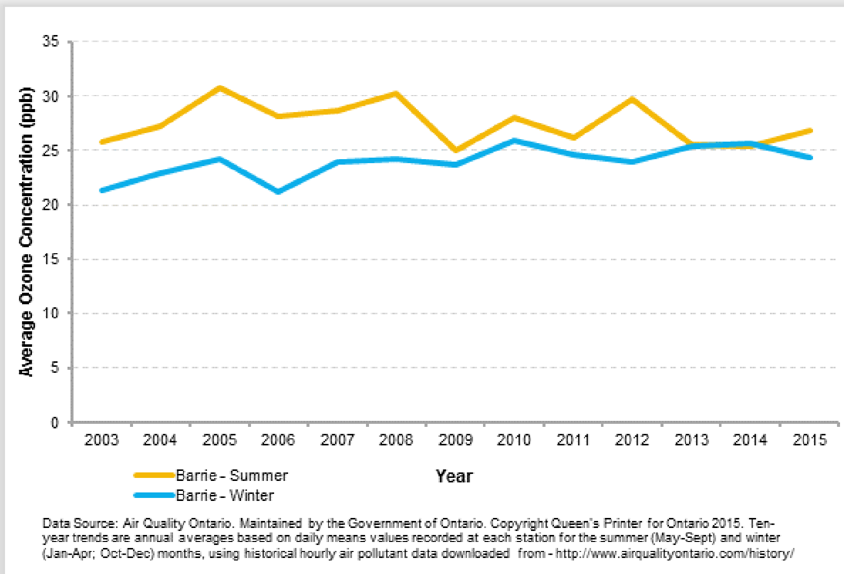
In Dorset (the Northern Region air monitoring location), between 2003 and 2014, summer ozone concentrations have decreased by 2% per year, which is statistically significant; however, winter ozone concentrations in Dorset have remained flat over this 12-year time period (Figure 10.3).

Figure 10.3: Trend of ozone summer and winter means (ppb), Northern Region, Dorset air quality monitoring station, 2003–2015.



In Barrie (the Southern Region monitoring location) during this same time period, ozone summer mean concentrations have remained relatively stable, whereas winter mean ozone concentrations have had a statistically significant increase from approximately 20 parts per billion (ppb) to approximately 25 ppb, an average of 1% per year (Figure 10.4). However, these levels are still much lower than the levels of concern outlined by Ontario's Ambient Air Quality Criterion (AAQC) of 80 ppb (see below for a further discussion on air quality criterion).

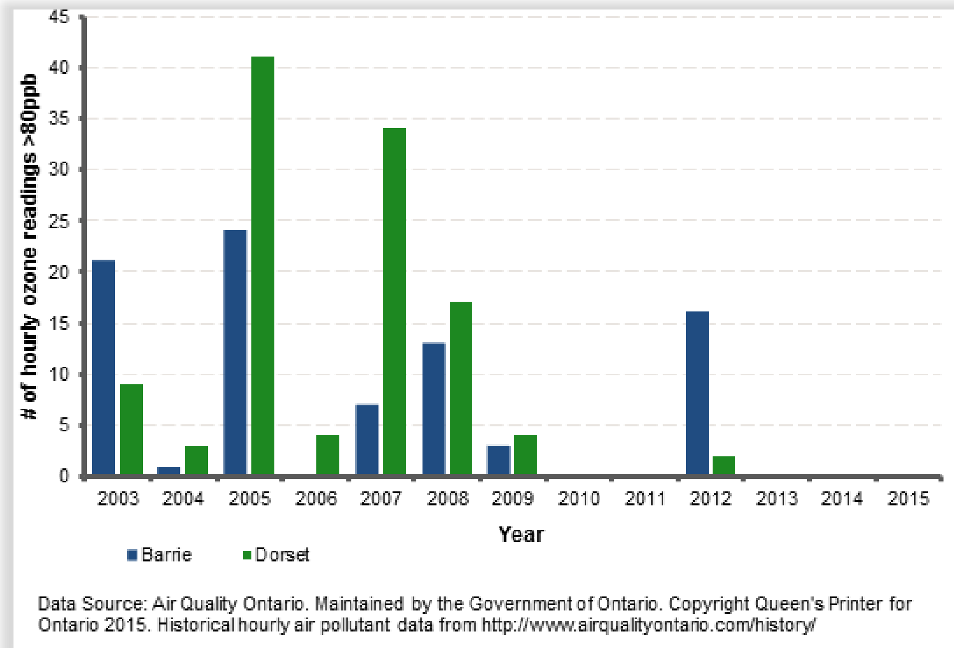
Figure 10.4: Trend of ozone summer and winter means (ppb), Southern Region, Barrie air quality monitoring station, 2003–2015



Ground-level ozone concentrations are monitored in parts per billion (ppb). Ontario's Ambient Air Quality Criterion (AAQC) identifies an exceedance if ozone levels rise to 80 ppb for a one-hour period. While Simcoe Muskoka ozone levels occasionally exceed the AAQC, the number of exceedances varies from year to year, with no exceedances having been observed at the air quality monitoring stations (Barrie and Dorset) since 2013 (Figure 9.5). However, a total of 16 hours on six separate days were recorded to exceed the 80 ppb criterion at the Barrie station in 2012; two exceedances on separate days were recorded at the Dorset station in 2012. Decreases of ozone levels within the province can be attributed to decreases in NO_x through emission controls in both Ontario and within the United States.[116]

Increases of ozone levels are large driven by increases in temperature.[127] Projections of ozone exceedances above the 80 ppb criteria are provided in the Ontario Climate Change and Health Modelling Study.[19] As ozone creation is greatly impacted by temperature,[126] rising temperatures within the Simcoe Muskoka region are projected to increase ozone exceedances above the 80 ppb criteria, from two days per year within the baseline period (1971–2000), to three days per year above the 80 ppb criteria by the 2080s.[19]

Figure 10.5: Number of hourly ozone exceedances (>80ppb), Northern and Southern Regions, Barrie and Dorset air monitoring stations, 2003–2015.

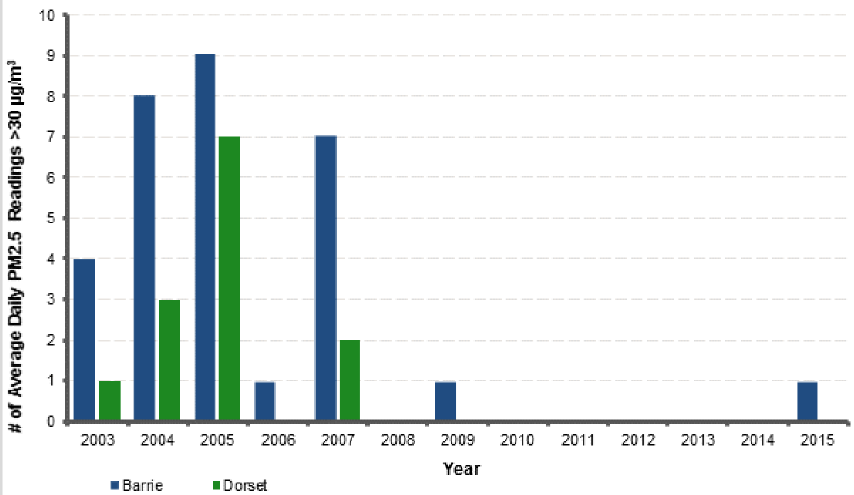


10.3.2 Particulate Matter ($PM_{2.5}$)

Another major component of air pollution is particulate matter ($PM_{2.5}$). $PM_{2.5}$ refers to inhalable particles that are less than 2.5 microns in diameter. Due to their small size, they have the capacity to penetrate deep into the respiratory system.[125] The health effects of inhalable particles can include acute illness from short-term exposure (e.g. asthma-related hospital visits) and chronic illnesses and death from longer-term exposure (e.g. cardiovascular disease and lung cancer).[128]

Fine particulate matter ($PM_{2.5}$) exceedances occur when the daily average readings are greater than the Ontario criteria (30 μg/m^3). $PM_{2.5}$ exceedances have been rare at both the Barrie and Dorset air monitoring stations over the past eight years, with just two occurrences in Barrie since 2007 (one in 2009 and one in 2015). Between 2003 and 2007, there were an average of six $PM_{2.5}$ exceedances in Barrie and three in Dorset per year (Figure 10.6). Decreases in $PM_{2.5}$ have been seen throughout the province through both a reduction in the emissions from electric utilities and industrial processes, as well as through strict emission controls in new vehicles;[116] these reductions in exceedances have also been observed throughout the Simcoe Muskoka region.

Figure 10.6: Number of fine particulate matter ($PM_{2.5}$) exceedances (>30µg/m^3), Barrie and Dorset monitoring stations, 2003–2015.



Data Source: Air Quality Ontario. Maintained by the Government of Ontario. Copyright Queen's Printer for Ontario 2015. Historical hourly air pollutant data from http://www.airqualityontario.com/history/

Predicting the impact of climate change on levels of $PM_{2.5}$ is challenging as it is affected by emissions, transport, dilution and chemical transformation. In addition, meteorological conditions such as temperature, humidity, wind speed and direction and mixing height can all influence $PM_{2.5}$ levels.[129] Literature for $PM_{2.5}$ is more limited than that for ozone and the impact of warming temperature on $PM_{2.5}$ is not clear.[129] Another consideration related to $PM_{2.5}$ will be related to the frequency, intensity and proximity of forest fires which produce $PM_{2.5}$.

10.3.3 Aeroallergens

Climate change is expected to impact on the volume, timing, and distribution of pollens and moulds within the environment. As carbon dioxide levels and temperatures rise, plant growth is also expected to increase. This is due to both a lengthened growing season as temperatures warm earlier in the year and extend into the autumn, and an increased ability of plants to grow in a higher carbon dioxide environment. These changes will result in an increased amount of pollen production per plant, as well as a lengthened pollen season throughout the year.[130] It can be expected that with these changes in growing seasons, pollen levels will increase across the region, impacting those with a predisposition for allergies and pre-existing asthma. In addition, some evidence has highlighted the connection between thunderstorms during pollen seasons and increased allergic asthmatic reactions in susceptible patients.[125] As extreme weather events become more frequent (see section 8.0) this may change pollen levels in our environment and exacerbate related health outcomes.

10.3.4 Traffic-Related Air Pollution

As previously stated, emissions related to traffic (including nitrogen oxides, carbon monoxide, fine particulate matter and volatile organic compounds) act as a main contributor to air pollution within Ontario, with concentrations of related pollutants higher near and on major roads and highwaysxxiii (PHO, 2016). Exposure to traffic-related air pollution (TRAP) can cause onset and worsening of asthma in children, and has also been associated with an increase in all-cause and cardiovascular mortality, cardiovascular disease, respiratory symptoms and decreased lung function, asthma onset in adults, and lung cancer.[132-134] Recent research has also highlighted an association between living near major roadways and an increased incidence of dementia.[135]

Exposure to TRAP is greatest at residences or facilities that are built within a 100-metre distance of a major roadway or 500 m of a highway.[131] Across the province, 28% of Ontario residents live within 100 m of a major road or 500 m of a highway; 26% of schools are located within 100 m of a major road or 500 m of a highway; and 48% of long-term care facilities are located within 100 m of a major road or 500 m of a highway.[131]

In Simcoe Muskoka in 2011, fewer than one-in-five (17.6%) residents lived in a TRAP-exposed area, which was lower than the Ontario population described above. While location of elementary schools in TRAP-exposed areas was slightly higher for Simcoe Muskoka than the provincial average, the percentage of long-term care facilities in TRAP-exposed areas was much lower in Simcoe Muskoka than the provincial average (Figure 10.7).

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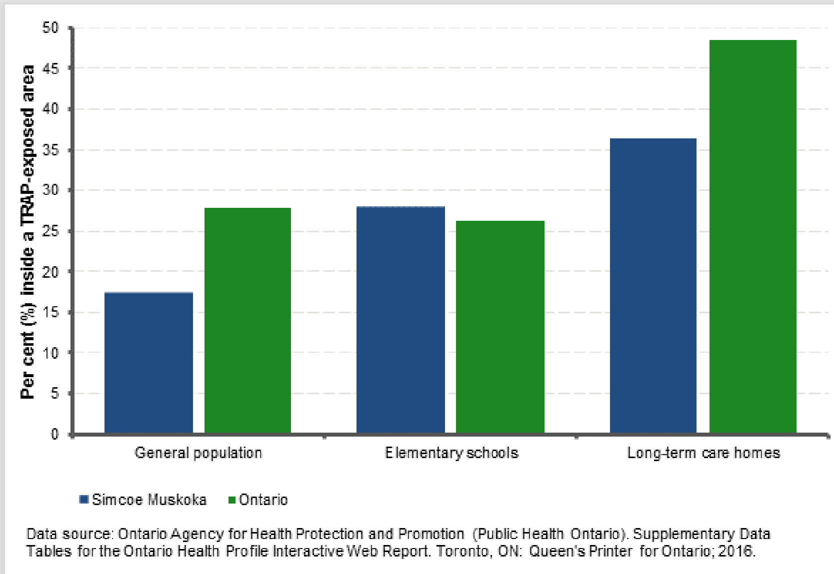
xxiii A major road is defined as a thoroughfare with medium to large traffic capacity, or an expressway (high-speed thoroughfare) with a combination of controlled access and intersections. A highway is defined as an unimpeded, high-speed controlled-access thoroughfare for through traffic with typically no at-grade intersections, usually with no property access or direct access and which is accessed by a ramp. Pedestrians are prohibited.[131]

Figure 10.7: Percent of population located within a TRAP-exposed area, Simcoe Muskoka, 2011.



While climate change will not influence the amount of TRAPs emitted within Ontario, greenhouse gas emissions from traffic are currently a main contributor to climate change, with an upward trend in automobile use expected in the future. Implementing policies and programs that support decreased traffic-related emissions should help to reduce TRAP-related health outcomes, as well as support climate change mitigation. Further discussion on potential adaptive capacity actions for TRAPs is presented in subsection 10.5 below.

10.4 Sensitivity

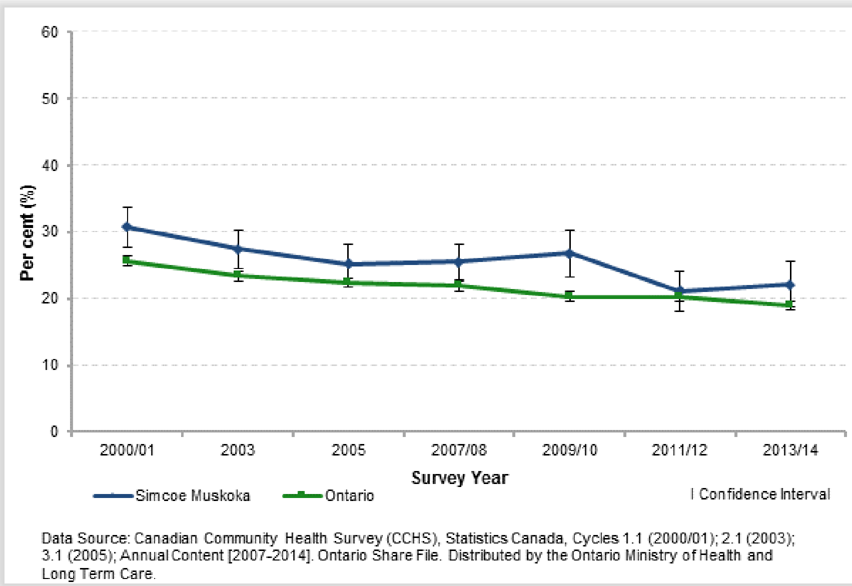
Certain populations may be more impacted by the change to air quality, including:

- children;
- the elderly;
- individuals with chronic respiratory diseases, including asthma and COPD; and
- socially and economically disadvantaged populations.

The percentage of the population that fits into these characteristics has been previously described in subsection 7.2. However, children who are active outdoors during the summer, when ozone levels are highest, are particularly at risk. Individuals with pre-existing respiratory disorders, such as asthma and chronic obstructive pulmonary disease (COPD), are also at risk.

Additionally, individuals who smoke tobacco are at increased risk for poor health outcomes related to changes in air quality. While rates of smoking have decreased since 2001 across the region (Figure 10.8), a total of 22% of adults in Simcoe Muskoka (20+ years) reported that they currently smoke, with 16% reporting they smoke daily. Rates of smoking were higher among men (26% identified as a current smoker; 18% were daily smokers) than women (17% identified as a current smoker; 15% were daily smokers). Levels of education and income also play a significant role in smoking rates within Simcoe Muskoka, with rates of smoking dropping as income and education levels increase.[136]

Figure 10.8: Adult (20+ years) current smokers, Simcoe Muskoka & Ontario, 2000/01–2013/14.



10.5 Adaptive Capacity

Table 10.1 below highlights current and potential actions, key partners, and mitigation co-benefits related to air quality adaptive capacity for which the health unit has a role. For information on examples of adaptive capacity measures occurring within the community by municipalities, conservation authorities and community organizations, see Section 14.0.

Table 10.1: Current and potential actions taken by the Simcoe Muskoka District Health Unit to support adaptive capacity for climate related air quality changes.

Public Health Role	Type of Action (current/for consideration)	Activities	Key Partners	Mitigation Co-Benefit
Population Assessment	Current	Identify populations at risk from poor air quality.		
	For consideration			
Surveillance	Current	Monitor Air Quality Health Index (AQHI).	Environment and Climate Change Canada	
		Monitor incidence of respiratory and cardiovascular illness.		
	For consideration	Monitor impacts of traffic related air pollutants.	Public Health Ontario	
		Monitor for aeroallergens.		
Health Promotion (Policy Development, Advocacy & Public Education)	Current	Provide public messaging to reduce exposure: carpooling, exertion levels, energy consumption.		✓
		Promote vehicle idling policies.	Municipal staff	✓
		Support policy development related to: community gardens, transit provision and use, school gardens.	Municipal planners Infrastructure & Engineering Environmental services Parks & Recreation School Boards	✓
		Support policy development and community engagement related to active transportation.	Municipal planners Infrastructure & Engineering	✓

Public Health Role	Type of Action (current/for consideration)	Activities	Key Partners	Mitigation Co-Benefit
			Environmental services Parks & Recreation	
		Provide Official Plan Policy Statements related to Air Quality, Environment, Forest strategy, Greenspace, Active Transportation, Complete Communities (which support live, work and play within one community).	Municipal planners Infrastructure & Engineering Environmental services Parks & Recreation	✓
		Evaluate the local outcomes of built environment initiative.		
		Provide public education in home visits with new mothers related to reducing indoor air temperatures and energy consumption during times of extreme heat.		✓
	For consideration	Increase promotion and messaging of AQHI.		
		Support the implementation of the Smart Commute Program into the SMDHU region.	Municipalities Smart Commute	
Health Protection (Disease and Injury Prevention)	Current	Implement internal travel conservation and vehicle idling policies.		✓
		Support internal policies and practices: - Carpooling parking spots & vehicles. - Fuel efficient fleet. - Hybrid vehicles available. - Reduced office footprints. - No vehicle idling at car seat clinics. - Teleconferencing/telecommuting. - Motion sensors and thermostat set-backs. - Waste diversion & reduction.		✓
	For consideration	Consider impact and plan for Severn wildfire event.		
		Consider impact of aero-allergens on health.		

11.0 Contamination and Availability of Food and Water

Key Considerations:

- Increased temperatures may lead to increased foodborne illnesses, due to an enhanced ability for pathogens to survive, and a rise in human activities during warmer months that increase risk of food contamination (i.e. barbeques).
- Water quality throughout the region could be impacted due to the increased potential for contamination by bacteriological agents, as well as increases in blue-green algae blooms.
- Currently 12% of Simcoe Muskoka households have experienced some form of food insecurity; that rate doubles to 24% among single-parent families. Further impacts to food access and security can be expected, as climate change weather events (temperature, flooding, drought and extreme storms) interrupt local and global food production systems.
- Individuals living in low income will have the highest rates of household food insecurity due to these changes, with increased food pricing due to changes in global food production. This has already been observed with the cost of a nutritious food basket increasing by 29.9% over the past six years.

Weather and climate are key factors that can impact both the quality and quantity of food and water. Temperature and precipitation levels influence the ability of plants to survive and thrive. Evidence has also shown that rates of foodborne illnesses tend to increase during the warmer summer months[137] and in response to higher temperatures.[138,139] Rates of enteric illness have been linked to temperature and rainfall, with bacteria associated with enteric disease shown to be more likely to grow on crops or to colonize food animals (e.g. broiler chickens) during warmer temperatures.[140-142] Most enteric pathogens survive well in warm temperatures and in humid environments, with both their proliferation and their survival rates increasing as ambient temperatures increase.[143,144] Increases in the presence of these pathogens in the environment translates directly to increased opportunities for human exposure and subsequent illness, through direct exposure, cross-contamination, treatment failure or other mechanisms.[145,146] Extreme weather and precipitation, which cause overland flows and increased nutrient loading in waterways, have the potential to increase algal blooms;[147] blooms can cause multiple health impacts and decrease access to water for drinking, agriculture and recreation.

The following section will examine the impacts of climate change on food and water within the Simcoe Muskoka region, from both contamination (safe food and water) and availability (food security/food systems) perspectives. Current burden of food- and waterborne illnesses within the region are also reviewed.

11.1 Current Burden of Illness

A variety of pathogens including bacteria, parasites and viruses can be transmitted via food and water. Transmission can occur through ingestion of contaminated food and water sources, and exposure during recreational use such as swimming. These different illnesses have a variety of symptoms, which may include nausea, vomiting, abdominal cramps and diarrhea. Many individuals with food- and waterborne illnesses will recover quickly, often with no treatment. In severe instances and among vulnerable populations, these illnesses can be life-threatening. Individuals more vulnerable to food- and waterborne illnesses are discussed in section 11.3 below.

In Canada there are an estimated four million cases of domestically acquired foodborne illness every year,[148,149] with over 90% of foodborne illness in the community attributed to norovirus, *Clostridium perfringens*, *Campylobacter* spp., and nontyphoidal *Salmonella* spp.[149] Illnesses related to food- and waterborne pathogens commonly go unreported due to the frequency of mild symptoms, short illness duration, and the occurrence of asymptomatic infections, as well as factors related to request and submission of samples for microbiological testing.[150,151] Of those individuals who seek treatment, over 11,500 hospitalizations and 240 deaths occur each year due to foodborne illnesses.[148] In 2014, the five most common laboratory-confirmed reportable food- and waterborne illnesses within Ontario were campylobacteriosis, salmonellosis, giardiasis, amoebiasis and cryptosporidiosis.[152]

It can be difficult to determine the number of waterborne illnesses due to the fact that many enteric illnesses can also be related to food or transmitted from person-to-person.[104] However, studies by Murphy and colleagues have estimated the number of acute gastrointestinal illness (AGI) caused by waterborne illness in Canada for private wells and small water systems servicing less than 1000 people[153] and municipal systems serving more than 1000 individuals.[154] Annually within Canada, there are an estimated 130,230 AGI cases attributed to waterborne illness from private wells and small water systems; these cases can be attributed to *Norovirus* (73%), *Cryptosporidium* (13%), *Campylobacter* (10%), *Giardia* (3.5%), and *E. coli* O157 (0.6%).[153] Among municipal systems servicing more than 100 people, there are an estimated annual 334,966 AGI cases which can be attributed to the consumption of tap water, accounting for 1.7% of the annual AGI burden in Canada.[154]

In Simcoe Muskoka, reported food- and waterborne illnesses can be examined by both the monthly incidence of illnesses and those that arise from outbreaks (an increase in incidence of an illness above expected levels in a defined geographic area). The average number of monthly food- and waterborne illnesses between 2005–2016 in Simcoe Muskoka, overall, and subdivided into cases in the Northern and Southern Regions, can be found in Figures 11.1 – 11.3 below (for a description of illness type included in the analysis, see Appendix K).

Figure 11.1: Monthly average cases of food- and waterborne illness and mean monthly temperature in Simcoe Muskoka, 2005–2016.

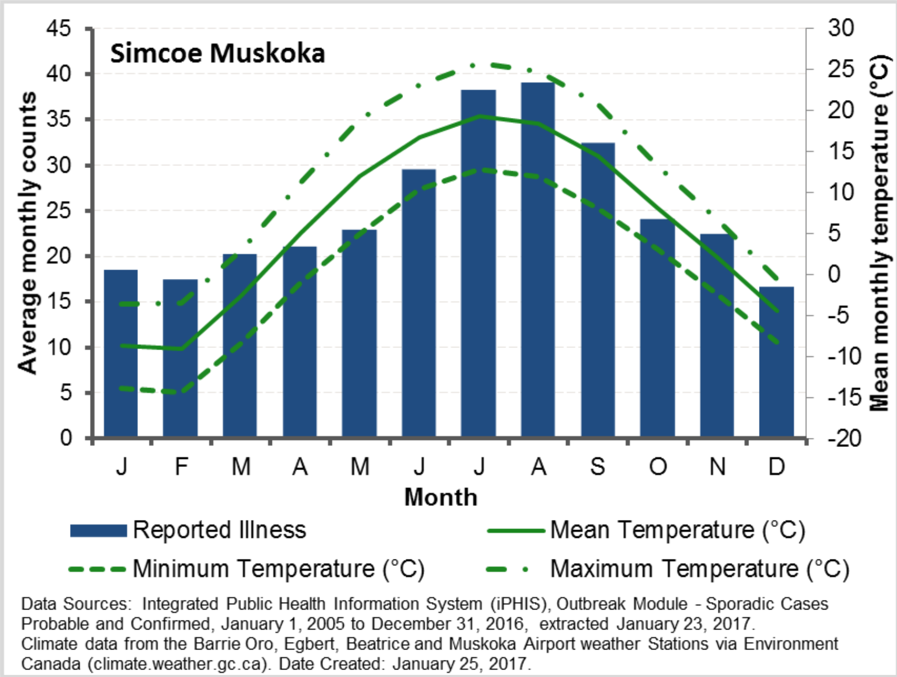


Figure 11.2: Monthly average cases of food- and waterborne illness and mean monthly temperature in the Northern Region, 2005–2016.

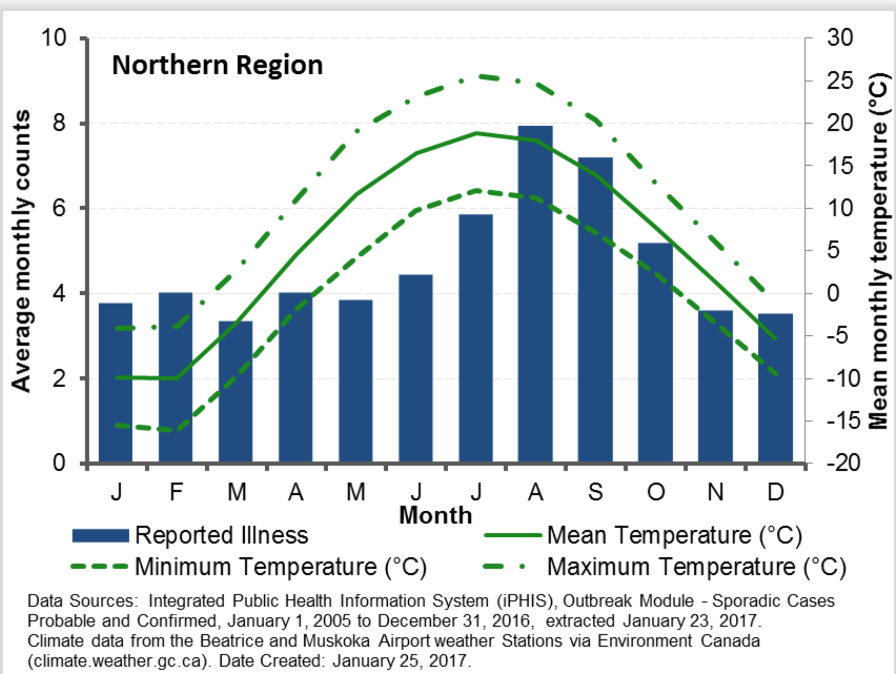
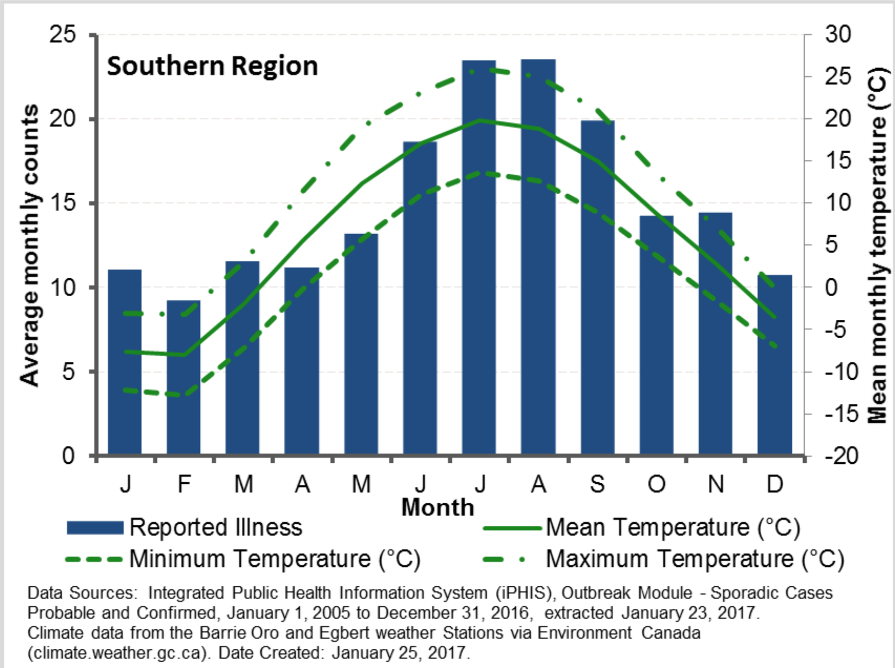


Figure 11.3: Monthly average cases of food- and waterborne illness and mean monthly temperatures for the Southern Region, 2005–2016.



When examining the monthly average cases in relation to monthly temperatures, the annual peak in cases of illness occurs over the same months as the seasonal peak in temperatures (mean, minimum and maximum) overall within Simcoe Muskoka, and in the Southern Region. There is a slight delay between peak temperatures and peak cases in the Northern Region; this is, however, over a small number of cases (<10/month). While a trend in cases was observed in relation to temperature, no obvious relationship is currently evident within Simcoe Muskoka data between mean total monthly precipitation and cases of illness. The annual incidence rate of food- and waterborne illness within Simcoe Muskoka was approximately 57.8 cases per 100,000 between 2005 and 2016. In contrast, Simcoe Muskoka rates are lower than the rate for Ontario illnesses, which has been observed at 78.7 per 100,000.

In addition, the number of outbreak cases that have occurred locally can also be examined (see Appendix L). From 2005 to 2016, four local outbreaks were identified in Simcoe Muskoka, with 65 cases, but overall 170 outbreak-related cases have been reported in Simcoe Muskoka as part of provincial, national or multijurisdictional outbreaks.

11.2 Exposure

11.2.1 Foodborne Illness

In any food system,[xxiv] there are many opportunities for food to become contaminated with infectious agents; including initial production/growth, processing, distribution, and preparation. Environmental factors, such as flooding and using contaminated water for irrigation can support contamination at the site of production. Behavioural factors, such as cross-contamination during cooking, handwashing with contaminated water, and poor food-handling skills, can increase risk of contamination during preparation and consumption.

A variety of climatic influences may increase the risk of exposure to foodborne illness due to climate change. Presently, rates of foodborne illness across Canada peak during warmer temperatures within the summer months;[137] this trend is also evidenced within the current burden of illness for Simcoe Muskoka. Increasing temperatures have been linked to increased rates of specific foodborne illnesses in Canada[139] and internationally.[138,156-159] Increasing temperatures could increase exposure to foodborne illness in two ways. First, research has identified that survival rates of enteric pathogens are positively correlated with increased ambient temperature, contributing to higher rates of illness.[137] Second, warming temperatures may result in a rising number of activities that increase the risk of food contamination and poor food hygiene, including outdoor events such as barbecues, picnics and camping.

Indirect impacts to foodborne illness due to climate change can occur from power outages associated with extreme summer storm events. For example, individuals and businesses may not be able to maintain adequate refrigeration and freezing and thus compromise food safety; food contamination and related illness can occur given that safe food temperatures cannot be maintained.

Other climatic impacts that may increase the risk of contamination of food include the following:

- flooding or the use of contaminated water for irrigation;[160,161]
- livestock stress from heat or transportation, which may increase the number of bacteria shed by the animals, increasing potential for contamination during processing; and
- the potential spread of new invasive species by migratory birds and animals, which may lead to potentially new foodborne pathogens in Canada.[137]

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xxiv A food system is defined as "all processes and infrastructure involved in satisfying a population's food security", including all aspects of food production (growing, harvesting, processing, storage, transporting, marketing, and consuming of food.)[155] These systems can occur on various geographical scales (local to global).

As climate affects the growing conditions and number of extreme weather events across the globe, the potential for increased contamination at the site of production can be expected to impact local illness rates, due to the interconnectedness of global food systems.

11.2.2 Waterborne Illness

Waterborne illnesses are acquired through ingestion or recreational exposure to bacteria, viruses, and chemical contaminants in ground or surface water.[137] In general, the impact of climate change on waterborne illness in developed countries, with well-maintained water treatment plants, is expected to be low. Drinking and waste water treatment systems are designed to operate within expected levels of precipitation, temperature, snow cover, snow melt and water levels. However, when these levels change due to an extreme weather event, pathogen entry and behaviour in source water and drinking water can become subject to change,[105,162] leading to potential for surface and ground water contamination by enteric pathogens and decreased effectiveness of water treatment systems.[1,163] Approximately 77% of Ontario's population relies on surface water sources and could be vulnerable to impacts to these sources.[164]

Weather has been a significant factor in triggering a number of reported waterborne illness events, with excess rainfall, snow melts, spring melts and flooding preceding many waterborne illness outbreaks[105,137] and acute gastrointestinal illnesses[165] (for list of local flooding events within Simcoe Muskoka, see subsection 9.3.1). Curriero and colleagues[166] found that more than half of the waterborne illness outbreaks in the US during the last half century followed a period of extreme rainfall, with 68% of the outbreaks following storms of a severity that ranked in the top 20% for that region; findings consistent with Canadian research which found a significant association between extreme rainfall events and waterborne illness outbreaks.[163] This was the case in May 2000, when a severe storm in Walkerton, Ontario caused cattle manure to run into the municipal water supply and contaminate it with *E. coli* 0157:87 and *Campylobacter*, resulting in the illness of over 2,300 individuals and the deaths of seven residents.[167]

While the incidents outlined above are mostly related to municipal drinking water systems, it is important to note that small and private water systems are even more vulnerable to contamination, with individuals served by these systems at higher risk of waterborne illness than those serviced by municipal systems.[153] Waterborne illness burden associated with extreme rainfall is expected to fall largely on the users of small systems with inadequate treatment.[168]

Across Simcoe Muskoka, there are a variety of types of drinking water systems, ranging from large municipal systems to private wells and surface water from which individuals access water. Regulated drinking water systems, both large and small, are required by both the Ministry of the Environment and Climate Change (MOECC) as well as local health units to identify and respond to Adverse Water Quality Incidents (AWQI) (for a breakdown of type of water system and the responsible inspection agency, see Appendix M). Regulated drinking water systems are also routinely inspected by MOECC or the local public health unit to ensure compliance with regulatory requirements. While the majority of residents are serviced by a municipal drinking water system, it is important to note that approximately 41,000 private wells service 24% of households in Simcoe County and just over 10,000 private wells service 43% of households in Muskoka. Unlike the municipal and small drinking water systems, private drinking water supplies are not mandated to be inspected by either the health unit or the MOECC. Residents who rely on private drinking water supplies, including wells and surface water, are encouraged to routinely submit water samples to the health unit for water quality testing to assess the safety of their water source.

An AWQI occurs "when a water sample test result exceeds the Ontario Drinking Water Quality Standards or an operator observes that the system may not be providing safe water".[169] Samples that are tested can be either treated or non-treated (raw), depending on the system type. Table 11.1 outlines both the number of AWQIs that have occurred across Simcoe Muskoka and the reason for the AWQI in regulated systems (a list of system type and responsible inspection agency can be found in Appendix M).

Table 11.1: Number of Adverse Water Quality Incidents where a test of a regulated system within Simcoe Muskoka exceeded the Ontario Drinking Water Standards or operator observed that system may not be providing safe water, 2005–2016.

Type of incident	Number of incidents reported											
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Total Coliform	243	180	199	166	162	205	251	187	250	207	123	151
E.coli	7	10	7	7	4	12	10	8	12	13	13	12
Overgrown	2	ND[xxv]	2	2	1	ND	4	3	14	1	3	ND
Nitrate	16	10	5	1	ND	ND	ND	ND	6	8	4	8
Trihalome-thane	23	44	65	31	34	45	29	12	8	3	6	3
Turbidity	36	30	20	6	2	9	5	12	12	11	8	3
UV Issue	3	9	2	2	8	3	7	3	8	6	5	2
Chlorine Issue	95	77	59	31	39	37	17	49	43	34	30	31
Pressure Loss	34	8	5	8	6	11	4	15	19	16	21	20
Sodium	ND	ND	ND	ND	ND	ND	20	46	27	17	29	22
Total Incidents	459	368	364	254	256	322	347	335	399	316	242	252

xxv ND = No Data

Recreational water exposure also plays an important role in enteric illness in Canada.[170] Exposure to waterborne illness can occur through contact with contaminated water while swimming or performing other recreational activities;[162] increases in the numbers of individuals utilizing recreational water – both man-made (pools and spas) and natural (lakes, etc.) – can potentially lead to higher contaminant loads. In addition, drought and rainfall can influence rates of contamination and water quality within recreational sites.[162]

Exposure can happen through primary contact—activities where the whole body or face and trunk are frequently exposed to water through spray or immersion, and where it is likely that some water will be ingested—or secondary contact—activities in which only limbs come in regular contact with water, where ingestion is unusual.[171] Health outcomes associated with exposure to contaminated recreational water include eye, ear, nose, skin, respiratory and gastrointestinal infections.[162]

Monitoring of select public beaches is routinely completed by the health unit and community partners. Public bathing beach monitoring examines the presence and levels of *E. coli* as an indicator of public health risk.

During the summer months, from June to August, monitoring of beach water at public beaches in Simcoe Muskoka is conducted. If levels of *E.coli* contamination exceed the Canadian Recreational Water Guideline levels[xxvi] of 200 *E.coli* per 100 mL, a swimming advisory is posted for the affected beach. Table 11.2 below outlines the number of beaches monitored, the number of beaches which had a swim advisory (postings), and the total number of postings at beaches in Simcoe Muskoka.

Table 11.2: Summary beach monitoring data for Simcoe Muskoka, 2007–2016 (Source: SMDHU Beaches Database).

Year	# of Monitored Beaches	# of Beaches Posted	# of Postings
2007	76	14	18
2008	72	16	23
2009	68	19	29
2010	70	18	26
2011	69	18	31
2012	71	16	22
2013	66	18	23
2014	60	30	52
2015	57	27	40
2016	57	18	25

xxvi Note: Prior to 2016, the SMDHU utilized the 'Public Health Inspector's Guide to the Principles and Practices of Environmental Microbiology' as the guidelines for beach water indicator bacteria contamination, which indicates 100 E.coli per 100mL. In 2016, the SMDHU aligned their water quality monitoring program with those guidelines outlined by Health Canada.

In addition to public beaches, currently the health unit provides inspections for 318 seasonal or year-round recreational water facilities such as pools and spas. The health unit also provides inspections for non-recirculated splash pads (14) and recirculated splash pads (5) across Simcoe Muskoka. In these recreational water facilities, water chemistry and treatment systems are vulnerable to influences of temperature and anticipated increased use by bathers. Increased use of the facilities will introduce increased organics into the water making it even more difficult to effectively treat.

Blue-Green Algae

Blue-green algae (also known as cyanobacteria) are microscopic organisms that naturally occur in streams, ponds, lakes, and other surface water.[172] These organisms thrive in warm, nutrient-rich, shallow, and slow-moving water environments. When a large number of cyanobacteria are present in a water source, a large mass can form either on the water's surface or throughout the water column. A blue-green algae bloom will often present with the appearance of a turquoise paint spill or pea soup. These areas of increased concentration of algae are known as surface scum. Because growth of the bacteria occurs most readily within warm water, algal blooms tend to occur during the late summer and early autumn.[172]

Blue-green algae presents concerns for health as they may be comprised of cells that produce toxins. Of prime public health concern is the toxin microcystin-LR. These hepatotoxins[xxvii] can have serious negative impacts on human and animal health. Health effects of blue-green algae exposure include abdominal pain, headache, vomiting, diarrhea, blistering around the mouth and pneumonia.[173]

The main source of exposure to microcystin-LR is through ingestion of contaminated water; however, individuals can also be exposed through showering and swimming as well as ingestion of food products, such as fish and certain crops, affected by contaminated water.[174]

Climate change has the potential to increase the occurrence of blue-green algae blooms through multiple routes. First, rising temperatures support heightened blue-green algae growth by increasing the surface water temperatures, allowing for optimal growth conditions and increased water stratification early in the spring and persisting later into the autumn.[175] In addition, it also strengthens vertical mixing of the water, which leads to better growth conditions due to a more stagnant water column. Buoyant cells float upward when mixing is weak and accumulate in dense surface blooms.[176] Increased water temperatures create optimal conditions for the growth of cyanobacteria, while decreasing the optimal growth environments for other phytoplankton species that would normally compete for growth,[177] allowing for the volume of cyanobacteria to increase.

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xxvii Hepatotoxins are toxins which are known to primarily attack the liver (Charlton et al, 2001).

Secondly, altered weather patterns will alter the amount of nutrients that support cyanobacteria growth present in waterways; specifically phosphorus and nitrogen. Phosphorus and nitrogen are significant nutrients that support the growth of microcystin-LR–producing cyanobacteria,[178] and are also key nutrients present in agricultural, cosmetic and landscape fertilizers, as well as animal manure. Currently, contamination of waterways due to agriculture occurs mainly from surplus water runoff, either through overland flow in hilly environments or leaching into waterways and through artificial drainage systems in low-lying and flat environments.[179] Changing precipitation patterns may increase the number and intensity of rainfall events, impacting on the amount of flooding and overland flows. In addition, changing climates result in modified agricultural management practices, including the amount of soil tillage and timing and amount of fertilizer application, which both influence the amount of nutrients transported into waterways.[180] Within Ontario, warming waters and longer ice-free periods may be a contributing factor in the increased number of algal blooms.[172] However, it must be noted that cyanobacteria are only one type of algae among a spectrum of algae organisms, and not all forms of algae have negative effects on human health. The full impact of climate change on all types of algae, as well as the potential interaction between species, is not fully understood, and may alter the potential for blue-green algae blooms in the future.

In Simcoe Muskoka, several water bodies, including Lake St. John, Lagoon City and Little Lake in the County of Simcoe, and Three Mile Lake in the District of Muskoka, have had algal blooms. In response to these blooms the health unit issued public health notices to residents to advise on public health precautions and the potential health impacts associated with a blue-green algae bloom. As temperatures rise and precipitation patterns become more extreme, there is the potential for blue-green algae blooms to increase in duration, distribution and intensity across the region in the future. Changes in algae growth may impact drinking water quality, especially for those systems who draw their water from surface water sources.

11.2.3 Food Security/Food Systems

Food security is achieved when individuals have "physical, social and economic access to sufficient, safe and nutritious foods that meets their dietary needs and food preferences for an active and healthy life" (pg. 53).[181] This is achieved through a sustainable food system that maximizes community self-reliance and social justice.[182] Food systems are susceptible to climate change impacts not only on production, but also on processing facilities, distribution networks, marketing venues, consumption sites like homes and restaurants, and on effective waste and organics collection. A climate resilient food system is one with support for a variety of innovative, economically viable and environmentally sensitive activities in all of these broad categories.

Climate change is expected to impact food security in a variety of ways, including the stability of food systems and their ability to provide sufficient quantities of food for a community.

Extreme precipitation events, droughts, changes to pest populations, and availability of water will all threaten levels of food production and associated food costs in the future.[183] Further discussions on the associations between food costs and food insecurity can be found in subsection 11.3.2.

Access to food in Canada is highly dependent on global food systems. As climate change alters local environments around the globe, changes in the ability to produce crops in certain environments, as well as the productivity of these crops, are expected to occur.[184] Projected changes in crop yield vary widely across emissions scenarios and are affected by changes in temperature, precipitation, and other environmental exposures such as carbon dioxide levels.[185] Inputs such as irrigation may be required to continue expanded food production, which has the potential to lead to water scarcity in certain areas,[186] with flooding or severe storms impacting yields in other areas. While certain regions may see an increase in productivity in the short term due to increased photosynthesis within elevated carbon dioxide environments, a general decrease in food production at a global scale is predicted.[155]

Agricultural production in Ontario has already experienced negative outcomes due to climate change; an early spring in 2012 resulted in early blooms of apple trees and a subsequent severe spring frost caused the loss of over 80% of apple crops.[187] Other potential impacts due to climate change that may affect agricultural productivity in Ontario include: heat stress on livestock; changes in pest species and volumes; changes in geographical range of growth for certain crops; and limitations on food production/processing based on other required resources such as water quality and quantity.[183] However, it must be noted that there are some potential opportunities for agricultural output to increase due to climate change in Ontario. These include the ability to produce an increased diversity of crops in warming climates, with various crop species differing in their response to changing climates; potential for increased productivity due to higher CO_2 levels; and the expansion of farming northwards with warming temperatures, as soil quality permits.[183]

Climate change can increase vulnerability of fish populations by changes to ecologies and food web systems, timing and success of fish reproduction, habitat disruption, invasive species and susceptibility to pathogens. Changes in climate will change lake water temperatures and decrease habitat for, and populations of, local cold-water fisheries such as lake and brook trout.[188]

Food access in the Simcoe Muskoka region relies heavily on global food systems, as is the case provincially. In Ontario current food imports equal $20 billion per year.[189] Nonetheless, there are many local food producers that support food production and access within the region; this includes an area of 510,584 acres of farmland within the County of Simcoe, and 27,375 acres of farmland within the District of Muskoka.[190] Local food charters, such as the Simcoe County Food and Agriculture Charter, which was completed in 2012, support the local agricultural community by increasing awareness of the importance of local food. Charters additionally support access to healthy, personally acceptable food for all members of the community; support agricultural sustainability and environmental responsibility; and provide for long-term economic growth and prosperity.[191]

The ability for these farms to continue to produce food for local and global markets will be contingent on many factors as our climate changes, such as access to water for irrigation, changing weather patterns, farmers' ability to adapt, and land-use planning pressures. For example, between 1976 and 2011, Ontario lost 2.8 million acres, or 18% of arable farmland, from agricultural production. Much of this land has been converted to urban areas, or is being used for other non-agricultural purposes.[192] However, many provincial and municipal policies, such as the Growth Plan for the Greater Golden Horseshoe, the Greenbelt Plan, the Oak Ridges Moraine Conservation Plan, the Niagara Escarpment Plan, and Places to Grow, have been implemented to support smart growth within Southern Ontario and conservation of green space and agricultural lands, as well as to conserve important water resources.[193]

11.3 Sensitivity

11.3.1 Food- and Waterborne Illness

While food- and waterborne illness can impact any individual who is exposed to contaminated food and water sources, certain individuals, including children, pregnant women, the elderly, immunocompromised individuals, and those with pre-existing chronic conditions are most vulnerable to food- and waterborne illness.[194] While research has identified that adults tend to be more sensitive to the impacts of blue-green algae toxins than those in younger age groups, infants have increased vulnerability to the impacts of blue-green algae toxins, due to the larger volume of water per body weight that they ingest.[174] Therefore, water with a recent or present bloom should not be used for infant feeding, as boiling the water will not remove the toxins; alternative sources should be sought.

Features of substandard housing that increase incidence of infectious diseases include lack of access to safe water sources and inadequate food storage.[195] Individuals who are under-housed or living in substandard housing may be more sensitive to the impacts of waterborne illness, especially if living in a rural setting with a reliance on wells or surface water as a drinking water source. This sensitivity is especially relevant depending on the type of well (dug or driven wells) which can be easy to contaminate due to their shallow depth.[196]

Alternatively, some research has identified that foodborne illness rates tend to be higher among individuals with higher income levels, which may be due to increased access (both financial and geographical with respect to grocery store access) to higher risk foods such as fresh produce, meats, poultry and eggs relative to individuals living in low income.[197] Additionally, individuals living in low income have been noted to have enhanced safe food preparation and handling knowledge, which decreases potentially unsafe practices such as cross-contamination. While broad research determining the reasoning behind these discrepancies in food handling practices has not been conducted, it has been noted that it may be due to an increased likelihood of employment in food preparation or handling industries, which would increase food-related hygiene education.[197]

11.3.2 Household Food Insecurity

Climate change may also impact household food insecurity, which is defined as inadequate or insecure access to food due to insufficient income to support basic needs. As previously stated, climate change has the potential to impact food affordability, which is a contributor to food insecurity. For example, increases to food prices after extreme weather events have historically been observed,[155] making food affordability even more difficult for those individuals who already experience food insecurity.

Living in a food-insecure household has many negative health outcomes for both children and adults; children experience poorer physical and mental health. Youth are at increased risk of depression, social anxiety and suicide.[198-200] Food insecure adults also experience worsening physical and mental health, such as higher rates of depression, diabetes, high blood pressure and heart disease.[200] Additionally, parents in food-insecure homes may feel embarrassed about not being able to adequately feed their children, which can lead to feelings of social exclusion and isolation from neighbours and their community.[199]

Currently, the Simcoe Muskoka District Health Unit conducts the Nutritious Food Basket (NFB) survey to assess the affordability of food within the region. This annual survey measures the cost of basic healthy eating within Simcoe Muskoka, and investigates whether or not lower-income Simcoe Muskoka residents are likely to have enough income to pay for a healthy diet after other costs such as those associated with housing are also considered. Foods chosen to complete the assessment are consistent with healthy eating patterns recommended in Canada's Food Guide.

Year after year, results from the NFB confirm that food insecurity is an issue of concern in Simcoe Muskoka. According to 2016 survey results, the cost of the NFB for a reference family of four[xxviii] would be $210.86 per week ($913.02 per month) in Simcoe County and $205.88 per week ($891.46 per month) in the District of Muskoka. For Simcoe Muskoka combined, the weekly cost of the NFB in May 2016 for the reference family of four was $208.35 (or $902.16 per month), a cost of $207.67 more per month than in May 2010, representing a 29.9% increase in cost over a six-year period, or $2492.04 more per year in 2016 than in 2010. An examination of what this means based on total income for Ontario Works recipients and those living on minimum wage is found within Table 11.3.

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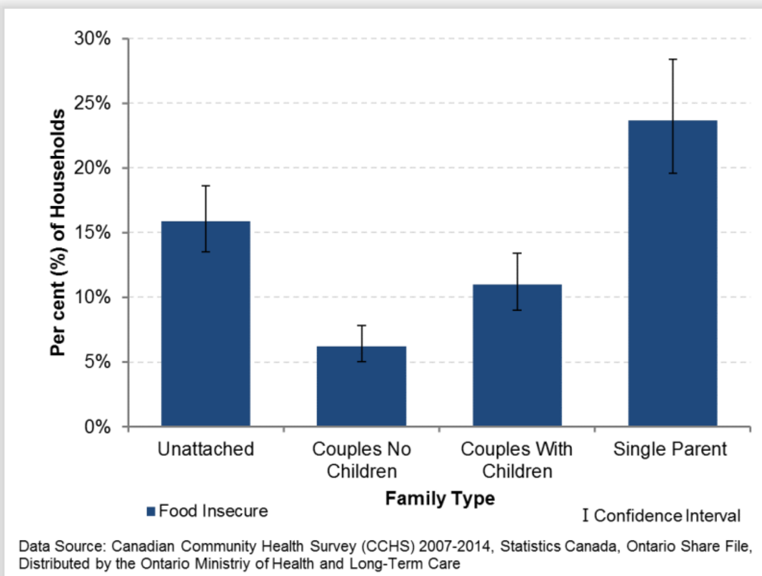
xxviii A family of four for the NFB consists of a man and a woman each aged 31-50 years; a boy aged 14-18 years; and a girl aged 4-8 years.

Table 11.3: Percentage (%) of total monthly income needed for food and rent for a reference family of four, for individuals receiving Ontario Works or living on minimum wage, Simcoe Muskoka, 2011 & 2016.

	2011	2016
Ontario Works	89%	96%
Minimum Wage	68%	72%

The Canadian Community Health Survey (CCHS) also identifies the number of individuals who experience food insecurity.[xxix] Between 2007 and 2014, 12% of Simcoe Muskoka households said they had experienced food insecurity at least once in the past 12 months, similar to the 12% (11.3%, 12%) of Ontario households that reported some level of food insecurity. Food insecurity is highest among single-parent families, with 24% reporting some level of food insecurity (Figure 11.4), the highest level of food insecurity compared with all other types of families.

Figure 11.4: Marginal, moderate, or severe household food insecurity by family type, Simcoe Muskoka, 2007 – 2014.



Additionally, when examining current food insecurity by income distribution, rates of food insecurity rise to 29% among those Simcoe Muskoka households that fall within the bottom 20% of income earnings. This rate is approximately four times higher than those in the top

xxix The number of those experiencing food insecurity represents households that report either marginal, moderate, or severe food insecurity. Marginal food insecurity captures concepts such as "worry about running out of food and/or limit food selection because of lack of money for food."

80% of income earners. As climate change alters food availability and affordability, it is those residents within Simcoe Muskoka who already experience a level of food insecurity, and those within the lowest income earnings, who will be most impacted by these changes.

11.3.3 Water Availability

While water sources currently appear abundant in Simcoe Muskoka, climate change may impede the availability of water in the future, for both personal and agricultural use. Water availability is defined as the volume of fresh water available compared to the amount of water currently being used.[201] To assess water availability in Canada, Environment and Climate Change Canada (ECCC) has created a water availability indicator that examines current supply relative to demand/use. Results of surveys in 2005 and 2007 indicate that the threat to water availability is high within Southern Ontario, meaning that more than 40% of available water is currently being used. However, low rates of use within other parts of the province indicate a low threat to water availability.[201] In Simcoe County, a report from the Nottawasaga Valley Conservation Authority[202] indicates areas of sensitivity due to climate change and agricultural use. Areas with the largest agricultural component, the Nottawasaga River and Innisfil Creek watersheds, had the highest level of sensitivity due to climate change. These areas currently have extensive irrigation for potato and sod crops, and historical low water levels have been noted.[202]

11.4 Adaptive Capacity

Table 11.4 below highlights current and potential actions, key partners, and mitigation co-benefits surrounding adaptive capacity for the contamination and availability of food and water within the health unit jurisdiction. For information on a sample of adaptive capacity measures occurring within the community by municipalities, conservation authorities and community organizations, please see Section 14.0.

Table 11.4: Current and potential actions taken by the Simcoe Muskoka District Health Unit to support adaptive capacity for the contamination and availability of food and water.

Public Health Role	Type of Action (current/ for consideration)	Activities	Key Partners	Mitigation Co-Benefit
Population Assessment	Current	Disease and outbreak case investigation.	Health care providers	
		Identification of most vulnerable populations.		
		Monitoring the cost of healthy eating in Simcoe Muskoka.	Municipal decision makers Community groups and organizations Schools Workplaces Public	
	For Consideration			
Surveillance	Current	Bathing beach surveillance and monitoring.	Municipal staff	
		Food Recall System.	Health Canada MOHLTC	
		Monitoring of incidence of food- and waterborne illness.		
	For Consideration	Monitoring of the number of food access policy statements that get added into municipal official plans.	Municipalities	

Public Health Role	Type of Action (current/ for consideration)	Activities	Key Partners	Mitigation Co-Benefit
		Monitoring of the number of hectares of agricultural land in Simcoe and Muskoka.	Municipalities	
		Monitoring and identification of changes in surface water algae populations due to climate change and related health implications.	Health Canada ECCC MOECC MOHLTC Municipalities Conservation Authorities Watershed organizations	
Health Promotion (Policy Development, Advocacy & Public Education)	Current	Promotion of litterless lunches.	School Boards Workplaces	✓
		Promotion of use of municipal versus bottled water.	Municipal staff Public	✓
		Promotion of breastfeeding (waste and energy reduction).	Public	✓
		Education re: food skills and food safety practices.	Food handlers Public	
		Education re: community and household food security.	Municipal decision makers Community groups and organizations Schools Workplaces Public	
		Participation in Source Water Protection.	Conservation Authorities Watershed organizations Municipal staff	
		Public Messaging re: water quality and drinking water testing.	Municipalities	

Public Health Role	Type of Action (current/ for consideration)	Activities	Key Partners	Mitigation Co-Benefit
		Public messaging re: Boil Water Advisories, drinking water advisories (i.e., blue-green algae), bathing beach advisories.	Municipal staff Provincial Parks Conservation Authorities Watershed organizations	
		Support for strengthening of local and regional food systems including production, processing, distribution, marketing and accesses, consumption, and waste recovery.	Municipalities School Boards Public Agricultural Community Provincial partners Community partners Food industry partners	
		Support for improvements to drinking water and food systems.	Municipal staff Agricultural community Conservation Authorities Watershed organizations	
		Official & Other Master Plans - policy statements re: local foods systems, protection of agricultural lands and water.	Municipal staff Conservation Authorities Watershed organizations Agricultural community	✓
		Policy development related to strengthening local food systems, for example, production, support for local food, food share, gleaning, seed saving.	Municipal staff Agricultural community Conservation Authorities Watershed organizations	✓
		Promotion and implementation of Food and Agricultural Charters.	Municipal staff Agricultural community Conservation Authorities Watershed organizations	✓
		Support the creation of community gardens to increase access to locally grown food.	Community organizations Municipalities	✓

Public Health Role	Type of Action (current/ for consideration)	Activities	Key Partners	Mitigation Co-Benefit
	For Consideration	Support/advocacy for critical infrastructure assessments of drinking water, sanitation and waste systems.	Municipal planners Infrastructure & Engineering Environmental services	
		Policy development related to reduction in nutrient loading in surface waters.	Municipalities Conservation Authorities Province	
		Support water preservation, conservation, and reclamation initiatives within the community.	Municipalities Conservation Authorities Watershed organizations Environmental organizations	
		Support/advocate for policy development for reduced waste at source, especially packaging, single use plastic and non-recyclable plastics.	Community Municipalities Province	
		Support/advocacy for policy development to encourage innovative technology such as green power systems (solar, biogas).	Community Municipal Province	
		Education re: the impact of climate change on food systems and food access.	Municipal decision makers Community groups and organizations Schools Workplaces Public	
		Advocacy for development of local municipal food / agriculture plans (or embed food systems and food access information into municipal climate change plans).	Municipal decision makers	

Public Health Role	Type of Action (current/ for consideration)	Activities	Key Partners	Mitigation Co-Benefit
Health Protection (Disease and Injury Preven-tion)	Current	Food Safety Inspections - premises and special events.		
		Support for breastfeeding - food security.	Community & Social Service agencies	
		Food Handler Training.	Food Handlers Public	
		Inspection and monitoring of small drinking water systems.		
		Provision of information re: disinfecting private wells.	Municipal staff Agricultural community Conservation Authorities Watershed organizations Public	
		Boil water advisories issuance.	Municipal staff Drinking water operators	
		Bathing beach advisories.	Municipal staff Provincial Parks Conservation Authorities Watershed organizations	
	For Consideration	Explore the connection between ‘One-Health’ and climate change.	MOHLTC PHO CVO	

12.0 Vector-Borne Disease

Key Considerations:

- Increased risk of West Nile virus is anticipated, due to an enhanced ability of vectors to propagate, as well as increasing viral proliferation in warmer temperatures.
- Climate change will support an increased range within Ontario and Simcoe Muskoka of blacklegged ticks, the vector responsible for transmitting the bacteria which causes Lyme disease.

There are different species of ticks and mosquitoes present in Simcoe Muskoka, however only a few of these species are capable of transmitting diseases to humans. The presence and type of vectors (defined as living organisms that can transmit diseases to humans)[203] in a given area are dependent on multiple factors such as: climate; temperature range and precipitation quantity; geographic distribution; reservoir hosts; and available habitat. As the climate of Simcoe Muskoka changes, rates of diseases spread by vectors such as mosquitoes (including West Nile Virus (WNv) and possibly Eastern Equine Encephalitis Virus (EEEV)) and blacklegged ticks (Lyme disease) are also expected to change. This section describes the current burden of illness attributed to vectors within Simcoe Muskoka, focusing on vector-borne diseases (VBD) of immediate public health concern for this area, including WNv, EEEV, and Lyme disease. In addition, it reviews the impact that climate change will have on VBD in the future. While there are many other VBDs established globally that are capable of impacting human health (including Zika, Dengue, Chikungunya, and malaria), this report focuses on VBDs with locally established vector species that present risks for local disease transmission. Other VBDs are beyond the scope of this report.

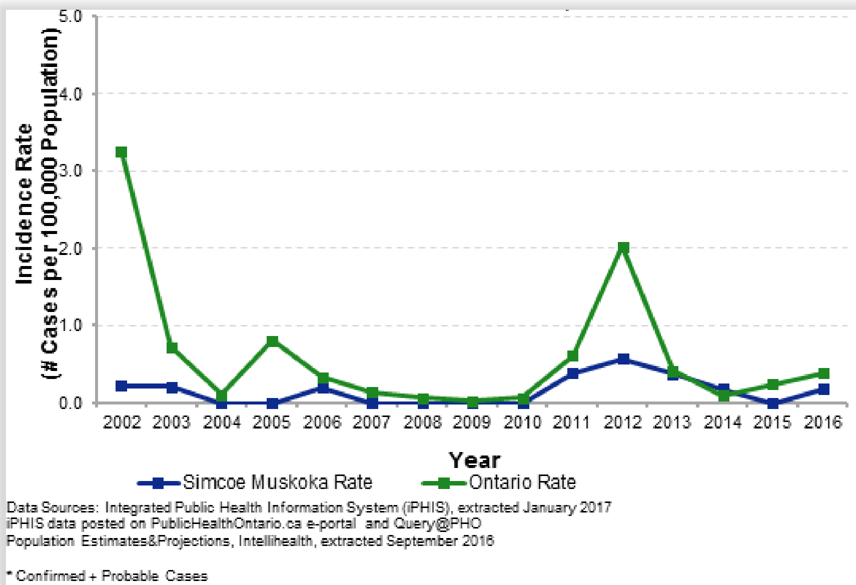
12.1 Current Burden of Illness

12.1.1 Mosquito-borne Illness

West Nile virus and EEEV are spread by infected mosquitoes to humans and horses. Birds act as a reservoir for the viruses, and during the disease transmission cycle mosquitoes acquire the virus after feeding on infected birds.[204] WNv presents in three clinical manifestations, including asymptomatic, non-neurological and neurological.[205] While the majority of individuals infected with WNv will be asymptomatic, approximately 20% of those infected with WNv will present with the non-neurological syndrome, which includes flu-like symptoms such as fever, head and body aches, skin rash. Less than one percent of WNv cases present with neurological syndrome, which has symptoms such as encephalitis or Parkinson's disease.[205] EEEV infections are characterized by symptoms such as fever, headache, nausea, muscle and joint pains, weakness and confusion.[204] Most persons infected with EEEV have no apparent illness but if symptoms develop they can cause permanent neurological outcomes and an estimated case fatality rate of 30 to 50%;[204] severe impairments including brain dysfunction, seizures, and cranial nerve dysfunction can occur for individuals who recover from the illness.[206]

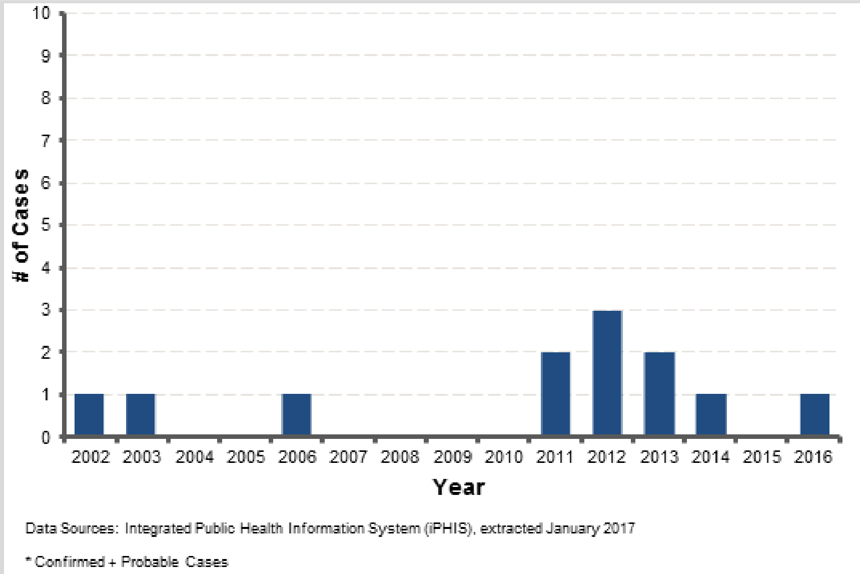
The incidence rate of WNv in Simcoe Muskoka remains consistently lower than provincial incidence rates (Figure 12.1). Since 2002, Simcoe Muskoka has experienced a total of 12 WNv human cases, with the largest number of human cases occurring in 2012 (Figure 12.2). It is important to note that due to the prevalence of under-reporting for mild WNv exposures, the number of human infections in the community is likely higher.

Figure 12.1: Incidence rate of West Nile virus cases, confirmed and probable,[xxx] in Simcoe Muskoka and Ontario, 2002–2016.



xxx A confirmed case of WNv is one in which a laboratory confirmed the presence of WNv or significant WNv antibodies. A probable case has laboratory evidence indicating but not confirming WNv (e.g., some increased antibody, the presence of virus particles or antibodies similar to those of WNv).[207]

Figure 12.2: Annual number of West Nile virus cases, confirmed and probable, in Simcoe Muskoka, 2002–2016.



Eastern Equine Encephalitis Virus is one of the most severe mosquito-borne diseases acquired in North America. Luckily, it is extremely rare; no human cases have been reported in Ontario to date.[208] However, infection with EEEV is not reportable in the province of Ontario unless a patient develops EEEV-associated encephalitis,[208] therefore cases with mild symptoms may not be reported to public health by primary health care providers. The first positive identification of Canadian mosquitoes carrying EEEV was detected in Simcoe Muskoka in 2009.[209] Additionally, between 2010 and 2015 six positive equine cases of EEEV were reported within the Simcoe Muskoka area.[210]

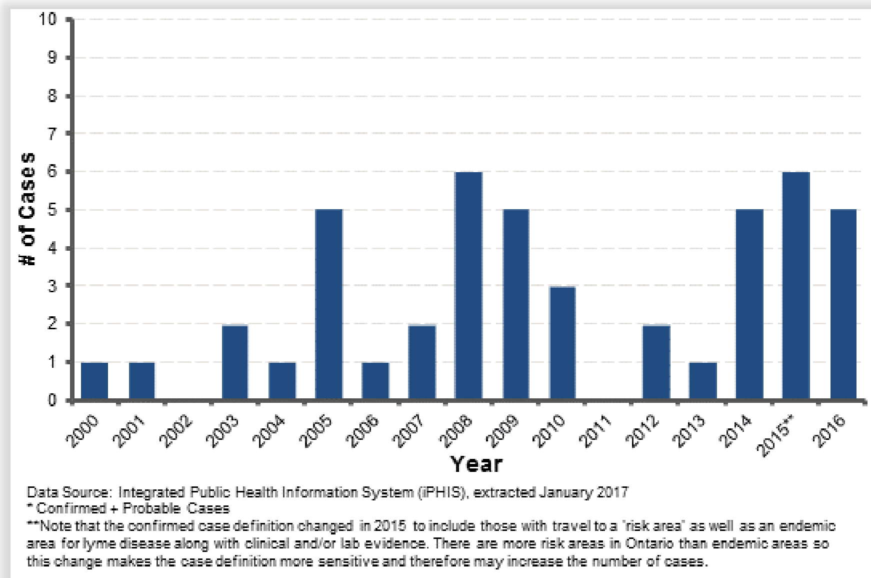
12.1.2 Tick-borne Illness

The primary tick-borne illness of concern within Ontario is Lyme disease. Lyme disease is an illness caused by the bacteria *Borrelia burgdorferi*, which is transmitted through the bite of an infected blacklegged tick (*Ixodes scapularis*).[208] Lyme disease can present as three phases, including early localized disease; early disseminated disease; and late disease.[211] Initial symptoms (early localized disease) can include headaches, fever, muscle and joint pain, and in most cases a circular type rash called erythema migrans;[212] early disseminated disease can lead to symptoms of nerve palsies, lymphocytic meningitis, conjunctivitis, muscle and joint pain, headaches and fatigue.[211] If left untreated (late disease) Lyme disease can lead to chronic health issues, which may include cardiac symptoms, extreme fatigue, and damage to the nervous system.[212]

Incidence rates of Lyme disease across the province have increased steadily since Lyme disease became reportable provincially in 1988. These increases are due in part to increased awareness among primary health care providers, as well as the increased potential for exposure to the expanding blacklegged tick populations throughout the province.[213] Incidence rates are highest within health unit jurisdictions found in the eastern portion of the province, correlating with areas reporting higher numbers of blacklegged tick populations, as reported through passive surveillance.[213]

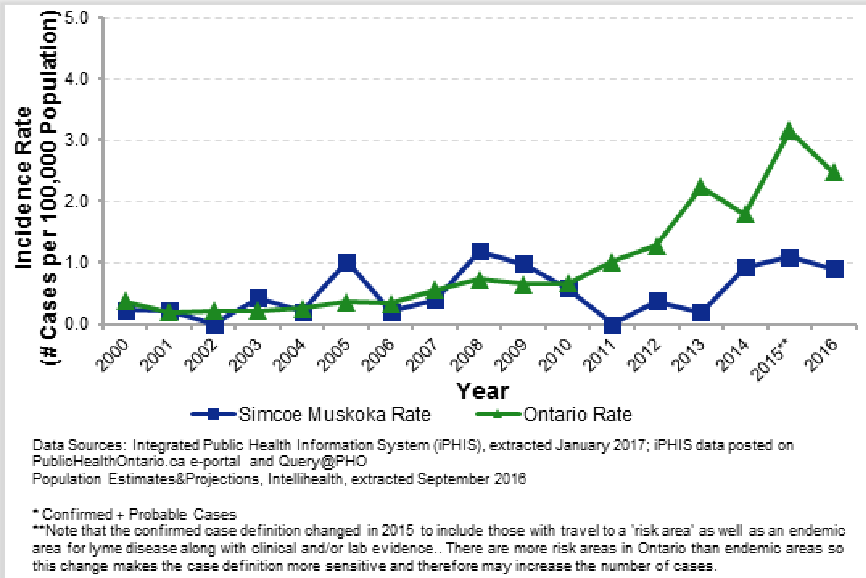
Between 2000 and 2016, there have been a total of 46 Lyme disease cases[xxxi] among Simcoe Muskoka residents (Figure 12.3). The incidence of Lyme disease has increased in recent years; however, the incidence rate of Lyme disease from 2000 to 2016 has been lower in Simcoe Muskoka (0.9 cases per 100,000 population) compared to Ontario (2.5 cases per 100,000 population) (Figure 12.4).

Figure 12.3: Annual number of Lyme disease cases, confirmed and probable, in Simcoe Muskoka, 2000–2016.



xxxi Includes both confirmed and probable cases. A confirmed case of Lyme disease includes: Clinician-confirmed erythema migrans (EM) greater than 5 cm in diameter with a history of residence in, or visit to, a Lyme disease endemic area or risk area OR Clinical evidence of Lyme disease with laboratory confirmation by PCR or culture OR Clinical evidence of Lyme disease with laboratory support by serological methods, and a history of residence in, or visit to, an endemic area or risk area. A probable case includes: Clinical evidence of Lyme disease with laboratory support by serological methods, but with no history of residence in, or visit to an endemic area or risk area OR Clinician-confirmed erythema migrans (EM) greater than 5 cm in diameter but with no history of residence in, or visit to an endemic area or risk area.[211]

Figure 12.4: Incidence rate of Lyme disease, including confirmed and probable, in Simcoe Muskoka and Ontario, 2000–2016.



12.2 Exposure

12.2.1 Mosquito-borne Illness

The risk of human exposure to mosquito-borne illnesses is primarily dependent on two factors: the presence of vectors with the ability to transmit the virus to humans in a geographical area; and whether or not those vectors are infected with a pathogen.[214] Other factors determining exposure include: seasonality (with positive mosquitoes typically presenting in mid- to late-August);[208] the location of the human population relative to the mosquito habitat; temperature (which impacts on both the rapidity of the life-cycle of the mosquito population and the intensity of viral activity); and the level of exposure between humans and mosquitoes, moderated by personal protection measures such as activity, clothing, repellant, and housing (e.g. screens). Individuals who spend greater time outdoors for work or recreation may be at greater risk of being exposed to mosquito-borne illnesses such as WNv if they do not take preventative measures against mosquito bites.

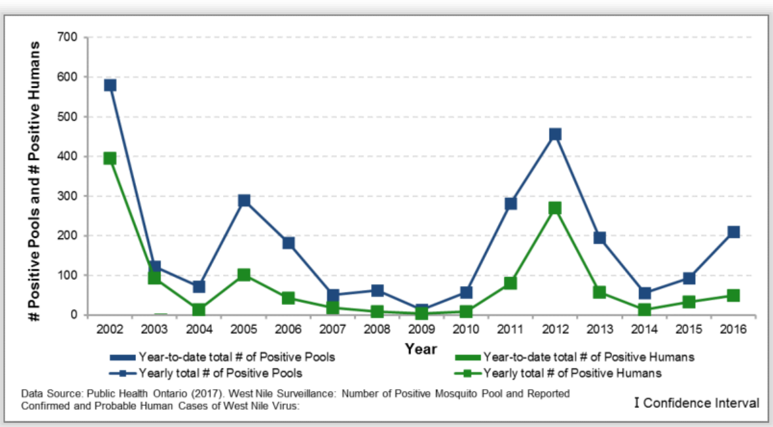
Mosquitoes that are able to transmit WNv and EEEV from birds to humans are called 'bridge vectors'; within Ontario, the main bridge vectors for WNv are the species *Culex pipiens* and *Culex restuans*. These *Culex* spp. mosquitoes typically develop in man-made containers (e.g. bird baths, empty flower pots, rain barrels, catch basins) and thus are generally of greater threat in urban environments. When looking at adult mosquito surveillance data, overall numbers of mosquitoes tend to be highest within Muskoka municipalities, although the predominant species identified is *Coquillettidia perturbans*, a ‘nuisance biter’ and an incompetent WNv vector. In contrast, within urban municipalities located in southern Simcoe County, mosquito numbers tend to be lower than that of the north, but the percentage of *Cx. pipiens/restuans* within the trapped adult mosquito population tend to be high.[214] This tendency for *Cx. pipiens/restuans* to be present in urban environments may be important with our warming climate, as urban heat islands impact on the temperature experienced in our urban municipalities. Alternatively, the mosquito vector primarily responsible for transmitting EEEV, *Culiseta melanura*, tend to develop in flooded hardwood forests, which typically occur in rural areas. The proximity to swampy environments (within approximately 8 km) is an important risk factor to consider for human exposure to EEEV.[204]

While *Cx. pipiens/restuans.* mosquitoes are the main vectors responsible for transmitting WNv in Ontario, there are other species that are also capable of spreading WNv and EEEV from birds to humans (See Appendix M for list of identified mosquito species in Simcoe Muskoka). In 2015, 36% of the adult mosquitoes trapped during vector-borne disease surveillance in Simcoe Muskoka were identified as WNv bridge vectors (with WNv enzootic vectors *Cx. pipiens/restuans* making up approximately 5% of all mosquitos tested), 0.5% were EEEV vectors, and 64% of mosquitoes trapped were non-WNv or EEEV vectors.[215]

Positive Mosquito Pools

Within Ontario, the presence of WNv-positive mosquito pools is an indicator of WNv risk and activity within a community. A mosquito pool is generally defined as a collection of mosquitoes (approximately 50) of a species that have been trapped during mosquito surveillance. In the case of WNv and EEEV, positive mosquito pools are collections which have tested positive for WNv or EEEV. As the number of mosquitoes with the virus increases in the province, rates of human cases tends to increase; thus positive pools can be used to help determine disease and exposure risk within a community. This trend can be observed within Figure 12.5.

Figure 12.5: West Nile virus: number of yearly human cases (confirmed and probable) and number of positive mosquito pools in Ontario, 2002–2016 (Data Source: PHO, 2016*).*



Within Simcoe County, adult mosquito trapping is routinely completed throughout the months of June to September. Between 2005 and 2016, a total of 11 WNv positive pools were identified, with the largest number of pools identified in 2012, a year which was the second highest with respect to WNv activity since its emergence in 2002 (Table 12.1).

Table 12.1: Total number of traps, mosquitoes, pools tested and positive pools, and human cases (confirmed and probable) for WNv within Simcoe Muskoka, 2010–2016.[214]

	2010	2011	2012	2013	2014	2015	2016	Average all years
Total # of Traps	202	248	286	301	265	232	270	258
Total # of Mosquitos collected	12,500	16,854	15,665	12,618	16,410	11,178	6,482	13,101
# of Pools viral tested (WNV)	484	219	241	154	354	331	247	290
# of Positive Pools (WNV)	0	1	3	2	0	1	2	1
# of Human Cases	0	2	3	2	1	0	1	1.29

Climate Change and West Nile virus Exposure Risk

Climatological factors, including temperature and precipitation, play an important role in the life-cycle of mosquitoes.[216] As temperatures increase, the speed at which the *Cx. pipiens/restuans* mosquito will move through its lifecycle will be increased. As the average spring, summer, and autum temperatures increase across Simcoe Muskoka (see Section 7.0), it can also be expected that the WNv vectors will emerge earlier in the year and continue later into the autumn than currently experienced. More generations of potential WNv vectors per year will increase the abundance of species like *Cx. pipiens/restuans*, and increased temperatures will create optimal conditions for the virus to replicate within the mosquito. Changes in precipitation patterns may also support or inhibit the ability for mosquitoes to proliferate WNv, by impacting the availability of larval habitats[217-219] and changing the distribution of other preferred hosts such as birds.[219] In addition, with warmer winters there is an increased overwintering potential for mosquitoes infected with the virus, supporting the initiation of the infection cycle earlier in the spring.[220]

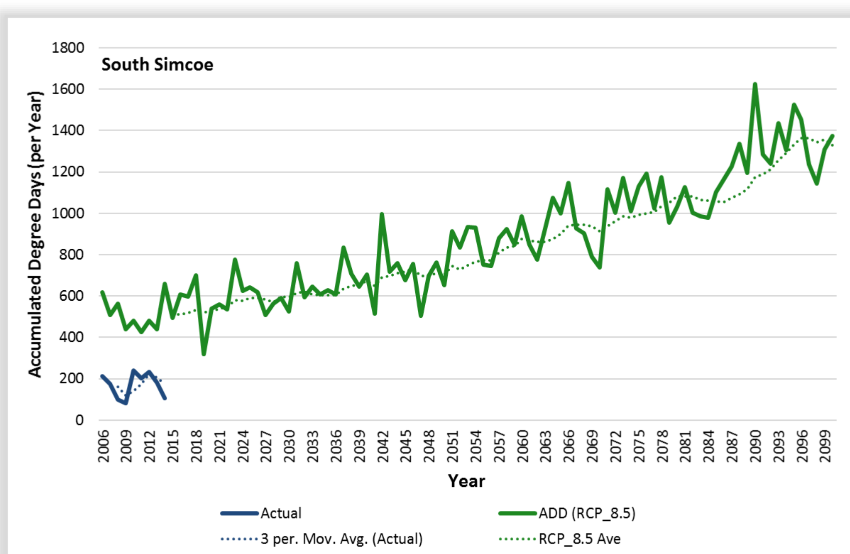
To identify the risk of WNv activity, degree days can be examined. A 'degree day' is a:

> "unit of measurement for temperature. Degree days are the amount of heat required for an organism to develop within certain life stages. Degree days are typically used in agriculture to determine when insect pests will become a problem".[221]

Accumulated degree days (ADD) are "the continuous addition of consecutive degree days from a set starting point".[221] For WNv, ADDs are used to measure the amount of heat over the course of a season. This is useful to inform WNv risk levels, possible environmental interventions (e.g. larviciding), and public education strategies, and to analyze trends over time. A degree day for *Cx. pipiens/restuans* occurs when temperatures exceeding 18.3°C have accumulated for a total of 24 hours.[209]

The impact of climate change on projected ADDs for south Simcoe County can be seen in Figure 12.6. As temperature increases under the RCP8.5 'business as usual' scenario, it is projected that the number of accumulated degree days will increase from approximately 600 in 2006 to approximately 1400 by 2098, increasing the favourable climate conditions for *Cx. pipiens/restuans* proliferation in our area.

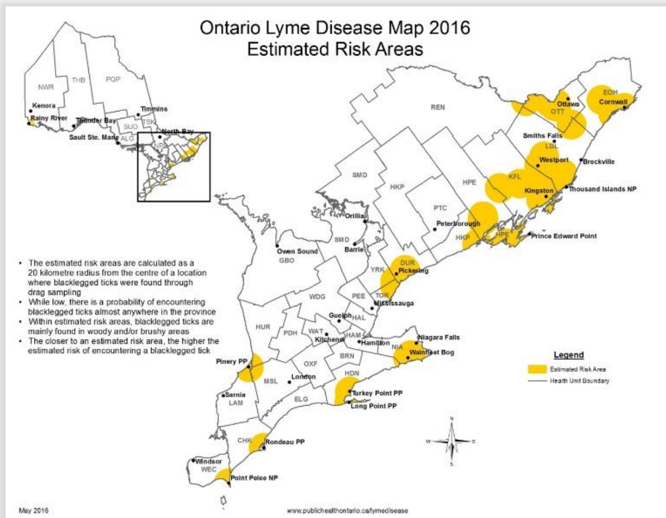
Figure 12.6: Projected accumulated degree days (above 18°C) for South Simcoe under climate change scenario RCP8.5, 2006–2099 (Ontario Climate Change Projections.)[9]



12.2.2 Tick-borne Illness

Lyme disease is the primary tick-borne illness of concern in Ontario, with interactions between ticks and humans generally occurring in deciduous or mixed forests areas - the primary habitat of the blacklegged tick.[208] In the early 1990s there was only one recognized Lyme disease endemic area in Ontario (Long Point Provincial Park); the distribution of blacklegged tick populations has since increased across the province, facilitated by migratory birds that transport ticks[222] and increasing temperatures,[223] with associated risk areas for Lyme disease also spreading. Individuals who spend time outdoors for work or recreation in these affected areas are at greater risk of exposure to blacklegged ticks carrying *B. burgdorferi* if they do not adopt preventative measures against tick bites. Estimated risk areas for Lyme disease across the province can be seen in Figure 12.7. Currently, there is no identified risk area for Lyme disease within the Simcoe Muskoka region.

Figure 12.7: Estimated risk areas for Lyme disease in Ontario in 2016).[224; xxxii]



Since 2007, SMDHU has been performing passive tick surveillance, which involves the submission of ticks that have been attached to a human.[xxxiii] The passive tick surveillance program facilitates the identification and bacterial testing[xxxiv] of ticks through the Public Health Ontario and Public Health Agency of Canada laboratories. Between 2007 and 2016, 502 ticks were submitted to the SMDHU for identification and testing; 30% of ticks submitted during this time frame were identified as *I. scapularis*. An increase in tick submissions has occurred since the beginning of passive tick surveillance at the health unit; this can be attributed to both an increased awareness of Lyme disease as well as the tick submission program by the public.

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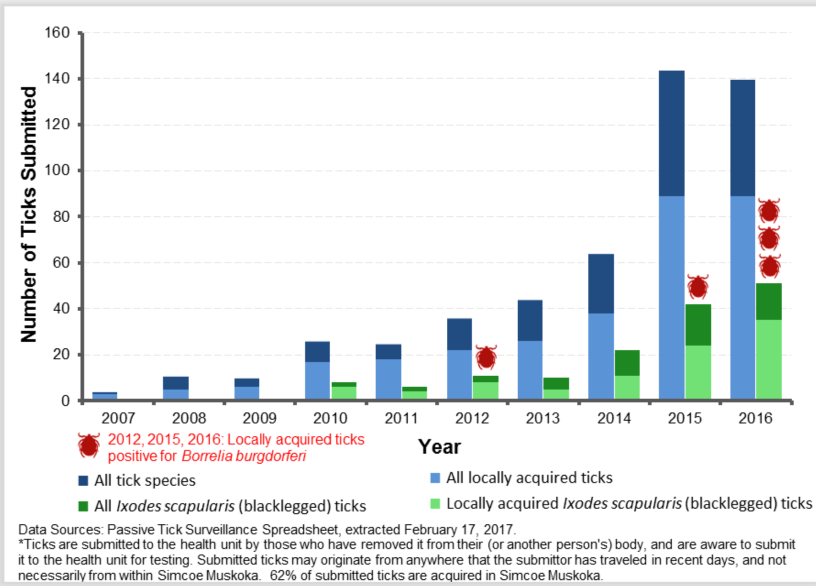
xxxii This illustration was adapted with the permission of Public Health Ontario.224 Public Health Ontario assumes no responsibility for the content of any publication resulting from translation/changes/adaptation of PHO documents by third parties.

xxxiii At the beginning of the passive tick surveillance program, all ticks (those attached to humans and pets) where submitted for identification.

xxxiv As blacklegged ticks are the only carriers of the bacteria which causes Lyme disease, only ticks which are identified as blacklegged are sent on for bacterial testing.

Of blacklegged ticks submitted, the majority (62%) were acquired locally, 23% were acquired outside of Simcoe Muskoka, and 15% had an unknown acquisition location. Four locally acquired blacklegged ticks tested positive for the bacteria that causes Lyme disease (*Borrelia burgdorferi*); one each in 2012 and 2015, and two in 2016. Five additional blacklegged ticks have tested positive for *B. burgdorferi* in 2014–2016; three were acquired in Ontario outside of Simcoe Muskoka, one was acquired in the US, and one had an unknown acquisition location (Figure 12.8).

Figure 12.8: Tick submissions to Simcoe Muskoka District Health Unit, 2007–2016.

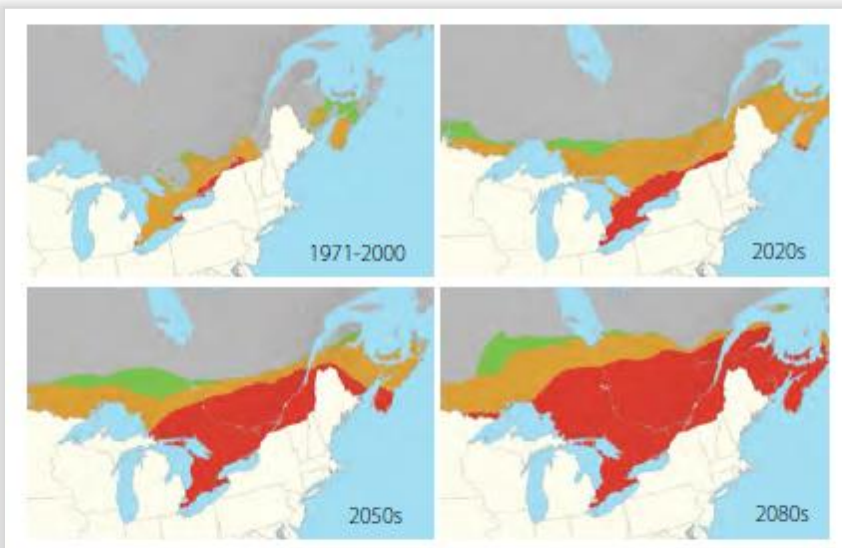


Climate Change and Lyme Disease Exposure Risk

The ability for blacklegged ticks to become established in an area is impacted by multiple factors, including both climate and habitat.[223] Public Health Ontario identified "climate change, specifically the increase in the mean annual degree days above 0°C", as a driving factor in the expansion of blacklegged ticks across the province (p.2),[213] with climate change expected to continue to support the expansion of tick populations throughout the province.[222] The other factors of importance in the spread of blacklegged ticks are land use (conversion of farmland to forests, human encroachment) and availability of habitat,[213] and the range and availability of the main hosts of blacklegged ticks, the white-footed mouse and white-tailed deer.[213]

A study by Ogden and colleagues[222] examined the potential range expansion of blacklegged ticks with respect to climate change (Figure 12.9). Within the study, maps were created which highlight areas of high risk for blacklegged tick expansion, areas where ticks are likely to be established, and areas of very low risk of tick expansion, for baseline (1971–2000), 2020s, 2050s and 2080s. These maps illustrate potential expansion range of blacklegged ticks, covering all of Southern Ontario and Quebec by the 2080s. This spread has also been observed through the review of vector surveillance data which indicates the spread of vectors along climate-determined geographic trajectories at a rate of 35 to 55 km per year.[5] As the climate changes and temperatures rise, the risk of more established blacklegged tick populations, and thus potential for Lyme disease, can be expected to increase in Simcoe Muskoka. It should also be noted that there must be both suitable habitat and hosts within these potentially expanding risk areas, for the blacklegged tick to become established.

Figure 12.9: Risk maps for the establishment and spread of the Lyme disease vector Ixodes scapularis for 1971–2000, the 2020s, 2050s and 2080s. Green areas identify locations where I. scapularis may become established; orange and red areas indicate increased risk of I. scapularis population establishment; grey areas indicate low risk of I. scapularis population emergence (Source: Ogden and colleagues, 2008).[222]



12.3 Sensitivity

While any individual who is bitten by an infected vector, such as a mosquito or tick, has the potential to contract a vector-borne disease; certain populations[xxxv] (the elderly, children, pregnant women, individuals with pre-existing illnesses) are more sensitive to health impacts of vector-borne illnesses. As the global climate changes, individuals who travel to areas of the world where other VBDs are endemic will also have increased susceptibility to those diseases.[18]

xxxv For specific information on number and distribution of these individuals within Simcoe Muskoka, please see the discussion within Sections 6.0 & 7.0.

12.4 Adaptive Capacity

Table 12.2 below highlights current and potential actions, key partners, and mitigation co-benefits surrounding VBD adaptive capacity within the health unit jurisdiction. For information on a sample of adaptive capacity measures occurring within the community by municipalities, conservation authorities and community organizations, see Section 14.0.

Table 12.2: Current and potential actions taken by the Simcoe Muskoka District Health Unit to support adaptive capacity for climate related impacts to VBDs.

Public Health Role	Type of Action (current/for consideration)	Activities	Key Partners	Mitigation Co-Benefit
Population Assessment	Current	Identification of populations most at risk for VBD.		
		Case investigation of reported cases of VBD.	Health care providers	
	For Consideration			
Surveillance	Current	Monitoring of incidence of VBD.		
		Adult mosquito & larval monitoring (species & abundance). Viral testing of adult mosquito pools.	Municipal staff Laboratories Universities	
		Passive tick surveillance.	Health care providers Veterinarians	
	For Consideration	Active tick surveillance.	Provincial Parks Municipal partners Veterinarians	
		Monitoring of other mosquito and tick species that may become established in SMDHU with climate	Laboratories Provincial Parks	

Public Health Role	Type of Action (current/for consid-eration)	Activities	Key Partners	Mitigation Co-Benefit
		change.	Municipal partners	
Health Promo-tion (Policy Development, Advocacy & Public Educa-tion)	Current	Policy development related to property standard by-laws and stormwater infrastructure relating to standing water.	Municipal staff	
		Public Education re: prevention and protection.	Media Health care providers Conservation Authorities	
	For Consideration			
Health Protec-tion (Disease and Injury Preven-tion)	Current	Risk assessment process to determine locations for larviciding.	Municipal staff	
		Support for larviciding on non-municipal lands.	MOECC	
		Support development of policies for outdoor workers with partners.	Ministry of Labour Municpalities	
		WNV Adulticiding Contingency Plan.	MOHLTC PHO	
	For Consideration			

13.0 Exposure to Ultraviolet Radiation

Key Considerations:

- Temperature increases, as well as behavioral variables, are expected to impact levels of ultraviolet radiation exposure, increasing rates of non-melanoma skin cancers.
- Basal cell carcinomas are projected to increase by 7.8% (2050) and 13.1% (2080) due to climate change; squamous cell carcinomas are projected to increase by 14.8% (2050) and 24.8% (2080).
- Individuals with fair skin with a tendency to burn are at higher risk of developing skin cancers. Within the 2011 National Household survey, 92% of individuals living in Simcoe Muskoka self-identified as Caucasian, a group which is at higher risk of skin cancers due to UV radiation exposure.

Ultraviolet radiation (UVR) is an electromagnetic radiation that is emitted from the sun into our atmosphere. Two main types, UVA and UVB, impact health; UVA rays are linked to long-term skin damage, and have been linked to increased skin cancer risk. UVB rays have higher levels of energy than UVA, and are the main cause of sunburns. UVB damages the DNA of skin cells, and is a main cause of skin cancers.[225]

Exposure to UVR is a facilitator in the synthesis of vitamin D, an important vitamin that supports calcium absorption.[226] However, overexposure to UVR can be detrimental, increasing risk of skin cancers[227] and exposure to UVB radiation has been well documented to be linked to non-melanoma skin cancers.[19] Exposure to solar UVR is the leading environmental cancer-causing agent in Ontario, significantly ahead of the next leading environmental carcinogens, radon and $PM_{2.5}$.[122] The following section identifies the current burden of illness due to skin cancer for the Simcoe Muskoka region, and identifies the factors that influence risk of exposure to UVR, sensitivity to UVR, and adaptive capacity actions that can be implemented to decrease impacts in the future.

13.1 Current Burden of Illness

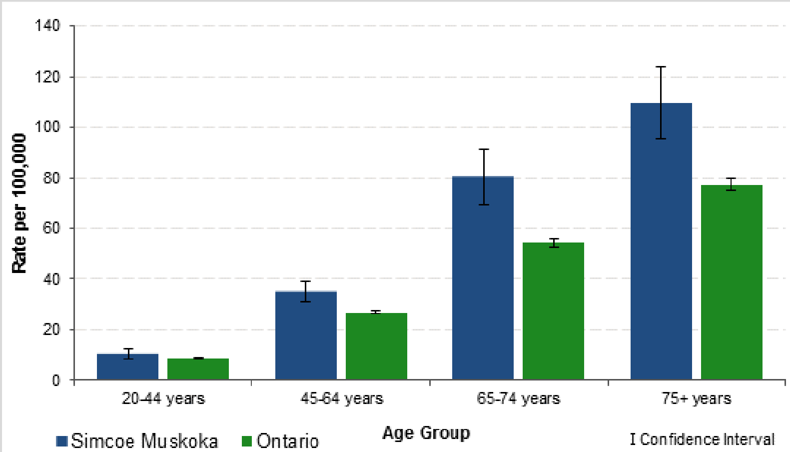
Skin cancer is the most commonly diagnosed type of cancer in Canada. It can be categorized into two types: non-melanoma, a generally non-life threatening illness that originates in the basal and squamous cells of the skin; and melanoma cancers, a life-threatening illness that develops in the melanocytes of the skin.[228]

Within non-melanoma cancers, there are two common types, basal cell and squamous cell carcinomas. Basal cell carcinomas are the most common of the non-melanoma skin cancers, making up 75% of non-melanoma cases; 20% of non-melanoma cases are made up of squamous cell carcinomas.[229] Other rare non-melanoma cancers can also occur, including Merkel cell carcinoma and Kaposi's sarcoma.[229] While non-melanoma skin cancers are the most commonly diagnosed cancers in Canada, specific rates and statistics for non-melanoma skin cancers in Canada are not currently reported, due in part to their ease of treatment in general physicians' offices.[228]

The second form of skin cancer, melanoma, is a malignant tumour that originates in the melanocytes of the skin.[230] While malignant melanoma is less common than other forms of skin cancer; it is an illness which has the potential to metastasize to other areas of the body.[231] Leading causes of melanoma are UV exposure and sunburns; in Ontario, 2540 cases of melanoma each year can be attributed to solar UV radiation, or approximately 80% of cases.[122]

Cancer incidence and mortality rates for malignant melanomas in Simcoe Muskoka can be accessed through the Ontario Cancer Registry (OCR) operated by Cancer Care Ontario.[232] In 2012, among Simcoe Muskoka residents there were 141 new cases of malignant melanoma diagnosed (age-standardized rate of 20 new cases per 100,000 persons); a rate that is significantly higher than the Ontario age-standardized rate (16 per 100,000). The rates of malignant melanoma diagnosis in Simcoe Muskoka have increased by an average of 2.5% per year from 1986 to 2012.[232] Age-standardized incidence rates were significantly higher among males (26 per 100,000) than females (15 per 100,000). The risk of being diagnosed with malignant melanoma also significantly increased with age, with the highest incidence rates found in those aged 75 and older, at 109 per 100,000 (Figure 13.1).

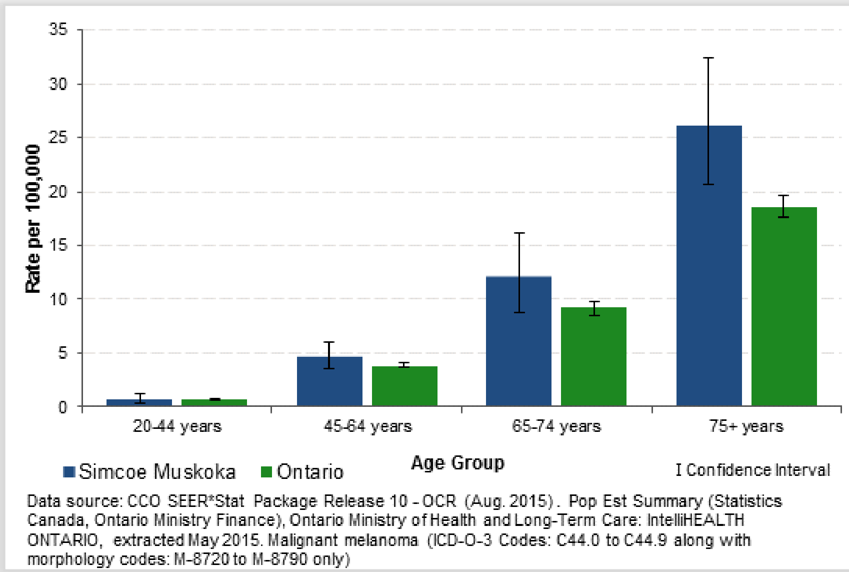
Figure 13.1: Age-specific incidence rate (per 100,000) malignant melanoma, Simcoe Muskoka and Ontario, 2007–2012 (combined).



Data source: CCO SEER*Stat Package Release 10 - OCR (Aug. 2015). Pop Est Summary (Statistics Canada, Ontario Ministry Finance), Ontario Ministry of Health and Long-Term Care: IntelliHEALTH ONTARIO, extracted May 2015. Malignant melanoma (ICD-O-3 Codes: C44.0 to C44.9 along with morphology codes: M-8720 to M-8790 only)

Between 2004 and 2012, 195 residents of Simcoe Muskoka died from malignant melanoma (age standardized mortality rate of 3.2 per 100,000); a rate significantly higher than that of Ontario (2.5 per 100,000). Rates were significantly higher among males (4.9 per 100,000) than females (1.8 per 100,000), with mortality increasing significantly with age (Figure 13.2).

Figure 13.2: Age-specific mortality rate (per 100,000) malignant melanoma, Simcoe Muskoka and Ontario, 2004–2012 (combined)



13.2 Exposure to Ultraviolet Radiation

Many factors dictate the amount and type of UVR that an individual is exposed to when outdoors, including variation due to geographic location, the time of year and season, and the time of day; generally, rates of UVR are greatest in areas closest to the equator, during the summer months, and during the peak daylight hours of 10 a.m. to 3 p.m.[233] Other factors that influence exposure to UVR include the level of ozone and cloud cover, pollution levels, and altitude, with higher UV exposure experienced at higher altitudes due to the decreased ability of the thinner atmosphere to filter UV rays.[234]

Changes to temperature due to climate change may also elevate the level of UVR exposure and associated non-melanoma skin cancers, through increased length of warmer seasons, as well as increased temperatures during the warmer months. A study by van der Leun and colleagues[235] identified a link between temperature, UV exposure, and rates of basal and squamous cell carcinomas. This study identified an increase in the incidence of basal (2.9%) and squamous (5.5%) cell carcinomas per degree Celsius increase in summer temperature. Based on increases in temperature in Simcoe Muskoka projected as a result of climate change, this could result in 13.1% and 24.8% increases in the rates of basal and squamous cell carcinomas, respectively, by the 2080s (Table 13.1). While we have limited data to track the incidence and trends in non-melanoma skin cancers, research suggests that the incidence of basal and squamous cell carcinomas in Canada may be increasing at a rate similar to that observed for melanoma skin cancers.[236,237] The lack of longitudinal studies exploring the relationship between non-melanoma skin cancers and temperatures make it difficult to determine the interaction between long-term trends in cancer incidence and the impacts of increasing temperatures.

Table 13.1: Projected percentage (%) increase in basal and squamous cell carcinoma for the Simcoe Muskoka District Health Unit for the 2050s and 2080s over the baseline period (1971–2000).[19]

	2050s	2080s
% increase in Basal Cell Carcinomas	7.8	13.1
% increase in Squamous Cell Carcinomas	14.8	24.8

Additionally, individuals who work outdoors may have greater exposure to UVR and its impacts, due to their increased time spent in outdoor environments. Information about the rate of individuals working outdoors is not available for Simcoe Muskoka. However, the County of Simcoe and the District of Muskoka have 2189 and 175 census farms, respectively, within their borders.[54] Within the 2011 National Household Survey 4395, or 1.2% of the labour force in Simcoe County, identified that they were occupied within natural resources, agriculture and related production occupations;[55] a total of 730, or 2.5% of the total labour force within Muskoka, identified as working within these same sectors. This does not include other types of outdoor workers (e.g. construction workers) who may also be at risk as a result of occupational exposures.

While environmental factors influence the amount of UVR present in a specific location, individuals have the opportunity to influence the amount of exposure to UVR that they experience on a daily basis. Practising personal protective measures, including wearing protective clothing, such as hats, sunglasses, and tightly-knit clothing; avoiding the intense midday sun; and applying sunscreens that protect against both UVA and UVB rays can aid in limiting the level of radiation to which an individual is exposed.[238] Additionally, community design can increase protection from UVR, through the increased availability of shade, either from urban tree canopies (which also help to decrease impacts due to extreme heat), or artificial shade structures.[239] However, other research has pointed out that warmer ambient temperatures due to climate change may be associated with individuals wearing fewer clothes that protect the skin, increasing exposure.[234] Sun avoidance may also decrease levels of physical activity[240] which can increase risk for other chronic illnesses.

In 2012, information on sunburns and rates of personal protective behaviours was collected using the Rapid Risk Factor Surveillance System (RRFSS) (Results found in Table 13.2). While some Simcoe Muskoka adults (≥18 years) do practise protective behaviours to reduce their UVR exposure, enhanced messaging to promote these behaviours may be needed to increase the proportion of adults who are engaging in sun-protective behaviours as our future climate change increases.

Table 13.2: Proportion of Adults (18+) within Simcoe Muskoka who reported practicing sun safety protective behaviours, 2012 (Rapid Risk Factor Surveillance System, 2012).

	% (CI)
Proportion of adults who report avoiding the sun during peak hours between 11 a.m. and 4 p.m.	42.2% (36.9 – 47.5%)
Proportion of adults who report wearing sunglasses with U.V. protection	69.8% (64.9 – 74.7%)
Proportion of adults who report wearing protective clothing, including a hat, when in the sun	53.2% (47.8 – 58.5%)
Proportion of adults who report wearing sunscreen when in the sun	39.9% (34.7 – 45.2%)

13.3 Sensitivity to Ultraviolet Radiation

Specific groups may be more sensitive to the impacts of UVR within our area; specifically children, due to their reliance on caregivers.[238] Within Ontario, childcare centres are mandated to have at least two hours of 'outdoors' time per day (weather permitting) for children that receive care for six or more hours in one day.[241] These guidelines include the infant population of 0 to 18 months. Although some childcare centres do ensure measures are in place to decrease UVR exposure during this time, there is currently no requirement to provide shade and/or use other protective measures such as sunscreen within provincial regulations.[241]

Individuals who are fair-skinned with a tendency to burn due to the sun may also be more sensitive to the impacts of UVR.[238] Other risk factors for skin cancer include blue or green eyes, blonde or red hair, a family history of skin cancer, and a history of sunburns, especially those that occur early in life.[242] On the basis of visible minority statistics available from the National Household Survey,[55] 92% of individuals in Simcoe Muskoka self-identify as Caucasian. This indicates that a large majority of the Simcoe Muskoka population is at high risk for UVR exposure-related skin damage and skin cancer.

13.4 Adaptive Capacity Measures to Reduce Ultraviolet Radiation Impacts

Table 13.3 below highlights current and potential actions, key partners, and mitigation co-benefits surrounding UV radiation adaptive capacity within the health unit jurisdiction. For information on a sample of adaptive capacity measures occurring within the community by municipalities, conservation authorities and community organizations, please see Section 14.0.

Table 13.3: Current and potential actions taken by the Simcoe Muskoka District Health Unit to support adaptive capacity for UV radiation exposure.

Public Health Role	Type of Action (current/for consideration)	Activities	Key Partners	Mitigation Co-Benefit
Population Assessment	Current Activities	RRFSS data to indicate sun safety behaviours.		
	For Consideration	Identification of population that does not engage in sun protective measures.		
Surveillance	Current Activities	Monitoring and reporting of malignant melanoma.		
		Include UV Index in weather monitoring.		
	For Consideration	Approach the Ontario Cancer Registry to track basal cell and squamous cell carcinoma.		
Health Promotion (Policy Development, Advocacy & Public Education)	Current Activities	Official policy statements related to preservation of trees and provision of shade structures.		✓
		Engagement with municipal/park staff and workplaces re: tree preservation and planting, and provision of shade structures.	Municipalities Conservation Authorities	✓
		Provision of sun safety material in Child Care Manual and Recreational Camp Manual.		
		Policy development to support naturalized outdoor play areas.	Municipalities School Boards	✓
		Public messaging and education re: sun safety.	Municipalities Provincial Parks	
	For Consideration	Public Messaging when the UV Index is high.		
Health Protection (Disease and Injury Prevention)	Current Activities	Internal policies re: sun safety for outdoor workers.		
	For Consideration			

14.0 Community Actions: Mitigation and Adaptation

Climate change mitigation is defined as the reducing, stabilizing, and/or sequestering of greenhouse gas emissions.[4] Mitigation can be accomplished through the decreased emission of carbon; for example, decreasing emissions within industry, decreasing traffic related emissions, etc. It can also be achieved through increasing activities that sequester carbon from the atmosphere; for example, through planting trees or preserving greenspace to utilize carbon within the photosynthesis process. Adaptation, another key and equally necessary component associated with climate change, is defined as the preparing for and adapting to environmental changes as a result of climate change.[6] Adaptation ensures policies, programs, and infrastructure are in place so communities can cope with climate change impacts that cannot be mitigated; being resilient and able to adapt to this change will help to reduce health burdens caused by a changing climate.[7]

To support stakeholder engagement and to identify a sampling of mitigation and adaptation activities which are currently occurring in Simcoe Muskoka, key informant interviews were completed during the vulnerability assessment process. Fifteen individuals from a variety of organizations, including conservation authorities, education, health care, government ministries, local municipalities, and not-for-profits, participated in this process. Participants were asked to identify mitigation and adaptation activities which their organization is currently participating in, or that they hope to implement in the future (discussed below). Participants were also asked about priority health risks and key vulnerabilities that they felt were of relevance for Simcoe Muskoka. The full results of the key informant interviews will be available within a separate report released later this year.

Table 14.1 and 14.2 identify current and future mitigation actions being implemented by local organizations, municipalities, and conservation authorities across the Simcoe Muskoka region. Current and future adaptation activities are presented in Tables 14.3 and 14.4. Because actions are not being associated with specific organizations in the tables below, it must be noted that some actions may be included in both the current and future tables; this is due to the fact that the organizations participating within the key informant interviews are at a variety of stages of readiness, and actions which are currently implemented for some organizations may be future actions for other agencies. While these mitigation and adaptation actions are being led and implemented by community and municipal partners, some of the activities also have co-benefits for public health.

Additionally, while the key informant interviews included participation from a variety of organizations from multiple fields, the information gathered from the interviews is only a sampling of potential actions that are currently occurring throughout the region. A more fulsome engagement of stakeholders is expected to occur within Phase II (Stakeholder Engagement) of the SMDHU Climate Change Action Plan. For listing of actions being taking by the health unit, please refer to adaptive capacity sections in previous chapters.

Table 14.1: Current mitigation activities being addressed by organizations within Simcoe Muskoka.

Mitigation Action	Description of Activities
Active Transportation	• Encouraging employees to use active transportation to get to work. • Supporting the widening of roads to include active transportation infrastructure.
EcoSchools and In-house Education Programs	• Providing supports to reduce electricity use and decrease waste in schools. • Greening school grounds. • Educating school staff and students about the environment. • Supporting EcoSummits for elementary and secondary school students. • Implementing composting programs in schools. • Implementing environmental awareness campaigns in schools. • Participating in the Ministry of Natural Resources Envirothon for schools.
Energy Conservation/ Reduction	• Implementing energy audits and targets. • Conducting LEED certification of buildings. • Installing LED lighting. • Utilizing natural light rather than artificial. • Installing light sensors. • Battery backups for emergency situations. • Installing solar panels. • Making adjustments to heating, air conditioning and ventilation. • Enhancing the energy efficiency of buildings.
Green Products	• Using environmentally friendly cleaning products.
Green Spaces	• Encouraging and enhancing tree planting. • Supporting native tree selection during the planting process. • Implementing sustainable forest management practices. • Protecting current green spaces and wetlands. • Implementing green roofs and gardens. • Supporting school ground greening. • Enhancing natural heritage programs, especially within urban environments.
Locally Sourced Food	• Using a voucher program to support food-insecure individuals to access local food at farmers markets. • Gleaning[xxxvi] programs to reduce food waste.
Reducing Contamination	• Reducing the amount of salt used in road maintenance.

xxxvi Gleaning is the removal/collecting of food products left in production areas after the initial harvest by a farmer has been completed.

Mitigation Action	Description of Activities
Reducing Emissions	• Installing charging ports for electric vehicles. • Purchasing hybrid and electric vehicles for fleets. • Encouraging carpooling. • Promoting and developing policies related to tele-meetings. • Implementing policies to reduce idling of fleet vehicles. • Purchasing locally sourced food to reduce travel-related emissions.
Reducing Waste	• Enhancing recycling programs within office/school environments. • Enhancing organics programs within office/school environments. • Installing water bottle filling stations to decrease plastic water bottle use. • Supporting ‘litterless lunch’ campaigns and ‘no-waste’ schools. • Repurposing day-old bakery products to reduce food waste.
Renewable Energy	• Utilizing wind power generated energy.
Use of Technology	• Utilizing computer programs such as Google Docs to decrease the amount of photocopying. • Promoting virtual meetings (web conferencing, teleconferencing). • Telecommuting and working from home programs.
Water Management	• Managing sports fields irrigation systems (e.g. reducing use of irrigation equipment if raining/recently rained). • Supporting erosion management of creeks through engineering standards.

Table 14.2: Future mitigation activities identified by organizations within Simcoe Muskoka.

Mitigation Action	Description
Energy Conservation/ Reduction	• Implement environmental standards for new construction, including LEED standards.
Green Products	• Mandate the use of environmentally friendly/green products.
Green Spaces	• Plant trees. • Create community gardens. • Greening of school grounds, including school community gardens and vegetable gardens to supplement the breakfast club.
Reducing Emissions	• Enforcing anti-idling by-laws/policies.
Reducing Waste	• Address the issue of single use plastics and vending machines in schools. • Put in a water-filling station.
Use of Technology	• Use technology more to decrease paper use. • Explore what other avenues can be implemented to make virtual offices (i.e. tele-working policy) more effective.
Water Management	• Address other phosphorus sources. • Focus on cold water fisheries and the impacts of climate change.

Table 14.3: Current adaptation actions being addressed by organizations within Simcoe Muskoka.

Adaptation Action	Description
Budget Allocation	• Including climate change adaptation within the budgeting process (i.e. enhancing budget for emergencies, supporting further planning through increasing research to support decreased building in flood plains).
Community Programs	• Neighbours helping neighbour programs that helps build resiliency and preparedness for extreme weather events.
Education and Awareness	• Educating communities about resilience. • Educating students on the current impacts of climate change. • Engaging communities in discussions on climate change. • Increasing municipal knowledge on the impacts of climate change. • Student engagement through environmental leadership programs, enviro film fest, outdoor education, water festivals, and campaigns on single-use plastics. • Enhancing skills for food preparation/preservation (canning, freezing, etc.). • Community climate change report cards.
Infrastructure/Built Environment Design	• Planning for severe storms when designing buildings or infrastructure. • Greening school grounds and increasing access to shade. • Including generators in building design.
Partnership and Collaboration	• Partnering with other agencies experiencing similar impacts to increase knowledge exchange. • Partnering in storm water management programs, water quality and quantity monitoring. • Partnering between municipalities to support climate change adaptation. • Emergency preparedness collaborations.
Planning and Preparedness	• Creating sustainability plans. • Creating climate change strategic plans, strategies, and action plans. • Including climate change planning within master plans. • Implementing plans to deal with inclement weather emergencies. • Implementing policies relating to climate change, including extreme cold, and planning related policies. • Annual HIRA review including a climate change perspective. • Increasing surveillance. • Updating storm water management guidelines. • Creating storm water model and infrastructure plans.

Adaptation Action	Description
Research and Re-sources	• Conducting research to better understand storm water management capacity, management of floods and frequent high flows. • Completing science and policy publications surrounding climate change that support the assessment of local ecosystems and watershed vulnerabilities, assess risk, and generate adaptive solutions that provide benefits for people and biodiversity. • Implementing comprehensive monitoring programs. • Completing phosphorus monitoring.
Water Management	• Increasing storm water management strategies, including the use of extended parking lots to reduce run-off, creating storm water management guidelines, and increasing size of culverts. • Updating flood plain mapping. • Assessing ecosystem and watershed vulnerabilities to climate change. • Reducing the amount of phosphorus in water runoff into river systems and lakes by determining where the main sources of phosphorus are coming from through models that take climate change into account.

Table 14.4: Future adaptation actions identified by organizations within Simcoe Muskoka.

Adaptation Action	Description
Assisting At-Risk Populations	• Assist at-risk populations 24 hours a day during extreme heat and cold warnings.
Education and Awareness	• Share initiatives that have been done to address climate change with other agencies. • Educate the public on the impacts of idling (e.g. air quality). • Continue to support “eco clubs” in schools. • Educate employees on infrastructure resiliency. • Educate the public about what perishable items can be donated to food banks (e.g. fruit, vegetables, eggs, milk). • Host adaptation planning workshop for emergency management. • Appoint climate adaptation liaison to increase awareness. • Educate school children about protecting the environment.
Infrastructure/Built Environment Design	• Supporting infrastructure resiliency and how to build and plan better. • Include a back-up generator in new buildings to ensure 24-hour coverage for extreme heat and cold.
Partnerships and Collaboration	• Collaborate to determine what the focus should be moving forward for climate change. • Determine role in helping community partners with flood management. • Work with community partners to get fresh produce for food banks all year round. • Work with community partners to develop a policy around expiry versus best-before dates. • Collaborate with stakeholders to implement local work, and provide encouragement and guidance to move forward. • Collaborate to address climate change (e.g. ensuring that those who are doing similar projects work together).
Planning and Preparedness	• Develop a climate change plan/strategy. • Create a strategic plan that includes the development of an action plan to advance smart, sustainable community building and development. • Create a policy for food banks regarding expiry date versus best-before date. • Finish climate change strategy that will inform other work (e.g. master and official plans).
Research	• Expand water quality monitoring program beyond phosphorus to learn more about the changing climate (e.g. temperature, invasive species).

15.0 Conclusion

According to the Facing Climate Change report,[20] no single policy or program can solve climate change. Cooperation and collaboration between partners, on a wide range of mitigation policies and adaptation strategies, can result in multiple benefits. The public health community has an important perspective to share about climate change, a perspective that can help to make the problem more personally relevant, significant, and understandable to members of the public.[3] Reframing climate change from an environmental to a public health issue increases public engagement in adaptive and mitigative behaviour change, and increases support for climate change policy.

Moving forward, SMDHU has an opportunity to support adaptive capacity actions which will decrease exposure and sensitivity to climate-related impacts on health, and to engage community partners in increasing resiliency to climate change impacts within our communities. The opportunity to increase knowledge translation surrounding mitigation (e.g. sustainable business practices) and adaptation activities (e.g. the extreme temperature response), helps to highlight tangible efforts taken to act locally. These opportunities could influence and advance strategies and policies related to climate change, both within the SMDHU, as well as within community agencies and with our municipal partners.

Next steps for the SMDHU climate change program:

- Develop, utilizing information from the vulnerability assessment and stakeholder engagement, priorities and actions for Phase II of the SMDHU Climate Change Action Plan, including health promotion and community education and engagement plans; and an examination and prioritization of current and future adaptive capacity needs. Priorities will be based on current and future climate change conditions.
- Develop and implement a stakeholder engagement plan that aligns with Phase II (Stakeholder Engagement) of the SMDHU Climate Change Action Plan.
- Review MOECC's Climate Change Action Plan and ensure alignment with SMDHU activities.
- Review updated OPHS standards (when available) and ensure alignment with SMDHU Climate Change Action Plan.
- Share the results of this vulnerability assessment with municipalities and other agencies.
- Launch and promote the SMDHU interactive climate change GIS tool.
- Participate with municipalities and other community agencies in local climate change planning processes.
- Develop a review process for further iterations of the vulnerability assessment, including reporting timelines and indicators.

- Support the creation of an information sharing network that will help to enhance local climate change mitigation and adaptation activities.
- Create resources for community members to increase knowledge of local climate change impacts.
- Review the actions of the SMDHU Environmentally Sustainable Business Practices program to enhance internal mitigation activities.

Final Thoughts: SMDHU supports and agrees with the MOECC's statement below and will continue to strive to mitigate and adapt to climate change:

"Global warming is real. Ontario's people and businesses are already feeling the effects and paying the price. Climate change has damaged the environment. It has caused extreme weather events such as flooding and drought. It has damaged and destroyed infrastructure. It has hurt our ability to grow food in some regions. Climate change is a grave concern but by moving ahead now - Ontario will help make the difference that must be made ..." (pg. 6).[243]

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Appendix A: Northern Region Extreme Climate Data

Indicator	Base line (1990s)	2020s					2050s					2080s				
		5th %	25th %	50th %	75th %	95th%	5th %	25th %	50th %	75th %	95th %	5th %	25th %	50th %	75th %	95th %
Tropical Nights (#)	2.2	0.9	3.3	6.1	10.3	23.8	5.7	14.0	21.0	33.9	57.5	17.3	30.6	40.7	58.9	84.6
Heat Wave Duration Index (#)	12.2	8.6	15.8	23.4	35.1	66.2	19.4	34.4	59.5	91.4	157.1	41.9	77.1	118.5	154.5	250.0
Summer Days (#)	47.9	38.3	51.6	61.4	72.8	89.6	55.3	71.0	82.8	95.5	112.7	74.6	91.6	103.8	116.8	135.3
Frost Days (#)	151.8	117.4	131.4	140.4	148.9	160.0	90.5	110.5	121.6	132.0	145.2	63.5	88.0	101.0	113.2	128.5
Icing Days (#)	79.4	46.7	60.7	69.8	78.8	94.1	27.4	43.7	54.8	65.1	79.0	11.3	25.7	37.9	49.8	66.1
Cold Days (%)	33.4	0	10.2	18.9	30.1	51.7	0	0.8	9.6	19.1	29.7	0	0	3.7	15.2	23.9
Cold Nights (%)	33.3	0	4.8	13.8	22.7	44.4	0	0	8.2	15.9	24.2	0	0	3.7	14.2	20.9

Appendix B: Southern Region Extreme Climate Data

Indicator	Base line (1990s)	2020s					2050s					2080s				
		5th %	25th%	50th %	75th %	95th %	5th %	25th %	50th %	75th %	95th %	5th %	25th %	50th %	75th %	95th %
Tropical Nights (#)	3.5	2.1	5.1	8.6	13.6	26.8	8.2	17.8	25.6	39.1	61.2	22.6	35.2	46.9	65.2	87.9
Heat Wave Duration Index (#)	13.3	7.1	14	21.4	33.3	64	15.1	31.9	58.8	88.8	153.6	33.4	74.2	118.1	152.8	246.3
Summer Days (#)	57.0	33.7	51.4	63.2	77.1	96.7	53.9	72.4	86.1	99.3	118.9	74.8	93.0	106.5	120.5	141.1
Frost Days (#)	150.2	114.3	129.2	137.6	146.3	158.0	88.0	107.5	119.1	129.2	143.2	61.4	84.4	98.5	110.8	126.6
Icing Days (#)	73.1	39.3	52.9	62.1	72.5	88.0	20.5	36.6	47.7	58.5	73.5	5.85	19.8	31.3	43.1	60.2
Cold Days (%)	32.9	0	8.3	17.7	29.4	50.4	0	0	6.6	16.2	27.4	0	0	0.2	11.1	23.2
Cold Nights (%)	33.3	0	4.8	13.8	22.7	44.4	0	0	8.2	15.9	24.2	0	0	3.7	14.2	20.9

Appendix C: Northern Region Average Temperatures (deg. Celsius)

Indicator	Baseline (1990s)	2020s					2050s					2080s				
		5th %	25th %	50th %	75th %	95th %	5th %	25th %	50th %	75th %	95th %	5th %	25th %	50th %	75th %	95th %
Minimum	1.3	0.9	2.2	2.9	3.6	5.4	2.9	4.2	5.1	6.0	7.9	5.2	6.5	7.5	8.7	10.9
Mean	5.6	5.3	6.4	7.0	7.8	9.5	7.1	8.3	9.2	10.0	12.0	9.4	10.5	11.4	12.6	14.9
Maximum	10.5	10.2	11.2	11.8	12.5	14.2	11.8	13.0	13.9	14.8	16.8	13.8	15.1	16.1	17.3	19.8

Appendix D: Southern Region Average Temperatures (deg. Celsius)

Indicator	Baseline (1990s)	2020s					2050s					2080s				
		5th %	25th %	50th %	75th %	95th %	5th %	25th %	50th %	75th %	95th %	5th %	25th %	50th %	75th %	95th %
Minimum	2.0	1.7	2.9	3.6	4.4	6.1	3.6	4.9	5.8	6.7	8.6	5.9	7.2	8.1	9.2	11.6
Mean	6.4	5.9	7.1	7.7	8.4	10.1	7.7	9.0	9.8	10.7	12.5	10.0	11.1	12.1	13.3	15.5
Maximum	11.4	10.7	11.8	12.5	13.2	14.9	12.4	13.7	14.6	15.6	17.6	14.5	15.8	16.9	18.1	20.7

Appendix E: Northern Seasonal Temperatures (deg. Celsius)

Indicator		Baseline (1990s)	2020s					2050s					2080s				
			5th %	25th %	50th %	75th %	95th %	5th %	25th %	50th %	75th %	95th %	5th %	25th %	50th %	75th %	95th %
Spring	Min.	-0.7	-2.8	-1.1	0.0	1.2	3.4	-1.8	0.0	1.5	2.9	5.4	-1.5	1.3	3.4	5.0	8.1
	Mean	3.5	1.5	3.0	4.1	5.2	7.5	2.2	4.0	5.5	6.9	9.5	2.4	5.0	7.3	9.0	12.3
	Max.	8.4	6.3	7.9	9.1	10.2	12.9	6.9	8.8	10.4	12.0	15.0	6.8	9.5	12.2	14.2	17.8
Summer	Min.	12.2	11.7	12.6	13.3	14.0	15.5	13.1	14.1	15.0	16.0	18.0	14.5	15.8	16.9	18.2	21.0
	Mean	17.8	17.2	18.2	18.9	19.7	21.5	18.6	19.8	20.8	21.8	23.9	20.1	21.6	22.9	24.2	26.9
	Max.	23.9	23.0	24.2	25.0	26	27.9	24.5	25.9	27.0	28.1	30.5	25.9	27.8	29.3	30.6	33.3
Autumn	Min.	4.6	4.4	5.6	6.5	7.5	9.6	6.2	7.6	8.9	10.6	13.4	8.3	9.9	11.9	14.4	18.1
	Mean	8.1	8.0	9.2	10.1	11.2	13.3	9.8	11.3	12.5	14.4	17.5	11.9	13.6	15.5	18.2	22.3
	Max.	12.9	12.7	14.0	15.0	16.2	18.6	14.7	16.3	17.6	19.5	22.9	16.8	18.6	20.5	23.5	28.1
Winter	Min.	-10.9	-12.7	-10.0	-8.2	-6.4	-2.7	-10.1	-7.0	-5.0	-3.2	0.2	-6.8	-4.0	-1.7	0.5	3.6
	Mean	-7.0	-8.5	-6.2	-4.8	-3.4	-0.4	-6.3	-3.8	-2.2	-0.6	2.4	-3.5	-1.3	0.7	2.5	5.4
	Max.	-3.2	-4.7	-2.8	-1.7	-0.6	1.9	-2.8	-0.9	0.4	1.8	4.6	-0.5	1.3	2.9	4.5	7.5

Appendix F: Southern Seasonal Temperatures (deg. Celsius)

Indicator		Baseline (1990s)	2020s					2050s					2080s				
			5th %	25th %	50th %	75th %	95th %	5th %	25th %	50th %	75th %	95th %	5th %	25th %	50th %	75th %	95th %
Spring	Min.	0.0	-2.1	-0.5	0.7	1.8	3.9	-1.2	0.6	2.1	3.4	5.8	-0.9	1.9	3.9	5.4	8.5
	Mean	4.2	2.1	3.6	4.8	5.8	8.0	2.8	4.7	6.2	7.5	10.1	2.9	5.7	7.9	9.6	12.9
	Max.	9.4	7.0	8.7	10.0	11.1	13.6	7.6	9.7	11.4	12.9	15.7	7.6	10.4	13.1	15.1	18.6
Summer	Min.	12.4	12.1	13.0	13.7	14.4	15.9	13.5	14.5	15.5	16.5	18.5	15.0	16.3	17.4	18.7	21.7
	Mean	18.4	17.5	18.5	19.3	20.2	22.0	18.9	20.2	21.2	22.2	24.5	20.5	22.0	23.3	24.7	27.7
	Max.	24.8	23.1	24.3	25.4	26.4	28.6	24.6	26.2	27.4	28.7	31.3	26.1	28.2	29.7	31.2	34.3
Autumn	Min.	4.7	4.6	5.9	6.8	7.8	9.9	6.5	7.9	9.2	10.9	13.9	8.5	10.2	12.2	14.8	18.7
	Mean	8.6	8.3	9.5	10.5	11.6	13.9	10.2	11.7	12.9	14.9	18.2	12.3	14	16.0	18.9	23.1
	Max.	13.8	13.1	14.6	15.7	16.9	19.5	15.3	17.0	18.3	20.4	24.1	17.4	19.4	21.3	24.4	29.5
Winter	Min.	-9.0	-10.8	-8.2	-6.6	-4.9	-1.6	-8.4	-5.5	-3.6	-1.8	1.3	-5.3	-2.8	-0.5	1.6	4.3
	Mean	-5.8	-7.3	-5.0	-3.7	-2.3	0.4	-5.1	-2.7	-1.1	0.4	3.2	-2.4	-0.3	1.7	3.4	6.2
	Max.	-2.4	-3.9	-2.0	-0.8	0.4	2.8	-2.1	-0.1	1.3	2.8	5.5	0.3	2.1	3.8	5.5	8.4

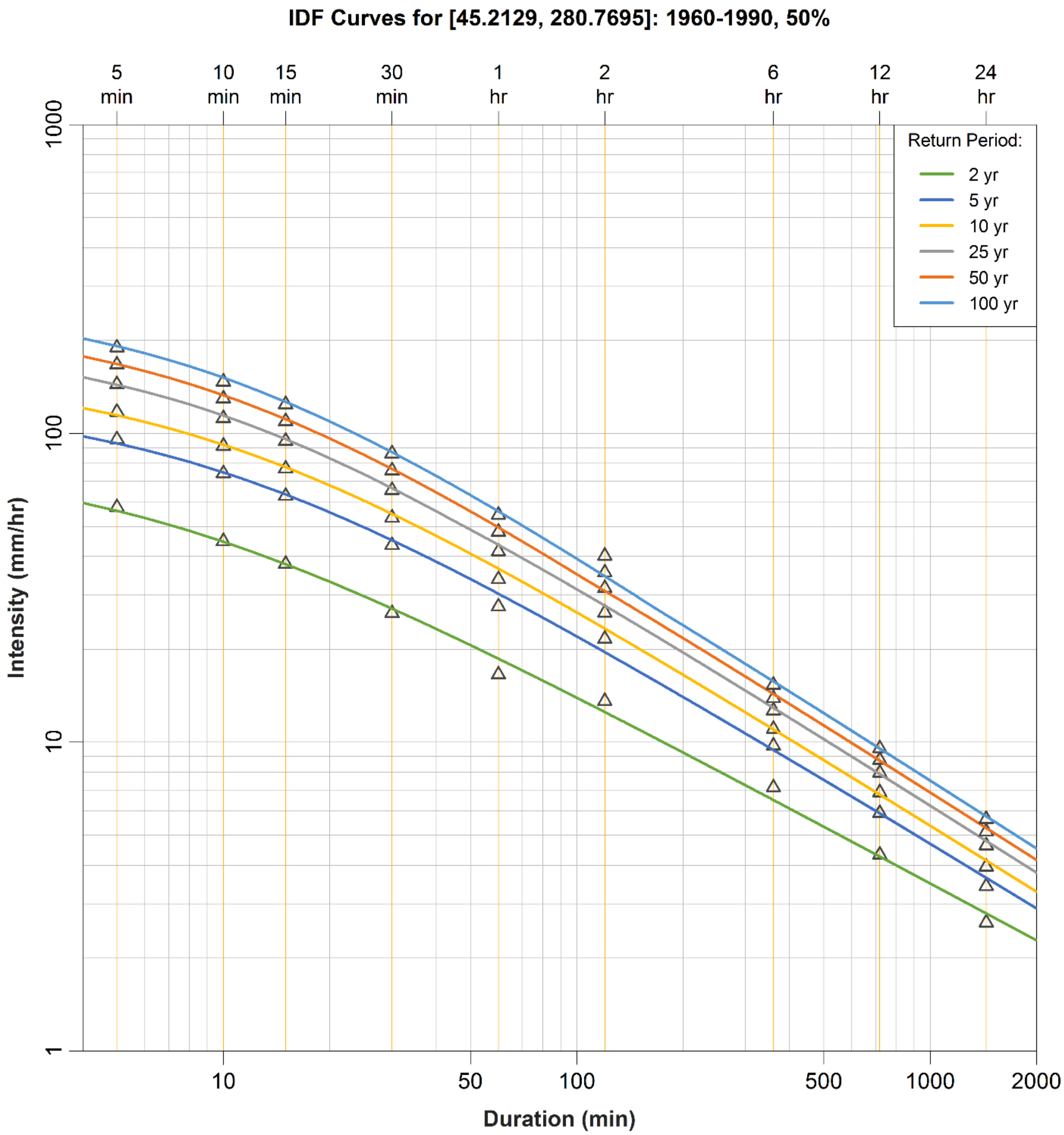
Indicator	Baseline (1990s)	2020s					2050s					2080s				
		5th %	25th %	50th %	75th %	95th %	5th %	25th %	50th %	75th %	95th %	5th %	25th %	50th %	75th %	95th %
CWD (days)	12.04	6.66	8.93	10.94	13.2	17.46	6.37	9.06	11.03	13.5	18.49	5.96	8.97	11.19	13.73	18.39
CDD (days)	13.14	8.11	10.86	12.99	15.5	20.19	8.04	10.54	12.74	15.54	20.46	7.96	10.99	13.26	16.31	22.49
EWD (days)	8.7	6.97	9.67	11.76	13.99	17.17	7.61	10.63	12.93	15.21	19.19	8.07	11.63	14.19	16.67	20.47
HPD (days)	30.33	27.36	32.59	36.44	40.24	46.46	28.49	33.67	37.83	41.86	48.3	29.4	35.06	39.04	43.39	49.8
MMP (mm)	38.01	27.83	34.89	41	48.97	63.53	28.74	36.97	43.57	51.5	67.56	30.8	39	46.73	55.51	73.59

Appendix H: Extreme Precipitation Data for the Southern Region

Indicator	Baseline (1990s)	2020s					2050s					2080s				
		5th %	25th %	50th %	75th %	95th %	5th %	25th %	50th %	75th %	95th %	5th %	25th %	50th %	75th %	95th %
CWD (days)	10.78	6.4	8.33	10.25	12.4	16.25	6.28	8.68	10.45	12.68	16.78	5.73	8.38	10.43	12.63	16.55
CDD (days)	12.25	7.8	10.15	12.13	14.3	18.48	7.8	10.13	12.03	14.65	19.03	7.93	10.43	12.58	15.4	21.05
EWD (days)	8.78	5.78	8.23	10.13	12.18	15.38	6.38	9.15	11.35	13.48	17.35	7	10	12.25	14.93	18.43
HPD (days)	29.23	23.05	27.88	31.55	35.28	41.05	24.25	29.2	32.85	37.03	42.4	24.88	30.28	34.05	38.15	44.15
MMP (mm)	39.33	28.2	35.95	42.45	50.78	65.65	29.23	37.13	44.23	52.7	69	30.03	39.25	46.55	55.73	72.78

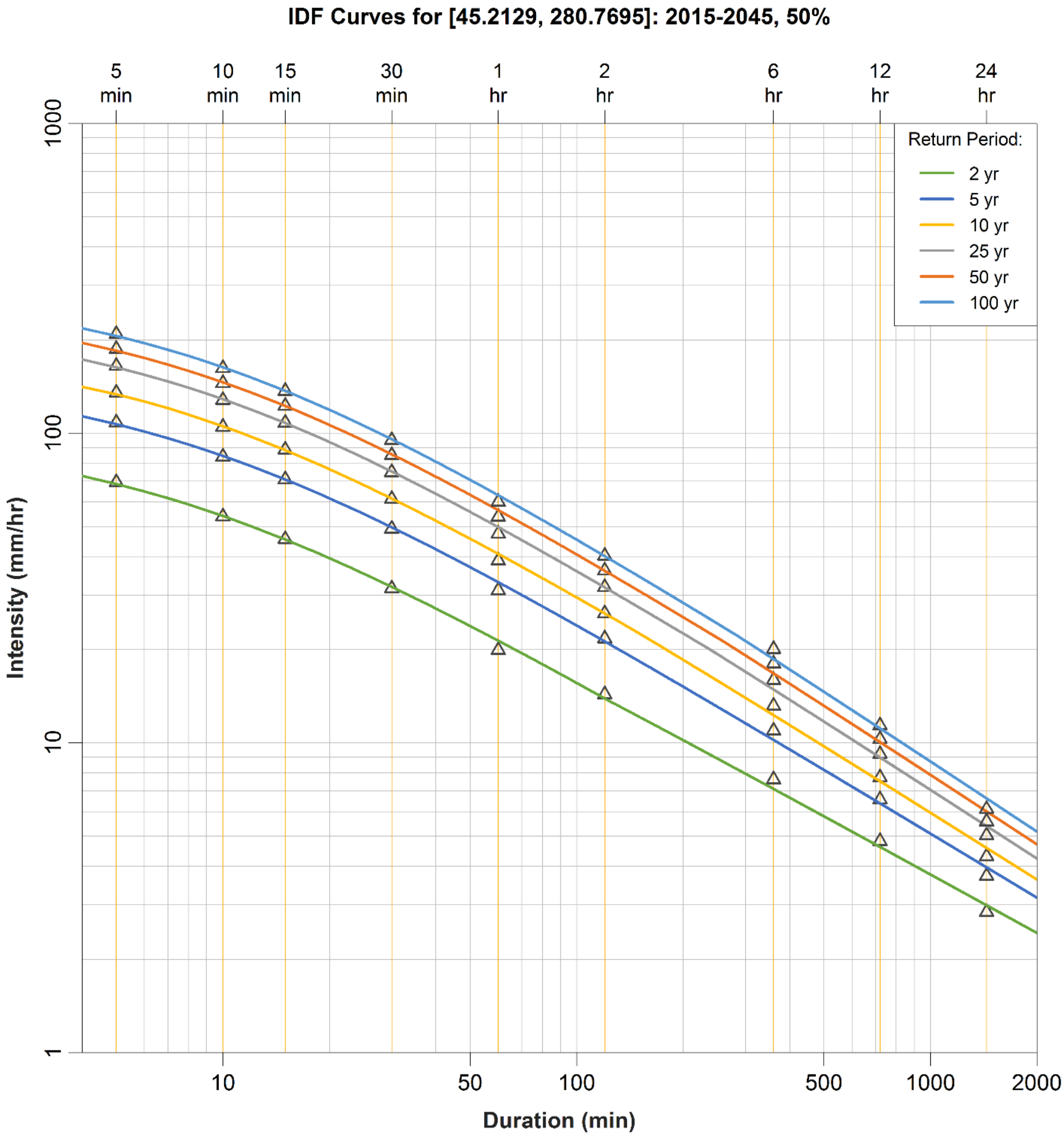
Appendix I: Intensity, duration and frequency curves (plots of precipitation) for the Northern Region, for baseline (1990s), 2020s, 2050s, and 2080s (Wang, Xiuquan and Gordon Huang (2013). Ontario Climate Change Data Portal. www.ontarioccdp.ca.)

Baseline



This graph was produced by Xander Wang on April 15, 2014.
More IDF curves are available at: http://www.ontarioccdp.ca
For any queries please email to: xander.wang@ontarioccdp.ca

2020s



This graph was produced by Xander Wang on April 15, 2014.
More IDF curves are available at: http://www.ontarioccdp.ca
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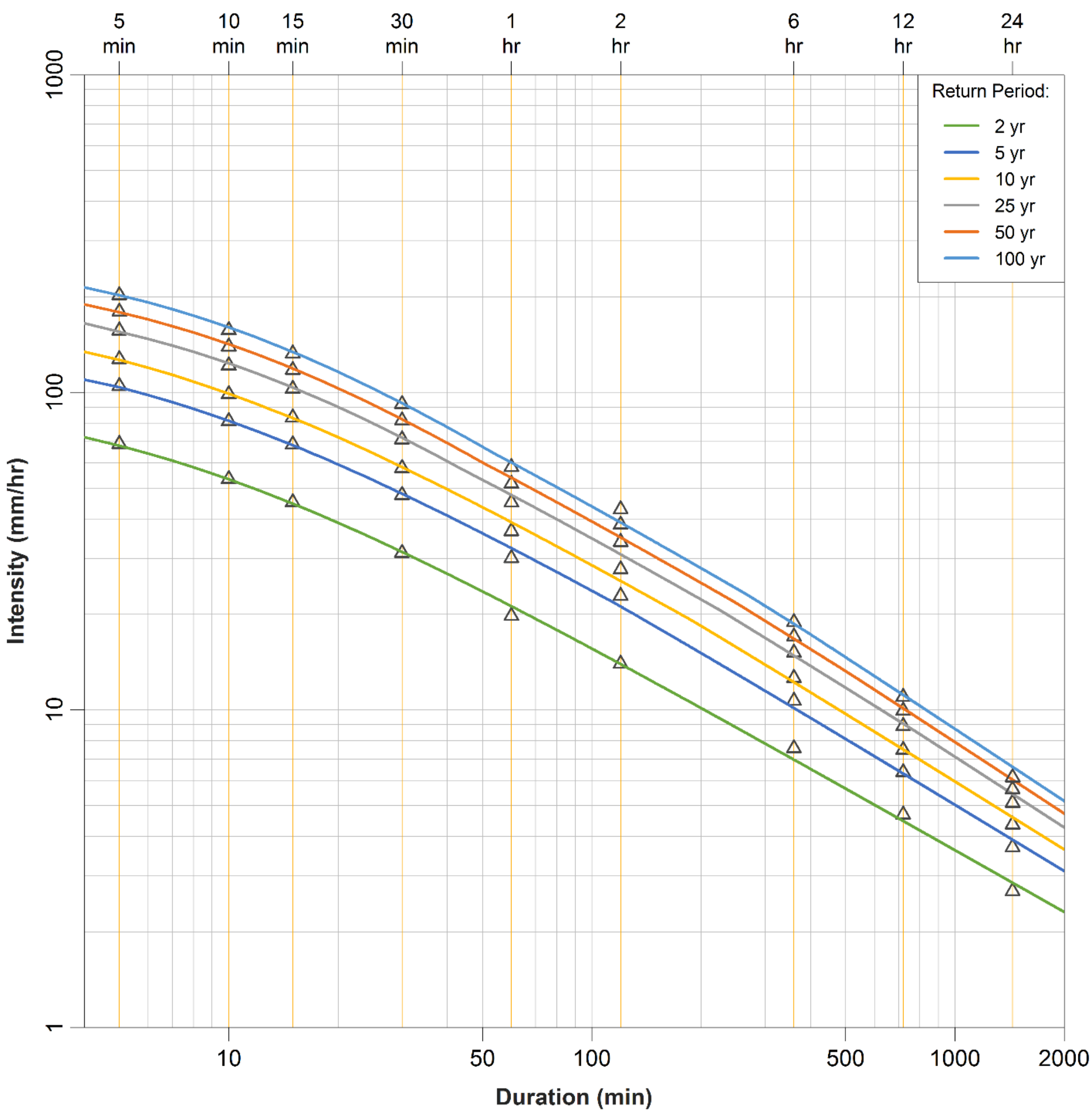
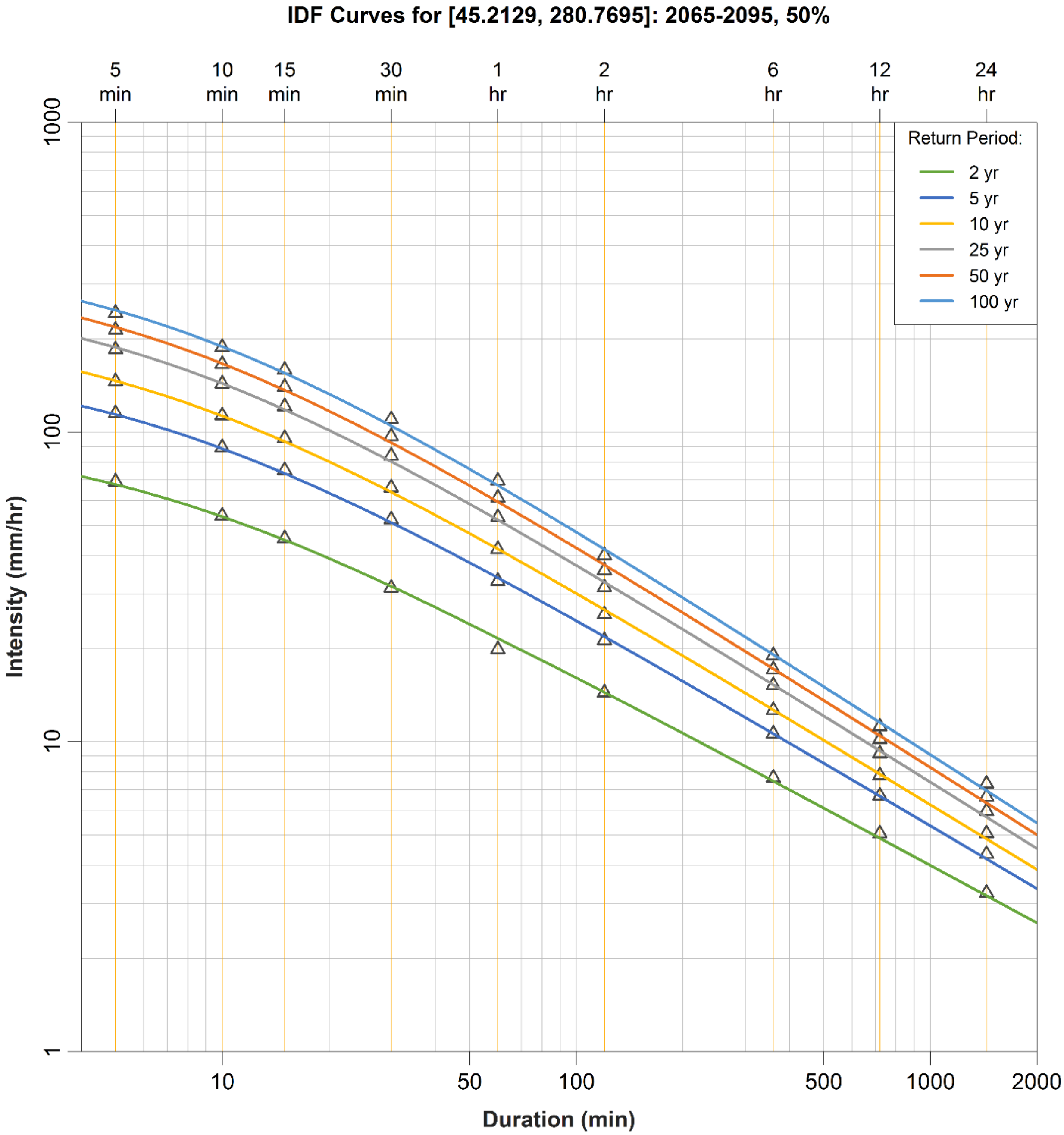
2050s

IDF Curves for [45.2129, 280.7695]: 2035-2065, 50%



This graph was produced by Xander Wang on April 15, 2014.
More IDF curves are available at: http://www.ontarioccdp.ca
For any queries please email to: xander.wang@ontarioccdp.ca



This graph was produced by Xander Wang on April 15, 2014.
More IDF curves are available at: http://www.ontarioccdp.ca
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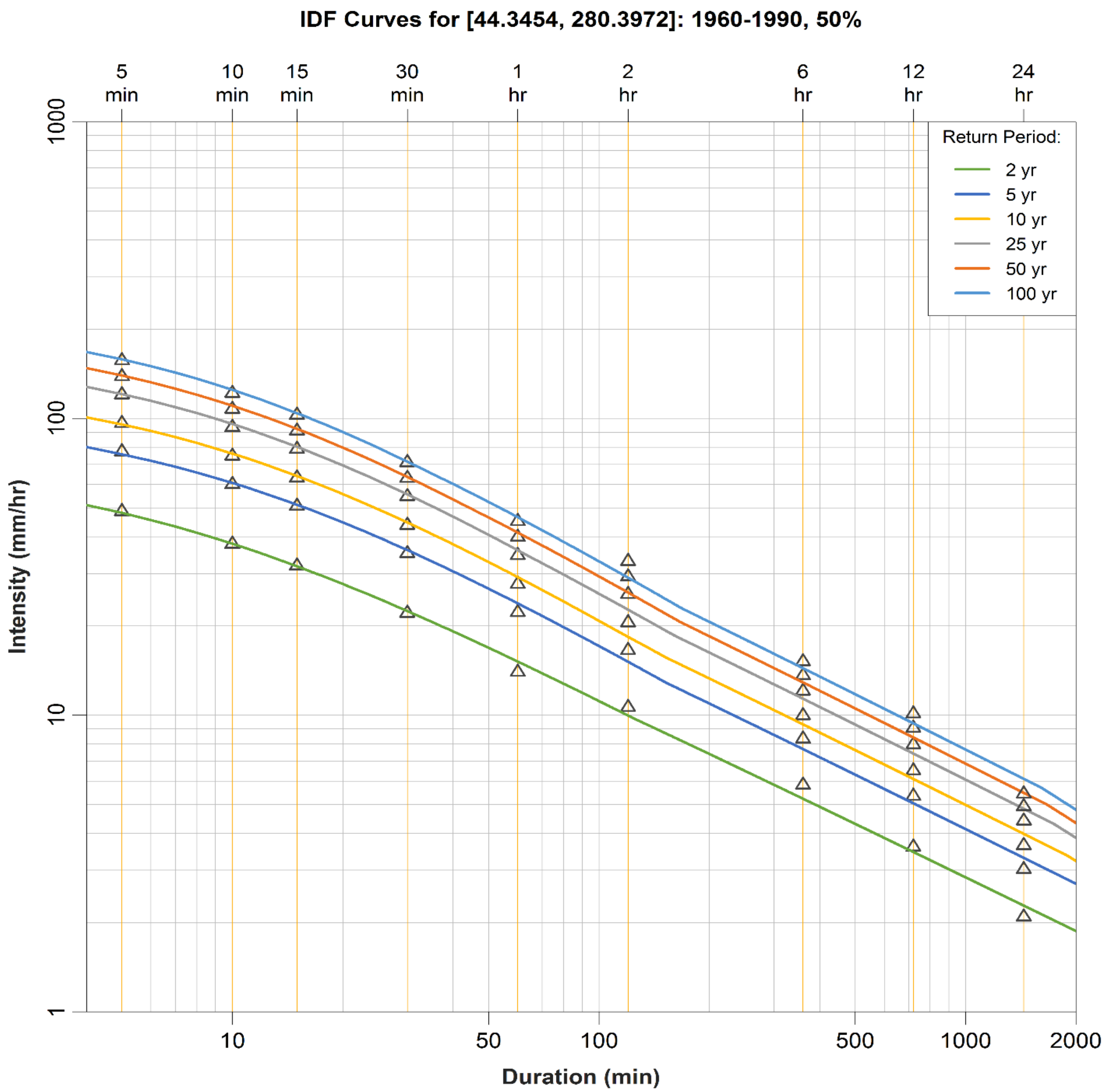
Appendix J: Intensity, duration and frequency curves (plots of precipitation) for the Southern Region, for baseline (1990s), 2020s, 2050s, and 2080s (Wang, Xiuquan and Gordon Huang (2013). Ontario Climate Change Data Portal. www.ontarioccdp.ca.)

Baseline



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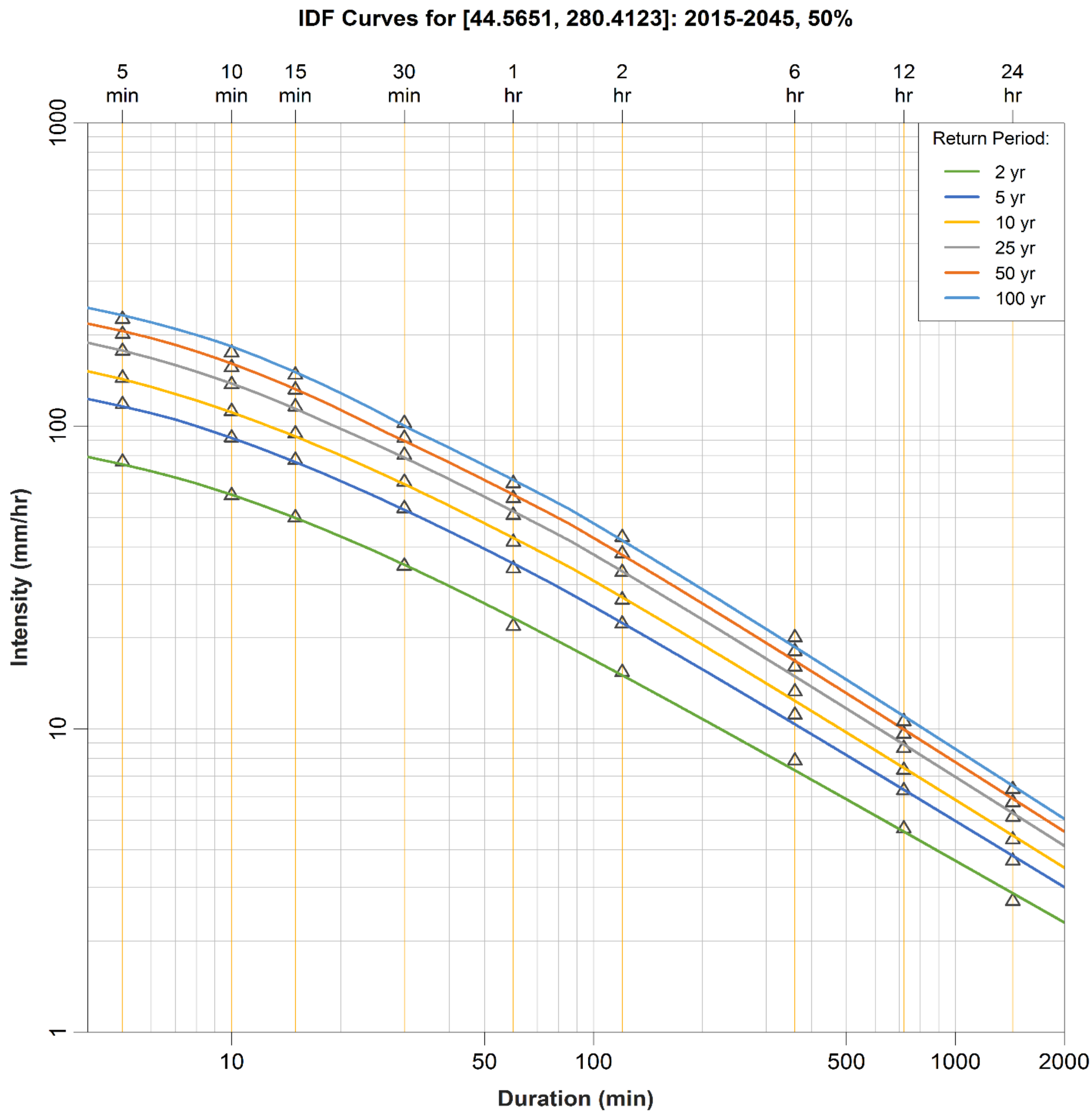

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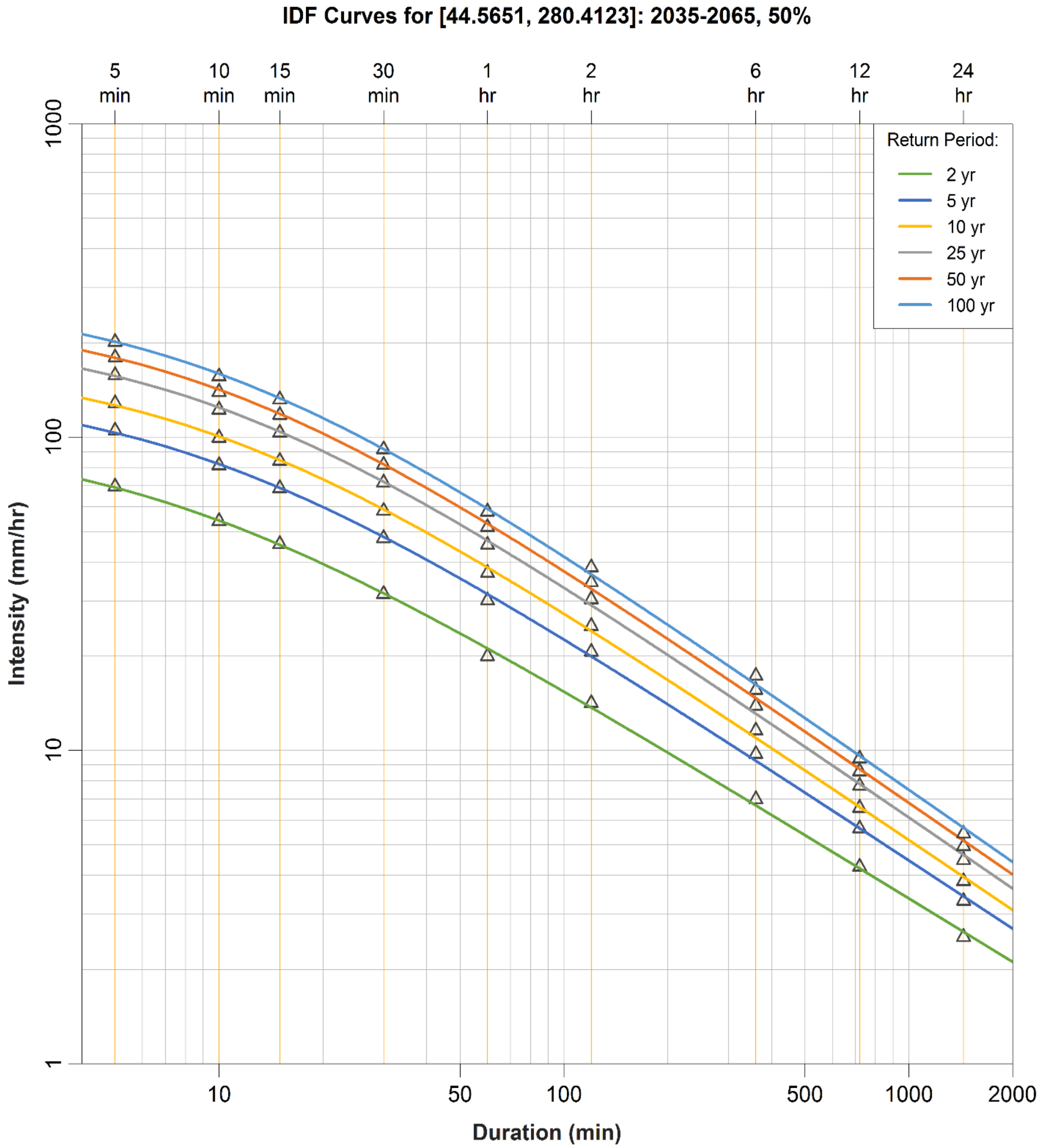

This graph was produced by Xander Wang on April 15, 2014.
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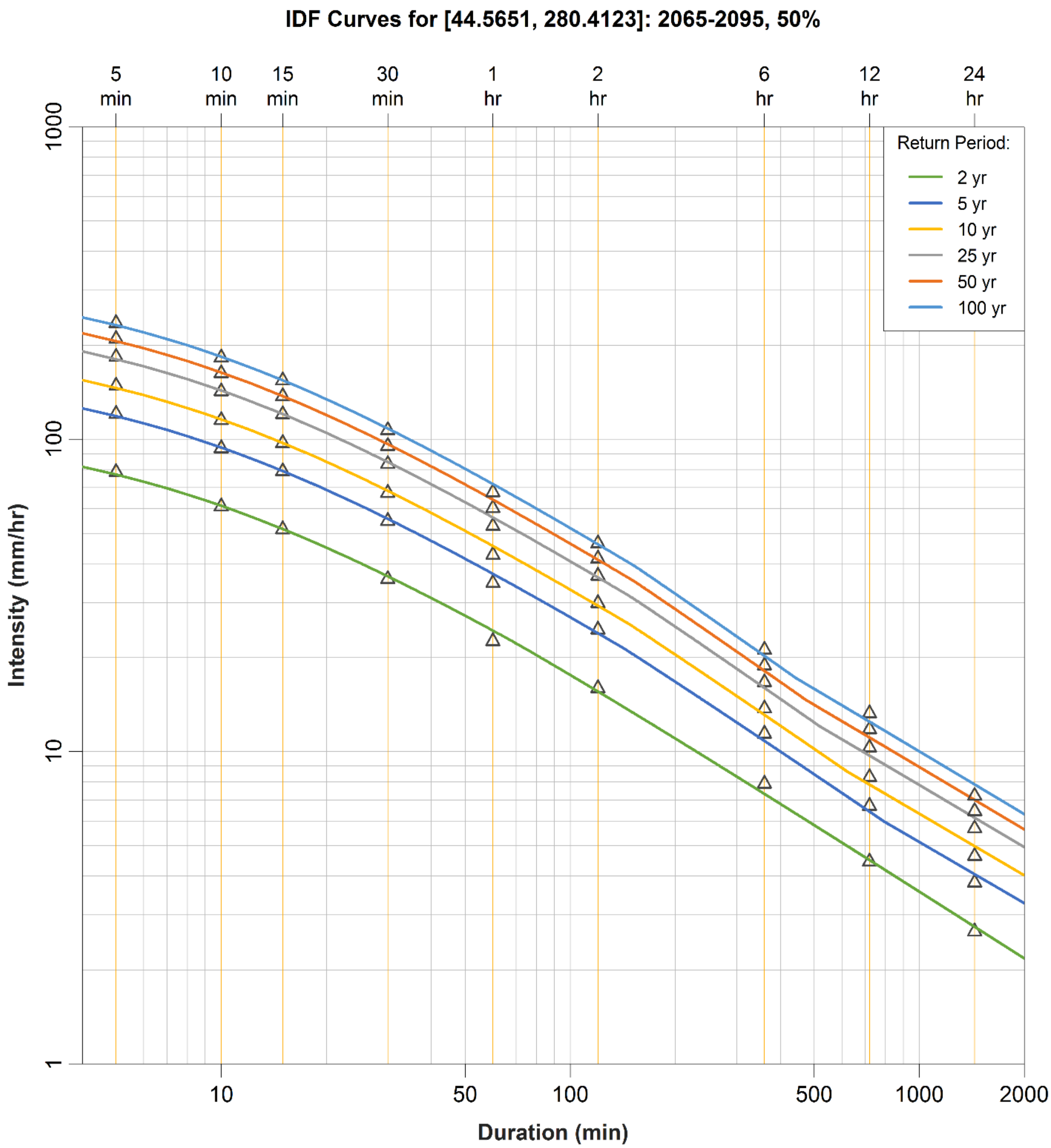
For any queries please email to: xander.wang@ontarioccdp.ca

2080s



This graph was produced by Xander Wang on April 15, 2014.
More IDF curves are available at: http://www.ontarioccdp.ca
For any queries please email to: xander.wang@ontarioccdp.ca

Appendix K: Type of illness included within the analysis for food- and waterborne illnesses within Simcoe Muskoka

Illness	Reason for Inclusion
Amebiasis	One mode of transmission is through ingestion of contaminated food or water.
Botulism	Most common mode of transmission is ingestion of contaminated food (home canning, etc.).
Campylobacteriosis enteritis	One mode of transmission linked to consumption of undercooked poultry, fish, etc.
Cryptosporidiosis	Most common mode of transmission is contaminated water (e.g., recreational pools, drinking water, etc.).
Cyclosporiasis	Transmission through ingestion of contaminated food or water (fresh produce primarily affected).
Giardiasis	Most common mode of transmission is contaminated water (e.g., recreational pools, drinking water, etc.).
Hepatitis A	Transmission occurs from person to person or through ingestion of contaminated food.
Listeriosis	Transmission occurs from consumption of contaminated food (often soft cheeses, deli meats, etc.).
Paratyphoid fever	Transmission through ingestion of contaminated food or water (usually travel-related).
Salmonellosis	One mode of transmission linked to consumption of undercooked poultry, fish, etc.
Shigellosis	Transmission occurs from person to person or through ingestion of contaminated food or water.
Typhoid fever	Transmission through ingestion of contaminated food or water (usually travel-related).
Verotoxigenic E. coli infection	One mode of transmission through ingestion of contaminated food or water.
Yersiniosis	One mode of transmission through ingestion of contaminated food or water.

Note: Reported food-poisoning cases were included
Source: Control of Communicable Diseases Manual, 19th edition.

Appendix L: Description of food- or waterborne outbreaks resulting in local cases, 2005 - 2016

(Data Source: Integrated Public Health Information System (iPHIS), Outbreak Module, Outbreak Cases, Confirmed and Probable (January 1 2005 to December 31, 2016), extracted January 25, 2017).

Level	Outbreak Causative Agent	Year	Month Declared	SMDHU Cases Associated
Multi-jurisdictional	Salmonella	2005	May	3
Provincial	Salmonella	2006	January	16
Local	VTEC	2006	December	3
Local	Campylobacter	2007	October	5
Provincial	Listeria	2008	November	1
Provincial	Salmonella	2008	December	2
Provincial	Salmonella	2009	March	3
Provincial	Salmonella	2009	April	1
Multi-jurisdictional	Hepatitis A	2009	April	1
Local	Cyclosporiasis	2009	June	10
National	VTEC	2010	September	1
Provincial	Salmonella	2010	October	1
Provincial	Hepatitis A	2011	May	1
Multi-jurisdictional	Food Poisoning[xxxvii]	2011	June	6
Multi-jurisdictional	Food Poisoning	2011	June	2
Multi-jurisdictional	Food Poisoning	2011	June	5
Provincial	Salmonella	2011	July	1
Provincial	Cyclosporiasis	2011	August	2
Provincial	VTEC	2011	September	1
Multi-jurisdictional	VTEC	2011	November	2
Provincial	Salmonella	2012	February	1
National	Salmonella	2012	July	2

xxxvii Presumptive foodborne illness, not otherwise specified.

Level	Outbreak Causative Agent	Year	Month Declared	SMDHU Cases Associated
Provincial	Salmonella	2012	October	5
National	VTEC	2013	January	4
Provincial	Salmonella	2013	March	2
Provincial	Food Poisoning	2013	August	1
Provincial	VTEC	2013	November	1
National	Salmonella	2014	May	2
Provincial	Salmonella	2014	June	3
Provincial	Salmonella	2014	November	16
Provincial	Salmonella	2015	February	2
National	Salmonella	2015	June	3
National	Cyclosporiasis	2015	July	3
Provincial	VTEC	2015	September	2
Provincial	Salmonella	2015	October	1
National	Listeria	2016	January	1
Provincial	Listeria	2016	January	3
Local	Salmonella	2016	May	47
National	Cyclosporiasis	2016	July	3
National	VTEC	2016	August	1

Appendix M: Types of drinking water systems and responsible inspection agency within Simcoe Muskoka

System Type	Number or Type of Individuals Served	Inspection Agency	Number of Systems within SMDHU Area
Large municipal residential systems	Municipal systems serving > 100 private residents	MOECC	1 Ground Water 18 Surface Water
Small municipal residential	Municipal systems serving <100 private residents	MOECC	1 Ground Water 4 Surface Water
Non-municipal year round residential	Privately owned drinking water system with 6 or more private residents	MOECC	5 Ground Water 3 Surface Water
Small non-residential	Designated facilities such as recreational camps and schools	MOECC	17 Ground Water 22 Surface Water
Small drinking water systems	Public facilities (motels, resorts, gas stations, churches, etc.)	SMDHU	595 Ground Water 118 Surface Water 10 Other

Appendix N: Types and percentage of mosquitoes identified from surveillance sites within the Simcoe Muskoka District Health Unit region in 2015

(Source: Hunter and Gasparotto, 2015)

	Number	Type	Percentage of Total
WNV Enzootic Vectors	358	Culex pipiens/restuans	4.70%
	1	Culex species	0.01%
WNV Bridge Vectors	1239	Aedes vexans vexans	16.27%
	476	Ochlerotatus canadensis	6.25%
	258	Ochlerotatus trivittatus	3.39%
	154	Ochlerotatus japonicas	2.02%
	83	Anopheles punctipennis	1.09%
	72	Ochlerotatus stimulans	0.95%
	40	Anopheles quadrimaculatus	0.53%
	28	Ochlerotatus triseriatus	0.37%
	23	Anopheles walkeri	0.30%
EEEV Vectors	41	Culiseta melanura	0.54%
Non Vectors	4352	Coquillettidia perturbans	57.16%
	180	Ochlerotatus black-legged	2.36%
	102	Aedes /Ochlerotatus species	1.34%
	69	Ochlerotatus broad-banded	0.91%
	59	Culiseta morsitans	0.77%
	32	Aedes cinereus	0.42%
	29	Ochlerotatus excrucians	0.38%
	7	Anopheles earlei	0.09%
	3	Ochlerotatus sollicitans	0.04%
	3	Uranotaenia sapphirina	0.04%
	2	Culex territans	0.03%
	2	Ochlerotatus dorsalis	0.03%
	1	Ochlerotatus provocans	0.01%