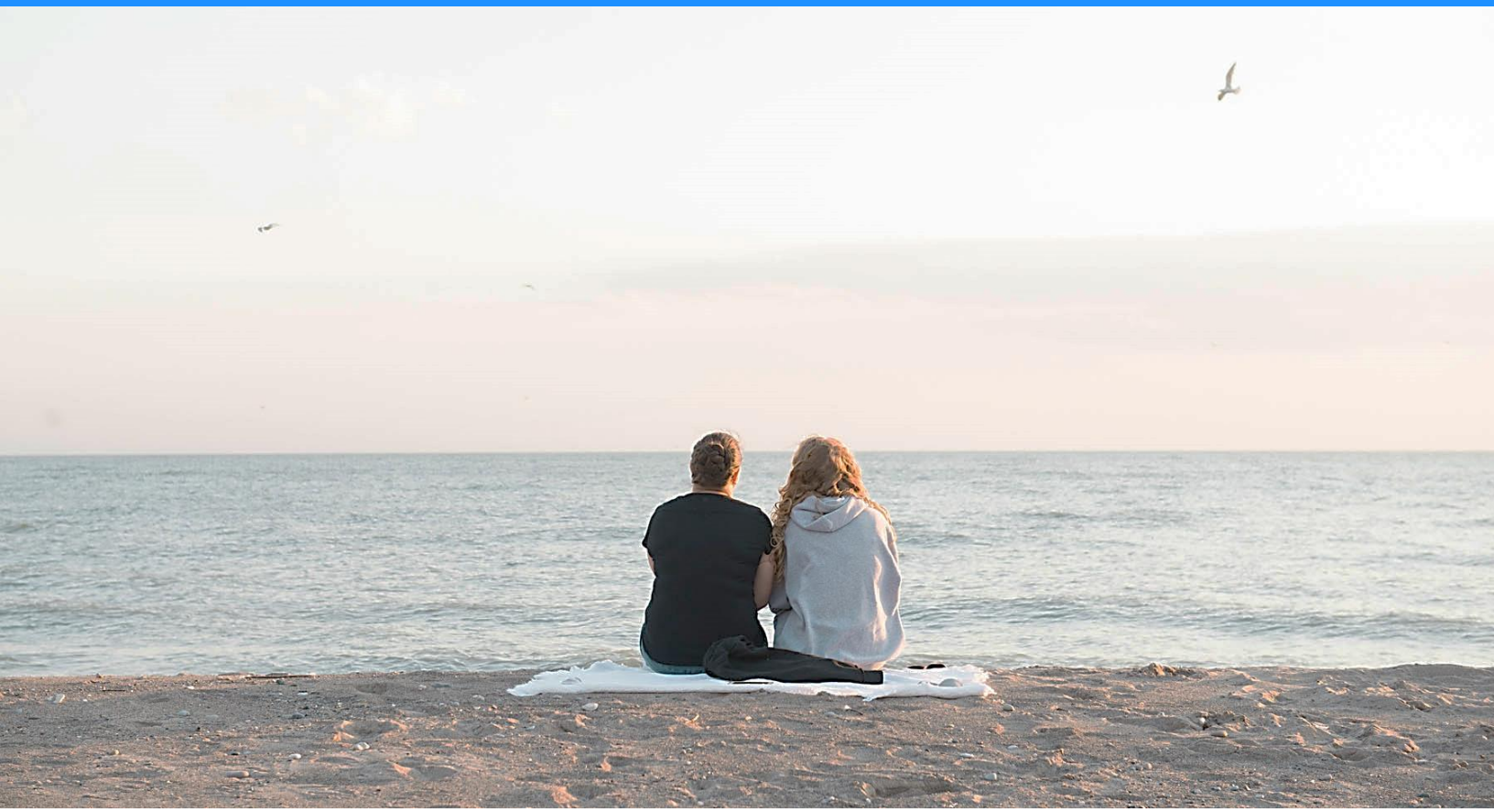
Health in a Changing Climate



Health Impacts and Vulnerabilities Related to Climate Change in Chatham-Kent

February 2019

Health in a Changing Climate

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Executive Summary

Background

Canada's climate is changing and the changing climate is impacting the health of Canadians (1). In Canada, average temperatures have increased 1.7°C since 1948 and continue to rise at double the average global rate of 0.3°C to 0.7°C (2,3). Rising temperatures are directly linked to human activities and will cause significant changes in climate conditions, including more frequent extreme weather events, range expansion of disease vectors, and poor air quality (1,4). The human health effects of such phenomena include increases in heat- and cold-related illnesses, respiratory and cardiovascular disease, vector-borne disease, food- and waterborne illness, injuries, and death (1).

Under the *Ontario Public Health Standards*, Chatham-Kent Public Health Unit (CKPHU) is mandated to assess, address, and monitor the health impacts of climate change. To understand how to adapt to climate change, it is necessary to assess the current situation, identify how climate will change in Chatham-Kent, and determine the effect of those changes.

CKPHU used the *Ontario Climate Change and Health Toolkit, 2016* (5) published by the Ministry of Health and Long-Term Care to guide a climate change health impact and vulnerability assessment. The intent of the assessment was:

- To identify and describe current and projected future climate-sensitive health outcomes in Chatham-Kent; and
- To determine which populations are most at risk of experiencing climate-sensitive health outcomes within Chatham-Kent.

Report Findings

Chatham-Kent's Climate

Chatham-Kent's climate is warming. Mean temperatures are expected to rise 2.2°C by mid-century and 4.8°C by 2080 (6). Rising temperatures will cause significant changes to the region's climate. For example, by the end of the century, approximately four months of out each year will consist of very hot days, where temperatures exceed 30°C (7). In comparison, the average number of very hot days per year over the past 30 years was 17 (8). A substantial rise in annual precipitation is also expected over this period, leading to more frequent extreme rainfall events (6,7).

Human Health Impacts

Warmer temperatures and increased precipitation create conditions that affect human health. This report illustrates six broad areas of climate-related hazards that will impact human health in Chatham-Kent. These are summarized below.

TEMPERATURE EXTREMES

- Temperature extremes disrupt the body's ability to maintain its core temperature, causing tissue damage and illness
- Chatham-Kent's climate will warm significantly over the coming decades, leading to more instances of heat-related illness
- Winters will be milder on average, but extreme cold events are also more likely
- A large proportion of the population is vulnerable to the effects of extreme heat, including older adults, children, pregnant women, and people who spend time outdoors

EXTREME WEATHER

- Extreme weather events cause direct health impacts, such as injury and death, and indirect health impacts, such as enteric illness
- Extreme weather events, including heavy rainfall, storms, and flooding will increase as temperatures rise
- Flood events were previously more common in the spring, but now occur year-round
- At least 15,000 to 20,000 Chatham-Kent residents (14.7 to 19.6% of the population) reside in flood-prone areas
- People with low income, children, and seniors are disproportionately affected by extreme weather

AIR QUALITY

- Poor air quality causes increased morbidity and premature death
- When it comes to air quality, Chatham-Kent is among the most vulnerable regions in Canada because of high levels of air pollution and the high proportion of residents who are susceptible to the negative health impacts of air pollution
- The current burden of illness related to poor air quality is high
- Rising temperatures are expected to caused poor air quality in the future
- Seniors, children, people with chronic conditions, and those who work outdoors are at greater risk of adverse health impacts related to air pollution

FOOD- AND WATERBORNE ILLNESS

- Warmer ambient temperatures support the growth of food- and waterborne pathogens in the environment
- Heavy rainfall and extreme weather events will increase food- and waterborne illness
- People with low income, those who obtain their drinking water from unsecured sources, and people with weakened immune systems are particularly at risk of food- and waterborne illness

VECTOR-BORNE ILLNESS

- Climate change will create conditions that support the growth of insect disease vectors
- Warmer temperatures and migration of tick and mosquito species may lead to the emergence of new diseases
- People who work outdoors, as well as older adults and children are vulnerable to vector-borne illnesses

ULTRAVIOLET RADIATION

- Ozone depletion will lead to increased exposure to harmful ultraviolet radiation, which causes DNA damage
- Chatham-Kent residents experience the highest level of UV radiation in Canada
- The incidence of skin cancer is expected to increase
- At risk are people who work outdoors, as well as children and older adults
- Males are less likely to practice sun safety behaviours than females, putting them at greater risk of UV damage

Priority Populations

Though all residents of Chatham-Kent are vulnerable to the health impacts of climate change, certain groups are particularly at risk because of greater physical susceptibility and/or environmental and socioeconomic circumstances, or a combination of these. The following priority population groups are vulnerable to four or more climate-related health impacts:

Older adults

- Older adults are vulnerable to temperature extremes, extreme weather, air quality, food- and waterborne illness, vector-borne illness, UV radiation
- There are 21,450 adults over the age of 65 in Chatham-Kent (15)

Children

- Children are vulnerable to temperature extremes, extreme weather, air quality, food- and waterborne illness, vector-borne illness, UV radiation
- There are 16,740 children under 14 years of age in Chatham-Kent (15)

Pregnant women

- Pregnant women are vulnerable to temperature extremes, air quality, food- and waterborne illness, vector-borne illness, UV radiation
- There are 1,037 live births per year on average in Chatham-Kent (30)

Outdoor workers

- Outdoor workers are vulnerable to temperature extremes, air quality, vector-borne illness, UV radiation
- There are approximately 7,250 outdoor workers in Chatham-Kent (15)

Chronic health conditions

- People with chronic health conditions are vulnerable to temperature extremes, extreme weather, air quality, food- and waterborne illness, vector-borne illness, UV radiation
- 65.4% of 12-64 year old residents and 93.7% of residents 65 years or older have at least one chronic condition (71)

Low socioeconomic status

- People of low socioeconomic status are vulnerable to temperature extremes, extreme weather, air quality, food- and waterborne illness, UV radiation
- 16,910 residents live in low income (15)

Collectively, these groups make up a large portion of Chatham-Kent's population.

Next Steps

This assessment comprised the first three steps in the six-step vulnerability and adaptation assessment process outlined in the *Ontario Climate Change and Health Toolkit, 2016*. The next three steps are to:

- Identify and prioritize policies and programs to manage the additional health risks associated with a changing climate;

- Establish an iterative process for managing and monitoring health risks; and,
- Examine the potential health benefits and co-harms of adaptation and mitigation options implemented in other sectors.

CKPHU will disseminate these results to municipal and community partners, the public, and those affected by the impacts of our changing climate. Through community discussions, efforts may be pursued to examine current policies and programs that address climate-sensitive health outcomes and identify and prioritize policies and programs to mitigate and adapt to the health impacts of climate change.

"For public health, climate change is the defining issue for the 21st century"

Dr. Margaret Chan
Former Director-General of the World Health Organization

Introduction

Canada's climate is changing and the changing climate is impacting the health of Canadians (1). In Canada, average temperatures have increased 1.7°C since 1948 and continue to rise at double the average global rate of 0.3°C to 0.7°C (2,3). Rising temperatures are directly linked to human activities and will cause significant changes in climate, including more frequent extreme weather events, range expansion of disease vectors, and poor air quality (1,4). The human health effects of such phenomena include increases in heat- and cold-related illnesses, respiratory and cardiovascular disease, vector-borne disease, food- and waterborne illness, injuries, and death (1).

The health impacts of climate change are severe. This was underscored in the latest *Countdown Report* on health and climate change released by the *Lancet* in November 2018. Among the key findings were that, in 2017, 157 million more vulnerable people were exposed to heatwaves worldwide than in 2000, resulting in 153 billion hours of lost labour (9). In 2015 alone, 7,142 Canadians died because of chronic exposure to air pollution, resulting in $53.5 billion in economic losses (10).

"In 2015 alone, 7,142 Canadians died because of chronic exposure to air pollution, resulting in $53.5 billion in economic losses."

The health impacts of climate change are avoidable. In October 2018, the Intergovernmental Panel on Climate Change (IPCC), a United Nations body created to assess the science related to climate change, released a special report on the impacts of global warming of 1.5°C (11). Its authors warn that, though the health impacts of climate change are already being felt, there is still time to act to limit human suffering (11). Importantly, to avoid the worst health

impacts, global warming will have to be limited to 1.5°C, which is below the 2°C limit set by the 2015 Paris Agreement (11). Significant efforts will be needed to achieve this goal, though these efforts will be much less than if warming of 2°C is permitted (11). Action must begin now. The report warns that global warming will reach 1.5°C in as little as 12 years (11).

> *"Chatham-Kent will be a leader in healthy public policies and the management of natural and built resources and energy conservation."*

Action starts at the local level. Under the *Ontario Public Health Standards*, Chatham-Kent Public Health Unit (CKPHU) is required to assess, address, and monitor the health impacts of climate change (12). Chatham-Kent's community strategic plan ("CK Plan 2035") articulates the intent that within one generation, Chatham-Kent will be a leader in healthy public policies and in the management of natural and built resources and energy conservation (12,13). To date, various municipal plans and strategies have been developed that indirectly address the health impacts of climate change in Chatham-Kent. These include:

- Chatham-Kent Natural Heritage Implementation Strategy (2014)
  - Identifies how the municipality will work with landowners in the community to maintain and enhance the natural heritage system and manage ecological goods and services (e.g., to protect woodlands, wetlands, and grasslands)
- Chatham-Kent Community Energy Plan (2016)
  - Outlines the management of energy use and supply over the next 20 years with the goal of promoting a sustainable, affordable, and livable community
- Chatham-Kent Official Plan (2017)
  - Guides land use decisions in the municipality with the goal of creating more sustainable developments and protecting natural features and cultural heritage
- Lake St. Clair and Rondeau-Erie Coast Conservation Action Plans (2013)
  - Identify ecosystem threats and recovering habitats, and outline monitoring and evaluating recovery efforts.

As of yet, there has been no coordinated action to directly measure and monitor the health impacts of climate change in our community.

With this health impact and vulnerability assessment, CKPHU seeks to understand the impacts of climate change on human health in Chatham-Kent and to identify vulnerabilities in our local population, given the unique features of our environment. By describing climate change indicators and gathering baseline data, this assessment will enable CKPHU to monitor changes in health over time. Based on this assessment, future efforts may be made to review mitigation and adaptation options to protect and promote the health of our population.

Methodology

Understanding Climate Change Impacts

To understand the risks of climate change, IPCC developed a framework which describes the magnitude of climate change impacts as a function of three factors (pictured below): the climate-related hazard; the population exposed to that hazard; and the vulnerability of the exposed population to that hazard. It also demonstrates that exposure and vulnerability are influenced by socioeconomic processes, including actions to mitigate climate change impacts.

Hazard

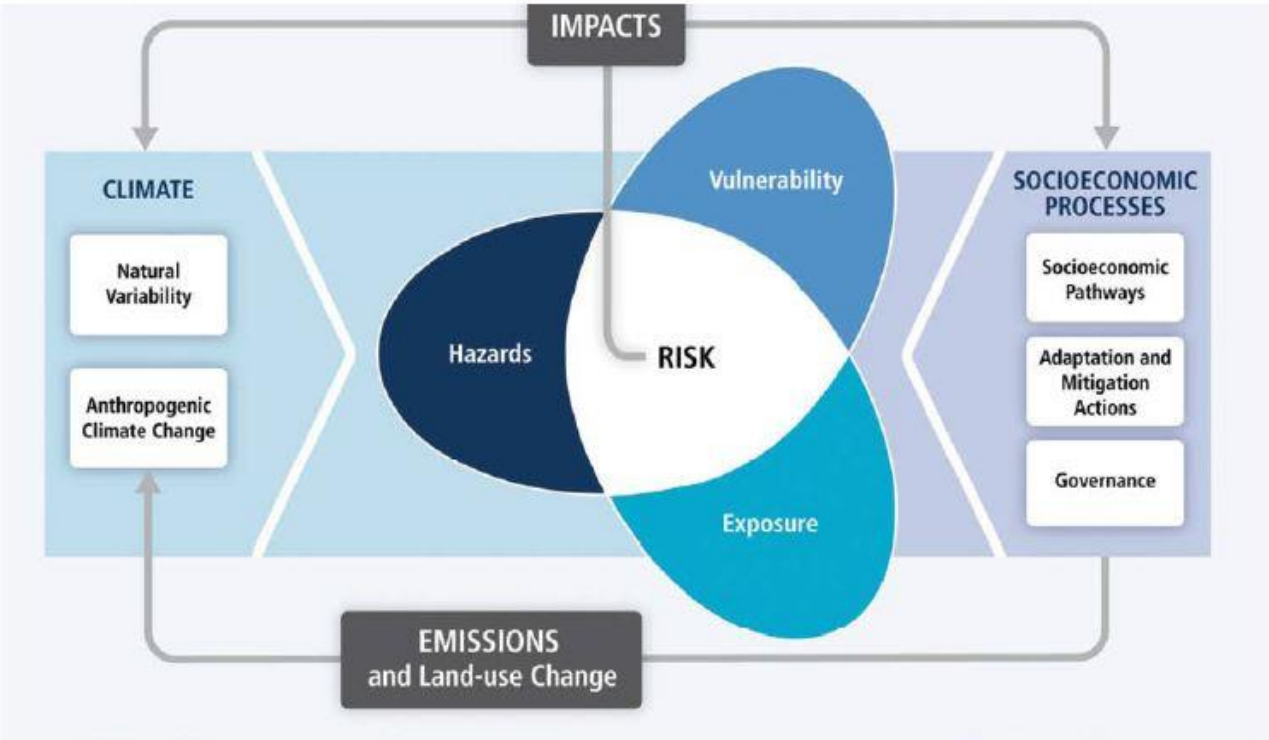
- The **hazard** caused by climate change, such as extreme weather or poor air quality;

Exposure

- The population **exposed** to the hazard;

Vulnerability

- The **vulnerability** or **sensitivity** of the population exposed to the hazard, including the ability of the population to cope with, respond to, or recover from the hazard impacts.



Source: IPCC, 2014

Health Impact and Vulnerability Assessments

Using the IPCC framework, health impact and vulnerability assessments are conducted to understand current health impacts and projected future risks of climate change and to identify policies and programs to increase resilience in the face of these risks.

To support boards of health in responding to climate change, the Ministry of Health and Long-Term Care (MOHTLC) developed the *Ontario Climate Change and Health Toolkit, 2016*. Using the methodology outlined in this toolkit, CKPHU undertook the following steps:

1. Frame/scope assessment

- Describe the assessment parameters, resources and timeframe; establish communication plans for engaging stakeholders and informing decision makers and the public of progress and results.

2. Describe current health risks

- Describe current exposures, health impacts and vulnerabilities related to climate change in Chatham-Kent, gathering data and information from peer-reviewed literature, grey literature, provincial and municipal reports, and public health surveillance systems. Health impacts of climate change include, for example, incidence of food-, water- and vector-borne illness and adverse cardiovascular and respiratory outcomes related to poor air quality.
  - Note: An assessment of the effectiveness of current policies and programs that affect climate-sensitive health outcomes was not conducted.

3. Project future health risks

- Describe how health impacts may change as a result of climate change in Chatham-Kent and establish timeframes for risk projections (e.g., 2050s, and 2080s). Future health risks related to climate change may include range expansion for disease vectors (e.g., blacklegged ticks) or changes in precipitation leading to extreme weather events (e.g., flooding).

Assessment Goals

The purpose of this health impact and vulnerability assessment is:

1. To identify and describe current and projected future climate-sensitive health outcomes in Chatham-Kent.
2. To determine which populations are most at risk of experiencing climate-sensitive health outcomes in Chatham-Kent.

Limitations

The science of climate change is broad and complex. Comprehensively describing all climate change health impacts, both direct and indirect, as well as the various vulnerabilities to these impacts, which can compound, confound and interact in unknown ways is a difficult undertaking. This assessment aims to provide an overview of the key health impacts that will be felt in Chatham-Kent, using local data.

Our understanding of climate change is evolving. For this assessment, CKPHU sought to use the most currently available information. Gaps in our knowledge exist and data is not readily available for all relevant subjects. These gaps are described within this report.

While awareness of the health impacts of climate change is growing, it remains a new area of focus for local boards of health. Relevant program data were not available for all indicators. Where data was not available, this was noted in the report. Where possible, efforts were made to provide a close approximation. For example, data on the number of pregnant women in Chatham-Kent was approximated by the number of live births.

Data for climate change projections were drawn from two models. While projections were determined to be similar, slight variations may exist due to differences in methodologies. A thorough assessment of climate models and their reliability can be found in the *IPCC Fifth Assessment Report* (14).

How to Read this Report

This report is organized into chapters.

Chapter 1: Chatham-Kent's Community

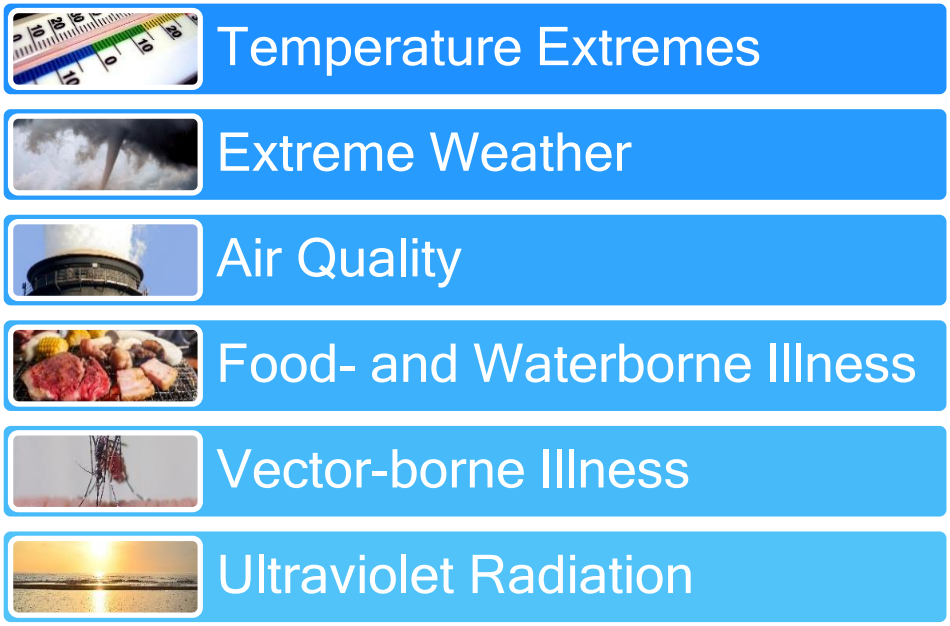
We describe Chatham-Kent's community, highlighting key characteristics of the population, including where residents live and their socioeconomic characteristics.

Chapter 2: Chatham-Kent's Climate

We provide a description of Chatham-Kent's historic climate patterns, and how the climate is expected to change over the coming decades.

Chapter 3: Health Impacts

This chapter is divided into sections, with each section examining one of six key climate-related hazards likely to impact the health of Chatham-Kent residents. These hazards were selected for analysis based on high morbidity or mortality related to the hazard; high level of concern in the community and among stakeholders surrounding the hazard; and/or recent events or studies highlighting issues that could affect health in Chatham-Kent.



Health Impact Analysis

For each of the six climate-related health hazards, we analyze current and projected health impacts and identify groups who are vulnerable to those hazards. Each section is subdivided as below:

Exposure

- We describe the current exposure of Chatham-Kent residents to climate-related hazards and the risks those hazards pose to human health.

Current Health Impacts

- We establish baseline data, describing current climate change health indicators. Where possible, data over the preceding 10 years (2007-2017) is provided.

Projected Health Impacts

- We describe how climate change health indicators are expected to change, given projected changes in climate. Projections are provided for the 2050s and the 2080s.

Vulnerability

- We describe characteristics of the communities and priority populations who are vulnerable to experiencing climate change health impacts.

Chapter 4: Conclusion

The report concludes with a brief overview of next steps.

Supplementary Information

This report includes a number of Appendices with supplementary information.

Appendix A: Indicators	Lists exposure, health impact, and vulnerability indicators referred to in this report.
Appendix B: Tables	Presents data contained within figures throughout this report in table format. Supplementary tables are also provided.
Appendix C: Maps	A collection of maps displaying flood-prone areas and areas with intrinsic susceptibility to groundwater contamination identified in the Chatham-Kent Official Plan.
Appendix D: Glossary	A glossary of terms used throughout this report.

About the Data

This report synthesizes data from a wide variety of sources, including academic literature, grey literature, government reports, and internal program data. Below is a summary of key sources of data and information.

Population Data

2016 CENSUS OF POPULATION

Data and information contained within the "Population Characteristics" section of this report were obtained from the 2016 Census of Population completed by Statistics Canada. The 2016 data provide information about the population, age and sex, type of dwelling, families, households, marital status, language, income, immigration and ethno-cultural diversity, housing, Aboriginal peoples, education, labour, journey to work, language of work, and mobility and migration (15).

LABOUR

Data and information concerning labour and employment were obtained from the 2016 Census, with the exception of data concerning migrant workers. These data were obtained from the Chatham-Kent Local Immigration Partnership's 2013 report *Exploring the Impacts of Regulatory Change on Temporary Foreign Workers in Chatham-Kent* (5).

Climate Data

CLIMATE CLASSIFICATION

Chatham-Kent's climate was classified using the Köppen-Geiger climate classification. The Köppen-Geiger climate classification is the most frequently used method of describing the different climates that exist throughout the world, which it classifies according to levels of precipitation and temperature patterns (16).

CLIMATE MODELS

Climate models are tools used to predict how climates will change over time. They predict changes in surface temperatures with very high confidence (14). Regional downscaling methods are used to translate data from climate models to the local level (14). In Canada, the Ontario Climate Data Portal and the Climate Atlas of Canada provide projections at the municipal level. We have used data from these models to describe climate change projections in Chatham-Kent.

Climate models typically present different pathways in their projections, representing different warming scenarios. For example, the Climate Atlas of Canada distinguishes between a high carbon scenario, in which emissions continue to rise and maximal warming will occur, and a low carbon scenario, in which the world's countries implement mitigation measures that decrease emissions by mid-century, resulting in less warming (17). The standard term for

these different scenarios is Representative Concentration Pathway (RCP). In this report, we have used RCP8.5, which represents the highest level of warming. This is the path the world is currently following (11).

Time Series

Climate change projections predict changes over defined time periods, starting from a baseline period. For the Climate Atlas of Canada, the baseline period used is 1976-2005 and projections are provided for the 2050s and 2080s (18). For the Ontario Climate Data Portal, the baseline period used is 1986-2005 and projections are provided for the 2050s and 2080s (19).

ENVIRONMENT DATA

Data on heat and cold alerts, UV Index, Air Quality Health Index, and tornado events were obtained from Environment and Climate Change Canada (20-24).

CLIMATE NORMALS

Historic climate normals for Chatham-Kent for the period 1981-2010 were obtained from Environment and Climate Change Canada (8). Data from the monitoring system located in Chatham were used.

NATURAL DISASTERS

Data on natural disasters were obtained from the Canadian Disaster Database, which is maintained by Public Safety Canada. This database tracks natural, technological, or conflict events that have occurred since 1900 and which meet the following criteria:

- 10 or more people killed;
- 100 or more people affected/injured/infected/evacuated or homeless;
- An appeal for national/international assistance;
- Historical significance; or,
- Significant damage/interruption of normal processes such that the community affected cannot recover on its own (25).

Health Impact Data

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE ASSESSMENT REPORTS

The Intergovernmental Panel on Climate Change (IPCC) is the United Nations body created to assess the science related to climate change. It provides regular assessments of the scientific basis for climate change, its current and future impacts, and the options to mitigate its effects (3).

THE LANCET COUNTDOWN: TRACKING PROGRESS ON HEALTH AND CLIMATE CHANGE

The *Lancet Countdown* is an international research collaboration created following the 2015 *Lancet Commission on Health and Climate Change*, which concluded that climate change threatens to reverse the past 50 years of improvements in public health (9). The goal of the countdown is to provide an independent, global monitoring system of the health impacts of climate change and of efforts to mitigate its effects, between 2016 and 2030 (9). The most recent annual *Countdown Report* was released in November 2018.

HUMAN HEALTH IN A CHANGING CLIMATE: A CANADIAN ASSESSMENT OF VULNERABILITIES AND ADAPTIVE CAPACITY

The report *Human Health in a Changing Climate: A Canadian Assessment of Vulnerabilities and Adaptive Capacity* was prepared by Health Canada in 2008. It provides a health impact and vulnerability analysis of climate change at the national level (26).

ONTARIO CLIMATE CHANGE AND HEALTH MONITORING STUDY

The *Ontario Climate Change and Health Monitoring Study Report* was created by the Ministry of Health and Long-Term Care in partnership with the Ministry of the Environment and Climate Change (now the Ministry of the Environment, Conservation and Parks) and the University of Toronto Climate Lab to:

- Assess the potential impacts of climate change on human health and forecast key health risks across Ontario;
- Generate projection scenarios for the 2050s and 2080s for each of 36 public health unit areas; and,
- Provide graphical representation to illustrate the spatial distribution of potential health risks (27).

Health Data

INTEGRATED PUBLIC HEALTH INFORMATION SYSTEM (IPHIS)

Data on the incidence of communicable diseases were obtained from the Integrated Public Health Information System (iPHIS), a database used by Ontario's public health units to report information and reportable diseases to the Ministry of Health and Long-Term Care (28).

INTELLIHEALTH ONTARIO

Data on hospital stays and emergency department visits were obtained from IntelliHealth Ontario, a database of administrative and clinical data collected from various sectors of Ontario's health care system (29).

INTEGRATED SERVICES FOR CHILDREN INFORMATION SYSTEM

The number of live births was used as an estimate of the number of pregnant women in Chatham-Kent each year. Data were obtained from the Integrated Services for Children Information System (ISCIS), a database used to collect data from the Healthy Babies, Healthy Children program offered at health units in Ontario (30).

ONTARIO ASTHMA SURVEILLANCE INFORMATION SYSTEM

The Ontario Asthma Surveillance Information System (OASIS) was established by the Hospital for Sick Children (SickKids) in 2003. It draws information from Ontario health administrative systems to provide a long-term surveillance system of asthma in Ontario, from 1996 to present (31).

PUBLIC HEALTH ONTARIO

Data on self-reported smoking rates, alcohol and drug use, weight, and chronic conditions in Chatham-Kent were obtained from Public Health Ontario (PHO) Snapshots (32–36). PHO is an arms-length government agency that provides scientific evidence and technical support to Ontario's public health units.

CHATHAM-KENT PUBLIC HEALTH UNIT

Data and information about CKPHU's programs, including the vector-borne disease program, the beach sampling program, and the health hazards program were obtained from CKPHU. CKPHU provides public health programs and services to the citizens of Chatham-Kent in accordance with the *Ontario Public Health Standards*, published under the Health Protection and Promotion Act, R.S.O. 1990.

CHAPTER 1

Chatham-Kent's Community

CKPHU is a division of the Community Human Services Department within the Municipality of Chatham-Kent. It serves a primarily rural community, covering a low-lying landmass of 2,470.52 km^2 (15). Bordered on the south by Lake Erie and the north-west by Lake St. Clair, Chatham-Kent is traversed by the Thames, Sydenham, and Snye river systems. Together, these bodies of water forge 300 km of shoreline throughout the region (37).

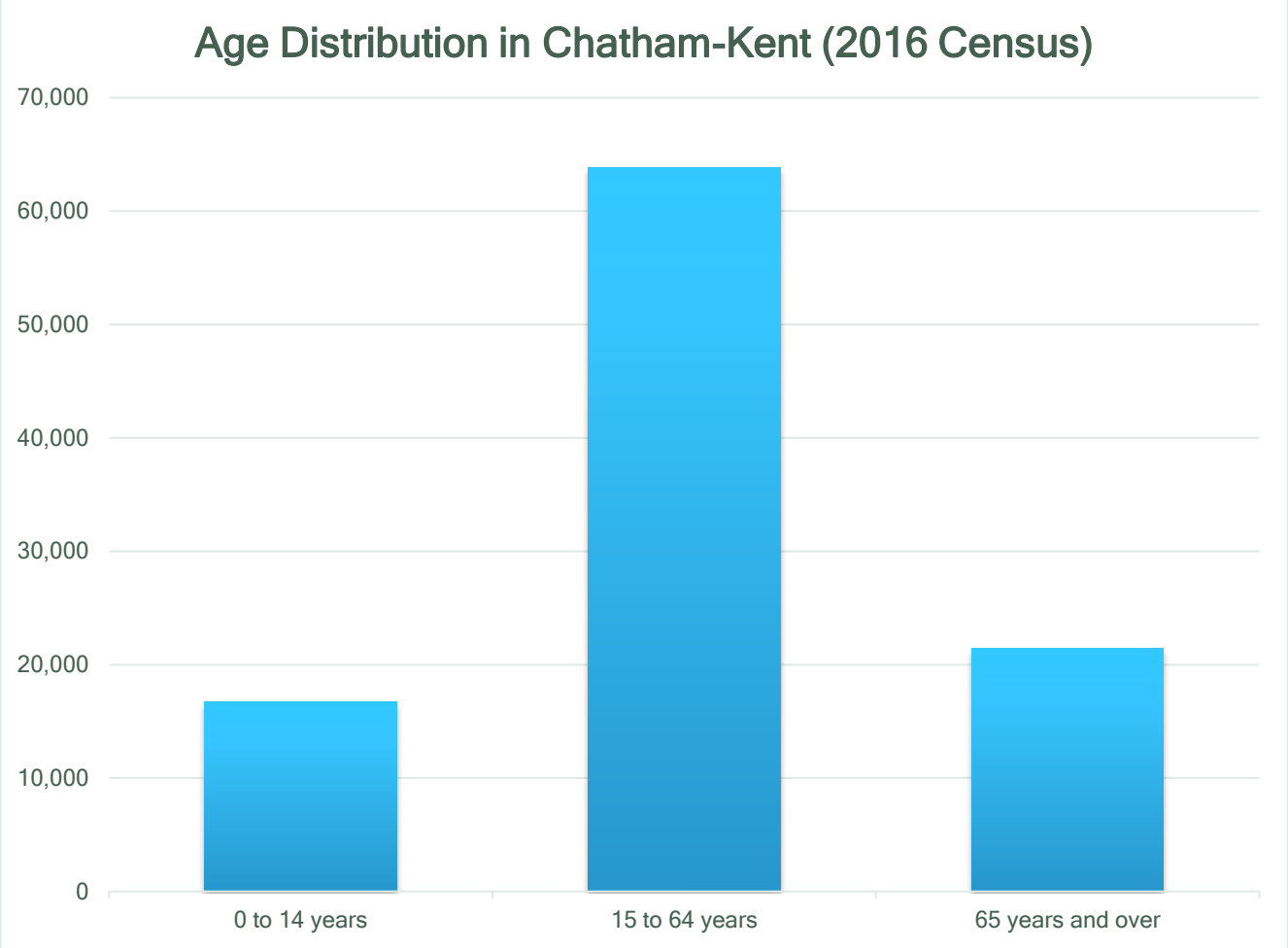
The Municipality of Chatham-Kent was established in 1998 following the amalgamation of 23 former municipalities (38). Chatham-Kent has a population 102,042, a change of -2.0% since 2011 (15). Population density is low at 41.3 people per square kilometre (15), with more than 96% of Chatham-Kent covered by farm lands (39). Urban centres include Chatham, Wallaceburg, Tilbury, Blenheim, Ridgetown, Wheatley, and Dresden (38) (see Appendix B: Table 1). The largest of these, Chatham, has a population of 44,145 (15). Delaware First Nation is located within Chatham-Kent, while Walpole Island First Nation spans its north-west corner along Lake St. Clair.

Population Characteristics

Demographics

AGE

Chatham-Kent has an older population, compared to the rest of Ontario. The average age of Chatham-Kent residents is 43.4 years (15). Chatham-Kent has a large number of adults over the age of 65, comprising 22.6% of the population, which is greater than the provincial average of 16.7% (15). The number of seniors is expected to increase significantly over the next 20 years, while the number of children and adults under 65 years is expected to decrease (38).



Data Source: Statistics Canada. 2017. Chatham-Kent [Census agglomeration], Ontario and Ontario [Province] (table). Census Profile. 2016 Census. Statistics Canada Catalogue no. 98-316-X2016001. Ottawa. Released November 29, 2017. https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/index.cfm?Lang=E (accessed December 2, 2018).

(See Table 2).

HOUSEHOLDS

Most Chatham-Kent residents (76.6%) live in small households in detached homes, rather than apartments (15). There are 43,175 private dwellings in the region (15). Average household size is 2.3, though 29.8% of households consist of one person living alone (15).

NEW IMMIGRANTS

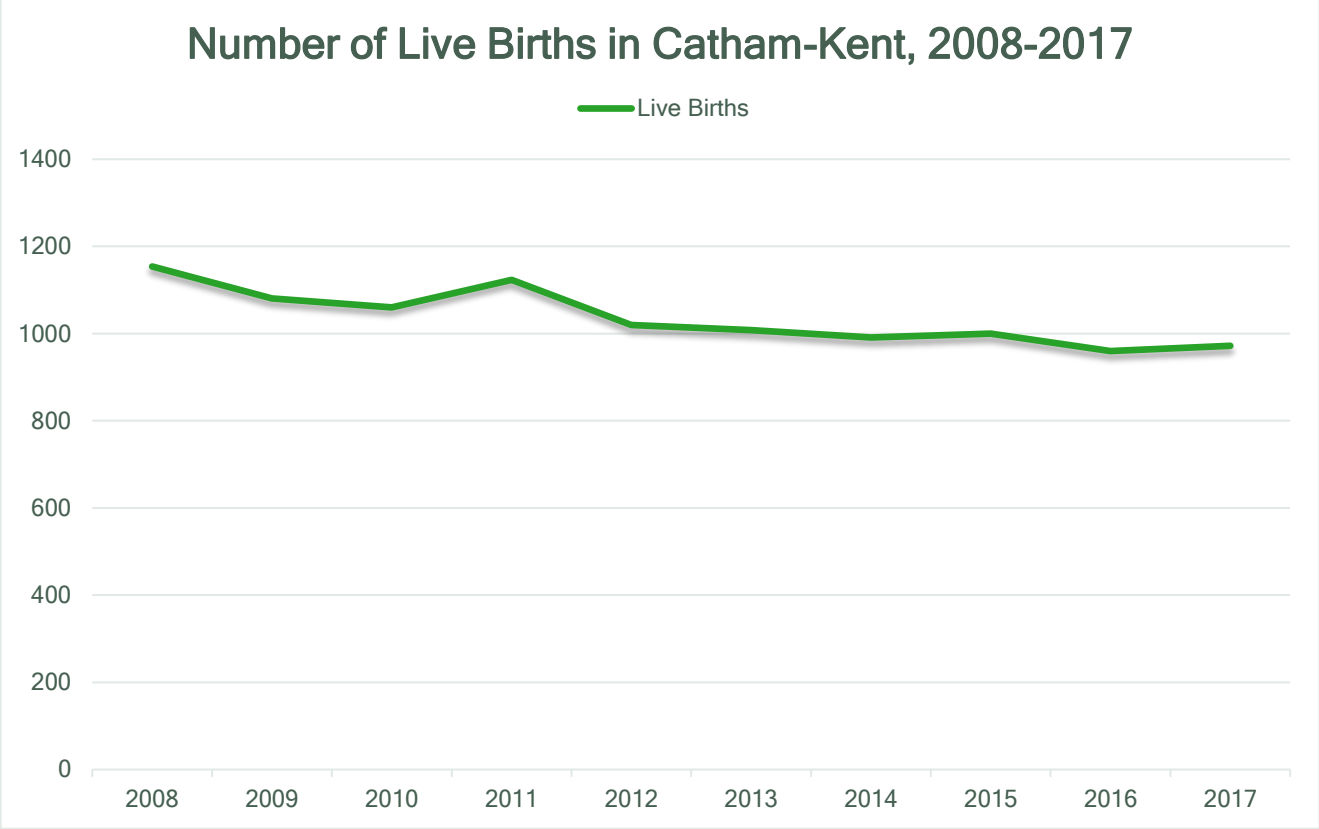
Chatham-Kent has a small community of newcomers. A total of 8,630, or 8.7% of residents are immigrants with 655 having immigrated within the past five years (15). There are 705 refugees living in Chatham-Kent and 350 non-permanent residents (15).

Migrant Workers

As a farming community, Chatham-Kent hosts a large number of temporary migrant workers. In 2014, the Chatham-Kent Local Immigration Partnership reported that there are approximately 1,000 temporary foreign workers employed in Chatham-Kent each year through the Temporary Foreign Workers Programs (5). Based on demand, the number of temporary foreign workers is expected to grow in coming years (5).

POPULATION GROWTH

Although Chatham-Kent's population has decreased over the past decade, the Chatham-Kent Official Plan forecasts a modest increase of 4,200 persons by 2031 (38). There has been an average of 1,037 live births per year in Chatham-Kent since 2008 (30).



Data Source: Integrated Services for Children Information System. [2008-2017], Extracted: September 2018.

(See Table 3).

Ethno-cultural Characteristics

ETHNICITY

In Chatham-Kent, 4,070 (4.0%) residents identify as Aboriginal, while 1,805 (1.8%) residents have Registered or Treaty Indian status (15). Visible minorities account for a further 4.5% of the population, most commonly: Black (2.1%), South Asian (0.6%), and Chinese (0.4%) (15).

LANGUAGE

More than 90 percent of the population speaks English only (15). Just 75 residents speak French only, while 570 speak neither English nor French (15). A total of 8,390 residents (8.30%) claim a non-official language as their mother tongue (15). The most commonly spoken non-official languages are German (2,590), Portuguese (575), Dutch (475), Spanish (395), and Italian (345) (15).

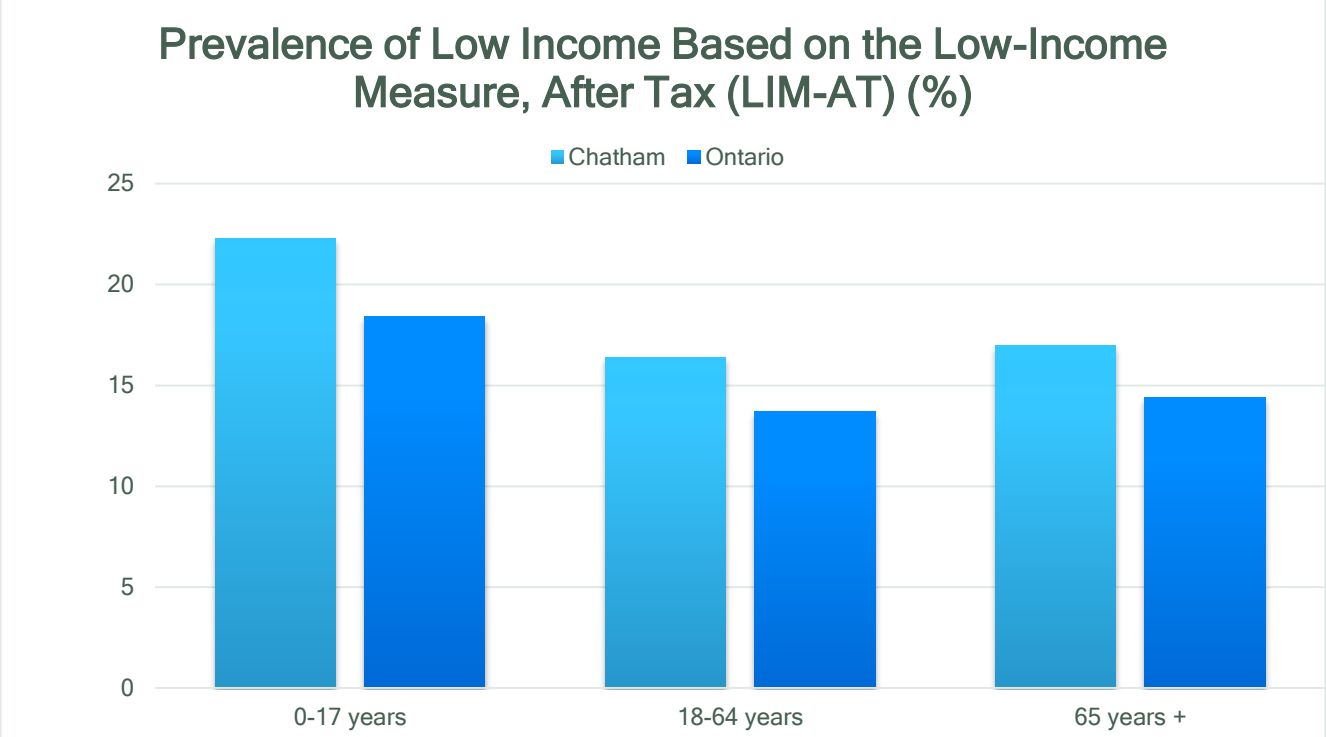
Socioeconomic Characteristics

EDUCATION

Among residents over the age of 15, 24.1% have no certificate, diploma, or degree, compared to the provincial average of 17.5% (15). Nearly half of residents have completed a post-secondary certificate, diploma, or degree (15). Females in Chatham-Kent are more educated than males, on average, with 48.1% having completed post-secondary training compared to 43.5% of males (15).

INCOME

In 2015, 97.0% of residents in Chatham-Kent had income. Median after-tax income was $28,426, below the provincial median of $35,753 (15). On average, males in Chatham-Kent earn more than females, with a median after-tax income of $33,046, compared to $24,474 for females (15).



Data Source: Statistics Canada. 2017. Chatham-Kent [Census agglomeration], Ontario and Ontario [Province] (table). Census Profile. 2016 Census. Statistics Canada Catalogue no. 98-316-X2016001. Ottawa. Released November 29, 2017. https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/index.cfm?Lang=E (accessed December 2, 2018).

(See Table 4).

A higher proportion of Chatham-Kent residents live in low income (17.0%) than the provincial average (14.4%) and 17.8% of households receive government assistance, compared to 11.1% for the rest of Ontario (15).

LABOUR

In 2016, the unemployment rate in Chatham-Kent (7.4%) was approximately on par with the provincial average (7.5%) (15). More males (8.2%) were unemployed than females (6.9%) (15). Chatham-Kent has a large proportion of residents who are not in the labour force (39.8%), compared to 35.3% for the rest of Ontario (15).

CHAPTER 2

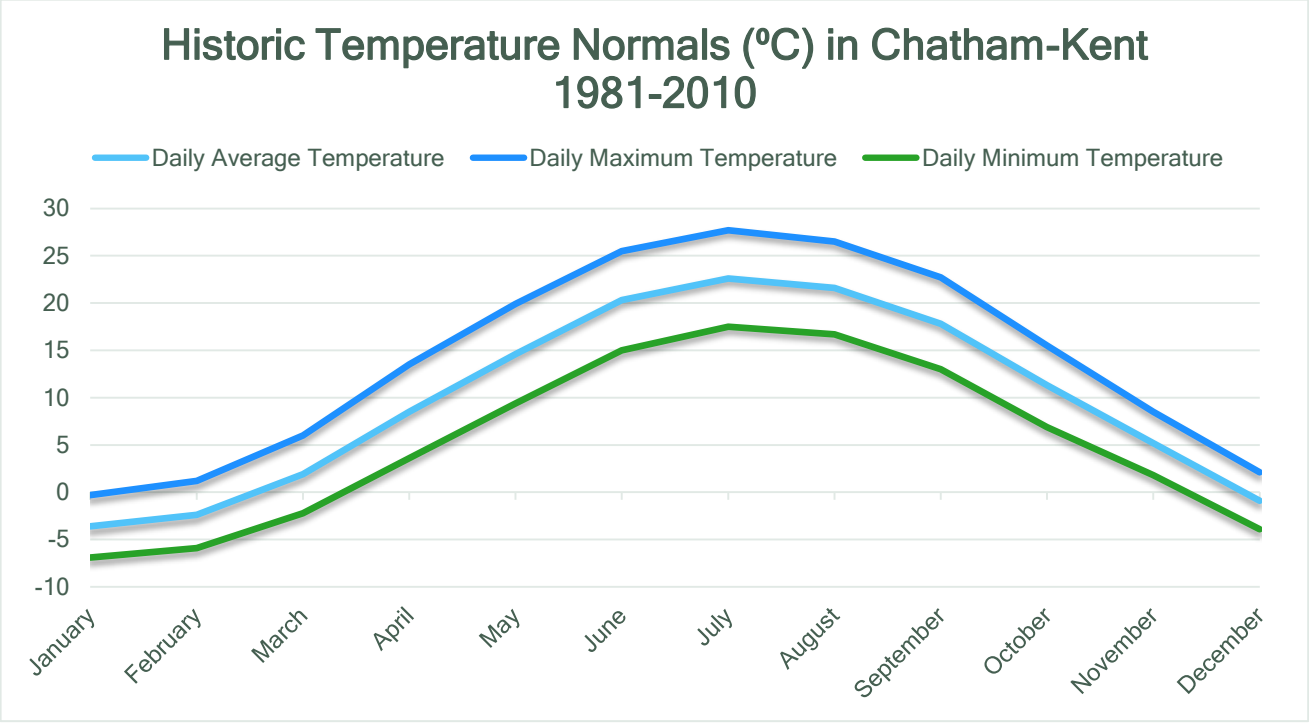
Chatham-Kent's Climate

Historic Climate Patterns

According to the Köppen-Geiger climate classification, Chatham-Kent has a humid continental climate, characterized by warm to hot summers and cold winters with precipitation distributed throughout the year (16). Under this classification, at least four months out of the year must have temperatures above 10°C, while the coldest month must have a temperature below 10°C (16). Tables 5-12 in Appendix B describe historic climate normals in Chatham-Kent for the period 1981-2010. Key trends are highlighted below.

Temperature

Historical climate data reveals that the average daily temperature between 1981 and 2010 was 9.8°C (8). On average, there have been 17 days each year with temperatures above 30°C and 0.55 days each year with temperatures above 35°C (8). Heat waves, defined as three or more consecutive days with temperatures above 32°C, are uncommon with an average of 0.48 per year, (27). The average year has had no days with temperatures below -30°C (8).

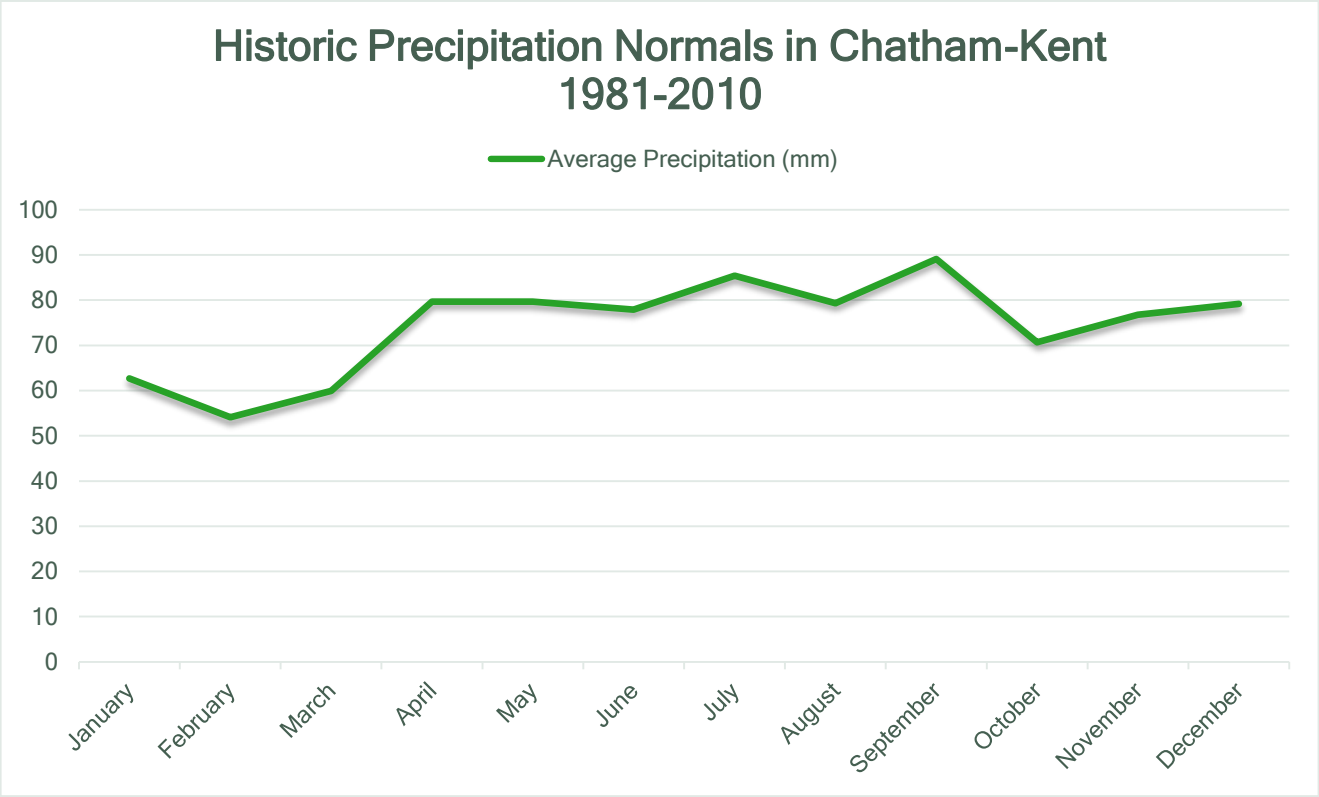


Data Source: Environment and Climate Change Canada. 2017. Canadian Climate Normals 1981-2010. http://climate.weather.gc.ca/climate_normals./index_e.html (accessed July 2018).

(See Table 5)

Precipitation

Historically, Chatham-Kent has seen an average of 882.3 mm of precipitation each year (8). Precipitation is nearly equally distributed throughout the year, with the least precipitation occurring during the winter months from January to March and the most occurring during the summer between July and September (8). Extreme precipitation events have more commonly been recorded between April and September (8).



Data Source: Environment and Climate Change Canada. 2017. Canadian Climate Normals 1981-2010. http://climate.weather.gc.ca/climate_normals./index_e.html (accessed July 2018).

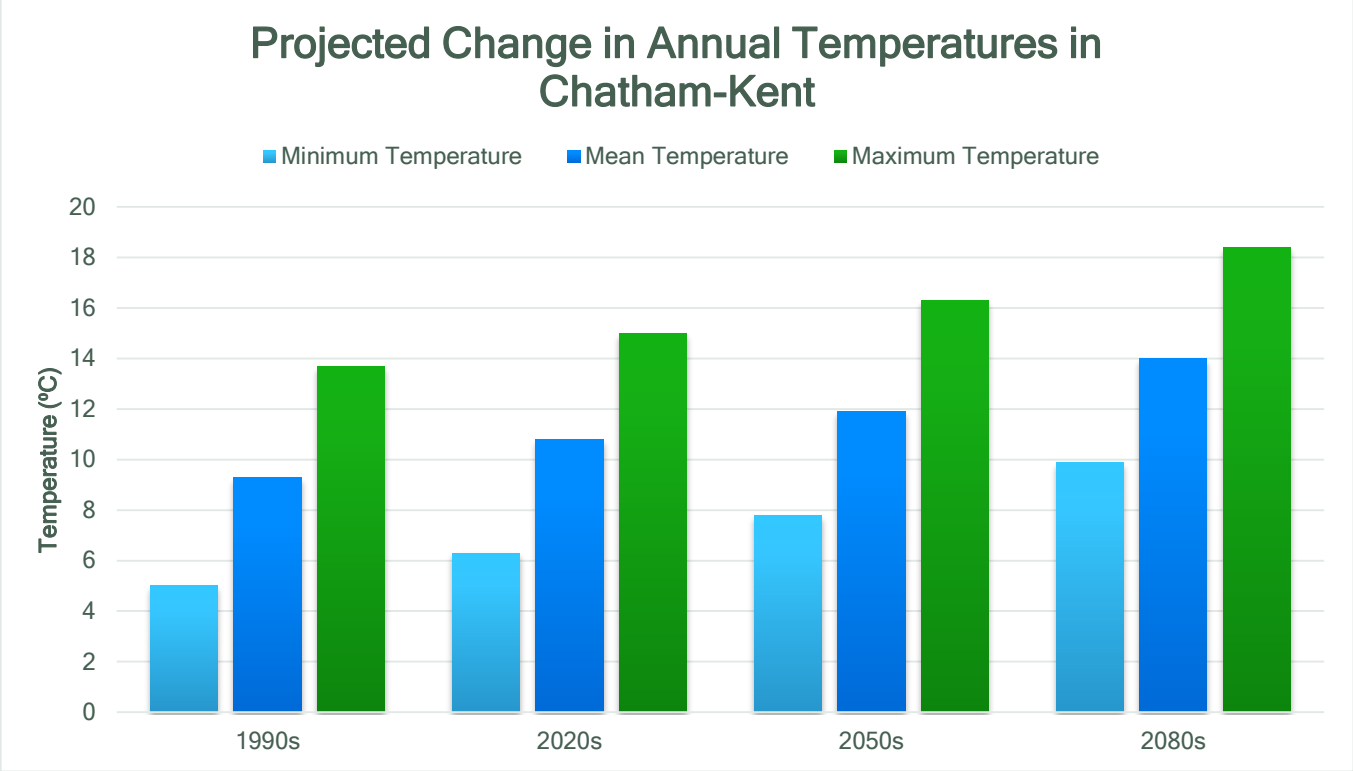
(See Table 6)

Future Climate Projections

Climate models predict how Chatham-Kent's climate will change. Tables 13-17 in Appendix B describe these projections. Key trends are highlighted below.

Temperature

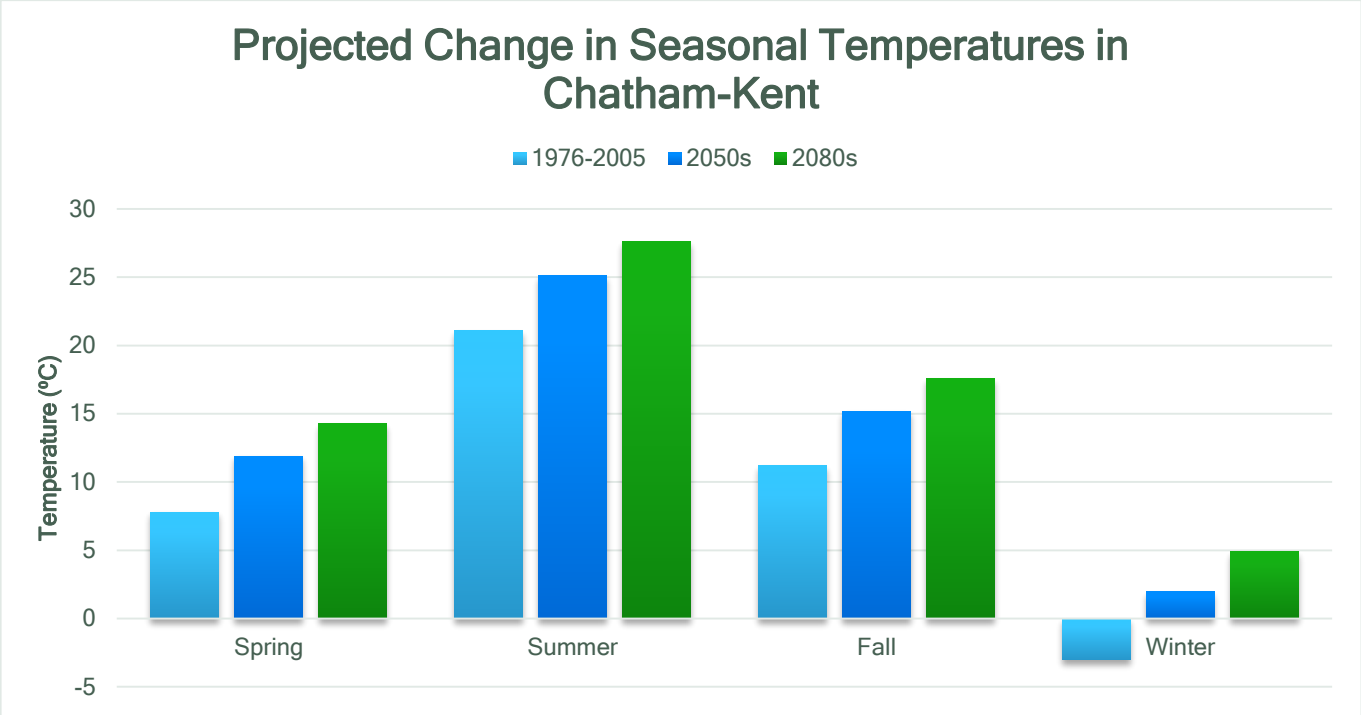
Over the coming decades, Chatham-Kent's climate will warm significantly. By the 2050s, average annual mean temperature will reach 11.9°C, on par with the current average in Frankfurt, Kentucky, more than 600 km to the south (7,40).



Data Source: Prairie Climate Centre. 2018. The Climate Atlas of Canada. https://climateatlas.ca/ (accessed July 2018).

(See Table 13)

Summers in Chatham-Kent will be longer and hotter and winters will be shorter and milder. By the 2050s, there will be as many as 69 very hot days each year, during which temperatures exceed 30°C (7). This is more than four times the average over the past 30 years and equivalent to nearly 10 weeks of extreme heat (7,8). By the 2080s, this number will rise to 99 very hot days, or nearly one third of each year (7). The number of heat waves will rise. By the 2050s, Chatham-Kent will experience 2.32 heat waves per year and 4.99 per year by the 2080s (27). Winters will be warmer, with the average temperature rising from -3°C to 4.9°C by 2080 (7). By the 2050s, the first fall frost will occur nearly a month later, by the end of November (7).

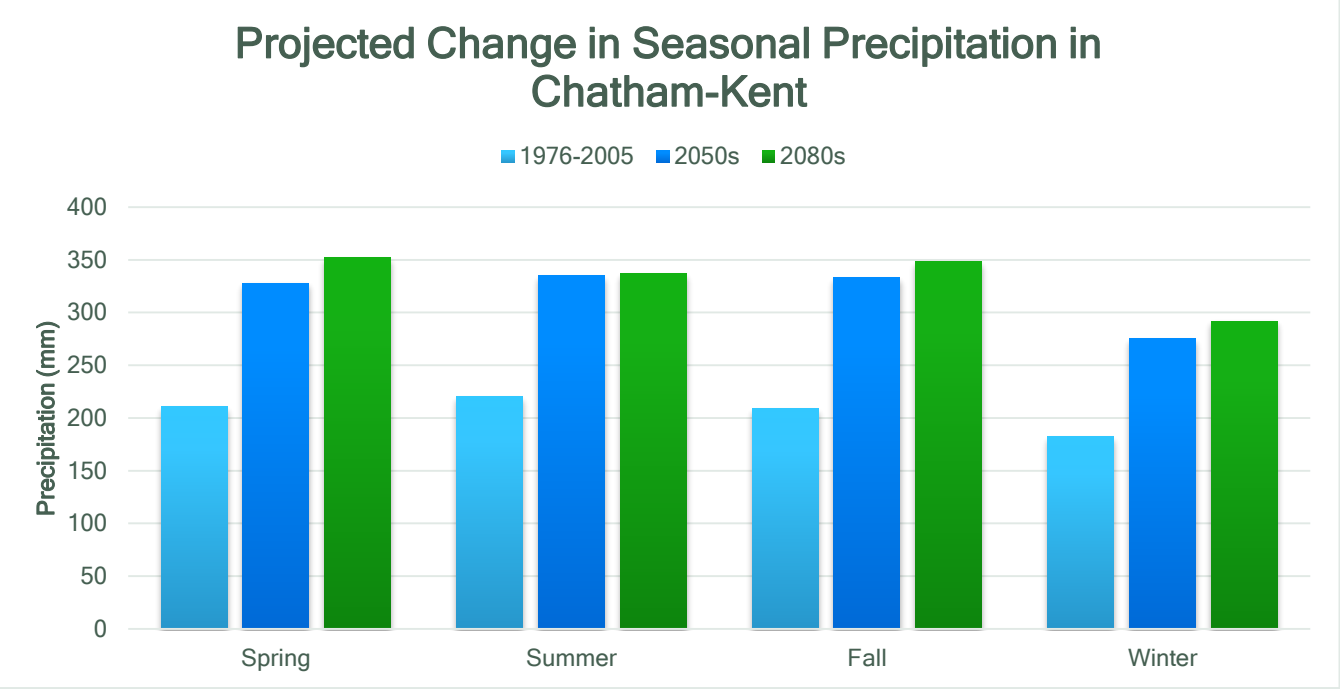


Data Source: Prairie Climate Centre. 2018. The Climate Atlas of Canada. https://climateatlas.ca/ (accessed July 2018).

(See Table 14)

Precipitation

Warmer temperatures cause greater precipitation. Higher evaporation rates are expected to lead to more frequent storms, heavy rainfall and, consequently, flooding. Chatham-Kent will experience 29% more precipitation by the 2050s and 34% more by the 2080s (7). This will bring levels of precipitation on par with what is currently seen in Canada's Maritime Provinces (2).



Data Source: Prairie Climate Centre. 2018. The Climate Atlas of Canada. https://climateatlas.ca/ (accessed July 2018).

(See Table 17)

Temperature Extremes

KEY TAKEAWAYS

- Temperature extremes disrupt the body's ability to maintain its core temperature, causing tissue damage and illness
- Chatham-Kent's climate will warm significantly over the coming decades, leading to more instances of heat-related illness
- Winters will generally be milder, but extreme cold events are still possible
- A large proportion of the population is vulnerable to the effects of extreme heat, including older adults, children, pregnant women, and people who spend time outdoors

Temperature extremes directly impact human health (41). This is because the human body is sensitive to changes in core temperature, which is normally maintained at 37°C. The hypothalamus is the part of the brain that regulates body temperature. When the hypothalamus senses changes in temperature, such as too much or too little heat, it signals the body to respond, causing reactions like sweating or shivering, to bring the body back to normal temperature (42). During extreme temperatures, this regulation system can become overwhelmed, with severe consequences (43).

Extreme Heat

When we become hot, our bodies work to shed heat, primarily by sweating (44). During extreme heat, our bodies may not be able to shed heat quickly enough, causing core body temperature to rise (44). When core temperature rises above 38°C, heat exhaustion occurs, with signs of physical and cognitive impairment (41). Above 40°C, the body experiences serious heat overload, leading to cell injury and death (42). This is known as heat stroke, which carries a risk of organ damage, loss of consciousness, and death (41). Other direct health impacts of extreme heat include swelling, heat cramps, heat rash, dehydration, fainting, stress, and exacerbation of existing medical conditions (26).

Extreme Cold

Extreme cold also affects health. When we become cold, our bodies act to decrease heat loss and increase heat production, such as by shivering (45). A decrease in core body temperature below 37°C causes blood vessels in extremities to constrict, decreasing blood flow (46). This can result in tissue and nerve damage, known as frostbite (46). Left untreated, severely frostbitten skin and tissues can become infected and loss of limbs can occur (47). At body temperatures below 35°C, hypothermia sets in (47). Blood becomes thicker and heart beat slows (45). Severe cases may experience cognitive and physical impairments and, eventually, death (45,47). Cold temperatures also cause many indirect health impacts, such as accidental injury due to slips and falls (26).

Exposure

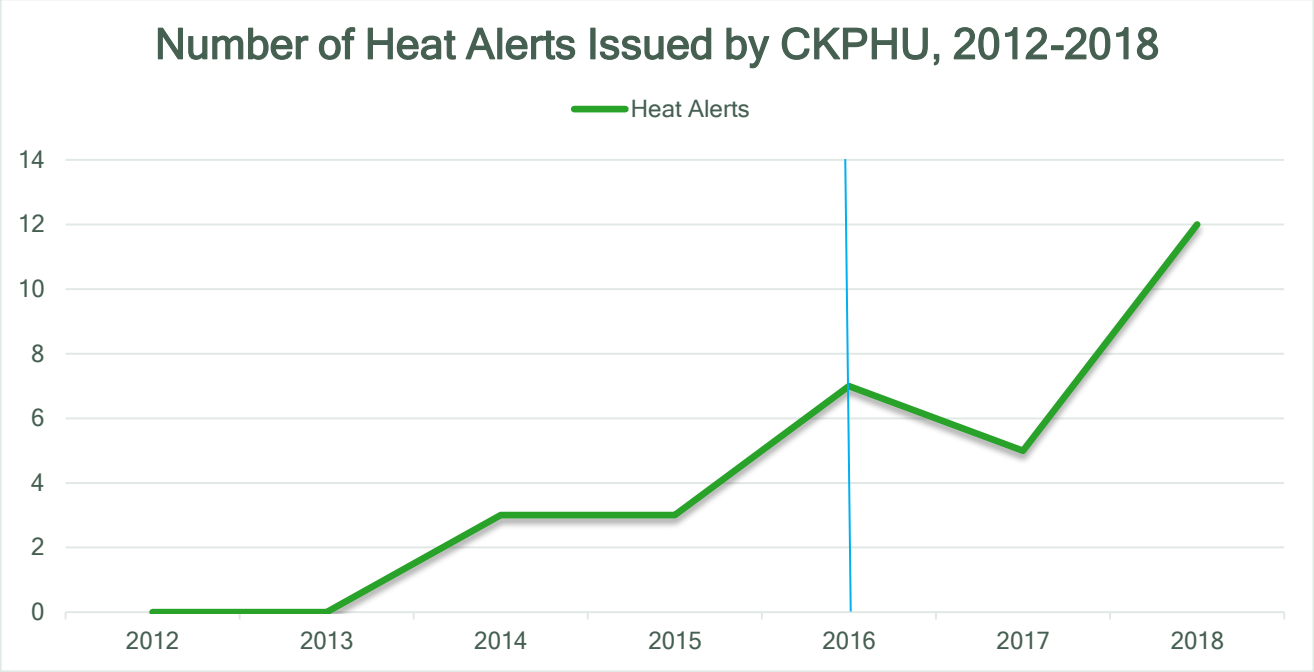
Historically, exposure to both extreme heat and extreme cold in Chatham-Kent has been limited (8). Environment Canada and CKPHU issue alerts for extreme heat and extreme cold, warning members of the public to take protective measures. Prior to 2016, CKPHU used its own criteria for determining when to issue a cold alert. In 2016, CKPHU changed its criteria to align with Environment Canada guidelines. The changes are outlined below. The number of alerts serves as an indicator of exposure to extreme heat and extreme cold in Chatham-Kent.

Extreme Heat

In 2016, Environment Canada changed its guidelines for issuing an extreme heat alert. The table below describes these changes.

Criteria Prior to 2016	Current Criteria
• Expected daytime maximum temperature greater than or equal to 31°C and expected minimum nighttime temperature greater than or equal to 20°C; or, • Two or more consecutive days with expected humidex values of 40 or higher.	• Two or more consecutive days with expected daytime maximum temperatures of 31°C or warmer and nighttime minimum temperatures of 21°C or warmer; or, • Two or more consecutive days with expected humidex values of 42 or higher.

Between 2012 and 2017, CKPHU issued an average of three heat alerts per year (48). No heat alerts were issued in 2012 and 2013 and only one in 2014 (48). Recent years have seen a rise in the number of heat alerts. There were 12 heat alerts issued in 2018.



Data Source: Chatham-Kent Public Health Unit. 2018.

(See Table 18)

URBAN HEAT ISLAND EFFECT

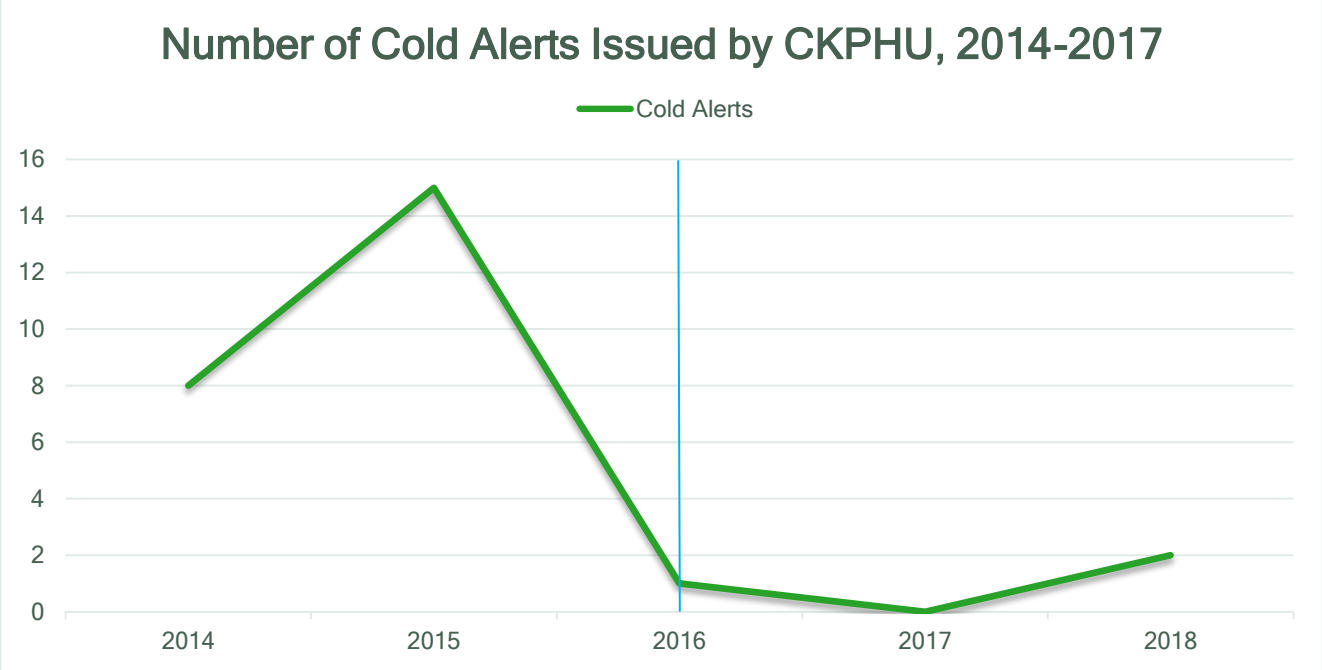
The urban heat island effect occurs when asphalt and building surfaces absorb the sun's heat (26). This causes temperatures in urban areas to increase by 0.5°C to 5.6°C above ambient temperature, exacerbating the effects of extreme heat (26). Though typically associated with large cities, urban heat islands have been identified as a concern in the City of Chatham as well. A heat study conducted at 275 schoolyards and 529 public spaces throughout Windsor-Essex, Sarnia-Lambton, and Chatham-Kent in 2010 found that surface temperatures in Chatham were nearly 10°C warmer than in Windsor, Sarnia, and surrounding areas, with a mean of 60.6°C (49).

Extreme Cold

Prior to 2016, CKPHU used its own criteria for issuing cold alerts. In 2016, CKPHU changed its criteria for issuing cold alerts to align with Environment Canada guidelines.

Criteria Prior to 2016	Current Criteria
• Expected temperature of -15°C or lower, without wind chill; or, • Wind chill warning for outdoor activity; or, • Extreme weather conditions, such as a blizzard or ice storm	• Expected temperature or wind chill of -30°C for at least two hours

Between 2012 and 2017, Environment Canada issued two cold alerts for Chatham-Kent per year, on average (48), while CKPHU issued an average of four cold alerts per year during the same time period, the discrepancy being due to the different criteria followed prior to 2016 (50). In 2014 and 2015, Environment Canada issued a higher number of cold alerts than usual, with six in each year (48). Two cold alerts were issued in 2018.



Data Source: Chatham-Kent Public Health Unit. 2018.

(See Table 20)

Current Health Impacts

Extreme Heat

Over the last 10 years (2008 to 2017) there have been 285 emergency department visits and 21 hospitalizations related to heat exposure (51). No deaths in the last 10 years (2003 to 2012) had a primary cause of heat exposure

(52). For the most recent five years, there were 26 emergency department visits per year on average, and the average crude rate of heat-related emergency department visits was 25.0 per 100,000 (51,53).

Extreme Cold

Over the last 10 years (2008 to 2017) there have been 201 emergency department visits, 33 hospitalizations, and three deaths (2003 to 2012) related to cold exposure (51,52). For the most recent five years, there were 20 emergency department visits per year on average, and the average crude rate of cold-related emergency department visits was 19.1 per 100,000 (51-53).

Projected Health Impacts

Climate change is expected to cause hotter summers and more frequent heat waves, leading to substantial increases in heat-related morbidity and mortality (41). Exacerbating the problem, warmer temperatures encourage more people to spend time outdoors, making them vulnerable to the effects of extreme heat (26).

By contrast, milder winters are expected to decrease morbidity and mortality related to extreme cold, though this decrease may be modest, and extreme cold will continue to pose a risk to human health (41,54). Despite the overall winter warming trend, there is concern that global warming may cause more frequent cold-air outbreaks in winter, during which temperatures plunge to extreme lows (55,56). This is because of changes to the stratospheric polar vortex, a mass of air that naturally forms over the arctic each winter, contained by a circling jet stream (55). Unusually warm temperatures in the arctic can cause this jet stream to weaken, allowing cold arctic air to break out from the pole, causing bitterly cold temperatures in more temperate regions (55). This phenomenon, and its relation to climate change, is an area of active researched (55).

Vulnerability

Socioeconomic and Environmental Circumstances

SOCIOECONOMIC STATUS

Certain socioeconomic groups are disproportionately affected by extreme heat. This includes those who have lower education levels and lower income, those whose ethnic background is non-White and people living in isolation (57).

An approximation of the number of individuals of low socioeconomic status (SES) in Chatham-Kent can be made by education and income levels, though other factors may affect SES. A large proportion of Chatham-Kent residents have lower levels of education and low income when compared to the rest of Ontario with one in four residents having no certificate, diploma or degree and 17.0% living on low income (15).

In Chatham-Kent, 4,070 residents identify as Aboriginal (4.0%), while 1,805 (1.8%) residents have Registered or Treaty Indian status (15). Visible minorities account for a further 4.5% of the population (15).

ACCESS TO AIR CONDITIONING

Vulnerability to extreme temperatures depends in part on living circumstances as people who lack access to places where they can cool off, such as air conditioned homes, are at greater risk of heat-related illness (58). In fact, access to a working air conditioner can reduce the risk of heat-related illness by 80% (59). Access to a working fan has a lesser effect (57). A survey conducted in 2016 found that 94% of adults in Chatham-Kent reported having an air conditioner in their home and 86% reported having a portable fan (60).

LACK OF SHELTER

People experiencing homelessness are particularly vulnerable to the health impacts of temperature extremes because they lack shelter and often have chronic conditions (57). During the 2018 registry week enumeration, Chatham-Kent's Enumeration Planning Committee surveyed 47 of 70 individuals who were homeless or at risk of becoming homeless to develop a snapshot of homelessness in Chatham-Kent (61). Among the key findings were that males were nearly twice as likely as females to experience homelessness (61). Individuals surveyed also frequently reported mental health issues, addictions, and chronic health conditions (61), factors that further increase susceptibility to extreme heat. The report also highlights the fact that Indigenous people were overrepresented in the survey (61).

The *Chatham-Kent Homelessness Assessment and Plan* estimates that between 2,360 and 2,516 households in Chatham-Kent experience homelessness each year (62). A large proportion of this number are the hidden homeless, or those who rely on friends or family and other short-term accommodations, but cannot find permanent housing of their own (62).

OCCUPATION

People who work outdoors are more vulnerable to heat-related illness (58). In fact, it has been found that for every 1% increase in the number of people working in construction, there is an 8.1% increase in heat-related emergency department visits and a 7.9% increase in heat-related hospitalizations (63). Similarly, for every 1% increase in the number of agricultural workers, there is a 10.9% increase in heat-related emergency department visits (63). Moreover, the 2018 *Lancet Countdown Report* notes that, of the 153 billion hours of labour lost to extreme heat globally in 2017, 80% of these losses were in the agricultural sector (9).While the total number of people who work outdoors in Chatham-Kent is difficult to determine, a rough estimate can be made by the number of people employed in industries where outdoor work is common:

- Agriculture, forestry, fishing and hunting: 3,795 (7.6%)
- Mining, quarrying, and oil and gas extraction: 170 (0.3%)
- Construction: 3,285 (6.6%) (15).

By this estimate, approximately 7,250 people, nearly 15% of the working population in Chatham-Kent, are at risk of heat-related illness while at work.

Migrant Farm Workers

Migrant farm workers are particularly vulnerable to heat-related illness (64). Reasons for this include lack of training on preventing heat-related illness, lack of breaks, and lack of access to shade (64). In 2017, there were 1,000 temporary foreign workers in Chatham-Kent (5). This number is expected to grow in coming years (5).

Individual Circumstances

INFANTS AND CHILDREN

Infants and young children are more susceptible to heat-related illness. This is because of both physiological and environmental reasons. For example, because their brains are still developing, infants' bodies are not yet fully able to recognize and respond to heat stress (42). Several other factors compound the risk: children sweat less than adults, making it harder for them to shed heat; they produce more metabolic heat during physical activity; and their bodies take on heat faster than adults' because they have a greater surface-area-to-body weight ratio (65). Finally, infants and young children are reliant on caregivers to

monitor their exposure to extreme heat and to take action to reduce the impacts (42).

In Chatham-Kent, there are 16,740 children under 14 years of age, making up 16.4% of the population (15). This number is expected to decrease in coming years (38).

PREGNANT WOMEN

Exposure to extreme heat affects pregnancy health and outcomes. For example, a mother's prolonged exposure to extreme heat during pregnancy can lead to congenital heart defects in the fetus (66,67). Exposure of pregnant mothers to extreme heat has also been linked to low birth weight, preterm birth, and stillbirth (68).

An estimate of the number of pregnant women in Chatham-Kent can be made based on the number of live births. The actual number of pregnant women is lower, as counts of live births include multiples. In 2017, there were 972 live births in Chatham-Kent (30). The rate of live births has been steady over the past decade, with an average of 1,037 live births per year (30).

OLDER ADULTS

Older adults are some of the worst impacted by the effects of extreme heat (57). This is because of physiological, social, and environmental reasons. As we age, changes in our bodies reduce our ability to adapt to extreme heat. For example, older adults are at greater risk of dehydration as they experience reduced thirst sensation, particularly while exercising in warm environments (65). Older adults also sweat less and experience less blood flow to the skin, reducing their ability to shed heat (57). Older adults may be less physical fit due to agility and mobility issues and are more likely to have impaired cardiac output, affecting their ability to respond to heat (57). They are also more likely to experience social isolation, as well as visual, cognitive, and hearing impairments, affecting their ability to access help (69).

There are 21,450 adults over the age of 65 in Chatham-Kent, or 22.6% of the population (15). This number is expected to grow significantly over the coming decades (38).

Social Isolation

Older adults who live alone, those who live in institutions and those who are confined to a bed are more likely to experience heat-related illness (57). Nearly one third of Chatham-Kent adults live alone (15).

CHRONIC DISEASE AND HEALTH CONDITIONS

Chronic Health Conditions

People with chronic health conditions are more sensitive to extreme heat. This includes individuals with cardiovascular and respiratory conditions, mental illness and overweight (69). People taking certain drugs and medications are also at risk (69).

There is a higher prevalence of chronic conditions in Chatham-Kent than in the rest of Ontario (70). The majority (65.4%) of Chatham-Kent residents aged 12 to 64 have at least one chronic health problem (71). Nearly all residents over the age of 65 years (93.7%) have at least one chronic health problem (71).

Public Health Ontario's *Self-Reported Chronic Health Problems Snapshot* illustrates the chronic conditions most frequently reported by Chatham-Kent residents:

- Asthma: 9.3%
- Heart disease: 4.2%
- High blood pressure: 17.4%
- Stroke: 1.8%
- Diabetes 6.7%
- Mood disorders: 14.8%
- Anxiety disorders: 9.7% (32).

Medication Use

Individuals who take certain medications commonly prescribed for chronic health conditions are at greater risk of heat-related illness as these medications can affect water and/or salt retention and they affect the body's ability to regulate temperature (58,72). Drugs with this effect include antidepressants, antipsychotics, blood pressure medication, and anti-Parkinson's drugs (58).

ALCOHOL AND DRUG USE

People who use alcohol and narcotics are more vulnerable to the health impacts of temperature extremes (73). They are overrepresented in cases of accidental hypothermia (74). The proportion of Chatham-Kent adults that report heavy drinking (five or more drinks for men or four or more drinks for women on at least one occasion per month) is 20.3%, which is above the provincial average

of 18.5% (33). Between 2009 and 2012, 9.7% of residents reported having used an illicit substance within the past 12 months, below the provincial average of 13% (34).

Overweight and Obesity

Adults who are overweight or obese are 3.5 times more likely to die of heat stroke than adults of average weight (57). The reasons for this are not entirely understood, but are thought to be related to higher heat production in overweight individuals, a reduced ability to shed heat, and reduced sensitivity to heat (57). In Chatham-Kent, 31.5% of adults report that they are overweight, below the provincial average of 33.2% (35).

Extreme Weather

KEY TAKEAWAYS

- Extreme weather events cause direct health impacts, such as injury and death, and indirect health impacts, such as enteric illness
- Extreme weather events, including heavy rainfall, storms, and flooding will increase as temperatures rise
- Flood events were previously more common in the spring, but now occur year-round
- At least 15,000 to 20,000 Chatham-Kent residents (14.7 to 19.6% of the population) reside in flood-prone areas
- People with low income, children, and seniors are disproportionately affected by extreme weather

The health impacts of extreme weather can be vast. They range from direct impacts, such as drowning, injuries, hypothermia, and death to indirect impacts, including foodborne illness and vector-borne disease (41). Extreme weather events also cause significant psychological stress (41,75). A study of Burlington residents impacted by serious flooding in 2014 found that nearly half of respondents continued to experience negative mental health impacts three years after the flood and more than half of residents had to take time off work, with an average of seven lost work days (75). Extreme weather has also been linked to higher rates of depression, anxiety, post-traumatic stress, drug and alcohol use, and suicide (76). Where extreme weather events affect vulnerable people, they become natural disasters (77).

Exposure

Rain Storms

Warm air holds more moisture. As temperatures rise, the moisture-holding capacity of air increases (78). Evaporation also increases (79). This results in increased moisture in the air, leading to more precipitation, which in turn causes more frequent extreme weather events (80,81).

FLOODING

Flood Risk Areas

Flooding is the most common natural disaster (41). It is also one of the most deadly: 15% of deaths related to natural disasters are caused by floods (9). Chatham-Kent has a long history of flooding, with several areas at risk, including:

- Approximately 9,000 hectares of low-lying areas in Dover, Tilbury North, Tilbury East, and Raleigh;
- The entire village of Thamesville;
- Low-lying areas along the Thames River in Chatham and 9,000 hectares of agricultural land along the Thames River from Chatham to the Chatham-Kent/Elgin boundary;
- Approximately 650 hectares of agricultural land and lakeshore homes in the south Harwich, Erie Beach, and Erieau areas; and,
- The entire community of Wallaceburg (38,82).

Schedule E of the Chatham-Kent Official Plan illustrates flood prone areas throughout the municipality (see Appendix C: Flood-Prone Areas). Based on population counts, we conservatively estimate that 15,000 to 20,000 people throughout Chatham-Kent reside in flood-prone areas.

Historic Flood Events

Chatham-Kent has experienced two 50-year flood events since 1985 (83). From February to March 1985, mild temperatures leading to snowmelt caused heavy flooding of the Thames River, as well as MacGregor Creek and Indian Creek in Chatham (83). A total of 1,180 homes were flooded and an Ontario Provincial Police Helicopter was used to evacuate 30 people from outlying areas (25).

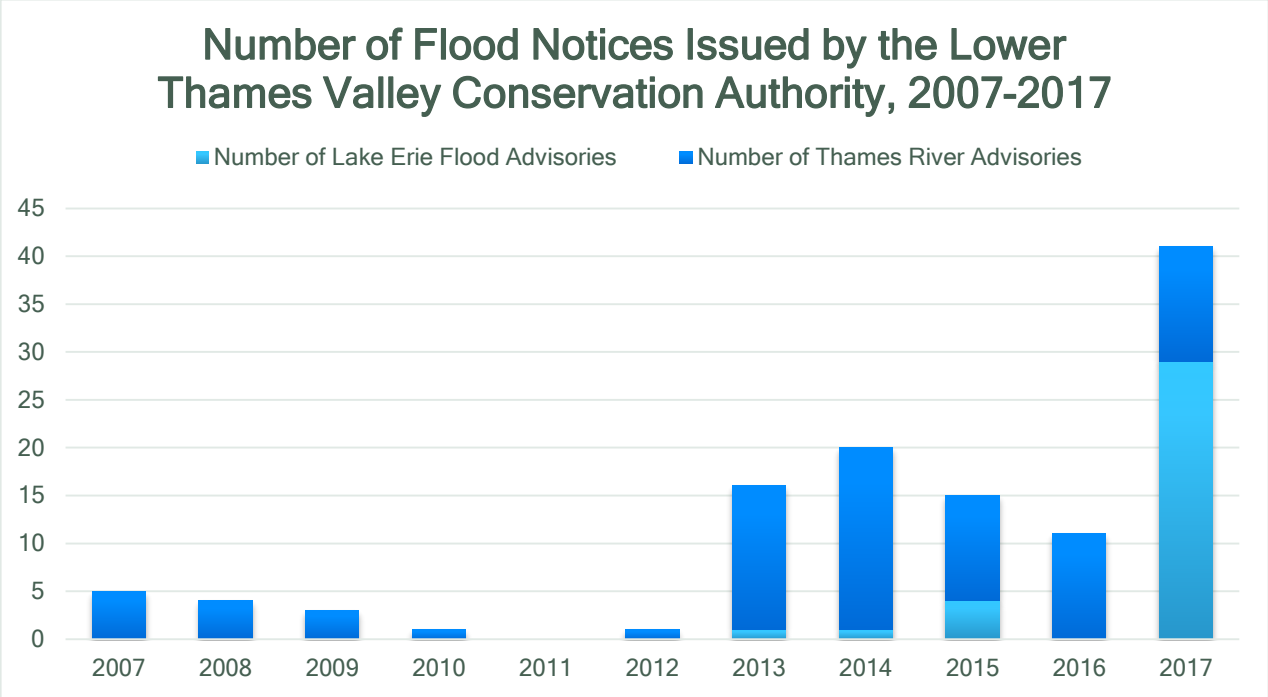
In February 2009, the W. Darcy McKeough Dam north of Wallaceburg was closed and a state of emergency was declared when an imminent flood risk arose due to an ice jam (84). The Sydenham District Hospital, now the Chatham-Kent Health Alliance, located fewer than 200 metres from the riverbank, issued a Code Orange Standby alert, though plans to evacuate the hospital were ultimately abandoned (84).

Recent Floods

More recently, in February 2018, the dam north of Wallaceburg was closed when heavy rains, coupled with significant snowmelt following mild temperatures, caused water levels to rise. Concurrent flooding along the Thames River led to a declaration of a state of emergency in Thamesville (85). The municipality requested that residents voluntarily evacuate the area and the Chatham-Kent Fire Department shut off gas to 430 homes and businesses (85,86). The Lower Thames Valley Conservation Authority (LTVCA) noted that water levels along some parts of the Thames River reached their highest since 1977 (83).

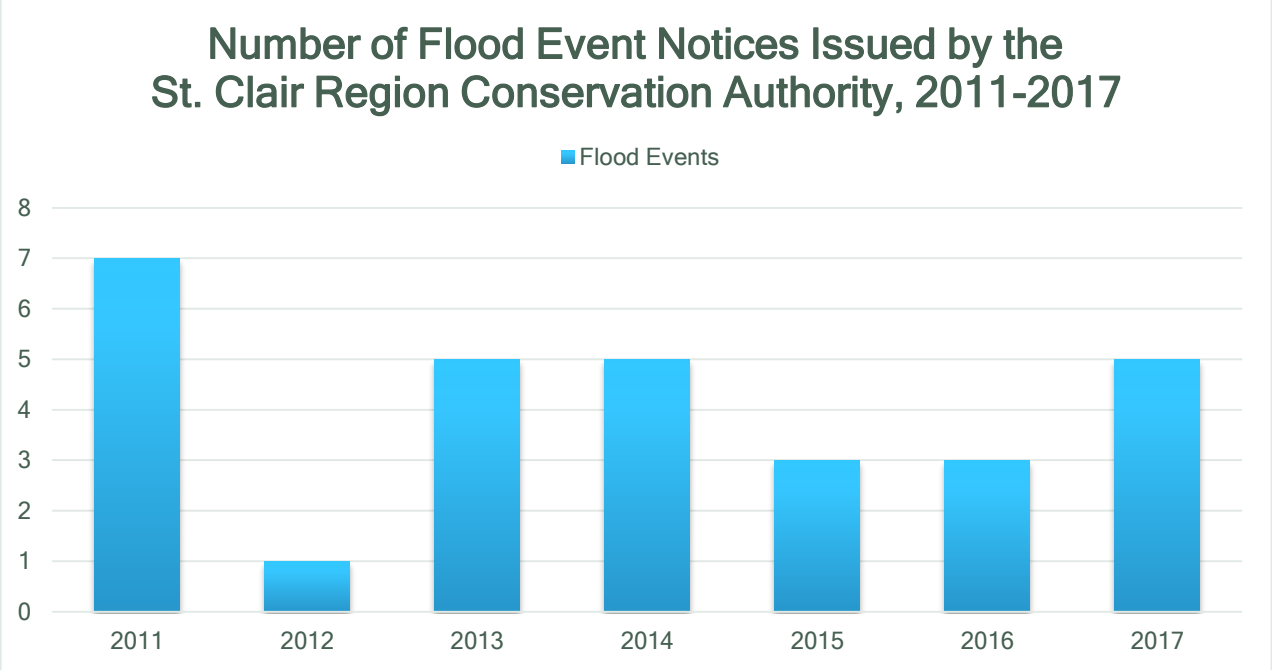
In September 2018, following heavy rainfall, a number of homes and businesses in Tilbury were flooded and two schools had to be closed for nearly a week for cleanup (87).

In 2017, LTVCA issued 41 flood notices and St. Clair Region Conservation Authority (SCRCA) reported five flood events (83,88).



Data Source: Lower Thames Valley Conservation Authority. 2007-2017. Extracted: August 2018.

(See Table 22)



Data Source: St. Clair Region Conservation Authority. 2011-2017. Extracted: August 2018.

(See Table 23)

TORNADOES

Chatham-Kent is located within a tornado corridor that extends from Windsor to Barrie, where the probability of tornado events occurring is high: more than two events per 10,000 km^2 are expected per year (89). Between 1980 and 2009, there were 378 verified tornado events in Ontario, 12 of which occurred in Chatham-Kent, or approximately one tornado every 2.5 years (20). Despite the likelihood of such an event, there has not been a verified tornado event within the boundaries of the municipality since 2000 (20). Draft data from Environment and Climate Change Canada indicates that there were no verified tornado events in Chatham-Kent between 2010 and 2017, though 11 verified events occurred in neighboring Windsor-Essex (21).

Winter Storms

Chatham-Kent has typically experienced the least snow fall in Ontario, averaging just 79.2 cm per year, with snowfall occurring on just 22 days out of year, on average (8). For comparison, neighbouring Windsor-Essex experiences an average of 44 snowfall days per year totalling 129.3 cm, nearly 40% more (8).

The Canadian Disaster Database records one winter storm disaster that affected Chatham-Kent in the past century. In January 1999, a snowstorm

throughout Ontario led to 11 fatalities and seven injuries (25). This event brought nation-wide attention to Toronto when the mayor sought military assistance to clear the snow. Chatham-Kent was the other municipality that sought military assistance to deal with the fallout (25).

Current Health Impacts

Between 2008 and 2017 there were 15 emergency department visits related to extreme weather among Chatham-Kent residents, most of which were because of unspecified forces of nature (90).

Projected Health Impacts

Rain Storms

Precipitation in Chatham-Kent is expected to increase significantly over the coming decades, with nearly 30% more rainfall by the 2050s (7). This trend is already being felt; the intensity of rain storms in Ontario has been increasing over the last 30 years and extreme rainfall events are becoming more frequent (27,91). This threatens to overwhelm current wastewater infrastructure, impacting water quality and quantity (27,91).

FLOODING

Increased precipitation is likely to increase the frequency of flooding over the coming decades (79). Changes in flood patterns are already being observed. The SCRCA has noted that the region's freshet period, when winter thaw poses a serious flood risk, was previously expected in March of each year (92). Now, flooding is possible at any time of the year, with snowmelt occurring as early as December (92).

TORNADOES

Though it is not certain that climate change will cause more frequent tornado events, there is a real risk that more destructive tornado events will occur in future (81).

Winter Storms

Though milder winter temperatures are likely to reduce the number of snowstorms, other winter storms may become more frequent. Freezing rain events in Ontario are expected to increase 40% by the 2050s and 45% by the 2080s (93).

Vulnerability

Socioeconomic and Environmental Circumstances

INCOME AND EDUCATION

Socially and economically disadvantaged populations may be less likely to receive warning messages and experience greater difficulty seeking shelter and evacuating during extreme weather events (26,94). These groups may have fewer resources to prepare for disasters, such as choosing not to live in flood-prone areas (26,94). They also experience greater difficultly recovering from extreme weather events compare to those with higher SES (94).

A large number of Chatham-Kent residents, 24.1%, have no certificate, diploma or degree, compared to the provincial average of 17.5% (15). Chatham-Kent also has a greater proportion of residents living on low income than the provincial average (15).

LANGUAGE

In an emergency, individuals with communication barriers may have difficulty accessing and understanding warning messages. Though the majority of Chatham-Kent residents are native English speakers, a small proportion of the population is not. There are 75 Chatham-Kent residents who speak French only, while 570 speak neither English nor French (15). A large proportion of residents, 8.3%, are native speakers of neither French nor English (15). There are 655 new immigrants and 705 refugees in Chatham-Kent(15).

PHYSICAL ENVIRONMENT

Individuals residing in flood zones are likely to be impacted by flood events. In Chatham-Kent, this comprises a significant portion of the population, including the communities of Wallaceburg, Thamesville, Dover Centre, Mitchell's Bay and a substantial portion of south Chatham. By a conservative estimate, between 15,000 and 20,000 people (14.7 to 19.6% of the population) are vulnerable. Appendix C illustrates areas at risk of flooding throughout the municipality.

Individual Circumstances

AGE

Older Adults

Older adults often live in isolation, making it difficult to access warning messages (26). Older adults often have mobility issues that make it difficult to

evacuate, making them more susceptible to injury and adverse health outcomes (26). Older adults are also more likely to have chronic conditions that make them more susceptible to secondary health effects from storms, such as carbon monoxide poisoning related to indoor use of fuel-powered generators during power outages (26). People with chronic conditions and those who rely on medications may have difficulty accessing services during natural disasters (26).

There are 21,450 adults over the age of 65 in Chatham-Kent, or 22.6% of the population (15). This number is expected to grow significantly over the coming decades (38).

Children

Children are particularly vulnerable to the health impacts of extreme weather, particularly when those events reach the level of a natural disaster. During natural disasters, caring for children is more complicated than caring for adults (95). During a disaster, for example, when resources are strained, child-appropriate medications may be less available (95). Children and adolescents are also more susceptible to experiencing negative mental health impacts following traumatic events (95). Due to their small size and still developing immune systems, children may also be more susceptible to secondary health effects related to extreme weather events, such as poor air quality from wildfires; carbon monoxide poisoning related to indoor use of barbeques and generators during power outages; and vector-borne disease following floods (26,95).

In Chatham-Kent, there are 16,740 children under 14 years of age, making up 16.4% of the population (15). This number is expected to decrease in coming years (38).

MOBILITY

People with mobility limitations may find it more difficult to evacuate during extreme weather events. In Chatham-Kent, 7.2% of adults over the age of 15 report having mobility limitations (96).

Air Quality

KEY TAKEAWAYS

- Poor air quality causes increased morbidity and premature death
- When it comes to air quality, Chatham-Kent is among the most vulnerable regions in Canada due to high levels of air pollution and the high proportion of residents who are susceptible to negative health impacts related to air quality
- The burden of illness related to poor air quality is high
- Rising temperatures are expected to caused poor air quality in the future
- Seniors, children, people with chronic conditions, and those who work outdoors are at greater risk of adverse health impacts related to air pollution

The burning of fossil fuels releases pollution into the atmosphere. When we breath polluted air, air pollution contaminants enter our airways, causing tissue inflammation and damage with a wide range of negative health effects (97). Among the health effects linked to poor air quality are higher rates of respiratory and cardiovascular illness; diabetes; cancer, mental illness (including depression and suicide); birth defects; neurodegenerative diseases; and premature death (41,98–103). Pollutants of particular concern for human health are ground-level ozone, nitrogen dioxide, and particulate matter (27).

Ground-Level Ozone

Ground-level ozone is formed as the result of reactions between the greenhouse gases nitrogen oxide, carbon monoxide, methane, and volatile organic compounds in the presence of sunlight and heat (104). Ground-level ozone irritates the lungs, causing airway muscles to constrict, which leads to chest tightness and shortness of breath, even in healthy individuals (105). Even small increases in ground-level ozone increase the risk of pre-mature death (41). Exposure to ground-level ozone has been linked to both chronic and acute damage to the respiratory system, including increased airway permeability,

decreased lung function, and airway inflammation (26). Short-term exposure to ground-level ozone has been linked to heart attacks and heart rate variability (26).

Nitrogen Dioxide

Nitrogen dioxide is a reddish-brown, malodorous gas that forms during combustion reactions (106). When breathed into our lungs, it forms nitrous acid and nitric acid, which damage lung tissue, leading to lung disease (107). It can also impair the immune system, decreasing the body's ability to fight off infections (107).

Particulate Matter

Particulate matter is a mixture of particles and droplets that forms when fuels are combusted (108). It can include aerosols, smoke, fumes, dust, ash, and pollen (108). Particulate matter varies in size from course (PM_{10}) to fine ($PM_{2.5}$) and ultrafine ($PM_{0.1}$). Fine and ultrafine particulate matter can penetrate deep into the lungs and enter the bloodstream, where they are disseminated to other parts of the body (26). Exposure to particulate matter has been tied to higher respiratory and cardiovascular mortality, exacerbation of asthma, decreased lung function, and inflammation of the heart (26).

Aeroallergens

Climate change can improve growing conditions and increase the growing season for certain plants and has been tied to an increase in aeroallergens, such as fungal spores and plant pollen, which can trigger asthma and allergic reactions (41). As pollen levels rise, the number of ambulance calls related to asthma and the number of hospital visits related to respiratory symptoms also increase (41).

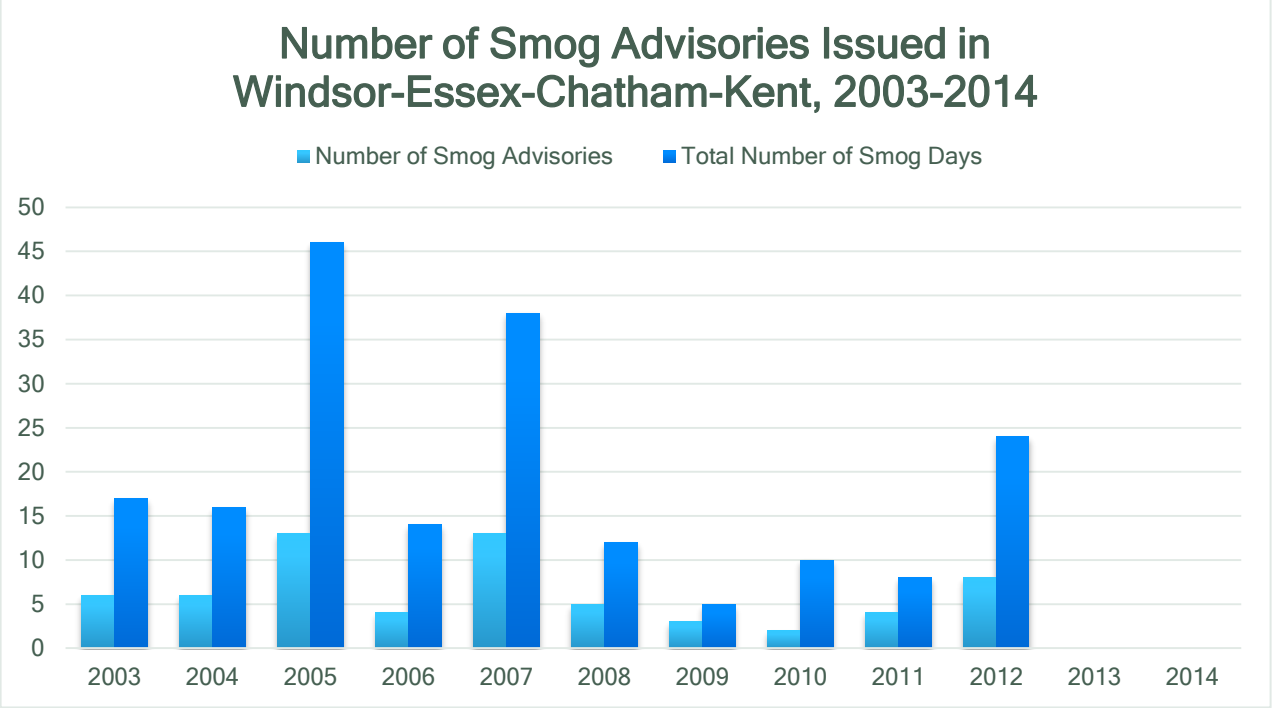
Exposure

Despite being a primarily rural area with few industrial pollution sources, Chatham-Kent has high levels of air pollution, with concentrations similar to those seen in many major cities (109). This is concerning, considering that as many as 35.7 to 41.2% of Chatham-Kent residents are vulnerable to experiencing negative health impacts related to air pollution (110). These factors combined mean that, when it comes to air pollution, Chatham-Kent is among the most vulnerable regions in Canada (110).

High levels of air pollution in Chatham-Kent are primarily due to trans-boundary movement of air pollution from other regions (109). In fact, on some days, as much as 95% of ozone over the region originates from other areas (109).

Air Quality Monitoring

Prior to 2015, the Ontario Ministry of the Environment issued smog advisories when there was a strong likelihood of elevated smog levels within the next 24 hours or if smog conditions developed without warning. In the preceding years, the number of smog advisories and smog days had been decreasing (111).



Data Source: Environment and Climate Change Canada. 2018. Extracted: August 2018.

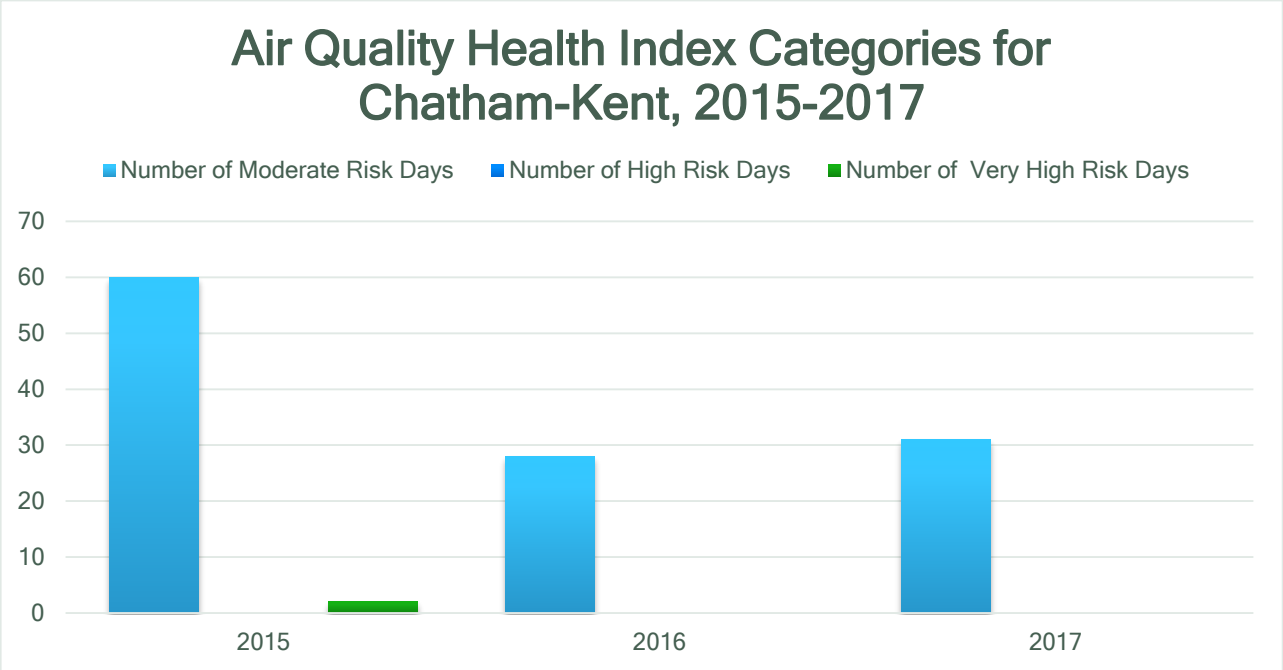
(See Table 25)

In 2015, the Ministry of Health and Long-Term Care and the Ministry of the Environment and Climate Change introduced the Air Quality Health Index (AQHI), which represents the relative risk of three common pollutants: ground-level ozone, fine particulate matter and nitrogen dioxide. The AQHI assigns a number from one to 10, corresponding the level of risk. These risk levels are divided into four risk categories:

- 1-3 Low health risk;
- 4-6 Moderate health risk;
- 7-10 High health risk;
- 10 + Very high health risk.

Each risk category corresponds to different public health messaging surrounding protective measures that individuals should take.

Between 2015 and 2017, Chatham-Kent experienced an average of 40 moderate-risk days per year and no high- or very high-risk days (23).



Data Source: Environment and Climate Change Canada. 2018. Extracted: August 2018.

(See Table 26)

Current Health Impacts

Between 2008 and 2017, there were 5,116 emergency department visits, 329 hospitalizations, and 10 deaths (2003 to 2012) among Chatham-Kent residents related to asthma (29,52). For the most recent five years, there were 438 emergency department visits and 30 hospitalizations per year on average, and the average crude rates of asthma-related emergency department visits and hospitalizations was 415 per 100,000 and 29 per 100,000, respectively (29,53). There were five emergency department visits over the last 10 years by Chatham-Kent residents where exposure to air pollution was specified as a cause (29).

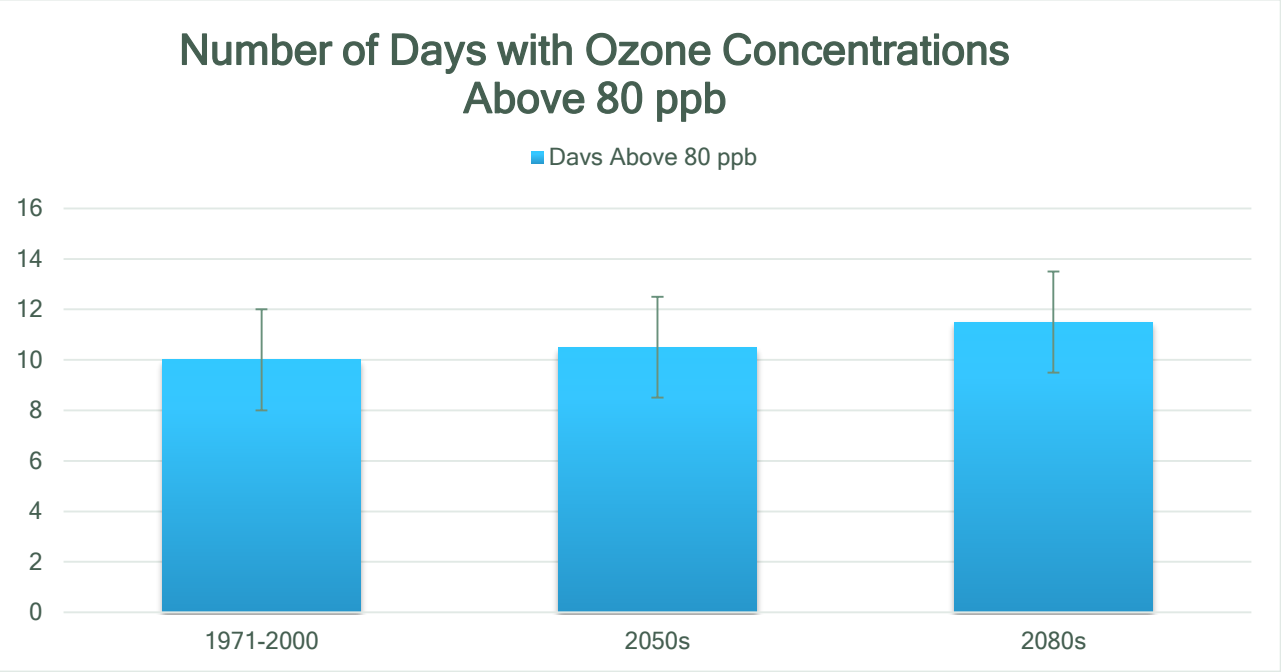
Since 1996, the incidence of asthma in Chatham-Kent (i.e., the number of new cases each year) has decreased, while the prevalence of asthma (i.e., the total number of cases in the population) has increased (31). In 2016, there were 200 new cases of asthma, with a crude incidence rate of 1.92 per 1,000 (31). There

were 17,768 people in Chatham-Kent with asthma, a crude rate of 17.04 per 100 (31).

Projected Health Impacts

Efforts to reduce greenhouse gas emissions in Ontario have resulted in improved air quality over the past decade (109). However, rising temperatures are expected to cause an increase in the number of days with poor air quality in future (27). The Ontario Climate Change and Health Modelling Study predicts a rise in ozone levels. This is measured by the number of ozone exceedances, days on which ozone concentrations rise above 80 ppb (27).

Chatham-Kent is expected to see an extra half day of ozone exceedances by the 2050s, and an extra day and a half by the 2080s (27). These numbers do not take into account trans-boundary movement of air pollution from other regions, which is significant source of pollution in Southern Ontario (27).



Data Source: Ministry of Health and Long-Term Care. 2016. *Ontario Climate Change and Health Modelling Study: Report. http://www.health.gov.on.ca/en/common/ministry/publications/reports/climate_change_toolkit/climate_change_health_modelling_study.pdf* (accessed August 2018).

(See Table 27)

The *IPCC Fifth Assessment Report* states that there is little evidence that climate change consistently affects levels of particulate matter (41). However,

high levels of air pollution are known to exacerbate the effects of climate-related hazards, such as extreme heat (26,41).

Vulnerability

Socioeconomic and Environmental Circumstances

SOCIOECONOMIC STATUS

Socially and economically disadvantaged populations are more likely to experience poor health outcomes related to poor air quality (112-114). The reasons for this are largely environmental. Lower income populations are more likely to live next to pollution sources, such as highways and industrial areas, and are exposed to higher concentrations of air pollution (114). People of lower SES are also more susceptible to poor health outcomes because they often experience higher levels of psychosocial stress and have fewer resources to promote health (113,114)

Chatham-Kent has a higher proportion of the population with lower levels of education and low income compared to the rest of Ontario with one in four residents having no certificate, diploma, or degree and 17.0% living on low income (15).

PROXIMITY TO TRAFFIC-RELATED AIR POLLUTION SOURCES

Motor vehicles are one of the most important sources of air pollution (97). In a critical review of the health effects of traffic-related air pollution, the Health Effects Institute concluded that those residing within 300 to 500 metres of major roads and highways are at greater risk of experiencing negative health effects related to air pollution (97). A major road was defined as one with Average Annual Daily Traffic (AADT) of 15,000 vehicles or more (97).

The stretch of the 401 that runs through Chatham-Kent is by far the busiest thoroughfare in the municipality, with AADT of 23,000 vehicles (115). The next busiest road in the municipality is the stretch of Highway 40 that connects the 401 to Park Avenue in Chatham, with AADT of 9,000 vehicles (115).

Nearly all of Chatham-Kent's major urban centres are located further than 500 metres from Highway 401, with the exception of Tilbury. In fact, some homes in the north end of Tilbury are located fewer than 50 metres from the highway. There are 4,815 people living in Tilbury (15).

Individual Circumstances

AGE

Older Adults

Older adults are more likely to suffer from age-related frailties and chronic conditions that make them more susceptible to the harmful effects of air pollution (116). For example, they may experience reduced lung function, which is further exacerbated by contaminants in air pollution (116,117).

Contaminants in air pollution also cause inflammation and damage to the central nervous system, with significant health effects (118). Chronic exposure to air pollution has been linked to neurodegenerative diseases, such as Alzheimer's and Parkinson's, and stroke (118). It has also been linked to cognitive decline in the elderly (98,119). In Ontario, 6.1% of all dementia cases are caused by exposure to air pollution (103). Exposure to high levels of air pollution is estimated to cause cognitive decline equivalent to two years of aging (98,119).

There are 21,450 adults over the age of 65 in Chatham-Kent, or 22.6% of the population (15). This number is expected to grow significantly over the coming decades (38).

Children

Because they spend more time outdoors, children are often exposed to more air pollution than adults (120). They are also more physically active and have higher breathing rates, taking more air pollution into their bodies (120). Because their respiratory tracts and immune systems are still developing, they are also more sensitive to the effects of air pollutants (112). Children exposed to air pollution are more likely to develop respiratory illnesses, such as asthma, as well as influenza, severe colds, and ear, nose and throat infections (112,121). Air pollution has also been linked to impaired cognitive development in children (122).

In Chatham-Kent, there are 16,740 children under 14 years of age, making up 16.4% of the population (15). This number is expected to decrease in coming years (38).

Fetal Development

Maternal exposure to air pollution can negatively impact fetal development. Pregnant women exposed to air pollution are more likely to deliver babies with low birth weight (102). Contaminants in air pollution may also cross the

maternal-fetal barrier, affecting neural development of the fetus and increasing the risk of early childhood cancer (100,118). In Chatham-Kent, there are an average of 1,037 live births per year (30).

CHRONIC HEALTH CONDITIONS

People with certain health conditions are more vulnerable to poor air quality. This includes people with chronic diseases that weaken their immune system, people who smoke tobacco, and people suffering from asthma or allergies (26).

Between 2015 and 2016, 19% of Chatham-Kent adults reported smoking (36). Nearly one in 10 residents report suffering from asthma (32).

OUTDOOR ACTIVITIES

People who spend time outdoors, such as outdoor workers and people who engage in outdoor recreational activities, are often exposed to higher levels of air pollution (123,124). Physically active individuals may spend more time outdoors engaging in intensive activities during poor air quality days, making them more susceptible to adverse health effects (123). Most Chatham-Kent residents are not physically active. A survey conducted between 2013 and 2014: found that 49% of Chatham-Kent adults reported being inactive during leisure time (71).

AWARENESS

Many Chatham-Kent residents are unaware of the negative health impacts of air pollution. In a survey conducted between 2013 and 2014, fewer than half of adults (36.9%) thought that air pollution has a somewhat negative or very negative impact on health (125). Even fewer adapt their behaviour to reduce their exposure to poor air quality. Fewer than one in five adults in Chatham-Kent make changes to their daily activities out of concern for the negative health impacts of air pollution and fewer than one third of parents check air quality alerts when planning their children's outdoor activities (125).

Food- and Waterborne Illness

KEY TAKEAWAYS

- Warmer ambient temperatures support the growth of food- and waterborne pathogens in the environment
- Heavy rainfall and extreme weather events will increase food- and waterborne illness
- People with low income, those who obtain their drinking water from unsecured sources and people with weakened immune systems are particularly at risk of food- and waterborne illness

Food- and waterborne illness is common. Every year, 4 million Canadians experience foodborne illness and 400,000 experience waterborne illness (126-128). These types of illness are caused by ingestion of food or water contaminated with pathogens. Waterborne illness can also be caused by contact with contaminated recreational water. Climate change may lead to a rise in food- and waterborne illness by creating conditions favourable to the survival, growth, transmission, and virulence of certain pathogens (41). It may also create habitats favourable to the expansion of species that harbour pathogens and of species that transmit pathogens to humans (41).

Exposure

Foodborne Illness

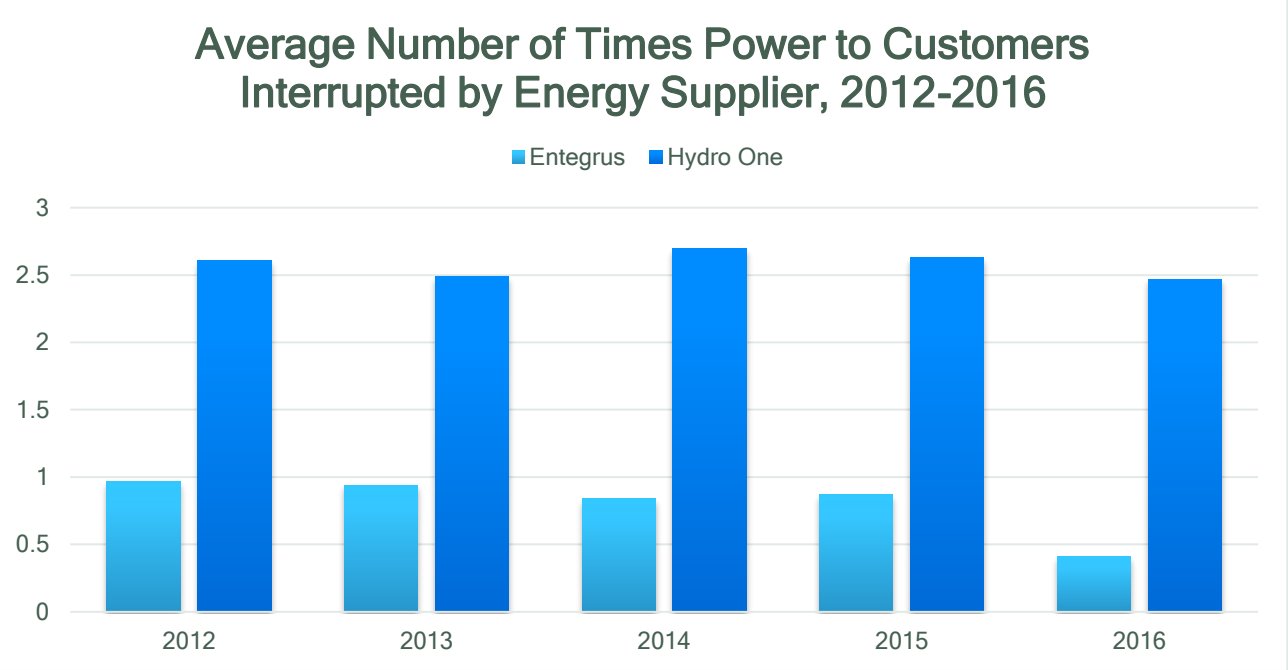
Warmer temperatures have been linked to increases in foodborne illness. Three of the most common foodborne pathogens, *Salmonella*, *Campylobacter jejuni,* and *Escherichia coli* O157:H7 are known to cause more infections during warmer months (26,41,126). Symptoms of infection with these pathogens range from mild gastrointestinal illness to severe disease, including kidney failure (129). Long-term complications are also possible. For example, infection with *Campylobacter jejuni* has been associated with Guillain-Barré Syndrome, an autoimmune disorder that can cause nerve damage, muscle weakness, and paralysis (129).

OUTDOOR BBQS AND MASS GATHERINGS

Foodborne illness is more common during the summer months. Part of the reason is that warmer temperatures encourage people to spend more time outdoors where they attend barbeques, picnics, and mass gatherings (26). Temperature abuse of hazardous foods, i.e. keeping foods at temperatures that support the growth of pathogens, are common at such events (26). In 2017, there were 212 special events held on Municipal property in Chatham-Kent (130).

POWER OUTAGES

Foodborne illness related to climate change may be indirectly impacted by power outages following extreme weather events (26). Restaurants and private homes without power may be unable to maintain adequate cold storage temperatures for hazardous foods, increasing the risk of microbial growth.



Data Source:
Ontario Energy Board. 2016. *Scorecard: Entegrus Powerlines Inc.*
Ontario Energy Board. 2016. *Scorecard: Hydro One Networks Inc.*

(See Table 28)

Between 2012 and 2016, Chatham-Kent residents experienced few power outages. People residing in rural areas were more likely to experience power outages lasting for longer periods of time than those residing in urban areas. Urban-dwelling residents in Chatham-Kent (primarily served by Entegrus Powerlines Inc.) lost power an average of 0.41 times in 2016 and were without

power for an average of one hour, when power outages occurred (131). Those residing in rural areas (primarily served by Hydro One Networks Inc.) lost power 2.47 times per year on average in 2016, for an average of seven hours each time (132).

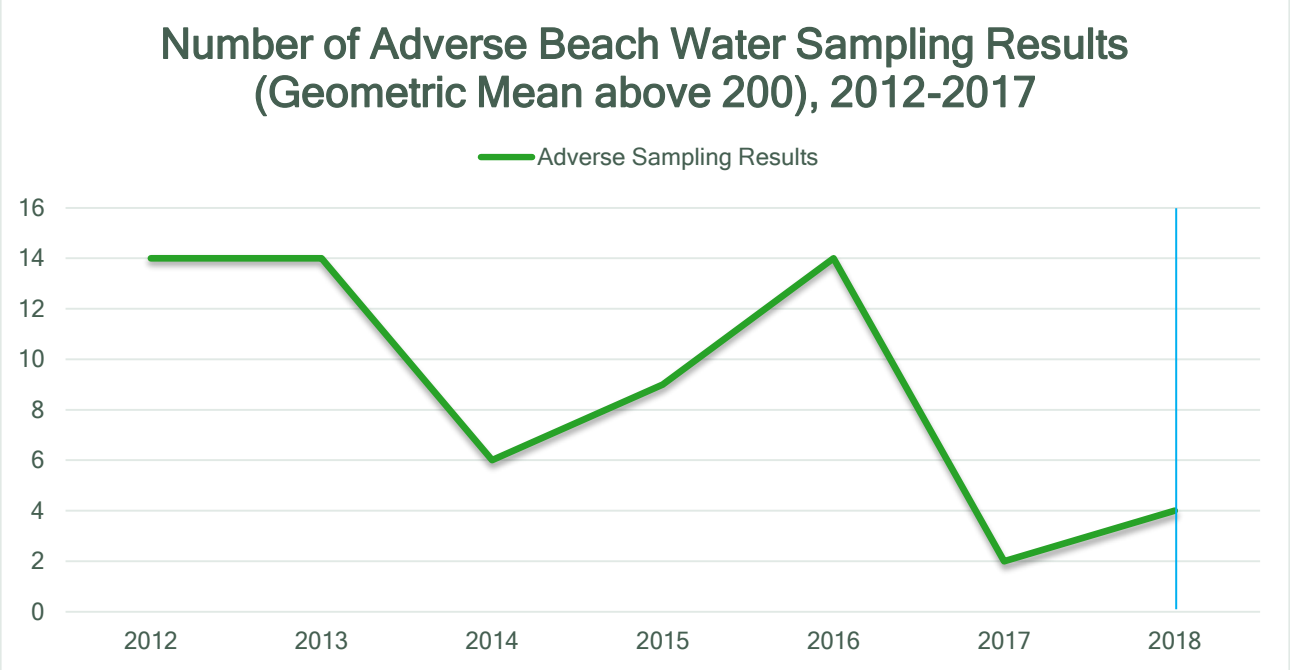
Recreational Water

Recreational water at public beaches often becomes contaminated with bacteria and parasites that can make people ill. The likelihood of contamination occurring depends on several factors, chiefly precipitation and water temperature (133). Following heavy rainfall, runoff from land surfaces can carry water contaminated by manure from farm fields and sewage from septic systems into waterways. In the Great Lakes, contamination usually occurs when rainfall exceeds five to six centimeters (133).

BEACH SURVEILLANCE

CKPHU conducts routine beach surveillance at nine public beaches throughout the municipality between June and September each year to assess the risk of exposure to contaminated water. Beach samples are tested for *E. coli*, which is used as an indicator of bacterial contamination. At each beach, five or more samples are collected. From these, a geometric mean is calculated, representing the average level of bacteria present in beach water (134). Where the geometric mean for samples taken at a beach exceeds 200 *E. coli* per 100 mL, or where any one sample exceeds 400 *E. coli* per 100 mL, beach users are at a higher risk of illness related to recreational water exposure.

Prior to 2018, beach water samples were collected weekly from June to September. Because high levels of bacterial contamination are regularly observed at Chatham-Kent's beaches throughout the season, CKPHU began sampling beach water three times per year in 2018, while posting permanent signs at all beaches warning beach users to take precautions to avoid illness.



Data Source: Chatham-Kent Public Health Unit. 2018. Extracted: September 2018.

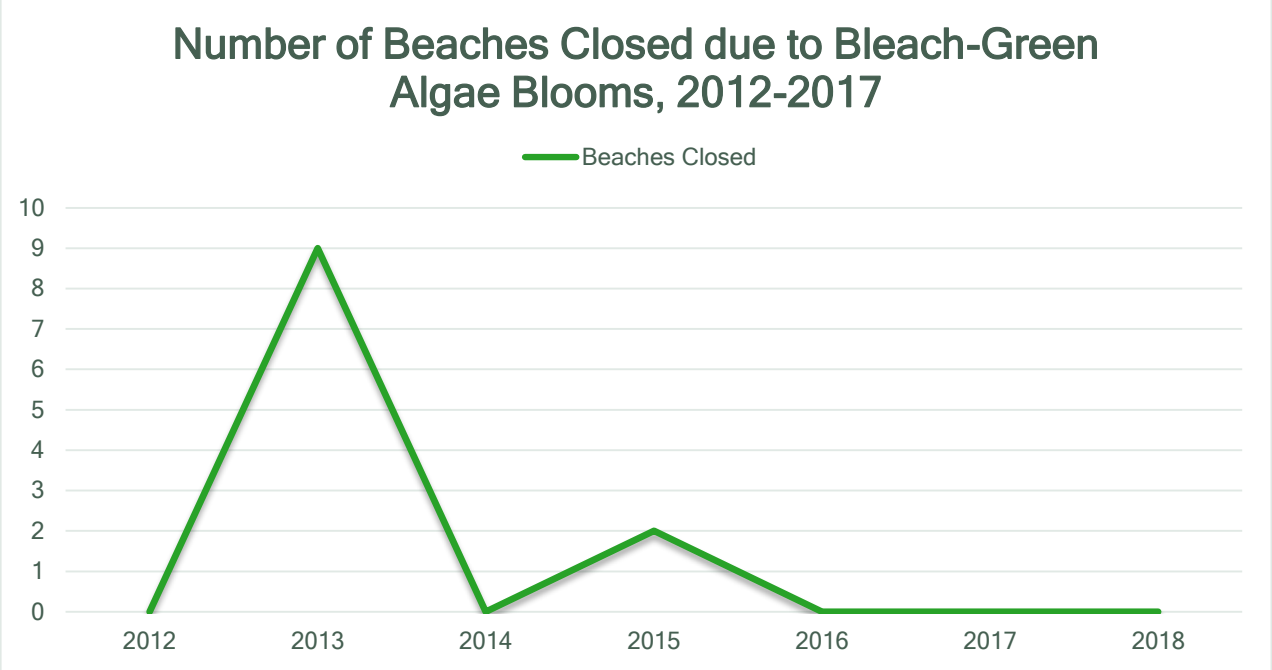
(See Table 29)

BLUE-GREEN ALGAE BLOOMS

Cyanobacteria, more commonly known as blue-green algae, are microscopic freshwater plants which can rapidly increase to form large blooms when water temperatures rise. Human activities that increase runoff of phosphorus and nitrogen into waterways, such as agriculture, also increase the risk of algae blooms developing (135). Cyanobacteria produce toxins that affect human health, including liver toxins and neurotoxins (136). Contact with cyanobacteria can cause acute health effects, including eye and skin irritation, while ingesting contaminated water can lead to headaches, fever, diarrhea, abdominal pain, nausea, and vomiting (136). Chronic health effects are unclear (136).

Between 2012 and 2017, Chatham-Kent experienced two cyanobacteria blooms. In 2013, CKPHU closed all seven public beaches along Lake Erie for two days because of an extensive algae bloom on the lake (137). In 2015, two beaches in Wheatley were closed for two days (134).

In 2017, three large cyanobacteria blooms appeared on the Thames River between mid-August and October, prompting the Lower Thames Valley Conservation Authority, which monitors rivers, to alert residents to stay away from the river (138).



Data Source: Chatham-Kent Public Health Unit. 2018. Extracted: September 2018.

(See Table 30)

Drinking Water

Climate change-related heavy rainfall events could lead to contamination of well water (139). Heavy rainfall can produce more water than can be absorbed into soil. This excess water drains to waterways as runoff, carrying with it contaminants from soil and land surfaces. Unsecured wells, namely, those that are not constructed to protect them from surface water contamination or those that are located at unsafe distances from pollution sources, are vulnerable. The most famous example of this in recent memory occurred in Walkerton in 2000 when manure runoff following heavy rainfall contaminated an unsecured well used to supply the town's drinking water. Nearly one third of the town's 5,000 residents became infected with *E. coli* O157:H7 and *Campylobacter jejuni* bacteria and six people died as a result (140).

MUNICIPAL DRINKING WATER

Chatham-Kent's six municipal drinking water treatment plants provide water to 39,636 customer connections (141). Municipal drinking water in Chatham-Kent is drawn from a variety of surface and groundwater sources, including rivers fed by Lake St. Clair, deep wells, and Lake Erie (142). In general, drinking water from municipal systems is less susceptible to contamination because these systems have comprehensive, multi-step treatment processes, frequent testing

requirements, and backup measures when problems occur (143). However, they are not immune to the impacts of climate change.

An event illustrating the potential impact of disruption to drinking water systems occurred in 2014, when over 400,000 Ohio residents were advised not to drink or boil their water after an extensive cyanobacteria bloom on Lake Erie entered deep water intakes for a municipal drinking water system (144). Levels of *Microcystin*, a liver toxin produced by cyanobacteria, were measured at 3.19 µg/L, more than three times the limit prescribed by the Ohio Environmental Protection Agency (144).

PRIVATE DRINKING WATER SYSTEMS

A significant portion of lands throughout Chatham-Kent are susceptible to groundwater contamination (See Appendix C: Intrinsic Susceptibility to Groundwater Contamination). People who obtain their drinking water from private wells and small drinking water systems in areas with medium or high susceptibility to groundwater contamination may be at greater risk of waterborne illness.

Private Wells

There are 4,855 private domestic wells in Chatham-Kent (145). The majority (74.8%) of these were constructed prior to 1990 (145), when the Well Regulation (O. Reg. 903/90) under the Ontario Water Resources Act, R. S. O. 1990 came into effect. This regulation governs minimum construction standards for wells. Maintenance of private wells is the responsibility of the homeowner. For this reason, little is known about the state of private wells in Chatham-Kent. Wells that are not maintained may become vulnerable to contamination, such as from manure runoff from fields.

Small Drinking Water Systems

Certain drinking water systems, such non-municipal systems serving small communities, are inspected by CKPHU. These are known as Small Drinking Water Systems (SDWS). SDWSs tend to be more vulnerable to contamination than municipal systems for a variety of reasons, including lack of operator training and high operation costs (128,143). Though the sources of waterborne outbreaks are not consistently reported, it has been suggested that as many as half of waterborne outbreaks are caused by SDWSs (143). There are 26 SDWSs that fall under CKPHU's jurisdiction. Of these, nine are high-risk systems, meaning that they obtain water from an unsecured source or that they have a history of poor water quality.

Current Health Impacts

Over the last 10 years (2008 to 2017) there have been 456 confirmed cases of reportable food- or waterborne illness among Chatham-Kent residents (146). On average there were approximately 45 reported cases per year, and monthly averages ranged from two to four cases per month from January to May and from September to December, with slightly higher monthly averages (five to six cases per month) in the months of June to August (146).

Projected Health Impacts

Human pathogens are affected by environmental conditions. Greater precipitation and warmer temperatures are expected to create conditions that support the growth of pathogens, leading to higher rates of food- and waterborne illness (147). For example, it has been found that for every 1°C increase in ambient temperature, rates of *Salmonella*, *E. coli* O157:H7 and *Campylobacter* increase 2 to 6%(148). Similarly, the relative odds of an outbreak of waterborne disease increase by 1.007 for each degree day above 0°C and by 2.283 following extreme rainfall events (149).

Increases in power outages related to extreme weather and stress on the electrical grid from increased demand to cool homes during heat waves may also lead to higher rates of foodborne illness by disrupting refrigeration of hazardous foods (26).

Warmer temperatures also pose the risk of more frequent cyanobacteria blooms. Certain species of cyanobacteria grow optimally at temperatures above 25°C, while others are capable of overwintering, raising concerns that algae blooms could become more common and could emerge at different times of year than previously expected (135).

Food Insecurity

Climate change is expected to have significant impacts on Ontario's food production system, including agriculture and fisheries (150). Our food system is also dependent on global imports. The impacts of climate change on food production systems both at home and abroad could affect supply and access to food in our community (150).

Vulnerability

Socioeconomic and Environmental Circumstances

SOCIOECNOMIC STATUS

People of low SES and people from certain racial or ethnic groups may experience more frequent episodes foodborne illness (151). While the reasons for this are not certain, this may in part be due to poorer microbiological quality of food available to people in low SES neighbourhoods (151). People of low SES groups also demonstrate less food safety knowledge (151). They may lack adequate information or resources to handle, prepare, or store food safely (151,152).

Nearly one in 10 Chatham-Kent households report being either moderately or severely food insecure, meaning that food quality and/or quantity is compromised or food intake is reduced due to income (125). Residents with higher education levels are more likely to practice food safety behaviours, such as keeping a thermometer in their refrigerator to ensure that foods are being held at appropriate temperatures (125). In addition, Chatham-Kent adults who have not graduated from high school are more likely to report thawing meat at room temperature, a practice that increases the risk of foodborne illness (125).

Chatham-Kent has a higher proportion of the population with lower levels of education and low income when compared to the rest of Ontario, with one in four residents having no certificate, diploma, or degree and 17.0% living on low income (15).

In Chatham-Kent, 4,070 residents identify as Aboriginal (4.0%), while 1,805 (1.8%) of residents have Registered or Treaty Indian status (15). Visible minorities account for a further 4.5% of the population (15).

WATER SOURCE

People who obtain their drinking water from unsecure sources are at greater risk of waterborne illness. CKPHU recommends that private well owners have their well water tested three to four times a year to ensure that it is safe to drink. Microbiological testing is available for free through CKPHU.

Between 2015 and 2017, a total of 2,017 water samples from private homeowners were submitted to CKPHU for testing, an average of 672 per year (153). This suggests that few homeowners are regularly testing their wells, a fact that aligns with community surveys. The majority of Chatham-Kent well

owners (66.7%) report that they do not test their well for microbial contamination (125). Of water samples submitted, the majority (72.7%) were satisfactory, but a large number (22.2%) showed evidence of bacterial contamination, including 1.6% which showed evidence of sewage contamination (153).

Individual Circumstances

AGE

Older Adults

As we age, our immune system weakens, which affects the ability of our bodies to fight off illness (154). Older adults are also more likely to have a combination of risk factors that further increase their risk of food- and waterborne illness. For example, older adults are more likely to have nutritional deficits and chronic conditions requiring medications that increase susceptibility to food- and waterborne illness (154).

There are 21,450 adults over the age of 65 in Chatham-Kent, or 22.6% of the population (15). This number is expected to grow significantly over the coming decades (38).

Children

For several reasons, young children are particularly susceptible to foodborne illness. Their immune systems are still developing, making it harder for their bodies to fight off illness; they have lower bodyweight, so fewer pathogens are needed to cause infection; they rely on others to prepare their food and have no control over food safety; and they have lower stomach acidity than adults, making it harder for them to kill pathogens (154–156). They are also more likely to experience complications from foodborne illness, such as irritable bowel syndrome and hemolytic uremic syndrome, a blood disorder that can cause kidney failure (156,157).

In Chatham-Kent, there are 16,740 children under 14 years of age, making up 16.4% of the population (15). This number is expected to shrink in coming years (38).

Pregnant Women

Pregnancy alters the immune system, causing pregnant women to be more vulnerable to foodborne illness and more likely to experience complications from illness (158,159). Enteric pathogens can also affect the fetus. For example, *C.*

jejuni can cause intrauterine infection of the fetus, leading to abortion, stillbirth, or early death (159).

On average, there are 1,037 live births in Chatham-Kent per year (30).

Health Status and Stomach Acidity

Individual health factors can increase the risk of foodborne illness. These include diseases that weaken the immune system, such as cancer, HIV/AIDS, diabetes and alcoholism; malnutrition; reduced stomach acidity; and use of antacids and antidiarrheal medication (154).

Estimates for some, though not all, of these conditions are available:

- In Chatham-Kent, the crude rate of all cancers in 2013 was 702.9 per 100,000 (160);
- In 2015, there were 1,076 people living with HIV in the South West health region (an amalgamation of health units in Southwestern Ontario that includes Chatham-Kent) (161);
- In 2015-2016, 6.7% of Chatham-Kent residents reported having diabetes (32); and,
- The proportion of Chatham-Kent adults that report heavy drinking (five or more drinks for men or four or more drinks for women on at least one occasion per month) in 2015-2016 was 20.3% (33).

Vector-borne Illness

KEY TAKEAWAYS

- Climate change will create conditions that support the growth of insect disease vectors
- Warmer temperatures and migration of tick and mosquito species may lead to the emergence of new diseases
- People who work outdoors, as well as older adults and children are vulnerable to vector-borne illness

Diseases transmitted to humans by biting insects, such as mosquitoes, ticks, or fleas are known as vector-borne illnesses. In Ontario, the most common vector-borne illnesses are West Nile Virus and Lyme disease (162). Other vector-borne diseases include Eastern Equine Encephalitis Virus, Zika virus, dengue fever, malaria, and chikungunya, spread by mosquitoes, and Rocky Mountain spotted fever, Babesiosis, and Anaplasmosis, spread by ticks. Changes in climate can expand habitats and produce the conditions necessary to support the growth of disease vectors.

Exposure

West Nile Virus

West Nile Virus (WNV) is transmitted by the bite of certain species of mosquito. The majority of human cases either experience no symptoms or, less commonly, flu-like illness (129). A small number of cases, however, may develop severe neuro-invasive disease (129). Symptoms include swelling of the brain, seizures and polio-like paralysis (129). While most severe cases recover fully, they may experience long-term complications, including fatigue, weakness, paralysis, and neurological deficits (129).

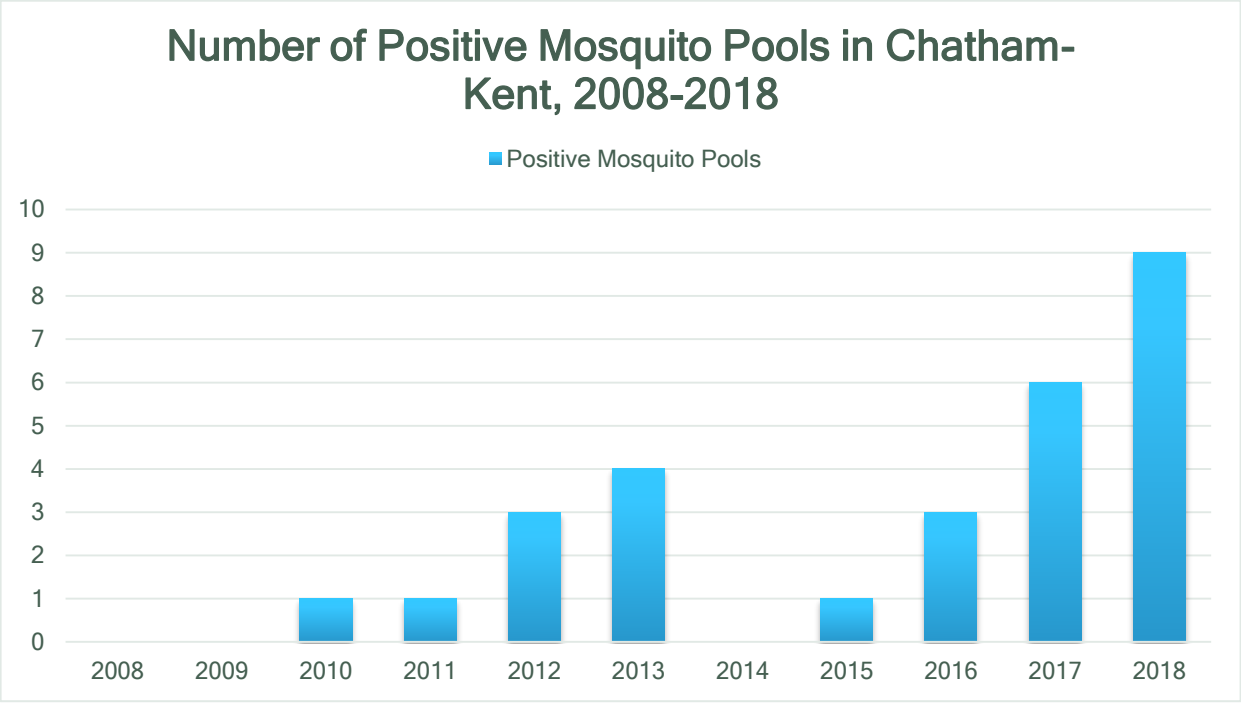
MOSQUITO SURVEILLANCE

WNV was first identified in Chatham-Kent in 2001 when three blue jays tested positive for the virus (163). The first human case was confirmed a year later (163). CKPHU has since engaged in mosquito monitoring and control activities,

including surveillance of breeding sites, dead birds, adult mosquitoes and human cases, and larviciding catch basins.

The mosquito species that are most often implicated in transmitting WNV to humans are *Culex pipiens* and *Culex restuans* (164). High populations of these species predict higher rates WNV cases in humans (164). From 2015-2017 the number of *Culex* species mosquitoes identified in Chatham-Kent was low (164-166).

In order to predict when positive mosquito pools are likely to occur, the Accumulated Degree Day (ADD) model is used. A degree day occurs when the average temperature for one day (24 hours) is above 18.3°C, the threshold required for WNV to replicate in mosquito vectors (167). The number of accumulated degree days is used as a measure of risk. The first human cases of WNV in Ontario typically occur after 100 to 125 ADD (167). A total of 380 ADD is required for 50% of infected *Culex pipiens/restuans* mosquitoes to test positive for WNV, at which point positive mosquito pools are expected to be found (164). From 2015-2017, the ADD threshold was not met in Chatham-Kent, however, one WNV-positive mosquito pool was found in 2015, three in 2016, six in 2017, and nine in 2018 (164-166).



Data Source: Chatham-Kent Public Health Unit. 2018-2018. Extracted: September 2018.

(See Table 31)

New Mosquito Vectors

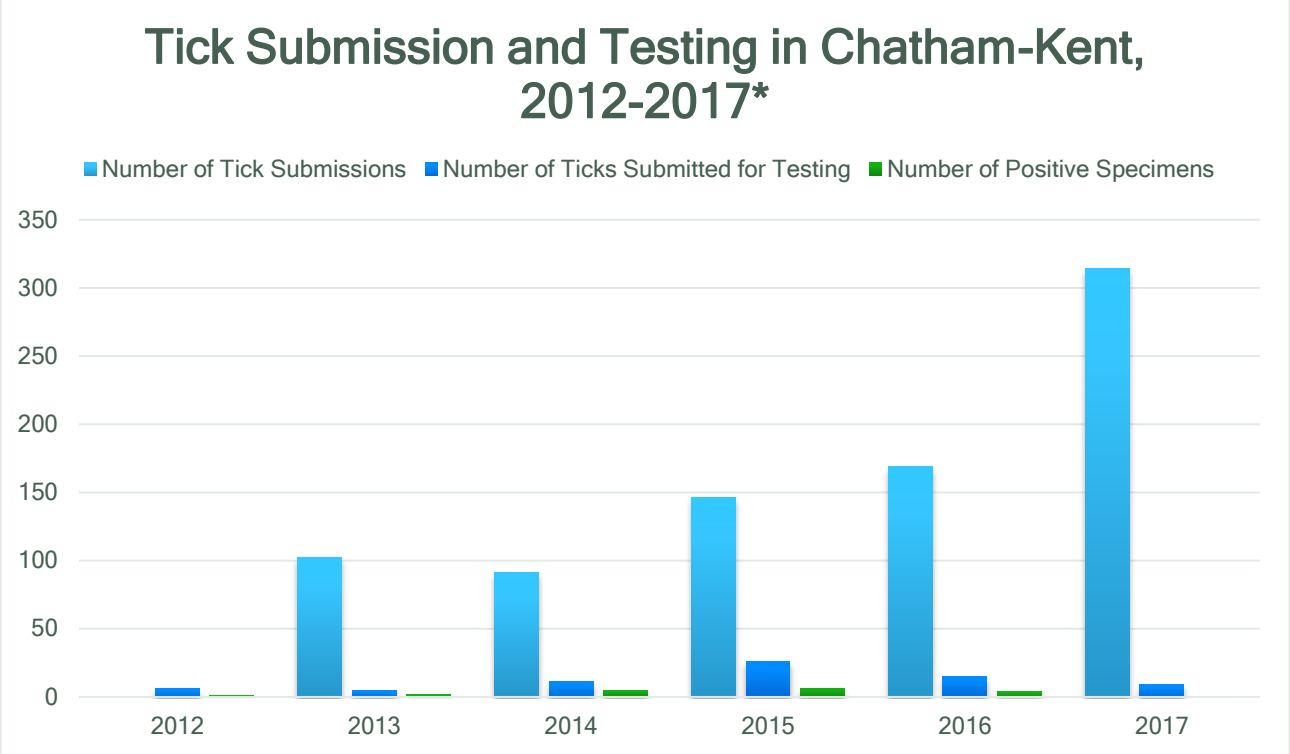
In 2017, a new mosquito species, *Culex erraticus*, was established in Chatham-Kent and collected in traps throughout the surveillance season (164). This species has been implicated as a vector of Eastern Equine Encephalitis Virus (EEEV) in the United States (164). EEEV, like WNV, is often asymptomatic, but can lead to swelling of the brain and polio-like paralysis in a some cases (129). Unlike WNV, however, it has a high case-fatality rate with 30-75% of symptomatic cases resulting in death and is considered the most severe mosquito-borne illness in North America (129,168). To date, no EEEV-positive mosquito pools have been found in Chatham-Kent (164). *Aedes aegypti*, the primary vector of Zika virus, a febrile illness that can cause serious congenital defects, was found in the neighbouring Windsor-Essex County Health Unit for the first time in 2017 (169). This species has yet to be found in Chatham-Kent.

Lyme Disease

Lyme disease is caused by the bacteria *Borrelia burgdorferi* (129). It is spread by the bite of the blacklegged tick (*Ixodes scapularis*) (170). For the majority of cases, the first sign of illness is a red, bullseye-shaped rash larger than five centimetres (129). This is followed by fatigue, fever, headaches, neck and joint pain, and swelling of the lymph nodes (129). Left untreated, cases may go on to experience neurological symptoms, cardiac abnormalities, and chronic arthritis. If treated early, the majority of cases recover fully following a short course of antibiotics (129). A small number of cases may experience post-treatment Lyme disease syndrome (PTLDS) months to years after treatment (129). Symptoms include chronic fatigue, muscle and joint pain, and mental confusion (129). Possible causes of PTLDS are still being researched.

TICK SURVEILLANCE

Borrelia burgdorferi was first isolated in blacklegged ticks found at Rondeau Provincial Park in 1999 and blacklegged ticks were soon after confirmed to be endemic to the park (171,172). CKPHU has engaged in both active and passive tick surveillance methods since 2011. Active tick surveillance (i.e., tick dragging in suspected risk areas) has failed to uncover blacklegged ticks in areas beyond the park. Passive tick surveillance (i.e., collection of ticks submitted to CKPHU by members of the public) has seen an uptick in the number of tick submissions since 2016, though the majority of ticks identified to date have been dog ticks (*Dermacentor variabilis*), which do not spread Lyme disease (173).



Data Source: Chatham-Kent Public Health Unit. 2012-2017. Extracted: July 2018.

(See Table 33)

*As of 2017, blacklegged ticks found in the Rondeau Provincial Park area are no longer submitted for testing, based on high infection rates in ticks found in this area. People who acquire blacklegged ticks near the park are advised to seek treatment immediately.

New Tick Vectors

In both 2017 and 2018, lone star ticks (*Amblyomma americanum*) were submitted to CKPHU by residents who had no recent travel history outside the province. This tick has been shown to spread Rocky Mountain spotted fever and tularemia (173). Residents have also submitted groundhog ticks (*Ixodes cookie*), the leading vector of Powassan virus (173).

Current Health Impacts

Between 2008 and 2017, there were 14 confirmed cases of Lyme disease and 10 confirmed cases of WNV reported among Chatham-Kent residents (146). On average there was approximately one confirmed case reported for each disease per year (146). In 2017, there were three confirmed cases of Lyme disease and no reported cases of WNV (146).

Other Vector-borne Illness

No other human cases of vector-borne disease were confirmed in Chatham-Kent between 2008 and 2017 (146).

Projected Health Impacts

Cases of vector-borne illness are expected to increase over the coming decades (27). While warmer temperatures and increased precipitation generally predict increases in vector-borne illness, incidence of these illnesses also depends on the interplay between several factors, including the availability of suitable habitat and the presence of host species.

Mosquito-borne Illness

WEST NILE VIRUS

Incidence of WNV is tied to temperature and precipitation (174,175). Warmer winter temperatures have been shown to lead to more human cases of WNV during the following summer months (174). Cooler, dryer spring seasons have also been linked to higher rates of infection (174). Higher numbers of accumulated degree days in Chatham-Kent will increase the survival period of mosquitoes in coming years, increasing the risk of WNV (27).

OTHER MOSQUITO-BORNE ILLNESSES

Of concern is that the warmer climate Chatham-Kent will experience may lead to the emergence of new mosquito-borne illnesses. For example, transmission of malaria, a parasitic illness spread by mosquitoes, has occurred in Southern Ontario in the past (176). Species of mosquito that spread malaria (i.e., *Anopheles* species) are currently present in Chatham-Kent (164–166). The projected doubling of the summer period in Chatham-Kent could support replication of the Malaria parasite in vector species (176). The increasing popularity of international travel poses a risk of this parasite being re-introduced to Canada (176).

Tick-borne Illness

LYME DISEASE AND BLACKLEGGED TICKS

Lyme disease is becoming more common in Ontario. In 2017, there were 959 probable or confirmed cases of Lyme disease in the province, which was three

times higher than the provincial average over the previous four years (170). Warmer temperatures and changes in precipitation levels are expected to increase the range of blacklegged ticks in Ontario (27).

Range Expansion of Blacklegged Ticks

Predicting where ticks will spread is largely dependent on the availability of suitable habitat (177). Factors that determine whether a habitat is suitable to support blacklegged ticks include soil and vegetation type, climate mix and availability of host species (i.e., white tailed deer) (177,178). Habitats that have been associated with higher numbers of blacklegged ticks are areas with deciduous forest with at least 50 percent tree canopy and moist soil (177,178).

Current conditions in Chatham-Kent support blacklegged tick populations in the forested area of Rondeau Provincial Park. Active surveillance by CKPHU has not identified new risk areas for blacklegged ticks, though reports from passive surveillance suggest that ticks may be present in other forested areas. The lack of tree canopy in Chatham-Kent may limit the spread of blacklegged ticks.

OTHER TICKS SPECIES

While range expansion of blacklegged ticks has not been confirmed in Chatham-Kent, American dog ticks (also known as wood ticks) appear to be present in greater numbers in the area, based on passive and active surveillance. This is likely due to the greater availability of hosts (dog ticks feed on a variety of small mammals (179)) and habitat. Dog ticks are as likely to be found in forested areas as grasslands and agricultural fields (180). While this species is rarely associated with disease transmission in Ontario, it has been confirmed as a vector of disease in other regions, including tularemia and Rocky Mountain spotted fever (173,181,182). The pathogens that cause these diseases, *Francisella tularensis* and *Rickettsia rickettsii* have been isolated in ticks in Ontario (173). Northward expansion of other species of tick have also been documented in North America (183).

Vulnerability

Socioeconomic and Environmental Circumstances

OUTDOOR WORKERS

People who spend time outdoors are more likely to be affected by vector-borne illness. Outdoor workers are particularly vulnerable (184). Studies have found

that the risk of Lyme disease is up to five times higher in outdoor workers than in those who work indoors (184).

Roughly 15% of the working population in Chatham-Kent, just over 7,000 people work outdoors (15).

Individual Circumstances

AGE

Older Adults

Oder adults and people with chronic conditions or weakened immune systems are more likely to experience more severe illness and complications related to certain vector-borne illnesses, such as WNV (129). For example, age-related changes in immune response can cause elderly people infected with WNV to experience a greater inflammatory response to the virus, which has the effect of increasing permeability of the blood-brain barrier (185). This allows the virus to enter the nervous system where it causes severe neuro-invasive disease (185).

There are 21,450 adults over the age of 65 in Chatham-Kent, or 22.6% of the population (15). This number is expected to grow significantly over the coming decades (38).

Children

Children are more likely to be affected by certain vector-borne illnesses. For example, Lyme disease is most common in older adults, but also in children five to nine years old (186). Though Lyme disease is more common in this age group, children often experience milder symptoms and a shorter duration of illness (187). However, illness can be difficult to detect in children, because the symptoms may resemble other illnesses, posing the risk of it not being treated promptly (187).

In Chatham-Kent, there are 16,740 children under 14 years of age, making up 16.4% of the population (15). This number is expected to shrink in coming years (38).

Ultraviolet Radiation

KEY TAKEAWAYS

- Ozone depletion will lead to increased exposure to harmful ultraviolet radiation, which causes DNA damage
- Chatham-Kent residents experience the highest level of UV radiation in Canada
- The incidence of skin cancer is expected to increase as a result
- At risk are people who work outdoors, as well as children and older adults
- Males are less likely to practice sun safety behaviours than females, putting them at greater risk of UV damage

Ozone is an atmospheric gas that protects us from harmful ultraviolet (UV) radiation from the sun (188). Most ozone is found in the stratosphere, where it forms a protective shield, called the ozone layer (188). High concentrations of greenhouse gases from pollution cause changes in the atmosphere, which in turn cause the protective ozone layer to break down (188). Depletion of stratospheric ozone allows more UV radiation to reach the earth's surface, where it impacts human health (188).

UV radiation causes damage to our bodies, ranging from sunburn, skin damage, and aging to skin cancer and eye damage (41,188). UV radiation also suppresses our immune systems, putting us at greater risk of autoimmune disorders and weakening our resistance to infectious pathogens, such as influenza, cytomegalovirus, and *Listeria monocytogenes* (188,189). UV radiation-induced weakening of immune responses may decrease the efficacy of vaccines, increasing the risk of outbreaks of vaccine-preventable diseases, such as measles and hepatitis (189).

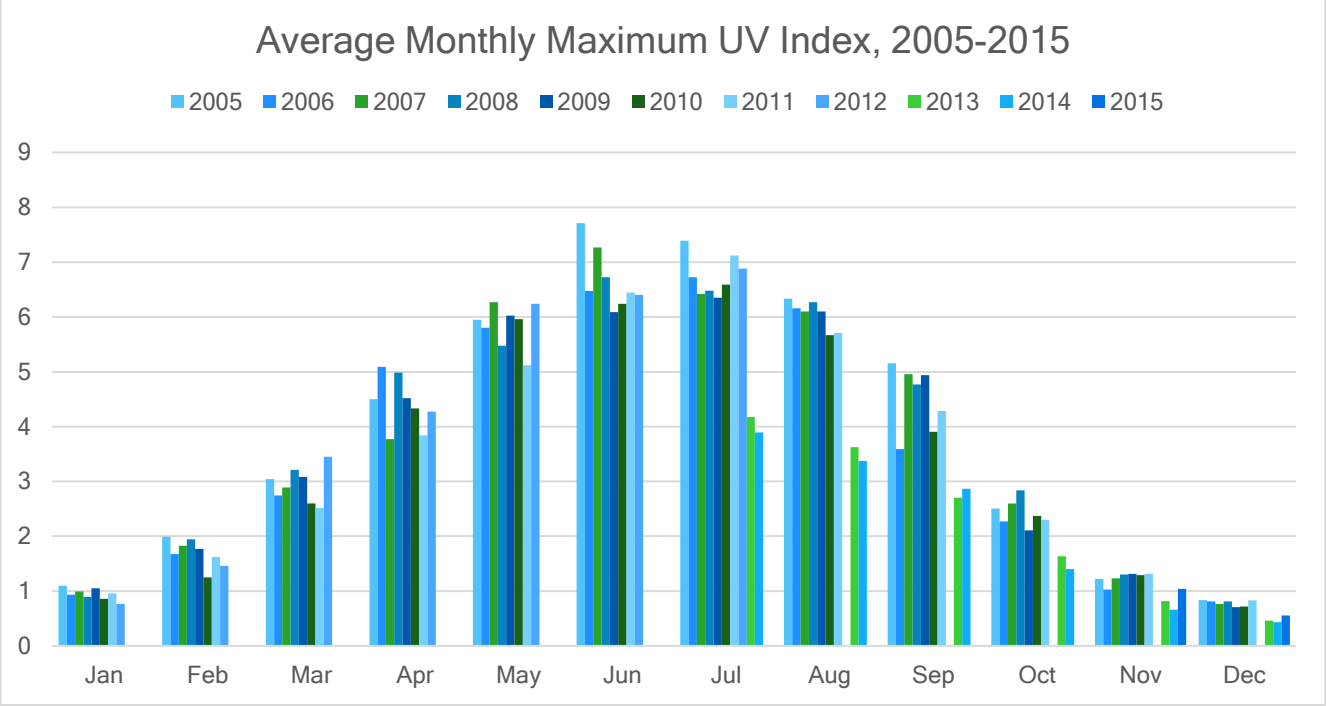
Exposure

The UV index was created by Environment and Climate Change Canada as a measure of exposure to ultraviolet radiation. It ranges from zero to 11+ and is grouped into five levels of risk:

- Low (0-2)
- Moderate (3-5)
- High (6-7)
- Very high (8-10)
- Extreme (11+)

Each level of risk corresponds to the intensity of UV radiation and is meant to communicate to Canadians the degree of caution they should take when spending time in the sun.

Historically, the UV index for Chatham-Kent has been high to very high during the summer months of May to August and low during the winter months of December to March (190). In fact, Chatham-Kent experiences the highest levels of UV radiation in Canada, with mean UV radiation exposure from June to August in the 7,000 to 7,500 J/m^2 range (191).



Data Source: Toronto Brew. 2018. *Chatham-Historical Weather.* https://www.worldweatheronline.com/lang/en-ca/chatham-weather-history/ontario/ca.aspx (accessed July 2018).

(See Table 34)

Tree Coverage

Trees provide protection from UV radiation by shielding us from the sun (192,193). Chatham-Kent has very low tree coverage at just 4.1% (194), down from 16% pre-settlement (38). Tree coverage continues to decline; between 2010 and 2015, 1,392.3 acres of trees were removed (194). For comparison, a survey of U.S. and Canadian cities indicated that most have established goals to increase tree canopy to 20 to 70% (195).

Current Health Impacts

Acute Sun Exposure

A survey conducted in 2012 found that 32% of adults in Chatham-Kent reported having been sunburned in the past 12 months (by any UV light source)(60). Over the last 10 years (2008 to 2017) there have been 17 emergency department visits among Chatham-Kent residents related to exposure to sunlight (29).

Long-term Sun Exposure

Skin cancers are divided into two types: melanoma and non-melanoma skin cancer, which includes basal cell carcinoma and squamous cell carcinoma (27). The majority of cases of skin cancer are caused by non-melanoma skin cancers (196).

NON-MELANOMA SKIN CANCER

Despite being the most common form of cancer in Canada, non-melanoma skin cancers are not reported and data on incidence rates in Ontario are not available (192). Data from other provinces may provide a rough estimate. The incidence of basal cell carcinoma in Manitoba in 2000 was 93.9 per 100,000 and in Alberta it was 147.0 per 100,000 in 2006 (197).

MELANOMA

Melanoma accounts for relatively fewer cases of skin cancer, but is more aggressive and more likely to spread to other parts of the body (198). Compared to the rest of Ontario, Chatham-Kent residents do not experience higher rates of malignant melanoma and rates have not changed substantially over time. In 2013 there were 31 new cases of malignant melanoma among Chatham-Kent residents, for an overall crude incidence rate of 29.2 per 100,000 and in 2012 there were two deaths due to melanoma (crude rate: 1.9 per 100,000) (199).

Projected Health Impacts

Depletion of the ozone layer will lead to increased exposure to UV radiation (27). This is expected to lead to more cases of skin cancer in Chatham-Kent. Rates of melanoma skin cancer are known to be on the rise, increasing by 67% between 1992 and 2006 (200). The Ontario Health Modelling Study predicts that the rate of basal cell carcinoma in Chatham-Kent will increase 7.8% by the 2050s and 12.8% by the 2080s (27). The rate of squamous cell carcinoma is expected to increase 14.8% by the 2050s and 24.3% by the 2080s (27).

Vulnerability

Socioeconomic and Environmental Circumstances

INCOME AND EDUCATION

Incidence of melanoma varies depending on socioeconomic status (SES). People with lower income and lower levels of education are at greater risk, as are people of higher income and higher education levels, though for very different reasons (200-202). People with higher income are presumed to have a higher incidence of melanoma because they have more leisure time and take more sun vacations (200). Though the incidence of melanoma is higher in this group, however, they also experience higher survival and lower mortality from melanoma compared to people with lower SES (200). Higher income individuals may have greater access to dermatologists and may be more likely to seek treatment for unusual skin lesions (200).

OUTDOOR WORKERS

People with lower income and education levels, as well as people who work outdoors have higher rates of melanoma (202). This is presumably because they spend more time outdoors day-to-day (202). A survey of outdoor workers found that the majority (70%) spend more than two hours a day outside (203). This is significant given that a 10% increase in time spent outdoors is associated with an increase of 2.8 to 5.8% in the risk of developing melanoma (204).

Chatham-Kent has a higher proportion of the population with lower levels of education and low income when compared to the rest of Ontario with one in four residents having no certificate, diploma, or degree and 17.0% living on low income (15). Roughly 15% of the working population in Chatham-Kent, just over 7,000 people work outdoors (15).

URBAN DWELLERS

Individuals who reside in urban areas have a higher incidence of melanoma, compared to those residing in rural areas (200). While the reasons for this are not clear, it has been suggested that the difference may be that people in urban areas have better access to dermatologists, resulting in skin cancers being detected more frequently (200).

Individual Circumstances

AGE

Older Adults

Adults over the age of 65 are at greater risk of experiencing adverse health outcomes and complications from skin cancer (196,205). People over the age of 65 have the highest rates of basal cell carcinoma, for example, and are more likely to develop larger tumours (196). This may be due to neglect of tumours by elderly patients, particularly those of lower SES, those with functional and cognitive impairments and those experiencing social isolation, who may be less likely to seek or receive treatment (196). Older adults also experience poorer health outcomes. They more likely to experience recurrence of melanoma, for example, and they are more likely to die from it (196,205).

There are 21,450 adults over the age of 65 in Chatham-Kent, or 22.6% of the population (15). This number is expected to grow significantly over the coming decades (38).

Children

Children are particularly sensitive to UV radiation. In fact, more than half of our lifetime exposure to UV radiation occurs before the age of 18, when we spend more time outdoors (188). Structural differences in children's skin causes them to receive a higher UV dosage and to experience greater DNA damage than adults exposed to the same about of UV radiation (206). This results in harmful long-term effects that remain latent until adulthood (206).

In Chatham-Kent, there are 16,740 children under 14 years of age, making up 16.4% of the population (15). This number is expected to shrink in coming years (38).

PHYSICAL CHARACTERISTICS

People with certain physical characteristics are at greater risk for skin cancer. This includes people with light-coloured eyes, light-coloured hair, fair skin, and

skin that burns easily (192). Though they appear to be less susceptible, there has been less research on skin cancer in darker skinned individuals (192).

GENDER

On average, males experience higher rates of melanoma than females (201). This is because males spend more time outdoors and are less likely to practise protective behaviours, such as wearing sunscreen, than females (201).

SUN-SAFETY BEHAVIOURS

Roughly half of Chatham-Kent residents report that they practise sun safety. In 2012, 46% of adults reported always or often avoiding the sun between 11 a.m. and 4 p.m.; 63% reported always or often wearing UV protective sunglasses when in the sun; 43% reported always or often wearing UV protective clothing, including a hat, when in the sun; and 38% reported always or often wearing sunscreen when in the sun (60).

Conclusion

Mitigating the health impacts of climate change in Chatham-Kent will require coordinated action and cooperation among diverse municipal departments, organizations, and community partners within the municipality.

CKPHU is mandated to assess, address, and monitor the health impacts of climate change. This assessment comprised the first three steps in the six-step vulnerability and adaptation assessment process outlined in the *Ontario Climate Change and Health Toolkit, 2016*. The next three steps are to:

- Identify and prioritize policies and programs to manage the additional health risks associated with a changing climate;
- Establish an iterative process for managing and monitoring health risks; and,
- Examine the potential health benefits and co-harms of adaptation and mitigation options implemented in other sectors.

CKPHU will disseminate these results to municipal and community partners, the public, and those affected by the impacts of our changing climate. Through community discussions, efforts may be pursued to examine current policies and programs that address climate-sensitive health outcomes and identify and prioritize policies and programs to mitigate and adapt to the health impacts of climate change.

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Appendices

Appendix A: Indicators

Health Impact Indicators

Hazard	Indicator	Significance	Current Burden of Illness
Extreme Heat Event	Number of emergency room visits due to heat-related illness	Extreme heat can affect the body's ability to regulate its core temperature, leading to adverse outcomes, including skin rashes, cramps, dehydration, syncope, exhaustion and heat stroke.	Total (2008-2017): 285 Average: 26/year Crude rate: 25.0 per 100,000 Citation: (29,53) ICD10-CA Codes: • T67: Effects of heat and light • X30: Exposure to excessive natural heat

Hazard	Indicator	Significance	Current Burden of Illness
Extreme Heat Event	Number of hospitalizations due to heat-related illness	Extreme heat can affect the body's ability to regulate its core temperature, leading to adverse outcomes, including skin rashes, cramps, dehydration, syncope, exhaustion and heat stroke.	Total (2008-2017): 21 Citation: (29) ICD10-CA Codes: • T67: Effects of heat and light • X30: Exposure to excessive natural heat
Extreme Heat Event	Number of deaths due to exposure to heat	Extreme heat can exacerbate underlying conditions, such as cardiovascular, respiratory diseases and neurological conditions, increasing mortality. Other heat-related outcomes, such as dehydration and heat stroke may result in death.	Total (2003-2012): 0 Citation: (52)

Hazard	Indicator	Significance	Current Burden of Illness
Extreme Cold Event	Number of emergency room visits due to exposure to cold	Exposure to extreme cold can result in adverse outcomes, including windburn, frostbite and hypothermia.	Total (2008-2017): 201 Average: 20/year Crude rate: 19.1 per 100,000 Citation: (29,53) CD10-CA Codes • T33-T35: Frostbite • T68: Hypothermia • X31: Exposure to excessive natural cold
Extreme Cold Event	Number of hospitalizations due to exposure to cold	Exposure to extreme cold can result in adverse outcomes, including windburn, frostbite and hypothermia.	Total (2008-2017): 33 Citation: (29) ICD10-CA Codes • T33-T35: Frostbite • T68: Hypothermia • X31: Exposure to excessive natural cold

Hazard	Indicator	Significance	Current Burden of Illness
Extreme Cold Event	Number of deaths due to exposure to cold	Exposure to extreme cold can decrease the body's core temperature, leading to shock and hypothermia, which can cause death.	Total (2003-2012): 3 Citation: (52)
Extreme Weather Event	Number of emergency room visits due to extreme weather events	Extreme weather events may lead to injuries, such as through contact with downed power lines. They can also cause adverse stress-related health outcomes, such as cardiac arrest and stroke.	Total (2008-2017): 15 Citation: (29) ICD10-CA Codes: • X33: Victim of lightning • X34: Victim of earthquake • X35: Victim of volcanic eruption • X36: Victim of avalanche, landslide and other earth movements • X37: Victim of cataclysmic storm • X38: Victim of flood • X39: Exposure to other and unspecified forces of nature

Hazard	Indicator	Significance	Current Burden of Illness
Extreme Weather Event	Number of hospitalizations due to extreme weather events	Extreme weather events may lead to injuries, such as through contact with downed power lines, and stress-related health outcomes, such as cardiac arrest and stroke.	no data ICD10-CA Codes: • X33: Victim of lightning • X34: Victim of earthquake • X35: Victim of volcanic eruption • X36: Victim of avalanche, landslide and other earth movements • X37: Victim of cataclysmic storm • X38: Victim of flood • X39: Exposure to other and unspecified forces of nature
Extreme Weather Event	Number of deaths due to extreme weather events	Extreme weather events may lead to injuries or stress-related adverse health outcomes, such as cardiac arrest and stroke, resulting in death.	no data

Hazard	Indicator	Significance	Current Burden of Illness
Poor air quality	Number of emergency room visits due to air pollution-related cardiac events, such as heart attack.	Exposure to ground-level ozone and particulate matter can cause adverse cardiac events, such as heart attack.	no data
Poor air quality	Number of emergency room visits due to air pollution-related respiratory events, such as asthma attacks	Contaminants in air pollution, such as ground-level ozone, nitrogen dioxide, and particulate matter, can lead to respiratory symptoms. They can also exacerbate underlying conditions, such as asthma.	Total (2008-2017): 5116 Average: 438/year Crude rate: 415 per 100,000 Citation: (29,53) ICD10-CA Codes: • Asthma: J45 • Exposure to air pollution: Z58.1
Poor air quality	Number of hospitalizations due to air pollution-related respiratory events, such as asthma attacks	Contaminants in air pollution, such as ground-level ozone, nitrogen dioxide, and particulate matter, can lead to respiratory symptoms. They can also exacerbate underlying conditions, such as asthma.	Total (2008-2017): 329 Average: 30/year Crude rate: 29 per 100,000 Citation: (29,53)

Hazard	Indicator	Significance	Current Burden of Illness
Poor air quality	Number of deaths due to air pollution-related respiratory events, such as asthma attacks	Contaminants in air pollution, such as ground-level ozone, nitrogen dioxide, and particulate matter, can lead to respiratory symptoms. They can also exacerbate underlying conditions, such as asthma.	Total (2003-2012): 10 Citation: (52)
Air Quality	Number of emergency room visits due to aeroallergens – related respiratory events, such as asthma attacks	Allergens, such as pollen and mould, may be affected by changes in weather and can increase the risk of allergic reactions and asthma.	no data

Hazard	Indicator	Significance	Current Burden of Illness
Food- and Waterborne Illness	Number of confirmed cases of food- and waterborne illness	Increasing temperatures may prolong survival rates of certain pathogens correlated with higher ambient temperature. Higher rates of foodborne illness may also be associated with power outages related to extreme weather events.	Total (2008-2017): 456 Average: 45/year Citation: (146) Food and waterborne illnesses searched: • Amebiasis • *Campylobacter enteritis* • Cryptosporidiosis • Cyclosporiasis • Giardiasis • Hepatitis A • Legionellosis • Listeriosis • Salmonellosis • Shigellosis • Typhoid Fever • Verotoxin Producing *E. Coli* (including Hemolytic Uremic Syndrome) • Yersiniosis

Hazard	Indicator	Significance	Current Burden of Illness
Vector-borne Illness	Number of confirmed cases of Lyme disease	Lyme disease is spread by blacklegged ticks, whose range is increasing with warmer temperatures	Total (2008-2017): 14 Average: 1/year Citation: (146)
Vector-borne Illness	Number of confirmed cases of West Nile Virus	West Nile Virus is spread by *Culex* species mosquitoes. The incidence of WNV is associated with warmer winter temperatures.	Total (2008-2017): 10 Average: 1/year Citation: (146)
Vector-borne Illness	Number of confirmed cases of other vector-borne illnesses, such as Eastern and Western Equine Encephalitis and Rocky Mountain spotted fever	Warmer temperatures may increase the range of vectors, increasing the incidence of vector-borne illness.	Total (2008-2017): 0 Citation: (146)
UV radiation	Proportion of residents who report having been sunburned	Exposure to UV radiation can cause sunburn. Repeated cases of sunburn, particularly during childhood, can increase the risk of cancer later in life.	Proportion (2012): 32% (18 years and older) have been sunburned within the past 12 months. Citation: (60)

Hazard	Indicator	Significance	Current Burden of Illness
UV radiation	Number of cases of malignant melanoma	Exposure to UV radiation can increase the risk of cancer later in life.	Total (2013): 31 Crude rate: 29.2 per 100,000 Citation: (199)
UV radiation	Number of preventable deaths from skin cancer	Exposure to UV radiation can increase the risk of cancer later in life.	Total (2013): 2 Crude rate: 1.9 per 100,000 Citation: (199)
UV radiation	Number of emergency department visits related to exposure to sunlight	Exposure to UV radiation can cause skin and DNA damage leading to sunburn.	Total (2008-2017): 18 Citation: (29) ICD10CA Codes: • X32 Exposure to sunlight

Exposure Indicators

Hazard	Indicator	Significance	Current Burden
Temperature Extremes	Maximum, minimum and average temperatures	Climate change will increase extreme heat events, causing increased morbidity.	Historical temperatures, 1981-2010): Daily average: 8.4°C Daily max: 12.9°C Daily min: 3.8°C Citation: (8)
Temperature Extremes	Number of heat alerts/warnings	A heat warning is issued in Chatham-Kent when two consecutive days are forecasted to have a daytime high temperature greater than or equal to 31°C and a nighttime temperature greater than or equal to 21°C or a humidex greater than 42°C. Elevated temperatures have been tied to higher mortality and morbidity.	Annual average (2014-2018): 4.3 Citation: (48)

Hazard	Indicator	Significance	Current Burden
Temperature Extremes	Number of heat waves	A heat wave is defined as at least three consecutive days with temperature exceeding 32°C. Extreme heat is associated with adverse health outcomes, such as respiratory disease and cardiac events.	Annual average (1971-2000): 0.48 Citation: (27)
Temperature Extremes	Number of cold alerts/warnings	A Cold Weather Alert goes into effect when there is an expected temperature or wind chill of -30°C for at least two hours	Annual average (2014-2018): 2 Citation: (48)
Temperature Extremes	Annual temperature projections	Climate change may result in more extreme climate and weather patterns due to changes in average temperatures.	Annual average mean temperature (2050s): 11.9°C Annual average mean temperature (2080s): 14°C Citation: (7)

Hazard	Indicator	Significance	Current Burden
Temperature Extremes	Seasonal temperature projections	Climate change may result in warmer summers and/or colder winters.	Average seasonal temperature (°C): Spring, 2050s: 11.9 Spring, 2080s: 14.3 Summer, 2050s: 25.1 Summer, 2080s: 27.6 Fall, 2050s: 15.2 Fall, 2080s: 17.6 Winter, 2050s: 2 Winter, 2080s: 4.9 Citation: (7)
Extreme Weather Events	Historical precipitation intensity, duration and frequency patterns	Changes in temperature may cause changes in precipitation, such as with more frequent extreme rainfall events.	Annual total (days rainfall ≥25 millimetres, 1981-2010): 5.6 Citation: (8)

Hazard	Indicator	Significance	Current Burden
Extreme Weather Events	Projected changes in precipitation	The occurrence of extreme precipitation events is increasing, placing strain on current storm water and wastewater infrastructure and impacting water quality and quantity.	Annual total (days rainfall ≥25 millimetres): 2050s: 6 2080s: 8 Citation: (6)
Extreme Weather Events	Historical frequency, severity, distribution and duration of wildfires, flooding, droughts and tornadoes	Warmer temperatures are expected to lead to more frequent extreme weather events, such as storms and floods.	Verified tornado events (1980-2009): 12 Citation: (20) Flood notices (LTVCA; 2017; Lake Erie, Thames River): 29, 12 Flood alerts (SCRCA, 2017): 5 Citation: (83,207)
Air pollution	Ground-level ozone estimates due to climate change	Air pollution events are expected to rise with increases in average temperatures.	Total (number of days with ozone exceedances, 1971-2000): 10.1-12 Citation: (27)

Hazard	Indicator	Significance	Current Burden
Air pollution	Number and duration of smog advisories	Greenhouse gases, including ground-level ozone, fine particulate matter and nitrogen dioxide, lead to poor air quality.	Total (moderate AQHI days, 2017): 31 Citation: (23)
Air pollution	Ozone and particulate matter concentrations and exceedance	Air pollution events are expected to rise due to increases in average temperature. Ozone exceedances occur when concentrations exceed 80 ppb.	Average (exceedances, 2017): 10 (range 8-12) Citation: (27)
Air pollution	Number of vehicle miles travelled/automobile use	Poor air quality is associated with motor vehicle emissions.	Proportion (use of vehicle to commute to work, 2016): 92.3% Average (minutes of commute time, 2016): 19.3 Citation: (15)
Aeroallergens	Duration of allergy season	Warmer temperatures are expected to lead to a longer growing season for vegetation, extending allergy season.	Date (first fall frost, 1976-2005): October 27 Citation: (7)

Hazard	Indicator	Significance	Current Burden
Foodborne Illness	Number and duration of power outages	More frequent extreme weather events are expected to lead to more power failures, increasing the risk of foodborne illness due to improper storage temperature control.	Annual average (Entegrus, 2016): 0.41 Average duration (Entegrus, 2016): Annual average (Hydro One, 2016): 2.47 Average duration (Hydro One, 2016): Citation: (131,132)
Foodborne Illness	Number of mass gatherings	Warmer temperatures are expected to encourage more outdoor events, increasing the risk of foodborne illness due to improper temperature control.	Total (events on municipal property, 2017): 212 Citation: (130)
Waterborne illness	Number of blue-green algae blooms	Warmer temperatures, coupled with increased runoff associated with heavy rainfall events, encourage the rapid growth of cyanobacteria.	Total (Lake Erie, 2017): 0 Citation: (208)

Hazard	Indicator	Significance	Current Burden
Waterborne illness	Number of adverse beach sampling results	Warmer temperatures, coupled with increased runoff associated with heavy rainfall events, encourage the growth of bacteria in recreational water.	Total (2017): 2 Citation: (208)
Waterborne illness	Number of floods notices	Extreme weather events leading to heavy rainfall are expected to increase the incidence of flooding.	Total (2017): 41 Citation: (83)
Vector-borne Illness	Number of positive test results in reservoirs/sentinels/vectors	Warmer temperatures are expected to increase the season during which disease vectors grow, allowing disease to spread in reservoirs/sentinels/vectors.	Total (2017): 3 Citation: (163)
Vector-borne Illness	Projected expansion of disease vectors	Warmer temperatures and changes in precipitation are expected to expand the growing season for disease vectors.	Number (accumulated degree days, 2050): 901-1,000 Number (accumulated degree days, 2080s): 1,101-1,200 Citation: (27)

Hazard	Indicator	Significance	Current Burden
Vector-borne Illness	Vector and bridge vector species	Changes in climate, such as warmer temperatures, may result in the development of habitats able to support new disease vectors.	Proportion (WNV enzootic vectors, 2017): 7.15% Proportion (WNV bridge vectors, 2017): 25.28 Total (tick submissions, 2017): 314 Total (confirmed blacklegged tick submissions, 2017): 22 Citation: (163)
Vector-borne Illness	Accumulated degree days	The number of accumulated degree days is used to predict when positive mosquito pools will occur. At 380 ADD, 50% of mosquito pools are expected to be infected with WNV and the first positive mosquito pools are expected to be found at surveillance sites.	Total (2017): 267 Citation: (164)
UV radiation	Number of high UV index days	Depletion of the ozone layer is expected to increase exposure to UV radiation.	Average quarterly UV index: (2017, January-March): 5

Hazard	Indicator	Significance	Current Burden
			(2017, April-June): 13 (2017, July-September): 15 (2017, October-December): 3 Citation: (190)

Vulnerability Indicators

Hazard	Indicator	Significance	Current Count
Temperature Extremes	Proportion of households with central air conditioning	Access to air conditioning reduces the risk of illness related to extreme heat.	Proportion (air conditioner in home, 2016): 94% Proportion (portable or ceiling fan in home, 2014): 86% Citation: (125)
Temperature Extremes	Number of adults age 65 and over	Older adults are more susceptible to illness related to extreme heat due to weakened immune systems and chronic conditions.	Total (2016): 21,450 Citation: (15)
Temperature Extremes	Number of children under 14 years	Infants and young children are more susceptible to illness related to extreme heat due to poor body temperature regulation.	Total (2016): 16,740 Citation: (15)
Temperature Extremes	Number of people with chronic illness/physically impaired (e.g., diabetes, cardiovascular or renal disease, nervous system disorders)	People with chronic conditions and weakened immune systems are more susceptible to illness related to extreme heat.	Proportion (under 65 years): 64.5% Proportion (65 years and older): 93.7%

Hazard	Indicator	Significance	Current Count
			Citation: (71)
Temperature Extremes	Number of pregnant women	Pregnant women are more sensitive to extreme heat and are particularly vulnerable to dehydration.	Annual average (live births, 2012-2017): 1037 Citation: (30)
Temperature Extremes	Number of people who drink alcohol, use illicit substances or take medication	Individuals who abuse alcohol or drugs or who take certain types of medication are more vulnerable to heat stress.	Crude rate (self-reported heavy drinking, 2015-*2016): 19.5% Citation: (33)
Extreme Weather Event	Socially and economically disadvantaged populations	Socially and economically disadvantaged populations may have difficulty seeking shelter and evacuating during extreme weather events.	Proportion (low-income households, 2016): 7.9% Citation: (15)
Extreme Weather Event	Number of people with mobility limitations	People with mobility limitations may have difficulty evacuating during extreme weather events, making them more susceptible to adverse storm-related health impacts, such as injury.	Proportion (mobility limitations, 15 years and older, 2012): 7.2% Citation: (96)

Hazard	Indicator	Significance	Current Count
Extreme Weather Event	Number of adults age 65 and over	Older adults may live in isolation, making it difficult to access warning messages. Mobility issues may make it difficult to evacuate. Chronic conditions may make older adults more susceptible to secondary health effects from storms, such as carbon monoxide poisoning during power outages.	Total (2016): 21450 Citation: (15)
Extreme Weather Event	Number of children under 14 years	Young children may be more susceptible to secondary health effects related to extreme weather events, such as poor air quality from wildfires and carbon monoxide poisoning during power outages.	Total (2016): 16740 Citation: (15)
Extreme Weather Event	Number of people living in flood-prone areas	Flooding is expected to increase as a result of more frequent extreme weather events. Individuals living in flood zones will be most at risk.	Total estimated (2016): 15,000 to 20,000* *See Flood Risk Areas under Extreme Weather events section of Chapter 3.

Hazard	Indicator	Significance	Current Count
Extreme Weather Event	Number of socially disadvantaged individuals and communities	Socially disadvantaged individuals may have difficulty accessing warning messages and may have difficulty seeking shelter or evacuating	Proportion (low-income households, 2016): 7.9% Citation: (15)
Extreme Weather Event	Number of new immigrants (2011 to 2016)	New immigrants may have lower proficiency in English. Individuals with communication barriers may have difficulty accessing and understanding warning messages. New immigrants may also live in lower income areas.	Total (new immigrants, 2016): 655 Total (knowledge of neither English nor French, 2016): 570 Citation: (15)
Extreme Weather Event	Employment and unemployment rates	People of lower socioeconomic status may have more difficulty evacuating and recovering from extreme weather events.	Total (employed, 2016): 55.6% Total (unemployed, 2016): 7.5% Citation: (15)
Extreme Weather Event	Number of people living below poverty line	People living below the poverty line may have more difficulty evacuating and recovering from extreme weather events.	Total (low income, 2016): 16,915 Citation: (15)

Hazard	Indicator	Significance	Current Count
Poor air quality	Number of relevant occupational groups (e.g. outdoor workers)	People who work outdoors are more likely to be exposed to air pollution, increasing their risk of adverse health outcomes.	Total (2016): 7,250 Sectors included in total: • agriculture, forestry, fishing and hunting • mining, quarrying, and oil and gas extraction • construction Citation: (15)
Poor air quality	Number of physically active individuals	Physically active individuals may spend more time outdoors engaging in intensive activities during poor air quality days, making them more susceptible to adverse health events, such as respiratory events.	Proportion (inactive during leisure time, 2013-2014): 49% Citation: (71)
Poor air quality	Number of smokers	Smokers may be more susceptible to adverse respiratory events related to poor air quality.	Total (2016): 19% Citation: (36)
Poor air quality	Number of adults age 65 and over	Adults over 65 may be more susceptible to adverse respiratory events related to poor air quality due to chronic conditions and weakened immune systems.	Total (2016): 21450 Citation: (15)

Hazard	Indicator	Significance	Current Count
Poor air quality	Number of children under 14 years	Children under 14 years may be more susceptible to adverse respiratory events related to poor air quality due to developing immune systems.	Total (2016): 16740 Citation: (15)
Poor air quality	Number of people suffering from asthma and allergies	People suffering from asthma or allergies may see their conditions exacerbated due to poor air quality.	Annual average (asthma, 2006-2015): 17,717 Citation: (209)
Foodborne Illness	Number of people suffering from food insecurities	Low income or socially disadvantaged individuals may not have adequate information or resources to handle, prepare, or store food safely.	Proportion (moderately or severely food insecure due to income, 2013-2014): 8% Citation: (125)
Foodborne Illness	Number of people with chronic illness/physically impaired (e.g.. diabetes, cardiovascular or renal disease, nervous system disorders)	People with chronic illnesses may be more susceptible to foodborne illness due to weakened immune systems. They may also be more likely to experience complications.	Under 65 years: 64.5% (59.2, 69.8) 65 and older: 93.7% (90.1, 97.4) Citation: (71)

Hazard	Indicator	Significance	Current Count
Foodborne Illness	Number of adults age 65 and over	Adults over 65 years may be more susceptible foodborne illness due to weakened immune systems. They may also be more likely to experience complications.	Total (2016): 21450 Citation: (15)
Foodborne Illness	Number of children under 14 years	Children under 14 years may be more susceptible foodborne illness and may be more likely to experience complications.	Total (2016): 16740 Citation: (15)
Foodborne Illness	Number of pregnant women	Pregnant women may be more likely to experience complications related to foodborne illness.	Annual average (live births, 2017): 1037 Citation: (30)
Waterborne illness	Number of small drinking water systems	Small drinking water systems may be more susceptible to contamination following extreme weather events.	Total (2018): 26
Waterborne illness	Number of private wells	Private wells may be more susceptible to contamination following extreme weather events.	Total (2018): 4,855 Citation: (145)

Hazard	Indicator	Significance	Current Count
Waterborne illness	Number of people with chronic illness/physically impaired (e.g., diabetes, cardiovascular or renal disease, nervous system disorders)	People with chronic illnesses may be more susceptible to waterborne illness due to weakened immune systems. They may also be more likely to experience complications.	Total (under 65 years, 2016): 64.5% Total (65 years and older, 2017): 93.7% Citation: (71)
Waterborne illness	Number of adults age 65 and over	Adults over 65 years may be more susceptible waterborne illness due to weakened immune systems and may be more likely to experience complications.	Total (2016): 21450 Citation: (15)
Waterborne illness	Number of children under 14 years	Children under 14 years may be more susceptible waterborne illness and may be more likely to experience complications.	Total (2016): 16740 Citation: (15)
Waterborne illness	Number of pregnant women	Pregnant women may be more likely to experience complications related to waterborne illness.	Annual average (live births, 2012-2017): 1037 Citation: (30)

Hazard	Indicator	Significance	Current Count
Vector-borne diseases	Number of outdoor workers	Outdoor workers may be more likely to encounter disease vectors.	Total (2016): 7,250 Sectors included in total: • agriculture, forestry, fishing and hunting • mining, quarrying, and oil and gas extraction • construction Citation: (15)
Vector-borne diseases	Number of citizens age 65 years or older	Adults over 65 may be more likely to experience complications as a result of diseases, such as WNV.	Total (2016): 21450 Citation: (15)
UV radiation	Number of citizens age 65 years or older	Adults over 65 years may be at greater risk of experiencing adverse health outcomes and complications related to UV radiation.	Total (2016): 21450 Citation: (15)
UV radiation	Number of children under 14 years	People under the age of 18 years are most at risk of exposure to UV radiation as they spend more time outside. One bad sunburn before the age of 18 doubles your risk of melanoma.	Total (2016): 16740 Citation: (15)

Hazard	Indicator	Significance	Current Count
UV radiation	Number of relevant occupational groups (e.g. outdoor workers)	Outdoor workers are more likely to be exposed to UV radiation.	Total (2016): 7,250 Sectors included in total: • agriculture, forestry, fishing and hunting • mining, quarrying, and oil and gas extraction • construction Citation: (15)

Appendix B: Tables

List of Tables

Table 1: Population Distribution in Chatham-Kent by Community (2016 Census)

Community	Population
Chatham	44145
Rural Area	24720
Wallaceburg	10145
Tilbury	4815
Blenheim	4350
Ridgetown	3130
Wheatley	3045
Dresden	2493
Bothwell	860
Thamesville	855
Merlin	655
Shrewsbury	450
Pain Court	405
Erieau	390
Charing Cross	315
Highgate	300
Mitchell's Bay	265
Cedar Springs	205
Morpeth	185

Data Source: Statistics Canada. 2017. Chatham-Kent [Census agglomeration], Ontario and Ontario [Province] (table). Census Profile. 2016 Census. Statistics Canada Catalogue no. 98-316-X2016001. Ottawa. Released November 29, 2017. https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/index.cfm?Lang=E (accessed December 2, 2018).

Table 2: Age Distribution of Chatham-Kent Population (2016 Census)

Age Range	Population	Proportion
0 to 14 years	16,740	16.4
15 to 64 years	63,850	62.6
65 years and over	21,455	22.6

Data Source: Statistics Canada. 2017. Chatham-Kent [Census agglomeration], Ontario and Ontario [Province] (table). Census Profile. 2016 Census. Statistics Canada Catalogue no. 98-316-X2016001. Ottawa. Released November 29, 2017. https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/index.cfm?Lang=E (accessed December 2, 2018).

Table 3: Number of Live Births in Chatham-Kent, 2008-2017

Year	Live Births for Resident Families
2008	1154
2009	1081
2010	1060
2011	1123
2012	1020
2013	1008
2014	991
2015	1000
2016	960
2017	972

Data Source: Integrated Services for Children Information System. 2008-2017. Extracted: September 2018.

Table 4: Prevalence of low income based on the Low-income measure, after tax (LIM-AT)

Age	Males (%)	Females (%)	Total - Chatham (%)	Total - Provincial
0-17 years	2,310 (22.3)	2,210 (22.3)	4,520 (22.3)	489,905 (18.4)
18-64 years	4,505 (15.4)	5,270 (17.4)	9,775 (16.4)	1,155,315 (13.7)
65 years+	970 (10.6)	1,645 (15.6)	2,615 (13.3)	253,755 (12.0)
Total	**7,780 (16.0)**	**9,130 (18.0)**	**16,910 (17.0)**	**1,898,975 (14.4)**

Data Source: Statistics Canada. 2017. Chatham-Kent [Census agglomeration], Ontario and Ontario [Province] (table). Census Profile. 2016 Census. Statistics Canada Catalogue no. 98-316-X2016001. Ottawa. Released November 29, 2017. https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/index.cfm?Lang=E (accessed December 2, 2018).

Table 5: Daily Average Temperature Normals in Chatham-Kent

Month	Daily Average Temperature (°C)	Standard Deviation
January	-3.6	2.8
February	-2.4	2.4
March	1.9	1.8
April	8.5	1.4
May	14.6	2
June	20.3	1.4
July	22.6	1.2
August	21.6	1.4
September	17.8	1.2
October	11.3	1.3

Month	Daily Average Temperature (°C)	Standard Deviation
November	5.2	1.8
December	-0.9	3
Year	**9.8**	**1.2**

Data Source: Environment and Climate Change Canada. 1981-2010. Extracted: August 2018.

Table 6: Daily Maximum and Minimum Temperature Normals in Chatham-Kent

Month	Daily Maximum (°C)	Daily Minimum (°C)
January	-0.3	-6.9
February	1.2	-5.9
March	6	-2.2
April	13.5	3.6
May	19.9	9.4
June	25.5	15
July	27.7	17.5
August	26.5	16.7
September	22.7	13
October	15.5	6.9
November	8.5	1.8
December	2.1	-3.9
Year	**14.1**	**5.4**

Data Source: Environment and Climate Change Canada. 1981-2010. Extracted: August 2018.

Table 7: Extreme Maximum and Extreme Minimum Temperatures in Chatham-Kent

Month	Extreme Maximum (°C)	Extreme Minimum (°C)
January	14	-27
February	19	-23.5
March	25	-22
April	30	-8
May	32.5	-2.5
June	38.5	1.5
July	37.5	6
August	36.5	6
September	33.5	1.5
October	29	-4.5
November	22.5	-10
December	19	-23

Data Source: Environment and Climate Change Canada. 1981-2010. Extracted: August 2018.

Table 8: Number of Days with Temperature above 30°C, 35°C in Chatham-Kent

Month	>30°C	>35°C
January	0	0
February	0	0
March	0	0
April	0	0

Month	>30°C	>35°C
May	1	0
June	4.9	0.09
July	6.5	0.33
August	3.7	0.13
September	0.83	0
October	0	0
November	0	0
December	0	0
Year	**17**	**0.55**

Data Source: Environment and Climate Change Canada. 1981-2010. Extracted: August 2018.

Table 9: Number of Degree Days above 18°C in Chatham-Kent

Month	Number of Degree Days above 18°C
January	0
February	0
March	0.1
April	2.8
May	22.4
June	91.7
July	144.6
August	117.2
September	50.2

Month	Number of Degree Days above 18°C
October	4.5
November	0
December	0
Year	**433.5**

Data Source: Environment and Climate Change Canada. 1981-2010. Extracted: August 2018.

Table 10: Average Precipitation Normals in Chatham-Kent

Month	Average Rainfall (mm)	Average Snowfall (cm)	Average Precipitation (mm)
January	31.6	31.1	62.7
February	36.5	17.6	54.1
March	48.6	11.3	59.9
April	78.3	1.4	79.7
May	79.7	0	79.7
June	77.9	0	77.9
July	85.4	0	85.4
August	79.3	0	79.3
September	89.1	0	89.1
October	70.7	0	70.7
November	75	1.7	76.8
December	51.1	15.9	79.2
Year	**803.1**	**79.2**	**882.3**

Data Source: Environment and Climate Change Canada. 1981-2010. Extracted: August 2018.

Table 11: Extreme Precipitation in Chatham-Kent

Month	Extreme Daily Rainfall (mm)	Extreme Daily Snowfall (cm)	Extreme Daily Precipitation (mm)
January	34	26	38
February	49.2	20	49.2
March	34.6	15	34.6
April	67	4.5	67
May	43.2	0	43.2
June	66.4	0	66.4
July	86.1	0	85.1
August	67.2	0	67.2
September	84.8	0	84.8
October	56.8	1	56.8
November	32	5.2	32
December	34.2	18	34.2

Data Source: Prairie Climate Centre. 2018. The Climate Atlas of Canada. https://climateatlas.ca/ (accessed July 2018).

Table 12: Average Snowfall in Chatham-Kent

Snowfall (cm)	Average Number of Days per Year
≤0.2	22.4
≤5	4.6
≤10	1.8

Snowfall (cm)	Average Number of Days per Year
≤25	0.09

Data Source: Prairie Climate Centre. 2018. The Climate Atlas of Canada. https://climateatlas.ca/ (accessed July 2018).

Table 13: Projected Change in Annual Temperatures in Chatham-Kent

Climate index	Reference Value (°C)	1990s (°C)	2020s (°C)	2050s (°C)	2080s (°C)
Mean Temperature	9.7	-0.4	0.8	2.2	4.3
Maximum Temperature	14.1	-0.4	0.9	2.2	4.3
Minimum Temperature	5.4	-04	0.9	2.4	4.5

Data Source: Prairie Climate Centre. 2018. The Climate Atlas of Canada. https://climateatlas.ca/ (accessed July 2018).

Table 14: Projected Change in Seasonal Temperatures in Chatham-Kent

Season	1976-2005 (°C)	2050s (°C)	2080s (°C)
Spring	7.8	11.9	14.3
Summer	21.1	25.1	27.6
Fall	11.2	15.2	17.6
Winter	-3	2	4.9

Data Source: Prairie Climate Centre. 2018. The Climate Atlas of Canada. https://climateatlas.ca/ (accessed July 2018).

Table 15: Projected Change in Last and First Frost in Chatham-Kent

Frost	1976-2005	2050s	2080s
Last Spring Frost	April 25	April 30	April 21
First Fall Frost	October 27	November 20	November 30

Data Source: Prairie Climate Centre. 2018. The Climate Atlas of Canada. https://climateatlas.ca/ (accessed July 2018).

Table 16: Projected Change in Frequency of Heat Waves with at Least Three Consecutive Days Exceeding 32°C

1971-2000	2050s	2080s
0.48	2.32	4.99

Data Source: Prairie Climate Centre. 2018. The Climate Atlas of Canada. https://climateatlas.ca/ (accessed July 2018).

Table 17: Projected Change in Seasonal Precipitation in Chatham-Kent

Season	1976-2005 (mm)	2050s (mm)	2080s (mm)
Spring	211	328	352
Summer	220	3335	337
Fall	209	333	348
Winter	182	275	292
Annual	**824**	**1066**	**1112**

Data Source: Prairie Climate Centre. 2018. The Climate Atlas of Canada. https://climateatlas.ca/ (accessed July 2018).

Table 18: Number of Heat Alerts Issued by CKPHU, 2012-2017

Year	Number of Heat Warnings	Number of Extended Heat Warnings
2012	0	0
2013	0	0
2014	1	0
2015	3	0
2016	4	3
2017	4	1
2018	6	5

Data Source: Chatham-Kent Public Health Unit. 2012-2017. Extracted: August 2018.

Table 19: Number of Heat Alerts Issued by Environment Canada, 2012-2017

Year	Number of Heat Alerts
2012	0
2013	0
2014	3
2015	3
2016	7
2017	5
2018	12

Data Source: Environment and Climate Change Canada. 2012-2017. Extracted: August 2018.

Table 20: Number of Cold Alerts Issued by CKPHU, 2014-2017

Year	Number of Cold Alerts
2014	8
2015	15
2016	1
2017	0

Data Source: Chatham-Kent Public Health Unit. 2014-2017. Extracted: August 2018.

Table 21: Number of Cold Alerts Issued by Environment Canada, 2012-2017

Year	Number of Cold Alerts
2012	0
2013	0
2014	6
2015	6
2016	0
2017	1
2018	2

Data Source: Environment and Climate Change Canada. 2012-2017. Extracted: August 2018.

Table 22: Number of Flood Notices Issued by the Lower Thames Valley Conservation Authority, 2007-2017

Year	Number of Lake Erie Flood Advisories	Number of Thames River Flood Advisories
2007	0	5

Year	Number of Lake Erie Flood Advisories	Number of Thames River Flood Advisories
2008	0	4
2009	0	3
2010	0	1
2011	0	0
2012	0	2
2013	1	15
2014	1	19
2015	4	11
2016	0	11
2017	29	12

Data Source: Lower Thames Valley Conservation Authority. 2007-2017. Extracted: August 2018.

Table 23: Number of Flood Event Notices Issued by the St. Clair Region Conservation Authority, 2011-2017

Year	Number of Flood Event Notices
2011	7
2012	1
2013	5
2014	5
2015	3
2016	3

Year	Number of Flood Event Notices
2017	5

Data Source: St. Clair Region Conservation Authority. 2011-2017. Extracted: August 2018.

Table 24: Number of Verified Tornado Events in Chatham-Kent, 1980-2009

Year	Location
1980	Blenheim
1980	Wheatley
1981	Bothwell
1982	Chatham-Kent
1985	Wheatley
1990	Tilbury
1992	Chatham-Kent
1993	Tilbury
1994	Thamesville
1997	Chatham-Kent
1999	Blenheim
2000	Merlin

Data Source: Environment and Climate Change Canada. 2018. Extracted: August 2018.

Table 25: Number of Smog Advisories -Issued in Windsor-Essex-Chatham-Kent, 2003-2014

Year	Number of Smog Advisories	Total Number of Smog Days
2003	6	17
2004	6	16
2005	13	46
2006	4	14
2007	13	38
2008	5	12
2009	3	5
2010	2	10
2011	4	8
2012	8	24
2013	0	0
2014	0	0

Data Source: Environment and Climate Change Canada. 2018. Extracted: August 2018.

Table 26: Air Quality Health Index Categories for Chatham-Kent, 2015-2017

Year	Number of Moderate Risk Days	Number of High Risk Days	Number of Very High Risk Days
2015	60	0	0
2016	28	0	0
2017	31	0	0

Data Source: Environment and Climate Change Canada. 2018. Extracted: August 2018.

Table 27: Number of Days with Ozone Concentrations above 80 ppb

Days above 80ppb (1971-2000)	Days above 80ppb (2050s)	Days above 80ppb (2080s)
Range 8-12, Average 10	Range 9-12, Average 10.5	Range 10-13, Average 11.5

Data Source: Ministry of Health and Long-Term Care. 2016. *Ontario Climate Change and Health Modelling Study: Report. http://www.health.gov.on.ca/en/common/ministry/publications/reports/climate_change_toolkit/climate_change_health_modelling_study.pdf* (accessed August 2018).

Table 28: Power Disruptions in Chatham-Kent by Energy Supplier, 2012-2016

	Entegrus	Hydro One	Entegrus	Hydro One
Year	Average Number of Hours that Power to a Customer is Interrupted		Average Number of Times that Power to a Customer is Interrupted	
2012	1.18	6.98	0.97	2.61
2013	1.23	6.88	0.94	2.49
2014	1.31	7.49	0.84	2.70
2015	1.18	7.65	0.87	2.63
2016	0.51	7.83	0.41	2.47

Data Source: Ontario Energy Board. 2016. *Scorecard: Entegrus Powerlines Inc;* Ontario Energy Board. 2016. *Scorecard: Hydro One Networks Inc.*

Table 29: Number of Adverse Beach Water Sampling Results (Geometric Mean above 200), 2012-2017

Year	Number of Adverse Beach Sample Results
2012	14
2013	14
2014	6
2015	9
2016	14
2017	2
2018[a]	4

Data Source: Chatham-Kent Public Health Unit. 2012-2017. Extracted: September 2018.

[a] Beaches were sampled 12 times between 2012 and 2017 and three times in 2018.

Table 30: Number of Beaches Closed due to Bleach-Green Algae Blooms, 2012-2017

Year	Number of Beaches Closed
2012	0
2013	9
2014	0
2015	2
2016	0
2017	0
2018	0

Data Source: Chatham-Kent Public Health Unit. 2012-2018. Extracted: September 2018.

Table 31: West Nile Virus exposure indicators in Chatham-Kent, 2008-2018

Year	Proportion of WNV Enzootic Vectors (*Culex pipiens/restuans*) (%)	Proportion of WNV Bridge Vectors (%)	Number of Accumulated Degree Days	Number of Positive Mosquito Pools	WNV Risk Rating
2008	No data	No data	No data	0	No data
2009	No data	No data	No data	0	No data
2010	No data	No data	No data	1	No data
2011	No data	No data	No data	1	No data
2012	No data	No data	No data	3	No data
2013	8.78	11.99	267	4	low
2014	No data	No data	No data	0	No data
2015	8.77	67.91	254	1	low
2016	13.17	28.41	347.4	0	low
2017	7.15	25.28	267	3	low
2018				9	

Data Source: Chatham-Kent Public Health Unit. 2008-2018. Extracted: July 2018.

Table 32: West Nile Virus Sentinel Surveillance in Chatham-Kent, 2008-2017

Year	Number of Positive Cases of WNV Identified in Horses
2010	0
2011	0
2012	1

Year	Number of Positive Cases of WNV Identified in Horses
2013	1
2014	0
2015	1
2016	0
2017	0

Data Source: Chatham-Kent Public Health Unit. 2008-2018. Extracted: September 2018.

Table 33: Tick Submissions and Results of Testing for *Borrelia burgdorferi* in Blacklegged Ticks in Chatham-Kent, 2012-2017[a]

Year	Number of Ticks Submitted to CKPHU for Identification	Number of Suspected Blacklegged Ticks Identified	Number of Suspected Blacklegged Ticks Submitted to Lab for Testing*	Number of Confirmed Blacklegged Ticks	Number of Positive Blacklegged Tick Specimens (%)
2012	No data	6	6		1 (16.67)
2013	102	5	5		2 (40.0)
2014	91	11	11	9	5 (45.5)
2015	146	23	26	25	6 (23.1)
2016	169	13	15		4 (26.7)
2017	314	22	9		0 (0)

Data Source: Chatham-Kent Public Health Unit. 2012-2017. Extracted: July 2018.

[a] As of 2017, blacklegged ticks found in the Rondeau Provincial Park area are no longer submitted for testing, based on high infection rates in ticks found in this area. Clients who acquire blacklegged ticks near the park are advised to seek treatment immediately.

Table 34: Average Monthly Maximum UV Index, Toronto Brewer Station, 2005-2015

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2005	2.14124	3.75328	4.85332	6.88224	8.14924	10.1053	8.85796	8.31608	7.61628	4.7644	2.72648	1.43487
2006	1.72872	2.71756	4.57268	7.86507	8.13264	8.6094	8.78462	7.73757	6.24783	4.67459	2.1074	1.27786
2007	1.53769	2.90951	5.51372	6.98064	8.90787	9.22826	8.71995	8.52877	7.15715	4.83447	2.39585	1.44637
2008	1.648	2.86336	5.19456	7.41768	8.96673	10.0578	8.84461	7.95093	7.03337	4.3087	2.45609	1.305
2009	1.85868	2.82304	5.03115	7.56315	8.39979	9.20136	7.99959	7.42145	6.25467	3.73325	2.35348	1.16149
2010	1.42271	1.85302	4.02261	5.70351	8.5451	8.73462	9.56877	7.59249	5.84581	4.03138	2.12448	no data
2011	1.60683	2.84035	4.18906	7.05188	8.7927	8.95564	8.86576	8.12365	6.59238	4.17784	2.45161	1.34206
2012	1.46847	2.89253	5.28338	6.47867	8.42378	8.48027	8.73655	no data	no data	no data	no data	no data
2013	no data	no data	no data	no data	no data	no data	5.35432	4.94799	3.86396	2.99694	1.50127	0.743837
2014	no data	no data	no data	no data	no data	no data	5.21021	4.7201	3.78809	2.49196	1.36697	0.785192
2015	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data	2.02476	0.752683

Data Source: World Ozone and Ultraviolet Radiation Centre. 2018. https://woudc.org/data/explore.php?lang=en (accessed July 2018)

Appendix C: Maps

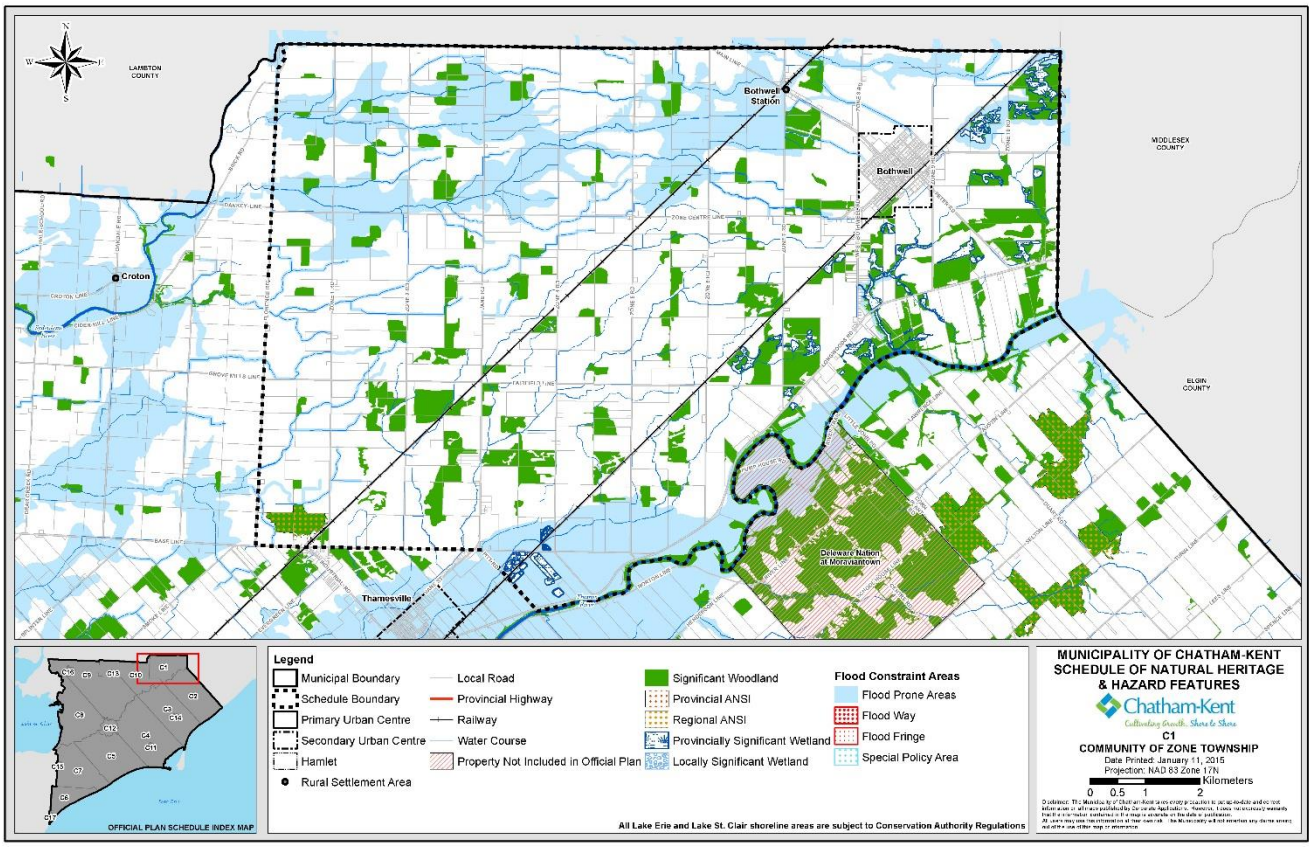
This section includes maps obtained from *Schedule C – Natural Heritage Features and Hazards* of Chatham-Kent's Official Plan (38). It provides a visual representation of natural hazards throughout Chatham-Kent, including flood-prone areas and areas susceptible to groundwater contamination.

Flood-Prone Areas

Schedule C of the Official Plan maps natural hazards throughout Chatham-Kent. Flood-prone areas (i.e., areas near bodies of water likely to be covered in floodwaters), are indicated in blue. A text description summarizes key risk areas indicated on the map. This section illustrates areas in Chatham-Kent that are currently at risk in the event of a flood.

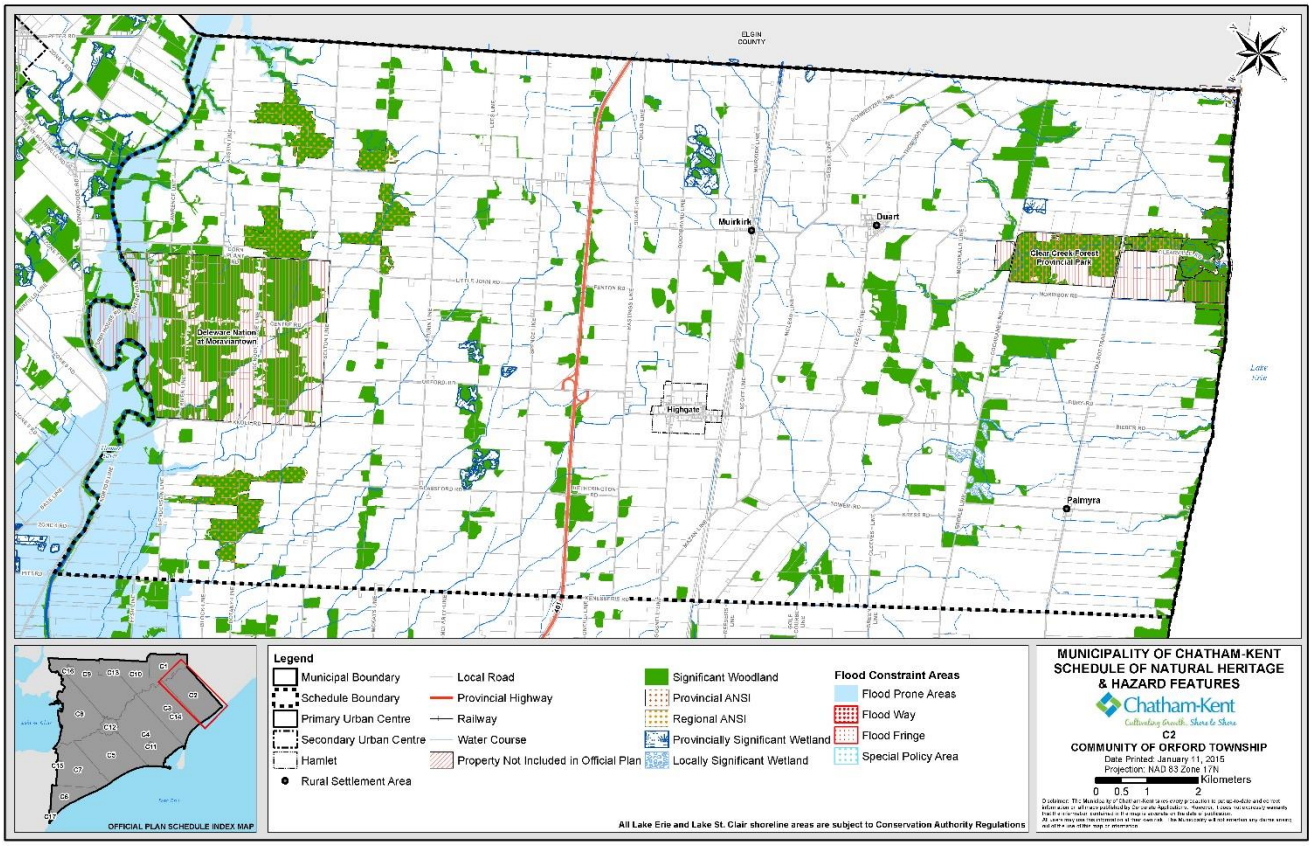
ZONE TOWNSHIP

Zone Township includes the community of Bothwell. Flood-prone areas include lands along the Thames and Sydenham rivers and their tributaries.



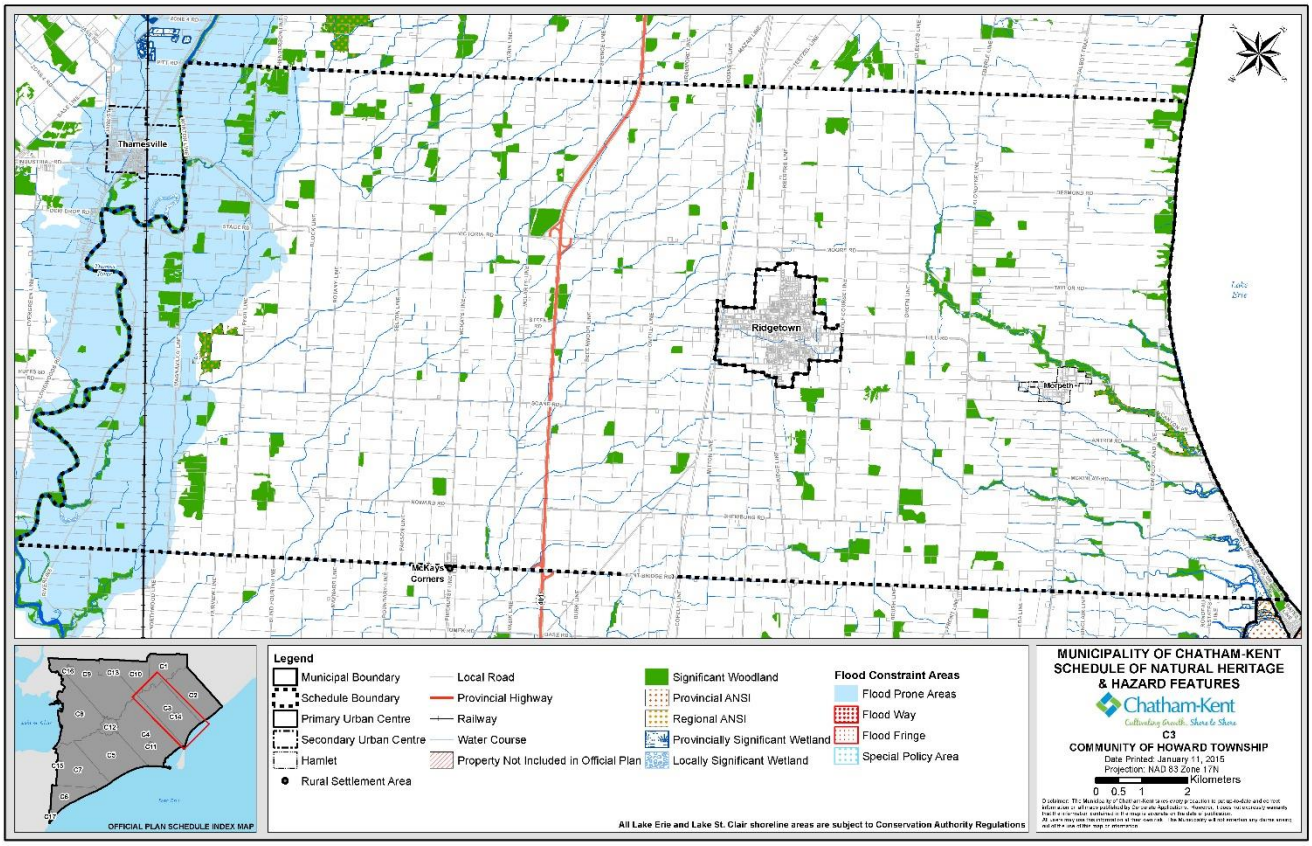
ORFORD TOWNSHIP

Orford Township borders Delaware Nation at Moraviantown. The northern portion of Moraviantown and lands along the Thames River are at risk of flooding.



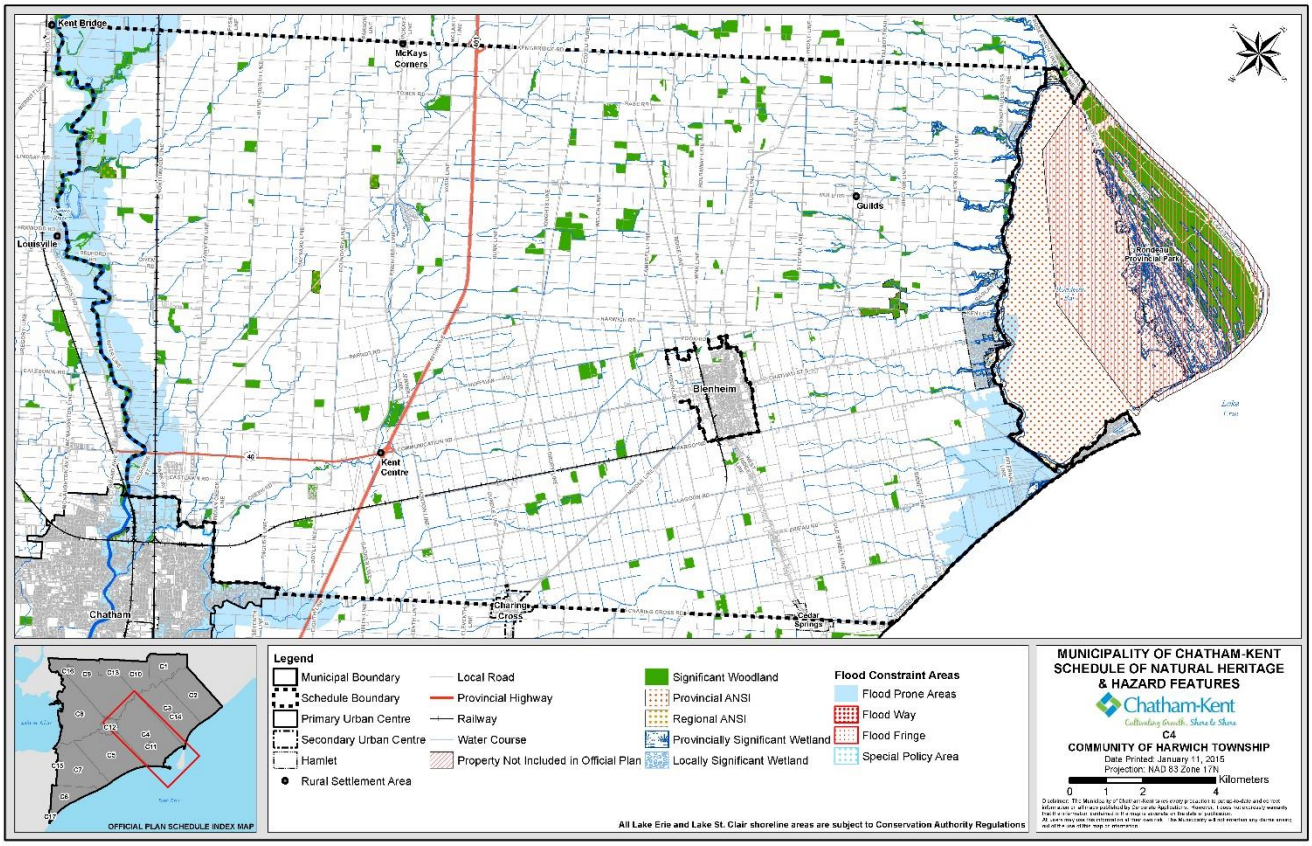
HOWARD TOWNSHIP

Howard Township borders and surrounds the communities of Thamesville and Ridgetown, respectively. The entire Village of Thamesville (population: 855 (15)) and lands along the Thames River are at risk of flooding.



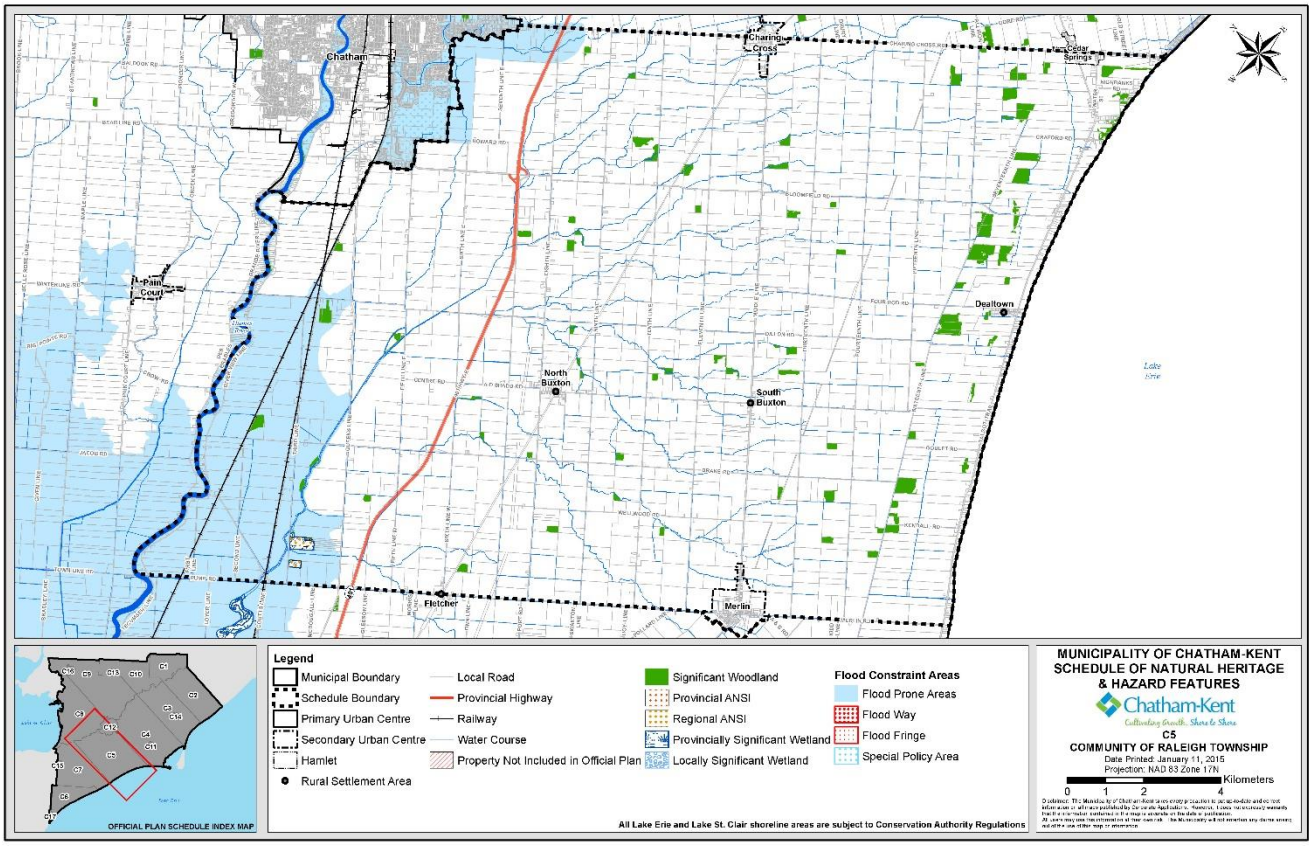
HARWICH TOWNSHIP

Lands along the banks of the Thames River, as well as those along the shores of Lake Erie near Erieau (population: 390) and all of Shrewsbury (population: 450) are at risk of flooding (15).



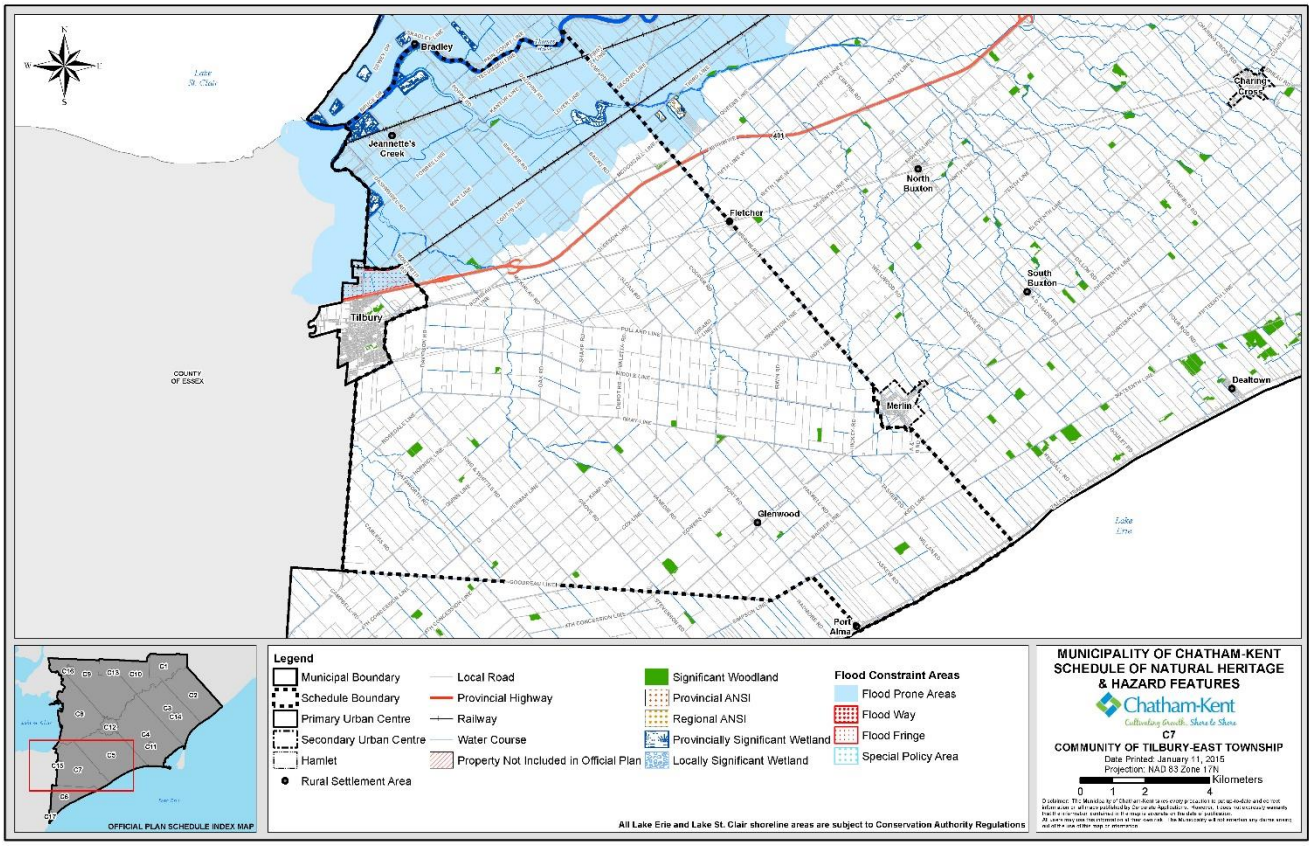
RALEIGH TOWNSHIP

Lands along the Thames River at the northern corners of Raleigh Township are prone to flooding.



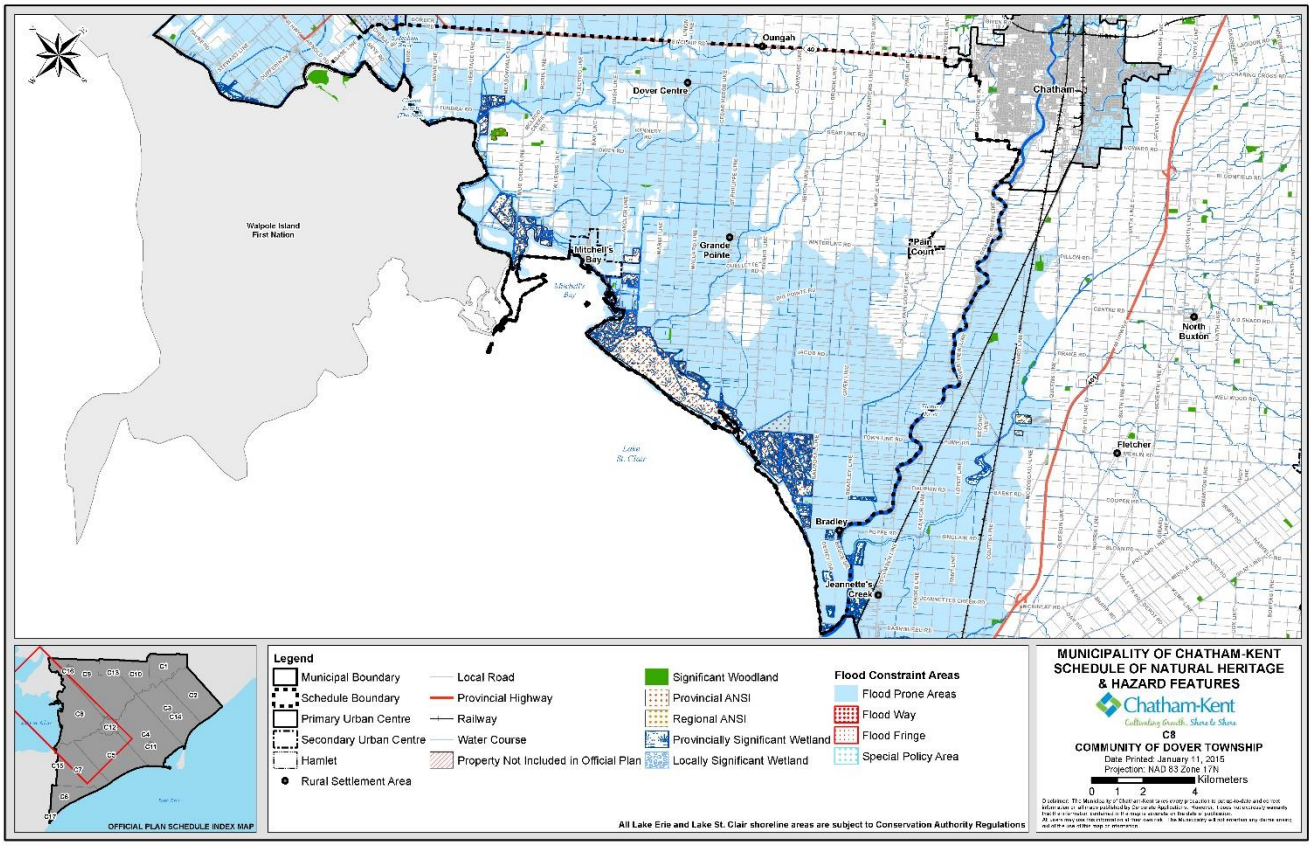
TILBURY EAST TOWNSHIP

The northern portion of the Tilbury East Township, bordering Lake St. Clair and the Thames River are at risk of flooding. This includes the communities of Jeanette's Creek and Bradley.



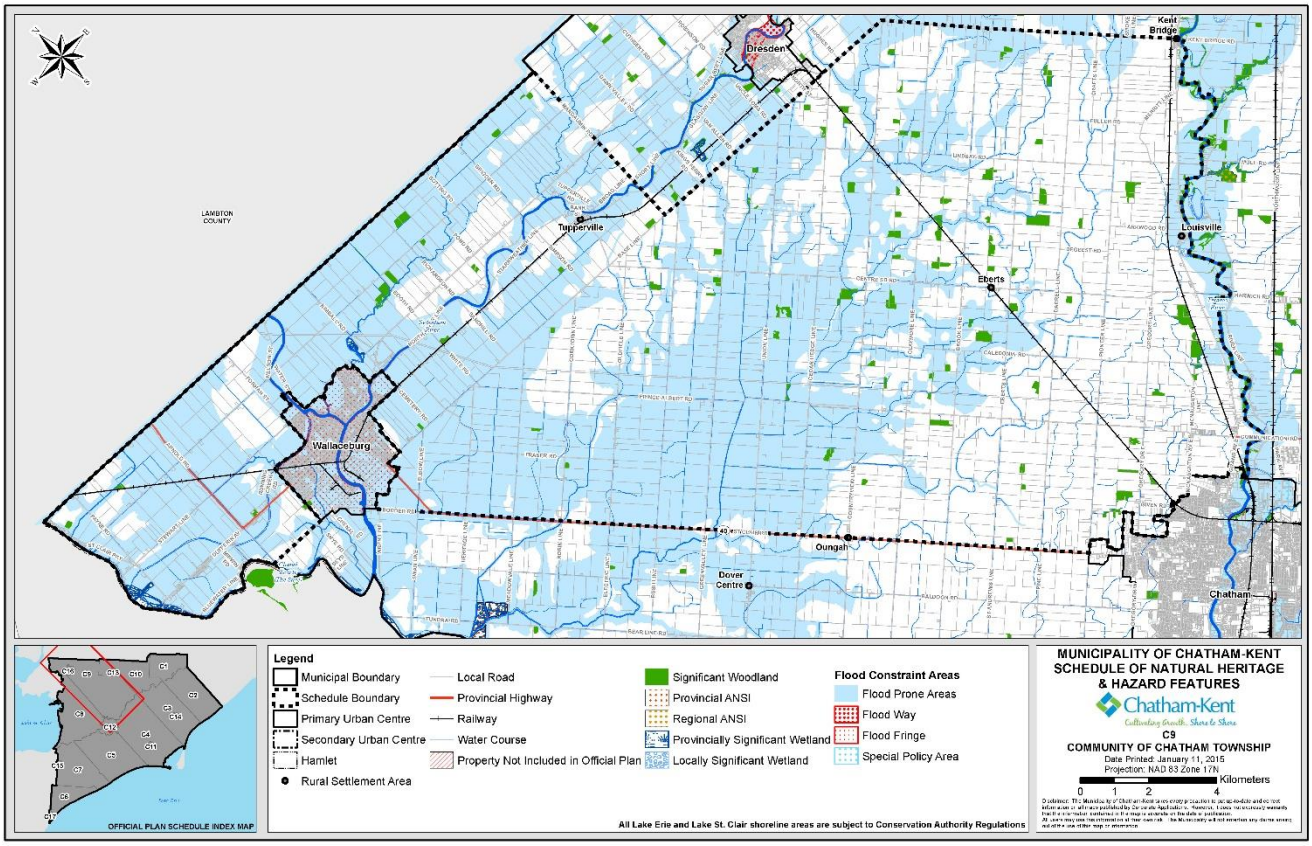
DOVER TOWNSHIP

Nearly all of Dover Township, which borders Walpole Island First Nation and Lake St. Clair, is at risk of flooding. Also at risk is Mitchell's Bay (population: 265) (15).



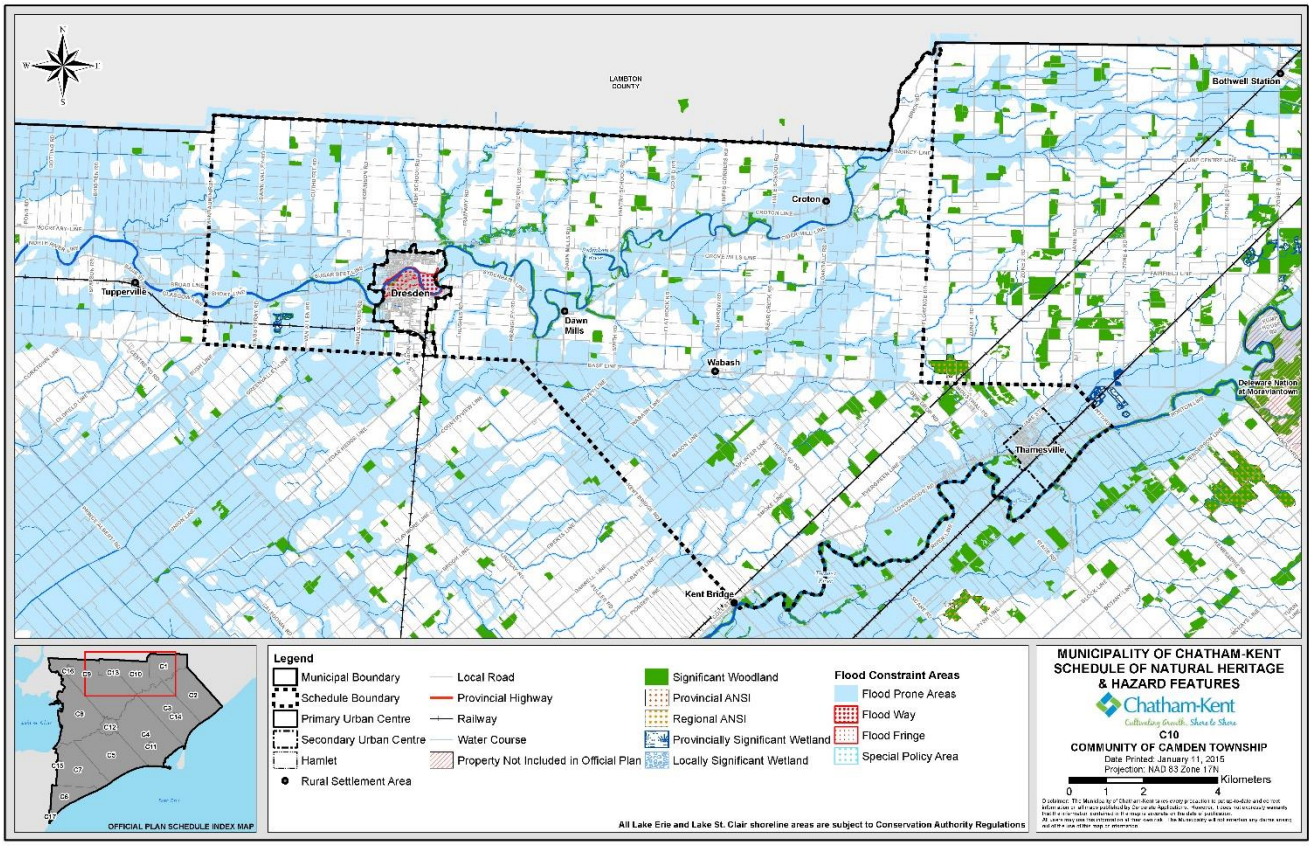
CHATHAM TOWNSHIP

The greater portion of Chatham Township, including the community of Tupperville, is at risk of flooding.



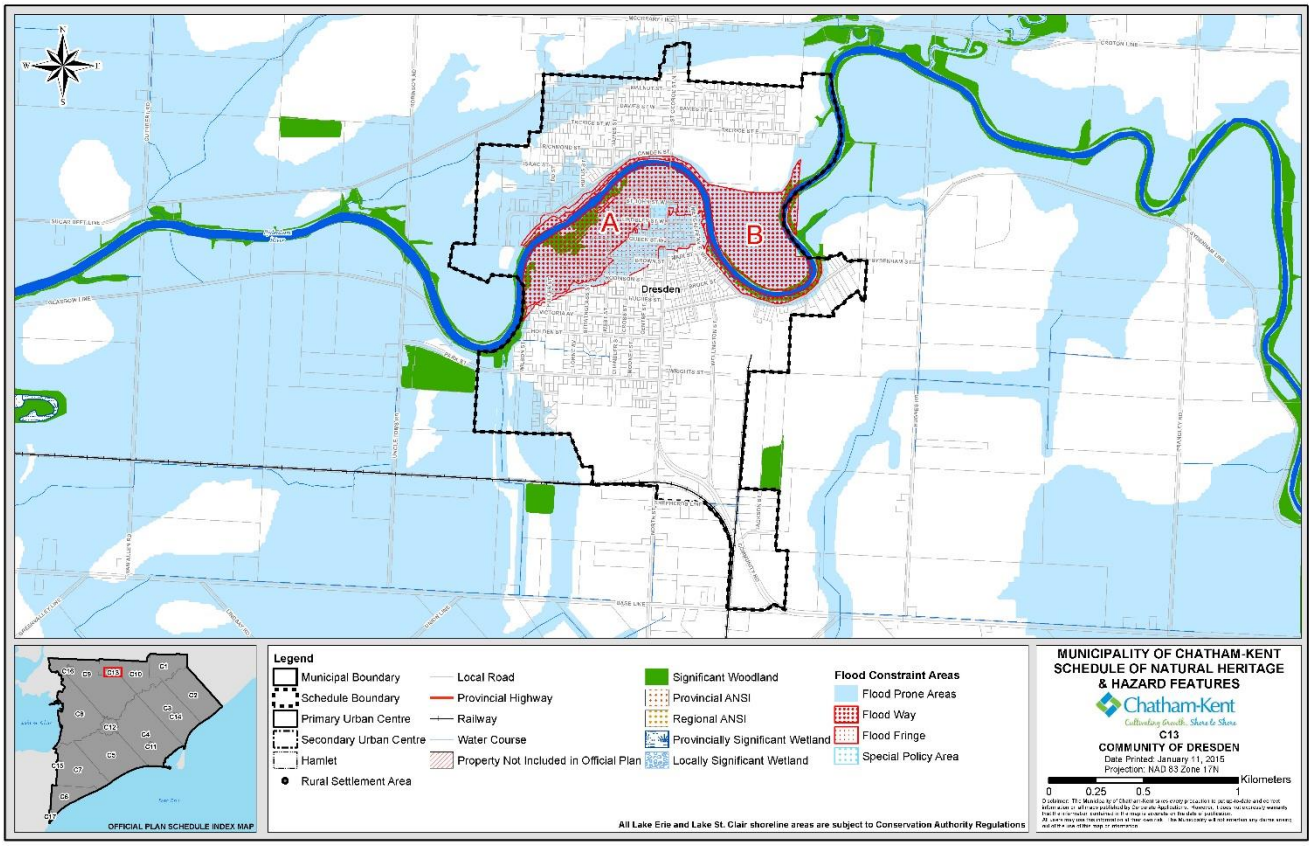
CAMDEN TOWNSHIP

Large portions of Camden Township, bordering Dresden and Thamesville, are at risk of flooding.



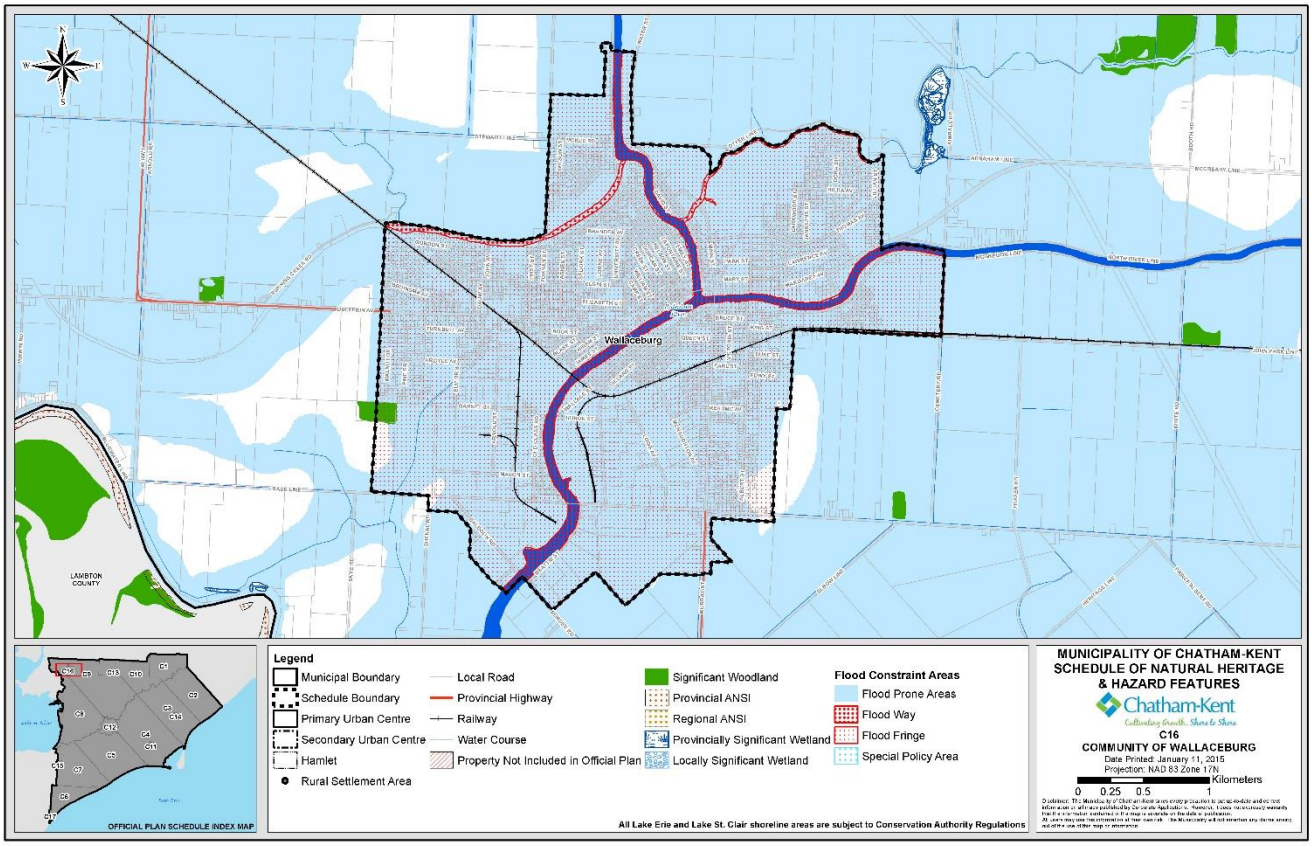
COMMUNITY OF DRESDEN

Large swaths of land surrounding Dresden, as well as those portions of Dresden surrounding the Sydenham River are at risk of flooding.



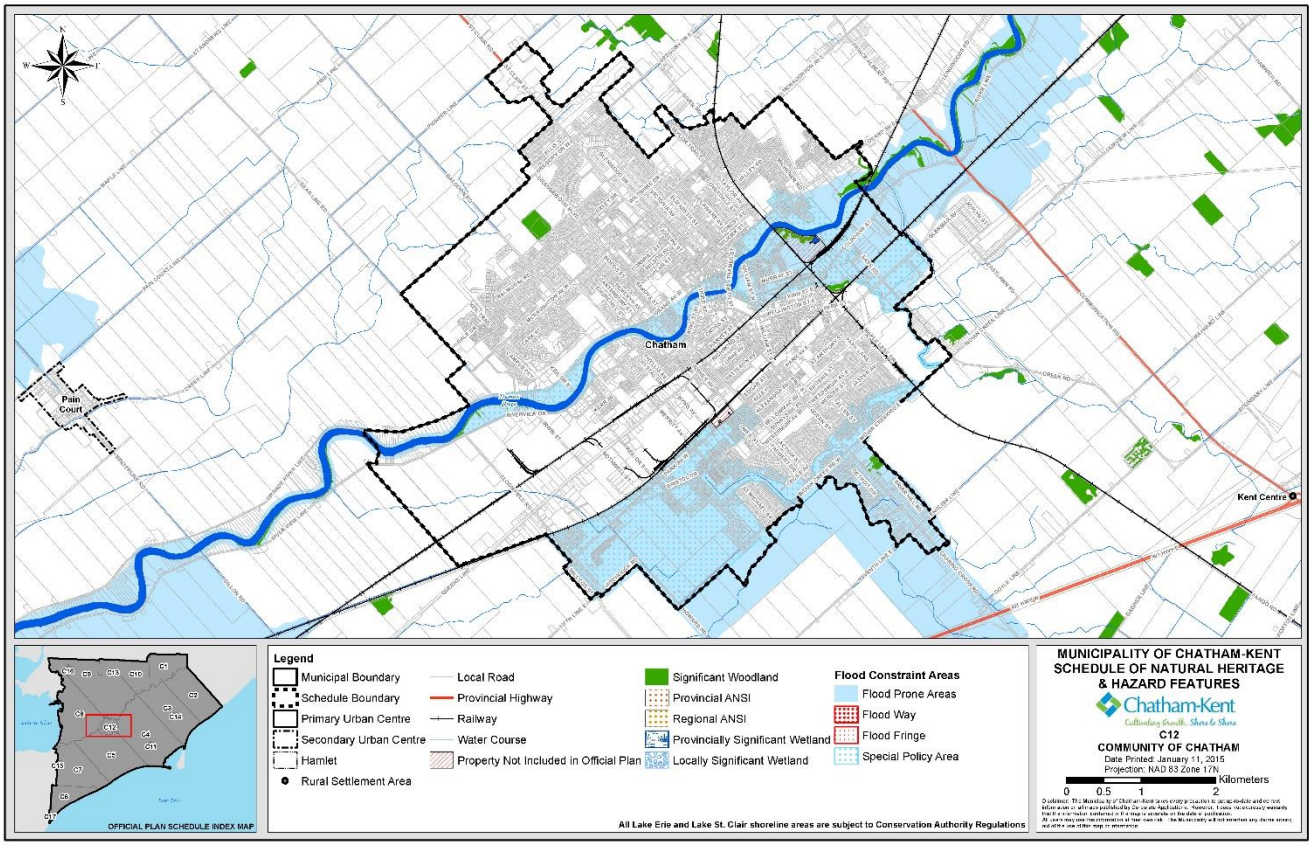
COMMUNITY OF WALLACEBURG

The entire community of Wallaceburg (population: 10,145 (15)), as well as the lands along the shores of the Sydenham and St. Clair Rivers are at risk of flooding.



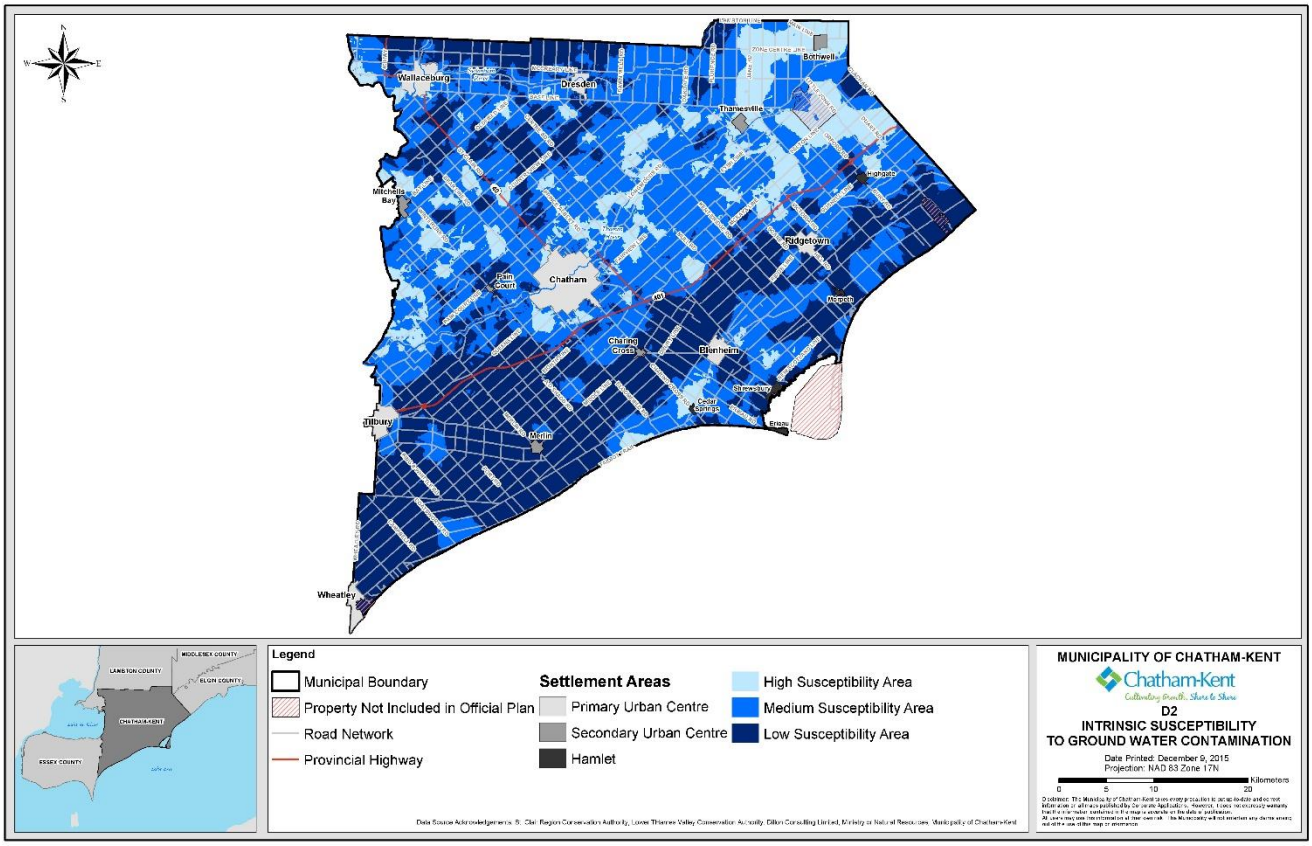
CITY OF CHATHAM

A large portion of the City of Chatham (population 44,145 (15)) is at risk of flooding. This includes lands border the Thames River, as well as the eastern and southwestern corners of the city.



Intrinsic Susceptibility to Groundwater Contamination

A significant portion of lands throughout Chatham-Kent are at medium to high risk of groundwater contamination.



Appendix D: Glossary

Climate	A region's climate is the average weather pattern over time. It is relatively stable and describes the type of weather you would expect to see in that region throughout the year.
Climate change	Climate change describes shifts in average weather patterns. This can cause a region to experience changes in weather that are not typical.
Degree day	A degree day is a measure of temperature. It is used to count the number of days above a specified temperature threshold.
Disease vector	A disease vector is any agent that spreads disease to humans.
Exposure	Exposure describes people or groups who are at imminent risk of harm from a hazard.
Hazard	A hazard is any condition, event, or thing that can cause harm.
Health impact	Health impacts are any deviations from normal health.
IPCC	Intergovernmental Panel on Climate Change
MOECP	Ontario Ministry of the Environment, Conservation and Parks
MOHTLC	Ontario Ministry of Health and Long-Term Care
Morbidity	Morbidity describes the rate of disease in a population.
Mortality	Mortality describes the rate of death in a population.
Ontario Public Health Standards	The Ontario Public Health Standards are published under the Health Protection and Promotion Act and describe the mandatory programs and service that public health units must provide.
Pathogen	Pathogens are living organism that harm human health. They include bacteria, viruses, and parasites.

Priority population	Priority populations are groups that experience and/or are at greater risk of experiencing poor health outcomes.
Public health	Public health is the science of promoting and protecting the health of a community.
Risk	Risk describes the likelihood that a hazard will cause harm.
Socioeconomic status (SES)	Socioeconomic status describes an individual's social class. It is often determined by education and income.
Vector-borne disease	Vector-borne diseases are diseases that are spread to humans by arthropod insects, such as ticks and mosquitoes.
Vulnerability	Vulnerability describes the degree to which people are likely to experience harm from a hazard.