

# Clarington

## Community Climate Risk Assessment and Adaptation Plan Climate Science Report



June 2026



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## Executive Summary

The Municipality of Clarington is confronting the realities of a climate that is growing warmer and less predictable with each passing decade. Residents have faced a growing range of climate-related challenges in recent years, from rising Lake Ontario water levels and intense heat events to severe storms and flooding. Notable local incidents—including heat waves in July 2023 and June 2025, Lake Ontario flooding in 2017 and 2019, and significant flooding and washouts in March 2025 and February 2026—underscore the accelerating frequency and compounding nature of climate hazards across the municipality. These events are not isolated occurrences; rather, they reflect broader climatic trends observed throughout southern Ontario and point to an escalating pattern of climate risk that is projected to intensify in the decades ahead.

This Climate Science Report characterizes Clarington's historical climate baseline and projects how temperature, precipitation, extreme weather events, and growing-season dynamics are expected to shift through the coming decades. Projections are derived from an ensemble of statistically downscaled CMIP6 global climate models and are presented under two emissions scenarios — SSP5-8.5 (high emissions) and SSP2-4.5 ('middle of the road') — at Clarington's census subdivision (CSD) spatial scale, using data sourced from [climatedata.ca](https://climatedata.ca). This methodology aligns with current Canadian climate risk assessment practice. To capture projection uncertainty, ensemble percentiles (10th, 50th, and 90th) are reported throughout for each climate variable. Key findings in the executive summary are based on the SSP5-8.5 high emissions scenario and the median (50th percentile) projection; SSP2-4.5 projections are available in the tables that follow.

## Key Findings

For all the following climate variables, the baseline period is 1971–2000, and the data have been projected to 2100.

### 1. Rapid and Persistent Warming

Average annual temperatures in Clarington are projected to increase **6.4°C by 2100**, relative to the 1971–2000 baseline. Seasonal warming is expected across all months, with the most pronounced increase occurring in winter.

### 2. Extreme Heat Becoming a Dominant Hazard

Extreme heat is projected to increase significantly through the century:

- **Hottest day** temperature rises from **32.2°C** to **38.8°C** by 2100.
- **Days above 30°C** increase nearly *sevenfold*—from **6 days** historically to **69 days** by 2100.
- **Days with humidex >30** increase from **37** to **115 days** by 2100.
- **Tropical nights** (nightly low >20°C) rise from a baseline of **3** to **59 nights per year** by 2100.

- **Heat waves** increase from **less than 1 per year** to **almost 7 per year**, with total heat wave days per year increasing from a baseline of **less than 1** to **37 days** by 2100.

These shifts pose significant risks to human health, electricity reliability, and critical infrastructure and will require expanded cooling strategies, risk communications, and preparedness planning.

### 3. Milder Winters with Fewer Cold Extremes

Consistent with a warming climate, cold-weather hazards are projected to decline substantially across the municipality.

- **Days with temperatures below -15°C** decline from a baseline of **22 days per year** to **0** by 2100.
- **Frost days** decrease from **143 days per year** to **69 days per year** by 2100.
- **Ice days** decline from **58** to **13 days per year** by 2100.
- **Freeze–thaw cycles**, which affect pavement and building durability, decline from **70** to **56 days per year** by 2100.

**Heating degree days** drop sharply, indicating reduced winter heating energy demand and shifting requirements for building performance and winter operations.

### 4. Longer, Warmer Growing Seasons With New Agricultural Risks

Clarington's **Frost Free Season** expands from **161 days** to **216 days** by century's end—a projected increase of nearly **2 months**. **Growing degree days (>5°C)** rise from **2097** to **3637**, potentially enabling new crop opportunities but also amplifying risks from pests, water stress, heat injury, and late-spring frost damage. Warmer winters may prolong pest activity periods, such as those of black-legged ticks, though climate variables alone do not reliably predict tick abundance.

### 5. Increasing Annual Precipitation but Higher Variability

Annual precipitation is projected to increase by **151 mm per year** by 2100 relative to the baseline, with the greatest seasonal increase in winter and, to a lesser extent, spring and fall. Summer precipitation is projected to increase, then return to just above baseline levels by the late century. Given higher projected temperatures and more variable precipitation patterns, this can elevate drought risk. **Maximum consecutive dry days** remain relatively stable over the century albeit with a slight upward trend.

### 6. Heavy Rainfall and Stormwater Hazards Intensify

Extreme precipitation indices for the municipality show consistent increases:

- **Wet days ≥10 mm: +6 days per year** by 2100 compared to baseline.
- **Wet days ≥20 mm: +4 days per year** by 2100.
- **Maximum 1-day precipitation** increases from **38 mm** to **48 mm** by 2100.

Climate-adjusted Intensity-Duration-Frequency (IDF) curves for the Bowmanville Mostert station<sup>1</sup> show substantial increases in rainfall intensity for 25-, 50-, and 100-year storms, with more rain falling in shorter periods. These changes heighten flood risk, exceed the design basis of legacy infrastructure, and require integration of climate-scaled IDF values into stormwater planning, as recommended by ECCC and CSA W231:25.

### **Implications for Adaptation Planning**

The climate projections presented here highlight a future characterized by more frequent and severe heat events, fewer cold-weather constraints, shifting agricultural conditions, and heightened risks from intense rainfall. These trends will interact with built, sociocultural, economic, and ecological systems, increasing exposure and amplifying risk across the Municipality of Clarington.

This climate science report provides the technical foundation for the next steps in the Building Adaptive and Resilient Communities (BARC) process: identifying priority climate risks and developing sector-specific adaptation actions. These findings also underscore the importance of updating infrastructure design and policy assumptions to reflect a changing climate.

## **Glossary of Terms**

Definitions have been adapted from the Intergovernmental Panel on Climate Change (IPCC) and ClimateData.ca.

### **Baseline**

A climatological baseline is a reference period, typically three decades (or 30 years), that is used to compare fluctuations of climate between one period and another. Baselines can also be called references or reference periods.

### **Census Subdivision (CSD)**

A municipal-level geographic unit defined by Statistics Canada, used here as one of the finer spatial scales available on ClimateData.ca for climate projections. CSDs provide more localized information than larger reporting units such as Health Regions or Watersheds.

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<sup>1</sup> It is acknowledged that the Bowmanville Mostert weather station has been inactive for over a decade. IDF curve projections have nevertheless been derived using climate data from this station for the following reasons: Bowmanville Mostert weather station's baseline record is complete and internally consistent, allowing for reliable comparison across climate variables; alternative stations in the region, such as the Cobourg station, have shorter periods of record and incomplete baseline data that limit their utility for long-term trend analysis; and the Bowmanville Mostert dataset remains the current reference source for other Municipality of Clarington departments pending the adoption of data from an alternative monitoring station. Until a replacement station with a sufficiently robust historical record is identified, the Bowmanville Mostert data represents the most defensible choice for characterizing Clarington's local climate baseline.

## **Climate Change**

A change in the state of the climate, identifiable through changes in the mean and/or variability of climatic properties (e.g., temperature, precipitation) that persists for an extended period, typically decades or longer. Climate change may result from natural processes or from persistent anthropogenic changes in atmospheric composition or land use.

## **Climate Change Scenario**

A climate change scenario is a plausible description of future climate conditions based on assumptions about greenhouse gas emissions and related socioeconomic factors. It represents how the climate may differ from today under specific emission pathways, using scientific models to explore potential future outcomes.

## **Climate Projections**

A projection of the response of the climate system to emissions or concentration scenarios of greenhouse gases and aerosols. These projections depend upon the climate change (or emission) scenario used, which is based on assumptions concerning future socioeconomic and technological developments that may or may not be realized and are therefore subject to uncertainty.

## **Coupled Model Intercomparison Project (CMIP)**

An international framework that coordinates standardized climate-model experiments so results from different global climate models can be compared, evaluated, and used in climate-change research. Successive phases—CMIP5 and CMIP6—provide the model outputs that underpin many climate scenarios, including RCPs and SSPs.

## **Ensemble Approach**

An ensemble approach uses the average of global climate models (GCMs) for temperature and precipitation. Research has shown that running multiple models yields a more realistic projection of annual and seasonal temperatures and precipitation than using a single model.

## **Extreme Heat Days**

An extreme heat day occurs when temperatures meet or exceed 30°C. When using ClimateData.ca, this variable is referred to as 'Days above Tmax +30°C'.

## **Extreme Weather Event**

A meteorological event that is rare at a place and time of year, such as an intense storm, tornado, hail storm, flood, or heatwave, and is beyond the normal range of activity. An extreme weather event would normally occur very rarely or fall into the tenth percentile of probability.

## **General Circulation Models**

Based on physical laws and physically-based empirical relationships and are mathematical representations of the atmosphere, ocean, ice caps and land surface processes. They are, therefore, the only tools that estimate changes in climate due to increased greenhouse gases for a large number of climate variables in a physically consistent manner.

## **Greenhouse Gas (GHG) Emissions**

Gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of thermal infrared radiation, emitted by the Earth's surface, the atmosphere itself, and by clouds. Water vapour (H<sub>2</sub>O), carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), nitrous oxide (N<sub>2</sub>O), ozone (O<sub>3</sub>), and chlorofluorocarbons (CFCs) are the six primary greenhouse gases in the Earth's atmosphere in order of abundance.

## **Heat Warning**

A Heat Warning is issued when temperatures are projected to be at least 31°C during the day and overnight temperatures are at least 20°C or Humidex is at least 40. An Extended Heat Warning is issued when these conditions are expected for more than two days. For the purpose of this report, heat warning is synonymous with 'Heat Wave'.

## **Intensity-Duration-Frequency curve (IDF Curve)**

A graphical representation of the probability that a given average rainfall intensity will occur. Rainfall Intensity (mm/hr), Rainfall Duration (how many hours it rained at that intensity) and Rainfall Frequency/Return Period (how often that rainstorm repeats itself) are the parameters that make up the axes of the graph of the IDF curve. An IDF curve is created with long term rainfall records collected at a rainfall monitoring station.

## **Radiative forcing**

The change in the value of the net radiative flux (i.e. the incoming flux minus the outgoing flux) at the top of the atmosphere in response to some perturbation, in this case, the presence of greenhouse gases.

## **Representative Concentration Pathways (RCPs)**

These are four greenhouse gas concentration (not emissions) trajectories adopted by the IPCC for its fifth Assessment Report (AR5) in 2014. It supersedes the Special Report on Emissions *Scenarios* (SRES) projections published in 2000.

## **Shared Socio-economic Pathways (SSPs)**

Scenarios used to characterize possible future development pathways for human societies, particularly in relation to its use of fossil fuels and the social and economic factors which drive fossil fuel use.

## Temperature anomaly

A departure from a reference value or long-term average. A positive anomaly indicates that the observed temperature was warmer than the reference value, while a negative anomaly indicates that the observed temperature was cooler than the reference value.

## Climate Variables Overview

The climate variables included in this report are listed and defined in Table 1. Each variable is discussed in more detail in its respective sections below.

**Table 1: Climate Variable Definitions**

| CLIMATIC DRIVER | CLIMATE VARIABLE                     | DESCRIPTION                                                                                                                                                                                                       | UNITS                      |
|-----------------|--------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------|
| Hot Temperature | Mean Temperature                     | The average seasonal (or annual) temperature.                                                                                                                                                                     | °C                         |
|                 | Hottest Day                          | The warmest daytime temperature in a given year.                                                                                                                                                                  | °C                         |
|                 | Extreme Heat Days<br>Tmax +30°C Days | Days when the temperature rises to at least +30 °C.                                                                                                                                                               | Days                       |
|                 | Humidex Days                         | Days where the humidex is greater than 30.                                                                                                                                                                        | Days                       |
|                 | Tropical Nights                      | Days when the minimum temperature remains above +20 °C.                                                                                                                                                           | Days                       |
|                 | Heat Wave (Heat Warning) Frequency   | The average number of heat waves per year, where a heat event is defined as two or more consecutive days with Tmax ≥ 31 °C and Tmin ≤ 20°C, or humidex > 40.                                                      | Number of heat wave events |
|                 | Heat Wave (Heat Warning) Duration    | The total number of heat wave days, where a heat wave is defined as 2+ consecutive days with Tmax ≥ 31 °C and Tmin ≤ 20°C, or humidex > 40.                                                                       | Days                       |
|                 | Cooling Degree Days                  | <i>Cooling degree days</i> (CDDs) give an indication of the amount of space cooling, i.e., air conditioning, that may be required to maintain comfortable conditions in a building during warmer months. When the | Cooling Degree Days        |

|                         |                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |      |
|-------------------------|------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
|                         |                        | daily average temperature is hotter than the threshold temperature, CDDs are accumulated (see <i>Degree Days Above</i> ). Threshold values may vary, but 18°C is commonly used in Canada. Larger CDD values indicate a greater need for air conditioning.                                                                                                                                                                                                                                                                               |      |
| <b>Cold Temperature</b> | Coldest Day            | The lowest nighttime temperature recorded in a given year.                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | °C   |
|                         | Days Below Tmin - 15°C | Days where daily minimum temperature is below a threshold of -15°C.                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Days |
|                         | Heating Degree Days    | <i>Heating degree days</i> (HDDs) give an indication of the amount of space heating (e.g., from a gas boiler/furnace, baseboard electric heating or fireplace) that may be required to maintain comfortable conditions inside a building during cooler months. When the daily average temperature is colder than the threshold temperature, HDDs are accumulated (see <i>Degree Days Below</i> ). Threshold values may vary, but 17°C or 18°C are commonly used in Canada. Larger HDD values indicate a greater need for space heating. | Days |
|                         | Frost Days             | Days on which the coldest temperature of the day is lower than 0°C.                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Days |
|                         | Ice Days               | Days on which the air temperature does not go above freezing (0°C).                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Days |
|                         | Freeze-Thaw Cycles     | Days when the air temperature fluctuates between freezing and non-freezing temperatures.                                                                                                                                                                                                                                                                                                                                                                                                                                                | Days |
|                         | Frost Free Season      | The <i>Frost Free Season</i> is the approximate length of the growing season during which there are no freezing temperatures to kill or damage frost-sensitive plants. This index describes the number of days between the Last Spring Frost and the First Fall Frost.                                                                                                                                                                                                                                                                  | Days |

|                              |                              |                                                                                                                                                                                |                               |
|------------------------------|------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|
| <b>Changing Seasons</b>      | Growing Degree Days (>5°C)   | A measure of heat available for plant growth, calculated by summing each day's average temperature above +5 °C. Higher totals indicate a longer or warmer growing season.      | Degree-Days (cumulative unit) |
| <b>Precipitation</b>         | Mean Precipitation           | The average precipitation for a given time period (e.g., yearly, seasonally).                                                                                                  | mm                            |
|                              | Maximum Consecutive Dry Days | The maximum number of consecutive days with precipitation below 1mm/day, within a given year.                                                                                  | Days                          |
| <b>Extreme Precipitation</b> | Wet Days (≥10mm)             | The number of days where at least 10 mm of precipitation (rain and snow combined) falls during the selected temporal frequency.                                                | Days                          |
|                              | Wet Days (≥20mm)             | The number of days where at least 20 mm of precipitation (rain and snow combined) falls during the selected temporal frequency.                                                | mm                            |
|                              | Max. 1-Day Precipitation     | The amount of precipitation that falls on the wettest day of the year.                                                                                                         | mm                            |
|                              | Rainfall IDF Curves          | The annual maximum rainfall intensity for specific durations. Common durations for design applications are: 5-min, 10-min, 15-min, 30-min, 1-hr, 2-hr, 6-hr, 12-hr, and 24-hr. | mm/hr                         |

To view an extended list of climate variables and data projections, see Appendix A and B.

## Introduction

Climate change is imposing increasing pressures at local, regional, and national scales. Canada's climate is becoming warmer, wetter, and more volatile, placing greater stress and strain on the systems our communities depend on to maintain quality of life. These changes manifest across two interconnected dimensions. Slow variables—such as mean annual temperature and precipitation—shift gradually over years to decades and can be difficult for humans to perceive, yet they quietly reshape species distributions, agricultural practices, and infrastructure design thresholds. Extreme weather events, by contrast, tend to gain immediate attention. Recent storms, flooding, extreme heat, and wildfire events serve as reminders of the urgency facing communities as they work to strengthen preparedness for ongoing and intensifying climate-related risks.

The Municipality of Clarington has experienced a notable increase in weather-related events in recent years, including heat waves in July 2023 and June 2025, Lake Ontario flooding in 2017 and 2019, creek bank flooding in August 2025, and significant flooding and washouts in March 2025 and February 2026. These events reflect the growing frequency and compounding nature of climate hazards affecting the municipality, and are consistent with observed climate trends across southern Ontario. Together, they illustrate the range of risks that a warmer and more variable climate is expected to bring and intensify in the years ahead.

These events can generate both direct and indirect health effects, place stress on local ecosystems, damage infrastructure, and lead to substantial economic losses. Province-wide analogues from the insurance industry illustrate potential loss scales. For example, the July 2024 Southern Ontario flash flooding event incurred an estimated \$880.5 million in insured damages, while the December 2022 Eastern Canada bomb cyclone and the December 2021 Eastern Canada windstorm caused \$282.6 million and \$145.4 million in damages, respectively.

In Clarington, three major events Between 2022 and 2025, collectively resulted in approximately \$4.5 million in municipal insured losses across 290 claims. The Ontario & Quebec Derecho of 2022 was by far the most damaging, accounting for roughly 81% of total losses (\$3.6 million) and 86% of all claims (249), with an average claim cost of \$14,609. The 2025 Ice Storm was the second most costly at \$818,674 across 37 claims, while the 2023 Spring Ice Storm was comparatively minor at \$26,822 across just 4 claims. It is important to note that these figures reflect insured losses only reported on CatIQ and do not capture uninsured losses, which are typically considerably higher<sup>2</sup>.

This Climate Science Report examines baseline and historical climate conditions, along with near-term and long-term projections, with a primary focus on temperature and precipitation. These variables are consistently available across climate-model ensembles and form the foundational drivers of hazards such as extreme heat, drought, and extreme rainfall. The projection results support the identification of Clarington's key climate vulnerabilities and risks and provide the analytical basis for subsequent stages of the Building Adaptive and Resilient Communities (BARC) process, which is currently being undertaken

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<sup>2</sup> CatIQ Inc., *Canadian Catastrophe Database* (subscription required), accessed 2025, <https://www.catiq.com>

by the municipality in order to develop its forthcoming Community Climate Risk Assessment and Adaptation Plan.

All climate projections carry inherent uncertainty due to variability in emissions pathways, global climate sensitivity, and model structure. This uncertainty is acknowledged and discussed, along with details on the modelling approach, in subsequent sections. These projections nonetheless offer a robust, evidence-based foundation to inform adaptation planning and to strengthen the municipality's long-term resilience.

## What Causes Climate Change

Climate change refers to long-term shifts in global weather patterns driven by the accumulation of heat-trapping greenhouse gases (GHGs) in the atmosphere. GHGs warm the planet through the greenhouse effect, a natural process that traps heat near the Earth's surface. The greenhouse effect is essential to life on Earth, but the rapid increase of GHGs being released to the atmosphere from human activity since the industrial revolution has increased the concentration of carbon dioxide in the atmosphere by nearly 50% since 1750<sup>3</sup>. This intensification of the greenhouse effect slows heat loss from the Earth to space, resulting in rising temperatures over time—driven primarily by human activity since the 1800s, particularly the burning of fossil fuels.

## Data Collection and Reporting

Data for localized climate change projections were primarily collected from ClimateData.ca - a federally supported, publicly available online climate change data and scenarios tool. ClimateData.ca is a project undertaken by Environment and Climate Change Canada (ECCC), the Computer Research Institute of Montreal (CRIM), Evolving Web, the Pacific Climate Impacts Consortium (PCIC), ClimateWest, the Prairie Climate Centre, ORCCA, Ouranos and CLIMAtlantic.

The scale for the data collected and analyzed was at the *census subdivision* spatial scale, which provides a consistent and comparable reference point across climate projection datasets and serves as a practical midpoint for what residents of Clarington can expect to experience. Reported projection ranges reflect the distribution of an ensemble: unless otherwise specified, the low value corresponds to the 10th percentile, the median represents the 50th percentile (i.e., the median), and the high value reflects the 90th percentile, providing a structured summary of model spread and uncertainty.

## Climate Change Modelling and Downscaling

This report draws on global climate models (GCMs) and emissions scenarios developed for the

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<sup>3</sup> NASA. (2024). The Causes of Climate Change. <https://science.nasa.gov/climate-change/causes/>

Intergovernmental Panel on Climate Change's Sixth Assessment Report. Temperature and precipitation projections use data from the Coupled Model Intercomparison Project Phase 6 (CMIP6), the most current coordinated ensemble of global climate models. CMIP6 expands on CMIP5 by incorporating a larger set of modelling centres and simulations, improving representation of key Earth system processes.

In April 2026, the international scientific community published an updated scenario framework for the next generation of climate models (CMIP7). This update refined the upper end of plausible limits downward, so that very high-emissions scenarios such as SSP5-8.5 and RCP-8.5 are now considered less likely than previously assessed, primarily because of falling renewable energy costs and the spread of climate policy. The update also found that the lowest-emissions scenarios are no longer attainable, as global emissions have not yet begun to fall, meaning that at least some overshoot of 1.5°C of global warming is now expected. The plausible range has therefore narrowed from both ends, but the physical climate risks highlighted in forthcoming Vulnerability and Risk Assessment report remain serious and are not diminished by this revision. CMIP7 climate projection data is not yet available through [climatedata.ca](https://climatedata.ca), so the CMIP6-based projections used in this report remain the best available federally supported data for Canadian municipalities. It is advised that the Municipality of Clarington monitors the CMIP7 rollout and incorporates updated projections into its climate science reporting as they become available. This report has been designed for climate adaptation planning purposes only. Future infrastructure decisions should review climate projections against the most current science of plausible scenarios over the service life of the asset at the time of design.

Multiple approaches exist for constructing climate change scenarios, but GCMs remain the primary tools for assessing large-scale responses to increasing greenhouse gas concentrations. They use mathematical representations of atmospheric, oceanic, cryospheric, and land-surface processes to simulate how the climate system may evolve under different emissions pathways.

Wherever possible, this report uses a multi-model ensemble approach, which relies on a group of models rather than a single model — though the group of models may not necessarily be run by the same modelling centre. Research has shown that this provides a more accurate projection of annual and seasonal temperatures and precipitation than a single model would on its own<sup>4</sup>.

## Greenhouse Gas Emissions Scenarios

Climate change scenarios are based on models developed by a series of international climate modelling centers. They are socioeconomic storylines used by analysts to make projections about future greenhouse gas emissions and to assess future vulnerability to climate change. Producing scenarios requires estimates of future population levels, economic activity, governance structures, social values,

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<sup>4</sup> Government of Canada. (2023). Multi-model ensemble scenarios. Retrieved from The official website of the Government of Canada: <https://climate-scenarios.canada.ca/?page=multimodel-ensembles>

and patterns of technological change. In this report, climate change scenarios from the Fifth and Sixth IPCC Assessments are considered.

## SSP Scenarios - IPCC Sixth Assessment Report (AR6)

Shared Socio-economic Pathways (SSPs) are the newest set of climate change scenarios that provide the basis for IPCC's Sixth Assessment Report (AR6). While the Representative Concentration Pathways (RCPs) used in the IPCC's Fifth Assessment Report (AR5) focus on mitigation targets to address physical climate change, the SSPs focus on the underlying socioeconomic contexts which may present challenges to mitigation and/or adaptation policies. The SSPs incorporate socioeconomic characteristics and other human-caused climate drivers (e.g., population growth, education levels, GDP growth, income inequality, use of technology, energy use, political contexts, and land-use change) to derive scenarios that describe differing influences on greenhouse gas emissions and society's ability to adapt. AR6 assesses and compares the RCP and SSP scenarios and incorporates new data, new models, and updated climate research from around the world to allow for a standardized comparison of society's choices and their resulting levels of climate change. The premise is that every radiative forcing pathway (see Glossary) can result from a diverse range of socioeconomic and technological development scenarios. SSP-based scenarios are categorized by their relationship to both adaptation and mitigation challenges, and their approximate total radiative forcing in the year 2100 relative to pre-industrial levels, and are labelled as SSP1 to SSP5.

For this report, projections are shown under SSP2-4.5 and SSP5-8.5, which represent a 'middle of the road', medium challenge to both mitigation and adaptation scenarios, and worst-case, 'fossil-fueled development' scenario, respectively. SSP5-8.5 assumes a world with high economic growth fueled by fossil fuels, leading to high greenhouse gas emissions and thus making it difficult to reduce them. The high emissions scenario also assumes that with high economic development, societies will have more resources to invest in adapting to the resulting climate impacts, making adaptation easier. Although SSP2-4.5 can be used as a more moderate reference point, SSP5-8.5 was chosen as the primary scenario for this report because it represents a business-as-usual future climate, has associated projections available from many different climate models, and corresponds with the Representative Concentration Pathway (RCP8.5) utilized in the IPCC's AR5 Report. Additionally, it is important that municipalities, which are generally very risk-averse, be aware of the most dramatic potential effects of climate change should global emissions persist. This report has been designed for adaptation planning purposes only; future infrastructure decisions should review climate projections with updated science of plausible scenarios over the service life of the asset at the time of design. Table 2 provides a bulleted description of SSP scenarios 1, 2, 3, 4, and 5, while Figure 1 illustrates the projected global warming associated with these scenarios. Appendix A and B also provide a full comparison table for climate variables under SSP5-8.5 and SSP2-4.5, respectively.

**Table 2: IPCC Sixth Assessment Report Climate Change Scenario Characteristics**

| Scenario                                                                           | Description                                                                                                                                                                                                                                                                                                                                                                                      |
|------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>SSP1-2.6 – Sustainability</b><br><i>Taking the Green Road</i>                   | <ul style="list-style-type: none"> <li>• Low challenges to both mitigation and adaptation</li> <li>• Policy focused on sustainable development</li> <li>• Effective international cooperation</li> <li>• Reduced inequality within and across countries</li> <li>• Low consumption</li> <li>• Low population growth</li> </ul>                                                                   |
| <b>SSP2-4.5</b><br><b>Middle of the Road</b>                                       | <ul style="list-style-type: none"> <li>• Medium challenges to both mitigation and adaptation</li> <li>• Current development and consumption patterns continue</li> <li>• National and global institutions are slow to achieve sustainable development goals</li> <li>• Environmental systems decline</li> <li>• Slow improvements to inequality</li> <li>• Moderate population growth</li> </ul> |
| <b>SSP3-7.0</b><br><b>Regional Rivalry</b><br><i>A Rocky Road</i>                  | <ul style="list-style-type: none"> <li>• High challenges to mitigation and adaptation</li> <li>• Policy focused on security</li> <li>• Barriers to international trade</li> <li>• High inequality</li> <li>• Slow economic growth</li> <li>• Low population growth in rich countries, high in other countries</li> </ul>                                                                         |
| <b>Scenario 4</b><br><b>SSP4-6.0</b><br><b>Inequality</b><br><i>A Road Divided</i> | <ul style="list-style-type: none"> <li>• Policy focused on the elite</li> <li>• High consumption</li> <li>• High inequality</li> <li>• Low to medium economic growth</li> <li>• Low population growth in rich countries, high in other countries</li> </ul>                                                                                                                                      |

|                                                                          |                                                                                                                                                                                                                                                                                                                                     |
|--------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>SSP5-8.5 – Fossil-fueled Development</b><br><i>Taking the Highway</i> | <ul style="list-style-type: none"> <li>• High challenges to mitigation, low challenges to adaptation</li> <li>• Policy focused on free markets</li> <li>• High consumption</li> <li>• Effective international cooperation</li> <li>• Reduced inequality</li> <li>• High economic growth</li> <li>• Low population growth</li> </ul> |
|--------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

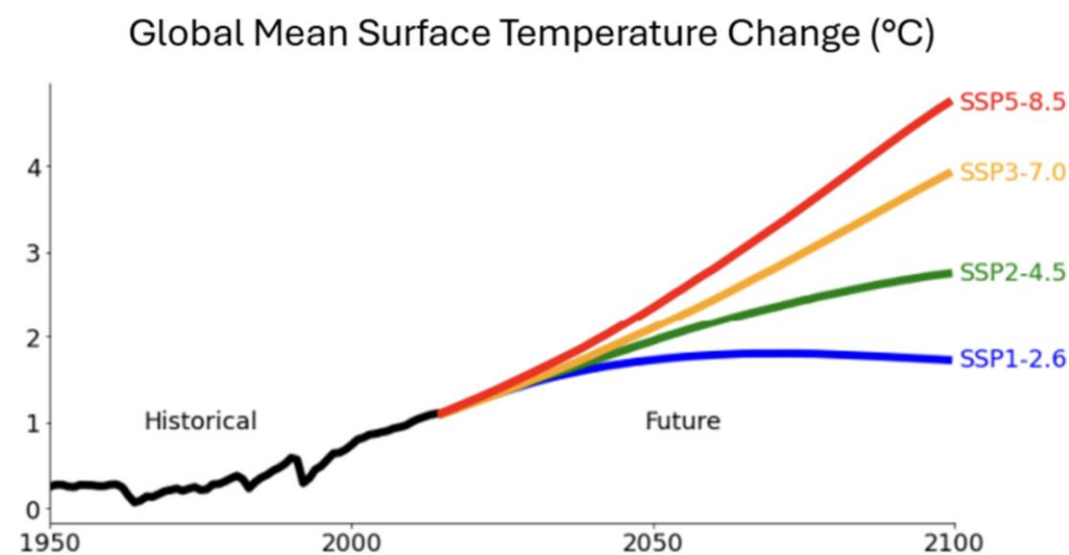


Figure 1: Projected Global Surface Temperature Change for CMIP6 SSP Scenarios

## Time Periods

This report establishes a consistent baseline period to accurately compare projections with historical trends. When utilizing data from ClimateData.ca:

- The baseline is 1971–2000.
- The future time periods used for this report are 2011–2040, 2041–2070, and 2071–2100.

Many climate indices are also divided into seasonal periods, defined in Table 3 below.

**Table 3: Seasonal timeframes**

| Season | Months                       |
|--------|------------------------------|
| Spring | March, April, May            |
| Summer | June, July, August           |
| Fall   | September, October, November |
| Winter | December, January, February  |

Where ClimateData.ca did not provide the required data, projections from alternative sources using different time periods were applied.

## Uncertainty

It is important to note that uncertainty is an integral part of the study of climate change. Uncertainty is factored into climate change scenarios, models, and data, and reflects the complex reality of environmental change and the evolving relationship between humans and the planet. Climate change cannot be predicted with absolute certainty in any given case, and all data must be considered with this in mind. While it is not possible to anticipate future climatic changes with absolute certainty, most contemporary climate analyses rely on ensemble modelling—drawing on multiple models or simulations to capture a broader range of plausible futures and minimize model-specific bias, i.e., the influence of any single model’s structural assumptions. Climate change scenarios like SSP2-4.5 and SSP5-8.5 help create plausible representations of future climate conditions, based on assumptions about future atmospheric composition and an understanding of the effects of increased atmospheric concentrations of greenhouse gases (GHGs), particulates, and other pollutants.

## Climate Projections

### Temperature

#### Mean Temperature

Over the last six decades, Canada has become warmer, with average annual temperatures increasing by 1.3°C between 1948 and 2016. This rate of warming is almost double the global average reported over the same period<sup>5</sup>. Assuming emissions continue at the current rate of global output, Clarington is projected to experience an annual average temperature increase of 6.4°C by the end of the century compared to its baseline. The table below displays the projected annual and seasonal temperature changes in Clarington based on the IPCC Sixth Assessment Report (AR6). Climate modelling suggests that these changes will continue, and the climate change associated risks will increase in the future.

**Table 4: Annual and Seasonal Mean Temperature (°C) for Clarington - SSP5-8.5**

| Time-frame | Baseline<br>1971<br>-2000 | 2011-2040 |        |      | 2041-2070 |        |      | 2071-2100 |        |      |
|------------|---------------------------|-----------|--------|------|-----------|--------|------|-----------|--------|------|
|            |                           | Low       | Median | High | Low       | Median | High | Low       | Median | High |
| Annual     | 7.3                       | 8.6       | 9.2    | 10.2 | 10.4      | 11.3   | 12.8 | 12.3      | 13.7   | 16   |

<sup>5</sup> Douglas, A. G., & Pearson, D. (2022). Ontario. In F. J. Warren, N. Lulham, D. L. Dupuis, & D. S. Lemmen (Eds.), Canada in a changing climate: Regional perspectives report. Government of Canada.

|        |             |      |             |      |      |             |          |      |             |      |
|--------|-------------|------|-------------|------|------|-------------|----------|------|-------------|------|
| Winter | <b>-5.3</b> | -3.8 | <b>-2.8</b> | -1.4 | -1.7 | <b>-0.5</b> | 1.6      | 0.6  | <b>1.9</b>  | 4.6  |
| Spring | <b>6</b>    | 6.9  | <b>7.6</b>  | 8.3  | 8.8  | <b>9.6</b>  | <b>6</b> | 6.9  | <b>7.6</b>  | 8.3  |
| Summer | <b>19.2</b> | 20.3 | <b>20.9</b> | 21.9 | 21.9 | <b>22.9</b> | 24.7     | 23.4 | <b>25.6</b> | 27.8 |
| Fall   | <b>9.2</b>  | 10.3 | <b>10.9</b> | 11.7 | 11.9 | <b>12.8</b> | 14.8     | 13.4 | <b>15.4</b> | 18.6 |

**Table 5: Annual and Seasonal Mean Temperature (°C) for Clarington - SSP2-4.5**

| Time-frame    | Baseline<br>1971<br>-2000 | 2011-2040 |             |      | 2041-2070 |             |      | 2071-2100 |             |      |
|---------------|---------------------------|-----------|-------------|------|-----------|-------------|------|-----------|-------------|------|
|               |                           | Low       | Median      | High | Low       | Median      | High | Low       | Median      | High |
| <b>Annual</b> | <b>7.3</b>                | 8.7       | <b>9</b>    | 10.2 | 9.6       | <b>10.4</b> | 11.5 | 10.4      | <b>11.3</b> | 12.8 |
| Winter        | <b>-5.3</b>               | -3.8      | <b>-3.2</b> | -2   | -2.6      | <b>-1.9</b> | -0.1 | -1.8      | <b>-1.1</b> | 1.1  |
| Spring        | <b>6</b>                  | 7.3       | <b>7.6</b>  | 8.2  | 8.1       | <b>8.8</b>  | 9.6  | 8.8       | <b>9.5</b>  | 10.9 |
| Summer        | <b>19.2</b>               | 20.2      | <b>20.8</b> | 21.8 | 21.2      | <b>22</b>   | 23.2 | 21.7      | <b>23.1</b> | 24.5 |
| Fall          | <b>9.2</b>                | 11.9      | <b>10.8</b> | 12.2 | 11.2      | <b>11.9</b> | 13.4 | 11.9      | <b>12.8</b> | 14.5 |

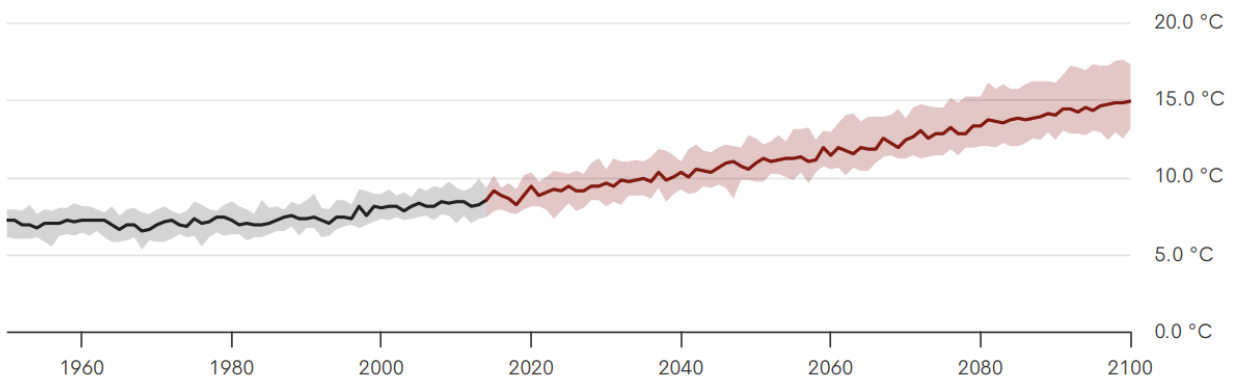


*Figure 2: Projected Mean Annual Temperature Change for Clarington - SSP5-8.5*

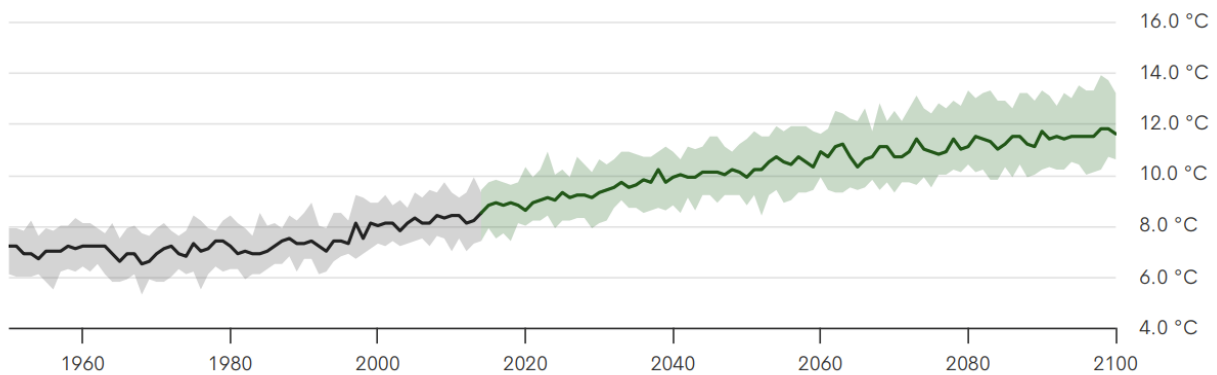


Figure 3: Projected Mean Annual Temperature Change for Clarington - SSP2-4.5

## Hot Weather

Extreme heat is the best-documented natural hazard associated with health consequences and increased all-cause mortality. Still, the thresholds and duration of extreme heat days and events vary across the country<sup>6</sup>. Examples of the health risks associated with extreme heat include heat rash, heat cramps (muscle cramps), heat edema (swelling of hands, feet, ankles), heat syncope (fainting), heat exhaustion, and heat stroke. Health Canada outlines the following at-risk groups for extreme heat event: older adults, infants and young children, people with chronic illnesses (like breathing problems, mental illness and heart problems), people who are unable to keep their living space cool, people who work in the heat (indoors or outdoors), people who exercise in the heat (indoors or outdoors), people experiencing homelessness, and people with low incomes<sup>7</sup>. Moreover, while higher summer temperatures increase electricity demand for cooling, extreme temperatures can also reduce the capacity of transmission lines to carry electricity, potentially leading to reliability issues during heat waves<sup>8</sup>. High temperatures determine if plants and animals can thrive; they limit or enable outdoor activities, define how we design our buildings and vehicles, and shape our transportation and energy use.

<sup>6</sup> Gosselin, P., Campagna, C., Demers-Bouffard, D., Qutob, S., & Flannigan, M. (2022). Natural hazards. In P. Berry & R. Schnitter (Eds.), *Health of Canadians in a changing climate: Advancing our knowledge for action* (pp. [specific page numbers]). Government of Canada.

<sup>7</sup> Health Canada. (2024, May 7). Extreme heat events: Health risks and who is at risk of extreme heat events. Government of Canada. <https://www.canada.ca/en/health-canada/services/climate-change-health/extreme-heat/who-is-at-risk.html>

<sup>8</sup> Centre for Climate and Energy Solutions. (n.d.). Heat waves and climate change. C2ES. Retrieved from <https://www.c2es.org/content/heat-waves-and-climate-change/>

## Hottest Day and Extreme Heat

Under the SSP5-8.5 scenario, the hottest day in Clarington is projected to increase by 6.6°C, from a baseline of 32.2°C to 38.8°C, by 2100. The number of Tmax >30°C days in Clarington will increase from a baseline of 6 days to 69 days by 2100.

**Table 6: Hottest Day (°C) for Clarington – SSP5-8.5 and SSP2-4.5**

| Emissions Scenario | Baseline 1971 -2000 | 2011-2040 |             |      | 2041-2070 |             |      | 2071-2100 |             |      |
|--------------------|---------------------|-----------|-------------|------|-----------|-------------|------|-----------|-------------|------|
|                    |                     | Low       | Median      | High | Low       | Median      | High | Low       | Median      | High |
| SSP5-8.5           | 32.2                | 32.9      | <b>34.1</b> | 35.7 | 34.6      | <b>36.0</b> | 39.2 | 36.5      | <b>38.8</b> | 42.9 |
| SSP2-4.5           |                     | 33.1      | <b>34.0</b> | 35.5 | 34.2      | <b>35.4</b> | 37.1 | 34.8      | <b>36.1</b> | 39.1 |

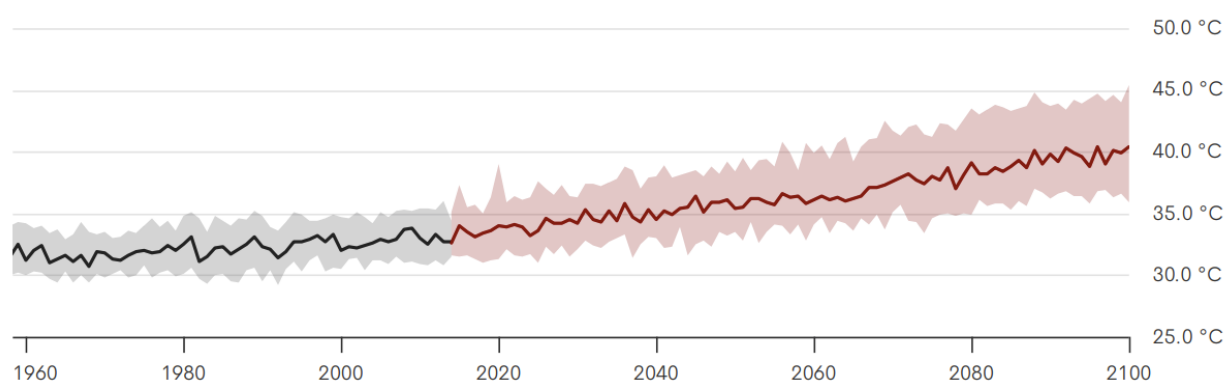


*Figure 4: Projected Hottest Day for Clarington - SSP5-8.5*

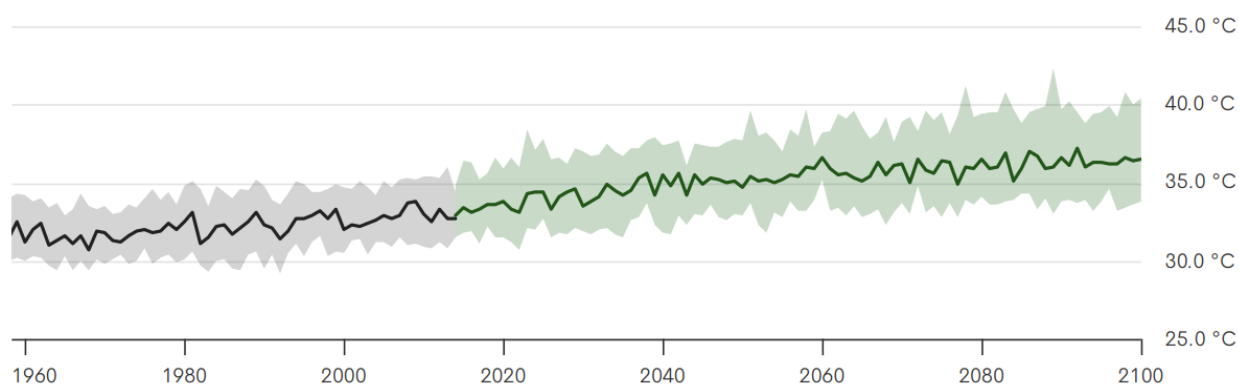


*Figure 5: Projected Hottest Day for Clarington - SSP2-4.5*

**Table 7: Number of days above Tmax 30°C for Clarington – SSP5-8.5 and SSP2-4.5**

| Emissions Scenario | Baseline 1971 -2000 | 2011-2040 |           |      | 2041-2070 |           |      | 2071-2100 |           |      |
|--------------------|---------------------|-----------|-----------|------|-----------|-----------|------|-----------|-----------|------|
|                    |                     | Low       | Median    | High | Low       | Median    | High | Low       | Median    | High |
| SSP5-8.5           | 6                   | 11        | <b>16</b> | 26   | 24        | <b>37</b> | 62   | 43        | <b>69</b> | 106  |
| SSP2-4.5           |                     | 12        | <b>15</b> | 23   | 17        | <b>27</b> | 45   | 24        | <b>38</b> | 61   |

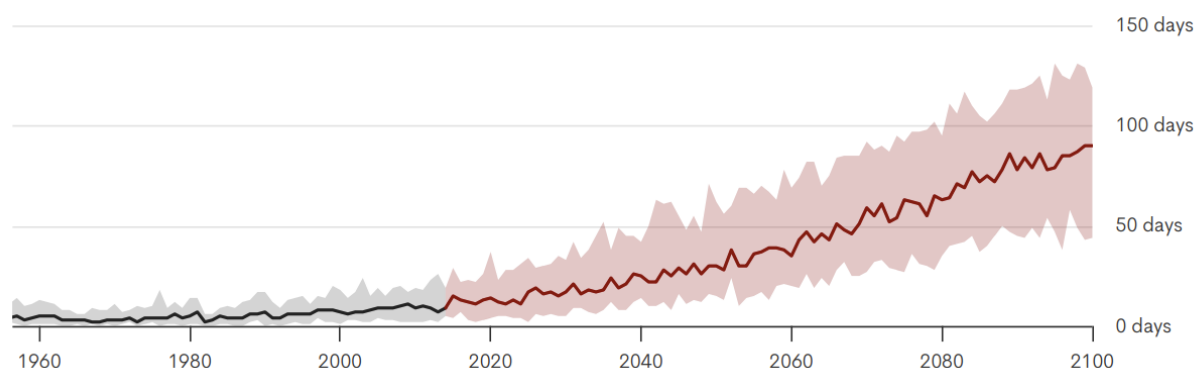


*Figure 6: Projected Days Above Tmax >30°C for Clarington - SSP5-8.5*

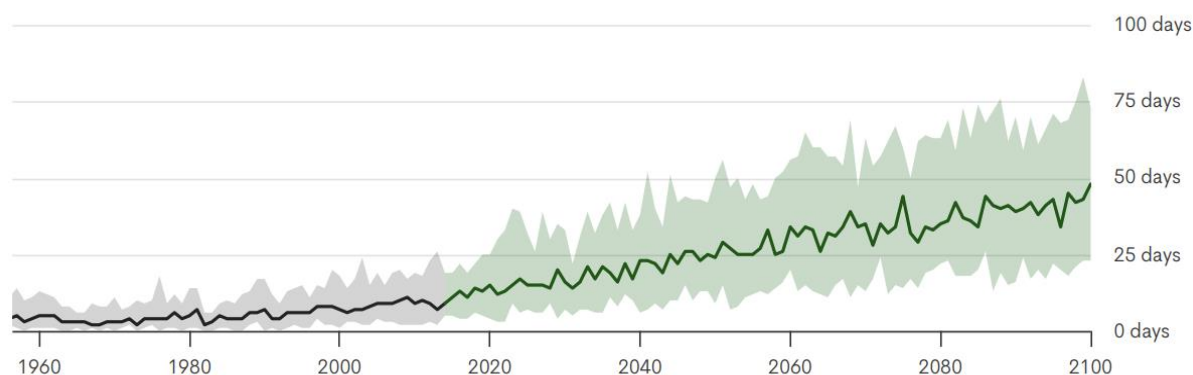


*Figure 7: Projected Days Above Tmax >30°C for Clarington - SSP2-4.5*

The humidex days variable provides the number of days where the humidex is greater than 30 ( $Hx > 30$ ). The humidex index was developed by the Meteorological Service of Canada to describe how hot and humid the weather *feels* to the average person. In Canada, it is recommended that outdoor activities be limited or modified when the humidex exceeds 30, and that all unnecessary physical activities be reduced when it passes 40<sup>9</sup>. The number of  $Hx > 30$  days in Clarington is projected to increase from a

<sup>9</sup> Environment and Climate Change Canada. (n.d.). Humidex. Retrieved December 4, 2025, from <https://www.canada.ca/en/services/environment/weather/severeweather/humidex.html>

baseline average of 37 days to 115 days by 2100 under the SSP5-8.5 scenario.

**Table 8: Number of Days With Humidex >30 for Clarington – SSP5-8.5 and SSP2-4.5**

| Emissions Scenario | Baseline 1971 -2000 | 2011-2040 |           |      | 2041-2070 |           |      | 2071-2100 |            |      |
|--------------------|---------------------|-----------|-----------|------|-----------|-----------|------|-----------|------------|------|
|                    |                     | Low       | Median    | High | Low       | Median    | High | Low       | Median     | High |
| SSP5-8.5           | 32                  | 53        | <b>59</b> | 69   | 77        | <b>86</b> | 97   | 93        | <b>115</b> | 134  |
| SSP2-4.5           |                     | 53        | <b>58</b> | 65   | 64        | <b>74</b> | 86   | 75        | <b>87</b>  | 103  |

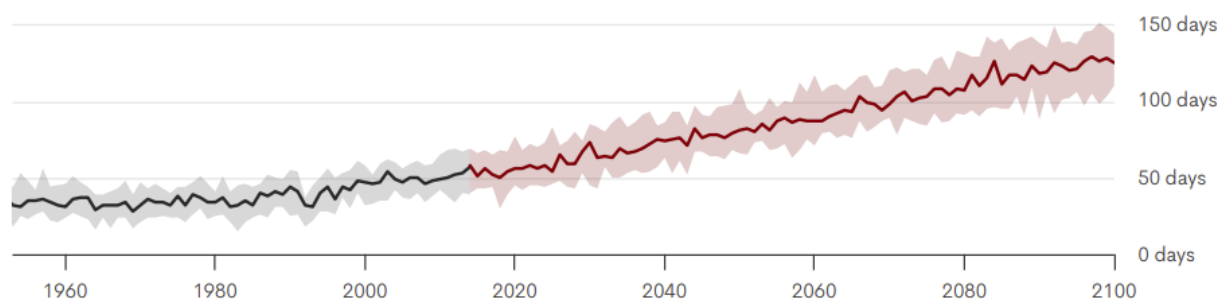


*Figure 8: Projected Number of Humidex Days >30 for Clarington - SSP5-8.5*

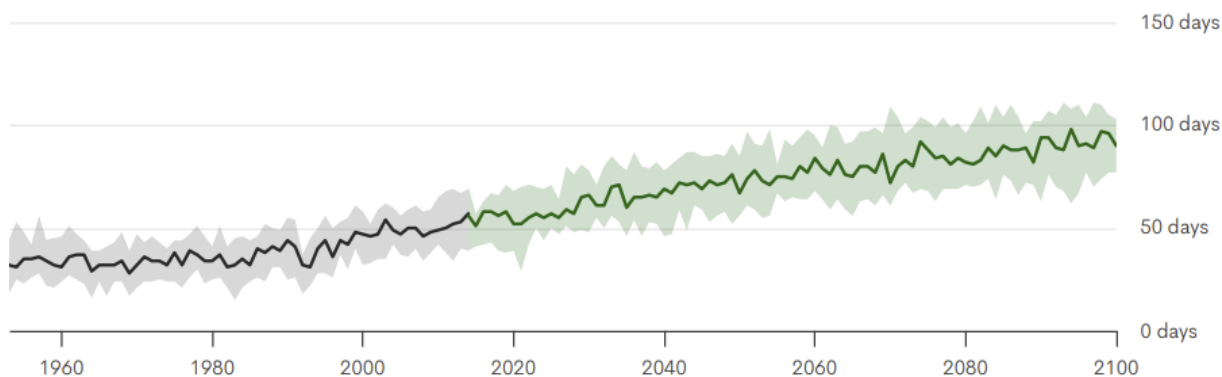


*Figure 9: Projected Number of Humidex Days >30 for Clarington - SSP2-4.5*

## Tropical Nights

Tropical nights—days when the minimum temperature remains above 20 °C—are a key indicator of prolonged heat exposure because they limit overnight cooling and reduce recovery time for people, infrastructure, and ecosystems. Projections for Clarington show a clear increase in the frequency of tropical nights, consistent with regional warming and more persistent heat events. From its baseline of 3 days per year, the number of tropical nights is projected to rise from 10 to 59 days per year by 2100 across the municipality under the SSP5-8.5 scenario. The projection illustrates a sharp increase across

successive 30-year periods, rising from 3 to 59, nearly a twentyfold increase overall.

**Table 9: Tropical Nights for Clarington – SSP5-8.5 and SSP2-4.5**

| Emissions Scenario | Baseline 1971 -2000 | 2011-2040 |        |      | 2041-2070 |        |      | 2071-2100 |        |      |
|--------------------|---------------------|-----------|--------|------|-----------|--------|------|-----------|--------|------|
|                    |                     | Low       | Median | High | Low       | Median | High | Low       | Median | High |
| SSP5-8.5           | 3                   | 7         | 10     | 14   | 18        | 26     | 38   | 35        | 59     | 87   |
| SSP2-4.5           |                     | 7         | 9      | 14   | 13        | 18     | 25   | 17        | 26     | 37   |

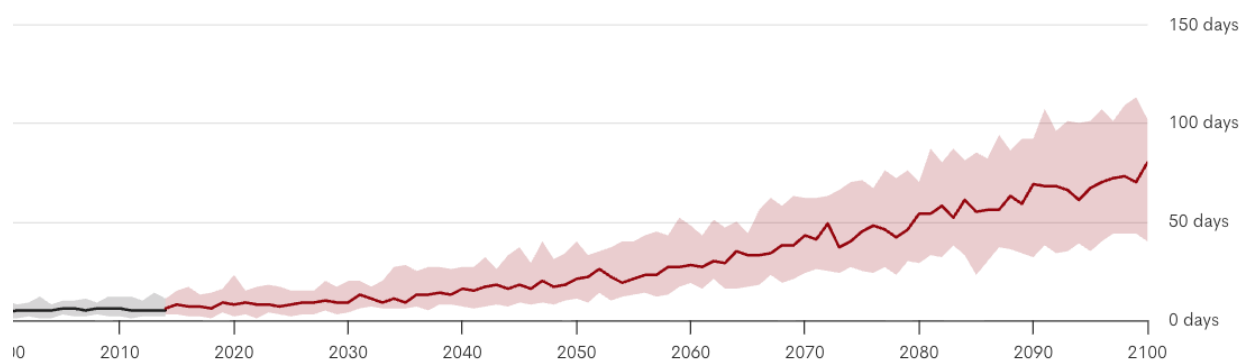


*Figure 10: Projected Tropical Nights for Clarington - SSP5-8.5*

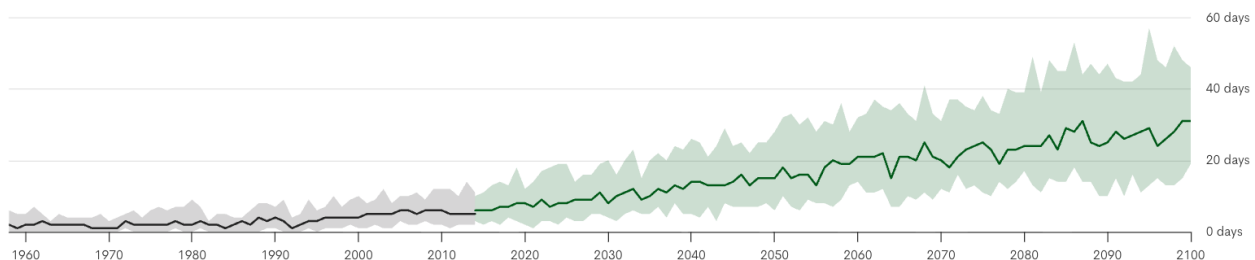


*Figure 11: Projected Tropical Nights for Clarington - SSP2-4.5*

## Heat Waves

Environment and Climate Change Canada (ECCC) issues a heat warning when ‘daytime highs’ are forecast to reach at least 31 °C ( $T_{max} > 31^{\circ}\text{C}$ ) and ‘nightly lows’ are forecast to fall no lower than 20 °C ( $T_{min} > 20^{\circ}\text{C}$ ), or when the Humidex is projected to reach 40, for two consecutive days. An extended heat warning applies when these conditions persist for three days or more. Public-health agencies integrate temperature, humidity, and nighttime cooling into warning thresholds to capture acute human-health risk.

## Heat Wave Frequency

Heat wave frequency refers to how often heat waves occur in a specific area over a given time period. As shown in the table below, Clarington is projected to experience a substantial and accelerating increase in heat wave frequency over the 21st century. From a baseline of effectively zero heat waves per year (1971–2000), projections indicate an increase to approximately 1 event per year by the 2040s, rising further to 3.1 events per year by mid-century (2041–2070). By the late century period (2071–2100), the frequency is projected to reach 6.9 heat waves per year, indicating that multiple heat wave events could occur in most years.

**Table 10: Number of Heat Waves per year for Clarington – SSP5-8.5 and SSP2-4.5**

| Emissions Scenario | Baseline 1971 -2000 | 2011-2040 |            |      | 2041-2070 |            |      | 2071-2100 |            |      |
|--------------------|---------------------|-----------|------------|------|-----------|------------|------|-----------|------------|------|
|                    |                     | Low       | Median     | High | Low       | Median     | High | Low       | Median     | High |
| SSP5-8.5           | 0                   | 0         | <b>0.7</b> | 2.1  | 1.1       | <b>3.1</b> | 5.8  | 4.4       | <b>6.9</b> | 8.7  |
| SSP2-4.5           |                     | 0         | <b>0.6</b> | 1.6  | 1         | <b>2.1</b> | 3.3  | 2         | <b>3.2</b> | 4.2  |

## Heat Wave Duration

Heat wave duration is a climate variable that totals the number of days per year that a heat event meets the thresholds of Tmax 31°C and Tmin 20°C, or humidex >40 for 2+ days. The total annual duration of heat waves in Clarington is projected to increase significantly over the course of the century. From a baseline of essentially zero heat wave days per year (1971–2000), projections indicate an increase to 2 days per year by 2040, rising to 11 days per year by mid-century (2041–2070). By the late century period (2071–2100), total heat wave duration is projected to reach 37 days per year, indicating that prolonged periods of extreme heat could persist for multiple weeks each year.

**Table 11: Heat Wave Duration (total days) for Clarington – SSP5-8.5 and SSP2-4.5**

| Emissions Scenario | Baseline 1971 -2000 | 2011-2040 |            |      | 2041-2070 |           |      | 2071-2100 |             |      |
|--------------------|---------------------|-----------|------------|------|-----------|-----------|------|-----------|-------------|------|
|                    |                     | Low       | Median     | High | Low       | Median    | High | Low       | Median      | High |
| SSP5-8.5           | 0                   | 0         | <b>2</b>   | 6.4  | 3         | <b>11</b> | 26   | 16        | <b>37</b>   | 58   |
| SSP2-4.5           |                     | 0         | <b>1.6</b> | 4    | 2         | <b>6</b>  | 11.5 | 5.1       | <b>10.7</b> | 15.9 |

Overall, more heat wave events and total heat wave days per year are projected to occur toward the end of the century. Sustained over several days at a time, extreme heat poses a significant risk to the health of individuals in Clarington– heat illnesses can manifest quickly, and lead to long-term health problems and even death. Overexposure to extreme heat is especially dangerous for children and

elderly adults, and those who work outside or are physically active outdoors<sup>10</sup>. Beyond human health, extended extreme heat events can cause accelerated wear and tear to built infrastructure, overwhelm the energy grid due to higher energy demand, and negatively impact regional ecosystems, wildlife and agriculture.

## Cooling Degree Days

As extreme heat becomes more frequent and persistent, measures of cumulative heat exposure provide more insight into how temperature changes translate into impacts on buildings, energy use, and community well-being. Cooling degree days (CDD)—the sum of degrees by which daily mean temperature exceeds 18 °C per year—offer a way to assess how often and by how much conditions drive the need for mechanical cooling (air conditioning). Rising CDD values across Clarington reflect both higher average temperatures and a greater number of days exceeding comfort thresholds. Incorporating CDD into the assessment of extreme heat helps illustrate how warming translates into increased cooling demand, with implications for electricity planning, building design, and vulnerability to heat-related stress.

**Table 12: Cooling Degree Days for Clarington - SSP5-8.5 and SSP2-4.5**

| Emissions Scenario | Baseline 1971 -2000 | 2011-2040 |        |      | 2041-2070 |        |      | 2071-2100 |        |      |
|--------------------|---------------------|-----------|--------|------|-----------|--------|------|-----------|--------|------|
|                    |                     | Low       | Median | High | Low       | Median | High | Low       | Median | High |
| SSP5-8.5           | 209                 | 297       | 342    | 440  | 467       | 556    | 786  | 657       | 921    | 1279 |
| SSP2-4.5           |                     | 298       | 357    | 448  | 392       | 469    | 619  | 451       | 578    | 741  |

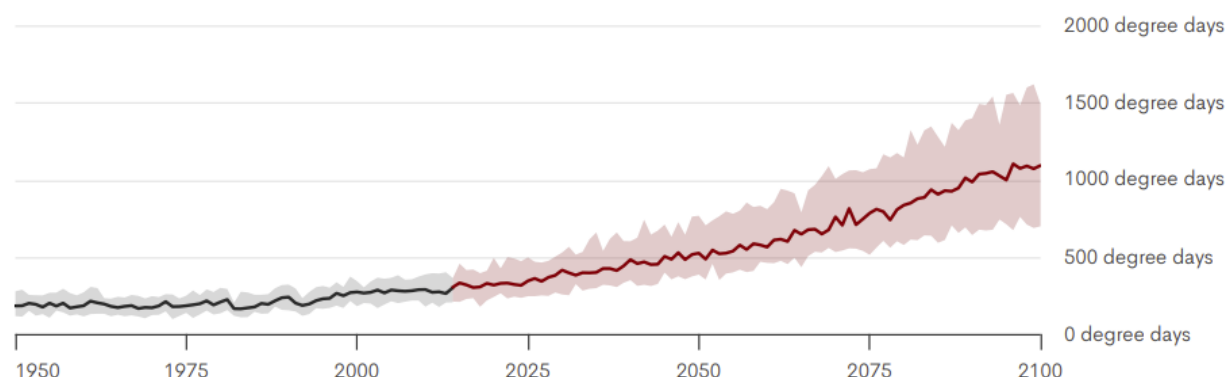


*Figure 12: Projected Cooling Degree Days for Clarington - SSP5-8.5*

<sup>10</sup> Berry, P., & Schnitter, R. (Eds.). (2022). Health of Canadians in a changing climate: Advancing our knowledge for action. Government of Canada. <https://changingclimate.ca/site/assets/uploads/sites/5/2022/02/CCHA-REPORT-EN.pdf>

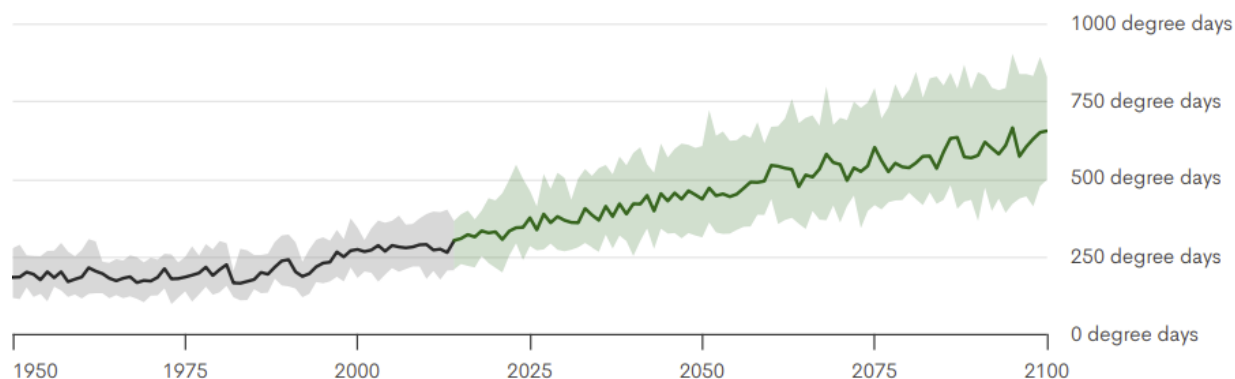


Figure 13: Projected Cooling Degree Days for Clarington - SSP2-4.

## Cold Weather

Cold weather is an important aspect of life in Canada and many places in Canada are well adapted to very cold winters. Overall, the frequency and severity of cold days is decreasing across the country, and in Clarington, the trend is no different. It is important to consider how cold weather temperatures will change in the future as these have implications for health and safety, factor into the feasibility of growing plants and raising animals, can limit or enable outdoor activities, define how we design our buildings and vehicles, and shape our transportation and energy use.

## Coldest Day

The coldest day describes the lowest nighttime temperature in the selected time period. In general, the coldest day of the year occurs during the winter months. Given the warming of annual temperatures, the coldest day in Clarington is projected to become less extreme, from a baseline of -25.2°C to -21.6°C by 2040, warming up to -17.1°C by 2070 and -12.5°C by 2100.

Table 13: Coldest Day (°C) for Clarington – SSP5-8.5 and SSP2-4.5

| Emissions Scenario | Baseline 1971-2000 | 2011-2040 |        |       | 2041-2070 |        |       | 2071-2100 |        |       |
|--------------------|--------------------|-----------|--------|-------|-----------|--------|-------|-----------|--------|-------|
|                    |                    | Low       | Median | High  | Low       | Median | High  | Low       | Median | High  |
| SSP5-8.5           | -25.2              | -22.9     | -21.6  | -18.6 | -19.8     | -17.1  | -12.9 | -15.4     | -12.5  | -7.0  |
| SSP2-4.5           |                    | -23.4     | -22.0  | -18.4 | -21.1     | -18.8  | -15.3 | -19.1     | -17.3  | -11.7 |

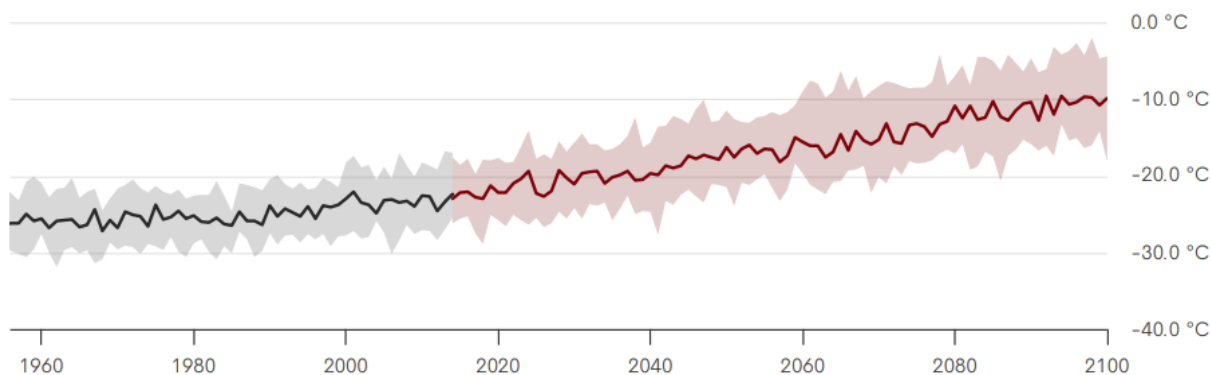


Figure 14: Projected Coldest Day for Clarington - SSP5-8.5

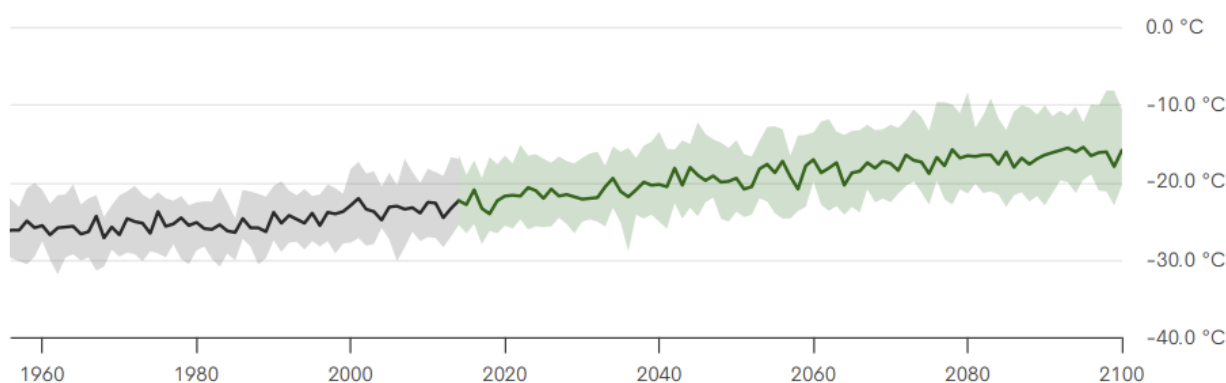


Figure 15: Projected Coldest Day for Clarington - SSP2-4.5

## Extreme Cold Days

Extreme cold days, defined as a day where the temperature drops to at least  $-15^{\circ}\text{C}$ , are projected to decrease significantly in Clarington from a baseline of 22 days to 11 days per year by 2040; further decreasing to 4 days per year by 2070; down to 0 days by 2100.

**Table 14: Days with  $T_{\min} < -15^{\circ}\text{C}$  for Clarington – SSP5-8.5 and SSP2-4.5**

| Emissions Scenario | Baseline 1971 -2000 | 2011-2040 |        |      | 2041-2070 |        |      | 2071-2100 |        |      |
|--------------------|---------------------|-----------|--------|------|-----------|--------|------|-----------|--------|------|
|                    |                     | Low       | Median | High | Low       | Median | High | Low       | Median | High |
| SSP5-8.5           | 22                  | 5         | 11     | 15   | 1         | 4      | 7    | 0         | 0      | 2    |
| SSP2-4.5           |                     | 6         | 13     | 15   | 2         | 7      | 10   | 0         | 3      | 6    |

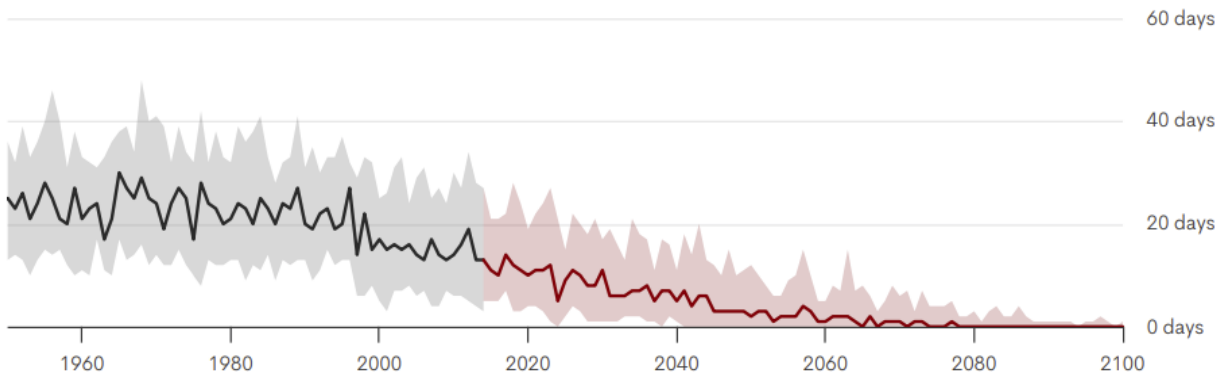


Figure 16: Projected Days with  $T_{min} < -15^{\circ}\text{C}$  for Clarington – SSP5-8

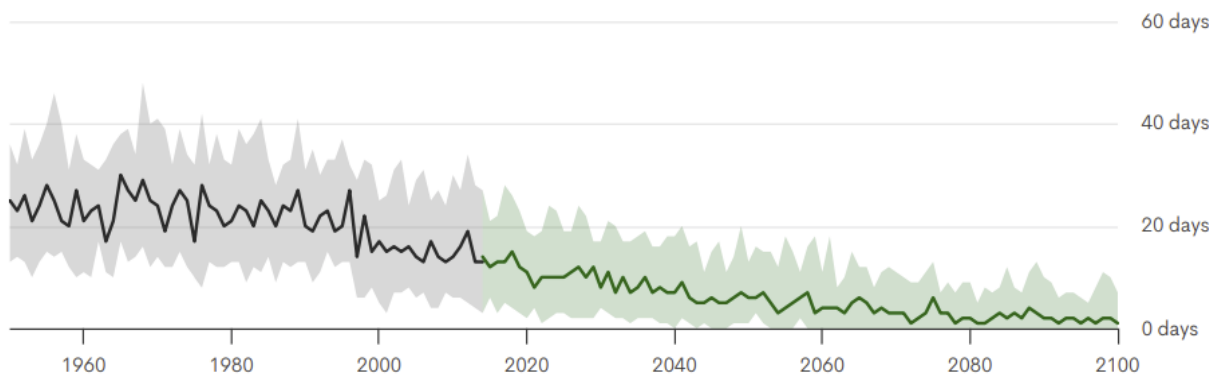


Figure 17: Projected Days with  $T_{min} < -15^{\circ}\text{C}$  for Clarington– SSP2-4.5

## Heating Degree Days

Heating Degree Days (HDD) measure cumulative heating demand by tracking how often temperatures fall below  $18^{\circ}\text{C}$ . As temperatures rise, HDD values decline, indicating fewer cold days and reduced heating needs. In Clarington, HDD is projected to decrease steadily under both emissions scenarios. Under SSP5-8.5, values decline from a baseline of 4,110 to 3562 HDDs by the 2040s, to 3015 HDDs by the 2070s, and 2458 HDDs by 2100. This trend reflects a consistent reduction in cold-season heating demand and fewer extreme cold conditions. While this may reduce energy use for heating, it also signals broader changes in winter conditions, with implications for infrastructure performance and freeze–thaw dynamics.

Table 15: Heating Degree Days for Clarington - SSP5-8.5 and SSP2-4.5

| Emissions Scenario | Baseline 1971-2000 | 2011-2040 |             |      | 2041-2070 |             |      | 2071-2100 |             |      |
|--------------------|--------------------|-----------|-------------|------|-----------|-------------|------|-----------|-------------|------|
|                    |                    | Low       | Median      | High | Low       | Median      | High | Low       | Median      | High |
| SSP5-8.5           | 4110               | 3285      | <b>3562</b> | 3723 | 2654      | <b>3015</b> | 3250 | 2048      | <b>2458</b> | 2695 |
| SSP2-4.5           |                    | 3303      | <b>3598</b> | 3772 | 2985      | <b>3282</b> | 3451 | 2606      | <b>3070</b> | 3292 |

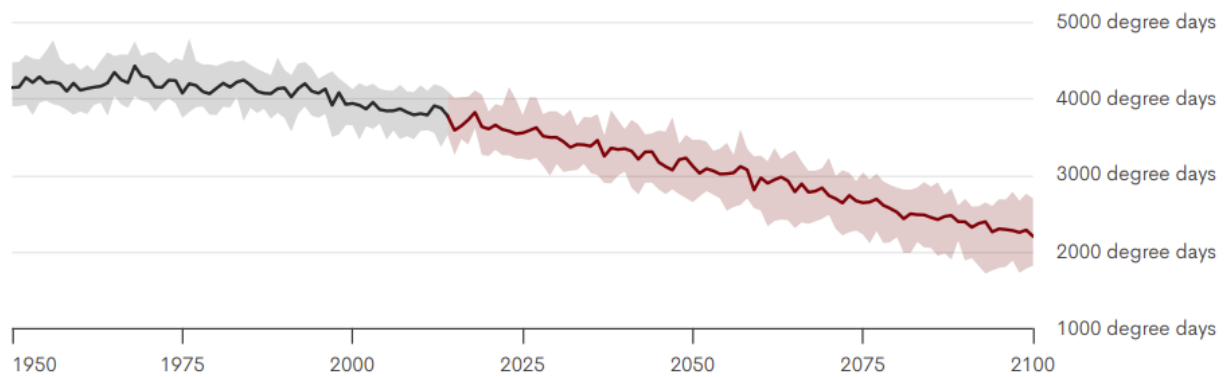


Figure 18: Projected Heating Degree Days for Clarington - SSP5-8.5

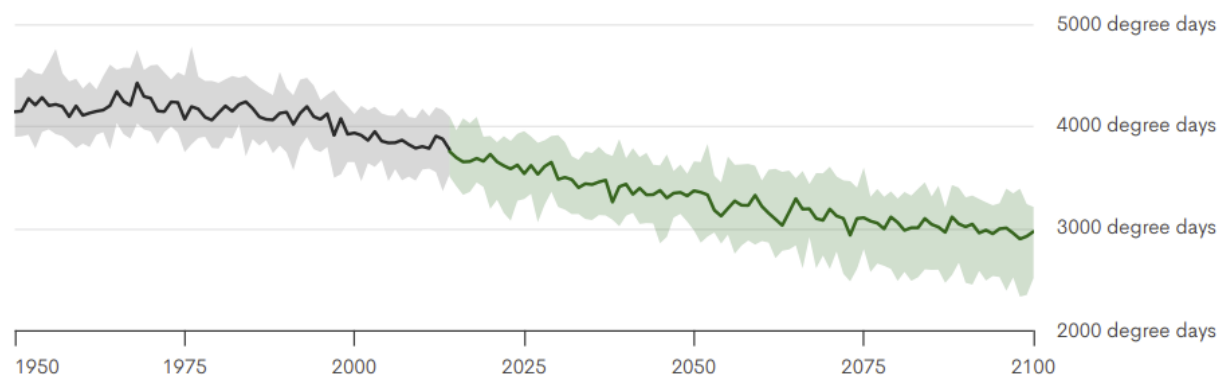


Figure 19: Projected Heating Degree Days for Clarington - SSP2-4.5

## Frost Days

Other indicators of cold temperatures are frost days and icing days, which can help to understand freeze and thaw patterns throughout the municipality, and are correlated to risks relating to injury and mortality from traffic accidents, damage to roads and infrastructure, facility closures and more.

A frost day is a day in which the minimum temperature is below 0°C. From a baseline of 143 days, frost days in Clarington are projected to decrease to 122 days per year by 2040; to 99 days per year by 2070; and to 69 days per year by 2100.

**Table 16: Frost Days for Clarington - SSP5-8.5 and SSP2-4.5**

| Emissions Scenario | Baseline 1971 -2000 | 2011-2040 |        |      | 2041-2070 |        |      | 2071-2100 |        |      |
|--------------------|---------------------|-----------|--------|------|-----------|--------|------|-----------|--------|------|
|                    |                     | Low       | Median | High | Low       | Median | High | Low       | Median | High |
| SSP5-8.5           | 143                 | 112       | 122    | 129  | 75        | 99     | 110  | 35        | 69     | 85   |
| SSP2-4.5           |                     | 112       | 124    | 129  | 93        | 109    | 118  | 74        | 99     | 110  |

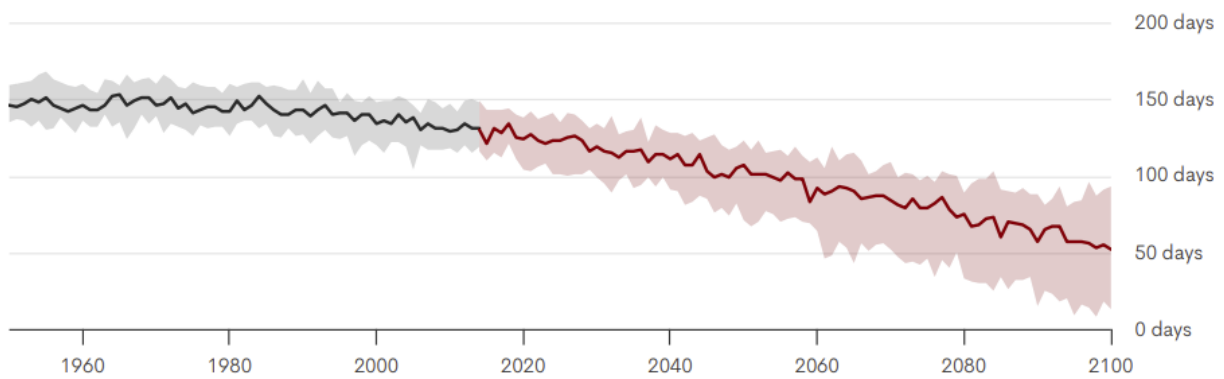


Figure 20: Projected Frost Days for Clarington - SSP2-4.5

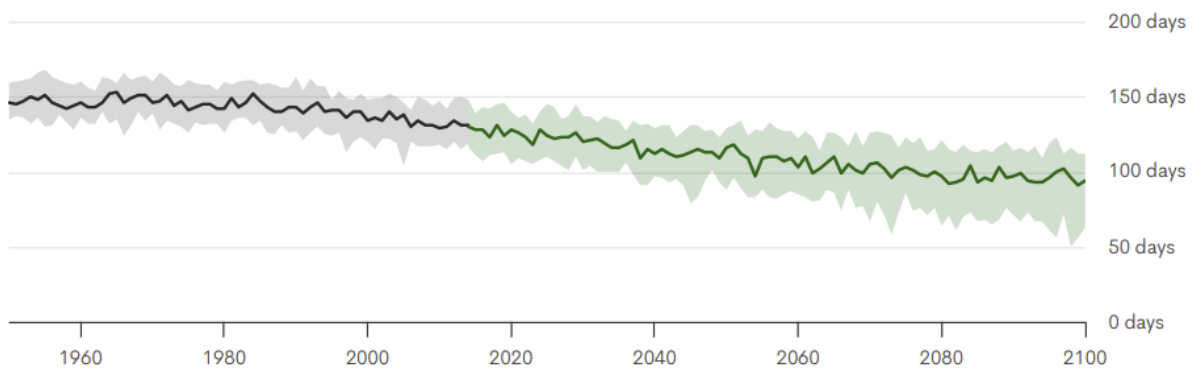


Figure 21: Projected Frost Days for Clarington - SSP5-8.5

Figure 11: Projected Frost Days for Clarington - SSP5-8.5 (above); SSP2-4.5 (below)

## Ice Days

Similarly, the number of ice days are projected to decrease in Clarington. Ice days are the total number of days when the daily maximum temperature is at or below 0°C. Ice days are projected to decrease from a baseline of 58 days to 42 days by 2040; to 26 days by 2070; down to 13 days by 2100.

Table 17: Ice Days for Clarington - SSP5-8.5 and SSP2-4.5

| Emissions Scenario | Baseline 1971 -2000 | 2011-2040 |           |      | 2041-2070 |           |      | 2071-2100 |           |      |
|--------------------|---------------------|-----------|-----------|------|-----------|-----------|------|-----------|-----------|------|
|                    |                     | Low       | Median    | High | Low       | Median    | High | Low       | Median    | High |
| SSP5-8.5           |                     | 32        | <b>42</b> | 49   | 15        | <b>26</b> | 35   | 3         | <b>13</b> | 18   |

|          |    |    |    |    |    |    |    |    |    |    |
|----------|----|----|----|----|----|----|----|----|----|----|
| SSP2-4.5 | 58 | 36 | 44 | 48 | 24 | 36 | 41 | 12 | 26 | 37 |
|----------|----|----|----|----|----|----|----|----|----|----|

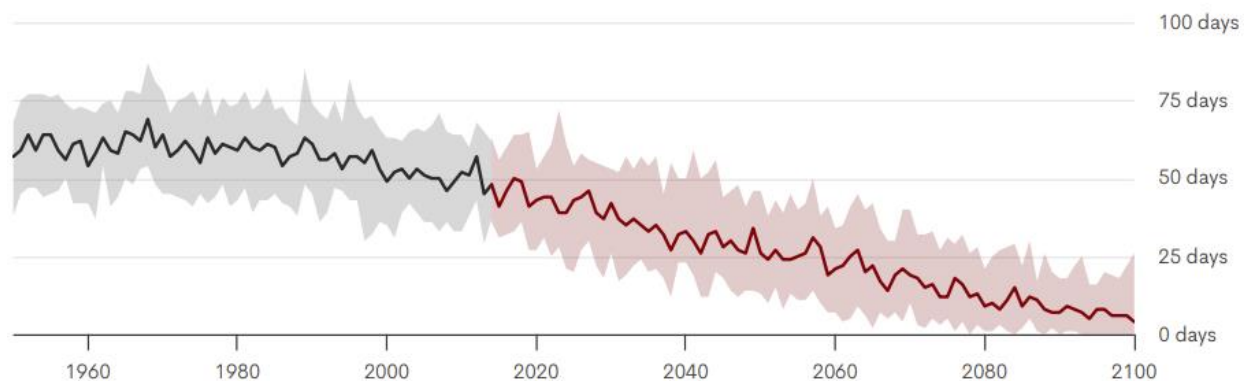


Figure 22: Projected Ice Days for Clarington - SSP5-8.5

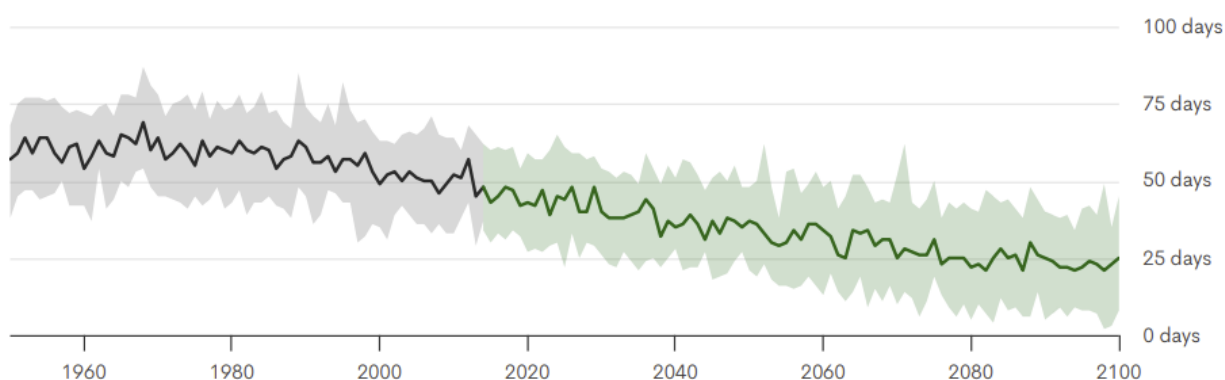


Figure 23: Projected Ice Days for Clarington - SSP2-4.5

## Freeze-Thaw

A freeze-thaw cycle is any day where the minimum temperature is below 0°C and the maximum temperature is above 0°C. Freeze-thaw cycles are projected to decrease due to overall warmer temperatures. This projection is likely due to the fact that days are getting warmer and Clarington is expected to experience fewer days per year that reach a minimum temperature below 0°C.

Under these conditions, it is likely that some water at the surface is both liquid and ice at some point during the 24-hour period. Freeze-thaw cycles can have major impacts on infrastructure. Water expands when it freezes, so the freezing, melting, and re-freezing of water can over time cause significant damage to roadways, sidewalks, and other outdoor structures. Potholes that form during the spring, or during mid-winter melts, are good examples of the damage caused by this process.

As shown in the table below, freeze-thaw cycles are projected to decrease from a baseline of 70 days per year to 65 days per year by 2040; to 61 days per year by 2070; down to 44 days per year by 2100.

**Table 18: Annual Freeze-Thaw Cycles for Clarington - SSP5-8.5 and SSP2-4.5**

| Emissions Scenario | Baseline 1971 -2000 | 2011-2040 |           |      | 2041-2070 |           |      | 2071-2100 |           |      |
|--------------------|---------------------|-----------|-----------|------|-----------|-----------|------|-----------|-----------|------|
|                    |                     | Low       | Median    | High | Low       | Median    | High | Low       | Median    | High |
| SSP5-8.5           | 70                  | 60        | <b>65</b> | 69   | 51        | <b>61</b> | 67   | 20        | <b>44</b> | 54   |
| SSP2-4.5           |                     | 60        | <b>65</b> | 69   | 43        | <b>57</b> | 64   | 43        | <b>55</b> | 65   |

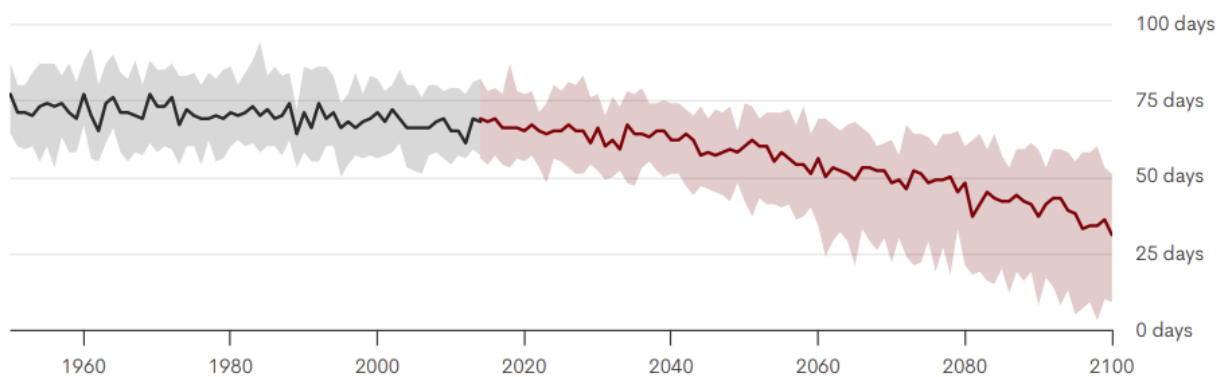


*Figure 24: Projected Freeze-Thaw Cycles for Clarington - SSP5-8.5*

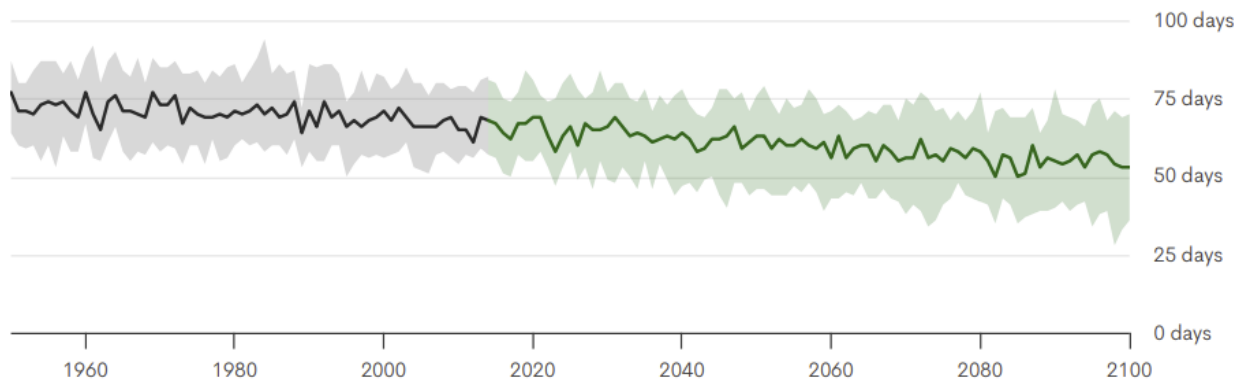


*Figure 25: Projected Freeze-Thaw Cycles for Clarington - SSP2-4.5*

## Agricultural Indices

### Growing-Season Dynamics and Heat Availability

Climate change is altering seasonal temperature patterns, precipitation regimes, and the overall length of the growing season in Ontario, with direct implications for agriculture and related ecosystems in Clarington. Longer frost-free periods and warmer average temperatures may expand the range of crops that can be grown, but these potential benefits are also offset by increasing risks. Higher temperatures can elevate the likelihood of drought, reduce water availability for irrigation, disrupt pollination processes, and create more favourable conditions for certain pests and pathogens. For example, warmer winters are extending the activity period of black-legged ticks—typically active in spring and fall<sup>11</sup>. In Clarington, where agricultural lands form a significant part of the landscape, these shifts will require adjustments in farm management practices, crop suitability, and long-term planning to manage both emerging opportunities and growing climate-related risks<sup>12</sup>.

### Frost Free Season (Growing Season)

The frost free season is the approximate length of the growing season during which there are no freezing temperatures to kill or damage frost-sensitive plants. This index describes the number of days between the Last Spring Frost and the First Fall Frost. Compared to a baseline of 161 days, the growing season is projected to increase by 17 days per year by 2040; 32 days by 2070; and by 55 days by 2100. In other words, the annual growing season is projected to increase by nearly 8 weeks within a century. To illustrate this another way, by 2100 the last spring frost is projected to occur earlier in the year—on April 5 from a baseline of May 2—and the first fall frost is expected to occur later in the year—on November 7 from a baseline of October 10.

**Table 19: Growing Season Length for Clarington - SSP5-8.5 and SSP2-4.5**

| Emissions Scenario | Baseline 1971 -2000 | 2011-2040 |        |      | 2041-2070 |        |      | 2071-2100 |        |      |
|--------------------|---------------------|-----------|--------|------|-----------|--------|------|-----------|--------|------|
|                    |                     | Low       | Median | High | Low       | Median | High | Low       | Median | High |
| SSP5-8.5           | 161                 | 164       | 178    | 187  | 188       | 195    | 218  | 210       | 225    | 264  |
| SSP2-4.5           |                     | 163       | 175    | 191  | 180       | 189    | 204  | 185       | 198    | 223  |

<sup>11</sup> Whereas warmer temperatures can be attributed to greater black-legged tick activity, no single climate variable provides a reliable proxy for tick abundance or Lyme disease risk.

<sup>12</sup> Ontario Climate Consortium for Integrated Assessment and Research (OCCIAR). (2017). The Ontario climate and agriculture assessment framework. Retrieved from [http://www.climateontario.ca/doc/p\\_OCAAF/OCAAF\\_FinalReport\\_June2017.pdf](http://www.climateontario.ca/doc/p_OCAAF/OCAAF_FinalReport_June2017.pdf)

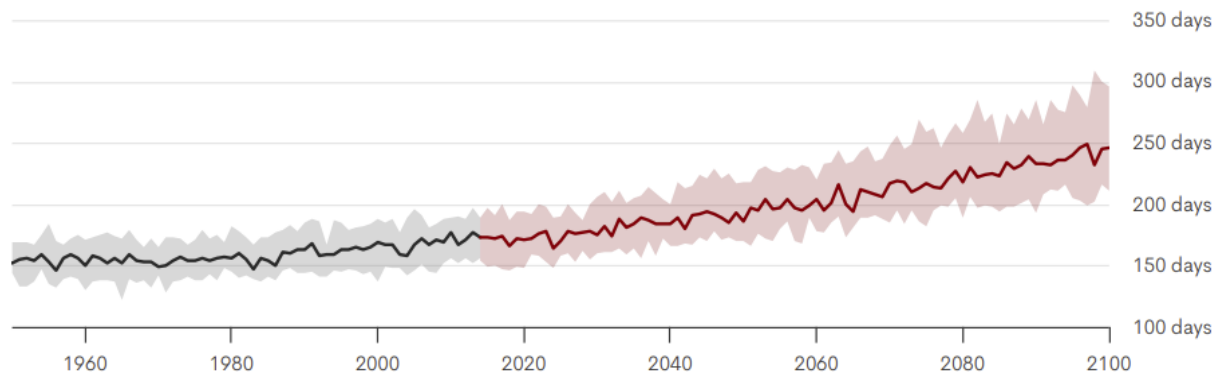


Figure 26: Projected Growing Season Length for Clarington - SSP5-8.5

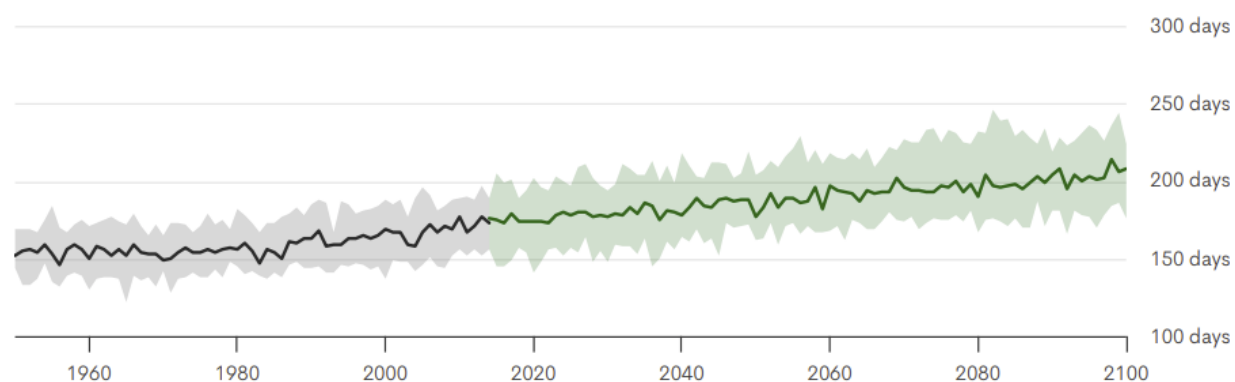


Figure 27: Projected Growing Season Length for Clarington - SSP2-4.5

## Growing Degree Days

Plant and insect development rates depend largely on the amount of heat they receive throughout the growing season, from planting to harvest. This heat accumulation is quantified using growing degree days (GDD). GDD measures the difference between the average daily temperature and a specific base temperature, which varies for different species<sup>13</sup>. Each plant species has a unique base temperature, below which its growth is limited. To account for varying heat requirements, different base temperatures are used for different organisms: +5°C GDDs are typically used for canola and forage crops; +10°C GDDs are more suitable for crops like corn and beans; and +15°C GDDs are often applied to assess the growth and development of insects and pests. This approach helps in understanding and predicting the growth patterns and developmental stages of various species based on their specific thermal needs<sup>14</sup>.

<sup>13</sup> Climate Central. (2022). Growing degree days. Retrieved from Climate Central: <https://www.climatecentral.org/climate-matters/growing-degree-days>

<sup>14</sup> Climate Atlas of Canada. (n.d.). Growing degree days. Retrieved from Climate Atlas of Canada: [https://ClimateAtlas.ca/map/canada/dd5\\_2060\\_85](https://ClimateAtlas.ca/map/canada/dd5_2060_85)

Climate change is increasing the number of GDDs, which can both extend growing seasons and shift agricultural and ecological dynamics, introducing new opportunities and risks. With more GDDs, crops may mature earlier in the season, potentially producing more food and growing different types of crops. However, this warming trend also brings challenges, such as increased water stress, more favourable conditions for pests and diseases, and altered timing for key events like pollination. Additionally, more variability in spring and fall temperatures can stress fruit trees causing blossom loss due to late frosts<sup>15</sup>. In Clarington, growing degree days are projected to increase from the baseline of 2097 degree-days per year to 2451 degree days by 2040; 2909 by 2070; and 3637 by 2100. This trend indicates a longer and potentially more productive growing season but also highlights the need for adaptation strategies in agricultural management to address the impacts of climate change.

**Table 20: Growing Degree Days (>5°C) for Clarington - SSP5-8.5 and SSP2-4.5**

| Emissions Scenario | Baseline 1971 -2000 | 2011-2040 |             |      | 2041-2070 |             |      | 2071-2100 |             |      |
|--------------------|---------------------|-----------|-------------|------|-----------|-------------|------|-----------|-------------|------|
|                    |                     | Low       | Median      | High | Low       | Median      | High | Low       | Median      | High |
| SSP5-8.5           | 2097                | 2327      | <b>2451</b> | 2656 | 2784      | <b>2909</b> | 3268 | 3093      | <b>3637</b> | 4202 |
| SSP2-4.5           |                     | 2359      | <b>2430</b> | 2674 | 2544      | <b>2731</b> | 2965 | 2703      | <b>2965</b> | 3280 |

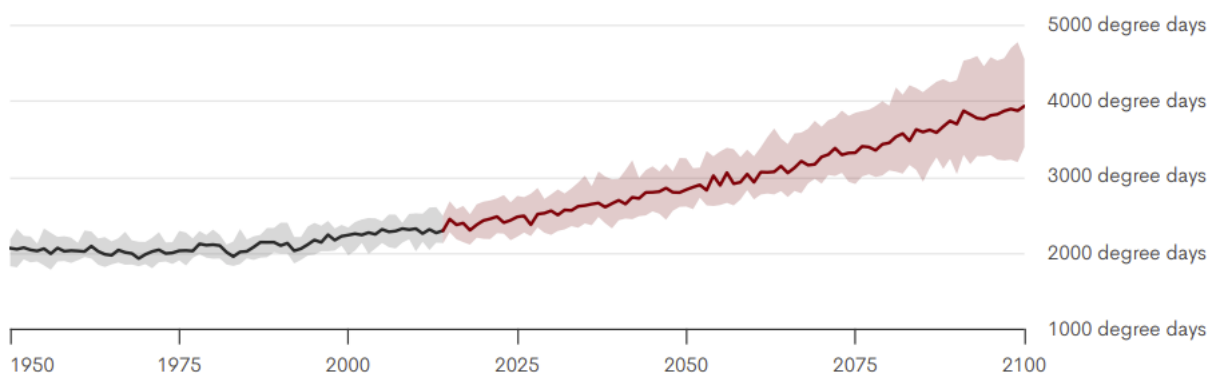


*Figure 28: Projected Growing Degree Days for Clarington - SSP5-8.5*

<sup>15</sup> Agriculture and Agri-Food Canada. (2020, January 31). Climate change impacts on agriculture. <https://agriculture.canada.ca/en/environment/climate-change/climate-change-impacts-agriculture>

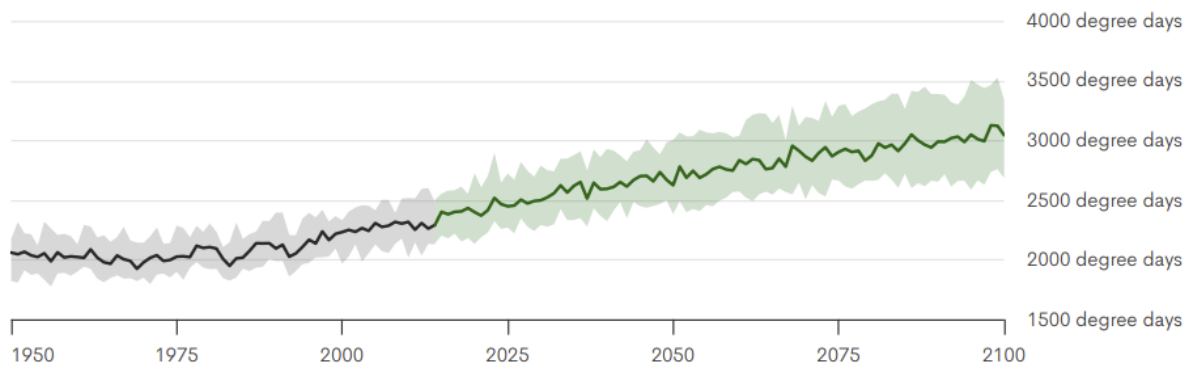


Figure 29: Projected Growing Degree Days for Clarington - SSP2-4.5

## Precipitation

Canada has become wetter over the past several decades, with increases in average annual precipitation in many regions. Some parts of the country are projected to see a significant percentage increase in precipitation, particularly in Northern Canada. Projections for Clarington show somewhat less dramatic but still significant changes to precipitation patterns.

### Total Precipitation

For Clarington, the baseline total annual precipitation is 910 mm. Under a high emission scenario, the municipality is projected to experience an total annual precipitation increase of 64mm by 2040; of 93mm by 2070; up to an increase of 151mm by 2100. The table below presents the precipitation accumulation projections for Clarington. Figure 16 presents the precipitation accumulation projections for Clarington based on the SSP5-8.5 scenario.

Seasonal projections indicate that precipitation gains will not be distributed evenly across the year. Winter and spring are projected to see the largest increases, with winter precipitation rising by 62 mm and spring by 54 mm above baseline by the end of the century. Fall precipitation also increases, reaching 276 mm by 2100 compared to a baseline of 246 mm. Summer precipitation is projected to remain relatively stable across all time periods, with a 10mm rise by 2040 but returning close to its baseline by 2100. The concentration of gains in the cold season, combined with potential summer moisture deficits, may affect water availability and increase drought risk during the growing season even as annual totals continue to rise.

**Table 21: Total Annual and Seasonal Precipitation (mm) for Clarington - SSP5-8.5**

|  | Baseline<br>2071<br>-2000 | 2011-2040 |        |      | 2041-2070 |        |      | 2071-2100 |        |      |
|--|---------------------------|-----------|--------|------|-----------|--------|------|-----------|--------|------|
|  |                           | Low       | Median | High | Low       | Median | High | Low       | Median | High |
|  |                           |           |        |      |           |        |      |           |        |      |

|               |            |     |            |      |     |             |      |     |             |      |
|---------------|------------|-----|------------|------|-----|-------------|------|-----|-------------|------|
| <b>Annual</b> | <b>910</b> | 922 | <b>974</b> | 1000 | 975 | <b>1003</b> | 1045 | 998 | <b>1061</b> | 1120 |
| Winter        | <b>215</b> | 219 | <b>235</b> | 251  | 239 | <b>249</b>  | 270  | 262 | <b>277</b>  | 311  |
| Spring        | <b>226</b> | 227 | <b>241</b> | 256  | 238 | <b>260</b>  | 280  | 252 | <b>280</b>  | 303  |
| Summer        | <b>223</b> | 208 | <b>232</b> | 252  | 203 | <b>230</b>  | 246  | 188 | <b>227</b>  | 257  |
| Fall          | <b>246</b> | 239 | <b>256</b> | 281  | 248 | <b>268</b>  | 280  | 250 | <b>276</b>  | 304  |

**Table 22: Total Annual and Seasonal Precipitation (mm) for Clarington - SSP2-4.5**

|               | Baseline<br>2071<br>-2000 | 2011-2040 |            |      | 2041-2070 |             |      | 2071-2100 |             |      |
|---------------|---------------------------|-----------|------------|------|-----------|-------------|------|-----------|-------------|------|
|               |                           | Low       | Median     | High | Low       | Median      | High | Low       | Median      | High |
| <b>Annual</b> | <b>910</b>                | 929       | <b>963</b> | 994  | 956       | <b>1006</b> | 1037 | 972       | <b>1010</b> | 1055 |
| Winter        | <b>215</b>                | 219       | <b>234</b> | 245  | 230       | <b>247</b>  | 260  | 235       | <b>259</b>  | 279  |
| Spring        | <b>226</b>                | 227       | <b>242</b> | 257  | 235       | <b>255</b>  | 267  | 246       | <b>258</b>  | 282  |
| Summer        | <b>223</b>                | 213       | <b>230</b> | 246  | 206       | <b>233</b>  | 249  | 206       | <b>235</b>  | 257  |
| Fall          | <b>246</b>                | 240       | <b>256</b> | 276  | 253       | <b>265</b>  | 289  | 243       | <b>268</b>  | 282  |

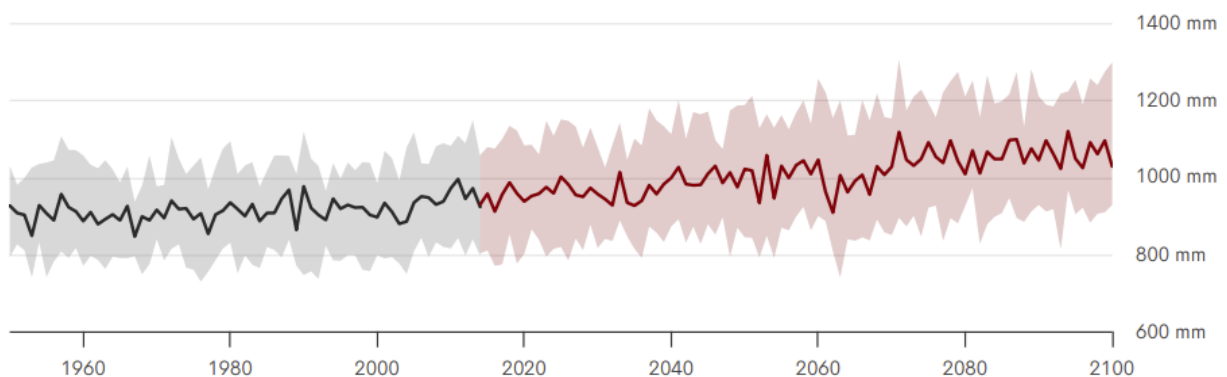


*Figure 30: Projected Total Annual Precipitation for Clarington – SSP5-8.5*

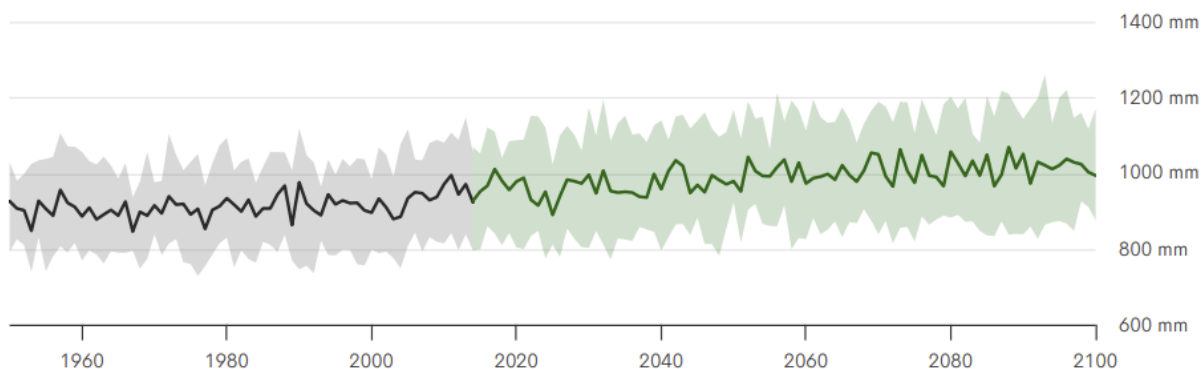


Figure 31: Projected Total Annual Precipitation for Clarington – SSP2-4.5

## Maximum Consecutive Dry Days

Maximum consecutive dry days indicate the maximum number of consecutive days with precipitation below 1mm/day, within the selected time period. Periods of dry weather can directly impact water availability, agriculture, and energy demand. Drought conditions may result when dry periods are long-lasting. As shown in the table below, maximum consecutive dry days are projected to remain relatively stable over the course of the century.

**Table 23: Maximum Consecutive Dry Days for Clarington - SSP5-8.5 and SSP2.4-5**

| Emissions Scenario | Baseline 1971 -2000 | 2011-2040 |           |      | 2041-2070 |           |      | 2071-2100 |           |      |
|--------------------|---------------------|-----------|-----------|------|-----------|-----------|------|-----------|-----------|------|
|                    |                     | Low       | Median    | High | Low       | Median    | High | Low       | Median    | High |
| SSP5-8.5           | 14                  | 14        | <b>14</b> | 15   | 14        | <b>15</b> | 15   | 14        | <b>15</b> | 17   |
| SSP2-4.5           |                     | 13        | <b>15</b> | 15   | 13        | <b>14</b> | 16   | 14        | <b>15</b> | 16   |

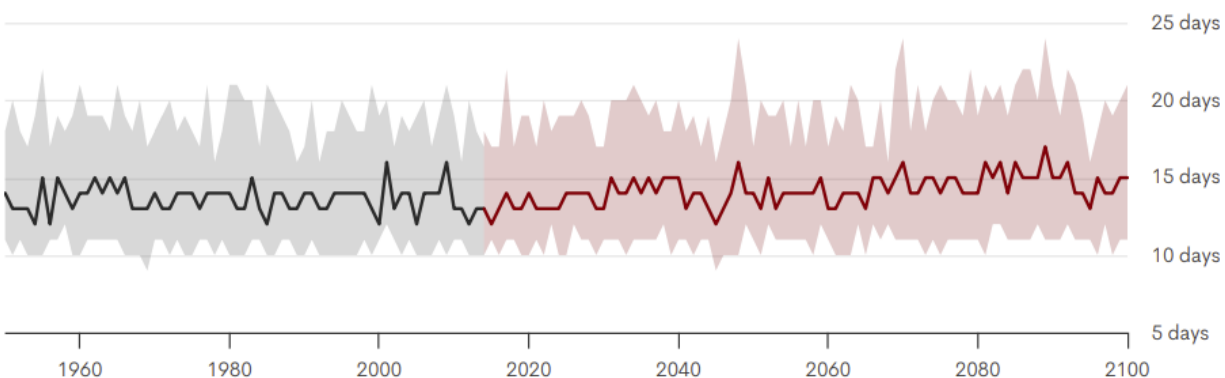


Figure 32: Maximum Consecutive Dry Days for Clarington - SSP5-8.5

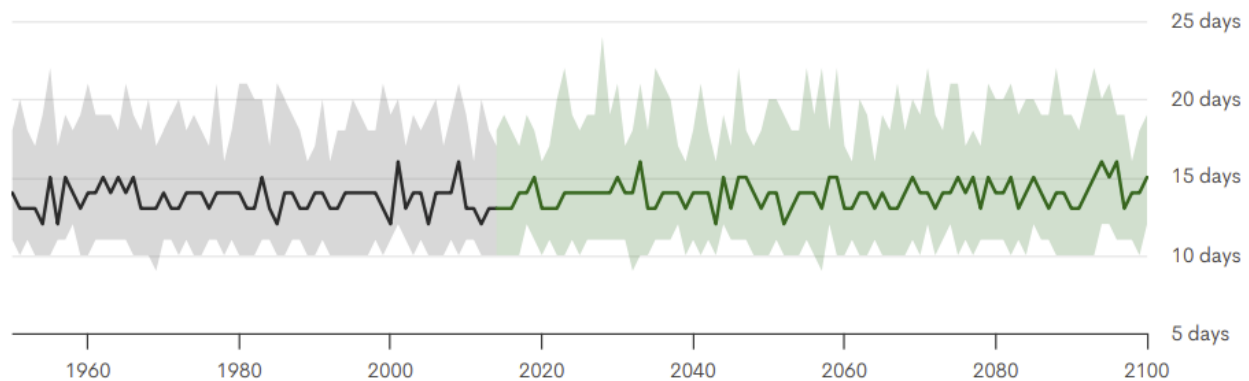


Figure 33: Maximum Consecutive Dry Days for Clarington - SSP2-4.5

## Extreme Weather Events

In the past decade, Canada has been experiencing more frequent and intense extreme weather events that significantly affect our population and industries. These events come in the form of heat waves, wildfires, more frequent and intense extreme precipitation and flooding events, and wind and ice storms. Over the last forty years, extreme weather events have resulted in damages of \$31 billion in Canada alone, with global costs estimated at nearly \$5 trillion. The likelihood and the severity of these events are increasing with climate change, and are projected to cause hundreds of trillions of dollars in economic damage globally. Extreme weather events will affect communities across Canada, from damage to infrastructure and critical services, to economic and industry productivity, and in particular the health of vulnerable populations<sup>16</sup>. Future extreme weather models predict shorter return periods of extreme events – that is, an increase in the likelihood of 25, 50, and 100 year events – in the future.

It helps to clarify what terms like "25-year" or "100-year event" actually describe because they are widely misunderstood. Rather than indicating how often an event occurs, these terms express an annual probability: a "100-year event" simply means there is a 1% chance of that event occurring in any given year, while a "25-year event" carries a 4% annual chance. These probabilities reset every year regardless of what happened the year before, meaning severe events can and do occur in consecutive years or multiple times within a decade. As climate change intensifies, an extreme weather event that historically carried a 1% annual chance may occur with 2%, 5%, or greater likelihood in any given year, meaning what previous generations experienced as a rare, once-in-a-lifetime event may occur several times within the lifespan of a community or single piece of municipal infrastructure.

<sup>16</sup> Feltmate, B., & Moudrak, M. (2021). Climate change and the preparedness of 16 major Canadian cities to limit flood risk. Intact Centre on Climate Adaptation, University of Waterloo.

## Heavy or Extreme Precipitation

Warmer air holds more moisture and drives greater evaporation, increasing both the intensity and variability of precipitation across the region. Increased intensity and frequency of heavy rainfall and storm events are among the major climate hazards facing Ontario's infrastructure and communities under climate change<sup>17</sup>. As Southern Ontario is the most intensely urbanized area of the province, the magnitude and costs to insured and uninsured damages associated with flooding is significantly higher than elsewhere in the province<sup>18</sup>. Extreme rain and flood events have frequently been experienced in Southern Ontario in the last 10 years, and with projected increases in annual precipitation there is the potential of increased flood risk and high intensity storms.

The projections of several extreme precipitation indices are presented in this section. Wet days are days on which at least a total of 10 mm or 20 mm of rain or frozen precipitation falls. Frozen precipitation is measured according to its liquid equivalent: 10 cm of snow is usually about 10 mm of precipitation<sup>19</sup>.

Max 1-day precipitation indicates the amount of precipitation that falls on the wettest day of the year. The max 1-day precipitation amount could be the result of a short but intense precipitation event, such as a storm, or because a moderate amount of snow/rain falls continuously all day, rather than all at once.

The two tables below show the projected wet days (both 10 mm and 20 mm) and the maximum 1-day precipitation for Clarington. Wet days that experience more than 10mm of precipitation are projected to increase by 6 days—from 27 to 33 days per year—by 2100, and wet days that experience more than 20mm per year are projected to increase by 4 days—from 6 to 10 days per year—by 2100. Maximum 1-day precipitation is also projected to increase from the baseline of 38mm to 48mm per year by 2100.

**Table 24: Wet Days  $\geq 10$ mm for Clarington - SSP5-8.5 and SSP2-4.5**

| Emissions Scenario | Baseline 1971 -2000 | 2011-2040 |        |      | 2041-2070 |        |      | 2071-2100 |        |      |
|--------------------|---------------------|-----------|--------|------|-----------|--------|------|-----------|--------|------|
|                    |                     | Low       | Median | High | Low       | Median | High | Low       | Median | High |
| SSP5-8.5           | 27                  | 27        | 30     | 31   | 30        | 32     | 34   | 32        | 33     | 35   |
| SSP2-4.5           |                     | 28        | 30     | 31   | 29        | 34     | 32   | 30        | 32     | 34   |

<sup>17</sup> Ontario Ministry of the Environment, Conservation and Parks. (2023, August). Ontario Provincial Climate Change Impact Assessment. <https://www.ontario.ca/files/2023-08/mecp-ontario-provincial-climate-change-impact-assessment-en-2023-08-17.pdf>

<sup>18</sup> Feltmate, B., & Moudrak, M. (2021). Climate change and the preparedness of 16 major Canadian cities to limit flood risk. Intact Centre on Climate Adaptation, University of Waterloo.

<sup>19</sup> Prairie Climate Centre (2020). Climate Variables. Climate Atlas of Canada. Retrieved from <https://ClimateAtlas.ca/variables>

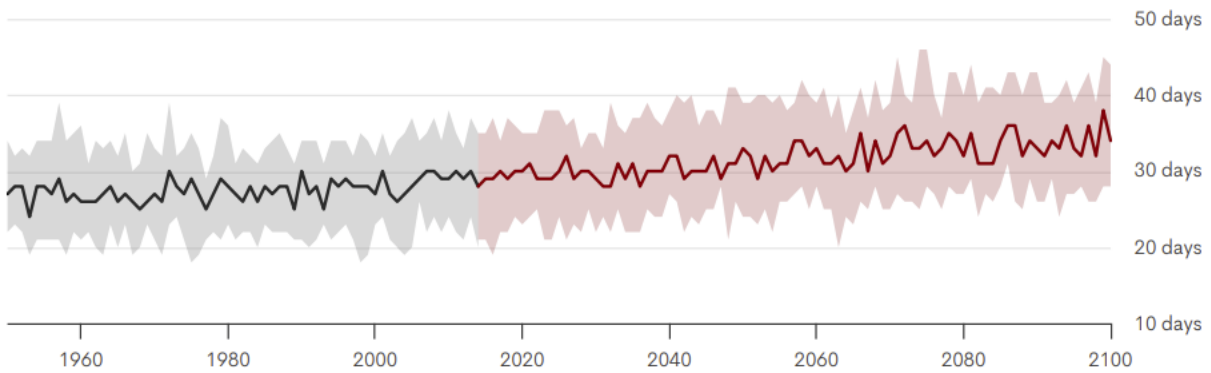


Figure 34: Wet Days  $\geq 10\text{mm}$  for Clarington - SSP5-8.5

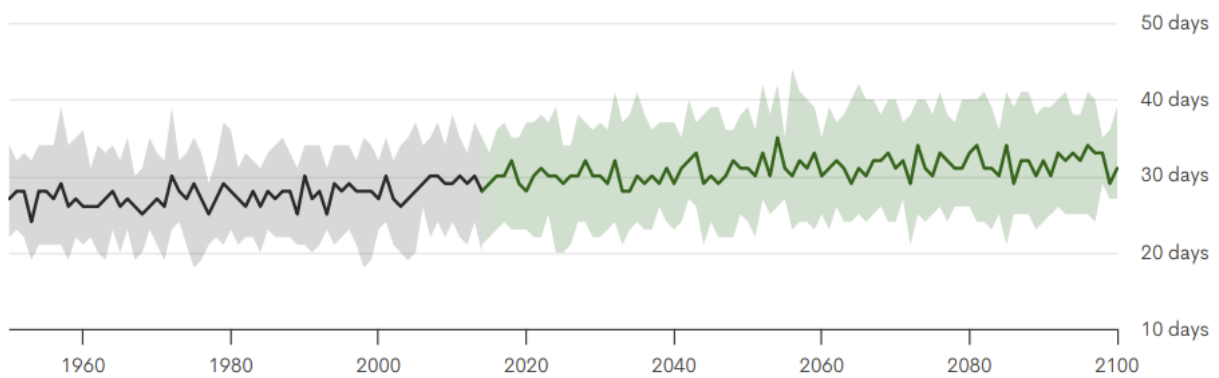


Figure 35: Wet Days  $\geq 10\text{mm}$  for Clarington - SSP2-4.5

Table 25: Wet Days  $\geq 20\text{mm}$  for Clarington - SSP5-8.5 and SSP2-4.5

| Emissions Scenario | Baseline 1971 -2000 | 2011-2040 |        |      | 2041-2070 |        |      | 2071-2100 |        |      |
|--------------------|---------------------|-----------|--------|------|-----------|--------|------|-----------|--------|------|
|                    |                     | Low       | Median | High | Low       | Median | High | Low       | Median | High |
| SSP5-8.5           | 6                   | 7         | 8      | 8    | 8         | 9      | 20   | 9         | 10     | 12   |
| SSP2-4.5           |                     | 7         | 7      | 8    | 7         | 8      | 9    | 7         | 9      | 10   |

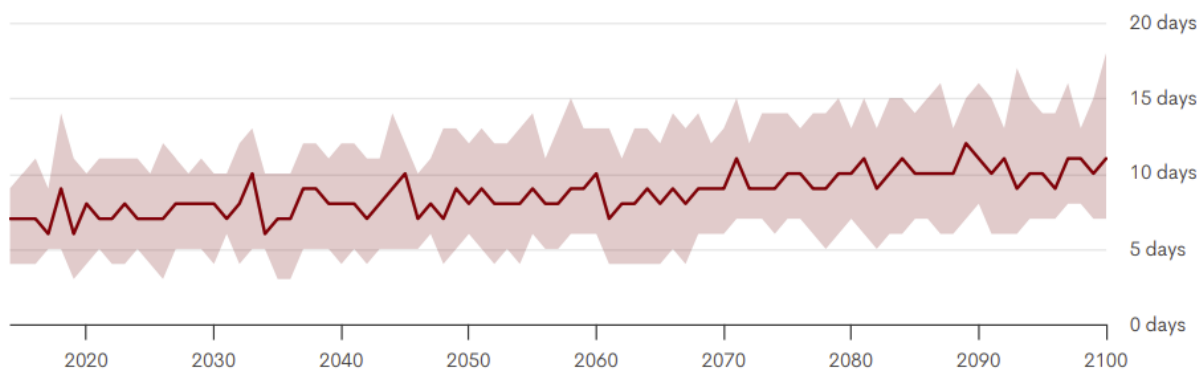


Figure 36: Projected Wet Days  $\geq 20\text{mm}$  for Clarington - SSP5-8.5

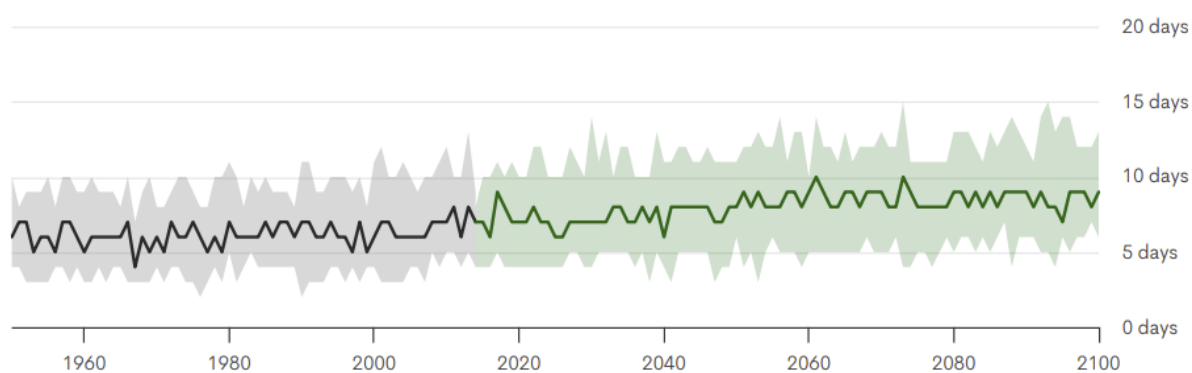


Figure 37: Projected Wet Days  $\geq 20\text{mm}$  for Clarington - SSP2-4.5

**Table 26: Maximum 1-Day Precipitation for Clarington - SSP5-8.5 and SSP2-4.5**

| Emissions Scenario | Baseline 1971-2000 | 2011-2040 |           |      | 2041-2070 |           |      | 2071-2100 |           |      |
|--------------------|--------------------|-----------|-----------|------|-----------|-----------|------|-----------|-----------|------|
|                    |                    | Low       | Median    | High | Low       | Median    | High | Low       | Median    | High |
| SSP5-8.5           | 38                 | 39        | <b>42</b> | 45   | 40        | <b>44</b> | 48   | 45        | <b>48</b> | 52   |
| SSP2-4.5           |                    | 39        | <b>41</b> | 44   | 40        | <b>44</b> | 48   | 41        | <b>45</b> | 48   |

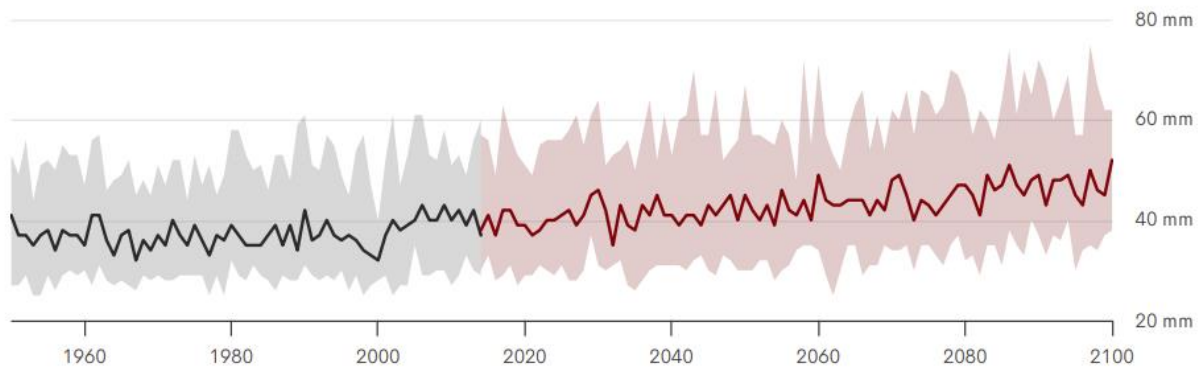


Figure 38: Maximum 1-Day Precipitation for Clarington - SSP5-8.5

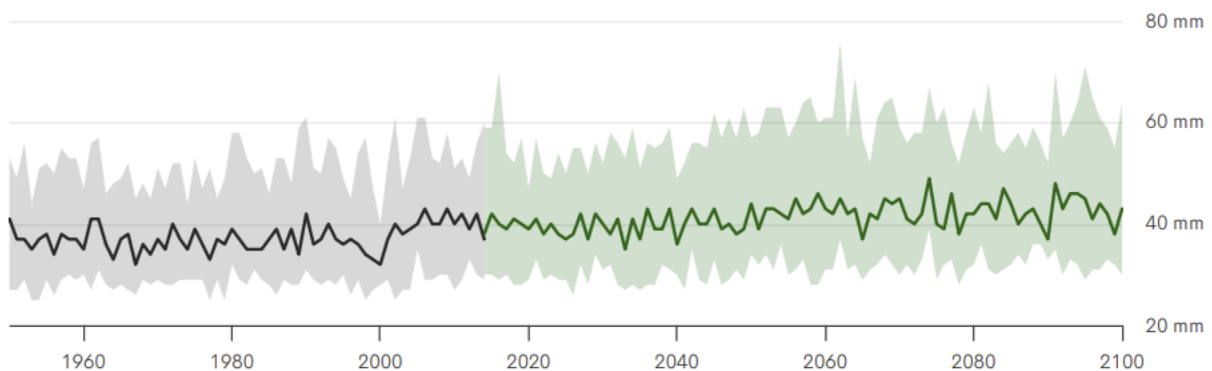


Figure 39: Maximum 1-Day Precipitation for Clarington - SSP2-4.5

## Intensity-Duration-Frequency

Intensity-duration-frequency (IDF) curves represent one way to analyze and predict heavy precipitation under a changing climate. They provide a graphical representation of the probability that a given average rainfall intensity will occur. IDF Curves are used to design stormwater infrastructure. To date, much of stormwater infrastructure has been built for the historical rainfall intensities. Rainfall intensity (mm/hr), rainfall duration (how many hours it rained at that intensity) and rainfall frequency/ return period (how often that rain storm repeats itself) are the parameters that make up the axes of the graph of the IDF curve<sup>20</sup>.

Due to the changing climate, using IDF curves based on historical observations alone are inappropriate for long-term decision-making. To account for climate change impacts on extreme rainfall and IDF curves, Environment and Climate Change Canada (ECCC) recommends the use of a temperature scaling methodology, as there is strong evidence that the intensity of precipitation is closely linked to temperature increases, by a general factor of around 7% for every 1°C increase in temperature. This

<sup>20</sup> IDF Curve. (n.d.). The Climate Workspace. Retrieved from <http://www.glisacclimate.org/node/2341>

methodology is described in more detail in CSA W231:25 ‘Developing and interpreting intensity-duration-frequency (IDF) information under a changing climate’<sup>21</sup>. ClimateData.ca provides historical and climate change-scaled IDF data for all ECCC IDF stations in Canada.

The station selected to produce localized IDF curves for Clarington was the Bowmanville Mostert. Projections are based on increases from the precipitation baseline, which is the average amount of precipitation in the years the station was active. For the Bowmanville Mostert station, this baseline was calculated between 1968 and 2001. The table below depicts baseline precipitation intensity.

**Table 27: Historical Return Period Rainfall Amounts (mm) and Return Period Rainfall Rates (mm/hr) (1965-1989)**

|          | Return Period Rainfall Amounts (mm) |      |      |      |      |      | Return Period Rainfall Rates (mm/hr) |       |      |       |       |       |
|----------|-------------------------------------|------|------|------|------|------|--------------------------------------|-------|------|-------|-------|-------|
| T(years) | 2                                   | 5    | 10   | 25   | 50   | 100  | 2                                    | 5     | 10   | 25    | 50    | 100   |
| 5 min    | 8.2                                 | 10.5 | 12.1 | 14.0 | 15.5 | 16.9 | 98.6                                 | 126.5 | 145  | 168.4 | 185.7 | 202.9 |
| 10 min   | 11.1                                | 14.1 | 16.1 | 18.6 | 20.4 | 22.2 | 66.6                                 | 84.5  | 96.4 | 111.4 | 122.5 | 133.5 |
| 15 min   | 13.3                                | 17.0 | 19.5 | 22.6 | 24.9 | 27.2 | 53.3                                 | 68.2  | 78.1 | 90.5  | 99.8  | 109.0 |
| 30 min   | 16.9                                | 21.1 | 24.0 | 27.6 | 30.2 | 32.9 | 33.7                                 | 42.3  | 47.9 | 55.1  | 60.4  | 65.7  |
| 1 h      | 21.2                                | 27.0 | 30.8 | 35.6 | 39.2 | 42.8 | 21.2                                 | 27.0  | 30.8 | 35.6  | 39.2  | 42.8  |
| 2h       | 25.3                                | 32.6 | 37.4 | 43.5 | 48.0 | 52.5 | 12.7                                 | 16.3  | 18.7 | 21.8  | 24.0  | 26.2  |
| 6 h      | 34.2                                | 43.7 | 50.0 | 57.9 | 63.8 | 69.7 | 5.7                                  | 7.3   | 8.3  | 9.7   | 10.6  | 11.6  |
| 12h      | 40.2                                | 49.4 | 55.5 | 63.2 | 68.9 | 74.5 | 3.3                                  | 4.1   | 4.6  | 5.3   | 5.7   | 6.2   |
| 24 h     | 44.0                                | 55.8 | 63.6 | 73.5 | 80.8 | 88.0 | 1.8                                  | 2.3   | 2.7  | 3.1   | 3.4   | 3.7   |

Tables 28, 29 and 30 represent the change in IDF curves under the SSP5-8.5 emission scenario. The projections cover a 30-year frame from 2011-2040, 2041-2070 and 2071-2100. As shown in these tables, the intensity of rainfall is projected to increase. While longer, more frequent rainfall events (e.g. a typical rainy day) will bring slightly higher amounts of rain, the intensity of rainfall during more infrequent, extreme storms (i.e. 1 in 25, 50, 100-year storms) is projected to significantly increase. The projected IDFs demonstrate that the intensity (mm/h) of rainfall will increase, with more rain falling in shorter time periods. Storms that occur less frequently (e.g. 100-year storms) are projected to see the greatest increase in intensity. Furthermore, such heavy precipitation events are projected to become more common than they once were.

<sup>21</sup> ClimateData.ca (n.d.) IDF Data and Climate Change. Retrieved from <https://ClimateData.ca/resource/idf-data-and-climate-change/>

**Table 28: Projected Return Period Rainfall Amounts (mm) and Return Period Rainfall Rates**

|          | Return Period Rainfall Amounts (mm) |      |      |      |      |       | Return Period Rainfall Rates (mm/hr) |       |       |       |       |       |
|----------|-------------------------------------|------|------|------|------|-------|--------------------------------------|-------|-------|-------|-------|-------|
| T(years) | 2                                   | 5    | 10   | 25   | 50   | 100   | 2                                    | 5     | 10    | 25    | 50    | 100   |
| 5 min    | 9.3                                 | 11.9 | 13.7 | 15.9 | 17.6 | 19.2  | 112.0                                | 143.0 | 164.0 | 191.0 | 211.0 | 230.0 |
| 10 min   | 12.7                                | 16.0 | 18.2 | 21   | 23.2 | 25.2  | 76.0                                 | 96.0  | 109.0 | 126.0 | 139.0 | 151.0 |
| 15 min   | 15                                  | 19.3 | 22.3 | 25.8 | 28.3 | 31    | 60.0                                 | 77.0  | 89.0  | 103.0 | 113.0 | 124.0 |
| 30 min   | 19                                  | 24   | 27   | 31   | 34.5 | 37.5  | 38.0                                 | 48.0  | 54.0  | 62.0  | 69.0  | 75.0  |
| 1 h      | 24                                  | 31   | 35   | 40   | 44   | 49    | 24.0                                 | 31.0  | 35.0  | 40.0  | 44.0  | 49.0  |
| 2h       | 28                                  | 36   | 42   | 50   | 54   | 60    | 14.0                                 | 18.0  | 21.0  | 25.0  | 27.0  | 30.0  |
| 6 h      | 39                                  | 49.8 | 56.4 | 66   | 72   | 78    | 6.5                                  | 8.3   | 9.4   | 11.0  | 12.0  | 13.0  |
| 12h      | 44.4                                | 56.4 | 62.4 | 72   | 78   | 84    | 3.7                                  | 4.7   | 5.2   | 6.0   | 6.5   | 7.0   |
| 24 h     | 48.0                                | 62.4 | 74.4 | 84   | 93.6 | 100.8 | 2.0                                  | 2.6   | 3.1   | 3.5   | 3.9   | 4.2   |

(mm/hr) Baseline Precipitation Intensity Rates (mm/h) (2011-2040) - SSP5-8.5

**Table 29: Projected Return Period Rainfall Amounts (mm) and Return Period Rainfall Rates  
(mm/hr) Baseline Precipitation Intensity Rates (mm/h) (2041-2070) - SSP5-8.5**

|          | Return Period Rainfall Amounts (mm) |      |      |      |       |       | Return Period Rainfall Rates (mm/hr) |       |       |       |       |       |
|----------|-------------------------------------|------|------|------|-------|-------|--------------------------------------|-------|-------|-------|-------|-------|
| T(years) | 2                                   | 5    | 10   | 25   | 50    | 100   | 2                                    | 5     | 10    | 25    | 50    | 100   |
| 5 min    | 10.7                                | 13.7 | 15.7 | 18.2 | 20    | 21.9  | 128.0                                | 164.0 | 188.0 | 218.0 | 240.0 | 263.0 |
| 10 min   | 14.3                                | 18.2 | 20.8 | 24   | 26.5  | 28.8  | 86.0                                 | 109.0 | 125.0 | 144.0 | 159.0 | 173.0 |
| 15 min   | 17.3                                | 22   | 25.3 | 29.3 | 32.3  | 35.3  | 69.0                                 | 88.0  | 101.0 | 117.0 | 129.0 | 141.0 |
| 30 min   | 22                                  | 27.5 | 31   | 35.5 | 39    | 42.5  | 44.0                                 | 55.0  | 62.0  | 71.0  | 78.0  | 85.0  |
| 1 h      | 27                                  | 35   | 40   | 46   | 51    | 55    | 27.0                                 | 35.0  | 40.0  | 46.0  | 51.0  | 55.0  |
| 2h       | 32                                  | 42   | 48   | 56   | 62    | 68    | 16.0                                 | 21.0  | 24.0  | 28.0  | 31.0  | 34.0  |
| 6 h      | 44.4                                | 56.4 | 66   | 78   | 84    | 90    | 7.4                                  | 9.4   | 11.0  | 13.0  | 14.0  | 15.0  |
| 12h      | 51.6                                | 63.6 | 72   | 82.8 | 88.8  | 96    | 4.3                                  | 5.3   | 6.0   | 6.9   | 7.4   | 8.0   |
| 24 h     | 55.2                                | 72   | 84   | 96   | 105.6 | 115.2 | 2.3                                  | 3.0   | 3.5   | 4.0   | 4.4   | 4.8   |

**Table 30: Projected Return Period Rainfall Amounts (mm) and Return Period Rainfall Rates (mm/hr) Baseline Precipitation Intensity Rates (mm/h) (2071-2100) - SSP5-8.5**

|          | Return Period Rainfall Amounts (mm) |      |      |       |       |       | Return Period Rainfall Rates (mm/hr) |       |       |       |       |       |
|----------|-------------------------------------|------|------|-------|-------|-------|--------------------------------------|-------|-------|-------|-------|-------|
| T(years) | 2                                   | 5    | 10   | 25    | 50    | 100   | 2                                    | 5     | 10    | 25    | 50    | 100   |
| 5 min    | 12.5                                | 16   | 18.3 | 21.3  | 23.5  | 25.8  | 150.0                                | 192.0 | 220.0 | 256.0 | 282.0 | 309.0 |
| 10 min   | 16.8                                | 21.3 | 24.5 | 28.2  | 31    | 33.8  | 101.0                                | 128.0 | 147.0 | 169.0 | 186.0 | 203.0 |
| 15 min   | 20.3                                | 26   | 29.8 | 34.5  | 38    | 41.5  | 81.0                                 | 104.0 | 119.0 | 138.0 | 152.0 | 166.0 |
| 30 min   | 25.5                                | 32   | 36.5 | 42    | 46    | 50    | 51.0                                 | 64.0  | 73.0  | 84.0  | 92.0  | 100.0 |
| 1 h      | 32                                  | 41   | 47   | 54    | 60    | 65    | 32.0                                 | 41.0  | 47.0  | 54.0  | 60.0  | 65.0  |
| 2h       | 38                                  | 50   | 56   | 66    | 72    | 80    | 19.0                                 | 25.0  | 28.0  | 33.0  | 36.0  | 40.0  |
| 6 h      | 52.2                                | 66   | 78   | 90.0  | 96    | 108   | 8.7                                  | 11.0  | 13.0  | 15.0  | 16.0  | 18.0  |
| 12h      | 60                                  | 74.4 | 84   | 97.2  | 104.4 | 112.8 | 5.0                                  | 6.2   | 7.0   | 8.1   | 8.7   | 9.4   |
| 24 h     | 64.8                                | 84   | 98.4 | 112.8 | 124.8 | 134.4 | 2.7                                  | 3.5   | 4.1   | 4.7   | 5.2   | 5.6   |

Figure 21 illustrates how the 24-hour rainfall volume (mm) is expected to change over time. Historically, a 1:100 year event was represented by a total rainfall volume of 88 mm over a 24-hour period. Under the SSP5-8.5 climate scenario, the future 1:100 year event in the time frame of 2071-2100 will see a total rainfall volume of 134.4 or a 52.7% increase. Another way to note this change is that a 24-hour rainfall event that historically resulted in 88 mm is projected to have a return period of less than 50 years between 2011-2040; a return period of less than 25 years between 2041-2070; and a return period of less than 10 years between 2071-2100. The increasing intensity of rainfall events may have implications for stormwater systems designed for historical rainfall patterns, affecting the municipality's ability to maintain service levels into the future.

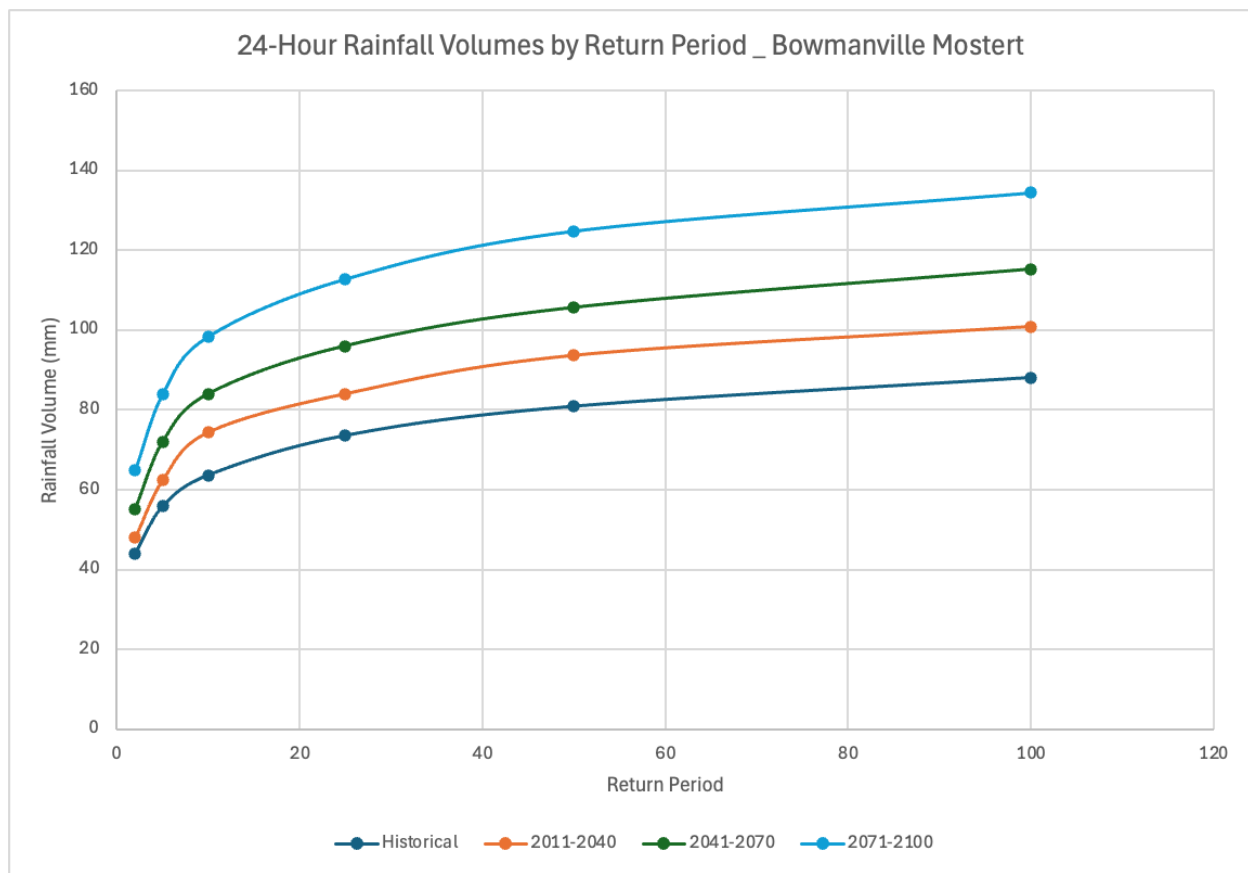


Figure 40: 24-Hour Rainfall Volumes by Return Period for Bowmanville Mostert

## Conclusion

This Climate Science Report is the baseline that will inform the Clarington Community Climate Risk and Adaptation Plan by offering updated climate data to support informed decision making as the municipality advances the consolidation of a refreshed plan.

The climate data in this report offers a clear indication that climate change is affecting Canada, Ontario, and Clarington. Rising temperatures, changes in precipitation, and an increase in extreme weather events result in significant climate impacts that will have potential ecological, infrastructural, socioeconomic and cultural implications for the community.

Future climate projections for Clarington show significant and multifaceted changes. With rising annual temperatures and increased frequency and intensity of heat waves, the community faces heightened risks of heat-related illnesses and impacts, especially for populations that are more highly exposed and have a lower capacity to adapt. Additionally, the projected decrease in extreme cold days and frost days, coupled with changes in precipitation, could disrupt ecosystems and exacerbate challenges like water availability and the spread of vector-borne diseases. These changes signify the urgent need for

comprehensive adaptation strategies to safeguard public health, infrastructure, and natural resources in the Municipality of Clarington.

## Appendix A: Summary of Climate Variable Data - SSP5-8.5

| Variable                                | Unit        | 1971-2000<br>Baseline | RESULTS under SSP5-8.5 |        |      |           |        |      |           |        |      |
|-----------------------------------------|-------------|-----------------------|------------------------|--------|------|-----------|--------|------|-----------|--------|------|
|                                         |             |                       | 2011-2040              |        |      | 2041-2070 |        |      | 2071-2100 |        |      |
|                                         |             |                       | Low                    | Median | High | Low       | Median | High | Low       | Median | High |
| Mean Temperature - Annual               | °C          | 7.3                   | 8.6                    | 9.2    | 10.2 | 10.4      | 11.3   | 12.8 | 12.3      | 13.7   | 16   |
| Mean Temperature - Winter               | °C          | -5.3                  | -3.8                   | -2.8   | -1.4 | -1.7      | -0.5   | 1.6  | 0.6       | 1.9    | 4.6  |
| Mean Temperature - Spring               | °C          | 6                     | 6.9                    | 7.6    | 8.3  | 8.8       | 9.6    | 10.5 | 10.6      | 11.9   | 13.2 |
| Mean Temperature - Summer               | °C          | 19.2                  | 20.3                   | 20.9   | 21.9 | 21.9      | 22.9   | 24.7 | 23.4      | 25.6   | 27.8 |
| Mean Temperature - Fall                 | °C          | 9.2                   | 10.3                   | 10.9   | 11.7 | 11.9      | 12.8   | 14.8 | 13.4      | 15.4   | 18.6 |
| Minimum Temperature - Annual            | °C          | 2.6                   | 4                      | 4.6    | 5.2  | 5.8       | 6.6    | 8    | 7.9       | 9.1    | 11.2 |
| Minimum Temperature - Winter            | °C          | -9.4                  | -7.8                   | -6.6   | -4.8 | -5.3      | -4     | -1.4 | -2.7      | -1.1   | 1.8  |
| Minimum Temperature - Spring            | °C          | 1                     | 2                      | 2.7    | 3.2  | 3.9       | 4.6    | 5.3  | 5.8       | 6.8    | 8.1  |
| Minimum Temperature - Summer            | °C          | 13.7                  | 14.9                   | 15.4   | 16.1 | 16.5      | 17.5   | 18.5 | 18.2      | 20.1   | 21.9 |
| Minimum Temperature - Fall              | °C          | 4.7                   | 5.8                    | 6.3    | 7    | 7.4       | 8      | 10   | 8.5       | 9.6    | 12.4 |
| Maximum Temperature - Annual            | °C          | 12.1                  | 13.2                   | 13.8   | 14.8 | 15        | 15.9   | 17.6 | 16.8      | 18.4   | 20.8 |
| Maximum Temperature - Winter            | °C          | -1.2                  | 0                      | 1      | 2    | 1.8       | 3      | 4.3  | 4         | 5.1    | 6.9  |
| Maximum Temperature - Spring            | °C          | 10.9                  | 11.9                   | 12.5   | 13.4 | 13.7      | 14.6   | 15.7 | 15.3      | 16.9   | 18.4 |
| Maximum Temperature - Summer            | °C          | 24.6                  | 25.7                   | 26.4   | 27.6 | 27.3      | 28.5   | 30.7 | 28.6      | 31     | 34.6 |
| Maximum Temperature - Fall              | °C          | 13.7                  | 14.9                   | 15.3   | 16.6 | 16.5      | 17.3   | 19.4 | 17.9      | 20     | 23.4 |
| Hottest Day                             | °C          | 32.2                  | 32.9                   | 34.1   | 35.7 | 34.6      | 36.0   | 39.2 | 36.5      | 38.8   | 42.9 |
| Days with Tmax > 30°C                   | Days        | 6                     | 11                     | 16     | 26   | 24        | 37     | 62   | 43        | 69     | 106  |
| Days with Tmax > 25°C                   | Days        | 51                    | 66                     | 75     | 89   | 88        | 98     | 119  | 106       | 127    | 155  |
| Days with Humidex > 30                  | Days        | 37                    | 53                     | 59     | 69   | 77        | 86     | 97   | 93        | 115    | 134  |
| Tropical Nights (Days with Tmin > 20°C) | Days        | 3                     | 7                      | 10     | 14   | 18        | 26     | 38   | 35        | 59     | 87   |
| Heat Wave Frequency                     | Events      | 0                     | 0                      | 0.7    | 2.1  | 1.1       | 3.1    | 5.8  | 4.4       | 6.9    | 8.7  |
| Heat Wave Total Duration                | Days        | 0                     | 0                      | 2      | 6.4  | 3         | 11     | 26   | 16        | 37     | 58   |
| Cooling Degree Days                     | Degree Days | 209                   | 297                    | 342    | 440  | 467       | 556    | 786  | 657       | 921    | 1279 |

| Variable                               | Unit        | 1971-2000<br>Baseline | RESULTS under SSP5-8.5 |                 |          |           |               |          |           |              |        |
|----------------------------------------|-------------|-----------------------|------------------------|-----------------|----------|-----------|---------------|----------|-----------|--------------|--------|
|                                        |             |                       | 2011-2040              |                 |          | 2041-2070 |               |          | 2071-2100 |              |        |
|                                        |             |                       | Low                    | Median          | High     | Low       | Median        | High     | Low       | Median       | High   |
| Coldest Day                            | °C          | <b>-25.2</b>          | -22.9                  | <b>-21.6</b>    | -18.6    | -19.8     | <b>-17.1</b>  | -12.9    | -15.4     | <b>-12.5</b> | -7.0   |
| Days with Tmin < -15°C                 | Days        | <b>22</b>             | 5                      | <b>11</b>       | 15       | 1         | <b>4</b>      | 7        | 0         | <b>0</b>     | 2      |
| Heating Degree Days                    | Degree Days | <b>4110</b>           | 3285                   | <b>3562</b>     | 3723     | 2654      | <b>3015</b>   | 3250     | 2048      | <b>2458</b>  | 2695   |
| Frost Days                             | Days        | <b>143</b>            | 112                    | <b>122</b>      | 129      | 75        | <b>99</b>     | 110      | 35        | <b>69</b>    | 85     |
| Ice days                               | Days        | <b>58</b>             | 32                     | <b>42</b>       | 49       | 15        | <b>26</b>     | 35       | 3         | <b>13</b>    | 18     |
| Freeze-Thaw Cycles                     | Days        | <b>70</b>             | 60                     | <b>65</b>       | 69       | 51        | <b>61</b>     | 67       | 48        | <b>56</b>    | 64     |
| Last Spring Frost                      | Date        | <b>May-2</b>          | 18-Apr                 | <b>25-April</b> | 30-April | 3-Apr     | <b>16-Apr</b> | 20-April | 25-Mar    | <b>5-Apr</b> | 15-Apr |
| First Fall Frost                       | Date        | <b>Oct-10</b>         | 14-Oct                 | <b>20-Oct</b>   | 25-Oct   | 20-Oct    | <b>26-Oct</b> | 5-Nov    | 31-Oct    | <b>7-Nov</b> | 27-Nov |
| Frost Free Season (Growing Season)     | Days        | <b>161</b>            | 179                    | <b>178</b>      | 178      | 200       | <b>193</b>    | 199      | 220       | <b>216</b>   | 226    |
| Growing Degree-Days Above 5°C          | Degree Days | <b>2097</b>           | 2327                   | <b>2451</b>     | 2656     | 2784      | <b>2909</b>   | 3268     | 3093      | <b>3637</b>  | 4202   |
| Cumulative Degree-Days Above 0°C       | Degree Days | <b>3296</b>           | 3598                   | <b>3753</b>     | 3965     | 4100      | <b>4330</b>   | 4752     | 4623      | <b>5127</b>  | 5819   |
| Total Precipitation - Annual           | mm          | <b>910</b>            | 922                    | <b>974</b>      | 1000     | 975       | <b>1003</b>   | 1045     | 998       | <b>1061</b>  | 1120   |
| Total Precipitation - Winter           | mm          | <b>215</b>            | 219                    | <b>235</b>      | 251      | 239       | <b>249</b>    | 270      | 262       | <b>277</b>   | 311    |
| Total Precipitation - Spring           | mm          | <b>226</b>            | 227                    | <b>241</b>      | 256      | 238       | <b>260</b>    | 280      | 252       | <b>280</b>   | 303    |
| Total Precipitation - Summer           | mm          | <b>223</b>            | 208                    | <b>232</b>      | 252      | 203       | <b>230</b>    | 246      | 188       | <b>227</b>   | 257    |
| Total Precipitation - Fall             | mm          | <b>246</b>            | 239                    | <b>256</b>      | 281      | 248       | <b>268</b>    | 280      | 250       | <b>276</b>   | 304    |
| Maximum Number of Consecutive Dry Days | Days        | <b>14</b>             | 14                     | <b>14</b>       | 15       | 14        | <b>15</b>     | 15       | 14        | <b>15</b>    | 17     |
| Maximum 1-Day Total Precipitation      | mm          | <b>38</b>             | 39                     | <b>42</b>       | 45       | 40        | <b>44</b>     | 48       | 45        | <b>48</b>    | 52     |
| Wet Days >= 10mm                       | Days        | <b>27</b>             | 27                     | <b>30</b>       | 31       | 30        | <b>32</b>     | 34       | 32        | <b>33</b>    | 35     |
| Wet Days >= 20mm                       | Days        | <b>6</b>              | 7                      | <b>8</b>        | 8        | 8         | <b>9</b>      | 20       | 9         | <b>10</b>    | 12     |

## Appendix B: Summary of Climate Variable Data - SSP2-4.5

| Variable                                | Unit        | 1971-2000<br>Baseline | RESULTS under SSP2-4.5 |        |      |           |        |      |           |        |      |
|-----------------------------------------|-------------|-----------------------|------------------------|--------|------|-----------|--------|------|-----------|--------|------|
|                                         |             |                       | 2011-2040              |        |      | 2041-2070 |        |      | 2071-2100 |        |      |
|                                         |             |                       | Low                    | Median | High | Low       | Median | High | Low       | Median | High |
| Mean Temperature - Annual               | °C          | 7.3                   | 8.7                    | 9      | 10.2 | 9.6       | 10.4   | 11.5 | 10.4      | 11.3   | 12.8 |
| Mean Temperature - Winter               | °C          | -5.3                  | -3.8                   | -3.2   | -2   | -2.6      | -1.9   | -0.1 | -1.8      | -1.1   | 1.1  |
| Mean Temperature - Spring               | °C          | 6                     | 7.3                    | 7.6    | 8.2  | 8.1       | 8.8    | 9.6  | 8.8       | 9.5    | 10.9 |
| Mean Temperature - Summer               | °C          | 19.2                  | 20.2                   | 20.8   | 21.8 | 21.2      | 22     | 23.2 | 21.7      | 23.1   | 24.5 |
| Mean Temperature - Fall                 | °C          | 9.2                   | 11.9                   | 10.8   | 12.2 | 11.2      | 11.9   | 13.4 | 11.9      | 12.8   | 14.5 |
| Minimum Temperature - Annual            | °C          | 2.6                   | 4                      | 4.3    | 5.1  | 5         | 5.5    | 6.8  | 5.8       | 6.5    | 8.3  |
| Minimum Temperature - Winter            | °C          | -9.4                  | -7.7                   | -7.1   | -5.5 | -6.3      | -5.4   | -3.5 | -5.1      | -4.1   | -1.6 |
| Minimum Temperature - Spring            | °C          | 1                     | 2.2                    | 2.7    | 3.3  | 3.2       | 3.7    | 4.4  | 3.9       | 4.4    | 6    |
| Minimum Temperature - Summer            | °C          | 13.7                  | 14.9                   | 15.3   | 15.9 | 15.8      | 16.3   | 17.4 | 16.3      | 17.4   | 18.6 |
| Minimum Temperature - Fall              | °C          | 4.7                   | 5.8                    | 6.2    | 7.5  | 6.7       | 7.4    | 8.7  | 7.1       | 8.1    | 9.9  |
| Maximum Temperature - Annual            | °C          | 12.1                  | 13.4                   | 13.8   | 14.8 | 14.2      | 15.2   | 16.3 | 14.9      | 15.9   | 17.7 |
| Maximum Temperature - Winter            | °C          | -1.2                  | 0.1                    | 0.6    | 1.4  | 1.1       | 1.7    | 3.1  | 1.9       | 2.9    | 4.5  |
| Maximum Temperature - Spring            | °C          | 10.9                  | 12.2                   | 12.6   | 13.1 | 13        | 14     | 14.6 | 13.4      | 14.3   | 15.6 |
| Maximum Temperature - Summer            | °C          | 24.6                  | 25.6                   | 26.3   | 27.4 | 26.7      | 27.6   | 29.2 | 27.2      | 28.6   | 30.7 |
| Maximum Temperature - Fall              | °C          | 13.7                  | 14.9                   | 15.4   | 16.9 | 15.7      | 16.6   | 18.2 | 16.3      | 17.0   | 18.9 |
| Hottest Day                             | °C          | 32.2                  | 33.1                   | 34.0   | 35.5 | 34.2      | 35.4   | 37.1 | 34.8      | 36.1   | 39.1 |
| Days with Tmax > 30°C                   | Days        | 6                     | 12                     | 15     | 23   | 17        | 27     | 45   | 24        | 38     | 61   |
| Days with Tmax > 25°C                   | Days        | 51                    | 66                     | 73     | 88   | 79        | 91     | 106  | 87        | 102    | 121  |
| Days with Humidex > 30                  | Days        | 37                    | 53                     | 58     | 65   | 64        | 74     | 86   | 75        | 87     | 103  |
| Tropical Nights (Days with Tmin > 20°C) | Days        | 3                     | 7                      | 9      | 14   | 13        | 18     | 25   | 17        | 26     | 37   |
| Heat Wave Frequency                     | Events      | 0                     | 0                      | 0.7    | 1.9  | 1         | 2.1    | 3.3  | 2         | 3.2    | 4.2  |
| Heat Wave Total Duration                | Days        | 0                     | 0                      | 1.6    | 4    | 2         | 6      | 11.5 | 5.1       | 10.7   | 15.9 |
| Cooling Degree Days                     | Degree Days | 209                   | 298                    | 357    | 448  | 392       | 469    | 619  | 451       | 578    | 741  |

| Variable                               | Unit        | 1971-2000<br>Baseline | RESULTS under SSP2-4.5 |                 |            |           |               |          |           |               |          |
|----------------------------------------|-------------|-----------------------|------------------------|-----------------|------------|-----------|---------------|----------|-----------|---------------|----------|
|                                        |             |                       | 2011-2040              |                 |            | 2041-2070 |               |          | 2071-2100 |               |          |
|                                        |             |                       | Low                    | Median          | High       | Low       | Median        | High     | Low       | Median        | High     |
| Coldest Day                            | °C          | <b>-25.2</b>          | -23.4                  | <b>-22.0</b>    | -18.4      | -21.1     | <b>-18.8</b>  | -15.3    | -19.1     | <b>-17.3</b>  | -11.7    |
| Days with Tmin < -15°C                 | Days        | <b>22</b>             | 6                      | <b>13</b>       | 15         | 2         | <b>7</b>      | 10       | 0         | <b>3</b>      | 6        |
| Heating Degree Days                    | Degree Days | <b>4110</b>           | 3303                   | <b>3598</b>     | 3772       | 2985      | <b>3282</b>   | 3451     | 2606      | <b>3070</b>   | 3292     |
| Frost Days                             | Days        | <b>143</b>            | 112                    | <b>124</b>      | 129        | 93        | <b>109</b>    | 118      | 74        | <b>99</b>     | 110      |
| Ice days                               | Days        | <b>58</b>             | 36                     | <b>44</b>       | 48         | 24        | <b>36</b>     | 41       | 12        | <b>26</b>     | 37       |
| Freeze-Thaw Cycles                     | Days        | <b>70</b>             | 60                     | <b>65</b>       | 69         | 43        | <b>57</b>     | 64       | 26        | <b>48</b>     | 58       |
| Last Spring Frost                      | Date        | <b>May-2</b>          | Apr-16                 | <b>April-27</b> | May 1      | Apr-9     | <b>Apr-20</b> | April-24 | Apr-4     | <b>Apr-18</b> | April-22 |
| First Fall Frost                       | Date        | <b>Oct-10</b>         | Oct-21                 | <b>Oct-26</b>   | November 5 | Oct-21    | <b>Oct-26</b> | Nov-5    | Oct-22    | <b>Oct-30</b> | Nov-11   |
| Frost Free Season (Growing Season)     | Days        | <b>161</b>            | 188                    | <b>182</b>      | 188        | 195       | <b>189</b>    | 195      | 201       | <b>195</b>    | 203      |
| Growing Degree-Days Above 5°C          | Degree Days | <b>2097</b>           | 2359                   | <b>2430</b>     | 2674       | 2544      | <b>2731</b>   | 2965     | 2703      | <b>2965</b>   | 3280     |
| Cumulative Degree-Days Above 0°C       | Degree Days | <b>3296</b>           | 3663                   | <b>3736</b>     | 3972       | 3871      | <b>4106</b>   | 4340     | 4079      | <b>4339</b>   | 4777     |
| Total Precipitation - Annual           | mm          | <b>910</b>            | 929                    | <b>963</b>      | 994        | 956       | <b>1006</b>   | 1037     | 972       | <b>1010</b>   | 1055     |
| Total Precipitation - Winter           | mm          | <b>215</b>            | 219                    | <b>234</b>      | 245        | 230       | <b>247</b>    | 260      | 235       | <b>259</b>    | 279      |
| Total Precipitation - Spring           | mm          | <b>226</b>            | 227                    | <b>242</b>      | 257        | 235       | <b>255</b>    | 267      | 246       | <b>258</b>    | 282      |
| Total Precipitation - Summer           | mm          | <b>223</b>            | 213                    | <b>230</b>      | 246        | 206       | <b>233</b>    | 249      | 206       | <b>235</b>    | 257      |
| Total Precipitation - Fall             | mm          | <b>246</b>            | 240                    | <b>256</b>      | 276        | 253       | <b>265</b>    | 289      | 243       | <b>268</b>    | 282      |
| Maximum Number of Consecutive Dry Days | Days        | <b>14</b>             | 13                     | <b>15</b>       | 15         | 13        | <b>14</b>     | 16       | 14        | <b>15</b>     | 16       |
| Maximum 1-Day Total Precipitation      | mm          | <b>38</b>             | 39                     | <b>41</b>       | 44         | 40        | <b>44</b>     | 48       | 41        | <b>45</b>     | 48       |
| Wet Days >= 10mm                       | Days        | <b>27</b>             | 28                     | <b>30</b>       | 31         | 29        | <b>34</b>     | 32       | 30        | <b>32</b>     | 34       |
| Wet Days >= 20mm                       | Days        | <b>6</b>              | 7                      | <b>7</b>        | 8          | 7         | <b>8</b>      | 9        | 7         | <b>9</b>      | 10       |