ONTARIO RESOURCE CENTRE FOR CLIMATE ADAPTATION

TOWN OF EAST GWILLIMBURY

Climate Science Report

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Glossary of Terms

Definitions have been taken from the Intergovernmental Panel on Climate Change (IPCC) (https://www.ipcc.ch/report/sr15/glossary/), Climatedata.ca, and the Climate Atlas of Canada (climateatlas.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.

Climate Change

Climate change refers to changes in long-term weather patterns caused by natural phenomena and human activities that alter the chemical composition of the atmosphere through the build-up of greenhouse gases which trap heat and reflect it back to the earth's surface.

Climate Projections

Climate projections are 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 are based on assumptions concerning future socioeconomic and technological developments that may or may not be realized and are therefore subject to uncertainty.

Climate Change Scenario

A climate change scenario is the difference between a future climate scenario and the current climate. It is a simplified representation of future climate based on comprehensive scientific analyses of the potential consequences of anthropogenic climate change. It is meant to be a plausible representation of the future emission amounts based on a coherent and consistent set of assumptions about driving forces (such as demographic and socioeconomic development, technological change) and their key relationships.

Ensemble Approach

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

Extreme Weather Event

A meteorological event that is beyond the normal range of activity at a place and time of year, such as an intense storm, tornado, hurricane, hail storm, flood or heatwave. An extreme weather event would normally occur very rarely or fall into the tenth percentile of probability. Weather models predict shorter return periods of extreme weather events in the future.

General Climate Models (GCM)

Computer model that is a mathematical representation of the climate system, based on equations that drive the physical processes governing the climate, including the role of the atmosphere, hydrosphere, biosphere, etc. It represents a unique tool that helps reproduce a complex ensemble of processes relevant for climate evolution. Note the term Global (or General) Circulation Model is often used as a synonym.

Greenhouse Gas (GHG) Emissions

Greenhouse gases are those 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_2O), carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), ozone (O_3), and chlorofluorocarbons (CFCs) are the six primary greenhouse gases in the Earth's atmosphere in order of abundance.

Heat Wave

The Government of Ontario defines a heat wave for Southern Ontario as "two or more days in a row with daytime highs expected to reach 31°C or warmer and nighttime falling to 20°C or warmer; or two or more days in a row of humidex values expected to reach 40°C or higher."

Intensity-Duration-Frequency curve

An Intensity-Duration-Frequency curve (IDF Curve) is 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 or computerized tools. IDF_CC is a publicly available web-based intensity-duration-frequency tool to update and adapt local extreme rainfall statistics to climate change.

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

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

Shared Socio-economic Pathways

Shared Socio-economic Pathways (SSPs) are five "families" of socio-economic characteristics that influence greenhouse gas emissions (and subsequently Radiative Forcing) based on the Sixth Phase of the Coupled Model Intercomparison Project (CMIP6) used by the IPCC for its Sixth Assessment Report (AR6). SSP scenarios further refine previous greenhouse gas concentration scenarios known as Representative Concentration Pathways.

Climate Indices

The climate indices included in this study are listed and defined in the table below. The indices represent a broad range of important climate variables that impact daily life in East Gwillimbury. Each indicator is discussed in more detail in their respective sections below.

Table 1: Climate Indices Definitions

Climatic Driver	Climate Indicator	Description	Units
	Hottest Day	The highest maximum temperature in the selected time period	ºC
Hot Temperature	Mean Temperature	The average temperature of the season (or annually).	ºC
	Hot Days (+30ºC)	A Hot Day is a day when the temperature rises to at least 30°C. This is the temperature where a Heat Alert is issued by Environment Canada.	Days
	Heat wave total duration	The average length of a heat wave.	Days
	Heat wave frequency	Two or more days in a row with daytime highs expected to reach 31°C or warmer and nighttime falling to 20°C or warmer; or two or more days in a row of humidex values expected to reach 40°C or higher.	Number of heat waves
Cold Temperature	Coldest day	The lowest nighttime temperature in the selected time period. In general, the coldest day of the year occurs during the winter months.	ºC
	Freeze-Thaw Cycles	This is a simple count of days when the air temperature fluctuates between freezing and non-freezing temperatures.	Days
	Icing Days	An Icing Day is a day on which the air temperature does not go above 0°C.	Days
	Days below -15ºC	The number of days where the lowest temperature of the day is colder than -15°C.	Days

Growing Season	Frost Free Season	The number of days between the date of the last spring frost and the date of the first fall frost, equivalent to the number of consecutive days during the 'summer' without any daily minimum temperatures below 0°C.	Days
Precipitation	Total precipitation	The total amount of precipitation (rain and snow combined) that falls within the selected time period	mm
	Mean Precipitation	The average precipitation for a given season (or annually)	mm
	Heavy Precipitation Days (10mm)	A Heavy Precipitation Day (10mm) is a day on which at least a total of 10 mm of rain or frozen precipitation falls.	Days
	Heavy Precipitation Days (20mm)	A Heavy Precipitation Day (20mm) is a day on which at least a total of 20mm of rain or frozen precipitation falls.	Days
	Max. 1-day Precipitation (mm)	The amount the precipitation that falls on the wettest day of the year.	mm
Extreme Weather	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/h
	Humidex	Days with Humidex > 30 (Hx>30°C) gives an indication of the number of hot and humid days.	event
Sea Level Rise	Relative Sea Level Change	The change in ocean level relative to land. Relative sea-level change is the combination of the effects from global sea-level change and the vertical motion of the land (i.e., subsidence and/or rebound).	cm

Location

In order to collect data from a consistent location, the "East Gwillimbury, York, Ontario" census subdivision was selected on climatedata.ca. A note that the climate data for that location is representative of the Town of East Gwillimbury location and that it does not necessarily reflect an exact point, particularly where there may be varying microclimates. Additional research should be conducted to retrieve more precise downscaled climate projections where appropriate.

Introduction

Climate change is an increasingly critical issue at the national and local levels. Recent events in Canada, including flooding, intense heat waves, hurricanes, and other occurrences of extreme weather over the past several decades, have highlighted the need to be prepared for ongoing challenges.

Ontario has already witnessed climate change as evidenced by recent events such as flooding, heat waves, and unusually high climate variability or extremes. These events have not only affected the natural environment but also had an impact on economic sectors, ecosystems, communities and daily lives of people[1].

Projections for Ontario show an increase in the number of extreme climate events, specifically increases in the number of extreme heat days, increases in annual precipitation, and changes in the seasonal pattern of precipitation. These changes will result in a high risk of negative impacts to municipal infrastructure, services, and public safety within the province.

York Region in particular, has witnessed firsthand the consequences of extreme weather. The region has experienced a range of significant climatic events, including major rainfall and flooding events that resulted in infrastructure damage and large recovery costs. An extreme rainfall event on June 23, 2017 caused severe flooding and affected several water and wastewater sites (pumping stations and wastewater treatment facilities) across the Region[2]. During this event, East Gwillimbury experienced rainfall levels comparable to a 1 in 50-year event[3]. North York Regions including East Gwillimbury have the largest number of low-income individuals who reside within a flood plain and are more vulnerable to flooding events due to limited resources and standard housing conditions[4].

This report will primarily focus on changes in temperature and precipitation patterns which will affect the social, natural, built, and economic systems of East Gwillimbury. The purpose of this report is to summarize localized climate projections. These projections will help determine the impacts of what vulnerabilities and risks the community faces as a result of climate change. This process is one of the first steps to inform and guide the Town and its residents toward greater resilience and preparedness for future climatic impacts.

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1 Climate Risk Institute. (2023). Ontario Provincial Climate Change Impact Assessment. Report prepared by the Climate Risk Institute, Dillon Consulting, ESSA Technologies Ltd., Kennedy Consulting, and Seton Stiebert for the Ontario Ministry of Environment, Conservation and Parks. Available at: https://www.ontario.ca/page/ontario-provincial-climate-change-impact-assessment

[2] Regional Municipality of York. (2021). *York Region Climate Change and Health Vulnerability Assessment*. Available from https://www.york.ca/media/93506/download

[3] Regional Municipality of York. (2021). *York Region Climate Change and Health Vulnerability Assessment*. Available from https://www.york.ca/media/93506/download

[4] Regional Municipality of York. (2021). *York Region Climate Change and Health Vulnerability Assessment*. Available from https://www.york.ca/media/93506/download

Data Collection

Data for this report was collected through several platforms. Primarily, localized climate change data was collected from two online, publicly available tools. These include:

- Climate Change Data and Scenarios Tool - Climatedata.ca
- The Climate Atlas of Canada was used to collect data relating to CMIP5 climate projections where CMIP6 data was unavailable from climatedata.ca

More information concerning these online tools is provided in the Glossary. Other information about expected climatic changes in Ontario was taken from various academic or government reports. These are identified and cited where applicable.

Climate Change Modelling and Downscaling

Wherever possible, the data presented in this report is based on global climate models (GCMs) and emission scenarios defined by the Intergovernmental Panel on Climate Change (IPCC), drawing from the Sixth Assessment Reports. Data projecting temperature and precipitation changes have been constructed using Coupled Model Intercomparison Project (CMIP6) data as they are the most current global climate model data available. CMIP6 improves upon CMIP5 by including 49 climate modelling groups running 100 climate models. Many different methods exist to construct climate change scenarios, however, GCMs are the most conclusive tools available for simulating responses to increasing greenhouse gas concentrations, as they are based on mathematical representations of the atmosphere, ocean, ice cap, and land surface processes.[5]

Wherever possible, this report uses an ensemble approach, which refers to a system that runs multiple climate models at once. 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.[6]

Greenhouse Gas Emissions Scenarios

Climate change scenarios are based on models developed by a series of international climate modeling 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 global model scenarios requires estimates of future population levels, economic activity, the structure of governance, social values, 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 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

[5] Government of Canada. Multi-model ensemble scenarios (canada.ca). Published 2022-07-22

[6] Government of Canada. Multi-model ensemble scenarios (canada.ca). Published 2022-07-22

that describe differing influences on greenhouse gas emissions. 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, and their approximate total radiative forcing in the year 2100 relative to pre-industrial levels, and are labeled as SSP1-SSP5.

These five pathways range from SSP1, where challenges to mitigation and adaptation are low, to SSP3 where challenges to mitigation and adaptation are both high, and the remaining SSPs are representative of the spectrum of possible societal futures.

For this report, where possible, projections will use both **SSP2-4.5, and SSP5-8.5**, as they represent a carbon-reduced future with support of adaptation actions, and a 'fossil-fueled development' scenario with high challenges to mitigation and low challenges to adaptation. These scenarios were chosen because they represent a wide range of possible future climates, have associated projections available from many different climate models, and correspond with Representative Concentration Pathways (RCP) 4.5 and 8.5 utilized in the IPCC's AR5 Report. Additionally, it is important that municipalities are aware of some of the most potentially dramatic effects of climate change should global emissions persist. Table 2 describes SSP scenarios 1, 2, and 5, while Figure 1 illustrates the projected global warming associated with the three scenarios.

Table 2: IPCC Sixth Assessment Report Climate Change Scenario Characteristics[5]

Scenario	Description
SSP1-2.6 – Sustainability ***Taking the Green Road***	● Low challenges to both mitigation and adaptation ● Policy focused on sustainable development ● Effective international cooperation ● Reduced inequality within and across countries ● Low consumption ● Low population growth
SSP2-4.5 ***Middle of the Road***	● Medium challenges to both mitigation and adaptation ● Current development and consumption patterns continue ● National and global institutions are slow to achieve sustainable development goals ● Environmental systems decline ● Slow improvements to inequality ● Moderate population growth

SSP5-8.5 – Fossil-fueled Development ***Taking the Highway***	● High challenges to mitigation, low challenges to adaptation ● Policy focused on free markets ● High consumption ● Effective international cooperation ● Reduced inequality ● High economic growth ● Low population growth

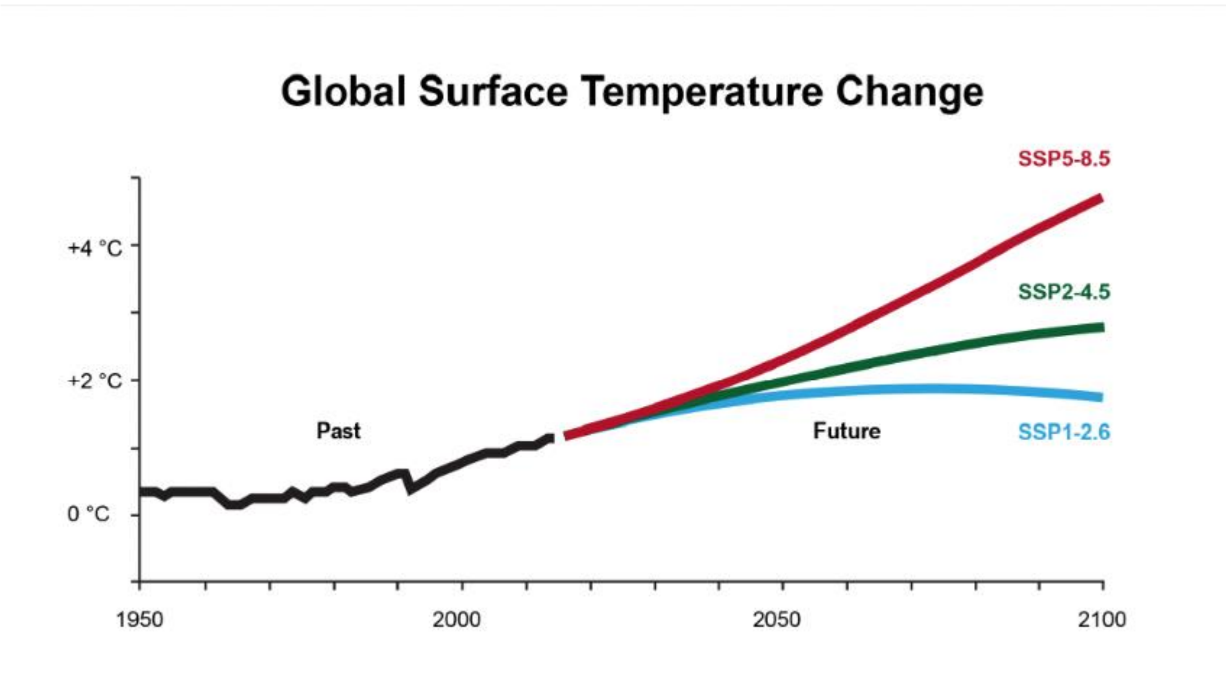

Figure 1: Global Surface Temperature Change

Time Periods

A consistent baseline period is established so that projections can be accurately compared with historical trends. When utilizing data from Climatedata.ca:

- The baseline is 1971 – 2000.
- The future time periods used are near future 2021-2050 and long-term future 2051-2080.

Table 3: Seasonal Timeframes

Season	Months

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

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, climate change scenarios help to create plausible representations of future climate conditions. These conditions are based on assumptions of future atmospheric composition and on an understanding of the effects of increased atmospheric concentrations of greenhouse gases, particulates, and other pollutants.

The ensemble models do not represent a 'best' model as there is not one and therefore, as mentioned under climate change modelling, an ensemble model is used. For this report the 50th percentile (median) was used in order to present where the majority of results fall.[7]

Temperature

Annual and Seasonal Temperatures

National and Provincial Context

Over the last six decades, Canada has become warmer, with average temperatures over land increasing by 1.5°C between 1950 and 2010 [8]. This rate of warming is almost double the global average reported over the same period[9]. The average temperature for the year 2022 in Canada was 1.2 °C above the baseline, making it the 16th warmest year since 1948[10].

In Ontario, temperatures have increased by 1.3°C between 1948 and 2016[11]. Assuming emissions continue at the current rate of global output, Ontario is projected to experience an increase in annual average temperature of 4.8°C by the end of the century. Table 2 displays the expected seasonal temperature change in the province of Ontario based on the IPCC Fifth Assessment Report (AR5).

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[7] "Uncertainty in Climate Projections — Climate Data Canada." *Climate Data Canada*, https://climatedata.ca/resource/uncertainty-in-climate-projections/. Accessed 14 September 2023.

[8] Douglas, A.G. and Pearson, D. (2022). Ontario; Chapter 4 *in* Canada in a Changing Climate: Regional Perspectives Report, (ed.) F.J. Warren, N. Lulham, D.L. Dupuis and D.S. Lemmen; Government of Canada, Ottawa, Ontario.

[9] Douglas, A.G. and Pearson, D. (2022). Ontario; Chapter 4 *in* Canada in a Changing Climate: Regional Perspectives Report, (ed.) F.J. Warren, N. Lulham, D.L. Dupuis and D.S. Lemmen; Government of Canada, Ottawa, Ontario.

[10] "Temperature change in Canada." *Canada.ca*, 10 July 2023, https://www.canada.ca/en/environment-climate-change/services/environmental-indicators/temperature-change.html Accessed 20 November 2023.

[11] Bush, E. and Lemmen, D.S., editors (2019): Canada's Changing Climate Report; Government of Canada, Ottawa, ON. 444 p.

Climate modelling suggests that these changes will continue and the climate change associated risks will increase in the future.

Table 4: Annual and Seasonal Temperature in Ontario for RCP8.5*

Emissions Scenarios	Time of Year	Baseline (1976-2005)	2021-2050 (in °C)			2051-2080 (in °C)		
			Low	Mean	High	Low	Mean	High
RCP8.5	Spring	-0.6	-1.2	1.4	4.3	0.8	3.6	7.0
	Summer	15.7	16.2	17.8	19.4	17.9	20.0	22.0
	Fall	3.4	3.8	5.6	7.3	5.9	7.8	9.6
	Winter	-16.2	-16.3	-13.3	-10.3	-13.1	-10.1	-6.9
	Annual	**0.6**	**1.5**	**3.0**	**4.5**	**3.6**	**5.4**	**7.4**

*Province wide data not available for SSP5-8.5 – see Data Collection section above for more information

Town of East Gwillimbury

Temperatures in East Gwillimbury are expected to rise in congruence with the provincial changes observed in the data above. The climatedata.ca tool was used to collect downscaled climate projections, using a baseline of 1971-2000.

In East Gwillimbury, there is a projected annual temperature increase from the baseline mean of 6.7°C to 9.2°C in the near future and 11.4°C in the long-term future under scenario SSP5-8.5. Table 5 and Figure 2 depict the projected temperatures using an ensemble of global climate models applying the SSP2-4.5 and SSP5-8.5 scenarios.

Table 5: Projected Mean Temperatures for the East Gwillimbury (°C) by Season – SSP2-4.5 and SSP5-8.5

Emissions Scenarios	Time of Year	Baseline (1971-2000)	2021-2050 (in °C)			2051-2080 (in °C)		
			Low	Mean	High	Low	Mean	High
SSP2-4.5	Spring	5.4	7.0	7.6	8.3	7.9	8.6	9.9
	Summer	18.8	20.2	20.9	22.0	21.1	22.2	23.3
	Fall	8.6	10.1	10.7	12.1	10.9	11.7	13.4
	Winter	-6.4	-4.2	-3.7	-2.6	-3.2	-2.4	-0.4
	Annual	**6.7**	**8.5**	**8.9**	**10.1**	**9.3**	**10.1**	**11.5**
SSP5-8.5	Spring	5.4	7.0	7.8	8.5	9.2	9.8	10.8

	Summer	18.8	20.5	21.1	22.4	22	23.5	25.4
	Fall	8.6	10.3	11	11.9	12	12.9	15.3
	Winter	-6.4	-4.4	-3.1	-1.6	-2.1	-0.4	1.6
	Annual	**6.7**	**8.6**	**9.2**	**10.5**	**10.6**	**11.4**	**13.2**

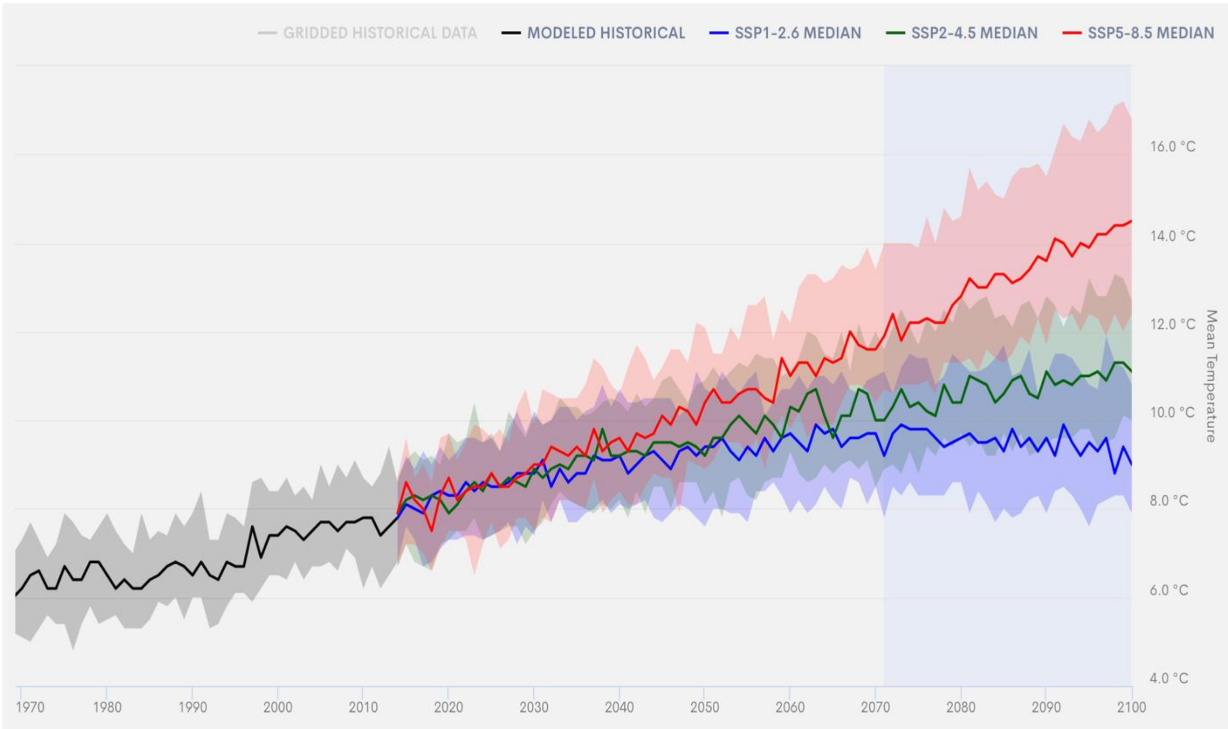

Figure 2: Mean Temperatures for East Gwillimbury SSP1-2.6, SSP2=4.5, SSP5-8.5

Hot Weather

Maximum and minimum temperature trends show the average high temperatures and the average low temperatures for a given season.

Extreme Heat

Extreme heat is the best-documented natural hazard associated with health consequences and increased all-cause mortality but the thresholds and duration of extreme heat days and events vary across the country.[12]

Examples of the health risks associated with extreme heat include heat cramps, heat edema, heat exhaustion, or heat stroke. Specific groups, such as those who work outside, infants and young children, older adults (over the age of 65), those with chronic medical conditions, people experiencing homelessness, people playing outdoor sports or activities, and those with limited mobility may be more adversely affected.[13] Moreover, while higher summer temperatures increase electricity demand for

[12] 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. Ottawa, ON: Government of Canada.

[13] Health Canada. (2011). Adapting to Extreme Heat Events: Guidelines for Assessing Health Vulnerability. Ottawa, ON. Retrieved from http://www.hc-sc.gc.ca/ewh-semt/pubs/climat/adapt/index-eng.php

cooling, at the same time, these temperatures can lower the ability of transmission lines to carry power, possibly leading to electricity reliability issues during heat waves.[14]

The baseline average number of days when the maximum temperature (TMax) was greater than or equal to 30°C was 9 days for East Gwillimbury. In long-term future, this is expected to increase to an average of 50 days, with a possible range in any given year of 34 to 80 days under the SSP5-8.5 scenario, as shown in Table 6 and Figure 3.

Table 6: Hot Days (Tmax ≥30°C) for East Gwillimbury– SSP2-4.5 and SSP5-8.5

Emissions Scenario	Tmax	Baseline (1971-2000)	2021-2050 (days)			2051-2080 (days)		
			Low	Mean	High	Low	Mean	High
SSP2-4.5	30°C or more	9	18	25	35	26	37	56
SSP5-8.5	30°C or more	9	18	26	40	34	50	80

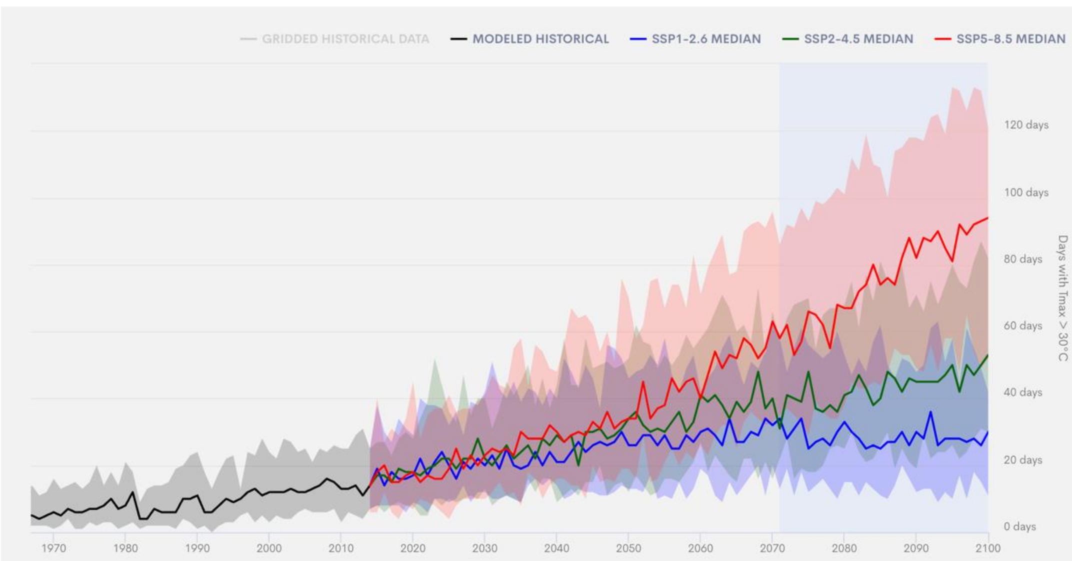

Figure 3: Hot Days (Tmax ≥30°C) for East Gwillimbury SSP1-2.6, SSP2-4.5, SSP5-8.5

[14] 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/

Heat Waves

The Government of Ontario defines a heat wave for Southern Ontario as "two or more days in a row with daytime highs expected to reach 31°C or warmer and nighttime falling to 20°C or warmer; or two or more days in a row of humidex values expected to reach 40°C or higher."

The baseline number of heat waves for East Gwillimbury is 3 as presented in Table 7. According to the SSP5-8.5, East Gwillimbury can expect to experience an average of 13.7 heat wave events per year during the 2021-2050 period, and 35.9 heat wave events per year during the 2051-2090 period.

Table 7: Number of Annual Heat Waves for East Gwillimbury – SSP2-4.5 and SSP5-8.5

Emissions Scenarios	Baseline 1971-2000	2021-2050			2051-2080		
		Low	Mean	High	Low	Mean	High
SSP2-4.5	3	7	16.6	29	16	32	22.5
SSP5-8.5	3	5	13.7	21	20	35.9	53

With regards to the average length of heat waves (in days), East Gwillimbury experienced 0 days of heat wave conditions in the baseline period as displayed in Table 8. In the 2021-2050 period and the 2051-2080 period, according to SSP5-8.5, East Gwillimbury can expect to see an average heat wave event length occurring for 3.4 and 16.3 days, respectively.

Table 8: Average Annual Length of Heat Waves (in days) for East Gwillimbury – SSP2-4.5 and SSP5-8.5

Emissions Scenarios	Baseline 1971-2000 (in days)	2021-2050			2051-2080		
		Low	Mean	High	Low	Mean	High
SSP2-4.5	0.0	0	3.1	6	3	7.5	12
SSP5-8.5	0.0	0	3.4	9	6	16.3	33

Overall, heat waves are projected to occur more frequently and for longer periods of time, leading to greater occurrences of extreme heat events in East Gwillimbury. These changes become more pronounced over time, and in response to higher emissions scenarios. High, persistent temperatures also increase the risk of drought, which can severely contribute to health impacts including poor air quality, food and waterborne diseases, and water insecurity with an increased risk of wildfire. More frequent and extended heat waves will impact those who currently don't have access to cooling.

Humidex

The humidex measurement provides the number of days where the humidex is greater than 30°C (Hx>30°C). 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 moderated when the humidex exceeds 30, and that all unnecessary activities cease when it passes 40.[15]

As depicted in Table 9 and Figure 4, the number of hot and humid days in East Gwillimbury will increase from a Hx>30°C baseline average of 38 days to 67 days during the 2021-2050 period, and further to 97 days during the 2051-2080 period under the SSP5-8.5 scenario.

Table 9: Number of Humidex days >30°C for East Gwillimbury – SSP2-4.5 and SSP5-8.5

Emissions Scenario	Humidex	Baseline 1971-2000	2021-2050 (Days)			2051-2080 (Days)		
			Low	Mean	High	Low	Mean	High
SSP2-4.5	>30°C	38	57	64	73	68	71	91
SSP5-8.5	>30°C	38	60	67	81	83	97	110

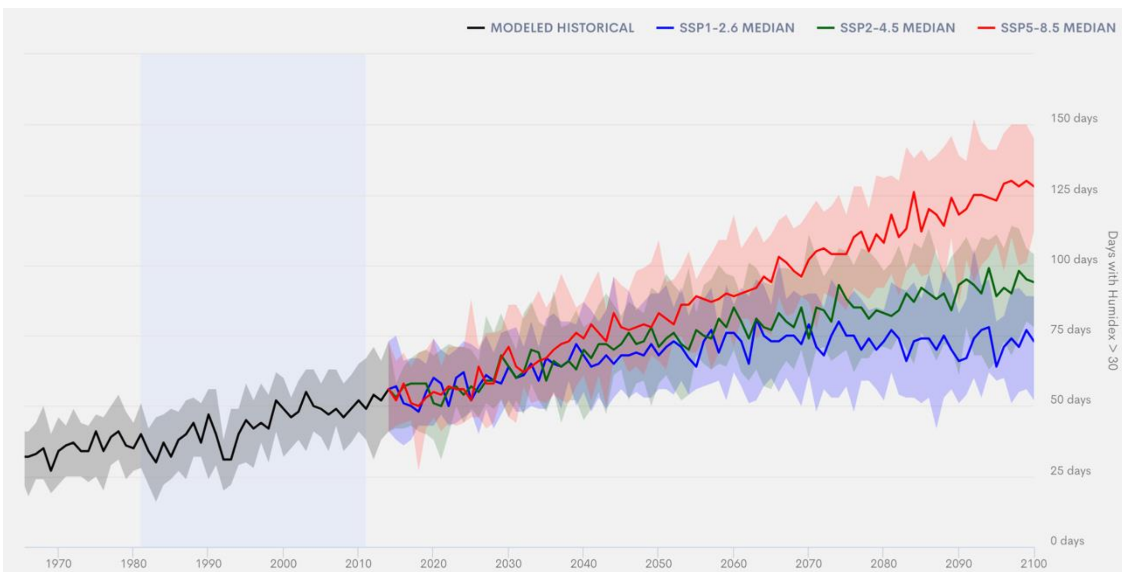

Figure 4: Days with Humidex >30°C for East Gwillimbury SSP1-2.6, SSP2-4.5, SSP5-8.5

Cold Weather

Overall, the frequency and severity of cold days are decreasing across Canada, and it is important to know how our winters will change in the future, because cold temperatures affect health and safety, where and how plants and animals survive, limit or enable outdoor activities, define how we design our buildings and vehicles, and shape our transportation and energy use.

[15] Mekis, Éva & Vincent, Lucie & Zhang, Xuebin & Shephard, Mark. (2015). Observed Trends in Severe Weather Conditions Based on Humidex, Wind Chill, and Heavy Rainfall Events in Canada for 1953–2012. Atmosphere-ocean. 53. 383-397. 10.1080/07055900.2015.1086970.

Coldest Day and Extreme Cold

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 East Gwillimbury is expected to be warmer, from –27.2°C to –21.7°C in 2021-2050 period and –11.7°C in the 2051-2080 period under SSP5-8.5 (see Table 10 below).

Table 10: Coldest Day in East Gwillimbury – SSP2-4.5 and SSP5-8.5

Emissions Scenarios	Baseline 1971-2000 (in °C)	2021-2050 (in °C)			2051-2080 (in °C)		
		Low	Mean	High	Low	Mean	High
SSP2-4.5	-27.2	-24.4	-22.7	-19.3	-22.6	-20.5	-15.3
SSP5-8.5	-27.2	-24.4	-21.7	-18.6	-20.4	-11.7	-12.4

Extreme cold days, defined as a day where the temperature drops to at least -15°C, are projected to decrease significantly in East Gwillimbury from a baseline of 28 days to 12 days per year between 2021-2050. Additionally, there is expected to be a further decrease to 4 days per year between 2051-2080 under SSP5-8.5 (see Table 11 below).

Table 11: Number of Days < -15°C for East Gwillimbury – SSP2-4.5 and SSP5-8.5

Emissions Scenarios	Baseline 1971-2000	2021-2050 (days)			2051-2080 (days)		
		Low	Mean	High	Low	Mean	High
SSP2-4.5	28	7	14	17	2	9	13
SSP5-8.5	28	5	12	17	1	4	7

Ice Days

Cold weather indicators, such Frost and Ice Days, can help to understand freeze and thaw patterns throughout the region and document risks relating to morbidity and mortality from traffic accidents, damage to roads and infrastructure, facility closures and more.

A Frost Day is a day with frost potential, meaning the **minimum** temperature is below 0°C. Frost Days are predicted to decrease by an average of nearly 27 days between 2021-2050, and by 52 days between 2051-2080 under SSP5-8.5 from a baseline of 155 days (see Table 12 below).

Table 12: Project Frost Days for East Gwillimbury - SSP2-4.5 and SSP5-8.5

Emissions Scenarios	Baseline 1971-2000	2021-2050 (days)			2051-2080 (days)		
		Low	Mean	High	Low	Mean	High
SSP2-4.5	155	120	131	135	105	1107	126

SSP5-8.5	155	117	128	133	74	103	114

Ice Days are the total number of days when the daily **maximum** temperature is at or below 0°C. This index is an indicator of the length and severity of the winter season. A reduction in days below 0°C could have an impact on the survival and spread of ticks and Lyme disease, as ticks can be active in temperatures above 4°C.[16] While deer ticks are most active in spring and fall, warmer winters could extend their window of activity. Ice Days are expected to decrease from 69 days to 46 days between 2021-2050 and to 28 days between 2051-2080 under the SSP5-8.5 scenario (see Table 13 below).

Table 13: Projected Ice Days for East Gwillimbury – SSP2-4.5 and SSP5-8.5

Emissions Scenarios	Baseline 1971-2000	2021-2050 (days)			2051-2080 (days)		
		Low	Mean	High	Low	Mean	High
SSP2-4.5	69	42	49	57	26	42	49
SSP5-8.5	69	34	46	55	15	28	39

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. Under these conditions, some water at the surface was likely 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.

The SSP5-8.5 ensembles project that freeze-thaw cycles will decrease due to overall warmer temperatures. This is likely a result of the overall increase in projected warmer days. As shown in Table 14, East Gwillimbury is likely to experience a decrease in the number of days that reach a minimum temperature below 0°C.

Table 14: Average Annual Freeze-Thaw Cycles for East Gwillimbury– SSP2-4.5 and SSP5-8.5

Emissions Scenarios	Baseline 1971-2000	2021-2050 (days)			2051-2080 (days)		
		Low	Mean	High	Low	Mean	High
SSP2-4.5	71	59	65	71	51	62	68
SSP5-8.5	71	58	65	72	41	57	66

[16] Alberta Health. (2019). Lyme disease tick surveillance. Retrieved from https://www.alberta.ca/lyme-disease-tick-surveillance.aspx

Growing Season

Growing Season Start Date, End Date, and Length

Changes in seasonal temperatures, precipitation events, the length of growing seasons, and the timing of extreme heat and cold days all determine the types of vegetation and crops that can be grown now and in the future. While increased temperatures will extend the growing season of some plants, other climate change projections are expected to result in a series of deleterious factors which may negate any benefit. For instance, increased temperatures may also increase the likelihood of drought conditions, reduce the water supply for irrigation, improve conditions for some pests, and disrupt pollination patterns.

The growing season is defined by the last and first frosts and also the median frost-free days. The SSP5-8.5 ensemble projects earlier start dates and later end dates to the growing season for East Gwillimbury in Table 15. The baseline start date is typically around May 7, while the end date is typically October 7, resulting in a growing season of approximately 153 days. According to the SSP5-8.5 ensemble, between 2021 – 2050, the growing season is projected to occur approximately 11 days earlier, while the end date will likely occur approximately 15 days later. This means, on average, the growing season will likely increase by approximately 3.7 weeks a year. Between 2051-2080, there will be a further increase in growing season by approximately 6.4 weeks from the baseline, following a high emissions scenario.

Table 15: Growing Season Length for East Gwillimbury – SSP5-8.5

	SSP5-8.5		
	Median Start date (Date of Last Spring Frost)	**Median End date (Date of First Fall Frost)**	**Mean frost-free days**
1971-2000 (Baseline)	May 7	October 7	153
2021-2050	April 26	October 22	178
2051-2080	April 17	November 1	196

Precipitation

Annual and Seasonal Precipitation

National and Provincial Context

Canada has, on average, become wetter during the past half century, with average precipitation across the country increasing by approximately 20%.[17] Other parts of the country can expect to see a significant percentage increase in precipitation, particularly Northern Canada.

[17] Natural Resources Canada. (2019) Canada in a Changing Climate. https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/energy/Climate-change/pdf/CCCR_FULLREPORT-EN-FINAL.pdf Government of Canada, Ottawa, ON. p.156.

Ontario has seen a 9.7% increase in precipitation between 1948 and 2012 with a 5.2 % observed increase in winter, a 12.5% increase in spring, a 17.8% increase in autumn and an 8.6% increase in the summer season[18].

Projections for Ontario show precipitation increases across all seasons, notably in spring, fall and winter. Table 16 below details the projected precipitation changes for the province of Ontario under the RCP8.5 scenario.

Table 16: Projected Annual and Seasonal Precipitation (mm) for Ontario– RCP8.5*

Emissions Scenario	Time of Year	Baseline 1976-2005 (in mm)	2021-2050 (in mm)			2051-2080 (in mm)		
			Low	Mean	High	Low	Mean	High
RCP8.5	Spring	136	110	147	185	119	160	205
	Summer	224	180	229	281	173	225	278
	Fall	202	170	216	263	174	222	276
	Winter	122	106	136	168	118	151	183
	Annual	**684**	**637**	**728**	**814**	**665**	**758**	**853**

*Province-wide data not available for SSP5-8.5 – see Data Collection section above for more information

East Gwillimbury

Precipitation across all seasons is projected to increase. Table 17 presents the precipitation accumulation projections for East Gwillimbury according to seasons under SSP2-4.5 and SSP5-8.5. Figure 5 presents the precipitation accumulation projections for East Gwillimbury from 2021 to 2050 and 2051 to 2080.

For East Gwillimbury, the baseline average annual precipitation is 795 millimetres. In a high-emission scenario, East Gwillimbury can expect to experience an average annual precipitation increase of 65 millimetres during 2021-2050 and 106 millimetres during 2051-2080.

Table 17: Projected Annual and Seasonal Precipitation (mm) by Season for East Gwillimbury– SSP2-4.5 and SSP5-8.5

Emissions Scenario	Time of Year	Baseline	2021-2050 (in mm)			2051-2080 (in mm)		
			Low	Mean	High	Low	Mean	High

[18] Zhang, P., Wiens, K., Wang, R., Luong, L., Ansara, D., Gower, S., Bassil, K. and Hwang, S. W. (2019). Cold Weather Conditions and Risk of Hypothermia Among People Experiencing Homelessness: Implications for Prevention Strategies. International Journal of Environmental Research and Public Health, 16(18), 3259. https://doi.org/10.3390/ijerph16183259

		1971-2000 (in mm)						
SSP2-4.5	Spring	199	198	214	233	208	224	239
	Summer	222	207	228	253	208	229	255
	Fall	220	211	230	240	291	239	251
	Winter	178	185	197	201	196	212	223
	Annual	**795**	**819**	**845**	**880**	**849**	**883**	**918**
SSP5-8.5	Spring	199	197	217	237	208	232	258
	Summer	222	198	232	254	187	229	257
	Fall	220	206	229	250	213	244	254
	Winter	178	185	204	214	199	217	225
	Annual	**795**	**808**	**860**	**905**	**846**	**901**	**942**

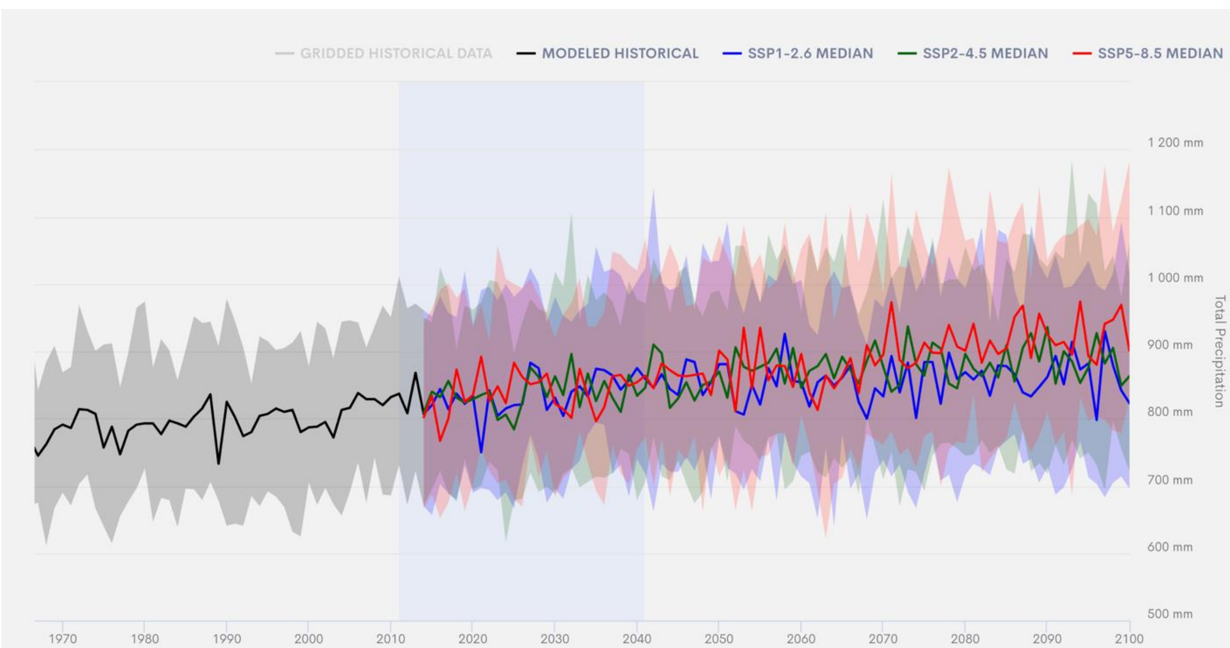

Figure 5: Projected Annual Precipitation for East Gwillimbury – SSP1-2.6, SSP2-4.5, and SSP5-8.5

Extreme Weather Events

Canada has seen more frequent and intense extreme weather events over the last 50-60 years than ever before. These events come in the form of extreme heat days, more instances of extreme precipitation and flooding, windstorms, wildfires, and snow or 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 (2019 dollars).[19] Extreme weather events will affect communities across Canada, from damage to infrastructure and critical services, to economic and industry productivity, and the health of our communities, with an increased risk to vulnerable populations.[20]

With an increase in frequency and severity of extreme weather events, Ontario will be faced with extreme weather changes and health risks. Increased annual precipitations levels and extreme precipitation events will likely lead to increased flooding concerns for East Gwillimbury.

Heavy or Extreme Precipitation

The projections of several extreme precipitation indices are presented in this section. Heavy Precipitation Days (both 10mm and 20mm) are days on which at least a total of 10mm or 20mm of rain or frozen precipitation falls.

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.

Table 18 shows the projected Heavy Precipitation Days (both 10mm and 20mm), as well as the Max 1-Day Precipitation for East Gwillimbury.

Table 18: Extreme Precipitation Indices for East Gwillimbury – SSP2-4.5 and SSP5-8.5

Variable	Emissions Scenario	Baseline 1971-2000	2021-2050			2051-2080		
			Low	Mean	High	Low	Mean	High
Wet Days (>=10mm)	**SSP2-4.5**	22	24	25	26	24	26	28
	SSP5-8.5	22	23	25	27	24	27	29
Wet Days (>=20mm)	**SSP2-4.5**	6	6	6	7	6	7	8
	SSP5-8.5	6	6	7	8	7	8	8
Max 1-Day Precipitation (mm)	**SSP2-4.5**	39	40	43	46	42	46	49
	SSP5-8.5	39	40	44	49	42	46	50

Heavy Precipitation Days in East Gwillimbury are expected to increase slightly for both 10mm days and 20mm days according to SSP5-8.5 in both the near-term future and long-term future. Maximum 1-Day events are also expected to increase from a baseline of 39 days to 45 days by 2021-2050 and 46 days by 2051-2080 for SSP5-8.5.

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[19] Boyd, R. and Markandya, A. (2021): Costs and Benefits of Climate Change Impacts and Adaptation; Chapter 6 in Canada in a Changing Climate: National Issues Report, (Eds.) F.J. Warren and N. Lulham; Government of Canada, Ottawa, Ontario.

[20] Feltmate, B. and M. Moudrak. 2021. Climate Change and the Preparedness of 16 Major Canadian Cities to Limit Flood Risk. Intact Centre on Climate Adaptation, University of Waterloo

Intensity-Duration-Frequency

Intensity-duration-frequency (IDF) curves represent one way to analyze and predict heavy precipitation under a changing climate. They provide a 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 IDF curve.[21]

IDF curves based on historical observations alone are inappropriate for long-term decision-making. To account for climate change impacts to extreme rainfall and IDF curves, Environment and Climate Change Canada (ECCC) recommends use of a scaling methodology. Climatedata.ca provides historical and climate change-scaled IDF data for all ECCC IDF stations in Canada.

The station selected to produce localized IDF data for East Gwillimbury was the "Oak Ridges, ON" station on Climatedata.ca. The baseline was calculated between 1974 and 2005. Projections are based on increases from the precipitation rate baseline, which is the average amount of precipitation in the years the station was active. Table 19 depicts the baseline precipitation intensity for East Gwillimbury.

Table 19: Baseline Precipitation Intensity Rates for East Gwillimbury (mm/h) (1974-2005)

Duration	1-in-2 year return period	1-in-5 year return period	1-in-10 year return period	1-in-25 year return period	1-in-50 year return period	1-in-100 year return period
5 min	104.5	133.8	153.2	177.7	195.9	213.9
10 min	77.8	106.9	126.1	150.4	168.4	186.3
15 min	64	90.2	107.6	129.5	145.7	161.9
30 min	40.6	58.7	70.7	85.8	97	108.1
1 h	23.9	34.6	41.7	50.7	57.4	64
2 h	13.9	19.1	22.6	26.9	30.2	33.4
6 h	6	8.6	10.2	12.4	13.9	15.5
12 h	3.5	4.8	5.6	6.7	7.4	8.2
24 h	2.1	2.8	3.3	4	4.4	4.9

Tables 20 and 21 below represents the change in IDF data under a high emissions scenario. The projections cover a near-term and long-term timeframe from 2021-2050 and 2051-2080. As seen below, the intensity of rainfall (mm/h) is projected to increase compared to the baseline, with more rain falling in shorter time periods. While longer, more frequent rainfall events will bring slightly higher amounts of rain, the intensity of rainfall during more infrequent, extreme storms is projected to increase. Furthermore, such heavy precipitation events are projected to become more common than they once

[21] IDF Curves 101. ClimateData.ca. Accessed from: https://climatedata.ca/interactive/idf-curves-101/

were, impacting stormwater systems and increasing the risk of flooding resulting in infrastructure damage and large recovery costs.

Table 20: Projected Precipitation Intensity Rates for East Gwillimbury (mm/h) 2021-2050 – SSP5-8.5

Duration	1-in-2 year return period	1-in-5 year return period	1-in-10 year return period	1-in-25 year return period	1-in-50 year return period	1-in-100 year return period
5 min	123	158	180	209	231	252
10 min	92	126	148	177	198	219
15 min	75	106	127	152	172	191
30 min	48	69	83	101	114	127
1 h	28	41	49	60	68	75
2 h	16	22	27	32	36	39
6 h	7.1	10	12	15	16	18
12 h	4.1	5.7	6.6	7.9	8.7	9.7
24 h	2.5	3.3	3.9	4.7	5.2	5.8

Table 21: Projected Precipitation Intensity Rates for East Gwillimbury (mm/h) 2051-2080– SSP5-8.5

Duration	1-in-2 year return period	1-in-5 year return period	1-in-10 year return period	1-in-25 year return period	1-in-50 year return period	1-in-100 year return period
5 min	142	182	208	241	266	290
10 min	106	145	171	204	229	253
15 min	87	122	146	176	198	220
30 min	55	80	96	116	132	147
1 h	32	47	57	69	78	87
2 h	19	26	31	37	41	45
6 h	8.1	12	14	17	19	21
12 h	4.8	6.5	7.6	9.1	10	11
24 h	2.9	3.8	4.5	5.4	6	6.7

Conclusion

The information provided in this report provides a clear indication that climate change is affecting Canada, Ontario, and the Town of East Gwillimbury. Rising temperatures, changes in precipitation, and an increase in extreme events are major climate impacts that will have potential ecological, infrastructural, economic and sociological implications for the community.

The future climate projections for the Town of East Gwillimbury 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 on vulnerable populations. Moreover, 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 East Gwillimbury.

This report is meant to provide a background and introduction to climate change in this area. Additional research is recommended to obtain more precise downscaled climate projections where appropriate.