Sunshine Coast Regional District

CLIMATE SCIENCE REPORT

December 2021

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Glossary of Terms

Definitions have been taken from the Intergovernmental Panel on Climate Change (IPCC) (http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr_appendix.pdf), and Environment Canada (http://www.ec.gc.ca/ges-ghg/default.asp?lang=En&n=B710AE51-1).

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 Change Atlas of Canada

The Climate Atlas of Canada is an interactive tool that combines climate science, mapping, and storytelling to depict expect climatic changes across Canada to the end of the century. The 250-layer map is based on data from 12 global climate models. Users are shown a baseline period of warming trends by region that spans from 1950 to 2005 and can toggle between two future projection periods, 2021 to 2050 and 2051 to 2080.

Climate Change Data and Scenarios Tool

The Canadian Climate Data and Scenarios (CCDS) site was originally launched in February 2005 with support from Environment and Climate Change Canada the Climate Change Adaptation Fund (CCAF) and the University of Regina. The CCDS supports climate change impact and adaptation research in Canada through the provision of climate model and observational data.

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.

Computerized Tool for the Development of Intensity-Duration-Frequency Curves Under Climate Change Version 3.0

The IDF_CC tool is designed as a simple and generic decision support system to generate local IDF curve information that accounts for the possible impacts of climate change. It applies a user-friendly GIS interface and provides precipitation accumulation depths for a variety of return periods and durations and allows users to generate IDF curve information based on historical data, as well as future climate conditions that can inform infrastructure decisions.

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 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 (GCM)

General Circulation Models are 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

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.

Heavy Rainfall

Heavy rainfall is defined as rainfall that is greater or equal to 50mm an hour or is greater than or equal to 75mm of rain in three hours.

Hot Days

A hot day occurs when temperatures meet or exceed 30°C.

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.

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.

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 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 the Sunshine Coast Regional District. Each indicator is discussed in more detail in their respective sections below.

Table 1: Climate Indices Definitions

Climatic Driver	Climate Indicator	Description	Units
Temperature	Mean Temperature	The average temperature of the season (or annually).	ºC
	Mean Seasonal Maximum Temperature	The average monthly maximum temperature.	ºC
	Mean Seasonal Minimum Temperature	The average monthly minimum temperature.	ºC
	Very Hot Days (+30ºC)	A Very 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

	Number of Heat Waves	The average number of heat waves per year. A heat wave occurs when at least three days in a row reach or exceed 30°C.	Number of heatwaves
	Average Length of Heat Waves	The average length of a heat wave. A heat wave occurs when at least three days in a row reach or exceed 30°C.	Days
Cold Temperature	Freeze-Thaw Cycles	This is a simple count of days when the air temperature fluctuates between freezing and non-freezing temperatures.	Days
	Frost Days	A frost day is one on which the coldest temperature of the day is lower than 0°C.	Days
	Icing Days	An Icing Day is a day on which the air temperature does not go above freezing (0°C).	Days
	Mild Winter Days (-5ºC)	A Winter Day is a day when the temperature drops to at least -15°C.	Days
Precipitation	Total Precipitation	The total amount of rain, drizzle, snow, sleet, etc. Frozen precipitation is measured according to its liquid equivalent: 10 cm of snow is usually about 10 mm of precipitation.	mm
	Mean Precipitation	The average precipitation for a given season (or annually)	mm
	Heavy Precipitation Days (10mm)	A Heavy Precipitation Day (10 mm) 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 (20 mm) is a day on which at least a total of 20 mm 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
	Max 5-day Precipitation (mm)	The wettest five-day period.	mm
	Precipitation intensity rate	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
Extreme Weather Events	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

Sea-Level Rise	Sea-Level Rise	Centimetres of relative sea-level rise (both median and 95th percentile values)	cm

Introduction

Climate change is an increasingly critical issue at the national and local level. Recent events in British Columbia and the SCRD, including sea-level rise, coastal flooding, and other occurrences of extreme weather over the past months and in the last several decades, have highlighted the need to be prepared for ongoing challenges. The BARC Program is designed to assist municipalities in understanding community climate impacts and developing plans and actions to address priority risks. This report will primarily focus on changes in temperature, precipitation patterns, and sea level rise (SLR) which will affect the social, natural, built, and economic systems in the District at the community level. The regional projections will allow for exploration of climate change impacts, and will illuminate the realities of Canadian climate change more generally.

The information included in this report will develop a basis for a deeper and more thorough exploration of climate change impacts in the District and will illuminate the realities of Canadian climate change more generally. In most cases, data was retrieved from weather stations located within Sechelt Region.

Data Collection

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

- Climate Change Data and Scenarios Tool - http://climate-scenarios.canada.ca
- Climate Atlas of Canada Tool - https://climateatlas.ca/
- Computerized Tool for the Development of Intensity-Duration-Frequency Curves under Climate Change Version 3.0 - http://www.idf-cc-uwo.ca/home

Other information pertaining to expected climatic changes in British Columbia were taken from various academic or government reports. These are identified and cited where applicable.

Climate Change Modelling and Downscaling

The data presented in this report is based on global climate models (GCM's) and emission scenarios defined by the Intergovernmental Panel on Climate Change (IPCC), drawing from both the Fourth Assessment Report (AR4) and Fifth Assessment Report (AR5) publications. Data projecting temperature and precipitation changes have been constructed using Environment Canada's Canadian Climate Data and Scenarios (CCDS) tool, the Climate Atlas, and the Institute for Catastrophic Loss Reduction's *Intensity-Duration-Frequency Climate Change Tool.*

Many different methods exist to construct climate change scenarios, however global climate models are the most conclusive tools available for simulating responses to increasing greenhouse gas concentrations, as they are based on mathematical representations of atmosphere, ocean, ice cap, and land surface processes.[i]

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. In cases where an ensemble approach was unavailable, this report uses the CGCM3T47 model, which is the third version of the Canadian Centre for Climate Modelling and Analysis' (CCCma) Coupled Global Climate Model. This model has a well-established track record for simulating current and future climates, and has been used in all IPCC exercises pertaining to GCMs.[ii]

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 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 both the Fourth and the Fifth IPCC Assessments are considered.

2) RCP Scenarios - IPCC Fifth Assessment Report (AR5)

Representative Concentration Pathways (RCPs) are the most complete set of climate change scenarios that provide the basis for the Fifth Assessment report from the IPCC.[iii] These RCPs have replaced the Special Report on Emissions Scenarios (SRES) in order to be more consistent with new data, new models, and updated climate research from around the world. The RCPs contain information regarding emission concentrations and land-use trajectories, and are meant to be representative of the current literature on emissions and concentration of greenhouse gases. The premise is that every radiative forcing pathway (see Glossary) can result from a diverse range of socioeconomic and technological development scenarios.[iv] They are identified by their approximate total radiative forcing in the year 2100 relative to 1750, and are labeled as RCP 2.6, 4.5, 6.0 and 8.5. These four RCPs include one mitigation scenario leading to a very low forcing level (RCP2.6), two stabilization scenarios (RCP4.5 and RCP6.0), and one scenario with continued rising greenhouse gas concentrations (RCP8.5).[v] The RCPs also consider the presence of 21st century climate policies, as compared with the no-climate policy assumption of the SRESs in the Third and Fourth Assessment Reports.[vi]

For this report, projections will use both RCP4.5 and RCP8.5, as they represent a carbon reduced future, and a ‘business as usual’ pathway with emissions continuing to increase unabated. If current emissions trends continue, the higher emissions scenarios and associated temperature increases will likely apply. 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 provides a description of each RCP scenario, while Figure 1 illustrates the projected global warming associated with the four scenarios.

* The IPCC's Sixth Assessment Report (AR6) was published on August 9th of 2021. Due to the novelty of the AR6, the models, tools and research repositories used to develop this locally specific climate science report have not yet had the opportunity to integrate the findings and techniques featured in the AR6. Of most notable difference within AR6 is the adoption of Shared Socioeconomic Pathways (SSPs) in place of AR5's use of Representative Concentration Pathways.[vii] SSPs "cover a broader range of greenhouse gas and air pollutant futures" than earlier reports which better capture variations in pollution control and mitigation stringency.[viii]

Table 2: IPCC Fifth Assessment Report Climate Change Scenario Characteristics

Scenario	Description	
RCP4.5	Moderate projected GHG concentrations, resulting from substantial climate change mitigation measures. It represents an increase of 4.5 W/m^2 in radiative forcing to the climate system. • RCP 4.5 is associated with 580-720ppm of CO_2 and would more than likely lead to 3°C of warming by the end of the 21st century.	Overshoot*
RCP6.0	Moderate projected GHG concentrations, resulting from some climate change mitigation measures. It represents an increase of 6.0 W/m^2 in radiative forcing to the climate system. • RCP 6.0 is associated with 720-1000ppm of CO_2 and would likely lead to 4°C of warming by the end of the 21st century.	Overshoot*
RCP8.5	Highest projected GHG concentrations, resulting from business-as-usual emissions. It represents an increase of 8.5 W/m^2 in radiative forcing to the climate system. • RCP 8.5 is associated with >1000ppm of CO_2 and would more than likely lead to warming greater than 4°C by the end of the 21st century.	Rising

***** The term 'overshoot' refers to scenarios in which the international goal of limiting global warming to 2°C by the end of the century, as set out by the UNFCCC in the Paris Agreement, is not met[ix].

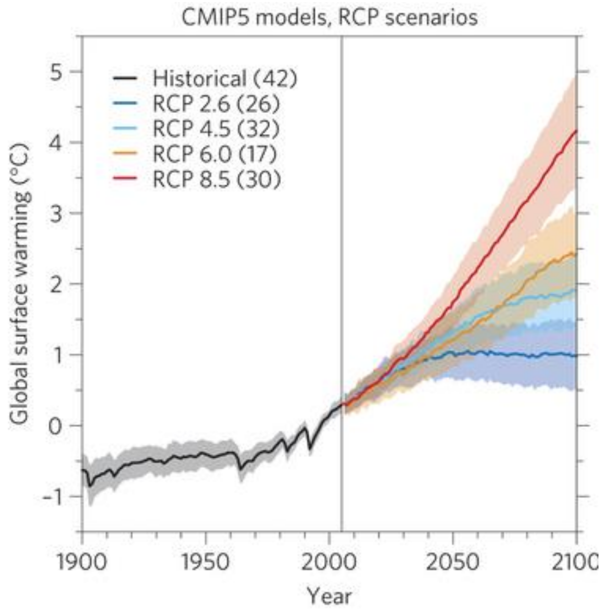

Figure 1: Projected Global Warming for CMIP5 RCP Scenarios

Time Periods

Climatic projections are typically provided within time periods of 20-30 years. Additionally, a consistent baseline period is established so that projections can be accurately compared with historical trends. In this report, the time periods of 2021-2050 and 2051-2080 are used most frequently. In some cases, timeframes are divided into three: "2020s" (2016-2035); "2050s" (2046-2065); and "2080s" (2081-2100). Many climate indices are also divided into seasonal periods, defined below.

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 climactic 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 (GHG), particulates, and other pollutants.

Temperature

British Columbia

Over the last six decades, Canada has become warmer, with average temperatures over land increasing by 1.5°C between 1950 and 2010.[x] This rate of warming is almost double the global average reported over the same period.[xi] Assuming emissions continue at the current rate of global output, the Province of British Columbia could experience an average annual temperature rise of approximately 3.9°C by the end of the century.

Table 4 displays the expected seasonal temperature change in British Colombia based on the IPCC Fifth Assessment Report (AR5). An ensemble of global climate models was used, and the high emissions scenario was selected because if current emissions trends continue, RCP8.5 and associated temperature increases will likely apply.

Table 4: Annual and Seasonal Temperature in British Columbia for RCP8.5

Emissions Scenarios	T Mean (°C)	Baseline (1976-2005)	2021-2050			2051-2080		
			Low	Mean	High	Low	Mean	High
RCP8.5	Spring	0.8	0.6	2.8	5.1	1.9	4.6	7.3
	Summer	11.7	12.2	13.8	15.3	13.9	15.9	18
	Fall	1.4	1.3	3.1	4.8	3.1	5.1	7
	Winter	-10.1	-11.3	-8	-5	-9.4	-6	-2.9
	Annual	**1**	**1.6**	**3**	**4.4**	**3.1**	**4.9**	**6.7**

Sunshine Coast Regional District

Temperatures in the Sunshine Coast Regional District are expected to rise in congruence with the provincial changes observed in the data above. The Climate Atlas of Canada tool was used to collect downscaled climate projections, using a baseline of 1976-2005. Within the tool, the Town of Sechelt data point was selected to collect this information, as it was the best available area with long-range observed historical data and future climate projections for the District.
In the SCRD there is a projected annual temperature increase between 2.7°C in the immediate future and 3.5°C by 2080 from the baseline mean under scenario RCP 8.5. Table 5 and Figure 2 depict the projected temperatures using an ensemble of global climate models applying RCP 4.5 and RCP8.5 scenarios.

Table 5: Projected Mean Temperatures for Sunshine Coast Regional District (°C) by Season – RCP4.5 and 8.5

Emissions Scenarios	T Mean (°C)	Baseline (1976-2005)	2021-2050			2051-2080		
			Low	Mean	High	Low	Mean	High
RCP4.5	Spring	8.5	8.4	10	11.5	9.3	10.8	12.6
	Summer	16.3	16.7	18	19.3	17.3	19	20.6
	Fall	9.7	9.9	11.1	12.3	10.6	11.9	13.2
	Winter	3.4	3	4.7	6.3	4.1	5.8	7.3
	Annual	**9.5**	**10**	**11**	**11.9**	**10.8**	**11.9**	**13**
RCP8.5	Spring	8.5	8.6	10.2	11.9	9.9	11.7	13.8
	Summer	16.3	16.9	18.3	19.7	18.5	20.3	22.2
	Fall	9.8	10.1	11.3	12.5	11.5	13.1	14.7
	Winter	3.4	3.1	5.1	6.6	4.9	6.7	8.5
	Annual	**9.5**	**10.2**	**11.2**	**12.2**	**11.7**	**13**	**14.4**

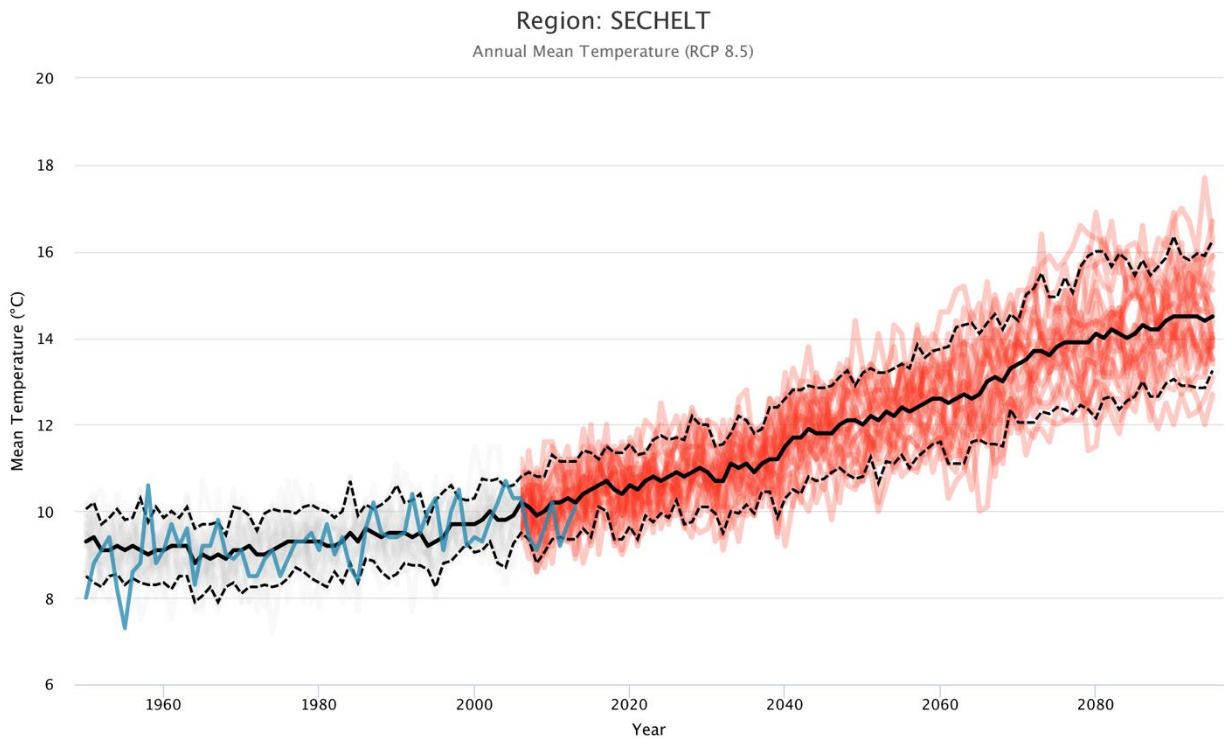

Figure 2: Projected Annual Mean Temperature Increase for the Sunshine Coast Regional District under RCP 8.5

Hot and Cold Days

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

In terms of minimum temperatures, the baseline mean minimum temperatures across each season were 4.5, 11.8, 6.4, and 0.9°C for spring, summer, fall and winter respectively. Minimum seasonal temperatures under an RCP8.5 scenario are projected to increase substantially, with an increase of 3.2°C in spring, 3.7°C in summer, 3.3°C in fall and 3.6°C in winter 2051-2080.

Table 6: Projected Average Seasonal Minimum Temperatures for Sunshine Coast Regional District – RCP4.5 and 8.5

Emissions Scenario	T Mean (°C)	Baseline (1976-2005)	2021-2050			2051-2080		
			Low	Mean	High	Low	Mean	High
RCP4.5	Spring	4.5	4.6	6.0	7.3	5.5	6.9	8.2
	Summer	11.8	12.2	13.3	14.5	12.8	14.2	15.7
	Fall	6.4	6.6	7.7	8.8	7.3	8.6	9.7
	Winter	0.9	0.5	2.4	4.0	1.8	3.5	5.0
	Annual	**5.9**	**6.4**	**7.4**	**8.3**	**7.3**	**8.3**	**9.3**
RCP8.5	Spring	4.5	4.8	6.2	7.6	6.1	7.7	9.3
	Summer	11.8	12.4	13.6	14.8	13.9	15.5	17.2
	Fall	6.4	6.9	8.0	9.1	8.3	9.7	11.2
	Winter	0.9	0.7	2.7	4.3	2.6	4.5	6.2
	Annual	**5.9**	**6.7**	**7.7**	**8.6**	**8.1**	**9.4**	**10.6**

In terms of Average Seasonal Maximum Temperatures, seasonal average baseline temperatures for the SCRD are 12.4, 20.8, 13.1, and 5.8˚C for spring, summer, fall and winter respectively. The SCRD will experience an increase in all seasonal maximum temperatures, with average summer maximum temperatures reaching 25˚C in the years 2051-2080 under RCP8.5. Average winter maximum temperatures will increase by 3.4˚C, and could reach nearly 10˚C annually by the end of century under RCP8.5

Table 7: Projected Average Seasonal Maximum Temperatures for Sunshine Coast Regional District – RCP4.5 and 8.5

Emissions Scenarios	T Mean (C˚)	Baseline (1976-2005)	2021-2050			2051-2080		
			Low	Mean	High	Low	Mean	High
RCP4.5	Spring	12.4	12.1	13.9	15.8	12.9	14.8	17.1
	Summer	20.8	21.0	22.7	24.4	21.6	23.8	25.8
	Fall	13.1	13.1	14.4	15.8	13.7	15.3	16.7

	Winter	5.8	5.4	7.1	8.7	6.4	8.1	9.7
	Annual	**13.1**	**13.6**	**14.6**	**15.6**	**14.2**	**15.5**	**16.8**
RCP8.5	Spring	12.4	12.2	14.2	16.3	13.5	15.7	18.5
	Summer	20.8	21.1	23.0	24.8	22.8	25.2	27.4
	Fall	13.1	13.3	14.7	16.1	14.7	16.5	18.3
	Winter	5.8	5.6	7.4	8.9	7.0	9.0	10.8
	Annual	**13.1**	**13.7**	**14.8**	**16.0**	**15.1**	**16.6**	**18.2**

For the District, the baseline Average Maximum Summer Temperature was 20.8°C. According to RCP8.5, the Average Warmest summer Maximum Temperature will increase to 23.0°C in the immediate future (2021-2050), and 25.2°C in the near future (2051-2080) according to the scenario mean. These temperatures do not factor in additional warming due to the humidex which could make it feel 5 to 10°C warmer. These extreme temperatures can cause heat-related illnesses in not only vulnerable populations but also healthy, young adults.

Days where the daily maximum temperatures exceed 30°C present the greatest threats to community health due to heat-related illnesses. Examples of these 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 planning outdoor sports or activities, and those with limited mobility may be more adversely affected.[xii] Moreover, while higher summer temperatures increase electricity demand for cooling, at the same time, it also can lower the ability of transmission lines to carry power, possibly leading to electricity reliability issues during heat waves.[xiii]

The baseline average number of days when the maximum temperature was greater than or equal to 30°C was 1.3 days for the SCRD. This is expected to increase to an average of 13.2 days in the 2051-2080 period under the RCP8.5 scenario. This means there will be about ten times more days above 30°C by 2080 in the District.

Table 8: Extreme Heat Days (Tmax ≥30°C) for the Sunshine Coast Regional District - RCP4.5 and 8.5

Emissions Scenario	Tmax (days)	Baseline 1976-2005	2021-2050			2051-2080		
			Low	Mean	High	Low	Mean	High
RCP4.5	30°C or more	1.3	0.0	3.9	10.7	0.4	7.3	17.0
RCP8.5	30°C or more	1.3	0.1	4.6	11.8	1.7	13.2	29.0

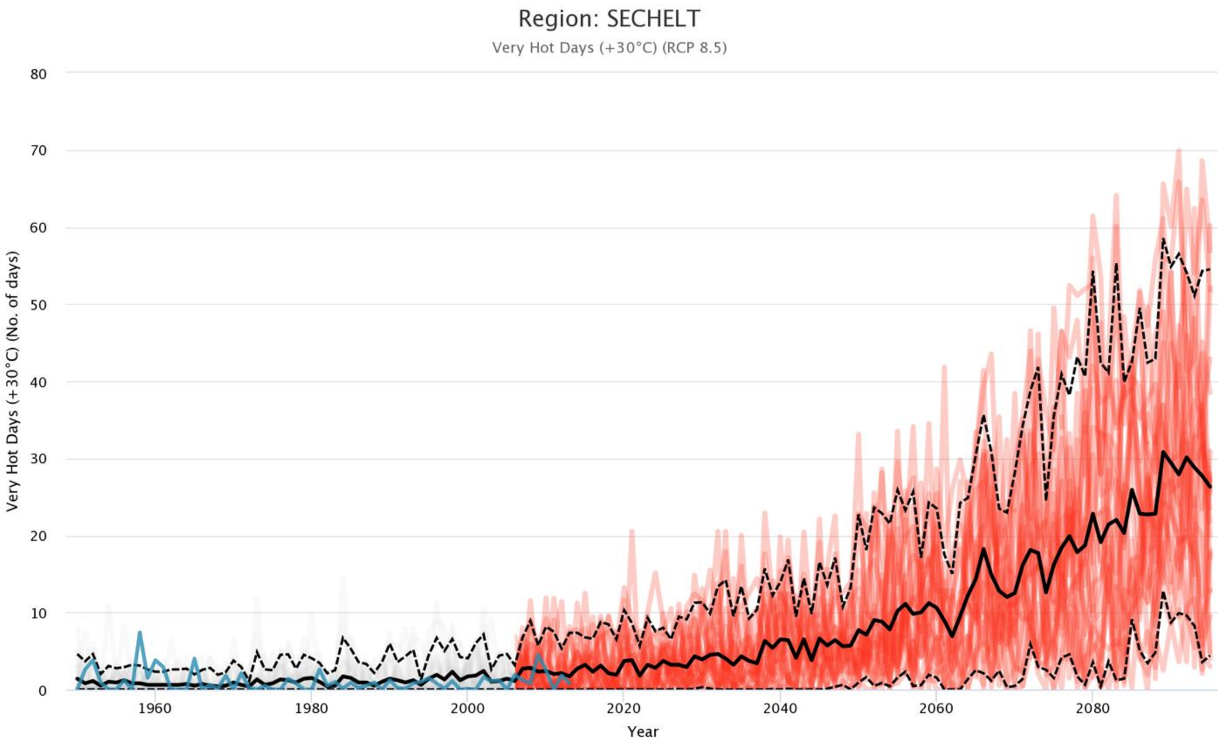

Figure 3: Projected Very Hot Days (30°C) for the Sunshine Coast Regional District under RCP8.5

The Climate Atlas of Canada defines a heat wave as three days in a row reach or exceed 30°C and considers two variables for heatwaves – the annual average length of heat waves, and the annual number of heat waves. The annual number of heatwave events measures the average number of times per year where the temperature reaches or exceeds 30°C. The baseline number of heat waves for the SCRD is 0.1, as presented in Table 9. In the 2051-2080 period according to RCP8.5, the SCRD can expect to experience nearly two heat wave events per year.

Table 9: Number of Annual Heat Waves for the Sunshine Coast Regional District - RCP4.5 and 8.5

Emissions Scenarios	Baseline (1976-2005)	2021-2050			2051-2080		
		Low	Mean	High	Low	Mean	High
RCP4.5	0.1	0.0	0.5	1.6	0.0	1.0	2.7
RCP8.5	0.1	0.0	0.6	1.8	0.1	1.8	3.9

With regards to the average length of heat waves (in days), the SCRD experienced an average of 0.5 days of heatwave conditions in the baseline period as displayed in Table 10. In the 2051-2080 period, according to RCP8.5, the District can expect to see an average heatwave event occurring for 3.9 days – over six times the current length.

Table 10: Average Annual Length of Heatwaves for the Sunshine Coast Regional District - RCP4.5 and 8.5

Emissions Scenarios	Baseline (1976-2005)	2021-2050			2051-2080		
		Low	Mean	High	Low	Mean	High
RCP4.5	0.5	0.0	1.5	4.6	0.0	2.7	6.5
RCP8.5	0.5	0.0	1.9	5.2	0.2	3.9	7.5

Overall, heatwave events are projected to occur more frequently and for longer periods of time. These changes become more pronounced as time goes on, and with regards to the higher emissions scenarios. Sustained over several days at a time, these extreme temperatures will have significant impacts on the health of individuals in the District – 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 in the outdoors[xiv].

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 are decreasing across Canada, and in the SCRD, while the number of hot days is increasing. However, it is important to know how our winters will change in the future, because cold temperatures affect health and safety, determine what plants and animals can live in the area, limit or enable outdoor activities, define how we design our buildings and vehicles, and shape our transportation and energy use.

Winter Days

Mild winter days, defined as a day where the temperature drops to at least -5°C, are projected to decrease in the District. In fact, by the end of the century the SCRD can expect to see less than two days a year where temperatures dip below -5°C (down from 7 at baseline).

Frost Days and Icing Days

Other indicators of cold temperatures are Frost Days and Icing Days - 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 an average of 37.3 days in the SCRD by the 2080s under RCP8.5.

Table 11: Projected Frost Days for the Sunshine Coast Regional District - RCP4.5 and 8.5

Emissions Scenarios	Baseline 1976-2005	2021-2050			2051-2080		
		Low	Mean	High	Low	Mean	High
RCP4.5	46.4	9.5	23.7	40.5	3.7	13.7	27.4
RCP8.5	46.4	7.3	20.7	38.4	1.3	9.1	20.5

Similarly, the number of ice days are projected to decrease. Ice days are the total number of days when the daily **maximum** temperature is at or below 0 °C. Icing Days are expected to decrease to nearly zero by the 2080s in RCP8.5.

Table 12: Projected Icing Days for the Sunshine Coast Regional District - RCP4.5 and 8.5

Emissions Scenarios	Baseline 1976-2005	2021-2050			2051-2080		
		Low	Mean	High	Low	Mean	High
RCP4.5	4.7	0.1	2.7	7.6	0.0	1.2	4.2
RCP8.5	4.7	0.0	2.1	6.9	0.0	0.9	3.2

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. The RCP8.5 scenario projects that freeze-thaw cycles will decrease due to overall warmer temperatures. This is likely due to the fact that overall, the days are getting warmer, and the District is expected to experience a decrease in the number of days that reach a minimum temperature below 0°C.

Under these conditions, it is likely that some water at the surface was both liquid and ice at some point during the 24-hour period.[xv] 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 SCRD is expected to experience less freeze-thaw cycles by the mid and end of century.

Table 13: Average Annual Freeze-Thaw Cycles for the Sunshine Coast Regional District - RCP4.5 and 8.5

Emissions Scenarios	Baseline 1976-2005	2021-2050			2051-2080		
		Low	Mean	High	Low	Mean	High
RCP4.5	26.7	4.6	13.3	24.0	1.5	7.7	16.0
RCP8.5	26.7	3.5	11.7	22.4	0.5	5.0	12.4

Agricultural Indices

Growing Season Start Date, End Date, and Length

Climate change creates both risks and opportunities for agriculture. 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 crops that can be grown now and in the future.[xvi] While increased temperatures will extend the growing season of some crops, it will bring with it 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 crop irrigation, improve conditions for some pests, and disrupt pollination patterns.[xvii] Managing for increased agricultural productivity and working to reduce risks under climate change will require careful consideration of changing weather and climate conditions, as well as key landscape and soil characteristics, crop suitability, farm management options, and policy and program support.[xviii]

Agricultural indices include the start and end of the growing season, as respectively defined by the last and first frosts, as well as the total length of the growing season. The RCP8.5 ensembles project earlier start dates and later end dates to the growing season in the SCRD as shown in Table 14. The baseline start date is typically around March 22nd, while the end date is typically November 19th, resulting in a growing season of approximately 238 days. According to the RCP8.5 ensemble, by the end of the 21st century, the growing season is projected to occur approximately 56 days earlier, while the end date will likely occur approximately 27 days later. This means, on average, the growing season will likely increase by nearly 3 months, following the high emissions scenario.

Table 14: Growing Season Length for the Sunshine Coast Regional District under RCP8.5

	RCP8.5		
	Mean Start date (Date of Last Spring Frost)	**Mean End date (Date of First Fall Frost)**	**Mean frost-free days**
1976-2005 (Baseline)	Mar. 22	Nov. 19	238.3
2021-2050	Feb. 17	Dec. 5	288.7
2051-2080	Jan. 25	Dec. 16	323.2

Precipitation

British Columbia

Canada has, on average, become wetter during the past half century, with average precipitation across the country increasing by approximately 20%. [xix] Although other parts of the country can expect to see a significant percentage increase in precipitation, particularly Northern Canada, projections for British Columbia show less dramatic changes to precipitation patterns.[xx] For information related to extreme weather events, please see the section on intensity-duration-frequency curves. Below are the projected precipitation changes for the province of British Columbia under the RCP8.5 scenario.

Table 15: Projected Annual Precipitation (mm) by Season for British Columbia – RCP8.5

Emissions Scenario	Total Precipitation (mm)	Baseline 1976-2005	2021-2050			2051-2080		
			Low	Mean	High	Low	Mean	High
RCP8.5	Spring	155	122	164	206	131	174	221
	Summer	192	148	198	248	144	198	255
	Fall	243	200	261	324	216	282	349
	Winter	247	191	263	339	205	283	360
	Annual	**837**	**768**	**886**	**1002**	**803**	**938**	**1063**

On a seasonal basis, in the SCRD, spring, winter and autumn precipitation accumulations are projected to increase by the end of the century with fall and winter experiencing the greatest increases. These seasonal trends, including decreasing summer rainfall amounts paired with the projected increases in summer temperatures and heatwave lengths may lead to increased instances of drought. Table 16 presents the precipitation accumulation projections for the District according to seasons under RCP4.5 and 8.5. Figure 4 presents the precipitation accumulation projections for SCRD according to RCP8.5.

For the SCRD, the baseline average annual precipitation is 1546 mm. In a high emission scenario, the District can expect to experience an average annual precipitation increase of 45mm during 2021-2050 and 121mm during 2051-2080.

Table 16: Projected Annual Precipitation (mm) by Season for the Sunshine Coast Regional District – RCP. 4.5 and 8.5

Emissions Scenario	Total Precipitation (mm)	Baseline 1976-2005	2021-2050			2051-2080		
			Low	Mean	High	Low	Mean	High
RCP4.5	Spring	313	203	321	456	207	328	467
	Summer	163	66	149	250	56	142	250
	Fall	472	305	497	691	301	499	700
	Winter	599	406	630	858	428	649	883
	Annual	**1546**	**1262**	**1591**	**1937**	**1277**	**1620**	**1988**
RCP8.5	Spring	313	199	323	464	206	330	471
	Summer	163	66	152	255	57	144	254
	Fall	472	298	484	695	316	518	739
	Winter	599	416	631	857	451	675	928
	Annual	**1546**	**1262**	**1591**	**1937**	**1288**	**1667**	**2065**

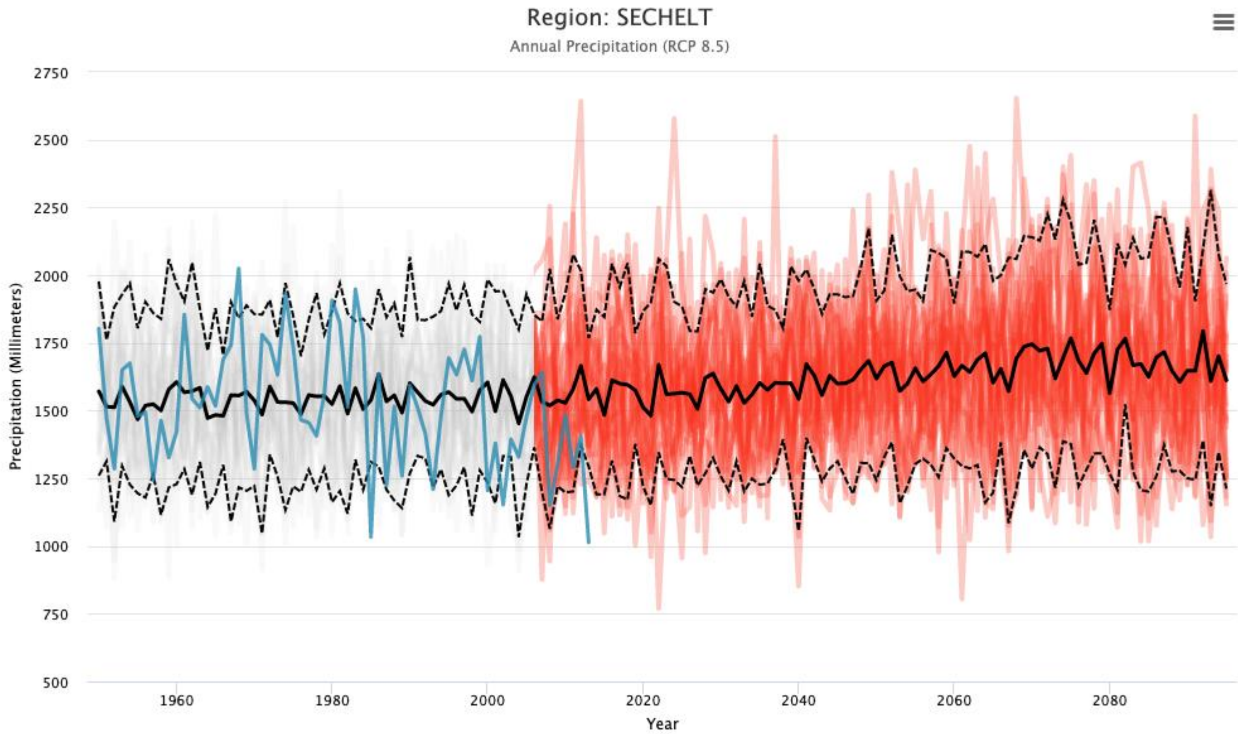

Figure 4: Projected Annual Precipitation for the Sunshine Coast Regional District under RCP8.5

Extreme Weather Events

Canada has seen more frequent and intense extreme 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 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.[xxi] The likelihood and the severity of these events are increasing with climate change and are expected to cause hundreds of trillions of dollars in economic damage globally.[xxii] Extreme weather events will affect communities across Canada, from damage to infrastructure and critical services, to economic and industry productivity, and the health of vulnerable populations, as the recent 'atmospheric river' event has demonstrated.[xxiii] 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.[xxiv]

Heavy or Extreme Precipitation

Extreme and heavy rain events are expected to become more intense and more frequent. The SCRD has experienced catastrophic flooding in the past month, and with projected increases in annual precipitation there is the potential of increased flood risk and high intensity storms.[xxv]

The projections of several extreme precipitation indices are presented in this section. Heavy Precipitation Days (both 10 mm and 20 mm) 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 rain.[xxvi]

Max 1-Day precipitation and Max-5 Day precipitation indicate the amount of precipitation that falls on the wettest day of the year, and the five wettest days of the year respectively. 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 17 shows the projected Heavy Precipitation Days (both 10 mm and 20 mm), as well as the Max 1-Day and 5-Day Precipitation for the SCRD.

Table 17: Extreme Precipitation Indices for the Sunshine Coast Regional District - RCP4.5 and 8.5

Variable	Emissions Scenario	Baseline 1976-2005	2021-2050			2051-2080		
			Low	Mean	High	Low	Mean	High
Heavy precipitation Day (10 mm)	RCP4.5	53.5	41.9	55.1	68.7	42.5	55.9	70.0
	RCP8.5	53.5	41.8	54.9	68.4	42.8	57.2	72.4
Heavy precipitation Day (20 mm)	RCP4.5	17.8	12.3	19.4	27.0	13.3	20.4	28.2
	RCP8.5	17.8	12.5	19.3	26.3	14.0	21.5	29.7
Max 1-Day Precipitation (mm)	RCP4.5	53	40	57	77	41	58	78
	RCP8.5	53	39	57	78	42	60	82
Max 5-Day Precipitation (mm)	RCP4.5	115	87	120	162	90	125	166
	RCP8.5	115	87	121	164	93	130	179

Across the District, heavy precipitation days are expected to increase by 3.7 days for 10 mm days and 3.7 days for 20 mm days according to RCP8.5 by 2051-2080. Maximum 1-Day and 5-day events are also expected to increase across the District, with the greatest increase in 5-day events. For example, Max 5-Day events are projected to increase from a baseline of 115 mm to 130 mm by 2051-2080 for RCP8.5.

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. 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.

The Institute for Catastrophic Loss Reduction (ICLR) has developed a tool that assists users in developing and updating IDF curves using precipitation data from existing Environment Canada hydro-meteorological stations. Available precipitation data is integrated with predictions obtained from Global climate models to assess the impacts of climate change on IDF curves.[xxvii]

Global climate models and scenarios developed for the IPCC Fifth Assessment Report (AR5) are used to provide future climate projections.

The station selected to produce localized IDF curves for the SCRD was the SECHELT AUT meteorological station due to its proximity to the District and data availability. Projections are based on increases from the precipitation rate baseline, which is the average amount of precipitation in the years the station was active. For the SECHELT AUT station, this baseline was calculated between 1983-2017. Table 18 and Figure 5 depict baseline precipitation intensity for the District.

Table 18: Baseline Precipitation Intensity Rates for the Sunshine Coast Regional District (mm/h) (1965-2004)

T (years)	2	5	10	20	25	50	100
1 h	10.29	12.92	14.75	16.58	17.17	19.04	20.97
2 h	7.16	9.11	10.59	12.16	12.70	14.46	16.39
6 h	4.28	5.07	5.46	5.75	5.83	6.04	6.21
12 h	2.97	3.58	3.92	4.21	4.29	4.54	4.75
24 h	2.15	2.65	2.92	3.15	3.22	3.40	3.55

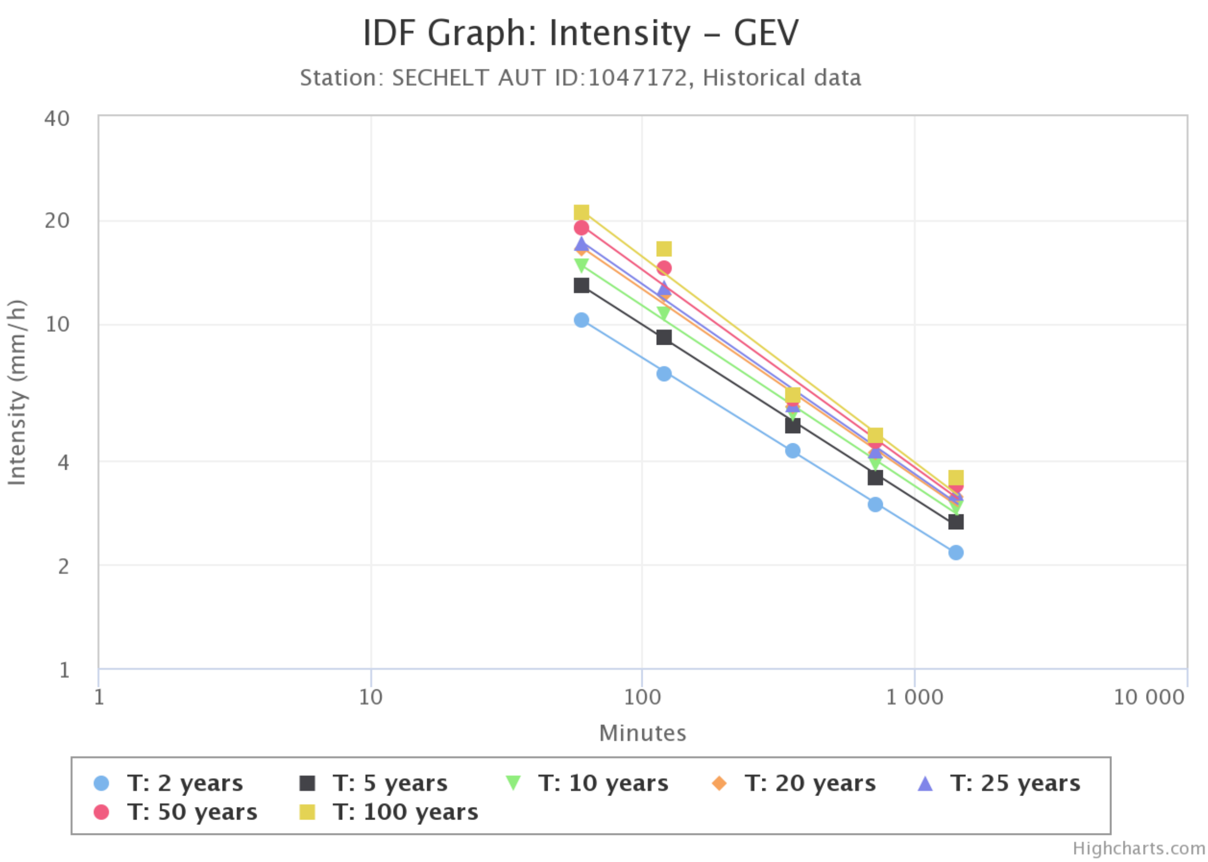

Figure 5: Baseline Precipitation Intensity Rates for the Sunshine Coast Regional District (mm/h)

Table 19 and Figure 6 below represent the change in IDF curves under a high emissions scenario. The projections cover an 85-year range from 2015-2100. As seen in the graphs, 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 100-year storms) is projected to significantly increase.

Table 19: Projected Precipitation Intensity Rates (mm/h) for the Sunshine Coast Regional District

T (years)	2	5	10	20	25	50	100
1 h	11.35	14.33	16.65	19.11	19.99	22.66	25.21
2 h	7.89	10.09	11.90	13.98	14.74	17.14	19.95
6 h	4.73	5.68	6.21	6.65	6.77	7.11	7.34
12 h	3.28	3.99	4.44	4.87	5.00	5.37	5.65
24 h	2.38	2.96	3.32	3.64	3.74	4.01	4.22

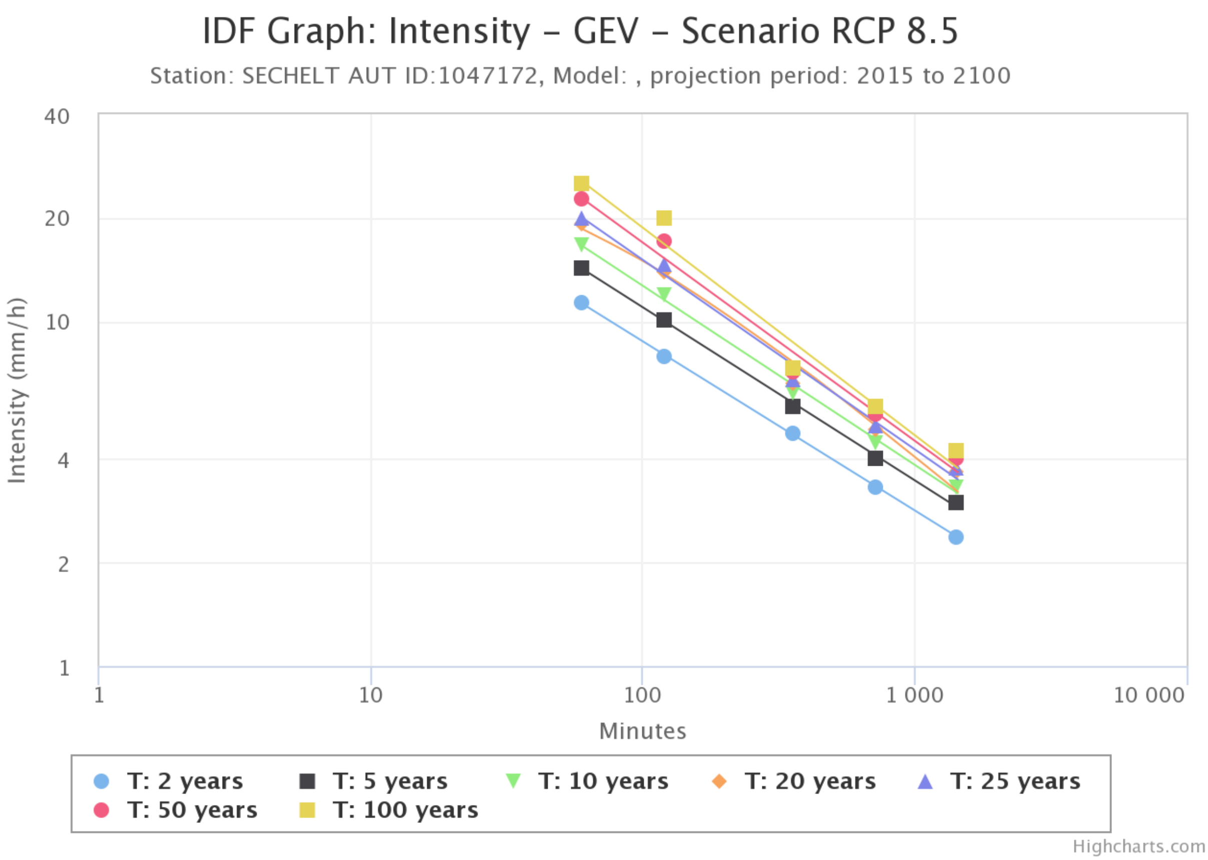

Figure 6: Projected Precipitation Intensity Rates (mm/h) for the Sunshine Coast Regional District

Sea-level Rise

Sea levels vary widely depending on many temporal, atmospheric, and oceanographic factors. Climate variabilities such as El Niño/La Niña Southern Oscillation contribute to extreme water levels, temperatures, and storm surge flooding. Climate change impacts such as melting glaciers, warmer temperatures (thermal expansion), changes in salinity, and land water storage changes have also contributed to changing sea levels. Between 1901-1990, the trend of global mean sea-level rise (GMSL) was on average 1.4mm/year, and increased to 3.6mm/year from 2006-2015.[xxviii] This is expected to rapidly increase. The IPCC projects a range of global sea-level rise of 0.61-1.10m by the year 2100, based on RCP8.5 emissions scenarios.[xxix]

On the British Columbia coast, the projected amount of sea level rise is not uniform. The most drastic sea level rise is projected to occur on the Fraser Lowland, southern Vancouver Island, and the north coast.[xxxxxxi] Guidance from the province is to plan for 0.5m of SLR by 2050, 1m of SLR by 2100 and 2m of SLR by 2200 (see Figure 7). This direction was first drafted in 2011 and updated in the Flood Hazard Area Land Use Management Guidelines (S.3.5 and 3.6) that came into effect in January 2018, along with two options on methodologies for setting flood construction levels (FCL).[xxxii]

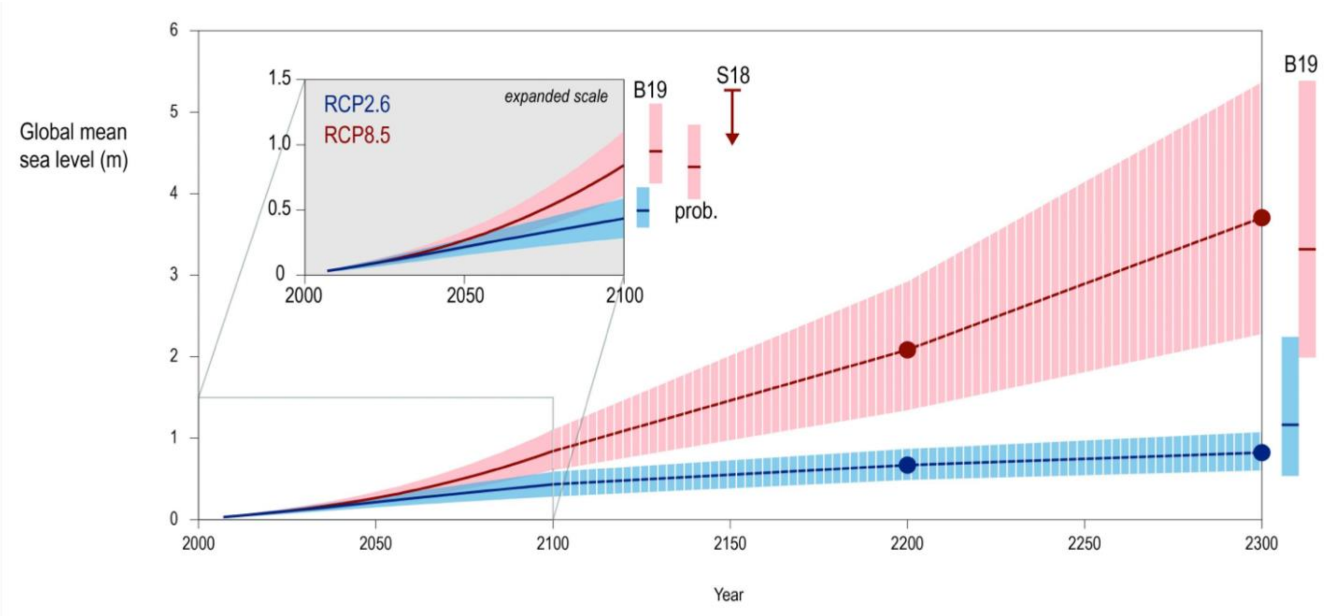

Figure 7: Projected sea level rise (SLR) until 2300.

In addition to GMSL, extreme sea level (ESL) events; caused by tides, surges, and waves, that are rare today will become more frequent in the future.[xxxiii] The combination of GMSL and ESL will increase what were historically 100-year events into potentially yearly events by the middle of the century, including low-lying coasts that experience surges infrequently.[xxxiv]

Conclusion

The information provided in this report provides a clear indication that climate change is affecting Canada, and specifically the SCRD. Rising annual temperatures as well as increases in precipitation and extreme events are major climate impacts that can have tremendous ecological, infrastructural, economic, and sociological effects for the community. This report is meant to act as a background and an introduction to climate change in the district, and additional research should be conducted to retrieve more precise downscaled climate projections where available.

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