# Capital Regional District

625 Fisgard St.,
Victoria, BC V8W 1R7

## Notice of Meeting and Meeting Agenda
## Electoral Areas Committee

**Wednesday, June 12, 2024** | **11:00 AM** | **6th Floor Boardroom, 625 Fisgard St., Victoria, BC V8W 1R7**

P. Brent (Chair), G. Holman (Vice Chair), A. Wickheim, C. Plant (Board Chair, ex-officio)

The Capital Regional District strives to be a place where inclusion is paramount and all people are treated with dignity. We pledge to make our meetings a place where all feel welcome and respected.

### 1. Territorial Acknowledgement

### 2. Approval of Agenda

### 3. Adoption of Minutes

**3.1.** 24-535 Minutes of the May 8, 2024 Electoral Areas Committee Meeting

***Recommendation:*** That the minutes of the Electoral Areas Committee meeting of May 8, 2024 be adopted as circulated.

***Attachments:*** Minutes - May 8, 2024

### 4. Chair's Remarks

### 5. Presentations/Delegations

*The public are welcome to attend CRD Board meetings in-person.*

*Delegations will have the option to participate electronically. Please complete the online application at www.crd.bc.ca/address no later than 4:30 pm two days before the meeting and staff will respond with details.*

*Alternatively, you may email your comments on an agenda item to the CRD Board at crdboard@crd.bc.ca.*

### 6. Committee Business

**6.1.** 24-245 Climate Projections for the Capital Region

***Recommendation:*** [At the April 10, 2024 CRD Board meeting, the recommendation was carried to refer the Climate Projections for the Capital Region (2024) report to the Electoral Areas Committee for information.
Please note, following the March 20, 2024 Environmental Services Committee meeting, a revised Appendix A was attached to update climate projection figures. A redlined copy of the changes is provided in the attached Supplemental.]
There is no recommendation. This report is for information only.

***Attachments:***
Staff Report: Climate Projections for the Capital Region
Appendix A (Revised): Climate Projections for the Capital Region Report - 2024
Appendix A: Climate Projections for the Capital Region Report - 2024 - PCIC
Supplemental: Revisions to Climate Projections (April 2024)
Presentation: Climate Projections for the Capital Region (2024)

**6.2.** 24-244 Extreme Heat Vulnerability Mapping and Information Portal Project

***Recommendation:*** [At the April 10, 2024 CRD Board meeting, the recommendation was carried to refer the Extreme Heat Vulnerability Mapping and Information Portal project for the capital region to the Electoral Areas Committee for information.]
There is no recommendation. This report is for information only.

***Attachments:***
Staff Report: Extreme Heat Vulnerability Mapping & Info Portal Project
Appendix A: Heat Vulnerability & Analysis Project Final Report

**6.3.** 24-525 Community Resiliency Initiative Grant: 2024 FireSmart Community Funding & Supports

***Recommendation:*** The Electoral Areas Committee recommends to the Capital Regional District Board:
That the Capital Regional District Board support an application to the Union of British Columbia Municipalities Community Resiliency Initiative Fund for the 2024 FireSmart Community Funding and Supports. Staff are directed to apply for, negotiate, and if successful, enter into an agreement, and do all such things necessary for accepting grant funds and overseeing grant management for the proposed projects.
(NWA)

***Attachments:***
Staff Report: Community Resiliency Initiative Grant - 2024 FireSmart
Appendix A: 2024 FireSmart Comm'ty Funding & Supports Grant App

**6.4.** 24-526 Appointment of Officers

***Recommendation:*** The Electoral Areas Committee recommends to the Capital Regional District Board:
That for the purpose of Section 233 of the Local Government Act and Section 28(3) of the Offence Act and in accordance with Capital Regional District Bylaw No. 2681, Gray Wardle, Rachelle Norris-Jones, Levi Holland, and Michael Riggs be appointed as Bylaw Enforcement Officers.
(NWA)

***Attachments:***
Staff Report: Appointment of Officers

**6.5.** 24-524 Previous Minutes of Other CRD Committees and Commissions for Information

***Recommendation:*** There is no recommendation. The following minutes are for information only:
a) Mayne Island Parks and Recreation Commission minutes of April 11, 2024
b) Pender Island Parks and Recreation Commission minutes of April 8, 2024
c) Southern Gulf Islands Electoral Area Community Economic Sustainability Commission minutes of January 16, 2024
d) Southern Gulf Islands Electoral Area Community Economic Sustainability Commission minutes of February 6, 2024
e) Willis Point Fire Protection and Recreation Facilities Commission minutes of April 23, 2024

***Attachments:*** Minutes: Mayne Island Parks & Rec Commission - Apr 11, 2024
Minutes: Pender Island Parks & Rec Commission - Apr 8, 2024
Minutes: SGIEA CESC - Jan 16, 2024
Minutes: SGIEA CESC - Feb 6, 2024
Minutes: Willis Pt Fire Prot'n & Rec Fac's Comm'n - Apr 23, 2024

## 7. Notice(s) of Motion

## 8. New Business

## 9. Adjournment

The next meeting is July 10, 2024.

To ensure quorum, please advise Jessica Dorman (jdorman@crd.bc.ca) if you or your alternate cannot attend.

# Capital Regional District

625 Fisgard St.,
Victoria, BC V8W 1R7

## Meeting Minutes

## Electoral Areas Committee

**Wednesday, May 8, 2024** | **9:15 AM** | **6th Floor Boardroom, 625 Fisgard St., Victoria, BC V8W 1R7**

PRESENT
Directors: P. Brent (Chair) (9:45 am), G. Holman (Vice Chair), A. Wickheim

Staff: T. Robbins, Chief Administrative Officer; K. Lorette, General Manager, Planning and Protective Services; K. Morley, General Manager, Corporate Services; S. Carby, Senior Manager, Protective Services; S. Henderson, Senior Manager, Real Estate and Southern Gulf Islands Administration; C. Anderson, Manager, Emergency Programs; J. Starke, Manager, Service Delivery, Southern Gulf Islands Electoral Areas; C. Vrabel. Manager, Fire Services; M. Lagoa, Deputy Corporate Officer; T. Pillipow, Committee Clerk (Recorder)

Guest: Director M. Little

Regrets: Director C. Plant

The meeting was called to order at 9:20 am by Vice Chair Holman.

### 1. Territorial Acknowledgement

Director Wickheim provided a Territorial Acknowledgement.

### 2. Approval of Agenda

**MOVED by Director Wickheim, SECONDED by Director Holman,**
**That the agenda for the May 8, 2024 Electoral Areas Committee meeting be approved.**
**CARRIED**

### 3. Adoption of Minutes

**3.1.** 24-454 Minutes of the April 10, 2024 Electoral Areas Committee Meeting

**MOVED by Director Wickheim, SECONDED by Director Holman,**
**That the minutes of the Electoral Areas Committee meeting of April 10, 2024 be adopted as circulated.**
**CARRIED**

### 4. Chair’s Remarks

There were no Chair's remarks.

## 5. Presentations/Delegations

There were no presentations or delegations.

## 6. Committee Business

**6.1.** [24-150] Bylaw No. 4592 to Expand Otter Point Fire Protection and Emergency Response Local Service Area Boundary (Bylaw No. 2042)

C. Vrabel spoke to Item 6.1.

**MOVED by Director Wickheim, SECONDED by Director Holman,**
**The Electoral Areas Committee recommends to the Capital Regional District Board:**
**1. That the attached Certificate of Results of the petitions to expand the service area boundary for the Otter Point Fire Protection and Emergency Response Service be received;**
**2. That Bylaw No. 4592, "Otter Point Fire Protection and Emergency Response Local Service Establishment Bylaw No. 1, 1992, Amendment Bylaw No. 8, 2024", be read a first, second, and third time; and**
**3. That elector approval be obtained by Electoral Area Director consent on behalf.**
**CARRIED**

**6.2.** [24-334] Fire Services Governance Review Report - 2024 - 2027 Implementation Plan and Draft Bylaw 4608 to Amend Bylaw 3654 for Fire Commissions

C. Vrabel spoke to Item 6.2.

**MOVED by Director Holman, SECONDED by Director Wickheim,**
**That Director Little be permitted to participate (without vote) in the May 8, 2024 meeting of the Electoral Areas Committee.**
**CARRIED**

**MOVED by Director Wickheim, SECONDED by Director Holman,**
**1. That the 2024-2027 Fire Services Governance Review Implementation plan be approved; and**
**2. That Bylaw No. 4608, "Fire Protection and Emergency Response Service Commissions Bylaw, 2010, Amendment Bylaw No. 2, 2024" be given first, second and third reading; and**
**3. That Bylaw No. 4608 be adopted.**
**CARRIED**

**Motion Arising:**
**MOVED by Director Wickheim, SECONDED by Director Holman,**
**That staff review the implementation plan, consult with the commissions, and report back to the Electoral Areas Committee in two years.**
**CARRIED**

**6.3.** 24-450 Governance Study of Magic Lake Estates, North Pender Island

J. Starke presented Item 6.3. for information.

Discussion ensued regarding anticipated next steps as a result of this study.

**6.4.** 24-237 Request for Inclusion of Property in the Ganges Sewer Service Area

T. Robbins spoke to Item 6.4.

Discussion ensued regarding:
- the property owner's grant-in-aid application
- the estimated infrastructure costs
- the cost of transporting the liquid waste for further treatment

**Director Brent joined the meeting at 9:45 am.**

**MOVED by Director Holman, SECONDED by Director Wickheim,**
**The Ganges Sewer Local Services Commission recommends the Electoral Area Committee recommend to the Capital Regional District Board:**
**1. To expand the boundary of the Ganges Sewer Local Service Area to include 105 Kilner Road;**
**2. The Applicant agrees to pay for all costs to include the property into the service area, and also pays the capacity purchase charge;**
**3. The Applicant agrees to pay all engineering, administration, permit fees, and construction costs associated with the extension of the sewer and connection to the existing sewer and the property;**
**4. That Bylaw 4601, "Salt Spring Island Ganges Sewerage Local Service Establishment Bylaw, 1991, Amendment Bylaw No. 14, 2024, be introduced and read a first, second and third time.**
**CARRIED**

**6.5.** 24-414 Previous Minutes of Other CRD Committees and Commissions for Information

**The following minutes were received for information:**
**a) Galiano Island Parks and Recreation Commission minutes of April 4, 2024**
**b) Magic Lake Estates Water and Sewer Committee minutes of February 13, 2024**
**c) Mayne Island Parks and Recreation Commission minutes of March 14, 2024**
**d) Pender Island Parks and Recreation Commission minutes of March 4, 2024**
**e) Saturna Island Parks and Recreation Commission minutes of March 11, 2024**
**f) Sticks Allison Water Local Service Committee minutes of November 7, 2023**
**g) Willis Point Fire Protection and Recreation Facilities Commission minutes of March 26, 2024**

## 7. Notice(s) of Motion

There were no notice(s) of motion.

## 8. New Business

There was no new business.

## 9. Adjournment

**MOVED by Director Brent, SECONDED by Director Wickheim,**
**That the May 8, 2024 Electoral Areas Committee meeting be adjourned at 9:47 am.**
**CARRIED**

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CHAIR

______________________________
RECORDER

**REPORT TO ENVIRONMENTAL SERVICES COMMITTEE**
**MEETING OF WEDNESDAY, MARCH 20, 2024**

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**SUBJECT** **Climate Projections for the Capital Region**

**ISSUE SUMMARY**

To present the updated report, *Climate Projections for the Capital Region (2024).*

**BACKGROUND**

In 2017, the CRD Climate Action service engaged the Pacific Climate Impacts Consortium (PCIC) to complete the first scientific analysis of downscaled climate projections for the capital region. In 2023, the PCIC was reengaged to update the downscaled regional climate projections and results are provided in an updated report *Climate Projections for the Capital Region (2024)* (see Appendix A).

Climate science has been evolving since the CRD published the first climate projections report, and new information is now available to reevaluate the projections and provide the most up-to-date information on how the region's climate may change by the middle and end of this century. The report provides a common understanding of how projected changes in temperature and precipitation will play out locally, how impacts will differ throughout the seasons, and what the effect could be of new climate extremes. The report identifies some potential impacts of climate change on different sectors of the region, based on consultation with CRD and municipal staff.

The report is based on new scientific modelling and includes new indices for extreme heat, as well as a new guidance section to support users of the report and accompanying data. The report, along with other data and modelling efforts completed by the PCIC, will serve as a resource for local and regional planners, engineers, land managers, policymakers and decision makers to make better-informed decisions.

At a high level, the results of this study show that in the coming decades, the capital region can expect:

- warmer summer temperatures, with more extreme heat days and heatwaves
- warmer nights and a longer growing season
- less rain and more dry days in the summer months
- warmer winter temperatures and less frequent frost
- more precipitation falling in fall, winter and spring
- less snowfall and more rain in the colder months
- more rain delivered in extreme rainfall events

**Next Steps**

The CRD Climate Action service will continue to support regional climate adaptation planning efforts. Near-term actions include:

- Sharing the report results with CRD and local government staff, First Nations and other regional stakeholders.
- Developing public educational materials linking report results with associated actions for use by the CRD, local governments and other regional stakeholders.

- Supporting future climate adaptation planning efforts, including identifying data gaps and costs associated with future local or regional studies and programming, with municipal/electoral area governments (i.e., the CRD's Climate Action Inter-Municipal Working and Task Force).
- Supporting the completion of other climate adaptation-related actions identified in the CRD's Climate Action Strategy (2021).

Furthermore, the CRD will consider the results for regional service delivery in operational plans and long-range infrastructure planning.

## ALTERNATIVES

*Alternative 1*
The Environmental Services Committee recommends to the Capital Regional District Board:
That the *Climate Projections for the Capital Region (2024)* report be referred to municipal councils, the Electoral Areas Committee and First Nations for information.

*Alternative 2*
That this report be referred back to staff for additional information.

## IMPLICATIONS

*Alignment with Board & Corporate Priorities*
The recommendations align with the Board's priority Climate Action & Environment initiative 3c to increase resilience, community and adaptation planning to address climate-related risks and disasters.

*Alignment with Existing Plans & Strategies*
The recommendations align with goal 2 of the CRD Climate Action Strategy to support the region on its pathway to livable, affordable and low-carbon communities that are prepared for climate change, and specifically contributes to the completion of action 2-4d to expand data collection and mapping efforts to identify vulnerabilities to the impacts of climate change.

*Intergovernmental Implications*
The data and mapping components can help local authorities prepare for climate impacts. By examining climate projections, community planners and emergency managers can better inform planning and policy initiatives. The data can also be used when updating local hazard, risk and vulnerability analyses (i.e., HRVAs). CRD staff will continue to engage the region's local governments through the CRD's Climate Action Inter-Municipal Working and Task Force on better understanding new climate adaptation related policy approaches and supporting implementation of existing programs and policies in a collaborative manner.

## CONCLUSION

The recently completed report, *Climate Projections for the Capital Region (2024)*, expands upon climate change data analysis previously undertaken by the Pacific Climate Impacts Consortium and the CRD. Using the most recent scientific information, the study updated high-resolution climate projections for the capital region to better understand how our climate may change by the 2030s, 2050s and 2080s. The report is based on the work undertaken by the Pacific Climate Impacts Consortium, with support from the CRD, and was developed in consultation with CRD and municipal staff working groups. The report benefits multiple services within the CRD, as well as all local and First Nations governments and community partners in the region in becoming resilient to a changing climate.

## RECOMMENDATION

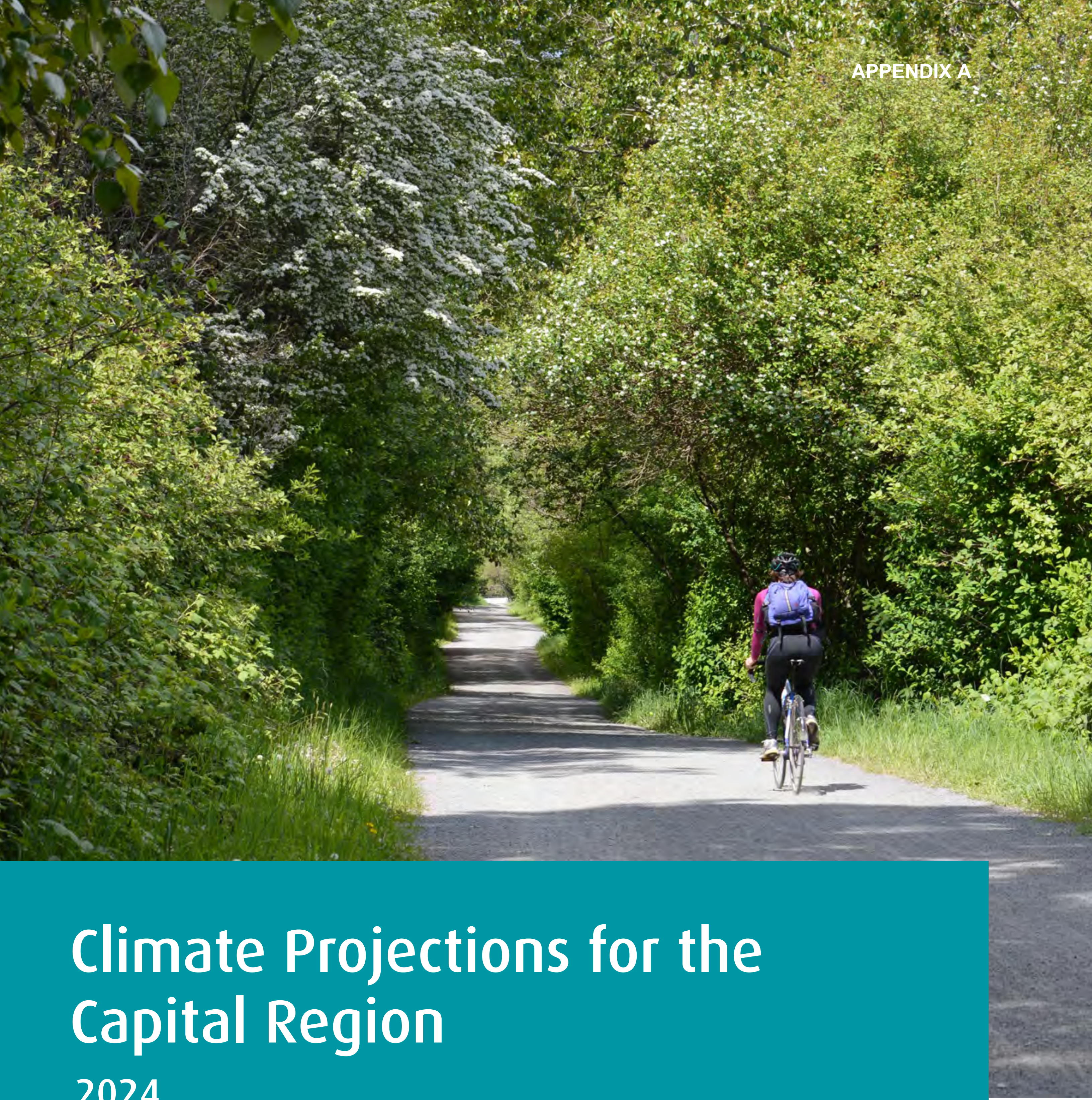
The Environmental Services Committee recommends to the Capital Regional District Board:
That the *Climate Projections for the Capital Region (2024)* report be referred to municipal councils, the Electoral Areas Committee and First Nations for information.

| | |
|---|---|
| Submitted by: | Nikki Elliott, BES, MPA, Manager, Climate Action Programs |
| Concurrence: | Larisa Hutcheson, P.Eng., Acting General Manager, Parks & Environmental Services |
| Concurrence: | Ted Robbins, B. Sc., C. Tech., Chief Administrative Officer |

## ATTACHMENT

Appendix A: Climate Projections for the Capital Region Report (2024) – Pacific Climate Impacts Consortium

APPENDIX A



# Climate Projections for the Capital Region

2024

Updated April 2024

PACIFIC CLIMATE IMPACTS CONSORTIUM

CRD
Making a difference...together

# EXECUTIVE SUMMARY

The Earth's climate system is warming, and signs of climate change are becoming evident across the planet. The capital region, located on Southern Vancouver Island and Gulf Islands of British Columbia (BC), is no exception. The Capital Regional District (CRD) has partnered with the Pacific Climate Impacts Consortium (PCIC) to produce high-resolution regional projections for temperature, precipitation, and related indices of extremes. These projections use the most up-to-date global modeling data (i.e., the Sixth Coupled Model Intercomparison Project, CMIP6) to illustrate how the region's climate may change by the middle of this century. Information provided by this report and the accompanying data is intended to support decision makers and community partners in the region with an improved understanding of projected local climate change and related impacts.

At a high level, the results of this study show that in the coming decades, the capital region can expect:

- Hotter summer temperatures, with more extreme heat days and heatwaves;
- Warmer nights and a longer growing season;
- Warmer winter temperatures and less frequent frost;
- Less rain and more dry days in the summer months;
- More precipitation falling in fall, winter and spring;
- Less snowfall in the colder months;
- Extreme rainfall events becoming wetter.

More specifically, warming temperatures will shift seasonal patterns, prompting a longer growing season and greater cooling demand across the region. Extreme temperatures will continue to get hotter, with heat waves becoming longer and more frequent. By the 2050s, the capital region can expect the number of summer days exceeding 25°C to triple, going from an average of 10 days per year to 32 days per year. Nighttime temperatures in the summer will also increase. Nights where the temperature stays above 16°C (the lower threshold for heat alerts for Southern Vancouver Island) are projected to occur around 8 times per year. The temperature for the 1-in-20-year hottest is projected to increase from 32°C to 36°C.

By the end of this century, annual precipitation is projected to increase modestly (4% increase by the 2050s and 11% by the 2080s). However, these changes will not occur evenly across seasons. In the colder months, rainfall increases notably because of warmer temperatures that convert more snow into rain. (By the 2050s, total rainfall in the winter increases by 25%, while total snowfall drops by nearly 60%.) Much of the rainfall in the colder months will occur during extreme events, with the very wet days becoming wetter by mid-century. In contrast to the fall, winter and spring, the summer months will become increasingly dry. Total rainfall in the summer is projected to decrease by roughly 15% by the 2050s with the duration of dry spells becoming longer.

Many of the projected climate changes described in this report will be felt uniformly across the region. However, the magnitude of some variables will be accentuated by the existing West-to-East climatic gradient in the capital region. For example, the Western region is typically wetter and cooler compared to the Eastern Region, where conditions are typically warmer and drier. In addition, temperatures may be warmer or cooler in specific areas due to other factors including tree canopy cover (or a lack thereof), paved surfaces, and buildings density.

The projected warming for the capital region will have implications for regional ecosystems, watersheds, agriculture and horticulture, housing, energy demand, infrastructure, and community health and safety. Chapter 7 provides a high-level overview of some of the impacts that might be expected from the projected changes in this assessment. This chapter was informed by input from local government staff during a workshop in October 2023 and is not a comprehensive assessment of regional impacts. It is intended to support further discussion and analysis for how climate change may impact the capital region.

The CRD and PCIC also collected input from local government staff to understand how these climatic changes may impact the region as whole. Across the capital region, communities are already witnessing and experiencing varied impacts of climate change. These impacts will persist and, in many cases, intensify over the coming decades based on the future global greenhouse gas emissions trajectory. These impacts will not be experienced equally across the region. People facing the greatest burdens are often the ones who are most affected by climate change, particularly for impacts that are compounding.

Information within this report and the accompanying data provides the region's decision makers, community planners, and community partners with an improved understanding of projected local climate change and related impacts.

## CONTRIBUTING AUTHORS

Charles Curry and Stephen Sobie from Pacific Climate Impacts Consortium (PCIC) conducted climate model downscaling, data analysis and interpretation and generated all data products, including maps, figures, and tables, for the report. Charles Curry and Izzy Farmer (PCIC) served as lead authors of this report, with advice and guidance from CRD staff.

## ACKNOWLEDGMENTS

We would like to acknowledge the effort and input received from CRD staff, municipal staff, and the CRD Climate Action Inter-Municipal Working Group in the development of this report. Working together ensures that we share knowledge and build on each other's success to create a more resilient region.

# TABLE OF CONTENTS

# LIST OF TABLES AND FIGURES

## Tables



## Figures

## Figures (continued)

# 1. INTRODUCTION

Over the last 150 years, the global average temperature has increased by over 1°C and this warming has been clearly linked to the emission of greenhouse gases (GHGs), aerosols, and other aspects of human development. This warming is expected to continue unless we make significant cuts to GHG emissions globally. Understanding, monitoring, and preparing for the regional and local manifestations of climate change is important for supporting safe and resilient communities in the decades to come.

The Capital Regional District (CRD) has undertaken this study to better understand how the climate of our region is expected to change over the coming decades. British Columbia's capital region spans an area of 2,340 $km^2$ and an elevation range of 1 to 1,100 m above sea level (Figure 1). Since 1950, air temperature observations for Vancouver Island have been increasing by 0.26 ± 0.07 °C per decade.[2] Both global and regional warming are expected to influence other climate variables, such as rainfall.

To explore the changes that may be in store for our region, the CRD has partnered with the Pacific Climate Impacts Consortium (PCIC) to produce high-resolution climate projections for the capital region. These projections are based on the latest generation of comprehensive global climate models (CMIP6). Like other populated areas worldwide, the region requires up-to-date, science-based, high-resolution information to enable effective planning and policy decisions in a changing climate. This information will be used with other resources to help prepare the capital region for the impacts of climate change.

A selected number of climate indicators are provided in this report to demonstrate how our climate is expected to change over time. In the first section, Chapter 2 provides a brief description of the study methodology and includes support for interpreting the figures and tables. Chapters 3 through 6 provide an analysis of selected climate indicators for the region, including information about summer temperatures, winter temperatures, precipitation, and climate extremes. Each section includes a description of each indicator and a summary of how it is projected to change over time.

In the second section, Chapter 7 identifies potential impacts from climate change expected across the capital region. These impacts are categorized by different sectors, including health and wellbeing, water supply and demand, rainwater management and sewerage, ecosystems and species, buildings and energy systems, transportation, food and agriculture, and recreation and tourism.

It should be noted that the information provided in this report is limited to changes in temperature and precipitation only. Other climate-related phenomena, like surface hydrology, wind, humidity, sea level rise and storm surge require different modelling techniques and are not included in the scope of this report. Therefore, the report should be used alongside other resources to help prepare our region for the impacts of climate change. For example, in 2021, working with and on behalf of municipal partners, the CRD undertook a coastal flood inundation mapping project, which includes an analysis of current and future storm surge due to sea level rise. Since that time, some municipalities in the region have been undertaking efforts to build upon this work.

This report and the supplementary data that accompany it are intended to support climate-focused decision making throughout the region and help community partners better understand how their work may be affected by our changing climate. The information provided here should be used with careful consideration for the local context. For guidance on how climate information can be used to support adaptation planning, see the appendices appearing at the end of this report.

[1] IPCC, 2023: Summary for Policymakers. In: Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (eds.)]. IPCC, Geneva, Switzerland, pp. 1-34, doi: 10.59327/IPCC/AR6-9789291691647.001.

[2] Results of an analysis conducted by PCIC for the annual "State of the Pacific Ocean" report; see Curry, C.L. and Lao, I., "Land temperature and hydrological conditions in 2022," pp 17-21. In: Boldt, J.L., Joyce, E., Tucker, S., and Gauthier, S. (Eds.), State of the physical, biological and selected fishery resources of Pacific Canadian marine ecosystems in 2022. Can. Tech. Rep. Fish. Aquat. Sci. 3542: viii + 312 p. (2023). The nearby Lower Fraser Valley displays a larger trend of magnitude 0.42 ± 0.07 °C per decade, which may be more similar to what the capital region has experienced.

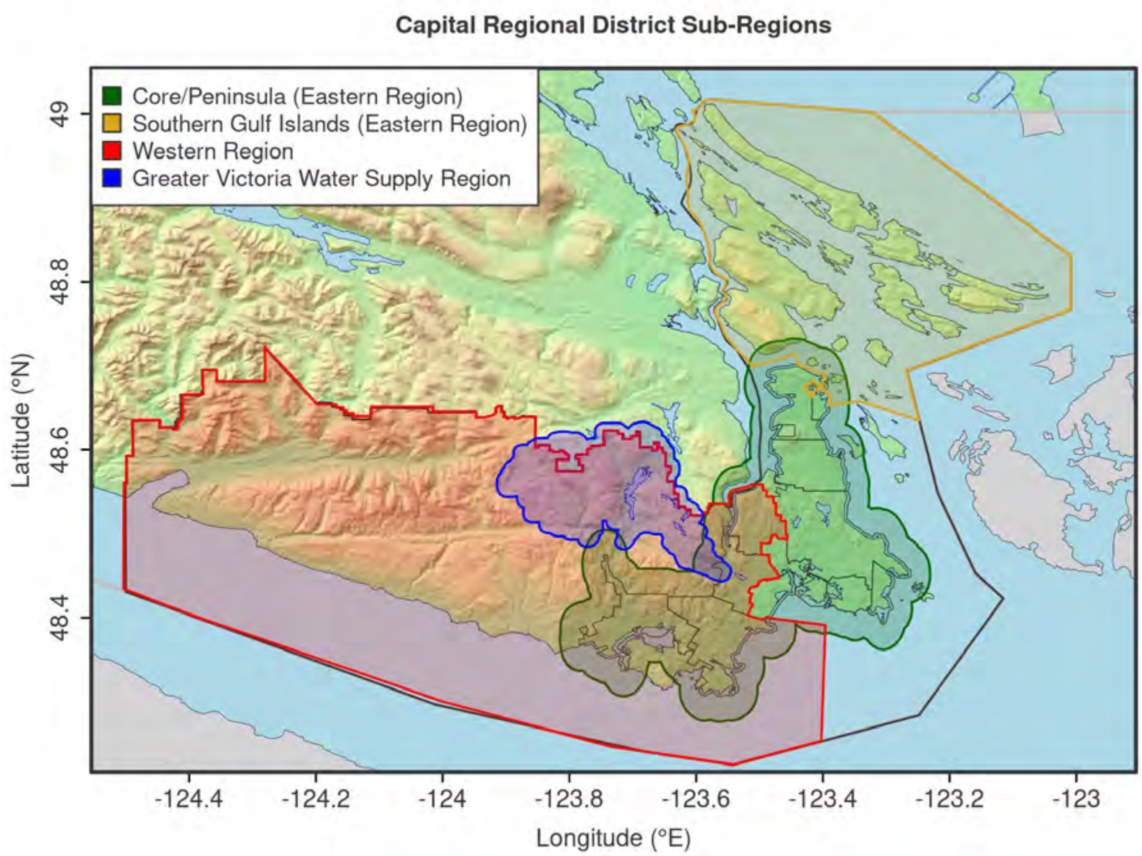



***Figure 1.*** *Domain of interest, the Capital Regional District, with background relief map and four sub-regions of interest. In several of the tables in the report, results for the Core/Peninsula and Southern Gulf Islands are combined into a single Eastern Region.*

# 2. METHODS AND PRESENTATION

## 2.1 Climate Model Projections

The climate projections are based on an ensemble of 9 global climate models (GCMs) drawn from a larger collection of models developed during the Sixth Coupled Model Intercomparison Project (CMIP6), coordinated by the World Climate Research Programme. The climate projections presented here are based on a high greenhouse gas emissions scenario, known as the Shared Socioeconomic Pathway 5-8.5 (SSP585), which describes a trajectory of future emissions spurred by continued and expanded use of fossil-fuels worldwide. Two other scenarios are also presented in the data package accompanying this report: a medium-intensity emissions pathway, SSP245, and a low-intensity pathway, SSP126, which covers the possibility of a low-carbon technology transformation of worldwide energy systems.[3] Planning based on climate projections under SSP585 could be considered a "no regrets" strategy for adaptation. By the 2090s under SSP585, global mean surface air temperature reaches a level 4.3°C higher than the 1850-1900 average. The evolution of air temperature and precipitation under the three SSPs, for BC specifically, is shown in Figure 2.

Each GCM represents the climate system using a global, horizontal grid with a limiting resolution between 100 km and 250 km, depending on the model. These coarse-grained data are first bias-corrected against available observations (spanning 1950-2012) and then statistically downscaled to 10 km resolution.[4]

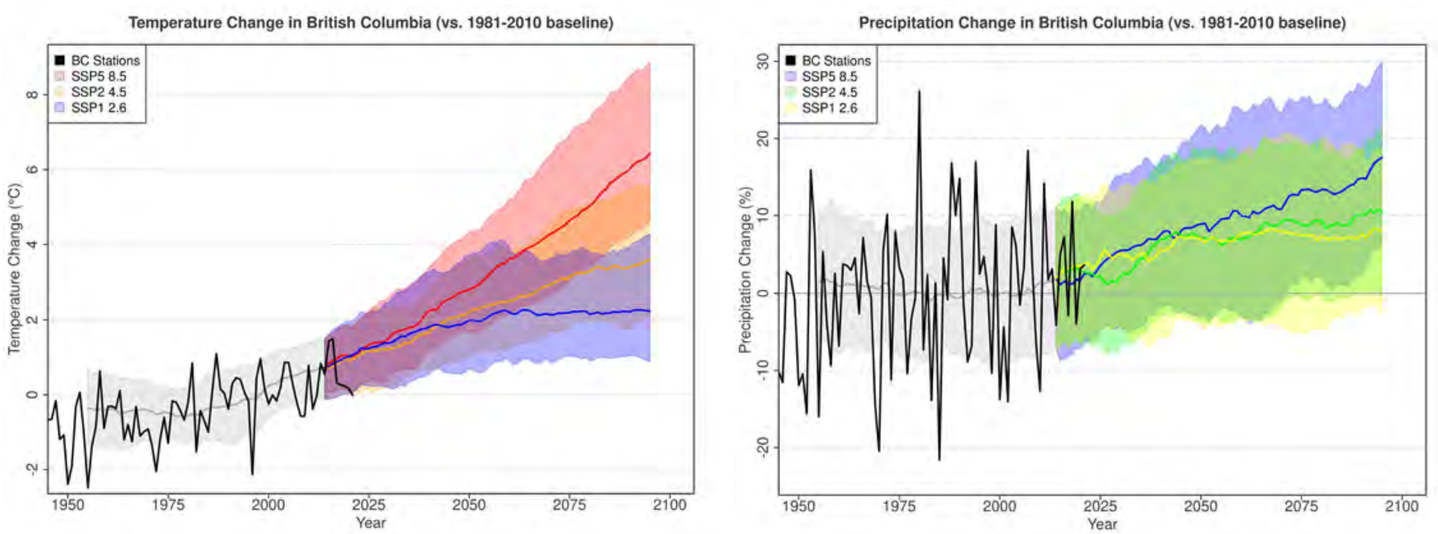



***Figure 2.*** *Changes in annual mean air temperature (left) and total precipitation (right) relative to their values in 1981-2010, averaged over all of BC. The black curves show historical values obtained from the station data in BC from 1948-2021, while the coloured curves show median GCM projections under the three development pathways (SSPs) from 2015-2100. The shaded areas show the 10th-90th percentile range in model-simulated results over the historical and future periods, for each SSP.*

[3] An accessible description of the SSPs may be found at https://climatedata.ca/resource/understanding-shared-socio-economic-pathways-ssps/.

[4] Details on the downscaling methods used at PCIC may be found on the Data Portal section of our website, pacificclimate.org.

In a second downscaling step, the model data are further downscaled to a resolution of 800 m using fine-scale climatological maps. It should be recognized, however, that while the latter account for fine-scale topography, important features of, and influences on, local daily climate are not represented in the dataset.[5]

Downscaled climate model results are presented for three 30-year periods: the historical reference period, 1981-2010 (referred to as the "Past" or "1990s" for short), the near future, 2021-2050 (the "2030s"), mid-century, 2041-2070 (the "2050s") and the end-of-century, 2071-2100 (the "2080s"). These 30-year periods are chosen both to smooth out year-to-year climate variability, and to provide a long enough period to characterize the behaviour of fairly rare events. The seasonal definitions used are "meteorological" seasons: i.e., winter (December 1 to February 28), spring (March 1 to May 31), summer (June 1 to August 31) and fall (September 1 to November 30). A range of indices are computed from daily temperature and precipitation to describe various aspects of the climate. For projections, median estimates from the climate model ensemble are typically emphasized, with the 10th to 90th percentile ranges over the ensemble also provided where appropriate.

It is important to recognize that not all projected changes emerging from the climate model ensemble are necessarily substantial. For a given variable, location, and emissions pathway, each model produces a projected future climate, resulting in a range of possible outcomes. Since no single model is "right," the median value of the ensemble can be used as a practical best-guess projection, with the 10th to 90th percentile spread indicating the uncertainty amongst the models. *If the spread includes zero change, meaning that not all models agree on the sign of the change, then relatively low confidence should be placed in the median value.* In the relatively rare cases when less than half of the models agree on the sign of change, users are alerted to the reduced confidence via a printed message on the maps.

[5] Examples of these being realistic day-to-day variability and co-variability between nearby locations, and fine-scale land cover type, for example. It should also be recognized that since the models are bias-corrected to daily observations spanning a specific time period, here 1981-2010, more recent observations will not be reflected in results displayed for the "Past."

## **2.2** Interpreting Figures and Tables

The data deliverables for the project comprise: (i) maps of climate variables over the region in Past and Future periods, for each of the three scenarios; and (ii) tables (Excel spreadsheets) of area-averaged results for the same. Results for absolute or relative difference are also provided, where appropriate. References to the tables are occasionally made in the report. Most of the figures presented below are maps, showing the capital region and the surrounding area. Colour contours indicate values of the indicated variable, with a nominal limiting resolution of 800 m. *Due to the limitations of the downscaling methodology mentioned above, along with the inherent uncertainty in future outcomes, the exact position of contours on the maps should not be taken literally.* On each map, the area average shown at bottom left is computed over the capital region only (area inside the black curve).

This report presents results for a number of key indicators, derived from the model-simulated daily temperature and precipitation, representing a "highlight reel" of the much more extensive set of climate indices delivered for this project. In consultation with CRD staff, they were selected either because they have implications for a range of climate-related impacts, because they feature particularly large changes from recent historical conditions, or both. In the next few chapters, a plain language definition is provided for each indicator, followed by a summary of its projected change for the 2030s, 2050s, and 2080s, under the high (SSP585) emissions scenario. Detailed definitions of all indicators are provided in the Appendix.

There are two types of maps: single period and future change. Single period maps, e.g., "Past: 1990s" or "Projection: 2050s," show actual values of a variable, e.g., temperature in °C. Future change maps, e.g., "Projected Change: 2050s - 1990s," show differences between historical and future-simulated periods, and may be in the units of the variable or in relative terms, e.g., percent change in precipitation. In the interest of concision, all future change maps shown in this summary report are for the 2050s under the high emissions (SSP585) pathway. For most indicators, the magnitude of these changes should be roughly comparable to that projected for the 2080s under the moderate emissions scenario (i.e., SSP245).

Other figures in the report use area-averages for the capital region while expressing the range of projected values over models and years for a certain variable. An example of this type of presentation, the "box-and-whisker" plot, is shown in Figures 6 and 9, and an aid to their interpretation is given below. Note that, in these figures, the range shown by the whiskers reflects both year-to-year and model-to-model variability. Finally, note that when cited in the text, values from the spreadsheets are often rounded to indicate the likely precision of the quantity being discussed, given the known model uncertainties. For example, a temperature of 29.8°C would be cited as 30°C, while 2717 degree-days become 2715 degree-days. The tables contain median values with ranges given in parentheses (10th – 90th percentile of different model projections). Usually medians are cited in the text; but ranges encompass the range of possible behaviour, and should not be ignored, especially when the climate variable in question might enter into critical decision-making.

Values in tables are averaged over the capital region (within the regional boundary shown on the maps), unless labeled as *Eastern Region* (Greater Victoria and Southern Gulf Islands), *Western Region,* or *Greater Victoria Water Supply Area.*

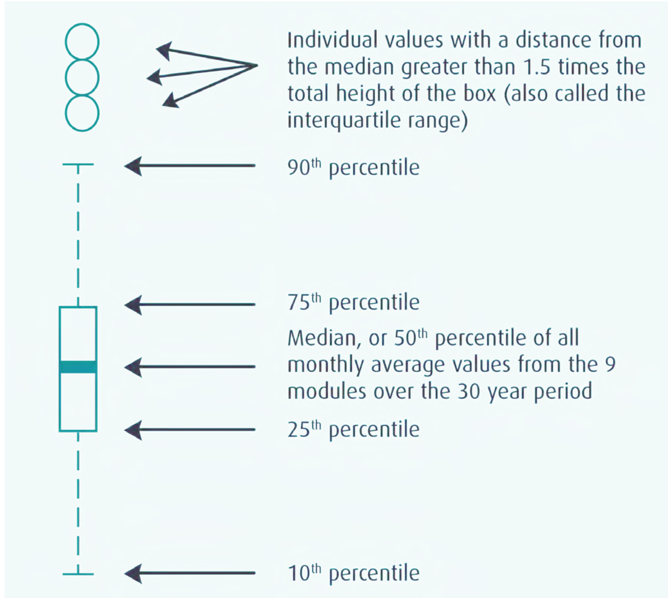



***Figure 3.*** *Explanatory schematic of a box-and-whisker plot.*

# 3. GENERAL CLIMATE PROJECTIONS

## **3.1** Warmer Temperatures

We begin by examining future temperature change over the region. *Daytime High and Nighttime Low Temperatures* are averaged over each season and annually in the tables and maps below.

In concert with global and regional warming, both daytime and nighttime temperatures are projected to increase in the capital region in future, as detailed in the tables (all changes shown are positive). The accompanying maps show the spatial pattern of Past and future-projected temperatures throughout the region.

### *Projections*

In the Past, winter daytime high temperatures in the region averaged around 6°C, while winter nighttime low temperatures averaged around 1°C. The median future-projected TX increases to around 8°C by the 2050s and to 9.5°C by the 2080s. The median future-projected TN reaches around 3°C by the 2050s and 4.5°C by the 2080s. Since the likelihood of snowfall rapidly decreases as temperatures rise above 0°C, we can anticipate that this local warming will affect the frequency of snowfall in the region, as detailed further below.

**Table 1: Regional Average Daytime High Temperature (TX)**

| | Past (°C) | 2050s Change (°C) | 2080s Change (°C) |
|---|---|---|---|
| Winter | 6 | 2.1 *(1.6 to 3.5)* | 3.5 *(2.8 to 6.5)* |
| Spring | 12 | 2.1 *(1.4 to 4.0)* | 3.5 *(2.6 to 6.3)* |
| Summer | 20 | 2.9 *(2.3 to 5.1)* | 4.7 *(4.1 to 8.7)* |
| Fall | 13 | 2.7 *(2.2 to 4.6)* | 4.0 *(3.6 to 7.2)* |
| Annual | 13 | 2.5 *(2.0 to 4.4)* | 3.9 *(3.4 to 7.0)* |

**Table 2: Regional Average Nighttime Low Temperature (TN)**

| | Past (°C) | 2050s Change (°C) | 2080s Change (°C) |
|---|---|---|---|
| Winter | 1 | 2.0 *(1.8 to 3.8)* | 3.6 *(3.2 to 6.8)* |
| Spring | 4 | 2.2 *(1.5 to 3.5)* | 3.2 *(2.8 to 5.6)* |
| Summer | 10 | 2.8 *(2.3 to 4.3)* | 4.6 *(3.9 to 7.4)* |
| Fall | 5 | 2.9 *(2.1 to 4.7)* | 4.2 *(3.6 to 7.3)* |
| Annual | 5 | 2.3 *(2.0 to 4.2)* | 3.9 *(3.5 to 6.6)* |

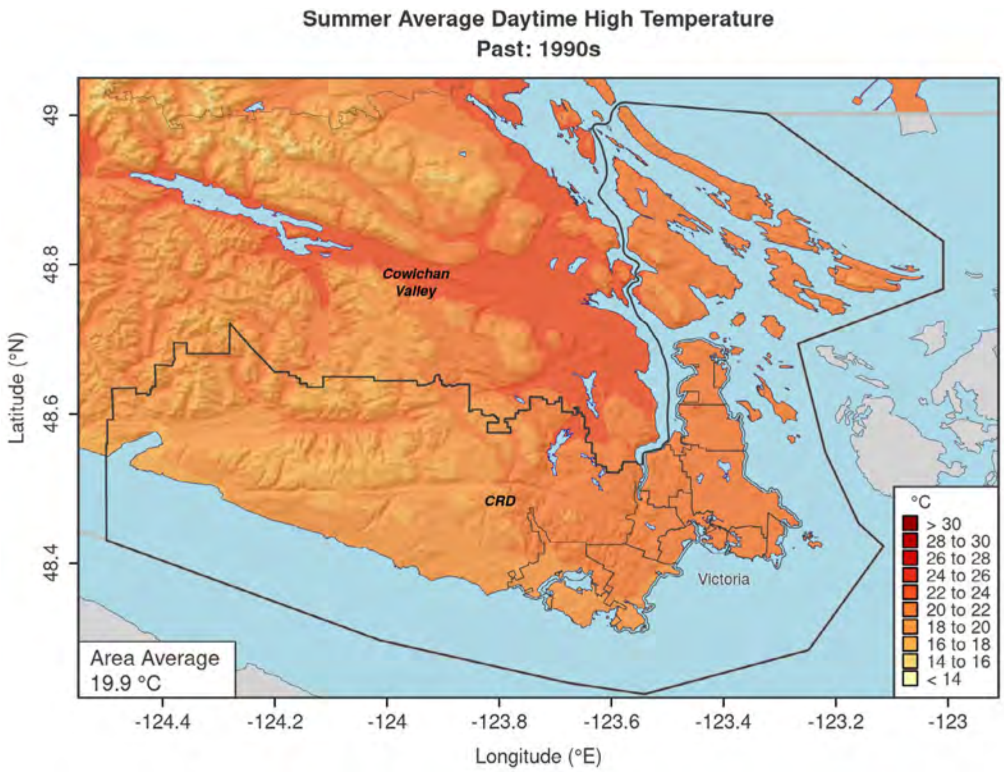



***Figure 4a:*** *Summer average daytime high temperature in the Past.*

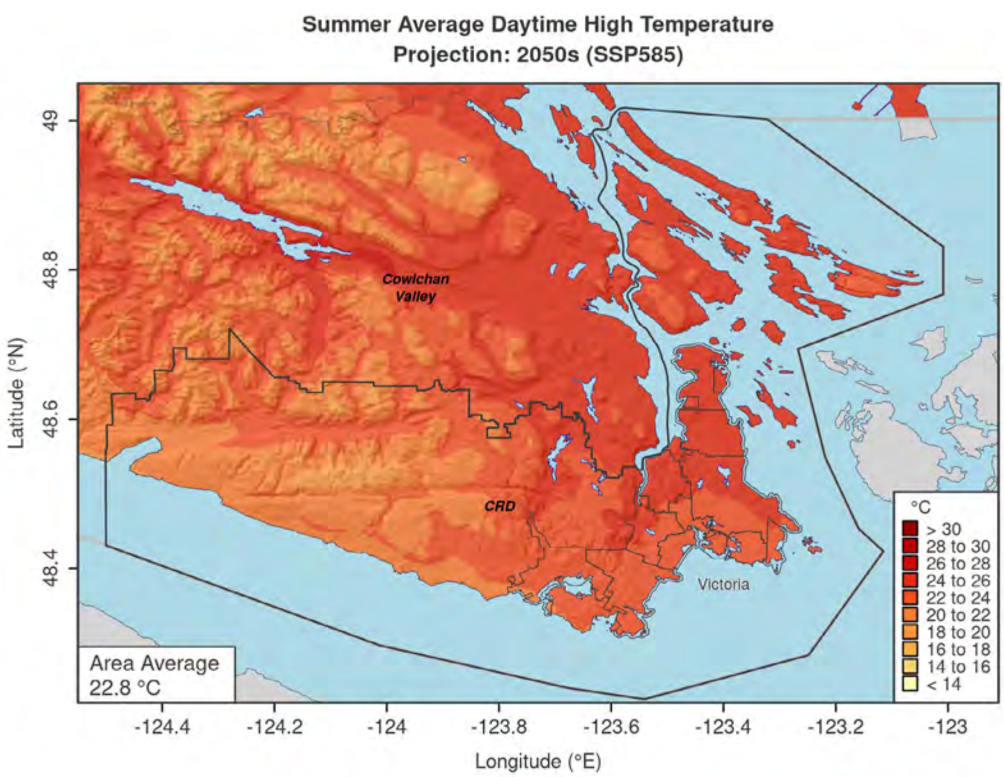



***Figure 4b:*** *Projected summer average daytime high temperature in the 2050s.*

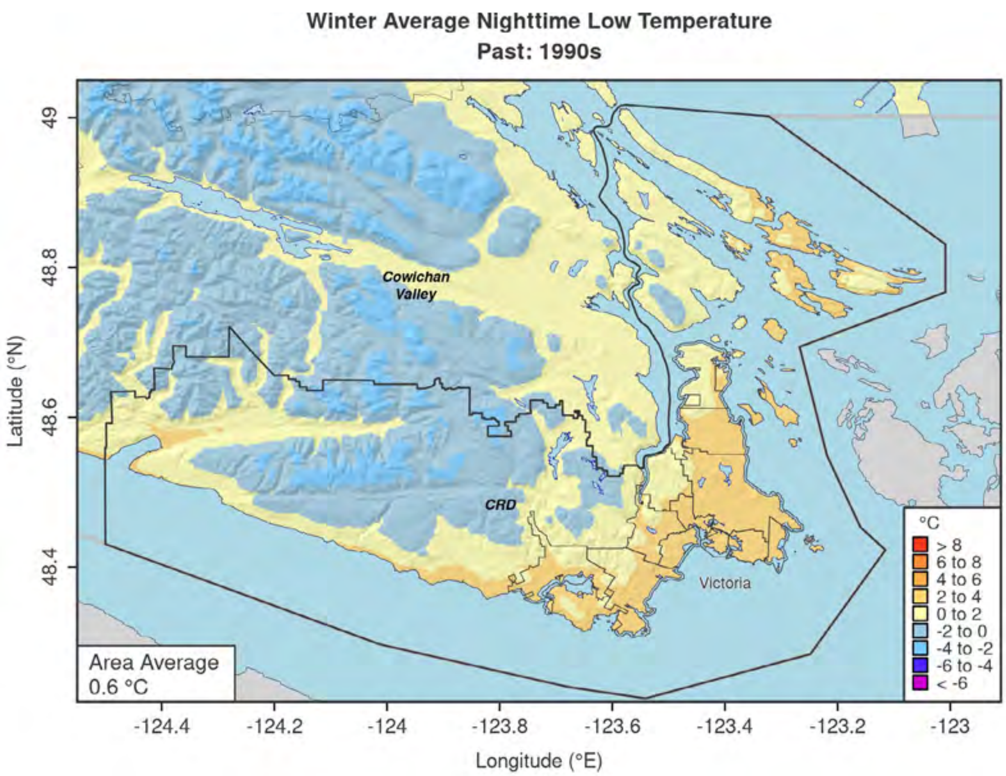



***Figure 5a:*** *Winter average daytime high temperature in the Past.*

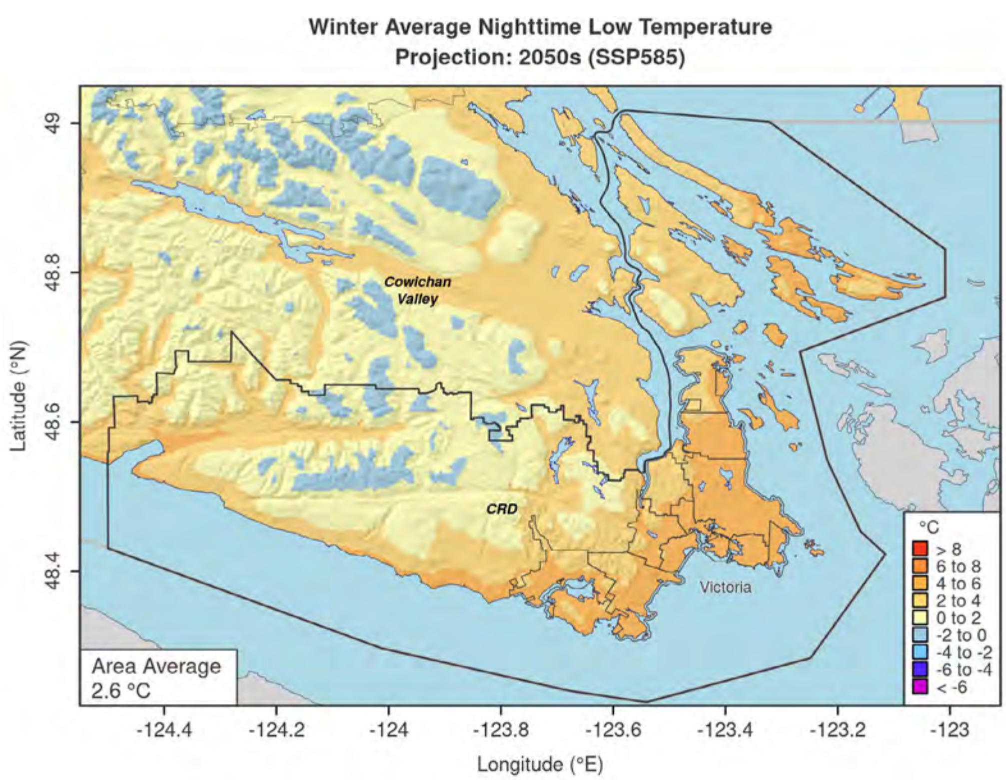



***Figure 5b:*** *Projected winter average daytime high temperature in the 2050s.*

## **3.2** Seasonal Temperature Change and Variability

Future-projected temperatures are compared with Past temperatures on a monthly basis in the figure below. The box-and-whisker plots reflect both year-to-year and model-to-model variability in all 30 Januaries, Februaries, etc., over the Past and Future periods.

Some features worth noting are:

- Freezing temperatures in the cold months become increasingly rare in the Future.
- Spring—loosely defined as the beginning of the growing season, when daily mean temperature $T_m$ consistently exceeds 5°C; see Temperature Indicators—begins earlier in the Future, while Fall—defined similarly as the end of the growing season—ends later, resulting in an effectively shorter winter season.
- The frequency of high extremes in summer increases notably, with July and August average daytime high temperatures exceeding 23°C in about three-quarters of models and years by the 2050s.

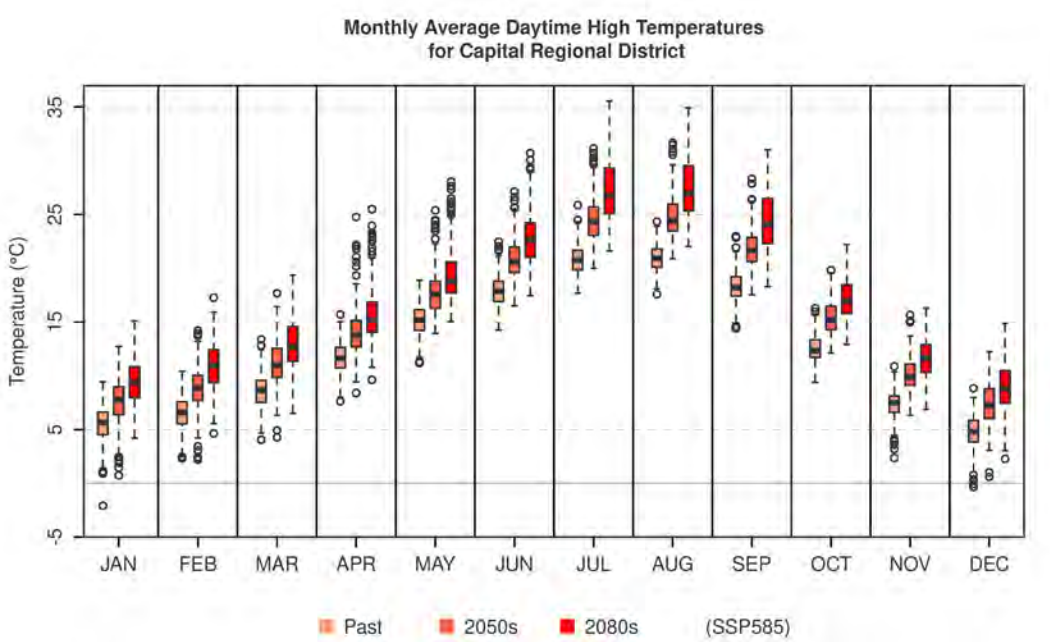



***Figure 6a.*** *Annual cycle of monthly mean daytime high temperature in the Past, 2050s and 2080s periods under the SSP585 scenario.*

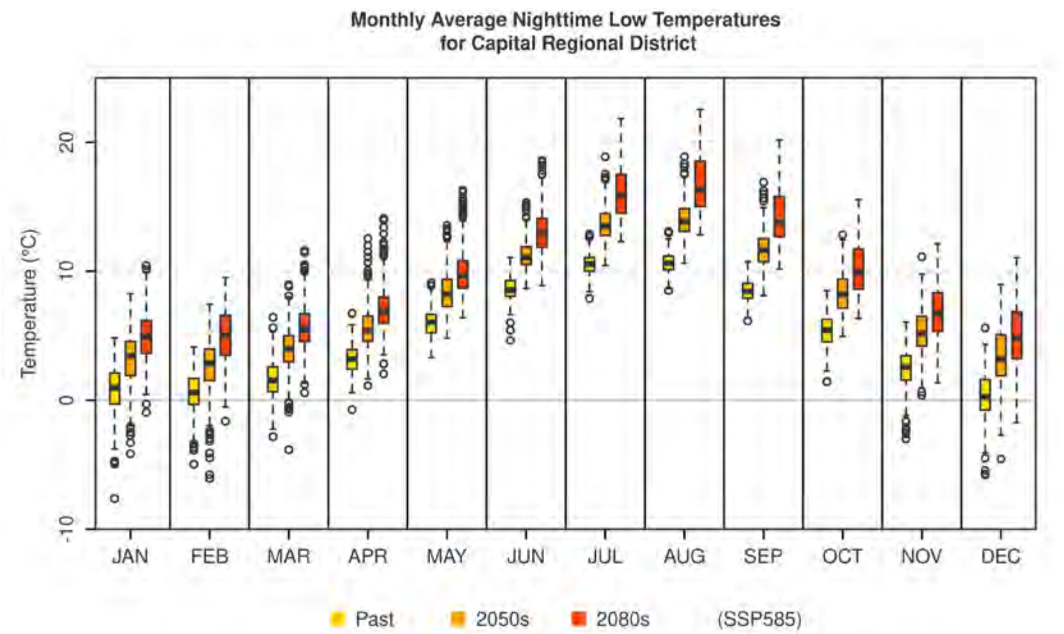



***Figure 6b.*** *Annual cycle of monthly mean nighttime low temperature in the Past, 2050s and 2080s periods under the SSP585 scenario.*

## **3.3** Wetter Winters, Drier Summers

*Precipitation* is the sum of rainfall and snowfall (expressed as water equivalent). Precipitation in the capital region has a strong seasonality, characterized by wet winters and dry summers. In the future projections, this behaviour is reinforced, so that winter becomes wetter (as do spring and fall) while summer becomes drier.

### *Projections*

In tandem with the higher summer temperatures mentioned above— which increase potential evaporation — reduced summer rainfall heightens the possibility of drought conditions. Rainfall increases are highest in winter, displaying a 25% increase in the 2050s region-wide, considerably higher in the west (+145 mm in the Western Region) than in the east (+25 mm in the Gulf Islands). Since the median increase in total winter precipitation by then is only +1%, we conclude that this is primarily due to the conversion of snow to rain under warmer winter conditions. While snowfall comprised about 15% of total precipitation in the Past, it amounts to only 5% in the 2050s. By the 2080s, the capital region should receive as little snowfall annually as it did in spring alone in the Past.

**Table 3: Average Precipitation (Rain and Snow) over the Region**

| | Past (mm) | 2050s (mm) | 2080s (mm) | 2050s Change (%) | 2080s Change (%) |
|---|---|---|---|---|---|
| **Winter** | | | | | |
| Rain | 643 | 804 | 864 | 25 (*11 to 39*) | 34 (*19 to 54*) |
| Snow | 197 | 83 | 36 | −58 (*-85 to -45*) | −82 (*-97 to -75*) |
| **Spring** | | | | | |
| Rain | 409 | 460 | 477 | 12 (*7 to 21*) | 17 (*3 to 26*) |
| Snow | 37 | 10 | 2 | −73 (*-95 to -44*) | −95 (*-100 to -78*) |
| **Summer** | | | | | |
| Rain | 159 | 135 | 129 | −15 (*-32 to -2*) | −19 (*-46 to -4*) |
| **Fall** | | | | | |
| Rain | 620 | 710 | 770 | 15 (*9 to 22*) | 24 (*13 to 34*) |
| Snow | 38 | 8 | 4 | −79 (*-95 to -62*) | −89 (*-99 to -83*) |
| **Annual** | | | | | |
| Rain | 1827 | 2102 | 2279 | 15 (*9 to 25*) | 25 (*12 to 28*) |
| Snow | 274 | 109 | 40 | −60 (*-88 to -50*) | −85 (*-97 to -78*) |
| **Precipitation**[6] | 2101 | 2179 | 2325 | 4 (*0 to 12*) | 11 (*-1 to 13*) |

[6] Note that in future, the summed medians of rain and snow may not equal the median precipitation, since the distribution of the two quantities may vary across the model ensemble.

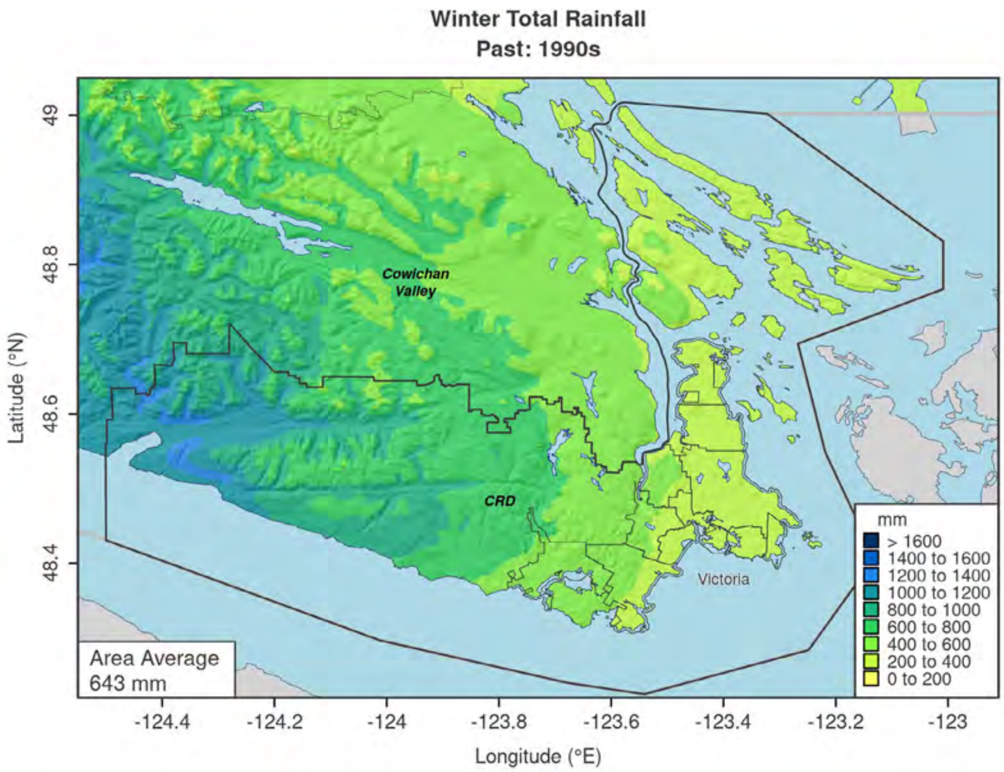



***Figure 7a.*** *Winter rainfall in the Past.*

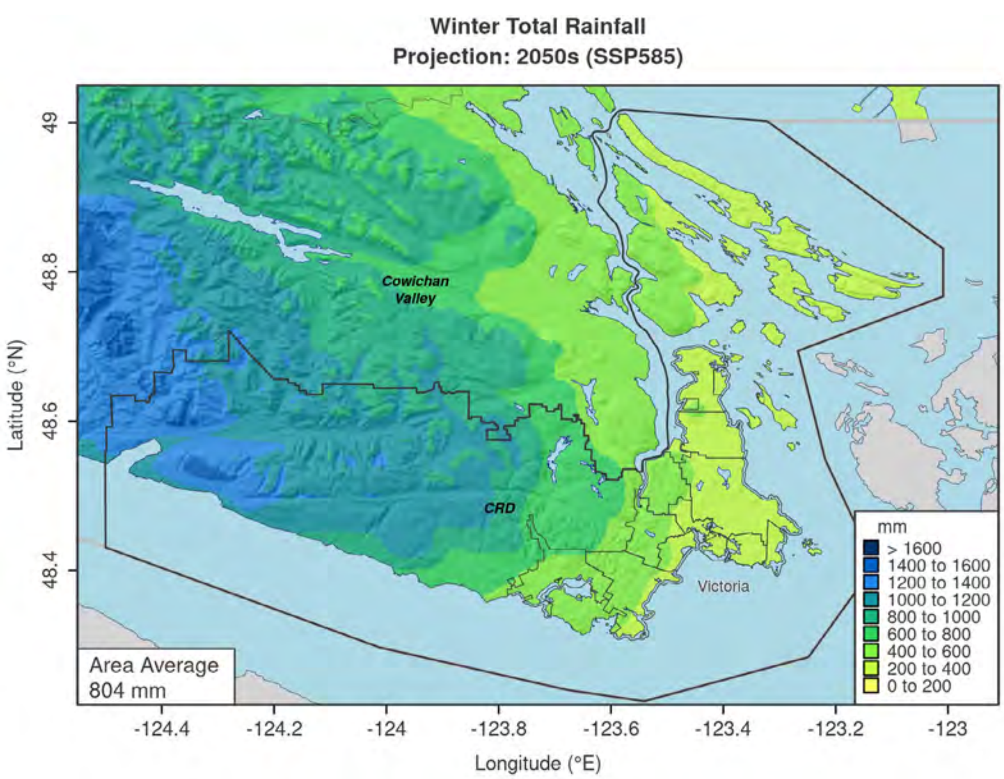



***Figure 7b.*** *Projected winter rainfall in the 2050s.*

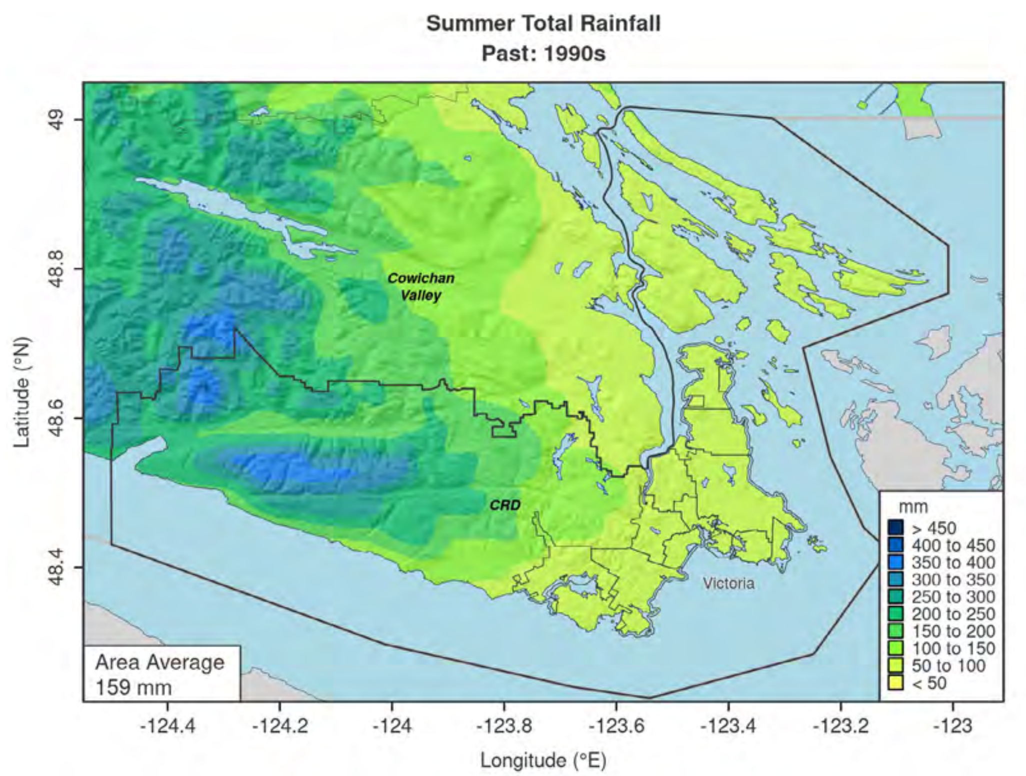



***Figure 8a.*** *Summer rainfall in the Past.*

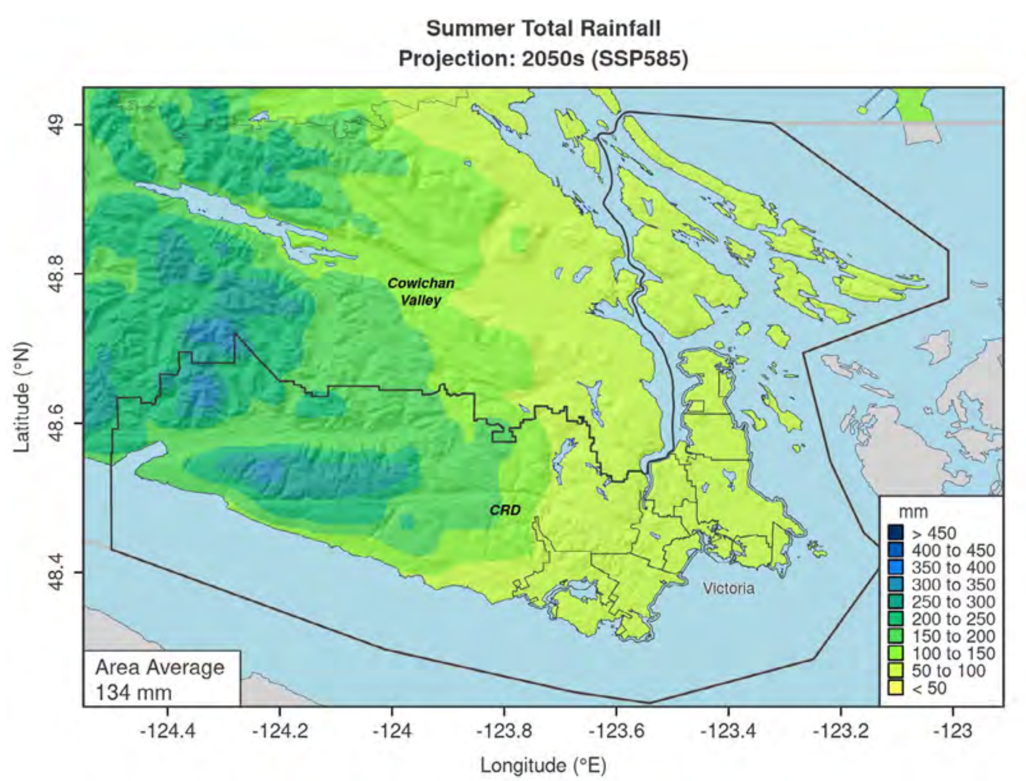



***Figure 8b.*** *Summer rainfall in the 2050s.*

## 3.4 Seasonal Precipitation Change and Variability

While precipitation in the capital region exhibits a notable seasonality, with far larger amounts in the colder months, this occurs against the background of high year-to-year variability. As a result, a climate change signal is more difficult to distinguish in precipitation than in temperature. One exception is the projected strong decline in snowfall, summarized in Table 3 and Figure 17. Combined with an increase in annual total precipitation of +4%, the resulting median projection of annual total rainfall for the entire region in the 2050s is +15%.

The figure below shows model estimates of monthly total rainfall in the Past and both Future periods. While median values increase in the colder months throughout the century, what is more striking are the changes in variability (occurring across both individual models and years, as shown for temperature above). For example, we note the occurrence of higher extreme monthly rainfall amounts in future periods, especially during the autumn months; some November rainfall totals could exceed 750 mm in future, compared to around 600 mm in the Past.[7]

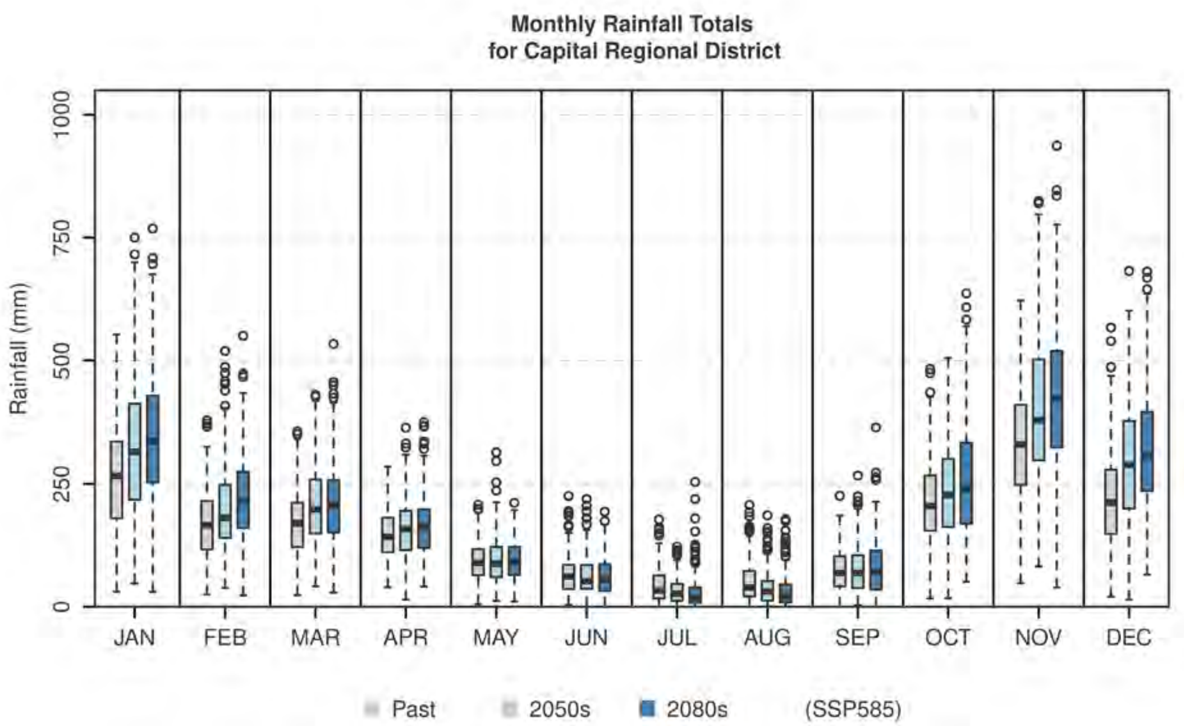



***Figure 9.*** *Annual cycle of total monthly rainfall in the Past, 2050s and 2080s periods.*

[7] 90th percentile values are cited. These totals are averaged across the region, with Past November values spanning a large range from the wetter Western Region (~650 mm) to the drier Gulf Islands Region (~300 mm). For reference, the highest recorded November precipitation at Victoria International Airport is 316 mm (in 2021).

# 4. WINTER TEMPERATURE INDICATORS

## 4.1 Warmest Winter Day, Coldest Winter Night

The *Warmest Winter Day* is the highest daily maximum temperature recorded during the winter months, in an average year. When considered along with the *Coldest Winter Night* (i.e., lowest daily minimum temperature), these indicators describe the projected "new normal" for winters in our region.

### *Projections*

By the 2050s, we can expect to see the warmest winter daytime temperature to rise from its Past value of 11°C to about 13°C, with a further increase to about 15°C by the 2080s.

In the Past, the coldest winter night had a temperature of about −8°C. Models project winter lows to increase by roughly 3.5°C by the 2050s, to −4.5°C, and by 6.5°C by the 2080s, to −1.5°C. The maps below illustrate that in the future, temperatures below freezing will usually occur only at the highest elevations in the region.

Warming winter temperatures will lead to an increased fraction of precipitation falling as rain instead of snow. Snow accumulation events, which typically occur a few times each winter in the region, will still occur, but less frequently.

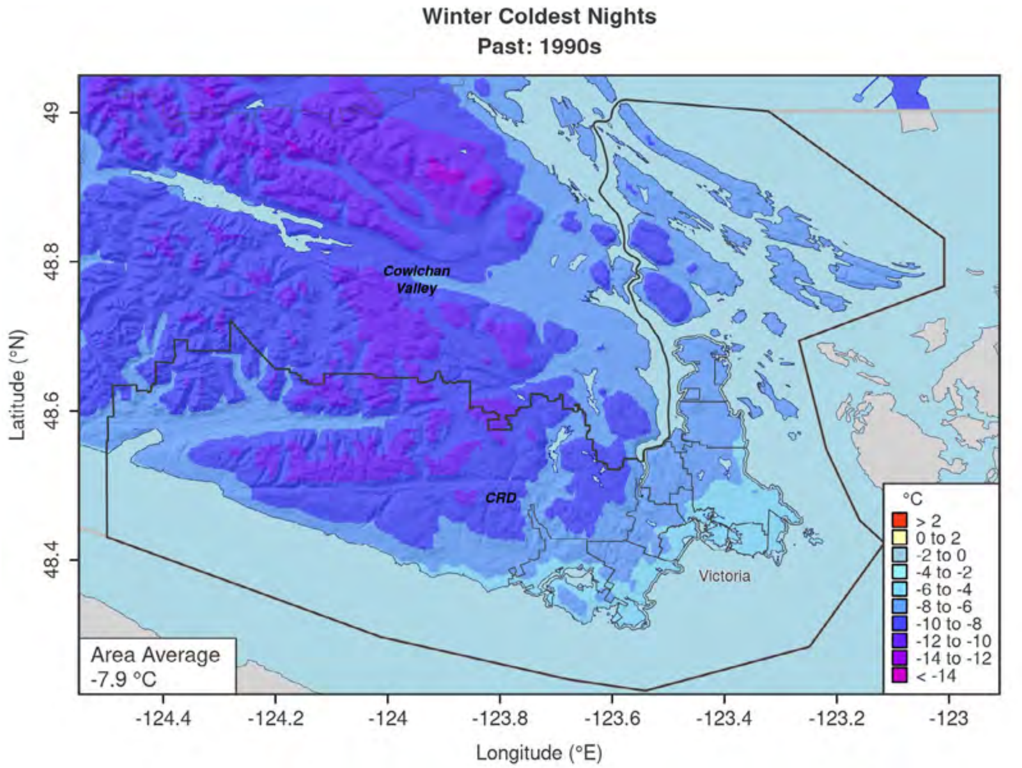



***Figure 10a.*** *Coldest winter night in the Past.*

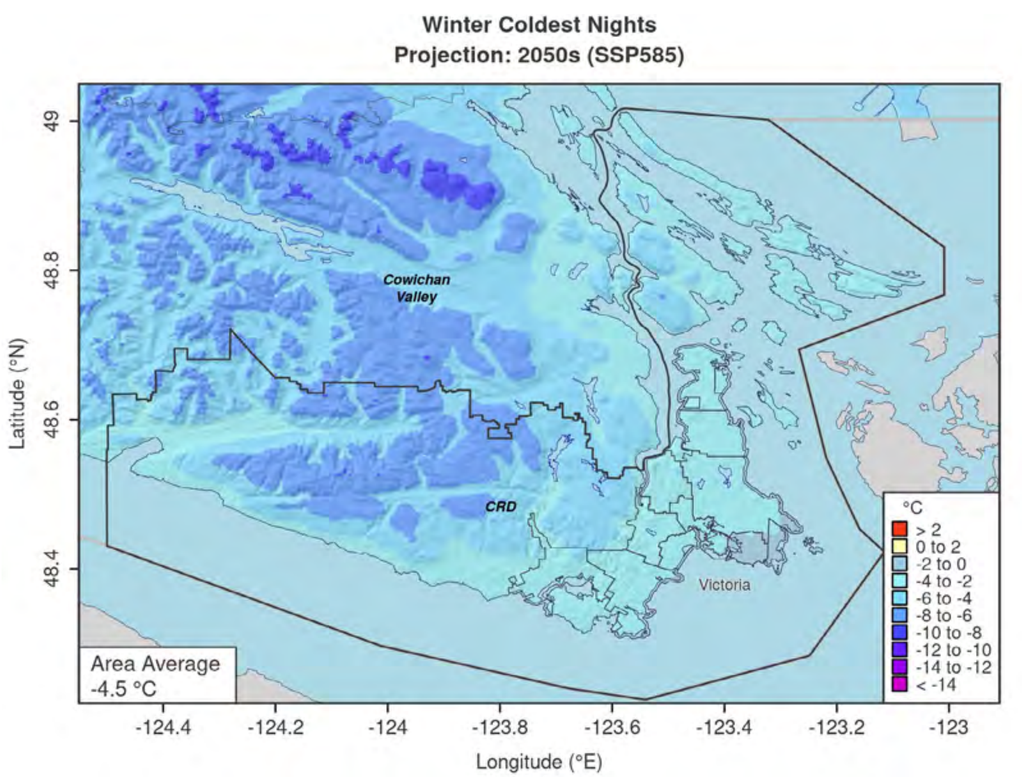



***Figure 10b.*** *Projected coldest winter night in the 2050s.*

## 4.2 1-in-20 Year Coldest Nighttime Low Temperature

This indicator describes extreme cold temperatures so low that they are expected to occur only once every 20 years in the historical climate. Equivalently, in the recent past the *1-in-20 Year Coldest Night* had a 5% chance of occurring in any given year. [8]

### Projections

In the Past, the 1-in-20 year coldest night had a temperature of −15°C. In the Future, the 1-in-20 year coldest night across the region will increase by about 5°C by the 2050s and by about 8.5°C by the 2080s.

[8] Note that the occurrence of such an event in one year doesn't preclude its occurrence in the following years, which is why the annual exceedance probability (i.e. 5% chance, in this case) is a helpful equivalent measure.

## 4.3 Frost Days and Ice Days

*Frost Days* is an annual count of days when the daily minimum temperature is less than 0°C which may result in frost at ground level. This indicator is useful to help predict how changes in the number of days with minimal temperatures below freezing could affect native and agricultural plant species.

*Ice Days* occur when daytime high temperatures do not exceed 0°C. While some of the same effects are expected as for frost days, these freezing temperatures may also affect transportation via the increased chance of icy road conditions.

### Projections

In the Past, the capital region experienced an average of 60 frost days and 6 ice days per year. In the 2050s, we should expect far fewer such days: around half as many frost days by the 2050s and only around one-fifth as many by the 2080s. Ice days may be very rare by the mid- to late-century.

**Table 4: Warmer Winter Extreme Temperatures**

| | Past (°C) | 2050s (°C) | 2080s (°C) | 2050s Change (°C) | 2080s Change (°C) |
|---|---|---|---|---|---|
| Warmest Winter Day | 11 | 13 | 15 | 2.4<br>(*1.7 to 4.2*) | 4.2<br>(*3.2 to 6.9*) |
| Coldest Winter Night | -8 | -4.5 | -1.3 | 3.4<br>(*2.9 to 5.5*) | 6.6<br>(*5.4 to 10.4*) |
| 1-in-20 Year Coldest Nighttime Low | -15 | -10 | -6.5 | 5.0<br>(*3.2 to 7.2*) | 8.5<br>(*7.5 to 13*) |

**Table 5: Annual Frost and Ice Days**

| | Past (days) | 2050s (days) | 2080s (days) | 2050s Change (days) | 2080s Change (days) |
|---|---|---|---|---|---|
| **Frost Days (TN <0 °C)** | | | | | |
| Region | 60 | 27 | 12 | −33<br>(*−51 to −27*) | −48<br>(*−58 to −45*) |
| Eastern Region* | 30 | 11 | 3 | −19<br>(*−28 to −16*) | −27<br>(*−30 to −23*) |
| Water Supply Area | 80 | 38 | 17 | −42<br>(*−67 to −36*) | −63<br>(*−76 to −59*) |
| **Ice Days (TX <0 °C)** | | | | | |
| Region | 6 | 2 | 0 | -4<br>(*-6 to -3*) | -6<br>(*-7 to -5*) |

**The Eastern Region encompasses both the Southern Gulf Islands and Core/Peninsula subregions (Figure 1).*

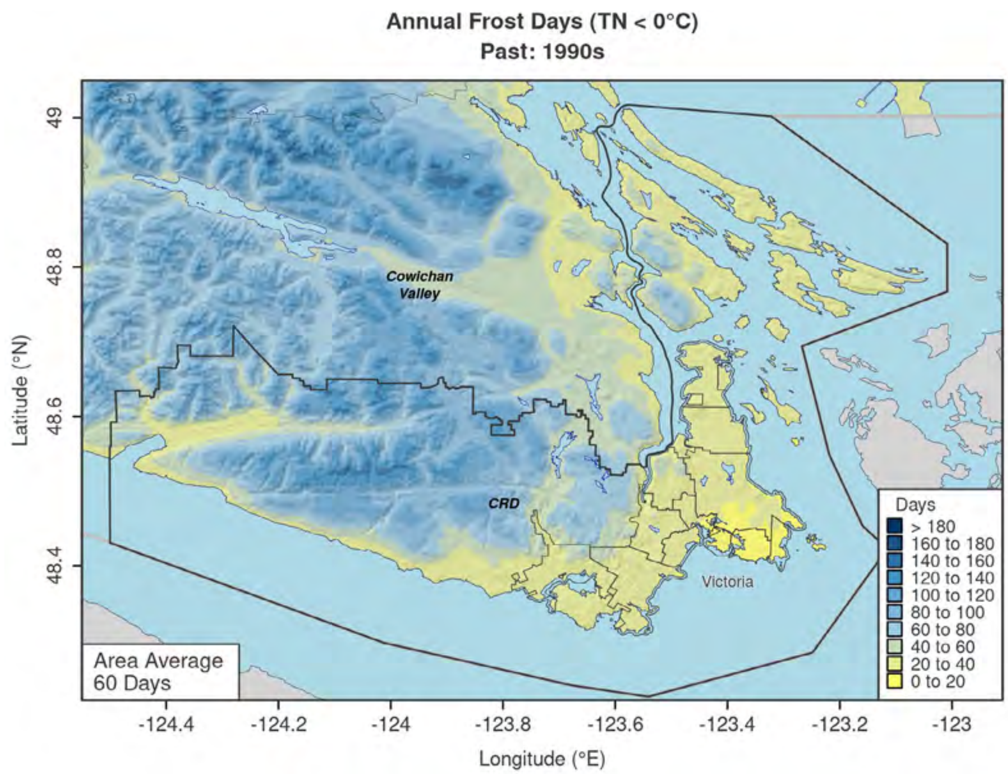



***Figure 11a.*** *Number of annual frost days in the Past.*

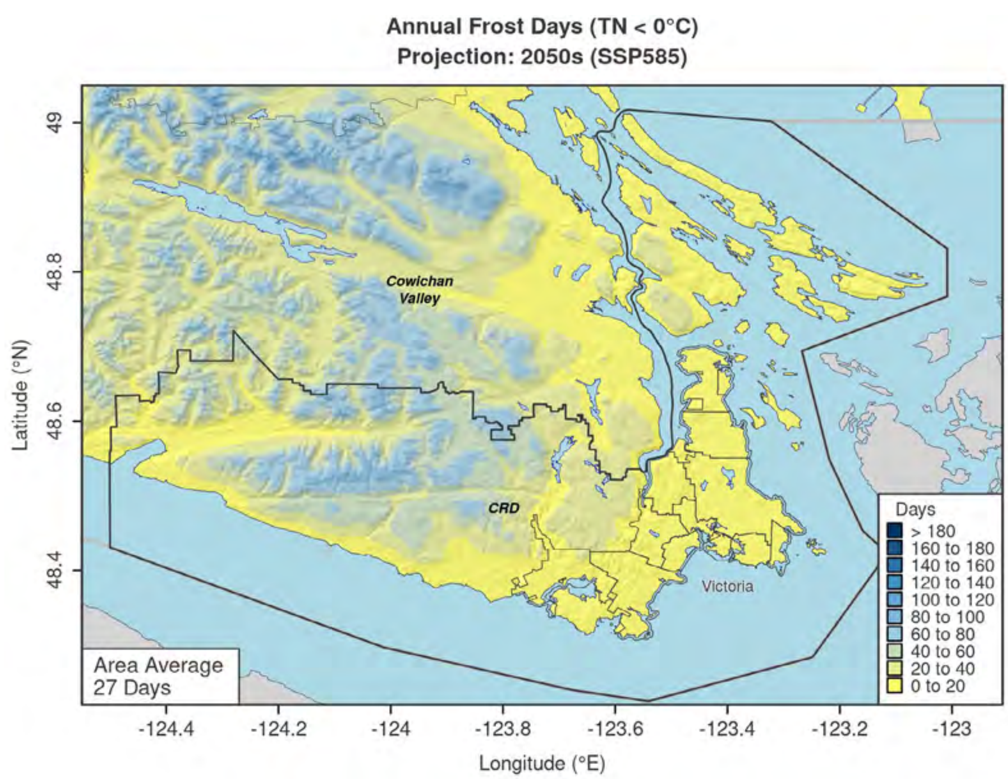



***Figure 11b.*** *Projected frost days in the 2050s.*

## **4.4** Heating Degree Days

*Heating Degree Days* (HDD) are calculated by summing the number of degrees that the daily mean temperature falls below 18°C for every day in a year.[9] This measure is commonly used to estimate the heating demand for buildings in the cooler months.

### *Projections*

In the Past, the capital region had a median of roughly 3405 HDD.[10] The median future-projected HDD decreases to 2644 (a 22% decrease) by the 2050s and to 2215 (a 35% decrease) by the 2080s. Due to its cumulative nature, a reduction in HDD is amongst the clearest indicators of warming, both in recent historical observations and in model projections. In addition, it should be noted that HDD varies considerably from west (higher values) to east (lower values) over the region.

Note that while mean winter temperatures will warm throughout the coming decades, the region's continued exposure to easterly polar outflows from Northwestern Canada through the Cascade Range suggests that the potential for multi-day cold snaps will persist in the future, though they should be less frequent. For this reason, building heating systems will still need to be responsive to occasional sub-zero winter temperatures.

**Table 6: Heating Degree Days**

| | Past (°C-days) | 2050s (°C-days) | 2080s (°C-days) | 2050s Change (%) | 2080s Change (%) |
|---|---|---|---|---|---|
| Region | 3405 | 2644 | 2125 | -22 (*-40 to -19*) | -35 (*-56 to -32*) |
| Southern Gulf Islands | 2836 | 2114 | 1755 | −25 (*-45 to -22*) | −38 (*−63 to −35*) |
| Core / Peninsula | 2904 | 2164 | 1773 | −25 (*−44 to −22*) | −39 (*−62 to −35*) |
| Western Region | 3387 | 2613 | 2158 | -23 (*-41 to -20*) | -36 (*-57 to -33*) |

[9] For example, if the daily mean temperature on January 1 is 10°C, followed by one day of 4°C, two days of −1°C and three days of 0°C, then HDD for that week are calculated as: (18−10) + (18−4) + 2 × (18−(−1)) + 3 × (18−0) = 114 degree-days. Note that days with a temperature equal to or greater than 18°C are not counted.

[10] Someone consulting the tables for the National Building Code of Canada (NBCC, 2015) will see different values of HDD listed for Victoria locations than the Past values cited in Table 6. One reason for this is the larger area covered by our Core/Peninsula subregion. Another is the different methodology and period of observations used to calculate HDD in the NBCC. As our estimate depends to some extent on coarse-grained climate models, while the NBCC employs interpolated station data, the NBCC value would normally be considered more reliable in this subregion (which contains several meteorological stations). For those interested in future HDD estimates, the relative differences from Past values can be used for HDD projections, regardless of which baseline value is used.

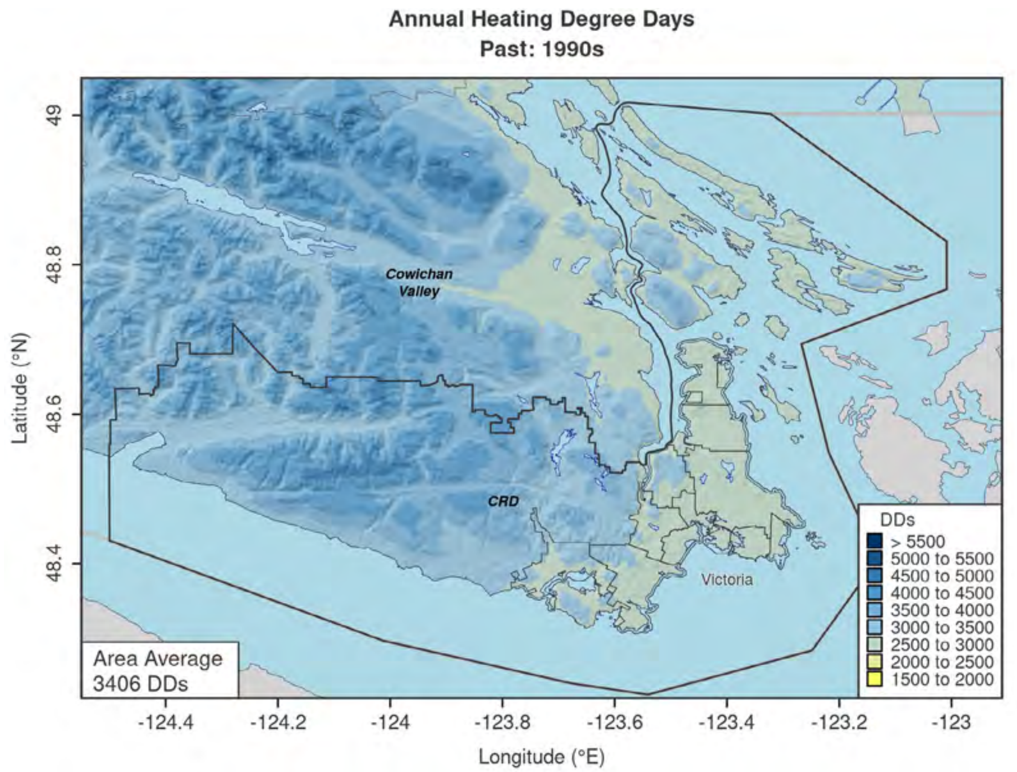



***Figure 12a.*** *Heating Degree Days in the Past.*

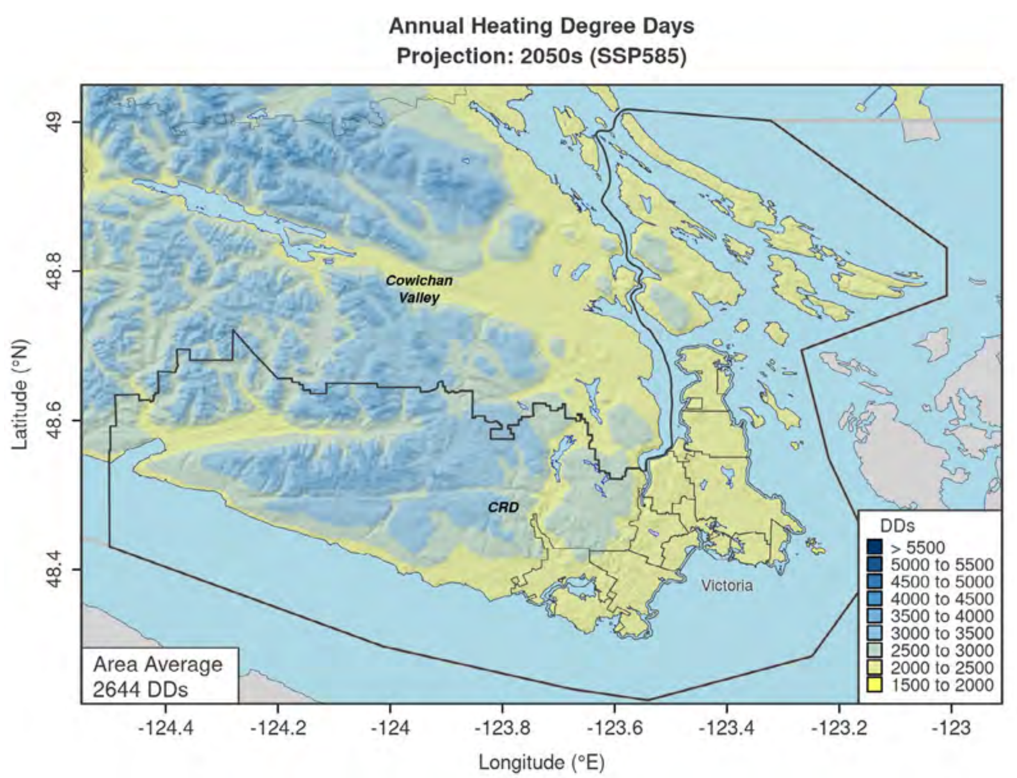



***Figure 12b.*** *Projected (decreased) HDD in the 2050s*

# 5. SUMMER TEMPERATURE INDICATORS

## 5.1 Growing Season Length

*Growing Season Length* (GSL) is an annual measure indicating the period when temperatures are warm enough for most vegetation to grow. The GSL is the number of days between the first span of at least 6 consecutive days with daily average temperatures above 5°C, and the first span, after July 1, of six days with temperatures below 5°C. This measure helps to highlight how urban forests, agricultural and landscaped areas, grasses, weeds (and their pollens) may be affected by climate change.

### *Projections*

In the Past, the growing season lasted roughly 270 days in the region. The median future-projected growing season increases by 47 days to 318 days by the 2050s and by 68 days to 339 days by the 2080s.

Other things being equal, a longer GSL implies potentially more productive vegetation in the future. However, since GSL uses only a lower temperature threshold (and not an upper threshold to account for heat stress) and ignores changes in precipitation (reduced rainfall in the warm season—Section 3.3, Table 3), it should be considered an upper limit for estimates of future productivity.

A related measure to GSL is the length of the frost-free season, which uses a lower threshold of 0°C for minimum daily temperature. As mentioned above, frost days will become increasingly rare in the future, resulting in frost-free conditions nearly year-round in the region by the 2080s.

**Table 7: Growing Season Length**

| | Past (days) | 2050s (days) | 2080s (days) | 2050s Change (days) | 2080s Change (days) |
|---|---|---|---|---|---|
| Region | 271 | 318 | 339 | 47 (*39 to 71*) | 68 (*60 to 86*) |
| Eastern Region | 315 | 348 | 358 | 33 (*25 to 42*) | 44 (*37 to 49*) |
| Western Region | 283 | 324 | 344 | 41 (*35 to 64*) | 61 (*53 to 76*) |
| Water Supply Area | 245 | 301 | 329 | 56 (*45 to 90*) | 84 (*75 to 112*) |

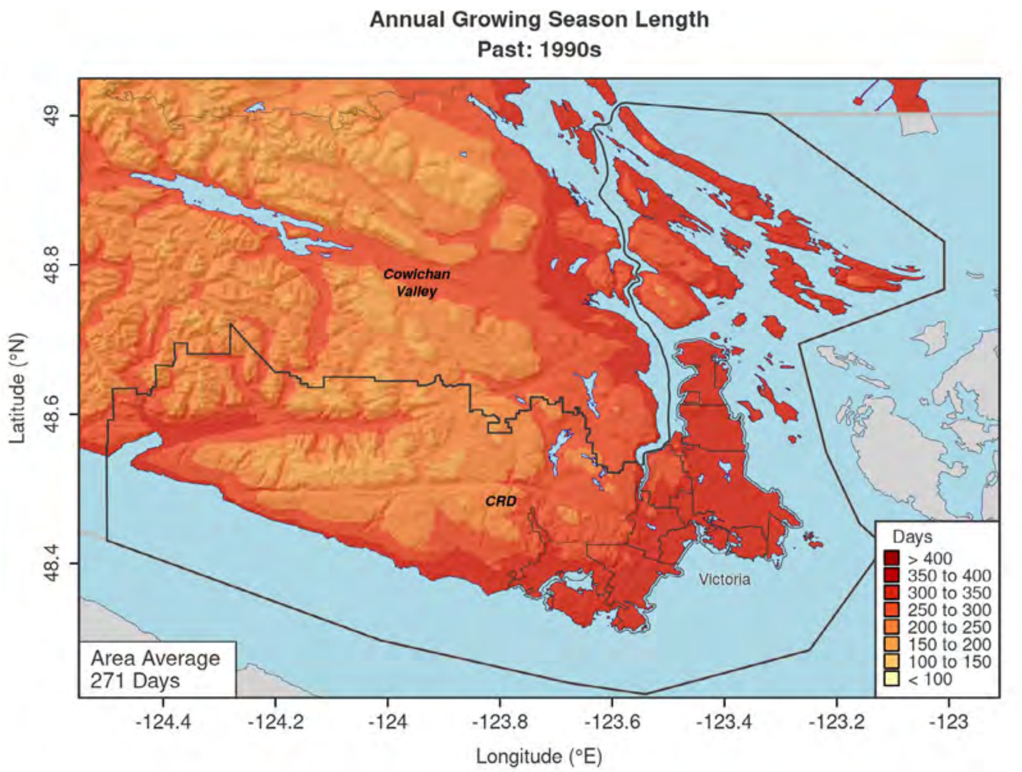



***Figure 13a.*** *Growing season length in the past*

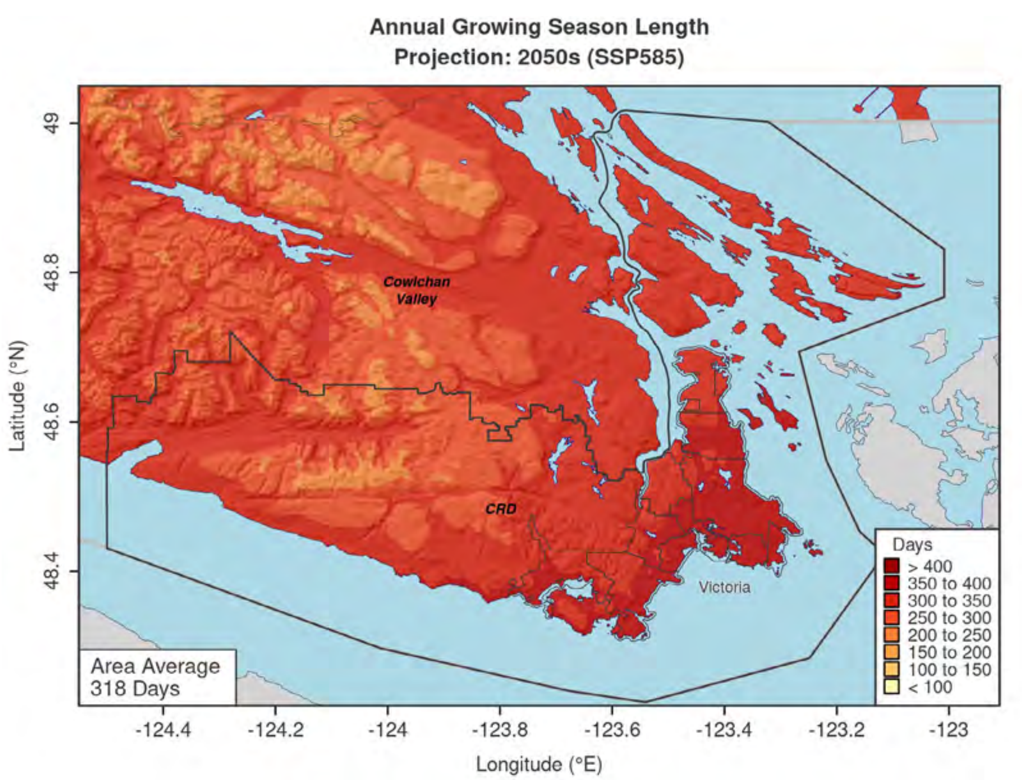



***Figure 13b.*** *Projected (increased) growing season length by the 2050s*

## **5.2** Cooling Degree Days

The opposite of HDD, *Cooling Degree Days* are calculated by summing the number of degrees that the daily mean temperature exceeds 18°C for every day in a year.[11] This measure is commonly used to estimate the demand for mechanical cooling (i.e., air conditioning) in buildings in the warmer months.

### *Projections*

In the Past, the capital region typically had around 17 cooling degree days, with the vast majority of such days occurring in summer. The median future-projected cooling degree days increase to about 119 (a 7-fold increase) by the 2050s and to nearly 240 (a 14-fold increase) by the 2080s. While most such days will continue to occur in summer, they will increasingly occur during late spring and early fall.

Like the projected decrease in HDD, an increase in cooling degree days is among the clearest indicators of warming, both in recent historical observations and model projections. Moreover, the magnitude of increase varies strongly from west (lower values) to east (higher values) across the capital region. To the extent that this index correlates with demand for cooling, new buildings may need to be designed differently to maintain thermal comfort.

**Table 8: Cooling Degree Days**

| | Past (°C-days) | 2050s (°C-days) | 2080s (°C-days) | 2050s Change (°C-days) | 2080s Change (°C-days) |
|---|---|---|---|---|---|
| Region | 17 | 119 | 237 | 102 (*62 to 235*) | 220 (*176 to 592*) |
| Southern Gulf Islands | 38 | 227 | 392 | 189 (*119 to 385*) | 354 (*297 to 820*) |
| Core / Peninsula | 25 | 169 | 317 | 144 (*87 to 310*) | 292 (*234 to 716*) |
| Western Region | 10 | 83 | 185 | 73 (*41 to 185*) | 175 (*135 to 525*) |

[11] For example, if the daily mean temperature on July 1 is 20°C, followed by three days of 21°C, one day of 25°C and two days of 16°C, then the cooling degree days for that week are calculated as: (20−18) + 3 × (21−18) + (25−18) = 18 degree-days.

Note that days with temperature equal to or less than 18°C are not counted.

## **5.3** Warm Summer Days and Nights, Annual Hottest Day and Heatwaves

These indicators highlight the most extreme warm temperatures occurring in the region. The results in the table below are for the Core/Peninsula subregion (see Figure 1) which has the highest population and therefore the highest exposure to many heat-related impacts (values for the Southern Gulf Islands are very similar). Three single-day extreme heat measures are included in the table: the peak temperature of the hottest day of the year (not necessarily occurring during a heatwave), the number of days with TX > 25°C (*Summer Days*), and the number of nights with TN > 16°C (*Temperate Nights*). Episodes of multi-day extreme heat, which were rare in the Past, are captured by several heatwave (HW) indicators defined in the Appendix. These are partly based on threshold temperatures for emergency health alerts used specifically in BC.[12] As with the variables discussed above, each of the indices describes a typical year within the indicated 30-year period.

### *Projections*

In the Past, there were typically around 12 days per year with a high temperature exceeding 25°C, and rarely did nighttime temperatures rise above 16°C. The median future-projected number of Summer Days increases to roughly 40 per year by the 2050s and 62 per year by the 2080s, while Temperate Nights begin to occur by the 2030s, with a frequency of 15 per year in the 2050s and 52 per year in the 2080s.

When it comes to heatwaves, in the Past, there was usually one HW per year, lasting up to 3 days and having a peak daily temperature of around 30°C. The median future-projected number of HWs increases to roughly 3 per year by the 2050s and 5 per year by the 2080s. HWs are also projected to increase in length in the future (approaching 9 consecutive days or more by the 2080s) and will feature both warmer daytime and nighttime temperatures. It is clear that residents of the area will need to adapt to more frequent, longer, and intense HWs in future.

**Table 9: Measures of extreme heat (Core/Peninsula subregion)**

| Core/Peninsula subregion: Heatwave (HW) Indices, Hot Summer Days and Warm Nights* | | | | | |
|---|---|---|---|---|---|
| **Index** | **Description** | **Past** | **2030s** | **2050s** | **2080s** |
| **HWD** | HW days (days) | 1 | 4<br>(*3 to 11*) | 10<br>(*6 to 27*) | 23<br>(*17 to 74*) |
| **HWXL** | HW Maximum length (days)[13] | 3 | 4<br>(*3 to 5*) | 4.5<br>(*4 to 10*) | 8.5<br>(*6 to 43*) |
| **HWN** | Annual number HWs | 1 | 2<br>(*1 to 4*) | 3<br>(*2 to 5*) | 5<br>(*4 to 7*) |
| **TXHX** | Avg. TX in most extreme annual HW (°C) | 30 | 31<br>(*30 to 32*) | 31<br>(*31 to 33*) | 32<br>(*32 to 34*) |
| **TNHX** | Avg. TN in most extreme annual HW (°C) | 15 | 16<br>(*15 to 16*) | 17<br>(*16 to 18*) | 19<br>(*18 to 21*) |
| **TXX** | TX on hottest day of year (°C) | 29 | 31<br>(*30 to 32*) | 32<br>(*32 to 35*) | 35<br>(*33 to 38*) |
| **SU** | Number of days reaching TX >25 °C | 12 | 28<br>(*22 to 41*) | 40<br>(*30 to 70*) | 62<br>(*57 to 111*) |
| **TR16C** | Number of nights reaching TN >16°C | 0 | 4<br>(*3 to 13*) | 15<br>(*9 to 47*) | 52<br>(*36 to 108*) |

**Upper values in each table cell are the ensemble median, with values in parentheses giving the 10$^{th}$ to 90$^{th}$ percentile range over the model ensemble.*

[12] See the report, BC Provincial Heat Alert and Response System (BC HARS): 2023, May 2023. Available at: http://www.bccdc.ca/health-professionals/professional-resources/heat-event-response-planning. The lower threshold temperatures used in our HW definition, which is intended for use throughout BC, are TX = 28°C and TN = 13°C. In addition, a HW must: 1) last at least 2 full days; and 2) have TX and TN exceeding their 95th percentile values in the Past.

[13] It may seem strange that HWD < HWXL in the Past, but this is an artifact of small number statistics. Some years in the Past contained no HWs, leading to a mean annual value of 0.4 for HWD (rounded to 1 in the table, since some years had a HW). Nevertheless, one or more years had HW lengths of 2 or 3 days, leading to the mean HWXL = 2.5 days (rounded to 3) over the 30-year period. As the number of HWs increases in future years of the simulations, the expected behaviour HWD > HWXL emerges.

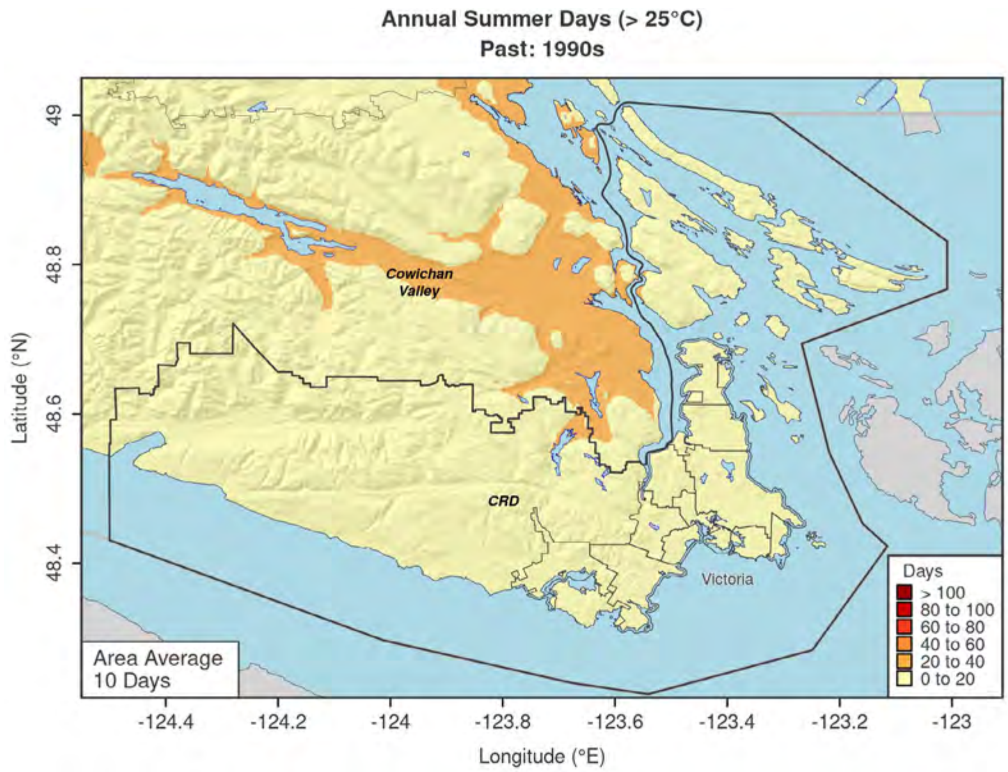



***Figure 14a.*** *Annual count of summer days in the Past*

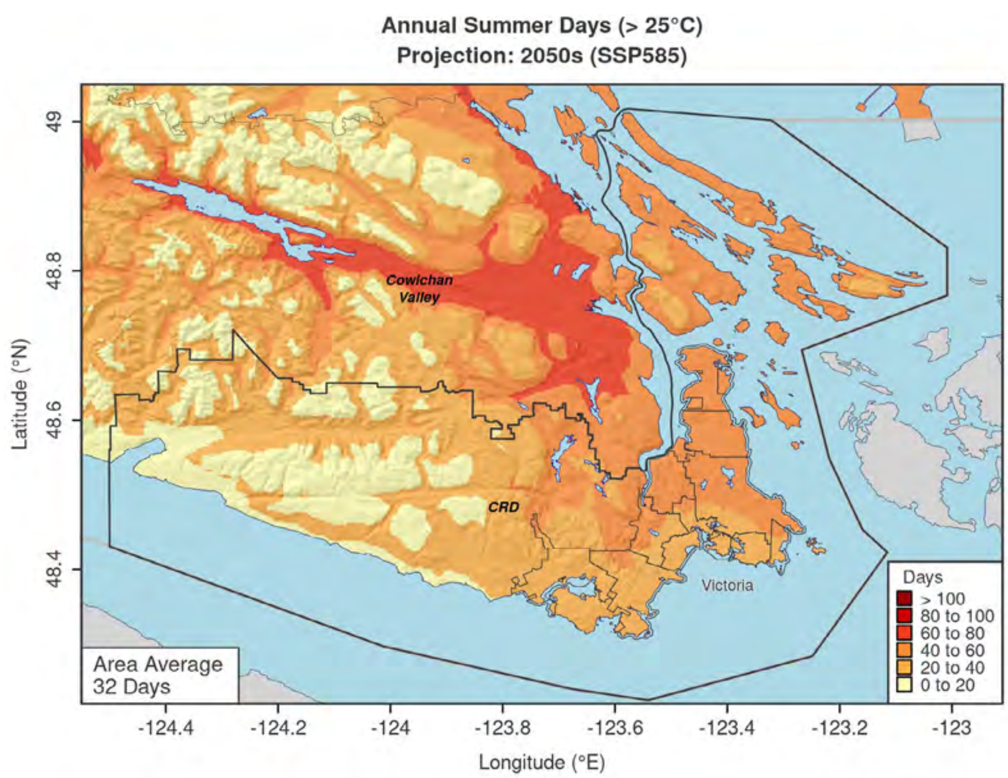



***Figure 14b.*** *Projected number of annual summer days by the 2050s*

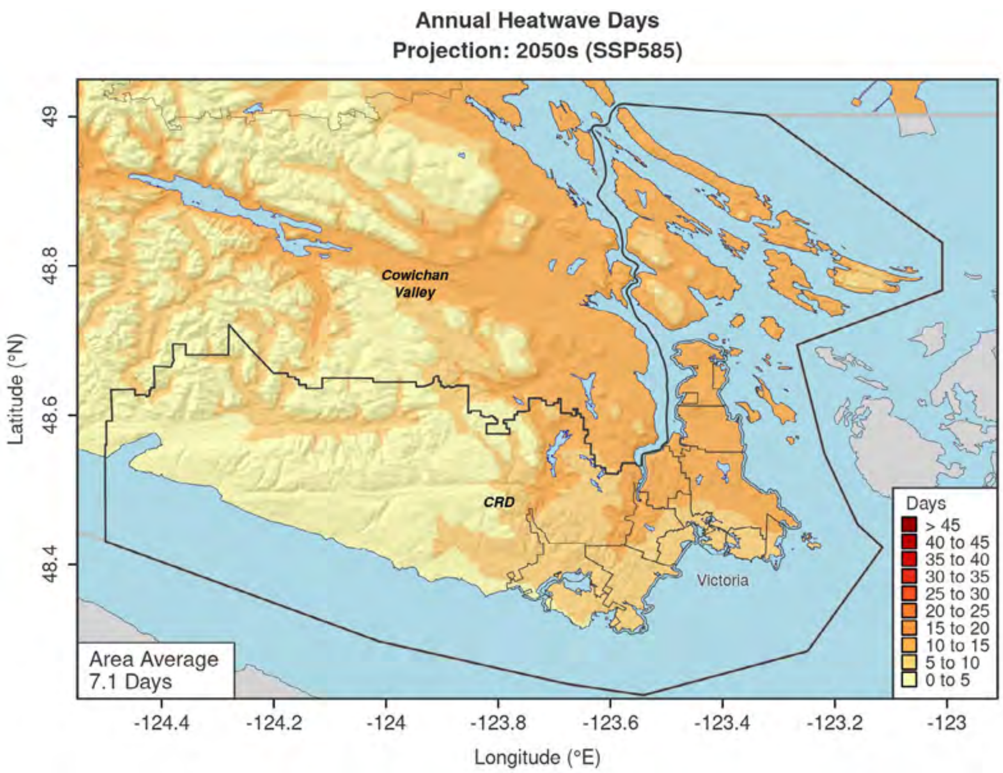
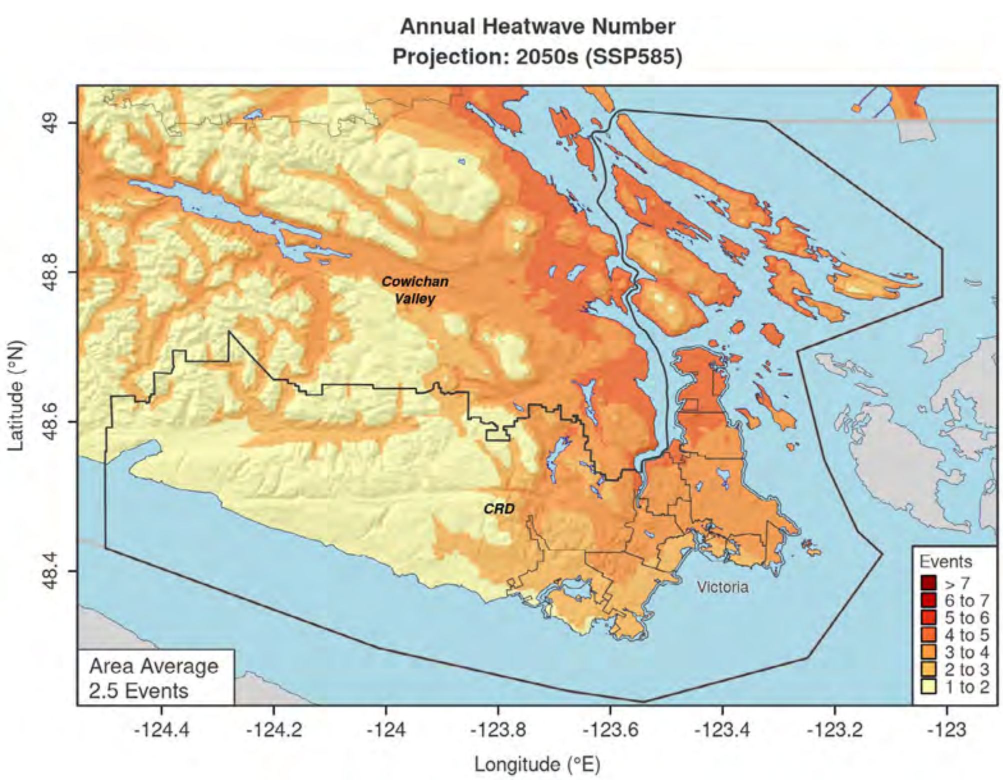



***Figure 15a***. *Projected annual count of heatwave days in the 2050s.*




*Note that: (i) for both measures, counts in the Past are very low (about 1 per year) and uniform throughout the capital region; and (ii) average values for Core/ Peninsula (Table 9) are larger than capital region averages shown on the maps.*

***Figure 15b.*** Projected number of annual heatwaves in the 2050s.

## 5.4 The 1-in-20-Year Annual Hottest Day

This indicator describes extreme daily high temperatures so warm, they are expected to occur only once every 20 years in the historical climate. In other words, the *1-in-20 Year Hottest Day* presently has a 5% chance of occurring in any given year.

### Projections

The figure below shows the projected changes in this type of event in two ways: first, in terms of how frequently an event of the same TX value occurs in the future; and second, in terms of how much TX increases for an event occurring with the same frequency (or annual probability) in the future.

For example, in the Past, a daily maximum temperature of 32°C or higher occurred once every 20 years or so in the capital region, or with a 5% annual exceedance probability (AEP). In the projections for the 2050s, this temperature is exceeded around 8 times in a 20-year period, or with a 40% AEP. Alternatively, one can say based on the same projections that in the 2050s, the magnitude of a 1-in-20 year (5% AEP) event increases to around 35.5°C (see the 'Return Levels' tab in the SSP585 Summary Table).

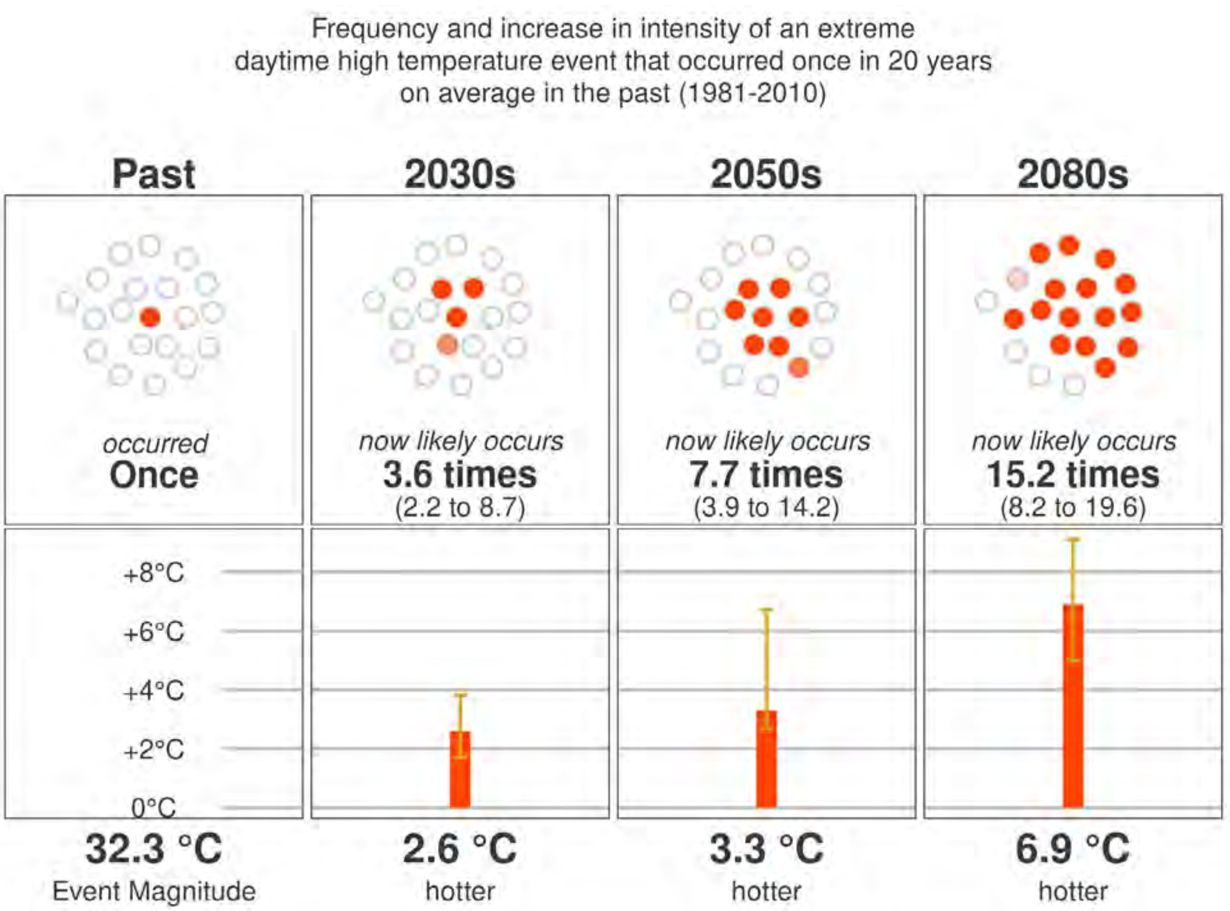



***Figure 16.*** *Upper panels: Frequency of a 1-in-20 year daily maximum temperature (TX) event in the Past and projected frequency of the same magnitude event (i.e. TX = 32°C) in the three future periods. Lower panels: Increase in magnitude of a 1-in-20 year TX event from the Past to Future periods. Figure design is taken from similar infographics in the IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., et al. (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 3-32, doi:10.1017/9781009157896.001.*

# 6. PRECIPITATION INDICATORS

## 6.1 Dry Spells

The *Consecutive Dry Days* indicator tracks the annual longest string of days with less than 1 mm of precipitation.

### Projections

In the Past, the median dry spell length in the capital region was 24 days. The median future-projected dry spell length increases by 8% to 26 days (range 24 - 34 days) by the 2050s and by 21% to 29 days (range 26 - 47 days) by the 2080s.

The increase in dry spell length is consistent with the higher summer temperatures and reduced summer rainfall highlighted in the previous chapters. The map of consecutive dry days (not shown) is quite uniform throughout the region, as are its changes in the future periods.

## 6.2 Snowfall

*Snowfall* is inferred from the downscaled total daily precipitation and temperature, using a widely validated empirical relationship.[14]

### Projections

In the Past, the median annual snowfall in the capital region was around 275 mm (snow water equivalent, or SWE). The median future-projected snowfall decreases by 60% to around 110 mm (range 32 to 134 mm) by the 2050s and by 85% to just 40 mm (range 7 to 60 mm) by the 2080s. Due to the robust projection of an increase in cold season temperature (Chapters 3 and 4), the expectation of a smaller fraction of precipitation falling as snow in future decades is reasonable, even if its magnitude is somewhat uncertain.

Of more concern is the limited model ability to simulate the unique meteorological conditions that lead to the rare, but sometimes heavy, snowfalls in southwest BC. The CMIP6 models used in this study are probably not able to capture this behaviour very well, meaning that the change in frequency of winter storms resulting in heavy snowfall is largely unknown.

[14] Dai, A. (2008). "Temperature and pressure dependence of the rain-snow phase transition over land and ocean," Geophysical Research Letters, 35(12). Snowfall projections should be taken with special caution, for two reasons. First, the amount of total precipitation that falls as snow is a sensitive function of local temperature, so whatever temperature biases remain after the downscaling procedure result in uncertainty in snowfall. Over time, however, as local temperatures exceed 0°C more often in winter, this uncertainty decreases.

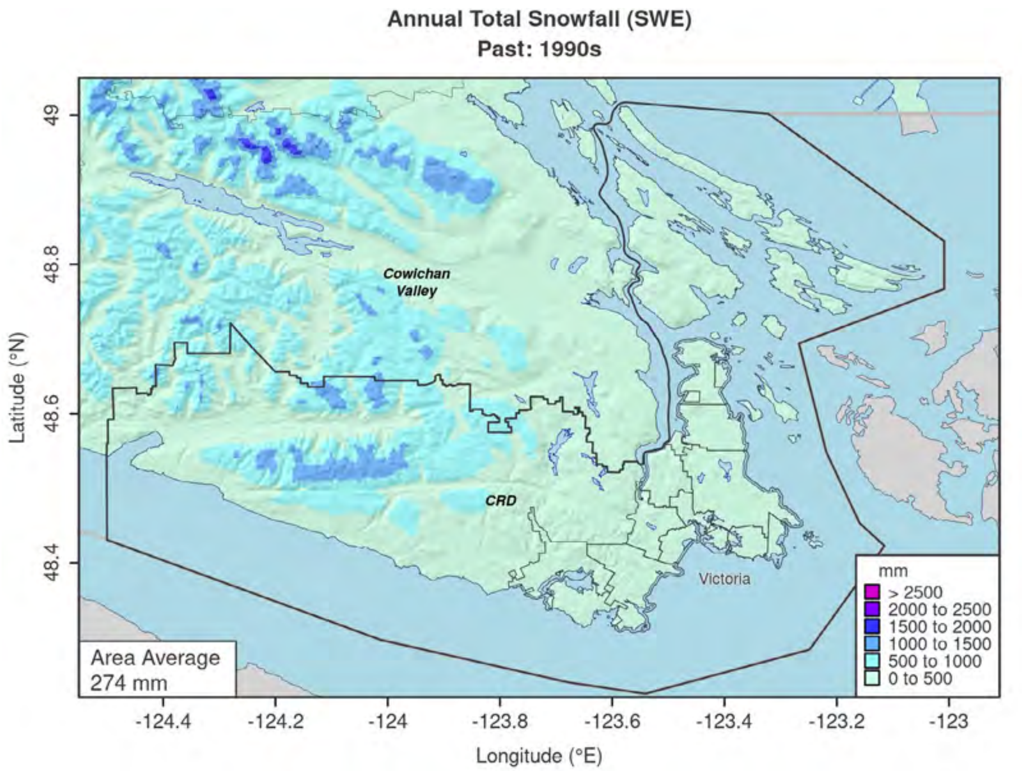



***Figure 17a.*** *Annual total snowfall in the Past.*

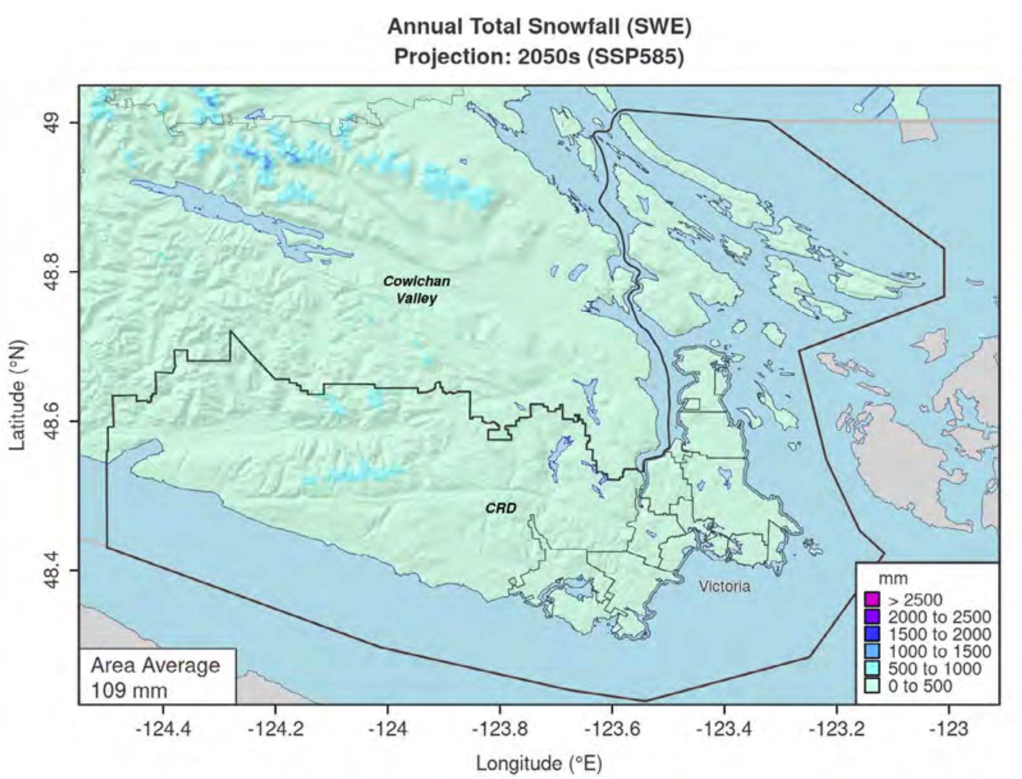



***Figure 17b.*** *Projected snowfall in the 2050s.*

## 6.3 Annual Maximum One-Day and 5-Day Precipitation and 95th-percentile Wettest Days

These indicators describe the largest precipitation events of the year. The *Annual Maximum One-Day Precipitation* (RX1DAY) is self-explanatory, while the *Annual Maximum 5-Day Precipitation* (RX5DAY) tracks the accumulated amount over consecutive 5-day periods during the year. If we compute the 95$^{th}$ percentile of daily precipitation over all wet days in the Past (i.e. those with a daily amount of at least 1 mm), and then sum the amounts over that threshold that fell on especially wet days, then we obtain the 95$^{th}$-percentile Wettest Days (R95P) index.

Note that R95P is potentially composed of several large precipitation events in a typical year, and does not (usually) describe single storms.

All amounts in the table below reflect the systematic difference in precipitation amount from west (high) to east (low) across the capital region. Across the region, percent increases for the 2050s differ somewhat for each index: from 10-16% for RX1DAY, to around 10% for RX5DAY to around 30% for R95P. Changes for the 2080s are correspondingly higher, as shown in the table.

**Table 10: Annual Extreme Precipitation Indices**

| | Past (mm) | 2050s(mm) | 2080s(mm) | 2050s Change (%) | 2080s Change (%) |
|---|---|---|---|---|---|
| **One-day maximum precipitation (RX1DAY)** | | | | | |
| Region | 63 | 72 | 77 | 14<br>(*4 to 24*) | 22<br>(*17 to 29*) |
| Western Region* | 67 | 74 | 80 | 10<br>(*4 to 24*) | 19<br>(*17 to 30*) |
| Eastern Region | 37 | 43 | 45 | 16<br>(*5 to 26*) | 22<br>(*17 to 33*) |
| **5-Day maximum precipitation (RX5DAY)** | | | | | |
| Region | 163 | 179 | 187 | 10<br>(*6 to 21*) | 15<br>(*12 to 33*) |
| Western Region | 172 | 188 | 197 | 9<br>(*6 to 20*) | 15<br>(*13 to 24*) |
| Eastern Region | 88 | 97 | 101 | 10<br>(*5 to 23*) | 15<br>(*12 to 23*) |
| **95$^{th}$ Percentile Wettest Days (R95P)** | | | | | |
| Region | 402 | 527 | 590 | 31<br>(*16 to 46*) | 47<br>(*30 to 77*) |
| Western Region | 423 | 553 | 622 | 31<br>(*16 to 46*) | 47<br>(*30 to 79*) |
| Eastern Region | 193 | 245 | 276 | 26<br>(*10 to 41*) | 43<br>(*23 to 64*) |

*Values for Water Supply Area and the entire region are slightly lower than those for the Western Region, and well within the spread of model results, so are not shown. Consult the data deliverable spreadsheets for values in all subregions.

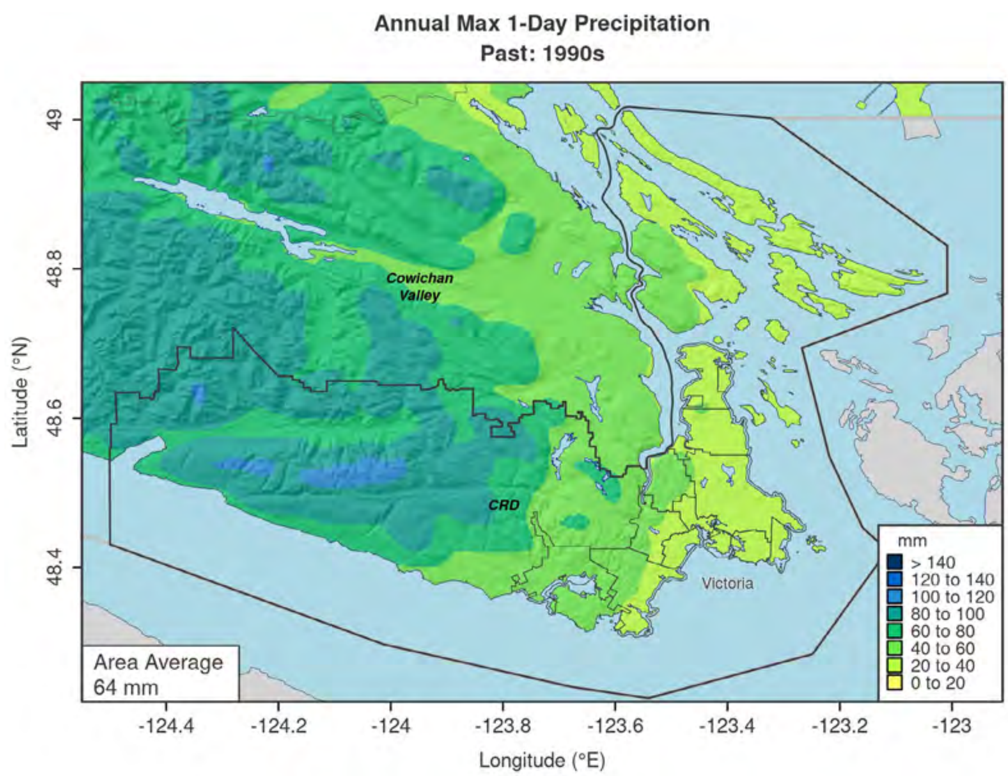



***Figure 18a.*** *Annual maximum 1-day precipitation in the Past.*

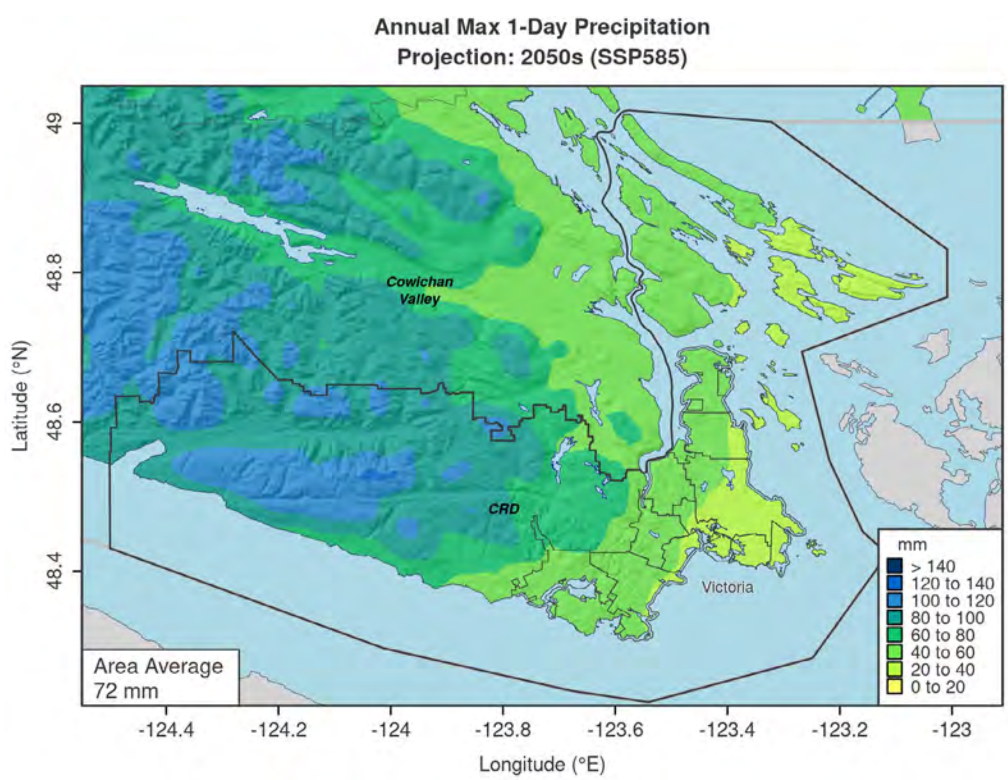



***Figure 18b.*** *Projected Annual maximum 1-day precipitation in the 2050s.*

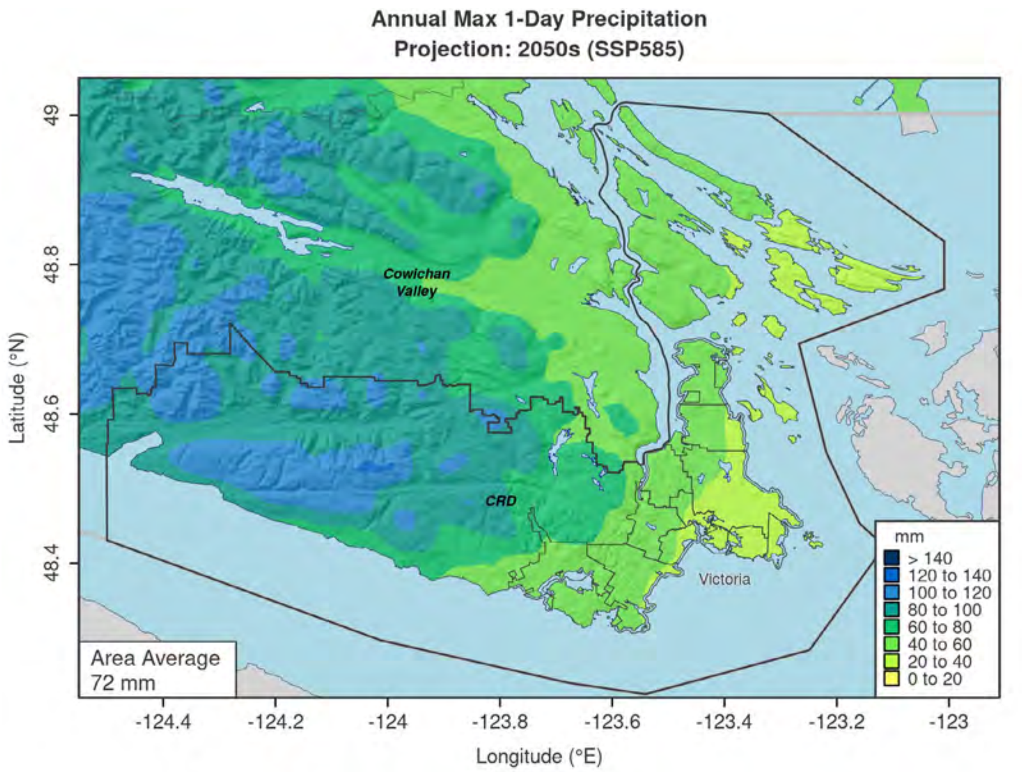



***Figure 19a.*** *1-in-20 year, maximum 5-day rainfall in the Past.*

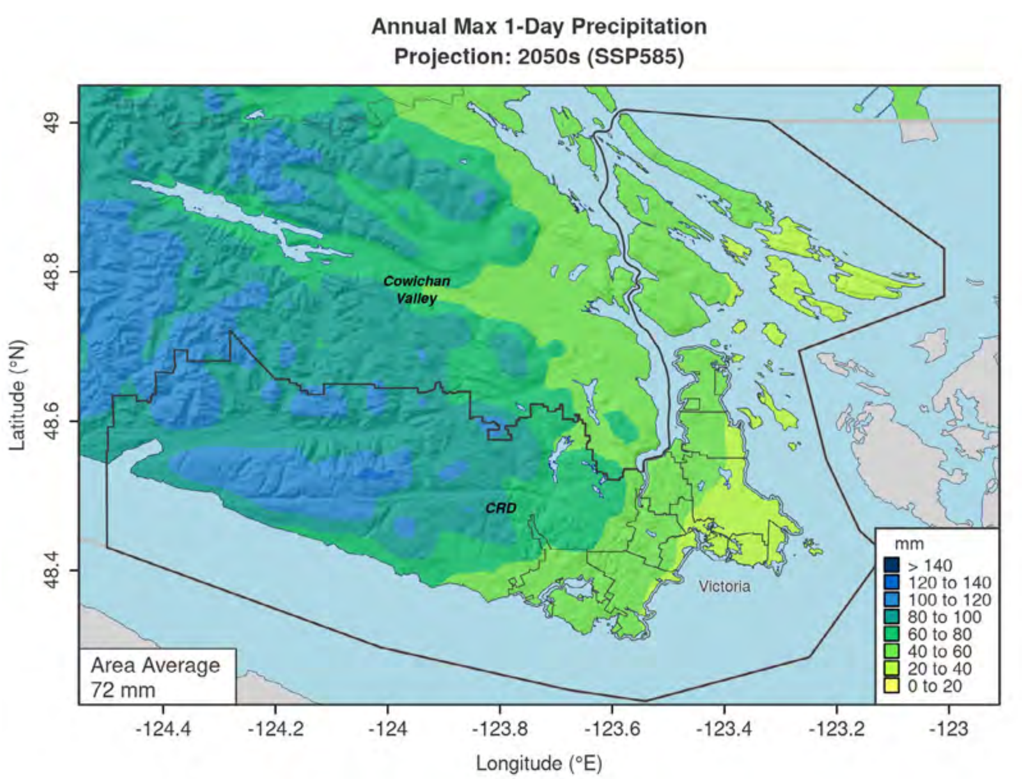



***Figure 19b.*** *1-in-20 year, maximum 5-day rainfall in the 2050s.*

## **6.4** The 1-in-20 Year Wettest Day and 1-in-20 Year Wettest 5-Day Period

These indicators describe rainfall events so extreme, they are expected to occur only once every 20 years in the Past climate. In other words, the *1-in-20 Year Wettest Day* and *Wettest 5 Days* have a 5% chance of occurring in any given year in the Past.

### *Projections*

In the Past, the median 1-in-20 Year, single-day rainfall in the capital region was around 100 mm, while the median 1-in-20 year, 5-day rainfall was about 230 mm. The median Future-projected 1-in-20 year, single-day rainfall increases by 15% to around 115 mm by the 2050s and by 25% to about 125 mm by the 2080s. The median future-projected 1-in-20 year, 5-day rainfall increases by 15% to around 270 mm by the 2050s and by 20% to about 280 mm by the 2080s. As shown in the maps above, the absolute rainfall amounts for both indices are considerably larger in the west of the region compared to the east.

By comparing these results with those shown in Table 3 of Chapter 3, it is evident that the relative changes in extreme rainfall indices are larger than those for seasonal or annual mean rainfall. Table 12, which gathers relevant results from other tables above, reinforces this point. This behaviour occurs due to the different mechanisms that control how extreme (e.g., daily) and average (e.g., monthly to annual) precipitation respond to warming.

As in the case of rare temperature events, one may express these changes in extreme rainfall in a more visually compelling way, as in the diagram on the following page.

**Table 11: 20-Year Return Level Rainfall**

| | Past (mm) | 2050s (mm) | 2080s (mm) | 2050s Change (%) | 2080s Change (%) |
|---|---|---|---|---|---|
| 1-in-20 Year Maximum One-Day Rainfall | | | | | |
| Region | 101 | 116 | 124 | 15<br>(*9 to 30*) | 24<br>(*22 to 42*) |
| Western Region[1] | 105 | 122 | 129 | 16<br>(*9 to 28*) | 23<br>(*21 to 39*) |
| Eastern Region | 62 | 72 | 79 | 16<br>(*10 to 23*) | 27<br>(*23 to 42*) |
| 1-in-20 Year Maximum 5-Day Rainfall | | | | | |
| Region | 232 | 268 | 281 | 14<br>(*3 to 31*) | 21<br>(*11 to 27*) |
| Western Region | 243 | 274 | 297 | 13<br>(*2 to 32*) | 22<br>(*11 to 27*) |
| Eastern Region | 132 | 155 | 159 | 17<br>(*0 to 32*) | 20<br>(*10 to 27*) |

**Table 12: Change in various precipitation indices: Means versus extremes**

| | Region | | Western Region | | Eastern Region | |
|---|---|---|---|---|---|---|
| | 2050s Change (%) | 2080s Change (%) | 2050s Change (%) | 2080s Change (%) | 2050s Change (%) | 2080s Change (%) |
| Annual Mean | 4 | 11 | 2 | 8 | 5 | 11 |
| RX1DAY | 14 | 22 | 10 | 19 | 15 | 22 |
| RX5DAY | 10 | 15 | 9 | 15 | 11 | 15 |
| R95P | 31 | 47 | 31 | 47 | 26 | 43 |
| 1-in-20 RX1DAY | 15 | 24 | 16 | 23 | 16 | 27 |
| 1-in-20 RX5DAY | 14 | 21 | 13 | 22 | 17 | 20 |

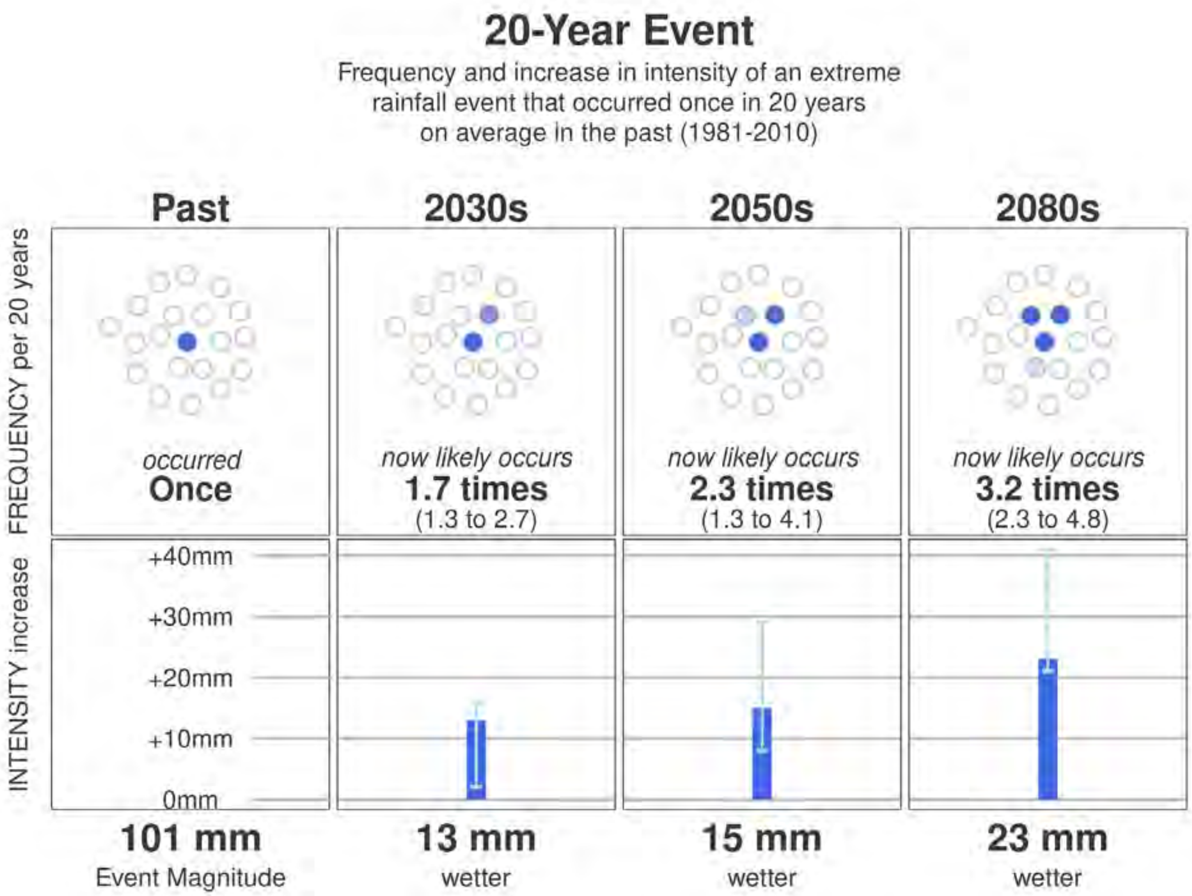



***Figure 20.*** *Upper panels: Frequency of a 1-in-20 year daily maximum rainfall event in the Past and projected frequency of the same magnitude event (i.e. 101 mm) in the three future periods. Lower panels: Increase in magnitude of a 1-in-20 year single-day rainfall event from the Past to Future periods. Figure design is taken from similar infographics in the IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., et al. (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 3-32, doi:10.1017/9781009157896.001.*

# 7. REGIONAL IMPACTS

Communities across the capital region are already witnessing and experiencing impacts from climate change. These impacts are likely to persist and, in many cases, intensify over the coming decades based on projected global GHG emissions trajectories. Collective efforts to reduce emissions and thereby slow the rate of global warming will be necessary to lessen the severity of these impacts. Equally important will be action on climate adaptation and preparing for the environment as it will be in the future, not as it was in the past.

Investing in climate adaptation has the potential to support thriving communities and economies for generations to come. Adaptation actions can safeguard communities and their critical infrastructure from extreme weather events, protect and sustain natural ecosystems, increase the resiliency of food systems, and improve the efficiency of energy and water use. Importantly, there is no "one-size-fits-all-solution"; adaptation can take many forms depending on the unique context of the community.

By the 2050s, the capital region can expect a climate that has diverged from that of the past, with warmer year-round temperatures, shifting precipitation patterns, and more noticeable climate extremes. Due to climate variability, these changes may not occur evenly from one year to the next. Although winters will generally become warmer and wetter, it's important to be prepared for some winters in the future to be colder and drier, especially in the near term. Similarly, while summers will become increasingly hot and dry, there will be summers that are cooler and wetter than the average summer in the future. Adaptation strategies must consider the inherent complexity and variability of projected changes to the regional climate.

This section provides a brief overview of the multiple, intersecting climate impacts expected across various sectors in the capital region. **It is not a comprehensive assessment of the impacts that can be expected from the projected changes outlined in this report.** Rather, this chapter reflects a discussion of regional climate impacts that took place among local government staff, emergency planners and environmental scientists in October 2023. It is intended to spark deeper discussion that explores how to prepare for the interrelated climate impacts facing the region.

While the development of this report did not actively involve First Nations in the capital region, it's crucial to recognize that Indigenous Peoples and their traditional territories bear a disproportionate impact from climate change compared to other groups in Canada.[15] Indigenous knowledge systems play a pivotal role in comprehending ecological resilience, monitoring local and regional impacts, and effectively responding to climate change challenges. Future initiatives aimed at exploring and mitigating the impacts of climate change should prioritize meaningful engagement with First Nations throughout the region.

> The case for investing in climate adaptation is clear: for every $1 spent on adaptation measures today, $13 to $15 is estimated to be returned in future years through direct and indirect benefits.[16]


***Figure 21.*** *Infographic summarizing key projections for the 2050s time period.*

[15] BC Centre for Disease Control. Climate Change and Health. http://www.bccdc.ca/health-info/prevention-public-health/climate-change-health

[16] Swayer, D., Ness, R., Lee, C., and Miller, S. (2022). Damage control: Reducing the costs of climate impacts in Canada. Climate Risk Institute.

## Climate Equity

The impacts discussed in this chapter will not be experienced the same way by all residents of the region. People facing the greatest economic and social challenges are often the ones most affected by climate change, particularly for impacts that are compounding (see below). During and after climate-related events, some people and communities experience disproportionate impacts because of existing vulnerabilities that often overlap, including:[15]

- People who experience poverty, colonization, racism, inadequate housing, and a lack of access to health care,
- People who are most likely to be exposed to climate impacts because of where and how they live and work,
- People living with disabilities, chronic diseases, and mental illnesses, and
- Babies in the womb, pregnant people, infants, children, and older adults.

Climate equity can be woven into broader efforts to address the socioeconomic, sociocultural, and physical impacts of climate change. This will require collaboration across various sectors to understand where climate change intersects with other crises (e.g., housing, mental health), and to address these issues holistically.

> Climate equity[17] is the goal of recognizing and addressing the unequal burdens made worse by climate change, while ensuring that all people share the benefits of climate action efforts. Achieving climate equity means that all people in our region have access to a safe, healthy, and fair environment.

### *Impacts*

The impacts examined in this chapter occur within a dynamic and increasingly complex global system. As a result, the impacts from projected climate change may be more severe due to the collective impact of multiple drivers. Examples of compounding interactions include, but are not limited to:

- In the warmer months, high temperatures combined with less rainfall can make drought conditions more likely. [18]
- Extended periods of drought can change soil conditions and reduce infiltration of heavy rainfall, exacerbating localized flooding.[19]
- Warmer water temperatures and increased stormwater runoff can promote conditions for algal blooms year-round.[19]
- Wildfire smoke during extreme heat events can aggravate pre-existing health conditions and cause exposure to poor air quality for residents seeking relief from the heat outdoors.[19]
- Ongoing emergency response associated with consecutive extreme events can overwhelm staff capacity and deplete emergency management resources.

[17] United States Environmental Protection Agency. Climate Equity. https://www.epa.gov/climateimpacts/climate-equity

[18] Intergovernmental Panel on Climate Change [IPCC]. 2023. Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (eds.)]. IPCC, Geneva, Switzerland, pp. 35-115, doi: 10.59327/IPCC/AR6-9789291691647

[19] Yumaguloca et al. 2022. Lived experience of extreme heat in BC: Final report to the Climate Action Secretariat. Government of BC.

# Health and Well-Being

The capital region has a growing and aging population. By 2038, the population is expected to grow by 20% and the number of people aged 65+ is expected to increase by over 50%.[20] Historically, the region has had excellent air quality and comfortable temperatures, with nights cooling off in the summer. In recent years, wildfire smoke and periods of extreme heat during the warmer months have forced residents to seek refuge indoors. Higher temperatures are typically experienced in the eastern parts of the region and in urban areas further from the coast. Developed areas are typically hotter due to the urban heat island effect, which describes how closely packed buildings and widespread paved surfaces in urban areas absorb and re-emit heat more effectively than natural ecosystems and areas shaded by trees and vegetation.[21]

## *Impacts*

In recent years, extreme weather events made worse by climate change have negatively impacted human health and well-being in the capital region. Climate change has the potential to undermine health determinants such as air quality, water supply, food security, cultural practices, and access to a safe environment. Climate change can also place additional strain on healthcare and social systems that are necessary for good health and well-being.

By the 2050s, the capital region can anticipate more multi-day extreme heat events that become longer and more intense by mid-century. The region can also expect hotter summer temperatures, with more days exceeding 25°C and more "temperate nights" where the temperature stays above 16°C.[22] These projected changes will increase the risk of heat-related illnesses and mortality and worsen pre-existing health conditions, particularly among equity-denied populations who do not have access to a cool indoor environment. Notably, these risks are heightened for the region's growing population of older adults.

Warming temperatures and shifting precipitation patterns may worsen air quality in the region. Across the Pacific Northwest, hotter and drier conditions can increase the likelihood of wildfire ignition. This may cause more frequent episodes of wildfire smoke in the capital region, which can irritate the lungs, cause inflammation, and alter immune function, particularly for people with pre-existing conditions.[24] The projected changes in temperature, precipitation and heat wave occurrence may also exacerbate other air pollutants that influence human health such as pollen, mould, and ground-level ozone.

Living through an extreme weather event, or grappling with uncertainty about the future, can impact mental health and wellbeing, often manifesting as stress, anxiety, fear, and exhaustion. During and after an extreme event, people who face property loss or displacement may endure significant and lasting trauma.

In June 2021, an unprecedented[23] "heat dome" event in the Pacific Northwest caused extended periods of record-breaking high temperatures that had severe implications for health and well-being. Over 600 heat-related deaths were recorded across BC, particularly among people with pre-existing medical conditions (including schizophrenia), older adults, people living alone, and people living in socially deprived areas[21]. In response to this event, numerous projects have been launched across the capital region to better understand extreme heat vulnerability and to build resilience towards extreme heat in the future. For more information, see Appendix D: Further Resources.

[20] BC Statistics. 2019. Capital Regional District 2019-2038 Population, Dwelling Units and Employment Projection Report.

[21] British Columbia Coroners Service. 2022. Extreme heat and human mortality: A review of heat-related deaths in BC in Summer 2021.

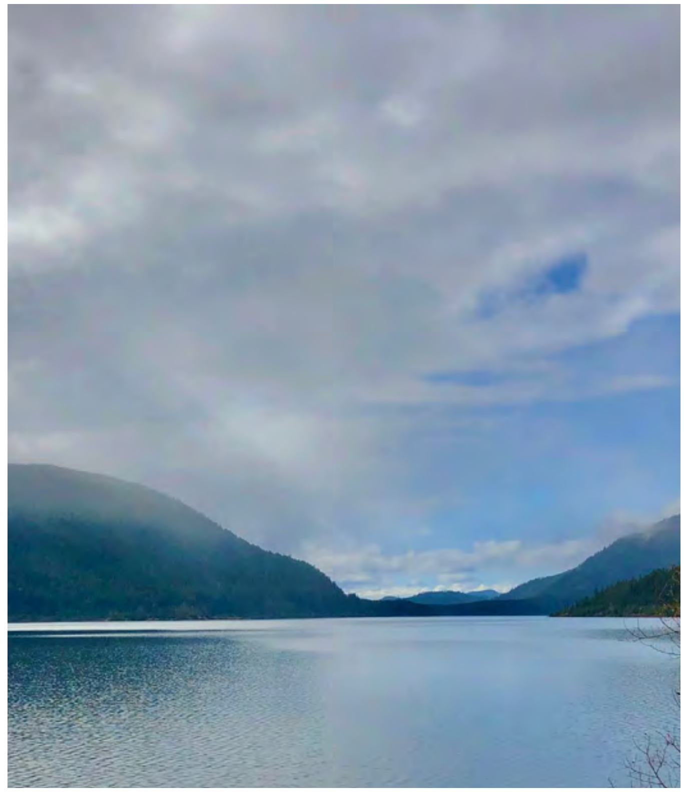
[22] The number of temperate nights is an important public health measure that reflects the lower temperature threshold for emergency health alerts used in the capital region. For more, see: Government of British Columbia. 2023. BC Provincial Heat Alert and Response System (BC HARS).

[23] The unprecedented nature of the June 2021 heat dome makes it difficult to estimate its return period (or annual probability of occurrence). Based on analysis of historical data, it was estimated as a 1-in-300-year (or 0.3% annually) at Seattle-Tacoma Airport to a 1-in-1000-year event (or 0.1% annually) in New Westminster (Philip et al., 2022; doi: 10.5194/esd-13-1689-2022). While the capital region can expect more frequent extreme temperatures in the future, estimates for how often an event of this magnitude will occur are difficult because historical records are far shorter than the estimated return periods for this event.

[24] Berry, P., and Schnitter, R. 2022. Health of Canadians in a changing climate. Government of Canada.

# Water Supply and Demand

The CRD supplies drinking water to over 390,000 customers from large reservoirs in the Sooke, Leech and Goldstream watersheds that make up the protected Greater Victoria Water Supply Area (GVWSA). The CRD also provides water to small service areas in the Southern Gulf Islands and the western portion of the region through surface water and groundwater systems. Similar privately owned systems provide water in other areas. In some rural and less developed areas, residents rely on groundwater wells on their properties. Residential water use accounts for the largest portion of water use in the region (60%). Water supplies across Southern Vancouver Island are almost entirely replenished from rainwater in the late fall, winter, and early spring (the wet season). Snow melt runoff contributes to groundwater recharge and is needed to sustain summer flows.



## *Impacts*

By the 2050s, less summer rainfall and longer dry spells will increase the risk of drought during the summer and into the early fall. At the same time, hotter temperatures and more extreme heat events will intensify water demand as residents consume more water to keep cool and stay hydrated. Hotter and drier conditions will also increase evaporation and evapotranspiration, raising outdoor watering demand. Water conservation initiatives will remain a priority in the region, given the growing population and the potential for the seasonal decline in water supplies to become more pronounced in the future. Greater densification and anticipated increases in peak demand may also trigger the need for more storage, supplements to existing water supplies, larger capacity infrastructure, and balancing reservoirs in water distribution systems.

> Hotter and drier summer conditions will be particularly challenging for those who rely on groundwater wells or small reservoirs that may not recharge sufficiently. In some instances, these systems may reach dangerously low levels or may even deplete completely. In coastal areas, overdrawing groundwater can lead to saltwater intrusion – an impact that is compounded by rising sea levels.

Hotter and drier conditions also increase the threat of wildfire in the GVWSA and other forested areas that supply water to residents of the region. Although fire is a natural and essential process in forest ecosystems, severe wildfire occurring in water supply areas can affect water quality and supply by increasing erosion during the following rainy season.[25] As the threat of wildfire increases in rural areas, water needs for wildfire protection will gain increasing importance in water conservation planning.

During the wet season, heavier rainfall may increase erosion of saturated slopes, leading to more fine sediment and organic material in streams entering water supply reservoirs. Increased turbidity from fine sediment can interfere with water disinfection and treatment, while excess organic material can promote algal blooms that produce cyanotoxins, cause taste and odour issues, and compromise disinfection and filterability. Where unprotected water supply catchment areas have been developed, more intense rainfall and runoff can lead to greater undesirable substances (pollutants) entering wells and surface reservoirs. Heavy rainfall and increased water inflows also pose a risk to dam safety. To support safe and resilient water supply through a changing climate, the potential for more intense rainfall events (see next section) will need to be considered in the planning and management of water supply systems.

[25] Brown et al. 2019. Long-term climate, vegetation and fire regime change in a managed municipal water supply area, SAGE Journals, 29(9), 1411-12.

## Rainwater Management and Sewerage

A myriad of rainwater management and sewerage infrastructure aims to protect quality of life, property, and aquatic ecosystems across the capital region. Local governments in British Columbia are responsible for managing drainage; as a result, much of the region's drainage infrastructure (hard and soft) is integrated into local land use and infrastructure planning and processes. Historically, stormwater infrastructure was designed to move water away from the built environment, channeling high volumes of rainwater into creeks and streams. Recently, local governments are shifting towards the use of green infrastructure, which mimics natural drainage systems that play a crucial role in rainwater management. Natural drainage systems (i.e., creeks and wetlands) slow runoff through water retention, helping to reduce flood magnitude and filter out substances that impact water quality. The use of green infrastructure is particularly important in areas with increasing urbanization and development, where greater impermeable surfaces (i.e., roads, parking lots and buildings) contribute to additional runoff.

### *Impacts*

In the past, flooding from extreme events has occasionally overwhelmed stormwater and sanitary systems in the region. With extreme precipitation events becoming wetter in the future, the region can expect aging and undersized infrastructure to continue to be overwhelmed, amplifying stressors on the receiving environment. During high intensity rain events, creeks may overflow and soils may become saturated, intensifying runoff, and increasing the chance of flooding in low-lying areas. This combination can increase erosion, decrease slope stability, and flood wetlands and lakes, impacting public infrastructure, drinking water quality, and surrounding aquatic ecosystems. Heavy rainfall events can also cause inflow and infiltration of rainwater into the sanitary system in crossover areas, increasing the likelihood of highly diluted sewage entering waterways.

When heavy rainfall occurs after prolonged periods of dry weather, the "first flush" of surface runoff typically contains high levels of contaminants that have accumulated on hard surfaces. This runoff makes its way into surface waters that are home to aquatic ecosystems. When paired with warmer water temperatures, increased stormwater runoff of nutrients can make conditions more favorable for algal blooms year-round – a growing issue in that region – that impacts water quality, ecosystems, recreation, and human health.

*Malahat washout during November 2021 extreme rain event (Credit: Emcon Services Inc.)*

> Certain areas in the region are at increased risk of flooding during heavy rainfall events due to flat terrain and proximity to the ocean, particularly when these events occur simultaneously with high tides and onshore winds. The CRD Coastal Flood Inundation Mapping Project (2021) may be used in conjunction with the projected changes outlined in this report, to understand how these factors, along with sea level rise, will influence future flood risk for lower-lying areas near the coast.

The projected increase in heavy rainfall may lead to a higher volume of runoff than the current capacity of infrastructure is able to handle. Green infrastructure, low impact development and multijurisdictional watershed management approaches will remain important strategies for reducing the flooding, runoff and pollution associated with extreme precipitation events. Designers of stormwater infrastructure (i.e., culverts, storm drains, etc.) will also need to plan for higher single- and multi-day rainfall amounts. For more information about how future precipitation is estimated using climate model projections, including the adjustment of Intensity-Duration-Frequency (IDF) curves in a future climate, see Appendix D: Further Resources.

# Ecosystems and Species

The capital region is home to various ecosystems, including Douglas-fir forests, Garry oak meadows, riparian zones, wetlands, estuaries, shorelines, and more. The diversity in the region brings with it a wide range of flora and fauna, including many species at risk that need protection. Natural assets providing connectivity and ecosystem services are essential for supporting climate resilience. Forests in the GVWSA contribute to the high quality of water in supply reservoirs, and green spaces in urban and suburban areas provide natural cooling capacity, stormwater retention, and help reduce air and water pollution.

## *Impacts*

Warming year-round temperatures and seasonal changes in precipitation will have important impacts on the ecosystems, native species and associated ecological relationships and processes existing in the capital region. Because ecological systems are highly complex, it will be difficult to make specific predictions for how they will be impacted by a changing climate. In general, the speed and scale of climate change may threaten the capability of many species to adapt, altering the ecological landscape. Shifting seasonal patterns, characterized by an earlier onset of spring or a later start to fall, may threaten processes that rely on temperature cues, including predator/prey, parasite/host, and pollinator dynamics. This may cause population declines for certain species, and/or outbreaks of species that are considered pests. Specialist species may be particularly vulnerable, which may threaten regional biodiversity and create new opportunities for invasive species to thrive.

> Climate change not only impacts ecosystems and species directly; it also interacts with environmental changes from human development.[26] Impacts from climate change may be amplified for ecosystems where land-use changes have caused fragmentation and, as a result, weakened resiliency. For example, the Bowker Creek watershed – covering 1,028 hectares of the capital region – historically supported coho and chum salmon and cutthroat trout. Today, Bowker Creek is highly urbanized, with roughly 50% now composed of impervious surfaces that cause low summer base flows and reduced water quality for aquatic ecosystems. Long range, multijurisdictional efforts are in place to protect its natural characteristics and reduce impacts from a changing climate.[27]

In the summer, hotter and drier conditions will continue to stress trees and other terrestrial and riparian (streamside) vegetation, particularly for species that are sensitive to drought such as the Western red cedar. Drought conditions can slow decomposition in below-ground communities consisting of bacteria, fungi, and other soil organisms, thereby reducing available nutrients. When plants undergo stress, they become more susceptible to competition with other plants and to damage from insects and diseases.

Warmer year-round temperatures will also raise water temperatures in aquatic ecosystems, which may be problematic for species that require cool water to thrive. In extreme cases, warm water can cause low oxygen levels and mortality, particularly when these conditions are compounded by low water levels and occur during critical life stages such as spawning, rearing, or hatching. Heavy rainfall can also disrupt critical ecological processes. For example, during an atmospheric river event in November 2021, increased channel erosion and sediment deposition resulting from high stream flows severely impacted salmon spawning beds.[28]

[26] IPCC. 2022. Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group, II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. [H.-O. Pörtner et al. (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, 3056 pp., doi: 10.1017/9781009325844.59327/IPCC/AR6-9789291691647

[27] Bowker Creek Initative. 2012. Bowker creek blueprint: A 100-year action plan to restore Bowker Creek Watershed.

[28] CBC. 2021, 21 November. For B.C.'s salmon, floods represent another challenge to survival.

## Buildings and Energy Systems

Energy use in buildings accounts for roughly one third of GHG emissions in the region. In the past climate, most buildings and homes in the capital region did not require active cooling capacity. During the 2021 heat dome, 98% of heat-related deaths in BC occurred in private residences, highlighting an urgency to implement cooling measures in homes across the region.[21] Retrofit programs and new building policies not only support the transition to renewable energy and energy efficient technologies but are leading to building envelope considerations and a greater adoption of low emission heat pumps that support thermal comfort. In both urban and rural communities across the region, many homes and other buildings are in coastal and riverine areas where flooding may be a concern.

### *Impacts*

As the climate warms and precipitation patterns change, the case for investing in well-designed, resilient buildings improves. Heavier rainfall events may increase the risk of flooding in the fall and winter, which can cause property damage, personal injury, and economic losses, particularly where development is located on flood plains. More episodes of multi-day extreme heat can also stress foundations and building materials, and potentially affect the functioning of heating, ventilation, and air conditioning (HVAC) systems.

Across the region, warmer year-round temperatures and more days going above 25°C in the summer will shift seasonal and long-term energy demands. Whereas heating demand is expected to decrease in the colder months, hotter temperatures and more multi-day extreme heat events during the warmer months will generate cooling demand where it did not exist previously. In the past, buildings and homes have relied on the region's cool summer nights to support thermal comfort during the warmer months. In the future, an increasing number of "temperate nights" (i.e., nights when the temperature stays above 16°C) will heighten the risk of buildings overheating.

Adaptive design strategies, such as passive cooling, outdoor shading, rainwater capture and reuse, green roofs, resilient landscaping, and rain gardens, can help address challenges from heat, drought, and overland flooding. In addition, concentrating development in already developed areas, balanced with access to urban greenspace, can protect opportunities for the surrounding natural ecosystems to buffer changes to our climate.

The projected increase in cooling degree days by mid-century will require that most buildings have some form of active cooling to maintain thermal comfort and prevent overheating. Certain units, such as older, multi-unit residences, often lack air conditioning and are not designed to handle hot temperatures, leaving occupants at greater risk of heat-related illnesses and mortality. The use of energy efficient technologies like heat pumps will play an important role in aligning with efforts to reduce GHG emissions while avoiding additional costs to residents. Authorities with jurisdiction over building codes should consider how to proactively integrate future climate considerations into the design of new and existing buildings.

## Transportation

The region's transportation network includes many local and arterial corridors, three major highway corridors (Highways 1, 14 and 17), two provincial and two international ferry corridors, a regional transit network, international and harbour airports, cruise ship and ferry terminals, and many active and multi-use trails. Regional transportation priorities include full realization of a multi-modal transportation network to help shift away from private vehicles to public transport, walking and cycling. As a coastal community, the capital region is vulnerable to significant transportation disruptions that complicate responses to emergencies and extreme events, and can interrupt the local supply chain.

### *Impacts*

The projected increase in heavy rainfall may intensify flooding across the region, potentially causing more frequent road closures, vehicle collisions and construction delays. Some communities, such as Sooke, have already seen recurrent road closures due to flooding and may be particularly vulnerable to heavy rainfall.[29] Extreme precipitation events may also impede the reliability of major transportation corridors. In November 2021, extreme rainfall and runoff from a landfalling atmospheric river caused extensive damage to the Malahat Highway (Highway 1), prompting its temporary closure. This disruption reverberated through the local supply chain, resulting in shortages of fuel and other essential goods and services across the region. Like flooding from heavy rainfall events, wildfires also pose risk to the closure of regional highways and roads. In the future, hotter temperatures and less rainfall occurring in the warmer months will increase fire danger. Wildfire damage along hillslopes near roadways may also heighten the risk of landslides during the subsequent rainy season.

> The effects of extreme weather on transportation may be particularly challenging for some equity-denied groups. Residents may find themselves unprepared to leave their homes, hindering their ability to access essential supplies and services.

By the 2050s, a shorter winter season characterized by less snowfall and fewer freezing days may lower the costs associated with snow removal and the repair of cracked roads from freeze-thaw cycles. However, equipment to manage severe winter conditions will need to be maintained as changes to the frequency of heavy snowfall events remains largely unknown because they are driven by "Arctic outflow" events from Northern BC.

Warming temperatures may enhance the appeal of active transportation (walking, cycling and transit use) during the colder months. Conversely, high temperatures, multi-day extreme heat events, and poor air quality from wildfires in nearby regions may deter residents from choosing active transportation methods in the summer and early fall. Active transportation routes may also be interrupted by heavy rainfall, which can cause localized flooding and erosion along trails and pathways.

To safeguard transportation across the region, projected changes to temperature and precipitation should be considered in the design and retrofit of transportation infrastructure. These changes should also be considered against the backdrop of other existing weather hazards that will continue to affect the region (e.g., windstorms). Efforts to reduce GHG emissions across the region will rely on a resilient active transportation network. Strategies to support active transportation may involve installing adequate cooling infrastructure (i.e., trees, benches, shade structures, misting stations and water fountains) and supporting nature's capacity to buffer climate impacts through stewardship and community engagement.

[29] Chek News. 2021. Heavy flooding and road closures forces Sooke into temporary isolation.

# Food and Agriculture

Food and agriculture are fundamental elements of the long-term sustainability, resilience and health and wellbeing of the capital region. In recent years, changes in climate, energy costs, water availability and agricultural production have drawn attention to the ongoing resilience of the region's food system. Ensuring a stable local food system requires management of changing wildlife populations, flooding and drainage concerns, water availability, as well as the amount of agricultural land in food crop production. The average age of farmers in the capital region remains higher than the Canadian average and represents a warning sign for the future of food production in the region.[30]

## *Impacts*

Increasing year-round temperatures will lead to fewer frost days, an earlier start to spring, and extended summer-like weather into the fall. These changes will result in a longer and warmer growing season that could enhance agricultural productivity in the region. However, climate change is also expected to introduce greater uncertainty for growers, as temperatures become hotter in the warmer months and precipitation patterns change. The projected increase in growing season length by 2050 (estimated to be roughly 17%) should be considered an upper limit for estimates of future productivity. This measure uses only a lower temperature threshold and does not account for reduced summer precipitation, which increases the risk of drought. In addition, shifting seasonal conditions from warming temperatures may cause pollinating species to emerge at misaligned times, limiting potential crop yields.

During the growing season, reduced water availability and extended dry periods leading to drought could have significant impacts on agriculture in the region. Less total rainfall in the summer will reduce water levels in ponds, wetlands and streams used for irrigation, while hotter temperatures will promote further evaporation and evapotranspiration. These conditions can increase heat stress and sun scald, competition for water resources, and may create opportunities for invasive species, pests, and plant diseases to flourish. Increased demand for irrigation strains water supply systems with competing demands, and negatively impacts ecosystems in water bodies, wetlands, and streams. Addressing these challenges will require innovative strategies that improve the efficiency of agricultural irrigation and transition to crops requiring less water. Growers may need to consider alternative soil-management approaches, as changes to soil moisture and composition may accompany the projected changes to the region.

In the fall, heavy rainfall events may impact crop harvest by increasing the risk of flooding and creating more opportunities for diseases and pests. Extreme precipitation can also lead to more runoff onto and off agricultural land, leading to erosion, soil nutrient leaching, and crop loss and damage. For low-lying agricultural areas near the coast, these impacts may be compounded by high tides, storm damage, and saltwater intrusion from rising sea levels.

[30] Capital Regional District. 2018. Regional Growth Strategy.

## Recreation and Tourism

With its mild climate, beautiful coastlines, and abundant ecosystems, the capital region continues to be a sought-after destination for visitors from across the globe and tourism remains a key local industry. Tourism is an estimated $1.9 billion dollar industry in Greater Victoria with more than three million visitors to the region annually.[31] The region boasts plenty of outdoor recreation, with more than 26,000 hectares of national, provincial, regional, and municipal parks and ecological reserves and four regional trails on southern Vancouver Island and the Gulf Islands.[32] In 2021, regional trails received over 3.7 million visits and regional parks received over 5 million visits from local residents and tourists. These areas contribute to the cultural, social, and economic vitality of the region.

### *Impacts*

By the 2050s, warmer year-round temperatures could lead to a longer season for summer recreation, providing more opportunities for outdoor activities and potentially boosting economic productivity. However, the rise in the number of hot summer days and multi-day extreme heat events may encourage more people to seek relief near lakes and coastlines, which can place additional stress on freshwater, marine and shoreline ecosystems. Careful protection and monitoring of recreational sites will be important to ensuring ecological health in areas where visitor use may increase.

The projected changes in temperature and precipitation may also influence the access and safety of recreation and tourism across the region. Less summer rainfall and longer dry spells may result in longer and more frequent campfire bans. Increasing fire danger may also result in the closure of parks and campgrounds due to wildfire risk. During the wet season, heavier rainfall may impact trail access and safety, and increase the costs associated with the maintenance of recreational infrastructure. At all times of the year, the potential increase in algal blooms may pose challenges to recreational water users, fishing, and tourism. Ensuring climate-resilient design of new and existing infrastructure and supporting ecosystem health and integrity through a changing climate can benefit both the economy and the physical, mental, and spiritual health of people across the region.

[31] Greater Victoria Chamber of Commerce. Destination Greater Victoria. https://www.tourismvictoria.com/

[32] Capital Regional District. 2023. Regional Parks and Trails Strategic Plan.

## Summary and Recommendations

This report uses the most up-to-date climate model projections to examine how climate change may unfold across the capital region in the coming decades. The region can expect an increase in daytime and nighttime temperatures throughout the year. In the summer months, this implies hotter daily highs, warmer nights, and more numerous and longer multi-day heatwaves. By the 2050s, winters will become milder overall with a steep reduction in frost days and snowfall.

The capital region can expect a modest increase in annual precipitation by the 2050s that will be distributed unevenly across the seasons. Whereas rainfall is projected to increase notably in the colder months, summers will become drier. Warmer cold season temperatures will result in less snowfall and increased rainfall, especially in winter. In the warmer months, longer dry spells are expected due to the combination of less rainfall and warmer temperatures. The magnitude and character of these changes will vary locally across the region.

Early action on climate adaptation will enable the region to best prepare for the changes ahead and increase climate resilience. The information provided in this chapter is intended to guide further discussion among decision makers and community partners across the region. Importantly, adaptation can take many forms depending on the unique context of each community. The regional impacts outlined in this report should be considered a starting point for further analysis of climate impacts and adaptation planning that engages relevant stakeholders and is tailored to the local context.

The CRD will continue to use these projections to incorporate climate change adaptation into planning cycles and ongoing activities. Adaptation planning is complex and requires consideration of multiple factors and compounding drivers. As such, continued data collection and monitoring will be important to establish baselines, monitor changes and ensure that adaptation actions are appropriate to the local context. Some examples of how the future climate projections provided in this assessment can be used to support climate adaptation include:

- Raising awareness about how climate change will impact the region
- Informing strategic and long-range planning
- Informing strategic planning for emergency responses to extreme events
- Conducting vulnerability and risk assessments to inform policy, planning, research, and monitoring
- Designing infrastructure that considers the future climate

This report highlights regional projections for the 2050s under a high emissions scenario, but alternative scenarios were also considered for this project. The complete data package includes information for low, moderate, and high emissions scenarios for the 2030s, 2050s and 2080s. It also includes separate assessments for four smaller sub-regions within the capital region. The report Appendices point to further online resources and general guidance for understanding and using climate projections.

# Appendix A

## BACKGROUNDER ON FUTURE CLIMATE DATA

The Earth's climate is changing due to the burning of fossil fuels, which emit greenhouse gases (GHGs) and aerosols into the atmosphere. Over the past century, these emissions have raised atmospheric GHG concentrations well above preindustrial levels, which has led to widespread warming over Earth's surface.

The global average temperature has increased by over 1°C to date, and Canada is warming even faster (Figure A1). This warming has resulted in widespread impacts in Canada and across the globe, and it is directly proportional to the total amount of GHGs emitted since the beginning of the industrial era. While a 1°C temperature change at your location may not feel like much, changes of only 1 or 2°C on a global scale are very substantial because they are averaged over the globe and a long period of time.

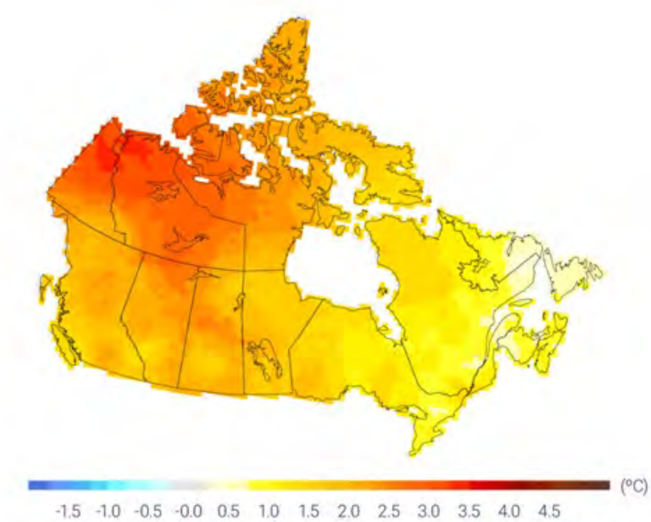



***Figure A1.*** *Warming in Canada between 1948-2018.*

### Understanding Weather, Climate, Natural Variability and Climate Change

To understand climate change, it is important to distinguish between weather and climate, and the natural and human influences that affect the climate on different time scales:

- Weather is what we experience when we step outside. It consists of short-term (minutes to days) variations in the atmosphere.
- Climate is the general state of weather, including its extremes, over periods ranging from months to many years. Climate can be thought of as the statistics of weather. Descriptions of normal climate conditions at a particular location are often derived from nearby weather observations and collected over long time periods – typically 30 years or more.
- Natural climate variability causes fluctuations in climate conditions that can span a few months to a few decades or longer. Natural climate variability is not influenced by human activity, but its influence can either mask or enhance human-induced climate change for the periods over which it occurs. Natural climate variability can also affect seasonal weather (e.g., El Niño/La Niña cycles).
- Climate change refers to changes in the state of the climate that persist over an extended period. Both natural processes and human influence can result in changes in climate. Climate science indicates that human influence is the unequivocal cause of the global warming that has been observed since the beginning of the 20th century.

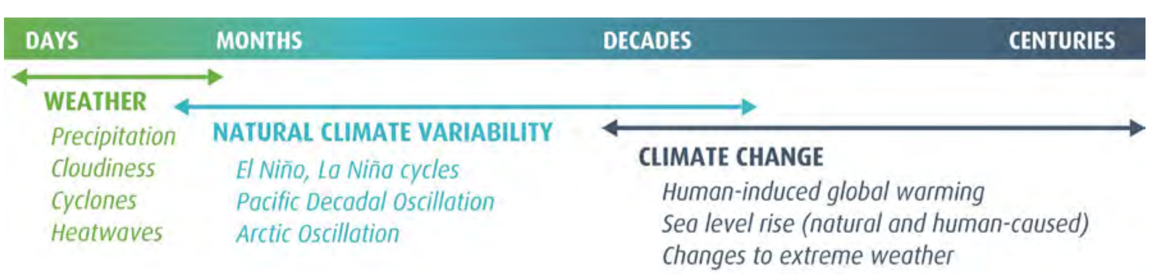



***Figure A2.*** *Timescales for weather, climate, natural climate variability, and climate change.*

# What is Future Climate Data?

In the context of a changing climate, historical climate observations are no longer suitable for assessing future climate-related risks. As a result, engineers, planners, and decision-makers are increasingly using future climate data to estimate the growing risks associated with climate change. Practitioners and decision-makers want to know how much climate change (and risk associated with that change) they can expect to encounter over the coming decades.

The extent of further warming depends on how global emissions change in the future. Unfortunately, it is impossible to predict the exact societal conditions of the future that will directly influence global emissions. Therefore, a range of potential futures, or scenarios, can be used to plan for the changes associated with rising global temperatures. These scenarios are based on assumptions about population growth, climate policy, land use changes, energy intensity, economic activity, and more, that lead to different levels of global GHG emissions. The scenarios used in this assessment are known as Shared Socio-economic Pathways, or SSPs for short – but more on that later.

To understand the future climate, scientists develop global climate models (GCMs) to simulate Earth's future climate in detail under each of the various scenarios. GCMs are extensively tested against historical observations and compared to one another. Through the Coupled Model Intercomparison Project (CMIP), we can construct an ensemble of different GCMs that describes a range of plausible climate futures. In Figure A2 below, each red line represents an individual GCM projection, developed by research groups from around the world. The solid black line in this case represents the ensemble median, with the lower and upper dotted lines showing the 10th to 90th percentile range of the model ensemble.

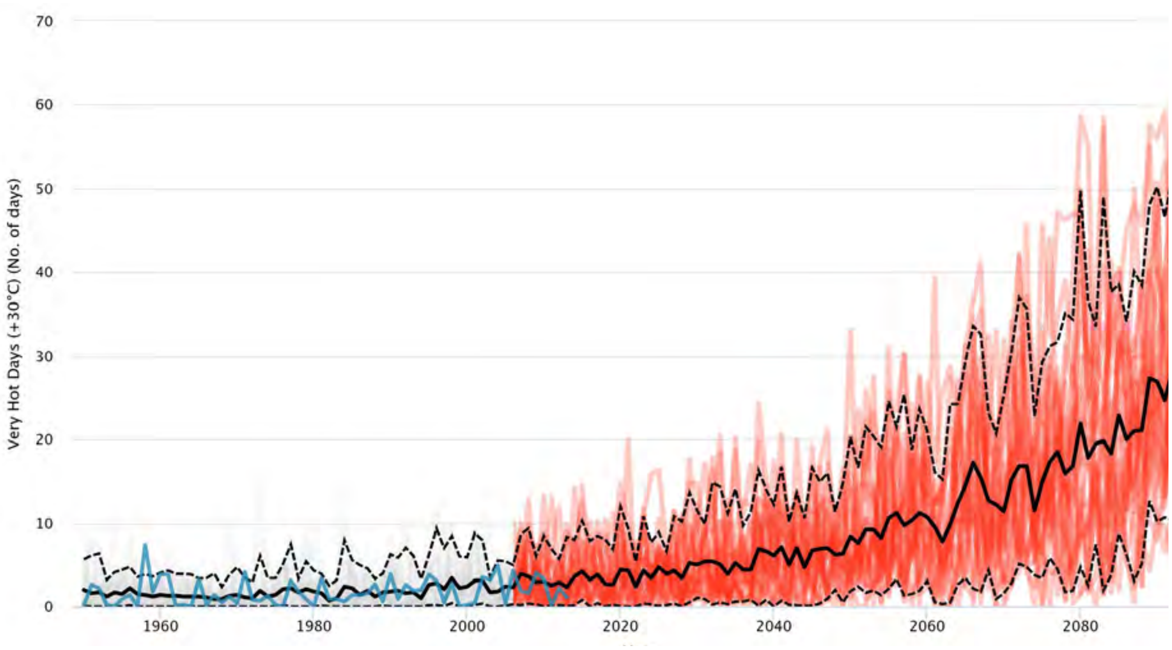



***Figure A3.*** *Example of a GCM ensemble.[1] Each red line represents a single GCM projection for the number of annual days with a maximum temperature exceeding 30°C in British Columbia. The solid black line is the median and the dotted lines are the 10th (lower range) and 90th (upper range) percentile values across all GCMs in the ensemble.*

[1] Retrieved from ClimateAtlas.ca, using modeled data from PCIC.

## Understanding Shared Socio-Economic Pathways

As noted above, to project the future climate, GCMs need input about the amount of future industrial emissions. Shared socio-economic pathways (or SSPs, Figure A3a) are such inputs, providing emissions scenarios based on assumptions of various societal decisions, including:

1. How population, education, energy use, technology – and more – may change over the next century, and;
2. The level of ambition for mitigating climate change globally.

The SSPs used in CMIP6 simulations are a set of five main socioeconomic pathways (SSP1 through SSP5) that illustrate different ways in which global societies may develop. They are the successors to the previous emissions scenarios used in CMIP5 called Representative Concentration Pathways, or RCPs. Figures A4a and A4b illustrate projections for GHG emissions and temperature under various SSPs. Here, it is important to note that global temperature projections for the near future are similar across different SSPs. The projections begin to diverge more meaningfully around 2050 (Figure A4b).

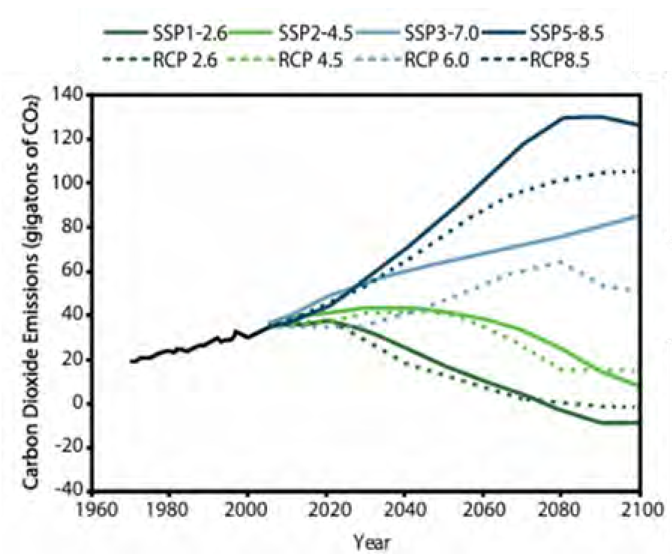



*Figure A4a*. *SSP scenarios used by CMIP6 models for global CO2 emissions by the end of this century. The scenarios used for CMIP5 (RCPs) are also shown.*

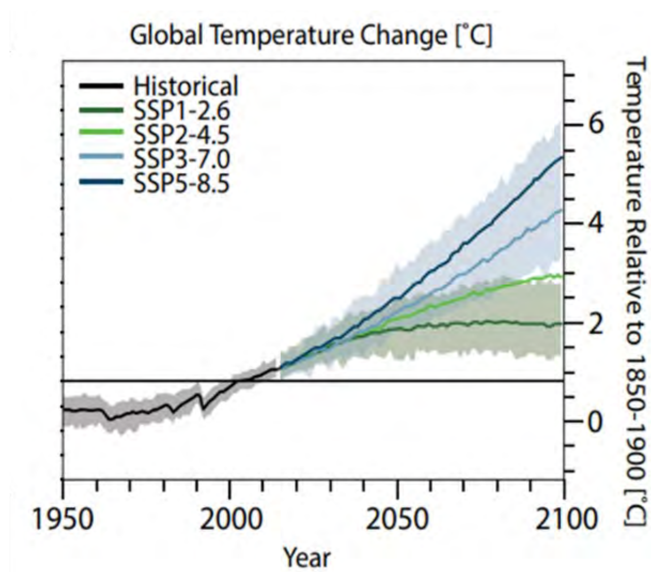



*Figure A4b*. *Historical and future temperature change from 1950-2100, relative to 1850-1900. After 2014, models are driven by the SSP scenarios indicated, with ranges shown for SSP1-2.6 and SSP3-7.0. The horizontal line shows temperature change that has occurred up to 1995-2014 (about +0.85°C).*

# Future Climate Uncertainty

While we know the future climate will be different from the climate of the past, we cannot precisely predict what the future climate will look like. There are three main sources of uncertainty inherent in future climate data: natural climate variability, model uncertainty, and scenario uncertainty. In the following sections, we provide support for making decisions in the presence of scenario uncertainty.

- **Natural climate variability** (as discussed above) refers to climatic fluctuations that occur without any human influence (i.e., independent of GHG emissions). Natural climate variability is largely unpredictable and can mask or enhance human-induced climate change.
- **Model uncertainty** arises because models can only represent the climate and earth system to a certain degree. Although they are highly sophisticated tools, GCMs can differ from reality. Furthermore, not all models represent the system processes in the same way, nor do all include the same processes. To help address model uncertainty, it is best practice to use an ensemble (i.e., a set of multiple GCMs), to display a range of possible futures. PCIC uses an ensemble of 9 GCMs that are best suited to analyses focused on British Columbia.
- **Scenario uncertainty** arises because different emissions scenarios lead to different levels of climate response, and it is not possible to know what global emissions will be in the future. The emissions pathway of the future depends on a wide range of policy decisions and socioeconomic factors that are impossible to predict. To help address scenario uncertainty, it is best to evaluate future projections under more than one emissions pathway.

**Uncertainty should not stand in the way of action.** Decision makers should use climate projections as a guide to the future but should not discount the possibility of changes occurring outside the projected range when managing risk. In the following sections, we provide support for making decisions in the presence of scenario uncertainty.

# Appendix B

## WHAT DATA SHOULD I USE?

The decision tree shown in Figure B1 can help determine which data and information from this assessment might be most useful for a given application. Before using climate projections, it is important to do appropriate background reading, identify relevant stakeholders and determine the appropriate level of stakeholder engagement. Stakeholder engagement is important for ensuring that the projected changes are both meaningful and well-suited to your context.

**Users accessing the complete data package should reference the Data Descriptor Document.** Contact climateaction@crd.bc.ca for more information.

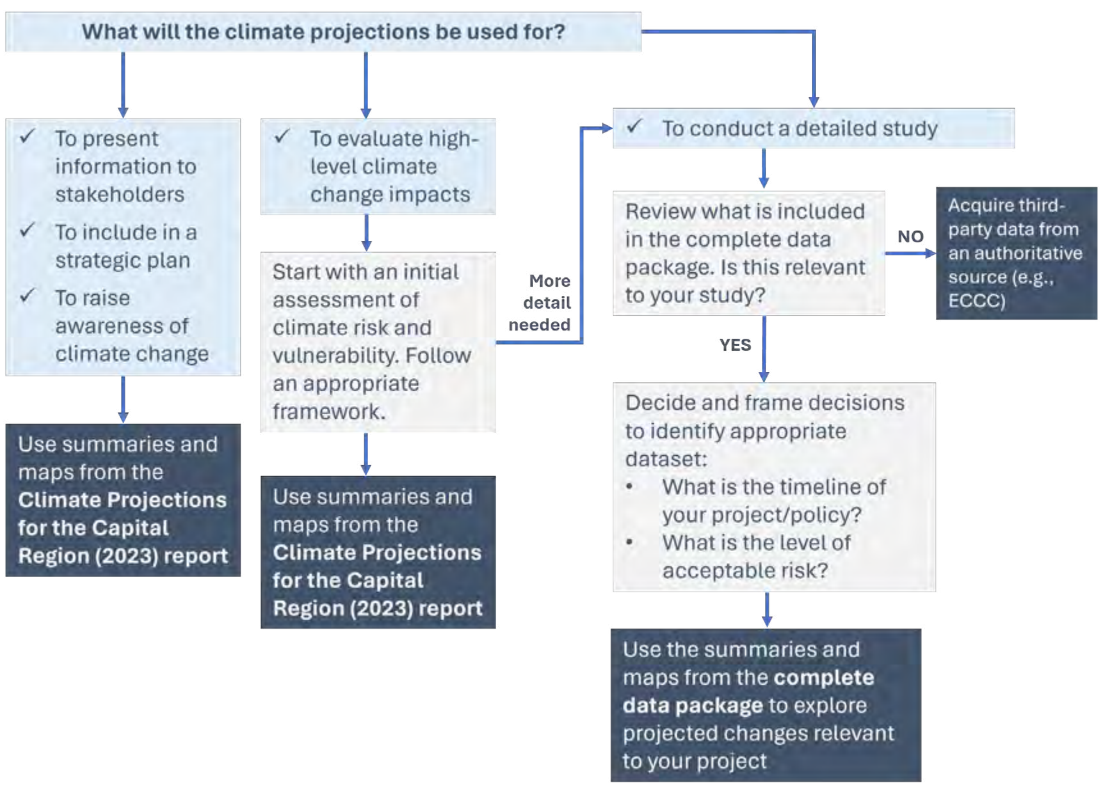



***Figure B1**. Decision tree for using climate projections data. This decision tree has been adapted from the Victoria (Australia) Climate Projections 2019 Technical Report (Clarke et al., 2019).*

# What is Provided in the Complete Data Package?

The Climate Projections for the Capital Region 2023 report highlights projected changes for a host of indices derived from temperature and precipitation under the highest emissions scenario (SSP5-8.5), mostly for the 2050s. The complete data package contains summary tables (Excel XLSX) and maps (PNG) for the following additional time periods, scenarios and sub-regional breakdowns:

### The capital region and four smaller sub-regions.

(see Figure B2 below)

- "Core/Peninsula" (Green)
- "Western Region" (Red)
- "Southern Gulf Islands" (Yellow) and
- "Greater Victoria Water Supply Region" (Blue)

### Four time periods.

- 1981-2010 or "1990s" (baseline period)
- 2021-2050 or "2030s"
- 2041-2070 or "2050s", and
- 2071-2100 or "2080s",

### Three emissions scenarios.

- Low: SSP1-2.6
- Moderate: SSP2-4.5, and
- High: SSP5-8.5.

### 77 indices derived from temperature and precipitation. *(see Appendix F for a complete list)*

Gridded data (NetCDF) is also available for all 77 climate indices projected to the 2050s under a high emissions scenario (SSP5-8.5). Contact climateaction@crd.bc.ca to access the complete data package and/or the gridded data.

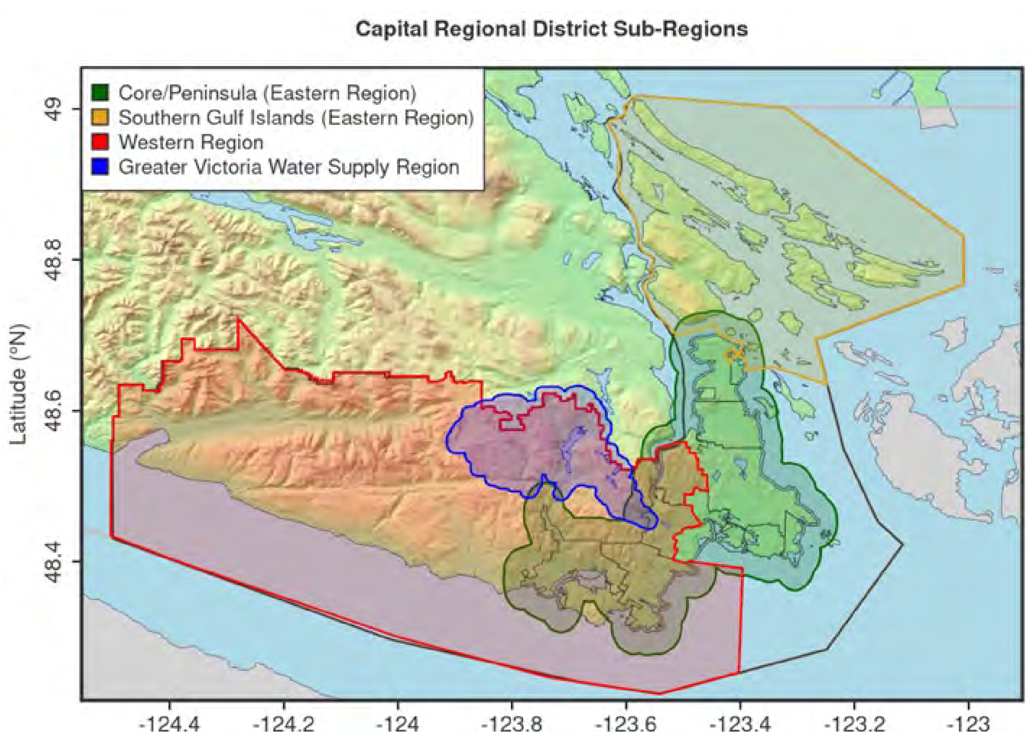



***Figure B2***. *The capital region and four sub-regions. Separate Excel files are available for each sub-region and for the region as a whole.*

# Appendix C

## GUIDANCE FOR USING CLIMATE PROJECTIONS

### Key Messages

- ✓ Projections of future climate are complex, and you will likely need advice and guidance from experts in the field. Allow adequate time for consultation.
- ✓ The climate has always been naturally variable. This variability now occurs on top of greenhouse-gas/aerosol forced trends. Over shorter time scales, climate variability can mask long-term trends.
- ✓ Since we do not know what future global emissions will be, climate projections are produced for a number of possible scenarios. In the CMIP6 ensemble, near-term projections are similar and diverge more clearly by the middle of this century (e.g., the 2050s).
- ✓ This assessment provides downscaled climate projections for variables derived from temperature and precipitation only. Variables related to other climate-related hazards, such as sea level rise or windstorms, are not provided. For supplemental resources, see Appendix D: Further Resources
- ✓ While climate models are run under different emissions scenarios, there is no such thing as a 'most likely' scenario. Selecting an emissions scenario is highly context-dependent and will depend on considerations such as risk tolerance and the life cycle of your project or policy.
- ✓ Consider multiple climate variables or indices to get a more complete picture for different manifestations of change. Review annual and seasonal projections to get a sense of how projections vary depending on the time of year.
- ✓ In many cases, using only the median climate projections will not be appropriate. Ensure the ranges of projected change (10th and 90th percentiles) are adequately accounted for in your assessment. Do not entirely discount changes above or below the projected range when managing risk – especially for high-impact, low-likelihood events.

# Understanding Climate Risk

As shown in Figure C1, climate risk depends on the complex interaction between hazards affected by climate change and natural climate variability, exposure to these hazards, and the vulnerability of the exposed elements. For example, a hazard (e.g., extreme heat) may impact a community more due to its exposure (e.g., occurring in a densely populated area) and/or vulnerability (e.g., demographic factors influencing heat sensitivity).

While future climate data can support the assessment of hazards affected by future climate change, there are different approaches to understanding climate risk. Decision-making about climate risk often involves a combination of top-down and bottom-up approaches.

**Top-down** approaches start with an analysis of potential climate change that can be used to guide actions and decisions.

**Bottom-up** approaches start with the project, policy or activity of interest and analyze the factors and conditions that impact the exposure, vulnerability and resilience of systems. These approaches look for pathways to reduce exposure and vulnerability while increasing the capacity to cope (irrespective of the future climate hazard).

Hence, **future climate data can be used to inform a top-down approach** to assessing climate risk.

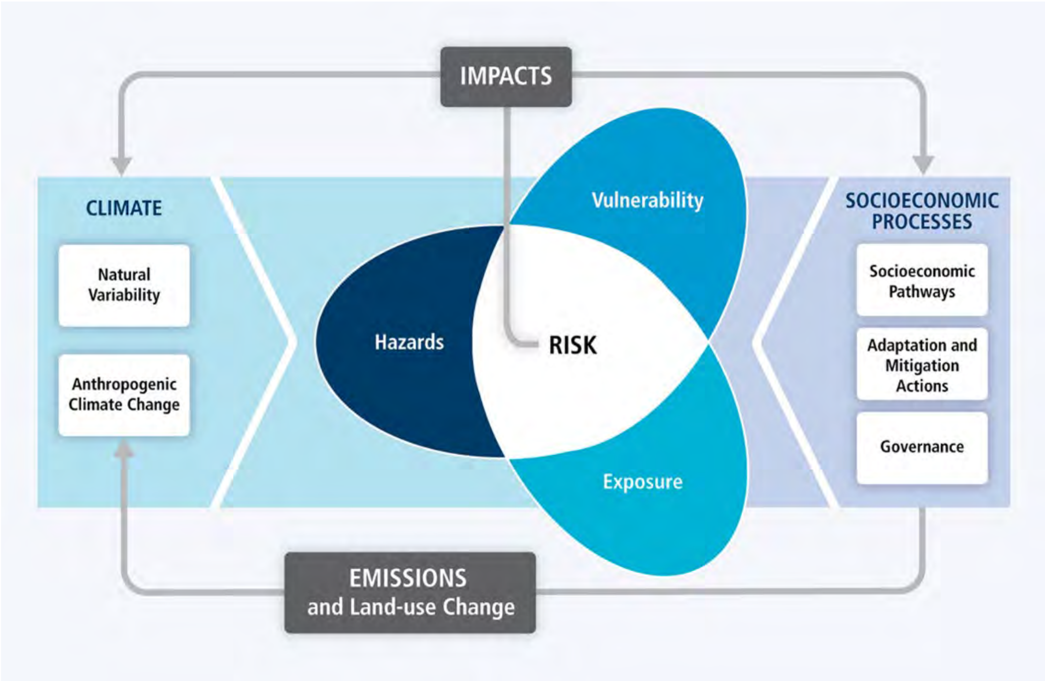



***Figure C1.*** *Climate risk envisioned as the overlap of hazard, exposure, and vulnerability.*[2]

[2]IPCC, 2014: Summary for policymakers. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1-32.

## Which Emissions Scenario(s) Should I Use?

Climate projections are generated by different climate models and using a range of emissions scenarios. Differences in the projections due to the use of different climate models reflect the fact that we still have an incomplete understanding of how the climate system functions, and differences due to the choice of emissions scenarios reflect the fact that we have only imperfect knowledge of how society, its land use practices, and its emissions may change in the future. Given these diverse sources of uncertainty, it is best to examine a range of possible futures as represented by different climate models and emissions scenarios.

To reduce climate model uncertainty, PCIC has selected a range of climate models that are best suited to regions in BC. Ultimately, deciding on which emissions scenario(s) to assess will depend on the context of your project or policy, including your risk tolerance and time horizon, as discussed next.

## Time Horizon

Users of climate projections should consider the time horizon, or life cycle, relevant to their project or policy before selecting a future scenario. This could be the expected lifetime of a given piece of infrastructure, or a policy that needs to be responsive to changing external conditions. As highlighted above in Understanding Shared Socioeconomic Pathways, in the near term – up to a few decades into the future – climate projections do not differ meaningfully across SSP scenarios. This is true at both the global regional scales. Hence, if there is a recurring opportunity to review a given decision every two to three decades, then the choice of emissions scenario may be less relevant. An example of a recurring decision might be the choice of paving material to use when repaving a roadway.

On the other hand, if an infrastructure element is expected to last 50 to 75 years, the choice of scenario becomes more critical because projected changes from different scenarios will differ substantially by the end-of-life of the structure. An example of a long-term infrastructure design decision might be determining the capacity of an upgraded storm sewer. Hence, planners and designers may be able to minimize the role of scenario uncertainty in adaptation planning by first determining the decision-making time-frame.

## Level of Acceptable Risk

Climate scientists can help practitioners and decision makers understand how climate-related hazards that affect the assets they are responsible for (i.e., systems, infrastructure, or policy) may change in the future. This requires dialog among practitioners, decision makers and climate scientists to understand and describe the potential impacts of projected climate change under different emissions scenarios. Because climate scientists are not experts on how risk to assets will materialize, it remains the responsibility of practitioners and decision makers to manage future climate-related risks to their assets.

When assessing future scenarios, decision makers should consider four questions:

1. "What components of my project are vulnerable to climate change?"
2. "How likely is it that society will follow a future emissions pathway that will intensity the hazards to which my assets will be exposed?"
3. "What level of risk am I comfortable assuming?"
4. "What is the trade-off between risk and cost?"

Regardless of the rationale used, understanding the level of risk that is appropriate to your work is complex. It will undoubtedly require engagement with diverse partners and stakeholder groups to understand the range of potential impacts.

## Scenario Choice

Ideally, public assets should be managed in a way that limits their vulnerability to plausible future hazards. Climate science has not yet ruled out the plausibility of any of the main socio-economic pathway scenarios that were considered in the most recent IPCC assessment. The choice of scenario will depend critically on the climate hazards that would affect the asset of interest. This is because some hazards will likely decline, such as extreme snow loads on buildings that could cause building collapse, while others, related to heat stress, intense rainfall, and flash flooding, will increase. If an asset is affected by both decreasing and increasing hazards, then the approach that would most completely limit vulnerability to future hazards would involve using a no change (historical climate) scenario for declining hazards, and a rapid change, high emissions scenario (e.g., SSP5-8.5) for increasing hazards.

## Tips for Using Climate Data

### ✓ View multiple variables (indices) within each category

To get a more complete understanding of projected changes, users should consider multiple climate variables. For example, if you want to know how precipitation will change in your region, review both a frequency-based variable (e.g., Number of Wet Days > 20 mm) and a volume-based variable (e.g., Total Precipitation). The Hazard Reference Tables (Appendix E) can help users identify which climate variables may be best suited to a particular context or application.

### ✓ Review both annual and seasonal data

Annual mean changes can mask important seasonal behaviour. For example, a small annual mean precipitation projection might contain a substantial reduction in the summer along with a projected increase in the fall, winter, or spring. Therefore, users should assess both annual and seasonal projections for certain climate variables.

### ✓ Select a relevant time period

The complete data package offers projections for the "2030s" (2021-2050), "2050s" (2041-2070) and "2080s" (2071-2100). As highlighted above, users should select the period that is most appropriate to the entire life cycle of their project or policy.

### ✓ Determine an appropriate emissions scenario(s)

There is no right or wrong emissions scenario to use in decision-making: all scenarios represent possible futures and decision-making is highly context dependent. Selecting a scenario requires consideration of risk tolerance, sensitivity to climate impacts and extreme events, the time horizon of the project, and more. It can be useful to remember that planning for a high emissions scenario can help ensure that adaptation measures are resilient for a longer period of time if, in fact, a lower emissions scenario were to play out.

### ✓ Examine both means and extremes

The median, 10th percentile, and 90th percentile values have been provided in all summary tables for this assessment. Depending on the application, one, two or all three of these values may be important. For instance, if one were designing a building for general use (e.g., retail space, detached home) with an anticipate lifetime of 50 years or so, then the change in the median of Cooling Degree Days (CDDcool18C) under SSP5-8.5 might be appropriate to consider. Alternatively, if the building were classified as critical, long-lived infrastructure (e.g., a hospital, or power plant) then it might be more appropriate to design to the 90th percentile value for that climate index, to capture the upper range of possibility.

# Appendix D

## FURTHER RESOURCES

There are a growing number of guidance materials, learning resources, and data tools available to support the use of climate projections for regional assessments. Below is a non-exhaustive list of open access resources suited to a broad range of users. For additional guidance, contact PCIC (climate@uvic.ca) or the CRD Climate Action Program (climateaction@crd.bc.ca).

### Additional Climate Projections Tools and Resources

#### ClimateData.ca

User-friendly tool for exploring climate projections and related data

Developed and maintained by the Canadian Centre for Climate Services, a team of information and outreach specialists at Environment and Climate Change Canada (ECCC), ClimateData.ca is an online, user-friendly data portal providing future climate projections for regions across Canada. Users can explore gridded data at small scales or aggregated by watershed, census subdivision, or health region. ClimateData.ca provides plain language descriptions for all climate variables and has various options for visualizing and analyzing climate data. Temperature and precipitation-based variables (the same as those provided by PCIC) as well as humidex, relative sea level change and climate change-scaled IDF data are available.

ClimateData.ca also includes a comprehensive learning zone (climatedata.ca/learn) that is regularly updated to support climate data users in a variety of applications, including some sector-specific information, as well as a Climate Services Support Desk for general or technical inquiries. The site is continuously evolving with more content and features in development.

#### PCIC Climate Explorer

*Useful for intermediate or advanced users analyzing a specific location*

PCIC Climate Explorer (PCEX) is an online map-based tool for viewing gridded historical climate data and future projections at any location of interest across Canada. Users can select an arbitrary region on the map, compare climate variables for that region, and download the results in Excel formats. Additional variables for extreme precipitation and streamflow are also available.

#### ClimateAtlas.ca

*Useful for creating communications materials and learning more about climate adaptation*

ClimateAtlas.ca is an interactive tool combining climate projections (again using PCIC's data), mapping, and storytelling to inspire local, regional, and national action and solutions. Users can explore videos, articles, educator resources, and various topic including Indigenous knowledges, agriculture, and health.

## Spatial Analogues Tool* (ClimateData.ca)

*Useful for visualizing the future climate at a target location*

With this tool, starting with a target city of interest**, users can search for other cities whose historical climate closely matches the future-projected climate of the target city. Users can search for spatial analogues under a low or high emissions scenario and considering up to four different climate indices. For example, one combination of indices suggests that by the 2050s, Quebec City may have a climate similar to present-day Boston. By examining how Boston has adapted to its current climate, planners in Quebec City might gain insights on how to prepare and adapt to climate change.

*This tool is a beta app, meaning it is a new tool being carefully monitored and is still under development.

**Target cities for British Columbia are presently limited to: Victoria, Vancouver, Abbotsford, Kelowna, and Prince George.

# Infrastructure Design Resources

## PCIC Design Value Explorer (DVE)

*Engineering design professionals can access future-projected climatic design values*

The DVE is an online, open-access technical tool for assessing 19 climate design values based on observed data and projections of how they may change in the future. It provides engineers, architects, planners, and other professionals with quantitative, fine-scale historical and future-projected climate information for designing buildings and infrastructure.

## PCIC Future-Shifted Weather Files

*Energy Modelers can access future-projected weather files*

Weather data adjusted for climate change has been produced for three time periods (2020s, 2050s, and 2080s) using the high emissions pathway RCP8.5 (CMIP5). Data are available for several hundred weather stations across Canada. Future-shifted weather files can help building designers simulate building performance under a changing climate, supporting resilient design. Further work is underway to update the weather files for CMIP6-SSPs and to create weather files that capture both mean change and extreme events.

## **CSA PLUS 4013-19:** Development, interpretation, and use of rainfall intensity-duration-frequency (IDF) information: Guideline for Canadian water resource practitioners*

*Guidance for Canadian water resource practitioners to better incorporate climate change into IDF information*

Technical guidance from the Canadian Standards Association (CSA)—informed by scientists at ECCC and other subject matter experts—for the development, interpretation, and use of rainfall intensity-duration-frequency (IDF) information. Chapters 5 and 6 include guidance for how to incorporate climate change into the formulation and application of IDF information.

*Access fee required

## Short-Duration Rainfall IDF Data (ClimateData.ca)

*Users can explore historical and climate change-scaled IDF information for weather stations across Canada*

ClimateData.ca offers easy access to historical short-duration rainfall IDF data (from 1 to 24 hours) and projected rainfall amounts under low, moderate, and high emissions scenarios at locations across Canada (12 locations within the capital region). This IDF information is consistent with the above-mentioned CSA guidance. Users can download a zip file containing all the historical and future estimated values.

In addition, the Learning Zone on ClimateData.ca has a topic dedicated to using IDF rainfall data to account for a changing climate. For more information on this product and about designing future-ready buildings, visit ClimateData.ca/learn/

# Appendix E

## HAZARD REFERENCE TABLES

The Hazard Reference Tables help users identify which climate variables included in the complete data package may be best suited to a particular context or application. Users should use the short name (left column) to navigate to the appropriate variable in the complete data package.

**Seasonal Patterns and Climate Change**

- ✓ Increasing temperatures year-round
- ✓ Fewer frost days and a longer growing season
- ✓ Shifting heating and cooling demands

**Key sectors:** Agriculture, Biodiversity, Parks, Infrastructure

| | |
|---|---|
| **Temperature** | |
| **TX** | Daytime high temperature, averaged over all days in a year or season |
| **TM** | Mean daily temperature, averaged over all days in a year or season |
| **TN** | Daytime low temperature, averaged over all days in a year or season |
| **Seasonal** | |
| **FD** Frost Days | Number of days in a year when the minimum temperature is below 0°C |
| **ID** Ice Days | Number of days in a year when the maximum temperature is below 0°C |
| **GSL** Growing Season Length | Number of days between: (i) the first span of 6 or more days in the year with a daily minimum temperature > 5°C and (ii) the first span after July 1st of 6 or more days with a daily minimum temperature < 5°C. |
| **WSDI** Warm Spells | A "warm spell" is defined as 6 or more consecutive days when the daily maximum temperature exceeds the 90th percentile value of the historical baseline. This index measures the number of days in a typical year that a warm spell occurs. (A warm spell can occur at any time of year). |
| **CSDI** Cold Spells | A "cold spell" is defined as 6 or more consecutive days when the daily minimum temperature is less than the 10th percentile value of the historical baseline. This index measures the number of days in a typical year that a cold spell occurs. (A cold spell can occur at any time of year). |
| **Design** | |
| **HDDheat18C** Heating Degree Days | Number of degree days below 18°C in a year. A rough estimate for the energy demand needed to heat a building in a typical year. |
| **CDDcold18C** Cooling Degree Days | Number of degree days above 18°C in a year. A rough estimate for the energy demand needed to cool a building in a typical year. |

**Increasing Temperatures and Extreme Heat**

- ✓ Hotter daytime temperatures
- ✓ Warmer nighttime temperatures
- ✓ Heat waves becoming hotter and more frequent

**Key sectors:** Emergency Management, Health, Biodiversity, Watershed

| | |
|---|---|
| **Daytime Temperatures** | |
| **TX** | Daytime high temperature, averaged over all days in a year or season |
| **TXx** | Hottest daytime high temperature in a year or season |
| **SU**<br>Summer Days | Number of days in a typical year when the daytime high is above 25°C |
| **SU30**<br>Hot Summer Days | Number of days in a typical year when the daytime high is above 30°C |
| **Nighttime Temperatures** | |
| **TN** | Daily minimum temperature in a typical year or season |
| **TNx** | Warmest nighttime low temperature in a typical year or season |
| **TR16C**<br>Temperate Nights | Number of days in a year when the nighttime low stays above 16°C |
| **TR**<br>Tropical Nights | Number of days in a year when the nighttime low stays above 20°C |
| **Heat Extremes** | |
| **HWD**<br>Heat Wave Days | Number of days in a typical year classified as a "heat wave" |
| **HWN**<br>Heatwave Number | Number of distinct heat wave events in a typical year |
| **HWXL**<br>Heatwave Length | Length (in days) of the longest heat wave in a typical year |
| **TXH**<br>Heatwave Intensity (Day) | Daytime high temperature averaged across all heat waves in a typical year |
| **TNH**<br>Heatwave Intensity (Night) | Nighttime low temperature averaged across all heat waves in a typical year |
| **TXHX** | Daytime high temperature during the most extreme heat wave in a year |
| **TNHX** | Nighttime low temperature during the most extreme heat wave in a year |
| **Return Periods**<br>(various) | The data package provides return levels and return period changes for the 5-, 10-, 20-, and 30-year Hottest Day. |

### Extreme Precipitation and Flooding

*In this data package, there are no direct indices for flooding.*
*Rainfall extremes may trigger flooding under certain circumstances.*

- ✓ More precipitation occurring over short time periods
- ✓ More days with heavy rainfall

**Key sectors:** Public Works/Engineering, Infrastructure, Biodiversity, Health, Agriculture, Watershed

| Precipitation | |
|---|---|
| **PR**<br>Total Precipitation | Total precipitation in a typical year or season |
| **Rain**<br>Total Rainfall | Total rainfall in a typical year or season |
| **Snow**<br>Summer Days | Total snowfall in a typical year or season |
| **Rainfall Extremes** | |
| **RX1DAY** | Maximum amount of precipitation (in mm) occurring in a single day in a typical year |
| **RX5DAY** | Maximum amount of precipitation (in mm) occurring over a 5-day period in a typical year |
| **R10MM** | Number of days in a typical year that receive more than 10mm of total precipitation |
| **R20MM** | Number of days in a typical year that receive more than 20mm of total precipitation |
| **R95P / R95DAYS** | Amount of precipitation over the year that exceeds the 95th percentile of historical (baseline) daily precipitation / Number of days in a typical year that exceed this amount. |
| **R99P / R99DAYS** | Amount of precipitation over the year that exceeds the 99th percentile of historical (baseline) daily precipitation / Number of days in a typical year that exceed this amount. |
| **Return Periods**<br>(Various) | The data package provides 5-, 10-, 20-, 30-, and 50-year return periods for annual wettest 1-, 2-, and 5-day rainfall events. It also provides changes to rainfall return periods for an event of given magnitude. |

**Drought**

*In this data package, there are no direct drought variables. Hotter temperatures, less rainfall and reduced snowpack may lead to drought conditions in the warmer months.*

**Key sectors:** Agriculture, Biodiversity, Health, Watershed

| | |
|---|---|
| **Precipitation** | |
| **PR – Summer**<br>Total Precipitation in Summer | Total precipitation in a typical summer (may also be important to consider PR for spring and fall) |
| **SNOW**<br>Total Snowfall | Total snowfall (fall-winter-spring) |
| **CDD**<br>Consecutive Dry Days | Number of days comprising the longest "dry spell" in a typical year. Dry spells are defined as consecutive days with less than 1mm of total precipitation. |
| **Temperature** | |
| **TX** | Daytime high temperature in a typical year or season |
| **TXx** | Hottest daytime high temperature in a typical year or season |
| **SU**<br>Summer Days | Number of days in a typical year when the daytime high is above 25°C |

**Wildfire and Air Quality**

*In this data package, there are no direct wildfire variables. Hotter temperatures and less rainfall in the warmer months may lead to more favourable conditions for wildfire.*

**Key Sectors:** Health, Biodiversity, Infrastructure, Agriculture

Variables listed under Drought (see above) can also be considered as informative for Wildfire. Additional variables such as humidity, wind speed, and wind direction must also be considered in order to establish favourable conditions for Wildfire. The Canadian Forest Service has analyzed such historical data to develop Fire Weather Normals, which provide insight into how "fire weather" varies spatially and throughout the year. See https://cwfis.cfs.nrcan.gc.ca/ha/fwnormals for more.

Future-projected temperature and precipitation conditions that may be favourable to increased incidence of Wildfire may be obtained from other regional climate projections reports in BC, including:

- Climate Projections for BC Northeast Region
- Climate Projections for the Okanagan Region
- Climate Projections for the Cowichan Valley Regional District
- Climate Projections for Metro Vancouver

# Appendix F

## COMPLETE LIST OF CLIMATE INDICES

| Name | Variable | Definition | Units |
|---|---|---|---|
| | | **Standard** | |
| **PR** | Precipitation | Annual/seasonal precipitation totals | mm |
| **RAIN** | Rainfall | Annual/seasonal rainfall portion of precipitation using temperature-based rain-snow partitioning | mm |
| **SNOW** | Snowfall | Annual/seasonal snowfall (snow water equivalent) portion of precipitation | mm (H2Oeq) |
| **TM** | Daily Average Temperature | Annual/seasonal daily average temperature | °C |
| **TX** | Daily Maximum Temperature | Annual/seasonal average daily maximum temperature | °C |
| **TN** | Daily Minimum Temperature (usually overnight) | Annual/seasonal average daily minimum temperature | °C |

| Name | Variable | Definition | Units |
|---|---|---|---|
| | | **CLIMDEX: Temperature Based** | |
| **TXX** | Maximum TX | Annual/seasonal maximum of TX | °C |
| **TNN** | Minimum TN | Annual/seasonal minimum of TN | °C |
| **TXN** | Minimum TX | Annual/seasonal minimum of TX | °C |
| **TNX** | Maximum TN | Annual/seasonal maximum of TN | °C |
| **TX90P** | Hot Days | Annual percentage of days with TX > 90th historical percentile | % |
| **TX10P** | Cool Days | Annual percentage of days with TX < 10th historical percentile | % |
| **TN90P** | Warm Nights | Annual percentage of days with TN > 90th historical percentile | % |
| **TN10P** | Cold Nights | Annual percentage of days with TN < 10th historical percentile | % |
| **DTR** | Diurnal Temperature Range | Annual/seasonal diurnal temperature range, TX – TN | °C |
| **SU** | Summer Days | Annual number of days with TX > 25 °C | days |
| **SU30** | Hot Summer Days | Annual number of days with TX > 30 °C | days |
| **TR** | Tropical Nights | Annual number of days with TN > 20 °C | days |
| **TR16C** | Temperate Nights | Annual number of days with TN > 16 °C | days |
| **ID** | Ice Days | Annual number of days with TX < 0 °C | days |
| **FD** | Frost Days | Annual number of days with TN < 0 °C | days |
| **CSDI** | Cold Spells | Annual count of days with at least 6 consecutive days when TN < 10th historical percentile | days |
| **WSDI** | Warm Spells | Annual count of days with at least 6 consecutive days when TX > 90th historical percentile | days |
| **GSL** | Growing Season Length | Growing season length (number of days between first span of at least 6 days with TM >5°C and first span after July 1st of 6 days with TM <5°C) | days |

| Name | Variable | Definition | Units |
|---|---|---|---|
| | | **CLIMDEX: Precipitation-Based** | |
| **CDD** | Consecutive Dry Days | Annual maximum length of consecutive dry days (PR < 1 mm) | days |
| **CWD** | Consecutive Wet Days | Annual maximum length of consecutive wet days (PR ≥ 1 mm) | days |
| **SDII** | Simple Daily Precipitation Intensity Index | Annual average PR on days with PR ≥ 1 mm | mm |
| **R1MM** | Precipitation ≥ 1 mm | Annual count of days with PR ≥ 1 mm | days |
| **R10MM** | Precipitation ≥ 10 mm | Annual count of days with PR ≥ 10 mm | days |
| **R20MM** | Precipitation ≥ 20 mm | Annual count of days with PR ≥ 20 mm | days |
| **RX1DAY** | Maximum 1-Day PR | Annual/seasonal maximum 1-day PR | mm |
| **RX2DAY** | Maximum 2-Day PR | Annual/seasonal maximum 2-day PR | mm |
| **RX5DAY** | Maximum 5-Day PR | Annual/seasonal maximum 5-day PR | mm |
| **RN1DAY** | Maximum 1-Day RAIN | Annual/seasonal maximum 1-day rainfall | mm |
| **RN2DAY** | Maximum 2-Day RAIN | Annual/seasonal maximum 2-day rainfall | mm |
| **RN5DAY** | Maximum 5-Day RAIN | Annual/seasonal maximum 5-day rainfall | mm |
| **R95P** | Very Wet Day PR | Annual total PR when PR > 95th percentile of daily PR in historical period | mm |
| **R95DAYS** | Very Wet Days | Annual number of days when PR > 95th percentile of daily PR in historical period | days |
| **R99P** | Extreme Wet Day PR | Annual total PR when PR > 99th percentile of daily PR in historical period | mm |
| **R99DAYS** | Extreme Wet Days | Annual number of days when PR > 99th percentile of daily PR in historical period | days |

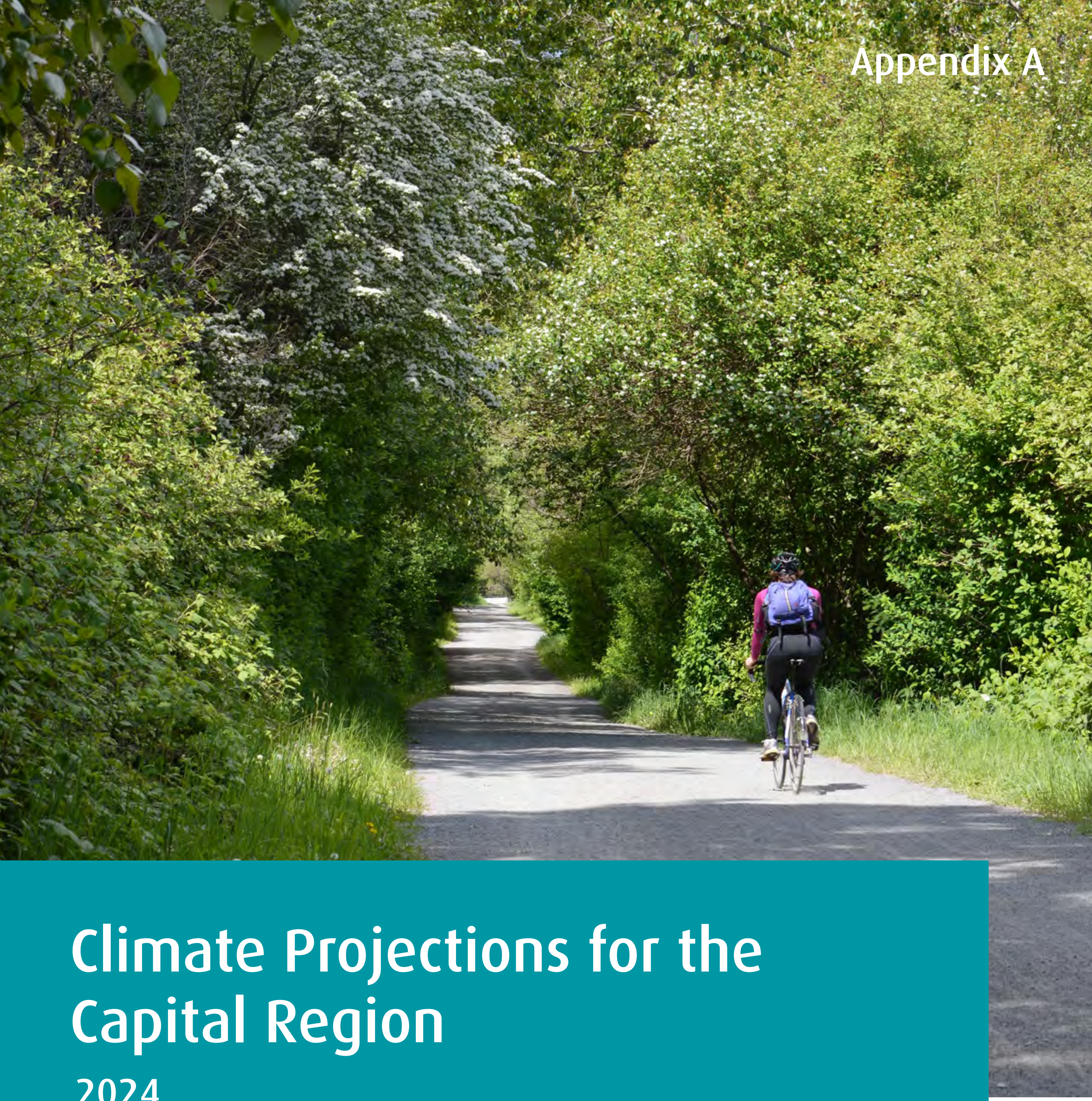
| Name | Variable | Definition | Units |
|---|---|---|---|
| | | **Degree Days** | |
| **CDDcold18C** | Cooling Degree Days | Annual, cumulative TM difference above 18 °C | °C-days |
| **GDDgrow5C** | Growing Degree Days | Annual, cumulative TM difference above 5 °C | °C-days |
| **HDDheat18C** | Heating Degree Days | Annual, cumulative TM difference below 18 °C | °C-days |
| **FDDfreeze0C** | Freezing Degree Days | Annual, cumulative TM difference below 0 °C | °C-days |

| Name | Variable | Definition | Units |
|---|---|---|---|
| | | **Heatwave Indices** | |
| **HWD** | Heatwave (HW) days | Annual count of HW days, where a HW is defined as both TX and TN exceeding: 1) their 95th percentiles (historical), AND; 2) BC HARS thresholds[3] for at least 2 consecutive days. | days |
| **HWN** | HW number | Annual number of distinct HWs | # |
| **HWXL** | HW duration | Annual maximum HW length | days |
| **TNH** | HW intensity (night) | Average TN over all HWs in a year | °C |
| **TXH** | HW intensity (day) | Average TX over all HWs in a year | °C |
| **TNHX** | Maximum TNH | Average TN during most extreme HW in a year | °C |
| **TXHX** | Minimum TNH | Average TX during most extreme HW in a year | °C |
| **HWDD** | HW degree days | Annual, cumulative TM difference above HW threshold | °C-days |

[3] The lower threshold temperatures used in our HW definition, which is intended for use throughout BC, are TX = 28°C and TN = 13°C. These are the lowest temperatures found in any region of the map in Figure 3, page 14 of the 2023 report, BC Provincial Heat Alert and Response System (BC HARS): 2023, May 2023. Available at: http://www.bccdc.ca/health-professionals/professional-resources/heat-event-response-planning.

| Name | Variable | Definition | Units |
|---|---|---|---|
| | | **Return Levels** | |
| **TX_RP5** | 5-Year return level of TX | 5-Year return level of TX | °C |
| **TX_RP10** | 10-Year return level of TX | 10-Year return level of TX | °C |
| **TX_RP20** | 20-Year return level of TX | 20-Year return level of TX | °C |
| **TX_RP25** | 25-Year return level of TX | 25-Year return level of TX | °C |
| **TX_RP30** | 30-Year return level of TX | 30-Year return level of TX | °C |
| **TN_RP5** | 5-Year return level of TN | 5-Year return level of TN | °C |
| **TN_RP10** | 10-Year return level of TN | 10-Year return level of TN | °C |
| **TN_RP20** | 20-Year return level of TN | 20-Year return level of TN | °C |
| **TN_RP25** | 25-Year return level of TN | 25-Year return level of TN | °C |
| **TN_RP30** | 30-Year return level of TN | 30-Year return level of TN | °C |
| **RN1_RP5** | 5-Year return level of RN1DAY | 5-Year return level of RN1DAY | mm |
| **RN1_RP10** | 10-Year return level of RN1DAY | 10-Year return level of RN1DAY | mm |
| **RN1_RP20** | 20-Year return level of RN1DAY | 20-Year return level of RN1DAY | mm |
| **RN1_RP30** | 30-Year return level of RN1DAY | 30-Year return level of RN1DAY | mm |
| **RN1_RP50** | 50-Year return level of RN1DAY | 50-Year return level of RN1DAY | mm |
| **RN2_RP5** | 5-Year return level of RN2DAY | 5-Year return level of RN2DAY | mm |
| **RN2_RP10** | 10-Year return level of RN2DAY | 10-Year return level of RN2DAY | mm |
| **RN2_RP20** | 20-Year return level of RN2DAY | 20-Year return level of RN2DAY | mm |
| **RN2_RP30** | 30-Year return level of RN2DAY | 30-Year return level of RN2DAY | mm |
| **RN2_RP50** | 50-Year return level of RN2DAY | 50-Year return level of RN2DAY | mm |
| **RN5_RP5** | 5-Year return level of RN5DAY | 5-Year return level of RN5DAY | mm |
| **RN5_RP10** | 10-Year return level of RN5DAY | 10-Year return level of RN5DAY | mm |
| **RN5_RP20** | 20-Year return level of RN5DAY | 20-Year return level of RN5DAY | mm |
| **RN5_RP30** | 30-Year return level of RN5DAY | 30-Year return level of RN5DAY | mm |
| **RN5_RP50** | 50-Year return level of RN5DAY | 50-Year return level of RN5DAY | mm |

Appendix A



# Climate Projections for the Capital Region

2024

PACIFIC CLIMATE IMPACTS CONSORTIUM

CRD Making a difference...together

# EXECUTIVE SUMMARY

The Earth's climate system is warming, and signs of climate change are becoming evident across the planet. The capital region, located on Southern Vancouver Island and Gulf Islands of British Columbia (BC), is no exception. The Capital Regional District (CRD) has partnered with the Pacific Climate Impacts Consortium (PCIC) to produce high-resolution regional projections for temperature, precipitation, and related indices of extremes. These projections use the most up-to-date global modeling data (i.e., the Sixth Coupled Model Intercomparison Project, CMIP6) to illustrate how the region's climate may change by the middle of this century. Information provided by this report and the accompanying data is intended to support decision makers and community partners in the region with an improved understanding of projected local climate change and related impacts.

At a high level, the results of this study show that in the coming decades, the capital region can expect:

- Hotter summer temperatures, with more extreme heat days and heatwaves;
- Warmer nights and a longer growing season;
- Warmer winter temperatures and less frequent frost;
- Less rain and more dry days in the summer months;
- More precipitation falling in fall, winter and spring;
- Less snowfall in the colder months;
- Extreme rainfall events becoming wetter.

More specifically, warming temperatures will shift seasonal patterns, prompting a longer growing season and greater cooling demand across the region. Extreme temperatures will continue to get hotter, with heat waves becoming longer and more frequent. By the 2050s, the capital region can expect the number of summer days exceeding 25°C to triple, going from an average of 12 days per year to around 40. Nighttime temperatures in the summer will also increase. Nights where the temperature stays above 16°C (the lower threshold for heat alerts for Southern Vancouver Island) are projected to occur up to 29 times per year by mid-century. The temperature for the 1-in-20-year hottest is projected to increase from 32°C to 36°C.

By the end of this century, annual precipitation is projected to increase modestly (4% increase by the 2050s and 11% by the 2080s). However, these changes will not occur evenly across seasons. In the colder months, rainfall increases notably because of warmer temperatures that convert more snow into rain. (By the 2050s, total rainfall in the winter increases by 25%, while total snowfall drops by nearly 60%.) Much of the rainfall in the colder months will occur during extreme events, with the very wet days becoming wetter by mid-century. In contrast to the fall, winter and spring, the summer months will become increasingly dry. Total rainfall in the summer is projected to decrease by roughly 15% by the 2050s with the duration of dry spells becoming longer.

Many of the projected climate changes described in this report will be felt uniformly across the region. However, the magnitude of some variables will be accentuated by the existing West-to-East climatic gradient in the capital region. For example, the Western region is typically wetter and cooler compared to the Eastern Region, where conditions are typically warmer and drier. In addition, temperatures may be warmer or cooler in specific areas due to other factors including tree canopy cover (or a lack thereof), paved surfaces, and buildings density.

The projected warming for the capital region will have implications for regional ecosystems, watersheds, agriculture and horticulture, housing, energy demand, infrastructure, and community health and safety. Chapter 7 provides a high-level overview of some of the impacts that might be expected from the projected changes in this assessment. This chapter was informed by input from local government staff during a workshop in October 2023 and is not a comprehensive assessment of regional impacts. It is intended to support further discussion and analysis for how climate change may impact the capital region.

The CRD and PCIC also collected input from local government staff to understand how these climatic changes may impact the region as whole. Across the capital region, communities are already witnessing and experiencing varied impacts of climate change. These impacts will persist and, in many cases, intensify over the coming decades based on the future global greenhouse gas emissions trajectory. These impacts will not be experienced equally across the region. People facing the greatest burdens are often the ones who are most affected by climate change, particularly for impacts that are compounding.

Information within this report and the accompanying data provides the region's decision makers, community planners, and community partners with an improved understanding of projected local climate change and related impacts.

## CONTRIBUTING AUTHORS

Charles Curry and Stephen Sobie from Pacific Climate Impacts Consortium (PCIC) conducted climate model downscaling, data analysis and interpretation and generated all data products, including maps, figures, and tables, for the report. Charles Curry and Izzy Farmer (PCIC) served as lead authors of this report, with advice and guidance from CRD staff.

## ACKNOWLEDGMENTS

We would like to acknowledge the effort and input received from CRD staff, municipal staff, and the CRD Climate Action Inter-Municipal Working Group in the development of this report. Working together ensures that we share knowledge and build on each other's success to create a more resilient region.

# TABLE OF CONTENTS

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## Tables



## Figures

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# 1. INTRODUCTION

Over the last 150 years, the global average temperature has increased by over 1°C and this warming has been clearly linked to the emission of greenhouse gases (GHGs), aerosols, and other aspects of human development. This warming is expected to continue unless we make significant cuts to GHG emissions globally. Understanding, monitoring, and preparing for the regional and local manifestations of climate change is important for supporting safe and resilient communities in the decades to come.

The Capital Regional District (CRD) has undertaken this study to better understand how the climate of our region is expected to change over the coming decades. British Columbia's capital region spans an area of 2,340 $km^2$ and an elevation range of 1 to 1,100 m above sea level (Figure 1). Since 1950, air temperature observations for Vancouver Island have been increasing by 0.26 ± 0.07 °C per decade.[2] Both global and regional warming are expected to influence other climate variables, such as rainfall.

To explore the changes that may be in store for our region, the CRD has partnered with the Pacific Climate Impacts Consortium (PCIC) to produce high-resolution climate projections for the capital region. These projections are based on the latest generation of comprehensive global climate models (CMIP6). Like other populated areas worldwide, the region requires up-to-date, science-based, high-resolution information to enable effective planning and policy decisions in a changing climate. This information will be used with other resources to help prepare the capital region for the impacts of climate change.

A selected number of climate indicators are provided in this report to demonstrate how our climate is expected to change over time. In the first section, Chapter 2 provides a brief description of the study methodology and includes support for interpreting the figures and tables. Chapters 3 through 6 provide an analysis of selected climate indicators for the region, including information about summer temperatures, winter temperatures, precipitation, and climate extremes. Each section includes a description of each indicator and a summary of how it is projected to change over time.

In the second section, Chapter 7 identifies potential impacts from climate change expected across the capital region. These impacts are categorized by different sectors, including health and wellbeing, water supply and demand, rainwater management and sewerage, ecosystems and species, buildings and energy systems, transportation, food and agriculture, and recreation and tourism.

It should be noted that the information provided in this report is limited to changes in temperature and precipitation only. Other climate-related phenomena, like surface hydrology, wind, humidity, sea level rise and storm surge require different modelling techniques and are not included in the scope of this report. Therefore, the report should be used alongside other resources to help prepare our region for the impacts of climate change. For example, in 2021, working with and on behalf of municipal partners, the CRD undertook a coastal flood inundation mapping project, which includes an analysis of current and future storm surge due to sea level rise. Since that time, some municipalities in the region have been undertaking efforts to build upon this work.

This report and the supplementary data that accompany it are intended to support climate-focused decision making throughout the region and help community partners better understand how their work may be affected by our changing climate. The information provided here should be used with careful consideration for the local context. For guidance on how climate information can be used to support adaptation planning, see the appendices appearing at the end of this report.

---

[1] IPCC, 2023: Summary for Policymakers. In: Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (eds.)]. IPCC, Geneva, Switzerland, pp. 1-34, doi: 10.59327/IPCC/AR6-9789291691647.001.

[2] Results of an analysis conducted by PCIC for the annual "State of the Pacific Ocean" report; see Curry, C.L. and Lao, I., "Land temperature and hydrological conditions in 2022," pp 17-21. In: Boldt, J.L., Joyce, E., Tucker, S., and Gauthier, S. (Eds.), State of the physical, biological and selected fishery resources of Pacific Canadian marine ecosystems in 2022. Can. Tech. Rep. Fish. Aquat. Sci. 3542: viii + 312 p. (2023). The nearby Lower Fraser Valley displays a larger trend of magnitude 0.42 ± 0.07 °C per decade, which may be more similar to what the capital region has experienced.

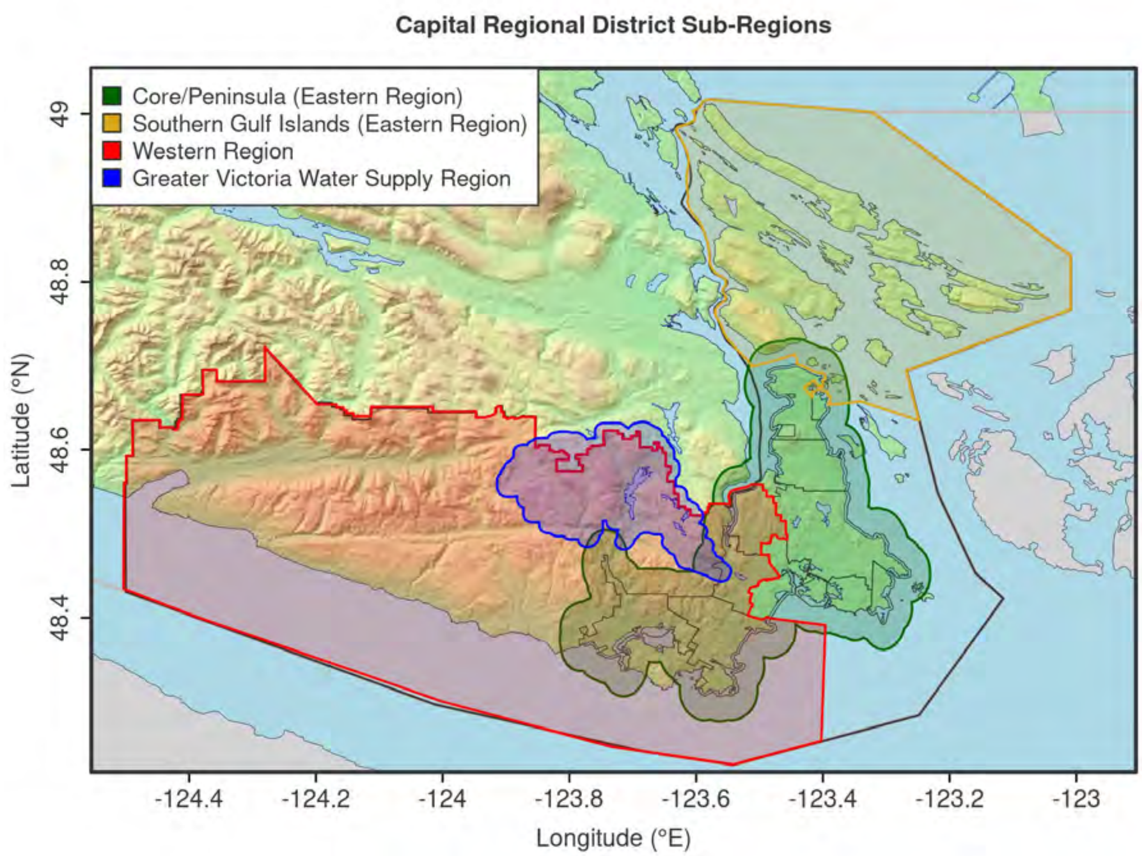



***Figure 1.*** *Domain of interest, the Capital Regional District, with background relief map and four sub-regions of interest. In several of the tables in the report, results for the Core/Peninsula and Southern Gulf Islands are combined into a single Eastern Region.*

# 2. METHODS AND PRESENTATION

## **2.1** Climate Model Projections

The climate projections are based on an ensemble of 9 global climate models (GCMs) drawn from a larger collection of models developed during the Sixth Coupled Model Intercomparison Project (CMIP6), coordinated by the World Climate Research Programme. The climate projections presented here are based on a high greenhouse gas emissions scenario, known as the Shared Socioeconomic Pathway 5-8.5 (SSP585), which describes a trajectory of future emissions spurred by continued and expanded use of fossil-fuels worldwide. Two other scenarios are also presented in the data package accompanying this report: a medium-intensity emissions pathway, SSP245, and a low-intensity pathway, SSP126, which covers the possibility of a low-carbon technology transformation of worldwide energy systems.[3] Planning based on climate projections under SSP585 could be considered a "no regrets" strategy for adaptation. By the 2090s under SSP585, global mean surface air temperature reaches a level 4.3°C higher than the 1850-1900 average. The evolution of air temperature and precipitation under the three SSPs, for BC specifically, is shown in Figure 2.

Each GCM represents the climate system using a global, horizontal grid with a limiting resolution between 100 km and 250 km, depending on the model. These coarse-grained data are first bias-corrected against available observations (spanning 1950-2012) and then statistically downscaled to 10 km resolution.[4]

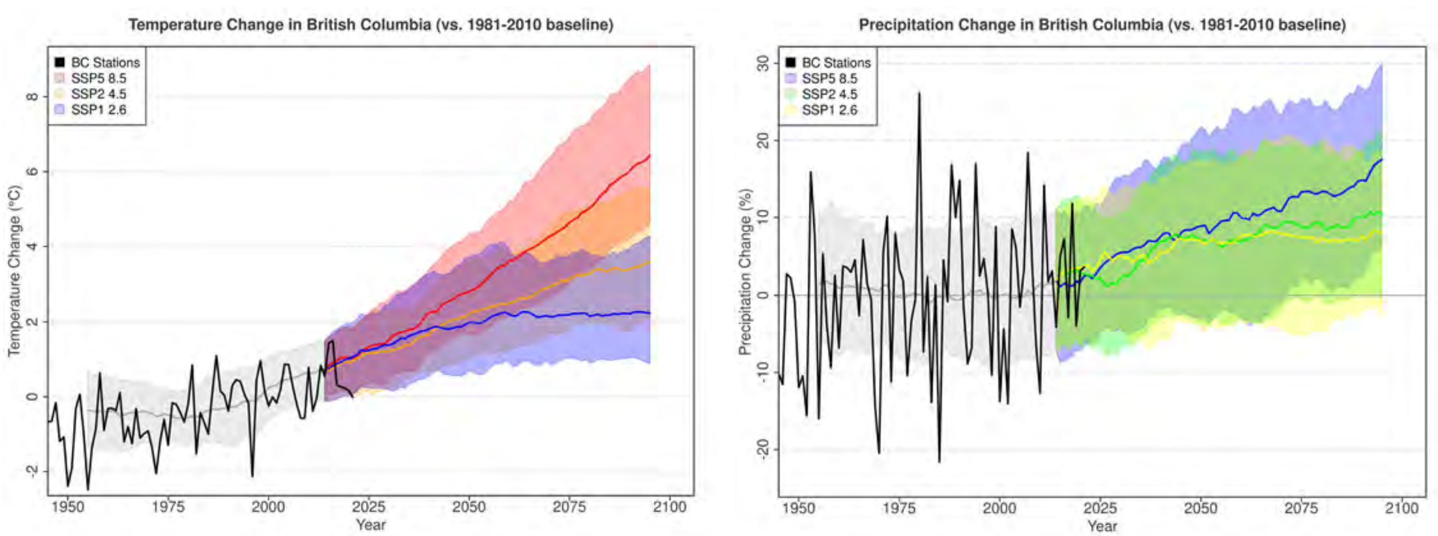



***Figure 2.*** *Changes in annual mean air temperature (left) and total precipitation (right) relative to their values in 1981-2010, averaged over all of BC. The black curves show historical values obtained from the station data in BC from 1948-2021, while the coloured curves show median GCM projections under the three development pathways (SSPs) from 2015-2100. The shaded areas show the 10th-90th percentile range in model-simulated results over the historical and future periods, for each SSP.*

[3] An accessible description of the SSPs may be found at https://climatedata.ca/resource/understanding-shared-socio-economic-pathways-ssps/.

[4] Details on the downscaling methods used at PCIC may be found on the Data Portal section of our website, pacificclimate.org.

In a second downscaling step, the model data are further downscaled to a resolution of 800 m using fine-scale climatological maps. It should be recognized, however, that while the latter account for fine-scale topography, important features of, and influences on, local daily climate are not represented in the dataset.[5]

Downscaled climate model results are presented for three 30-year periods: the historical reference period, 1981-2010 (referred to as the “Past” or “1990s” for short), the near future, 2021-2050 (the “2030s”), mid-century, 2041-2070 (the “2050s”) and the end-of-century, 2071-2100 (the “2080s”). These 30-year periods are chosen both to smooth out year-to-year climate variability, and to provide a long enough period to characterize the behaviour of fairly rare events. The seasonal definitions used are “meteorological” seasons: i.e., winter (December 1 to February 28), spring (March 1 to May 31), summer (June 1 to August 31) and fall (September 1 to November 30). A range of indices are computed from daily temperature and precipitation to describe various aspects of the climate.  For projections, median estimates from the climate model ensemble are typically emphasized, with the $10^{th}$ to $90^{th}$ percentile ranges over the ensemble also provided where appropriate.

It is important to recognize that not all projected changes emerging from the climate model ensemble are necessarily substantial. For a given variable, location, and emissions pathway, each model produces a projected future climate, resulting in a range of possible outcomes. Since no single model is “right,” the median value of the ensemble can be used as a practical best-guess projection, with the 10th to 90th percentile spread indicating the uncertainty amongst the models. *If the spread includes zero change, meaning that not all models agree on the sign of the change, then relatively low confidence should be placed in the median value.* In the relatively rare cases when less than half of the models agree on the sign of change, users are alerted to the reduced confidence via a printed message on the maps.

[5] Examples of these being realistic day-to-day variability and co-variability between nearby locations, and fine-scale land cover type, for example. It should also be recognized that since the models are bias-corrected to daily observations spanning a specific time period, here 1981-2010, more recent observations will not be reflected in results displayed for the “Past.”

## **2.2** Interpreting Figures and Tables

The data deliverables for the project comprise: (i) maps of climate variables over the region in Past and Future periods, for each of the three scenarios; and (ii) tables (Excel spreadsheets) of area-averaged results for the same. Results for absolute or relative difference are also provided, where appropriate. References to the tables are occasionally made in the report. Most of the figures presented below are maps, showing the capital region and the surrounding area. Colour contours indicate values of the indicated variable, with a nominal limiting resolution of 800 m. *Due to the limitations of the downscaling methodology mentioned above, along with the inherent uncertainty in future outcomes, the exact position of contours on the maps should not be taken literally.* On each map, the area average shown at bottom left is computed over the capital region only (area inside the black curve).

This report presents results for a number of key indicators, derived from the model-simulated daily temperature and precipitation, representing a "highlight reel" of the much more extensive set of climate indices delivered for this project. In consultation with CRD staff, they were selected either because they have implications for a range of climate-related impacts, because they feature particularly large changes from recent historical conditions, or both. In the next few chapters, a plain language definition is provided for each indicator, followed by a summary of its projected change for the 2030s, 2050s, and 2080s, under the high (SSP585) emissions scenario. Detailed definitions of all indicators are provided in the Appendix.

There are two types of maps: single period and future change. Single period maps, e.g., "Past: 1990s" or "Projection: 2050s," show actual values of a variable, e.g., temperature in °C. Future change maps, e.g., "Projected Change: 2050s - 1990s," show differences between historical and future-simulated periods, and may be in the units of the variable or in relative terms, e.g., percent change in precipitation. In the interest of concision, all future change maps shown in this summary report are for the 2050s under the high emissions (SSP585) pathway. For most indicators, the magnitude of these changes should be roughly comparable to that projected for the 2080s under the moderate emissions scenario (i.e., SSP245).

Other figures in the report use area-averages for the capital region while expressing the range of projected values over models and years for a certain variable. An example of this type of presentation, the "box-and-whisker" plot, is shown in Figures 6 and 9, and an aid to their interpretation is given below. Note that, in these figures, the range shown by the whiskers reflects both year-to-year and model-to-model variability. Finally, note that when cited in the text, values from the spreadsheets are often rounded to indicate the likely precision of the quantity being discussed, given the known model uncertainties. For example, a temperature of 29.8°C would be cited as 30°C, while 2717 degree-days become 2715 degree-days. The tables contain median values with ranges given in parentheses (10th – 90th percentile of different model projections). Usually medians are cited in the text; but ranges encompass the range of possible behaviour, and should not be ignored, especially when the climate variable in question might enter into critical decision-making.

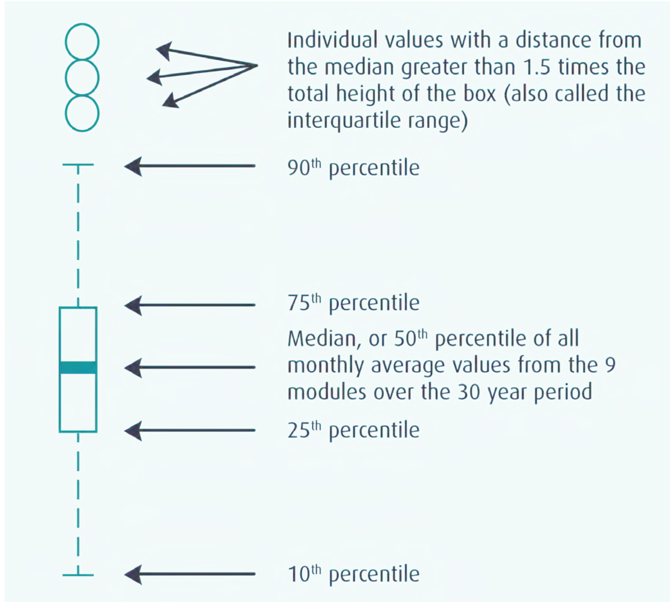



***Figure 3.*** *Explanatory schematic of a box-and-whisker plot.*

Values in tables are averaged over the capital region (within the regional boundary shown on the maps), unless labeled as *Eastern Region* (Greater Victoria and Southern Gulf Islands), *Western Region,* or *Greater Victoria Water Supply Area.*

# 3. GENERAL CLIMATE PROJECTIONS

## **3.1** Warmer Temperatures

We begin by examining future temperature change over the region. *Daytime High and Nighttime Low Temperatures* are averaged over each season and annually in the tables and maps below.

In concert with global and regional warming, both daytime and nighttime temperatures are projected to increase in the capital region in future, as detailed in the tables (all changes shown are positive). The accompanying maps show the spatial pattern of Past and future-projected temperatures throughout the region.

### *Projections*

In the Past, winter daytime high temperatures in the region averaged around 7°C, while winter nighttime low temperatures averaged around 1.7°C. The median future-projected TX increases to around 9°C by the 2050s and to 11°C by the 2080s. The median future-projected TN reaches around 4°C by the 2050s and to 5.5°C by the 2080s. Since the likelihood of snowfall rapidly decreases as temperatures rise above 0°C, we can anticipate that this local warming will affect the frequency of snowfall in the region, as detailed further below.

**Table 1: Regional Average Daytime High Temperature (TX)**

| | Past (°C) | 2050s Change (°C) | 2080s Change (°C) |
|---|---|---|---|
| Winter | 6 | 2.1 *(1.6 to 3.5)* | 3.5 *(2.8 to 6.5)* |
| Spring | 12 | 2.1 *(1.4 to 4.0)* | 3.5 *(2.6 to 6.3)* |
| Summer | 20 | 2.9 *(2.3 to 5.1)* | 4.7 *(4.1 to 8.7)* |
| Fall | 13 | 2.7 *(2.2 to 4.6)* | 4.0 *(3.6 to 7.2)* |
| Annual | 13 | 2.5 *(2.0 to 4.4)* | 3.9 *(3.4 to 7.0)* |

**Table 2: Regional Average Nighttime Low Temperature (TN)**

| | Past (°C) | 2050s Change (°C) | 2080s Change (°C) |
|---|---|---|---|
| Winter | 1 | 2.0 *(1.8 to 3.8)* | 3.6 *(3.2 to 6.8)* |
| Spring | 4 | 2.2 *(1.5 to 3.5)* | 3.2 *(2.8 to 5.6)* |
| Summer | 10 | 2.8 *(2.3 to 4.3)* | 4.6 *(3.9 to 7.4)* |
| Fall | 5 | 2.9 *(2.1 to 4.7)* | 4.2 *(3.6 to 7.3)* |
| Annual | 5 | 2.3 *(2.0 to 4.2)* | 3.9 *(3.5 to 6.6)* |

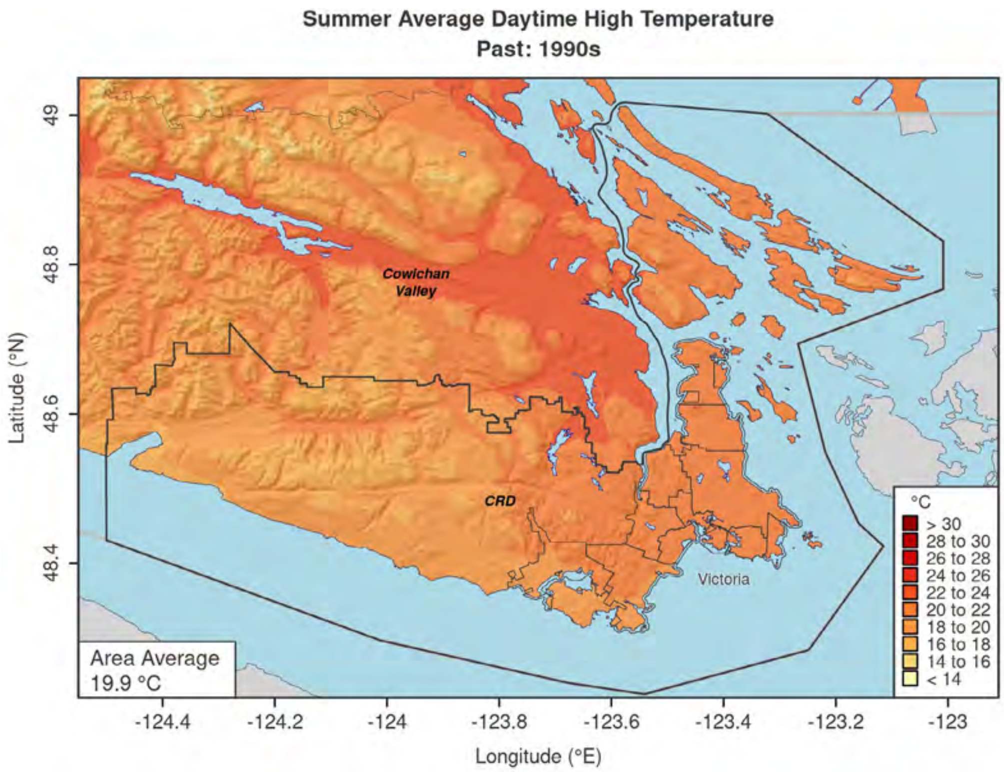



***Figure 4a:*** *Summer average daytime high temperature in the Past.*

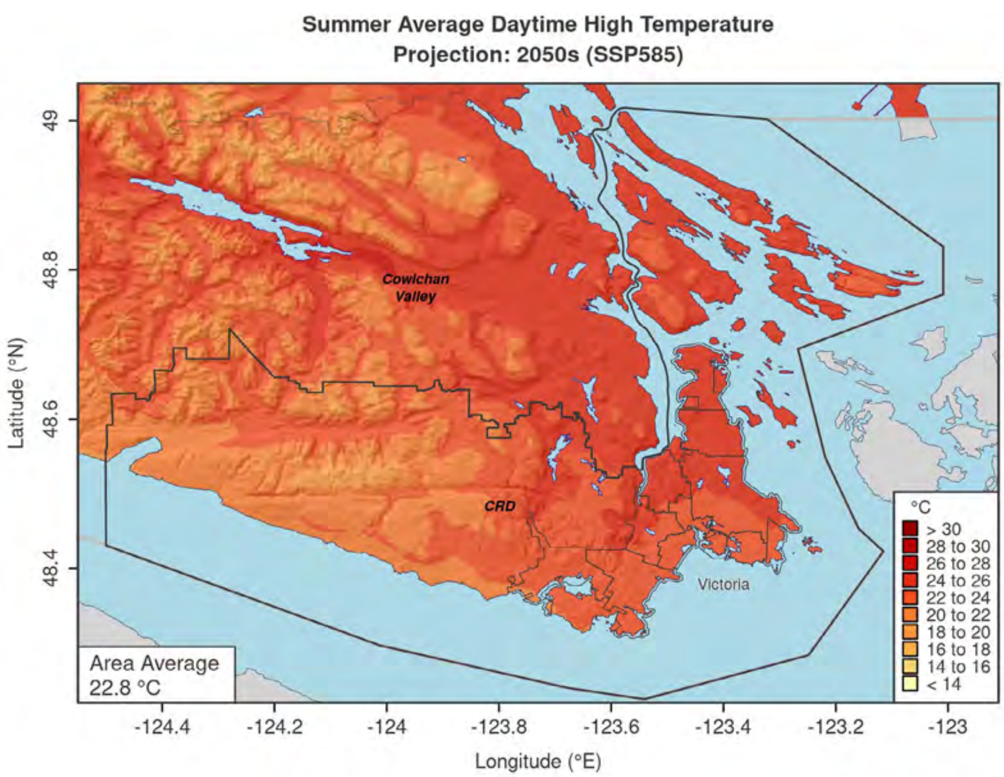



***Figure 4b:*** *Projected summer average daytime high temperature in the 2050s.*

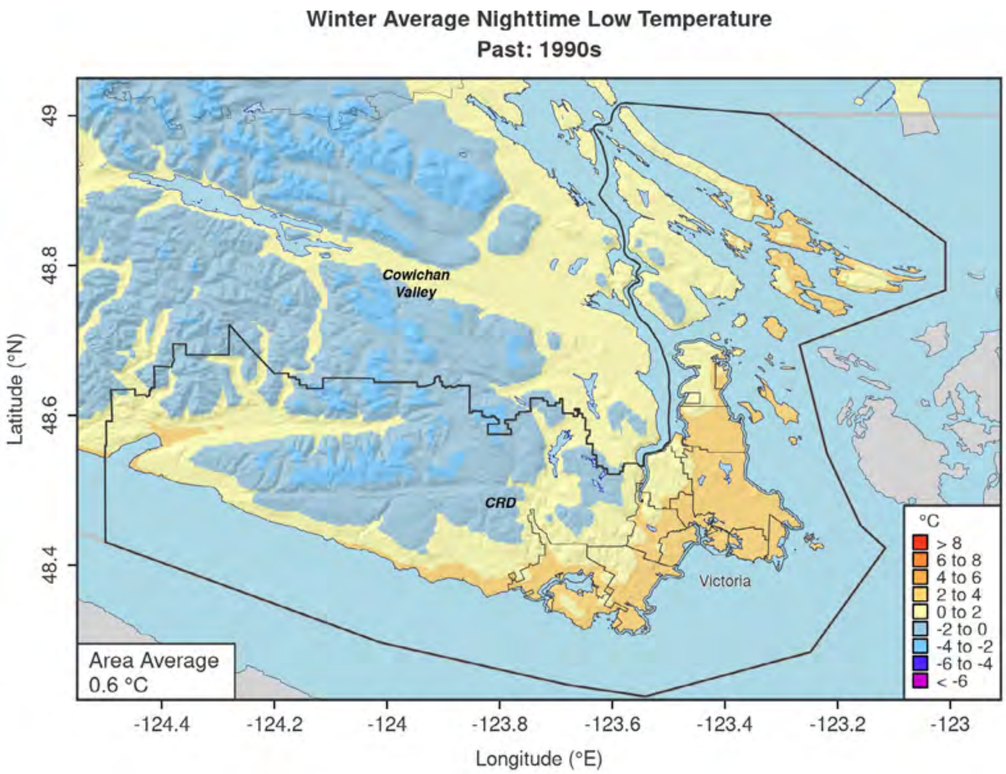



***Figure 5a:*** *Winter average daytime high temperature in the Past.*

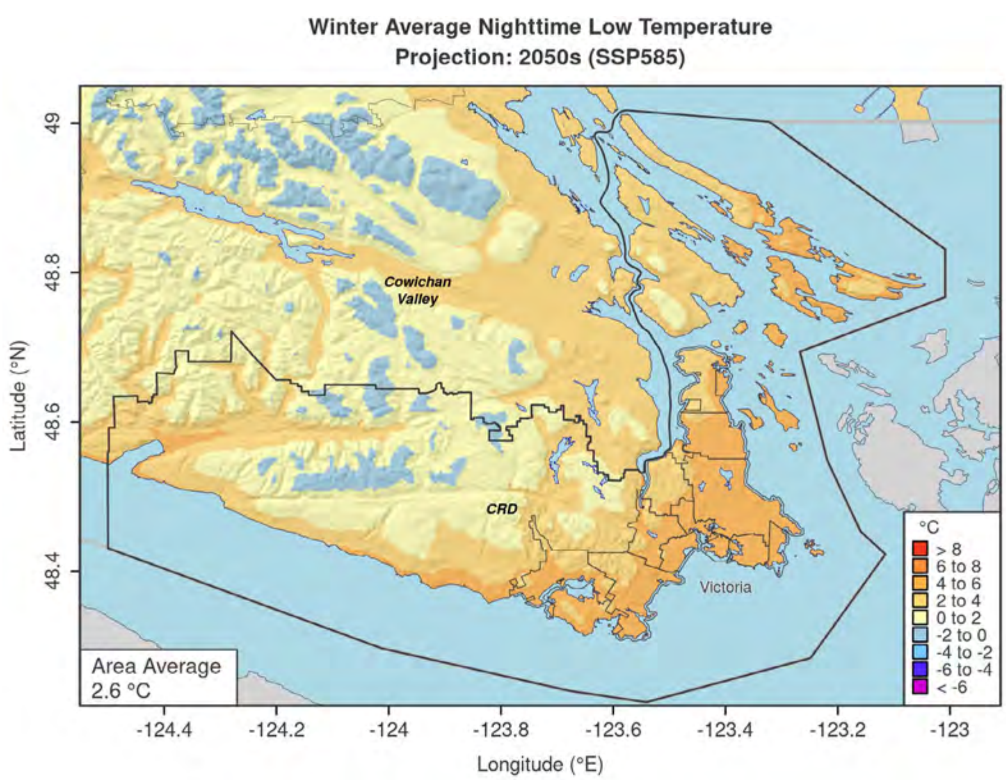



***Figure 5b:*** *Projected winter average daytime high temperature in the 2050s.*

## 3.2 Seasonal Temperature Change and Variability

Future-projected temperatures are compared with Past temperatures on a monthly basis in the figure below. The box-and-whisker plots reflect both year-to-year and model-to-model variability in all 30 Januaries, Februaries, etc., over the Past and Future periods.

Some features worth noting are:

- Freezing temperatures in the cold months become increasingly rare in the Future.
- Spring—loosely defined as the beginning of the growing season, when daily mean temperature $T_m$ consistently exceeds 5°C; see Temperature Indicators—begins earlier in the Future, while Fall—defined similarly as the end of the growing season—ends later, resulting in an effectively shorter winter season.
- The frequency of high extremes in summer increases notably, with July and August average daytime high temperatures exceeding 23°C in about three-quarters of models and years by the 2050s.

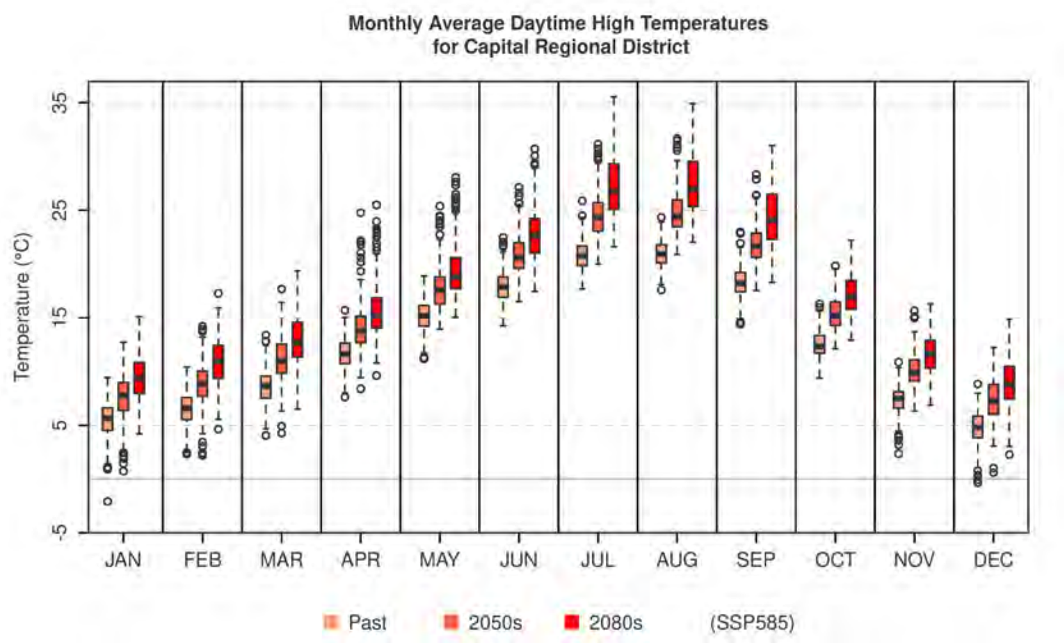



***Figure 6a.*** *Annual cycle of monthly mean daytime high temperature in the Past, 2050s and 2080s periods under the SSP585 scenario.*

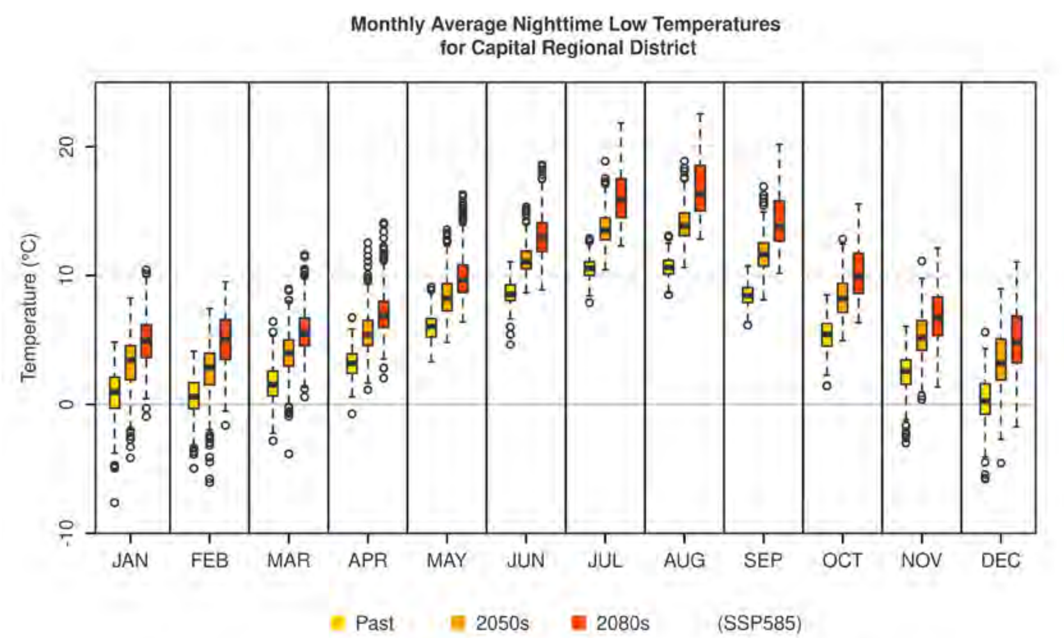



***Figure 6b.*** *Annual cycle of monthly mean nighttime low temperature in the Past, 2050s and 2080s periods under the SSP585 scenario.*

## **3.3** Wetter Winters, Drier Summers

*Precipitation* is the sum of rainfall and snowfall (expressed as water equivalent). Precipitation in the capital region has a strong seasonality, characterized by wet winters and dry summers. In the future projections, this behaviour is reinforced, so that winter becomes wetter (as do spring and fall) while summer becomes drier.

### *Projections*

In tandem with the higher summer temperatures mentioned above— which increase potential evaporation — reduced summer rainfall heightens the possibility of drought conditions. Rainfall increases are highest in winter, displaying a 25% increase in the 2050s region-wide, considerably higher in the west (+145 mm in the Western Region) than in the east (+25 mm in the Gulf Islands). Since the median increase in total winter precipitation by then is only +1%, we conclude that this is primarily due to the conversion of snow to rain under warmer winter conditions. While snowfall comprised about 15% of total precipitation in the Past, it amounts to only 5% in the 2050s. By the 2080s, the capital region should receive as little snowfall annually as it did in spring alone in the Past.

**Table 3: Average Precipitation (Rain and Snow) over the Region**

| | Past (mm) | 2050s (mm) | 2080s (mm) | 2050s Change (%) | 2080s Change (%) |
|---|---|---|---|---|---|
| **Winter** | | | | | |
| Rain | 643 | 804 | 864 | 25 *(11 to 39)* | 34 *(19 to 54)* |
| Snow | 197 | 83 | 36 | -58 *(-85 to -45)* | -82 *(-97 to -75)* |
| **Spring** | | | | | |
| Rain | 409 | 460 | 477 | 12 *(7 to 21)* | 17 *(3 to 26)* |
| Snow | 37 | 10 | 2 | -73 *(-95 to -44)* | -95 *(-100 to -78)* |
| **Summer** | | | | | |
| Rain | 159 | 135 | 129 | -15 *(-32 to -2)* | -19 *(-46 to -4)* |
| **Fall** | | | | | |
| Rain | 620 | 710 | 770 | 15 *(9 to 22)* | 24 *(13 to 34)* |
| Snow | 38 | 8 | 4 | -79 *(-95 to -62)* | -89 *(-99 to -83)* |
| **Annual** | | | | | |
| Rain | 1827 | 2102 | 2279 | 15 *(9 to 25)* | 25 *(12 to 28)* |
| Snow | 274 | 109 | 40 | -60 *(-88 to -50)* | -85 *(-97 to -78)* |
| **Precipitation**[6] | 2101 | 2179 | 2325 | 4 *(0 to 12)* | 11 *(-1 to 13)* |

[6] Note that in future, the summed medians of rain and snow may not equal the median precipitation, since the distribution of the two quantities may vary across the model ensemble.

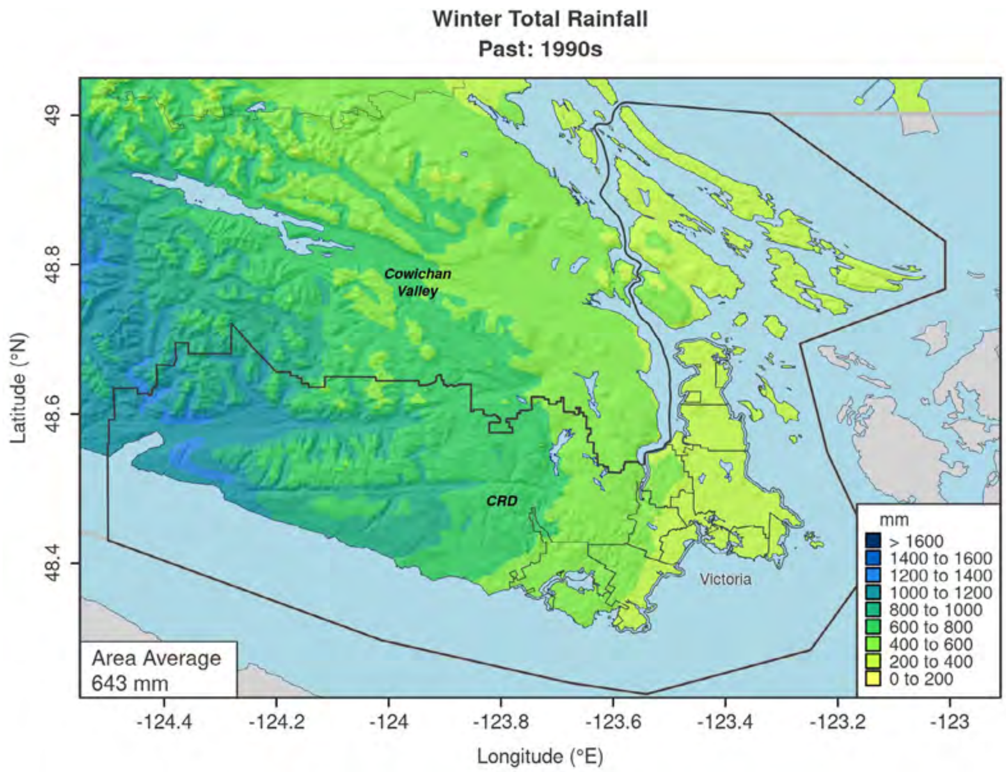



***Figure 7a.*** *Winter rainfall in the Past.*

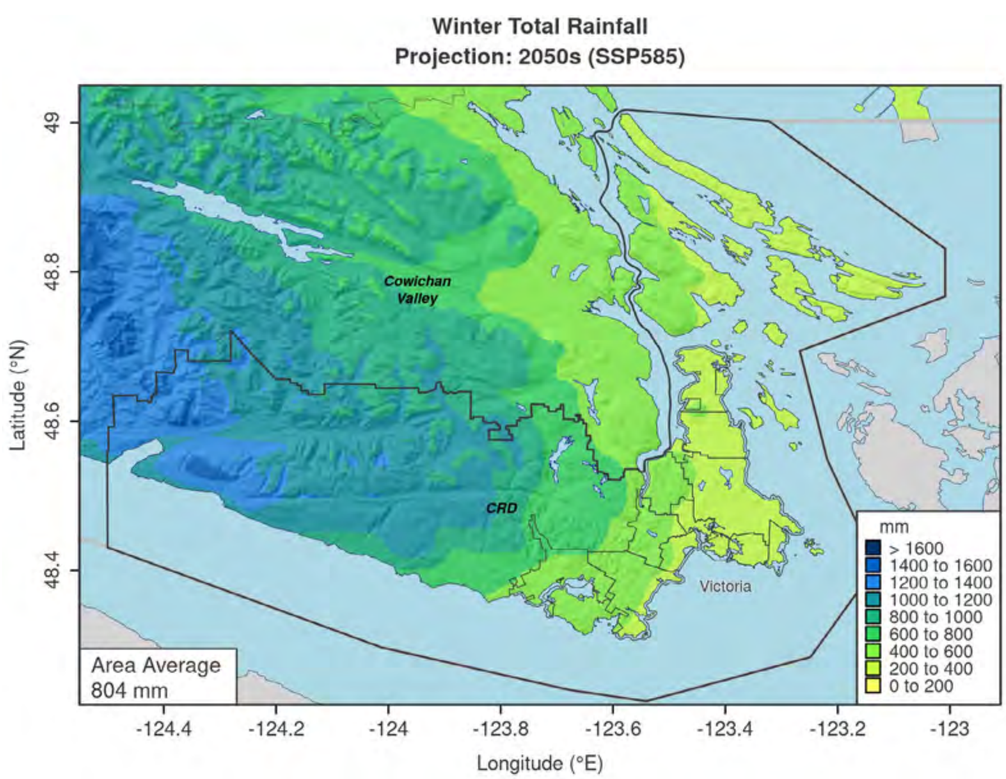



***Figure 7b.*** *Projected winter rainfall in the 2050s.*

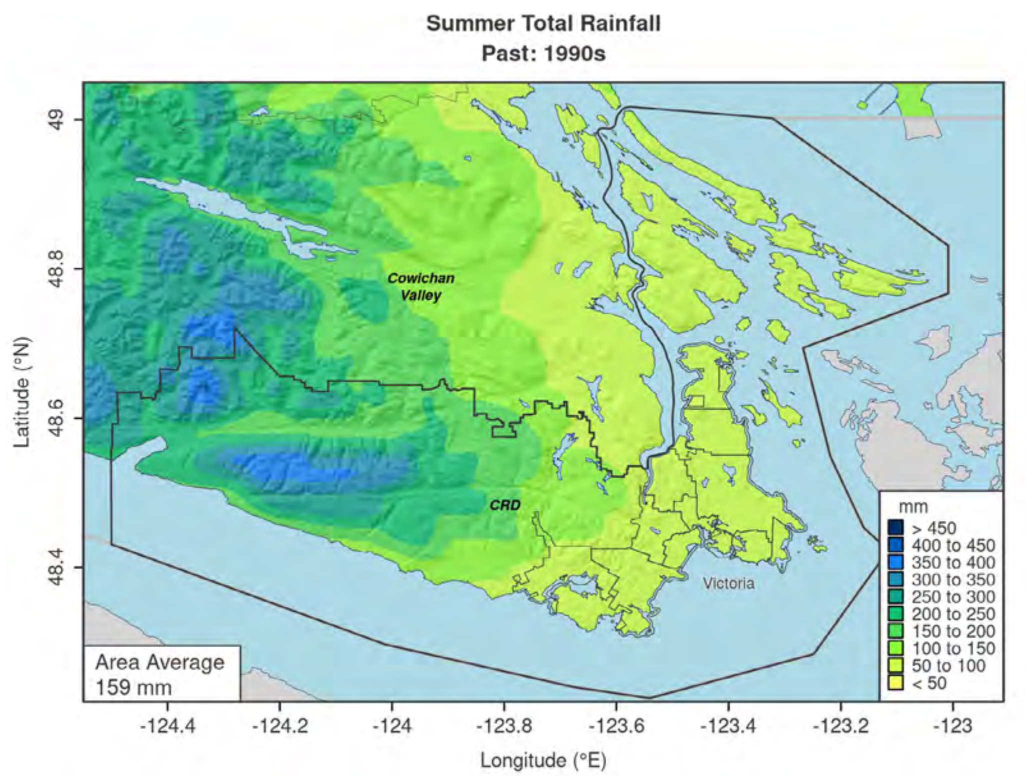



***Figure 8a.*** *Summer rainfall in the Past.*

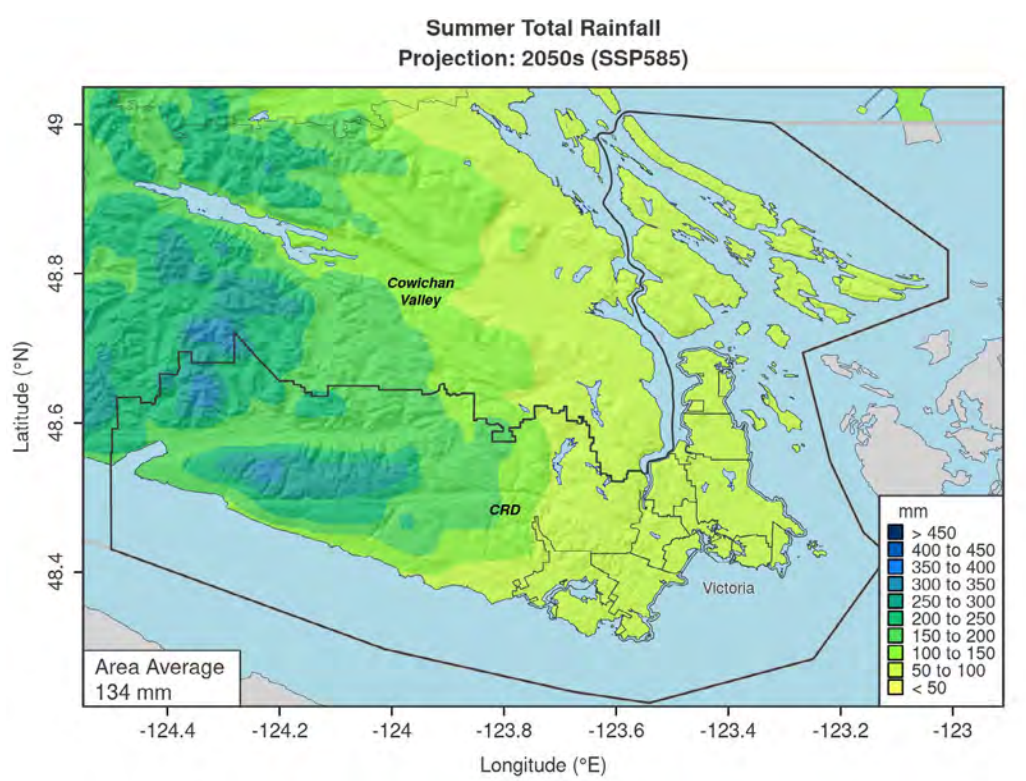



***Figure 8b.*** *Summer rainfall in the 2050s.*

## 3.4 Seasonal Precipitation Change and Variability

While precipitation in the capital region exhibits a notable seasonality, with far larger amounts in the colder months, this occurs against the background of high year-to-year variability. As a result, a climate change signal is more difficult to distinguish in precipitation than in temperature. One exception is the projected strong decline in snowfall, summarized in Table 3 and Figure 17. Combined with an increase in annual total precipitation of +4%, the resulting median projection of annual total rainfall for the entire region in the 2050s is +15%.

The figure below shows model estimates of monthly total rainfall in the Past and both Future periods. While median values increase in the colder months throughout the century, what is more striking are the changes in variability (occurring across both individual models and years, as shown for temperature above). For example, we note the occurrence of higher extreme monthly rainfall amounts in future periods, especially during the autumn months; some November rainfall totals could exceed 750 mm in future, compared to around 600 mm in the Past.[7]

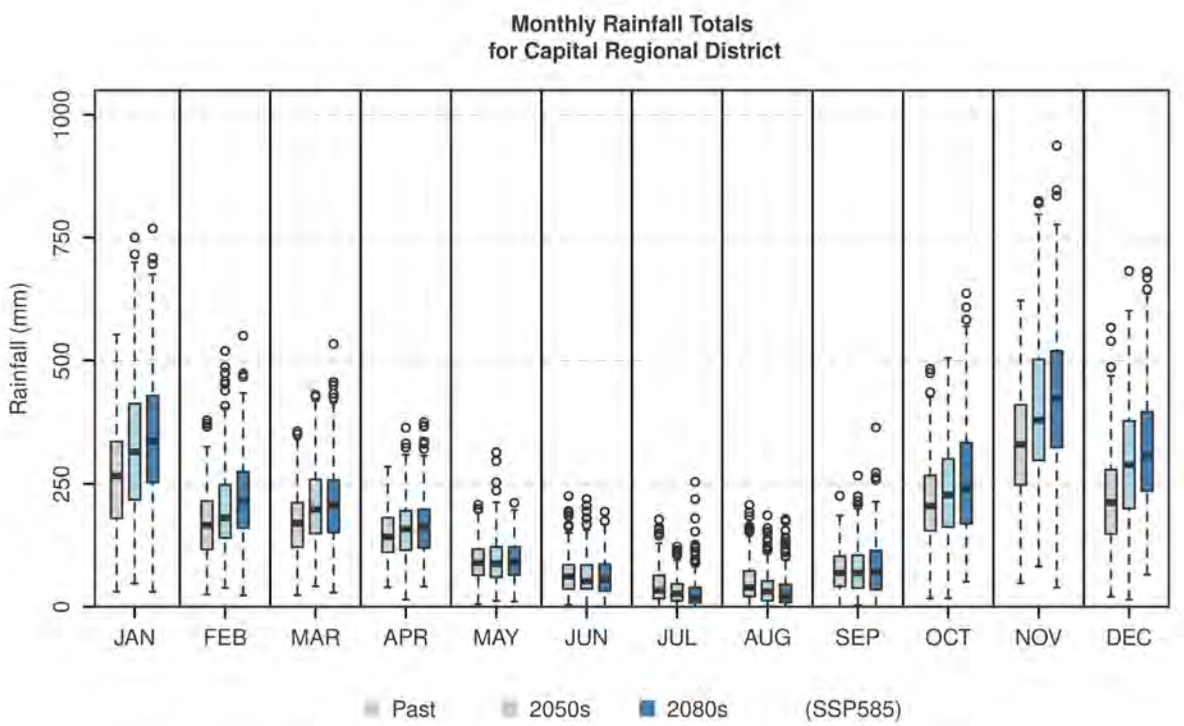



***Figure 9.*** *Annual cycle of total monthly rainfall in the Past, 2050s and 2080s periods.*

[7] 90th percentile values are cited. These totals are averaged across the region, with Past November values spanning a large range from the wetter Western Region (~650 mm) to the drier Gulf Islands Region (~300 mm). For reference, the highest recorded November precipitation at Victoria International Airport is 316 mm (in 2021).

# 4. WINTER TEMPERATURE INDICATORS

## 4.1 Warmest Winter Day, Coldest Winter Night

The *Warmest Winter Day* is the highest daily maximum temperature recorded during the winter months, in an average year. When considered along with the *Coldest Winter Night* (i.e., lowest daily minimum temperature), these indicators describe the projected "new normal" for winters in our region.

### *Projections*

By the 2050s, we can expect to see the warmest winter daytime temperature to rise from its Past value of 11°C to about 13°C, with a further increase to about 15°C by the 2080s.

In the Past, the coldest winter night had a temperature of about −8°C. Models project winter lows to increase by roughly 3.5°C by the 2050s, to −4.5°C, and by 6.5°C by the 2080s, to −1.5°C. The maps below illustrate that in the future, temperatures below freezing will usually occur only at the highest elevations in the region.

Warming winter temperatures will lead to an increased fraction of precipitation falling as rain instead of snow. Snow accumulation events, which typically occur a few times each winter in the region, will still occur, but less frequently.

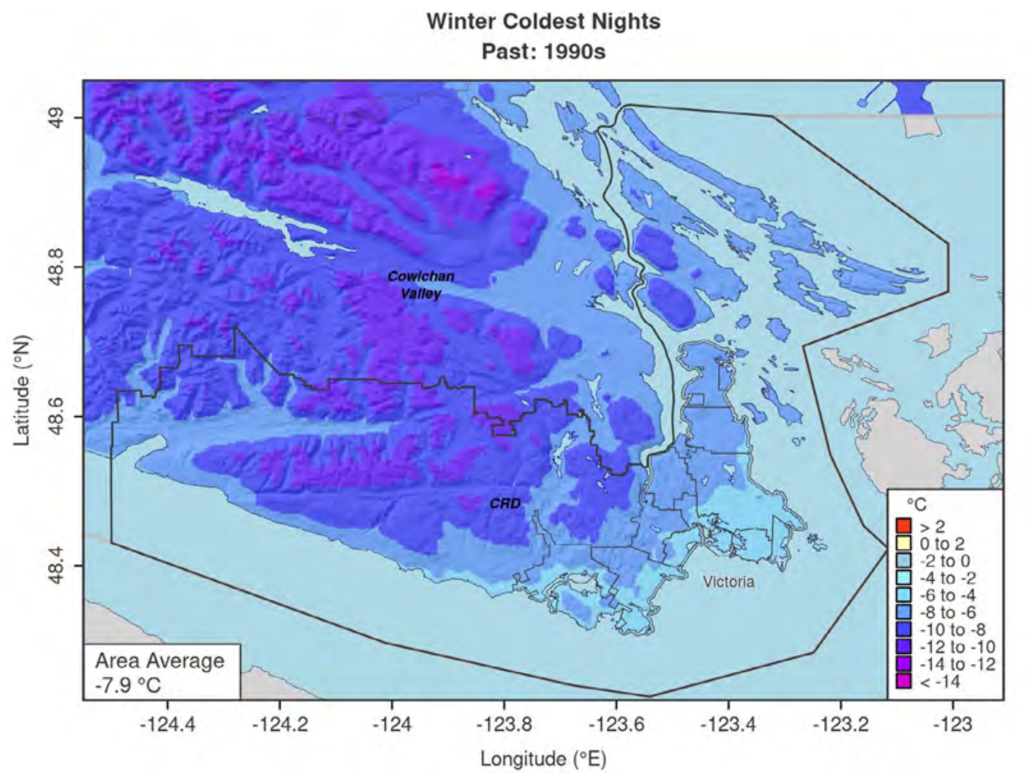



***Figure 10a.*** *Coldest winter night in the Past.*

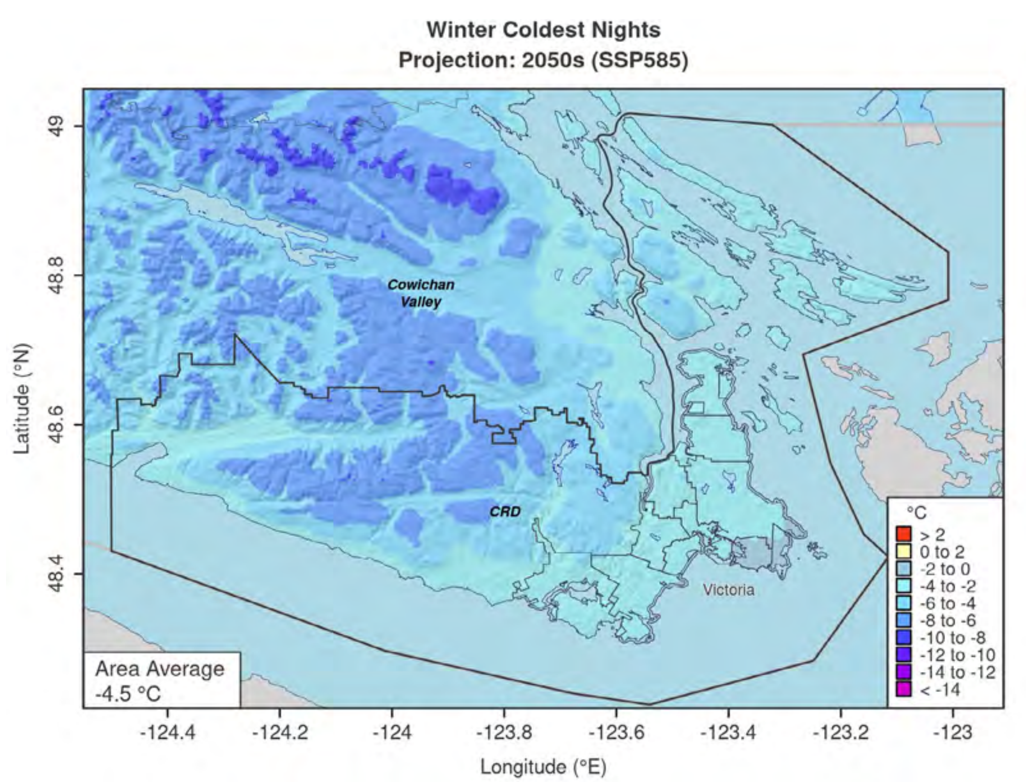



***Figure 10b.*** *Projected coldest winter night in the 2050s.*

## **4.2** 1-in-20 Year Coldest Nighttime Low Temperature

This indicator describes extreme cold temperatures so low that they are expected to occur only once every 20 years in the historical climate. Equivalently, in the recent past the *1-in-20 Year Coldest Night* had a 5% chance of occurring in any given year. [8]

### *Projections*

In the Past, the 1-in-20 year coldest night had a temperature of −15°C. In the Future, the 1-in-20 year coldest night across the region will increase by about 5°C by the 2050s and by about 8.5°C by the 2080s.

[8] Note that the occurrence of such an event in one year doesn't preclude its occurrence in the following years, which is why the annual exceedance probability (i.e. 5% chance, in this case) is a helpful equivalent measure.

## **4.3** Frost Days and Ice Days

*Frost Days* is an annual count of days when the daily minimum temperature is less than 0°C which may result in frost at ground level. This indicator is useful to help predict how changes in the number of days with minimal temperatures below freezing could affect native and agricultural plant species.

*Ice Days* occur when daytime high temperatures do not exceed 0°C. While some of the same effects are expected as for frost days, these freezing temperatures may also affect transportation via the increased chance of icy road conditions.

### *Projections*

In the Past, the capital region experienced an average of 60 frost days and 6 ice days per year. In the 2050s, we should expect far fewer such days: around half as many frost days by the 2050s and only around one-fifth as many by the 2080s. Ice days may be very rare by the mid- to late-century.

**Table 4: Warmer Winter Extreme Temperatures**

| | Past (°C) | 2050s (°C) | 2080s (°C) | 2050s Change (°C) | 2080s Change (°C) |
|---|---|---|---|---|---|
| Warmest Winter Day | 11 | 13 | 15 | 2.4<br>(*1.7 to 4.2*) | 4.2<br>(*3.2 to 6.9*) |
| Coldest Winter Night | -8 | -4.5 | -1.3 | 3.4<br>(*2.9 to 5.5*) | 6.6<br>(*5.4 to 10.4*) |
| 1-in-20 Year Coldest Nighttime Low | -15 | -10 | -6.5 | 5.0<br>(*3.2 to 7.2*) | 8.5<br>(*7.5 to 13*) |

**Table 5: Annual Frost and Ice Days**

| | Past (°C) | 2050s (°C) | 2080s (°C) | 2050s Change (°C) | 2080s Change (°C) |
|---|---|---|---|---|---|
| **Frost Days (TN <0 °C)** | | | | | |
| Region | 60 | 27 | 12 | −33<br>(*−51 to −27*) | −48<br>(*−58 to −45*) |
| Eastern Region* | 30 | 11 | 3 | −19<br>(*−28 to −16*) | −27<br>(*−30 to −23*) |
| Water Supply Area | 80 | 38 | 17 | −42<br>(*−67 to −36*) | −63<br>(*−76 to −59*) |
| **Ice Days (TX <0 °C)** | | | | | |
| Region | 6 | 2 | 0 | -4<br>(*-6 to -3*) | -6<br>(*-7 to -5*) |

**The Eastern Region encompasses both the Southern Gulf Islands and Core/Peninsula subregions (Figure 1).*

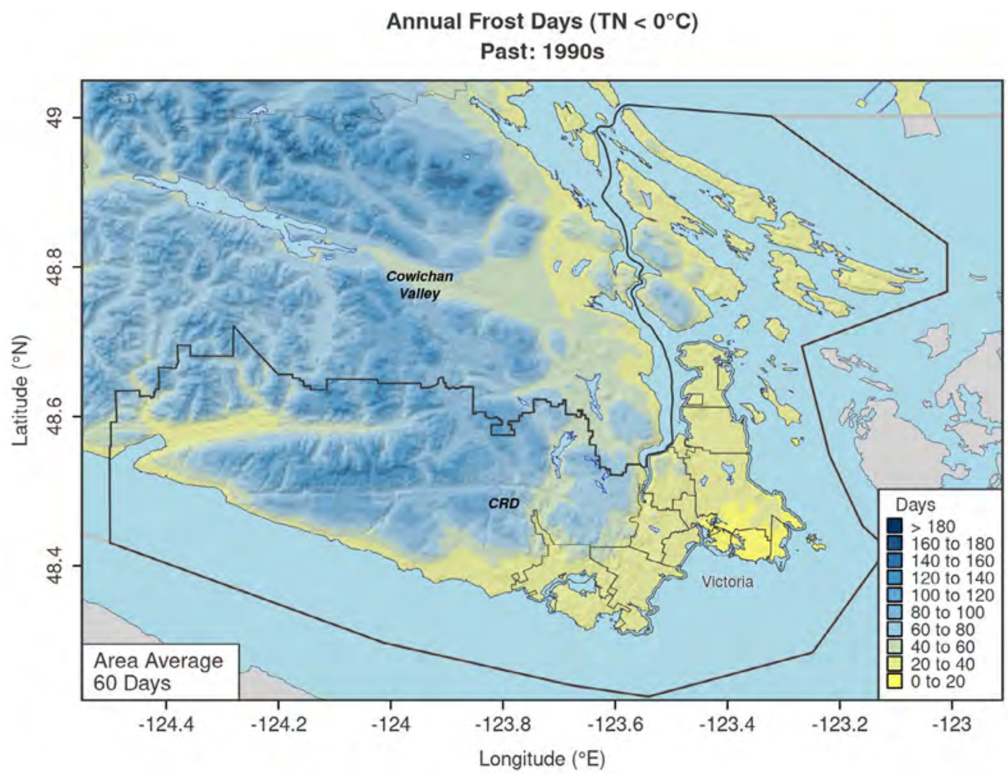



***Figure 11a.*** *Number of annual frost days in the Past.*

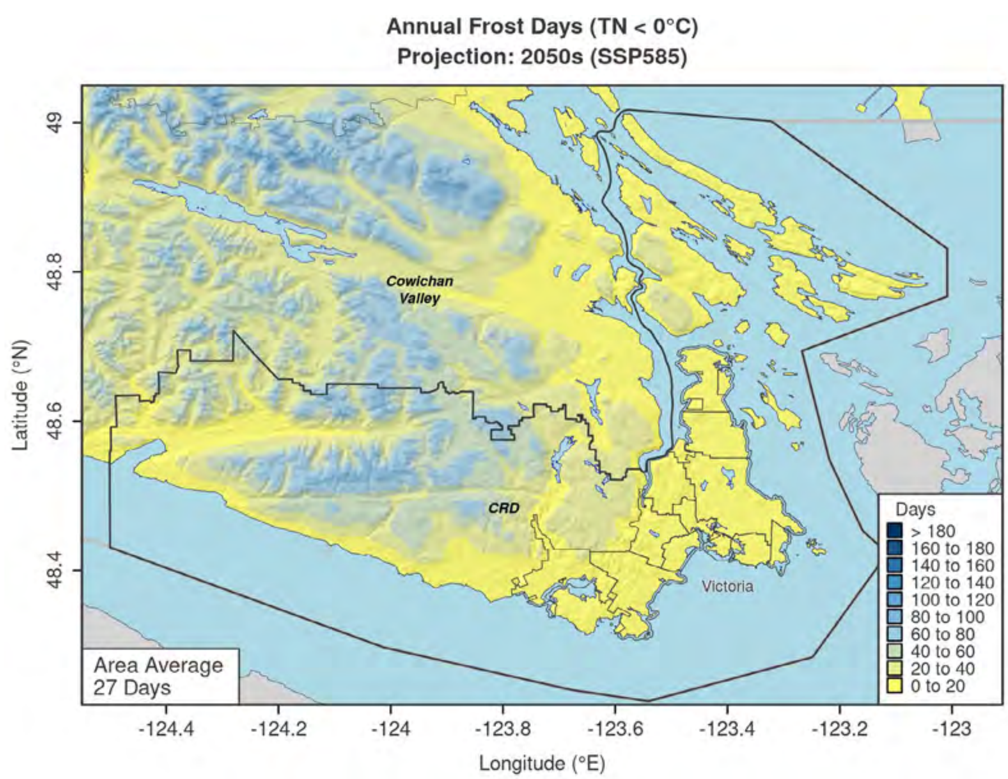



***Figure 11b.*** *Projected frost days in the 2050s.*

## 4.4 Heating Degree Days

*Heating Degree Days* (HDD) are calculated by summing the number of degrees that the daily mean temperature falls below 18°C for every day in a year.[9] This measure is commonly used to estimate the heating demand for buildings in the cooler months.

### *Projections*

In the Past, the capital region had a median of roughly 3405 HDD.[10] The median future-projected HDD decreases to 2644 (a 22% decrease) by the 2050s and to 2215 (a 35% decrease) by the 2080s. Due to its cumulative nature, a reduction in HDD is amongst the clearest indicators of warming, both in recent historical observations and in model projections. In addition, it should be noted that HDD varies considerably from west (higher values) to east (lower values) over the region.

Note that while mean winter temperatures will warm throughout the coming decades, the region's continued exposure to easterly polar outflows from Northwestern Canada through the Cascade Range suggests that the potential for multi-day cold snaps will persist in the future, though they should be less frequent. For this reason, building heating systems will still need to be responsive to occasional sub-zero winter temperatures.

**Table 6: Heating Degree Days**

| | Past (°C) | 2050s (°C) | 2080s (°C) | 2050s Change (°C) | 2080s Change (°C) |
|---|---|---|---|---|---|
| Region | 3405 | 2644 | 2125 | -22<br>*(-40 to -19)* | -35<br>*(-56 to -32)* |
| Southern Gulf Islands | 2836 | 2114 | 1755 | −25<br>*(-45 to -22)* | −38<br>*(−63 to −35)* |
| Core / Peninsula | 2904 | 2164 | 1773 | −25<br>*(−44 to −22)* | −39<br>*(−62 to −35)* |
| Western Region | 3387 | 2613 | 2158 | -23<br>*(-41 to -20)* | -36<br>*(-57 to -33)* |

[9] For example, if the daily mean temperature on January 1 is 10°C, followed by one day of 4°C, two days of −1°C and three days of 0°C, then HDD for that week are calculated as: (18−10) + (18−4) + 2 × (18−(−1)) + 3 × (18−0) = 114 degree-days. Note that days with a temperature equal to or greater than 18°C are not counted.

[10] Someone consulting the tables for the National Building Code of Canada (NBCC, 2015) will see different values of HDD listed for Victoria locations than the Past values cited in Table 6. One reason for this is the larger area covered by our Core/Peninsula subregion. Another is the different methodology and period of observations used to calculate HDD in the NBCC. As our estimate depends to some extent on coarse-grained climate models, while the NBCC employs interpolated station data, the NBCC value would normally be considered more reliable in this subregion (which contains several meteorological stations). For those interested in future HDD estimates, the relative differences from Past values can be used for HDD projections, regardless of which baseline value is used.

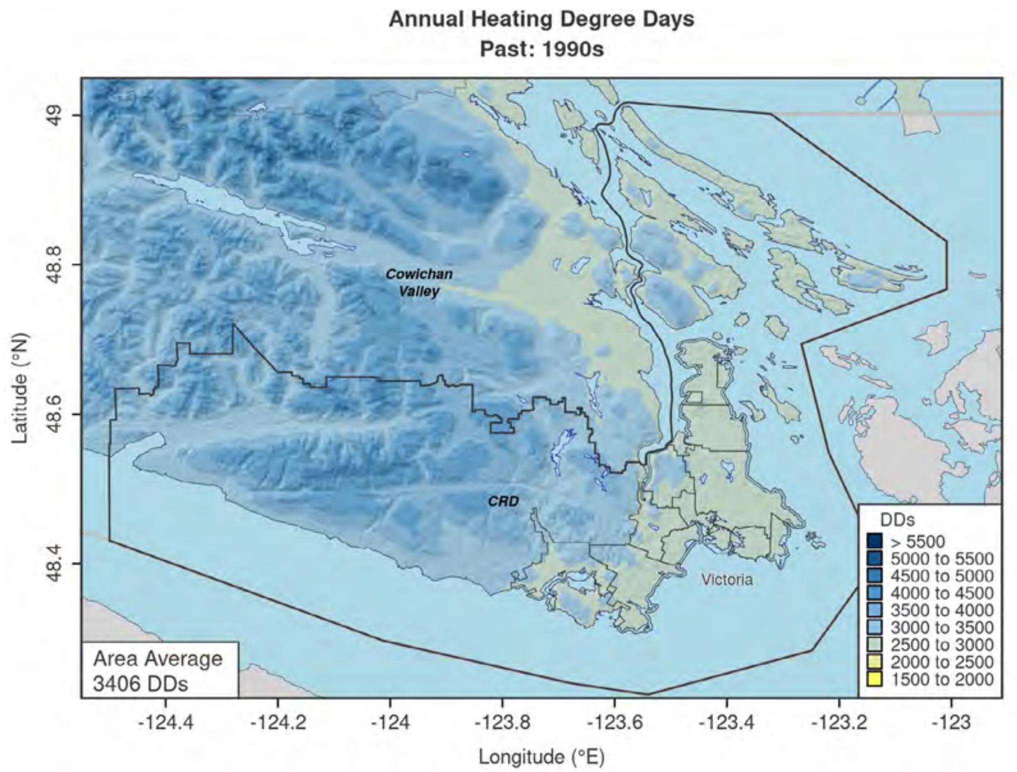



***Figure 12a.*** *Heating Degree Days in the Past.*

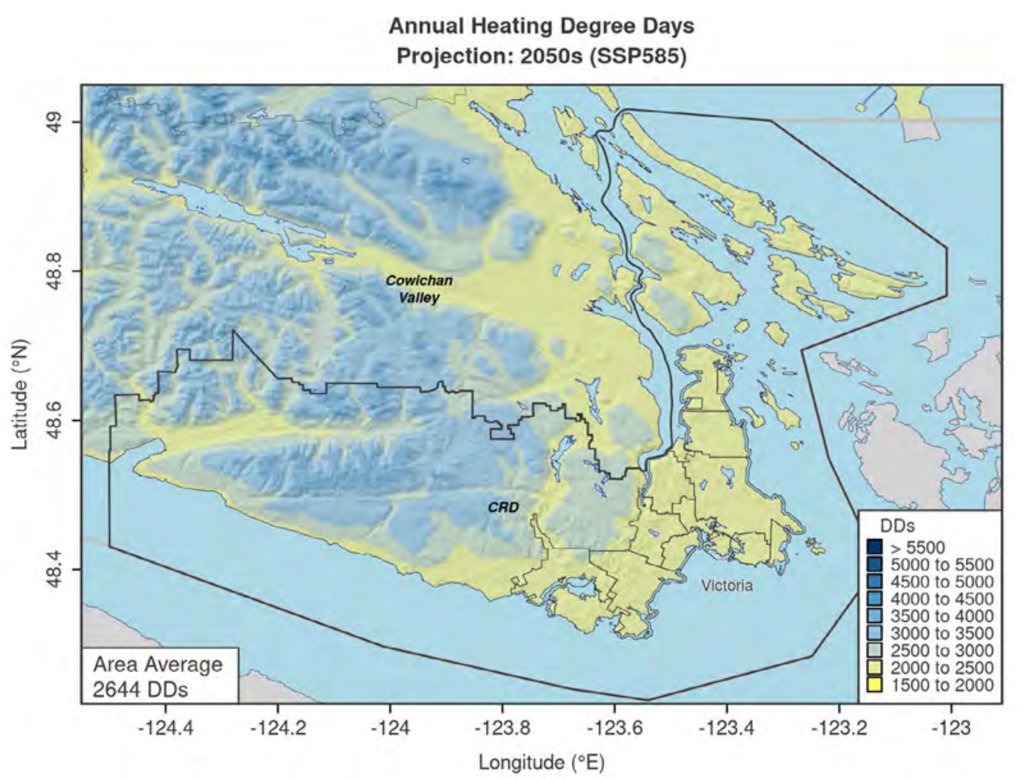



***Figure 12b.*** *Projected (decreased) HDD in the 2050s*

# 5. SUMMER TEMPERATURE INDICATORS

## 5.1 Growing Season Length

*Growing Season Length* (GSL) is an annual measure indicating the period when temperatures are warm enough for most vegetation to grow. The GSL is the number of days between the first span of at least 6 consecutive days with daily average temperatures above 5°C, and the first span, after July 1, of six days with temperatures below 5°C. This measure helps to highlight how urban forests, agricultural and landscaped areas, grasses, weeds (and their pollens) may be affected by climate change.

### *Projections*

In the Past, the growing season lasted roughly 270 days in the region. The median future-projected growing season increases by 47 days to 318 days by the 2050s and by 68 days to 339 days by the 2080s.

Other things being equal, a longer GSL implies potentially more productive vegetation in the future. However, since GSL uses only a lower temperature threshold (and not an upper threshold to account for heat stress) and ignores changes in precipitation (reduced rainfall in the warm season—Section 3.3, Table 3), it should be considered an upper limit for estimates of future productivity.

A related measure to GSL is the length of the frost-free season, which uses a lower threshold of 0°C for minimum daily temperature. As mentioned above, frost days will become increasingly rare in the future, resulting in frost-free conditions nearly year-round in the region by the 2080s.

**Table 7: Growing Season Length**

| | Past (°C) | 2050s (days) | 2080s (days) | 2050s Change (days) | 2080s Change (days) |
|---|---|---|---|---|---|
| Region | 271 | 318 | 339 | 47<br>(*39 to 71*) | 68<br>(*60 to 86*) |
| Eastern Region | 315 | 348 | 358 | 33<br>(*25 to 42*) | 44<br>(*37 to 49*) |
| Western Region | 283 | 324 | 344 | 41<br>(*35 to 64*) | 61<br>(*53 to 76*) |
| Water Supply Area | 245 | 301 | 329 | 56<br>(*45 to 90*) | 84<br>(*75 to 112*) |

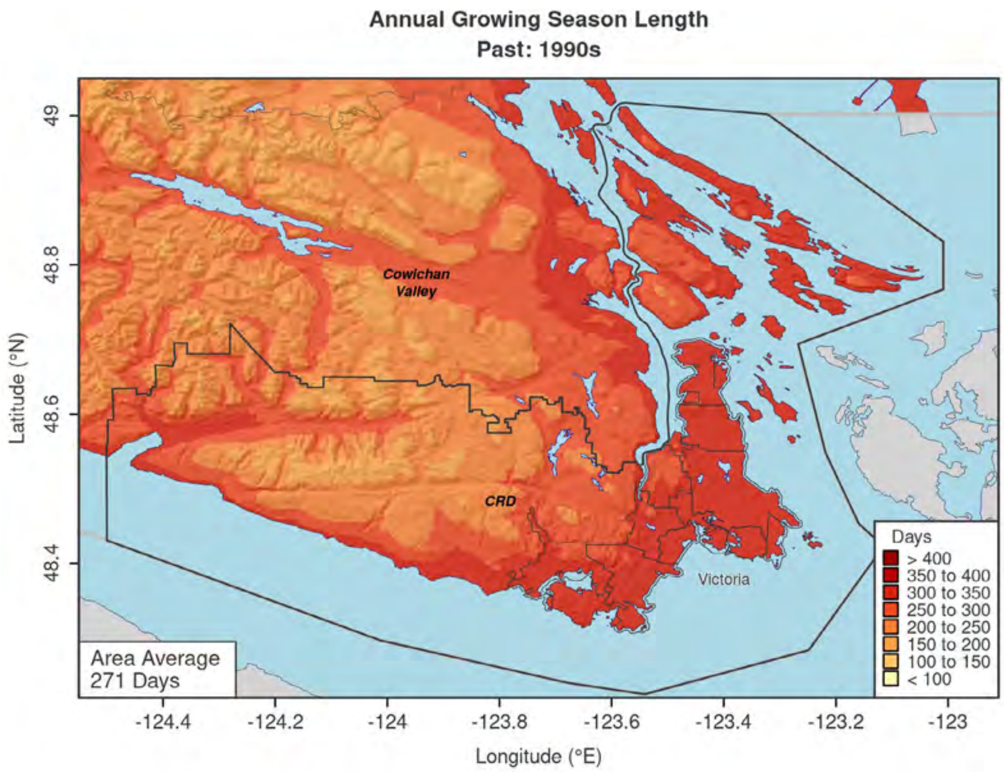



***Figure 13a.*** *Growing season length in the past*

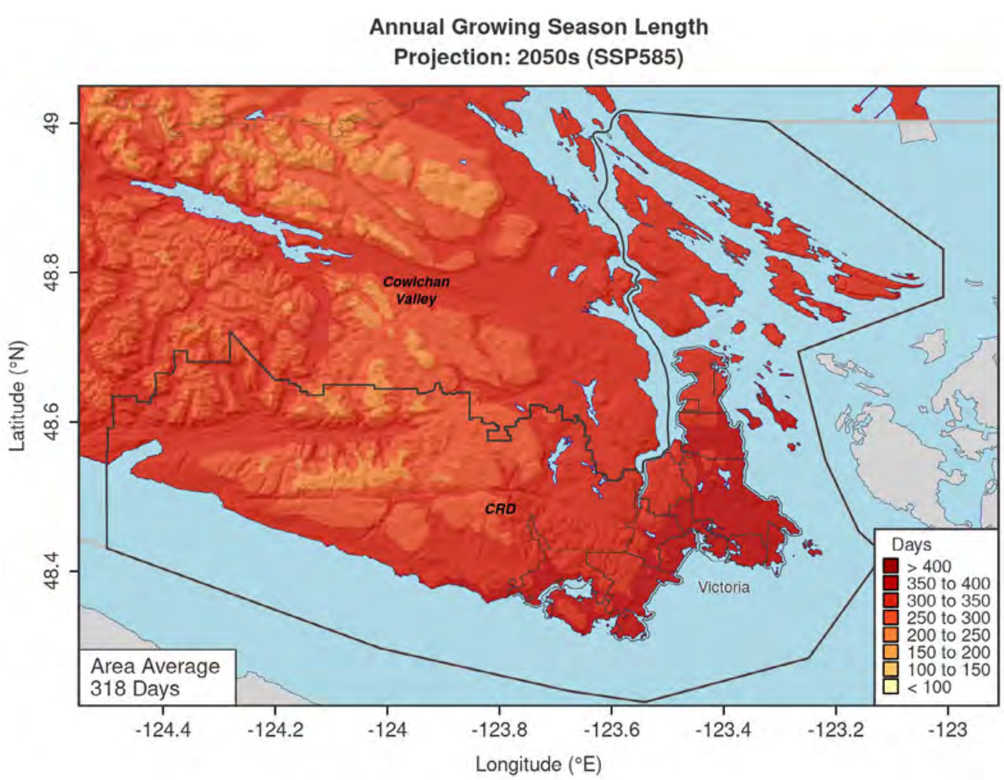



***Figure 13b.*** *Projected (increased) growing season length by the 2050s*

## 5.2 Cooling Degree Days

The opposite of HDD, *Cooling Degree Days* are calculated by summing the number of degrees that the daily mean temperature exceeds 18°C for every day in a year.[11] This measure is commonly used to estimate the demand for mechanical cooling (i.e., air conditioning) in buildings in the warmer months.

### *Projections*

In the Past, the capital region typically had around 17 cooling degree days, with the vast majority of such days occurring in summer. The median future-projected cooling degree days increase to about 119 (a 7-fold increase) by the 2050s and to nearly 240 (a 14-fold increase) by the 2080s. While most such days will continue to occur in summer, they will increasingly occur during late spring and early fall.

Like the projected decrease in HDD, an increase in cooling degree days is among the clearest indicators of warming, both in recent historical observations and model projections. Moreover, the magnitude of increase varies strongly from west (lower values) to east (higher values) across the capital region. To the extent that this index correlates with demand for cooling, new buildings may need to be designed differently to maintain thermal comfort.

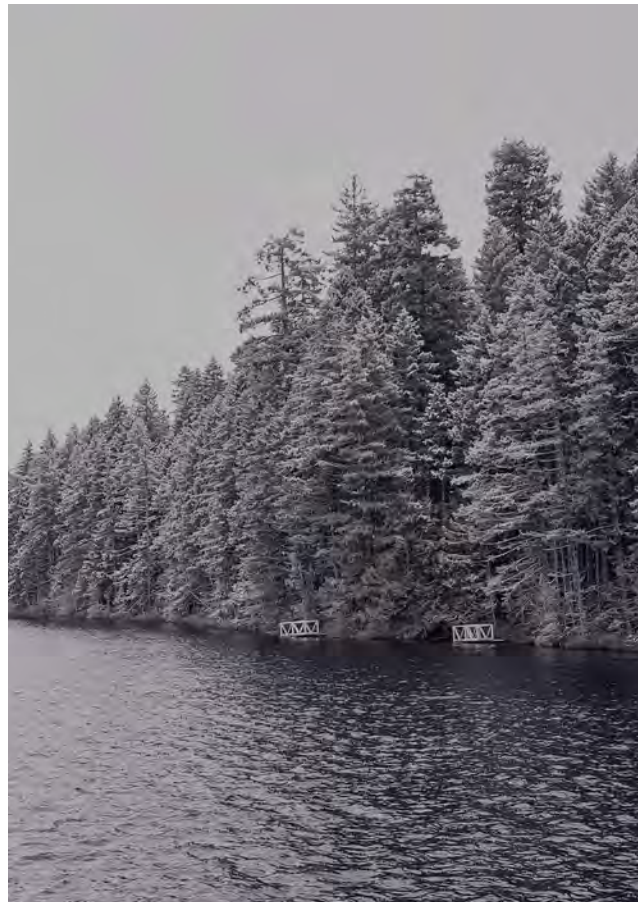


**Table 8: Cooling Degree Days**

| | Past (deg-days) | 2050s (deg-days) | 2080s (deg-days) | 2050s Change (deg-days) | 2080s Change (deg-days) |
|---|---|---|---|---|---|
| Region | 17 | 119 | 237 | 102 (*62 to 235*) | 220 (*176 to 592*) |
| Southern Gulf Islands | 38 | 227 | 392 | 189 (*119 to 385*) | 354 (*297 to 820*) |
| Core / Peninsula | 25 | 169 | 317 | 144 (*87 to 310*) | 292 (*234 to 716*) |
| Western Region | 10 | 83 | 185 | 73 (*41 to 185*) | 175 (*135 to 525*) |

[11] For example, if the daily mean temperature on July 1 is 20°C, followed by three days of 21°C, one day of 25°C and two days of 16°C, then the cooling degree days for that week are calculated as: (20−18) + 3 × (21−18) + (25−18) = 18 degree-days.

Note that days with temperature equal to or less than 18°C are not counted.

## 5.3 Warm Summer Days and Nights, Annual Hottest Day and Heatwaves

These indicators highlight the most extreme warm temperatures occurring in the region. The results in the table below are for the Core/Peninsula subregion (see Figure 1) which has the highest population and therefore the highest exposure to many heat-related impacts (values for the Southern Gulf Islands are very similar). Three single-day extreme heat measures are included in the table: the peak temperature of the hottest day of the year (not necessarily occurring during a heatwave), the number of days with TX > 25°C (*Summer Days*), and the number of nights with TN > 16°C (*Temperate Nights*). Episodes of multi-day extreme heat, which were rare in the Past, are captured by several heatwave (HW) indicators defined in the Appendix. These are partly based on threshold temperatures for emergency health alerts used specifically in BC.[12] As with the variables discussed above, each of the indices describes a typical year within the indicated 30-year period.

### *Projections*

In the Past, there were typically around 12 days per year with a high temperature exceeding 25°C, and rarely did nighttime temperatures rise above 16°C. The median future-projected number of Summer Days increases to roughly 40 per year by the 2050s and 62 per year by the 2080s, while Temperate Nights begin to occur by the 2030s, with a frequency of 15 per year in the 2050s and 52 per year in the 2080s.

When it comes to heatwaves, in the Past, there was usually one HW per year, lasting up to 3 days and having a peak daily temperature of around 30°C. The median future-projected number of HWs increases to roughly 3 per year by the 2050s and 5 per year by the 2080s. HWs are also projected to increase in length in the future (approaching 9 consecutive days or more by the 2080s) and will feature both warmer daytime and nighttime temperatures. It is clear that residents of the area will need to adapt to more frequent, longer, and intense HWs in future.

**Table 9: Measures of extreme heat (Core/Peninsula subregion)**

| Core/Peninsula subregion: Heatwave (HW) Indices, Hot Summer Days and Warm Nights* | | | | | |
|---|---|---|---|---|---|
| **Index** | **Description** | **Past** | **2030s** | **2050s** | **2080s** |
| **HWD** | HW days (days) | 1 | 4<br>(*3 to 11*) | 10<br>(*6 to 27*) | 23<br>(*17 to 74*) |
| **HWXL** | HW Maximum length (days)[13] | 3 | 4<br>(*3 to 5*) | 4.5<br>(*4 to 10*) | 8.5<br>(*6 to 43*) |
| **HWN** | Annual number HWs | 1 | 2<br>(*1 to 4*) | 3<br>(*2 to 5*) | 5<br>(*4 to 7*) |
| **TXHX** | Avg. TX in most extreme annual HW (°C) | 30 | 31<br>(*30 to 32*) | 31<br>(*31 to 33*) | 32<br>(*32 to 34*) |
| **TNHX** | Avg. TN in most extreme annual HW (°C) | 15 | 16<br>(*15 to 16*) | 17<br>(*16 to 18*) | 19<br>(*18 to 21*) |
| **TXX** | TX on hottest day of year (°C) | 29 | 31<br>(*30 to 32*) | 32<br>(*32 to 35*) | 35<br>(*33 to 38*) |
| **SU** | Number of days reaching TX >25 °C | 12 | 28<br>(*22 to 41*) | 40<br>(*30 to 70*) | 62<br>(*57 to 111*) |
| **TR16C** | Number of nights reaching TN >16°C | 0 | 4<br>(*3 to 13*) | 15<br>(*9 to 47*) | 52<br>(*36 to 108*) |

**Upper values in each table cell are the ensemble median, with values in parentheses giving the 10th to 90th percentile range over the model ensemble.*

[12] See the report, BC Provincial Heat Alert and Response System (BC HARS): 2023, May 2023. Available at: http://www.bccdc.ca/health-professionals/professional-resources/heat-event-response-planning. The lower threshold temperatures used in our HW definition, which is intended for use throughout BC, are TX = 28°C and TN = 13°C. In addition, a HW must: 1) last at least 2 full days; and 2) have TX and TN exceeding their 95th percentile values in the Past.

[13] It may seem strange that HWD < HWXL in the Past, but this is an artifact of small number statistics. Some years in the Past contained no HWs, leading to a mean annual value of 0.4 for HWD (rounded to 1 in the table, since some years had a HW). Nevertheless, one or more years had HW lengths of 2 or 3 days, leading to the mean HWXL = 2.5 days (rounded to 3) over the 30-year period. As the number of HWs increases in future years of the simulations, the expected behaviour HWD > HWXL emerges.

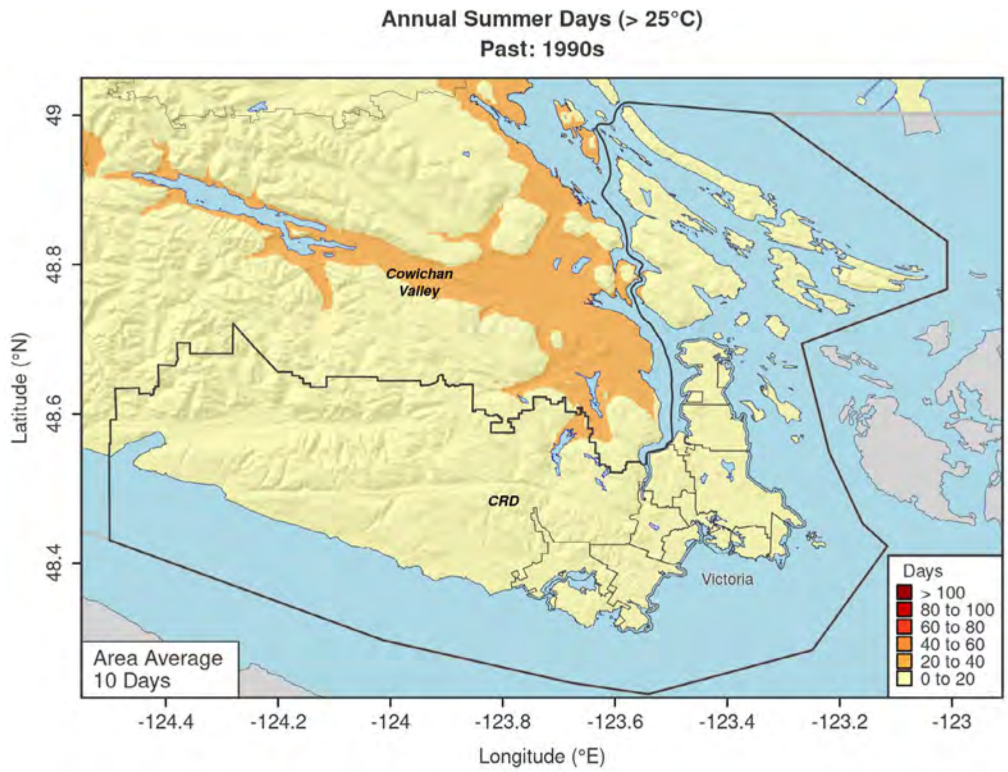



***Figure 14a.*** *Annual count of summer days in the Past*

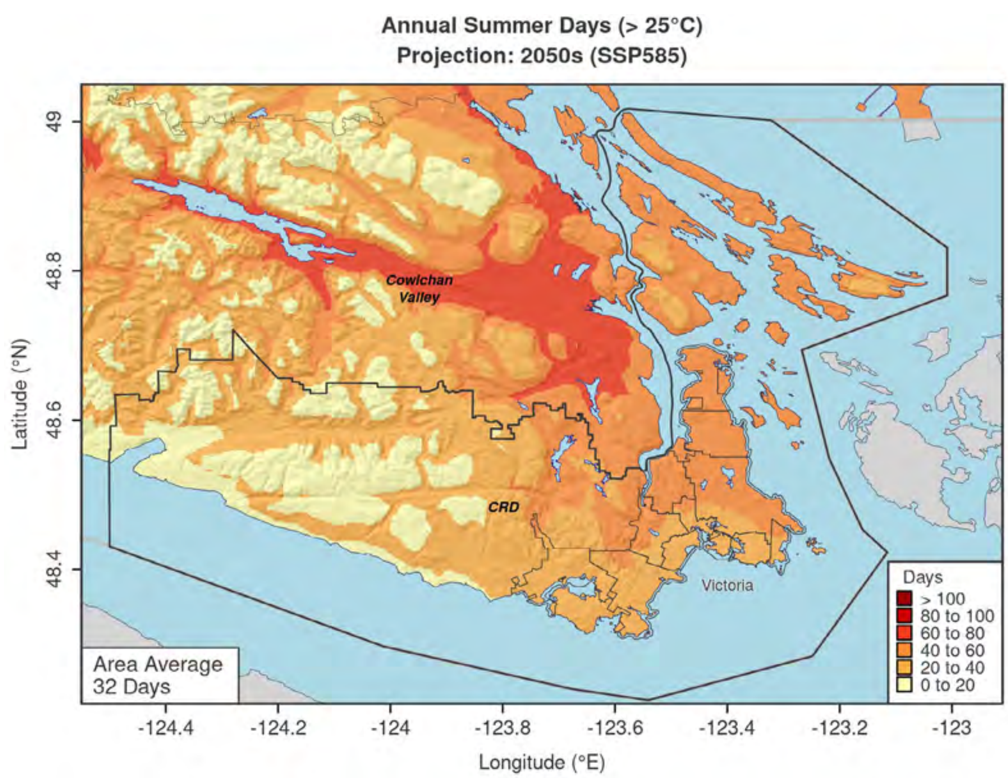



***Figure 14b.*** *Projected number of annual summer days by the 2050s*

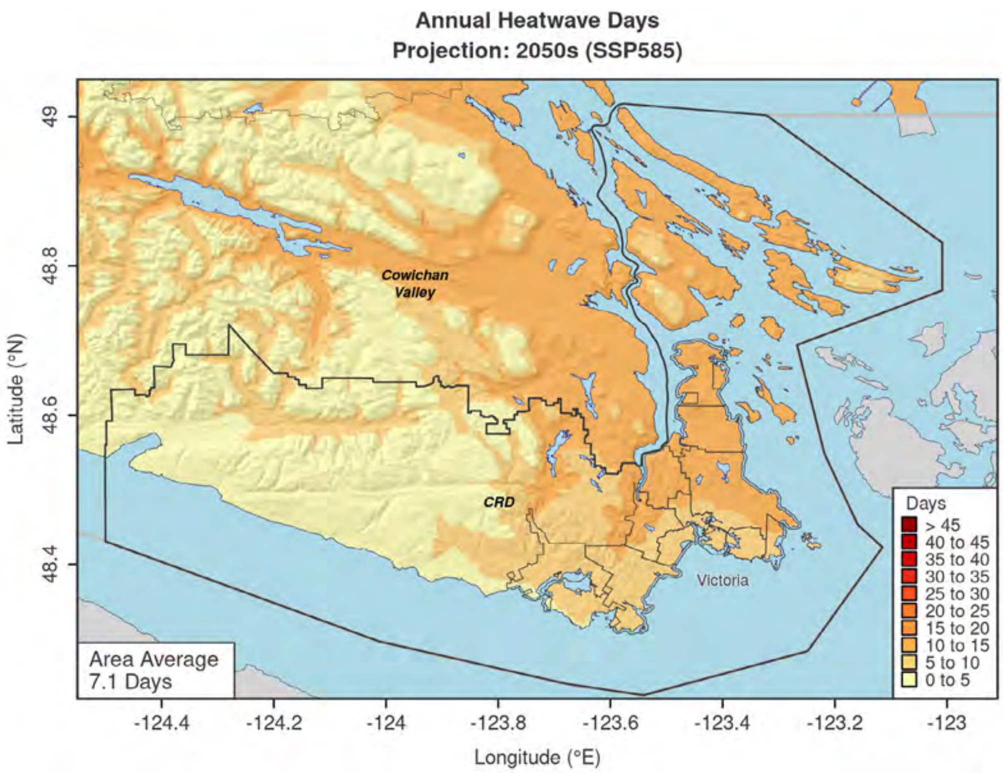



***Figure 15a***. *Projected annual count of heatwave days in the 2050s.*

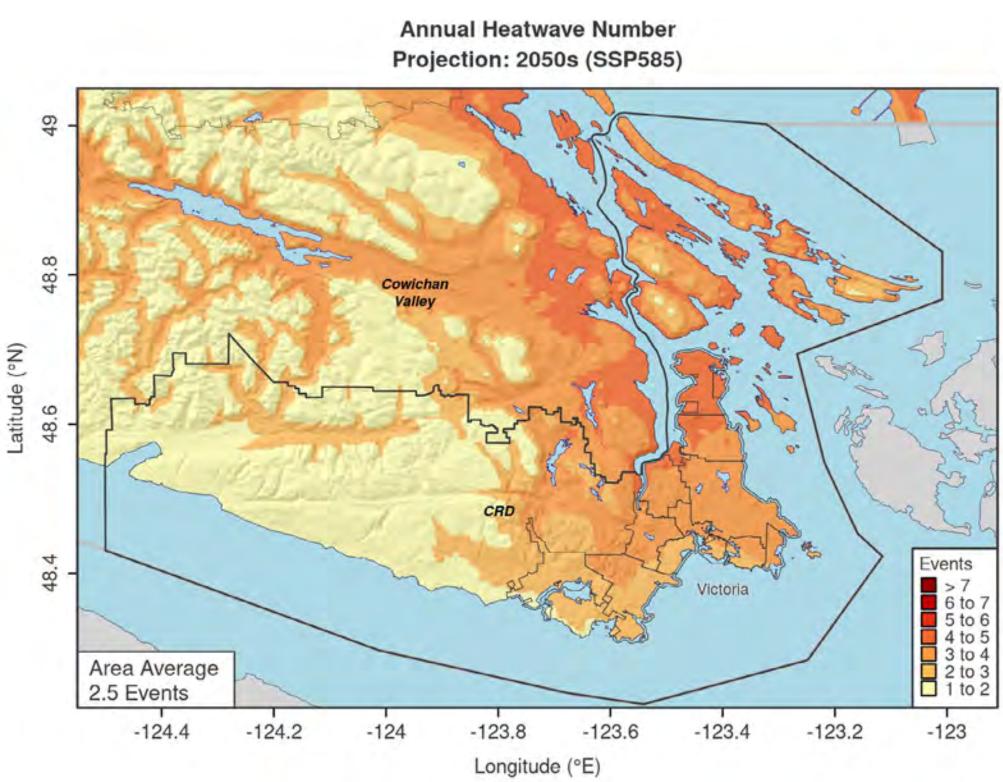



***Figure 15b.*** Projected number of annual heatwaves in the 2050s.

*Note that: (i) for both measures, counts in the Past are very low (about 1 per year) and uniform throughout the capital region; and (ii) average values for Core/ Peninsula (Table 9) are larger than capital region averages shown on the maps.*

## 5.4 The 1-in-20-Year Annual Hottest Day

This indicator describes extreme daily high temperatures so warm, they are expected to occur only once every 20 years in the historical climate. In other words, the *1-in-20 Year Hottest Day* presently has a 5% chance of occurring in any given year.

### Projections

The figure below shows the projected changes in this type of event in two ways: first, in terms of how frequently an event of the same TX value occurs in the future; and second, in terms of how much TX increases for an event occurring with the same frequency (or annual probability) in the future.

For example, in the Past, a daily maximum temperature of 32°C or higher occurred once every 20 years or so in the capital region, or with a 5% annual exceedance probability (AEP). In the projections for the 2050s, this temperature is exceeded around 8 times in a 20-year period, or with a 40% AEP. Alternatively, one can say based on the same projections that in the 2050s, the magnitude of a 1-in-20 year (5% AEP) event increases to around 35.5°C (see the 'Return Levels' tab in the SSP585 Summary Table).

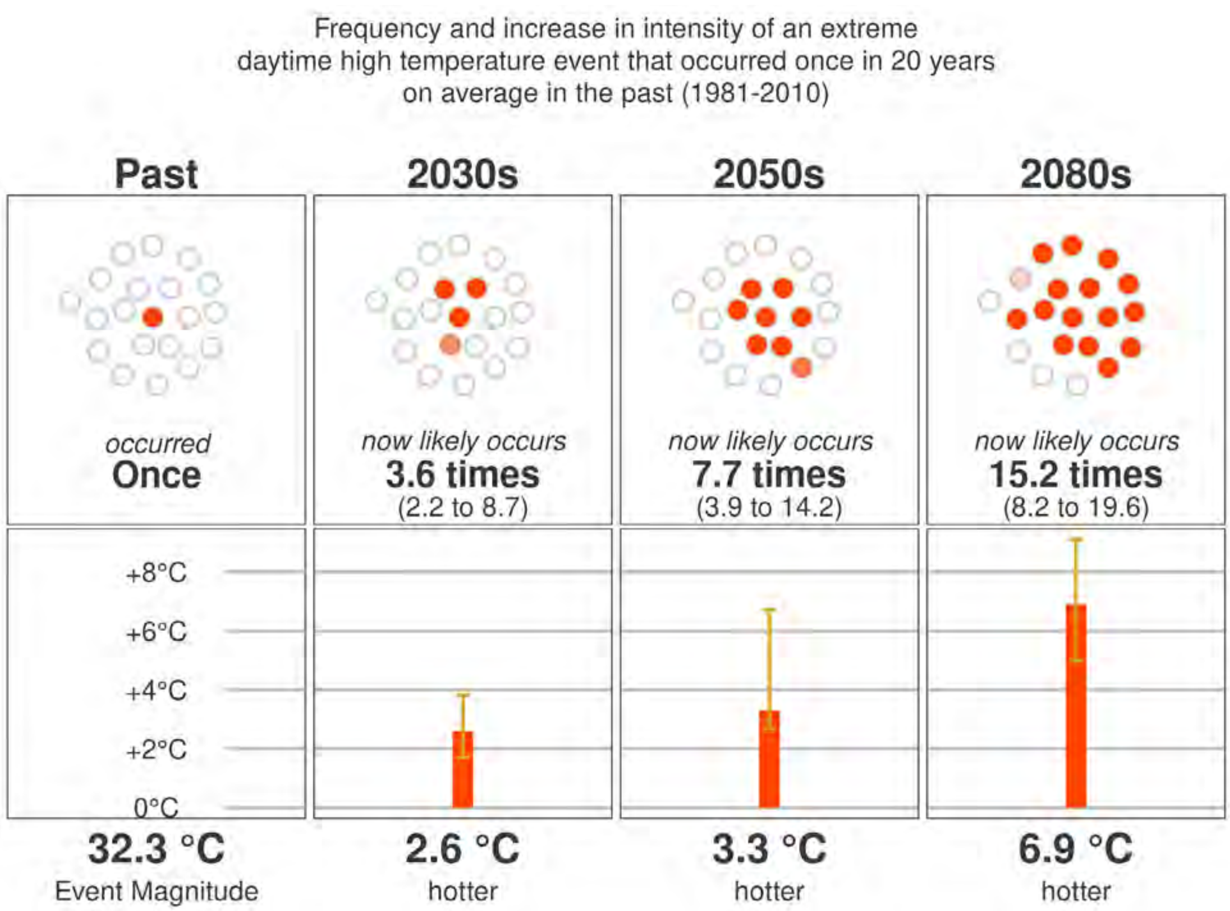



***Figure 16.*** *Upper panels: Frequency of a 1-in-20 year daily maximum temperature (TX) event in the Past and projected frequency of the same magnitude event (i.e. TX = 32°C) in the three future periods. Lower panels: Increase in magnitude of a 1-in-20 year TX event from the Past to Future periods. Figure design is taken from similar infographics in the IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., et al. (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 3-32, doi:10.1017/9781009157896.001.*

# 6. PRECIPITATION INDICATORS

## 6.1 Dry Spells

The *Consecutive Dry Days* indicator tracks the annual longest string of days with less than 1 mm of precipitation.

### Projections

In the Past, the median dry spell length in the capital region was 24 days. The median future-projected dry spell length increases by 8% to 26 days (range 24 - 34 days) by the 2050s and by 21% to 29 days (range 26 - 47 days) by the 2080s.

The increase in dry spell length is consistent with the higher summer temperatures and reduced summer rainfall highlighted in the previous chapters. The map of consecutive dry days (not shown) is quite uniform throughout the region, as are its changes in the future periods.

## 6.2 Snowfall

*Snowfall* is inferred from the downscaled total daily precipitation and temperature, using a widely validated empirical relationship.[14]

### Projections

In the Past, the median annual snowfall in the capital region was around 275 mm (snow water equivalent, or SWE). The median future-projected snowfall decreases by 60% to around 110 mm (range 32 to 134 mm) by the 2050s and by 85% to just 40 mm (range 7 to 60 mm) by the 2080s. Due to the robust projection of an increase in cold season temperature (Chapters 3 and 4), the expectation of a smaller fraction of precipitation falling as snow in future decades is reasonable, even if its magnitude is somewhat uncertain.

Of more concern is the limited model ability to simulate the unique meteorological conditions that lead to the rare, but sometimes heavy, snowfalls in southwest BC. The CMIP6 models used in this study are probably not able to capture this behaviour very well, meaning that the change in frequency of winter storms resulting in heavy snowfall is largely unknown.

[14] Dai, A. (2008). "Temperature and pressure dependence of the rain-snow phase transition over land and ocean," Geophysical Research Letters, 35(12). Snowfall projections should be taken with special caution, for two reasons. First, the amount of total precipitation that falls as snow is a sensitive function of local temperature, so whatever temperature biases remain after the downscaling procedure result in uncertainty in snowfall. Over time, however, as local temperatures exceed 0°C more often in winter, this uncertainty decreases.

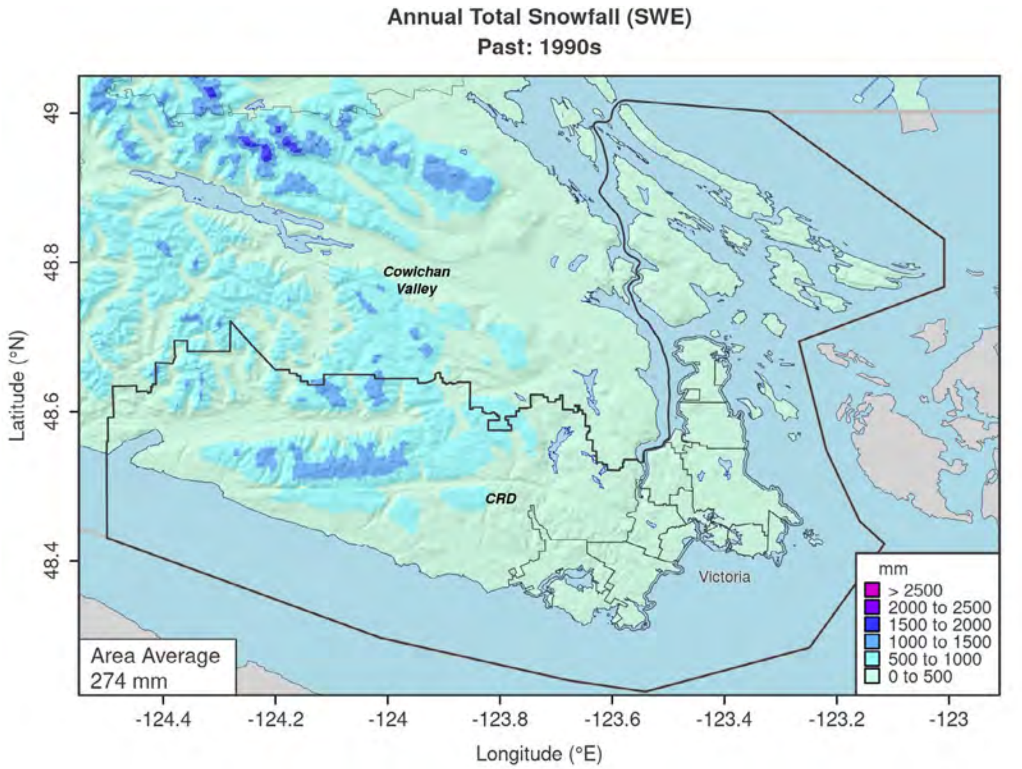



***Figure 17a.*** *Annual total snowfall in the Past.*

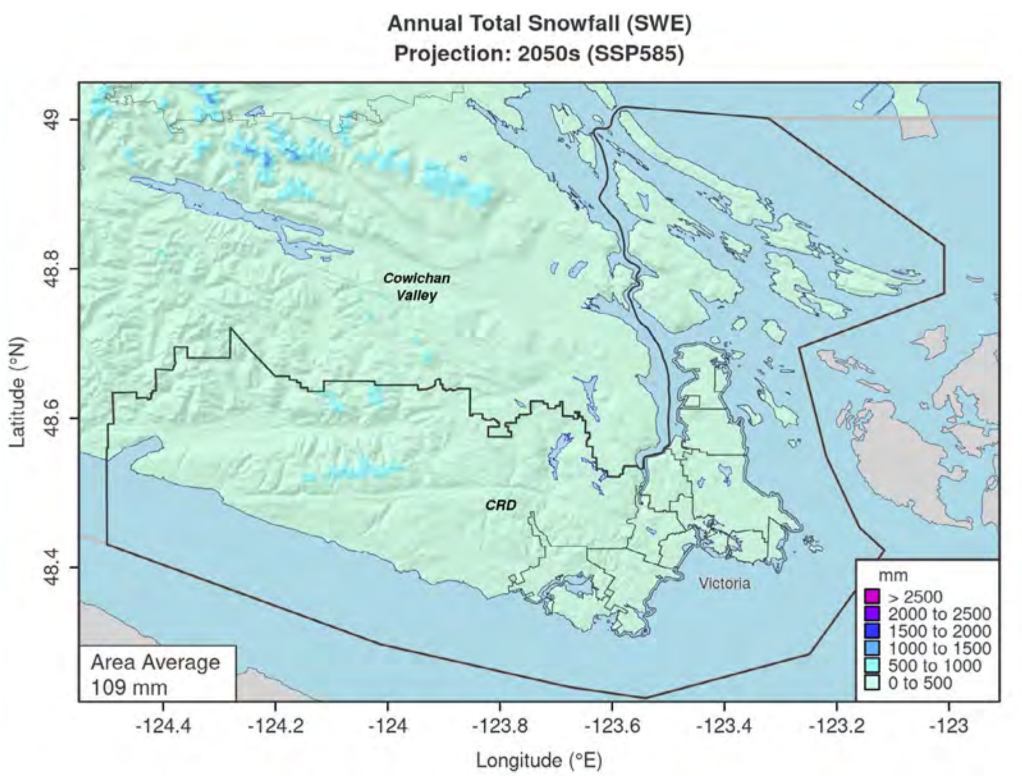



***Figure 17b.*** *Projected snowfall in the 2050s.*

## **6.3** Annual Maximum One-Day and 5-Day Precipitation and 95th-percentile Wettest Days

These indicators describe the largest precipitation events of the year. The *Annual Maximum One-Day Precipitation* (RX1DAY) is self-explanatory, while the *Annual Maximum 5-Day Precipitation* (RX5DAY) tracks the accumulated amount over consecutive 5-day periods during the year. If we compute the 95$^{th}$ percentile of daily precipitation over all wet days in the Past (i.e. those with a daily amount of at least 1 mm), and then sum the amounts over that threshold that fell on especially wet days, then we obtain the 95$^{th}$-percentile Wettest Days (R95P) index.

Note that R95P is potentially composed of several large precipitation events in a typical year, and does not (usually) describe single storms.

All amounts in the table below reflect the systematic difference in precipitation amount from west (high) to east (low) across the capital region. Across the region, percent increases for the 2050s differ somewhat for each index: from 10-16% for RX1DAY, to around 10% for RX5DAY to around 30% for R95P. Changes for the 2080s are correspondingly higher, as shown in the table.

**Table 10: Annual Extreme Precipitation Indices**

| | Past (mm) | 2050s(mm) | 2080s(mm) | 2050s Change (%) | 2080s Change (%) |
|---|---|---|---|---|---|
| **One-day maximum precipitation (RX1DAY)** | | | | | |
| Region | 63 | 72 | 77 | 14<br>(*4 to 24*) | 22<br>(*17 to 29*) |
| Western Region* | 67 | 74 | 80 | 10<br>(*4 to 24*) | 19<br>(*17 to 30*) |
| Eastern Region | 37 | 43 | 45 | 16<br>(*5 to 26*) | 22<br>(*17 to 33*) |
| **5-Day maximum precipitation (RX5DAY)** | | | | | |
| Region | 163 | 179 | 187 | 10<br>(*6 to 21*) | 15<br>(*12 to 33*) |
| Western Region | 172 | 188 | 197 | 9<br>(*6 to 20*) | 15<br>(*13 to 24*) |
| Eastern Region | 88 | 97 | 101 | 10<br>(*5 to 23*) | 15<br>(*12 to 23*) |
| **95$^{th}$ Percentile Wettest Days (R95P)** | | | | | |
| Region | 402 | 527 | 590 | 31<br>(*16 to 46*) | 47<br>(*30 to 77*) |
| Western Region | 423 | 553 | 622 | 31<br>(*16 to 46*) | 47<br>(*30 to 79*) |
| Eastern Region | 193 | 245 | 276 | 26<br>(*10 to 41*) | 43<br>(*23 to 64*) |

*Values for Water Supply Area and the entire region are slightly lower than those for the Western Region, and well within the spread of model results, so are not shown. Consult the data deliverable spreadsheets for values in all subregions.

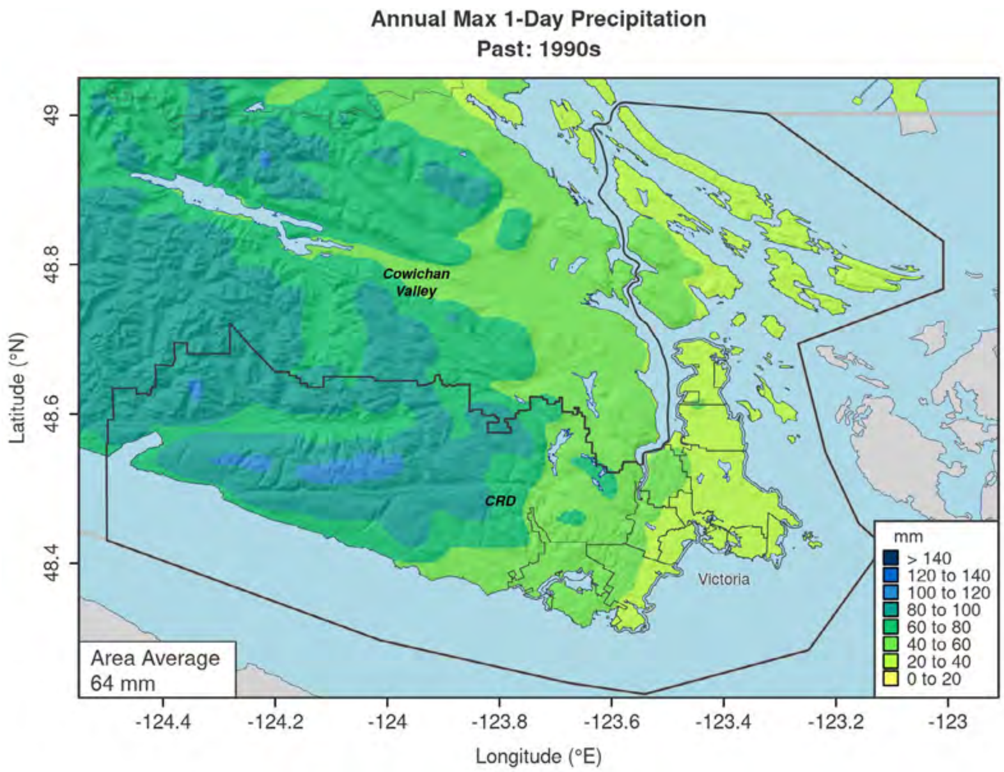



***Figure 18a.*** *Annual maximum 1-day precipitation in the Past.*

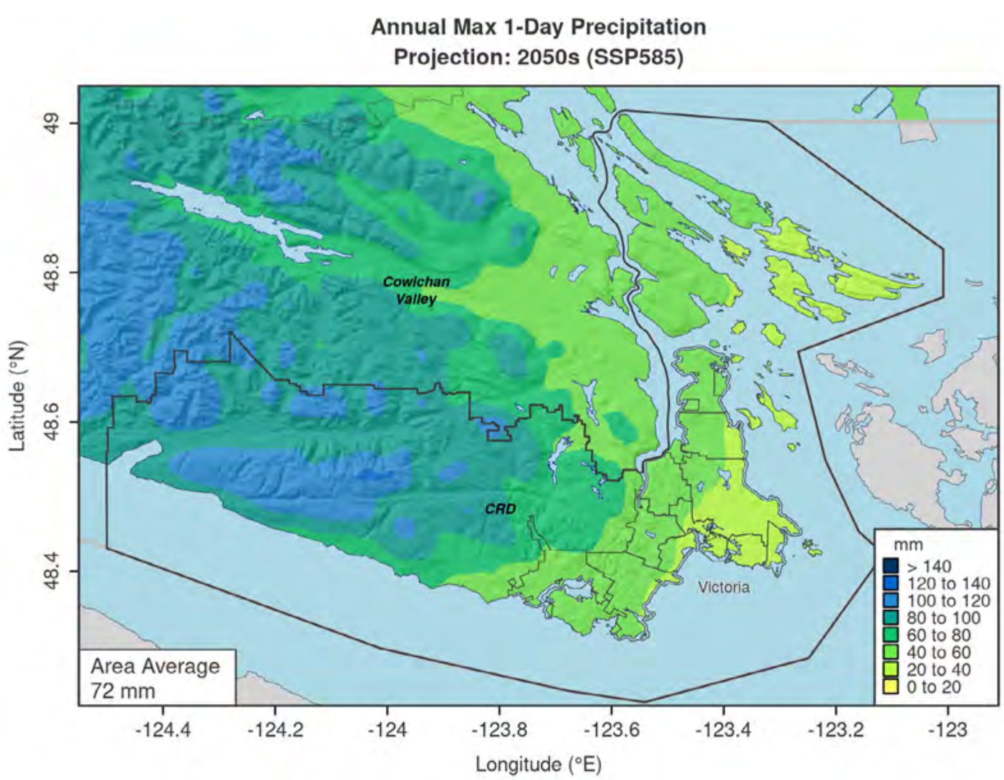



***Figure 18b.*** *Projected Annual maximum 1-day precipitation in the 2050s.*

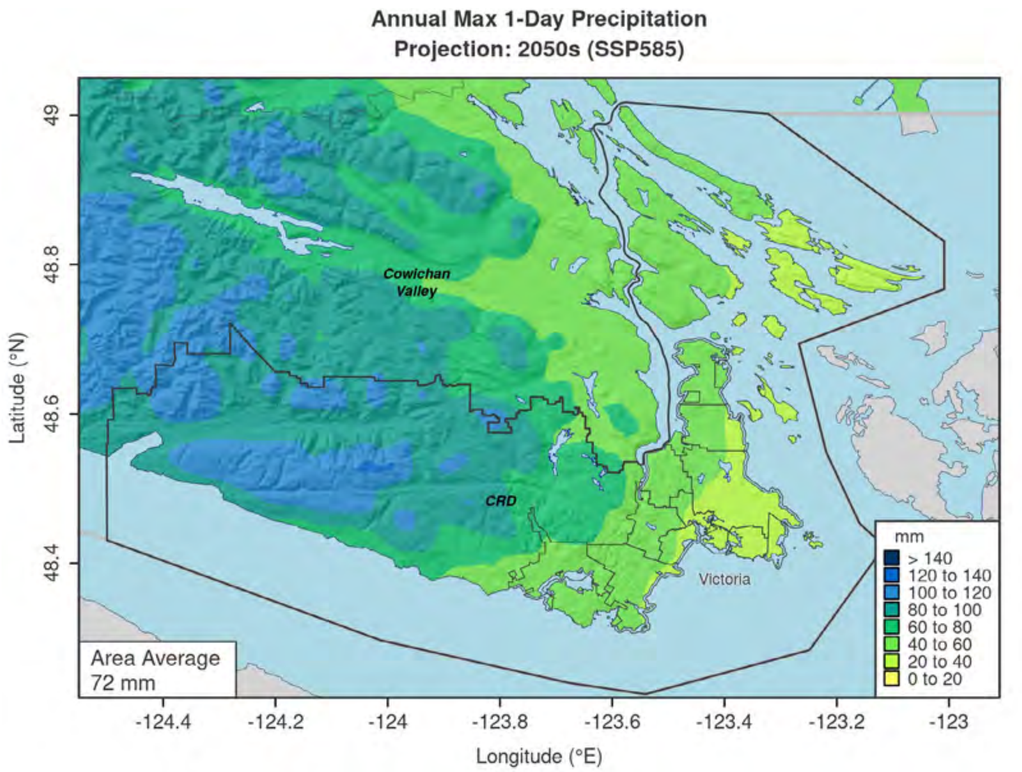



***Figure 19a.*** *1-in-20 year, maximum 5-day rainfall in the Past.*

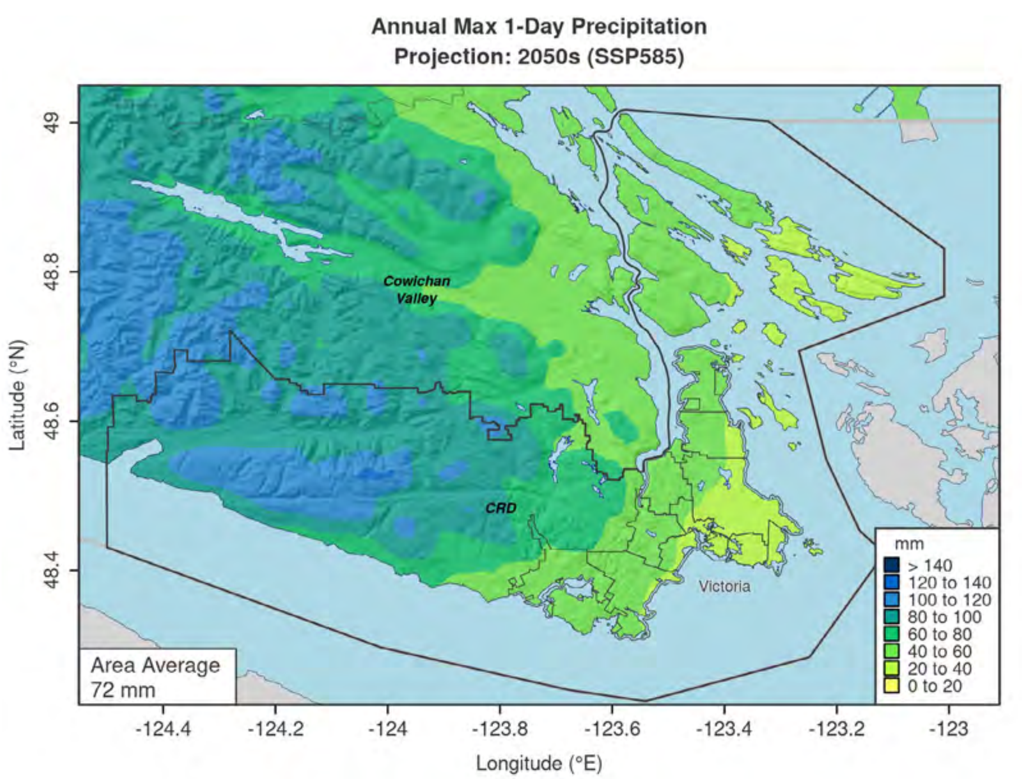



***Figure 19b.*** *1-in-20 year, maximum 5-day rainfall in the 2050s.*

## **6.4** The 1-in-20 Year Wettest Day and 1-in-20 Year Wettest 5-Day Period

These indicators describe rainfall events so extreme, they are expected to occur only once every 20 years in the Past climate. In other words, the *1-in-20 Year Wettest Day* and *Wettest 5 Days* have a 5% chance of occurring in any given year in the Past.

### *Projections*

In the Past, the median 1-in-20 Year, single-day rainfall in the capital region was around 100 mm, while the median 1-in-20 year, 5-day rainfall was about 230 mm. The median Future-projected 1-in-20 year, single-day rainfall increases by 15% to around 115 mm by the 2050s and by 25% to about 125 mm by the 2080s. The median future-projected 1-in-20 year, 5-day rainfall increases by 15% to around 270 mm by the 2050s and by 20% to about 280 mm by the 2080s. As shown in the maps above, the absolute rainfall amounts for both indices are considerably larger in the west of the region compared to the east.

By comparing these results with those shown in Table 3 of Chapter 3, it is evident that the relative changes in extreme rainfall indices are larger than those for seasonal or annual mean rainfall. Table 12, which gathers relevant results from other tables above, reinforces this point. This behaviour occurs due to the different mechanisms that control how extreme (e.g., daily) and average (e.g., monthly to annual) precipitation respond to warming.

As in the case of rare temperature events, one may express these changes in extreme rainfall in a more visually compelling way, as in the diagram on the following page.

**Table 11: 20-Year Return Level Rainfall**

| | Past (mm) | 2050s(mm) | 2080s(mm) | 2050s Change (%) | 2080s Change (%) |
|---|---|---|---|---|---|
| 1-in-20 Year Maximum One-Day Rainfall | | | | | |
| Region | 101 | 116 | 124 | 15<br>(*9 to 30*) | 24<br>(*22 to 42*) |
| Western Region[1] | 105 | 122 | 129 | 16<br>(*9 to 28*) | 23<br>(*21 to 39*) |
| Eastern Region | 62 | 72 | 79 | 16<br>(*10 to 23*) | 27<br>(*23 to 42*) |
| 1-in-20 Year Maximum 5-Day Rainfall | | | | | |
| Region | 232 | 268 | 281 | 14<br>(*3 to 31*) | 21<br>(*11 to 27*) |
| Western Region | 243 | 274 | 297 | 13<br>(*2 to 32*) | 22<br>(*11 to 27*) |
| Eastern Region | 132 | 155 | 159 | 17<br>(*0 to 32*) | 20<br>(*10 to 27*) |

**Table 12: Change in various precipitation indices: Means versus extremes**

| | Region | | Western Region | | Eastern Region | |
|---|---|---|---|---|---|---|
| | 2050s Change (%) | 2080s Change (%) | 2050s Change (%) | 2080s Change (%) | 2050s Change (%) | 2080s Change (%) |
| Annual Mean | 4 | 11 | 2 | 8 | 5 | 11 |
| RX1DAY | 14 | 22 | 10 | 19 | 15 | 22 |
| RX5DAY | 10 | 15 | 9 | 15 | 11 | 15 |
| R95P | 31 | 47 | 31 | 47 | 26 | 43 |
| 1-in-20 RX1DAY | 15 | 24 | 16 | 23 | 16 | 27 |
| 1-in-20 RX5DAY | 14 | 21 | 13 | 22 | 17 | 20 |

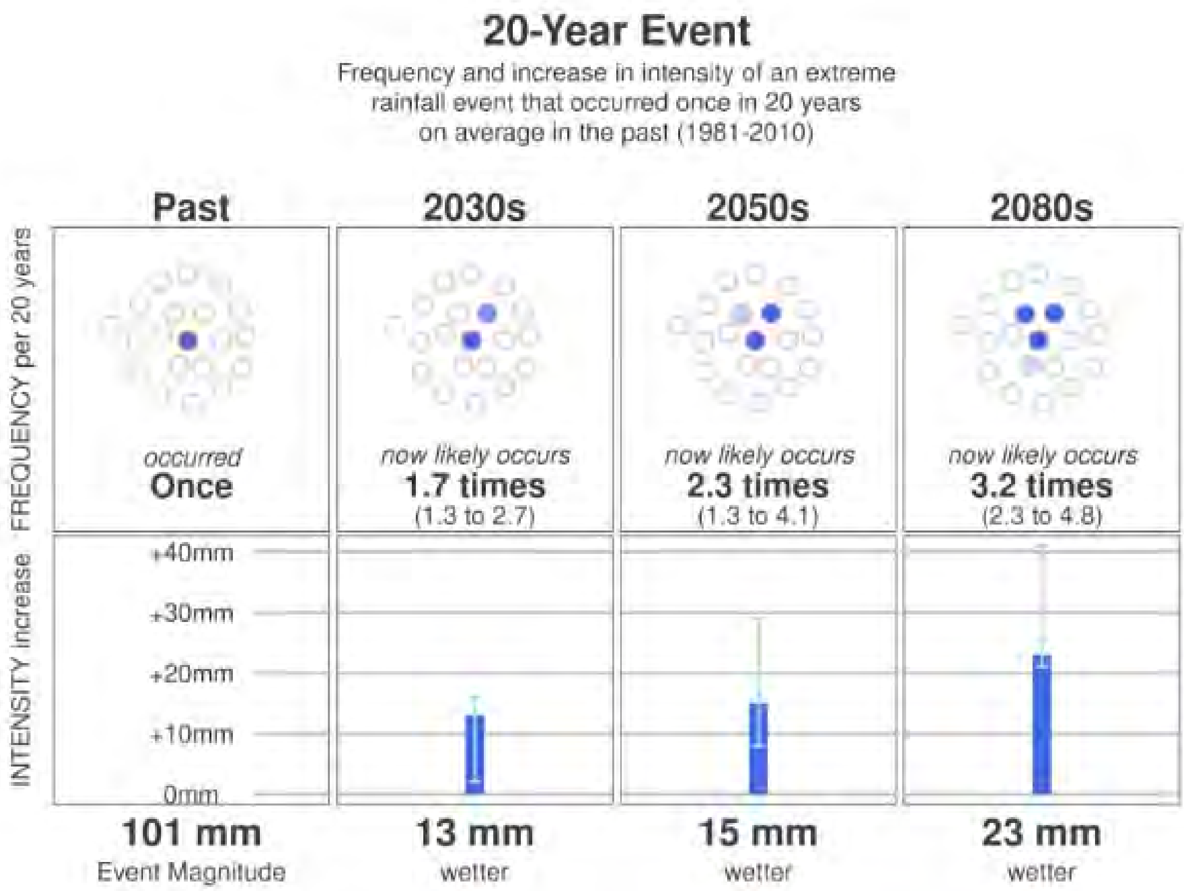



***Figure 20.*** *Upper panels: Frequency of a 1-in-20 year daily maximum rainfall event in the Past and projected frequency of the same magnitude event (i.e. 101 mm) in the three future periods. Lower panels: Increase in magnitude of a 1-in-20 year single-day rainfall event from the Past to Future periods. Figure design is taken from similar infographics in the IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., et al. (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 3-32, doi:10.1017/9781009157896.001.*

# 7. REGIONAL IMPACTS

Communities across the capital region are already witnessing and experiencing impacts from climate change. These impacts are likely to persist and, in many cases, intensify over the coming decades based on projected global GHG emissions trajectories. Collective efforts to reduce emissions and thereby slow the rate of global warming will be necessary to lessen the severity of these impacts. Equally important will be action on climate adaptation and preparing for the environment as it will be in the future, not as it was in the past.

Investing in climate adaptation has the potential to support thriving communities and economies for generations to come. Adaptation actions can safeguard communities and their critical infrastructure from extreme weather events, protect and sustain natural ecosystems, increase the resiliency of food systems, and improve the efficiency of energy and water use. Importantly, there is no "one-size-fits-all-solution"; adaptation can take many forms depending on the unique context of the community.

By the 2050s, the capital region can expect a climate that has diverged from that of the past, with warmer year-round temperatures, shifting precipitation patterns, and more noticeable climate extremes. Due to climate variability, these changes may not occur evenly from one year to the next. Although winters will generally become warmer and wetter, it's important to be prepared for some winters in the future to be colder and drier, especially in the near term. Similarly, while summers will become increasingly hot and dry, there will be summers that are cooler and wetter than the average summer in the future. Adaptation strategies must consider the inherent complexity and variability of projected changes to the regional climate.

This section provides a brief overview of the multiple, intersecting climate impacts expected across various sectors in the capital region. **It is not a comprehensive assessment of the impacts that can be expected from the projected changes outlined in this report.** Rather, this chapter reflects a discussion of regional climate impacts that took place among local government staff, emergency planners and environmental scientists in October 2023. It is intended to spark deeper discussion that explores how to prepare for the interrelated climate impacts facing the region.

While the development of this report did not actively involve First Nations in the capital region, it's crucial to recognize that Indigenous Peoples and their traditional territories bear a disproportionate impact from climate change compared to other groups in Canada.[15] Indigenous knowledge systems play a pivotal role in comprehending ecological resilience, monitoring local and regional impacts, and effectively responding to climate change challenges. Future initiatives aimed at exploring and mitigating the impacts of climate change should prioritize meaningful engagement with First Nations throughout the region.

> The case for investing in climate adaptation is clear: for every $1 spent on adaptation measures today, $13 to $15 is estimated to be returned in future years through direct and indirect benefits.[16]

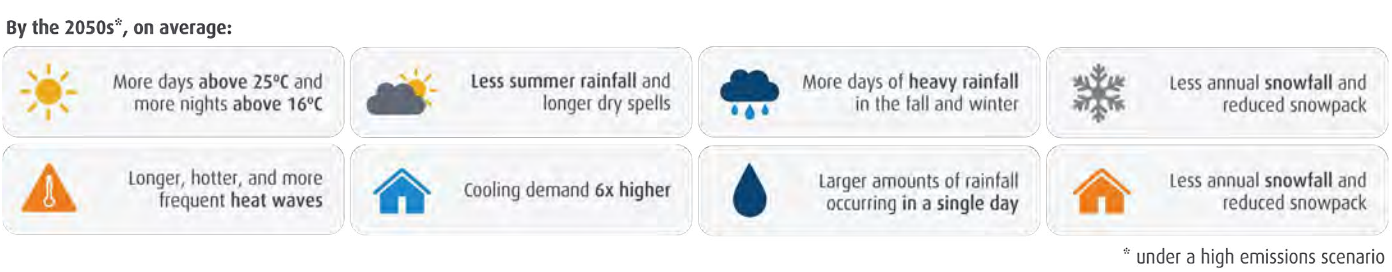



***Figure 21.*** *Infographic summarizing key projections for the 2050s time period.*

[15] BC Centre for Disease Control. Climate Change and Health. http://www.bccdc.ca/health-info/prevention-public-health/climate-change-health

[16] Swayer, D., Ness, R., Lee, C., and Miller, S. (2022). Damage control: Reducing the costs of climate impacts in Canada. Climate Risk Institute.

## Climate Equity

The impacts discussed in this chapter will not be experienced the same way by all residents of the region. People facing the greatest economic and social challenges are often the ones most affected by climate change, particularly for impacts that are compounding (see below). During and after climate-related events, some people and communities experience disproportionate impacts because of existing vulnerabilities that often overlap, including:[15]

- People who experience poverty, colonization, racism, inadequate housing, and a lack of access to health care,
- People who are most likely to be exposed to climate impacts because of where and how they live and work,
- People living with disabilities, chronic diseases, and mental illnesses, and
- Babies in the womb, pregnant people, infants, children, and older adults.

Climate equity can be woven into broader efforts to address the socioeconomic, sociocultural, and physical impacts of climate change. This will require collaboration across various sectors to understand where climate change intersects with other crises (e.g., housing, mental health), and to address these issues holistically.

> Climate equity[17] is the goal of recognizing and addressing the unequal burdens made worse by climate change, while ensuring that all people share the benefits of climate action efforts. Achieving climate equity means that all people in our region have access to a safe, healthy, and fair environment.

### *Impacts*

The impacts examined in this chapter occur within a dynamic and increasingly complex global system. As a result, the impacts from projected climate change may be more severe due to the collective impact of multiple drivers. Examples of compounding interactions include, but are not limited to:

- In the warmer months, high temperatures combined with less rainfall can make drought conditions more likely. [18]
- Extended periods of drought can change soil conditions and reduce infiltration of heavy rainfall, exacerbating localized flooding.[19]
- Warmer water temperatures and increased stormwater runoff can promote conditions for algal blooms year-round.[19]
- Wildfire smoke during extreme heat events can aggravate pre-existing health conditions and cause exposure to poor air quality for residents seeking relief from the heat outdoors.[19]
- Ongoing emergency response associated with consecutive extreme events can overwhelm staff capacity and deplete emergency management resources.

[17] United States Environmental Protection Agency. Climate Equity. https://www.epa.gov/climateimpacts/climate-equity

[18] Intergovernmental Panel on Climate Change [IPCC]. 2023. Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (eds.)]. IPCC, Geneva, Switzerland, pp. 35-115, doi: 10.59327/IPCC/AR6-9789291691647

[19] Yumaguloca et al. 2022. Lived experience of extreme heat in BC: Final report to the Climate Action Secretariat. Government of BC.

# Health and Well-Being

The capital region has a growing and aging population. By 2038, the population is expected to grow by 20% and the number of people aged 65+ is expected to increase by over 50%.[20] Historically, the region has had excellent air quality and comfortable temperatures, with nights cooling off in the summer. In recent years, wildfire smoke and periods of extreme heat during the warmer months have forced residents to seek refuge indoors. Higher temperatures are typically experienced in the eastern parts of the region and in urban areas further from the coast. Developed areas are typically hotter due to the urban heat island effect, which describes how closely packed buildings and widespread paved surfaces in urban areas absorb and re-emit heat more effectively than natural ecosystems and areas shaded by trees and vegetation.[21]

## *Impacts*

In recent years, extreme weather events made worse by climate change have negatively impacted human health and well-being in the capital region. Climate change has the potential to undermine health determinants such as air quality, water supply, food security, cultural practices, and access to a safe environment. Climate change can also place additional strain on healthcare and social systems that are necessary for good health and well-being.

By the 2050s, the capital region can anticipate more multi-day extreme heat events that become longer and more intense by mid-century. The region can also expect hotter summer temperatures, with more days exceeding 25°C and more “temperate nights” where the temperature stays above 16°C.[22] These projected changes will increase the risk of heat-related illnesses and mortality and worsen pre-existing health conditions, particularly among equity-denied populations who do not have access to a cool indoor environment. Notably, these risks are heightened for the region’s growing population of older adults.

Warming temperatures and shifting precipitation patterns may worsen air quality in the region. Across the Pacific Northwest, hotter and drier conditions can increase the likelihood of wildfire ignition. This may cause more frequent episodes of wildfire smoke in the capital region, which can irritate the lungs, cause inflammation, and alter immune function, particularly for people with pre-existing conditions.[24] The projected changes in temperature, precipitation and heat wave occurrence may also exacerbate other air pollutants that influence human health such as pollen, mould, and ground-level ozone.

Living through an extreme weather event, or grappling with uncertainty about the future, can impact mental health and wellbeing, often manifesting as stress, anxiety, fear, and exhaustion. During and after an extreme event, people who face property loss or displacement may endure significant and lasting trauma.

In June 2021, an unprecedented[23] “heat dome” event in the Pacific Northwest caused extended periods of record-breaking high temperatures that had severe implications for health and well-being. Over 600 heat-related deaths were recorded across BC, particularly among people with pre-existing medical conditions (including schizophrenia), older adults, people living alone, and people living in socially deprived areas[21]. In response to this event, numerous projects have been launched across the capital region to better understand extreme heat vulnerability and to build resilience towards extreme heat in the future. For more information, see Appendix D: Further Resources.

[20] BC Statistics. 2019. Capital Regional District 2019-2038 Population, Dwelling Units and Employment Projection Report.

[21] British Columbia Coroners Service. 2022. Extreme heat and human mortality: A review of heat-related deaths in BC in Summer 2021.

[22] The number of temperate nights is an important public health measure that reflects the lower temperature threshold for emergency health alerts used in the capital region. For more, see: Government of British Columbia. 2023. BC Provincial Heat Alert and Response System (BC HARS).

[23] The unprecedented nature of the June 2021 heat dome makes it difficult to estimate its return period (or annual probability of occurrence). Based on analysis of historical data, it was estimated as a 1-in-300-year (or 0.3% annually) at Seattle-Tacoma Airport to a 1-in-1000-year event (or 0.1% annually) in New Westminster (Philip et al., 2022; doi: 10.5194/esd-13-1689-2022). While the capital region can expect more frequent extreme temperatures in the future, estimates for how often an event of this magnitude will occur are difficult because historical records are far shorter than the estimated return periods for this event.

[24] Berry, P., and Schnitter, R. 2022. Health of Canadians in a changing climate. Government of Canada.

# Water Supply and Demand

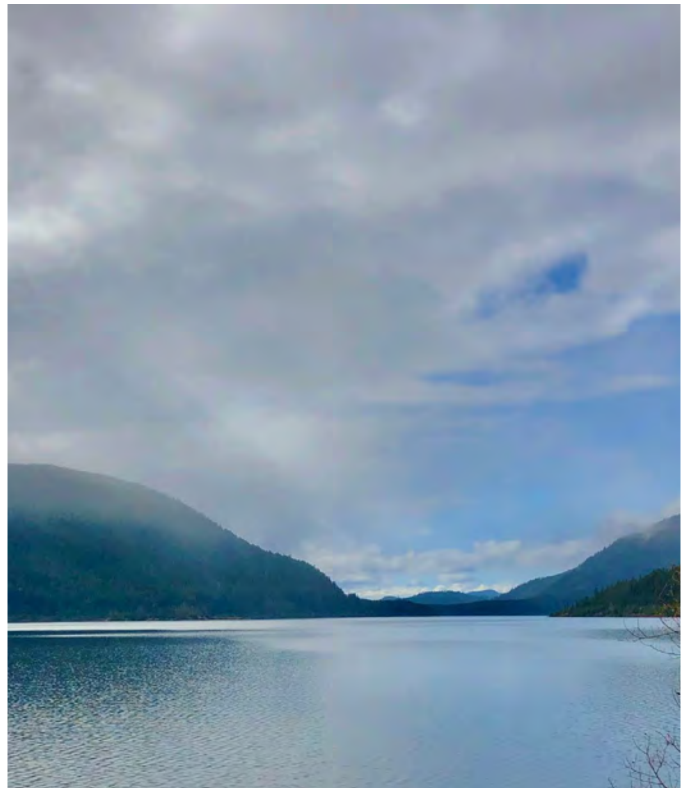
The CRD supplies drinking water to over 390,000 customers from large reservoirs in the Sooke, Leech and Goldstream watersheds that make up the protected Greater Victoria Water Supply Area (GVWSA). The CRD also provides water to small service areas in the Southern Gulf Islands and the western portion of the region through surface water and groundwater systems. Similar privately owned systems provide water in other areas. In some rural and less developed areas, residents rely on groundwater wells on their properties. Residential water use accounts for the largest portion of water use in the region (60%). Water supplies across Southern Vancouver Island are almost entirely replenished from rainwater in the late fall, winter, and early spring (the wet season). Snow melt runoff contributes to groundwater recharge and is needed to sustain summer flows.

## *Impacts*

By the 2050s, less summer rainfall and longer dry spells will increase the risk of drought during the summer and into the early fall. At the same time, hotter temperatures and more extreme heat events will intensify water demand as residents consume more water to keep cool and stay hydrated. Hotter and drier conditions will also increase evaporation and evapotranspiration, raising outdoor watering demand. Water conservation initiatives will remain a priority in the region, given the growing population and the potential for the seasonal decline in water supplies to become more pronounced in the future. Greater densification and anticipated increases in peak demand may also trigger the need for more storage, supplements to existing water supplies, larger capacity infrastructure, and balancing reservoirs in water distribution systems.

> Hotter and drier summer conditions will be particularly challenging for those who rely on groundwater wells or small reservoirs that may not recharge sufficiently. In some instances, these systems may reach dangerously low levels or may even deplete completely. In coastal areas, overdrawing groundwater can lead to saltwater intrusion – an impact that is compounded by rising sea levels.

Hotter and drier conditions also increase the threat of wildfire in the GVWSA and other forested areas that supply water to



residents of the region. Although fire is a natural and essential process in forest ecosystems, severe wildfire occurring in water supply areas can affect water quality and supply by increasing erosion during the following rainy season.[25] As the threat of wildfire increases in rural areas, water needs for wildfire protection will gain increasing importance in water conservation planning.

During the wet season, heavier rainfall may increase erosion of saturated slopes, leading to more fine sediment and organic material in streams entering water supply reservoirs. Increased turbidity from fine sediment can interfere with water disinfection and treatment, while excess organic material can promote algal blooms that produce cyanotoxins, cause taste and odour issues, and compromise disinfection and filterability. Where unprotected water supply catchment areas have been developed, more intense rainfall and runoff can lead to greater undesirable substances (pollutants) entering wells and surface reservoirs. Heavy rainfall and increased water inflows also pose a risk to dam safety. To support safe and resilient water supply through a changing climate, the potential for more intense rainfall events (see next section) will need to be considered in the planning and management of water supply systems.

[25] Brown et al. 2019. Long-term climate, vegetation and fire regime change in a managed municipal water supply area, SAGE Journals, 29(9), 1411-12.

## Rainwater Management and Sewerage

A myriad of rainwater management and sewerage infrastructure aims to protect quality of life, property, and aquatic ecosystems across the capital region. Local governments in British Columbia are responsible for managing drainage; as a result, much of the region's drainage infrastructure (hard and soft) is integrated into local land use and infrastructure planning and processes. Historically, stormwater infrastructure was designed to move water away from the built environment, channeling high volumes of rainwater into creeks and streams. Recently, local governments are shifting towards the use of green infrastructure, which mimics natural drainage systems that play a crucial role in rainwater management. Natural drainage systems (i.e., creeks and wetlands) slow runoff through water retention, helping to reduce flood magnitude and filter out substances that impact water quality. The use of green infrastructure is particularly important in areas with increasing urbanization and development, where greater impermeable surfaces (i.e., roads, parking lots and buildings) contribute to additional runoff.

*Malahat washout during November 2021 extreme rain event (Credit: Emcon Services Inc.)*

### *Impacts*

In the past, flooding from extreme events has occasionally overwhelmed stormwater and sanitary systems in the region. With extreme precipitation events becoming wetter in the future, the region can expect aging and undersized infrastructure to continue to be overwhelmed, amplifying stressors on the receiving environment. During high intensity rain events, creeks may overflow and soils may become saturated, intensifying runoff, and increasing the chance of flooding in low-lying areas. This combination can increase erosion, decrease slope stability, and flood wetlands and lakes, impacting public infrastructure, drinking water quality, and surrounding aquatic ecosystems. Heavy rainfall events can also cause inflow and infiltration of rainwater into the sanitary system in crossover areas, increasing the likelihood of highly diluted sewage entering waterways.

When heavy rainfall occurs after prolonged periods of dry weather, the "first flush" of surface runoff typically contains high levels of contaminants that have accumulated on hard surfaces. This runoff makes its way into surface waters that are home to aquatic ecosystems. When paired with warmer water temperatures, increased stormwater runoff of nutrients can make conditions more favorable for algal blooms year-round – a growing issue in that region – that impacts water quality, ecosystems, recreation, and human health.

> Certain areas in the region are at increased risk of flooding during heavy rainfall events due to flat terrain and proximity to the ocean, particularly when these events occur simultaneously with high tides and onshore winds. The CRD Coastal Flood Inundation Mapping Project (2021) may be used in conjunction with the projected changes outlined in this report, to understand how these factors, along with sea level rise, will influence future flood risk for lower-lying areas near the coast.

The projected increase in heavy rainfall may lead to a higher volume of runoff than the current capacity of infrastructure is able to handle. Green infrastructure, low impact development and multijurisdictional watershed management approaches will remain important strategies for reducing the flooding, runoff and pollution associated with extreme precipitation events. Designers of stormwater infrastructure (i.e., culverts, storm drains, etc.) will also need to plan for higher single- and multi-day rainfall amounts. For more information about how future precipitation is estimated using climate model projections, including the adjustment of Intensity-Duration-Frequency (IDF) curves in a future climate, see Appendix D: Further Resources.

# Ecosystems and Species

The capital region is home to various ecosystems, including Douglas-fir forests, Garry oak meadows, riparian zones, wetlands, estuaries, shorelines, and more. The diversity in the region brings with it a wide range of flora and fauna, including many species at risk that need protection. Natural assets providing connectivity and ecosystem services are essential for supporting climate resilience. Forests in the GVWSA contribute to the high quality of water in supply reservoirs, and green spaces in urban and suburban areas provide natural cooling capacity, stormwater retention, and help reduce air and water pollution.

## *Impacts*

Warming year-round temperatures and seasonal changes in precipitation will have important impacts on the ecosystems, native species and associated ecological relationships and processes existing in the capital region. Because ecological systems are highly complex, it will be difficult to make specific predictions for how they will be impacted by a changing climate. In general, the speed and scale of climate change may threaten the capability of many species to adapt, altering the ecological landscape. Shifting seasonal patterns, characterized by an earlier onset of spring or a later start to fall, may threaten processes that rely on temperature cues, including predator/prey, parasite/host, and pollinator dynamics. This may cause population declines for certain species, and/or outbreaks of species that are considered pests. Specialist species may be particularly vulnerable, which may threaten regional biodiversity and create new opportunities for invasive species to thrive.

Climate change not only impacts ecosystems and species directly; it also interacts with environmental changes from human development.[26] Impacts from climate change may be amplified for ecosystems where land-use changes have caused fragmentation and, as a result, weakened resiliency. For example, the Bowker Creek watershed – covering 1,028 hectares of the capital region – historically supported coho and chum salmon and cutthroat trout. Today, Bowker Creek is highly urbanized, with roughly 50% now composed of impervious surfaces that cause low summer base flows and reduced water quality for aquatic ecosystems. Long range, multijurisdictional efforts are in place to protect its natural characteristics and reduce impacts from a changing climate.[27]

In the summer, hotter and drier conditions will continue to stress trees and other terrestrial and riparian (streamside) vegetation, particularly for species that are sensitive to drought such as the Western red cedar. Drought conditions can slow decomposition in below-ground communities consisting of bacteria, fungi, and other soil organisms, thereby reducing available nutrients. When plants undergo stress, they become more susceptible to competition with other plants and to damage from insects and diseases.

Warmer year-round temperatures will also raise water temperatures in aquatic ecosystems, which may be problematic for species that require cool water to thrive. In extreme cases, warm water can cause low oxygen levels and mortality, particularly when these conditions are compounded by low water levels and occur during critical life stages such as spawning, rearing, or hatching. Heavy rainfall can also disrupt critical ecological processes. For example, during an atmospheric river event in November 2021, increased channel erosion and sediment deposition resulting from high stream flows severely impacted salmon spawning beds.[28]

[26] IPCC. 2022. Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group, II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. [H.-O. Pörtner et al. (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, 3056 pp., doi: 10.1017/9781009325844.59327/IPCC/AR6-9789291691647

[27] Bowker Creek Initative. 2012. Bowker creek blueprint: A 100-year action plan to restore Bowker Creek Watershed.

[28] CBC. 2021, 21 November. For B.C.'s salmon, floods represent another challenge to survival.

## Buildings and Energy Systems

Energy use in buildings accounts for roughly one third of GHG emissions in the region. In the past climate, most buildings and homes in the capital region did not require active cooling capacity. During the 2021 heat dome, 98% of heat-related deaths in BC occurred in private residences, highlighting an urgency to implement cooling measures in homes across the region.[21] Retrofit programs and new building policies not only support the transition to renewable energy and energy efficient technologies but are leading to building envelope considerations and a greater adoption of low emission heat pumps that support thermal comfort. In both urban and rural communities across the region, many homes and other buildings are in coastal and riverine areas where flooding may be a concern.

### *Impacts*

As the climate warms and precipitation patterns change, the case for investing in well-designed, resilient buildings improves. Heavier rainfall events may increase the risk of flooding in the fall and winter, which can cause property damage, personal injury, and economic losses, particularly where development is located on flood plains. More episodes of multi-day extreme heat can also stress foundations and building materials, and potentially affect the functioning of heating, ventilation, and air conditioning (HVAC) systems.

Across the region, warmer year-round temperatures and more days going above 25°C in the summer will shift seasonal and long-term energy demands. Whereas heating demand is expected to decrease in the colder months, hotter temperatures and more multi-day extreme heat events during the warmer months will generate cooling demand where it did not exist previously. In the past, buildings and homes have relied on the region's cool summer nights to support thermal comfort during the warmer months. In the future, an increasing number of "temperate nights" (i.e., nights when the temperature stays above 16°C) will heighten the risk of buildings overheating.

Adaptive design strategies, such as passive cooling, outdoor shading, rainwater capture and reuse, green roofs, resilient landscaping, and rain gardens, can help address challenges from heat, drought, and overland flooding. In addition, concentrating development in already developed areas, balanced with access to urban greenspace, can protect opportunities for the surrounding natural ecosystems to buffer changes to our climate.

The projected increase in cooling degree days by mid-century will require that most buildings have some form of active cooling to maintain thermal comfort and prevent overheating. Certain units, such as older, multi-unit residences, often lack air conditioning and are not designed to handle hot temperatures, leaving occupants at greater risk of heat-related illnesses and mortality. The use of energy efficient technologies like heat pumps will play an important role in aligning with efforts to reduce GHG emissions while avoiding additional costs to residents. Authorities with jurisdiction over building codes should consider how to proactively integrate future climate considerations into the design of new and existing buildings.

## Transportation

The region's transportation network includes many local and arterial corridors, three major highway corridors (Highways 1, 14 and 17), two provincial and two international ferry corridors, a regional transit network, international and harbour airports, cruise ship and ferry terminals, and many active and multi-use trails. Regional transportation priorities include full realization of a multi-modal transportation network to help shift away from private vehicles to public transport, walking and cycling. As a coastal community, the capital region is vulnerable to significant transportation disruptions that complicate responses to emergencies and extreme events, and can interrupt the local supply chain.

### *Impacts*

The projected increase in heavy rainfall may intensify flooding across the region, potentially causing more frequent road closures, vehicle collisions and construction delays. Some communities, such as Sooke, have already seen recurrent road closures due to flooding and may be particularly vulnerable to heavy rainfall.[29] Extreme precipitation events may also impede the reliability of major transportation corridors. In November 2021, extreme rainfall and runoff from a landfalling atmospheric river caused extensive damage to the Malahat Highway (Highway 1), prompting its temporary closure. This disruption reverberated through the local supply chain, resulting in shortages of fuel and other essential goods and services across the region. Like flooding from heavy rainfall events, wildfires also pose risk to the closure of regional highways and roads. In the future, hotter temperatures and less rainfall occurring in the warmer months will increase fire danger. Wildfire damage along hillslopes near roadways may also heighten the risk of landslides during the subsequent rainy season.

> The effects of extreme weather on transportation may be particularly challenging for some equity-denied groups. Residents may find themselves unprepared to leave their homes, hindering their ability to access essential supplies and services.

By the 2050s, a shorter winter season characterized by less snowfall and fewer freezing days may lower the costs associated with snow removal and the repair of cracked roads from freeze-thaw cycles. However, equipment to manage severe winter conditions will need to be maintained as changes to the frequency of heavy snowfall events remains largely unknown because they are driven by "Arctic outflow" events from Northern BC.

Warming temperatures may enhance the appeal of active transportation (walking, cycling and transit use) during the colder months. Conversely, high temperatures, multi-day extreme heat events, and poor air quality from wildfires in nearby regions may deter residents from choosing active transportation methods in the summer and early fall. Active transportation routes may also be interrupted by heavy rainfall, which can cause localized flooding and erosion along trails and pathways.

To safeguard transportation across the region, projected changes to temperature and precipitation should be considered in the design and retrofit of transportation infrastructure. These changes should also be considered against the backdrop of other existing weather hazards that will continue to affect the region (e.g., windstorms). Efforts to reduce GHG emissions across the region will rely on a resilient active transportation network. Strategies to support active transportation may involve installing adequate cooling infrastructure (i.e., trees, benches, shade structures, misting stations and water fountains) and supporting nature's capacity to buffer climate impacts through stewardship and community engagement.

[29] Chek News. 2021. Heavy flooding and road closures forces Sooke into temporary isolation.

# Food and Agriculture

Food and agriculture are fundamental elements of the long-term sustainability, resilience and health and wellbeing of the capital region. In recent years, changes in climate, energy costs, water availability and agricultural production have drawn attention to the ongoing resilience of the region's food system. Ensuring a stable local food system requires management of changing wildlife populations, flooding and drainage concerns, water availability, as well as the amount of agricultural land in food crop production. The average age of farmers in the capital region remains higher than the Canadian average and represents a warning sign for the future of food production in the region.[30]

## *Impacts*

Increasing year-round temperatures will lead to fewer frost days, an earlier start to spring, and extended summer-like weather into the fall. These changes will result in a longer and warmer growing season that could enhance agricultural productivity in the region. However, climate change is also expected to introduce greater uncertainty for growers, as temperatures become hotter in the warmer months and precipitation patterns change. The projected increase in growing season length by 2050 (estimated to be roughly 17%) should be considered an upper limit for estimates of future productivity. This measure uses only a lower temperature threshold and does not account for reduced summer precipitation, which increases the risk of drought. In addition, shifting seasonal conditions from warming temperatures may cause pollinating species to emerge at misaligned times, limiting potential crop yields.

During the growing season, reduced water availability and extended dry periods leading to drought could have significant impacts on agriculture in the region. Less total rainfall in the summer will reduce water levels in ponds, wetlands and streams used for irrigation, while hotter temperatures will promote further evaporation and evapotranspiration. These conditions can increase heat stress and sun scald, competition for water resources, and may create opportunities for invasive species, pests, and plant diseases to flourish. Increased demand for irrigation strains water supply systems with competing demands, and negatively impacts ecosystems in water bodies, wetlands, and streams. Addressing these challenges will require innovative strategies that improve the efficiency of agricultural irrigation and transition to crops requiring less water. Growers may need to consider alternative soil-management approaches, as changes to soil moisture and composition may accompany the projected changes to the region.

In the fall, heavy rainfall events may impact crop harvest by increasing the risk of flooding and creating more opportunities for diseases and pests. Extreme precipitation can also lead to more runoff onto and off agricultural land, leading to erosion, soil nutrient leaching, and crop loss and damage. For low-lying agricultural areas near the coast, these impacts may be compounded by high tides, storm damage, and saltwater intrusion from rising sea levels.

[30] Capital Regional District. 2018. Regional Growth Strategy.

## Recreation and Tourism

With its mild climate, beautiful coastlines, and abundant ecosystems, the capital region continues to be a sought-after destination for visitors from across the globe and tourism remains a key local industry. Tourism is an estimated $1.9 billion dollar industry in Greater Victoria with more than three million visitors to the region annually.[31] The region boasts plenty of outdoor recreation, with more than 26,000 hectares of national, provincial, regional, and municipal parks and ecological reserves and four regional trails on southern Vancouver Island and the Gulf Islands.[32] In 2021, regional trails received over 3.7 million visits and regional parks received over 5 million visits from local residents and tourists. These areas contribute to the cultural, social, and economic vitality of the region.

### *Impacts*

By the 2050s, warmer year-round temperatures could lead to a longer season for summer recreation, providing more opportunities for outdoor activities and potentially boosting economic productivity. However, the rise in the number of hot summer days and multi-day extreme heat events may encourage more people to seek relief near lakes and coastlines, which can place additional stress on freshwater, marine and shoreline ecosystems. Careful protection and monitoring of recreational sites will be important to ensuring ecological health in areas where visitor use may increase.

The projected changes in temperature and precipitation may also influence the access and safety of recreation and tourism across the region. Less summer rainfall and longer dry spells may result in longer and more frequent campfire bans. Increasing fire danger may also result in the closure of parks and campgrounds due to wildfire risk. During the wet season, heavier rainfall may impact trail access and safety, and increase the costs associated with the maintenance of recreational infrastructure. At all times of the year, the potential increase in algal blooms may pose challenges to recreational water users, fishing, and tourism. Ensuring climate-resilient design of new and existing infrastructure and supporting ecosystem health and integrity through a changing climate can benefit both the economy and the physical, mental, and spiritual health of people across the region.

[31] Greater Victoria Chamber of Commerce. Destination Greater Victoria. https://www.tourismvictoria.com/

[32] Capital Regional District. 2023. Regional Parks and Trails Strategic Plan.

## Summary and Recommendations

This report uses the most up-to-date climate model projections to examine how climate change may unfold across the capital region in the coming decades. The region can expect an increase in daytime and nighttime temperatures throughout the year. In the summer months, this implies hotter daily highs, warmer nights, and more numerous and longer multi-day heatwaves. By the 2050s, winters will become milder overall with a steep reduction in frost days and snowfall.

The capital region can expect a modest increase in annual precipitation by the 2050s that will be distributed unevenly across the seasons. Whereas rainfall is projected to increase notably in the colder months, summers will become drier. Warmer cold season temperatures will result in less snowfall and increased rainfall, especially in winter. In the warmer months, longer dry spells are expected due to the combination of less rainfall and warmer temperatures. The magnitude and character of these changes will vary locally across the region.

Early action on climate adaptation will enable the region to best prepare for the changes ahead and increase climate resilience. The information provided in this chapter is intended to guide further discussion among decision makers and community partners across the region. Importantly, adaptation can take many forms depending on the unique context of each community. The regional impacts outlined in this report should be considered a starting point for further analysis of climate impacts and adaptation planning that engages relevant stakeholders and is tailored to the local context.

The CRD will continue to use these projections to incorporate climate change adaptation into planning cycles and ongoing activities. Adaptation planning is complex and requires consideration of multiple factors and compounding drivers. As such, continued data collection and monitoring will be important to establish baselines, monitor changes and ensure that adaptation actions are appropriate to the local context. Some examples of how the future climate projections provided in this assessment can be used to support climate adaptation include:

- Raising awareness about how climate change will impact the region
- Informing strategic and long-range planning
- Informing strategic planning for emergency responses to extreme events
- Conducting vulnerability and risk assessments to inform policy, planning, research, and monitoring
- Designing infrastructure that considers the future climate

This report highlights regional projections for the 2050s under a high emissions scenario, but alternative scenarios were also considered for this project. The complete data package includes information for low, moderate, and high emissions scenarios for the 2030s, 2050s and 2080s. It also includes separate assessments for four smaller sub-regions within the capital region. The report Appendices point to further online resources and general guidance for understanding and using climate projections.

# Appendix A

## BACKGROUNDER ON FUTURE CLIMATE DATA

The Earth's climate is changing due to the burning of fossil fuels, which emit greenhouse gases (GHGs) and aerosols into the atmosphere. Over the past century, these emissions have raised atmospheric GHG concentrations well above preindustrial levels, which has led to widespread warming over Earth's surface.

The global average temperature has increased by over 1°C to date, and Canada is warming even faster (Figure A1). This warming has resulted in widespread impacts in Canada and across the globe, and it is directly proportional to the total amount of GHGs emitted since the beginning of the industrial era. While a 1°C temperature change at your location may not feel like much, changes of only 1 or 2°C on a global scale are very substantial because they are averaged over the globe and a long period of time.

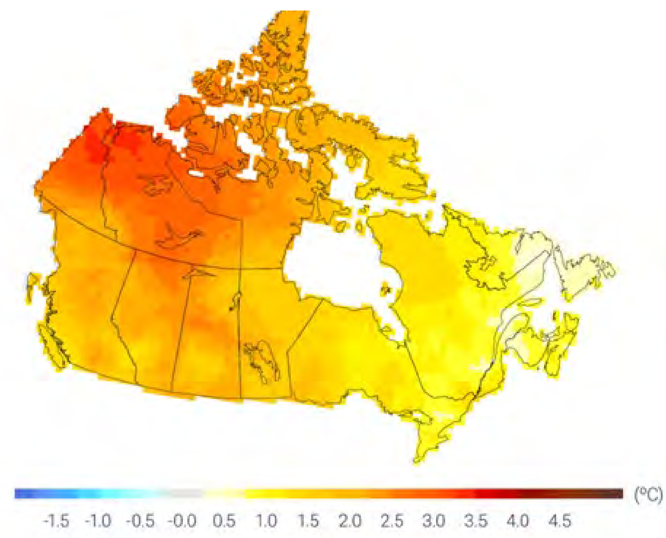



***Figure A1.*** *Warming in Canada between 1948-2018.*

### Understanding Weather, Climate, Natural Variability and Climate Change

To understand climate change, it is important to distinguish between weather and climate, and the natural and human influences that affect the climate on different time scales:

- Weather is what we experience when we step outside. It consists of short-term (minutes to days) variations in the atmosphere.
- Climate is the general state of weather, including its extremes, over periods ranging from months to many years. Climate can be thought of as the statistics of weather. Descriptions of normal climate conditions at a particular location are often derived from nearby weather observations and collected over long time periods – typically 30 years or more.
- Natural climate variability causes fluctuations in climate conditions that can span a few months to a few decades or longer. Natural climate variability is not influenced by human activity, but its influence can either mask or enhance human-induced climate change for the periods over which it occurs. Natural climate variability can also affect seasonal weather (e.g., El Niño/La Niña cycles).
- Climate change refers to changes in the state of the climate that persist over an extended period. Both natural processes and human influence can result in changes in climate. Climate science indicates that human influence is the unequivocal cause of the global warming that has been observed since the beginning of the 20th century.

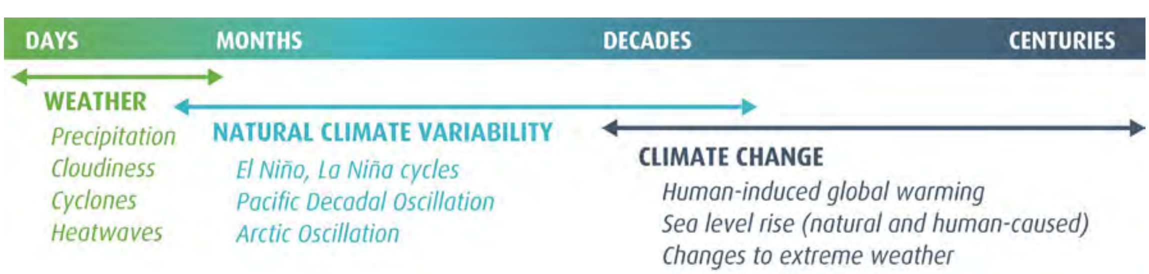



***Figure A2.*** *Timescales for weather, climate, natural climate variability, and climate change.*

# What is Future Climate Data?

In the context of a changing climate, historical climate observations are no longer suitable for assessing future climate-related risks. As a result, engineers, planners, and decision-makers are increasingly using future climate data to estimate the growing risks associated with climate change. Practitioners and decision-makers want to know how much climate change (and risk associated with that change) they can expect to encounter over the coming decades.

The extent of further warming depends on how global emissions change in the future. Unfortunately, it is impossible to predict the exact societal conditions of the future that will directly influence global emissions. Therefore, a range of potential futures, or scenarios, can be used to plan for the changes associated with rising global temperatures. These scenarios are based on assumptions about population growth, climate policy, land use changes, energy intensity, economic activity, and more, that lead to different levels of global GHG emissions. The scenarios used in this assessment are known as Shared Socio-economic Pathways, or SSPs for short – but more on that later.

To understand the future climate, scientists develop global climate models (GCMs) to simulate Earth's future climate in detail under each of the various scenarios. GCMs are extensively tested against historical observations and compared to one another. Through the Coupled Model Intercomparison Project (CMIP), we can construct an ensemble of different GCMs that describes a range of plausible climate futures. In Figure A2 below, each red line represents an individual GCM projection, developed by research groups from around the world. The solid black line in this case represents the ensemble median, with the lower and upper dotted lines showing the 10th to 90th percentile range of the model ensemble.

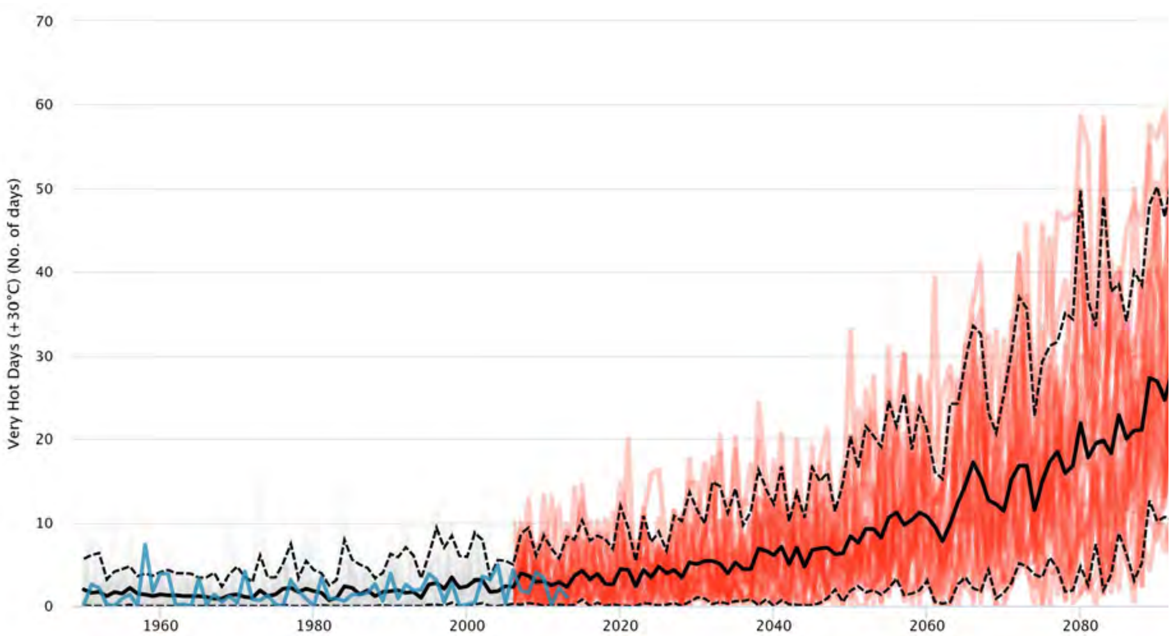



***Figure A3.*** *Example of a GCM ensemble.[1] Each red line represents a single GCM projection for the number of annual days with a maximum temperature exceeding 30°C in British Columbia. The solid black line is the median and the dotted lines are the 10th (lower range) and 90th (upper range) percentile values across all GCMs in the ensemble.*

[1]Retrieved from ClimateAtlas.ca, using modeled data from PCIC.

## Understanding Shared Socio-Economic Pathways

As noted above, to project the future climate, GCMs need input about the amount of future industrial emissions. Shared socio-economic pathways (or SSPs, Figure A3a) are such inputs, providing emissions scenarios based on assumptions of various societal decisions, including:

1. How population, education, energy use, technology – and more – may change over the next century, and;
2. The level of ambition for mitigating climate change globally.

The SSPs used in CMIP6 simulations are a set of five main socioeconomic pathways (SSP1 through SSP5) that illustrate different ways in which global societies may develop. They are the successors to the previous emissions scenarios used in CMIP5 called Representative Concentration Pathways, or RCPs. Figures A4a and A4b illustrate projections for GHG emissions and temperature under various SSPs. Here, it is important to note that global temperature projections for the near future are similar across different SSPs. The projections begin to diverge more meaningfully around 2050 (Figure A4b).

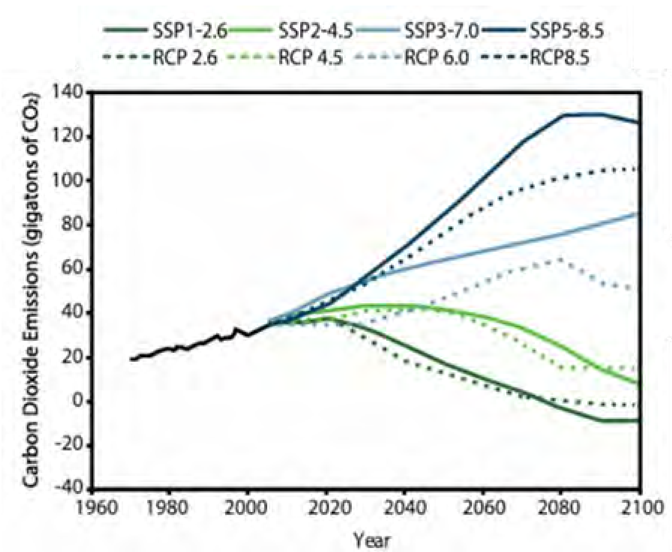



***Figure A4a***. *SSP scenarios used by CMIP6 models for global CO2 emissions by the end of this century. The scenarios used for CMIP5 (RCPs) are also shown.*

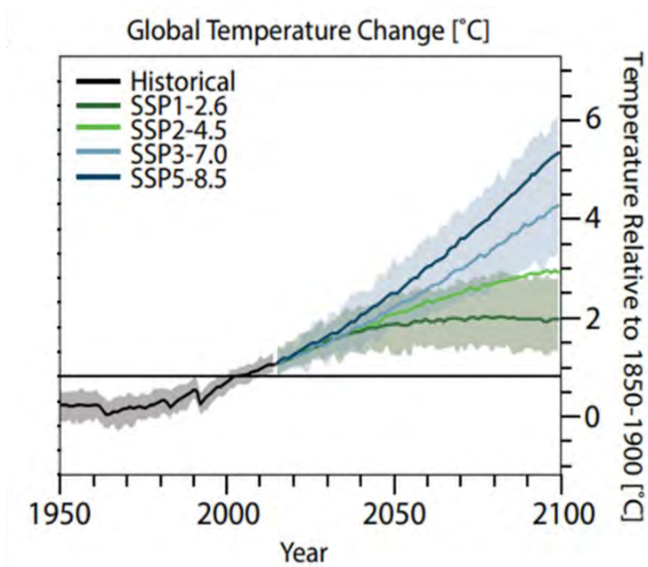



***Figure A4b***. *Historical and future temperature change from 1950-2100, relative to 1850-1900. After 2014, models are driven by the SSP scenarios indicated, with ranges shown for SSP1-2.6 and SSP3-7.0. The horizontal line shows temperature change that has occurred up to 1995-2014 (about +0.85°C).*

## Future Climate Uncertainty

While we know the future climate will be different from the climate of the past, we cannot precisely predict what the future climate will look like. There are three main sources of uncertainty inherent in future climate data: natural climate variability, model uncertainty, and scenario uncertainty. In the following sections, we provide support for making decisions in the presence of scenario uncertainty.

- **Natural climate variability** (as discussed above) refers to climatic fluctuations that occur without any human influence (i.e., independent of GHG emissions). Natural climate variability is largely unpredictable and can mask or enhance human-induced climate change.
- **Model uncertainty** arises because models can only represent the climate and earth system to a certain degree. Although they are highly sophisticated tools, GCMs can differ from reality. Furthermore, not all models represent the system processes in the same way, nor do all include the same processes. To help address model uncertainty, it is best practice to use an ensemble (i.e., a set of multiple GCMs), to display a range of possible futures. PCIC uses an ensemble of 9 GCMs that are best suited to analyses focused on British Columbia.
- **Scenario uncertainty** arises because different emissions scenarios lead to different levels of climate response, and it is not possible to know what global emissions will be in the future. The emissions pathway of the future depends on a wide range of policy decisions and socioeconomic factors that are impossible to predict. To help address scenario uncertainty, it is best to evaluate future projections under more than one emissions pathway.

**Uncertainty should not stand in the way of action.** Decision makers should use climate projections as a guide to the future but should not discount the possibility of changes occurring outside the projected range when managing risk. In the following sections, we provide support for making decisions in the presence of scenario uncertainty.

# Appendix B

## WHAT DATA SHOULD I USE?

The decision tree shown in Figure B1 can help determine which data and information from this assessment might be most useful for a given application. Before using climate projections, it is important to do appropriate background reading, identify relevant stakeholders and determine the appropriate level of stakeholder engagement. Stakeholder engagement is important for ensuring that the projected changes are both meaningful and well-suited to your context.

**Users accessing the complete data package should reference the Data Descriptor Document.** Contact climateaction@crd.bc.ca for more information.

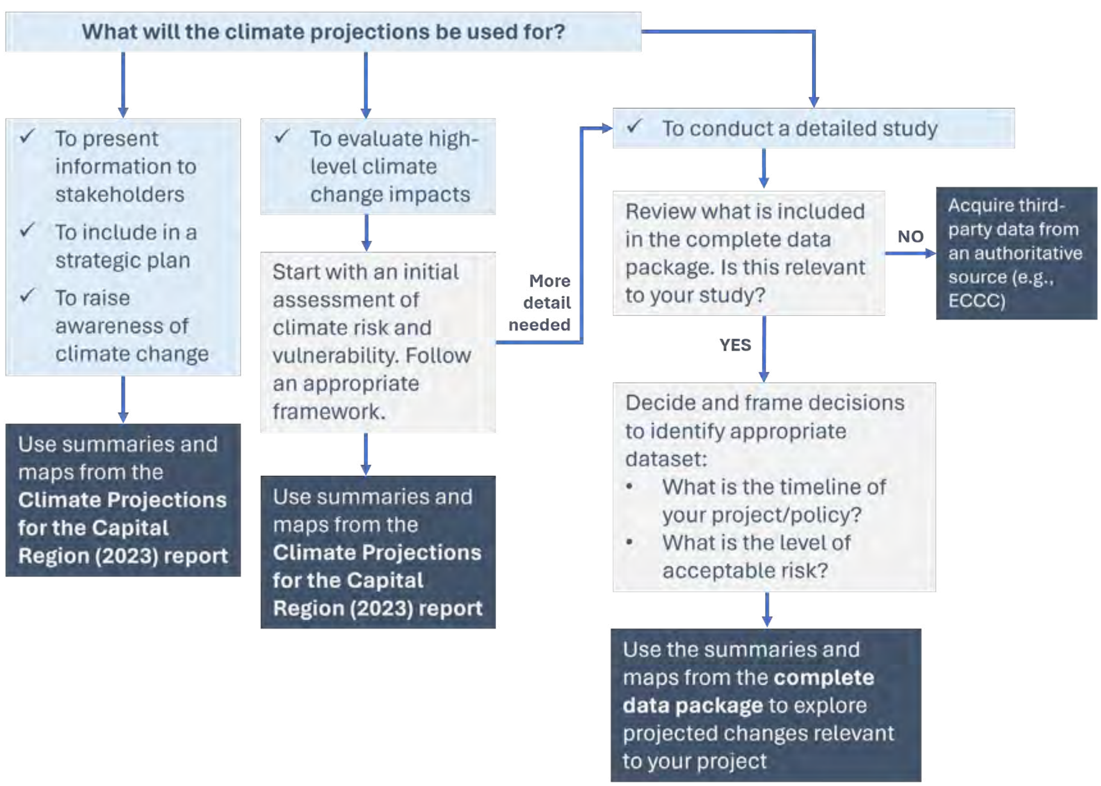



***Figure B1***. *Decision tree for using climate projections data. This decision tree has been adapted from the Victoria (Australia) Climate Projections 2019 Technical Report (Clarke et al., 2019).*

# What is Provided in the Complete Data Package?

The Climate Projections for the Capital Region 2023 report highlights projected changes for a host of indices derived from temperature and precipitation under the highest emissions scenario (SSP5-8.5), mostly for the 2050s. The complete data package contains summary tables (Excel XLSX) and maps (PNG) for the following additional time periods, scenarios and sub-regional breakdowns:

### The capital region and four smaller sub-regions.

(see Figure B2 below)

- "Core/Peninsula" (Green)
- "Western Region" (Red)
- "Southern Gulf Islands" (Yellow) and
- "Greater Victoria Water Supply Region" (Blue)

### Four time periods.

- 1981-2010 or "1990s" (baseline period)
- 2021-2050 or "2030s"
- 2041-2070 or "2050s", and
- 2071-2100 or "2080s",

### Three emissions scenarios.

- Low: SSP1-2.6
- Moderate: SSP2-4.5, and
- High: SSP5-8.5.

### 77 indices derived from temperature and precipitation. *(see Appendix F for a complete list)*

Gridded data (NetCDF) is also available for all 77 climate indices projected to the 2050s under a high emissions scenario (SSP5-8.5). Contact climateaction@crd.bc.ca to access the complete data package and/or the gridded data.

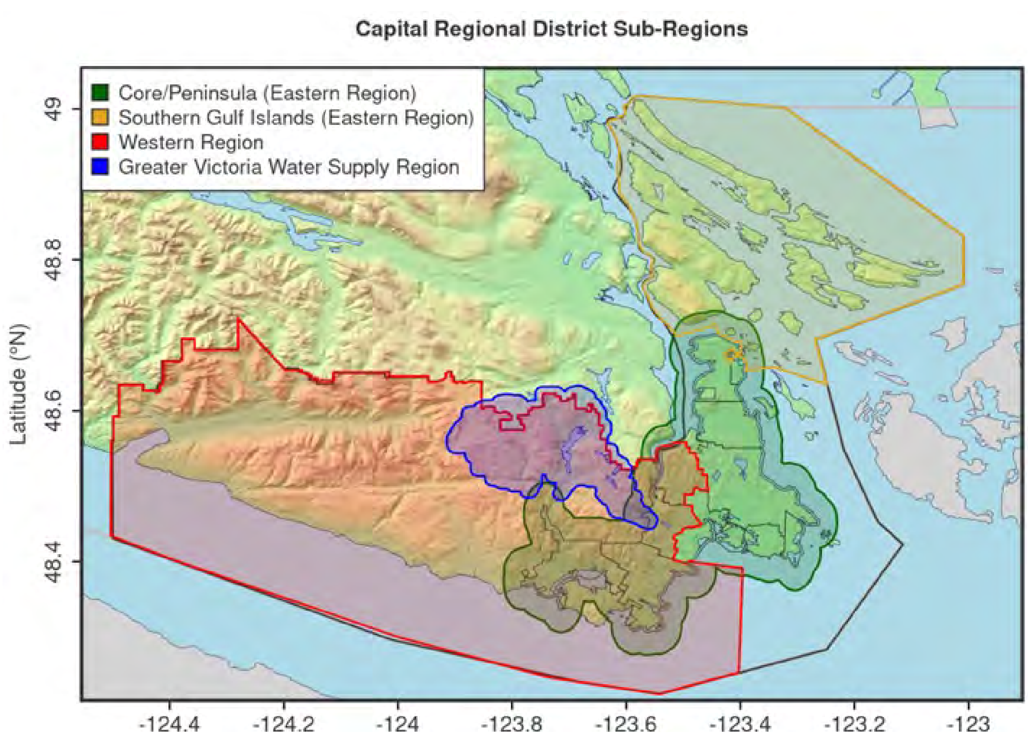



***Figure B2***. *The capital region and four sub-regions. Separate Excel files are available for each sub-region and for the region as a whole.*

# Appendix C

## GUIDANCE FOR USING CLIMATE PROJECTIONS

### Key Messages

- ✓ Projections of future climate are complex, and you will likely need advice and guidance from experts in the field. Allow adequate time for consultation.
- ✓ The climate has always been naturally variable. This variability now occurs on top of greenhouse-gas/aerosol forced trends. Over shorter time scales, climate variability can mask long-term trends.
- ✓ Since we do not know what future global emissions will be, climate projections are produced for a number of possible scenarios. In the CMIP6 ensemble, near-term projections are similar and diverge more clearly by the middle of this century (e.g., the 2050s).
- ✓ This assessment provides downscaled climate projections for variables derived from temperature and precipitation only. Variables related to other climate-related hazards, such as sea level rise or windstorms, are not provided. For supplemental resources, see Appendix D: Further Resources
- ✓ While climate models are run under different emissions scenarios, there is no such thing as a 'most likely' scenario. Selecting an emissions scenario is highly context-dependent and will depend on considerations such as risk tolerance and the life cycle of your project or policy.
- ✓ Consider multiple climate variables or indices to get a more complete picture for different manifestations of change. Review annual and seasonal projections to get a sense of how projections vary depending on the time of year.
- ✓ In many cases, using only the median climate projections will not be appropriate. Ensure the ranges of projected change (10th and 90th percentiles) are adequately accounted for in your assessment. Do not entirely discount changes above or below the projected range when managing risk – especially for high-impact, low-likelihood events.

# Understanding Climate Risk

As shown in Figure C1, climate risk depends on the complex interaction between hazards affected by climate change and natural climate variability, exposure to these hazards, and the vulnerability of the exposed elements. For example, a hazard (e.g., extreme heat) may impact a community more due to its exposure (e.g., occurring in a densely populated area) and/or vulnerability (e.g., demographic factors influencing heat sensitivity).

While future climate data can support the assessment of hazards affected by future climate change, there are different approaches to understanding climate risk. Decision-making about climate risk often involves a combination of top-down and bottom-up approaches.

**Top-down** approaches start with an analysis of potential climate change that can be used to guide actions and decisions.

**Bottom-up** approaches start with the project, policy or activity of interest and analyze the factors and conditions that impact the exposure, vulnerability and resilience of systems. These approaches look for pathways to reduce exposure and vulnerability while increasing the capacity to cope (irrespective of the future climate hazard).

Hence, **future climate data can be used to inform a top-down approach** to assessing climate risk.

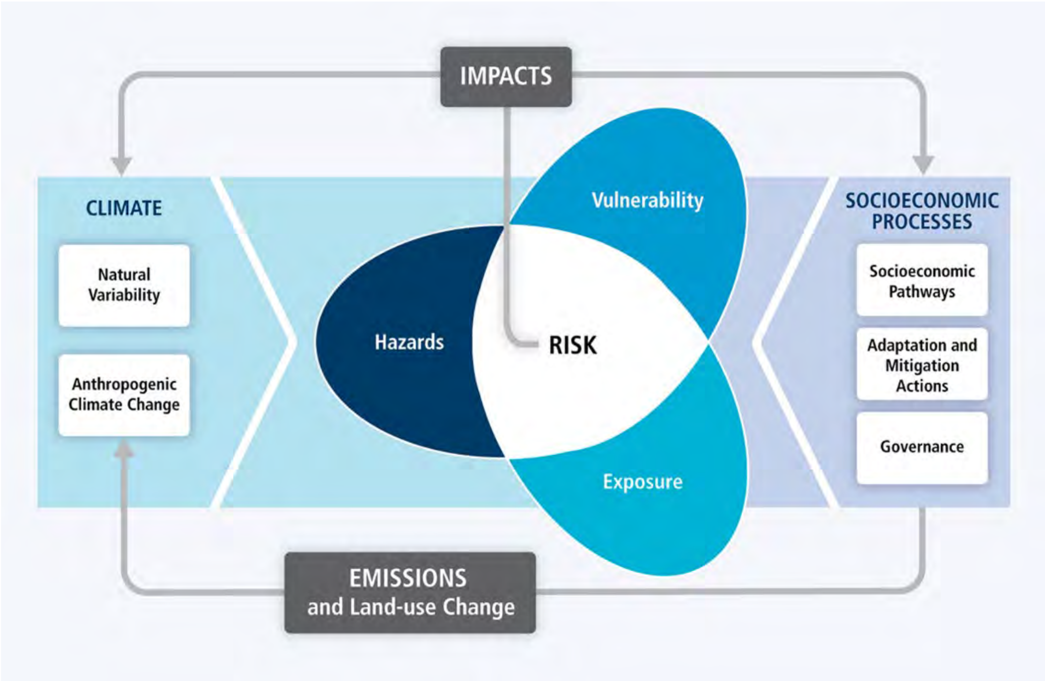



***Figure C1.*** *Climate risk envisioned as the overlap of hazard, exposure, and vulnerability.*[2]

[2] IPCC, 2014: Summary for policymakers. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1-32.

## Which Emissions Scenario(s) Should I Use?

Climate projections are generated by different climate models and using a range of emissions scenarios. Differences in the projections due to the use of different climate models reflect the fact that we still have an incomplete understanding of how the climate system functions, and differences due to the choice of emissions scenarios reflect the fact that we have only imperfect knowledge of how society, its land use practices, and its emissions may change in the future. Given these diverse sources of uncertainty, it is best to examine a range of possible futures as represented by different climate models and emissions scenarios.

To reduce climate model uncertainty, PCIC has selected a range of climate models that are best suited to regions in BC. Ultimately, deciding on which emissions scenario(s) to assess will depend on the context of your project or policy, including your risk tolerance and time horizon, as discussed next.

## Time Horizon

Users of climate projections should consider the time horizon, or life cycle, relevant to their project or policy before selecting a future scenario. This could be the expected lifetime of a given piece of infrastructure, or a policy that needs to be responsive to changing external conditions. As highlighted above in Understanding Shared Socioeconomic Pathways, in the near term – up to a few decades into the future – climate projections do not differ meaningfully across SSP scenarios. This is true at both the global regional scales. Hence, if there is a recurring opportunity to review a given decision every two to three decades, then the choice of emissions scenario may be less relevant. An example of a recurring decision might be the choice of paving material to use when repaving a roadway.

On the other hand, if an infrastructure element is expected to last 50 to 75 years, the choice of scenario becomes more critical because projected changes from different scenarios will differ substantially by the end-of-life of the structure. An example of a long-term infrastructure design decision might be determining the capacity of an upgraded storm sewer. Hence, planners and designers may be able to minimize the role of scenario uncertainty in adaptation planning by first determining the decision-making time-frame.

## Level of Acceptable Risk

Climate scientists can help practitioners and decision makers understand how climate-related hazards that affect the assets they are responsible for (i.e., systems, infrastructure, or policy) may change in the future. This requires dialog among practitioners, decision makers and climate scientists to understand and describe the potential impacts of projected climate change under different emissions scenarios. Because climate scientists are not experts on how risk to assets will materialize, it remains the responsibility of practitioners and decision makers to manage future climate-related risks to their assets.

When assessing future scenarios, decision makers should consider four questions:

1. "What components of my project are vulnerable to climate change?"
2. "How likely is it that society will follow a future emissions pathway that will intensity the hazards to which my assets will be exposed?"
3. "What level of risk am I comfortable assuming?"
4. "What is the trade-off between risk and cost?"

Regardless of the rationale used, understanding the level of risk that is appropriate to your work is complex. It will undoubtedly require engagement with diverse partners and stakeholder groups to understand the range of potential impacts.

## Scenario Choice

Ideally, public assets should be managed in a way that limits their vulnerability to plausible future hazards. Climate science has not yet ruled out the plausibility of any of the main socio-economic pathway scenarios that were considered in the most recent IPCC assessment. The choice of scenario will depend critically on the climate hazards that would affect the asset of interest. This is because some hazards will likely decline, such as extreme snow loads on buildings that could cause building collapse, while others, related to heat stress, intense rainfall, and flash flooding, will increase. If an asset is affected by both decreasing and increasing hazards, then the approach that would most completely limit vulnerability to future hazards would involve using a no change (historical climate) scenario for declining hazards, and a rapid change, high emissions scenario (e.g., SSP5-8.5) for increasing hazards.

## Tips for Using Climate Data

✓ **View multiple variables (indices) within each category**

To get a more complete understanding of projected changes, users should consider multiple climate variables. For example, if you want to know how precipitation will change in your region, review both a frequency-based variable (e.g., Number of Wet Days > 20 mm) and a volume-based variable (e.g., Total Precipitation). The Hazard Reference Tables (Appendix E) can help users identify which climate variables may be best suited to a particular context or application.

✓ **Review both annual and seasonal data**

Annual mean changes can mask important seasonal behaviour. For example, a small annual mean precipitation projection might contain a substantial reduction in the summer along with a projected increase in the fall, winter, or spring. Therefore, users should assess both annual and seasonal projections for certain climate variables.

✓ **Select a relevant time period**

The complete data package offers projections for the "2030s" (2021-2050), "2050s" (2041-2070) and "2080s" (2071-2100). As highlighted above, users should select the period that is most appropriate to the entire life cycle of their project or policy.

✓ **Determine an appropriate emissions scenario(s)**

There is no right or wrong emissions scenario to use in decision-making: all scenarios represent possible futures and decision-making is highly context dependent. Selecting a scenario requires consideration of risk tolerance, sensitivity to climate impacts and extreme events, the time horizon of the project, and more. It can be useful to remember that planning for a high emissions scenario can help ensure that adaptation measures are resilient for a longer period of time if, in fact, a lower emissions scenario were to play out.

✓ **Examine both means and extremes**

The median, 10th percentile, and 90th percentile values have been provided in all summary tables for this assessment. Depending on the application, one, two or all three of these values may be important. For instance, if one were designing a building for general use (e.g., retail space, detached home) with an anticipate lifetime of 50 years or so, then the change in the median of Cooling Degree Days (CDDcool18C) under SSP5-8.5 might be appropriate to consider. Alternatively, if the building were classified as critical, long-lived infrastructure (e.g., a hospital, or power plant) then it might be more appropriate to design to the 90th percentile value for that climate index, to capture the upper range of possibility.

# Appendix D

## FURTHER RESOURCES

There are a growing number of guidance materials, learning resources, and data tools available to support the use of climate projections for regional assessments. Below is a non-exhaustive list of open access resources suited to a broad range of users. For additional guidance, contact PCIC (climate@uvic.ca) or the CRD Climate Action Program (climateaction@crd.bc.ca).

### Additional Climate Projections Tools and Resources

| **ClimateData.ca** |
|---|
| User-friendly tool for exploring climate projections and related data |
| Developed and maintained by the Canadian Centre for Climate Services, a team of information and outreach specialists at Environment and Climate Change Canada (ECCC), ClimateData.ca is an online, user-friendly data portal providing future climate projections for regions across Canada. Users can explore gridded data at small scales or aggregated by watershed, census subdivision, or health region. ClimateData.ca provides plain language descriptions for all climate variables and has various options for visualizing and analyzing climate data. Temperature and precipitation-based variables (the same as those provided by PCIC) as well as humidex, relative sea level change and climate change-scaled IDF data are available.<br><br>ClimateData.ca also includes a comprehensive learning zone (climatedata.ca/learn) that is regularly updated to support climate data users in a variety of applications, including some sector-specific information, as well as a Climate Services Support Desk for general or technical inquiries. The site is continuously evolving with more content and features in development. |

| **PCIC Climate Explorer** |
|---|
| *Useful for intermediate or advanced users analyzing a specific location* |
| PCIC Climate Explorer (PCEX) is an online map-based tool for viewing gridded historical climate data and future projections at any location of interest across Canada. Users can select an arbitrary region on the map, compare climate variables for that region, and download the results in Excel formats. Additional variables for extreme precipitation and streamflow are also available. |

| **ClimateAtlas.ca** |
|---|
| *Useful for creating communications materials and learning more about climate adaptation* |
| ClimateAtlas.ca is an interactive tool combining climate projections (again using PCIC's data), mapping, and storytelling to inspire local, regional, and national action and solutions. Users can explore videos, articles, educator resources, and various topic including Indigenous knowledges, agriculture, and health. |

## Spatial Analogues Tool* (ClimateData.ca)

*Useful for visualizing the future climate at a target location*

With this tool, starting with a target city of interest**, users can search for other cities whose historical climate closely matches the future-projected climate of the target city. Users can search for spatial analogues under a low or high emissions scenario and considering up to four different climate indices. For example, one combination of indices suggests that by the 2050s, Quebec City may have a climate similar to present-day Boston. By examining how Boston has adapted to its current climate, planners in Quebec City might gain insights on how to prepare and adapt to climate change.

*This tool is a beta app, meaning it is a new tool being carefully monitored and is still under development.

**Target cities for British Columbia are presently limited to: Victoria, Vancouver, Abbotsford, Kelowna, and Prince George.

# Infrastructure Design Resources

## PCIC Design Value Explorer (DVE)

*Engineering design professionals can access future-projected climatic design values*

The DVE is an online, open-access technical tool for assessing 19 climate design values based on observed data and projections of how they may change in the future. It provides engineers, architects, planners, and other professionals with quantitative, fine-scale historical and future-projected climate information for designing buildings and infrastructure.

## PCIC Future-Shifted Weather Files

*Energy Modelers can access future-projected weather files*

Weather data adjusted for climate change has been produced for three time periods (2020s, 2050s, and 2080s) using the high emissions pathway RCP8.5 (CMIP5). Data are available for several hundred weather stations across Canada. Future-shifted weather files can help building designers simulate building performance under a changing climate, supporting resilient design. Further work is underway to update the weather files for CMIP6-SSPs and to create weather files that capture both mean change and extreme events.

## **CSA PLUS 4013-19:** Development, interpretation, and use of rainfall intensity-duration-frequency (IDF) information: Guideline for Canadian water resource practitioners*

*Guidance for Canadian water resource practitioners to better incorporate climate change into IDF information*

Technical guidance from the Canadian Standards Association (CSA)—informed by scientists at ECCC and other subject matter experts—for the development, interpretation, and use of rainfall intensity-duration-frequency (IDF) information. Chapters 5 and 6 include guidance for how to incorporate climate change into the formulation and application of IDF information.

*Access fee required

## Short-Duration Rainfall IDF Data (ClimateData.ca)

*Users can explore historical and climate change-scaled IDF information for weather stations across Canada*

ClimateData.ca offers easy access to historical short-duration rainfall IDF data (from 1 to 24 hours) and projected rainfall amounts under low, moderate, and high emissions scenarios at locations across Canada (12 locations within the capital region). This IDF information is consistent with the above-mentioned CSA guidance. Users can download a zip file containing all the historical and future estimated values.

In addition, the Learning Zone on ClimateData.ca has a topic dedicated to using IDF rainfall data to account for a changing climate. For more information on this product and about designing future-ready buildings, visit ClimateData.ca/learn/

# Appendix E

## HAZARD REFERENCE TABLES

The Hazard Reference Tables help users identify which climate variables included in the complete data package may be best suited to a particular context or application. Users should use the short name (left column) to navigate to the appropriate variable in the complete data package.

**Seasonal Patterns and Climate Change**

- ✓ Increasing temperatures year-round
- ✓ Fewer frost days and a longer growing season
- ✓ Shifting heating and cooling demands

**Key sectors:** Agriculture, Biodiversity, Parks, Infrastructure

| | |
|---|---|
| **Temperature** | |
| **TX** | Daytime high temperature, averaged over all days in a year or season |
| **TM** | Mean daily temperature, averaged over all days in a year or season |
| **TN** | Daytime low temperature, averaged over all days in a year or season |
| **Seasonal** | |
| **FD** Frost Days | Number of days in a year when the minimum temperature is below 0°C |
| **ID** Ice Days | Number of days in a year when the maximum temperature is below 0°C |
| **GSL** Growing Season Length | Number of days between: (i) the first span of 6 or more days in the year with a daily minimum temperature > 5°C and (ii) the first span after July 1st of 6 or more days with a daily minimum temperature < 5°C. |
| **WSDI** Warm Spells | A "warm spell" is defined as 6 or more consecutive days when the daily maximum temperature exceeds the 90th percentile value of the historical baseline. This index measures the number of days in a typical year that a warm spell occurs. (A warm spell can occur at any time of year). |
| **CSDI** Cold Spells | A "cold spell" is defined as 6 or more consecutive days when the daily minimum temperature is less than the 10th percentile value of the historical baseline. This index measures the number of days in a typical year that a cold spell occurs. (A cold spell can occur at any time of year). |
| **Design** | |
| **HDDheat18C** Heating Degree Days | Number of degree days below 18°C in a year. A rough estimate for the energy demand needed to heat a building in a typical year. |
| **CDDcold18C** Cooling Degree Days | Number of degree days above 18°C in a year. A rough estimate for the energy demand needed to cool a building in a typical year. |

**Increasing Temperatures and Extreme Heat**

- ✓ Hotter daytime temperatures
- ✓ Warmer nighttime temperatures
- ✓ Heat waves becoming hotter and more frequent

**Key sectors:** Emergency Management, Health, Biodiversity, Watershed

| | |
|---|---|
| **Daytime Temperatures** | |
| **TX** | Daytime high temperature, averaged over all days in a year or season |
| **TXx** | Hottest daytime high temperature in a year or season |
| **SU**<br>Summer Days | Number of days in a typical year when the daytime high is above 25°C |
| **SU30**<br>Hot Summer Days | Number of days in a typical year when the daytime high is above 30°C |
| **Nighttime Temperatures** | |
| **TN** | Daily minimum temperature in a typical year or season |
| **TNx** | Warmest nighttime low temperature in a typical year or season |
| **TR16C**<br>Temperate Nights | Number of days in a year when the nighttime low stays above 16°C |
| **TR**<br>Tropical Nights | Number of days in a year when the nighttime low stays above 20°C |
| **Heat Extremes** | |
| **HWD**<br>Heat Wave Days | Number of days in a typical year classified as a "heat wave" |
| **HWN**<br>Heatwave Number | Number of distinct heat wave events in a typical year |
| **HWXL**<br>Heatwave Length | Length (in days) of the longest heat wave in a typical year |
| **TXH**<br>Heatwave Intensity (Day) | Daytime high temperature averaged across all heat waves in a typical year |
| **TNH**<br>Heatwave Intensity (Night) | Nighttime low temperature averaged across all heat waves in a typical year |
| **TXHX** | Daytime high temperature during the most extreme heat wave in a year |
| **TNHX** | Nighttime low temperature during the most extreme heat wave in a year |
| **Return Periods**<br>(various) | The data package provides return levels and return period changes for the 5-, 10-, 20-, and 30-year Hottest Day. |

**Extreme Precipitation and Flooding**

*In this data package, there are no direct indices for flooding.*
*Rainfall extremes may trigger flooding under certain circumstances.*

- ✓ More precipitation occurring over short time periods
- ✓ More days with heavy rainfall

**Key sectors:** Public Works/Engineering, Infrastructure, Biodiversity, Health, Agriculture, Watershed

| | |
|---|---|
| **Precipitation** | |
| **PR**<br>Total Precipitation | Total precipitation in a typical year or season |
| **Rain**<br>Total Rainfall | Total rainfall in a typical year or season |
| **Snow**<br>Summer Days | Total snowfall in a typical year or season |
| **Rainfall Extremes** | |
| **RX1DAY** | Maximum amount of precipitation (in mm) occurring in a single day in a typical year |
| **RX5DAY** | Maximum amount of precipitation (in mm) occurring over a 5-day period in a typical year |
| **R10MM** | Number of days in a typical year that receive more than 10mm of total precipitation |
| **R20MM** | Number of days in a typical year that receive more than 20mm of total precipitation |
| **R95P / R95DAYS** | Amount of precipitation over the year that exceeds the 95th percentile of historical (baseline) daily precipitation / Number of days in a typical year that exceed this amount. |
| **R99P / R99DAYS** | Amount of precipitation over the year that exceeds the 99th percentile of historical (baseline) daily precipitation / Number of days in a typical year that exceed this amount. |
| **Return Periods**<br>(Various) | The data package provides 5-, 10-, 20-, 30-, and 50-year return periods for annual wettest 1-, 2-, and 5-day rainfall events. It also provides changes to rainfall return periods for an event of given magnitude. |

**Drought**

*In this data package, there are no direct drought variables. Hotter temperatures, less rainfall and reduced snowpack may lead to drought conditions in the warmer months.*

**Key sectors:** Agriculture, Biodiversity, Health, Watershed

| | |
|---|---|
| **Precipitation** | |
| **PR – Summer** Total Precipitation in Summer | Total precipitation in a typical summer (may also be important to consider PR for spring and fall) |
| **SNOW** Total Snowfall | Total snowfall (fall-winter-spring) |
| **CDD** Consecutive Dry Days | Number of days comprising the longest "dry spell" in a typical year. Dry spells are defined as consecutive days with less than 1mm of total precipitation. |
| **Temperature** | |
| **TX** | Daytime high temperature in a typical year or season |
| **TXx** | Hottest daytime high temperature in a typical year or season |
| **SU** Summer Days | Number of days in a typical year when the daytime high is above 25°C |

**Wildfire and Air Quality**

*In this data package, there are no direct wildfire variables. Hotter temperatures and less rainfall in the warmer months may lead to more favourable conditions for wildfire.*

**Key Sectors:** Health, Biodiversity, Infrastructure, Agriculture

Variables listed under Drought (see above) can also be considered as informative for Wildfire. Additional variables such as humidity, wind speed, and wind direction must also be considered in order to establish favourable conditions for Wildfire. The Canadian Forest Service has analyzed such historical data to develop Fire Weather Normals, which provide insight into how "fire weather" varies spatially and throughout the year. See https://cwfis.cfs.nrcan.gc.ca/ha/fwnormals for more.

Future-projected temperature and precipitation conditions that may be favourable to increased incidence of Wildfire may be obtained from other regional climate projections reports in BC, including:

- Climate Projections for BC Northeast Region
- Climate Projections for the Okanagan Region
- Climate Projections for the Cowichan Valley Regional District
- Climate Projections for Metro Vancouver

# Appendix F

## COMPLETE LIST OF CLIMATE INDICES

| Name | Variable | Definition | Units |
|---|---|---|---|
| | | **Standard** | |
| **PR** | Precipitation | Annual/seasonal precipitation totals | mm |
| **RAIN** | Rainfall | Annual/seasonal rainfall portion of precipitation using temperature-based rain-snow partitioning | mm |
| **SNOW** | Snowfall | Annual/seasonal snowfall (snow water equivalent) portion of precipitation | mm (H2Oeq) |
| **TM** | Daily Average Temperature | Annual/seasonal daily average temperature | °C |
| **TX** | Daily Maximum Temperature | Annual/seasonal average daily maximum temperature | °C |
| **TN** | Daily Minimum Temperature (usually overnight) | Annual/seasonal average daily minimum temperature | °C |

| Name | Variable | Definition | Units |
|---|---|---|---|
| | | **CLIMDEX: Temperature Based** | |
| **TXX** | Maximum TX | Annual/seasonal maximum of TX | °C |
| **TNN** | Minimum TN | Annual/seasonal minimum of TN | °C |
| **TXN** | Minimum TX | Annual/seasonal minimum of TX | °C |
| **TNX** | Maximum TN | Annual/seasonal maximum of TN | °C |
| **TX90P** | Hot Days | Annual percentage of days with TX > 90th historical percentile | % |
| **TX10P** | Cool Days | Annual percentage of days with TX < 10th historical percentile | % |
| **TN90P** | Warm Nights | Annual percentage of days with TN > 90th historical percentile | % |
| **TN10P** | Cold Nights | Annual percentage of days with TN < 10th historical percentile | % |
| **DTR** | Diurnal Temperature Range | Annual/seasonal diurnal temperature range, TX – TN | °C |
| **SU** | Summer Days | Annual number of days with TX > 25 °C | days |
| **SU30** | Hot Summer Days | Annual number of days with TX > 30 °C | days |
| **TR** | Tropical Nights | Annual number of days with TN > 20 °C | days |
| **TR16C** | Temperate Nights | Annual number of days with TN > 16 °C | days |
| **ID** | Ice Days | Annual number of days with TX < 0 °C | days |
| **FD** | Frost Days | Annual number of days with TN < 0 °C | days |
| **CSDI** | Cold Spells | Annual count of days with at least 6 consecutive days when TN < 10th historical percentile | days |
| **WSDI** | Warm Spells | Annual count of days with at least 6 consecutive days when TX > 90th historical percentile | days |
| **GSL** | Growing Season Length | Growing season length (number of days between first span of at least 6 days with TM >5°C and first span after July 1st of 6 days with TM <5°C) | days |

| Name | Variable | Definition | Units |
|---|---|---|---|
| | | **CLIMDEX: Precipitation-Based** | |
| **CDD** | Consecutive Dry Days | Annual maximum length of consecutive dry days (PR < 1 mm) | days |
| **CWD** | Consecutive Wet Days | Annual maximum length of consecutive wet days (PR ≥ 1 mm) | days |
| **SDII** | Simple Daily Precipitation Intensity Index | Annual average PR on days with PR ≥ 1 mm | mm |
| **R1MM** | Precipitation ≥ 1 mm | Annual count of days with PR ≥ 1 mm | days |
| **R10MM** | Precipitation ≥ 10 mm | Annual count of days with PR ≥ 10 mm | days |
| **R20MM** | Precipitation ≥ 20 mm | Annual count of days with PR ≥ 20 mm | days |
| **RX1DAY** | Maximum 1-Day PR | Annual/seasonal maximum 1-day PR | mm |
| **RX2DAY** | Maximum 2-Day PR | Annual/seasonal maximum 2-day PR | mm |
| **RX5DAY** | Maximum 5-Day PR | Annual/seasonal maximum 5-day PR | mm |
| **RN1DAY** | Maximum 1-Day RAIN | Annual/seasonal maximum 1-day rainfall | mm |
| **RN2DAY** | Maximum 2-Day RAIN | Annual/seasonal maximum 2-day rainfall | mm |
| **RN5DAY** | Maximum 5-Day RAIN | Annual/seasonal maximum 5-day rainfall | mm |
| **R95P** | Very Wet Day PR | Annual total PR when PR > 95th percentile of daily PR in historical period | mm |
| **R95DAYS** | Very Wet Days | Annual number of days when PR > 95th percentile of daily PR in historical period | days |
| **R99P** | Extreme Wet Day PR | Annual total PR when PR > 99th percentile of daily PR in historical period | mm |
| **R99DAYS** | Extreme Wet Days | Annual number of days when PR > 99th percentile of daily PR in historical period | days |
| Name | Variable | Definition | Units |
| | | **Degree Days** | |
| **CDDcold18C** | Cooling Degree Days | Annual, cumulative TM difference above 18 °C | °C-days |
| **GDDgrow5C** | Growing Degree Days | Annual, cumulative TM difference above 5 °C | °C-days |
| **HDDheat18C** | Heating Degree Days | Annual, cumulative TM difference below 18 °C | °C-days |
| **FDDfreeze0C** | Freezing Degree Days | Annual, cumulative TM difference below 0 °C | °C-days |
| Name | Variable | Definition | Units |
| | | **Heatwave Indices** | |
| **HWD** | Heatwave (HW) days | Annual count of HW days, where a HW is defined as both TX and TN exceeding: 1) their 95th percentiles (historical), AND; 2) BC HARS thresholds[3] for at least 2 consecutive days. | days |
| **HWN** | HW number | Annual number of distinct HWs | # |
| **HWXL** | HW duration | Annual maximum HW length | days |
| **TNH** | HW intensity (night) | Average TN over all HWs in a year | °C |
| **TXH** | HW intensity (day) | Average TX over all HWs in a year | °C |
| **TNHX** | Maximum TNH | Average TN during most extreme HW in a year | °C |
| **TXHX** | Minimum TNH | Average TX during most extreme HW in a year | °C |
| **HWDD** | HW degree days | Annual, cumulative TM difference above HW threshold | °C-days |

[3] The lower threshold temperatures used in our HW definition, which is intended for use throughout BC, are TX = 28°C and TN = 13°C. These are the lowest temperatures found in any region of the map in Figure 3, page 14 of the 2023 report, BC Provincial Heat Alert and Response System (BC HARS): 2023, May 2023. Available at: http://www.bccdc.ca/health-professionals/professional-resources/heat-event-response-planning.

| Name | Variable | Definition | Units |
|---|---|---|---|
| | | **Return Levels** | |
| **TX_RP5** | 5-Year return level of TX | 5-Year return level of TX | °C |
| **TX_RP10** | 10-Year return level of TX | 10-Year return level of TX | °C |
| **TX_RP20** | 20-Year return level of TX | 20-Year return level of TX | °C |
| **TX_RP25** | 25-Year return level of TX | 25-Year return level of TX | °C |
| **TX_RP30** | 30-Year return level of TX | 30-Year return level of TX | °C |
| **TN_RP5** | 5-Year return level of TN | 5-Year return level of TN | °C |
| **TN_RP10** | 10-Year return level of TN | 10-Year return level of TN | °C |
| **TN_RP20** | 20-Year return level of TN | 20-Year return level of TN | °C |
| **TN_RP25** | 25-Year return level of TN | 25-Year return level of TN | °C |
| **TN_RP30** | 30-Year return level of TN | 30-Year return level of TN | °C |
| **RN1_RP5** | 5-Year return level of RN1DAY | 5-Year return level of RN1DAY | mm |
| **RN1_RP10** | 10-Year return level of RN1DAY | 10-Year return level of RN1DAY | mm |
| **RN1_RP20** | 20-Year return level of RN1DAY | 20-Year return level of RN1DAY | mm |
| **RN1_RP30** | 30-Year return level of RN1DAY | 30-Year return level of RN1DAY | mm |
| **RN1_RP50** | 50-Year return level of RN1DAY | 50-Year return level of RN1DAY | mm |
| **RN2_RP5** | 5-Year return level of RN2DAY | 5-Year return level of RN2DAY | mm |
| **RN2_RP10** | 10-Year return level of RN2DAY | 10-Year return level of RN2DAY | mm |
| **RN2_RP20** | 20-Year return level of RN2DAY | 20-Year return level of RN2DAY | mm |
| **RN2_RP30** | 30-Year return level of RN2DAY | 30-Year return level of RN2DAY | mm |
| **RN2_RP50** | 50-Year return level of RN2DAY | 50-Year return level of RN2DAY | mm |
| **RN5_RP5** | 5-Year return level of RN5DAY | 5-Year return level of RN5DAY | mm |
| **RN5_RP10** | 10-Year return level of RN5DAY | 10-Year return level of RN5DAY | mm |
| **RN5_RP20** | 20-Year return level of RN5DAY | 20-Year return level of RN5DAY | mm |
| **RN5_RP30** | 30-Year return level of RN5DAY | 30-Year return level of RN5DAY | mm |
| **RN5_RP50** | 50-Year return level of RN5DAY | 50-Year return level of RN5DAY | mm |

**April 2024**

**REVISIONS FROM CONSULTANT**

**TO *CLIMATE PROJECTIONS FOR THE CAPITAL REGION* REPORT – 2024**
**after it was approved by CRD Environmental Services Committee on March 20, 2024**

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1. Page 2, Executive Summary, 3rd paragraph:

   By the 2050s, the capital region can expect the number of summer days exceeding 25°C to triple, going from an average of ~~12~~ 10 days per year to ~~around 40~~ 32 days per year. Nighttime temperatures in the summer will also increase. Nights where the temperature stays above 16°C (the lower threshold for heat alerts for Southern Vancouver Island) are projected to occur ~~up to 29 times per year by mid-century~~ around 8 times per year.

2. Page 12, Section 3.1 under *Projections:*

   In the Past, winter daytime high temperatures in the region averaged around ~~7~~ 6°C, while winter nighttime low temperatures averaged around ~~1.7~~ 1°C. The median future-projected TX increases to around ~~9~~ 8°C by the 2050s and to ~~11~~ 9.5°C by the 2080s. The median future-projected TN reaches around ~~4~~ 3°C by the 2050s and to ~~5.5~~ 4.5°C by the 2080s.

3. Page 23, Table 5: the units in the first row have been corrected from "°C" to "days".

4. Page 25:
   - The photo has been changed to better reflect the Heat Degree Days indicator.
   - Table 6: the units in the first row have been corrected from "°C" to "°C-days" in columns one, two and three and from "°C" to "%" in columns four and five.

5. Page 27, Table 7: the unit in the first column has been corrected from "°C" to "days".

6. Page 29:
   - The photo has been changed to better reflect the Cooling Degree Days indicator.
   - In Table 8, the units in the first row have been changed from "deg-days" to "°C-days" for consistency with previous tables.

# Climate Projections for the Capital Region (2024)

Nikki Elliott, Manager, Climate Action Programs

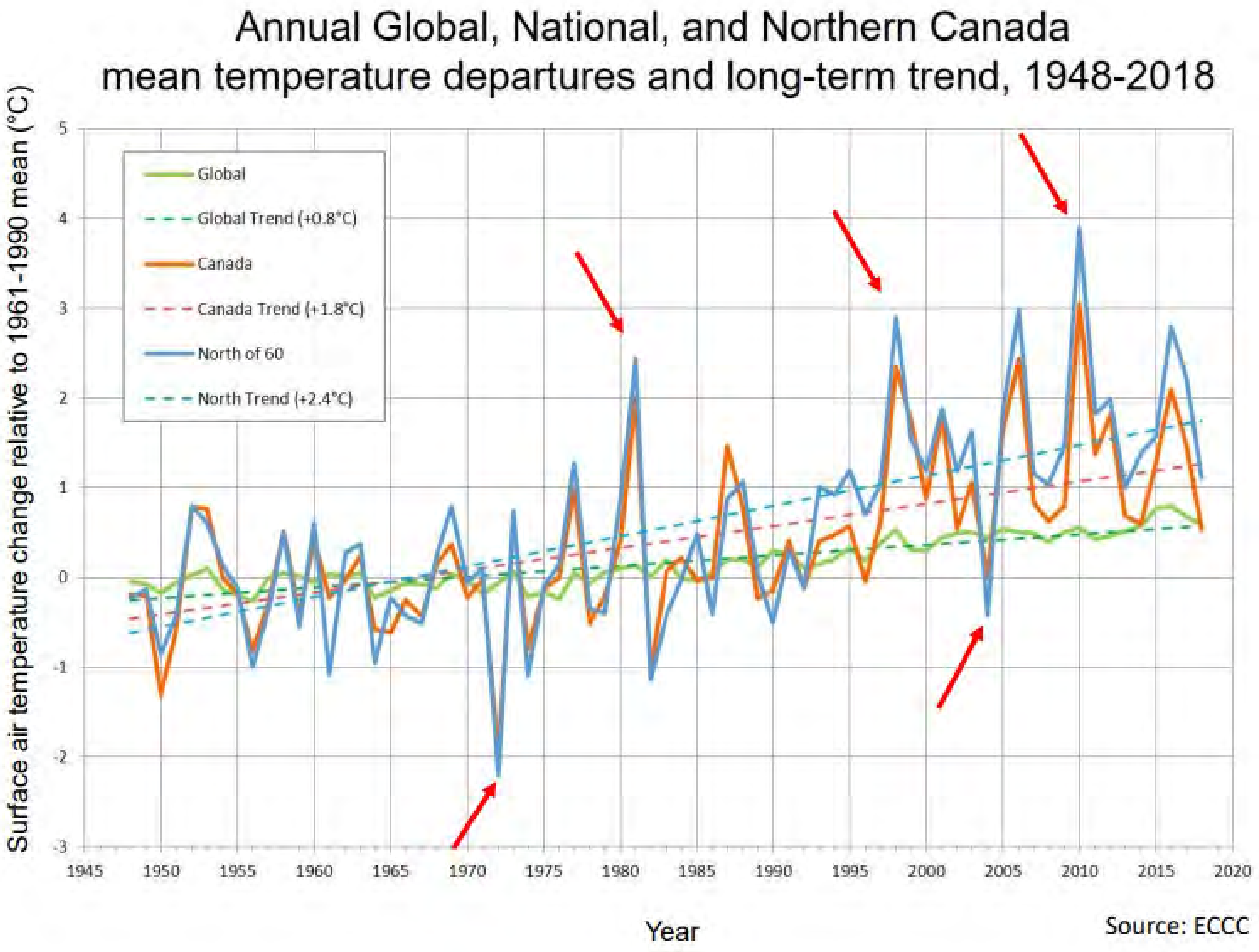
March 20, 2024

# Climate Change Trends

Climate change is both:

(1) Changes in average conditions over long periods time, and

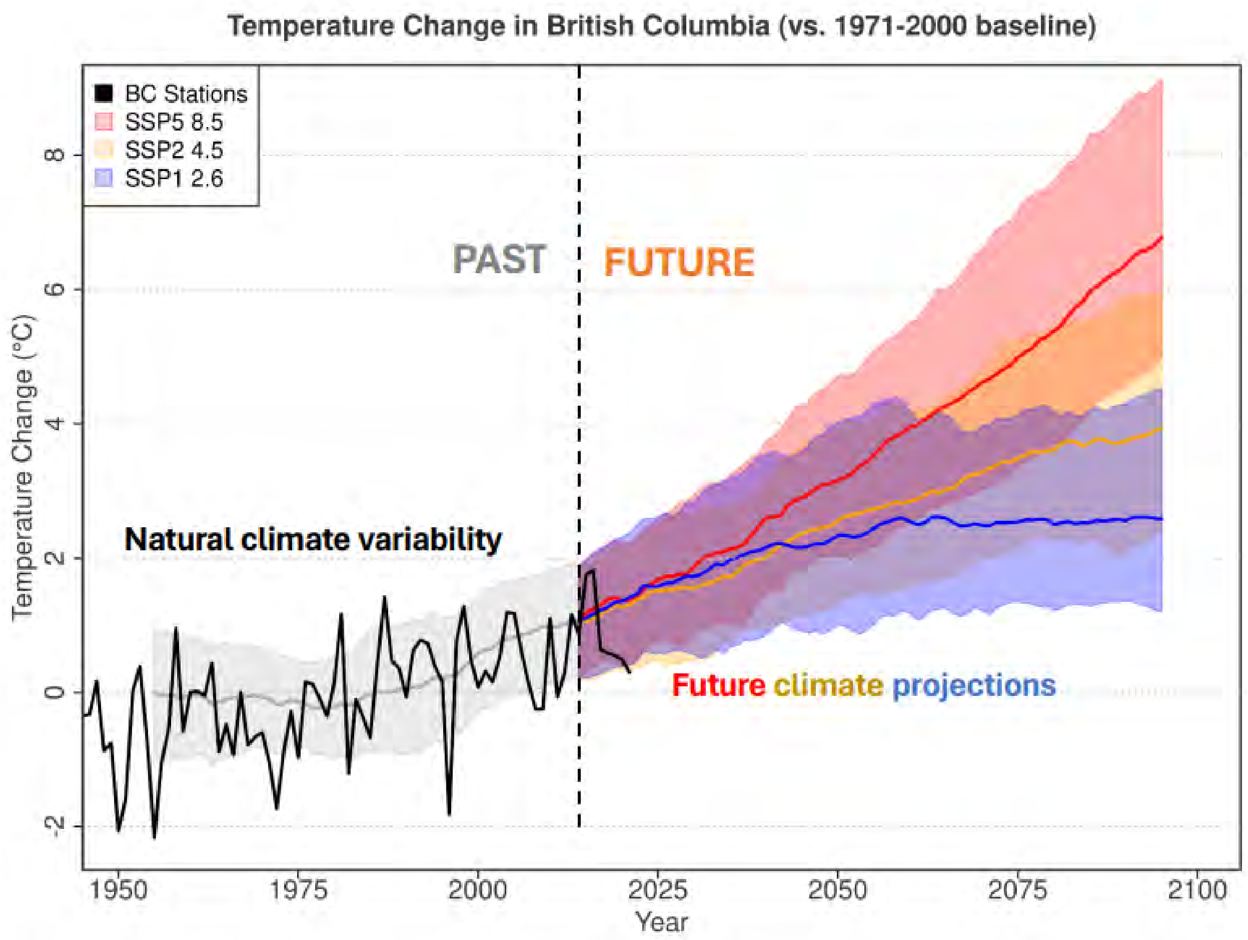
(2) Changes in the frequency intensity of extreme events






CRD

# Future Warming in BC





Climate projections are simulations of the future climate based on greenhouse gas ‘scenarios’

Source: PCIC (2024)


# Update Purpose

- Provide updated climate projections for the 2050s and 2080s
- Translate new global climate change projections to the regional and local scale
- Interpret what the projections imply for capital region
- Support and guide local planning and build local government staff capacity
- Provide a foundation of understanding for future, impacts-centered work

# New in 2024

- ✓ Updated modelling
- ✓ New indices for extreme heat
- ✓ Updated 'Regional Impacts' informed by local government staff
- ✓ New guidance section to support users
- ✓ GIS layers

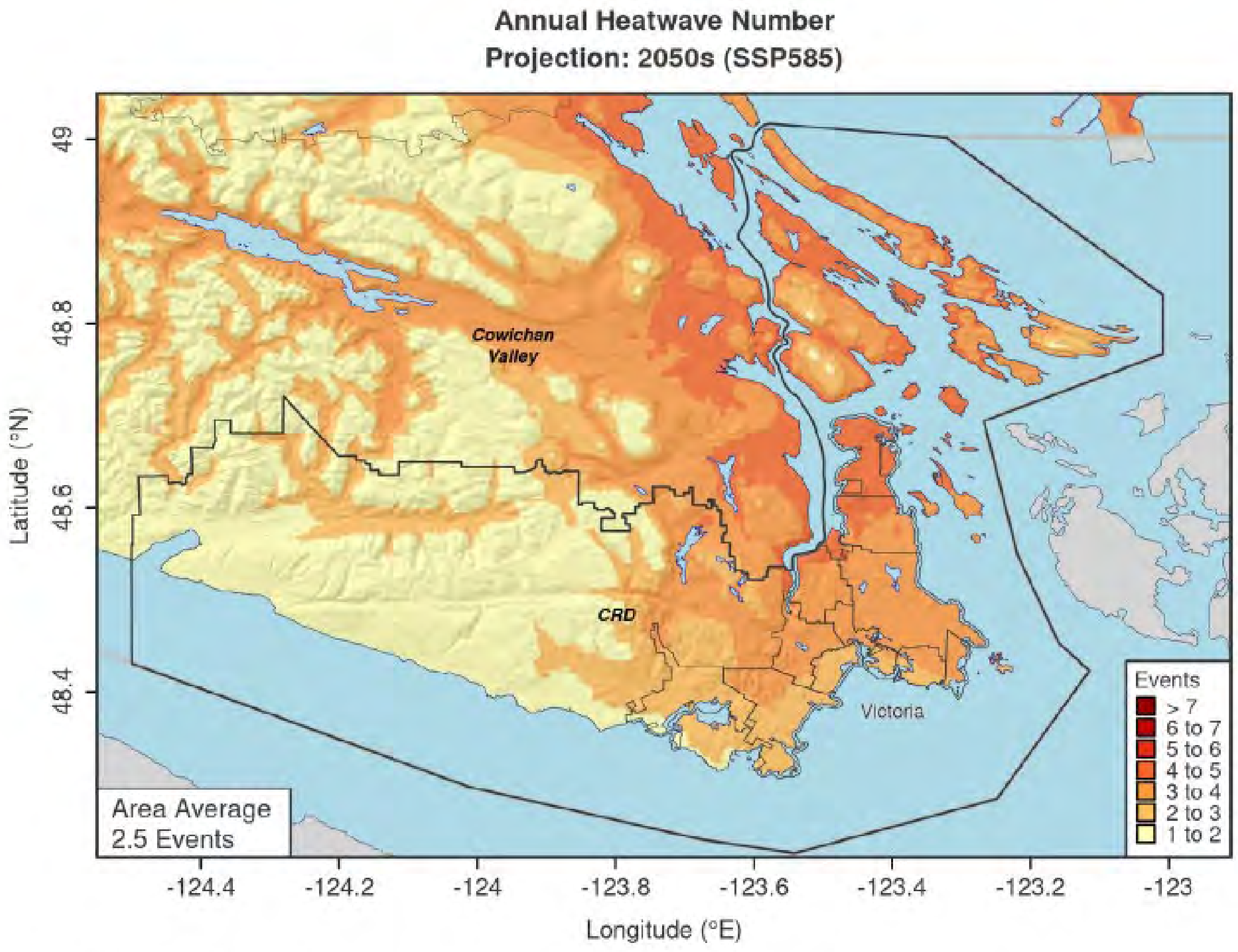



***Figure 15b.*** Projected number of annual heatwaves in the 2050s.

# What about other climate variables?

## Climate projections

| | | |
|---|---|---|
| High confidence | Temperature, Extreme Heat | • Hot Days<br>• Days above 25°C, 30°C<br>• Maximum Temperature |
| Medium confidence | Precipitation | • Wet Days<br>• Total Precipitation<br>• Max one-day precipitation |
| Low confidence | Wind, storms, snow accumulation, hydrology | • Storminess<br>• Storm Surges<br>• Wind |

## Coastal Flood Inundation Mapping

# High Level Results

- Hotter summer temperatures, with more extreme heat days and heatwaves
- Less rain and more dry days in the summer months
- Warmer winter temperatures, less frequent frost, and less snowfall
- More precipitation falling in fall, winter and spring
- Longer-lasting and more frequent extreme rainfall events

# Warmer Temperatures

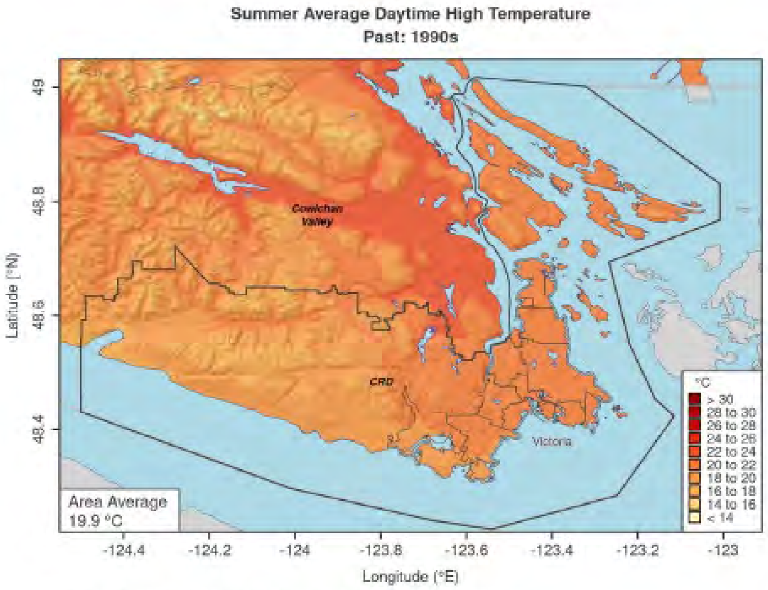



**Figure 4a:** *Summer average daytime high temperature in the Past.*

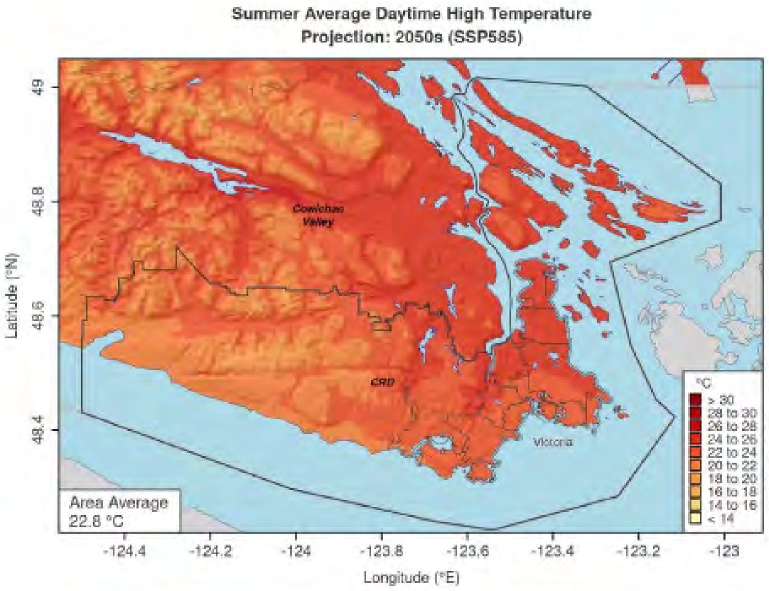
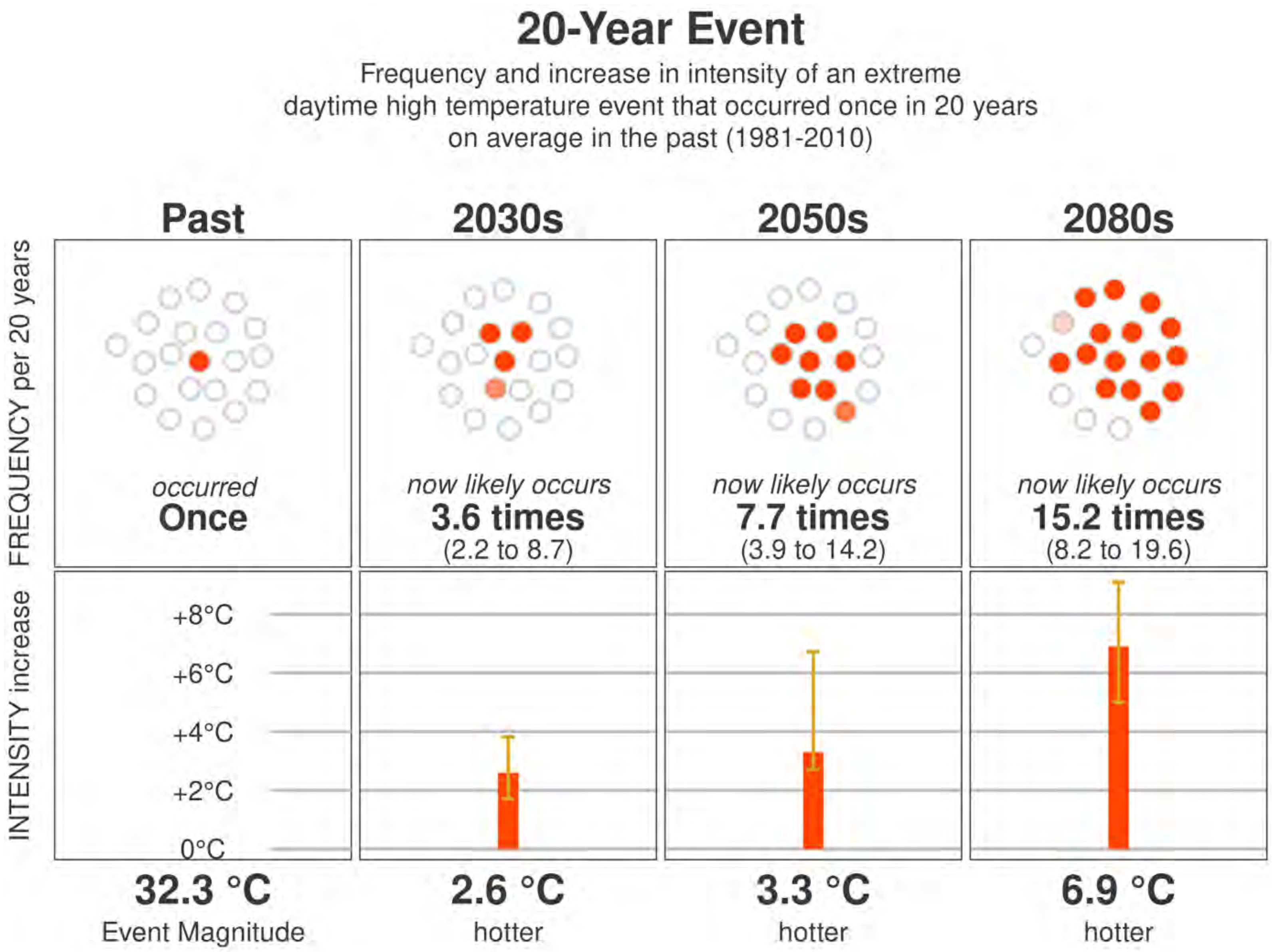



**Figure 4b:** *Projected summer average daytime high temperature in the 2050s.*

## Table 1: Regional Average Daytime High Temperature (TX)

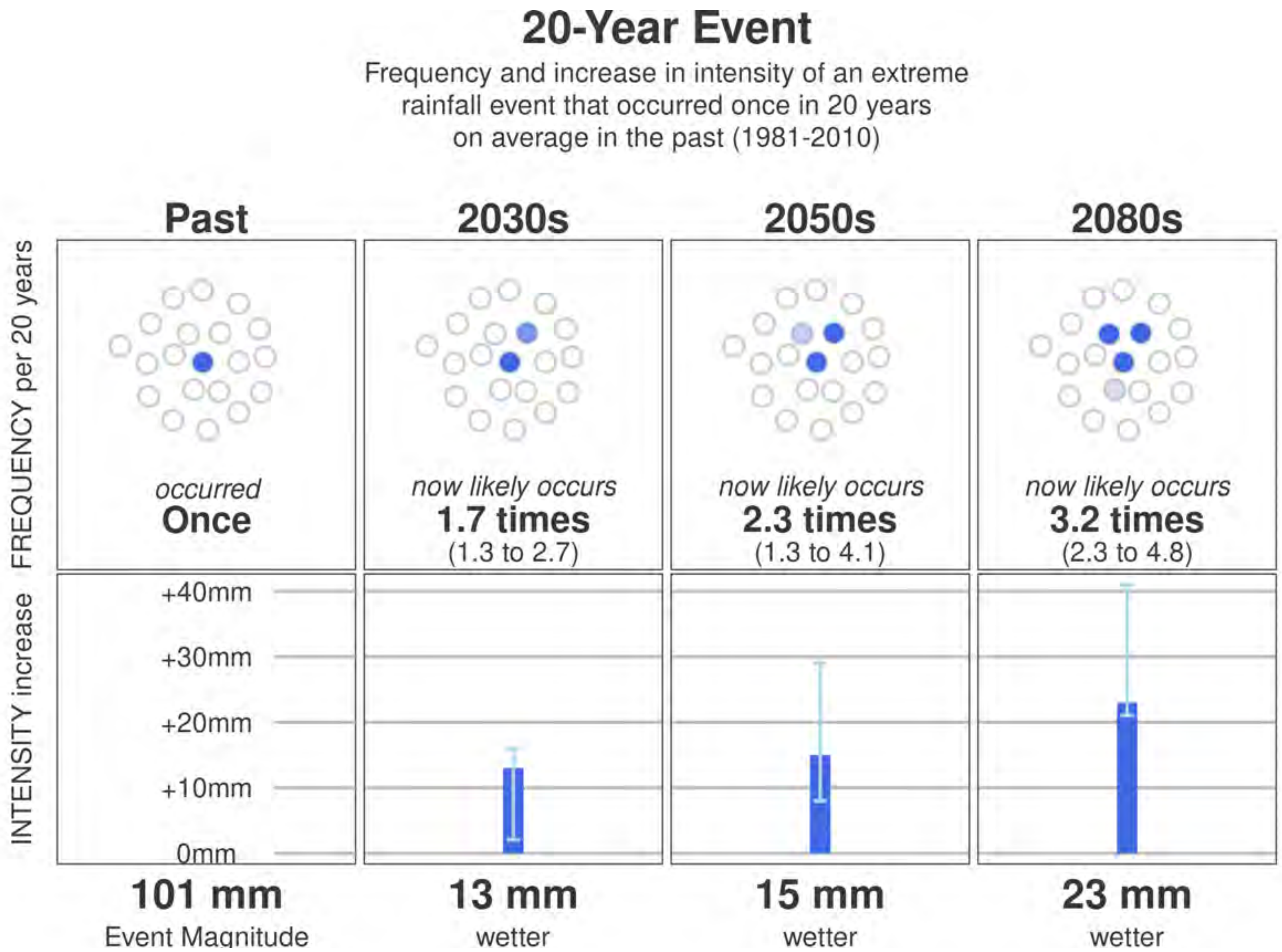
| | Past (°C) | 2050s Change (°C) | 2080s Change (°C) |
|---|---|---|---|
| Winter | 6 | 2.1 *(1.6 to 3.5)* | 3.5 *(2.8 to 6.5)* |
| Spring | 12 | 2.1 *(1.4 to 4.0)* | 3.5 *(2.6 to 6.3)* |
| Summer | 20 | 2.9 *(2.3 to 5.1)* | 4.7 *(4.1 to 8.7)* |
| Fall | 13 | 2.7 *(2.2 to 4.6)* | 4.0 *(3.6 to 7.2)* |
| Annual | 13 | 2.5 *(2.0 to 4.4)* | 3.9 *(3.4 to 7.0)* |

# Heat



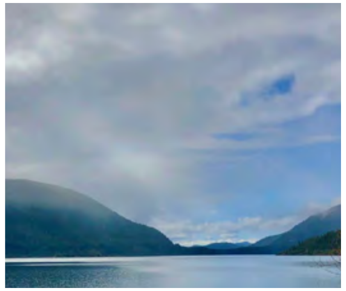
20-Year Event
Frequency and increase in intensity of an extreme daytime high temperature event that occurred once in 20 years on average in the past (1981-2010)
Past
2030s
2050s
2080s
FREQUENCY per 20 years
occurred
Once
now likely occurs
3.6 times
(2.2 to 8.7)
now likely occurs
7.7 times
(3.9 to 14.2)
now likely occurs
15.2 times
(8.2 to 19.6)
INTENSITY increase
+8°C
+6°C
+4°C
+2°C
0°C
32.3 °C
Event Magnitude
2.6 °C
hotter
3.3 °C
hotter
6.9 °C
hotter

# Precipitation



# Regional impacts

Health and Wellbeing



Water Supply and Demand

Rainwater Management and Sewerage

Ecosystems and Species

Buildings and Energy Systems

Transportation

Food and Agriculture

Recreation and Tourism

# Guidance for Users

**Seasonal Patterns and Climate Change**

- ✓ Increasing temperatures year-round
- ✓ Fewer frost days and a longer growing season
- ✓ Shifting heating and cooling demands

**Key sectors:** Agriculture, Biodiversity, Parks, Infrastructure

| Temperature | |
|---|---|
| TX | Da |
| TM | Me |
| TN | Da |

**Extreme Precipitation and Flooding**

*In this data package, there are no direct indices for flooding.*
*Rainfall extremes may trigger flooding under certain circumstances.*

- ✓ More precipitation occurring over short time periods
- ✓ More days with heavy rainfall

**Key sectors:** Public Works/Engineering, Infrastructure, Biodiversity, Health, Agriculture, Watershed

| Precipitation | |
|---|---|
| PR<br>Total Precipita | |
| Rain<br>Total Rainfa | |
| Snow | |

**Increasing Temperatures and Extreme Heat**

- ✓ Hotter daytime temperatures
- ✓ Warmer nighttime temperatures
- ✓ Heat waves becoming hotter and more frequent

**Key sectors:** Emergency Management, Health, Biodiversity, Watershed

| Daytime Temperatures | |
|---|---|
| TX | Daytime high temperature, averaged over all days in a year or season |
| TXx | Hottest daytime high temperature in a year or season |
| SU<br>Summer Days | Number of days in a typical year when the daytime high is above 25°C |

# Next Steps – Share Results

| Climate Projections for the Capital Region report | Complete data package (maps, tables, GIS files) |
|---|---|
| ✓ Raise awareness about climate change<br>✓ Present information to stakeholders<br>✓ Include in a strategic plan<br>✓ Evaluate high-level climate impacts | ✓ Conduct a detailed study<br>✓ Hazard, Vulnerability & Risk Assessments<br>✓ Specific design variables (e.g., emissions scenario, time period, subregion of interest) |

Making a difference...together

ECA 24-12

**REPORT TO ENVIRONMENTAL SERVICES COMMITTEE**
**MEETING OF WEDNESDAY, MARCH 20, 2024**

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## SUBJECT Extreme Heat Vulnerability Mapping and Information Portal Project

## ISSUE SUMMARY

To provide the results of the Capital Region Extreme Heat Vulnerability Mapping and Information Portal project.

## BACKGROUND

In 2018, a Regional Hazard Risk and Vulnerability Assessment (HRVA) for the capital region of BC was undertaken by the Regional Emergency Management Partnership, and extreme heat was identified as a hazard of regional significance. In the summer of 2021, BC experienced an extreme heat wave that claimed more than 700 lives, with 24 of those in the capital region.

To support emergency planning and local climate adaptation planning efforts, the Capital Regional District (CRD), with support from municipal partners, accessed a $150,000 Union of British Columbia Municipalities grant from the Community Emergency Preparedness Fund to undertake a regional extreme heat vulnerability mapping initiative. The intention of this initiative was to support the integration of extreme heat disaster risk reduction and climate adaptation planning through the development of a mapping product that provides a highly localized picture of vulnerability to heat in the capital region.

The CRD's Climate Action service worked collaboratively with local government climate/sustainability and emergency management program staff, and Island Health, to scope and execute the project. During the technical phase, CRD staff coordinated multiple workshops for representatives from all local governments in the region, including methodology review and project outputs, and undertook other key engagements to get technical input and guidance. Updates have been provided throughout the project via existing inter-municipal staff committees (climate and emergency management) and directly with key stakeholders, as required.

This project involved the development of three main indices:

- Extreme Heat Exposure
- Demographic Vulnerability Index
- Building Vulnerability Index

Each index was developed and analyzed with distinct methodologies, ranging from individual buildings to broader administrative geographic units. Results are provided in a project report (Appendix A).

As part of the grant initiative, the Capital Region Extreme Heat Information Portal has been collaboratively developed with project partners and the Province (GeoBC). This portal presents the data and analyses through interactive geographic maps for public exploration of their risk levels. Additionally, authorities have login access to the portal with more extensive maps and layers. The Extreme Heat Information Portal can be found at: https://heat.prepareyourself.ca.

**Next Steps**

The project findings can be used for a variety of purposes and will serve as important data input for further regional emergency and climate adaptation related mitigation, planning and policy initiatives.

The public portal, with accompanying geographic information system and products, will be shared directly with CRD and local government staff, regional emergency management programs, Island Health and provincial and federal agencies and can be used in educational initiatives. Staff will continue to connect with First Nations to provide the data and explore its applicability to their needs. As this work is very novel, staff will continue to connect with local governments to share learnings and resources and support the development of a provincial heat mapping guidance resource document.

The CRD remains committed to supporting established inter-municipal and inter-agency committees, seeking opportunities for enhanced collaboration. Recognizing the dynamic nature of technology and scientific advancements, ongoing risk modelling focused on extreme heat will be imperative to continuously update emergency preparedness, planning and response strategies.

## ALTERNATIVES

*Alternative 1*
The Environmental Services Committee recommends to the Capital Regional District Board:
That the results of the Extreme Heat Vulnerability Mapping and Information Portal project for the capital region be referred to municipal councils, the Electoral Areas Committee and First Nations for information.

*Alternative 2*
That this report be referred back to staff for additional information.

## IMPLICATIONS

*Alignment with Board & Corporate Priorities*

The recommendations align with the Board's priority Climate Action & Environment initiative 3c to increase resilience, community and adaptation planning to address climate-related risks and disasters.

*Alignment with Existing Plans & Strategies*

The recommendations align with goal 2 of the CRD Climate Action Strategy to support the region on its pathway to livable, affordable and low-carbon communities that are prepared for climate change, and specifically contribute to the completion of action 2-4d to expand data collection and mapping efforts to identify vulnerabilities to the impacts of climate change.

*Intergovernmental Implications*

The data and mapping components can help local authorities to recognize priority areas for risk reduction and enhanced emergency response efforts. By examining vulnerability to heat, emergency managers can strategically prioritize interventions and resources in areas most in need of attention. The data can also be used when updating local hazard, risk, and vulnerability analyses (i.e., HRVAs). CRD staff will continue to engage the region's local governments through the CRD's Climate Action Inter-Municipal Working and Task Force on better understanding new climate adaptation related policy approaches and supporting implementation of existing programs and policies in a collaborative manner.

## CONCLUSION

Working collaboratively with and on behalf of local governments in the capital region, the CRD secured a $150,000 grant from the Union of British Columbia Municipalities Community Emergency Preparedness Fund to initiate the Extreme Heat Vulnerability Mapping and Information Portal Project for the capital region. The data analyzed is provided in the new public Extreme Heat Information Portal. This work will help guide planning and decision-making to improve community resilience, emergency planning and public health strategies across the capital region.

## RECOMMENDATION

The Environmental Services Committee recommends to the Capital Regional District Board:
That the results of the Extreme Heat Vulnerability Mapping and Information Portal project for the capital region be referred to municipal councils, the Electoral Areas Committee and First Nations for information.

| | |
|---|---|
| Submitted by: | Nikki Elliott, BES, MPA, Manager, Climate Action Programs |
| Concurrence: | Larisa Hutcheson, P.Eng., Acting General Manager, Parks & Environmental Services |
| Concurrence: | Ted Robbins, B. Sc., C. Tech., Chief Administrative Officer |

## ATTACHMENT

Appendix A: Heat Vulnerability Data & Analysis Project Final Report – Licker Geospatial Consulting Company and Thrive Consulting (February 2024)

# Heat Vulnerability Data & Analysis Project

## Final Report

Prepared for Capital Regional District

February, 2024

**Licker Geospatial Consulting Co.**

2405 East Hastings St
Vancouver BC, V5K 1Y8

**Thrive Consulting**

Climate & Resilience Planning

## Table of Contents

## Key Terminology and Abbreviations

| | |
|---|---|
| 2021 extreme heat event | The fatal extreme heat event (also commonly referred to as the “heat dome”) that was experienced throughout much of British Columbia in late June, 2021. |
| Adaptive capacity | The characteristics of a community that increases resilience against extreme heat impacts, such as income and available shade-providing tree canopy. |
| AHP | Analytical Hierarchy Process |
| BCCDC | British Columbia Centre for Disease Control |
| BIR | Building Information Report |
| CRD | Capital Regional District |
| DA | Dissemination area |
| DSM | Digital Surface Model |
| DTM | Digital Terrain Model |
| Exposure | The distribution of extreme heat across the community |
| GCM | Global Circulation Model |
| IPCC | Intergovernmental Panel on Climate Change |
| LGeo | Licker Geospatial Consulting Co. |
| LiDAR | Light detection and ranging |
| LST | Land surface temperature |
| NDVI | Normalised difference vegetation index quantifies the greenness of vegetation. |
| Sensitivity | The characteristics of a community that increase susceptibility to extreme heat impacts, such as age and health |
| Urban heat island | The effect of urban islands capturing significantly more heat than surrounding, natural environments |

## List of Tables and Figures

**Executive summary**

In response to the recent extreme heat events in British Columbia, the Capital Regional District (CRD) has commissioned a comprehensive study to understand and address extreme heat vulnerability in the Capital Region. This report describes the collaborative effort between Licker Geospatial Consulting Co (LGeo), Thrive Consulting (Thrive), and the CRD and participating municipal partners and presents findings and recommendations emergent from the Heat Vulnerability and Data Analysis Project.

The Heat Vulnerability and Data Analysis Project's primary goal has been to develop a holistic understanding of extreme heat vulnerability across the capital region to inform regional partners in decision-making for emergency response, climate change adaptation and resilience planning, and public health initiatives and program design. The Project's significance has been underlined by the extreme heat event in 2021 (referred also as the "2021 heat dome"), which resulted in severe health impacts across the Province and brought to light the urgent need for extreme heat analyses and assessments across various levels of governments.

The methodology of this Project was developed in collaboration with consultants, local governments, and health agencies (Island Health and the BCCDC) involved in the effort. The effort includes three distinct phases in which a vulnerability-related index is produced. The three indices included in this effort are broadly described below.

- The *Socio-demographic Vulnerability Index*, which assesses the levels of community sensitivity to adverse impacts brought upon by extreme heat, and likewise the community's adaptive capacity to mitigate the impacts of extreme heat. Determinants of Socio-demographic Vulnerability include factors such as age, income, and chronic health conditions. The socio-demographic index involved an engagement process in which subject matter experts and those with lived experience helped develop a weighting schema for socio-demographic determinants of vulnerability. This weighting schema provides contextually-specific insight into regional characteristics of community derived vulnerability. The validation of this index showed the highly vulnerable areas in this index are aligned with observed hospitalisations and mortalities during the 2021 heat event.

- The *Heat Exposure Layer*, which describes the distribution of perceived outdoor temperature during the 2021 heat event. Determinants that describe extreme heat exposure include factors such as environmental composition (i.e. whether the local environment is heavily treed), land surface characteristics, measured temperatures during the 2021, and others. The heat exposure layer facilitates a nuanced understanding of outdoor extreme heat distribution across different urban and rural landscapes.

- The *Buildings Vulnerability Index*, which assesses the propensity of individual buildings to absorb and maintain heat during a heat wave. Determinants of building-specific vulnerability include factors such as building type, age, and height. The characteristics of a building contribute to the capacity a building has to cool (or remain cool) during an extreme heat event. Areas that score as highly vulnerable in the buildings index can present opportunities for emergency response, but also longitudinal planning that includes implementation of building retrofit programs.

The development of each index included engagements that spanned across the Project timeline in workshop and meeting formats. These various outreach and connection points helped to include perspectives from subject matter experts, those with lived experience in responding to extreme heat events, and other project stakeholders. The engagement objectives were to (1) confirm direction of approach, (2) confirm and refine selected determinants of vulnerability, and (3) allow for validation and feedback on the created vulnerability indices. The Project also includes an outreach phase, in which data and supporting language are hosted virtually for end-users to freely explore and employ the indices as needed.

The key findings of the vulnerability assessment at a municipal scale are summarised below. The findings are informed by the distribution of vulnerability indices, as well as geospatial analysis of vulnerability at the municipal scale:

- Amongst all of the incorporated areas in the CRD, the top demographic consideration was consistently either: percentage of the population who are renters or percentage of the population who are seniors.   The seniors finding is unsurprising as that was the highest weighted variable in the socio-demographic risk model.
- When combining buildings risk with socio-demographic vulnerability we note that Victoria, Saanich and Sidney have the most buildings which are in very vulnerable areas for both buildings and socio-demographics at 1,174, 806 and 628 residential buildings respectively. When examined by percentage of total residential buildings,  Sidney, Victoria and Esquimalt are the top three ranked communities with 19%, 13%, and 8% of all residential buildings being in both very high risk categories for buildings and sociodemographics. Conversely,  Metchosin, Highlands and North Saanich have no buildings in these two categories.
- With regards to air temperature, we note that Langford, Highlands and Colwood all have significant areas of their community in highest heat quintile (>=36.6℃ daily average air temperature) at 61%, 49% and 32% respectively, which may increase risk in the communities.  Conversely, communities more proximal to the ocean all have lower percentages of their communities in the highest heat quintile with Oak Bay, Sidney and Esquimalt at 5%, 2%, 1% of land area respectively.
- As urban heat is in many ways influenced by land use change and development, it is impactful to note that 84%, 56% and 48% of Langford, Colwood and Highlands' residential buildings are in the highest heat quintile. However,  all three of these communities have relatively lower socio-demographic risk and only 6% (648),  1% (54) and 0% (0) of Langford, Colwood and Highlands' residential buildings are in both the highest quintiles for air temperature and socio-demographics

Additionally, the distribution of indices allow for the identification of areas that have overlapping vulnerability concerns. These areas score highly vulnerable according to all three indices: heat exposure, socio-demographic, and buildings. They are priority areas for emergency response and extreme heat risk reduction planning. Of note: Saanich has 454 residential buildings in the three highest quintiles for heat risk, buildings risk and socio-demographic risk (1% of all residential buildings in the community), Victoria has 229 (2% of residential buildings) and Langford has 98 (1% of residential buildings in langford). Overall, there are 929 buildings in all three very high risk categories.

The Project's assessment of vulnerability to extreme heat in the Capital region allows for emergent recommendations that aim to actionably and equitably mitigate adverse extreme heat impacts. Key recommendations of this effort are included below.

- Integrate the use of these indices in planning for climate change adaptation, risk reduction, and emergency response with a focus on overlapping vulnerability.
- Nuance urban forestry and green infrastructure with vulnerability data. Tree planting and shade provisioning are elements of extreme heat adaptive capacity, and should be prioritised in areas that are presented as highly vulnerable.
- Strategically allocate resources, such as emergency response. Our analysis presents areas in which there are both high overlapping vulnerabilities and also a dearth of emergency response service coverage.
- Integrate the findings into local governments' hazard, risk, and vulnerability analysis (HRVAs) updates to allow for informed policy-making and climate action planning.
- Prioritise building retrofit programmes to highly vulnerable buildings. Take a multi-hazard perspective.

The Heat Vulnerability Data and Analysis Projects presents a significant step towards the enhancement of the CRD's capacity to support resilience planning through data-informed decision-making. The effort detailed in this report presents insights into region-specific vulnerabilities from heat exposure, socio-demographic, and buildings perspectives. The effort allows for nuanced vulnerability analyses and presents targeted recommendations. Indeed, the implementation of this Project's recommendations is anticipated to significantly contribute to building public health resilience, enhancing emergency preparedness, and equitable building retrofit programs and urban planning in the region. This report serves as both a tool for the CRD and municipal partners and also as a foundational study for ongoing research and adaptation strategies in regional and local government efforts in addressing extreme heat vulnerability.

**Introduction**

Climate change is already influencing our lives in British Columbia (BC) and more locally in the Capital Region. Over the next years and decades, we expect BC to see an increase in climate-related hazards, specifically extreme heat events[1]. We know these have, and will continue to, negatively affect the physical and mental health of residents living in the Capital Region[2,3]. Indeed, the fatal 2021 extreme heat event in BC (also referred to as the "2021 heat dome") underscored the significance in assessing and analysing localised impacts of extreme heat events. That said, there are many opportunities to act to reduce these impacts through properly understanding the risk, advancing emergency preparedness and response measures, enhancing adaptive capacity, and implementing risk reduction measures.

In this context, the Capital Regional District (CRD), in collaboration with municipal partners, initiated the Heat Vulnerability Data and Analysis Project, which aims to address extreme heat concerns localised to the Capital Region (the "Region"). Supported by the consultant team, Licker Geospatial Consulting (LGeo) and Thrive Consulting (Thrive), the Project has been designed to broaden the CRD's understanding of communities' vulnerability to extreme heat across the Capital Region through the development of three indices that refer to the 2021 heat event as a design event. These indices present an holistic approach to assessing extreme heat, and are summarised below:

- The *Heat Exposure Layer* describes extreme heat as it is distributed across the Region. This index uses factors such as land cover, local environmental factors, and incoming solar radiation to measure perceived temperature.

- The *Socio-demographic Vulnerability Index* describes population-specific determinants of vulnerability across the Region. This index is contextually-specific to the Region's communities and was informed through an engagement process. This index is formed by socio-demographic factors such as age, income, and chronic disease.

- The *Building Vulnerability Index* describes building-specific vulnerability across the Region. This index is described at the building footprint scale, and uses factors such as building type, age, and reflectivity to measure vulnerability.

These vulnerability indices are calculated from a comprehensive process of data collation, engagement, novel methods development, and validation. The Project's engagement and validation process has included a diverse group of subject matter experts, those with lived experience, and other project stakeholders. The Project's outcome is intended to inform the

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[1] Nature. (2021). Climate change made North America's deadly heatwave 150 times more likely. Nature. https://doi.org/10.1038/d41586-021-01869-0

[2] ClimateReady BC. (n.d.). Extreme Heat. Retrieved from https://climatereadybc.gov.bc.ca/pages/extreme-heat

[3] Henderson, S. B., McLean, K. E., Lee, M., & Kosatsky, T. (2021). Extreme heat events are public health emergencies. British Columbia Medical Journal, 63(9), 366-367. Retrieved from https://bcmj.org/bccdc/extreme-heat-events-are-public-health-emergencies

CRD's capacity to support local government's planning and decision-making processes as they relate to extreme heat adaptation and resilience building. The development of each of the three indices was conducted in close collaboration with the CRD, municipal partners and Island Health. The CRD and their project team influenced the design and evolution of the project through their combined expertise, specialised and contextual insights, and subject matter expertise.

### *1.1. Objectives and scope*

The primary objectives of this Project have been to:

- Facilitate group workshops and meetings with the project team and other key stakeholders to discuss, refine, and validate data collection and methodology;
- Determine key attributes which contribute to vulnerability, sensitivity or adaptive capacity to extreme heat;
- Assemble and document localised data to be used as inputs for modelling vulnerability/adaptive capacity;
- Create three aforementioned indices based on research, engagement, and data collection;
- Develop extreme heat event vulnerability data layers to be hosted on an interactive dashboard for end-users; and
- Develop a final report that disseminates methods and results to key stakeholders.

### *1.2. Issue addressed*

In 2018 the CRD identified extreme heat as a hazard of regional significance through a Regional Hazard Risk and Vulnerability Assessment (HRVA)[4]. In 2021, BC experienced an extreme heat wave that claimed more than 700 lives[5]. To address the growing risks posed by extreme heat, the region requires highly localised extreme heat vulnerability data to serve multiple initiatives related to emergency response, climate resilience and adaptation, forthcoming building retrofit programs, and regional and local/municipal planning activities. To this end, a multiple index-based approach encompassing three individual indices has been developed for this project.

The three developed indices that measure vulnerability through socio-demographic, heat exposure, and buildings lenses provide a *localised* understanding of vulnerability to extreme heat in the region. Potential end-use cases of these vulnerability indices may include:

- Supporting emergency planning and local climate adaptation planning efforts;
- Supporting the integration of extreme heat disaster risk reduction and climate adaptation planning;
- Building risk awareness and setting priorities for the implementation of disaster risk reduction initiatives;
- Supporting risk communication and planning efforts; and

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[4] Regional Emergency Management Partnership in the Capital Region. (2018). Annual Report.
[5] Henderson, S. B. et al (2021)

- Serving multiple initiatives related to emergency response, resilience and climate adaptation, forthcoming building retrofit programs, and regional and local/municipal planning activities.

### 1.3. *Novelty and significance*

A focus of this project has been to contextualise the extreme heat assessment to the localised scale relevant to the capital region. As a result, in collaboration with the CRD-led project team, this project has developed several novel approaches that may apply to other studies seeking to complete similar assessments. Below are some identified areas of novelty and significance that have been designed to localise the project to the region.

The Socio-demographic Vulnerability Index has been developed through an analytical hierarchy process (AHP), in which a group of project stakeholders, local subject matter experts, and those with lived experience, were engaged. Those engaged included local and regional governments, health practitioners, First Nation representatives, emergency services and first responders, and climatologists and meteorologists. The AHP engagement sought to inform our understanding of the relevance and importance of determinants of Socio-demographic Vulnerability that are specific to the region. Notably, this engagement approach advances from similar, previous assessments that solely employ statistical methods to determine the relevance and importance of determinants of vulnerability[6,7].

This project also introduces novel approaches in assessing building-by-building vulnerability through a highly localised analysis of extreme heat at the building footprint scale. This project addresses a common gap in such assessments, in that a significant discrepancy in the degree of vulnerability exists between outdoor and indoor heat[8]. That is to say, specific building characteristics can affect a building's level of vulnerability despite its position in the distribution of outdoor heat exposure. Many heat-related deaths, especially those observed during extreme events, can be credited to indoor heat exposure[9, 10]. This project successfully attributes multiple determinants of building vulnerability to building footprints throughout the region[11], that include dwelling type, building age, building height, solar insolation, rooftop albedo and cooling capacity.

The measurement of heat exposure has also been advanced in this project. While previous assessments have used varying approaches to assessing the distribution of extreme heat

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[6] Université Laval. (2023). Summary Report. Retrieved from https://vaguesdechaleur.ffgg.ulaval.ca/wp-content/uploads/2023/07/summary-report_ulaval.pdf

[7] Conlon, K. C., Mallen, E., Gronlund, C. J., Berrocal, V. J., Larsen, L., & O'Neill, M. S. (2020). Mapping human vulnerability to extreme heat: A critical assessment of heat vulnerability indices created using principal components analysis. Environmental Health Perspectives. https://doi.org/10.1289/EHP4030

[8] Alam, M., Sanjayan, J., Zou, P. X. W., Stewart, M. G., & Wilson, J. (2016). Modelling the correlation between building energy ratings and heat-related mortality and morbidity. *Sustainable Cities and Society*, *22*, 29–39. https://doi.org/10.1016/j.scs.2016.01.006

[9] Samuelson, H., Baniassadi, A., Lin, A., Izaga González, P., Brawley, T., & Narula, T. (2020). Housing as a critical determinant of heat vulnerability and health. *Science of The Total Environment*, 720, 137296. https://doi.org/10.1016/j.scitotenv.2020.137296

[10] CDC, 2013. Heat illness and deaths—New York City, 2000–2011. MMWR Morb. Mortal. Wkly Rep. 62, 617.

[11] See validation considerations in section 2.3.6

exposure[12,13]; such approaches often fail to capture either the localised distribution of heat exposure or fail to capture the human experience of extreme heat exposure. For example, while weather stations may accurately measure temperature and humidity levels during a heat wave, the interpolation between stations as an assessment of heat exposure distribution results in the loss of nuance that exists at localised contexts. Further, while monitoring land surface temperatures from satellite imagery can provide a localised understanding of the distribution of extreme heat, it inadequately captures the levels of discomfort that is experienced by a typical individual. The project team has sought to find the balance between appropriate measurement and nuanced distribution by developing an assessment of air temperature during the 2021 heat event.

While this approach has recently been employed by researchers elsewhere[14,15] and within the Region[16], the application of such an assessment within a larger extreme heat vulnerability assessment remains, to our knowledge, a first of its kind.

1.4. *Engagement and outreach*

The focus of engagement and outreach for this project was two-fold: the first being the project team and extensions thereof (i.e. broader end-user groups from around the region) and the second being key stakeholders and local subject matter experts from around the region (e.g. climate scientists, public health officials, etc.) (See figure 1 for a summary of engagement structure). Initial efforts were also made to reach out to First Nations' representatives in the region; some of whom are working on similar extreme heat assessment and response planning projects. Further effort and funding allocation is required in this area to integrate First Nation's data and values into a regional analysis and related efforts going forward.

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[12] Typically using landsat surface temperature or degree cooling days
[13] Yu, J., Castellani, K., Yao, A., Cawley, K., Zhao, X., & Brauer, M. (2020). Mapping spatial patterns in vulnerability to climate change-related health hazards. University of British Columbia.
[14] Ho, H. C., Knudby, A., Sirovyak, P., Xu, Y., Hodul, M., & Henderson, S. B. (2014). Mapping maximum urban air temperature on hot summer days. Remote Sensing of Environment, 154, 38-45.
[15] Xu, Y., Knudby, A., & Ho, H. C. (2014). Estimating daily maximum air temperature from MODIS in British Columbia, Canada. International Journal of Remote Sensing, 35(24), 8108-8121. https://doi.org/10.1080/01431161.2014.978957
[16] Steve Young at the City of Victoria partnered with Simon Fraser University to develop an air temperature model (2002-2012) for Victoria, available here: https://vicmap.maps.arcgis.com/apps/webappviewer/index.html?id=ae03a6af3648414fb7bf60f8f7bb4d7d


**Figure 1.0 Structure for engagement during Project development.**

A kick-off meeting was held to get to know the project team and hear their perspectives on how this mapping and modelling effort may support their ongoing and future work. At this meeting we heard a variety of ways in which these end-users were hoping to and could foresee using the data to inform:

- updates to their local hazard, risk and vulnerability assessments (HRVAs);
- climate adaptation planning/plans;
- planning for tree canopy/planting and urban forestry strategies; and
- assessment of where vulnerable populations are spatially located to inform response and preparedness planning.

The first workshop gathered a small group of those with specific, local subject matter expertise related to Socio-demographic Vulnerability (aka. the AHP workshop). The second workshop gathered a wider group of potential end-users to provide the background into the development of the three indices: socio-demographic vulnerability, heat exposure, and building vulnerability and gain critical feedback before proceeding to the analysis stage. The intent was to ensure project team members and additional stakeholders in the region were comfortable with the methods and approach before proceeding in earnest to the modelling and analysis stages. A third workshop was held with the consultant team and staff project team to review the final products and deliverables and review the draft public dashboard.

Several additional meetings were held to:

- Review the approach to the buildings index with internal stakeholders before completing the modelling effort for that particular index;
- Review various approaches to heat exposure modelling and ensure acceptability of this particular heat exposure approach; including meeting with the Pacific Climate Impacts Consortium (PCIC) and City of Victoria staff who conducted heat modelling for the City of Victoria; and
- Reach out to First Nations' representatives and organisations representing First Nations' interests in the region (e.g. First Nations' Health Authority, to discuss and explore the existing data and gaps in relation to First Nations' in the region and potential uses and improvements going forward.

A final workshop provided a final overview of all the end-products (i.e. including maps, modelling, GeoBC portal, story map) to support capacity building in the use of the mapping products for local government staff and other key end-users in the region.

## 2. Methods

For each index developed in this Project, considerable data collation and analysis has been undertaken. This Section provides a comprehensive presentation of methodology employed in calculating the three vulnerability indices: exposure, socio-demographic, and buildings. These indices form multiple perspectives on the Region's anticipated level of vulnerability to extreme heat.

Each index is calculated through a specific process of literature reviews, data acquisition and manipulation, analysis, and stakeholder engagement. The methodologies described in this Section present detailed processes in constructing each index and associated data validation, limitations, and quality assurance. The development of these indices aims to capture a comprehensive understanding of determinants of extreme heat vulnerability to both the community and building footprint levels.

This assessment references the 2021 extreme heat event as the design event for extreme heat in the capital region. Though this event is a so-called 'one-in-a-thousand-year' event, experts argue that as climate change progresses BC may experience heat events similar to the 2021 extreme heat event with greater frequency as high as every 5 - 10 years[17]. As such, it is beneficial to

[17] Union of BC Municipalities (2021). Preparing for more heat domes. Available from: https://www.ubcm.ca/about-ubcm/latest-news/preparing-more-heat-domes

consider the worst-case scenario that has been experienced when planning for the future[18, 19]. This assessment leverages available data in the development of each index to be temporarily aligned to the 2021 extreme heat event period[20]. This includes data sources, detailed further below, as census data, satellite observations, weather station data, building assessment data, and health data.

Below is a high-level summary of the methodology employed for each vulnerability index.

- Socio-demographic Vulnerability Index (Section 2.1).
  This index integrates a variety of demographic and health-related data utilising an Analytical Hierarchy Process (AHP) to weigh and prioritise multiple inputs based on their relevance to extreme heat vulnerability. This process involved collaboration with local subject matter experts to identify, weigh, and validate the index.

- Extreme Heat Exposure Layer (Section 2.2).
  This index describes the perceived outdoor air temperatures during the 2021 heat event. Using a non-linear modelling approach, this index considers multiple variables including land surface temperature, solar insolation, elevation, distance to coastline, and more. Climate station data that collected air temperature measurements during the 2021 heat event have also been used to train and validate this modelling process.

- Building Vulnerability Index (Section 2.3).
  This index addresses the physical characteristics of buildings and their local environment that affect the building's capacity to (remain) cool during an extreme heat event. The construction of this index is at the building footprint scale and includes leveraging inputs from multiple data sources, such as remotely sensed lidar (lidar - light detection and ranging) data and building assessment data. Factors that describe this index include building age, dwelling type, solar insolation, and building height.

Each index is underpinned by rigorous data validation and quality assurance processes, involving both technical analyses and stakeholder consultations. The methodologies employed are designed to ensure the indices provide an accurate, transparent, and reproducible representation of heat vulnerability in the Region. The project also includes a data dictionary, which presents a comprehensive view of all datasets used in this project, their currency, and their source. Please contact climateaction@crd.bc.ca if you would like a copy of the data dictionary.

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[18] IPCC. (2021). Summary for Policymakers. In V. Masson-Delmotte, P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, & B. Zhou (Eds.), Climate Change 2021: The Physical Science Basis. *Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. https://www.ipcc.ch/report/ar6/wg1

[19] Philip, S.Y., Kew, S.F., van Oldenborgh, G.J., et al. (2022). Rapid attribution analysis of the extraordinary heat wave on the Pacific coast of the US and Canada in June 2021. *Earth System Dynamics*, 13(4), 1689-1713. https://doi.org/10.5194/esd-13-1689-2022

[20] The 2021 extreme heat event in BC occurred during the 25th of June to the 7th of July. The design event we used for much of the modeling was June 28th, 2021.

### 2.1. *Socio-demographic Vulnerability Index*

The socio-demographic vulnerability index is designed to assess the *sensitivity* and *adaptive capacity* of communities to extreme heat events at a local level and includes determinants related to population health and socioeconomic status.

- Sensitivity in the context of extreme heat vulnerability refers to the extent to which a population is affected by an extreme heat extent. In the socio-demographic index, this includes factors such as age demographics, pre-existing health conditions, and income.
- Adaptive capacity in this context represents the ability of the community to adjust, absorb, and respond to the adverse impacts associated with extreme heat. In the socio-demographic index, this includes household size, education, and employment.

The socio-demographic vulnerability index has been developed through an Analytical Hierarchy Process (AHP), in which local experts such as epidemiologists, emergency managers, and social, community and climate planners were engaged in a workshop format. The selection of AHP over principal component analysis (PCA) was based on literature reviews and the consulting team's previous project experiences. Indeed, research suggests that PCA does not correlate well with actual heat-related health outcomes and is very sensitive to the input data used in the vulnerability index[21]. As a result, AHP was chosen for its ability to (1) include the engagement of groups that may have been traditionally excluded from such exercises, (2) more easily interpreted than PCA, and (3) provide a more relevant demographic weighting in relation to extreme heat related health outcomes.

The AHP workshop provided a platform for the group to evaluate over 50 identified socio-demographic determinants of vulnerability. The list of indicators was initially identified from an informal literature review and informed by previous studies on the subject[22]. For each indicator, a slide was presented that displayed the spatial distribution of the determinant across the region, as shown in Figure 2.0. Following the workshop, a survey was conducted to assign appropriate weights to each indicator, which were then used to calculate the socio-demographic vulnerability index for each Census dissemination area (DA) across the Region[23]. This approach ensures that the index is regionally relevant through the subject matter expert input in index design.

The full list of indicators used and their associated AHP weights are shown in Table 2.0 below.

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[21] Conlon, K. C., Mallen, E., Gronlund, C. J., Berrocal, V. J., Larsen, L., & O'Neill, M. S. (2020). Mapping human vulnerability to extreme heat: A critical assessment of heat vulnerability indices created using principal components analysis. Environmental Health Perspectives. https://doi.org/10.1289/EHP4030

[22] Bao, J., Li, X., & Yu, C. (2015). The Construction and Validation of the Heat Vulnerability Index, a Review. International Journal of Environmental Research and Public Health, 12(7), 7220–7234. https://doi.org/10.3390/ijerph120707220

[23] Due to time constraints that arose due to the rich discussion during the AHP workshop, remaining tasks were accomplished via survey. The consulting team was then able to run the index once the weightings were complete and the health data was acquired. Results were reviewed in a follow-up meeting with AHP workshop participants as well as a few additional stakeholders with socio-demographic expertise.

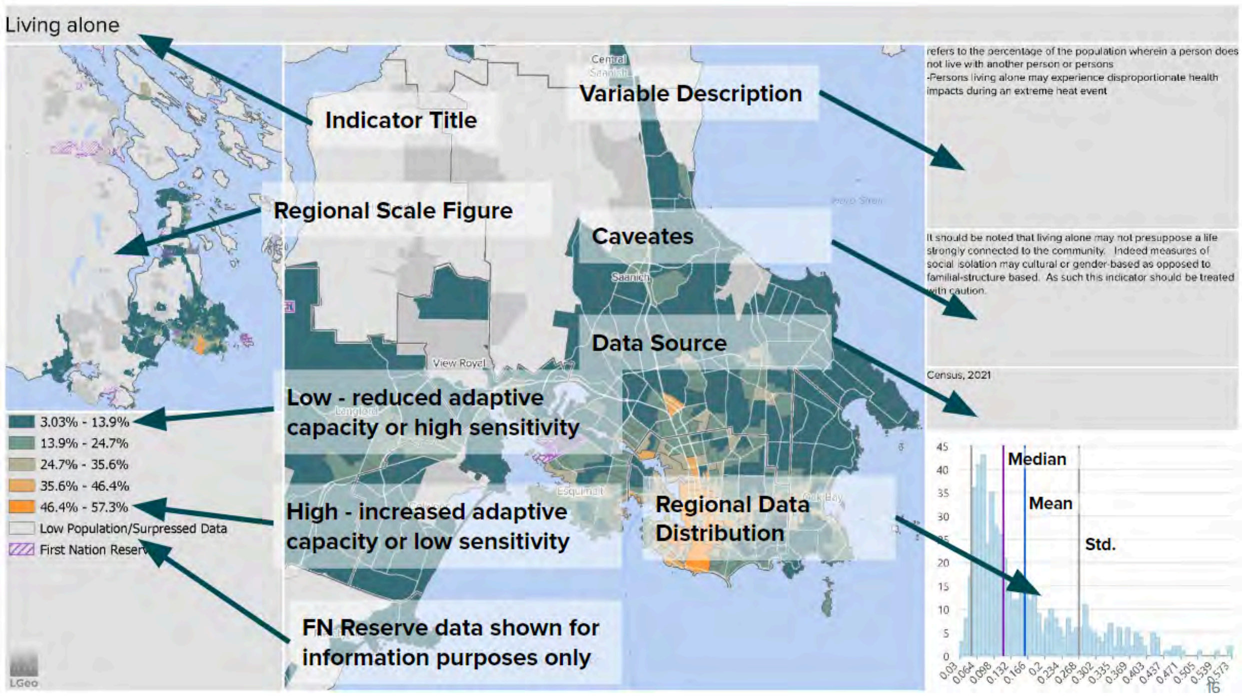


**Figure 2.0.** Sample slide of the demographic data review during the AHP workshop. Each variable was mapped, the distribution of data was assessed and data caveats and limitations were flagged and discussed.

**Table 2.0 Socio-demographic variables and their associated weights. The table is ordered from largest weight to smallest.**

| Theme | Variable Name | Source | Date | AHP Weight |
|---|---|---|---|---|
| Age | Population age 65 or older (%) | Census | 2021 | 5.79% |
| Health | Mental and Substance Use Disorders (crude rate) | BCCDC | 2021 | 5.65% |
| Income | Low Income Adults | Census | 2021 | 5.34% |
| Health | Chronic kidney disease (crude rate) | BCCDC | 2021 | 5.26% |
| Identity | Living alone | Census | 2021 | 5.15% |
| Health | Hospitalised stroke (crude rate) | BCCDC | 2021 | 5.16% |
| Health | Chronic Obstructive Pulmonary Disease (Crude Rate) | BCCDC | 2021 | 5.00% |
| Health | Acute Myocardial Infarction (Crude Rate) | BCCDC | 2021 | 5.00% |
| Health | Hypertension (crude rate) | BCCDC | 2021 | 4.76% |
| Health | Episodic Mood Anxiety Disorders Prevalence (Crude Rate) | BCCDC | 2021 | 4.66% |
| Income | Total - Adjusted after-tax economic family income decile group | Census | 2021 | 4.59% |
| Health | Asthma (crude rate) | BCCDC | 2021 | 4.21% |
| Identity | Population that are renters (%) | Census | 2021 | 3.88% |
| Identity | Indigenous Identity | Census | 2021 | 3.68% |
| Health | Diabetes (Crude Rate) | BCCDC | 2021 | 3.72% |

| | | | | |
|---|---|---|---|---|
| Employment | Outdoor Workers - Trades, transport and equipment operators etc. | Census | 2021 | 3.30% |
| Identity | Speaking Neither English Nor French at Home | Census | 2021 | 2.80% |
| Age | Primary household maintainers - 75 years and over | Census | 2021 | 2.80% |
| Identity | Recent Immigrants 2016-2021 | Census | 2021 | 2.60% |
| Age | Primary household maintainers - 85 years and over | Census | 2021 | 2.54% |
| Age | Primary household maintainers - 65 years and over | Census | 2021 | 2.35% |
| Identity | Has high (secondary) school diploma or equivalency certificate or no diploma/degree | Census | 2021 | 2.10% |
| Population | 2021 Population Density (per Hectare) | Census | 2021 | 2.03% |
| Housing | Housing Built Before 1960 | Census | 2021 | 2.03% |
| Housing | Major repairs needed at home | Census | 2021 | 1.91% |
| Housing | Average number of rooms per dwelling | Census | 2021 | 1.91% |
| Housing | Average spending on windows and doors | Environics | 2022 | 1.78% |

### 2.2. *Heat Exposure Layer*

The accurate measurement of the distribution and intensity of outdoor heat exposure is essential for a range of applications, including public health and urban planning[24, 25]. This assessment of heat exposure aims to provide a comprehensive picture of outdoor extreme heat throughout the capital region, with a focus on the 2021 extreme heat event. Our approach employs advanced remote sensing technology and environmental data analysis to develop a detailed Heat Exposure Layer. This layer visualises the intensity and distribution of extreme heat across the region and includes two key components:

- Land surface temperature (LST), measured in °C, provides a direct measure of heat emitted from the Earth's surface during the heat event. This layer captures the intensity of ground-level heat across the capital region.
- Air temperature, also measured in °C, provides a complementary perspective of how temperatures are experienced by individuals during the extreme heat event. This layer is indirectly measured from multiple inputs that are regressed against observed temperature from weather station data across the regional district.

The following subsections present detail on the components of the Heat Exposure Layer and their implications. This section includes the methodology included in calculating LST and air temperature, a comparison between both LST and air temperature assessments, limitations in the exposure methodologies, and potential future uses for these layers.

[24] McGregor, G. R., & Vanos, J. K. (2018). Heat: A primer for public health researchers. Public Health, 161, 138-146. https://doi.org/10.1016/j.puhe.2017.11.005
[25] Havenith, G. and Fiala, D. (2015). Thermal Indices and Thermophysiological Modeling for Heat Stress. In Comprehensive Physiology, R. Terjung (Ed.). https://doi.org/10.1002/cphy.c140051

### 2.2.1. *Forecasting the Heat Exposure Layer*

This assessment initially explored forecasting heat exposure to an end-of-century scenario as aligned with Intergovernmental Panel on Climate Change (IPCC) high-emission relative concentration pathway (RCP 8.5°C), i.e. the "worst case scenario"[26]. However, this additional analysis was dropped given the following key concerns:

- The modelling used in understanding the future distributions of heat are developed from global-scale models that are attributed with resolutions order of magnitudes greater than the current heat exposure layer. While these aggregated global circulation models work well at understanding climate change at larger scales, their impacts are currently homogenous at the capital region level. Further, at an end-of-century, high-emission scenario there are relatively large margins of error introduced to the magnitude of extreme heat described[27].
- Land surface temperature, solar insolation, and other important variables in the exposure layer are closely aligned with land cover. As the region's land cover changes, it is expected that the distribution of the current heat exposure layer would also change. It would therefore be necessary to predict land cover changes to the end-of-century to accurately predict future extreme heat distribution at the localised level. Naturally, such an analysis would introduce many assumptions and uncertainties.
- A missing component of a hypothetical forecasted heat exposure would be an understanding of the forecasted population and infrastructure that will directly experience extreme heat at the end-of-century. Without an understanding of future demographics and density, the construction of a forecasted extreme heat layer would disingenuously present tomorrow's hazards and risks to today's community.

### 2.2.2. *Land Surface Temperature Analysis*

Land surface temperature (LST) directly measures the heat emitted from the ground. This analysis uses satellite data captured over the 2021 heat event. We use the Landsat-8 constellation to gather multispectral images with a 30 $m^2$ resolution. The LST analysis includes the following calculations:

- a normalised difference vegetation index (NDVI; i.e. a "greenness" index);
- fractional vegetation (i.e. the proportion of vegetation within the satellite image mosaic pixel);
- emissivity (i.e. the capacity for ground-based objects to retain and emit heat); and
- thermal radiation (i.e. the direct measurement of heat radiated from the Earth's surface).

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[26] IPCC. (2021). Summary for Policymakers. In V. Masson-Delmotte, P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, & B. Zhou (Eds.), Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. https://www.ipcc.ch/report/ar6/wg1

[27] ClimateData.ca (n.d.) Uncertainty in climate projects. Available from https://climatedata.ca/resource/uncertainty-in-climate-projections/

### 2.2.3. *Air Temperature Analysis*

While LST is representative of the distribution of heat across the region during the 2021 heat event, it is less accurate at describing human-observed discomfort to heat during that event. Air temperature, usually measured 2 m above the ground, is a more accurate representation of how extreme heat is experienced by an individual. Air temperature is not a measurement that is captured by spaceborne or airborne remote sensing platforms, such as Landsat.

To align the extreme heat to the human experience, our exposure layer assessment calculated air temperature through a regression-based model that is informed by LST and other local environmental factors, shown to be correlated with air temperature[28,29]. The air temperature regression-model predictor variables include:

- Digital elevation model (DEM), at 1 $m^2$ spatial resolution and derived from 2019 lidar and for beyond lidar survey extents at 30 $m^2$, as acquired from the Shuttle Radar Topography Mission (SRTM) data[30];
- Solar insolation (Wh/$m^2$) at 1 $m^2$ terrain models from the 2019 lidar data;
- Sky View Factor (SVF), at 1 $m^2$ spatial resolution that describes the degree of viewable sky for points on the ground and is a representation of multiple other environmental factors[31];
- Land surface temperature (LST; °C), at 30 $m^2$ and calculated from multiple spectral bands of the Landsat-8 satellite images captured during the 2021 heat event (described in the previous Section);
- Normalised water difference index (NDWI), which measures water content of the environment. NDWI is also roughly 30 $m^2$ and calculated from multiple spectral bands of the Landsat-8 satellite images captured during the 2021 heat event;
- Distance to coastline (km), which is a euclidean measurement at 30 $m^2$ pixel resolution; and
- Longitude and latitude.

In addition to the dependent variables listed above, we use an average daytime temperature observed on the 28th June, 2021 between 9:00 to 21:00 from a network of 66 stations located throughout the Region (Figure 2.2) as the independent variable in this regression model. Upon iterative regression analyses, it was found that variables differed significantly in terms of their predictability of air temperature. We found that the regression model performs well with highly significant variables including solar insolation ($p \risingdotseq 0$), land surface temperature ($p = 0.0013$),

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[28] Ho, H. C., Knudby, A., Sirovyak, P., Xu, Y., Hodul, M., & Henderson, S. B. (2014). Mapping maximum urban air temperature on hot summer days. Remote Sensing of Environment, 154, 38-45

[29] Xu, Y., Knudby, A., & Ho, H. C. (2014). Estimating daily maximum air temperature from MODIS in British Columbia, Canada. International Journal of Remote Sensing, 35(24), 8108-8121. https://doi.org/10.1080/01431161.2014.978957

[30] NASA Shuttle Radar Topography Mission (SRTM)(2013). Shuttle Radar Topography Mission (SRTM) Global. Distributed by OpenTopography. DOI:10.5069/G9445JDF. Accessed November 15, 2023

[31] Zakšek, K., Oštir, K., & Kokalj, Ž. (2011). Sky-View Factor as a Relief Visualization Technique. Remote Sensing, 3, 398-415. https://doi.org/10.3390/rs3020398

distance to coast ($p$ = 0.0305), and elevation ($p$ = 0.037). The other predictors identified were found to be cross-correlated or not significant and were dropped from the model.

The linear regression model is constructed without an intercept. The assumption here is that in the absence of the environmental factors considered, the perceived outdoor temperature by a typical individual would be 0°C. Our justification for the decision in not including an intercept for this linear regression are summarised below for each predictor variable.

- *Land surface temperature.*
  Given that land surface temperature is a direct measure of the heat emitted by the ground, a value of zero would imply no heat emission, theoretically corresponding to a scenario of absolute zero where no molecular motion—and hence no temperature—exists. However, such a condition is physically impossible on Earth's surface, rendering the inclusion of an intercept unnecessary for this variable.
- *Solar insolation.*
  The presence of solar insolation is a necessary condition for positive temperatures. While the insolation value does not reach zero in our dataset, we suggest that in the absence of insolation, such as during a total solar eclipse or polar night, the temperature would tend toward the lowest possible values observed.

**Figure 2.2.** Weather stations used in air temperature modelling.

The average daytime temperature is used at each station to account for potentially faulty sensors and/or temperature spikes that cause anomalous in the data, as shown in Figure 2.3.

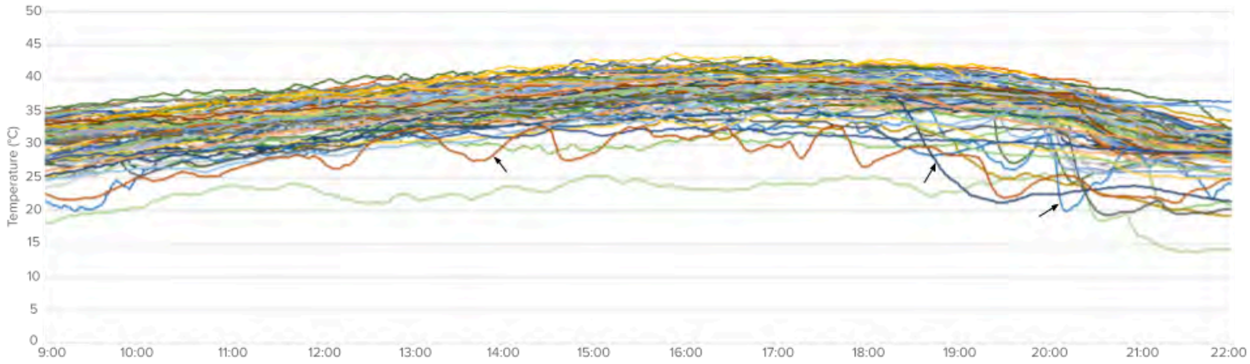


**Figure 2.3.** Hourly temperature observations at 66 weather stations throughout the Capital Region, as measured from 9:00 to 21:00 on the 28th of June, 2021. Black arrows indicate potentially anomalous and faulty sensor data.

In addition to the linear model, we also used a random forest model to produce predicted air temperature values throughout the Region. Our random forest model produces an $R^2$ of 0.73 and a root mean square error (RMSE) of 1.97 °C, a performance similar to that of similar studies[32]. While suggesting a strong model performance, the random forest model also produces an unexpected, inverted relationship between solar insolation and air temperature. For this reason, the regression model was selected for this study

### 2.3. *Buildings Index*

Building-level heat vulnerability mapping is multifaceted and has been a gap in many heat vulnerability indices that do not consider nuances at the building scale. Our approach aims to fill this gap by integrating multiple models that capture multidimensional factors of building-specific vulnerability to extreme heat events. This project assesses building-by-building vulnerability for all buildings throughout the region[33].

This Building Vulnerability Index Section presents key findings derived from a comprehensive review of relevant literature. Subsequently, each input of the building index is detailed with its respective model methodology, accompanied by discussions on index calculation and data verification.

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[32] Ho, H. C., et al. (2014)

[33] Not included are outhouses and other, non-primary buildings. The building footprint dataset is a combination of municipal and regional datasets, as well as lidar-based building footprint classifications as developed for this project in areas that are beyond the available building footprint data extents. Minor instances of misclassification and/or temporal misalignment are occasionally observed across building footprint datasets.

#### 2.3.1. Buildings Literature Review

The importance of building characteristics in heat vulnerability assessments cannot be understated. Notably, many heat-related deaths—especially during extreme events—can be credited to indoor heat exposure[34, 35]. This is particularly relevant for certain vulnerable groups, such as the elderly or those with limited mobility, who spend much of their time indoors and therefore disproportionately face the heat impacts associated with buildings. Further, research indicates a significant discrepancy between indoor and outdoor temperatures[36], thereby demonstrating the need to complement our previously described efforts on extreme heat exposure modelling (see Section 2.2). Indeed, studies show that heat-related mortality and morbidity resulting from outdoor and indoor exposure may not always be correlated, highlighting that the composition of building characteristics may be more informative than outdoor surface temperature[37]. By considering building-level characteristics, heat vulnerability indices can provide a more comprehensive and nuanced understanding of heat vulnerability and help to facilitate targeted heat response and risk reduction.

In review of the literature around heat vulnerability analysis, some emerging building-level indicators were reviewed and selected based on available and reputable data sources. Through a literature review, we elucidated the following regarding building-specific heat vulnerability:

- While social-vulnerability heat indices can inform where to act in the event of an extreme heat event, analysing housing characteristics of those areas allows for a more nuanced understanding of how to facilitate risk reduction and adaptive strategies before the onset of a heat event[38].
- Indoor heat temperature may be significantly misaligned from outdoor measured temperatures, thereby underscoring the importance of building-specific indoor heat modelling as a required component to heat vulnerability assessments[39].

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[34] Samuelson, H., Baniassadi, A., Lin, A., Izaga González, P., Brawley, T., & Narula, T. (2020). Housing as a critical determinant of heat vulnerability and health. *Science of The Total Environment*, 720, 137296. https://doi.org/10.1016/j.scitotenv.2020.137296

[35] CDC, 2013. Heat illness and deaths—New York City, 2000–2011. MMWR Morb. Mortal. Wkly Rep. 62, 617.

[36] Alam, M., Sanjayan, J., Zou, P. X. W., Stewart, M. G., & Wilson, J. (2016). Modelling the correlation between building energy ratings and heat-related mortality and morbidity. *Sustainable Cities and Society*, *22*, 29–39. https://doi.org/10.1016/j.scs.2016.01.006

[37] Uejio, C. K., Wilhelmi, O. V., Golden, J. S., Mills, D. M., Gulino, S. P., & Samenow, J. P. (2011). Intra-urban societal vulnerability to extreme heat: The role of heat exposure and the built environment, socioeconomics, and neighborhood stability. *Health & Place*, *17*(2), 498–507. https://doi.org/10.1016/j.healthplace.2010.12.005

[38] Samuelson et al. (2020).

[39] Alam et al. (2016)

- Buildings can contribute to heat gains[40] during extreme heat events through solar heat gains (via roofs, walls, and windows) and internal heat gains (from appliances and lighting).
- Both forms of heat gains are important in identifying potential vulnerabilities[41], however internal heat gain data is limited and therefore is considered through peer-reviewed proxy indicators that focus on thermal performance, including construction year and dwelling type[42].
- The reflectance or albedo of a rooftop's material contributes to the amount of heat absorbed into the building.
- Floor level and building type are predictors of increased mortality and morbidity during extreme heat events, particularly for those who are aged, have chronic conditions, mobility constraints, or disability[43].

### *2.3.2. Buildings Index Inputs*

To create a buildings level index, individual building footprints for the region were compiled from the various municipalities that make up the capital region. These compiled footprints were derived from various years ranging from 2018 to 2023. However, some areas in the capital region did not have readily available building footprints. Building footprint data gaps were present for Metchosin, parts of East Sooke and areas along the coast, west of Sooke out to Juan de fuca.

For Metchosin, where 2019 classified land cover data[44] was accessible, the project team opted for a cost-effective approach by deriving footprints from the available buildings class and regularising building polygons to simulate building form. Available lidar data was also used for the Metchosin area to derive building height information using a regional building height model (BHM), as detailed in section 2.3.2.4I.

For East Sooke and areas along the coast, west of Sooke out to the Juan de Fuca Electoral Areas, land cover classified data was not available. Instead, building footprints for these remaining areas were derived from Lidar BC's lidar portal containing 2019 lidar data[45]. After

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[40] Heat gains refer to the thermal energy that enters a building. It includes the heat absorbed from external sources, such as solar radiation penetrating through the building's roof, walls, and windows. As well as, from internal sources, including appliances, lighting, and human activities within the building. Heat gains play a crucial role in determining the indoor heat levels and overall thermal conditions within a building during heatwaves. Assessing and understanding heat gains is essential in evaluating the potential heat-related risks and vulnerabilities of buildings and their occupants

[41] BC Housing. (2022). *Extreme Heat and Buildings: An Analysis of the 2021 Heat Dome Related Deaths in Community Housing in British Columbia*.
https://www.bchousing.org/sites/default/files/media/documents/Extreme-Heat-Report%2B2022.pdf

[42] Samuelson et al. (2020).

[43] Haigh, F., Chok, H., & Harris, P. (2011). Housing density and health: A review of the literature and Health Impact Assessments.

[44] Caslys (2021). Capital Regional District Land Cover Classification [Map/Dataset]. Shared under data agreement with the Capital Regional District.

[45] Lidar BC, Open Data Portal. Data collected in 2019. https://lidar.gov.bc.ca/pages/download-discovery.

removing outliers in the lidar point cloud data, building features were classified using ESRI's lidar classification tool[46]. Building features in the lidar data were extracted as raster data and then converted into polygon shapes, regularised, and attributed with building height information from lidar. After quality assurance checks were conducted on footprint delineation, a few gaps remained where manual delineation of footprints was undertaken for completeness[47].

With building footprints delineated and the use of high resolution data inputs, this index has been designed to assess the vulnerability of individual buildings to extreme heat and represents a significant advancement in this field, particularly given the limited body of existing literature on building-specific responses to extreme heat. Our literature review on this topic, as well as engagement with subject-matter experts, found six emergent determinants of building-specific vulnerability: building age, dwelling type, rooftop albedo, building height, solar insolation, and the presence of heat pumps. Each of these determinants is detailed below.

*2.3.2.1. Building Age*

While older buildings are not definitively hotter in all scenarios, age acts a proxy for multiple other variables such building construction type and thermal properties[48], which were unavailable inputs for this Project. Rather, age primarily acts as a marker for BC step-code adoption. Building age helps to flag buildings that are less likely to be up to code in terms of heat regulation and air tightness within the BC context.

Older buildings are ranked at a higher vulnerability, based off of BC's historic building code[49]. Buildings built before 1970 used building codes under local bylaw standards with no coherence in standards across the District, whereas buildings built after 2012 have higher standards for ventilation (see Table 2.1 below).

**Table 2.1.** Building age vulnerability based on an understanding of BC building code eras and their respective level of standards.

| Building Age | Vulnerability |
|---|---|
| <1970 | Very Vulnerable |
| 1970-1985 | Vulnerable |

[46] *Classify LAS Building (3D Analyst)—ArcGIS Pro | Documentation*. (n.d.). Retrieved December 20, 2023, from https://pro.arcgis.com/en/pro-app/latest/tool-reference/3d-analyst/classify-las-building.htm
Parameters used in classification: The lidar building feature extraction algorithm was constrained by defining a minimum building height of 2m and a minimum area of 6 $m^2$.

[47] 446 building footprints were manually delineated.

[48] Samuelson et al. 2019

[49] Government of British Columbia. (2015). *History of British Columbia Building Regulations*. https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/construction-industry/building-codes-and-standards/guides/history_of_the_codes_2015_update.pdf

| | |
|---|---|
| 1985-1998 | Less Vulnerable |
| 1998-2006 | Moderately Vulnerable |
| 2006-2012 | Mildly Vulnerable |
| 2012-2018 | Minimally Vulnerable |
| > 2018 | Not Vulnerable |

#### *2.3.2.2. Dwelling Type*

Dwelling type is included in the buildings index as research has found that taller, multi-unit buildings may exhibit increased vulnerability to extreme heat[50]. Indeed, Haigh, Chok, and Harris (2011) assert that factors such as building floor level and type serve as predictors for elevated mortality and morbidity during extreme heat events[51]. Furthermore, a report from the BC Coroner in 2022 underscores the correlation between dwelling type and the incidence of heat-related deaths observed during the 2021 heat event.

To derive the vulnerability weight for each dwelling type, rankings were assigned based on the proportions of heat-related deaths by dwelling type during the 2021 extreme heat event, as reported by BC's Coroner. These proportions were then standardised relative to the capital region's housing stock proportions and normalised for the capital region's population per dwelling type (refer to Table 2.2). This standardisation process ensures that the dwelling type vulnerability weight is aligned with the composition of the capital region's housing stock.

**Table 2.2.** Dwelling type vulnerability ranking. Using the BC Coroner's report BC wide statistics, the proportion of deaths occuring in a dwelling type is normalised for the number of dwellings per dwelling type category within the capital region.

| Heat-Related Deaths By Place of Injury | BC Wide Proportion of Deaths (%) | Proportion of capital region Dwelling Type (%) | CRD Proportion of Deaths (%) | CRD Vulnerability Weight |
|---|---|---|---|---|
| Private Residence - Multi-unit | 39.1 | 30 | 45 | 0.36 |
| Private Residence - Detached | 33.9 | 64 | 39 | 0 |

[50] British Columbia Coroners Service (2022) Extreme Heat and Human Mortality: A review of heat-related Deaths in BC in Summer 2021.
[51] Haigh, F., Chok, H., & Harris, P. (2011). Housing density and health: A review of the literature and Health Impact Assessments.

| | | | | |
|---|---|---|---|---|
| Single Room Occupancy (SRO) or Supportive-/Social-housing | 10.0 | Data unavailable | Data unavailable | Data unavailable |
| Trailer Home/Mobile Home/RV/Camper | 6.5 | 2 | 8 | 1 |
| Senior/Long-Term Care Home | 6.5 | 3 | 8 | .86 |
| Outside | 2.1 | N/A | N/A | N/A |
| Other Residential | 1.9 | N/A | N/A | N/A |

Building age and dwelling type are both attributes taken from the BC Assessment's Building Information Report (BIR). In cases when flattening both the regional parcel fabric and the building information report onto the parcels, where multiple building information records exist for a single parcel, the building type assigned is determined by that of the largest square footage, and the age is designated based on the year corresponding to the largest square footage building type.

#### *2.3.2.3. Albedo*

Albedo was selected as a thermal performance proxy metric as it indicates how much solar thermal radiation is absorbed and emitted on building rooftops. Higher albedo surfaces (i.e white roofs) reflect light off the surface while darker surfaces have a low albedo and absorb more heat.

In our approach to calculate albedo, we utilise reflectance data from Sentinel-2 Multispectral Instrument (MSI)[52] imagery and weighting coefficients as developed by Vanino et al[53]. The weights represent the fraction of solar radiation within the spectral range for each Sentinel-2 band. These weights were established based on the spectral irradiance spectrum of the sun, essentially indicating the proportion of sunlight each band receives. Given these weights and the per-band reflectance values, we calculate the mean albedo for each pixel in the image using the following formula, as adaptive from Vinino et al (2018)[54]:

$$\alpha = \frac{\sum|\rho_{bi} \cdot \omega_{bi}|}{\sum \omega_{bi}} \quad (1)$$

where:

- $\alpha$ is mean albedo at a 10 $m^2$ pixel resolution;

[52] European Space Agency. (2015-present). Sentinel-2 Multispectral Instrument Level-1C data [Data set]. Copernicus Open Access Hub. https://scihub.copernicus.eu/dhus

[53] Vanino, S., Nino, P., De Michele, C., Bolognesi, S. F., D'Urso, G., Di Bene, C., Pennelli, B., Vuolo, F., Farina, R., Pulighe, G., & Napoli, R. (2018). Capability of Sentinel-2 data for estimating maximum evapotranspiration and irrigation requirements for tomato crop in Central Italy. Remote Sensing of Environment, 215, 452-470. https://doi.org/10.1016/j.rse.2018.06.035

[54] See Appendix A for corresponding band weights.

- $\omega_{bi}$ is the weight for band $i$; and
- $\rho_{bi}$ is the reflectance in band $i$.

This equation computes a weighted average of the reflectances across the different bands (summarised in Appendix A), with weights given by the $\omega_{bi}$ values. Each band's reflectance is multiplied by the corresponding weight, and these products are then summed. The sum of these weighted reflectances is divided by the sum of the weights to normalise the result, providing an estimate for mean albedo ($\alpha$) . Note that we diverge in methods from Vanino et al, in that we normalise our weights, thereby ensuring that the weights sum to 1. This way we maintain the reflectance values' relative importance and avoid artificially inflating or deflating the final albedo estimate.

*2.3.2.4. Building Height*

Taller buildings are more vulnerable irrespective of air conditioning[55], which is considered in the building index model using building height information derived from LiDAR. A digital surface model (DSM) and a digital terrain model (DTM also referred to as a ground elevation model) were derived from 2019 LiDAR[56] across the region. By subtracting the DTM from the DSM, building height is derived for each building footprint (See equation 2). Building height is averaged for each building footprint.

$$BHM = DSM - DTM \quad (2)$$

where:

- $BHM$ is Building Height Model, in metres;
- $DSM$ is Digital Surface Model, in metres; and
- $DTM$ is Ground Elevation, in metres.

*2.3.2.5. Solar Insolation*

Solar radiation refers to the amount of daily sun exposure a building receives; more sun exposure equates to hotter conditions. Solar heat gains are assessed using a solar loading model that considers various factors. Firstly, it uses the sun's position (azimuth and altitude), calculated via astronomical equations for different times of the day and year. A clear sky model is employed to estimate solar radiation, taking into account atmospheric conditions that can scatter and absorb radiation. The model also considers the impact of shade and shadows based on digital elevation models (DEMs), as well as the influence of surface characteristics like aspect and slope on radiation received. The tool calculates insolation, expressed in watt hours per square metre ($Wh/m^2$), for both direct and diffuse radiation, creating a raster output where each cell's value signifies the solar radiation received over a set period of time. The raster output has been averaged across each building footprint to better visualise relative variation in solar insolation.

[55] Samuelson et al. (2020)
[56] Lidar BC, Open Data Portal. Data collected in 2019. https://lidar.gov.bc.ca/pages/download-discovery.

### 2.3.2.6. *Heat Pumps*

Lastly, building-specific data is available for residential buildings that have a newly installed heat pump (installed between 2011 and 2022)[57][58]. If a building has a heat pump, the model assumes a heat vulnerability score of 0 as it is likely to have appropriate protective effects against extreme heat[59].

The distribution of heat pumps is unequal in the capital region region with wide degrees of adoption by jurisdiction as well as building type. Based on our analysis of the heat pump data we note that overall 5.8% of residential buildings have confirmed or suspected heat pump installations based on the Technical Safety BC and City of Victoria permit data.

As summarised in table 2.3 below: The highest overall adoption rates in Colwood and View Royal at 9.8% and 9.6% respectively. Notable in Colwood, was the highest regional penetration of heat pumps in single detached homes (8.9%) compared to a regional average of 4.8%. In View Royal we noted a 31.8% penetration rate (by building count) of heat pumps in multi-unit buildings which was the highest in the region and triple the regional average of 11.4%.

Conversely, we note that of larger jurisdictions, Central Saanich, Victoria and Oak Bay all have lower adoption rates for heat pumps (3.3%, 4.5% and 4.0% respectively). Interestingly, Central Saanich has a very low adoption rate for single detached homes (2.5%) whereas the City of Victoria has lower adoption rates across the board but worryingly in multi-unit residential buildings (4.2%) which we note are more risky from a buildings heat perspective more generally). We should note, however, that multi-unit building heat pump adoption rates may be lower in Victoria due to the use of alternate cooling technologies (such as HVAC or traditional AC units) which were not captured for this study.

**Table 2.3.** Heat pump adoption rates by community for residential buildings

| Community | Percentage of heat pumps in residential buildings |
|---:|:---:|
| Central Saanich | 3% |
| Colwood | 10% |
| Esquimalt | 6% |
| Highlands | 6% |
| Juan de Fuca (Part 1) | 4% |
| Juan de Fuca (Part 2) | 0% |
| Langford | 7% |
| Metchosin | 7% |
| North Saanich | 9% |
| Oak Bay | 5% |
| Saanich | 6% |

[57] From Technical Safety BC Data for all jurisdictions outside of the City of Victoria and from City of Victoria permits in the locale

[58] We note that heat pumps are but one mechanical cooling technology that can be used during a heat event. More commonly air conditioning is considered as the mitigative factor. However, building level air conditioning data does not exist at a scale that would render it effective for a project such as this one.

[59] Canadian Climate Institute. (2023). *Heat Pumps Pay Off.* https://climateinstitute.ca/wp-content/uploads/2023/09/Heat-Pumps-Pay-Off-Unlocking-lower-cost-heating-and-cooling-in-Canada-Canadian-Climate-Institute.pdf

| | |
|---|---|
| Saltspring Island | 0% |
| Sidney | 7% |
| Sooke | 12% |
| Southern Gulf Islands | 0% |
| Victoria | 4% |
| View Royal | 10% |

### *2.3.3. Buildings Index Calculation*

Given the scarcity of comprehensive studies in this area, we use a deterministic approach in modelling the buildings vulnerability index. The index is determined by calculating an equally weighted average of the aforementioned indicators. In cases where data for a specific indicator is unavailable for a particular building, that indicator is excluded from the vulnerability assessment for that building. This ensures that each building's vulnerability score is based only on available and relevant data. See Figure 2.5 below for a summary of the building index compilation.

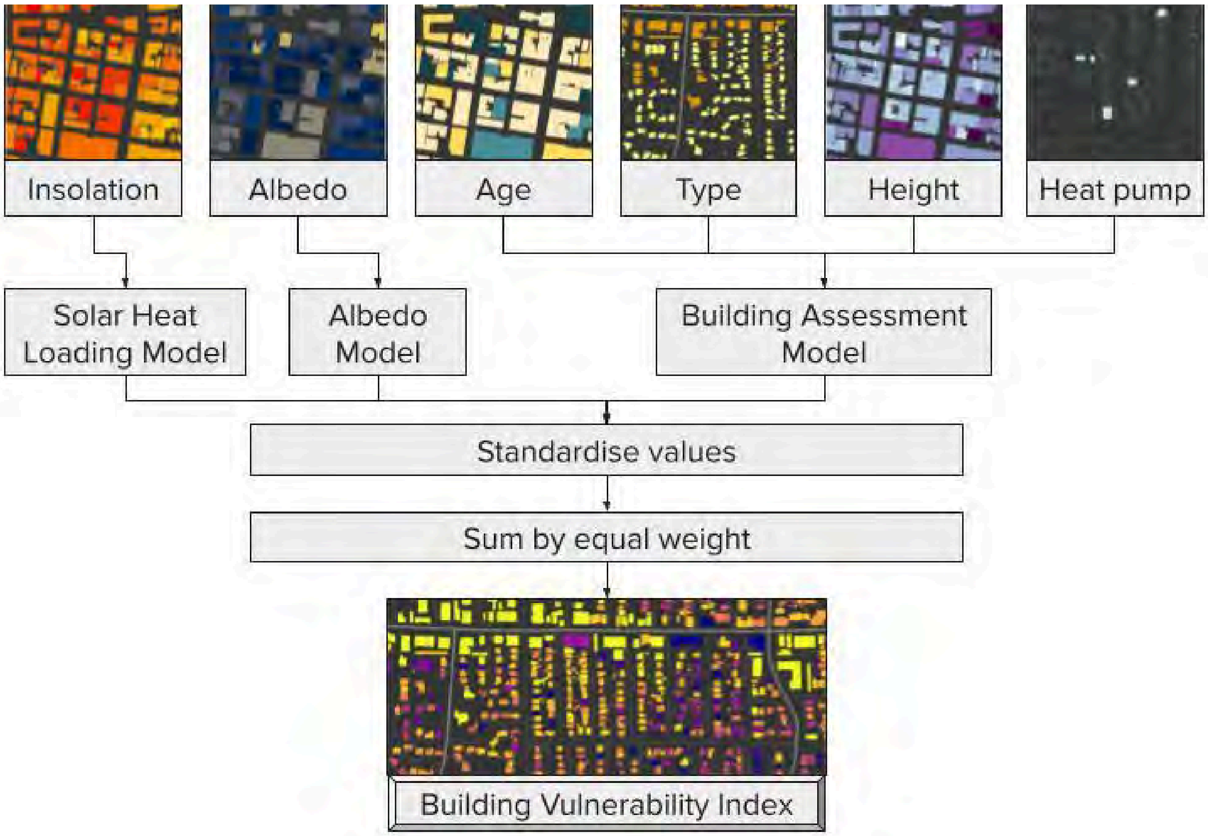


**Figure 2.5.** The Building Vulnerability Index consists of three models that capture multidimensional factors of building-specific vulnerability to extreme heat events. These factors include building age, dwelling type, building height and presence of heat pumps (Building Assessment Model), solar heat gain (Solar Heat Loading Model) and rooftop albedo (Albedo Model).

### *2.3.4. Anomalous and Missing Value Correction*

The process of relating input values, such as BHM or albedo, to building footprints revealed some inaccuracies that required a specifically designed correction process. These inaccuracies are largely brought about by tree canopy coverage of building footprints and temporally misaligned lidar data.

This correction process applies a lidar-derived land cover classification layer, that distinguishes between treed and non-treed surfaces[60]. Albedo and BHM values are averaged from non-tree footprint segments, so that a more accurate height and reflectance values can be assumed. The correction process also tails height data to account for anomalous averages. Further, the correction process identifies buildings with missing values (either due to a high proportion of tree canopy coverage or due to temporal misalignment between the footprint and lidar dataset) and

[60] Caslys (2021). Capital Regional District Land Cover Classification [Map/Dataset]. Shared under data agreement with the Capital Regional District.

applies an archetypical height value that is representative of buildings of the same type within the local area.

### 2.3.5. *Building Attribute Verification Process*

The building footprint attribution QA process involves a multi-faceted approach that ensures the reliability of the Building Vulnerability Index inputs, namely height, albedo, solar insolation, dwelling type, and year built.

- *Sample selection for validation.*
  A representative sample of 80 building footprints was selected from both the upper and lower ends of the Buildings Index values. This sampling strategy was designed to cover a broad spectrum of buildings, facilitating a comprehensive evaluation of various attributes.
- *Findings from the attribution quality assurance process.*
  Our analysis revealed patterns consistent with expectations. Buildings identified as highly vulnerable in the index typically exhibited greater height and exposure to solar radiation. Conversely, buildings classified as less vulnerable were generally shorter and had more extensive tree coverage. However, it was observed that smaller buildings, predominantly single-family dwellings, demonstrated more variability in results. This variability included occasional misidentifications of building footprints and potential tree obstructions affecting building height measurements.
- *Albedo assessment.*
  The albedo values for smaller buildings were found to be closely clustered due to the spatial resolution of albedo measurements (10 $m^2$). This clustering makes it challenging to discern clear patterns for these small buildings. In contrast, larger buildings displayed more distinct albedo values, which more accurately reflected the colour and material of the roofs, ranging from white to dark grey.
- *QA methodology.*
  The quality assurance (QA) process serves as an essential validation measure to verify the rationality and validity of the regional model in its classification of buildings at the individual level. QA checks include the following procedures:
    - Street view analysis: Attributes such as building height, solar insolation, and dwelling type were cross-verified using Google Street View imagery. For example, a building identified as a seniors living building type, 11.1 m height, and high solar insolation (i.e. open environment, low tree cover) was validated through Google Street View, which confirmed the building as a four-storey senior care home with minimal shading and older construction material (Figure 2.6).
    - Satellite imagery analysis: Attributes, such as albedo, were also cross-checked using high resolution, RGB satellite imagery[61]. This cross-check confirmed the

[61] Maxar. (2022, July 24). Vivid RGB 30 cm high resolution imagery. Retrieved from ArcGIS Online: https://www.arcgis.com

accuracy of albedo values alignment with roof colours in the Region. The same building discussed above shows a typical grey roof colour in Figure 2.7

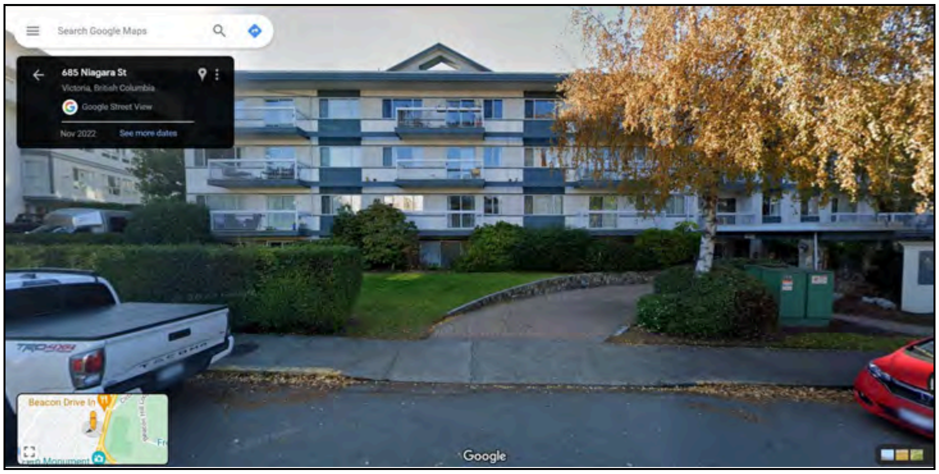


**Figure 2.6.** QA example of sense check methodology, Google Street View.

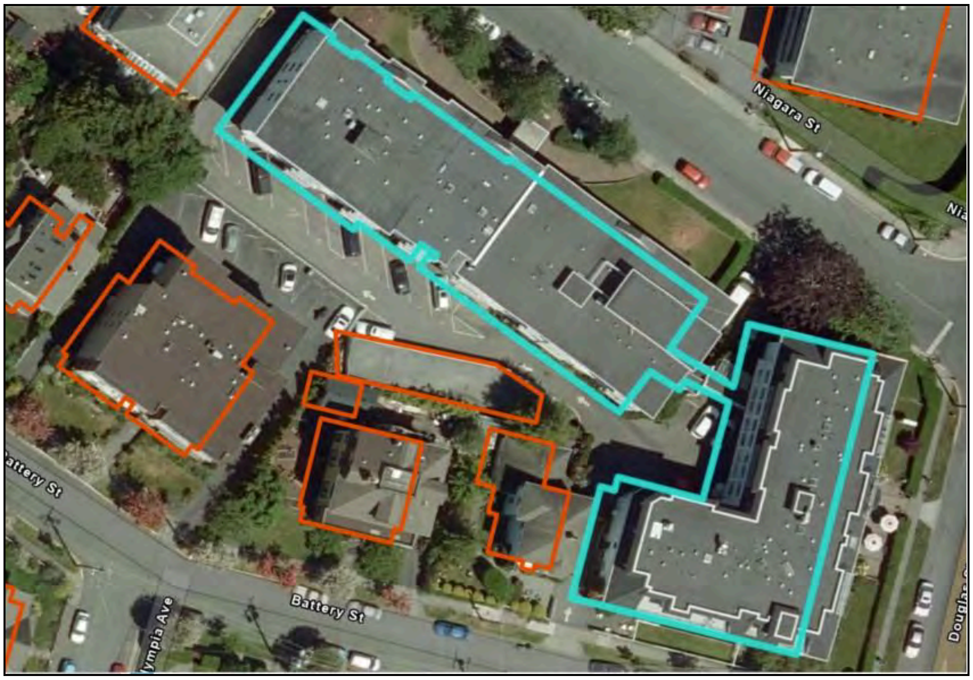


**Figure 2.7.** QA example of sense check methodology, aerial view.

The QA process concluded that 86% of the assessed buildings accurately represented all examined attributes. Discrepancies in the remaining 14% were attributed to various factors, as detailed in Table 2.4. These included construction-related changes (2.5%), misclassification of structures as buildings (3.7%), building height overestimations (2.5%), and tree interference in rural areas leading to inaccuracies in footprint delineation (4.9%). Imagery resolution challenges in rural areas further compounded these validation issues.

**Table 2.4.** Summary of error types found during the QA process

| Type of error | Proportion of dataset (%) |
|---|---|
| Construction Related | 2.5% |
| Misclassification of Buildings | 3.7% |
| Building Height Errors | 2.5% |
| Tree Interference | 4.9% |

In total, 100% of delineated building footprints were attributed a building height, albedo and solar insolation value while 97.12% of buildings were attributed with building construction year and dwelling type. Thus, 2.88% of buildings are left without BIR attributes. For buildings without BIR attributes, 1.43% of those buildings were on First Nations Lands and data is not available from the BIR for these buildings. There is also an estimated 2.28% of buildings missing from the buildings index model, which was gleaned from where a building information record was attached to a parcel, but no building footprint was present.

## 3. Results

This Section presents results pertaining to the socio-demographic vulnerability index, the heat exposure layer, and the building vulnerability index. For each, key patterns are described and emergent insights from the analysis are discussed. Additionally, the Section presents community-level and municipal analysis findings.

### *3.1. Socio-Demographic Vulnerability Index*

As mentioned in the sections above, the Socio-demographic Vulnerability Index was informed by a rigorous process involving the assignment of weights to each variable during the Analytic Hierarchy Process (AHP) workshop, which was a collaborative effort with regional subject matter experts, including epidemiologists, emergency managers, and social planners. The Socio-demographic Vulnerability Index identifies key contributors to vulnerability, and based on the insights garnered from the AHP workshop, three variables emerged as the most significant risk indicators during extreme heat events. The demographic factors most strongly influencing the vulnerability index encompassed the percentage of the population aged 65 or older, the crude rate of individuals with mental and substance use disorders, and the percentage of low-income adults (see Table 2.0 for the full list of variables with their associated weights). These variables were collectively deemed as the most at-risk populations during extreme heat, as established through the informed perspectives of the workshop participants and antecedent literature review.

The demographic index was further broken down into two distinct sub-indices to gain a more nuanced comprehension of the spatial dynamics influenced by health-related demographic variables and socio-demographic factors. When decomposed, we note that the individual sub-indices performed poorly in comparison to the singular index which suggests that both health and demographic information contribute more or less equally to heat risk.[62] The demographic index, excluding health factors, displays a spatial pattern with a concentration of vulnerability observed in Victoria's downtown core (see fig 3.1). The pattern indicates relatively less vulnerable areas radiating outward from Victoria. In contrast, the demographic index considering only health-related factors illustrates increased vulnerability proportions in Saanich as well as an increased amount of Dissemination Areas (DAs) in Sydney (see figure 3.2). Overall, the combined socio-demographic index highlights a few areas in the region that have a greater proportion of the population that is vulnerable to extreme heat events (see figure 3.3). These highly vulnerable areas include James Bay and the surrounding areas near downtown Victoria, pockets of Saanich, and the town of Sydney (See figures 3.1, 3.2, and 3.3 for maps of the socio-demographic index and the two sub-indices). Additional detailed findings are indicated by municipality in the municipal summaries outlined in section 3.6 below.

[62] While individually, each sub-index had weaker outcomes, on their own each can be used for alternative purposes or be combined with other variables and information to produce value-added outcomes. We suggest further evaluation regarding the combination of these sub-indices and other variables in future studies, as appropriate.

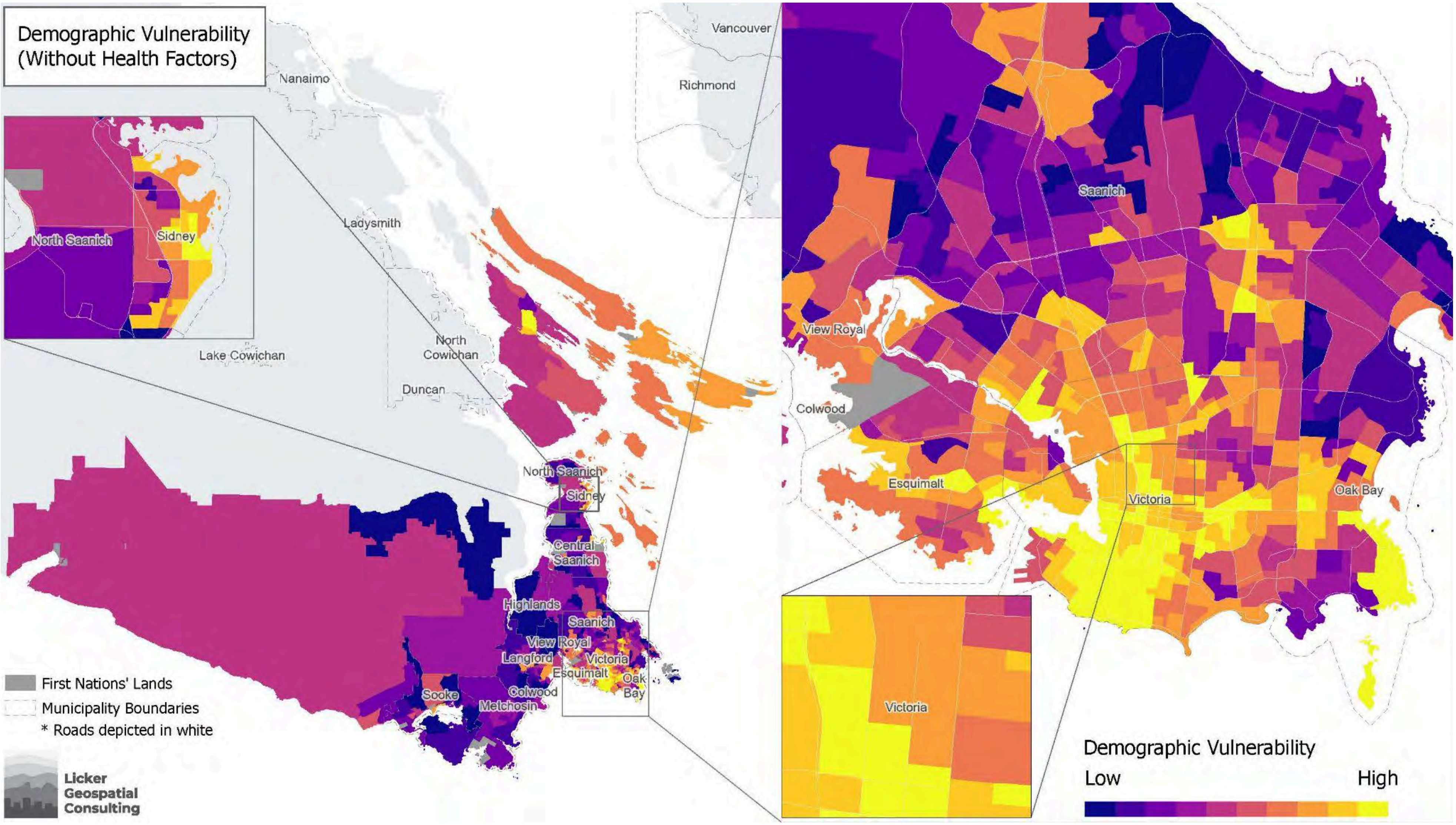


**Figure 3.1.** Extreme Heat – Demographic Vulnerability sub-index distribution (no health data included).

*3.1.1. Concentrations of health vulnerability*

When analysed by community, we note that significant health risk is present in Sidney (31% of its population reside in DAs with high health risk mainly due to an older population, however other determinants of health could still be a factor there), Esquimalt and the Southern Gulf Island and Salt Spring Island (Figures 3.1 and 3.3). When considered at a population level, the highest concentration of highly vulnerable populations reside in Victoria (28% share of the top two deciles), Saanich (20% share of the top two deciles) and Langford (11% share). However, when taken in proportion to the population as a whole, Sidney stands out with a 10% share of the highest two deciles compared to an overall 3% share of the capital region's population (resulting in a risk proportion ratio of 3.0). This is distantly followed by Esquimalt (1.43) and Victoria (1.36). (Tables 3.0 and 3.1 below).

Key determinants of health vulnerability in Sidney include:

- High rates of hypertension in the populace - 54th in the capital region
- High rates of episodic mood disorders - 54th in the capital region
- Higher rates of Acute Myocardial Infarction - 47th in the capital region; and
- Higher rates of Chronic kidney disease - 42nd percentile in the capital region

It bears noting that these are average percentile values and as such indicate a high degree of concentration of health risks in the municipality.

For reference, neighbouring North Saanich (which has a much lower index score) shows the following average rates (by capital region percentile):

- Hypertension - 39th Percentile
- Episodic mood disorders - 37th percentile
- Acute Myocardial Infarction - 29th percentile
- Chronic Kidney disease - 27th percentile

Colwood (the second lowest scoring municipality with regards to the health index) continues the trend:

- Hypertension - 17th Percentile
- Episodic mood disorders - 35th percentile
- Acute Myocardial Infarction - 15th percentile
- Chronic Kidney disease - 13th percentile

Indeed, areas such as Colwood, North Saanich and Saanich all have relatively lower proportions of at-risk populations in comparison to their proportionate share of capital region population (ratios of 0.56, 0.22 and 0.61 for Colwood, North Saanich and Saanich respectively). These ratios suggest that these areas have reduced concentrations of health risk overall.

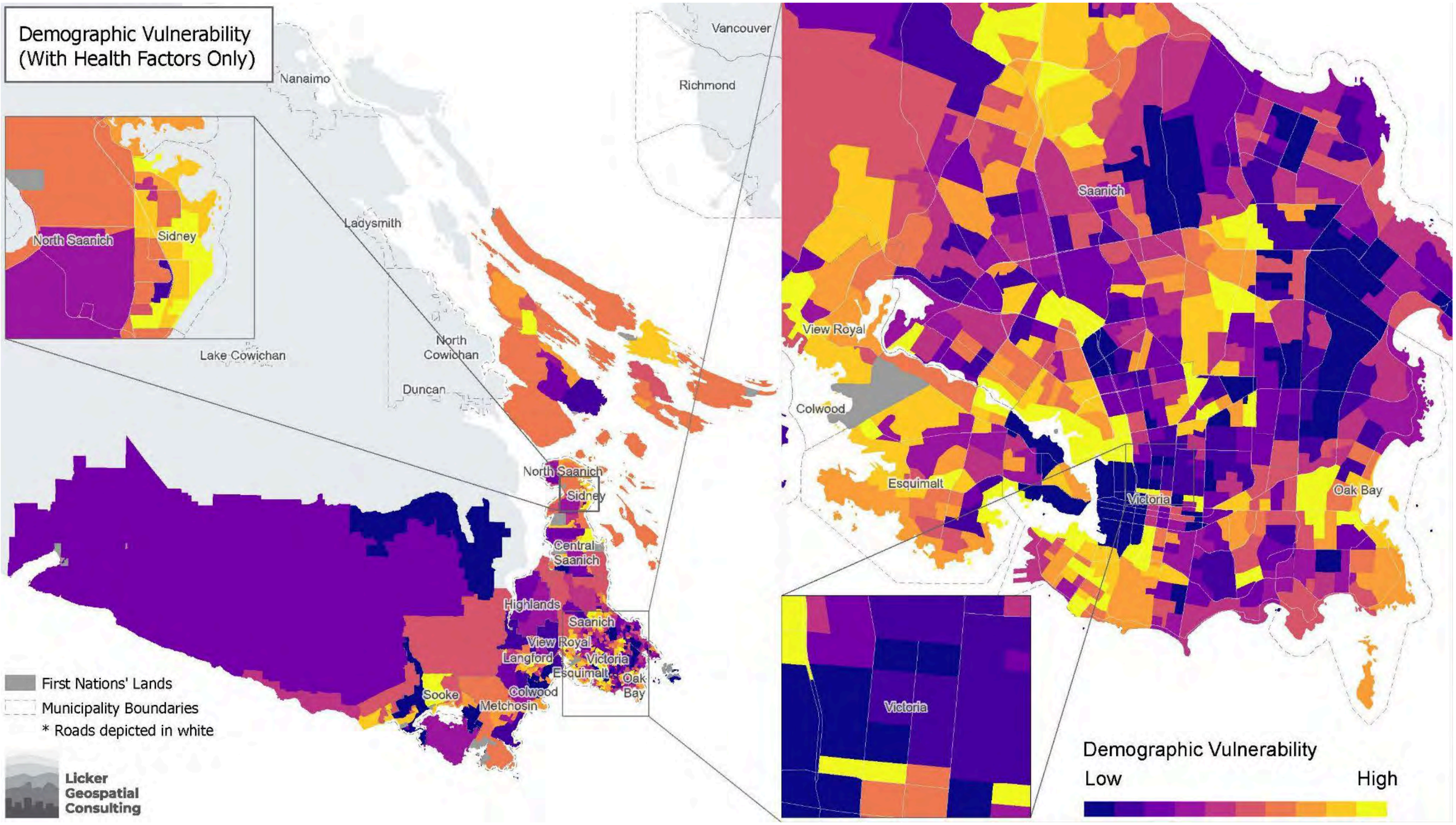


**Figure 3.2.** Extreme Heat – Health-Only Demographic Vulnerability sub-index distribution.

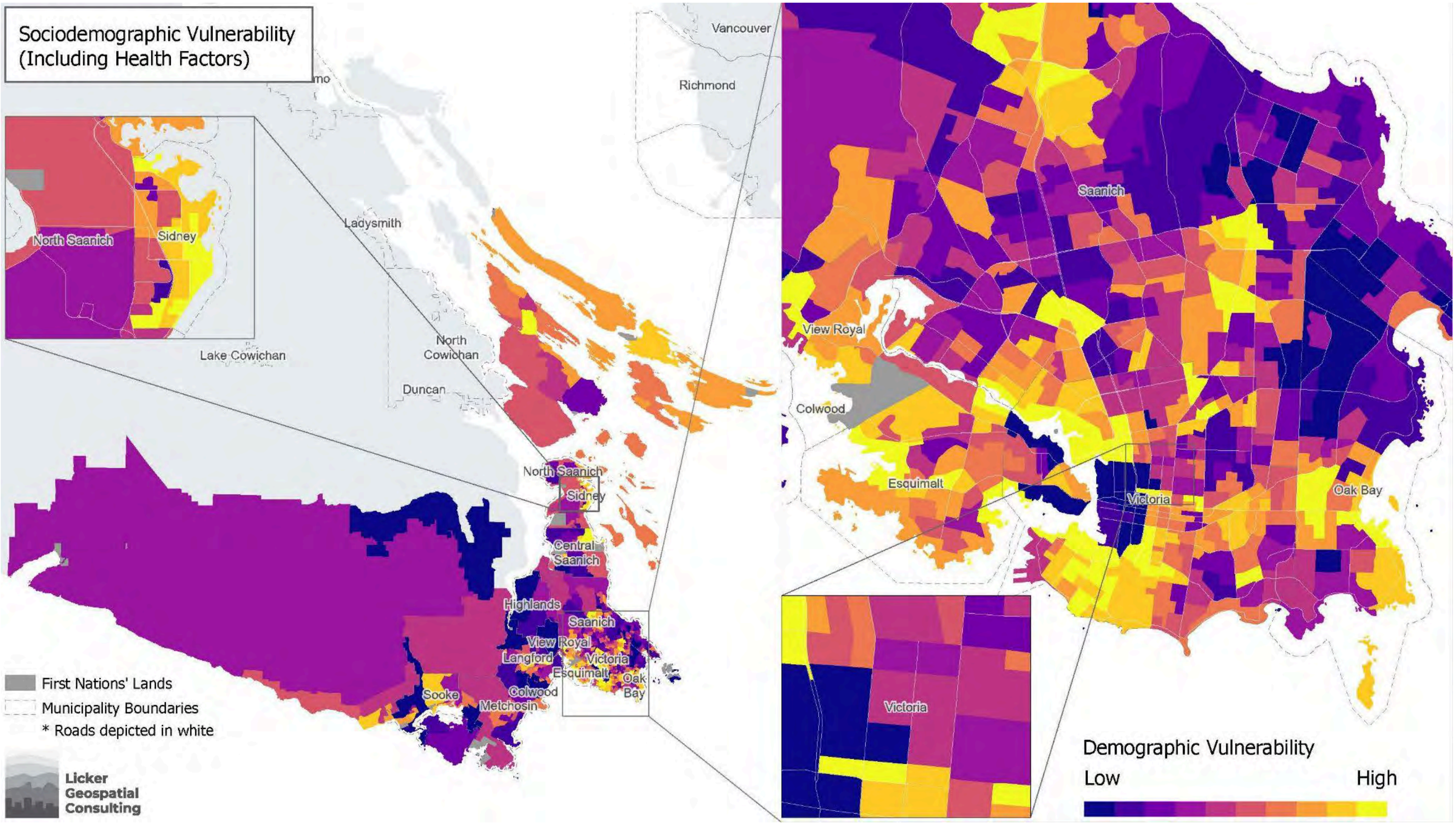


**Figure 3.3.** Extreme Heat – Socio-demographic Vulnerability Index with both demographic and health-related indicators

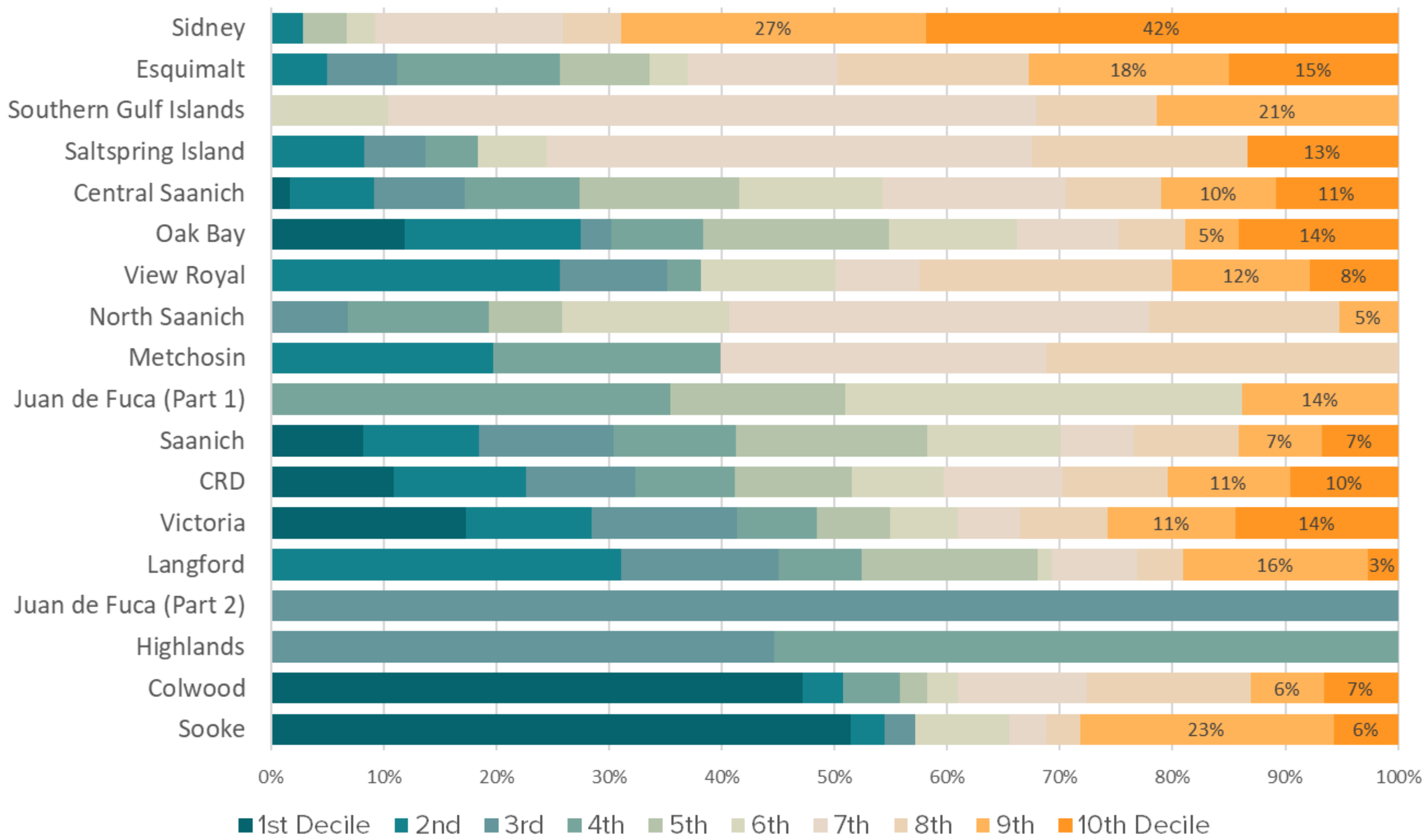


**Figure 3.4.** Demographic vulnerability (Health sub-index) by jurisdiction in the capital region, displayed by decile. Sidney BC, has the largest proportion of its population falling within the most vulnerable decile, while Juan de Fuca (part 2) and Highlands BC, have 0% of their populations within the most vulnerable decile.

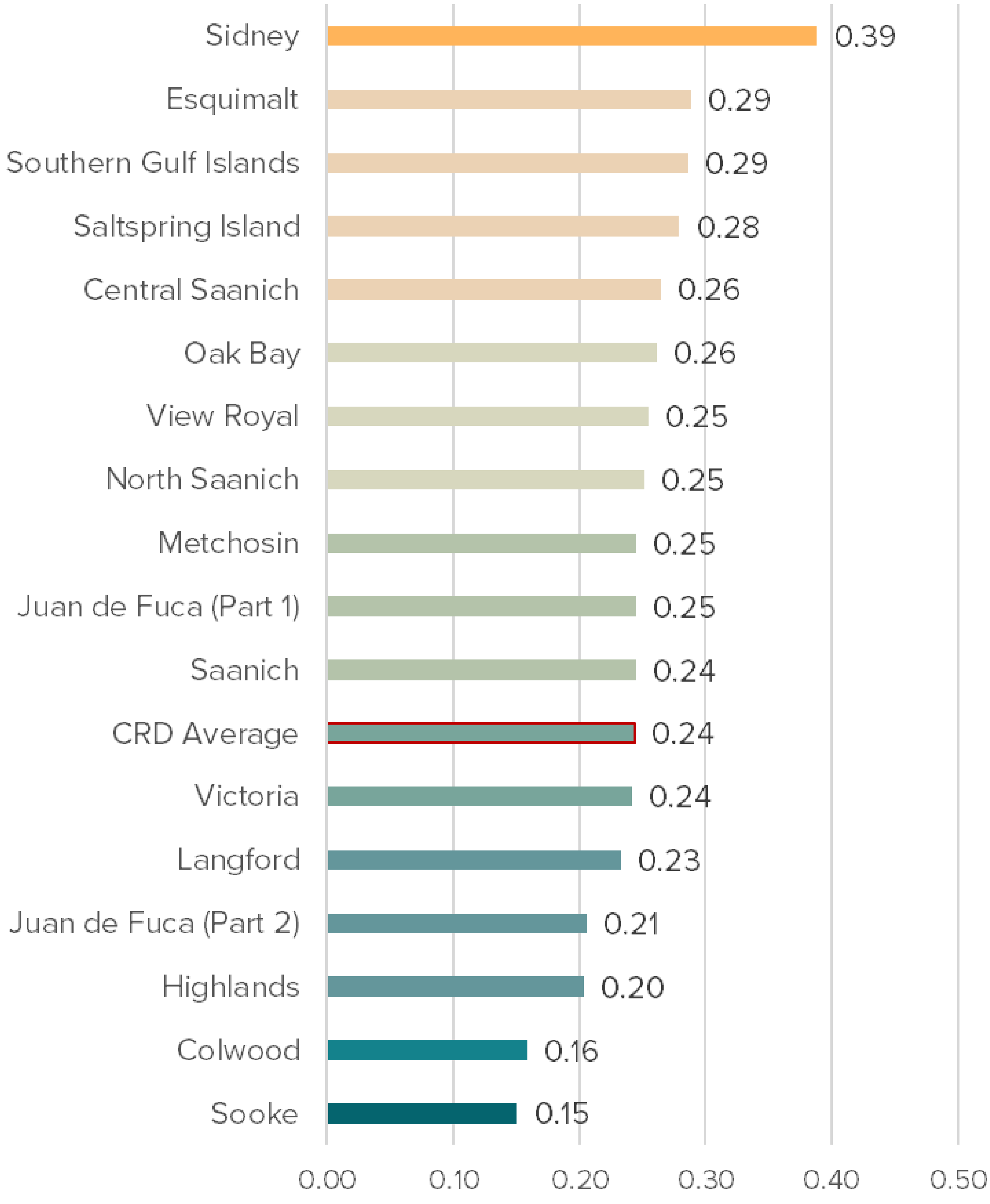


**Figure 3.5.** Demographic vulnerability by jurisdiction in the capital region (heath sub-index only).

**Table 3.0.** Population by demographic health sub-index decile by jurisdiction in the capital region (health data only).

| Jurisdiction | 1st Decile | 2nd | 3rd | 4th | 5th | 6th | 7th | 8th | 9th | 10th Decile |
|---|---|---|---|---|---|---|---|---|---|---|
| **Sooke** | 7,762 | 447 | 411 | | | 1,262 | 502 | 449 | 3,396 | 857 |
| **Colwood** | 8,939 | 689 | | 947 | 472 | 501 | 2,175 | 2,762 | 1,231 | 1,245 |
| **Highlands** | | | 1,109 | 1,373 | | | | | | |
| **Juan de Fuca (Part 2)** | | | 399 | | | | | | | |
| **Langford** | | 14,476 | 6,528 | 3,398 | 7,288 | 573 | 3,532 | 1,912 | 7,624 | 1,253 |
| **Victoria** | | 10,266 | 11,812 | 6,585 | 5,966 | 5,486 | 5,096 | 7,084 | 10,484 | 13,210 |
| **Saanich** | 9,593 | 12,181 | 14,057 | 12,697 | 20,076 | 13,885 | 7,677 | 10,936 | 8,639 | 7,994 |
| **Juan de Fuca (Part 1)** | | | | 1,817 | 796 | 1,808 | | | 711 | |
| **Metchosin** | | 998 | | 1,025 | | | 1,462 | 1,582 | | |
| **North Saanich** | | | 834 | 1,531 | 791 | 1,818 | 4,564 | 2,061 | 636 | |
| **View Royal** | | 2,971 | 1,097 | 344 | | 1,382 | 871 | 2,593 | 1,413 | 904 |
| **Oak Bay** | 2,143 | 2,799 | 486 | 1,475 | 2,955 | 2,041 | 1,639 | 1,048 | 856 | 2,548 |
| **Central Saanich** | 293 | 1,293 | 1,413 | 1,771 | 2,457 | 2,212 | 2,826 | 1,460 | 1,778 | 1,882 |
| **Saltspring Island** | | 959 | 638 | 536 | | 718 | 5,004 | 2,226 | | 1,554 |
| **Southern Gulf Islands** | | | | | | 637 | 3,509 | 651 | 1,304 | |
| **Esquimalt** | | 882 | 1,077 | 2,532 | 1,393 | 601 | 2,337 | 2,976 | 3,104 | 2,631 |
| **Sidney** | | 352 | | | 477 | 314 | 2,052 | 633 | 3,339 | 5,151 |
| **CRD Total** | | **48,313** | **39,861** | **36,031** | **42,671** | **33,238** | **43,246** | **38,373** | **44,515** | **39,229** |

**Table 3.1.** Relationship between population in high risk DAs and proportion of regional population.

| Jurisdiction | Proportion of Population in Top Two Deciles | Proportion of capital region's Population | Ratio of High Risk Proportion to Proportion of capital region Population |
|---|---|---|---|
| Sooke | 5.1% | 4.1% | 1.2 |
| Colwood | 3.0% | 5.2% | 0.6 |
| Highlands | 0.0% | 0.7% | 0.0 |
| Juan de Fuca (Part 2) | 0.0% | 0.1% | 0.0 |
| Langford | 10.6% | 12.7% | 0.8 |
| Victoria | 28.3% | 20.8% | 1.4 |
| Saanich | 19.9% | 32.2% | 0.6 |
| Juan de Fuca (Part 1) | 0.8% | 1.4% | 0.6 |
| Metchosin | 0.0% | 1.4% | 0.0 |
| North Saanich | 0.8% | 3.3% | 0.2 |
| View Royal | 2.8% | 3.2% | 0.9 |
| Oak Bay | 4.1% | 4.9% | 0.8 |
| Central Saanich | 4.4% | 4.8% | 0.9 |
| Saltspring Island | 1.9% | 3.2% | 0.6 |
| Southern Gulf Islands | 1.6% | 1.7% | 0.9 |
| Esquimalt | 6.8% | 4.8% | 1.4 |
| Sidney | 10.1% | 3.4% | 3.0 |

### *3.1.2. Concentrations of demographic vulnerability*

When analysed by community, we note that there is significant demographic risk in Victoria, Sidney and Esquimalt (Figures 3.6 and 3.7). This risk is driven by key factors such as family income, renting populations, and the overall age of the population. When considered at a population level, the highest concentration of highly vulnerable populations (per the demographic sub-index) reside in Victoria (67% share of the top two deciles), Saanich (12% of the top two deciles) and Sidney and Oak (Both 6.6%).

However, when using a proportionate share approach, Victoria stands out with a 66% share of the top two deciles compared with a 22.4% share of the capital region's population (resulting in a risk to proportion ratio of 3.0). Key factors that drive vulnerability in Victoria include:

- Percentage of renters in the community (59% community average, 18% model weighting)
- Spending on shelter improvements (windows and doors) (89th lowest percentile in the capital region, 12% model weighting)
- Percentage of the population living alone (28% community average, 12% model weighting)
- Percentage of the population that is 65 years and older (23% community average, 11% model weighting)
- Average number of rooms per dwelling (69th lowest percentile in the capital region, 10% model weighting).

Victoria's risk to proportion ratio is subsequently followed by Sidney (2.2) and Oak Bay (1.5) (Tables 3.2 and 3.3 below). Of note is the Oak Bay finding, which raises questions with regards to demographic risk in affluent areas which could suggest hidden poverty or a significant subset of the population who do not own their homes and potentially live in substandard housing. Accordingly, further investigation into this community is warranted.

Conversely, in West Shore communities such as Colwood, Sooke and Langford, we note no populations in highest deciles of the demographic sub-index which suggests very low risk in these communities overall (at least at the population level, noting the ecological fallacy discussed in the section above).

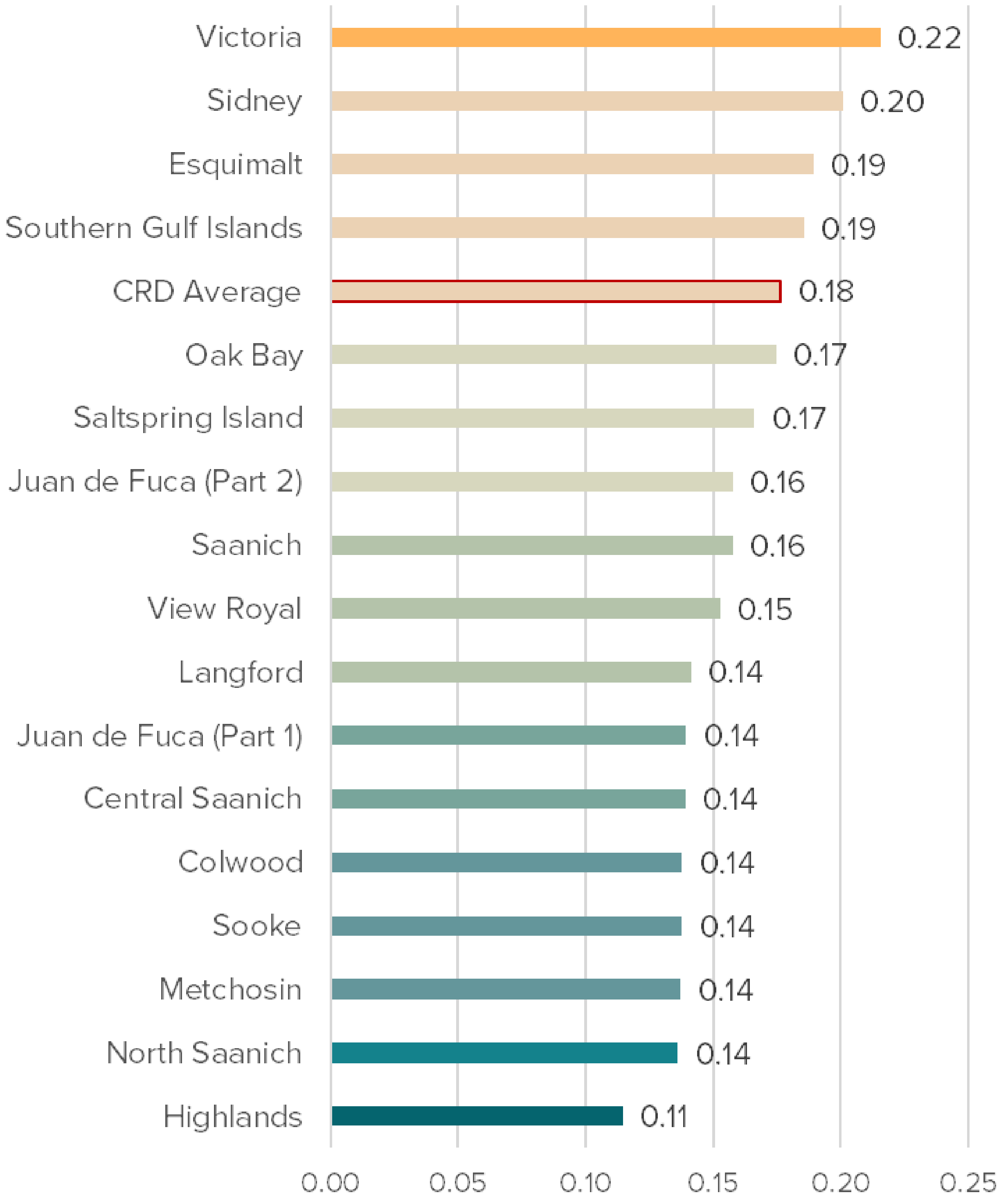


**Figure 3.6.** Demographic vulnerability by jurisdiction in the capital region (demographic sub-index only).

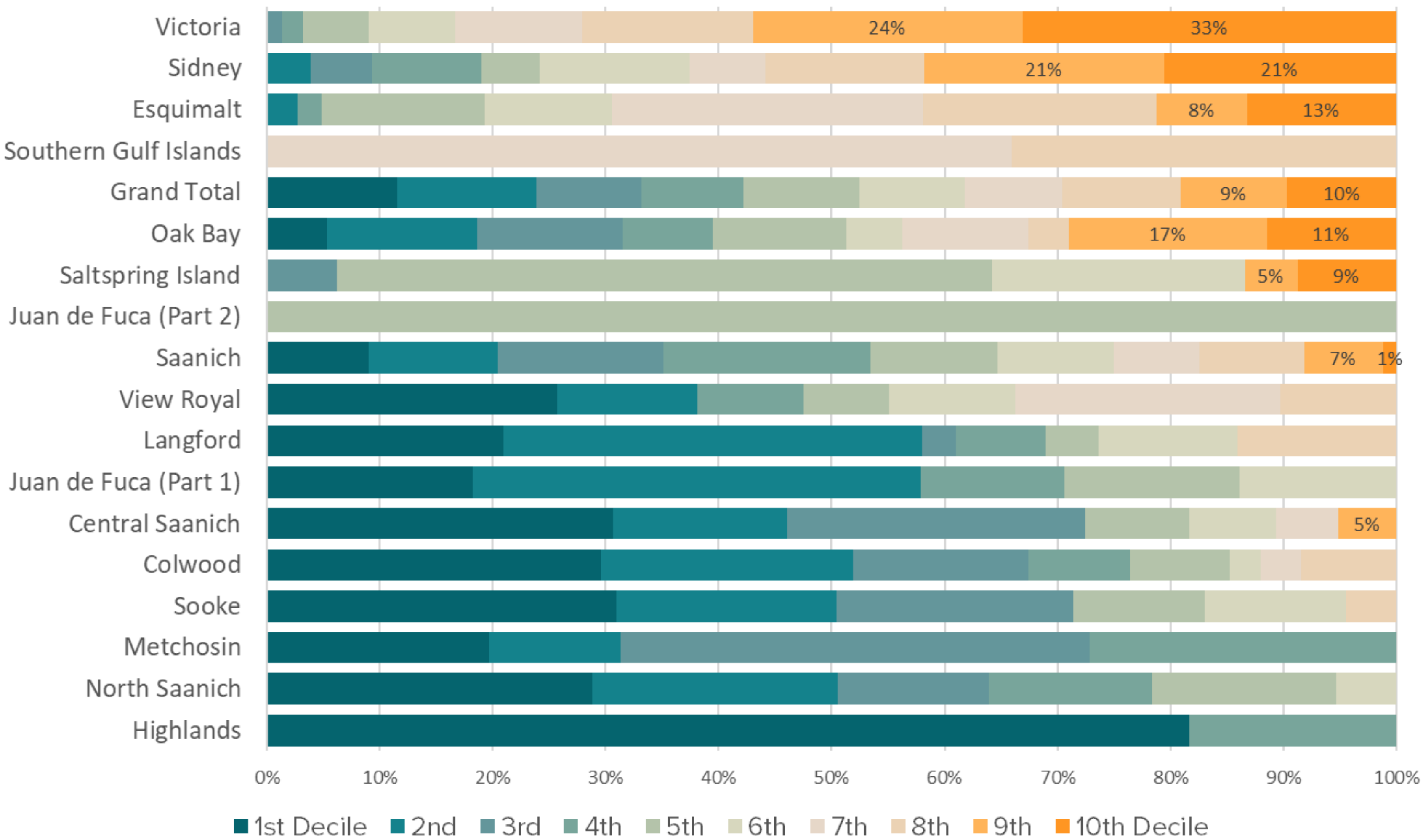


**Figure 3.7.** Demographic vulnerability (sub-index) by jurisdiction in the capital region, displayed by decile. Victoria, BC, has the largest proportion of its population falling within the most vulnerable decile, while North Saanich and Highlands BC, have 0% of their populations within the most vulnerable decile.

**Table 3.2.** Population by demographic sub index decile by jurisdiction in the capital region (no health data included).

| Jurisdiction | 1st Decile | 2nd | 3rd | 4th | 5th | 6th | 7th | 8th | 9th | 10th Decile |
|---|---|---|---|---|---|---|---|---|---|---|
| **Highlands** | 2,027 | | | 455 | | | | | | |
| **North Saanich** | 3,519 | 2,668 | 1,628 | 1,778 | 1,990 | 652 | | | | |
| **Metchosin** | 998 | 592 | 2,103 | 1,374 | | | | | | |
| **Sooke** | 4,665 | 2,950 | 3,149 | | 1,757 | 1,888 | | 677 | | |
| **Colwood** | 5,605 | 4,228 | 2,954 | 1,709 | 1,674 | 502 | 695 | 1,594 | | |
| **Central Saanich** | 5,327 | 2,679 | 4,593 | | 1,592 | 1,338 | 956 | | 900 | |
| **Juan de Fuca (Part 1)** | | 2,037 | | 653 | 796 | 711 | | | | |
| **Langford** | | 17,239 | 1,388 | 3,738 | 2,127 | 5,737 | | 6,575 | | |
| **View Royal** | 2,971 | 1,441 | | 1,093 | 871 | 1,297 | 2,709 | 1,193 | | |
| **Saanich** | 10,581 | 13,472 | 17,316 | 21,570 | 13,282 | 11,995 | 9,016 | 10,891 | 8,265 | 1,347 |
| **Juan de Fuca (Part 2)** | | | | | 399 | | | | | |
| **Saltspring Island** | | | 718 | | 6,748 | 2,615 | | | 536 | 1,018 |
| **Oak Bay** | 962 | 2,392 | 2,325 | 1,428 | 2,132 | 877 | 2,006 | 659 | 3,144 | 2,065 |
| **Southern Gulf Islands** | | | | | | | 4,026 | 2,075 | | |
| **Esquimalt** | | 477 | | 368 | 2,537 | 1,975 | 4,838 | 3,621 | 1,398 | 2,319 |
| **Sidney** | | 477 | 666 | 1,199 | 633 | 1,636 | 821 | 1,735 | 2,618 | 2,533 |
| **Victoria** | | | 1,229 | 1,707 | 5,374 | 6,999 | 10,342 | 13,872 | 21,917 | 30,427 |
| **CRD Total** | **47,370** | **50,652** | **38,069** | **37,072** | **41,912** | **38,222** | **35,409** | **42,892** | **38,778** | **39,709** |

**Table 3.3.** Relationship between population in high risk DAs and proportion of capital region population per the demographic sub-index.

| Jurisdiction | Proportion of Population in Top Two Deciles | Proportion of capital region's Population | Ratio of High Risk Proportion to Proportion of capital region Population |
|---|---|---|---|
| Highlands | 0.0% | 0.6% | 0.0 |
| North Saanich | 0.0% | 3.0% | 0.0 |
| Metchosin | 0.0% | 1.2% | 0.0 |
| Sooke | 0.0% | 3.7% | 0.0 |
| Colwood | 0.0% | 4.6% | 0.0 |
| Central Saanich | 1.1% | 4.2% | 0.3 |
| Juan de Fuca (Part 1) | 0.0% | 1.0% | 0.0 |
| Langford | 0.0% | 9.0% | 0.0 |
| View Royal | 0.0% | 2.8% | 0.0 |
| Saanich | 12.2% | 28.7% | 0.4 |
| Juan de Fuca (Part 2) | 0.0% | 0.1% | 0.0 |
| Saltspring Island | 2.0% | 2.8% | 0.7 |
| Oak Bay | 6.6% | 4.4% | 1.5 |
| Southern Gulf Islands | 0.0% | 1.5% | 0.0 |
| Esquimalt | 4.7% | 4.3% | 1.1 |
| Sidney | 6.6% | 3.0% | 2.2 |
| Victoria | 66.7% | 22.4% | 3.0 |

*3.1.3. Concentrations of overall socio-demographic vulnerability*

When analysed by community, we note a synthesis of patterns as detailed in the subindexes above. Of significance, we observe high index values for Sidney, Esquimalt, the Southern Gulf Island and Victoria. Notably, Victoria's health-related vulnerability is markedly lower compared to demographic factors. Conversely, Sidney is the true hot spot in the region with both high demographic and health sub-index values. (Figures 3.8 and 3.9). Given this prominence, we suggest outreach and proactive engagement in the community as a next step in regional risk reduction.

On a proportional basis, large concentrations of socio-demographic risk are present in both Victoria and Saanich (56% of the share of high risk areas). Notable is the comparatively lower risk profile of Saanich (0.6 ratio of high risk population to share of the capital regions population) in comparison to Victoria (1.7 ratio) (tables 3.4 and 3.5 below).

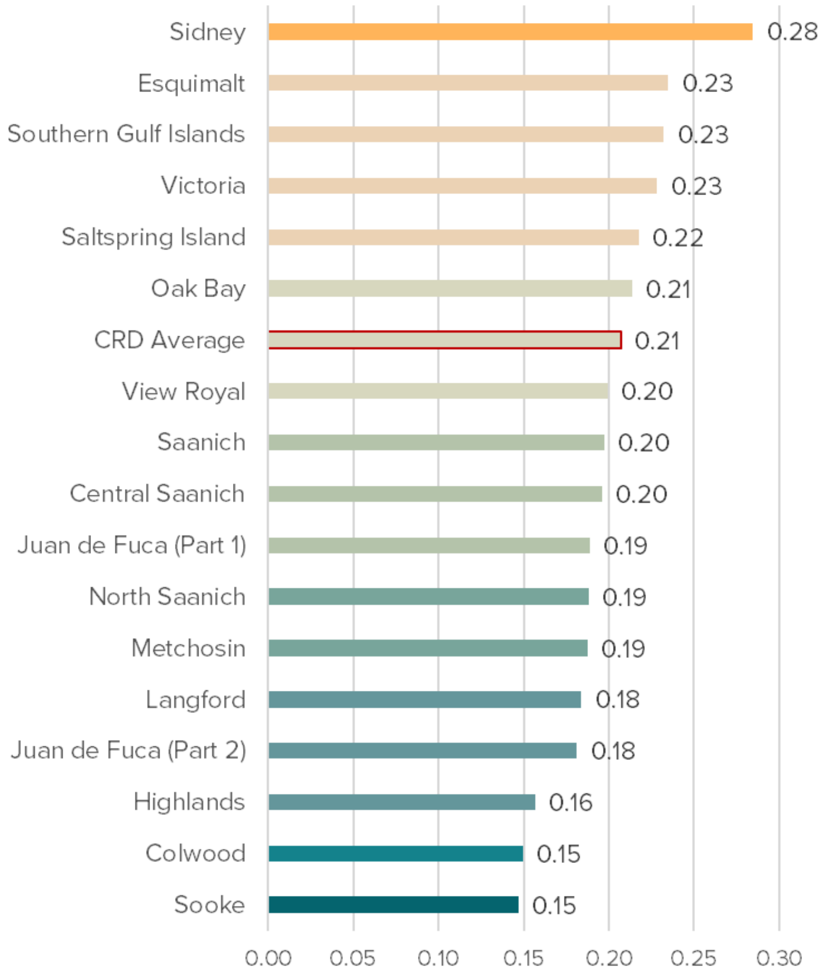


**Figure 3.8.** Average Socio-demographic vulnerability by jurisdiction in the capital region. Averages are weighted by population

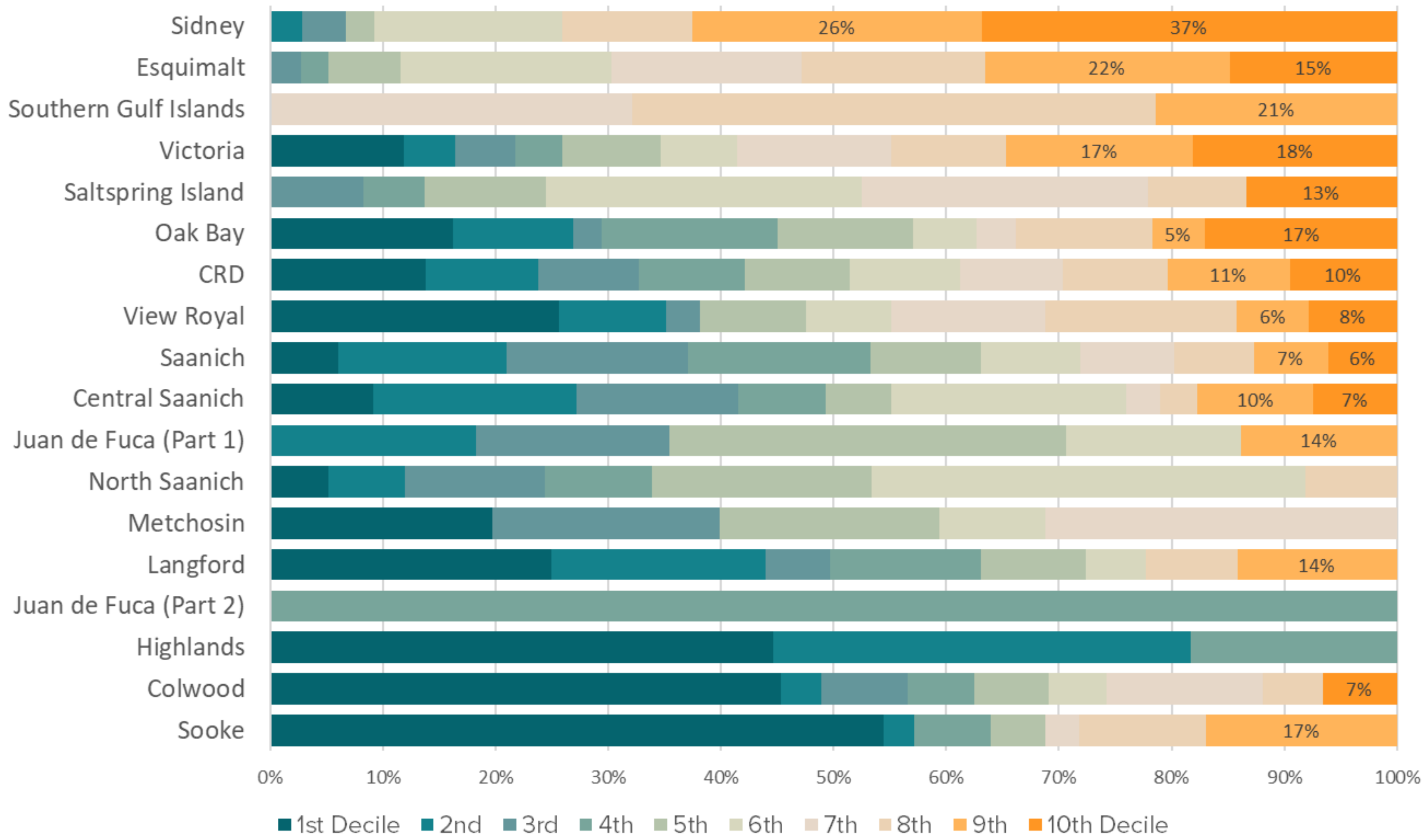


**Figure 3.9.** Socio-demographic vulnerability by jurisdiction in the capital region. Socio-demographic vulnerability is displayed by decile. Sidney BC, has the largest proportion of its population falling within the most vulnerable decile, while Juan de fuca (part 2) and Highlands BC, have 0% of their populations within the most vulnerable decile.

**Table 3.4.** Population by combined Socio-demographic Heat Vulnerability Index per jurisdiction in the capital region.

| Jurisdiction | 1st Decile | 2nd | 3rd | 4th | 5th | 6th | 7th | 8th | 9th | 10th Decile |
|---|---|---|---|---|---|---|---|---|---|---|
| **Sooke** | | 411 | | 1,025 | 739 | | 449 | 1,688 | 2,565 | |
| **Colwood** | | 689 | 1,448 | 1,112 | 1,254 | 985 | 2,630 | 1,008 | | 1,245 |
| **Highlands** | 1,109 | 918 | | 455 | | | | | | |
| **Juan de Fuca (Part 2)** | | | | 399 | | | | | | |
| **Langford** | | 8,855 | 2,655 | 6,270 | 4,335 | 2,480 | | 3,802 | 6,575 | |
| **Metchosin** | 998 | | 1,025 | | 986 | 476 | 1,582 | | | |
| **North Saanich** | 627 | 834 | 1,517 | 1,168 | 2,383 | 4,714 | | 992 | | |
| **Juan de Fuca (Part 1)** | | 935 | 882 | | 1,808 | 796 | | | 711 | |
| **Central Saanich** | 1,586 | 3,135 | 2,506 | 1,335 | 1,018 | 3,629 | 516 | 584 | 1,778 | 1,298 |
| **Saanich** | 7,112 | 17,556 | 19,005 | 19,023 | 11,605 | 10,315 | 9,877 | 8,251 | 7,778 | 7,213 |
| **View Royal** | 2,971 | 1,097 | 344 | | 1,093 | 871 | 1,586 | 1,964 | 745 | 904 |
| **Oak Bay** | 2,925 | 1,907 | 461 | 2,807 | 2,158 | 1,024 | 614 | 2,182 | 853 | 3,059 |
| **Saltspring Island** | | | 959 | 638 | 1,254 | 3,255 | 2,957 | 1,018 | | 1,554 |
| **Victoria** | 10,863 | 4,192 | 4,942 | 3,807 | 7,989 | 6,312 | 12,560 | 9,334 | 15,204 | 16,664 |
| **Southern Gulf Islands** | | | | | | | 1,963 | 2,834 | 1,304 | |
| **Esquimalt** | | | 477 | 426 | 1,121 | 3,279 | 2,964 | 2,857 | 3,814 | 2,595 |
| **Sidney** | | 352 | 477 | | 314 | 2,052 | | 1,416 | 3,168 | 4,539 |
| **CRD Total** | **56,602** | **40,881** | **36,698** | **38,465** | **38,057** | **40,188** | **37,698** | **37,930** | **44,495** | **39,071** |

**Table 3.5.** Relationship between population in high risk DAs and proportion of capital region population per the combined socio-demographic index.

| Jurisdiction | Proportion of capital region Population in Top Two Deciles | Proportion of capital region's Population | Ratio of High Risk Proportion to Proportion of capital region Population |
|---|---|---|---|
| Sooke | 3.1% | 1.7% | 1.8 |
| Colwood | 1.5% | 2.5% | 0.6 |
| Highlands | 0.0% | 0.6% | 0.0 |
| Juan de Fuca (Part 2) | 0.0% | 0.1% | 0.0 |
| Langford | 7.9% | 8.5% | 0.9 |
| Metchosin | 0.0% | 1.2% | 0.0 |
| North Saanich | 0.0% | 3.0% | 0.0 |
| Juan de Fuca (Part 1) | 0.9% | 1.3% | 0.7 |
| Central Saanich | 3.7% | 4.2% | 0.9 |
| Saanich | 17.9% | 28.7% | 0.6 |
| View Royal | 2.0% | 2.8% | 0.7 |
| Oak Bay | 4.7% | 4.4% | 1.1 |
| Saltspring Island | 1.9% | 2.8% | 0.7 |
| Victoria | 38.1% | 22.4% | 1.7 |
| Southern Gulf Islands | 1.6% | 1.5% | 1.0 |
| Esquimalt | 7.7% | 4.3% | 1.8 |
| Sidney | 9.2% | 3.0% | 3.1 |

### 3.1.4. *Validation of the socio-demographic vulnerability index*

Validation is a critical step in the process of the index creation and occurred in the development of this index in multiple forms:

- Validation with AHP workshop participants.
  The initial validation process of the socio-demographic vulnerability index was conducted in a workshop setting with participants of the aforementioned AHP workshop. This workshop served as a platform for AHP participants to provide feedback on their assessment of the index performance as based on their expertise.
- Correlation analysis with extreme heat related mortality and hospitalisation observations.
  The index was shared with Island Health Authority, who conducted a correlation assessment with confidential extreme heat related mortality and hospitalisation data that was observed from 2018 to 2023. This rigorous validation exercise allows the validation of the socio-demographic vulnerability index to be supported by statistical assessments of its effectiveness in predicting vulnerable populations across the Capital Region.
- To increase the sample size of mortality and morbidity data to validate against, we created a Vancouver Island-wide socio-demographic index for Island Health to analyse.

During the validation exercise, the socio-demographic index was disaggregated into two sub-indices: demographic sub-index (i.e. health data absent), and health-only sub-index. The validation results revealed different levels of correlations between the mortality and hospitalisation data and the socio-demographic index and sub-indices.

- The health-only demographic vulnerability sub-index showed a correlation coefficient ($R^2$) of 0.808 with Island Health data, indicating a strong relationship (Figure 2.1).
- The demographic-only vulnerability sub-index had a lower, but still significant, correlation coefficient of 0.66 (Figure 2.2).
- When considering the full Socio-demographic Vulnerability Index, which combines both health and demographic data, the correlation was very strong, with an $R^2$ value of 0.955 (Figure 2.3).

These findings suggest that the areas with fewer heat-related deaths in the Capital Regional align with lower vulnerability scores on the index, whereas areas with higher heat-related death incidences show higher vulnerability. This strong correlation confirms the performance of the AHP-derived socio-demographic vulnerability index. An important observation from this validation process is that the combined use of both health and demographic sub-indices leads to a very effective assessment tool. This approach is somewhat unique, as it considers both health determinants (demographics) and population-level health data in developing risk profiles for climate-related risks. This comprehensive approach reflects a more holistic understanding of the factors contributing to vulnerability in the context of climate change and extreme heat events.

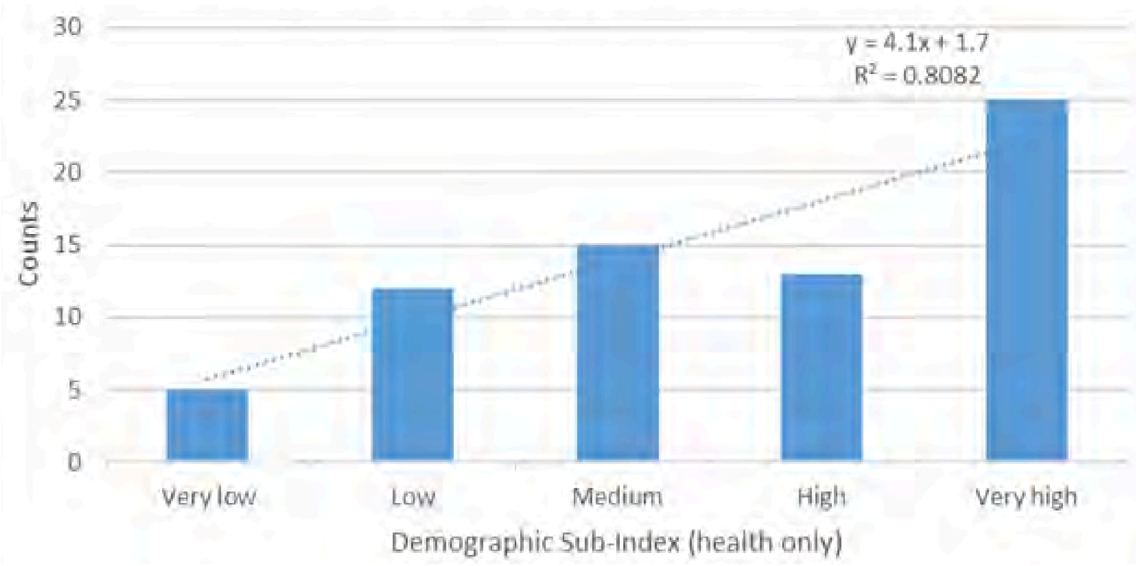


**Figure 3.10.** The demographic vulnerability sub-index (health data only) plotted on the x-axis against the counts of heat-related mortality and morbidity outcomes (2018 - 2023) on the y-axis. A strong correlation ($R^2$ value of 0.8) exists between heat related mortality and morbidity and where the demographic index predicts vulnerability.[63]

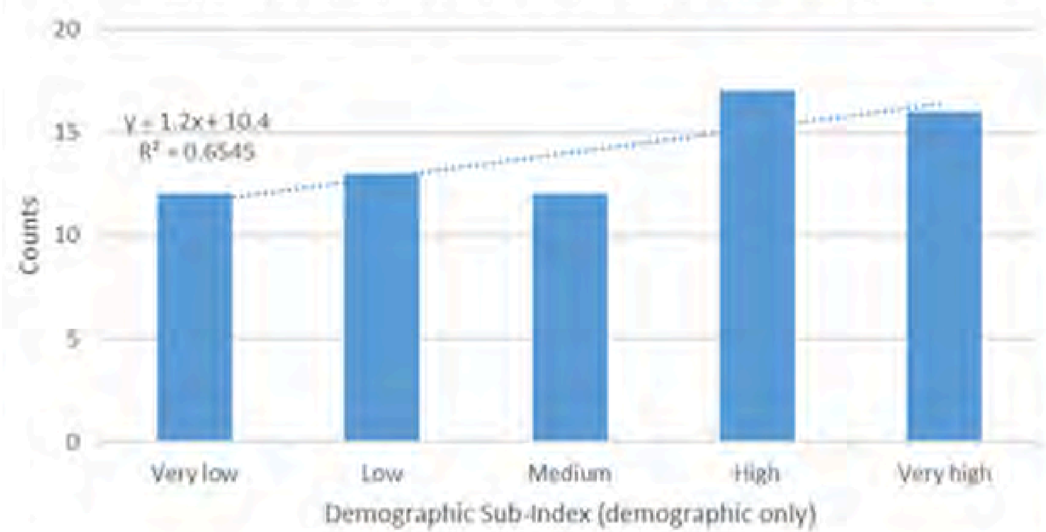


**Figure 3.11.** The demographic vulnerability sub-index (demographic data only) plotted on the x-axis against the counts of heat-related mortality and morbidity outcomes (2018 - 2023) on the y-axis. A positive linear relationship, evidenced by an $R^2$ value of 0.65, is observed between the demographic-only vulnerability sub-index and the counts of heat-related mortality and morbidity outcomes

[63]Note that the demographic-related graphs (figure 2.1 -2.4) are generated by Island Health which is why there is a discrepancy on titles and this will be changed for the final draft.

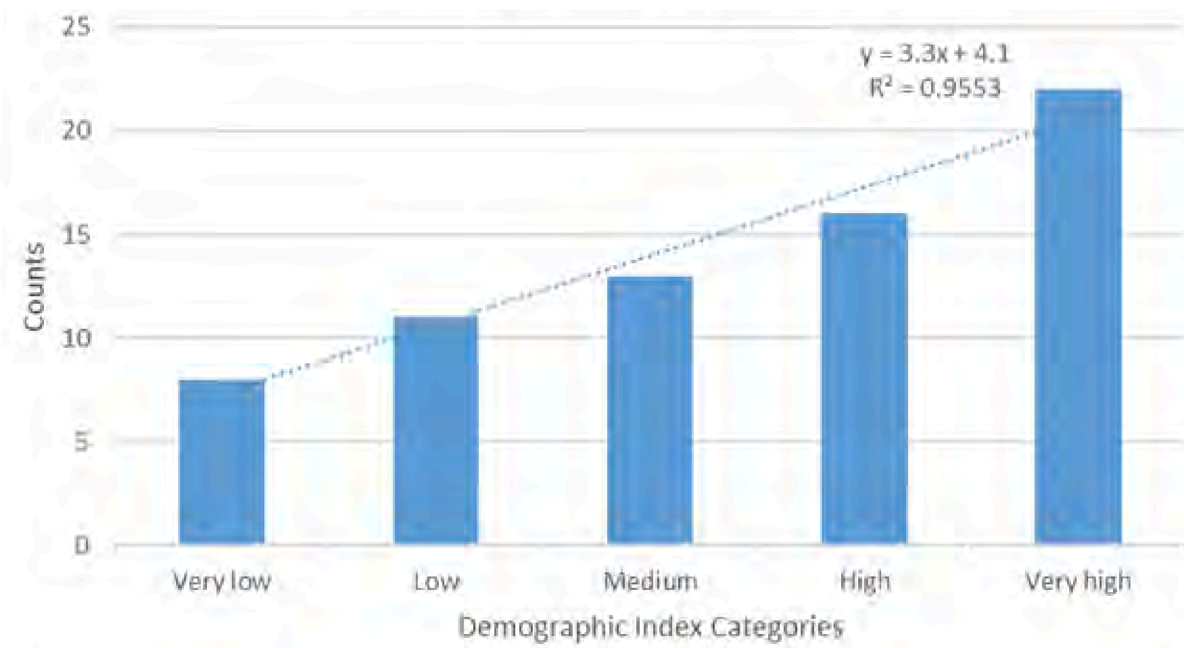


**Figure 3.12.** Socio-demographic vulnerability plotted on the x-axis against the counts of heat-related mortality and morbidity outcomes (2018 - 2023) on the y-axis. A strong correlation is present between where heat related health outcomes occurred and where the Socio-demographic Index predicts higher vulnerability.

To increase the sample size of heat related mortality and morbidity validation data points, we created the same Socio-demographic Index for all of Vancouver Island. Island Health validated this larger pool of data and found a 0.87 r2 value, which further confirms the Socio-demographic Vulnerability Index's validity within the CRD and for Vancouver Island as a whole (Figure 2.4). For further visualisation of this index, see the map figure B5 in appendix B.

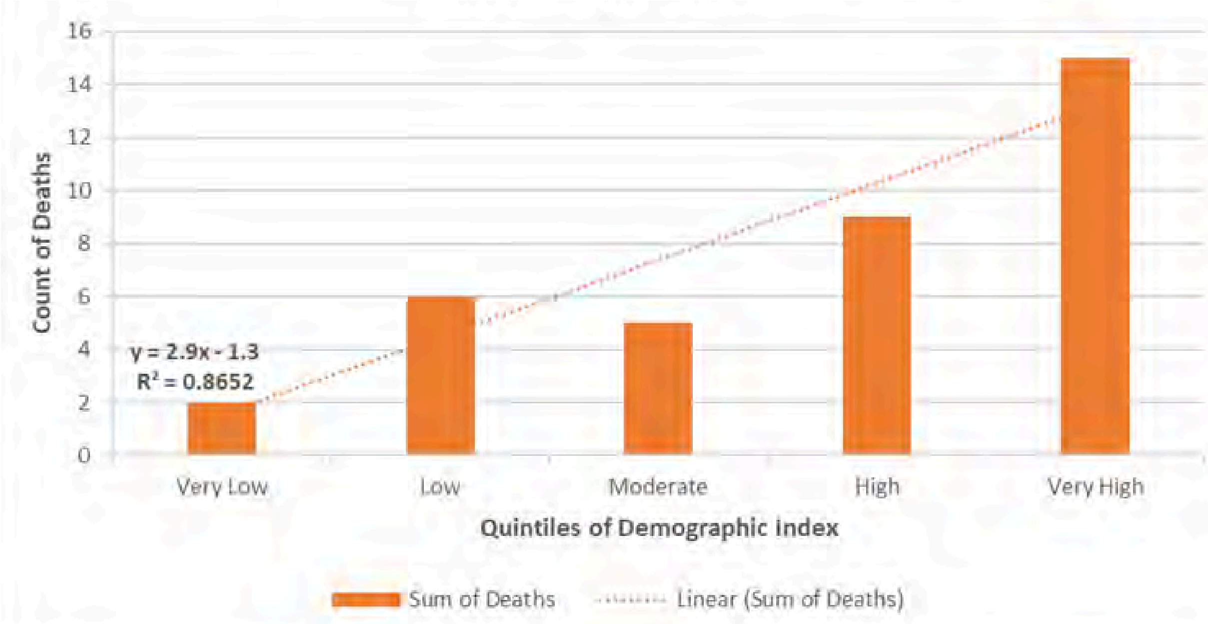


**Figure 3.13.** Vancouver Island Socio-demographic vulnerability plotted on the x-axis against the counts of heat-related mortality and morbidity outcomes (2021) on the y-axis.

### 3.2. *Heat Exposure Layer*

The distribution of predicted air temperature during the 2021 heat event is shown in Figure 3.0. The range in air temperatures that are observed in this model output are 23.8 to 39.8 °C. In this figure, the distribution of air temperature during the extreme heat event is evident. Warmer temperatures are mostly concentrated away from the coastline, which suggests that maritime cooling is a significant contributor to mitigating extreme levels of air temperature. Localised climatic variations of air temperature are also evident in urbanised areas (as shown in Figure 3.0 inset maps). Urban structures and surfaces in Victoria, Saanich, and Langford contribute to warmer temperatures. Coastal urban areas such as North Saanich and Sidney benefit from a high density of coastline that helps reduce temperature. Elevation and solar insolation are strong predictors of air temperature in this model, and as such higher, south facing areas appear as relatively warmer than lower elevation, north facing areas. Langford is identified as a higher risk area given its characteristics of being south facing, higher elevation, relative further from the coast, and having land cover characteristics that contribute significantly to higher land surface temperatures.

Note that the decision to represent heat exposure in Celsius rather than using an index distribution, as established in the two other mapping elements, serves to provide a more direct and tangible depiction of how temperatures are experienced during an extreme heat event. Unlike the socio-demographic and building indices that define the maximum value as "high vulnerability," using Celsius avoids imposing an artificial scale. Extreme heat vulnerability does not have a single universal or even Provincial threshold, as it can vary based on local climatic conditions and societal factors. Therefore, presenting the data in Celsius allows for a more flexible and context-specific assessment. Expressing heat exposure in Celsius also allows stakeholders and the general public to easily understand the magnitude of temperatures.

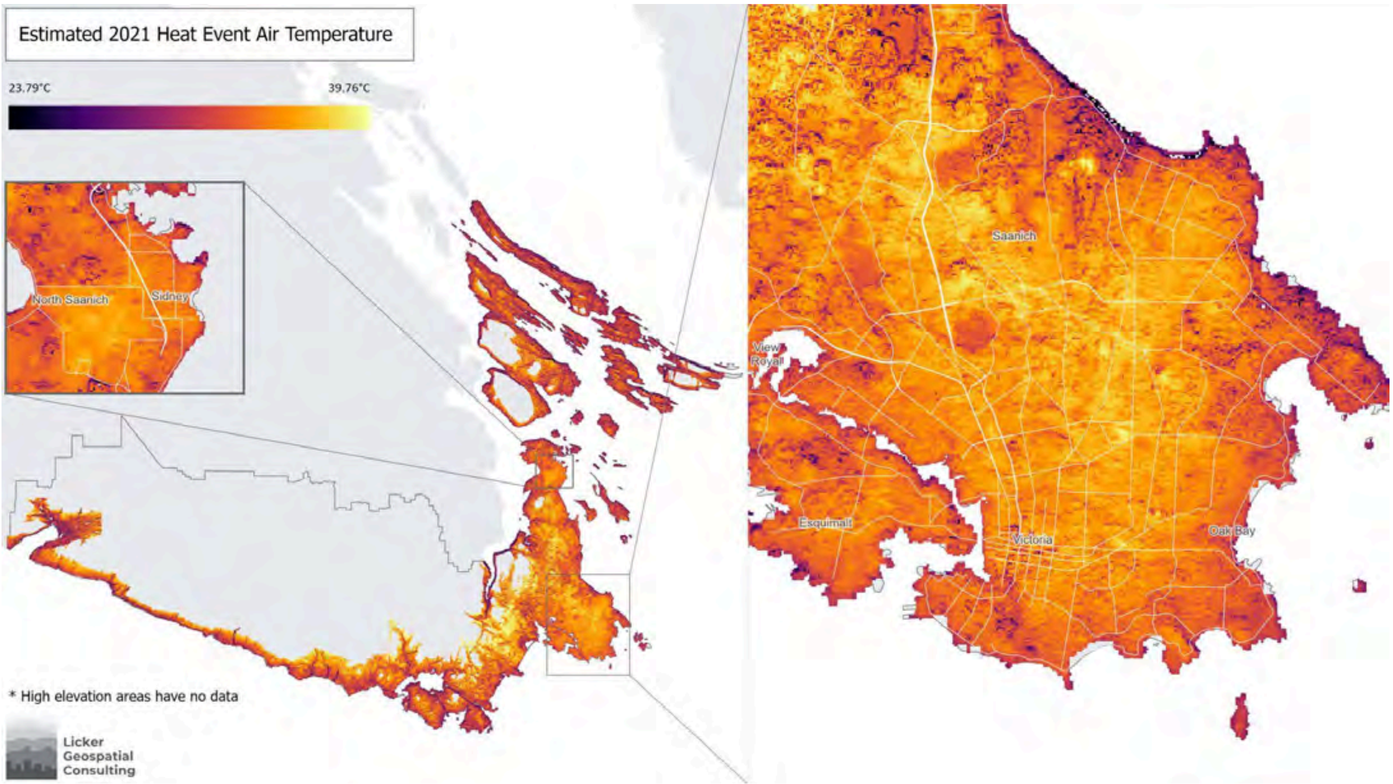


**Figure 3.14.** Predicted air temperature using a linear regression analysis of elevation, distance to coast, solar radiation, and land surface temperature.

### *3.2.1. Land Surface Temperature and Comparative Analysis*

The distribution of land surface temperature (LST) during the 2021 heat event is shown in layer throughout the regional district. The LST layer considers environmental factors such as natural vegetation that support localised dissipation of heat and impervious material (such as concrete and asphalt) that support greater heat absorption and retention and has range of 18.7 to 36 °C (Figure 3.15).

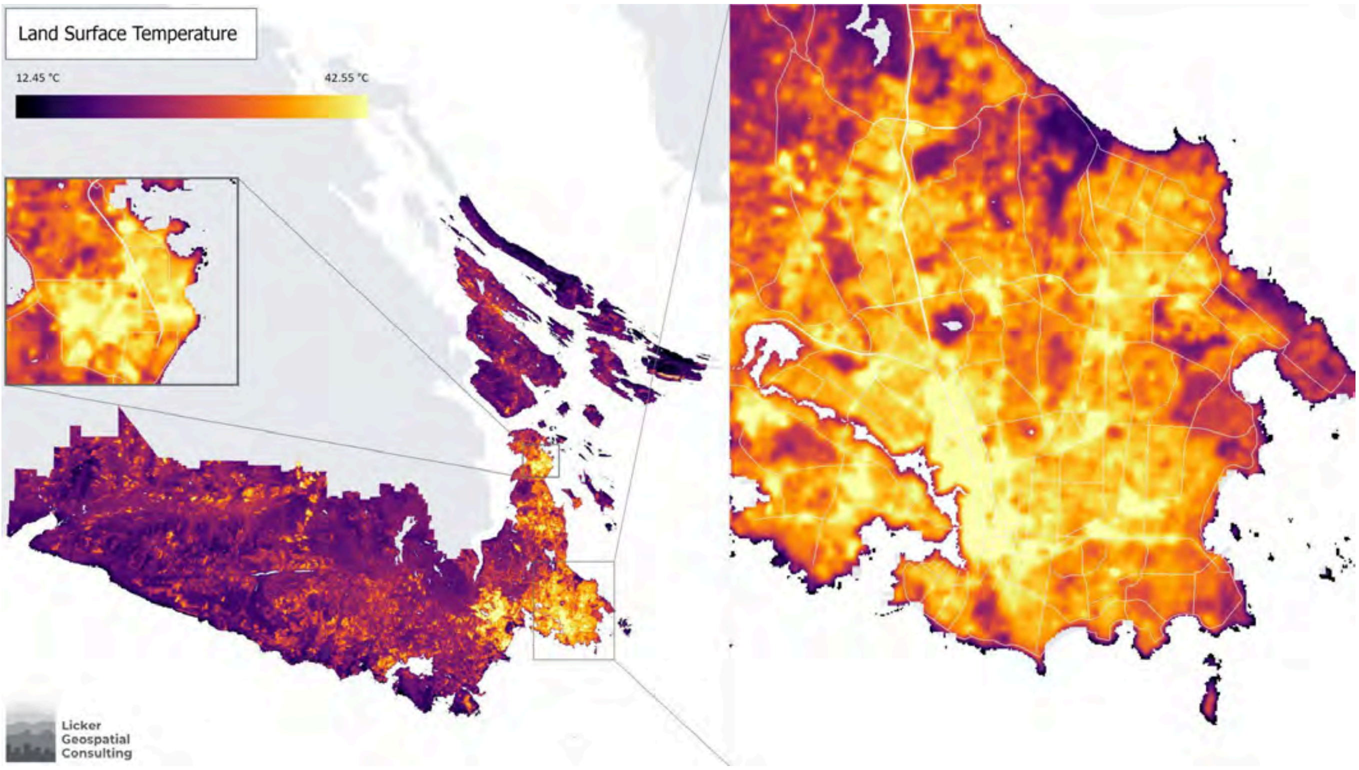


**Figure 3.15.** Land surface temperature (LST) in °C during the 2021 heat event, as calculated from the Landsat-8 satellite constellation and visualised at a 30 $m^2$ resolution.

While LST does show general distribution of heat throughout the region, it is not representative of the human experience and discomfort to extreme heat. Indeed, LST is closely associated with land cover, such as urban areas ("urban heat islands"), forestry cut-blocks, and vegetation. Air temperature and LST display different relationships of heat distribution across the capital regional district. While both are within a similar magnitude of temperature, the distribution of differences between these two layers provide a nuanced understanding of the region's effects on how temperature is absorbed, stored, and dissipated across the region (Figure 3.15).

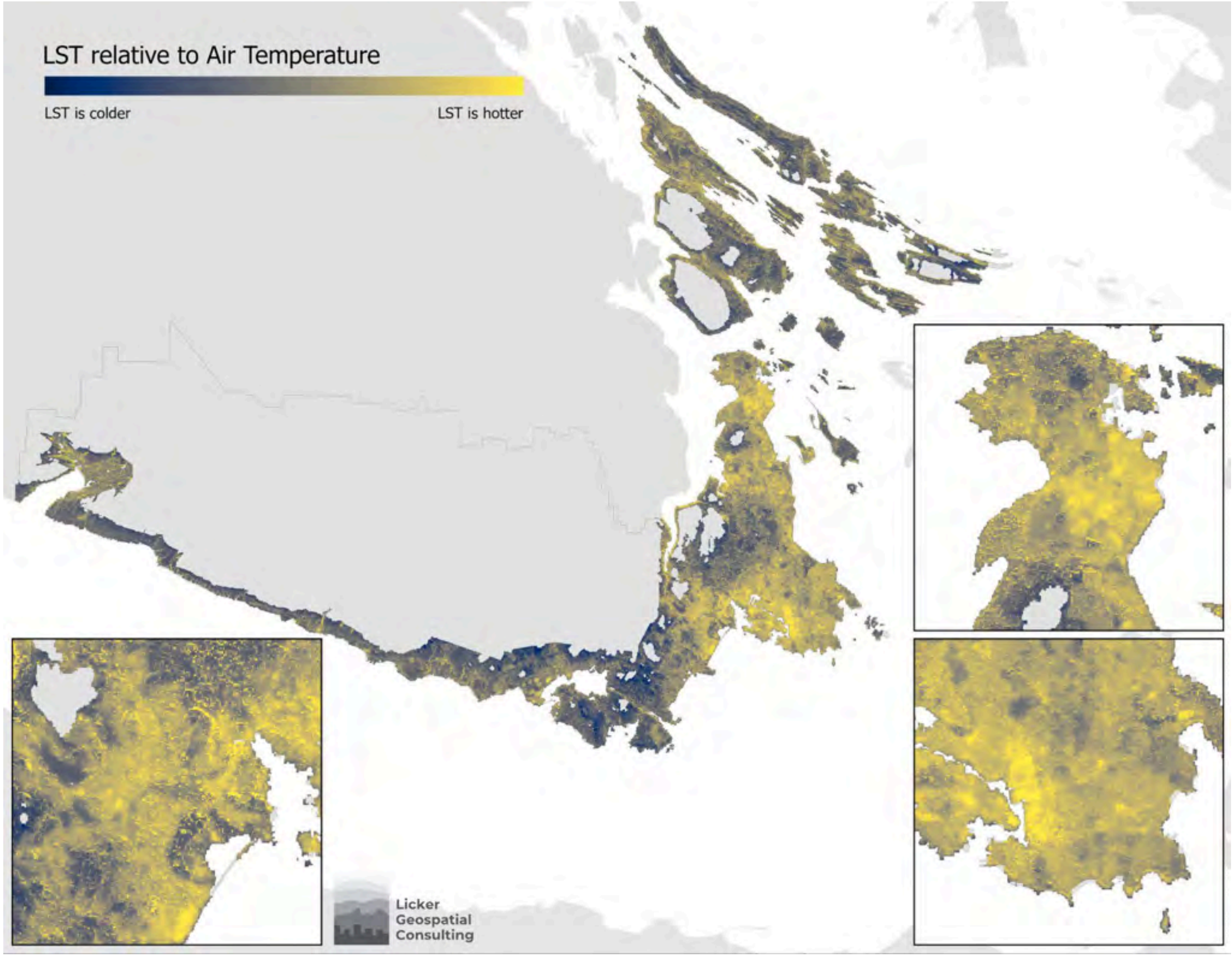


**Figure 3.16.** Relative difference between LST and air temperature. Blue areas indicate where air temperature is warmer than LST, yellow areas indicate where LST is warmer than air temperature. The range of temperature difference between these two models is -20.1 to 14.6 °C.

Figure 3.16 shows the temperature differences of LST relative to air temperature. Blue areas indicate where air temperature is warmer than LST, yellow areas indicate where LST is warmer than air temperature. The range of temperature difference of LST relative to air temperature is -20.1 to 14.6 °C. Areas in muted grey tones show where LST and air temperature are relatively similar. Not included in this assessment are areas beyond the lidar extent (namely most of the Electoral Area), and high elevations, given that predicted air temperature values are absent in these areas.

Evident in Figure 3.16 is the effect of coastal impacts on air temperature, wherein we see lower predicted air temperatures than observed land surface temperatures. Urban heat islands are also seen to be more clearly delineated in the LST layer. These urban heat islands appear so distinctly in the LST given the absorbing characteristics of roads and rooftops. While the air temperature also considers land cover and evapotranspiration, which correlate with urban heat islands, they are less impactful in the output prediction and thereby mute the effect of urban heat islands temperatures as measured on the surface.

*3.3. Building Vulnerability Index findings*

Using similar analytical lenses to those discussed in the socio-demographic section above, we can decompose risk factors by community or jurisdiction to understand overall heat risk in residential buildings (Figures 3.19, 3.20 and Tables 3.6, 3.7). Of note are the high concentrations of building risk in Victoria, Esquimalt and Oak Bay which consists of high volumes of older, taller buildings with some degree of prominence. As with the demographic sub-index above, West shore communities exhibit considerably lower risk than capital region core communities due to new construction, greater canopy retention and generally lower densities than the regional average. With the buildings index consisting of various vulnerability metrics, we can also see how the breakdown of each component contributes to the overall vulnerability of buildings at the jurisdictional level (refer to Figures 3.15 - 3.18). As noted in the validation section above, additional care should be taken when reviewing building index results as aggregate building information may misrepresent individual structural risk in some communities.

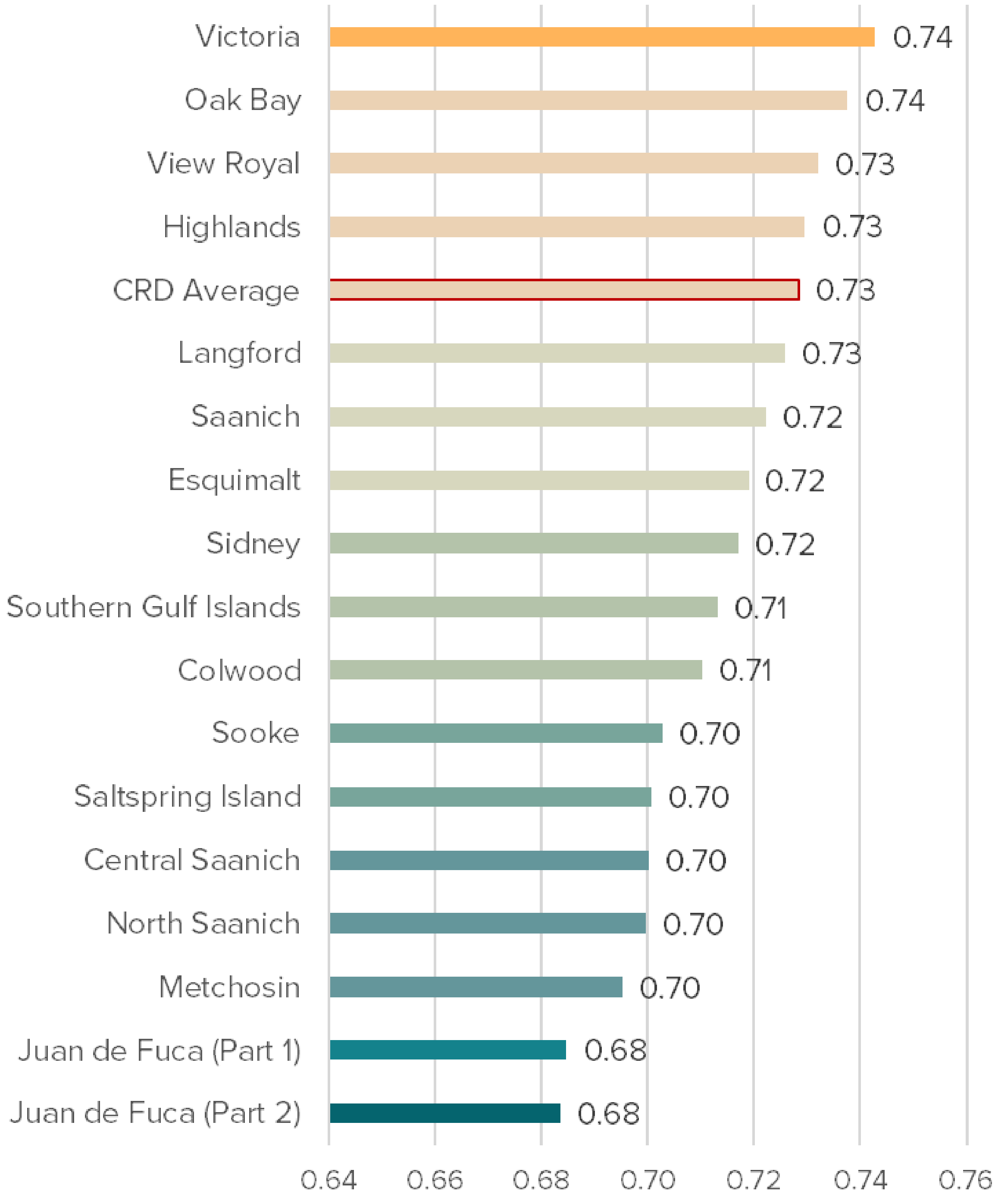


**Figure 3.15.** Average building albedo by jurisdiction in the capital region, for all buildings. Averages are weighted by the assumed interior floor area of buildings per DA.

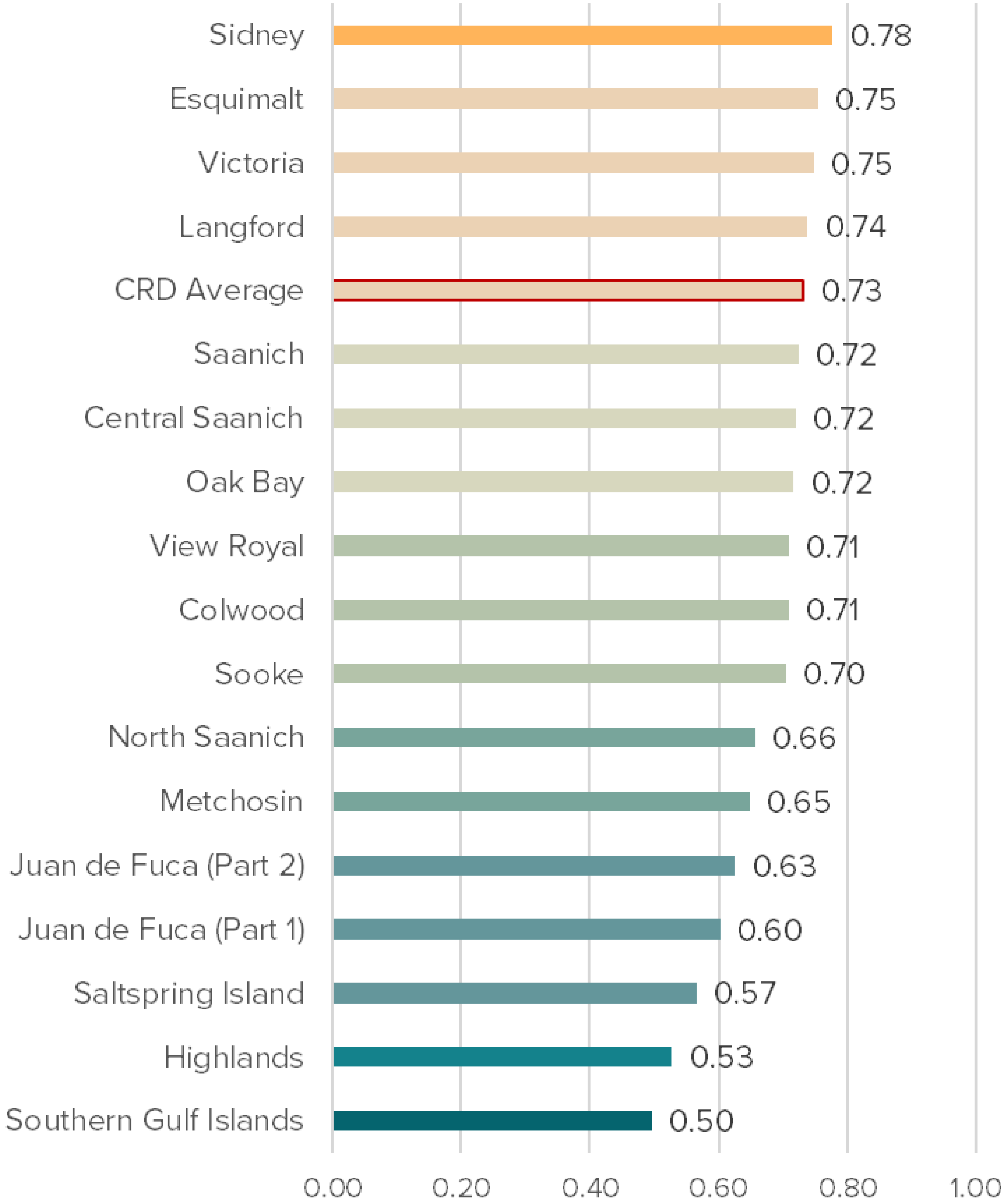


**Figure 3.16.** Average solar insolation index by jurisdiction in the capital region, for all buildings. Averages are weighted by the assumed interior floor area of buildings per DA.

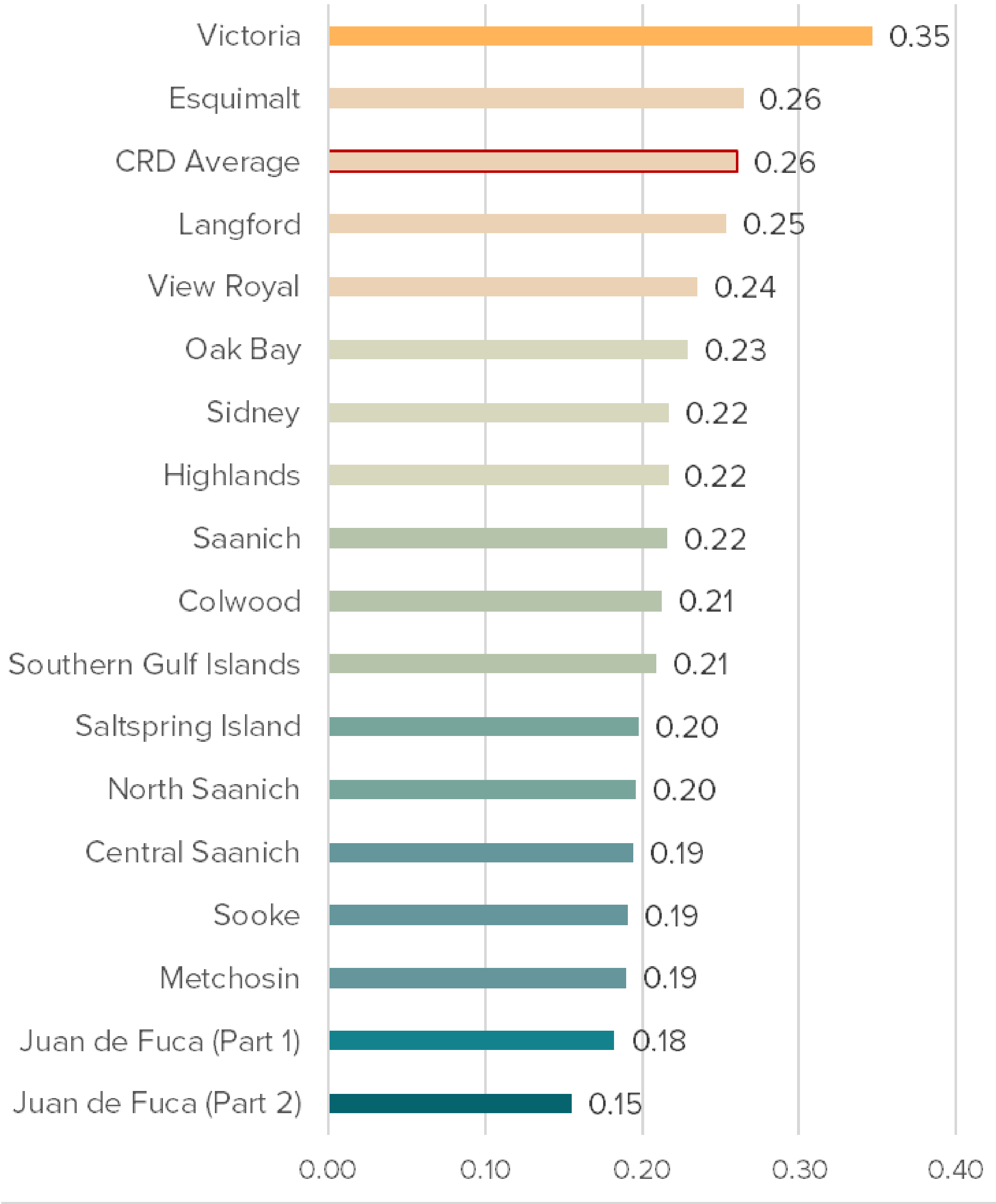


**Figure 3.17.** Average building height index by jurisdiction in the capital region, for all buildings. Averages are weighted by the assumed interior floor area of buildings per DA.

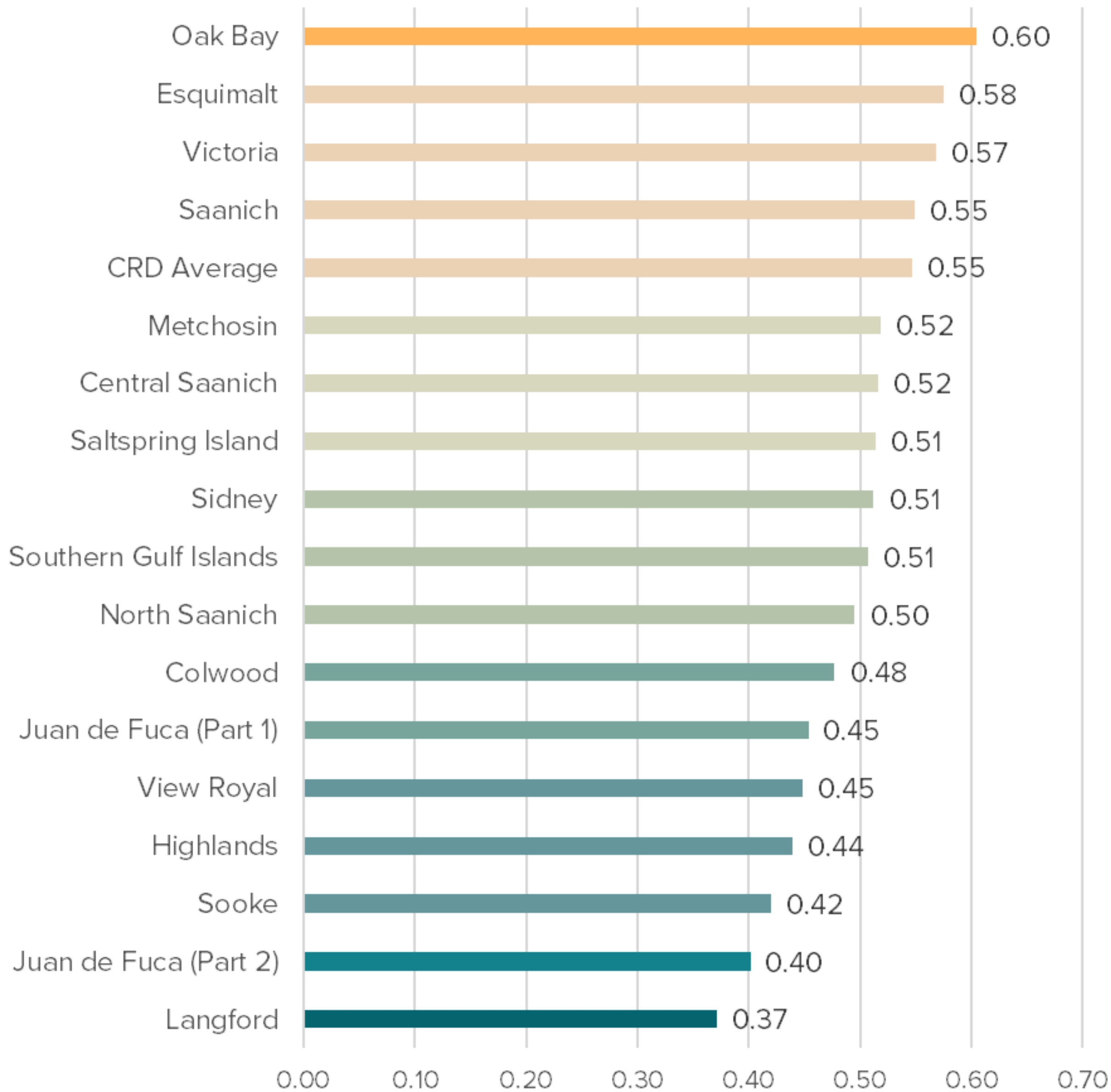


**Figure 3.18.** Average building age index by jurisdiction in the capital region, for all buildings. Averages are weighted by the assumed interior floor area of buildings per DA.

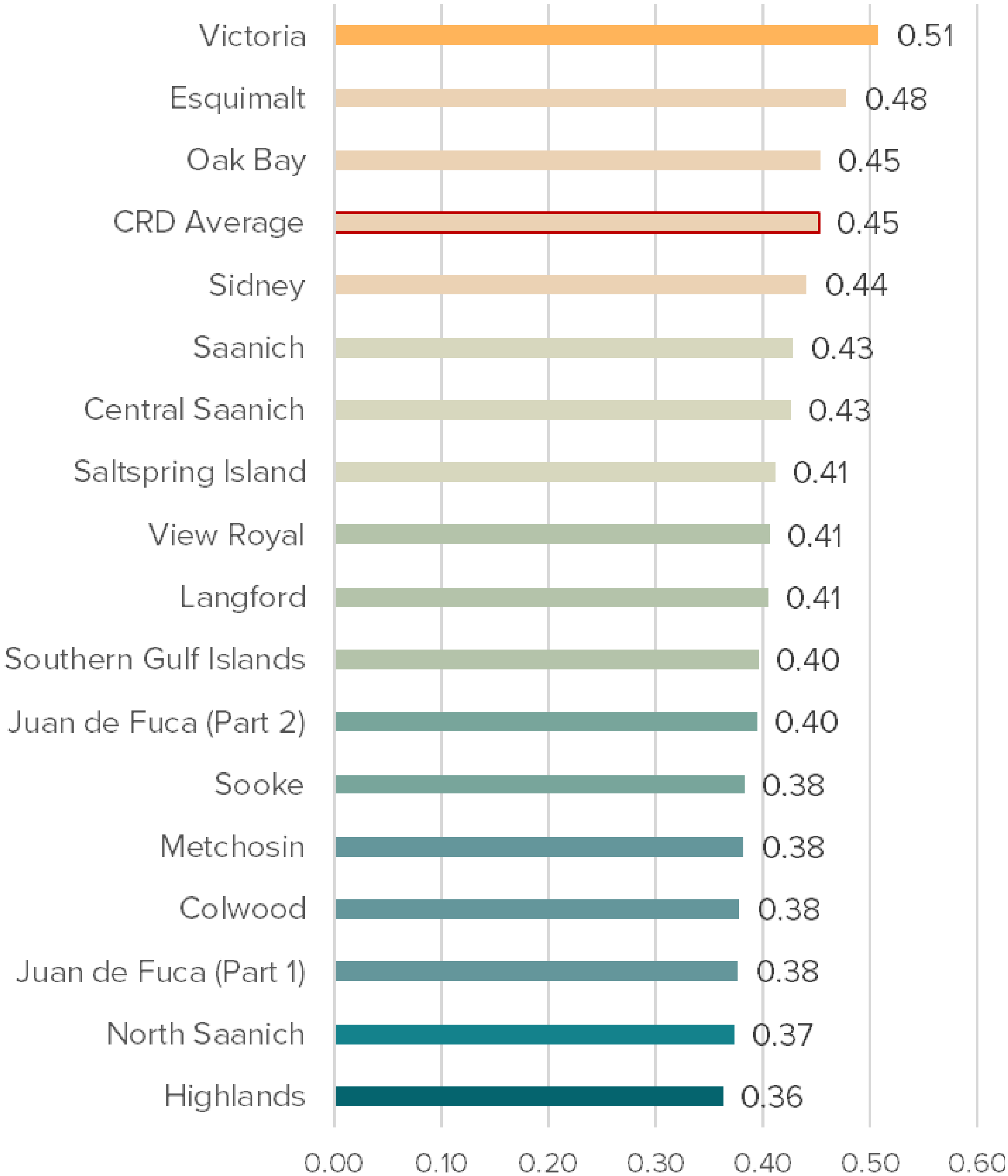


**Figure 3.19.** Average Building Vulnerability Index by jurisdiction in the capital region, for residential buildings only. Averages are weighted by the assumed interior floor area of buildings per DA.

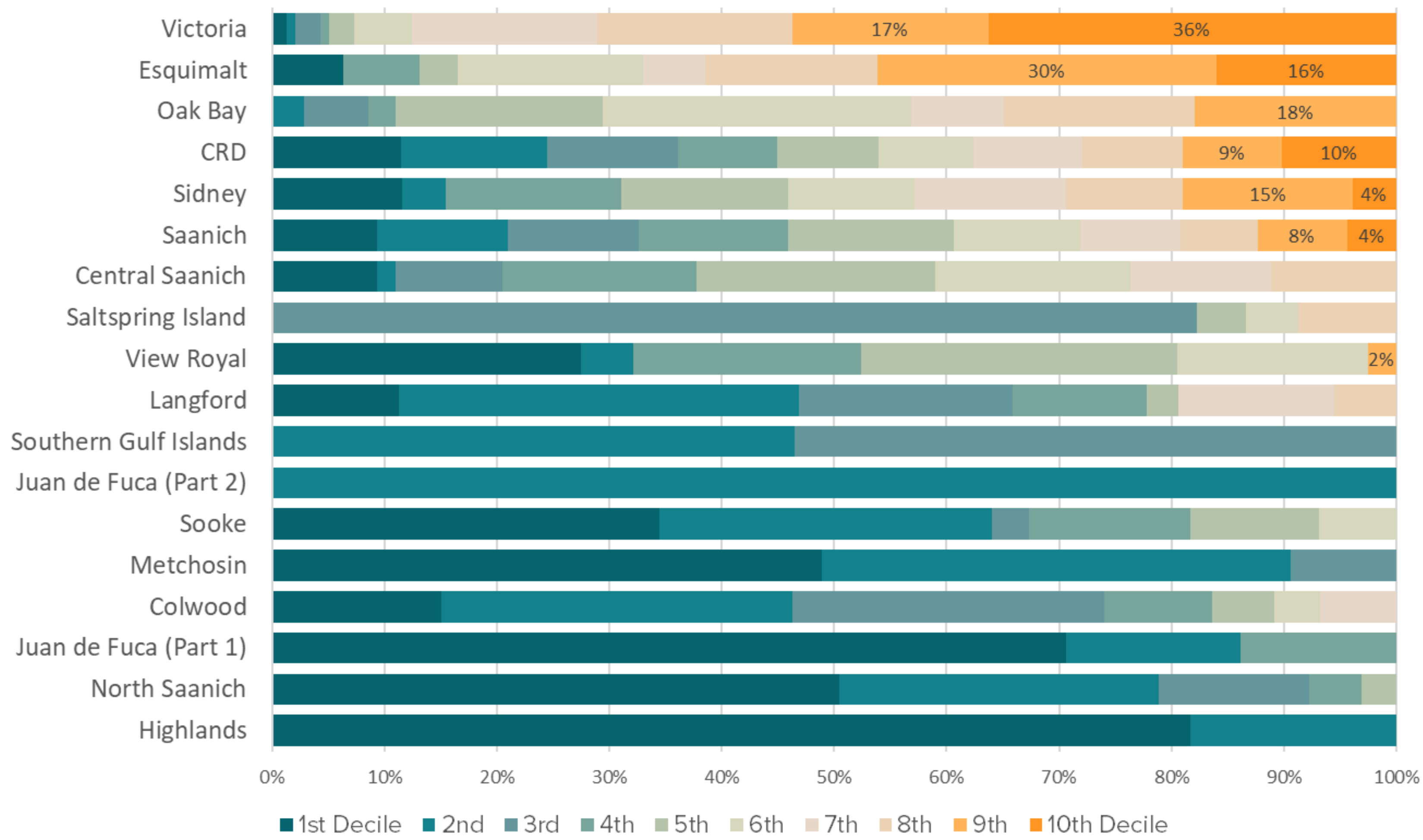


**Figure 3.20.** Residential building vulnerability by jurisdiction in the capital region, displayed by decile. Victoria, BC, has the largest proportion of its population falling within the most vulnerable decile, while North Saanich and Highlands BC, have 0% of their populations within the most vulnerable decile.

**Table 3.6.** Population by Residential Buildings Heat Vulnerability Index per jurisdiction in the capital region.

| Jurisdiction | 1st Decile | 2nd | 3rd | 4th | 5th | 6th | 7th | 8th | 9th | 10th Decile |
|---|---|---|---|---|---|---|---|---|---|---|
| Highlands | 2,027 | 455 | | | | | | | | |
| North Saanich | 6,171 | 3,484 | 1,627 | 576 | 377 | | | | | |
| Juan de Fuca (Part 1) | 3,625 | 796 | | 711 | | | | | | |
| Colwood | 2,749 | 5,711 | 5,056 | 1,766 | 1,008 | 731 | 1,245 | | | |
| Metchosin | 2,476 | 2,115 | 476 | | | | | | | |
| Sooke | 5,203 | 4,457 | 502 | 2,155 | 1,738 | 1,031 | | | | |
| Juan de Fuca (Part 2) | | 399 | | | | | | | | |
| Southern Gulf Islands | | 2,834 | 3,267 | | | | | | | |
| Langford | 5,255 | 16,568 | 8,876 | 5,542 | 1,322 | | 6,460 | 2,561 | | |
| View Royal | 3,181 | 535 | | 2,345 | 3,261 | 1,964 | | | 289 | |
| Saltspring Island | | | 9,570 | | 511 | 536 | | 1,018 | | |
| Central Saanich | 1,623 | 293 | 1,652 | 2,987 | 3,708 | 3,005 | 2,179 | 1,938 | | |
| Saanich | 11,033 | 13,662 | 13,723 | 15,646 | 17,294 | 13,282 | 10,487 | 8,116 | 9,344 | 5,148 |
| Sidney | 1,428 | 471 | | 1,927 | 1,832 | 1,376 | 1,664 | 1,284 | 1,861 | 475 |
| Oak Bay | | 508 | 1,030 | 432 | 3,324 | 4,933 | 1,480 | 3,053 | 3,230 | |
| Esquimalt | 1,114 | | | 1,190 | 592 | 2,890 | 976 | 2,678 | 5,297 | 2,796 |
| Victoria | 1,207 | 671 | 2,087 | 656 | 2,060 | 4,727 | 15,131 | 15,979 | 16,022 | 33,327 |
| **CRD Total** | **47,092** | **52,959** | **47,866** | **35,933** | **37,027** | **34,475** | **39,622** | **36,627** | **36,043** | **41,746** |

**Table 3.7.** Relationship between population in high risk DAs and proportion of capital region population per the residential buildings index

| Jurisdiction | Proportion of capital region Population in Top Two Deciles | Proportion of capital region's Population | Ratio of High Risk Proportion to Proportion of capital region Population |
|---|---|---|---|
| Highlands | 0.0% | 0.6% | 0.0 |
| North Saanich | 0.0% | 3.0% | 0.0 |
| Juan de Fuca (Part 1) | 0.0% | 1.3% | 0.0 |
| Colwood | 0.0% | 4.5% | 0.0 |
| Metchosin | 0.0% | 1.2% | 0.0 |
| Sooke | 0.0% | 3.7% | 0.0 |
| Juan de Fuca (Part 2) | 0.0% | 0.1% | 0.0 |
| Southern Gulf Islands | 0.0% | 1.5% | 0.0 |
| Langford | 0.0% | 11.4% | 0.0 |
| View Royal | 0.4% | 2.8% | 0.1 |
| Saltspring Island | 0.0% | 2.8% | 0.0 |
| Central Saanich | 0.0% | 4.2% | 0.0 |
| Saanich | 18.6% | 28.8% | 0.6 |
| Sidney | 3.0% | 3.0% | 1.0 |
| Oak Bay | 4.2% | 4.4% | 0.9 |
| Esquimalt | 10.4% | 4.3% | 2.4 |
| Victoria | 63.4% | 22.4% | 2.8 |

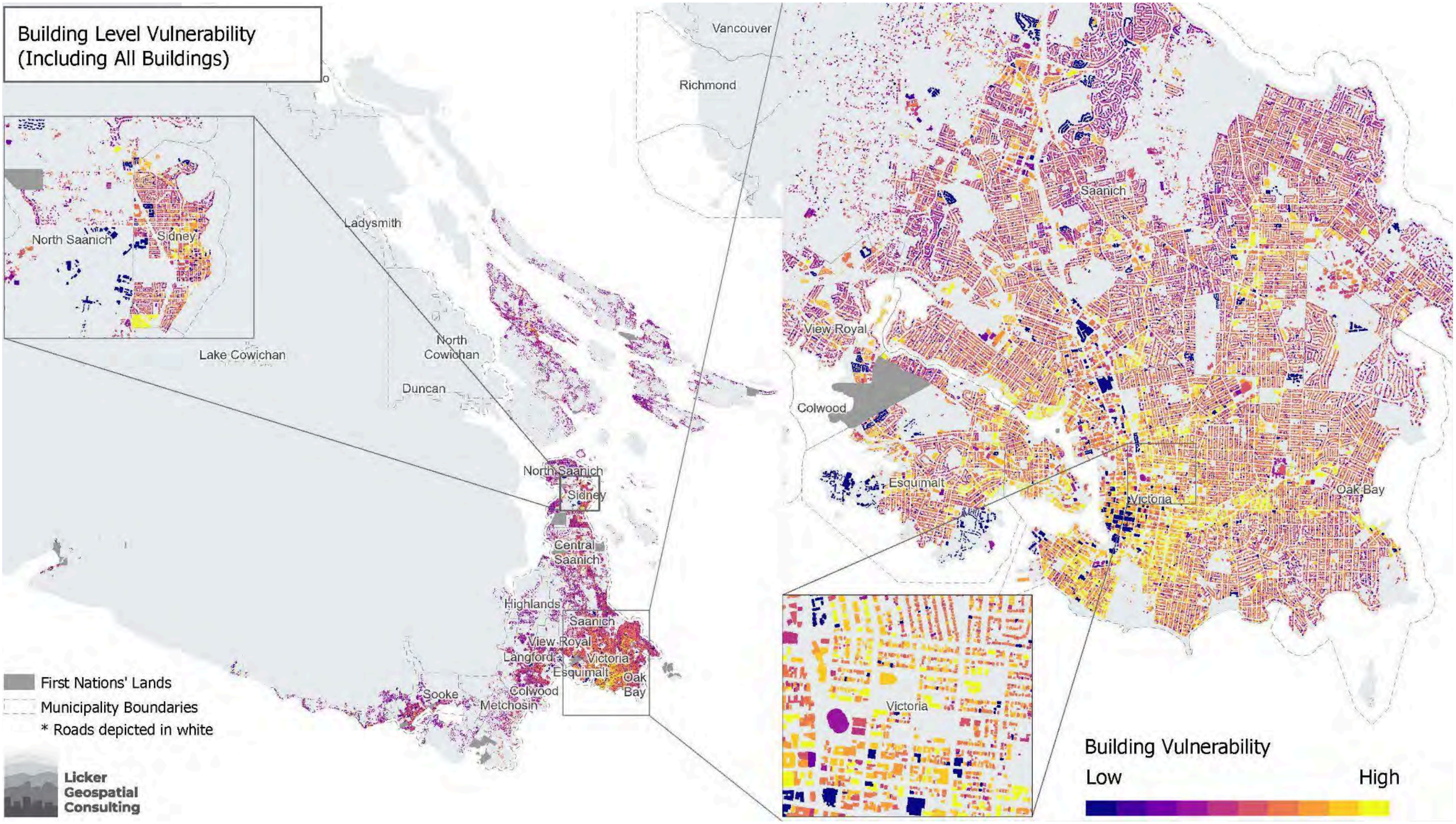


**Figure 3.21.** Extreme Heat - Building Vulnerability Index with all buildings included by building footprint.

### 3.3.1. *Validation of the building vulnerability index*

Much like the socio-demographic index validation, the buildings index went through a validation process to ensure empirical accuracy in estimating the risk associated with extreme heat for different buildings throughout the Capital Region. The buildings index validation process involved conducting a statistical analysis to inform the correlation between the index and historical health outcomes related to extreme heat. This analysis utilises morbidity and mortality data from 2018 to 2023[64], thereby providing a quantitative measurement of the index's predictive potential. The buildings index was disaggregated into two sub-indices that measure building vulnerability for residential and non-residential buildings.

- For non-residential buildings the index showed a moderate correlation, with an $R^2$ of 0.56, indicating some level of predictability (Figure 2.10).
- For residential buildings the index showed a stronger correlation, with an $R^2$ of 0.58 that suggests a higher degree of predictive accuracy (Figure 2.11).
- For all buildings (i.e. the complete Building Vulnerability Index), there is a weaker correlation with an $R^2$ value of 0.12 (Figure 2.12), suggesting a more complex relationship of factors that influence risk in broader buildings context.

The outcomes of this validation exercise support the index's application in regional planning and health strategy formulation. They reflect the nuanced application of the index, which exhibits varying levels of predictability across different building types. These findings underscore the necessity for a nuanced application of the index in planning and risk reduction strategies.

[64] Island Health used heat related morbidity and mortality data from 2018 - 2021 to ensure a large enough sample size in data points given that there were 9 deaths within the capital region during the 2021 heat-event.

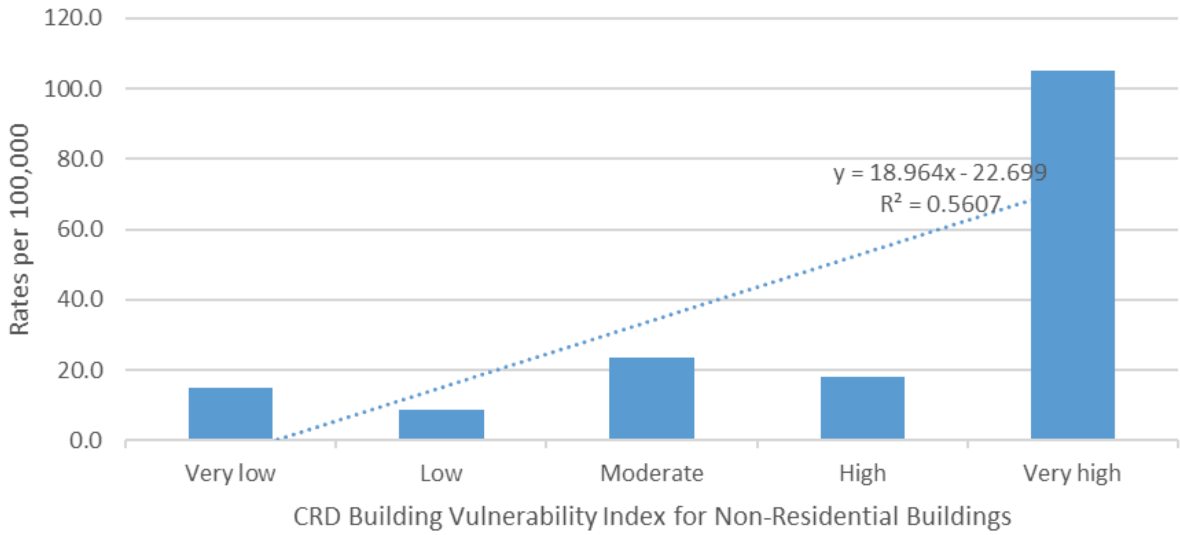


**Figure 3.22.** Correlation between capital region Building Vulnerability Index for Non-Residential Buildings and Heat-Related Health Outcomes (2018-2023). The bar chart depicts an ascending trend in health outcome rates per 100,000 as the vulnerability index increases from 'Very low' to 'Very high', with a trend line indicating a moderate correlation ($R^2$ = 0.5607).

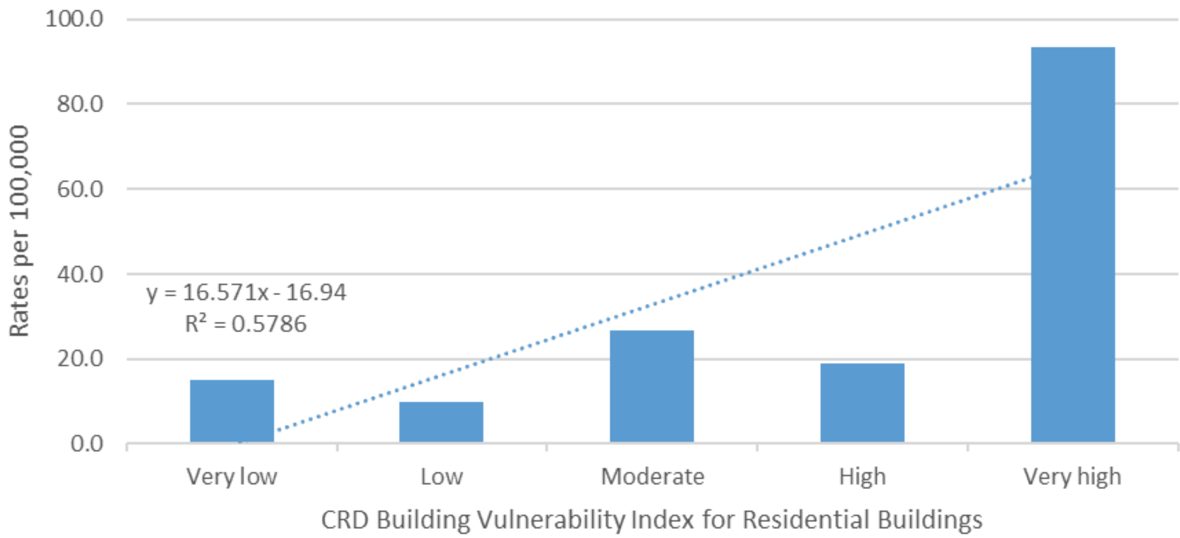


**Figure 3.23.** Relationship between capital region Building Vulnerability Index for Residential Buildings and Heat-Related Health Outcomes (2018-2023). This bar chart illustrates a clear upward trend in health outcome rates per 100,000 with increasing vulnerability index levels, with a stronger correlation evident for the 'Very high' vulnerability category ($R^2$ = 0.5786).

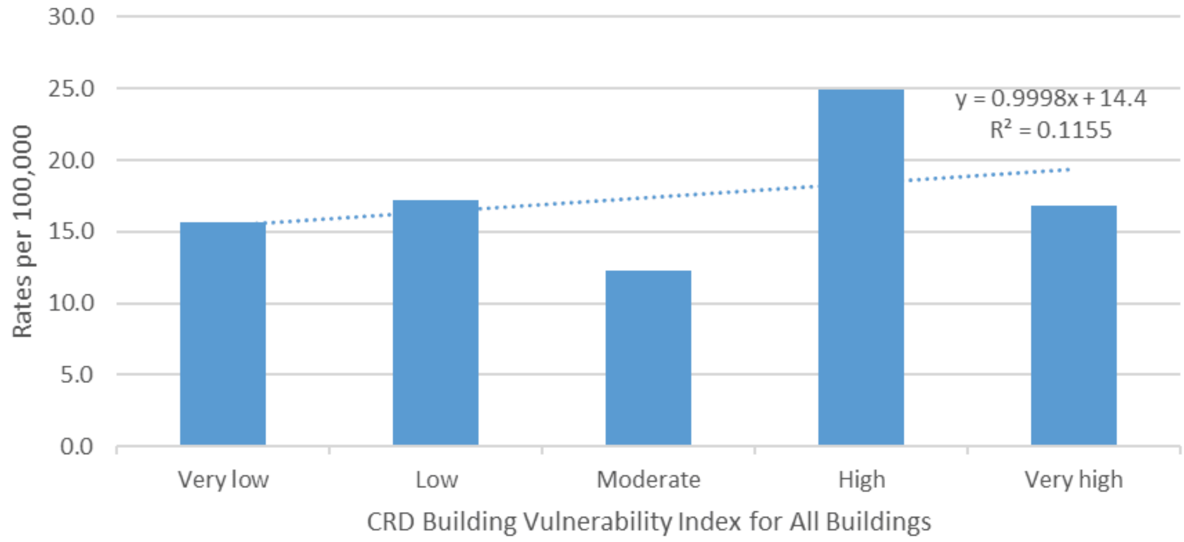


**Figure 3.24.** Analysis of capital region Building Vulnerability Index Across All Building Types and Corresponding Heat-Related Health Outcomes (2018-2023). The bar chart shows the rates of health outcomes per 100,000 in relation to building vulnerability, with a notable peak at 'High' vulnerability. The overall correlation is weaker ($R^2 = 0.1155$), suggesting additional factors may influence the rates for a combined analysis of buildings.

### *3.4. Key patterns and hotspots in the socio-demographic and building vulnerability indices*

Given the construction of the two indices (buildings and socio-demographics), it is additionally possible to overlay risk and develop an initial understanding of multiple component risk by community. Pursuant to table 3.8 below we can note that communities such as Sooke, Colwood, Lagnord, Central Saanich and the Southern Gulf Islands all exhibit some degree of socio-demographic vulnerability at the highest risk level and no corresponding vulnerability for residential buildings. Conversely, communities such as Esquimalt and Victoria, exhibit comparatively lower risk with regards to socio-demographics in comparison to residential buildings. Interestingly, the risk profile for Saanich (at least in the top two deciles) is nearly identical between socio-demographics and buildings (though low in comparison to Saanich's share of capital region population 32.2%).

When examining socio-demographic vulnerability in conjunction with building vulnerability, certain areas reveal a confluence of vulnerabilities. Illustrated in Figure 3.25, areas such as Gorge-Tillicum, Burnside, James Bay, and Sidney BC stand out due to their combination of elevated socio-demographic vulnerability and a significant prevalence of buildings with high vulnerability. On the contrary, areas such as Sooke, Metchosin and Gordon head exhibit low socio-demographic vulnerability as well as a lower prevalence of building vulnerability.

**Table 3.8** Summary of population in top vulnerability quintile for both socio-demographic and buildings vulnerability indices.

| Jurisdiction | Population Residing in Top Sociodemographic Quintile DAs | Population Residing in Top Residential Buildings Quintile DAs | % of Population in Socio Demographic Index Top Quintile | % of Population in Residential Buildings Index Top Quintile |
|---|---|---|---|---|
| **Sooke** | 2,565 | - | 3.1% | 0.0% |
| **Colwood** | 1,245 | - | 1.5% | 0.0% |
| **Highlands** | - | - | 0.0% | 0.0% |
| **Juan de Fuca (Part 2)** | - | - | 0.0% | 0.0% |
| **Langford** | 6,575 | - | 7.9% | 0.0% |
| **Metchosin** | - | - | 0.0% | 0.0% |
| **North Saanich** | - | - | 0.0% | 0.0% |
| **Juan de Fuca (Part 1)** | 711 | - | 0.9% | 0.0% |
| **Central Saanich** | 3,076 | - | 3.7% | 0.0% |
| **Saanich** | 14,991 | 14,492 | 17.9% | 18.6% |
| **View Royal** | 1,649 | 289 | 2.0% | 0.4% |
| **Oak Bay** | 3,912 | 3,230 | 4.7% | 4.2% |
| **Saltspring Island** | 1,554 | - | 1.9% | 0.0% |
| **Victoria** | 31,868 | 49,349 | 38.1% | 63.4% |
| **Southern Gulf Islands** | 1,304 | - | 1.6% | 0.0% |
| **Esquimalt** | 6,409 | 8,093 | 7.7% | 10.4% |
| **Sidney** | 7,707 | 2,336 | 9.2% | 3.0% |
| **CRD Total** | **83,566** | **77,789** | **100.0%** | **100.0%** |

Given the lack of granularity at the community scale, it can therefore be more effective to review overlapping risk at the DA level which is presented in figure 3.17 below. Notably the figure indicates where there are concentrations of the two indices coincident in space which suggests localised concentrations of risk that should be further investigated and explored. Of note are high concentrations in Victoria, Esquimalt and Oak Bay. Given the exploratory nature of this work, the next step would be to determine if combining these risk factors makes sense or introduces noise into the work. Additional validation against health outcomes would be highly beneficial in this regard.

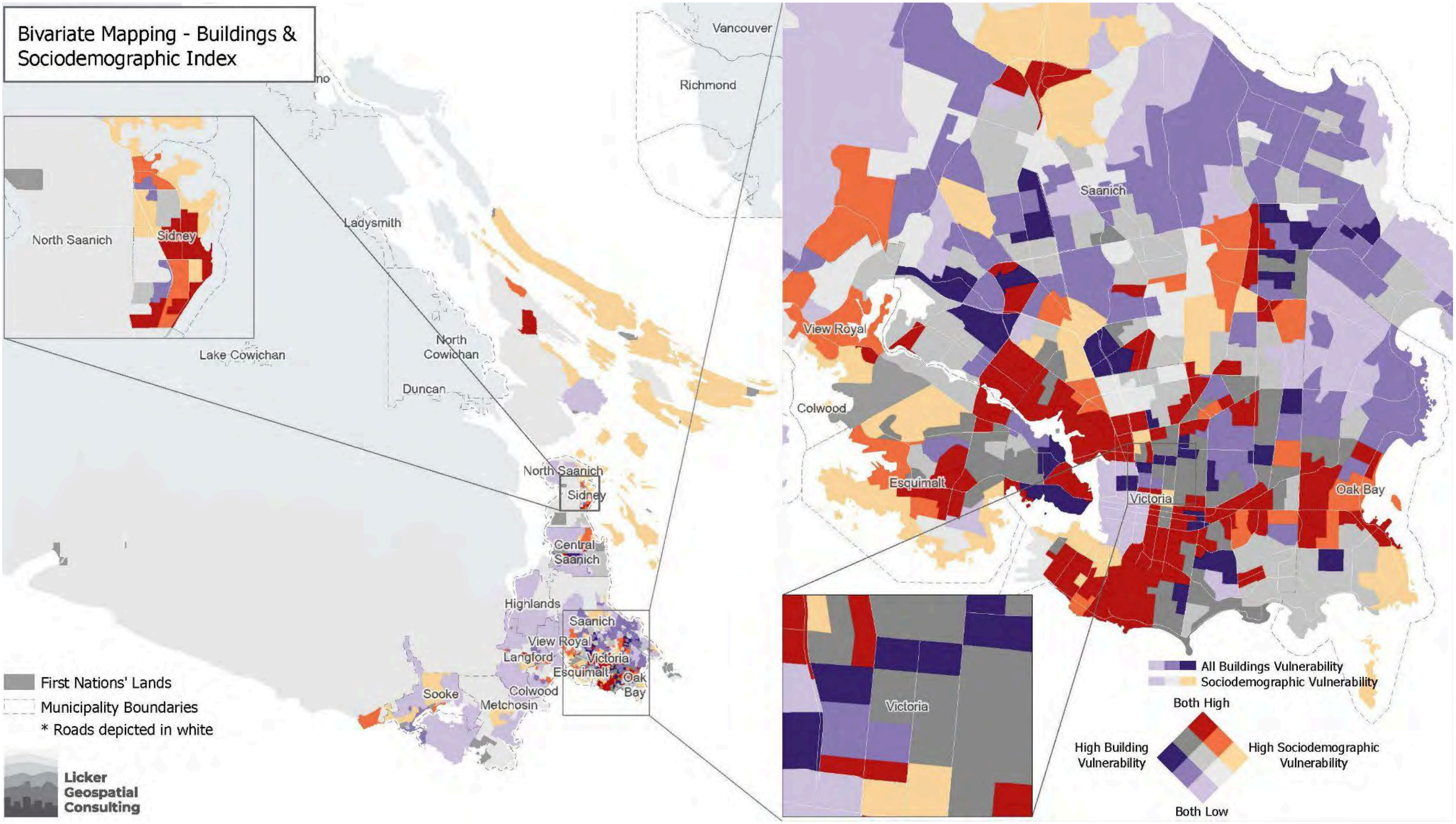


**Figure 3.25. Extreme Heat Bivariate Mapping - Buildings and Combined Socio-demographic Vulnerability Index.**

### *3.5. Community Level Summaries*

For each of the 13 municipalities and three (3) electoral areas, key findings have been identified for further specificity for each community's specific heat vulnerability characteristics. These community level summaries help to show hot spots of heat vulnerability for each of the three mapping components. Community summaries can be found in appendix C. The community summaries also indicate the top contributing attributes from both the Socio-demographic Vulnerability Index and the residential Building Vulnerability Index, pertinent to each community. In addition, there are statistics relating to how the heat exposure layer overlaps with socio-demographic and building level vulnerability. For example, the District of Saanich's summary statistics table is depicted below in figure 3.26. In the table, very high vulnerability relates to the mapping categories labelled as very high. The District of Saanich is characterised by having 12.7% of its population residing in areas classified as very highly vulnerable according to the Socio-demographic Vulnerability Index. The top contributing demographic factor to the socio-demographic index is "population age 65 or older" (which makes up 23.1% of the population), while the top contributing health factor is "episodic mood anxiety disorders" (crude rate).

Housing type minimally contributed to the District of Saanich's overall building vulnerability (1.6%), as the community is mostly made up of single family dwellings, which was not considered as a vulnerable housing type (see table 2.2 for housing type vulnerability rankings). Rather, albedo and solar insolation are the largest contributing factors to this community's building vulnerability. This means that many building roofs are classified as very dark (absorbing heat), and buildings are exposed to very high amounts of solar insolation (30.4% of buildings). High solar insolation is predominantly due to low proportions of tree cover or shade, building aspect, elevation, and slope. By overlapping both socio-demographic and residential building vulnerability, the District of Saanich has 806 buildings that are classified as very highly vulnerable in both indices. As for modelled heat exposure results, 28% of the community's land area is modelled to have experienced some of the very highest temperatures in the capital region during the 2021 heat event (> 36.1 degrees celsius). Lasty, this community has the greatest amount of residential buildings classified as very highly vulnerable across all three mapping components (454 buildings).

Please note that the heat exposure layer is displayed in quintiles to help show variability in temperatures across each community. Quintiles divide the data into five equal parts, each representing 20% of the distribution of the data. The quintiles help identify areas with varying levels of susceptibility to heat-related impacts, however it should be noted that the range of values are all very warm temperatures during the extreme heat event, displaying that it can get quite hot everywhere. Regardless, quintiles are used to help to show the relative differences in temperature distribution across the region. Per the example below the "Very high" quintile is indicated as any area predicted to reach above 36.1 degrees celsius during the design heat dome event.

# The Corporation of the District of Saanich

Heat Vulnerability Data & Analysis Project
Prepared for The Capital Regional District

**Demographic Vulnerability**

| | |
|---|---|
| Population 2021 | 117,735 |
| % population in very high Sociodemographic vulnerability | 12.70% |
| % population in very high demographic-only vulnerability | 8.20% |
| % population in very high Health vulnerability | 14.10% |
| Top contributing demographic factor | Population age 65 or older (23.1%) |
| Second contributing demographic factor | Population that are renters (30.8%) |
| Third contributing demographic factor | Private households by age of primary household maintainers - 65 years and over (18.2%) |
| Top contributing health factor | Episodic Mood Anxiety Disorders Prevalence (Crude Rate) |
| Second contributing health factor | Hypertension (crude rate) |
| Third contributing health factor | Diabetes (Crude Rate) |

**Building Vulnerability**

| | |
|---|---|
| Total # of residential buildings in the community | 35,638 |
| Housing type contribution to building vulnerability | 1.60% |
| Year Built contribution to building vulnerability | 24.90% |
| Albedo contribution to building vulnerability | 29.70% |
| Solar insolation contribution to building vulnerability | 30.40% |
| Building Height contribution to building vulnerability | 13.50% |
| # of buildings with very high demographic & building vuln. | 806 |
| # of buildings in very high | 6,873 |
| % of residential buildings in very high | 11.80% |
| Average age of buildings in very high | 1960 |

**Heat Exposure**

| | |
|---|---|
| % of community area in very high heat exposure | 28% |
| % of residential buildings with very high heat exposure | 36% |
| # of buildings with very high socio-demographic & heat expo. | 1,542 |
| # of residential buildings highly vulnerable across all 3 indices | 454 |


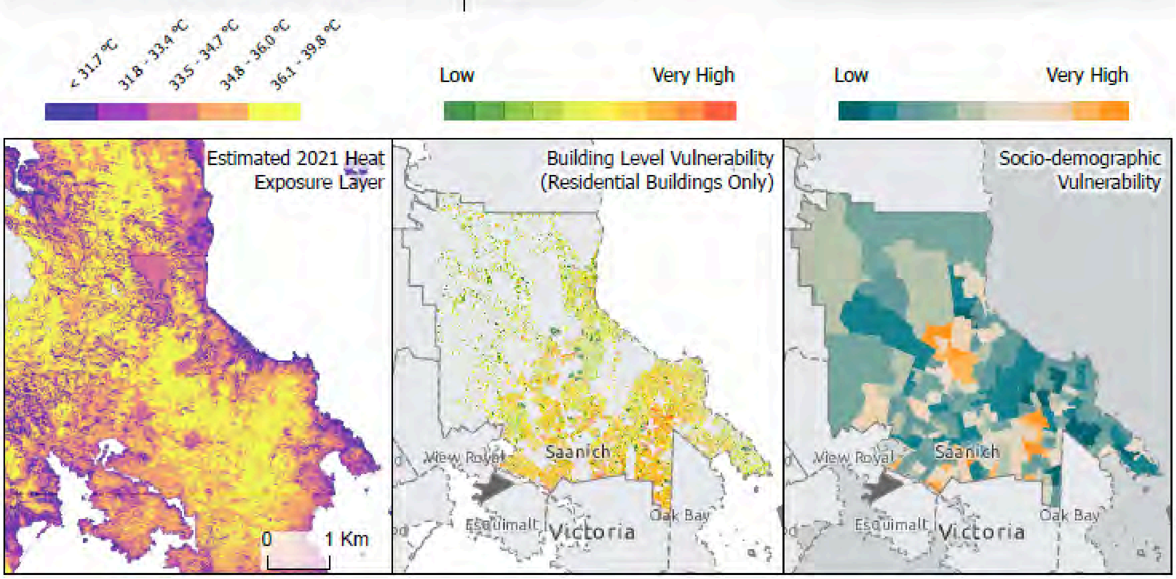


Figure 3.26. The Corporation of the District of Saanich Community Summary highlighting key determinants of heat vulnerability pertinent to Saanich.

### 3.6. *Community Level Key Findings*

While a detailed community-by-community analysis was out-of-scope for this assignment, we reviewed the summaries detailed above and can share the following key findings:

- Amongst all of the incorporated areas in the CRD, the top demographic consideration was consistently either: percentage of the population who are renters or percentage of the population who are seniors. The seniors finding is unsurprising as that was the highest weighted variable in the AHP model.
- The second highest demographic consideration encompassed considerably more variation including: % of population living alone (Victoria), Average number of rooms per dwelling (Langford), % of the population without post secondary education (Sooke), older housing (Oak Bay), and percentage of outdoor workers (Highlands).
- Low income residents did not factor in the top three for any community which suggests that no individual community in the CRD has elevated levels of poverty (recognizing, of course, that individual pockets of concentrated poverty are prevalent throughout the CRD).
- In most communities the primary health consideration is Episodic Mood Anxiety Disorders Prevalence followed by Hypertension (crude rate). This is noteworthy as neither mood anxiety disorders nor hypertension were weighted extremely highly in our model. This suggests that both of the health considerations are highly prevalent in the CRD and can be potentially addressed through municipal-level health measures which will reduce overall heat risk (for instance municipalities can consider food labelling bylaws or investments in active transportation which will reduce the incidence of hypertension).
- Noteworthy secondary health considerations include: high prevalence of diabetes in Colwood, high prevalence of Chronic Obstructive Pulmonary Disease (COPD)in Sooke, Victoria, Esquimalt and Salt Spring Island, high prevalence of Asthma in Langford and a high prevalence of Acute Myocardial Infarction in the Southern Gulf Islands and Metchosin.
- When unpacking the determinants of building risk, we note that Sidney, Victoria and Sooke all have the highest percentages of multi-family or congregant housing in their communities and therefore see higher values for the building type risk factor (all ~6%). Conversely communities that are nearly or mostly single detached in nature such as the JDF electoral areas, Highlands, North Saanich, Oak Bay and the Southern gulf islands all have the building risk factor contributing less than 1% to buildings risk.
- Owing to their comparatively new building stock, both Sooke and Langford (average age 1991 and 1984 respectively) indicate that era of construction (or building age) contributes less the 20% of building risk (18% and 19% respectively), conversely, Oak Bay, Esquimalt and Saanich all with comparatively older buildings indicate that era of construction contributes more than 25% to building heat risk.
- In general there is very little variance with regards to albedo and solar loading, though we note that Highlands has the lowest contribution for solar loading (24%) and the highest contribution for Albedo (35%) likely this is due to the fact that for the most part the

Highlands are very forested which can artificially increase albedo through shading and reduce solar loading commensurately. Also interesting to note is West facing communities such as Langford and Sidney have higher solar loading contribution percentages than other communities (though Oak Bay is an outlier here).

- When considered using region-wide averages, we note that 55% of Victoria's buildings are in the top quintile for building heat risk, followed by Oak Bay at 39%, Esquimalt at 33% and Sidney at 29%.
- When combined with demographic vulnerability we note that Victoria, Saanich and Sidney have the most buildings which are in very vulnerable areas for both buildings and socio-demographics at 1,174, 806 and 628 residential buildings respectively. When examined by percentage of total residential buildings, Sidney, Victoria and Esquimalt are the top three ranked communities with 19%, 13%, and 8% of all residential buildings being in both very high risk categories for buildings and sociodemographics. Conversely, Metchosin, Highlands and North Saanich have 0 buildings in these two categories.
- With regards to air temperature, we note that Langford, Highlands and Colwood all have significant areas of their community in highest heat quintile (>=36.6℃ daily average air temperature) at 61%, 49% and 32% respectively, which may increase risk in the communities. Conversely, communities more proximal to the ocean all have lower percentages of their communities in the highest heat quintile with Oak Bay, Sidney and Esquimalt at 5%, 2%, 1% of land area respectively.
- As urban heat is in many ways influenced by land use change and development, it is impactful to note that 84%, 56% and 48% of Langford, Colwood and Highlands' residential buildings are in the highest heat quintile. However, all three of these communities have relatively lower socio-demographic risk and only 6% (648), 1% (54) and 0% (0) of Langford, Colwood and Highlands' residential buildings are in both the highest quintiles for air temperature and socio-demographics
- Extending the above analysis to all three indices/layers we note that Saanich has 454 residential buildings in the three highest quintiles for heat risk, buildings risk and socio-demographic risk (1% of all residential buildings in the community), Victoria has 229 (2% of residential buildings) and Langford has 98 (1% of residential buildings in langford). Overall, there are 929 buildings in all three very high risk categories.

### *3.7. Sub-municipal analysis*

Using the vulnerability indices in tandem can help to recognise priority areas for adaptation, risk reduction, and enhanced emergency response efforts. By examining where both building vulnerability is high and where socio-demographic vulnerability is also high, it becomes possible to strategically prioritise interventions and resources in areas most in need of attention. In figure 3.18 below, these overlapping vulnerabilities were identified at the building level and subsequently assessed for proximity to first responder data points. Buildings that are highly vulnerable and also fall within a DA that has a high Socio-demographic Vulnerability Index score are displayed in purple on the map below if they are also further than 2 kilometres away from a first responder dispatch facility. This analysis reveals key hotspots of vulnerability that could benefit from enhanced emergency preparedness and response. Some emergent hotpots of note occur near Gorge-Tillicum, Otter point, Oaklands (Vancouver) & Quadra (Saanich), south Oak Bay, Cordova Bay, and the north and south areas of Sydney, among others.

While an exhaustive analysis of key considerations for each of the abovementioned hotspots is beyond the scope of this study, we note for interest potential concerns in the Oaklands/Quadra areas of Victoria and Saanich which exhibits a high degree of buildings that are at risk, along with sizable concerns with regards to at risk populations and a seemingly longer potential response time for first responders[65]:

- 54% lower adoption rates of heat pumps per capita than the regional average;
- Rates at twice or more the regional average for acute myocardial infarction, chronic obstructive pulmonary disease, chronic kidney disease and hospitalised stroke;
- Population density at 1.8x of the regional average;
- Percentage of population living alone 1.4x of the regional average;
- Unemployment rates 1.3x the regional average;
- Concentrations of recent immigrants 3.5x the regional average;
- Concentrations of poverty with 16% of the households being in the bottom decile of family incomes in the region (compared to an expected 10%);
- Top risk quartile solar insolation (4,400 watt/hrs versus a regional average of 3,950) and building age values (average year built 1954 versus regional average of 1974); and
- A somewhat higher proportion of seniors living in multi-unit buildings than the regional average.

We note that while presented as a conceptual example only, the above risk profiling can be completed for any subset of buildings and/or dissemination areas considered for this study and as such can with some additional effort, be extended to multiple, additional hazards or disaster response scenarios.

[65] We note the very close proximity to Royal Jubilee Hospital, which, to the best of our understanding, does not dispatch ambulances.

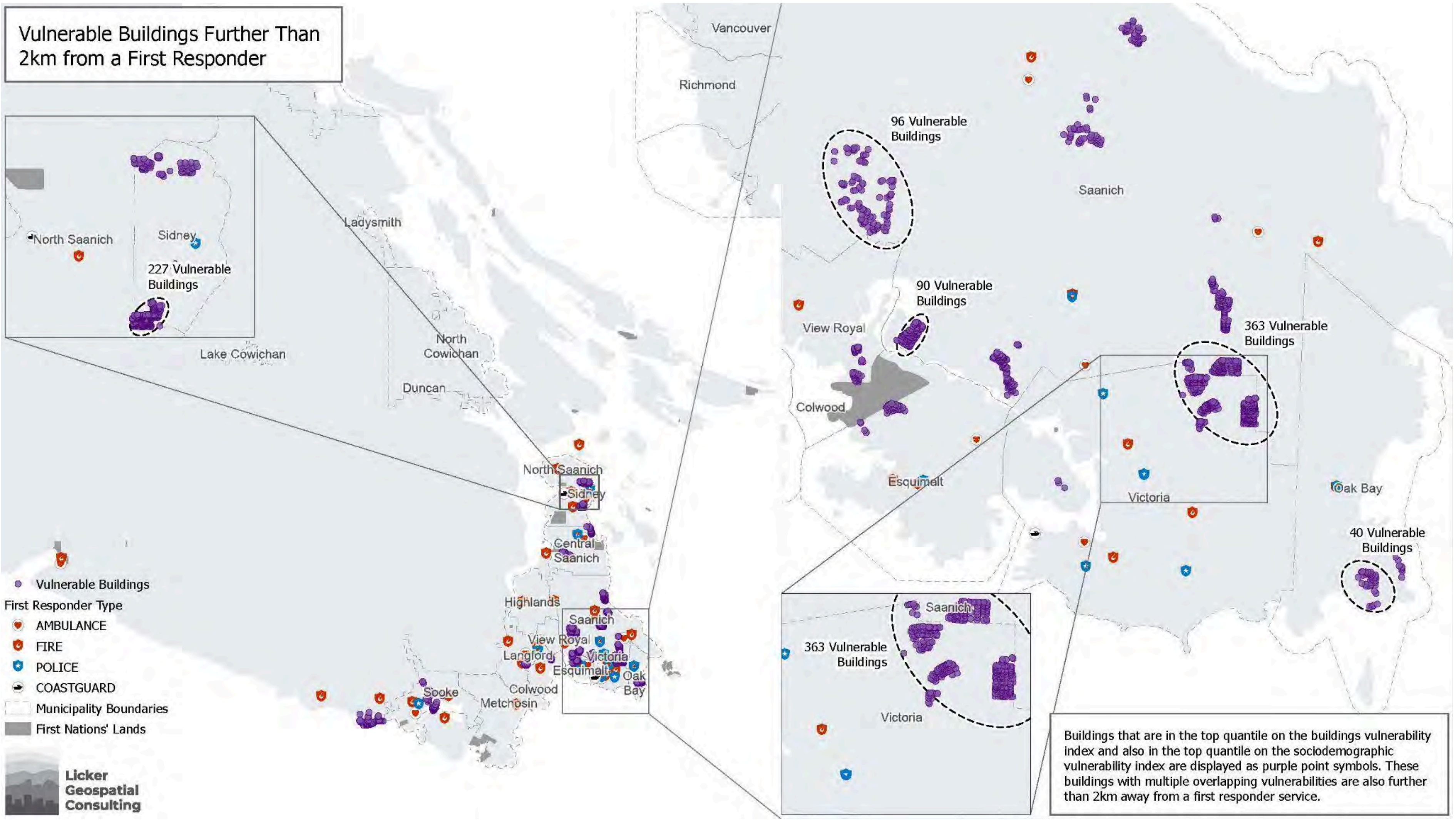


**Figure 3.27.** Buildings with multiple overlapping vulnerabilities that are also located further than 2 kilometres from a first responder dispatch facility.

## 4. Discussion

The findings of this study, while underscoring the multifaceted nature of extreme heat vulnerability and resilience in urban and rural environments, also bring to light the inherent complexities and constraints associated with such research. This Discussion section aims to detail these complexities, starting with a presentation of limitations of the socio-demographic vulnerability index, the heat exposure layer, and the building vulnerability index. The recognition of these constraints allows for transparency in our research, provides context of our findings, and also presents opportunities for future research in this area. Following a discussion on limitations, a carefully considered set of recommendations are provided, which have been drawn from our data-driven insights and are intended to guide practical interventions and policy formulations. Lastly, we present potential future uses of the analytical outputs of this study, in which we offer pathways to leverage this work towards the development of innovated solutions and strategies for enhancing resilience against extreme heat at the localised and regional level.

### *4.1. Methodology Limitations*

#### *4.1.1. Limitations of the Socio-Demographic Vulnerability Index*

Despite the increase in accuracy in this index through the use of AHP, there are still some limitations to the dataset that should be considered when interpreting the information. These include:

- Census data limitations: Census data is collected through a quinquennial mandatory survey carried out by Statistics Canada. Despite the legal obligation to complete the Census, certain households or individuals may choose to not answer the Census, not be present on Census day or may not answer the questionnaire truthfully. While Statistics Canada makes every effort to guarantee the accuracy of the Census there is a certain degree of non-response rate for all dissemination areas in the Study Area. These non-response rates vary from 0 to 51% in the capital region with an average non-response rate of 4% and can possibly reduce the accuracy of collected information in some cases.

- Ecological fallacy: As both Census and health data are aggregated to the Census Dissemination area level, there is a modest concern that any index prepared using this data is subject to the ecological fallacy[66], which can lead to errors of interpretation. That is to say, rates and values results described at the Dissemination Area level may not describe singular cohesive groups who all share the same attributes. Rather these data describe singular descriptors of different groups of individuals.

- Atemporality of socio-demographic data: The most recent Census was completed in 2021, as such the data are nearly three years old at the time of this study, and the populations that they describe may not conform to the ones that currently reside in the capital region

[66] The ecological fallacy is a common issue in the interpretation of statistical data that occurs when inferences about the nature of individuals are deduced from inferences about the group to which those individuals belong.

or future populations.  Accordingly, care should be taken when interpreting index data, to recognize that these data describe relative risk from 2021 with some degree of inaccuracy henceforth.

- During the socio-demographic index design phase we learned that the population with schizophrenia is at the highest risk for death during extreme heat due to a multitude of complex interacting factors[67]. While various health indicators pertaining to increased vulnerability during extreme heat were included in the index, we were unable to acquire data on schizophrenia at the DA level, leaving an important health indicator out of the equation.

- Future engagement could focus on outreach to key end-user groups. Many of these opportunities were discussed but not fully pursued given the timing and budget constraints of the project. Examples discussed were the Capital Region Housing Corporation (CRHC), other building managers/owners (BOMA, Devon properties, etc.), the Electoral Areas, and the health authority (i.e. Island Health).

- This effort did not include cross-tabulated Census data, which describes the intersection of data inputs. For example the spatial distribution of the population that are seniors *and* live alone (cross-tabulated), versus the spatial distribution of the population that are seniors *or* live alone (not cross-tabulated). Cross-tabulated Census data was not included in this project for several reasons, including project capacity limitations in regards to timing and cost, and privacy and confidentiality restrictions that are common for cross-tabulated data at the Census DA level. In regards to spatial resolution, Census data was accessed at the dissemination area level, meaning that any variations within dissemination areas are not fully captured.

- In the development of our AHP, we acknowledge potential limitations regarding representation and inclusion. Despite efforts to engage a diverse array of subject matter experts knowledgeable about the local context of the capital region, some perspectives will have been underrepresented or overlooked, thereby introducing gaps in the index creation. Further, the use of AHP introduces subjectivity due to its reliance on subjective judgments in weighting of inputs. The inherent biases and personal preferences of the analysts involved will influence weight attribution and thereby the demographic vulnerability index.

- The census data deployed in the analysis does not include the homeless population. Their adaptive capacity is perhaps higher for extreme heat as they are more connected to supporting resources during a heat event.

[67] Studies of Mortality in British Columbia During the 2021 Extreme Heat Event. Heat Preparedness Knowledge Exchange, May, 10th, 2023. With Sarah Henderson, Kathleen McLean, Michael Lee, Shirley Chen, Corinne Hohl.

In our analysis of extreme heat, we recognized the importance of considering First Nations' (FNs) communities in the region and sought to engage with them. First Nations representatives were included in the AHP workshop, for example, to ensure their perspectives were integrated in the way socio-demographic vulnerability/adaptive capacity was being defined in the region. Effort was also made to reach out to several other First Nations. The project timeline and budget constraints limited this consultation and inclusion process, as did data availability in certain circumstances. We acknowledge that more input and guidance from local FNs would have been valuable in enhancing our understanding of the specific vulnerabilities and needs of their communities in relation to extreme heat events.

Exploratory work to investigate available data for First Nations was conducted with available Census data. It was found that there were higher Census non-response rates on FN lands, which would decrease the confidence in the vulnerability assessment. Long-form[68] non-response rates [69] for FN reserve DAs has a mean of 35.5%, and for short-form[70] a mean of 20.2%, whereas for non-reserve DAs, the long-form non-response rate averages 4% and for short-form is ~3%. Multiplying non-response rates at the DA level by FN population equates to 27% of the population for long form Census and 13% of the population for the short-form. Whereas for non-reserve DAs, long-form and short-form non-response rates average 3.8% and 2.8% of the population respectively (see Table 2.1). However, Statistics Canada has reported that total non-responses to the long-form questionnaire are compensated for through imputation. Data for households that did not respond to any questions are imputed using data from a respondent household[71].

BC Assessment data (i.e. the buildings information report or BIR), as deployed in the buildings vulnerability index is not available for buildings on First Nations' reserve lands. Further, lived experiences on some First Nations reserves suggests a highly protective factor of living in these communities[72]. Accordingly, more work is required to develop a methodology that would help overcome data limitations and integrate these intercultural considerations.

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[68] The long-form questionnaire complements the short-form questionnaire and is designed to provide more detailed information on people in Canada according to their demographic, social and economic characteristics. It is disseminated to 25% of the population.

[69] Non-response rate is defined by Statistics Canada as the percentage of individuals or households that did not provide a completed response to the Census questionnaire. The non-response rate helps to understand the quality and coverage of Census results.

[70] Short-form refers to Canada's Census form that collects basic demographic and household information and is disseminated to 75% of the population.

[71] Statistics Canada (2022). *Guide to the Census of Population, 2021, Chapter 12 – Sampling and weighting for the long form*. Retrieved June 30, 2023, from https://www12.statcan.gc.ca/census-recensement/2021/ref/98-304/2021001/chap12-eng.cfm

[72] Canadian Climate Institute. (n.d.). Community is the solution. Available from https://climateinstitute.ca/publications/community-solution-2021-extreme-heat-emergency-experience-british-columbia-first-nations/

**Table 4.1.** Non response rate comparison within the capital region.

| Non Response Category | FN Reserve DAs | Non-reserve DAs |
|---|---|---|
| Long form - Non-Response | 35.5% | 4% |
| Short form - Non-Response | 20.2% | ~3% |
| Long form - Proportion of Population - Non-Response | 27% | 3.8% |
| Short form - Proportion of Population - Non-Response | 13% | 2.8% |

### *4.1.2. Limitations of the Heat Exposure Layer*

Both the air temperature and LST model have limitations in their calculations and usage. Below are limitations associated with the LST and air temperature layers:

- LST is sensitive to immediate land cover change. Because LST is very closely aligned with what is directly on the ground, any changes to that surface will as a result impact the LST measurement. This LST layer is specific to the 2021 heat event. While land cover may generally be similar in the short-medium term, it is expected that by the long-term, the LST distribution will change significantly from land cover changes alone, notwithstanding changes to the magnitude of extreme heat events.
- As aforementioned, LST can provide a detailed perspective of how the region heats during a heat event. However, the distribution of the layer is less appropriate when relating to the human experience of extreme heat events, given that temperatures differ as they dissipate up to 2 m above the surface.
- Air temperature is based off a regression-model without an intercept. This approach introduces assumptions including that without any input (elevation, solar insolation, distance from coastline, etc.) the air temperature will be 0°C.
- Air temperature also heavily relies on the selected environmental variables for predictions, which may not account for all the factors that influence air temperature (such as windchill).
- The air temperature layer is inflexible and may produce erroneous values when applied in different regions.
- The air temperature layer is a linear model, which may not necessarily be true under all scenarios, especially in complex urban environments.
- The air temperature regression analysis is dependent on a relatively small sample size of weather stations (66), which may have sensor inaccuracies and has a limited distribution. As such the model becomes inflexible at high elevations where there is a gap in reliable station data during the 2021 heat event.

### *4.1.3. Limitations of the Building Vulnerability Index*

While comprehensive, innovative and highly detailed, this index still presents a first attempt at regionally characterising potential heat in buildings and is subject to the following limitations:

- There are potential limitations of this model relating to data availability/accessibility (i.e air conditioning data for commercial buildings, indoor temperature, building wall material, single room occupancy (SROs)/residential hotels) and data nuance (i.e. have building components been updated since the building was built, averaging of building heights over their footprints). These are improvements the consulting team recommends be made in the future if and when possible.
- To help validate the model, ideally indoor air temperature gauges across the region would have been used to help validate the buildings index. Indoor air temperature data was sought after by ecobee. However, data was unavailable at the address level for the Project's use. If building level indoor air temperature data becomes available (for dates durings a heat wave), it would be recommended to incorporate this data into the modelling to help predict vulnerability as well as for model validation.
- Another limitation stems from the fact that, although each building is assigned specific values for height, albedo, and solar insolation, all buildings on a given parcel share a common set of building age and type information sourced from the Building Information Report. Thus, lower overall reliability exists in the ultimate ranking where there are multiple structures on the same parcel.
- Building albedo is based on the reflectance of a building's roof assembly only, that is to say, while the roof is a key element in heat loading, the walls of a building may absorb heat as well. Unfortunately, the albedo analysis, as conceived, can only be completed in planimetric (ie two dimensional) space and accordingly this nuance is lost in the buildings index model. During the meeting to discuss the buildings modelling approach, there were live experience comments that some new buildings, with lots of glass, that are south facing experienced extreme indoor temperatures during BC's 2021 heat event. With this in mind, we suggest that when possible, future model iterations consider building facade materials.
- Building age is a strong determinant of heat risk and it is fortunate that the BC assessment year of construction data captures this information. However, the year of construction of a building may not equate directly to the age of the interiors or exterior walls or windows of the building as these may have been renovated over time.
- A total of 2.9% of buildings lack information on building age or dwelling type. These data gaps can be attributed to four factors: temporal issues with BIR data, building footprint delineation and parcel boundary data, First Nations' Lands are not assessed by BC Assessment, occasional discrepancies when Joining Building Information on PID resulted in a small number of unmatched records, and the inherent potential for a minor degree of error in the BIR assessment process, which involves human evaluation.
- There is conflicting evidence around using building age as a predictor of vulnerability without also knowing construction material. Unfortunately, construction material was not a consistent attribute available for all buildings. Additionally, there is still no consensus among building experts and scientists on which construction materials are best in an extreme heat event, as specific building dynamics need to be considered which are very complex and not within the scope of this project to discern. However, in the context of the

District and BC as a whole, we are able to make approximate inferences about air tightness based on BC's building code history.  Therefore using building age gives us a reasonable proxy around building air tightness, however adjustments could be made to this variable based on future potential findings from the building science community.

- As noted in Section 2.3.2, footprints for East Sooke, Metchosin and Juan de Fuca were delineated by LGeo, whereas footprints for the rest of the capital region were sourced from their respective municipalities. Note that footprint delineation errors within the provided source footprints from capital region were not scoped for QA or revisions.
- The buildings index, functions as a regional model, and has undergone thorough quality assurance through comprehensive sense checks across all attribute types. Nevertheless, given the extensive volume of buildings within the region, a meticulous examination of each individual building wasn't feasible, which has the potential for introducing errors or discrepancies. It's essential to acknowledge that, at a certain point, the effort invested in quality assurance encounters diminishing returns when building a regional model.
- While heat pumps are known to provide protective effects against extreme heat, our model assumes that the heat pump is providing cooling for all buildings on the associated parcel, as heat pump data was only available at a base address level. For single family homes this assumption is fairly sound. However, for multi-unit buildings, the heat pump data available does not distinguish if it's for a singular residence, or if the heat pump is able to provide cooling for the entire building.

### *4.2. Recommendations for usage and future research*

- Analysing multiple overlapping vulnerability maps – Using all three mapping components together can help to recognise priority areas for risk reduction (i.e. risk reduction potential) and enhanced emergency response efforts. By examining vulnerability at the dissemination area level, considering both vulnerable populations and buildings along with the presence of urban heat islands, it becomes possible to strategically prioritise interventions and resources in areas most in need of attention.

- Identifying priority areas for tree canopy and green spaces – The data and maps derived from this project can help support urban forest strategies in the region. The vulnerability indices can be used to identify areas with a higher concentration of vulnerable populations that also have low proportions of canopy coverage. These areas can be prioritised for the development and enhancement of urban green spaces, parks, and tree canopies. Planting trees in areas with higher vulnerability can contribute to providing shade, reducing surface temperatures, and improving overall microclimates, thereby enhancing the well-being of vulnerable populations.

- Modelling and forecasting urban heat island effects  - Our air temperature index results from a function of topography, urban form and to a lesser extent density and canopy coverage. Given that air temperature is to a some degree anthropogenically influenced, we can potentially model this out into a baseline and design case scenarios. This can be readily accomplished using an exploratory forecasting approach wherein we forecast the correlating factors driving air temperature using a simulation-based approach. This is similar to how climate mitigation modelling is forecasted using land use as a driving factor.

As discussed in the air temperature section above, our air temperature model describes the relative predictive value of insolation and land surface temperature both of which can be forecasted using a future case. Future case considerations could include:

- Generic temperature increases due to climate change (as discussed 2.5 degrees median for South Island)
- Canopy regrowth and degrowth rates by land use typology (we know that there is a generic increase on public lands, modest decrease on infill lands, a spectacular decrease on greenfield development followed by rapid regrowth, static growth in mature single detached areas etc - this can be generated from landsat data and plugged into the Canopy growth model we developed for Vancouver). Cutblock simulations could be included as well.
- Urban intensification (would change energy density, population and employment density - this can be generated from build out models similar to those which have been developed previously for Victoria and Saanich)
- Greenfield development (significantly increasing road network / traffic density and reducing LST)
- Changes to vehicular travel behaviours / shifting to non heat generating modes of travel.

A business as usual or "dark-sky" case could be developed wherein deltas to urban heat could be considered as a result of unchecked development absent any mitigating effects of canopy regrowth and design considerations to increase albedo. Alternative cool-city cases could be developed considering reduced buildings thermal density (or increased r-values), design considerations to increase albedo, reduced vehicular density, road reallocation to greenspace, aggressive tree planting scenarios and secession of aggressive foresting practices. The difference in modelled LST between scenarios could be considered as a positive effect of good urban planning and could mitigate against future heat vulnerability (at least on the exposure side of things).

- Response Resource Allocation – Based on the extreme heat event experienced in British Columbia in 2021, we know that emergency response personnel were at or over capacity in many areas throughout the capital region. Understanding at the dissemination level where there are vulnerable people and where there is a shortage of emergency responders or a long distance for a response team to travel, can help to better plan for where greater emergency response resources are needed. In local authorities where establishing cooling centres is common practice, the mapping produced by this project can provide an evidence base for where cooling centres should be prioritised.

- Updating local hazard, risk, and vulnerability analyses (i.e. HRVAs) - The new Emergency and Disaster Management Act (i.e. EDMA) is ramping up requirements for local authorities to undertake hazard and risk assessments. The effort and investment made via this project can support these obligations for local authorities in the CRD. A large component of the work for an HRVA had been completed, with the ability to add in multi-hazard considerations for the other 'major hazards of concern' in the region.

- Supporting climate action planning and reporting – As mentioned above, this may involve considering changes in land use planning and policies to help mitigate the impacts of extreme heat. Specifically, high heat areas should be tested against canopy coverage to determine the influence of urban canopy on heat. Should the relationship prove durable then tree planting should be prioritised for hotter areas to reduce urban heat island effects.

- Supporting response to and adaptation of high risk buildings – The Building Vulnerability Index can help to inform which buildings are likely in need of retrofitting for extreme heat adaptation. It can also help prioritise areas for redevelopment. In the nearer term, the building modelling can help prioritise outreach and response. For example, in Burnaby, the emergency managers posted flyers in high-risk multi-unit buildings to educate residents about extreme heat hazards and options to help manage it. It can also support in-person wellness checks as first responders can respond to the buildings being mapped as high-risk, as they often cannot get information about the specific socio-demographics at a given building.

- Prioritising subsidies of heat pumps. Based on our findings, there is significant disparity with regards to the distribution of heat pumps in the region. In light of these findings, there should be some consideration for localised subsidies for heat pump adoption perhaps based on socio-demographic factors as well as overall building risk.

- Synergies with buildings benchmarking. As buildings benchmarking for energy performance becomes more common both in the capital region and province-wide, it may prove beneficial to require reporting for indoor air temperatures (as well as indoor air quality!) along with the mandatory energy reporting. Secondly, benchmarking information can be furthermore used to support identification of low or high risk buildings based on interpretation of hourly energy profiles which can indicate the presence of electric cooling or weak r values for instance.

- Community Engagement, Outreach and Education: The demographic and health-related vulnerability information can be used to help facilitate targeted community engagement and education efforts, regarding extreme heat events. This can include outreach programs to educate vulnerable populations on heat-related risks and the importance of preparedness.

4.3. *Future Model Updates*

As noted in the limitations sections for each index, data availability and granularity of validation are the predominant cause for any shortcomings in the model. If pertinent data becomes available at a later date, new indicators can be added in a streamlined fashion. For example, schizophrenia data could be added to the demographic index, if it becomes available at the DA scale. Proportions of the population having schizophrenia would simply need to be multiplied by a decided weighting factor (likely by a high weight percentage in relation to the other demographic variables given its significance) and added to the index score.

As new demographic information becomes available from the next Census, the demographic index could be updated with these new data. Data can be extracted from Statistics Canada's API by dissemination area unique identifier (DAUID)[73]. If you are unfamiliar with Census data scraping, LGeo has automated processes in place that can assist. After acquiring the appropriate Census data variables, adaptive capacity variables will need to be inverted to ensure that high values always represent higher vulnerability. In addition, variables that are not percent values, such as average number of dwellings and population density per hectare, would need to be scaled to have values ranging between 0 and 1. Once variables are configured, each variable is multiplied by their associated AHP assigned weight and then summed together to create the demographic index. We have automated this process through scripting and can assist in updating when needed.

To update the Heat Exposure Layer, a digital elevation model (DEM), at 1 $m^2$ spatial resolution will need to be derived from the newly available lidar data. Solar insolation ($WH/m^2$) at a spatial resolution of $30m^2$, derived from a digital terrain model (DTM; 30 $m^2$) will need to be rerun using the newly available lidar data. Then the Sky View Factor (SVF), will need to be re-assessed at 1 $m^2$ spatial resolution. In addition, land surface temperature (LST; °C), will need to be recalculated from Landsat-8 satellite images captured during the updated heat event time period. Similarly, Normalised water difference index (NDWI), will need to be recalculated with appropriate updated Landsat-8 satellite images. Lastly, if the distance to coastline (km) layer needs to be remade, it can be calculated using one of ESRI's distance tools using coastline polyline data and either a 30m2 raster or polygon-grid covering the Region.

To update the Building Vulnerability Index, effort would need to be made to update parcels with new BIR data including actual use codes, and year built. New LiDAR derived footprints would also need to be created and attributed with building height. New Sentinel-2 imagery can be downloaded from the European Space Agency[74] to process a new albedo layer for the region. And lastly, updated air conditioning or heat pump data would need to be geocoded and attributed to its associated parcel. Additionally, it should be noted that there is a lack of literature from building experts and scientists discussing how particular building characteristics affect

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[73] Statistics Canada. Application Program Interface (API). https://www.statcan.gc.ca/en/microdata/api

[74] European Space Agency. (2023). Sentinel-2 Multispectral Instrument Level-1C data [Data set]. Copernicus Open Access Hub. https://scihub.copernicus.eu/dhus

vulnerability to extreme heat events. As research emerges in this area of study, it would be beneficial to apply any new and relevant findings to future iterations of the buildings index.

With regards to validation we note that our validation efforts are based on aggregate levels of observed hospitalizations that can be attributed to heat. While this is a reasonably effective method for validating the sociodemographic and buildings indices at the dissemination area level, it does not account for risk at the individual or buildings level. Recognizing that individual demographic or health data is practically impossible to gather, disseminate and validate for a public study such as this one, it may prove more effective to produce custom Census cross-tabulations which can then be validated at the DA level with some reassurance that the ecological fallacy has been mitigated to a certain degree. For additional buildings validation, it may prove beneficial to promote the installation of indoor temperature monitors in suspected at-risk-buildings[75] such that real risk data can be captured and validated against modelled information produced for this study.

[75] Note that the project team made reasonable, though unsuccessful efforts, to acquire third party indoor air temperature data from a number of providers as well as to collect anecdotal information from buildings managers who had been present during the 2021 heat event. Our efforts were not successful due, in part to concerns with regards to data privacy which hampered appropriate sharing of sensitive information.

**Closing remarks**

This study conducted by the Capital Regional District (CRD) and in conjunction with Licker Geospatial Consulting Co (LGeo), Thrive Consulting (Thrive), and municipal partners, represents a significant advancement in both the understanding and identification of extreme heat vulnerability within the capital region, but also the way in which regional and local governments may measure and assess extreme heat vulnerability in their communities. By leveraging a multidisciplinary approach that combines socio-demographic vulnerability, heat exposure, and building vulnerability, this research offers a comprehensive and nuanced perspective on extreme heat vulnerability in the region that offers the identification of key areas and populations that exhibit elevated risk to extreme heat.

This study presents actionable insights and targeted recommendations aimed at enhancing climate change adaptation and mitigation strategies, prioritising emergency response mechanisms, and refining urban planning practices to foster resilience and equity in the face of extreme heat challenges. Key recommendations are identified below as:

- Integrate the use of these indices in planning for climate change adaptation, risk reduction, and emergency response with a focus on overlapping vulnerability;
- Nuance urban forestry and green infrastructure with vulnerability data. Tree planting and shade provisioning are elements of extreme heat adaptive capacity and should be prioritised in areas that are presented as highly vulnerable;
- Strategically allocate resources such as emergency response. Our analysis presents areas in which there are both high overlapping vulnerabilities and also a dearth of emergency response service coverage;
- Integrate the findings into local governments' hazard risk and vulnerability analysis (HRVAs) updates to allow for informed policy-making and climate action planning; and
- Prioritise building retrofit programs to highly vulnerable buildings, whereby a multi-hazard perspective is applied.

The collaboration among various project stakeholders, including local experts and community members, has enriched the study and ensures that the analysis and findings are grounded in local realities and experiences of extreme heat. Such a collaborative and data-informed approach not only maximises the relevancy and efficacy of the study's recommendations, but also underscores the importance of community engagement in addressing climate change-related hazards and vulnerabilities.

Moreover, the study's methodology and findings have a significant implication beyond the immediate scope of extreme heat vulnerability. Indeed, they contribute to a broader understanding of how regional and local governments may integrate scientific research with policy-making and community planning. This effort thereby offers a foundation for future initiatives aimed at addressing various aspects of climate change and public health preparedness. The emphasis on a holistic, evidence-based approach to addressing climate resilience challenges can serve as a guiding framework for other regions and municipalities that face similar challenges.

In summary, the initiative undertaken by the CRD marks a significant advancement in the discipline of local and regional government response and resilience to climate change, and offers a starting point for potential strategies to address heat vulnerability with actions that are informed, inclusive, and evidence-based. This research not only advocates our understanding of the complex dynamics of extreme heat exposure and its impacts, but also champions a proactive and collaborative model for building safer, more resilient communities in the face of escalating climate risks.

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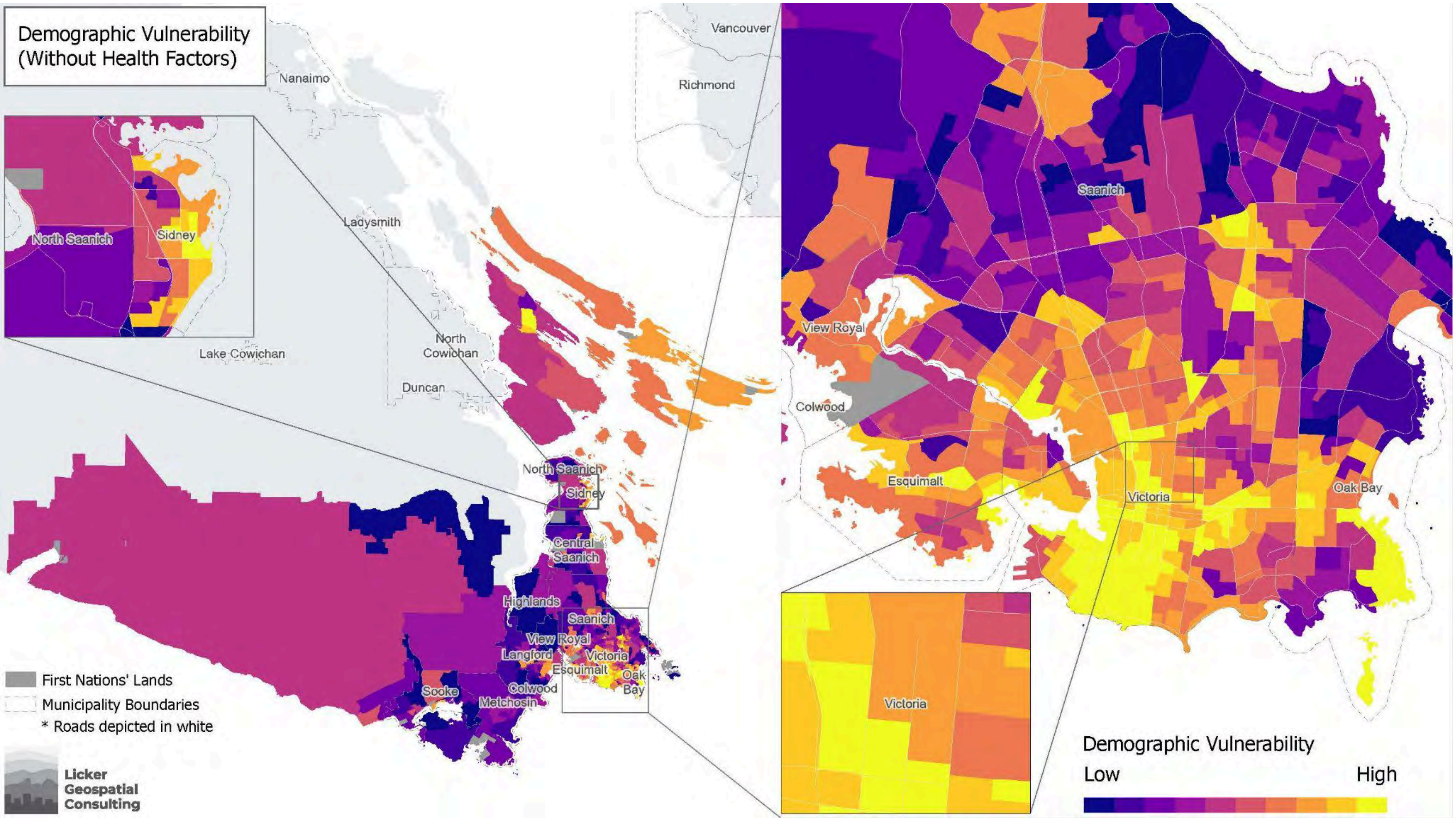
**Appendix A. Weights (ωbi) by spectral band for rooftop albedo calculation, derived from Vanino et al (2018)[76].**

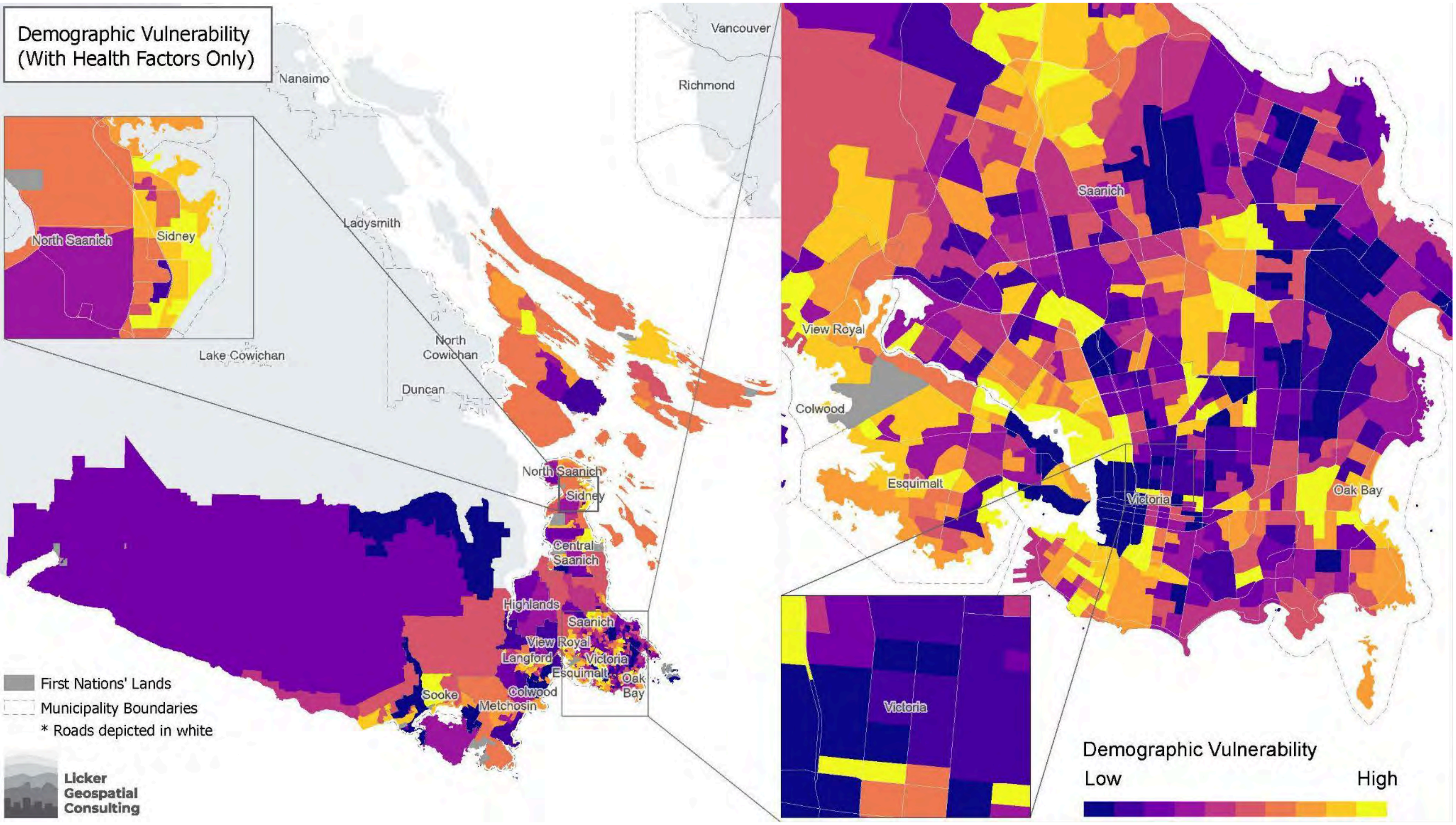
| Band | Center λ (μm) | Spectral width Δλ (μm) | Esun (W m−2) | $\omega_{bi}$ |
|---|---|---|---|---|
| **1** | 0.443 | 0.020 | 1,893 | - |
| **2** | 0.490 | 0.065 | 1,927 | 0.1324 |
| **3** | 0.560 | 0.035 | 1,846 | 0.1269 |
| **4** | 0.665 | 0.030 | 1,528 | 0.1051 |
| **5** | 0.705 | 0.015 | 1,413 | 0.0971 |
| **6** | 0.740 | 0.015 | 1,294 | 0.0890 |
| **7** | 0.783 | 0.020 | 1,190 | 0.0818 |
| **8** | 0.842 | 0.115 | 1,050 | 0.0722 |
| **8a** | 0.865 | 0.020 | 970 | - |
| **9** | 0.945 | 0.020 | 831 | - |
| **10** | 1.375 | 0.030 | 360 | - |
| **11** | 1.610 | 0.090 | 242 | 0.0167 |
| **12** | 2.190 | 0.180 | 3 | 0.0002 |

[76] Vanino, S., Nino, P., De Michele, C., Bolognesi, S. F., D'Urso, G., Di Bene, C., Pennelli, B., Vuolo, F., Farina, R., Pulighe, G., & Napoli, R. (2018). Capability of Sentinel-2 data for estimating maximum evapotranspiration and irrigation requirements for tomato crop in Central Italy. *Remote Sensing of Environment, 215*, 452-470. https://doi.org/10.1016/j.rse.2018.06.035

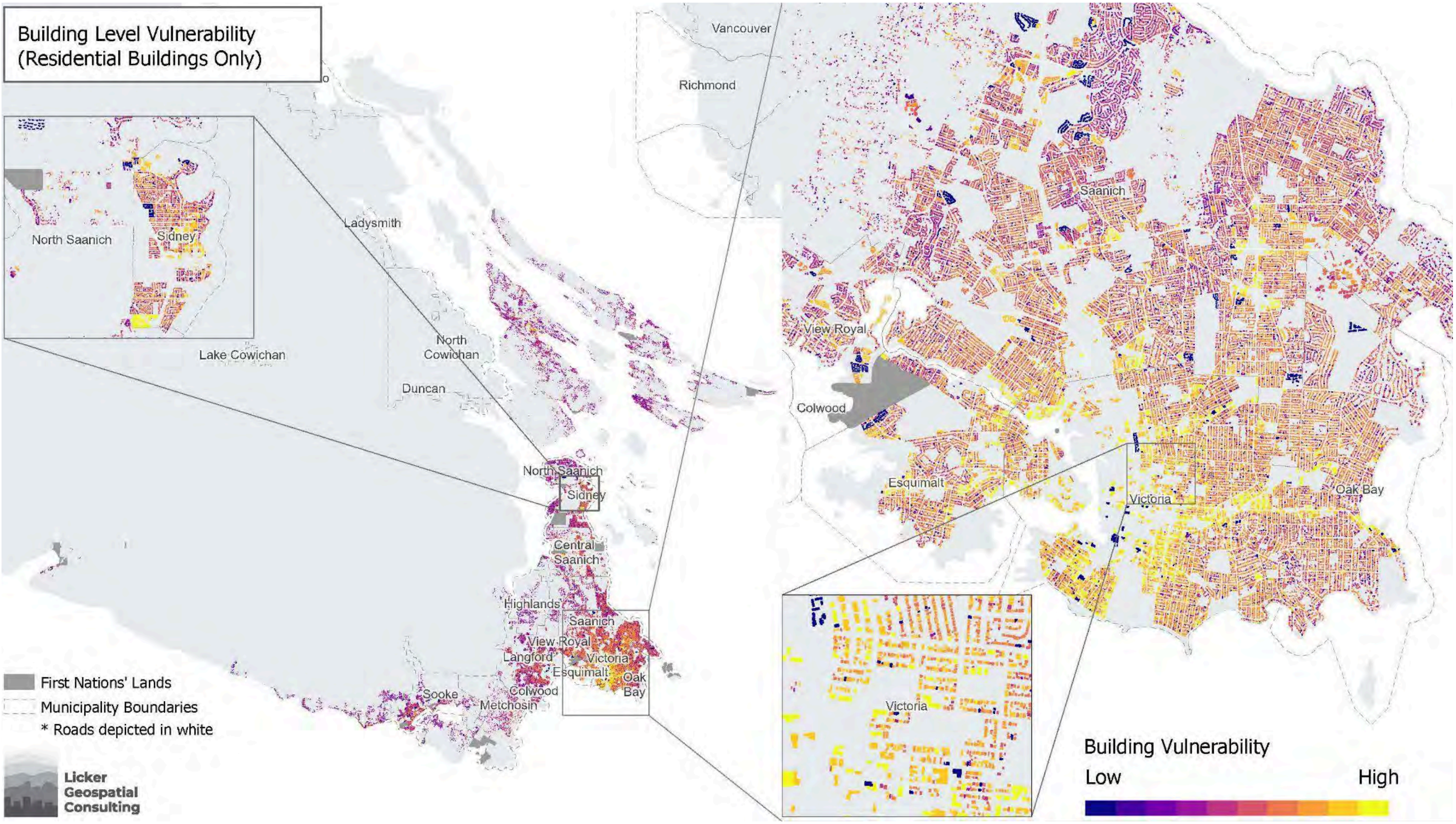
**Appendix B - Additional Maps: Sub-Indices**



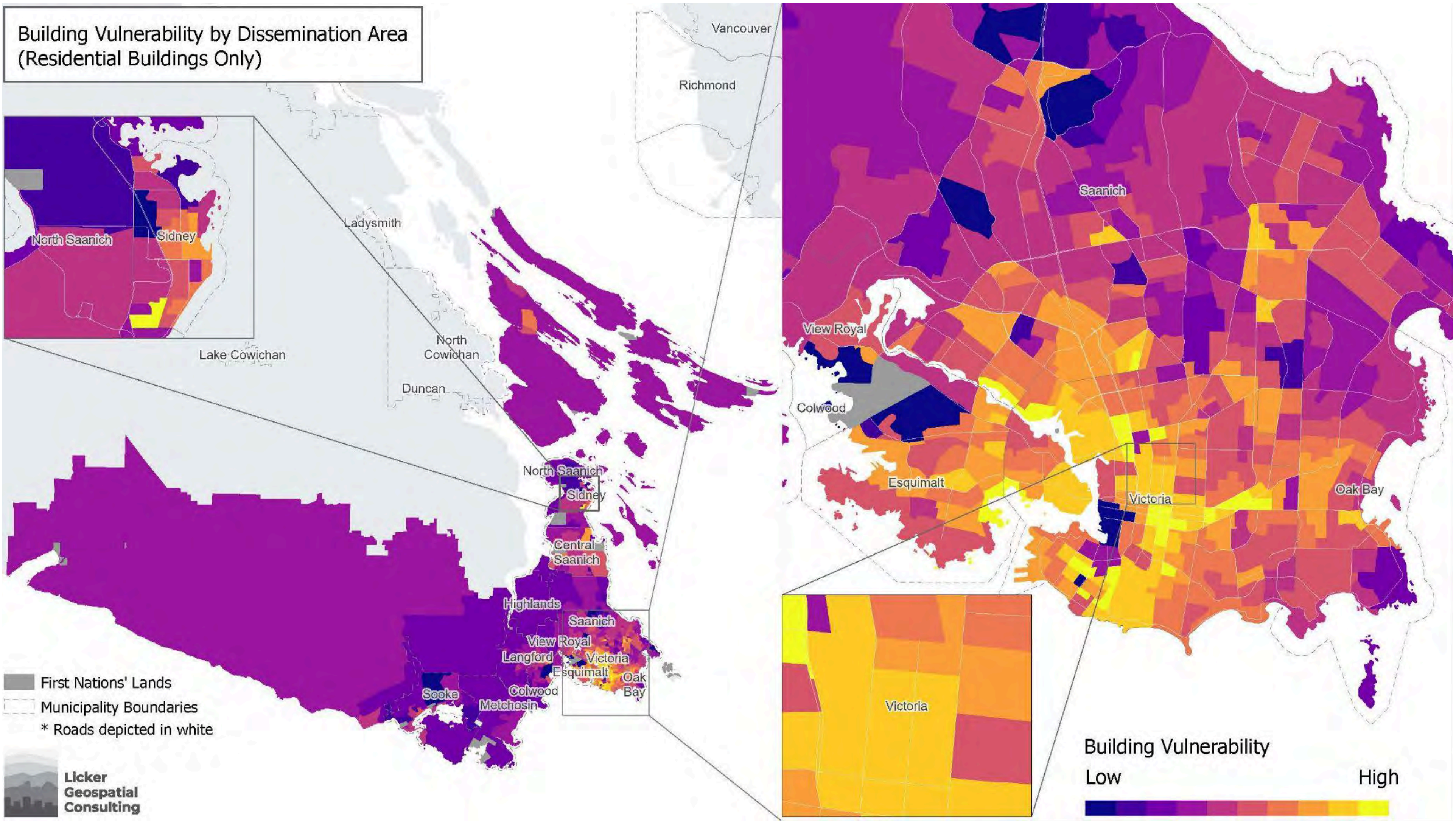

B1. Extreme Heat - Demographic Vulnerability Index without health-related factors.




B2. Extreme Heat - Demographic Vulnerability Index with health-related factors only.




B3. Extreme Heat - Building Vulnerability Index with residential buildings only, by building footprint.




B4. Extreme Heat - Building Vulnerability Index with residential buildings only, by DA.

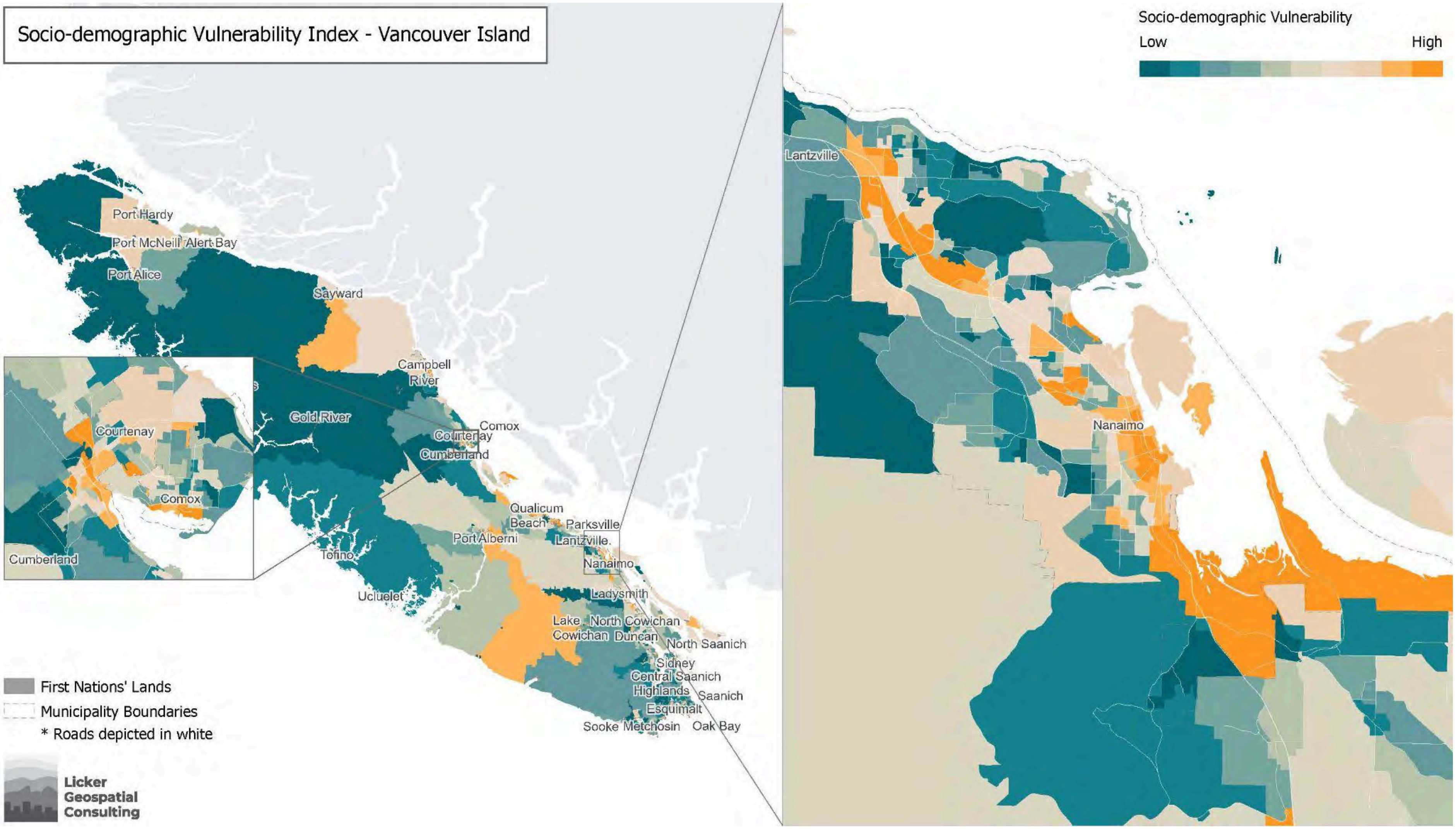



Figure B5. Vancouver Island wide Socio-demographic Vulnerability Index. Used for validation of the index at a greater scale.

Appendix C - Municipality Level Summaries

# Extreme Heat Vulnerability Summarised by Community

**Licker Geospatial Consulting Co.**

2405 East Hastings St
Vancouver BC, V5K 1Y8

# City of Colwood

**Heat Vulnerability Data & Analysis Project**
**Prepared for The Capital Regional District**

## Demographic Vulnerability

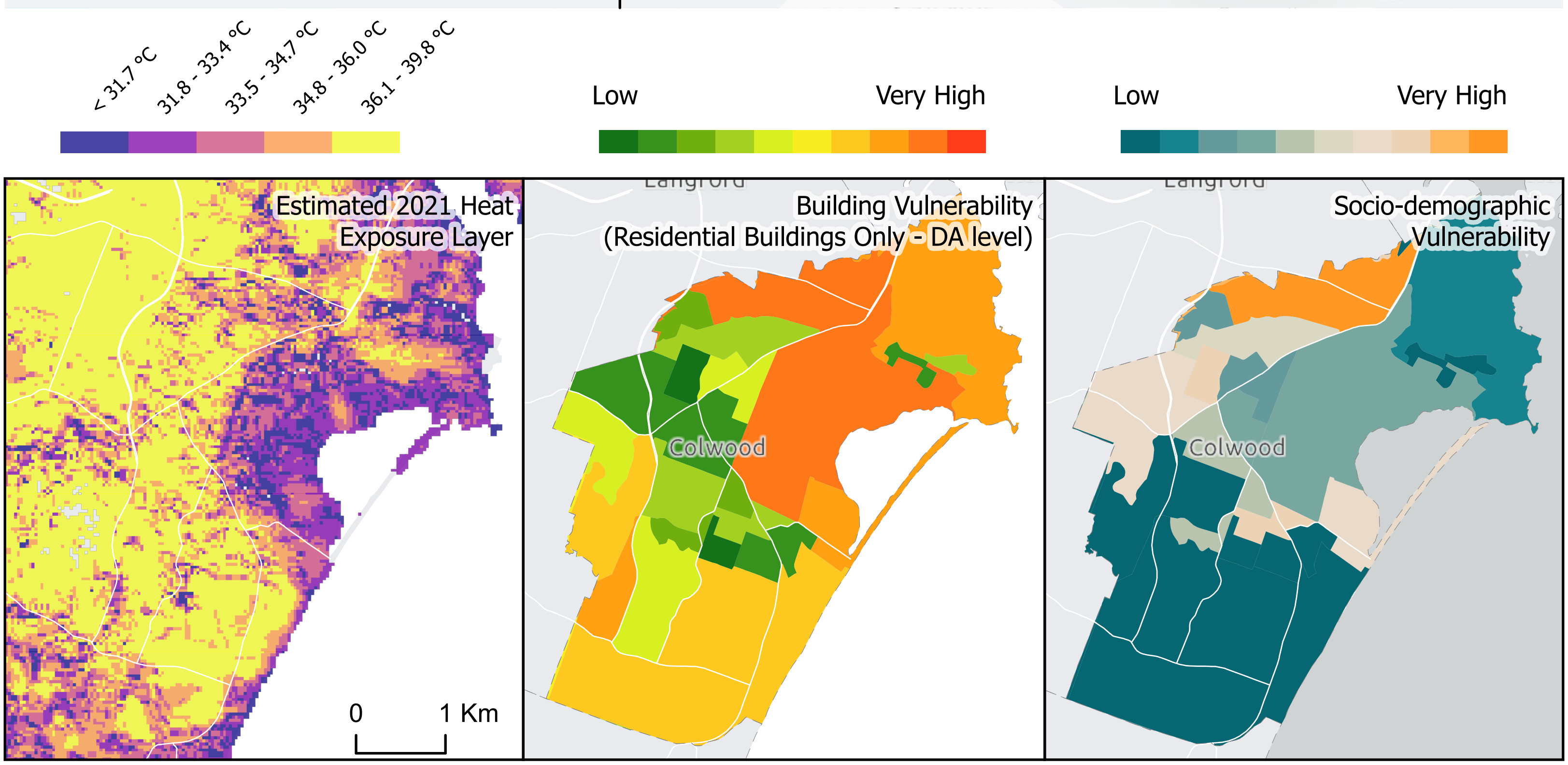
| | |
|---|---|
| Population 2021 | 18,961 |
| % population in very high Sociodemographic vulnerability | 6.60% |
| % population in very high demographic-only vulnerability | 0% |
| % population in very high Health vulnerability | 13.10% |
| Top contributing demographic factor | Population that are renters (26.7%) |
| Second contributing demographic factor | Population age 65 or older (19.3%) |
| Third contributing demographic factor | Has high (secondary) school diploma or equivalency certificate or no diploma or degree (45.3%) |
| Top contributing health factor | Episodic Mood Anxiety Disorders Prevalence (Crude Rate) |
| Second contributing health factor | Diabetes (Crude Rate) |
| Third contributing health factor | Hypertension (crude rate) |

## Building Vulnerability

| | |
|---|---|
| Total # of residential buildings in the community | 5,549 |
| Housing type contribution to building vulnerability | 2.00% |
| Year Built contribution to building vulnerability | 22.00% |
| Albedo contribution to building vulnerability | 30.60% |
| Solar insolation contribution to building vulnerability | 31.50% |
| Building Height contribution to building vulnerability | 13.80% |
| # of buildings with very high demographic & building vuln. | 59 |
| # of buildings in very high | 476 |
| % of residential buildings in very high | 11.80% |
| Average age of buildings in very high | 1981 |

## Heat Exposure

| | |
|---|---|
| % of community area in very high heat exposure | 32% |
| % of residential buildings with very high heat exposure | 56% |
| # of buildings with very high socio-demographic & heat expo. | 54 |
| # of residential buildings highly vulnerable across all 3 indices | 14 |

# City of Langford



## Demographic Vulnerability

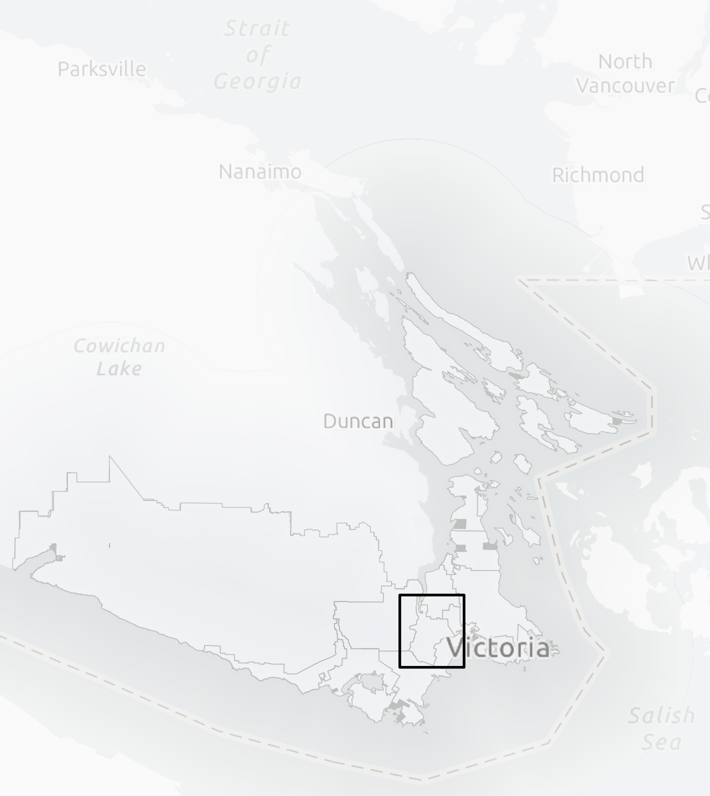
| | |
|---|---|
| Population 2021 | 46,584 |
| % population in very high Sociodemographic vulnerability | 14.10% |
| % population in very high demographic-only vulnerability | 0% |
| % population in very high Health vulnerability | 19.10% |
| Top contributing demographic factor | Population that are renters (35.2%) |
| Second contributing demographic factor | Average number of rooms per dwelling (5.6%) |
| Third contributing demographic factor | Population age 65 or older (13.7%) |
| Top contributing health factor | Episodic Mood Anxiety Disorders Prevalence (Crude Rate) |
| Second contributing health factor | Asthma (crude rate) |
| Third contributing health factor | Diabetes (Crude Rate) |

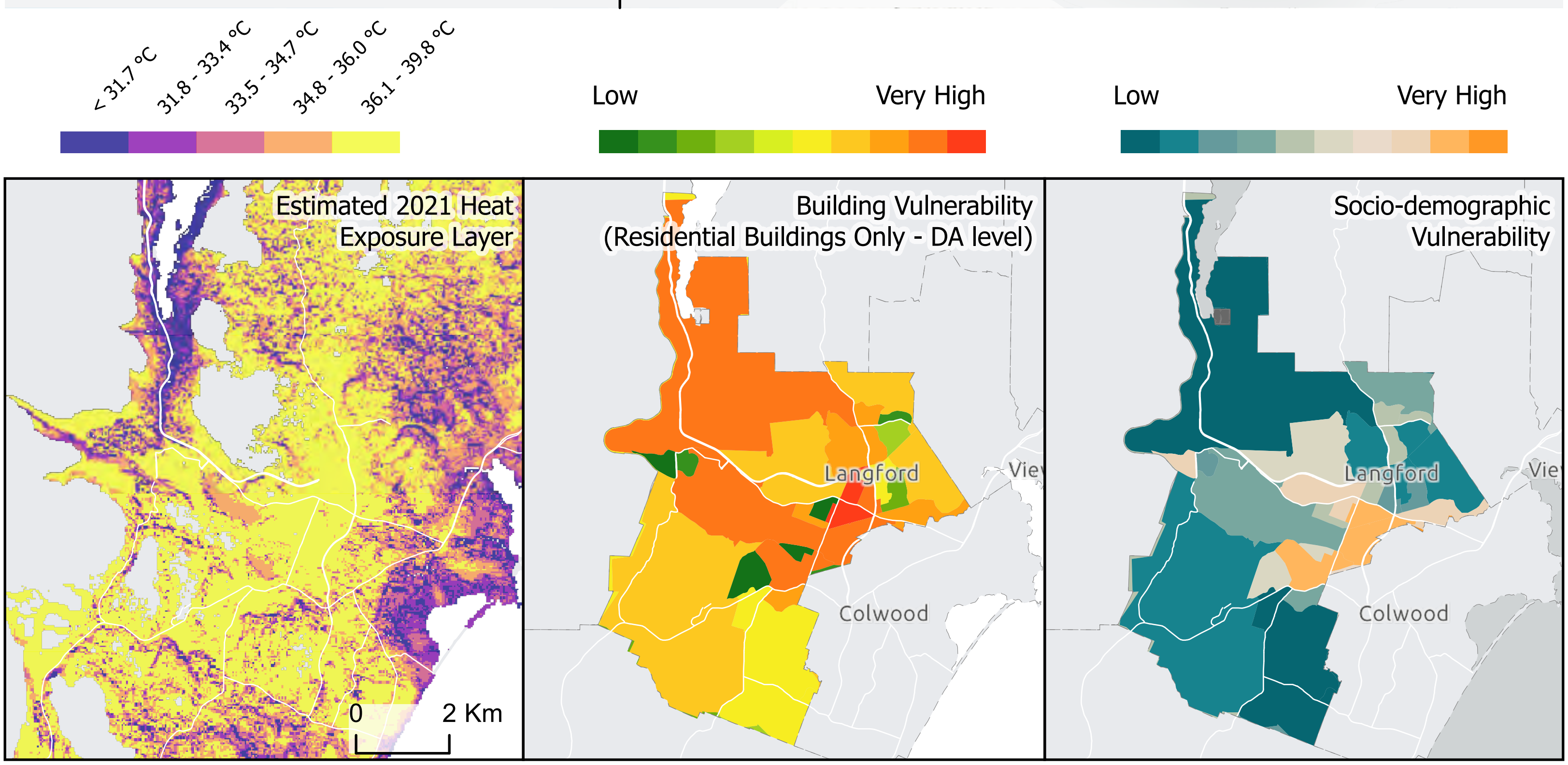
## Building Vulnerability

| | |
|---|---|
| Total # of residential buildings in the community | 10,437 |
| Housing type contribution to building vulnerability | 2.40% |
| Year Built contribution to building vulnerability | 18.20% |
| Albedo contribution to building vulnerability | 31.60% |
| Solar insolation contribution to building vulnerability | 33.20% |
| Building Height contribution to building vulnerability | 14.60% |
| # of buildings with very high demographic & building vuln. | 110 |
| # of buildings in very high | 945 |
| % of residential buildings in very high | 11.80% |
| Average age of buildings in very high | 1984 |

## Heat Exposure

| | |
|---|---|
| % of community area in very high heat exposure | 61% |
| % of residential buildings with very high heat exposure | 84% |
| # of buildings with very high socio-demographic & heat expo. | 648 |
| # of residential buildings highly vulnerable across all 3 indices | 98 |



# District of Highlands



## Demographic Vulnerability

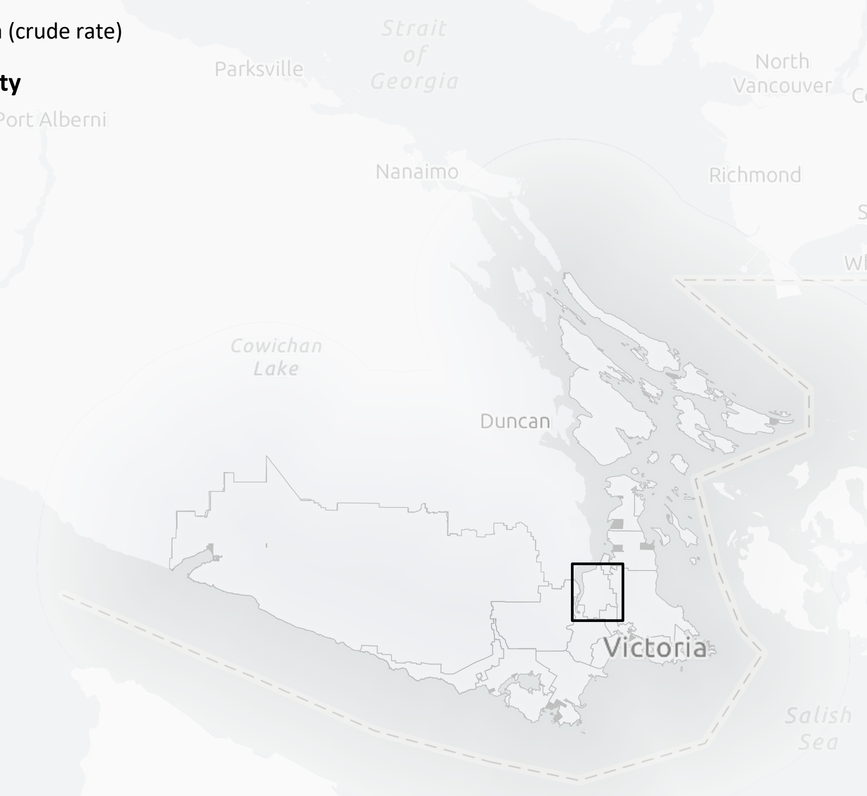
| | |
|---|---|
| Population 2021 | 2,482 |
| % population in very high Sociodemographic vulnerability | 0% |
| % population in very high demographic-only vulnerability | 0% |
| % population in very high Health vulnerability | 0% |
| Top contributing demographic factor | Population age 65 or older (18.1%) |
| Second contributing demographic factor | Outdoor Workers - Trades, transport and equipment operators and related occupations (27.1%) |
| Third contributing demographic factor | Has high (secondary) school diploma or equivalency certificate or no diploma or degree (42.9%) |
| Top contributing health factor | Episodic Mood Anxiety Disorders Prevalence (Crude Rate) |
| Second contributing health factor | Hypertension (crude rate) |
| Third contributing health factor | Asthma (crude rate) |

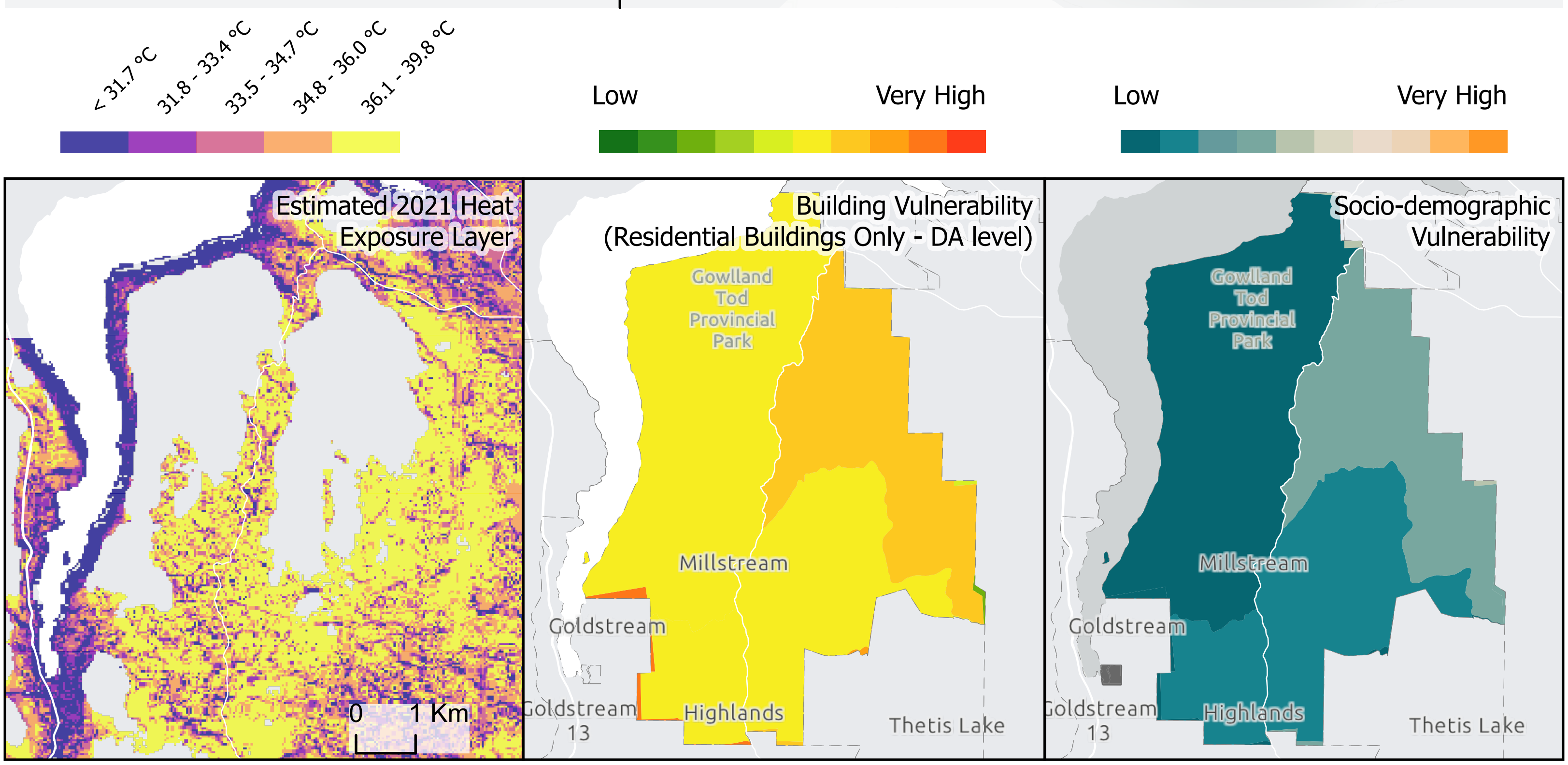
## Building Vulnerability

| | |
|---|---|
| Total # of residential buildings in the community | 1,432 |
| Housing type contribution to building vulnerability | 0.60% |
| Year Built contribution to building vulnerability | 22.00% |
| Albedo contribution to building vulnerability | 34.90% |
| Solar insolation contribution to building vulnerability | 23.90% |
| Building Height contribution to building vulnerability | 18.50% |
| # of buildings with very high demographic & building vuln. | nan |
| # of buildings in very high | 15 |
| % of residential buildings in very high | 11.80% |
| Average age of buildings in very high | 1969 |

## Heat Exposure

| | |
|---|---|
| % of community area in very high heat exposure | 49% |
| % of residential buildings with very high heat exposure | 48% |
| # of buildings with very high socio-demographic & heat expo. | 0 |
| # of residential buildings highly vulnerable across all 3 indices | 0 |



# District of Metchosin



## Demographic Vulnerability

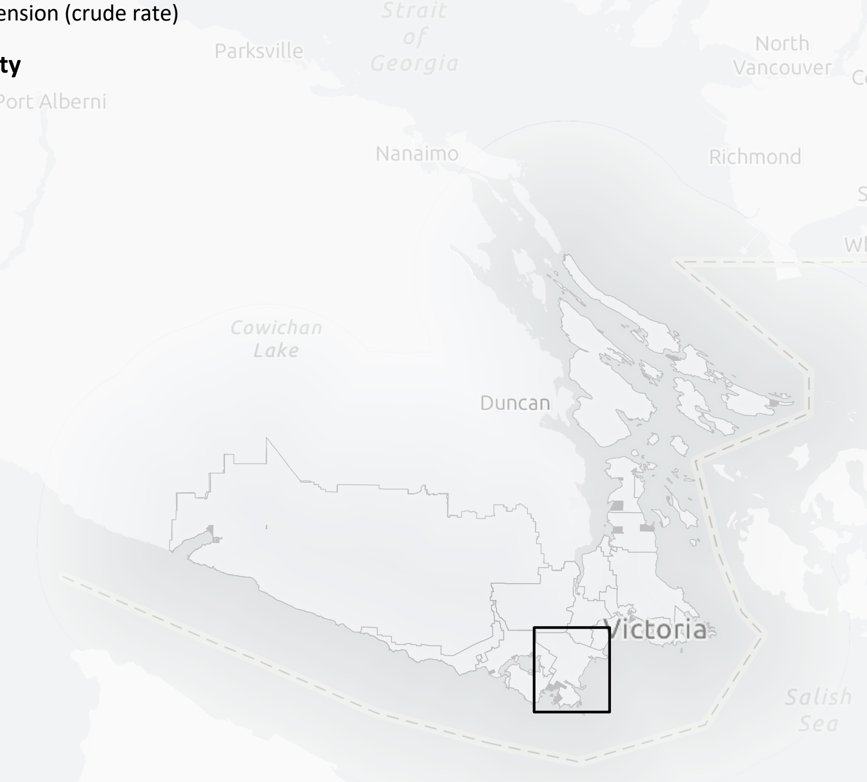
| | |
|---|---|
| Population 2021 | 5,067 |
| % population in very high Sociodemographic vulnerability | 0% |
| % population in very high demographic-only vulnerability | 0% |
| % population in very high Health vulnerability | 0% |
| Top contributing demographic factor | Population age 65 or older (26%) |
| Second contributing demographic factor | Private households by age of primary household maintainers - 65 years and over (24.3%) |
| Third contributing demographic factor | Outdoor Workers - Trades, transport and equipment operators and related occupations (22.9%) |
| Top contributing health factor | Episodic Mood Anxiety Disorders Prevalence (Crude Rate) |
| Second contributing health factor | Acute Myocardial Infarction (Crude Rate) |
| Third contributing health factor | Hypertension (crude rate) |

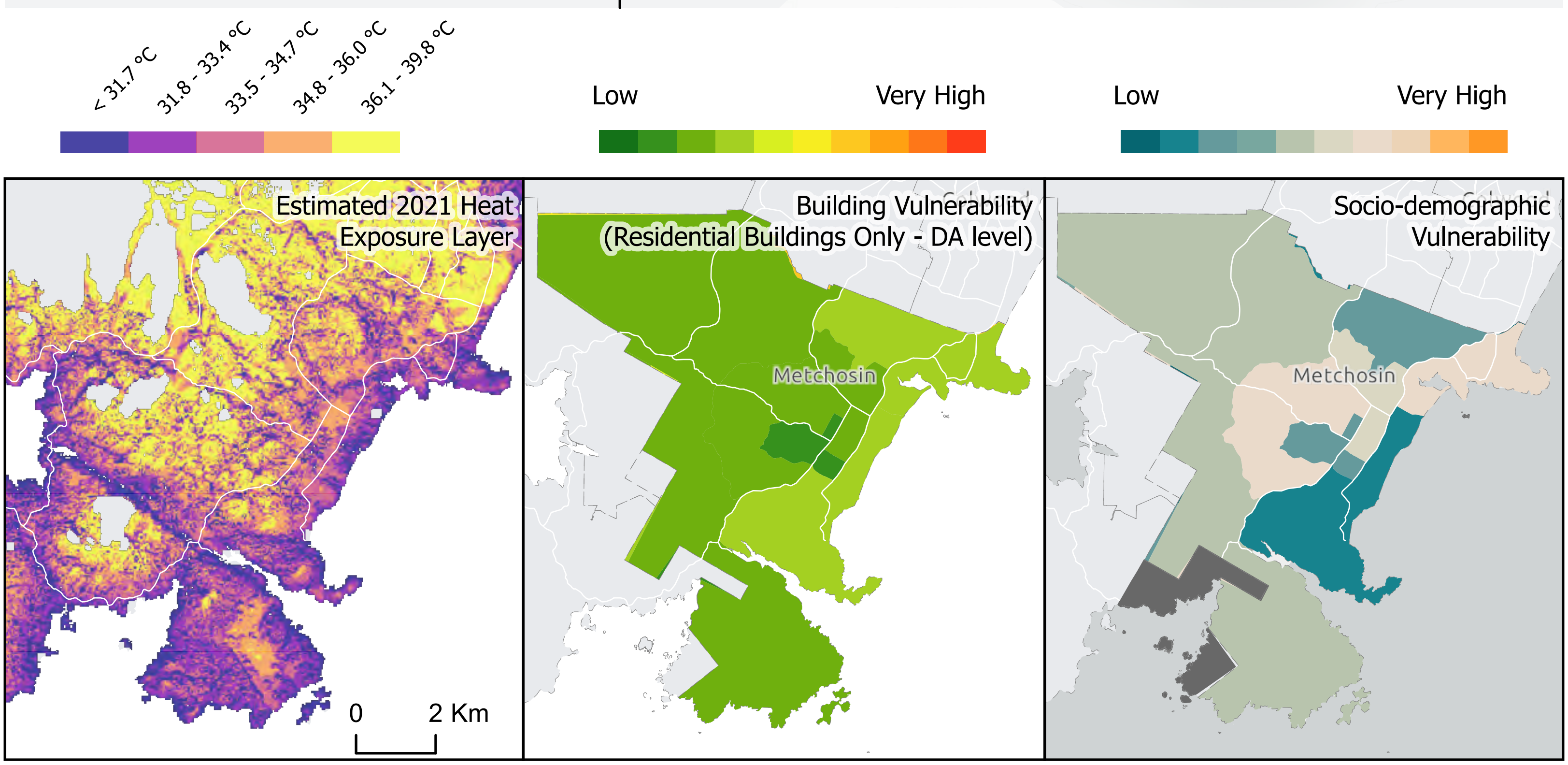
## Building Vulnerability

| | |
|---|---|
| Total # of residential buildings in the community | 1,912 |
| Housing type contribution to building vulnerability | 2.60% |
| Year Built contribution to building vulnerability | 24.00% |
| Albedo contribution to building vulnerability | 29.10% |
| Solar insolation contribution to building vulnerability | 30.50% |
| Building Height contribution to building vulnerability | 13.90% |
| # of buildings with very high demographic & building vuln. | nan |
| # of buildings in very high | 133 |
| % of residential buildings in very high | 11.80% |
| Average age of buildings in very high | 1968 |

## Heat Exposure

| | |
|---|---|
| % of community area in very high heat exposure | 18% |
| % of residential buildings with very high heat exposure | 12% |
| # of buildings with very high socio-demographic & heat expo. | 0 |
| # of residential buildings highly vulnerable across all 3 indices | 0 |



# District of North Saanich

Heat Vulnerability Data & Analysis Project
Prepared for The Capital Regional District

## Demographic Vulnerability

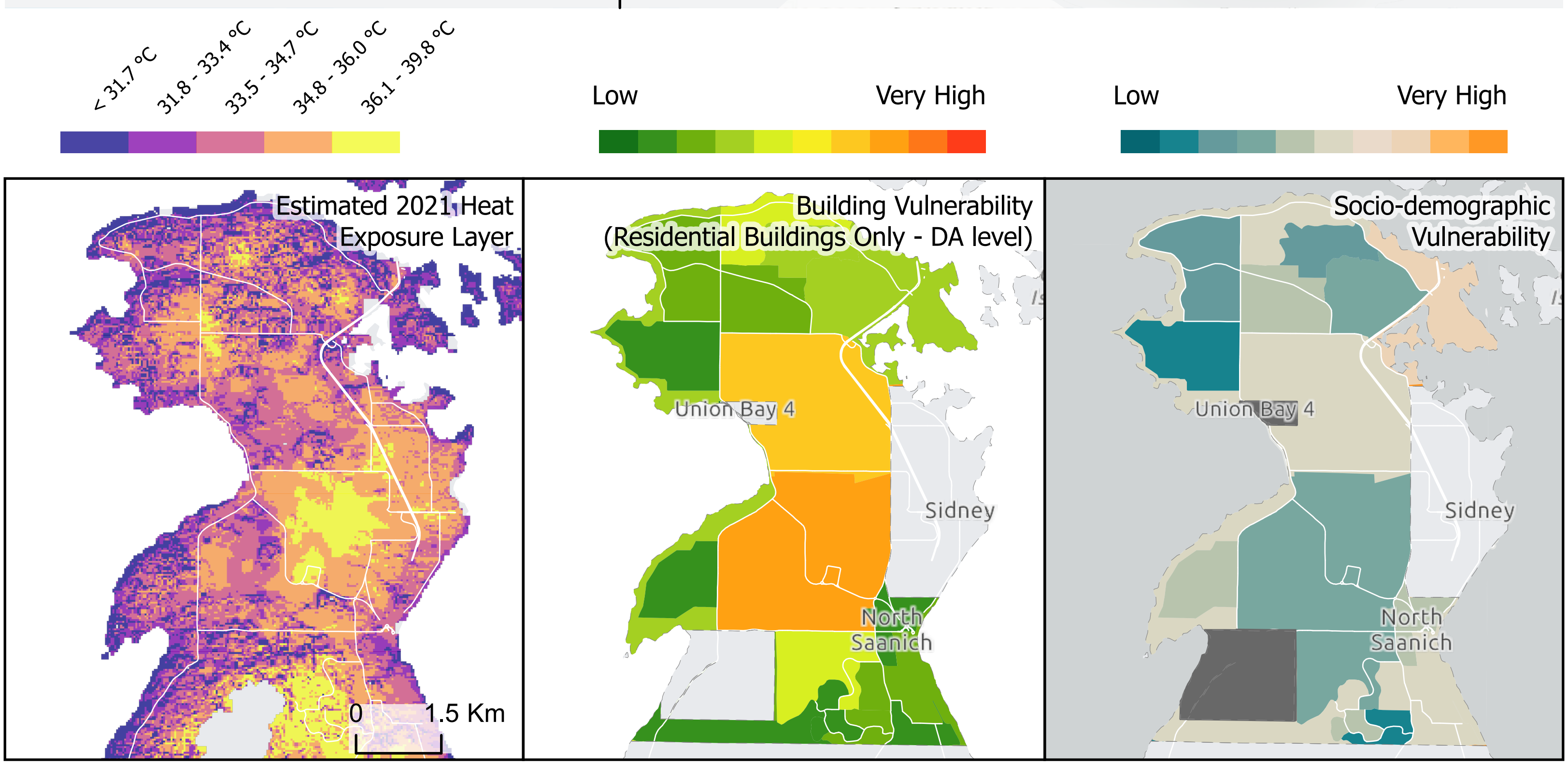
| | |
|---|---|
| Population 2021 | 12,235 |
| % population in very high Sociodemographic vulnerability | 0% |
| % population in very high demographic-only vulnerability | 0% |
| % population in very high Health vulnerability | 5.20% |
| Top contributing demographic factor | Population age 65 or older (34.7%) |
| Second contributing demographic factor | Private households by age of primary household maintainers - 65 years and over (27.3%) |
| Third contributing demographic factor | Private households by age of primary household maintainers - 75 years and over (15.9%) |
| Top contributing health factor | Hypertension (crude rate) |
| Second contributing health factor | Episodic Mood Anxiety Disorders Prevalence (Crude Rate) |
| Third contributing health factor | Acute Myocardial Infarction (Crude Rate) |

## Building Vulnerability

| | |
|---|---|
| Total # of residential buildings in the community | 5,788 |
| Housing type contribution to building vulnerability | 0.90% |
| Year Built contribution to building vulnerability | 23.80% |
| Albedo contribution to building vulnerability | 31.00% |
| Solar insolation contribution to building vulnerability | 29.40% |
| Building Height contribution to building vulnerability | 14.80% |
| # of buildings with very high demographic & building vuln. | nan |
| # of buildings in very high | 270 |
| % of residential buildings in very high | 11.80% |
| Average age of buildings in very high | 1968 |

## Heat Exposure

| | |
|---|---|
| % of community area in very high heat exposure | 6% |
| % of residential buildings with very high heat exposure | 10% |
| # of buildings with very high socio-demographic & heat expo. | 0 |
| # of residential buildings highly vulnerable across all 3 indices | 0 |

# District of Sooke



## Demographic Vulnerability

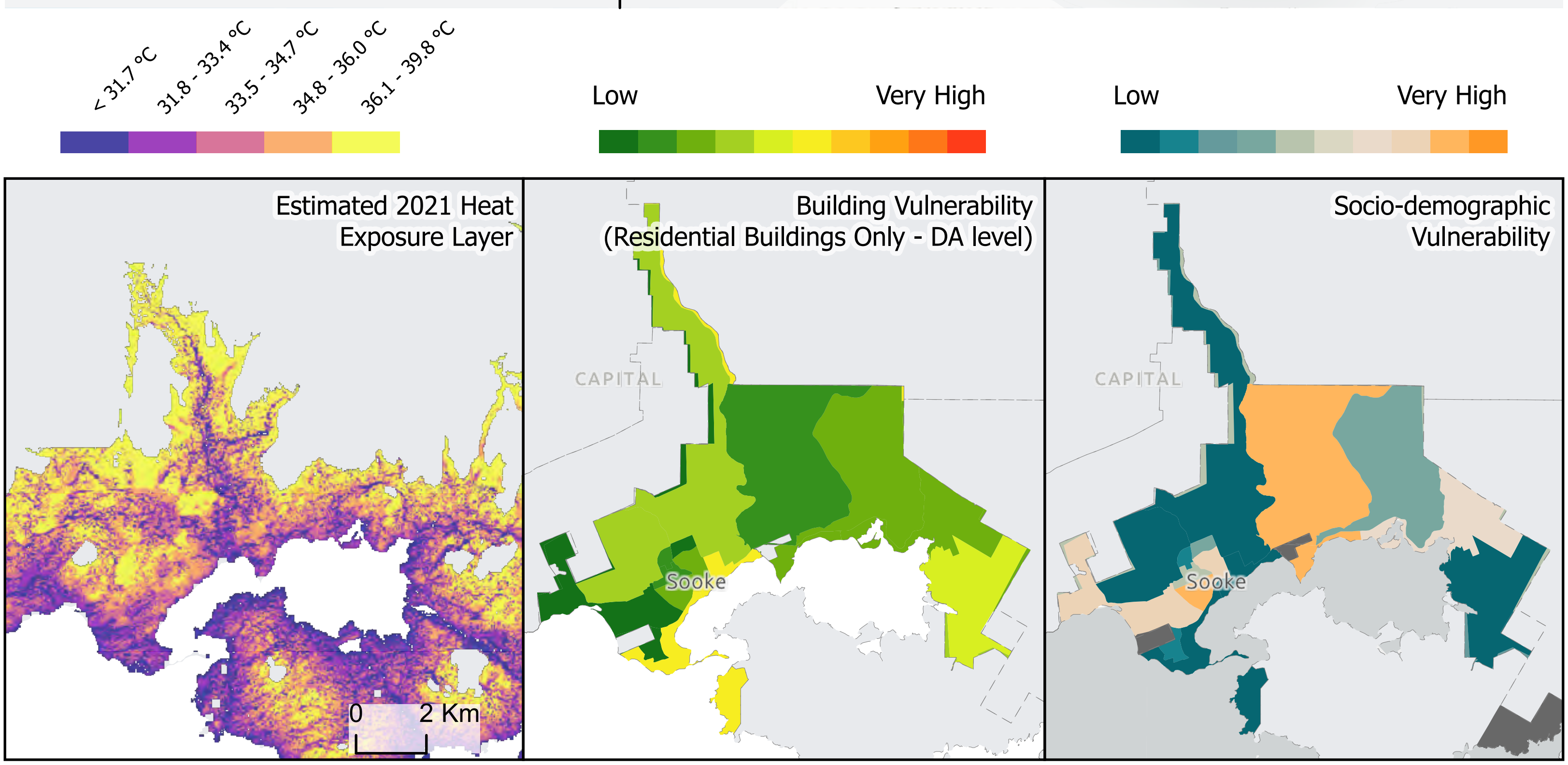
| | |
|---|---|
| Population 2021 | 15,086 |
| % population in very high Sociodemographic vulnerability | 17.00% |
| % population in very high demographic-only vulnerability | 0% |
| % population in very high Health vulnerability | 28.20% |
| Top contributing demographic factor | Population age 65 or older (20.3%) |
| Second contributing demographic factor | Has high (secondary) school diploma or equivalency certificate or no diploma or degree (45.9%) |
| Third contributing demographic factor | Outdoor Workers - Trades, transport and equipment operators and related occupations (23.2%) |
| Top contributing health factor | Episodic Mood Anxiety Disorders Prevalence (Crude Rate) |
| Second contributing health factor | Chronic Obstructive Pulmonary Disease (Crude Rate) |
| Third contributing health factor | Hypertension (crude rate) |

## Building Vulnerability

| | |
|---|---|
| Total # of residential buildings in the community | 6,251 |
| Housing type contribution to building vulnerability | 5.60% |
| Year Built contribution to building vulnerability | 19.40% |
| Albedo contribution to building vulnerability | 29.70% |
| Solar insolation contribution to building vulnerability | 31.60% |
| Building Height contribution to building vulnerability | 13.70% |
| # of buildings with very high demographic & building vuln. | 157 |
| # of buildings in very high | 753 |
| % of residential buildings in very high | 11.80% |
| Average age of buildings in very high | 1991 |

## Heat Exposure

| | |
|---|---|
| % of community area in very high heat exposure | 17% |
| % of residential buildings with very high heat exposure | 15% |
| # of buildings with very high socio-demographic & heat expo. | 9 |
| # of residential buildings highly vulnerable across all 3 indices | 0 |

# Juan de Fuca Electoral Area (Part 1)

## Demographic Vulnerability

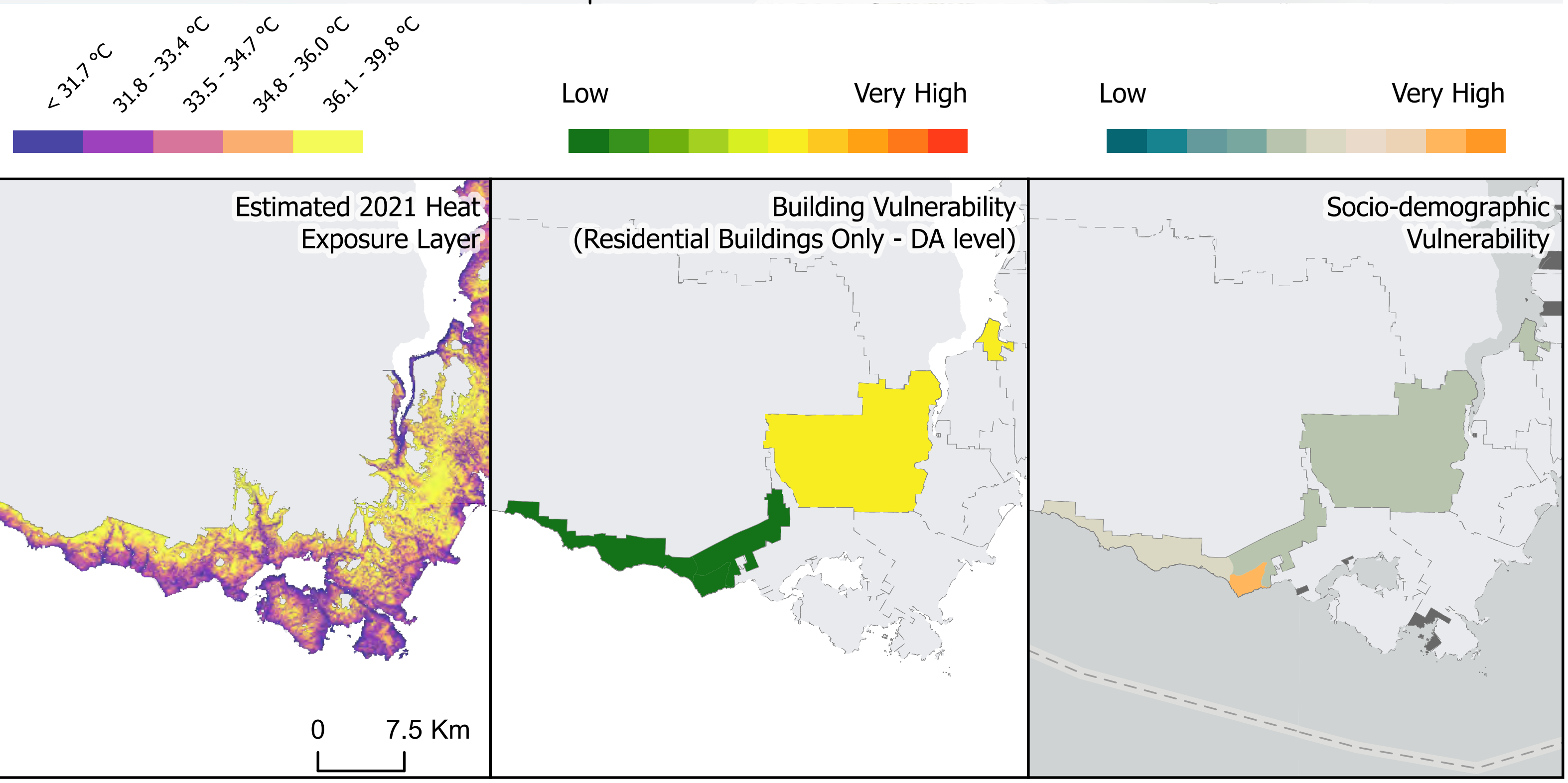
| | |
|---|---|
| Population 2021 | 5,132 |
| % population in very high Sociodemographic vulnerability | 13.90% |
| % population in very high demographic-only vulnerability | 0% |
| % population in very high Health vulnerability | 13.90% |
| Top contributing demographic factor | Population age 65 or older (20%) |
| Second contributing demographic factor | Has high (secondary) school diploma or equivalency certificate or no diploma or degree (25%) |
| Third contributing demographic factor | Private households by age of primary household maintainers - 65 years and over (26.1%) |
| Top contributing health factor | Episodic Mood Anxiety Disorders Prevalence (Crude Rate) |
| Second contributing health factor | Acute Myocardial Infarction (Crude Rate) |
| Third contributing health factor | Hypertension (crude rate) |

## Building Vulnerability

| | |
|---|---|
| Total # of residential buildings in the community | 3,040 |
| Housing type contribution to building vulnerability | 0.50% |
| Year Built contribution to building vulnerability | 21.60% |
| Albedo contribution to building vulnerability | 31.80% |
| Solar insolation contribution to building vulnerability | 33.60% |
| Building Height contribution to building vulnerability | 12.60% |
| # of buildings with very high demographic & building vuln. | 114 |
| # of buildings in very high | 203 |
| % of residential buildings in very high | 11.80% |
| Average age of buildings in very high | 1980 |

## Heat Exposure

| | |
|---|---|
| % of community area in very high heat exposure | 19% |
| % of residential buildings with very high heat exposure | 8% |
| # of buildings with very high socio-demographic & heat expo. | 0 |
| # of residential buildings highly vulnerable across all 3 indices | 0 |

# Juan de Fuca Electoral Area (Part 2)

Heat Vulnerability Data & Analysis Project
Prepared for The Capital Regional District

### Demographic Vulnerability

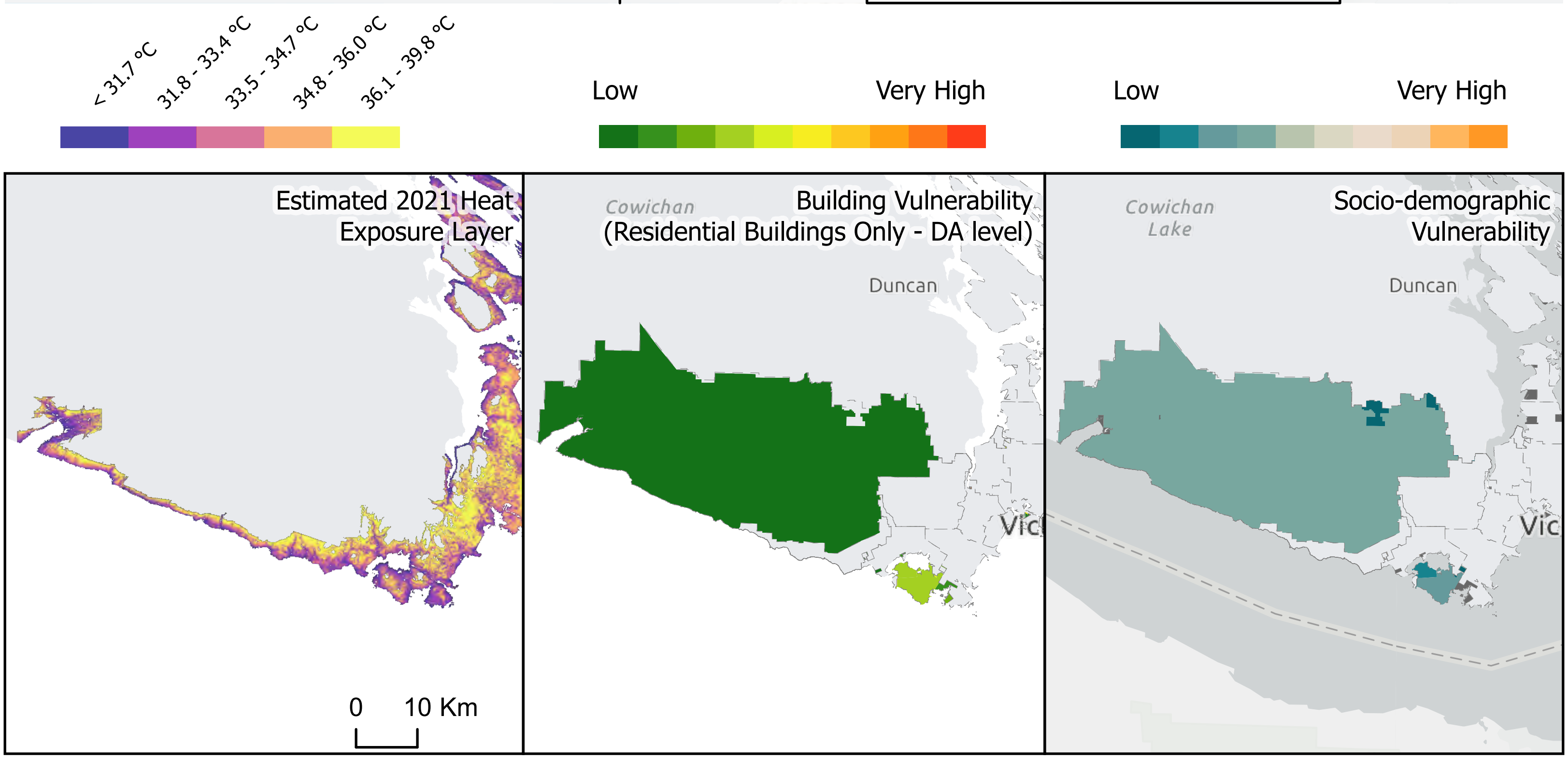
| | |
|---|---|
| Population 2021 | 399 |
| % population in very high Sociodemographic vulnerability | 0.00% |
| % population in very high demographic-only vulnerability | 0% |
| % population in very high Health vulnerability | 0% |
| Top contributing demographic factor | Average number of rooms per dwelling (6.6%) |
| Second contributing demographic factor | Population age 65 or older (24.1%) |
| Third contributing demographic factor | Living alone (10.5%) |
| Top contributing health factor | Chronic Obstructive Pulmonary Disease (Crude Rate) |
| Second contributing health factor | Acute Myocardial Infarction (Crude Rate) |
| Third contributing health factor | Asthma (crude rate) |

### Building Vulnerability

| | |
|---|---|
| Total # of residential buildings in the community | 438 |
| Housing type contribution to building vulnerability | 1.70% |
| Year Built contribution to building vulnerability | 25.60% |
| Albedo contribution to building vulnerability | 34.20% |
| Solar insolation contribution to building vulnerability | 38.60% |
| Building Height contribution to building vulnerability | 0.00% |
| # of buildings with very high demographic & building vuln. | nan |
| # of buildings in very high | 21 |
| % of residential buildings in very high | 11.80% |
| Average age of buildings in very high | 1980 |

### Heat Exposure

| | |
|---|---|
| % of community area in very high heat exposure | 39% |
| % of residential buildings with very high heat exposure | 5% |
| # of buildings with very high socio-demographic & heat expo. | 0 |
| # of residential buildings highly vulnerable across all 3 indices | 0 |

# Salt Spring Island Electoral Area

Heat Vulnerability Data & Analysis Project
Prepared for The Capital Regional District

## Demographic Vulnerability

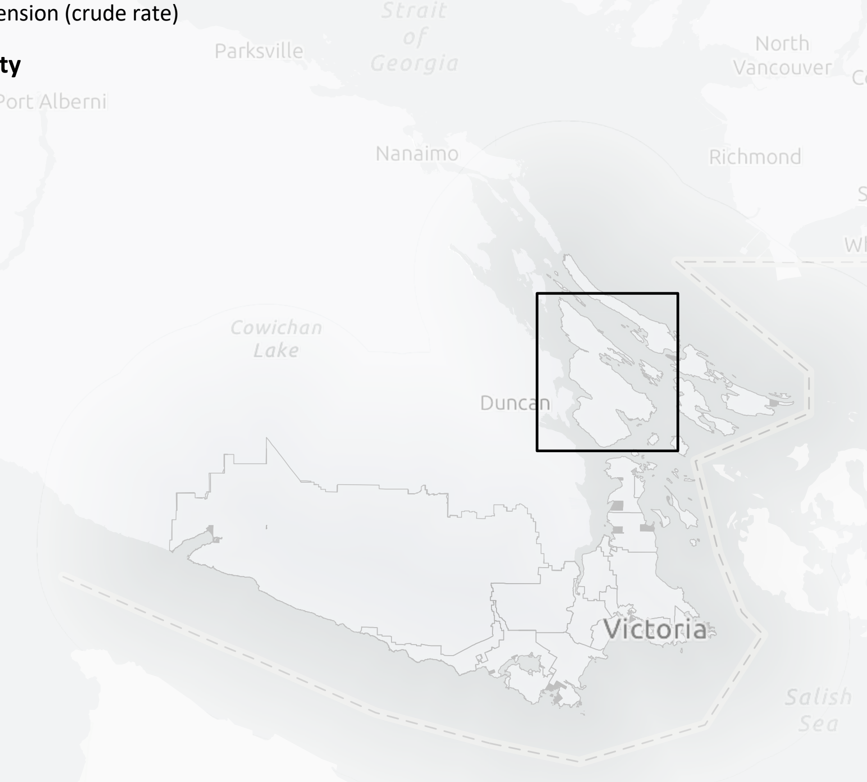
| | |
|---|---|
| Population 2021 | 11,635 |
| % population in very high Sociodemographic vulnerability | 13.40% |
| % population in very high demographic-only vulnerability | 13.40% |
| % population in very high Health vulnerability | 13.40% |
| Top contributing demographic factor | Population age 65 or older (34.8%) |
| Second contributing demographic factor | Private households by age of primary household maintainers - 65 years and over (28.4%) |
| Third contributing demographic factor | Average number of rooms per dwelling (6.1%) |
| Top contributing health factor | Episodic Mood Anxiety Disorders Prevalence (Crude Rate) |
| Second contributing health factor | Chronic Obstructive Pulmonary Disease (Crude Rate) |
| Third contributing health factor | Hypertension (crude rate) |

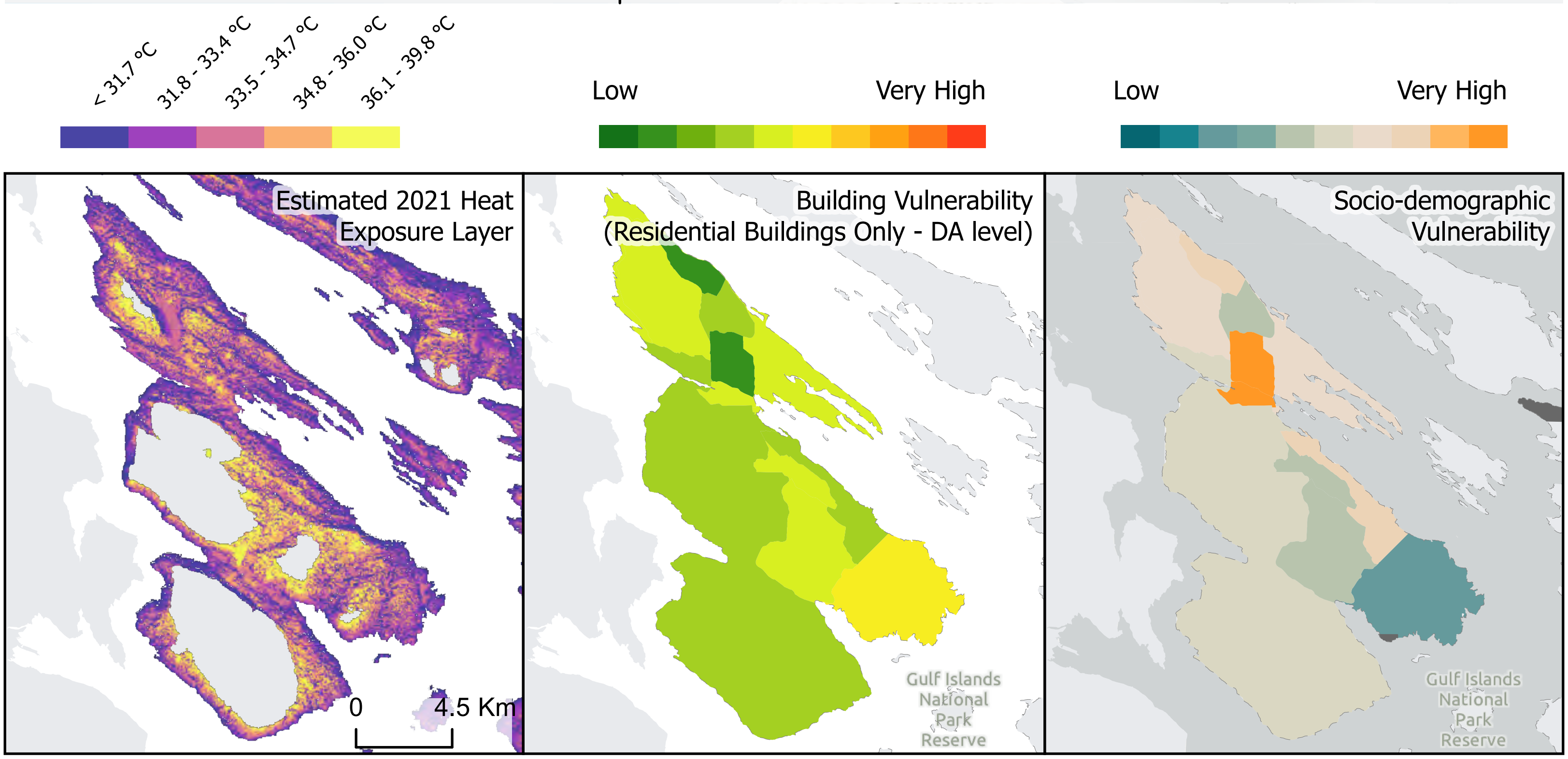
## Building Vulnerability

| | |
|---|---|
| Total # of residential buildings in the community | 7,212 |
| Housing type contribution to building vulnerability | 2.80% |
| Year Built contribution to building vulnerability | 22.30% |
| Albedo contribution to building vulnerability | 28.60% |
| Solar insolation contribution to building vulnerability | 31.80% |
| Building Height contribution to building vulnerability | 14.50% |
| # of buildings with very high demographic & building vuln. | 303 |
| # of buildings in very high | 651 |
| % of residential buildings in very high | 11.80% |
| Average age of buildings in very high | 1976 |

## Heat Exposure

| | |
|---|---|
| % of community area in very high heat exposure | 7% |
| % of residential buildings with very high heat exposure | 6% |
| # of buildings with very high socio-demographic & heat expo. | 78 |
| # of residential buildings highly vulnerable across all 3 indices | 74 |



# Southern Gulf Islands Electoral Area

Heat Vulnerability Data & Analysis Project
Prepared for The Capital Regional District

## Demographic Vulnerability

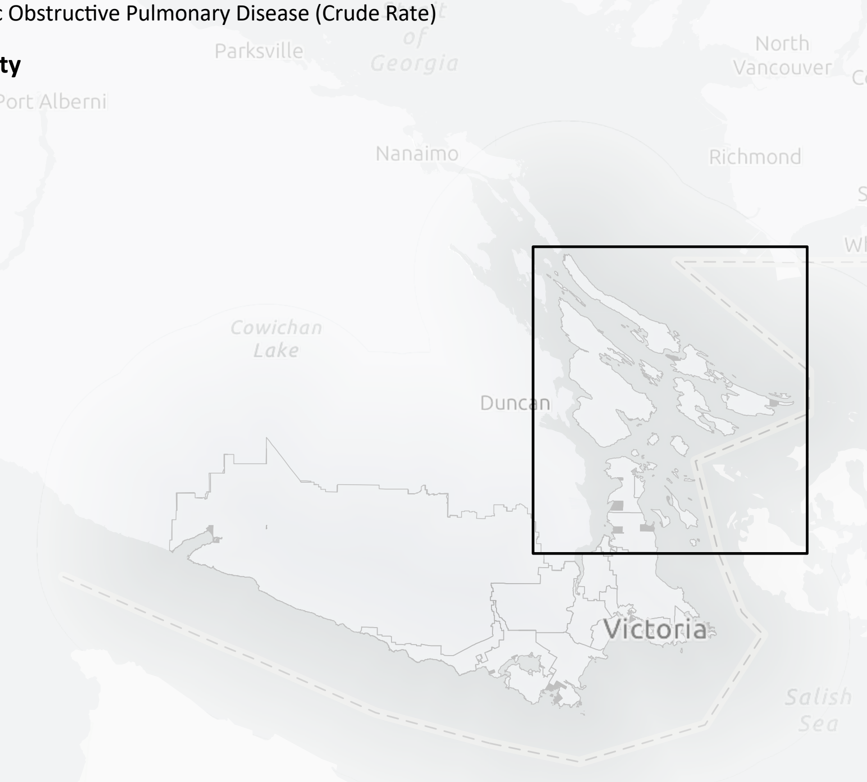
| | |
|---|---|
| Population 2021 | 6,101 |
| % population in very high Sociodemographic vulnerability | 21.40% |
| % population in very high demographic-only vulnerability | 0% |
| % population in very high Health vulnerability | 21.40% |
| Top contributing demographic factor | Population age 65 or older (42.4%) |
| Second contributing demographic factor | Private households by age of primary household maintainers - 65 years and over (33.5%) |
| Third contributing demographic factor | Average number of rooms per dwelling (5.5%) |
| Top contributing health factor | Hypertension (crude rate) |
| Second contributing health factor | Acute Myocardial Infarction (Crude Rate) |
| Third contributing health factor | Chronic Obstructive Pulmonary Disease (Crude Rate) |

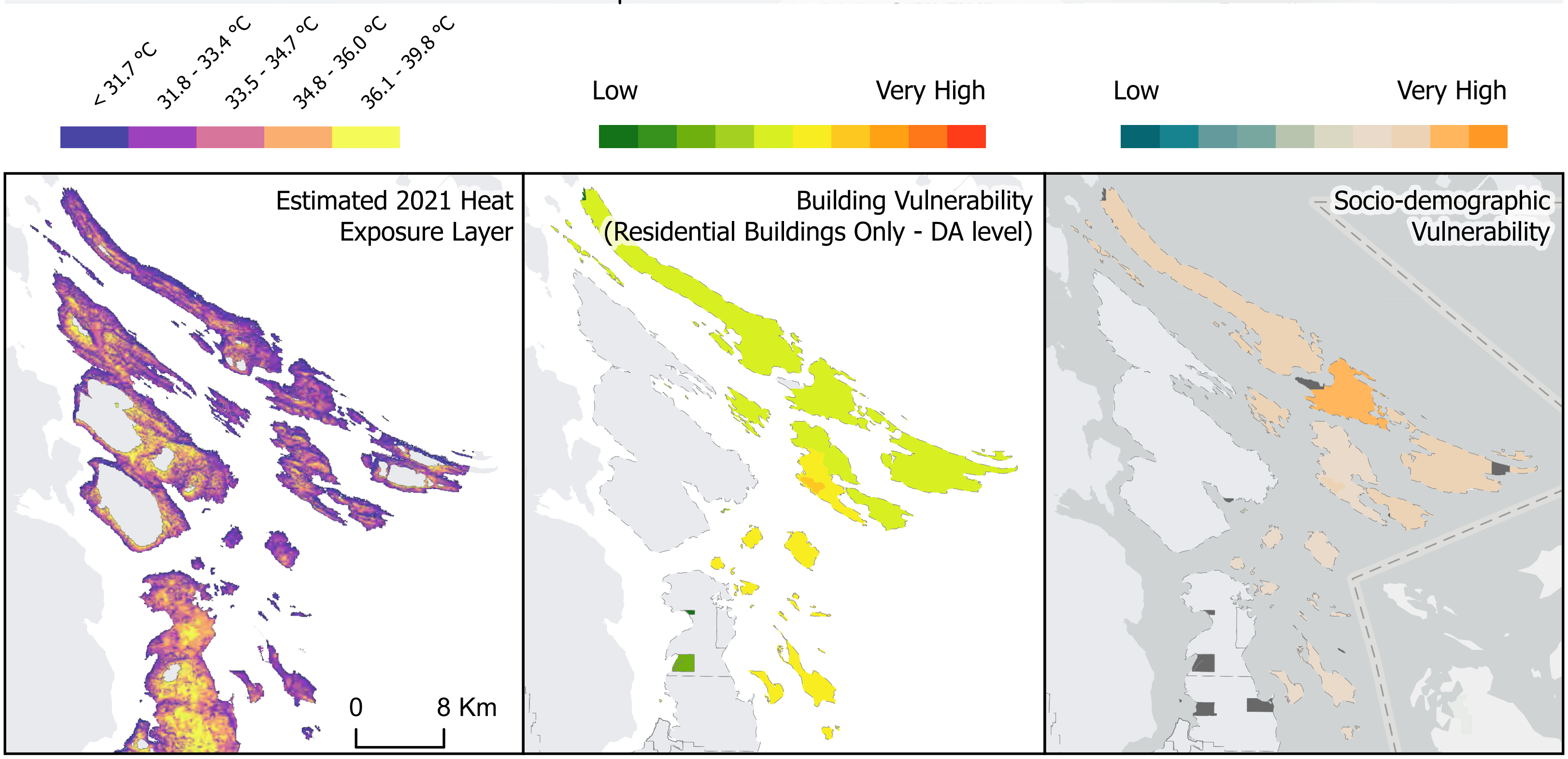
## Building Vulnerability

| | |
|---|---|
| Total # of residential buildings in the community | 6,329 |
| Housing type contribution to building vulnerability | 1.40% |
| Year Built contribution to building vulnerability | 22.40% |
| Albedo contribution to building vulnerability | 29.20% |
| Solar insolation contribution to building vulnerability | 31.80% |
| Building Height contribution to building vulnerability | 15.20% |
| # of buildings with very high demographic & building vuln. | 59 |
| # of buildings in very high | 271 |
| % of residential buildings in very high | 11.80% |
| Average age of buildings in very high | 1970 |

## Heat Exposure

| | |
|---|---|
| % of community area in very high heat exposure | 1% |
| % of residential buildings with very high heat exposure | 0% |
| # of buildings with very high socio-demographic & heat expo. | 8 |
| # of residential buildings highly vulnerable across all 3 indices | 0 |



# The Corporation of the City of Victoria



### Demographic Vulnerability

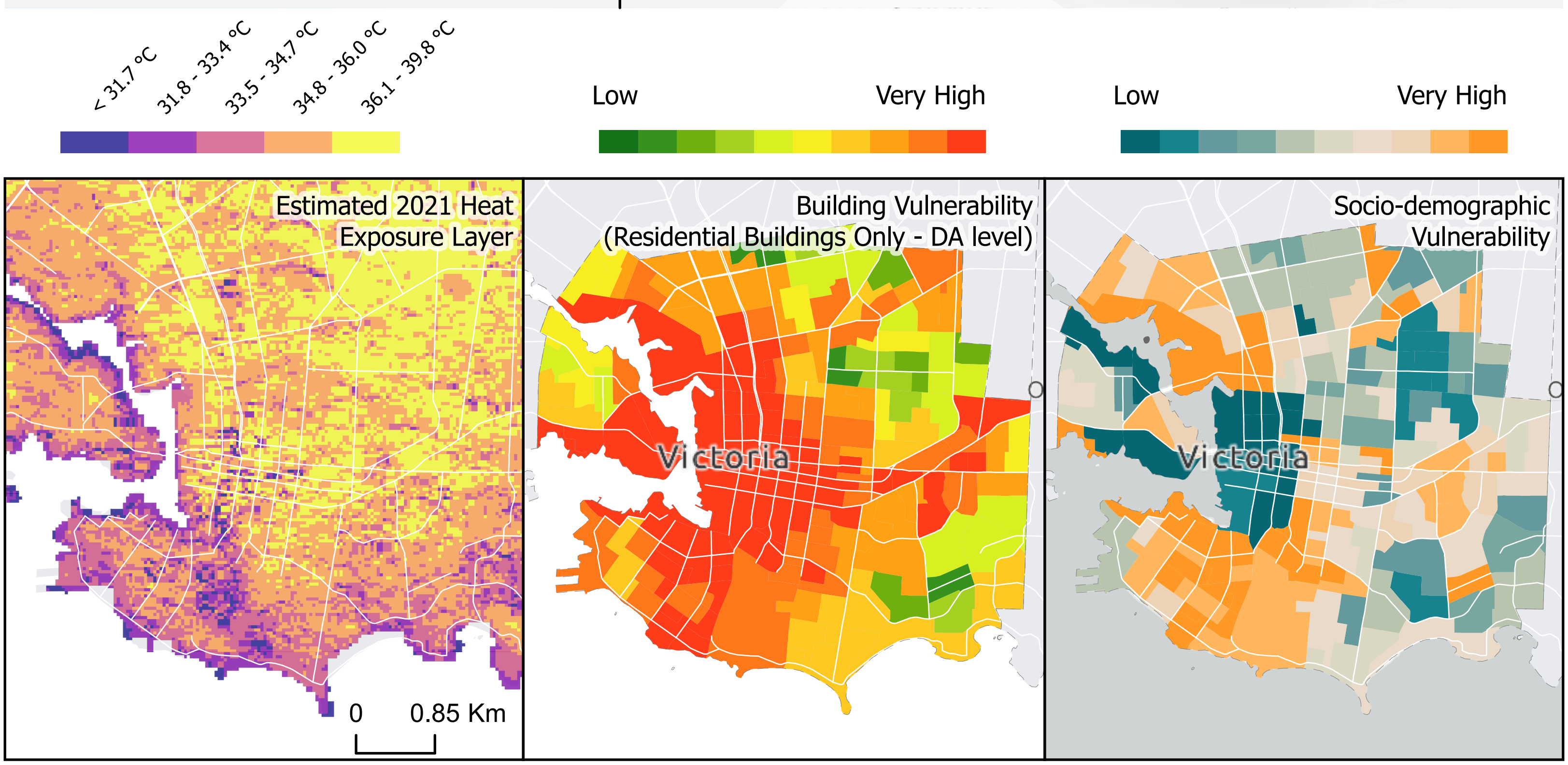
| | |
|---|---|
| Population 2021 | 91,867 |
| % population in very high Sociodemographic vulnerability | 34.70% |
| % population in very high demographic-only vulnerability | 57.00% |
| % population in very high Health vulnerability | 25.80% |
| Top contributing demographic factor | Population that are renters (60.5%) |
| Second contributing demographic factor | Living alone (27.4%) |
| Third contributing demographic factor | Population age 65 or older (23.2%) |
| Top contributing health factor | Episodic Mood Anxiety Disorders Prevalence (Crude Rate) |
| Second contributing health factor | Chronic Obstructive Pulmonary Disease (Crude Rate) |
| Third contributing health factor | Hypertension (crude rate) |

### Building Vulnerability

| | |
|---|---|
| Total # of residential buildings in the community | 13,753 |
| Housing type contribution to building vulnerability | 5.80% |
| Year Built contribution to building vulnerability | 23.40% |
| Albedo contribution to building vulnerability | 28.00% |
| Solar insolation contribution to building vulnerability | 28.80% |
| Building Height contribution to building vulnerability | 14.10% |
| # of buildings with very high demographic & building vuln. | 1,774 |
| # of buildings in very high | 7,583 |
| % of residential buildings in very high | 11.80% |
| Average age of buildings in very high | 1941 |

### Heat Exposure

| | |
|---|---|
| % of community area in very high heat exposure | 16% |
| % of residential buildings with very high heat exposure | 19% |
| # of buildings with very high socio-demographic & heat expo. | 485 |
| # of residential buildings highly vulnerable across all 3 indices | 229 |

# The Corporation of the District of Central Saanich



## Demographic Vulnerability

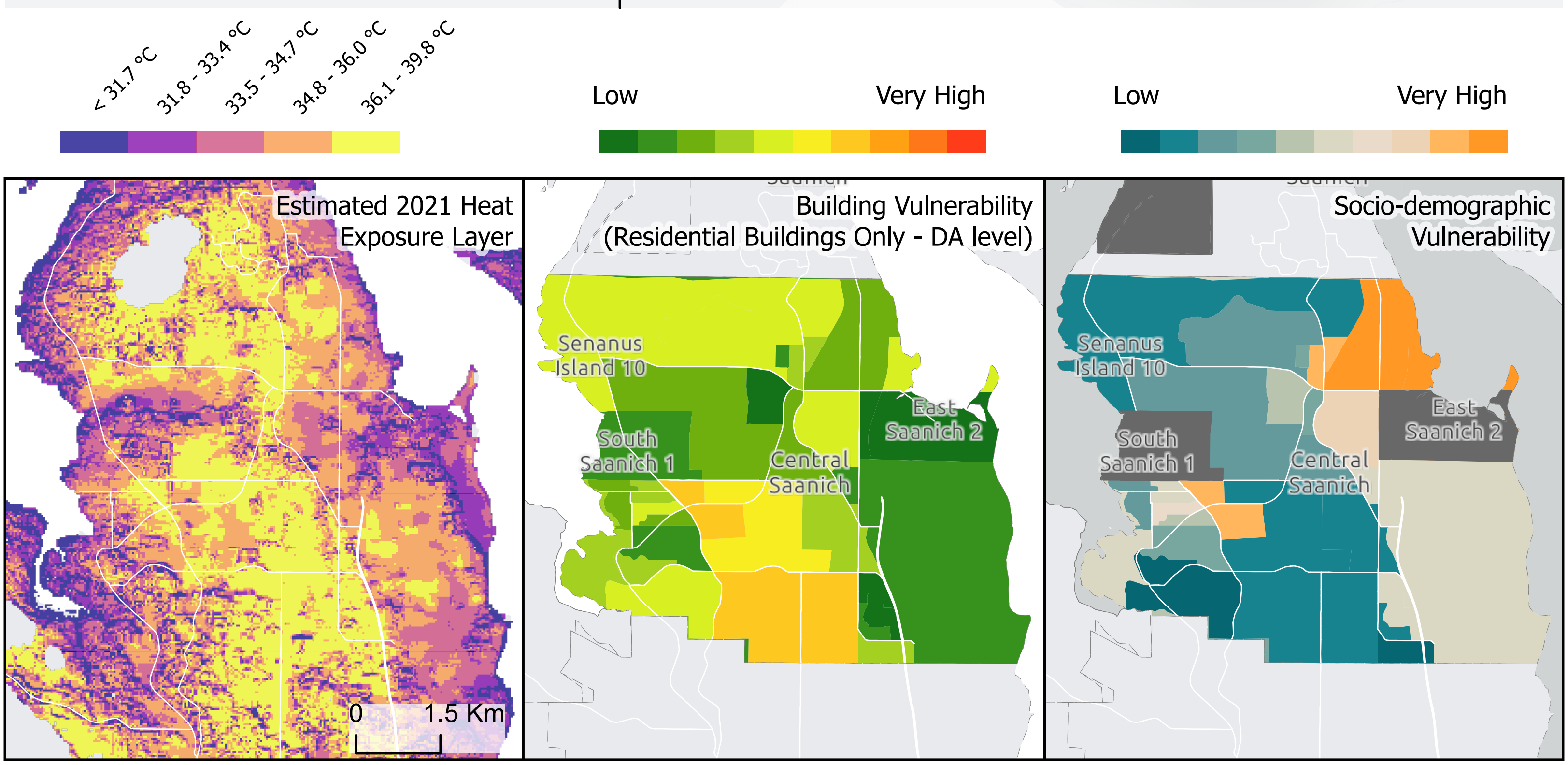
| | |
|---|---|
| Population 2021 | 17,385 |
| % population in very high Sociodemographic vulnerability | 17.70% |
| % population in very high demographic-only vulnerability | 5.20% |
| % population in very high Health vulnerability | 21.10% |
| Top contributing demographic factor | Population age 65 or older (27.2%) |
| Second contributing demographic factor | Private households by age of primary household maintainers - 65 years and over (23.3%) |
| Third contributing demographic factor | Population that are renters (20.1%) |
| Top contributing health factor | Episodic Mood Anxiety Disorders Prevalence (Crude Rate) |
| Second contributing health factor | Hypertension (crude rate) |
| Third contributing health factor | Acute Myocardial Infarction (Crude Rate) |

## Building Vulnerability

| | |
|---|---|
| Total # of residential buildings in the community | 5,908 |
| Housing type contribution to building vulnerability | 2.30% |
| Year Built contribution to building vulnerability | 23.40% |
| Albedo contribution to building vulnerability | 29.80% |
| Solar insolation contribution to building vulnerability | 30.90% |
| Building Height contribution to building vulnerability | 13.70% |
| # of buildings with very high demographic & building vuln. | 113 |
| # of buildings in very high | 742 |
| % of residential buildings in very high | 11.80% |
| Average age of buildings in very high | 1972 |

## Heat Exposure

| | |
|---|---|
| % of community area in very high heat exposure | 25% |
| % of residential buildings with very high heat exposure | 43% |
| # of buildings with very high socio-demographic & heat expo. | 324 |
| # of residential buildings highly vulnerable across all 3 indices | 60 |

# The Corporation of the District of Oak Bay

Heat Vulnerability Data & Analysis Project
Prepared for The Capital Regional District

## Demographic Vulnerability

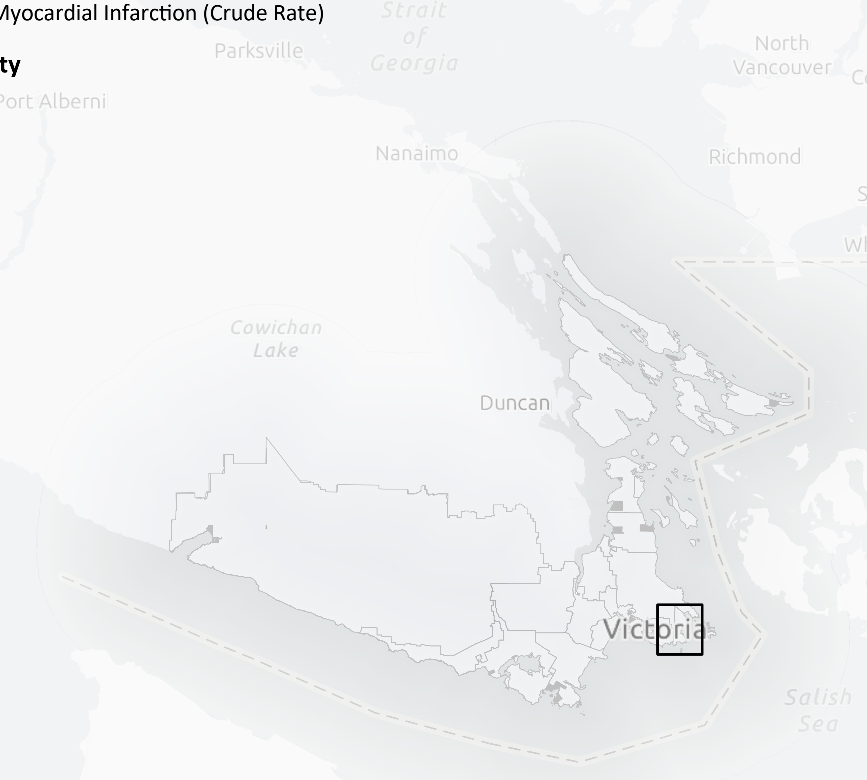
| | |
|---|---|
| Population 2021 | 17,990 |
| % population in very high Sociodemographic vulnerability | 21.70% |
| % population in very high demographic-only vulnerability | 29.00% |
| % population in very high Health vulnerability | 18.90% |
| Top contributing demographic factor | Population age 65 or older (34.2%) |
| Second contributing demographic factor | Housing Built Before 1960 (59%) |
| Third contributing demographic factor | Private households by age of primary household maintainers - 65 years and over (25.7%) |
| Top contributing health factor | Episodic Mood Anxiety Disorders Prevalence (Crude Rate) |
| Second contributing health factor | Hypertension (crude rate) |
| Third contributing health factor | Acute Myocardial Infarction (Crude Rate) |

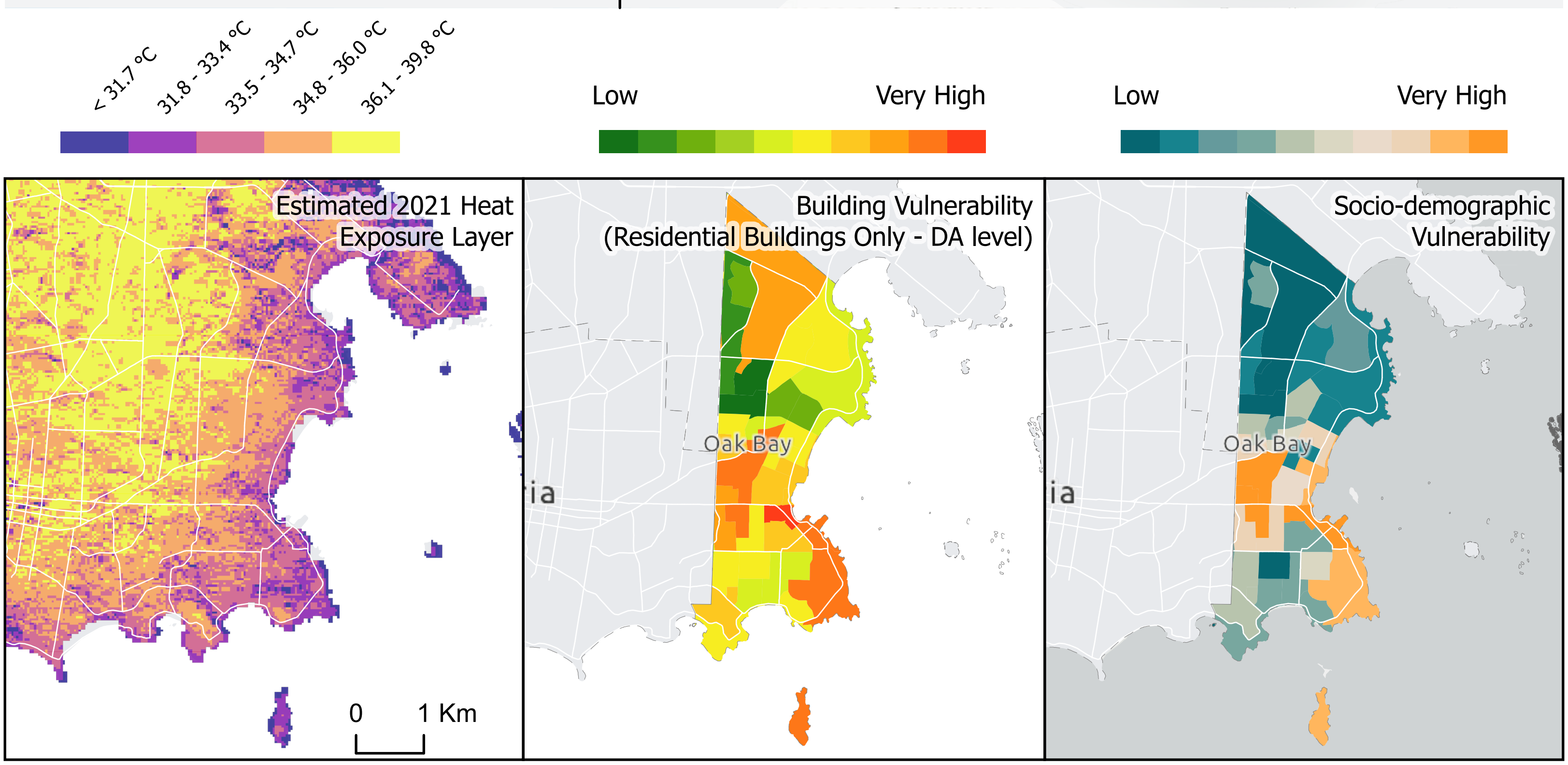
## Building Vulnerability

| | |
|---|---|
| Total # of residential buildings in the community | 6,360 |
| Housing type contribution to building vulnerability | 0.90% |
| Year Built contribution to building vulnerability | 26.30% |
| Albedo contribution to building vulnerability | 29.70% |
| Solar insolation contribution to building vulnerability | 29.20% |
| Building Height contribution to building vulnerability | 13.90% |
| # of buildings with very high demographic & building vuln. | 376 |
| # of buildings in very high | 2,498 |
| % of residential buildings in very high | 11.80% |
| Average age of buildings in very high | 1940 |

## Heat Exposure

| | |
|---|---|
| % of community area in very high heat exposure | 5% |
| % of residential buildings with very high heat exposure | 5% |
| # of buildings with very high socio-demographic & heat expo. | 12 |
| # of residential buildings highly vulnerable across all 3 indices | 0 |



# The Corporation of the District of Saanich



## Demographic Vulnerability

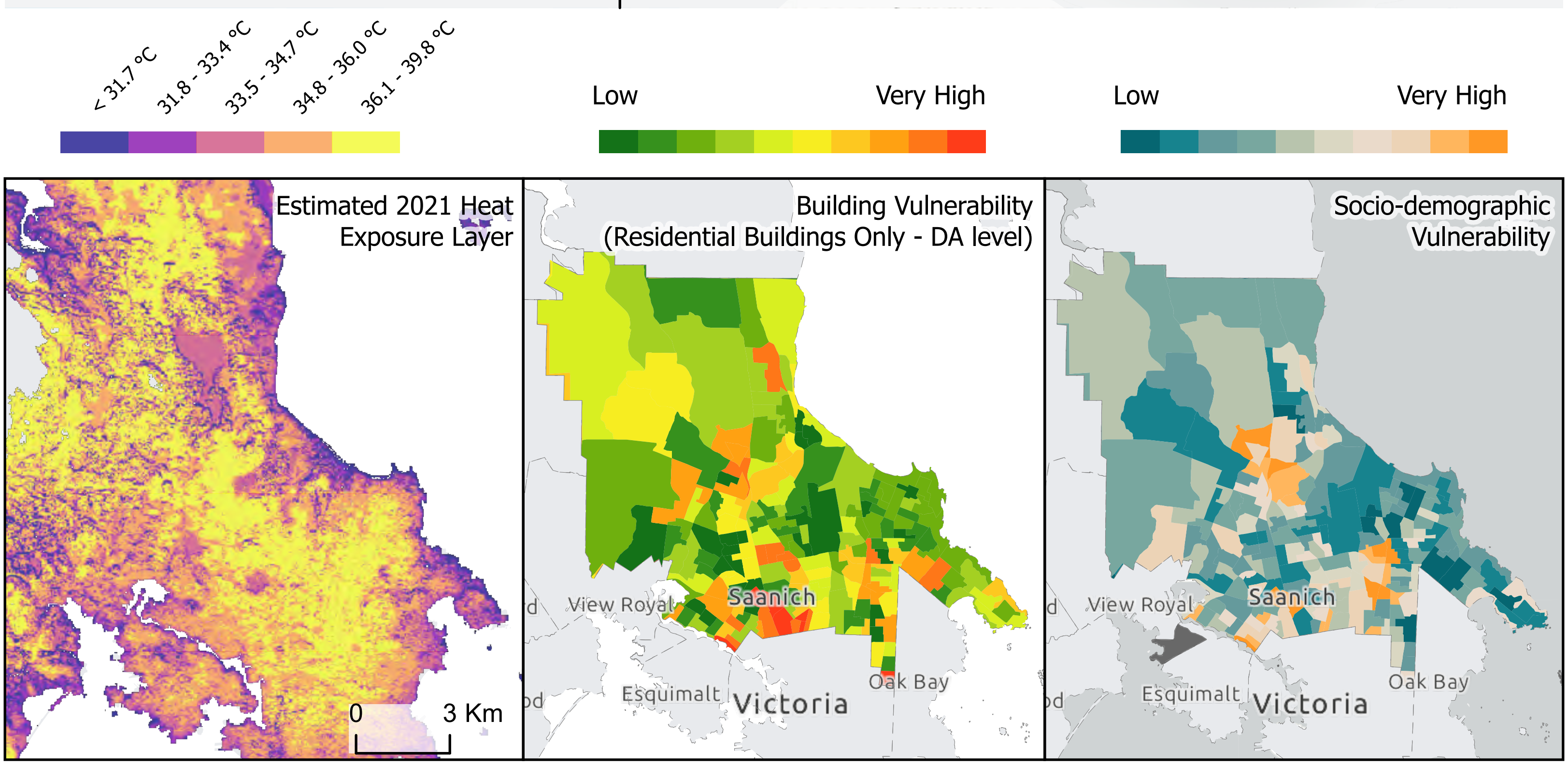
| | |
|---|---|
| Population 2021 | 117,735 |
| % population in very high Sociodemographic vulnerability | 12.70% |
| % population in very high demographic-only vulnerability | 8.20% |
| % population in very high Health vulnerability | 14.10% |
| Top contributing demographic factor | Population age 65 or older (23.1%) |
| Second contributing demographic factor | Population that are renters (30.8%) |
| Third contributing demographic factor | Private households by age of primary household maintainers - 65 years and over (18.2%) |
| Top contributing health factor | Episodic Mood Anxiety Disorders Prevalence (Crude Rate) |
| Second contributing health factor | Hypertension (crude rate) |
| Third contributing health factor | Diabetes (Crude Rate) |

## Building Vulnerability

| | |
|---|---|
| Total # of residential buildings in the community | 35,638 |
| Housing type contribution to building vulnerability | 1.60% |
| Year Built contribution to building vulnerability | 24.90% |
| Albedo contribution to building vulnerability | 29.70% |
| Solar insolation contribution to building vulnerability | 30.40% |
| Building Height contribution to building vulnerability | 13.50% |
| # of buildings with very high demographic & building vuln. | 806 |
| # of buildings in very high | 6,873 |
| % of residential buildings in very high | 11.80% |
| Average age of buildings in very high | 1960 |

## Heat Exposure

| | |
|---|---|
| % of community area in very high heat exposure | 28% |
| % of residential buildings with very high heat exposure | 36% |
| # of buildings with very high socio-demographic & heat expo. | 1,542 |
| # of residential buildings highly vulnerable across all 3 indices | 454 |

# The Corporation of the Township of Esquimalt

**Heat Vulnerability Data & Analysis Project**
**Prepared for The Capital Regional District**

### Demographic Vulnerability

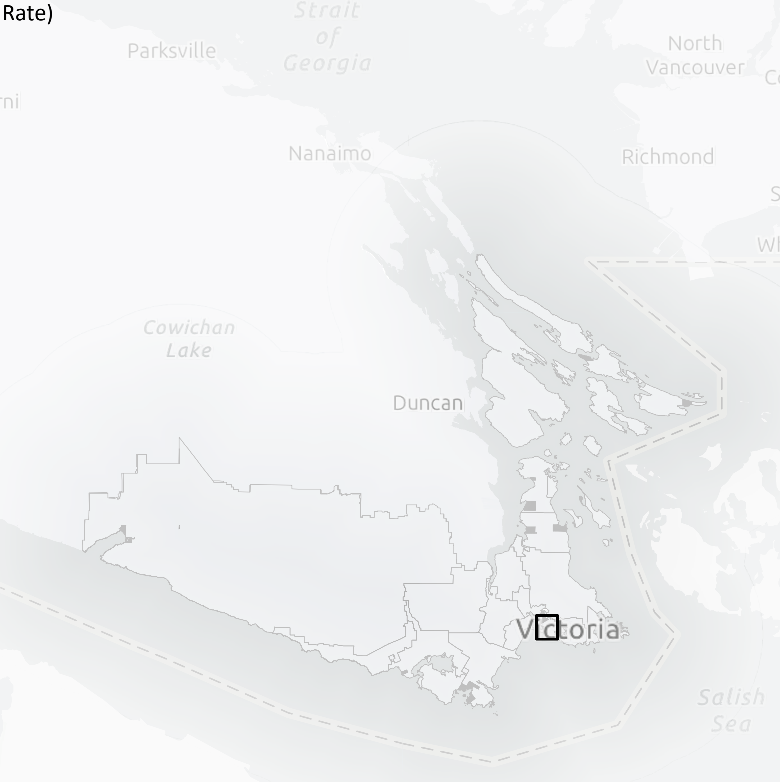
| | |
|---|---|
| Population 2021 | 17,533 |
| % population in very high Sociodemographic vulnerability | 36.60% |
| % population in very high demographic-only vulnerability | 21.20% |
| % population in very high Health vulnerability | 32.70% |
| Top contributing demographic factor | Population that are renters (51.1%) |
| Second contributing demographic factor | Population age 65 or older (20.7%) |
| Third contributing demographic factor | Average number of rooms per dwelling (5.1%) |
| Top contributing health factor | Episodic Mood Anxiety Disorders Prevalence (Crude Rate) |
| Second contributing health factor | Chronic Obstructive Pulmonary Disease (Crude Rate) |
| Third contributing health factor | Diabetes (Crude Rate) |

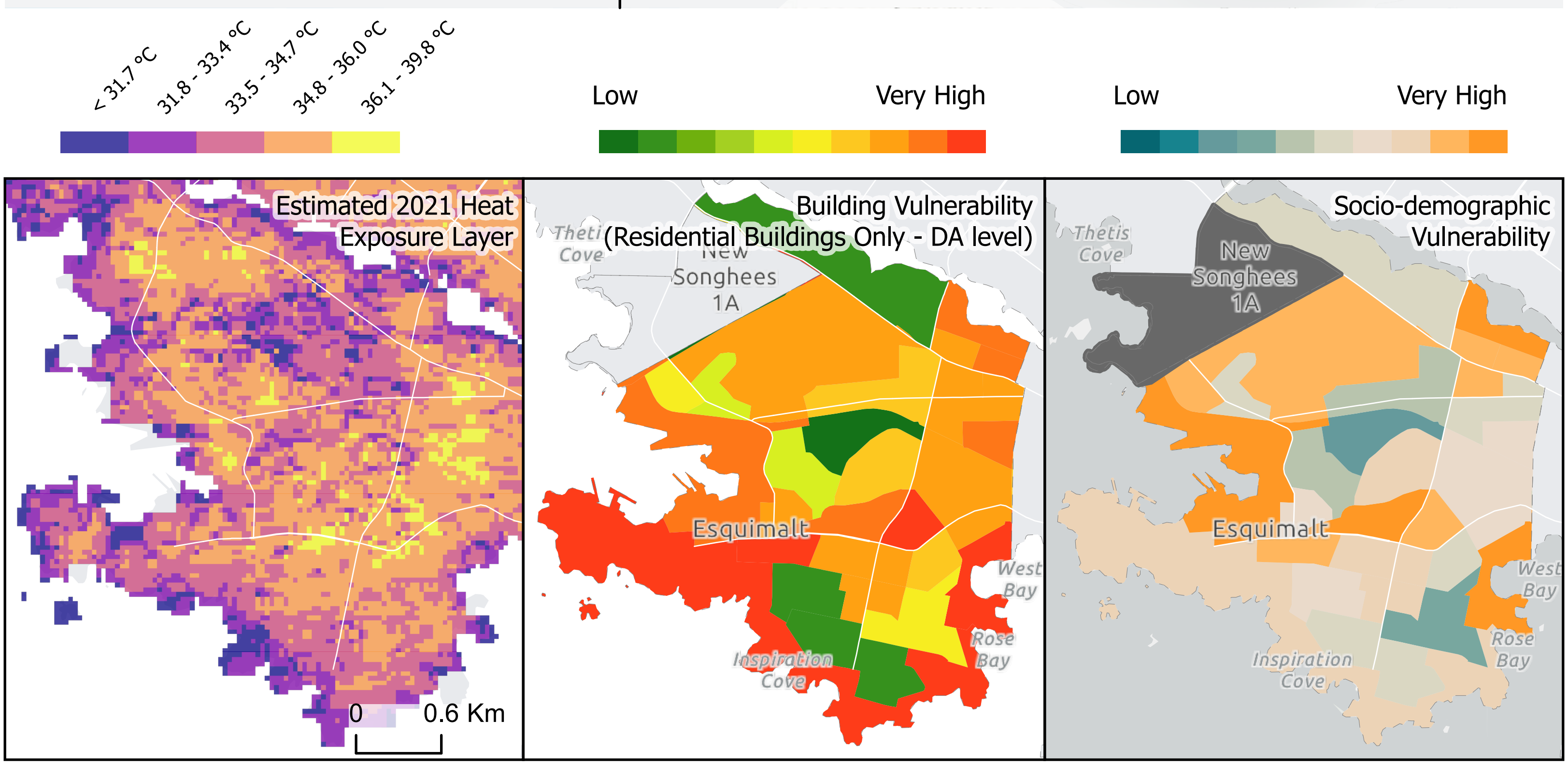
### Building Vulnerability

| | |
|---|---|
| Total # of residential buildings in the community | 3,410 |
| Housing type contribution to building vulnerability | 3.90% |
| Year Built contribution to building vulnerability | 25.00% |
| Albedo contribution to building vulnerability | 28.40% |
| Solar insolation contribution to building vulnerability | 29.50% |
| Building Height contribution to building vulnerability | 13.20% |
| # of buildings with very high demographic & building vuln. | 289 |
| # of buildings in very high | 1,138 |
| % of residential buildings in very high | 11.80% |
| Average age of buildings in very high | 1956 |

### Heat Exposure

| | |
|---|---|
| % of community area in very high heat exposure | 1% |
| % of residential buildings with very high heat exposure | 1% |
| # of buildings with very high socio-demographic & heat expo. | 8 |
| # of residential buildings highly vulnerable across all 3 indices | 0 |



# Town of Sidney



### Demographic Vulnerability

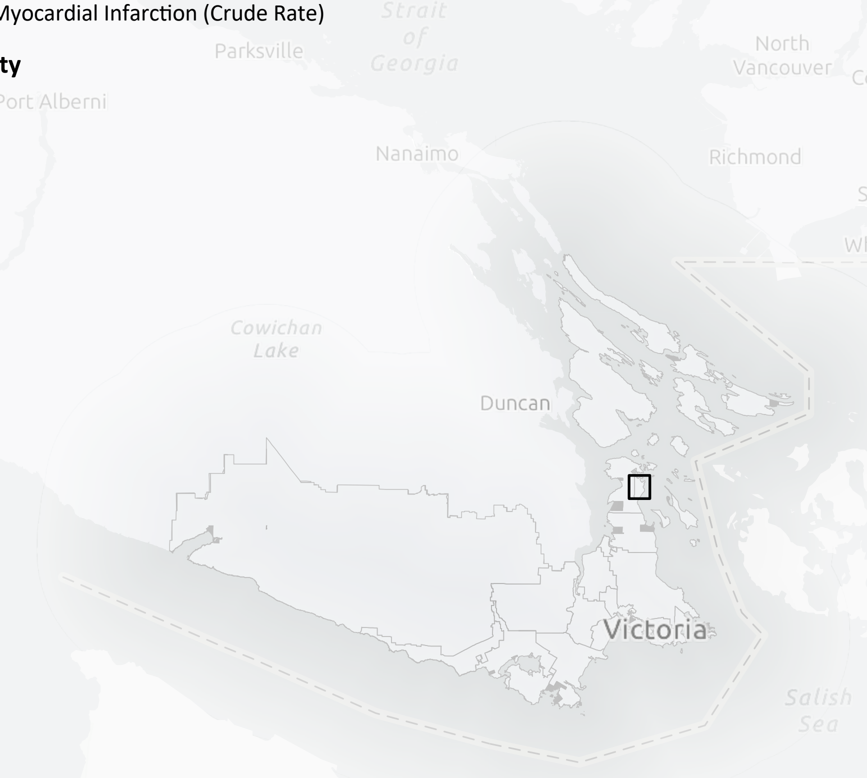
| | |
|---|---|
| Population 2021 | 12,318 |
| % population in very high Sociodemographic vulnerability | 62.60% |
| % population in very high demographic-only vulnerability | 41.80% |
| % population in very high Health vulnerability | 68.90% |
| Top contributing demographic factor | Population age 65 or older (45%) |
| Second contributing demographic factor | Private households by age of primary household maintainers - 65 years and over (25%) |
| Third contributing demographic factor | Living alone (19.6%) |
| Top contributing health factor | Hypertension (crude rate) |
| Second contributing health factor | Episodic Mood Anxiety Disorders Prevalence (Crude Rate) |
| Third contributing health factor | Acute Myocardial Infarction (Crude Rate) |

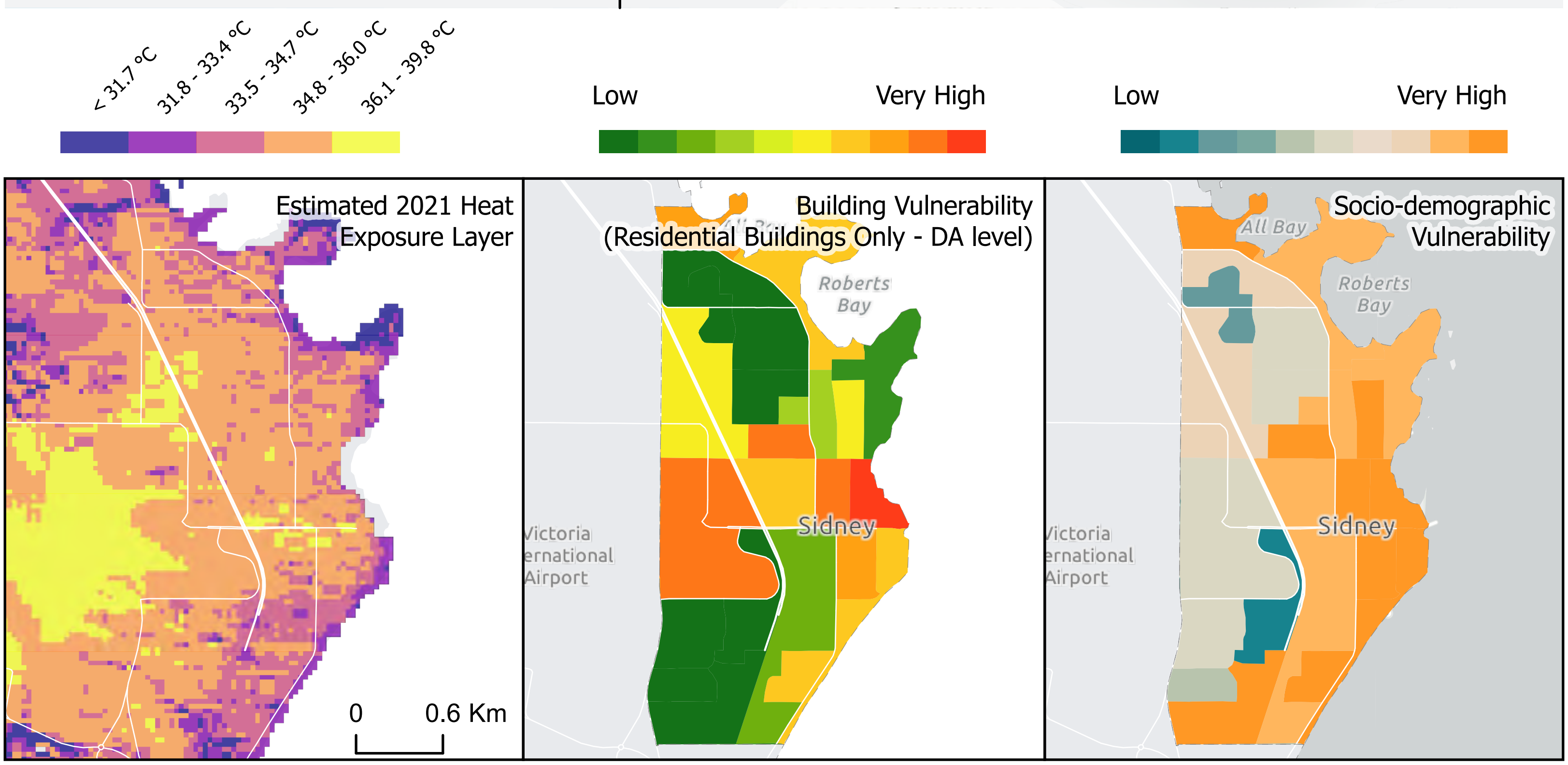
### Building Vulnerability

| | |
|---|---|
| Total # of residential buildings in the community | 3,274 |
| Housing type contribution to building vulnerability | 5.60% |
| Year Built contribution to building vulnerability | 21.30% |
| Albedo contribution to building vulnerability | 28.20% |
| Solar insolation contribution to building vulnerability | 32.20% |
| Building Height contribution to building vulnerability | 12.80% |
| # of buildings with very high demographic & building vuln. | 628 |
| # of buildings in very high | 941 |
| % of residential buildings in very high | 11.80% |
| Average age of buildings in very high | 1978 |

### Heat Exposure

| | |
|---|---|
| % of community area in very high heat exposure | 2% |
| % of residential buildings with very high heat exposure | 1% |
| # of buildings with very high socio-demographic & heat expo. | 2 |
| # of residential buildings highly vulnerable across all 3 indices | 0 |



# Town of View Royal



## Demographic Vulnerability

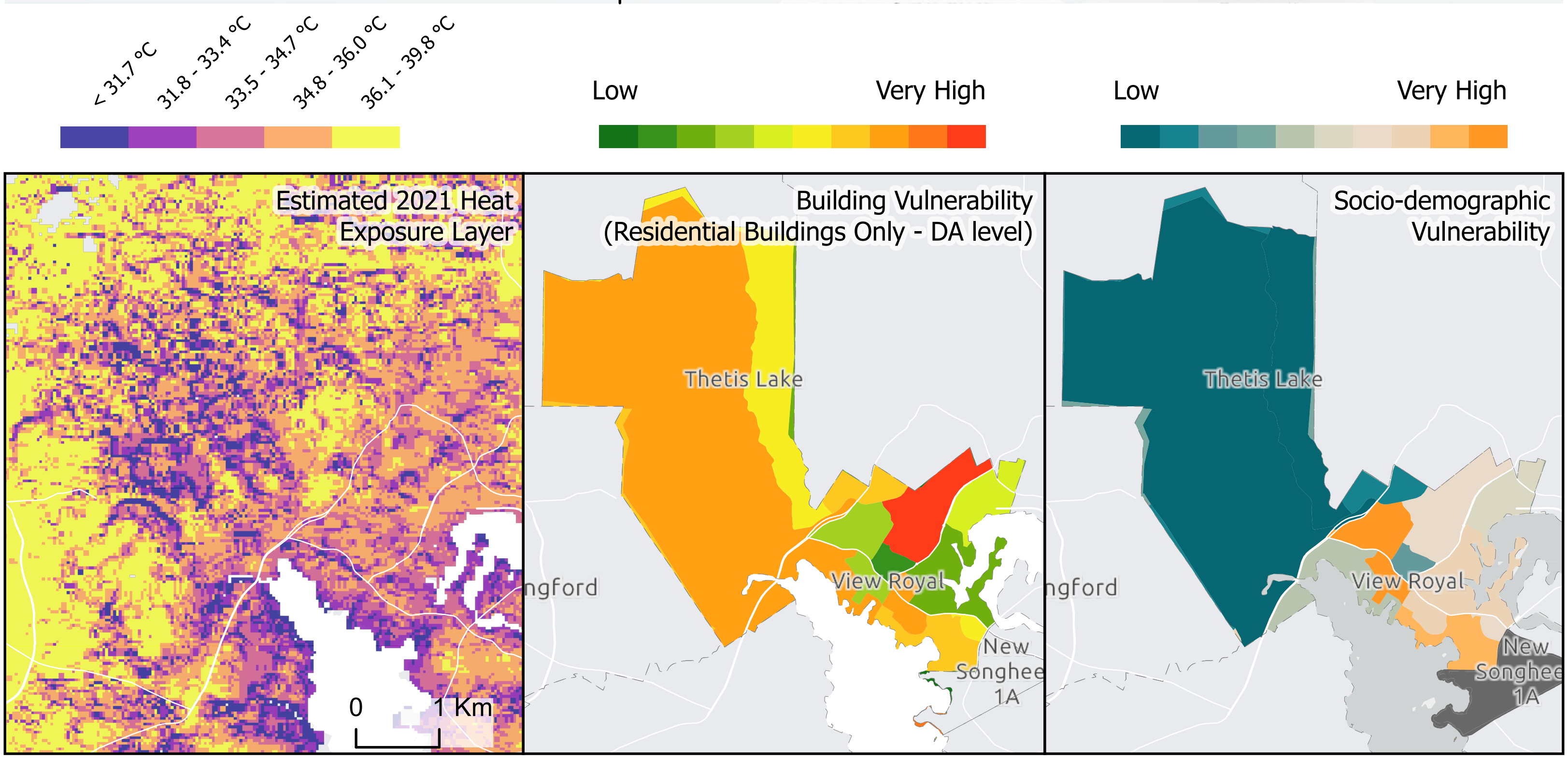
| | |
|---|---|
| Population 2021 | 11,575 |
| % population in very high Sociodemographic vulnerability | 14.20% |
| % population in very high demographic-only vulnerability | 0% |
| % population in very high Health vulnerability | 20.00% |
| Top contributing demographic factor | Population that are renters (32.6%) |
| Second contributing demographic factor | Population age 65 or older (20.9%) |
| Third contributing demographic factor | Average number of rooms per dwelling (5.9%) |
| Top contributing health factor | Episodic Mood Anxiety Disorders Prevalence (Crude Rate) |
| Second contributing health factor | Hypertension (crude rate) |
| Third contributing health factor | Diabetes (Crude Rate) |

## Building Vulnerability

| | |
|---|---|
| Total # of residential buildings in the community | 2,788 |
| Housing type contribution to building vulnerability | 3.00% |
| Year Built contribution to building vulnerability | 21.50% |
| Albedo contribution to building vulnerability | 30.60% |
| Solar insolation contribution to building vulnerability | 30.60% |
| Building Height contribution to building vulnerability | 14.20% |
| # of buildings with very high demographic & building vuln. | 55 |
| # of buildings in very high | 360 |
| % of residential buildings in very high | 11.80% |
| Average age of buildings in very high | 1978 |

## Heat Exposure

| | |
|---|---|
| % of community area in very high heat exposure | 11% |
| % of residential buildings with very high heat exposure | 4% |
| # of buildings with very high socio-demographic & heat expo. | 4 |
| # of residential buildings highly vulnerable across all 3 indices | 0 |

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**REPORT TO ELECTORAL AREAS COMMITTEE**
**MEETING OF WEDNESDAY, JUNE 12, 2024**

---

**SUBJECT** **Community Resiliency Initiative Grant: 2024 FireSmart Community Funding & Supports**

## ISSUE SUMMARY

The Capital Regional District (CRD) assists Electoral Area (EA) communities in reducing their wildfire risk through first responder coordination, public education, emergency planning, and agency cross-training. The CRD is applying to the Union of British Columbia Municipalities (UBCM) for funding to increase EA community wildfire resiliency activities (Appendix A). UBCM requires that all grant applications be accompanied by a motion of support from the local government.

## BACKGROUND

UBCM provides funding for a range of community-based projects, including wildfire preparedness. A 2024 grant opportunity is available to support local governments as they build local capacity. The FireSmart Community Funding & Supports program supports activities that reduce community risk from wildfire. As part of the application process, UBCM requires a motion of support to receive and manage grant funding.

Protective Services staff have engaged with EA fire departments, emergency programs, local FireSmart committees, and community stakeholders to inform this grant application. Effective wildfire preparedness programs include seven FireSmart disciplines: education, vegetation management, legislation and planning, development considerations, interagency cooperation, cross-training, and emergency planning.

The CRD has applied for this grant to improve wildfire resiliency in rural EA communities through:

- a FireSmart public education campaign,
- an expanded wood chipping program that provides accessible alternatives to burning,
- a home FireSmart assessment program conducted by local qualified assessors,
- a FireSmart rebate program for residents, and
- dedicated wildfire training for first responders.

If the proposal is approved by UBCM, most grant funding would flow to local volunteers, firefighters and residents. The grant supports payments to community volunteers and contract positions such as the CRD FireSmart Coordinator. Funds would be distributed roughly evenly between EAs and spent over the coming year. Due to the elevated risk of wildfire, the Regional District is eligible for $200,000 in base funding and each EA is eligible for an additional $50,000. It is the intention of the CRD Protective Services team to apply for the maximum in each category for an approximate total of $350,000.

## ALTERNATIVES

*Alternative 1*
The Electoral Areas Committee recommends to the Capital Regional District Board:
That the Capital Regional District Board support an application to the Union of British Columbia Municipalities Community Resiliency Initiative Fund for the 2024 FireSmart Community Funding and Supports. Staff are directed to apply for, negotiate, and if successful, enter into an agreement, and do all such things necessary for accepting grant funds and overseeing grant management for the proposed projects.

*Alternative 2*
That staff be directed to not submit the grant application to the Union of British Columbia Municipalities Community Resiliency Initiative FireSmart Community Funding & Supports program.

## IMPLICATIONS

*Alignment with Board & Corporate Priorities*
Emergency planning and training activity funded by this grant would enhance the CRD's ability to prepare for, mitigate, respond to, and recover from an environmental or climate related disaster.

*Alignment with Existing Plans & Strategies*
Capacity generated by this grant is aligned with existing emergency preparedness and strategies.

*Financial Implications*
The grant funding will have no impact on annual core CRD fire department or emergency program service budgets and the requisition revenue. But if the grant application is successful, the additional funding will provide an opportunity for additional projects that increase community resilience to wildfire, such as homeowner education and wood chipping events.

*Intergovernmental Implications*
A portion of this grant application is ear-marked to support the Island Trust's effort to establish a Development Permit Area. This cross-jurisdiction collaboration supports intergovernmental alignment and coordination.

*Service Delivery Implications*
Additional capacity funded through this grant would enhance service support capability to the CRD during an emergency or disaster.

## CONCLUSION

The CRD supports community wildfire preparedness in its EAs. The UBCM FireSmart Community Funding & Supports funding stream is an important resource to build wildfire resilience in the capital region. If supported by the Board, UBCM will consider the CRD's grant application.

## RECOMMENDATION

The Electoral Areas Committee recommends to the Capital Regional District Board:
That the Capital Regional District Board support an application to the Union of British Columbia Municipalities Community Resiliency Initiative Fund for the 2024 FireSmart Community Funding and Supports. Staff are directed to apply for, negotiate, and if successful, enter into an agreement, and do all such things necessary for accepting grant funds and overseeing grant management for the proposed projects.

| | |
|---|---|
| Submitted by: | Shawn Carby, CD, BHSc, MAL, Senior Manager, Protective Services |
| Concurrence: | Kevin Lorette, P. Eng., MBA, General Manager, Planning & Protective Services |
| Concurrence: | Nelson Chan, MBA, FCPA, FCMA, Chief Financial Officer |
| Concurrence: | Ted Robbins, Chief Administrative Officer |

## ATTACHMENTS

Appendix A: 2024 FireSmart Community Funding and Supports Grant Application

UBCM

# Community Resiliency Investment Program

# 2024 FireSmart Community Funding and Supports

## Allocation-based Funding Worksheet

The 2024 FireSmart Community Funding and Supports program will have an open intake. Funding permitting, eligible recipients can submit one funding request between **October 1, 2023 and September 30, 2024.**

First Nations and local governments with a higher risk of wildfire, generally demonstrated by WUI Risk Class 1 to 3, that have a FireSmart Position, participate in a Community FireSmart and Resiliency Committee and have an acceptable Community Wildfire Resiliency Plan/ Community Wildfire Protection Plan are eligible to receive FireSmart Community Funding and Supports funding for FireSmart activities only through the allocation-based program.

Please complete and return the worksheet with all required attachments. **Eligible recipients are not required to submit a full Application-based funding package**.

If you have any questions, contact cri@ubcm.ca or (604) 270-8226 ext. 220.

| **SECTION 1: Recipient Information** | |
|---|---|
| First Nation or Local Government full name:<br>Capital Regional District | File number*:<br>LGPS-10828 |

** Refer to the LGPS Online Application Form submission confirmation email.*

**SECTION 2: For Regional District Recipients Only**

1. **Electoral Areas.** Please identify which electoral areas you would like to receive allocation-based funding for:

   Juan de Fuca, Salt Spring Island, Southern Gulf Islands.

   *Note: In order to receive an additional $50,000 per electoral area, electoral areas must meet the risk class and eligibility criteria identified in Questions 2 and 4.*

**SECTION 3: Wildfire Risk & Additional Evidence**

2. **A. WUI Wildfire Risk Class.** Provide the WUI Risk Class (1 – 5) for the general area of interest of your community, including the WUI polygon name, from the risk class map. Refer to Appendix 2 of the *Allocation-based Funding Program and Application Guide*.

   Risk Class: Port Renfrew RC: 5; Jordan River RC: 2; Langford RC: 1; Ganges RC: 5

   WUI Polygon name: Port Renfrew; River Jordan; Langford (East Sooke, Malahat, Otter Point, Shirley, etc.); Ganges.

*Note: for regional districts only, please provide the risk class and WUI polygon name for each electoral area identified in Question 3.*

**B. Additional Evidence.** If local assessments provide additional evidence of higher wildfire risk than the WUI Risk Class, provide specific evidence of wildfire risk (reference to specific page of a CWRP/CWPP).

Each of the three CWRPs the CRD commissioned for the electoral areas (Juan de Fuca, Salt Spring Island, Southern Gulf Islands), identified the wildfire risk as "moderate" for their respective areas.

The "Local Wildfire Risk Summary" can be found on the specific pages of the CWRPs as follows:

Juan de Fuca: pg. 69

Salt Spring Island: pg. 69

Southern Gulf Islands: pg. 78

**SECTION 4: FireSmart Components and Eligibility Criteria**

**3. Progress to Date.** If you were approved for funding under previous rounds of the FireSmart Community Funding & Supports program, please provide the status of the previous project(s).

2021 project: EA FireSmart Program Initiation Project. Complete

2022 project: Education, Chipping, Assessments, and Rebates. Complete

2023 project: Education, Chipping, Assessments, and Rebates. 90% complete

*Refer to the Allocation-based Funding Program and Application Guide for reporting requirements for previous projects.*

**4. Required FireSmart Components.** To be eligible for allocation-based funding, all recipients must have the following FireSmart components developed and active in their community.

CWRPs and CWPPs must be complete and acceptable to the BCWS, FNESS and/or, where applicable, BC Parks. To be considered acceptable, CWRPs must be developed in accordance with the template and guidance document and must include assessment and identification of FireSmart and fuel management priorities.

☒ FireSmart Position: FireSmart Coordinator: In place since CRD FireSmart Program inception in 2021. Duties include:

Education

• Support the development of a detailed communications strategy for FireSmart.

• Distribute FireSmart materials through community partners and online.

Community Planning

• Support neighbourhoods to apply for FireSmart Canada Neighbourhood Recognition, including by supporting facilitation and FireSmart events.

Interagency co-operation

• Coordinate FireSmart initiatives between electoral areas and external partners as applicable, such as by representing the CRD in working groups or committees.

FireSmart Implementation

• With homeowners' consent:

  o Conduct Home Ignition Zone Assessments for residential properties or homes.

  o Help communities develop FireSmart Neighbourhood Plans.

• Coordinate chipping days or bin programs to facilitate vegetative debris disposal.

Administration

• Report on program implementation, progress, and community feedback regarding FireSmart to the Emergency Planning Coordinator and Manager, Emergency Services.

Protective Services staff work with adjacent CRD departments to perform the following FireSmart program support functions:

Development considerations

• Comment on wildfire issues within a development permit process on behalf of the Protective Services department.

Emergency planning

• Provide comments on wildfire issues during emergency plan and response preparation.

Administration

• Prepare grant applications.

☒ Community Wildfire Resiliency Plan or CWPP (if not previously submitted to UBCM, submit plan): Each electoral area (Juan de Fuca, Salt Spring Island, Southern Gulf Islands) had its own CWRP commissioned and delivered in 2023-Feb-23.

☒ Community FireSmart & Resiliency Committee: In place at local community and fire department levels. The CRD also participates in a regional level Community FireSmart & Resilience Committee that includes several local authorities in the capital region.

If you do not have one or more of the required FireSmart components in place, please provide a clear rationale: n/a

*Note: for regional districts only, please provide information on required FireSmart components for each electoral area identified in Question 1.*

| **SECTION 5: Allocation-based Funding Submission Requirements**<br>Only complete submissions will be considered for funding. | |
|---|---|
| Submissions | Related Attachments (as required) |
| Allocation-based Funding Worksheet | ☐ If available, workplans, budgets or other documents with information on anticipated FireSmart activities<br>☐ Completed CWPP or CWRP (if not previously submitted) |

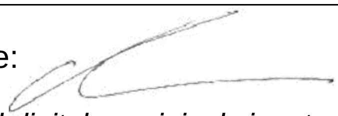
| | |
|---|---|
| Prior to commencing FireSmart activities (as required) | ☐ Approval from SPCO (if applying for Phase 2, 3 or 4) for FireSmart structure protection equipment<br>☐ Completed FireSmart Assessment(s) for eligible FireSmart Projects for Critical Infrastructure<br>☐ Completed FireSmart Assessment(s) for eligible FireSmart Projects for Community Assets<br>☐ Completed Prescription Checklist <u>and</u> FireSmart Assessment(s) for eligible FireSmart Projects for Culturally Significant Sites<br>☐ Completed Prescription Checklist <u>and</u> FireSmart Assessment(s) for eligible FireSmart Projects for Green Spaces<br>☐ In cases where critical infrastructure, community assets or culturally significant sites are located on **Provincial Crown Land** confirmation that the proposed activities are supported will be required from Provincial Crown Land Manager (BC Parks, Mountain Resort Branch, Natural Resource District and/or Recreation Sites and Trails) at the time of application submission. |
| For CWRP updates only<br><br>*Recipients with an acceptable plan that would like to amend/develop a CWRP must contact UBCM before commencing the project.* | ☐ PDF map <u>and</u> Google Earth compatible KML file, at appropriate scale, outlining the area of interest and eligible WUI<br>☐ In cases where the eligible WUI is outside of the AOI, confirmation that the proposed risk assessments activities are supported will be required <u>at the time of application submission</u> from Provincial Crown Land Manager (BC Parks, Mountain Resort Branch, Natural Resource District and/or Recreation Sites and Trails), other land managers (e.g., Indigenous Services Canada, local government) and/or First Nations (where overlap on reserves and/or traditional territories may exist).<br>☐ In cases where the eligible WUI includes Private Managed Forest Land (PMFL), confirmation that the proposed risk assessments activities are supported will be required <u>at the time of application submission</u> from the PMFL. |
| For Fuel Management only | • Refer to the Application-based program. Worksheet 2 can be submitted with the Allocation-based Funding Worksheet or at a later date. |
| For Additional Funding for Recipients Impacted by 2023 Wildfires only | • Refer to the Appendix 3. Worksheet 4 can be submitted with the Allocation-based Funding Worksheet or at a later date. |
| Resolution | ☐ Council, Board or Band Council resolution, indicating support for the current proposed activities and willingness to provide overall grant management |

**SECTION 6: Signature** – This worksheet is required to be signed by an authorized representative of the recipient *(i.e., staff member or elected official)*. Please note all materials will be shared with the Province of BC, First Nations' Emergency Services Society and the BC FireSmart Committee.

I certify that to the best of my knowledge: (1) all information is accurate, (2) the area covered by the proposed project is within the recipient's jurisdiction (or appropriate approvals are in place) and (3) it is understood that this project may be subject to a compliance audit under the program.

Further, for all funded activities, I certify that, to the best of my knowledge: all funded activities will meet eligibility and funding requirements as defined in the *Allocation-based Funding Program and Application Guide*.

Further, for FireSmart Positions, I certify that: (1) I have read and understand the recommended Job Description(s) and (2) the primary focus of the position is to support eligible FireSmart activities but that other activities related to emergency management (i.e., EOC, ESS, evacuations), structural fire and/or forestry (i.e., Indigenous Guardians) are eligible as no more than 20% of job duties.

| | |
|---|---|
| Name: Corey Anderson | Title: Manager, Emergency Programs |
| Signature: <br>*A certified digital or original signature is required.* | Date: 2024-May-23 |

**Documents should be submitted as Word, Excel, or PDF files.**
**Total file size for email attachments cannot exceed 20 MB.**

**All documents should be submitted to Local Government Program Services, Union of BC Municipalities by e-mail: cri@ubcm.ca.**

**Please note "2024 CRI-Allocation-based" in the subject line**

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**REPORT TO ELECTORAL AREAS COMMITTEE**
**MEETING OF WEDNESDAY, JUNE 12, 2024**

---

**SUBJECT** **Appointment of Officers**

## ISSUE SUMMARY

This report is to update bylaw enforcement appointments to reflect staff changes in the Capital Regional District (CRD) Bylaw and Animal Care Services Division.

## BACKGROUND

Pursuant to Section 233 of the *Local Government Act* and Section 28(3) of the *Offence Act* and in accordance with CRD Bylaw No. 2681, the Electoral Areas Committee must from time to time make resolutions for persons in new positions.

## ALTERNATIVES

*Alternative 1*
The Electoral Areas Committee recommends to the Capital Regional District Board:
That for the purpose of Section 233 of the *Local Government Act* and Section 28(3) of the *Offence Act* and in accordance with Capital Regional District Bylaw No. 2681, Gray Wardle, Rachelle Norris-Jones, Levi Holland, and Michael Riggs be appointed as Bylaw Enforcement Officers.

*Alternative 2*
That this report be referred back to staff for further information based on Electoral Areas Committee direction.

## IMPLICATIONS

*Service Delivery Implications*
These appointments ensure consistent bylaw enforcement in the CRD Bylaw and Animal Care Services Division.

## CONCLUSION

The bylaw enforcement appointments reflect staff changes in the CRD Bylaw and Animal Care Services Division.

## RECOMMENDATION

The Electoral Areas Committee recommends to the Capital Regional District Board:
That for the purpose of Section 233 of the *Local Government Act* and Section 28(3) of the *Offence Act* and in accordance with Capital Regional District Bylaw No. 2681, Gray Wardle, Rachelle Norris-Jones, Levi Holland, and Michael Riggs be appointed as Bylaw Enforcement Officers.

| | |
|---|---|
| Submitted by: | Shawn Carby, CD, BHSc, MAL, Senior Manager Protective Services |
| Concurrence: | Kevin Lorette, P.Eng., MBA, General Manager Planning & Protective Services |
| Concurrence: | Ted Robbins, Chief Administrative Officer |

**Minutes for a meeting of the Mayne Island Parks and Recreation Commission**
**Location: Mayne Island Library, 411 Naylor Road, Mayne Island, BC**
**Date/Time: April 11, 2024**

---

| | | |
|---|---|---|
| **Present:** | Debra Bell, (Chair) | Michael Kilpatrick, (Vice-Chair) |
| | Jacquie Burrows, (Treasurer) | Adrian Wright |
| | Kestutis Banelis | Lauren Edwards (Recorder) |

**Absent:** Veronica Euper
David Moss
Paul Brent, Director, CRD, Southern Gulf Islands

The meeting was called to order at 3:02 pm.

## 1. Territorial Acknowledgement

We are honoured to be gathered on the traditional lands of the Coast Salish First Nations. Miners Bay was and is an area of great significance to them, and it is notable that the library, where we are meeting today, is currently displaying the Elliott Family Exhibit which includes carvings, paintings, prints and textile weaving.

## 2. Approval of Agenda

**ADD:** 7.11 Email from Lions member regarding playground and fitness equipment matters.

**MOVED** by Commissioner Bell and **SECONDED** by Commissioner Burrows,
That the agenda be approved as amended.
**CARRIED**

## 3. Adoption of Minutes of March 14, 2024

**MOVED** by Commissioner Bell and **SECONDED** by Commissioner Kilpatrick,
That the minutes of March 14, 2024 be approved as presented.
**CARRIED**

## 4. Chair's Remarks

Commissioners and volunteers were thanked for their help with the Easter festivities at Dinner Bay Park. Leftover candy bags were donated to Mayne Island Assisted Living Society.

Commissioner Banelis arrived at 3:09 pm.

## 5. Presentations/Delegations

Bill Jamieson, President, Mayne Island Firefighters Association, will attend the May meeting to discuss alternatives for Halloween fireworks.

## 6. Reports

### 6.1. Treasurer's Reports

6.1.1. Treasurer's Report for the period March 1 - 31, 2024
A report was received with the agenda.

**MOVED** by Commissioner Burrows and **SECONDED** by Commissioner Bell, that the Treasurer's report for the period March 1 – 31, 2024 be approved as presented.
**CARRIED**

6.1.2. Finance Report
A report was received with the agenda.

### 6.2. Administration

6.2.1. Follow up Action Report (not covered elsewhere)

a) Fallow Deer: Adam Olsen, MLA, will provide a talk on the island on April 17th.
b) July 1st Celebration: Commissioner Kilpatrick will discuss event responsibilities with Lauren Underhill, MI Chamber of Commerce, and ask that she connect with the island's Legion representative.
c) Charter Road Assessment: Commissioner Banelis will email Rob Underhill, MI Conservancy, on this issue.
d) Community Works Fund Grant application: Commissioner Kilpatrick will follow up on the amendment to add the putting green to the grant application.
e) Fitness equipment: It was reported that the fitness equipment proposal and contract was signed and that the invoice with the 25% reduction had been approved by Justine Starke and sent to CRD Accounts Payables department. A purchase order accompanied the invoice and a cheque requisition had been completed.

f) Fitness track: Commissioner Kilpatrick will order a truckload of additional material for the track charged to Recreational Funding as part of the planned original track work.
g) Miners Bay rock placement along Village Bay Road: Commissioner Burrows will follow up for the delivery of the selected rocks.
h) Christmas tree lighting: Commissioner Kilpatrick will follow up on getting the electrical box updated.
i) Application for funding regarding the Japanese Canadian Legacy Fund (JCLF): MIPRC will know in June whether the grant application was successful. There was additional detail requested and provided. JCLF and CRD came to an agreement on insurance requirements.
j) Sandy Hook pocket park invasive species reduction: There was no response to a call for volunteers to assist with the removal of invasive species. A date will be set for the work soon.

6.2.2. Health and Safety Concerns

Playground assessments were discussed and it was agreed that the equipment is being monitored and repaired as needed for safety. Playground Assessment Reports will continue to be submitted.

**MOVED** by Commissioner Banelis and **SECONDED** by Commissioner Kilpatrick that Mayne Island Parks and Recreation Commission approve and acquire a new teeter totter in an amount not to exceed $3,000.
**CARRIED**

Repairs to the climbing net were investigated and it was reported that a new net needs to be ordered.

6.2.3. Events

A report received with the agenda.

a) Adachi Pavilion: The stoves will be checked prior to the next event and one oven required the door gasket be repaired. It was discussed and agreed that in addition to a spring cleanup a fall cleanup should be done.
b) Volunteer Appreciation Dinner: This item was discussed and dates considered will be August 7$^{th}$ or 20$^{th}$ depending on the caterer.
c) Mind and Body Light Fitness policy:

**MOVED** by Commissioner Kilpatrick and **SECONDED** by Commissioner Bell that MIPRC approve the Mind and Body Light Fitness Policy as proposed in the April 7th policy submission.
**CARRIED**

6.2.4. Monitoring local information affecting MIPRC
There was nothing to report this month.

6.3. Committees

6.3.1. Fitness Track
A report was received with the agenda.

6.3.2. Technology and Motion
A report was received with the agenda.
**MOVED** by Commissioner Kilpatrick and **SECONDED** by Commissioner Banelis that Mayne Island Parks and Recreation Commission proceed with creating a document storage area that can be shared with all commissioners.
**CARRIED**

6.3.3. Sanitation
A report was received with the agenda
The septic tank pump outs at Miners Bay were reported on and Dinner Bay tanks are fine. Miners Bay septic will be inspected next year.

6.4. Parks

6.4.1. Miners Bay
The blackberry bushes were pruned.

6.4.2. Dinner Bay

a) Monthly Playground assessments: Reports will be emailed.
b) Men's bathroom: The light ballast has failed and it was discussed and agreed that dated fixtures will be replaced with LED fixtures in all park bathrooms.
c) Alder trees near Leighton Lane: It was reported that the large alders pose a risk to a neighbouring fence. Commissioner Banelis will seek arborist quotes.

**MOVED** by Commissioner Banelis and **SECONDED** by Commissioner Wright that Mayne Island Parks and Recreation Commission approve an expenditure of up to $2500 for the removal of the alders that threaten the property on the corner of Dinner Bay Park and Leighton Lane.
**CARRIED**

- The chipped material will be moved and utilized for the regreening project.

- It was reported that the tree canopy between the horseshoe pit and Japanese Garden is solid and no need to reduce any limbs.

d) Culverts
One large ditch was fixed and material is required for any other culvert repairs. A catch-basin well was discussed and it was agreed that pricing for a commercially built one will be investigated.

e) Baseball field: Fencing along the first base line to be installed and ballplayer workforce will be requested. Commissioner Bell will coordinate insurance for baseball.

6.4.3. Cotton Park
A report was received with the agenda
The commissioners agreed the no dog policy shall remain as is and will be reviewed in three to five years.

6.4.4. Japanese Memorial Garden and Motions
A report was received with the agenda

**MOVED** by Commissioner Kilpatrick and **SECONDED** by Commissioner Bell that Mayne Island Parks and Recreation Commission approve the operation of an art show, that is not an art sale, featuring local artists from Mayne Island to be held on August 4, 2024 from 10 am to 4 pm at the Japanese Memorial Garden.
**CARRIED**

**MOVED** by Commissioner Kilpatrick and **SECONDED** by Commissioner Burrows that Mayne Island Parks and Recreation Commission approve the use of the Japanese Memorial Garden for a Haiku poetry event from July 5 to July 7, 2024 and that the Mayne Island Parks and Recreation Commission be a sponsor of the event.
**CARRIED**

6.4.5. Kippen Road/Village Bay Park
Staircase installation at Kippen Road will occur on Friday, April 12th at 1:00 pm.

6.4.6. Trail Network Development

a) Chu An Trail: It was discussed and agreed that the suggestion of extending the trail was a good project for MIPATA. Commissioner Kilpatrick will follow up.
b) Wilks Road: Development of this MOTI owned beach access was discussed and it is on hold to be revisited.
c) Walk Bike signs: The signs were installed.

d) Safety/Danger Tree Team reporting system: The input form was revised down to seven questions which can include not only danger trees but any other issues. It was discussed and agreed that the system will be used initially by commissioners. Trail guardians can be added at a later date.

6.4.7. Henderson Park

Outdoor Recreation Grants – information kiosk:

- It was discussed and agreed that MIPRC will apply for the outdoor recreation grant for Henderson Park.
- Commissioner Kilpatrick will review current board information and work towards developing a new graphics panel with Alea.

## 7. Correspondence/Meetings

7.1. Conference call with Jeff Milne, CRD Risk & Insurance regarding playground assessments.

7.2. Emails to/from CRD liaison regarding creation of online fillable forms for recreation grants.

7.3. Email from resident at Leighton Lane and Dinner Bay Road and issues with alder trees. Incident report filed with CRD, Risk & Insurance.

7.4. Further correspondence with Mayne Reading Centre Society and CRD and letter agreement regarding installation of library book drop box.

7.5. Email communications with various parties regarding Easter festivities at Dinner Bay Park, March 31, 2024.

7.6. Insurance documents received from CRD, Insurance for John Deere tractor at Dinner Bay Park.

7.7. Email from CRD, Information Management requesting participation in interview with consultant on Workplace Modernization Project. To be scheduled in April.

7.8. Email and information provided to CRD, Risk & Insurance on volunteer list and statistics.

7.9. Telephone call from Islands Trust regarding a request received for a dog park on the island.

7.10. Email from Church fair organizer regarding upcoming planning meetings.

7.11. Email from Lions member regarding playground and fitness pad matters.

- Discussed projects that MIPRC can pursue with Lions for their support.
- The roof on the Lion's garage will eventually need to be fixed within a year or two.
- Commissioner Banelis will develop a list of possible projects for Dinner Bay Park.

**8. New Business**

**9. Motion to Close the Meeting in accordance with Community Charter Part 4, Division 3, Section 90**

**10. Rise and Report**

**11. Meeting Adjournment**

**MOVED** by Commissioner Kilpatrick and **SECONDED** by Commissioner Banelis that the Mayne Island Parks and Recreation Commission meeting be adjourned.
**CARRIED**

The meeting adjourned at 5:40 pm

Original signed by | May 11, 2024

**Debra Bell, Chair** | **DATE**

Original signed by

**Lauren Edwards, Recorder**



**A D O P T E D**

# PENDER ISLAND PARKS AND RECREATION COMMISSION (PIPRC)
## Minutes of Regular Meeting
## April 08, 2024 1:30 pm
## Zoom/Pender Community Hall

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**Commissioners**: George Leroux (Chair/Treasurer), Erin O'Brien, Lisa Baile, Sandra Tretick, Richard Sullivan, Cecilia Suh, Paul Brent, Andrea Mills.
**Staff:** Ben Symons (Maintenance Contractor), Lori Seay-Potter (Recorder)
Melody Pender(CRD Liaison)
**Guests:** Liis Graham, Three in the Tree Society

**1. CALL TO ORDER** - Chair Leroux called the meeting to order at 3:00 pm.

**2. APPROVAL OF AGENDA**

> **MOTION** to approve the 08 April 2024 PIPRC agenda as amended to include 10.1 Cliffside Trail, 10.2 Buck Lake Fence, 10.3 Conery Railing.
> M-Commissioner Tretick, S-Commission Suh. **CARRIED.**

**3. ADOPTION OF MINUTES**

> **MOTION** to approve the 04 March 2024 PIPRC minutes as amended.
> M-Commissioner Brent, S-Commissioner Tretick. **CARRIED.**

**4. CORRESPONDENCE and BUSINESS ARISING**

4.1 **Found Rd Trail Signage:** Pending design support from CRD.
4.2 **Masthead:** Tree work delayed due to nesting activity.
4.2 **Buck Lake tree:** Arborist report has been sent to the homeowner.

**5. MAINTENANCE/OPERATIONS REPORT** - Ben Symons

Report circulated prior to the meeting. Thieves Bay Outhouse will be completed in April 2024. Planning Quotes for Shingle Way field work is underway.

**6. DELEGATIONS:**

Liis Graham from Three in the Tree Society proposed art installations with Pender School for Enchanted Forest and Heart Trail, and sought approval from PIPRC ( and other stakeholders including Islands Trust Conservancy and Parks Canada). Work will be created with Grade 5-7 students and be installed from June -September. Commission requested that signage be erected to inform the public that this is an art installation, to not remove items and to leave only natural materials.

> **MOTION** that PIPRC support Three in the Tree's art installations at Heart Trail and Enchanted Forest and that signage be installed to encourage users to respect the artwork and leave only natural materials M-Commissioner Tretick, S-Commissioner Baile. **CARRIED.**

> ACTION:Ben will approach Islands Trust Conservancy regarding art installation signage for Hart Trail and Enchanted Forest.

## 7. TOPICAL ISSUES

7.1 **Recreation Grants 2024:** Grant intake is open until June 30. Application is posted online and grants will be promoted via Pender Post and social media. 2023 grantees have been reminded to submit Grant Reports by June 30.

7.2 **Project Coordinator Update:** Rob Fawcett has been contracted to coordinate PIPRC Capital projects for one year, and has resigned his role as a Commissioner. Project Coordinator will attend Commission meetings to give a monthly report at the beginning of the agenda.

7.3 **Community Engagement:** Commission will hold a Presentation/ Open House on April 13 at the Pender Hall focused on capital projects. Project drawings and handouts will be available. PIPRC contractors have met with CRD staff to explore online engagement as well. Highlights of proposed projects will be posted on Facebook.
Some demand for another dog park continues. The status of the "Dogs under Control" bylaw for Pender will be investigated.
There is a growing interest on Pender in trail networking.

ACTION: Lori will contact CRD regarding Dogs under Control Bylaw.

7.4 **Special Event Permits:** The Commission reviewed the current Special Event Use form and agreed to make changes to accommodate large events such as Disk Park tournaments.

> **MOTION** to amend the PIPRC special event form to remove the event maximum of 125 people AND to read *"events attracting 25 or fewer participants, please fill out Part A only. For events attracting 26+participants, please fill out Part A and B"*. M-Commissioner Tretick, S-Commissioner Baile. **CARRIED.**

## 8. PROJECTS

8.1 **Schooner Way Trail:** ICET Community Works and Active Transportation grants have been approved. Projected cost for Phase I is $1.1 million. Fundraising target for Phase One is $250,000, over half secured in pledges. Pledges and donation forms will be available at the Open House and a Community Fundraising Committee has been struck. CRD is assigning an Engineer to lead the project. Necessary easement talks are underway.

8.2 **Pump Track:** Rob met with project proponents to review neighbour consultation activities and letters of support. Proponents have also met with those who have noted opposition to the track location and plan to attend the Open House to take questions and gather feedback.

8.3 **Shingle Bay / Masthead Restoration Plan:** UVic students assisted with one planting day and another event is planned for Earth Day. Cedar donations have been pledged.

8.4 **Magic Lake Dock:** Rob and Ben will work together to construct the dock; budget and rezoning are in place and community engagement is underway.

8.5: **Trail Inventory & Map Update:** Assets have been submitted to the designer including wildlife information. June 1 is the targeted draft date.

8.6 **TD Grant**: Commissioner Baile will submit the TD report to CRD.

**9. <u>REPORTS</u>**

9.1 **CRD Director:** No report.

9.2 **Chair**: Reported under projects and topical issues.

9.3 **Treasurer:** Dog waste management costs are up almost 50%. Budget is fully approved and the Q1 report will be reviewed at the May meeting.

9.4 **Communications**:Rob will write an Open House recap for May Pender Post

ACTION: Commissioner Tretick will contact the Chair about the June article.

**10. <u>NEW BUSINESS</u>**

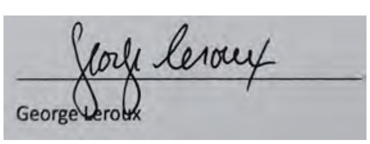
10.1 **Conery Request:** Neighbours are requesting a handrail for accessibility.
10.2 **Cliffside Trail:** Deferred to May 2024.
10.3 **Buck Lake Fence:** Deferred to May 2024.
10.4 **Commissioner Recruitment:** As Rob Fawcett has resigned, the Commission has a vacancy and will advertise in the post and social media.

ACTION: George will discuss hand rail for Conery with Ben.

11. **<u>MOTION TO ADJOURN</u>** The meeting adjourned at 4:45 p.m.

**NEXT MEETING MAY 6, 2024 at 3 p.m.**

Approved at the 06 May 2024 PIPRC meeting:




**George Leroux-Chair PIPRC**

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**SOUTHERN GULF ISLANDS ELECTORAL AREA**
**COMMUNITY ECONOMIC SUSTAINABILITY COMMISSION**
**Tuesday, January 16, 2024 at 1:00pm**
**Held by Zoom Video Conference**

**MINUTES**

**SGI CESC Commissioners**: Paul Brent, Director, Chair (Saturna), Mike Hoebel, Vice Chair (Galiano), Marcus Farmer (Mayne), Rob Fenton (Pender), Barbara Johnstone (Pender)
**Staff:** Melody Pender – Recorder/Pender Liaison; SGI Liaisons: Emma Davis (Galiano), Katie Dentry (Saturna), Kat Ferneyhough (Mayne)
**Regrets:** Justine Starke – Manager, SGI Service Delivery

1. **Introduction of new commissioners**
Marcus Farmer (Mayne) and Barbara Johnstone (Pender) were welcomed as new commissioners.

2. **Elections of Chair and Vice Chair – Melody Pender**
The following positions were elected by acclamation for the 2024/25 term:
**CHAIR – PAUL BRENT** nominated by Mike Hoebel.
All in favour. Paul Brent accepted.

**VICE CHAIR – MIKE HOEBEL** nominated by Paul Brent.
All in favour. Mike Hoebel accepted.

3. **Territorial Acknowledgement/Call Meeting to Order**
Chair Brent provided the territorial acknowledgement and called the meeting to order at 1:03pm.

4. **Approval of the Agenda**
***MOVED*** by Commissioner Farmer, ***SECONDED*** by Commissioner Hoebel to accept the Agenda as presented.

**CARRIED**

5. **Approval of Minutes from November 21, 2023.**
***MOVED*** by Commissioner Hoebel, ***SECONDED*** by Commissioner Farmer to accept the minutes from November 21, 2023 as presented.

**CARRIED**

6. **Financial Report – Melody Pender**
   - 2023 Financial Review

The finalized Budget will be presented to the Commission after March 31, 2024. Funding can then be allocated to the various initiatives the Commission chooses to support.

**Resolution:**

That the SGI CESC recommends to carry forward $27,650 to cover the outstanding contracts of $15,000 for the SGICRC and $12,650 for Food and Agriculture initiatives. The remaining estimated balance of $4,811.16 to be moved to the ORF for future projects.

***MOVED*** by Chair Brent, ***SECONDED*** by Commissioner Fenton to approve the resolution as presented.

**CARRIED**

7. **Southern Gulf Island Tourism Partnership Destination Management and Marketing Organization designation.**

**Resolution:**

That the SGI CESC supports a CRD Electoral Areas Committee recommendation that the CRD Board designate the Southern Gulf Islands Tourism Partnership as the Destination Management and Marketing Organization for the application of the MRDT accommodation tax in the Southern Gulf Islands Electoral Area for the next five years and provide a letter of support.

**Amendment:** In recognition of the positive work of the Southern Gulf Islands Tourism Partnership, it follows that the SGI CESC supports a CRD Electoral Areas Committee recommendation that the CRD Board designate that organization as the Destination Management and Marketing Organization for the application of the MRDT accommodation tax in the Southern Gulf Islands Electoral Area for the next five years and provide a letter of support.

***MOVED*** by Chair Brent, ***SECONDED*** by Commissioner Farmer to approve the Resolution as amended.

**CARRIED**

8. **SGI Liaisons Update – Justine Starke, Liaisons**

**Emma Davis (Galiano)** – Working on orienting new CESC and Parks & Rec Commissioners. Also working with Justine Starke on the CRD rural housing pilot project report commissioned by the CRD and being produced by Urban Matters Consulting. Also working with the Galiano Island Community Transportation Society to explore next steps after the referendum at the provincial election.

**Kat Ferneyhough (Mayne)** – Working on determining the different supports that the CRD needs to provide for all the different Parks & Rec commissions, also preparing numerous grants with Katie Dentry including the ICET grants for work on Miners Bay Dock and trails on Pender.

**Katie Dentry (Saturna)** – Involved in the team projects above, also assisting to draft a report for grant in aids retrospective of the last ten years to document where funding has gone previously.

9. **Annual Review of CESC Initiatives**
The CESC Strategic Review of Initiatives was presented to the Commission. A copy of the document will be shared with the Commission. The eight initiatives were summarized as follows: Broadband, Education/Edu Tourism, Experience the Gulf Islands, Resource Inventory – Salish Sea Registry, Social Finance, Transportation, Food and Agriculture, and Affordable Housing.

10. **New Business – Commissioner Fenton**
Promotion of off-season tourism idea: Work with the Nature Conservancies and local First Nations to put together a program for visitors to pay to learn about environmental issues / be involved in conservation projects may be a valuable initiative. He is hoping to put together a proposal to bring forward to the CESC and other relevant parties. A pilot project on one island may be useful for proof of concept. "Regenerative Tourism" - suggested he discuss further with the SGI Tourism Partnership Society.

11. **Next regular meeting - March 19, 2024**

12. **Meeting Adjournment**
***MOVED*** by Commissioner Fenton, ***SECONDED*** by Commissioner Farmer that the meeting be adjourned at 2:40pm.

**CARRIED**

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**SOUTHERN GULF ISLANDS ELECTORAL AREA**
**COMMUNITY ECONOMIC SUSTAINABILITY COMMISSION**
**Tuesday, February 6, 2024 at 3:00pm**
**Held by Zoom Video Conference**

**MINUTES**

**SGI CESC Commissioners**: Paul Brent, Director, Chair (Saturna), Mike Hoebel, Vice Chair (Galiano), Marcus Farmer (Mayne), Rob Fenton (Pender), Barbara Johnstone (Pender)
**Staff**: Justine Starke – Manager, SGI Service Delivery, Melody Pender – Recorder/ Pender Liaison; SGI Liaisons: Emma Davis (Galiano), Kat Ferneyhough (Mayne), Katie Dentry (Saturna).

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1. Territorial Acknowledgement/Call Meeting to Order
   Chair Brent provided the territorial acknowledgement and called the meeting to order at 3:06pm

2. Approval of the Agenda
   MOVED by Commissioner Fenton, SECONDED by Commissioner Farmer to accept the agenda as presented. **CARRIED**

3. Discussion on Referral from Islands Trust – Galiano Island

   Southern Gulf Islands Community Economic Sustainability Commission moves to support GL-TUP -2023.3 workforce housing proposal for the following reasons:

   a) the housing is needed now and using trailers, which are available immediately, means the housing can be provided as soon as the servicing is in place ,rather than waiting 2 to 3 years ;
   b) trailers are affordable compared to regular housing ;
   c) trailers are environmentally friendly, compared to regular housing ,as their overall footprint is substantially less due to their size and construction, and occupants use significantly less water than regular housing;
   d) This application delivers what is needed for workforce housing and for a sustainable economy on the islands.

   **MOVED** by Commissioner Hoebel and **SECONDED** by Commissioner Farmer **CARRIED**

4. Meeting Adjourned at 3:22pm

**WILLIS POINT FIRE PROTECTION**
**AND RECREATION FACILITIES COMMISSION**
**MEETING MINUTES**

**Tuesday, April 23, 2024 7:30 PM**

**Present**: Brent Kornelson, Gary Howell, Aran Puritch, Joel Cotter, Director Al Wickheim, Jim Potvin, Vern McConnell

**Absent:** Brian McCandless,

**Guests & Invitees:** Darren Pine, At Wynans, Daniel Kenway

Meeting called to order at 7:30 pm

**1) Approval of Agenda**
**MOTION** by Gary Howell, **SECONDED by** Brent Kornelson that the Agenda be accepted as presented, **CARRIED**

**2) MOTION** by Gary Howell, **SECONDED** by Vern McConnell that the minutes of Mar 26, 2024 be accepted as presented**, CARRIED**

**3) Business Arising:**

a) **Water Cistern Project:** Joel reports he now received all permits and the $144K grant is in the bank and preliminary work should begin in May (see attached report)
b) **Cell Tower:** Brent reports the tower is nearing completion, the excess dirt has yet to be removed. Brent will discuss this with contractor.
c) **Field Improvements:** Daniel the suggested the WPCA might be able to utilize the dirt as fill to raise the level of the grass play field in the saturated south end, there are a group of equipment owners willing to do this project at no cost.
d) **Governance Report:** Aran reports the final CRD approval process has been moved back several months.
e) **Asphalt Hall paving:** no report
f) **Wheel Chair Access:** There have been inquiries for Wheel Chair access to gym portion of the Hall; Al mentioned potential grant money might be available. Consider for next year capital project.
g) **Hall Usage Agreement:** Aran and Bob Scott are finalizing the Hall Usage Agreement incorporating the suggestions recommended by CRD staff.
h) **Wild land fire fighting Guidelines**: Aran will work with Art to draft the call out criteria.
i) **Generator Service Contract**: Vern reminded commission that we will be assuming responsibility for the standby generator servicing, Darren mentioned fire fighter Ryan Leaky might be interceded in doing the servicing. There will also be some rewiring required once the old Rogers cell tower is removed.

**4) Hall Managers Report**: no report

**5) Fire Chief Report:** spring training is underway with 5 new recruits, budget is on track.

**Motion by Brent, seconded by Joel to adjourn meeting 9 pm, CARRIED**

# WILLIS POINT FIRE PROTECTION
# AND RECREATION FACILITIES COMMISSION
# MEETING MINUTES

**Water Cistern Report: Joel Cotter**

**1. All permits from MOTI and funding are in place.**

**2. Brian and I had a meeting 17 April to discuss SOW and other details**

**3. First thing: Dig test hole with small excavator to determine depth of soil and obstructions**

**4. Reg, a tree guy will be looking at the trees this Friday and will provide a price for removal**

**5. SOW for tendering to be developed for main excavation; will be sent to CRD for approval.**

> **a. Site Work: I would like to tender the work on an hourly basis to select contractors. This will be cheaper and more manageable as there are unknowns; SOW for tendering of excavation involves purchase and installation of culvert along Mark Lane; build parking lot and install or not removable bollards; dig and remove soil for tank farm. Install or not engineered fill and gravel as base for tanks.**
>
> **b. Send out request for quote for 8-10 tanks to be delivered and installed.**

**6. Once test holes have been complete and no issues, we proceed as per:**

> **a. Trees to be topped and removed**
>
> **b. Culvert installed and parking lot constructed; bollards installed andtank location excavated and prepped**
>
> **c. Tanks to be delivered and placed**
>
> **d. Plumbing to be installed as per Fire Department specs (possible Cullen Water Service)**
>
> **e. Pea gravel placed by slinger fill between tanks and cover them as per Engineer specs**
>
> **f. Landscape soil to be spread by Slinger.**
>
> **g. Landscaping to be contracted to local company to blend site to surrounding Veg.**