Climate Change Projections

**CLIMATE CHANGE PROJECTIONS SUMMARY**

Prepared for: Richmond School District 38

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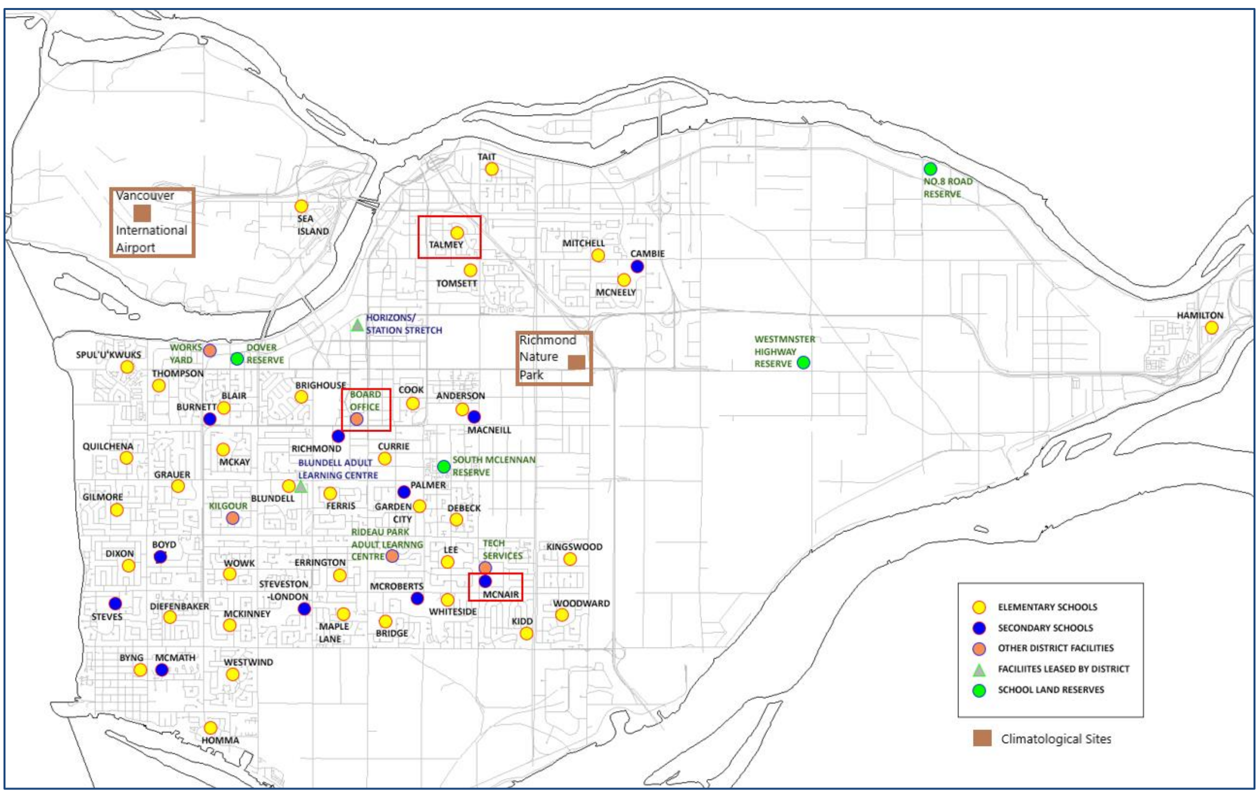
**Limits of Liability**

## Introduction

The changing climate may have adverse consequences on existing infrastructure. To ensure reliable service, operations and occupant health and safety, Richmond School District 38 is assessing potential risks and vulnerabilities due to climate change and extreme weather events for three buildings located in Richmond. These three buildings are listed in the following table:

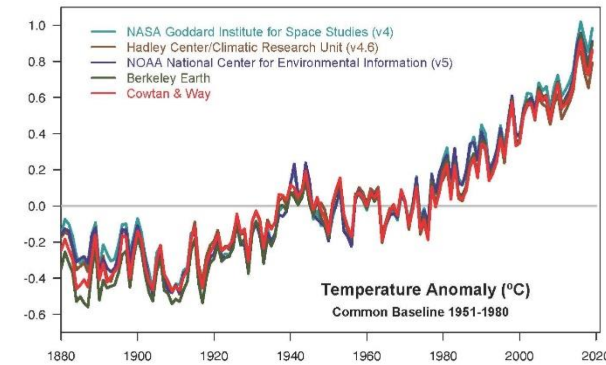
| | Building Name | Address | City |
|---|---|---|---|
| 1 | R.C. Talmey Elementary School | 9500 Kilby Drive | Richmond |
| 2 | Richmond School District 38 Board Office | 7811 Granville Avenue | Richmond |
| 3 | Matthew McNair Secondary School | 9500 No 4 Rd | Richmond |

Guided by principals of the Public Infrastructure Engineering Vulnerability Committee (PIEVC) Engineering Protocol, a Climate Projections analysis has been completed to inform the risk assessments. To provide a baseline of climate variable values for 2020, climate data from the Vancouver International Airport and the Richmond Nature Park was assessed. Both climate observation sites have long records of data collection up to the present and are reliable sources of data. The following map shows the location of the two climate sites as well as the three buildings for which a Climate Change Risk Assessment is being conducted.



## Climate Change

There is ample evidence that the global climate is changing primarily due to human activity, principally through the burning of fossil fuels. The increased concentration of greenhouse gases, including carbon dioxide, methane and nitrous oxide, in the atmosphere has increased the trapping of heat in the lower atmosphere due to the greenhouse effect. Scientists estimate that the atmospheric concentration of carbon dioxide has increased from under 300 parts per million (ppm) to 411 ppm in the last two centuries.




The impact of the changing climate has been significant. Warming of the earth's atmosphere has resulted in a reduction in the extent of sea ice, the melting of glaciers, a reduction in snow packs and stored water supplies, and a rise in the level of the oceans. There has also been an increase in the frequency and severity of extreme weather events, such as floods, droughts, and storms, although the precise link between individual events and climate change cannot be easily made. Changing temperatures and precipitation may impact building mechanical and electrical systems in terms of heating, cooling and ventilation requirements and life-cycle management, as well as drainage, filtration and protection from the elements.

## Methodology

Climate projections begin with a baseline from which to measure change, and then project changes in climate variables following output from Global Climate Models (GCM's). For the Richmond School District 38 projections, the two climate sites of Vancouver International Airport and the Richmond Nature Park, offer an excellent representation of the climate across the City of Richmond. The Airport is representative of the climate near the ocean, with its moderating influence on temperatures, and the Richmond Nature Park represents a climate more typical of the school buildings further inland. In most cases, the baselines were calculated by averaging the data from the two climate sites. To represent 2020 conditions, the data was averaged over the period 2015 to 2020. To calculate extremes, a longer period of data was examined, usually the period 1991-2020.

To obtain the projections of climate variables, two applications were utilized that use downscaled climate model data. ClimateBC v7.0, developed by the UBC Forestry Department, uses the latest GCM data from the Intergovernmental Panel on Climate Change (IPCC) Coupled Model Intercomparison Project 6 (CMIP6). Climate Explorer, a tool developed by the Pacific Climate Impacts Consortium at the University of Victoria, uses an older set of GCM output, but provides an excellent source of derived climate variables. Both applications extend projections to 2100. In most cases, the projections of GCM output by these applications are in terms of 20 or 30 year periods. This report provides decade level projections by interpolating between the longer periods of model outputs.

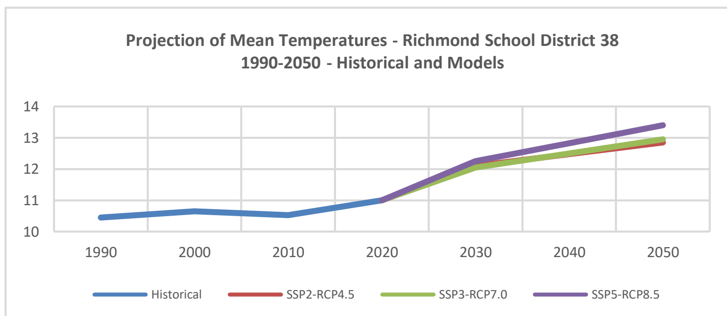
Climate modelers use a number of assumptions concerning the trend of emissions of greenhouse gases (GHG's). Until recently, the assumptions were presented as Representative Concentration Pathways (RCP's) of 2.6, 4.5 and 8.5. The three pathways can be thought of as low, medium and high rates of emissions through 2100. GCM output is based on these assumptions and projections of temperature and precipitation would vary depending upon which emissions scenario was selected. In the latest GCM run of CMIP6, five additional assumptions were added that also factor in possibilities of societal changes between now and 2100. The new assumptions are called Shared Socio-economic Pathways or SSP's. In brief terms, SSP's 1 to 5 can be described as ranging from "sustainability" or lower emissions to "high dependence on fossil fuels" or higher emissions. Out of the fifteen possibilities, three were selected for this analysis: SSP2-RCP4.5; SSP3-RCP7.0 and SSP5-RCP8.5. These could represent medium, high and very high emissions scenarios. Brief definitions of the RCP's and SSP's are provided in an appendix to this report. Lastly, neither GCM's nor the applications used in this analysis provide projections of some climate variables, notably wind or freezing precipitation, for example. In these cases, statistical methods are used to calculate recurrence intervals or return periods.

## Climate Projections to 2050

| Climate Parameters | |
|---|---|
| Temperature | Heating and Cooling Degree Day |
| Lightning | Precipitation (Rain and Snow) |
| Wind | Air Quality |
| Sea Level Rise | Accumulative Effects |

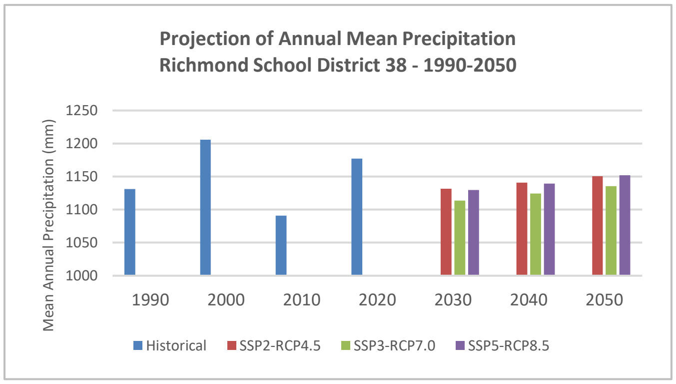
Overall, it is projected that the Richmond School District 38 will become warmer with little change in precipitation through 2050. Models show a slight increase in precipitation over time, but actually project less precipitation initially than has historically been recorded. While snowfalls will decrease in frequency, occasional heavy snowfalls will still be possible through 2050. Freezing temperatures during the winter will become less frequent, with some winters having very few nights with freezing temperatures. Sea Levels will increase by up to 50 cm, and coupled with other high water events, could pose a flooding risk to low-lying property. Air Quality will be impacted by smoke from increasing forest fires in BC and the Pacific Northwest and wildfires in California during the months of July through October.

**Mean Annual Temperatures** will increase by 1.9 to 2.4°C by 2050 with the higher values under the higher emissions scenarios. Extreme maximum temperatures (20 Year Recurrence) that currently occur in the range of 33.7°C will rise to 35.6-36.4°C by 2050. Extreme minimum temperatures (20 Year Recurrence) in the winter, currently as low as -14.6°C, will moderate to -13.1 to -13.4°C. Heating Degree Days will decrease by 20% from an average of 2524 to 1995-2203 HDD. Cooling Degree Days will increase dramatically, from 87 to 326-443 CDD by 2050. Extended warm spells will become more frequent and of longer duration, rising from the current average of 11 days to 36-61 days. Extended cold spells will almost disappear, dropping from 16 days to 6-9 days per year. Frost Days drop from 43 days to 20-27 days by 2050. Summer Days (Temperatures over 25°C) increase by 100%, increasing from 26 days per year to 53-64 days.




Outdoor air temperature is used as design parameter for various building mechanical and electrical systems to ensure system reliability in building operations and occupant comfort. Changes to severe outdoor temperature may impact the designed capacity of building systems. January Design 1% Temperatures will increase by 1.0 -1.3°C by 2050 from the 2018 Building Code values and the 2.5% Design Temperatures by the same amount. The July 2.5% Design Temperature is projected to increase by 2.2 - 3.0°C by 2050, and the July Wet Bulb Design Temperature by 2.5-3.1°C.

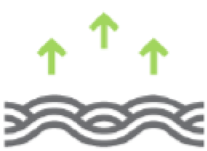
**Mean Annual Precipitation** will change little by 2050 on an annual basis over the 2020 baseline. The baseline precipitation is higher than the models project initially. However, the model trend is towards slightly more precipitation over time. Annual snowfalls are projected to decline by approximately 50% by 2050, from an average of 28 cm to an average of 11 to 15 cm. With moderating temperatures, freezing rain and blowing snow events will be rare if at all. Maximum Daily Snowfalls will range from 22 cm (10 year recurrence) to 35 cm (100 year recurrence).



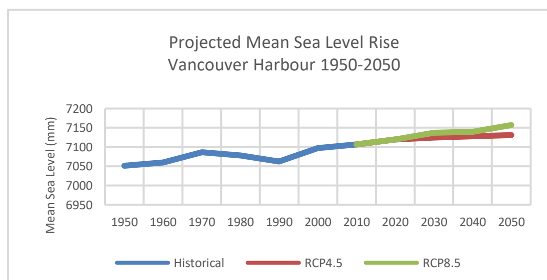

Building design considers intensity and severity of rainfall to determine the required protection from flooding and material resistance to corrosion from extended exposure. Taking into account precipitation informs drainage design and exterior material selection. Extreme rainfalls are projected to modestly increase from the historical patterns based on Climate Model projections and Intensity-Duration-Frequency (IDF) analyses. The maximum 24 hour rainfall with a 100 year return period increases from 98 mm to 115 mm accumulated in the high emissions scenario at 2050. The 15 minute maximum intensity rainfall with a 10 year return period is 9.67 mm increasing to 10.43 mm accumulated by 2050.

**Extreme Winds** are projected on a statistical basis as GCM's do not project wind. Extreme Winds can impact building enclosure. Wind can also have accumulative impact on buildings when combined with other climate parameters such as rain and snow precipitation. Some climate scientists are projecting increased wind storms as more heat in the atmosphere may provide more energy. However, there is no evidence yet from observational data that winds are increasing in step with increasing temperatures.

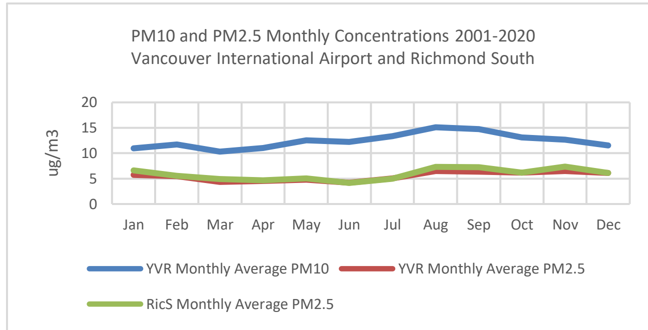
In fact, there is some evidence that globally, winds are decreasing, although the reasons for such a trend are not well understood. The current baseline of 113 km/h as a record is statistically projected to increase to 131 km/h with a 100 year return period for the Richmond School District 38.

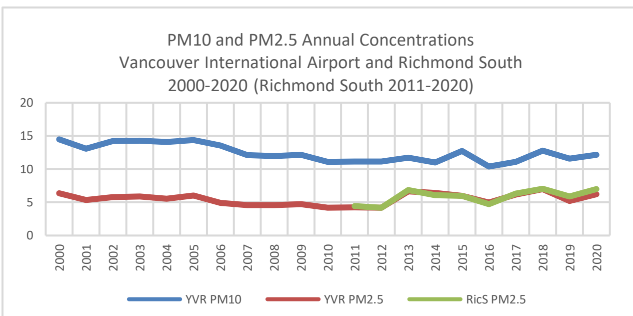


**Sea Level Rise** can cause flooding and infrastructure damage for coastal buildings. Sea levels are measured by a Permanent Service for Mean Sea Level (PSMSL) network of buoys situated around the globe, one of these buoys being located in Vancouver Harbour. Sea levels have been rising for at least a century although the trend in the rise is accelerating in recent decades. The rise in sea levels is mainly due to the melting of glaciers on land and to the thermal expansion of the oceans as the ocean temperature increases. Although the rate of increase over the last century has been approximately 1 mm per year, the rate has been accelerating recently to 2.3-3.7 mm per year. By 2050, sea levels in Richmond are projected to rise by 25-50 cm. While a sea level rise of 50 cm may not pose a significant risk to infrastructure, there are extreme high water level events that, if coupled with the sea level rise, would pose a risk to shoreline property. They include a storm surge of up to 1 metre, extreme tides that occur regularly, and high water levels associated with a strong ENSO (El Nino Southern Oscillation) event. If a shoreline is subject to waves, that is another factor to consider. Should all of the events coincide, though the probability may be low, the impact could be severe. A combination of events would mean an increase in water levels by 2050 of 2.1-2.4 m in Richmond.



**Air Quality -** It is not clear how climate change will directly affect air quality. However, where it concerns the Richmond School District 38, the frequency of smoke from forest fires in B.C. and the Pacific Northwest, as well as wildfires in California, will impact air quality. An increase in wildfire events due to climate change and prolonged periods of smoke particulate in the outdoor air, can impact indoor air quality in buildings and occupant safety. An air quality network in Richmond measures a number of parameters impacting air quality, including Particulate Matter, or PM. Two stations in Richmond, one at the Vancouver International Airport and the other at Williams and Aragon Road in Richmond. The network measures the concentration of PM at the level of 10 microns and 2.5 microns. Both are associated with smoke from a variety of sources including agriculture and vehicles, but during the fire season from July through September, should the atmospheric circulation permit, smoke from forest fires can invade the Richmond School District 38. While the trend of PM concentration has tended to improve in recent decades, the frequency and intensity of forest fires and wildfires is on the increase. Statistics on the number of acres burned show that fires are increasing at the rate of 5 to 9% per year from California to B.C. The two charts show the impact on PM2.5 and PM10 concentrations in Richmond, where there is a significant increase in concentrations July through October, and the general decline in PM concentrations is offset by forest fires periodically after 2012. In August of 2018, the concentrations of PM2.5 reached 187.9 ug/m$^3$ and in October 2020, PM10 reached 189.5 ug/m$^3$. These are levels where health of sensitive individuals could be impacted. With the increase in the extent of fires, and with hotter summer weather due to climate change, periodic high concentrations of PM2.5 and PM10 up to 200 ug/m3 are projected into the future.




## Confidence in Climate Projections

The climate projections in this analysis are impacted by a number of factors that impact the confidence in the projections.

- Observational data in Richmond that has become less reliable and less extensive. The automation of the measurement of certain parameters and the termination of many of the observation programs in the last two or three decades has eroded the confidence in the data to establish a baseline.
- Emission scenarios such as SSP and RCP pathways are complex and difficult to predict into the future.
- Uncertainty in climate models used in this and similar studies is inherent in their design and is mitigated somewhat by averaging projections from multiple models. Nevertheless, model development continues along with updated emission scenarios, and projections should be regularly reviewed

## Summary of Results

### Temperature

- ✓ Warmer mean temperatures by 1.9-2.4oC by 2050, with the higher temperatures projected under SSP5-RCP8.5.
- ✓ Extreme maximum temperatures occasionally (20 year recurrence) over 36oC during the summer by 2050, up from 33.7oC currently;
- ✓ Fewer freezing temperatures in winter, with frost days dropping from 43 per year in 2020 to 20-27 days by 2050;
- ✓ Reduced Heating Degree Days by 20% and dramatic increases in Cooling Degree Days;
- ✓ January Design Temperatures increase by 1.0-1.3oC by 2050; July Design Temperatures Increase by 2.2-3.0oC.

### Precipitation

- ✓ Slightly more (5%) annual precipitation by 2050 although the models diverge from the current baseline. Extreme daily rainfall up from 98 to 115 mm (100 Year Return Periods under RCP8.5).
- ✓ Slightly more intense short duration precipitation by 2050. The 15 Minute Maximum Intensity increasing from 9.67 mm to 10.43 mm by 2050;
- ✓ Less annual snowfall, down from 28 cm to 11-15 cm by 2050;
- ✓ Freezing precipitation and blowing snow will decrease from a few hours per year to nearly zero.

### Wind

- ✓ Wind extremes projected to increase from 113 km/h to 131 km/h based upon 100 year recurrence periods

### Sea Level Rise

- ✓ Trend is accelerating and projected to rise by up to 50 cm by 2050 (and up to 1 m by 2100).
- ✓ Coupled with other high water level events such as a storm surge and extreme tide, water levels could reach 2.1-2.4 m over current levels on Richmond shorelines by 2050.

### Air Quality

- ✓ Although the trend is slightly down in particulate matter (PM) in recent decades, forest fire and wildfire events are on the increase, and will cause a surge in PM in the Richmond School District during the months of July-October through 2050. Periodic concentrations as high as 200 ug/m3 are projected.

# Appendix – Definitions

### Representative Concentration Pathways (RCP's)

Scenarios that include time series of emissons and concentrations of the full suite of greenhouse gases (GHGs) and aerosols and chemically active gases, as well as land use/land cover.

**RCP2.6** One pathway where radiative forcing peaks at approximately 3 W $m^{-2}$ before 2100 and then declines;

**RCP4.5** An intermediate stabilisation pathway in which radiative forcing is stabilised at approximately 4.5 W $m^{-2}$ after 2100;

**RCP8.5** One high pathway for which radiative forcing reaches greater than 8.5 W $m^{-2}$ by 2100 and continues to rise for some amount of time.

### Shared Socio-economic Pathways (SSP's)

SSP1 - Sustainability – Taking the Green Road - The world shifts gradually, but pervasively, toward a more sustainable path, emphasizing more inclusive development that respects perceived environmental boundaries.

SSP2 - Middle of the Road - The world follows a path in which social, economic, and technological trends do not shift markedly from historical patterns.

SSP3 - Regional Rivalry – A Rocky Road - Policies shift over time to become increasingly oriented toward national and regional security issues. A low international priority for addressing environmental concerns leads to strong environmental degradation in some regions.

SSP4 - Inequality – A Road Divided - The globally connected energy sector diversifies, with investments in both carbon-intensive fuels like coal and unconventional oil, but also low-carbon energy sources. Environmental policies focus on local issues around middle and high income areas.

SSP5 - Fossil-fueled Development – Taking the Highway - The push for economic and social development is coupled with the exploitation of abundant fossil fuel resources and the adoption of resource and energy intensive lifestyles around the world.