State of Climate Adaptation

Town of Golden

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ACRONYMS

GDD	Growing Degree Days
EMBC	Emergency Management British Columbia
EOC	Emergency Operations Centre
ICI	Industrial, Commercial and Institutional
GCM	Global Climate Model
LiDAR	Light Detection and Ranging
NDMP	Natural Disaster Mitigation Program
NTU	Nephelometric Turbidity Units
$PM_{2.5}$	Fine Particulate Matter
RCP	Representative Concentration Pathways
RDCK	Regional District of Central Kootenay
RDI	Columbia Basin Rural Development Institute
SoCARB	State of Climate Adaptation and Resilience in the Basin
SWE	Snow Water Equivalent
WUI	Wildland Urban Interface

DISCLAIMER

The data for State of Climate Adaptation indicators has been collected and analyzed by a team of qualified researchers. A variety of municipal, regional and provincial data sets informed the indicator findings. In some cases, community-specific data is not available. State of Climate Adaptation indicator reporting should not be considered to be a complete analysis, and we make no warranty as to the quality, accuracy or completeness of the data. The Columbia Basin Rural Development Institute and Selkirk College will not be liable for any direct or indirect loss resulting from the use of or reliance on this data.

The preparation of this report was carried out with assistance from the Government of Canada and the Federation of Canadian Municipalities. Notwithstanding this support, the views expressed are the personal views of the authors and the Federation of Canadian Municipalities and the Government of Canada accept no responsibility for them.

INTRODUCTION

Purpose

Welcome to the Town of Golden's 2020 baseline report for the State of Climate Adaptation and Resilience in the Basin (SoCARB) indicator suite. SoCARB indicators were designed to provide data and insights relating to climate change, including local environmental impacts and community impacts (e.g., economic impacts), as well as information to help build adaptive capacity and track local actions. Originally developed in 2015, the SoCARB indicator suite measures community progress on climate adaptation across five climate impact pathways: extreme weather and emergency preparedness, water supply, flooding, agriculture, and wildfire.

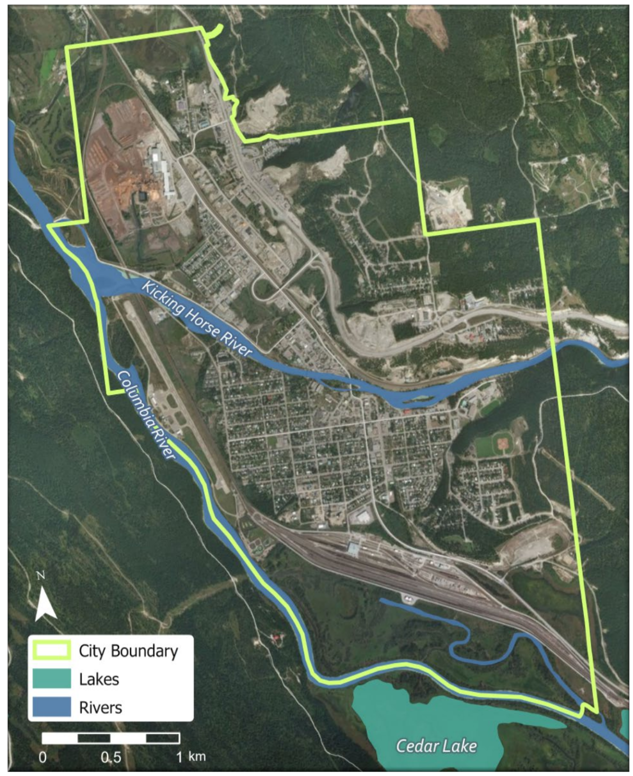

Figure 1: Town of Golden

Climate-related impacts like flooding, drought and high temperatures can be critical events for communities and are examples of events that are projected to occur with greater frequency and/or intensity as the climate gets warmer. Flooding poses a risk to water infrastructure and public safety, and contributes to turbidity in surface sources. Drought has implications for water supply, local food production and increasing wildfire risk. Higher temperatures can impact vulnerable populations, including the elderly, socially isolated, chronically ill and infants.

The information presented in this report is intended to highlight trends and impacts related to the local climate and surrounding environment, and to inform local planning and decision-making. This includes changes in indicators outside of Golden's jurisdiction such as glacier extent and wildfire starts, recognizing that a better understanding of trends associated with these indicators can help the community prepare for current and future changes. For other indicators, like per capita water consumption, local governments are better positioned to identify and track where their actions could increase community climate resilience.

The full SoCARB suite includes 58 climate adaptation indicators. This report, however, excludes indicators that the Town of Golden has not identified as a priority or where sufficient data was not available, as well as all indicators from SoCARB's Community Resilience Index. In addition, the evolution of adaptation practice since 2015 and learnings from pilot implementation in 2016-

2017 with four communities within the Columbia Basin resulted in minor updates to the suite in spring 2019.

Report Highlights

- Golden's climate is changing, with data showing trends toward higher average annual and seasonal temperatures. This upward trend is expected to continue with an increased overall rate of warming. There is also a trend toward more extreme heat days, a longer growing season and more growing degree days. Most historical precipitation trends are not statistically significant, but point to a slight increase in total annual and spring precipitation, and less precipitation in the winter. Future precipitation projections are also uncertain but indicate the potential for further increases in all seasons except summer, as well as small increases in heavy precipitation.
- Climate change is becoming evident through changes in environmental conditions. For example, glaciers in the Columbia Basin region are becoming smaller, the frequency of heavy snowfalls is declining along with spring snowpack, peak streamflows are moving earlier, summer low flow appears to be decreasing, and the amount of heat energy available for crop growth is on the rise.
- The Town of Golden has taken important steps to adapt to changes that have already happened and to prepare for future changes. These actions are primarily related to flood protection and mitigation and wildfire interface fuel treatment efforts. Opportunities exist to further Golden's readiness to adapt, which include exploring additional opportunities to reduce water consumption, and promoting community-based efforts to adapt (e.g., through programs aimed at enhancing personal emergency preparedness, adopting Fire Smart principles, and local food production).
- While some datasets are not lengthy or complete enough to evaluate trends in Golden's adaptation, the analyses conducted for this project provide a valuable baseline assessment against which future progress can be compared.

Methods

The State of Climate Adaptation and Resilience in the Basin indicator suite was released in 2015 by a team of climate change professionals. The full suite separates indicators into two instruments:

1) A set of five thematic pathways (wildfire, water supply, agriculture, flooding, and extreme weather) that, through 50+ indicators, measure climate change, climate change impacts, and climate change adaptation; and
2) a Community Resilience Index that uses an additional 20 indicators to provide insights on socio-economic conditions in the community that contribute to its capacity to adapt.

The Water Supply pathway (Figure 2) illustrates how SoCARB conceptualizes the relationships between categories of indicators. Climate changes have direct and indirect impacts on communities. Indirect impacts are experienced through both environmental and community impacts. Impacts can be addressed through adaptation actions and capacity building, and the results of such efforts improve adaptation outcomes.

For this report, the Town of Golden personnel identified 50 indicators reflecting local priorities. Community Resilience Index indicators were not assessed as part of this report; however, many of these indicators can be found in the RDI's annual State of the Basin reports and Community Profiles . This report includes an introductory Climate section, which presents climate change indicators common to all five pathways, followed by pathway-specific sections following the same structure as Figure 2.

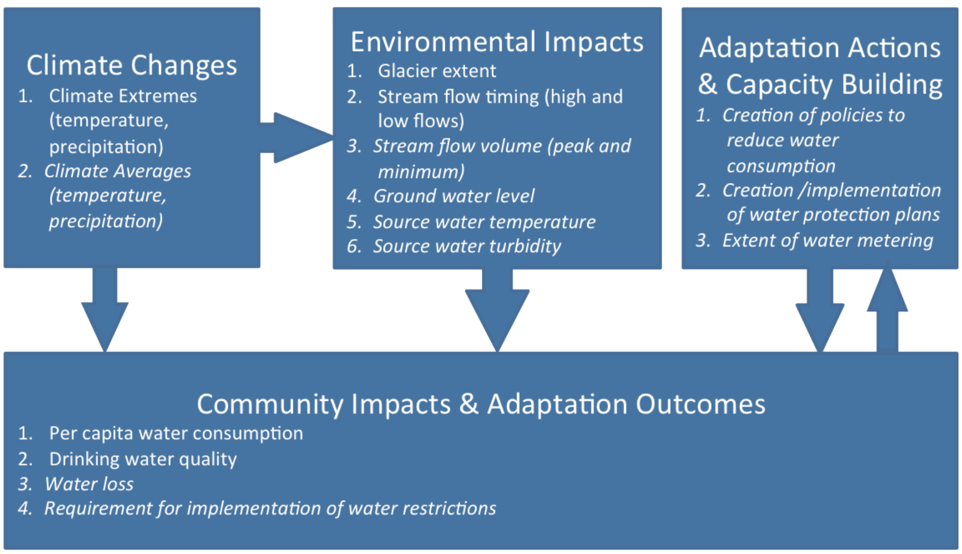

Figure 2: Water Supply pathway from the SoCARB indicator suite

Notes to the Reader

The indicators and their related data sets range from simple to complex. Additional detail on any of the datasets or analytical methods is available from the RDI. Understanding the data and its limitations is important for many reasons. The points below should be considered while reviewing the report.

- **Climate trends are complex**. It is difficult to look at climate trends over the short or medium term because there are other factors beyond climate change that can influence trends. Climate science experts were consulted when analysing and interpreting data for this report.
- **Use of proxy data**. For some indicators, there is no local data source. Where feasible and appropriate, proxy (or stand-in) data sources were used. Golden is one of five Columbia Basin communities with a long-term climate record dating back to 1901. More details are provided in the body of the report.

- **Confounding factors**. An indicator can be influenced by several factors, making it difficult to distinguish the cause of a change. For example, trends in water consumption may be influenced by water conservation initiatives, but other factors (e.g., anomalous weather) must also be considered.
- **No obvious trend**. Some data may show no obvious trend. However, this data still has value as i) a trend may eventually emerge, and ii) the information can still help inform decision making.
- **Trend that is not statistically significant**: Due to high variability and/or short time periods, some data trends fall below 95 per cent confidence levels (i.e. not statistically significant). This does not nullify the presence of a trend; it highlights that there is less than 95 per cent confidence that the trend captures the true mean.

About the Climate Data

Climate data for Golden was provided by Climatic Resources Consulting, Inc. and come from two main sources. Historical climate data was sourced from Environment Canada's Adjusted and Homogenized Canadian Climate Data (AHCCD), which provides long-term (since the early 1900s) observed data. Future projections are modeled and separated into two scenarios: low carbon and high carbon. Climate projections for the 2050s indicate the average for the 2041-2070 period. The low carbon scenario (RCP4.5) is considered to be optimistic and, although insufficient to maintain global temperatures to below 2°C warming above pre-industrial temperatures, would require significant international cooperation that exceeds current commitments of signatories to the Paris climate agreement.[1] The high carbon scenario (RCP8.5) is also referred to as 'business as usual'. Global emissions are still moving along a trajectory that could lead to 3 to 5°C of global warming by the end of the century.[2] Consequently, it is important to consider the high global emissions scenario (RCP8.5) in planning for climate change in the Columbia Basin and Boundary regions. Climate trends, i.e. rates of change, are expressed in units per century, meaning the change per 100 years.

Technical Information on Climate Models

Climate projections are based on output from an ensemble of 12 statistically downscaled Global Climate Model (GCM) projections[3] from the Coupled Model Intercomparison Project Phase 5 (CMIP5),[4] and downscaled using Bias Correction/Constructed Analogues with Quantile mapping recording[5] to a resolution of 10 km by 10 km.

Representative Concentration Pathways (RCPs) are numbered (e.g. RCP8.5 or RCP4.5) according to the radiative forcing in W/m^2 that will result from additional greenhouse gas emissions by the end of the century. Modellers use RCPs to generate scenarios of future climate.

CLIMATE

Four climate change indicators are common to most pathways: climate averages and extremes for both temperature and precipitation. They are presented first since changes in temperature and precipitation are key drivers of both environmental and community impacts. These four indicators encompass both historical trends and future projections for the Town of Golden. Additional climate data can be found in Appendix A.

The Overall Picture

Both annual and seasonal average temperatures are rising in the Golden area and are projected to continue rising through the 2050s. Annual average temperature has been rising by 2.0°C per century. By the 2050s, this rate of change is projected to increase to 3.5°C per century under a low global emissions scenario and 6.9°C per century in a business as usual scenario. Temperature extremes have become more frequent over the last century and are projected to continue increasing in frequency. Total annual precipitation has increased over the last century, but this trend is not consistent across seasons. Total annual precipitation is also projected to increase over the coming decades, with proportionately more precipitation falling in winter and spring under a high carbon scenario. Precipitation extremes do not show statistically significant trends in either historical or projected data for the Golden area.

Average annual and seasonal temperatures are increasing

Analysis of historical climate data for Golden shows increasing temperatures since the early 1900s. During that time average annual temperatures have ranged from a low of 2.0°C in 1911 to a high of 7.1 degrees in 1998. Average annual temperature has been increasing by +1.9°C per century (Table 1). The average annual temperature during the 1961-1990 baseline period was 4.7°C (Figure 3). Average seasonal temperatures have also increased in Golden. Winter temperatures have increased at the highest rate, with trends calculated at +3.3°C per century (Table 1).

Projections for the 2050s indicate that summers will be warming faster than other seasons in both low and high carbon scenarios, and that average annual temperature will increase by 2.6°C in a low carbon scenario, and by 3.2°C in a high carbon scenario.

Table 1: Annual and seasonal average temperature trends (rate of change) for Golden in degrees Celsius per century. Results that are not statistically significant (<95% confidence level)) are in italics.

	Annual	Winter	Spring	Summer	Fall
Historical (1905-2018)	+1.9°C per century	3.3	1.4	2.3	*0.6*
2050s (low carbon)	3.5	*1.7*	3.1	3.3	2.6
2050s (high carbon)	6.9	8.2	6.0	9.3	6.8

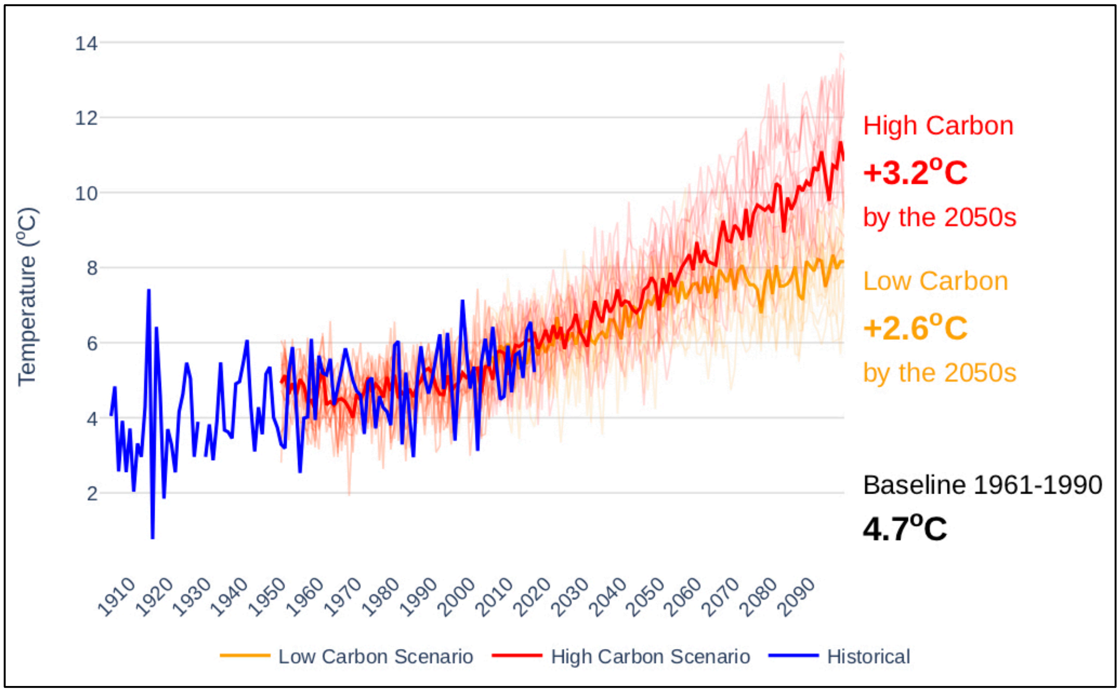

Figure 3: Historical and projected average annual temperature for Golden (1905-2090)

Precipitation trends are uncertain

Due to the high natural variability of precipitation, trends for average precipitation in Golden are not as definitive as those for average temperature and many fall below 95% confidence levels (Table 2). Data for Golden show that average annual precipitation ranged between 241.7 and 624.6 mm per year from 1908 to 2017, with a baseline of 453.7 mm for the 1961-1990 period (Figure 4). The dataset shows a small increasing trend for historical average annual precipitation. Seasonally, the Golden data trend shows that winter precipitation has been decreasing since 1908, whereas it has been increasing in other seasons, but these trends fall below the 95% confidence level, with the exception of spring.

Table 2: Annual and seasonal total precipitation trends (rate of change) for Golden, in millimetres per century. Results that are not statistically significant (< 95% confidence level) are in italics.

	Annual	Winter	Spring	Summer	Fall
Historical (1908-2017)	*8.3 mm/century*	*-23*	19	*20*	*10*
2050s (Low carbon)	*70*	*36*	*21*	*-10*	*8*
2050s (High carbon)	129	93	72	*-41*	*41*

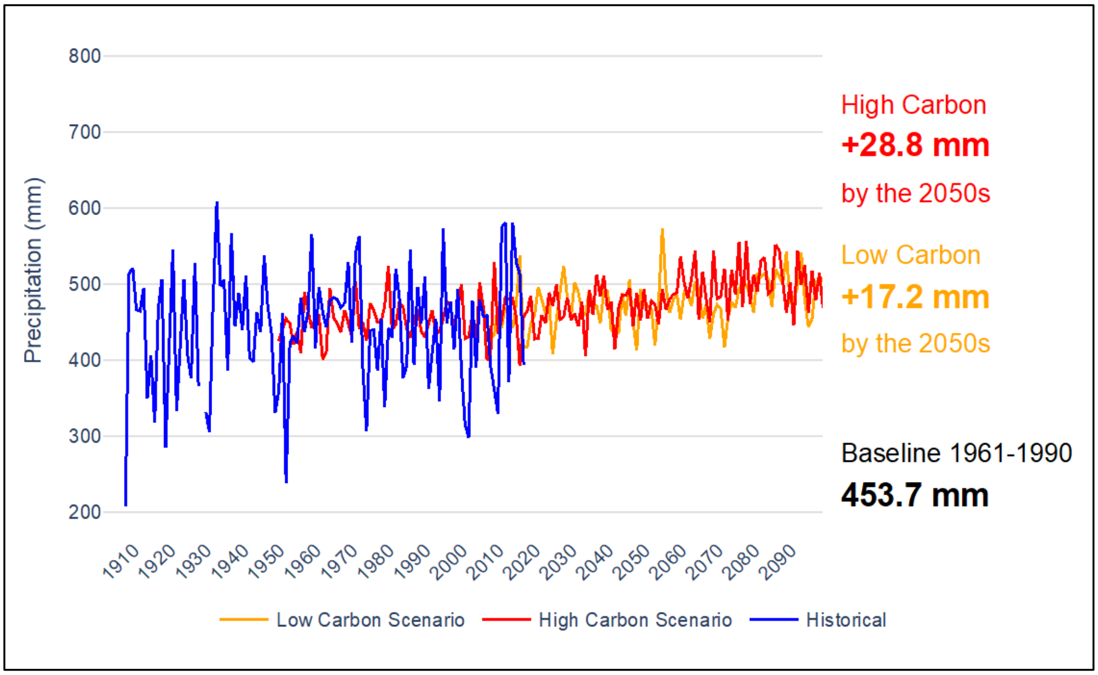

Figure 4: Total average annual precipitation for Golden (1908 – 2090)

Precipitation projections indicate increases of 15 to 28 percent in average annual precipitation by the 2050s, with more precipitation in winter and spring, and less precipitation in summer.

More hot days

The extreme temperature indicator measures the annual sum of days where the temperature exceeds the 90th percentile temperature for the 1961-1990 baseline period. For Golden, this translates into a baseline of 35.6 days above 25.9°C, and a statistically significant rate of increase in hot days (i.e days over 25.9°C) of 14 days per century. Hot days are projected to increase by 29 to 36 days by the 2050s, under low and high carbon scenarios, respectively, and the rate of increase could go as high as 96 days per century by the 2050s in a high carbon scenario.

More days with heavy rainfall

The extreme precipitation indicator measures the average annual sum of daily precipitation exceeding the 95th percentile for the 1961-1990 baseline period and can be described as the amount of rain that falls during very heavy rainfall days. For Golden's baseline period, the 95th percentile threshold for precipitation is 6 mm, with a total of 77.6 mm falling annually on days when precipitation exceeds 6 mm. The historical and projected extreme precipitation trends for Golden show a -58 mm/century downward trend since 1908 and a projected 114 mm/century upward trend by the 2050s in a high carbon scenario, which would add 28 mm (36%) to the 1961-1990 baseline of 77.6 mm. Under both high and low carbon scenarios, Golden in the 2050s is projected to have more heavy rain days above the 1961-1990 95th percentile threshold of 6 mm.

EXTREME WEATHER AND EMERGENCY PREPAREDNESS

Extreme weather events, such as extreme precipitation, windstorms, and heatwaves, can have significant impacts on communities. This was underscored by an independent review of BC's historic flood and fire events of 2017 commissioned by the BC government, which noted that "A range of data from reputable sources points to growing challenges with respect to heat, drought, lightning and intense rains intersecting with snowmelt, underlining the imperative for government to respond in new, different or better ways".[6] The review produced over 100 recommendations to improve emergency preparedness and disaster response. Future projections suggest an increase in some extreme weather events, such as warm days, extreme warm days, and extreme wet days. Communities can prepare for immediate and short-term responses to extreme weather events with adaptations such as emergency preparedness plans, backup power sources, municipal business continuity plans, and home emergency preparedness kits.

The Overall Picture

Golden is experiencing a higher number of extreme heat days than in the past. Other indicators of extreme weather in the area, however, are either lacking long-term datasets or not yet showing the trends that have been identified at larger scales. The Town of Golden's Emergency Plan will help mitigate the impacts of extreme weather events on residents and businesses. The number of Golden residents with emergency preparedness kits is low, suggesting the benefits of providing information, awareness, and encouragement of personal emergency preparedness.

Climate Changes

As discussed in the Climate section, Golden's weather station has recorded increases in annual and seasonal average temperatures, plus a small upward trend in total annual precipitation over the last century. The frequency of hot days has increased and will continue to increase, and a similar but less pronounced trend is occurring in respect of the total amount of rain falling on heavy rainfall days. Additional climate indicators related to the Extreme Weather pathway are discussed below.

Extreme heat days

Temperature data for Golden shows a clear upward trend in the frequency of days over 30°C, growing at a rate of 9 days per century. During the 1961-1990 baseline period, Golden experienced an average of 10.6 days per year above 30°C. By the 2050s this is projected to increase by 19.9 days in a low carbon scenario and by 27.6 days in a high carbon scenario, which translates to 30-38 days per year above 30°C (Figure 5). Heatwaves and heat extremes have negative health impacts on vulnerable populations including the elderly, socially isolated, chronically ill, and infants.

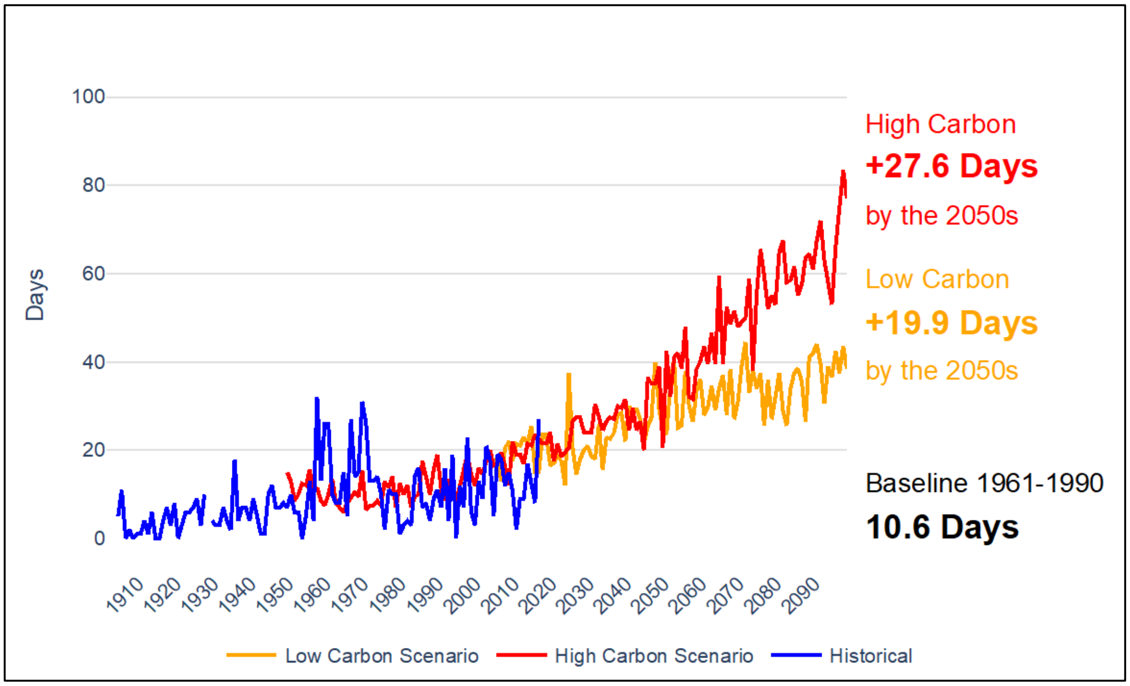

Figure 5: Extreme heat days (above 30°C) in Golden

Heavy Snowfall

Heavy snowfall days are defined as those receiving 15 cm or more over 24 hours. Snowfall records for Golden show a decline of 1.9 days per century in heavy snowfall days from 1908 through to 2018 (Figure 6). Since 1908, Golden has experienced between zero to nine such events each year, averaging 2.2 events per year[7]. During the historical record, the annual average maximum 1-day snowfall was 25.7 cm. There is no trend in the amount of snow falling during 1-day maximum snowfall events over this time period.

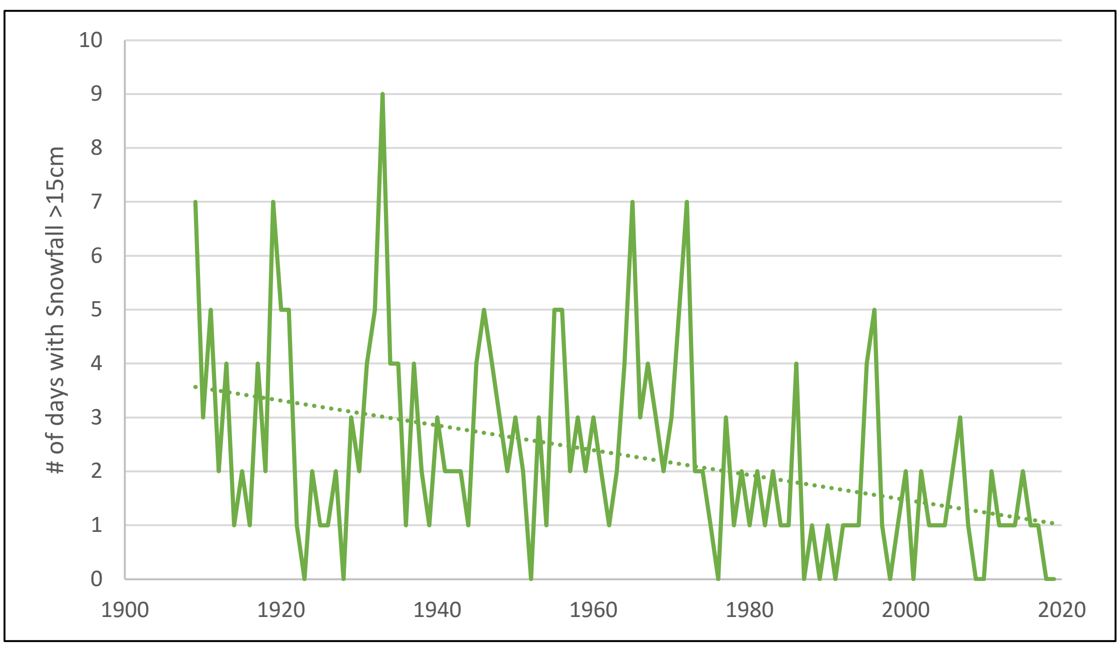

Figure 6: Number of days with snowfall above 15 cm (1909-2018)

Strong wind events characterized by insufficient data

Windstorms can damage infrastructure, bring down power lines and cause power outages. A strong wind event is defined as a day with winds of 70 km/h or more of sustained wind and/or gusts to 90 km/h or more. Wind data has been collected at the BC Ministry of Transportation and Infrastructure's Kicking Horse station since 1989. This station provides an hourly reading of sustained wind speed over a ten-minute period. The data record is characterized by data gaps and is too short to identify a trend in strong wind events.[8] Between 1999 and 2010 there were nine years with relatively complete records showing seven days with gusts over 70 km/h.

Maximum 1-day rainfall has decreased and is projected to increase

Heavy rainfall is a major cause of flooding of creeks and rivers and can cause stormwater management issues, erosion and debris slides. A warming climate generally increases the risk of extreme rainfall events because a warmer atmosphere can carry more water vapour, which can fuel more intense precipitation events. Historical data for Golden indicates 16.9 mm as the 1961-1990 baseline for annual maximum 1-day rainfall, with the highest maximum recorded in 1956 at just over 64 mm. From 1908-2018, maximum1-day rainfall decreased at a rate of -8 mm per century. In contrast, future projections show small increases (10 to 18% relative to the 1961-1990 baseline) in maximum 1-day rainfall by the 2050s under both low and high carbon scenarios.

Adaptation Actions and Capacity Building

Emergency preparedness plans in place

The Town of Golden has an emergency plan that was adopted in 2005. Of the important plan components included in our survey, all but one – plan for emergency shelter stocking – are in place (Table 3). The Town of Golden administers a joint emergency response program with Columbia Shuswap Regional District's Electoral Area A and has a mutual aid agreement in place with Nicholson. Hazard risk assessments are updated annually, and hazard-specific plans are subsequently updated as needed. Golden is also one of the only communities in the Columbia Basin with a dedicated Emergency Operations Centre.

	Included in Emergency Preparedness Plan?			
Component	Yes	In Progress	No	N/A
Hazard risk assessment[1]	☑	☐	☐	☐
Emergency procedures	☑	☐	☐	☐
Municipal business continuity plan[2]	☑	☐	☐	☐
Community evacuation plan	☑	☐	☐	☐
Public communication plan	☑	☐	☐	☐
Designated emergency response centre[3]	☑	☐	☐	☐
Emergency program coordinator	☑	☐	☐	☐

Designated emergency response team	☑	☐	☐	☐
Identified emergency roles and responsibilities	☑	☐	☐	☐
Action list for each type of hazard	☑	☐	☐	☐
Designated emergency/reception shelter	☑	☐	☐	☐
Plan for shelter stocking	☐	☐	☑	☐
Training and emergency exercise plan for response personnel	☑	☐	☐	☐
Contact list for all response personnel	☑	☐	☐	☐
Fan-out call list	☑	☐	☐	☐
Mutual aid agreements with any agencies helping in response (e.g. neighbouring municipalities, school board, local service groups)[4]	☑	☐	☐	☐

Table 3: Emergency preparedness plan components for Town of Golden

Table notes:
1: Reviewed and updated annually
2: This has been updated in the last five years to include more hazard-specific plans, including flooding in the downtown area due to ice jams.
3: The most recent joint emergency operations centre activation was in December 2017 and involved all key emergency response stakeholders.
4: Mutual aid agreements are typically created between communities and with regional districts to facilitate response to emergencies. The Town of Golden administers the emergency program for CSRD's Electoral Area A under the Golden and Area Emergency Management Program Agreement. Golden also has a mutual aid agreement in place with Nicholson.

Essential backup power in place

The Town of Golden has backup power sources in place for its Emergency Operations Centre and City Hall. The drinking water system has sufficient backup power to meet drinking water and fire suppression needs in the event of an emergency. A portion of sanitary sewer lift stations have backup generators. The Town's fire halls and public works yard do not have backup power; however, the Town has arrangements in place to access mobile generators in the community. Other important community facilities with backup power include the Golden & District Hospital, Search and Rescue building, and the local RCMP detachment.

Low resident uptake on emergency preparedness kits

Having an emergency preparedness kit can help alleviate some of the difficulties caused by an extreme weather event. Out of 100 Golden residents who completed a voluntary survey in summer 2019, only 28% of respondents reported having 72-hour emergency preparedness kits in their homes. Of those with kits, 70% reported having them consolidated in an easy to access location. The most commonly reported items in residents' kits were first aid kits, candles and matches, flashlights, can openers, non-perishable food, and water (Table 4). Many residents could better prepare for extreme weather events by compiling complete kits and storing them in a single accessible location.

Table 4: Prevalence of key items in the emergency kits of Golden residents who reported having 72-hour emergency kits

72-Hour Emergency Kit Items	%Yes
Drinking water (2 - 4 litres of water per person and pets per day)	96
Food that will not spoil (minimum 3-day supply)	96
Manual can-opener	96
Flashlight and batteries	100
Candles and matches/lighter	100
Battery-powered or wind-up radio	65
Cash in smaller bills and change	63
First aid kit	100
Special items such as prescription medications, infant formula or equipment for people with disabilities	63
Extra keys that you might need (e.g. for your car, house, safe deposit box)	63
A copy of your emergency plan including contact numbers (e.g. for out-of-town family)	42
Copies of relevant identification papers (e.g. licenses, birth certificates, care cards)	67
Insurance policy information	70
Mobile phone charger	81

Community Impacts and Adaptation Outcomes

Weather-related highway closures dominated by mudslides

From 2006 to 2017, there were 36 weather-related highway closures in the Golden area (Figure 7), lasting for a cumulative total of 256 hours (10.7 days). The most extreme year was 2007, which saw 16 closures due to mudslides (12), rockslides (3) and freezing rain (1), with many of these events occurring in mid-March and mid-May[9]. Most closures occur on Highway 1 between Golden and Revelstoke.

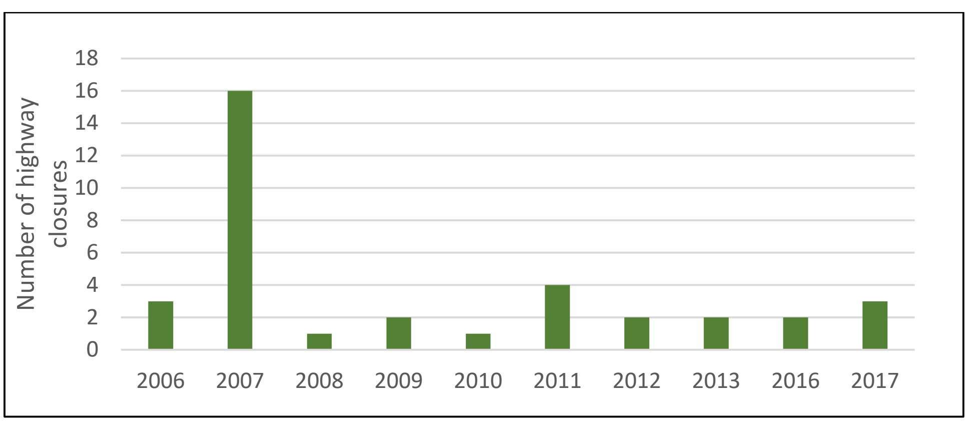

Figure 7: Number of highway closures in the Golden area (2006-2017

Avalanche-related highway closures have averaged 4.5 per year

While the impact of climate change on avalanches in BC's interior remains inconclusive[10], avalanche professionals are predicting more wet avalanches, reduced avalanche activity at lower elevations and increased avalanche activity at higher elevations.[11] From 2002 to 2019, there were 81 closures on Highway 1 east of Golden due to avalanche hazard and/or control, lasting for a cumulative total of 536 hours (just over 22 days). This is an average of 4.5 incidents per year and 30 hours of closure[12]. Data for avalanche closures on Roger's Pass west of Golden are recorded by Parks Canada. From 2006 to 2017, there were 480 closures, or an average of 40 closures per year and 8.4 hours per closure. The fewest closures occurred in 2006, with 20 closures totalling five days and approximately 15 hours. The most closures occurred in 2011, with 79 closures totalling 27 days and approximately 13 hours. No trend is evident in these short datasets.

Power outages due to adverse weather

Longer-duration power outages caused by extreme weather events can have significant impacts on local economies, health, and quality of life. BC Hydro data for Golden identifies outages caused by adverse weather, including floods, mud/snow slides, lightning, snow, and damage to trees between 2014 to 2018. The most common causes of outages are fallen trees and branches. The duration of outages ranged from 4 minutes to just under 55 hours, averaging 8.1 hours. Total annual outages ranged from a low of 24 in 2016 to a high of 158 in 2017. From 2015 to 2018 the average was 70 per year for an average total duration of 393 hours[13].

Provincial emergency assistance

Monitoring emergency assistance funding issued by the province can provide some measure of the economic impact of a disaster and associated recovery over time. Since 2013, the Town of Golden has had several significant weather-related events that resulted in provincial emergency assistance totalling $322,004. The events included three ice dams on the Kicking Horse River and a slide on Selkirk hill.

WATER SUPPLY

Projected changes to the climate could influence both the supply of and demand for freshwater for human use. Shifts in temperature and precipitation could change the amount of water stored in the snowpack and the timing of surface water availability in the spring. The water supply pathway focuses on the quality and quantity of water available for consumptive use and adaptation actions that help to conserve and protect the water supply. As noted in its 2016 *Water Smart Action Plan*, the Town of Golden operates a relatively complex water utility that relies on five groundwater sources and includes five storage reservoirs in three different locations and elevations. As of 2019, the Town of Golden's water utility has 1584 connections. Of these, there are 1287 unmetered residential connections, and 297 industrial, commercial, and institutional (ICI) connections. Peak water demand typically occurs in the months of July and August.

The Overall Picture

While the trend toward a wetter winter and spring in Golden may have positive implications for water supply, the overall warming trends and decline of glacial extent and spring snowpack may have the opposite effect. Regional research suggests changes to the climate could alter stream flow timing and reduce the volume or quality of water available for human use and for recharging the groundwater aquifer that Golden relies on for its water supply, especially in late summer and early fall. The short-term datasets available for Golden's source watersheds limit the assessment of this regional trend at a local level. The Town's water system demonstrates some of the challenges common to utilities in small communities, including limited system data and limited resources for system monitoring and improvements. At the same time, the Town of Golden is active in fixing system leaks and providing on-going public education on water consumption and conservation.

Climate Changes

As discussed in the Climate section, average annual and seasonal temperatures are increasing, and are projected to continue increasing over the coming decades. Annual precipitation has increased by a small amount over the last 100 years. Future projections indicate an increase in total annual precipitation by the 2050s under both low and high carbon scenarios, with less rain in the summer, and more rain in the other three seasons.

Environmental Impacts

Glacier extent

Glacier extent in the Canadian Columbia Basin declined by 15 per cent from 1985 to 2005 and glaciers are projected to mostly disappear by 2100.[14] Glaciers in the Basin lost an average of 80 cm of ice thickness per year from 2014-2018, a rate four times greater than the period 200-2009.[15] A decline in glacier extent and glacial meltwater has implications for reduced summer stream flow and higher summer water temperatures in water bodies that receive glacial flow. Figure 8 shows how the extent of the Wapta Icefield has changed since 1985. Notably, the glacial-fed Yoho River is a primary tributary to the Kicking Horse River.

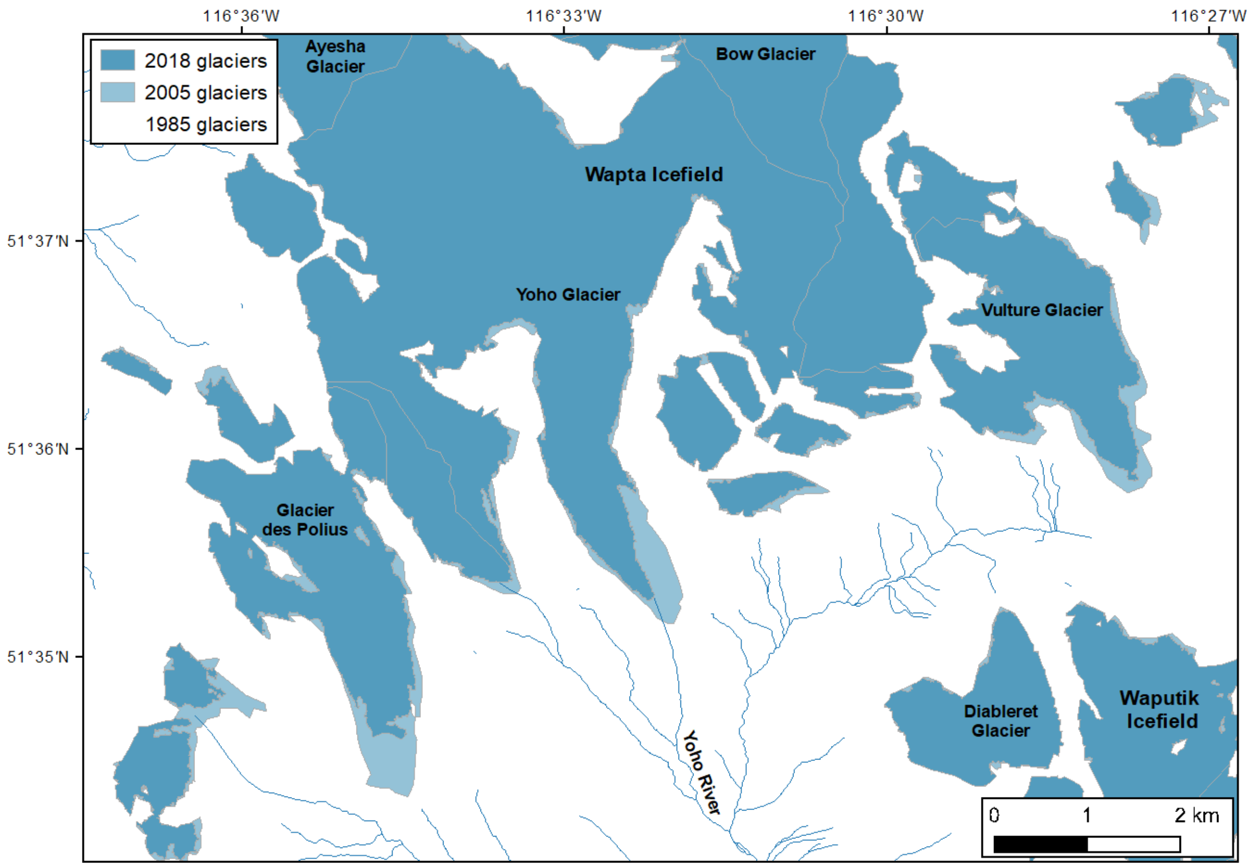

Figure 8: Change in glacier extent of Wapta Icefield (1985-2018)[16]

Peak stream flow is happening earlier

Stream flow timing is sensitive to climate change, especially in snowmelt-dominated river systems such as those in the Canadian Columbia Basin. Long-term stream flow gauging for the Columbia River at Nicholson (station # 08NA002) extending back to the early 1900s allows for an investigation of trends in streamflow timing over the past century. Streamflow data is also available for the Kicking Horse River at Golden (station #08NA006).

For the Columbia River at Nicholson, the nearly continuous record reveals that the timing of the annual maximum daily flow and half total annual flow have shifted substantially since gauging began (Figure 9). The timing of the maximum daily flow has shifted so that it is occurring on average 10 days earlier than during the early 1900s. Similarly, the timing of the half total flow day has shifted over six days earlier than in the early 1900s. The trends to earlier maximum daily flows and half annual flows are both statistically significant at the 95% confidence level.

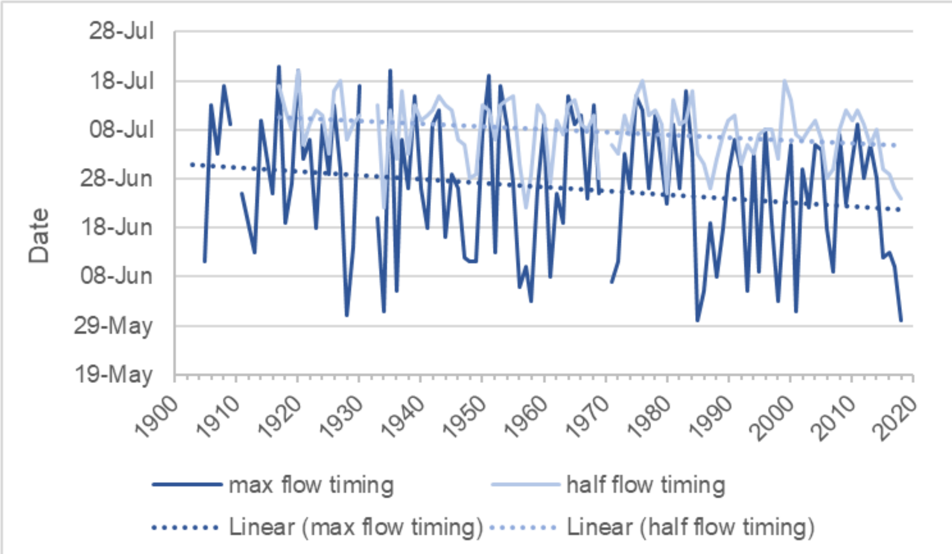

Figure 9: Timing of maximum daily flow and half total flow for the Columbia River

A shift to earlier runoff is also apparent on the Kicking Horse River, which has been monitored continuously since the early 1970s. Streamflow gauging was also conducted at this site between 1916 and 1922 and is included to provide information on longer-term trends. The timing of half total annual flow is almost 8 days earlier now than in the early 1900s (Figure 10). This trend is statistically significant at the 95% confidence level. The timing of summer low flows has also moved earlier by over three days since the early 1900s, although this trend is not significant at the 95% confidence level. There is no detectable trend in the timing of annual maximum daily flows.

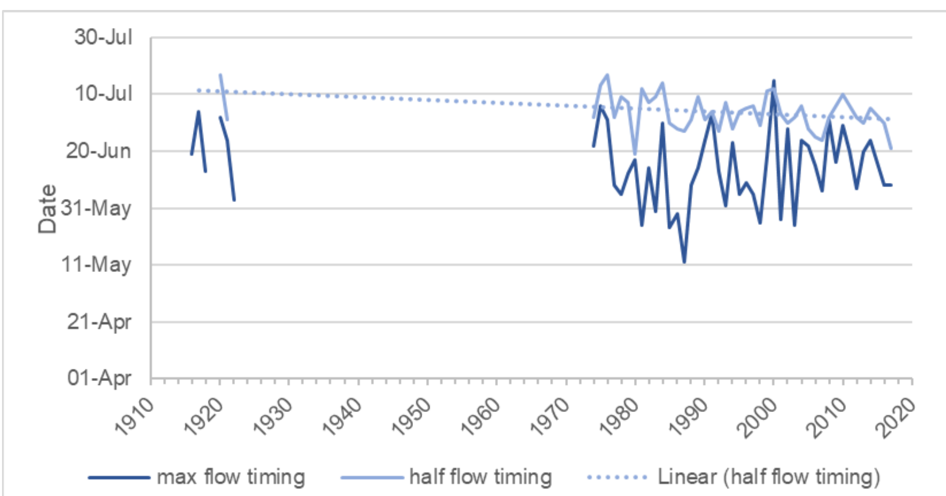

Figure 10: Timing of half flow volume on the Kicking Horse River

Stream flow volume appears to be decreasing in summer

No long-term trends in stream flow volume are apparent for maximum daily flows or half total annual flow on the Columbia River at Nicholson. A decrease in summer low flow volume of just over 8 percent is apparent but this trend is not significant at the 95% confidence level (Figure

11). However, a visual inspection of the summer low flow data indicates there has been a decrease in the variability of low flow volume over the past century. An F-test to compare two variances confirms that the variability of low flows in the past 30 years is significantly lower than those of the past ($\alpha = 0.05$). This trend is particularly concerning because it relates to runoff from alpine regions.

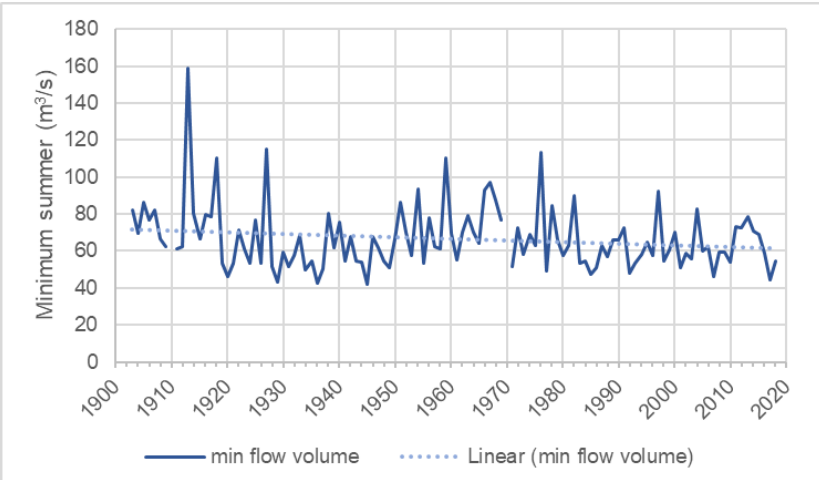

Figure 11: Summer low flow volumes on the Columbia River. Note trend is not statistically significant.

The volume of summer low flows has decreased for the Kicking Horse River (Figure 12). When the early 1900's flows are included in the trend analysis summer low flow volume has decreased by 4% over the past century. This trend is statistically significant at the 95% confidence level. There are no detectable trends for maximum daily flow volume or half annual flow volume on the Kicking Horse River.

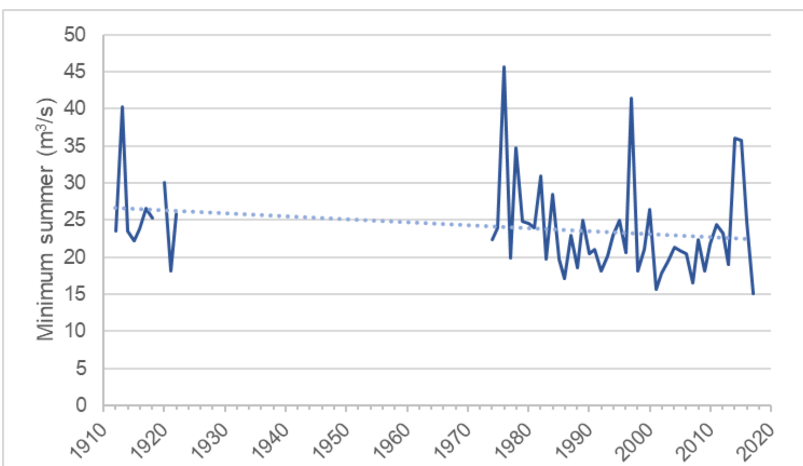

Figure 12: Summer low flows on the Kicking Horse River.

Groundwater levels are sensitive to surface runoff

The Town of Golden relies exclusively on groundwater sources for its water supply. The Town of Golden monitors groundwater levels for two of its wells. In addition, the Province of BC has operated a groundwater observation well on the south side of Golden since 1989. The data shows that groundwater levels have been relatively stable over the last 30 years, with an annual peak that corresponds with spring freshet and lowest levels occurring in late winter. Levels typically fluctuate annually within a predictable range of 22.5 to 24.5 metres.

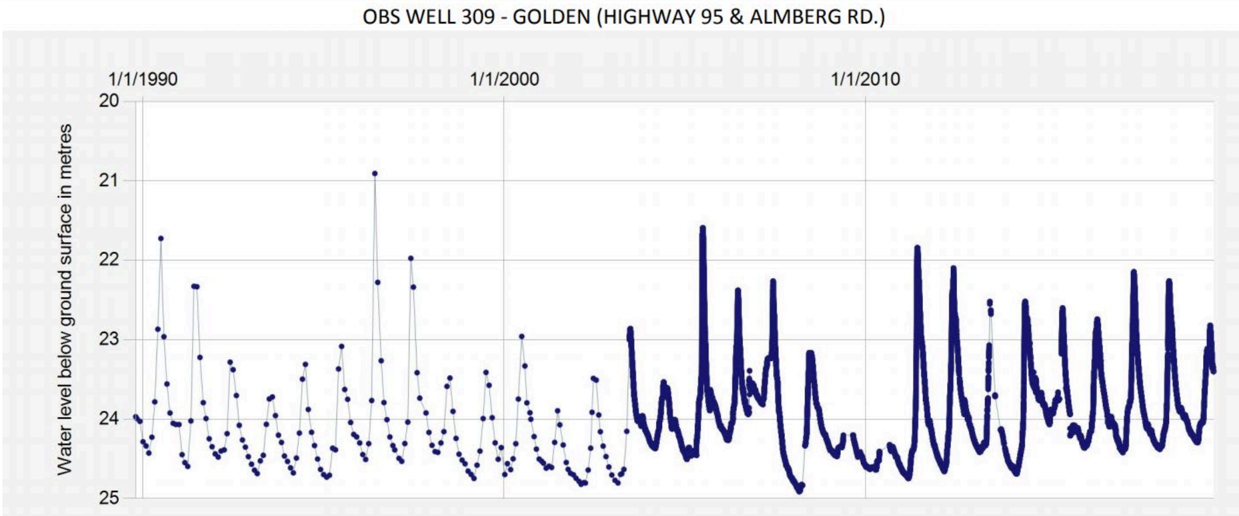

Figure 13: Groundwater levels for provincial groundwater observation well in Golden

Limited well log information available from the Province's groundwater wells and aquifers database[17] indicates that groundwater from wells in the town of Golden is derived from productive aquifers in alluvial gravels roughly 80 feet below the surface. Annual fluctuation in these wells indicates that there is relatively high connectivity between surface runoff and groundwater levels.

Source water temperature meets aesthetic objectives

Temperature can be an important determinant of water quality. Golden's source water comes from five groundwater wells – two on the north side of the Kicking Horse River and three on the south side. The Town of Golden does not do continuous temperature monitoring at its well stations. The Columbia Shuswap Regional District conducts sampling three times per year at Well 4. Water temperature for Well 4 was reported as 5°C in November and 12°C in May/June based on samples recorded in November 2007 and May 2015. These temperatures are well below 15°C—the aesthetic objective set by Health Canada for drinking water sources.

Source water turbidity is very low

Higher turbidity can result in boil water notices or water quality advisories. A turbidity reading less than 1 NTU is considered good quality, between 1 to 5 NTU is rated as fair quality, and a reading greater than 5 NTU indicates poor drinking water.[18] Golden's groundwater wells consistently supply water well below 1 NTU, averaging around 0.08-0.1 NTU.

Adaptation Actions and Capacity Building

Policies to reduce water consumption

The Town of Golden has implemented a range of water conservation measures, including water conservation targets, public education on water conservation, volumetric billing for industrial, commercial, and institutional users (ICI), water operator training and moderate implementation of targeted leak repair. Table 5 provides insights on opportunities to strengthen policies and practices to reduce water consumption.

Table 5: Implementation of policies to reduce water consumption in the Town of Golden

	Level of Implementation			
Policy/Practice	Full	Moderate	Minimal	None
Universal water metering	☐	☐	☐	☑
Public education and outreach on water conservation	☑	☐	☐	☐
Public education and outreach on water consumption trends	☑	☐	☐	☐
Water meter data analysis	☐	☐	☑	☐
Consumer billing by amount of water used (volumetric)[1]	☐	☑	☐	☐
Implementation of water utility rates sufficient to cover capital and operating costs of water system	☐	☑	☐	☐
Water conservation outcome requirements for developers	☐	☐	☑	☐
Water conservation targets	☑	☐	☐	☐
Stage 1 through 4 watering restriction bylaw[2]	☐	☑	☐	☐
Enforcement of watering restriction bylaw	☐	☐	☑	☐
Drought management plan	☐	☐	☐	☑
Actions to address water system leaks:				
Targeted leak repair	☐	☑	☐	☐
Water operator training	☑	☐	☐	☐
Replacement of aging mains	☐	☐	☑	☐
Addressing private service line leakage[3]	☐	☐	☑	☐
Pressure management solutions	☐	☐	☐	☑

1. *ICI customers only*
2. *Golden has a water restriction bylaw in place; however, it does not include Level 1-4 graduated restrictions.*
3. *If applicable, ICI customers will be sent leak notices with their account billing.*

Source water protection plan and climate change

The British Columbia Water Resources Atlas[19] shows the Golden area on a shallow sand and gravel aquifer that is highly productive and moderately vulnerable to contamination from surface land uses and events. Three of Golden's five municipal wells are located in the floodplain. A *Municipal Groundwater Supply Protection Strategy* was adopted in 2013, followed by a

Groundwater Monitoring Plan in 2014. The Town of Golden's *Municipal Water Supply Contingency Plan* is updated annually and integrated into the Town's *Emergency Response and Recovery Plan* as well as its *Water Operations Emergency Response Plan*. The Town has developed response procedures for protecting the community water supply in the event of impacts from flooding, landslides, power outages, fire or loss of source. There are numerous private wells in Golden and it is unknown how many of these wells are properly capped and protected from contamination in the event of a major flood event.[20]

Water loss detection practices

The Town of Golden was a participant in the Columbia Basin Water Smart program from 2009 to 2015. The Water Smart program supported Basin communities to develop capacity for water loss detection. Acoustic leak detection is the Town's primary tool for identifying water loss in its system. Night flow analysis and water loss audits see some application (Table 6). Golden requires metering for industrial, commercial and institutional (ICI) users, as well as multi-family dwellings constructed since 2008. There are also several legacy multi-family dwellings with metering.

Table 6: Implementation of water loss detection practices in Golden

	Level of Implementation			
	Full	Moderate	Minimal	None
District water meters	☐	☐	☐	☑
Residential water meters	☐	☐	☐	☑
Night flow analysis	☐	☐	☑	☐
Water loss audits	☐	☐	☑	☐
Acoustic leak detection	☐	☑	☐	☐
Leak noise correlation testing	☐	☐	☐	☑

Community Impacts and Adaptation Outcomes

Per capita water consumption

This indicator measures water use attributable to user demand and system water loss. Due to its location and recreational amenities, Golden receives substantial daily and short-stay visitor traffic via highways #1 and #95. Peak day consumption, which normally occurs in July or August, is approximately double the average daily consumption (Figure 14); as a result, a typical analysis of per capita water use over the course of a year may provide limited insight. Total water use was highest in 2017 and lowest in 2012. November typically sees the minimum consumption, which in 2018 was roughly 40 percent of the average daily consumption. Data collected through the Water Smart program demonstrated a correlation between increased water demand and temperatures above 14°C.[21] The average daily residential consumption in Golden was approximately 641 litres per person per day; the provincial average is 312 litres per day according to the 2016 BC Municipal Water Survey.[22]

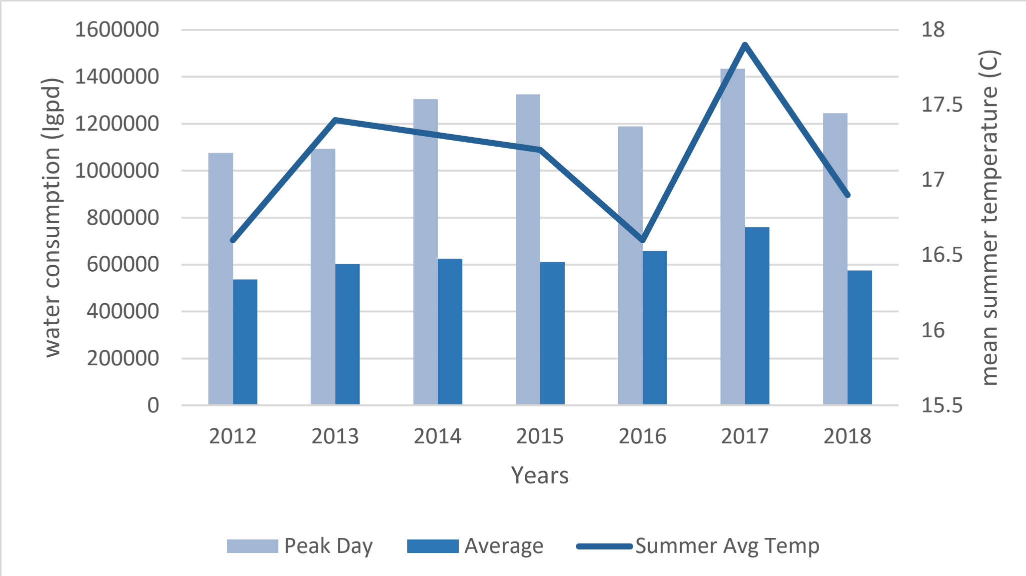

Figure 14: Peak day and average annual water consumption 2012-2018 with summer temperatures (JJA)

Drinking water quality

Water utilities are required to notify residents of high turbidity and/or the presence of pathogens in drinking water. The frequency of notices could increase with climate change due to potential changes in surface water quality associated with rising temperatures or more rapid runoff. Golden relies exclusively on groundwater for its water supply, which minimizes this risk. Water quality is tested weekly, with samples drawn from each wellhead and alternating reservoir sites. Golden's water monitoring program exceeds the requirements of the BC *Drinking Water Protection Act*. Since 1992, Interior Health Authority has issued only one Water Quality Advisory for Golden, due to high turbidity in 2008.[23]

Watering restrictions

Watering restriction bylaws provide a tool for utilities to reduce their vulnerability to water supply challenges, and by tracking the need to implement these restrictions, water operators can better understand how climate change is affecting supply and demand. The Town of Golden's *Water System Rates and Regulations* bylaw (2017) designates watering times based on the physical address of water users and contains provisions to increase water restrictions when warranted by weather and climate conditions or other system disruptions that make it necessary to conserve water for more essential uses. These restrictions are not enforced.

Water loss

The Town of Golden has estimated that its water system experiences an average of 20% leakage on a year-over-year basis. Leak detection and repairs are on-going. For example, in late 2017 and 2018, six leaks were detected and repaired, equivalent to approximately 4 to 5 per cent of the system's total pumping capacity. The Columbia Basin Water Smart Summary Report states that leakage within most systems in the Columbia Basin is 30-40% and that this is typical of aging systems in developed nations, and particularly small rural systems.

FLOODING

Projected climate changes, including more extreme precipitation events, warmer wetter winters, and more precipitation in spring all indicate a potential for greater flood risk. Flooding affects communities through damage to homes and infrastructure and negative impacts on water quality. Certain areas in Golden are vulnerable to flooding by the Kicking Horse River, Columbia River, and Hospital Creek. In many cases, including ice jams, flooding occurs rapidly, which may require the rapid implementation of emergency measures by the community. In addition, as Golden depends on groundwater for its drinking water supply, protection of the aquifer from surface and soil-based contaminants mobilized by flooding events is a high priority.

The Overall Picture

While Golden has not yet experienced the trends toward more extreme precipitation that some studies have predicted for our region, a trend toward higher average winter and spring precipitation may drive more rapid snowmelt, increasing spring flood risk. This risk may be partially mitigated by a declining trend in spring snowpack. A significant portion of the community is located within the floodplain of the Kicking Horse and Columbia rivers. The Town has been active in addressing flood risk for many decades and is taking major steps in 2019-2021 to increase flood protection and mitigation, including updating its floodplain mapping, completing a major dike works project on the Kicking Horse River, and initiating an ice jam monitoring program.

Climate Changes

As discussed in the Climate and Extreme Weather sections, trends toward more extreme rainfall have not been confirmed through an analysis of historical climate data for stations in and around Golden. An analysis of average precipitation data shows rising annual and spring precipitation. This upward trend is projected to continue into the coming decades with the biggest increases occurring in total annual, winter, and spring precipitation.

Freeze-thaw cycles

The frequency of freeze-thaw cycles is an important parameter for engineering design in cold regions and is based on the number of days when the temperature cycles between <-2°C to >+2°C. The historical data for Golden covers 1905 to 2018 and shows an annual downward trend of -26 days per century. The decline is occurring in the spring and fall seasons, with no discernible change to freeze-thaw cycles in the winter season. The downward trend in days with freeze-thaw cycles is projected to continue through the rest of the century, dropping from 59.2 days per year in the 1961-1990 reference period to 41.6 days per year by the 2050s in a high carbon scenario and 44.7 days per year in a low carbon scenario. Winters in the 2050s are projected to have more freeze-thaw cycles, increasing by 4.6 to 5.5 days in high and low carbon scenarios, respectively.

Environmental Impacts

As discussed in the Water Supply section, there is no discernible long-term trend in maximum daily flow volume in the Kicking Horse or Columbia Rivers near Golden; however, there is a trend to earlier stream flow timing. One additional environmental impact indicator from the Flooding Pathway is covered below.

April 1st snowpack is declining

Snowpack data provides an indication of the amount of snow available to contribute to water supplies and flooding. Rates of change in April 1st snow water equivalent (SWE) show a statistically significant decline of approximately 133 mm per century at the Kicking Horse snow station (50 km west of Golden at elevation 1650 m) since 1947 (Figure 15). Kicking Horse April 1 SWE averaged 347 mm during this period; while data for the Beaverfoot site (8 km SE of Golden at 1890 m elevation) also shows declining April 1 SWE, this trend is not statistically significant.[24]

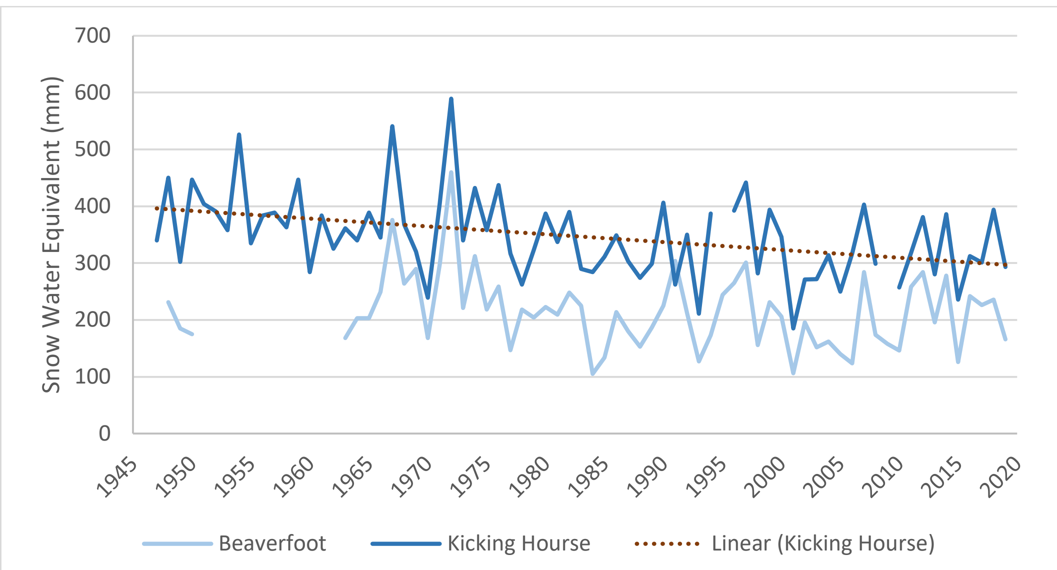

Figure 15: April 1st snowpack at Kicking Horse and Beaverfoot

Adaptation Actions and Capacity Building

As discussed in the Extreme Weather section, the Town of Golden has an Emergency Preparedness Plan in place.

Floodplain mapping is being updated

During 2019 and 2020, the Town of Golden is updating local floodplain mapping first completed by the BC government in 1979. This project is expected to be completed by spring 2020, producing digital files delineating floodplains, i.e. low lying areas at risk of rising waters, and flood hazard areas such as alluvial fans and areas at risk of debris torrents.

Flood protection expenditures are significant

Information on spending related to flood protection infrastructure provides some measure of a local government's efforts to improve their resilience to climate change. The Town of Golden is situated on the alluvial delta of the Kicking Horse River and has been diking and armouring the banks of the Kicking Horse River since the 1960s to mitigate against flood risks. Armoured dikes along the Kicking Horse River combined with existing road and rail embankments along the Columbia River act as flood protection for the town. Annual expenditures for dike-related operational flood protection work typically average $100,000 to $200,000 per year and annual expenditures for minor improvements/maintenance work related to stormwater and overland flooding average between $60,000-$100,000 per year.

The Town is currently undertaking a $5.87 million major dike works project, also known as the Kicking Horse River Dike Improvement Project, which will create a 1-meter freeboard above the 1-in-200-year flood elevation in priority areas. This project will be completed in 2021.

In November 2019, the Town of Golden initiated an Ice Monitoring Program for the Kicking Horse River. The Ice Monitoring Program is designed for long-term monitoring of ice jams on the Kicking Horse River and may provide early warnings of ice jams through remote monitoring of the river upstream of the town. Long-term data will be used to more accurately understand the frequency and severity of ice jams and track how they are affected by climate change.

Community Impacts and Adaptation Outcomes

Provincial emergency assistance for flood events

As noted in the Extreme Weather section, the Town of Golden has had several significant weather-related events since 2013 that resulted in provincial emergency assistance totalling $322,004. The events included three ice dams on the Kicking Horse River and a slide on Selkirk hill.

Large number of dwellings in the floodplain

According to floodplain mapping from 1979, Golden has 1697 developed and 218 undeveloped properties in the floodplain. This figure does not include properties in the Hospital Creek floodplain. Updated floodplain mapping in 2020 will provide a current assessment of flood risk to properties and could help the Town of Golden determine whether any additional flood protection works, development policies or practices are needed to support community resilience to flooding.

Mudslides were the main cause of highway closures

Since the provincial government began recording highway event data in 2006, 21 highway closures have affected Golden.[25] Twenty were caused by mudslides – with a record 12 mudslides in 2007. The mudslide events resulted in approximately 12 days of closures in total, and one washout closed Highway 1 for 29 hours.

AGRICULTURE

Climate has a significant, but complex, impact on food growing activities, with some projected climate changes expected to increase productivity and others reducing it. Climate change also has the potential to negatively affect food production in other parts of the world, which means that locally produced food and local food self-sufficiency could become important climate adaptations in the coming years. The Agriculture Pathway helps tracks the climate-related viability of food production, the impact of climate change on agricultural activity, and the degree to which farmers and backyard growers are prepared to deal with climate change.

The Overall Picture

A trend toward higher temperatures is influencing the growing climate in the region, with Golden experiencing more growing degree days than in the past and a small increase in the length of the growing season. Continued monitoring of drought levels will help planners understand how changing temperature and precipitation regimes are affecting agricultural viability and local food production. The number of Golden residents engaged in backyard gardening shows local enthusiasm for food self-sufficiency.

Climate Changes

As discussed in the Climate and Extreme Weather sections, average annual and seasonal temperatures are increasing, as is annual and spring precipitation. While Golden has not yet seen a significant trend in extreme precipitation, projections show it increasing, along with more precipitation in winter, spring, and fall. Summer precipitation is projected to decrease, and both the number and frequency of extreme heat days are on the rise.

Environmental Impacts

Drought Index is too short to infer a trend

The BC Drought Index is comprised of four core indicators: Basin snow indices; seasonal volume runoff forecast; 30-day percent of average precipitation; and 7-day average streamflow. This data set is too short to infer any kind of trend; however, it will contribute to creating a baseline against which future conditions can be assessed. Golden is situated in the Upper Columbia Basin. From 2015 to 2019, this Basin experienced an annual average of 67 “dry days” based on an average sampling season of 150 days, with a low of 42 and a high of 85 dry days. Unlike its counterparts elsewhere in the Columbia Basin and Boundary region, the Upper Columbia Basin did not experience any “very dry” days during this period[26].

Length of the growing season is increasing

A longer growing season[i] allows for a greater diversity of crops (especially crops requiring longer days to maturity), greater flexibility in early planting avoiding late summer drought, and more time for plant growth. Some communities in the Columbia Basin are already experiencing a longer growing season.[27] During the 1961 to 1990 period, Golden's growing season length averaged 188 days, and historical data for Golden (1905-2018) shows a small increasing trend in growing season length of 10 days per century. The growing season is projected to increase by 26 to 32 days by the 2050s under low and high carbon scenarios, respectively.

More growing degree days

Growing degree days[ii] describe the amount of heat energy that is available for plant growth, providing better insight on how plants are affected by temperatures than straight temperature data. Growing degree days for Golden (1905-2018) have been increasing by 324 growing degree days per century, respectively (Figure 16). By the 2050s, growing degree days are projected to increase by 542 and 700 for the low and high carbon scenarios, respectively, from a 1961-1990 baseline of 1496.5 growing degree days.

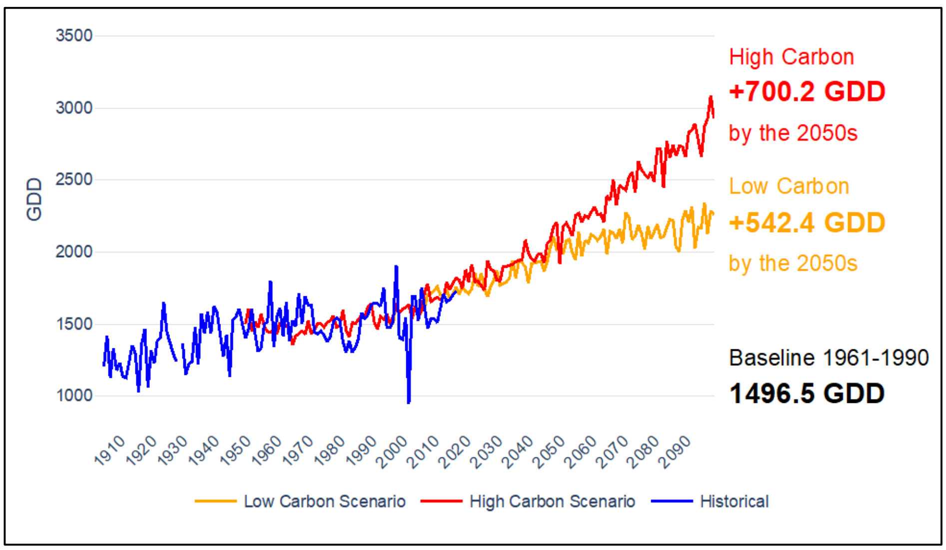

Figure 16: Growing degree days in Golden

Consecutive dry days have been decreasing

The annual maximum number of consecutive dry days for Golden has declined since 1908 at a rate of -7.9 days per century. During the 1961 to 1990 period, Golden's average annual maximum number of consecutive dry days was 18.5 days. This is projected to increase by 0.3 to

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[i] For the purposes of this report, growing season is defined as the number of days annually between the first and last five consecutive days with a mean temperature of 5 ºC.

[ii] For the purposes of this report, growing degree days was calculated by multiplying the number of days that the mean daily temperature exceeds 5 ºC (average base temperature at which plant growth starts) by the number of degrees above that threshold. Studies often use different definitions of growing degree days; therefore, caution should be exercised when comparing these results to other research.

0.5 days by the 2050s under low and high carbon scenarios, respectively; however, this trend falls below the 95% confidence level.

Adaptation Actions and Capacity Building

Many residents grow some of their own food

Backyard gardening of edible crops is an indicator of local self-sufficiency and food security. A voluntary survey completed by 79 Golden residents in summer 2019 found that 83% of respondents grow some of their own food, mostly in home gardens (97%), in plots ranging from 5 square feet to over 300 square feet (Table 7). No residents reported growing food in community gardens. The majority of respondents (67%) reported growing 1-10% of their total food and 68% reported storing their home-grown food. Almost all home gardeners (95%) recorded growing vegetables, 39% recorded growing fruit, and 46% recorded growing herbs. The most popular items grown were tomatoes, lettuce, potatoes, peas, herbs, and beans. Purchasing food from local producers was very common among respondents; of the 83% who reported purchasing locally, 19% recorded buying over a third of their food from local producers (Table 8). Additionally, some residents reported foraging for edible plants (32%), hunting wild game (18%), and keeping chickens (16%).

Table 7: Area under cultivation (excluding fruit trees and berry patches) by Golden residents.

Area	% of respondents	# of respondents
Less than 5 square feet	7.6	6
5-15 square feet	13.9	11
15-30 square feet	11.4	9
30-50 square feet	8.9	7
50-100 square feet	13.9	11
100-200 square feet	21.5	17
200-300 square feet	12.7	10
More than 300 square feet	10.1	8

Table 8: Percentage of food that respondents are buying from local producers.

% of respondents	% of food purchased from local producers
49	1-10
27	11-20
5	21-30
19	>30

WILDFIRE

Wildfire can cause serious damage to community infrastructure, water supplies, and human health, and may require residents to evacuate their homes and communities. It is projected that climate change will increase the length of the wildfire season and the annual area burned by wildfire due to warmer, drier summers. The Wildfire Pathway tracks fire risks and impacts on communities as well as adaptation actions being undertaken by communities. Golden is situated in the Columbia Fire Zone, which is part of BC's Southeast Fire Centre (Figure 17).

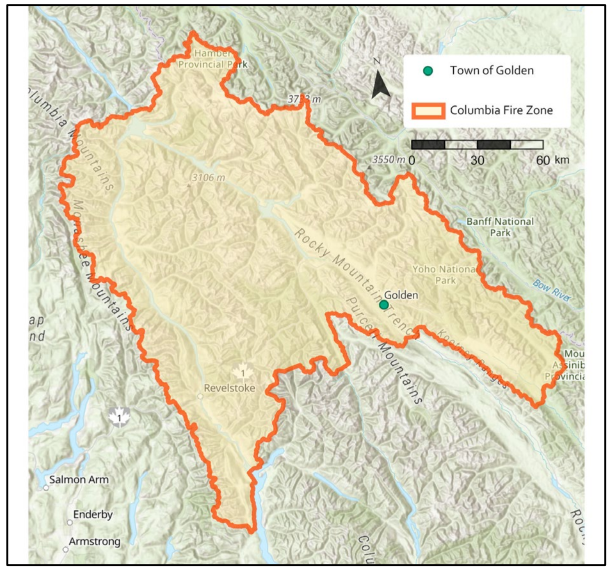

Figure 17: Columbia Fire Zone

The Overall Picture

Wildfires are becoming more frequent at regional and national scales and studies generally suggest that this trend, along with a trend to more area burned, will continue. Local-scale data relating to wildfire frequency and size does not show reliable trends but provides a baseline for future assessments. The active wildfire seasons experienced in 2017 and 2018 highlight the social and economic impacts of fire due to fire bans, evacuation notices and alerts, and road closures. Though interface fires have not historically been an issue for Golden, the Town has been actively taking steps to prepare for increased fire risk by undertaking fuel treatments in the wildland-urban interface and through public education on Fire Smart principles. Golden's success in completing fuel treatments for nearly 100 per cent of its wildfire interface zones makes it a leader in British Columbia.

Climate Changes

High fire danger ratings do not show a trend

The BC Wildfire Service establishes wildfire danger ratings using the Canadian Forest Fire Danger Rating System. The number of days in the high and extreme danger classes provides an indication of how weather and water availability are influencing fire risk. From 2004 to 2019, the Blaeberry fire weather station had an average of 12.9 days per year with a danger rating of high or above. The Whiskey fire weather station, which has data recorded from 1990 to 2019, had an average of 10.2 days at or above a high danger rating. These are the nearest and most representative fire danger forecasting stations to Golden. The highest number of days at a high danger rating or above occurred in 2017 with 57 days at Whiskey and 43 days at Blaeberry[28]. Figure 18 shows historical records from the Blaeberry fire weather station. No significant trends can be observed for either station. This may be due to the relatively short period of record and large annual variability in fire danger.

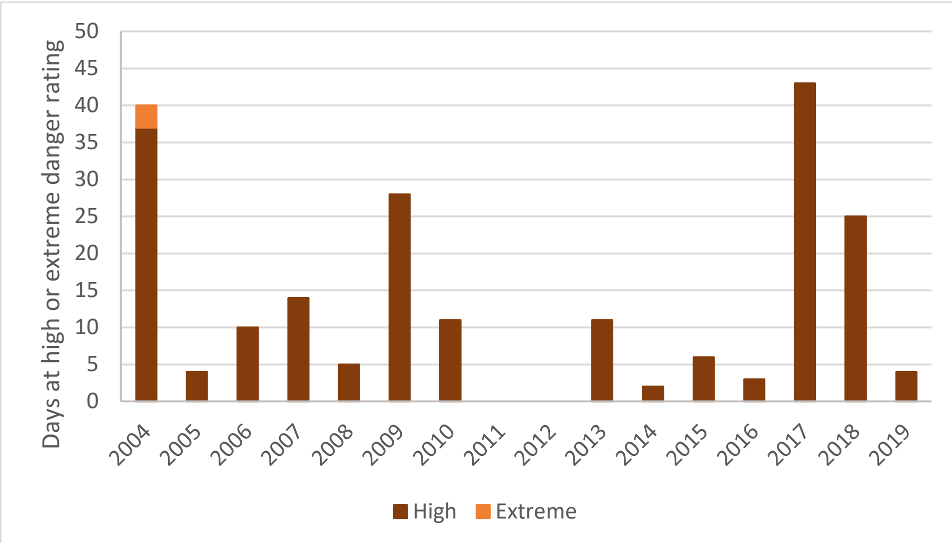

Figure 18: Number of days per year in high and extreme danger classes at the Blaeberry weather station

Environmental Impacts

Air quality is poor during severe fire seasons

The air quality indicator reports concentrations of fine particulate matter ($PM_{2.5}$) in the air and is strongly influenced by wildfire. High $PM_{2.5}$ concentrations can have significant impacts on human health[29]. Golden is one of only a few Basin communities with an air quality monitoring station that continuously monitors $PM_{2.5}$. Severe fire seasons such as 2017 and 2018 can have a considerable impact on air quality at a regional scale, with Golden experiencing 30 and 20 days, respectively[30], with $PM_{2.5}$ levels over 25 ug/m^3, which is the province's threshold for issuing an air quality advisory[31](Figure 19).

In 2017, the BC Ministry of Environment implemented a Smoky Skies Advisory service to advise communities when they may be affected by wildfire smoke. Smoke advisories are based on predictive air quality modelling and are particularly relevant for communities without an air quality monitoring station. The Ministry of Environment smoke advisories for the East Columbia region in 2017 and 2018 were issued for 48 and 39 days, respectively[32].

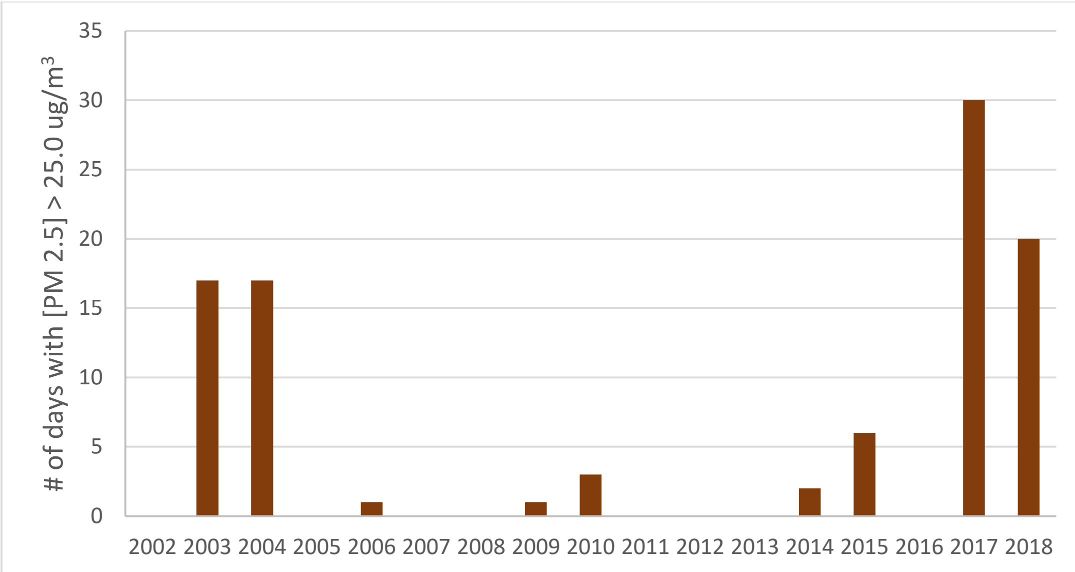

Figure 19: Daily average $PM_{2.5}$ readings for Golden

Number of wildfires

This indicator tracks the total number of human-caused and lightning-caused wildfire starts per year. Though national-scale data point to an increasing frequency of wildfires, since the mid-1900s, there is no statistically significant trend in the number of wildfires started annually in the Columbia Fire Zone[33]. However, the small geographic scale of this dataset may be preventing the effective evaluation of trends. An upward trend is apparent in the Southeast Fire Centre region in the number of fires greater than one hectare that have been mapped by the BC Wildfire Service (Figure 20).

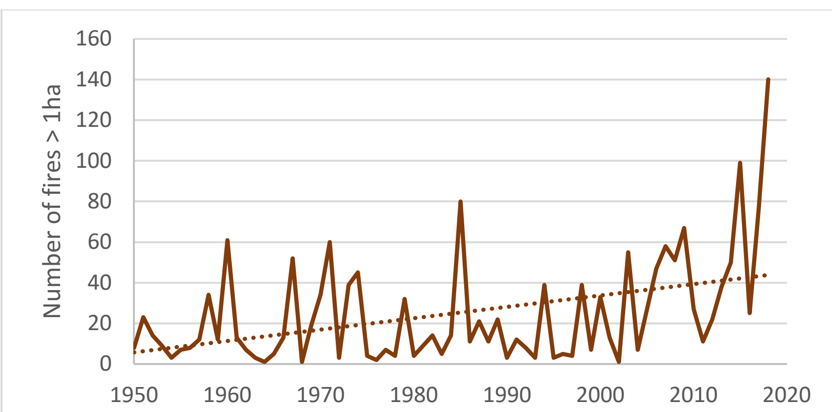

Figure 20: Fires > 1 ha in the Southeast Fire Centre region, 1950-2018

The ratio of fires caused by humans vs. lightning can be influenced by both climate and public awareness. Since 1950, the Columbia Fire Zone has had a significantly lower incidence of human-caused fires (~20%) in comparison to the entire Southeast Fire Centre (~45% of fires). Both areas are seeing a decline in human-caused fires over time, which could help temper the increased fire risk that could accompany climate change; however, 96% of the fires within the Town of Golden and the surrounding wildland-urban interface were human-caused.

On average, there have been 87 fires per year in the Columbia Fire Zone, and just over one per year in Golden and its interface area.

Annual area burned since 1950 equivalent to five percent of the Columbia Fire Zone

This indicator provides a direct measure of how much fire is occurring on a specific landscape. Since the onset of provincial wildfire suppression efforts in the mid-20th century, no statistically significant trend can be observed in the annual area burned in the Golden interface zone, the Columbia Fire Zone, or the Southeast Fire Centre region. The Columbia Fire Zone experienced significant wildfire years in 1998, 2003, 2017 and 2018. A total of 96,525 hectares burned between 1950 and 2018 in the Columbia Fire Zone, equivalent to 5% of the zone's total area. The zone sees an average of about 1399 hectares burned annually; 2017 was the most significant fire year since 1950, with 10,327 hectares burned[34].

Adaptation Actions and Capacity Building

Wildland urban interface fuel treatments are up to date

Interface fire risk reduction involves assessing and treating high-risk areas to reduce wildfire risk. As part of its Community Wildfire Protection Plan, the Town of Golden has mapped and assessed its wildland-urban interface, and successfully treated 100% of its high-risk areas between 2011 and 2015. It is estimated that future treatments will be required approximately every 20 years.

FireSmart recognition (or equivalent) is in early stages

This indicator reports on the number of neighbourhoods recognized through Fire Smart Canada's Community Recognition Program, providing a measure of citizen involvement in reducing the risk of wildfire to their homes. For communities that do not currently administer a Fire Smart program, this indicator examines policies and initiatives that contribute to a community being Fire Smart in practice. While Golden does not have any Fire Smart-recognized neighbourhoods, the Town of Golden recently began offering free Fire Smart property assessments and has ramped up its communications on wildfire prevention, including local Fire Smart education to be offered annually. There has not been significant resident uptake to date. Golden's Official Community Plan does not include Wildfire Hazard Development Permit Areas.

Community Impacts and Adaptation Outcomes

Frequency of interface fires is very low

This indicator measures the annual number of wildfires that come within two kilometres of municipal boundaries. Since 1950, Golden has experienced only three interface fires, with two occurring in 2007 and 1 in 2016, resulting in a total of 1.2 hectares burned[35].

Cost of fire suppression

The average annual cost of fire suppression in the Columbia Fire Zone from 1970 to 2019 was $1.25 million, with a peak of $12.5 million in 2003 and a low of $407 in 1976.[36] Costs of fire suppression will vary from year to year and will be influenced significantly by prevailing weather conditions. The dataset shows an upward trend over the period of record (Figure 21); however, given that reported values are not corrected for inflation, the true direction and magnitude of this trend cannot be assessed.

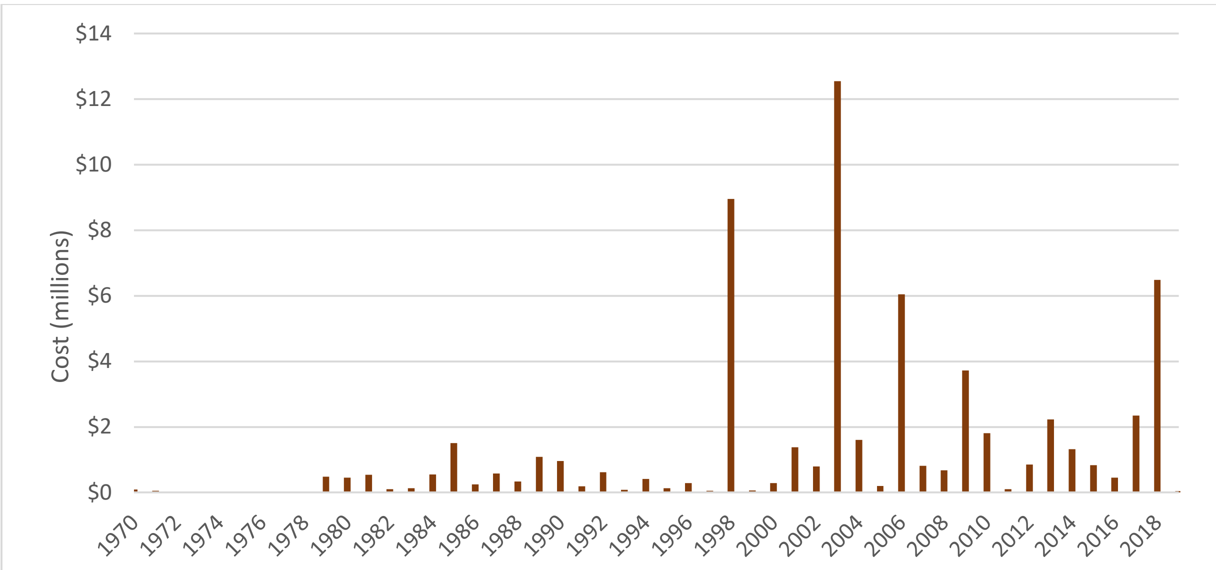

Figure 21: Annual cost of fire suppression in the Columbia Fire Zone. (Data values from the 1970s are generally too small to show on the scale needed to show data from recent years.)

No fire-related highway events

There have not been any fire-related highway closures affecting the Golden area since DriveBC began collecting data in 2006[37].

Annual days under campfire ban peaked in 2017

This indicator tracks the number of days annually for which the BC Wildfire Service has issued a campfire ban for the Southeast Fire Centre. It provides a measure of the social cost of the increasing wildfire risk that is projected to accompany climate change. Since 2000, there have been 7 years with campfire bans in the Columbia Fire Zone. The longest fire ban—77 days—occurred in 2017[38]. Long term tracking of this indicator is necessary to establish any trend.

NEXT STEPS

Action Areas

Assessment results indicate that the Town of Golden has initiated important steps to improve its adaptive capacity. Areas for further consideration are evident in the data:

- **Fire Smart principles**. Public engagement and education around Fire Smart principles and wildfire risk will help Golden and area residents advance their own contributions to risk reduction in the wildland-urban interface. There is an opportunity for continued adoption and integration of zoning, policies and practices that reduce wildfire risk.
- **Personal emergency preparedness**. Encouraging emergency preparedness among residents would help foster resilience to the types of extreme weather that are expected to increase with climate change. Preparedness begins with a 72-hour emergency kit and can also include household level actions to reduce the risks of extreme weather and a changing climate. More than two-thirds of Golden residents may not have an emergency kit. Local governments have an important role to play in personal emergency preparedness as they are often the 'front line' for residents when disaster strikes.
- **Local food production.** Climate change appears to be increasing agricultural viability in the Golden area with a longer growing season, higher annual average temperatures and more rainfall. Local interest in backyard farming and food production appears to be significant. The Town can play a role in communicating the benefits of food production on a local (and regional) scale to increase local self-sufficiency.
- **Vulnerable populations**. The elderly, chronically ill and the very young are more vulnerable to poor air quality events and extreme heat events. Publicly accessible buildings or refuges are a relatively new idea in most jurisdictions and rural communities may have few locations if any that would be suitable to act as a clean air shelter. While this is not a lead responsibility for local governments, they can play a supportive role in establishing these facilities.
- **Water conservation.** Golden's aquifers appear to have relatively high connectivity with surface runoff levels. Late summer low flows are showing evidence of a declining trend that is likely to continue into the future. Golden still has a relatively wide range of untapped opportunities and options to increase water conservation and reduce overall water consumption.
- **Urban trees.** The combination of historical and projected climate changes will increasingly cause stress to urban trees and forests as the local bioclimatic regime changes. Trees under stress are more susceptible to damage by high winds, freezing rain, heavy snowfalls, drought, floods, disease, and insects. Fallen trees and branches are already the leading cause of power outages. Urban tree care practices, and procedures for identifying and addressing "danger trees" may warrant review and new approaches.

- **Official Community Plan**. As Golden approaches the update and renewal of its Official Community Plan (OCP) in 2021/22, this provides a timely opportunity to identify and incorporate climate-resilient policies into the OCP that reflect and address the risks and challenges associated with a changing climate.

Future Assessments

Though some SoCARB indicators may be monitored on an annual basis, it is recommended that the next full assessment be conducted in five years (2025). Various SoCARB indicators are also tracked as part of the State of the Basin initiative, which means substantial data may be available through the RDI.

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