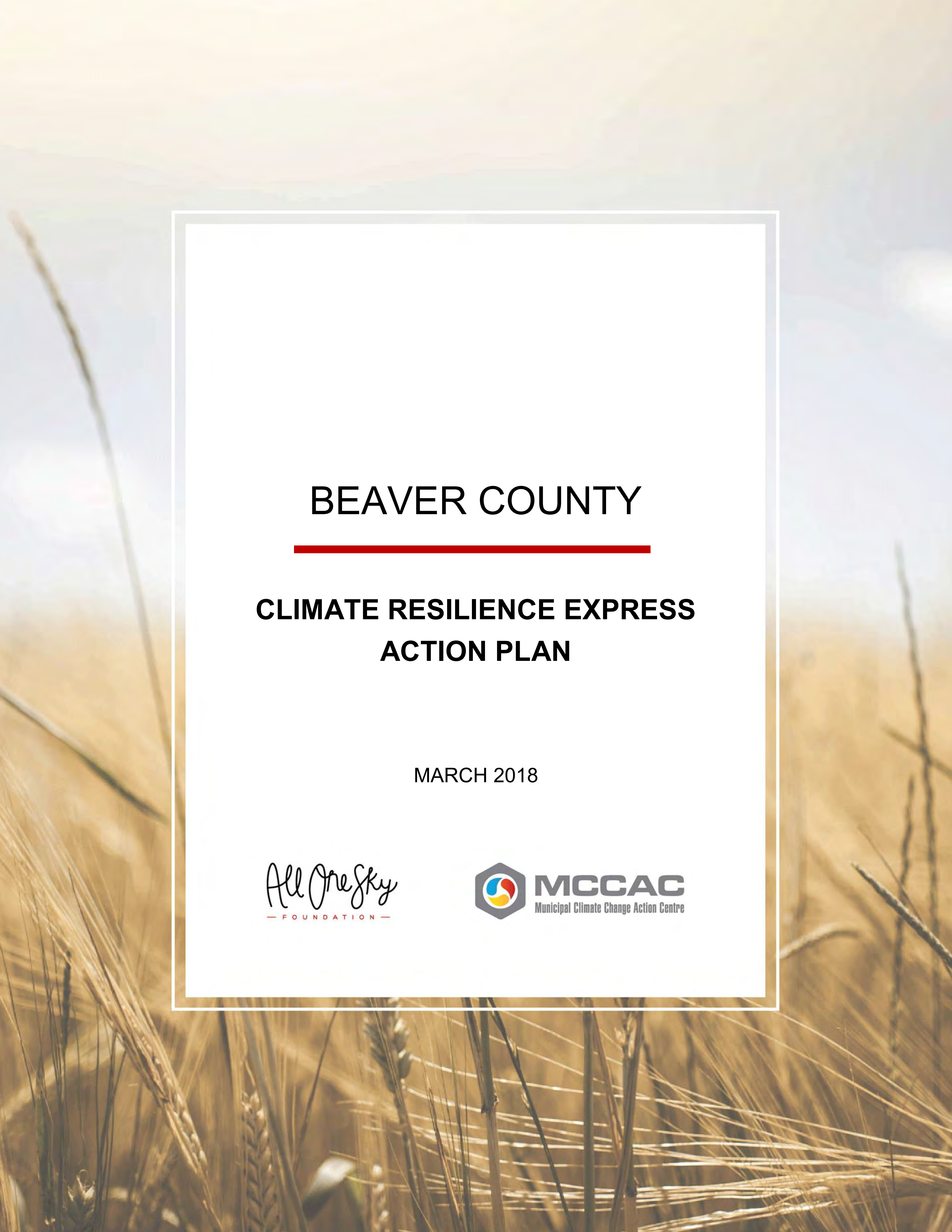


BEAVER COUNTY

CLIMATE RESILIENCE EXPRESS ACTION PLAN

MARCH 2018

All One Sky Foundation

MCCAC Municipal Climate Change Action Centre

"*A resilient community is one that has developed capacities to help absorb future shocks and stresses to its social, economic, and technical systems and infrastructures so as to still be able to maintain essentially the same functions, structures, systems, and identity.*"

[Working Definition, ResilientCity.org]

This Climate Resilience Action Plan (Action Plan) has been produced through the **Climate Resilience Express** project with financial support from the Municipal Climate Change Action Centre, the Calgary Foundation, Natural Resources Canada, All One Sky Foundation, and Alberta Ecotrust.

A key objective of the Climate Resilience Express project is to partner with communities across Alberta to complete a streamlined ("express") process aimed at developing a community-specific climate resilience action plan through a one-day workshop, and to develop and maintain an 'Action Kit' to support other communities in working through the process.

In 2016, six communities from across Alberta were selected to pilot the workshop process and aspects of the toolkit. In 2017, an additional seven communities participated in the project, including Beaver County[i].

For more information on the Climate Resilience Express visit: allonesky.ca/climate-resilience-express-project/ or mccac.ca/programs/climate-resilience-express.

Summary

The effects of climate change are already apparent in Beaver County, with observable changes in temperature, precipitation, and extreme weather events over the last century. The impacts of climate change on the County could be numerous and diverse, giving rise to uncertain consequences, for infrastructure and services, property, the local economy and environment, and the health and lifestyles of citizens. To better prepare for these potential impacts, Beaver County has prepared this Action Plan, which identifies some initial actions to help manage potentially significant risks and opportunities anticipated to result from climate change over the next several decades.

In total, 13 climate-related risks and one climate-related opportunity were identified by participants at a workshop in Beaver County on November 9th, 2017, of which three risks were judged to be priorities requiring immediate action:

1. Reduced water availability;
2. Wildland fires; and
3. Freeze-thaw cycles.

Starter action plans were developed for each of these priority risks.

Beaver County is already committed to numerous actions that help manage the above priority risks, including water conservation measures for agricultural producers and the exploration of management options for beaver to improve water availability, and ongoing road maintenance to manage adverse impacts from freeze-thaw cycles. It is important that the County continue with these and other standing commitments, as part of its effort to be prepared for weather and climate impacts now, and in the future.

In addition to existing actions that help mitigate the consequences of the priority risks, 14 further actions were identified for consideration to help the County better prepare for climate change. Several of these actions could be implemented quickly with minimal investment, whereas other actions have longer-term timeframes and require a higher level of investment. Implementation of these actions will ensure that Beaver County remains resilient under a wider range of potential future climate conditions.

This Action Plan is a living document and should be periodically reviewed and updated to ensure it remains relevant and effective.

Table of Contents

1. INTRODUCTION

The effects of climate change are already apparent in Beaver County, with observable changes in temperature, precipitation, and extreme weather events over the last century. The average annual temperature in the Beaver County area has increased by about +1.5°C since the early 1900s, with winter months seeing greater warming than summer months. Over the same period, the amount and timing of precipitation in the area have also changed.

The impacts of climate change on communities can be numerous and diverse, giving rise to potentially significant, though uncertain consequences, for municipal infrastructure and services, private property, the local economy and environment, and the health and lifestyles of citizens—be it through changing patterns of precipitation with increased risk of flooding and drought, increased strain on water resources, rising average temperatures and more common heatwaves, more frequent wildfires, or more intense ice, snow, hail or wind storms. Climate change may also present opportunities for communities.

Municipalities are at the forefront of these impacts—both because extreme weather events can be especially disruptive to urban systems and because they are where much of our population live, work and raise their families. Smaller communities with limited resources are particularly vulnerable and may lack the capacity to adequately respond to increasing impacts. It is therefore essential that communities take steps now to anticipate and better prepare for future climate conditions, to ensure they continue to prosper as a desirable place to live and work for generations to come.

Beaver County, through the preparation of this Action Plan, is taking steps towards a safe, prosperous and resilient future. The Action Plan identifies several anticipatory measures to manage priority risks and opportunities anticipated to result from climate change in the area over the next several decades.

2. DEVELOPING THE ACTION PLAN

Climate Resilience Express is a high-level ("express") screening process designed to support communities in beginning to identify and prioritize climate change risks and opportunities and develop a starter action plan. The overall approach to developing climate resilience action plans through Climate Resilience Express is grounded in existing standards for risk management based on the International Organization for Standardization's (ISO) 31000, Risk Management – Principles and Guidelines. It follows a four-step, iterative process (shown in Figure 1):

Step 1: Establish the local context for climate resilience action planning;

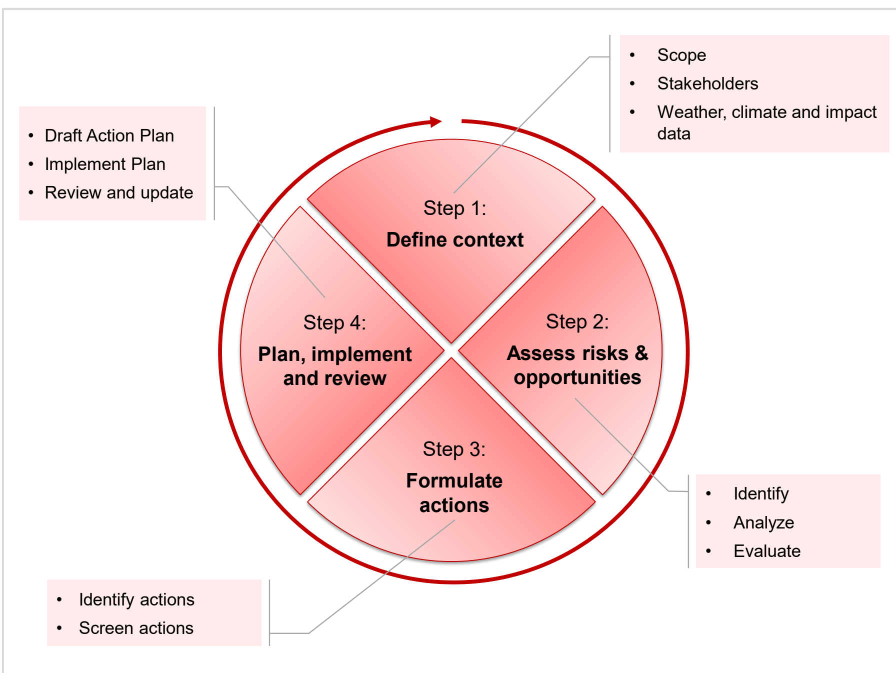
Step 2: Assess potential climate-related risks and opportunities to establish priorities for action;

Step 3: Formulate actions to manage priority risks and opportunities; and

Step 4: Prepare and implement an Action Plan, review progress, and update the Plan to account for new information and developments.

Step 2 and Step 3 of the process are the focus of the one-day workshop with local stakeholders, which is at the heart of Climate Resilience Express. Step 1 is undertaken in advance of the workshop; preparing the Action Plan and Step 4 takes place after the workshop.

Figure 1: Climate Resilience Express—action planning process



TIERED APPROACH TO THE ASSESSMENT

The Climate Resilience Express adopts a tiered approach to climate risk management, in which communities move from the broad to the more focused, in terms of both assessing risks and opportunities (at Step 2) and assessing viable adaptation actions (at Step 3). Rather than jumping straight into a data-driven, quantitative assessment of every climate impact and management option, Climate Resilience Express starts with a high-level qualitative screening of risks and opportunities, and corresponding actions. Communities can subsequently use this information to justify more detailed quantitative assessments of significant risks and opportunities, and to generate full business cases for priority actions if necessary.

BEFORE THE WORKSHOP: STEP 1

Prior to the workshop the context for climate resilience action planning in Beaver County is established. This involves:

- **Defining the spatial scope**

  The spatial scope is limited to direct impacts within the geographic boundaries of Beaver County.

- **Defining the operational scope**

  The assessment of risks and opportunities considers potential community-wide impacts, which includes impacts to municipal infrastructure, property and services, as well as impacts to private property, the local economy, the health and lifestyle of residents and the natural environment.

- **Defining the temporal scope**

  The assessment considers impacts arising from projected climate and associated environmental changes out to the 2050s. This timeframe looks ahead to the types of changes and challenges, which decision-makers and residents might face within their lifetimes. It also reflects a planning horizon that, although long in political terms, lies within the functional life of key public infrastructure investments and strategic land-use planning and development decisions.

- **Compiling climate and impact data**

  Climate projections for the 2050s are compiled for the Beaver County area and historical weather data is analyzed to identify observed trends in key climate variables. Information is also compiled on the main projected environmental changes for the area by the 2050s. This activity is discussed further in Section 3.

- **Developing scales to score risks and opportunities**

  Scales are required to establish the relative severity of impacts to determine priorities for action. The scales used in the risk and opportunity assessment at the workshop are provided in Appendices.

At the Workshop: Step 2 and Step 3

The one-day workshop used to generate the information underpinning this Action Plan comprises four main sessions. Workshop participants are listed in Appendix A.

- **Session 1: Exploring local weather and impacts**

  The session objective is to explore the relationship between weather, climate and key aspects of Beaver County in relation to past weather-related impacts. Outcomes from this session at the workshop are presented in Section 3.

- **Session 2: Introduction to climate science and impacts**

  The session objective is to present information about climate science, local climate trends and projections, corresponding projected environmental changes, and potential impacts for the area. This information is also presented in Section 3.

- **Session 3: Assess future risks and opportunities**

  The session objective is twofold; first, to determine how projected climate changes could impact Beaver County, and second, to prioritize the identified impacts in order to establish priorities for action planning. Outcomes from this session at the workshop are presented in Section 4.

- **Session 4: Action planning**

  The session objective is to determine what actions are necessary to increase resilience to priority risks and to capitalize on priority opportunities. Outcomes from this session at the workshop are presented in Section 5.

After the Workshop: Step 4

Outcomes from the workshop are used as the basis for this Action Plan. Building resilience to climate change is not a static process, but rather needs to be monitored and reviewed to both check progress on implementation and to take account of changing scientific knowledge about the physical impacts of climate change. Implementing this Action Plan, reviewing progress, and updating the Plan to keep it relevant are discussed in Section 6.

3. Observed Impacts, Climate Trends and Projections

Observed Local Weather and Climate Impacts

Session 1 at the workshop invited participants to identify how Beaver County has been affected by weather-related events in the recent past, considering impacts on the local economy, property and infrastructure, the natural environment, and resident's health and lifestyles. A selection of observed weather-related impacts on the community identified by participants is provided in Box 1.

Box 1: Summary of observed weather events and impacts

- ✓ Recurring droughts since 2000
- ✓ Wildland fires
- ✓ Reduced lake levels, and total loss of some water bodies
- ✓ Reduced agricultural output because of variable adverse weather conditions from year-to-year
- ✓ Reduced irrigation water during drought years
- ✓ Excessive precipitation and moisture impacting the agricultural sector in 2017
- ✓ Stress on infrastructure and drainage systems, and potential flood risk, from extreme precipitation events
- ✓ Spring flooding that damages roads, ditches and other infrastructure, with knock-on effects for county services; flooding impacts are exacerbated by vegetation loss and beaver activity

Local Climate Trends

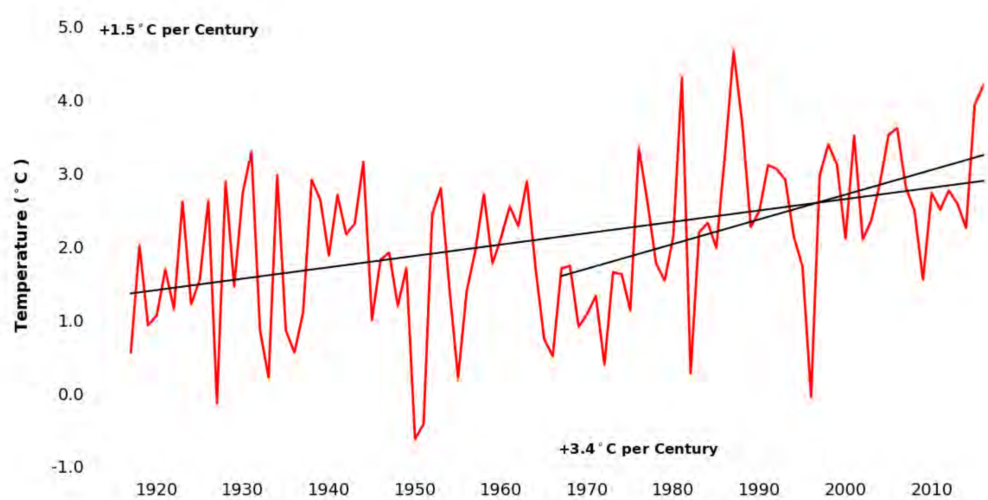
To provide a perspective of historic climate trends in Beaver County, data was collected and analyzed from ten Adjusted and Homogenized Canadian Climate Data (AHCCD) stations in the region (Athabasca, Cold Lake, Campsie, Edmonton, Calmar, Camrose, Lacombe, Rocky Mountain House, Edson, and Whitecourt)[ii]. These stations were selected because the available data cover multiple decades, are high quality, and the stations span an area that is comparable to the same area for which future climate projections are available.

Climate records of temperature and precipitation for Beaver County are assembled by averaging the individual records from these ten climate stations and applying appropriate statistical techniques to assess the robustness of estimated trends[iii].

➡ Temperature records

Temperature records for the area over the period 1917-2016 show that mean annual temperature has increased at a rate of +1.5°C per century (Figure 2), which is approximately 50% faster than the observed global rate of warming over the same last century. The rate of warming observed over the last 50 years is higher still, at +3.4°C per century.

Figure 2: Mean annual temperature in Beaver County (1917-2016)



The largest seasonal increase in temperature in Beaver County occurred during the winter (December-February). The observed rate of warming in winter over the last 100 years is +3.0°C per century (Figure 3). Over the last 50 years mean winter temperature increased at a rate of

+7.0°C per century, which is substantially greater than the mean annual rate of warming. In contrast, warming during the summer (June-August) over the last 100 years occurred at a slower rate of +1.2°C per century, and +1.9°C per century over the last 50 years (Figure 4).

Similar warming trends are also observed for mean spring and fall temperatures over the last 50 and 100 years.

Figure 3: Mean winter temperature in Beaver County (1917-2016)

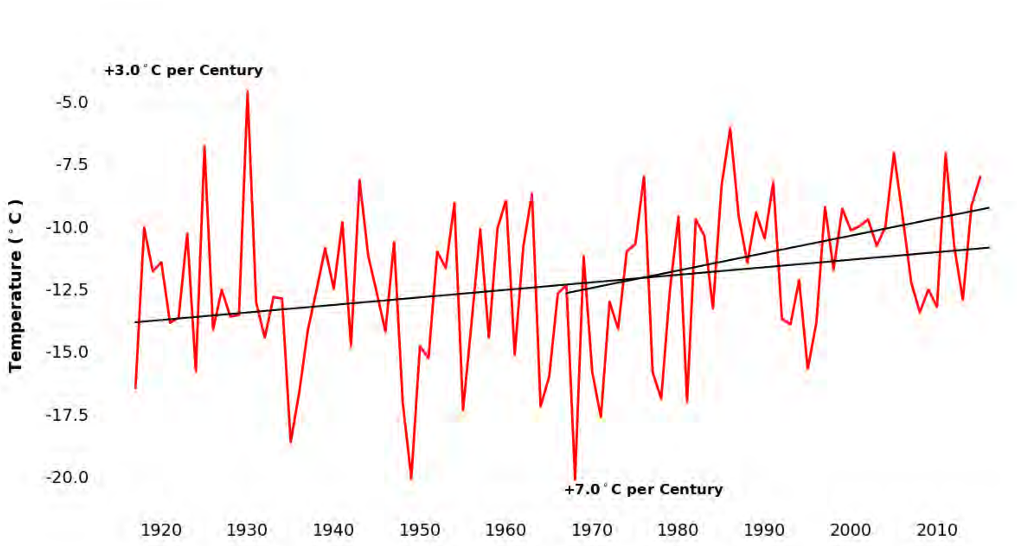
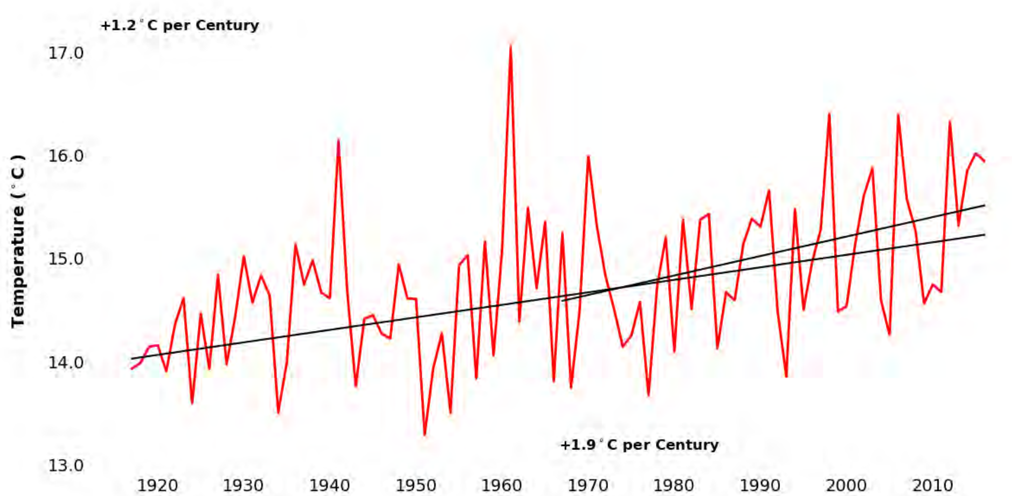


Figure 4: Mean summer temperature in Beaver County (1917-2016)



➡ Precipitation records

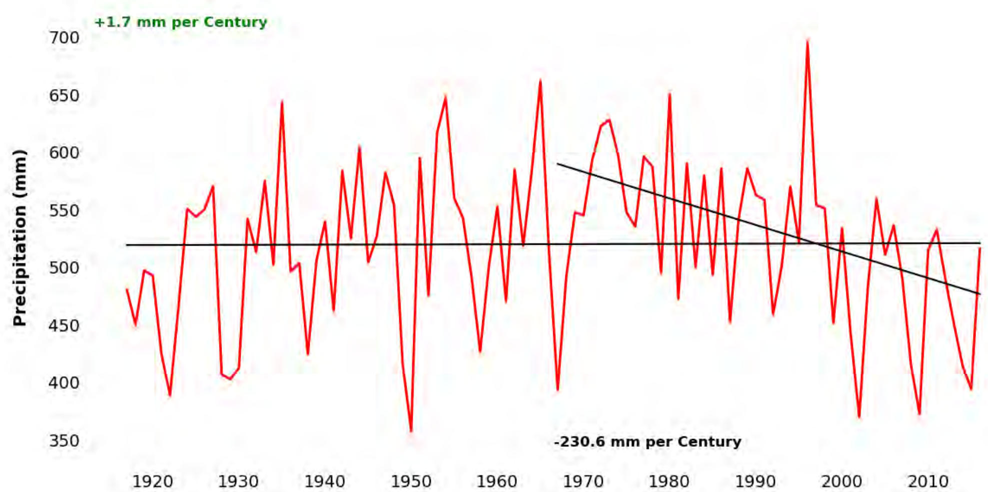
Over the last 100 years, mean annual precipitation in Beaver County increased at a rate of less than 2 mm per century; this trend is not statistically significant. However, over the last 50 years, mean annual precipitation has declined at a rate of 231 mm per century (Figure 5).

Changes in seasonal precipitation over the last 50 years show the following trends:

- +38 mm per century in spring;
- -29 mm per century in fall;
- -131 mm per century in summer; and
- -67 mm per century in winter.

Trends in summer and winter precipitation over the last 50 years are statistically significant at the 95% confidence level; trends in spring and fall precipitation are not statistically significant.

Figure 5: Mean annual precipitation in Beaver County (1917-2016)



Note: trends depicted in green font are not significant at the 95% confidence level

CLIMATE PROJECTIONS FOR BEAVER COUNTY

The outputs from global climate models provide us with projections of how the Earth's climate may change in the future. Global climate models are a mathematical representation of the climate that divide the earth, ocean and atmosphere into millions of grid boxes. The future values of climate variables predicted by these models, such as temperature and precipitation, are calculated for each grid box over time. The results presented below represent the averaged results from 10 km by 10 km grid boxes encompassing Beaver County, centred over Holden.

Predicting the future is inherently uncertain. To accommodate this uncertainty, projections of future climate change consider a range of plausible scenarios known as RCPs (Representative Concentration Pathways). Scenarios have long been used by planners and decision-makers to analyse futures in which outcomes are uncertain.

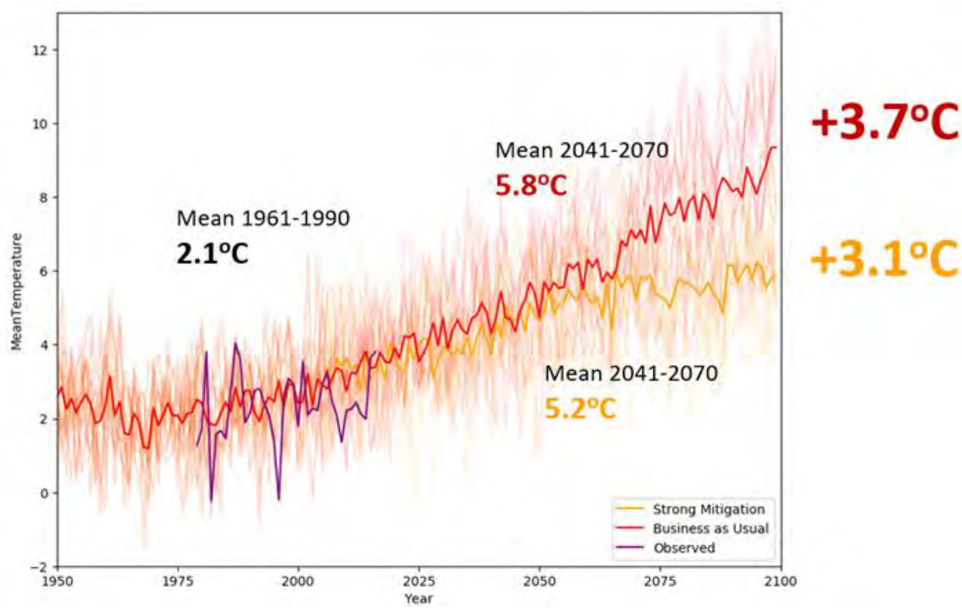
For this assessment, we have considered climate model projections for Beaver County under two RCPs: a 'business as usual' scenario (which is formally denoted RCP 8.5) where little additional effort is made to curtail factors contributing to climate change; and a 'strong mitigation' scenario (formally denoted RCP 4.5) where considerable additional effort is made to mitigate factors contributing to climate change. The numbers 8.5 and 4.5 refer to the additional warming (in Watts per square metre) anticipated under each scenario by 2100.

Both scenarios will result in significant changes to the local climate by mid-century, necessitating the development of robust adaptation strategies. However, changes projected under RCP 8.5 (business-as-usual) represent a worst-case scenario for adaptation planning.

➡ Temperature projections

Mean annual temperature in Beaver County is anticipated to increase by between +3.1°C (yellow line, RCP 4.5) and +3.7°C (red line, RCP 8.5) above the 1961-1990 baseline, which will increase the absolute mean annual temperature in the 2050s to between +5.2°C and +5.8°C, respectively (Figure 6)[iv]. These projected increases in temperature are consistent with the rate of change in mean annual temperature that has been observed in Beaver County over the last 50 years.

Figure 6: Projected mean annual temperature in Beaver County



Projected increases in mean winter temperature are +3.8°C and +4.7°C for RCP 4.5 and RCP 8.5, respectively (Figure 7). In summer, mean temperatures are projected to increase by +3.8°C and +4.7°C for RCP 4.5 and RCP 8.5, respectively (Figure 8).

➡ Precipitation projections

While annual and winter precipitation declined over the last 50 years, both variables are projected to increase by the 2050s. This may be explained by the higher uncertainty associated with projections of future precipitation compared with those for temperature. Mean annual precipitation is projected to increase by 7% to 12% for RCP 4.5 and RCP 8.5, respectively (Figure 9). Larger increases in precipitation are projected for the winter (Figure 10), while summer precipitation is projected to decrease slightly (Figure 11). All changes are expressed relative to the average value over the baseline period 1961-1990.

Figure 7: Projected mean winter temperature in Beaver County

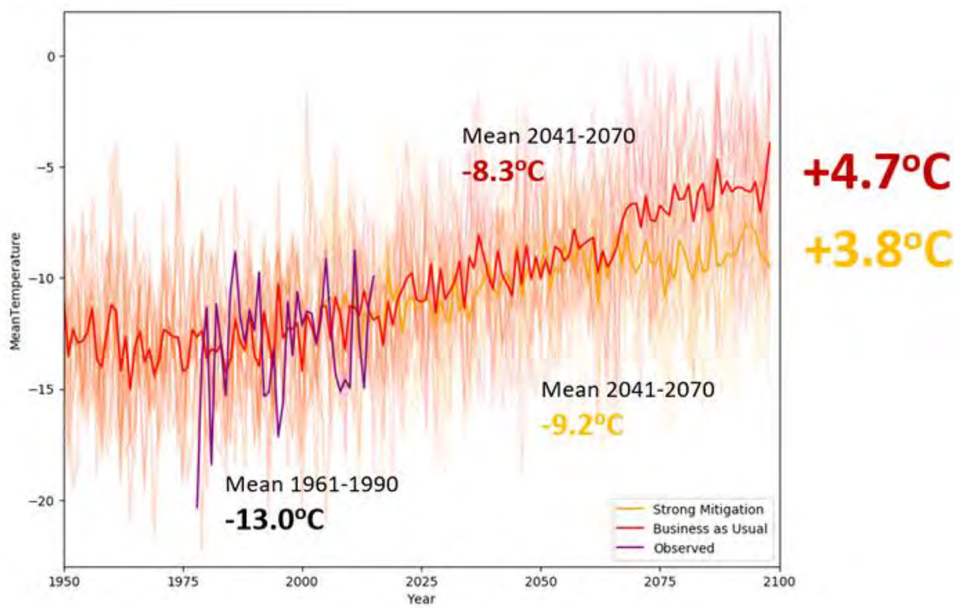


Figure 8: Projected mean summer temperature in Beaver County

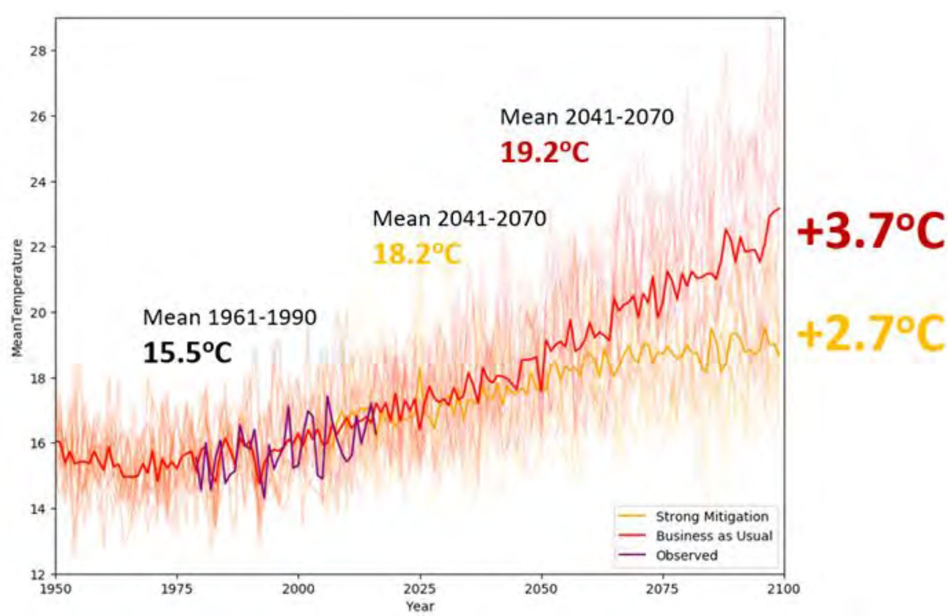


Figure 9: Projected mean annual precipitation in Beaver County

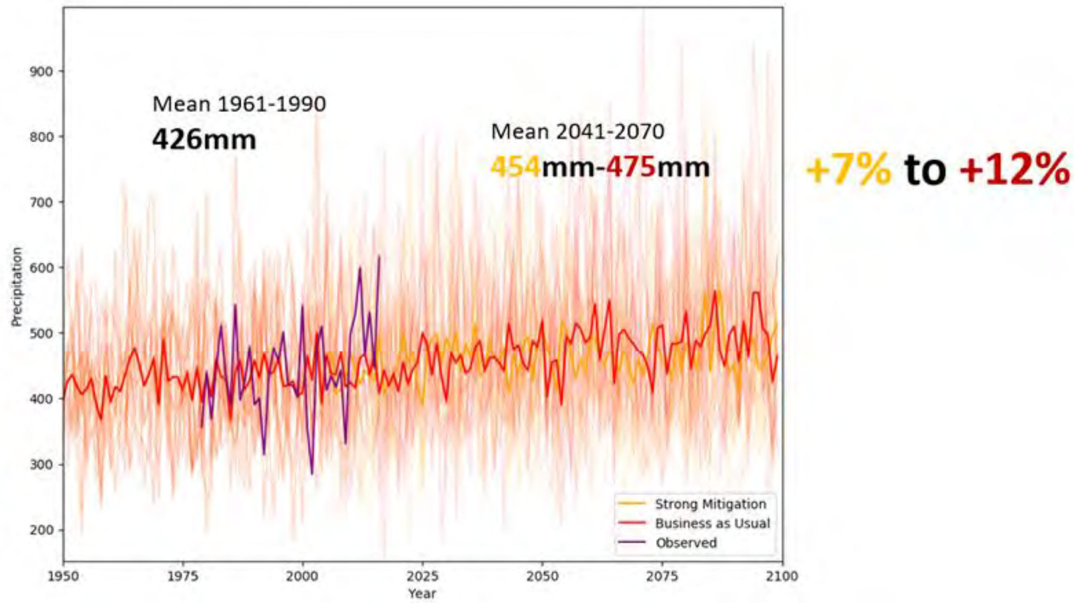


Figure 10: Projected mean winter precipitation in Beaver County

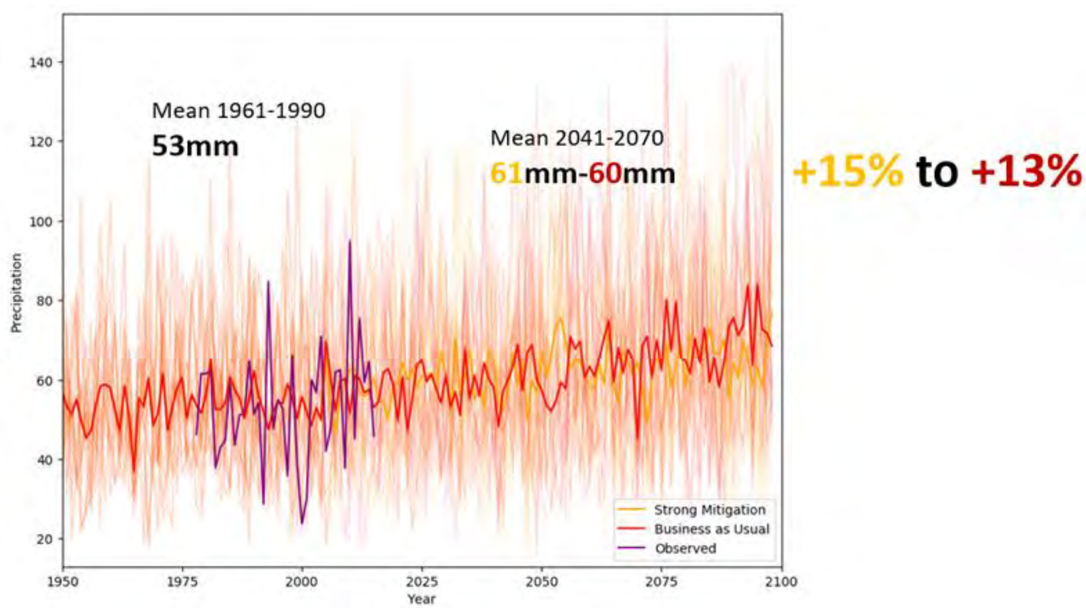


Figure 11: Projected mean summer precipitation in Beaver County

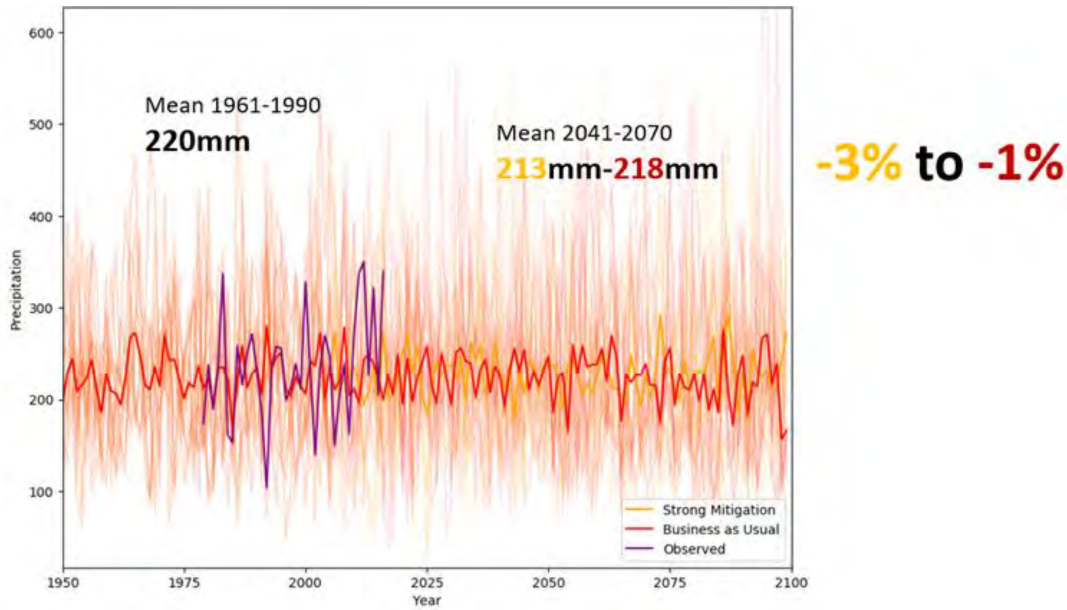


Table 1 presents a summary of projected climate changes for Beaver County by the 2050s.

Table 1: Summary of projected climate changes by 2050s (2041-2070) for Beaver County

Climate variable	Season[v]	Baseline value (1961-1990)	Strong mitigation scenario (RCP4.5)		Business-as-usual scenario (RCP8.5)	
			Change (+/-)	Absolute value	Change (+/-)	Absolute value
Temperature (°C)	Annual	+2.1	+3.1	+5.2	+3.7	+5.8
	Winter	-13.0	+3.8	-9.2	+4.7	-8.3
	Spring	+3.0	+3.0	+6.0	+3.4	+6.4
	Summer	+15.5	+2.7	+18.2	+3.7	+19.2
	Fall	+3.0	+2.3	+5.3	+3.7	+6.7
Precipitation (mm)	Annual	426	+7%	454	+12%	475
	Winter	53	+15%	61	+13%	60
	Spring	73	+23%	90	+36%	99
	Summer	220	-3%	213	-1%	218
	Fall	67	+12%	75	+15%	77

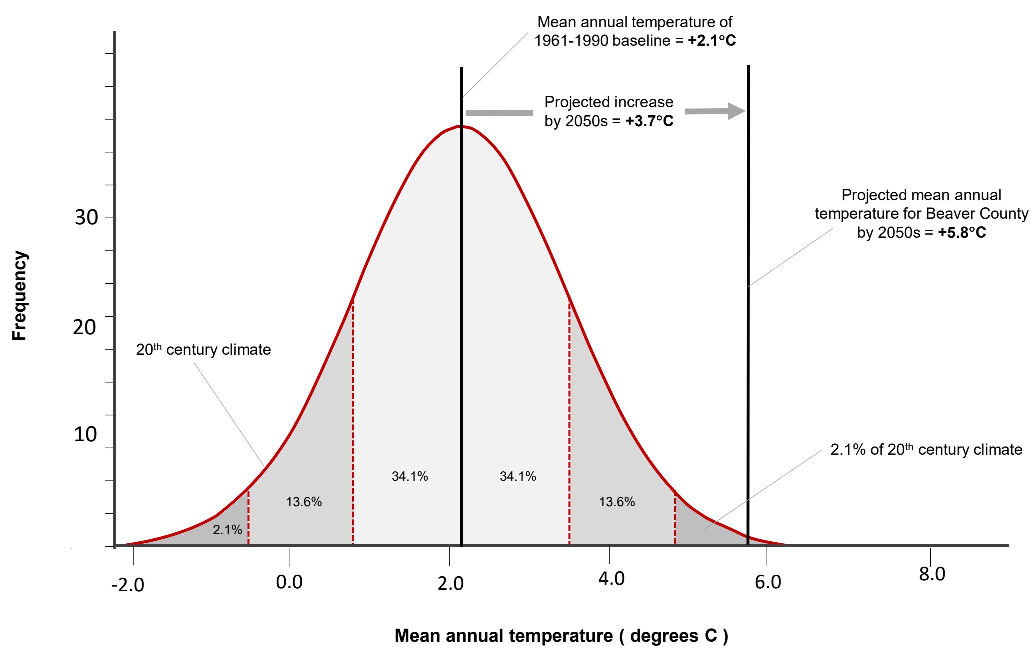
➡ Precipitation extremes

In recent years, numerous extreme precipitation events have occurred at various locations globally; several have occurred in western Canada with serious consequences, notably the 2013 flood that affected southern Alberta. Recent studies have demonstrated that extreme rainfall intensity increases by about 7% for every degree increase in global atmospheric temperature[vi]. Model projections of short-duration, high intensity precipitation is an emerging area of research and presents challenges due to—among other things—difficulties in modelling convective storms and the limited availability of hourly climate data for establishing long-term trends. However, as global temperatures increase, the capacity of the atmosphere to carry water vapor also increases. This will supply storms of all scales with increased moisture and produce more intense precipitation events[vii]. Consequently, it is very likely that Beaver County will see more extreme precipitation events as the climate continues to warm in the coming decades.

Box 2: Putting projected changes in mean annual temperature in context: business-as-usual scenario

To place the magnitude of the projected temperature changes by the 2050s into context, the 20th century climate of Beaver County (1917-2016) was fitted to a normal distribution (bell curve). The mean of the probability distribution is then shifted by the projected temperature increase under the *business-as-usual scenario* of +3.7°C above the 1961-1990 baseline. This increase in mean annual temperature represents a shift of more than two standard deviations above the 20th century mean temperature. In other words, the climate projections indicate that the mean annual temperature of the 2050s in Beaver County will be like the warmest 2-3% of 20th century climate.

Although a change in mean annual temperature of +3.7°C may not appear to be a large absolute shift in climate, when compared with the probability distribution of 20th century climate in Beaver County, a shift of this magnitude is substantial. By analogy, the projected shift in mean annual temperature will replace the climate of Beaver County with the historical climate (1961-1990) of Lethbridge, Alberta.



PROJECTED ENVIRONMENTAL CHANGES

Projected changes in average temperature and precipitation in Beaver County will have broad consequences across the natural environment, including for soil moisture, growing season, regional ecosystems, wetlands, river flows and wild fires.

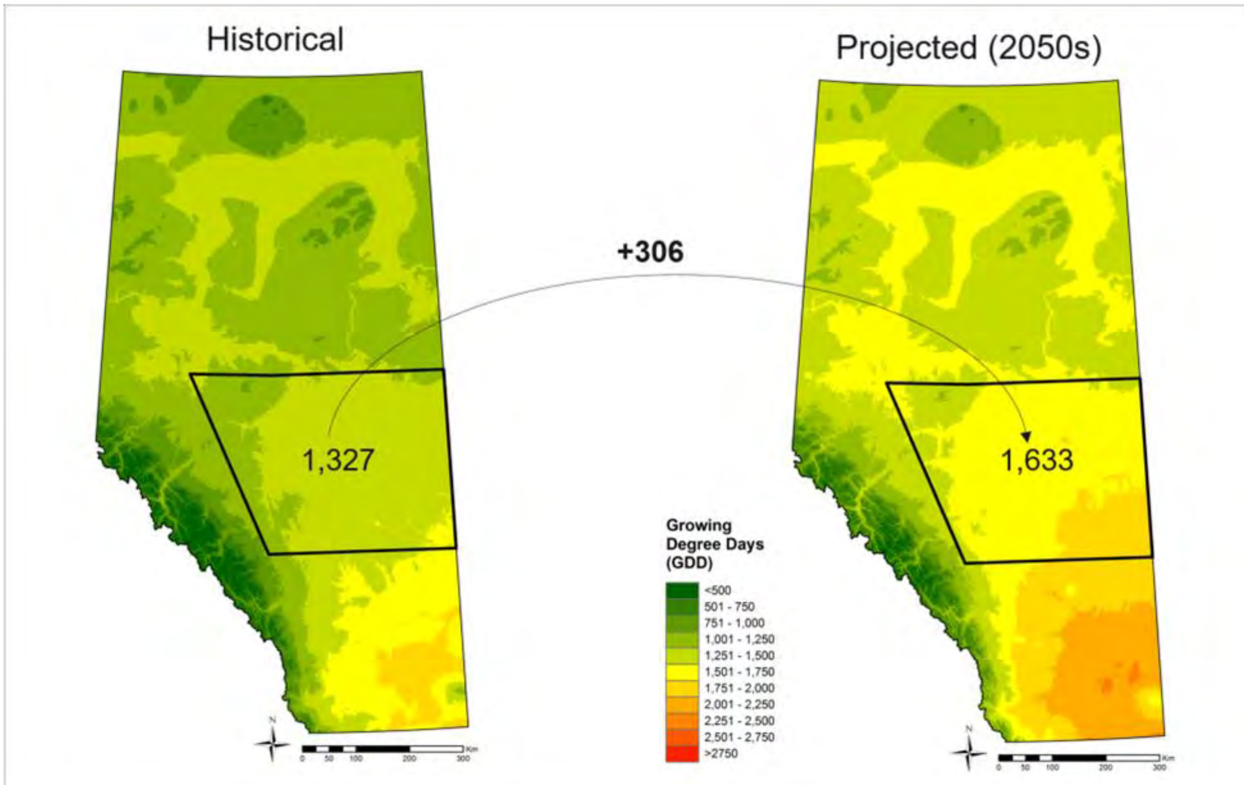
➡ Available moisture and growing season

Although mean annual precipitation is projected to increase in Beaver County by the middle of the century, the region is projected to become drier overall because warmer temperatures will increase the rate of evaporation from vegetation and soils, such that overall moisture loss will exceed the projected increase in mean annual precipitation[viii]. In addition, while mean annual precipitation is projected to increase, the slight projected decline in precipitation during the warm summer months will likely contribute to moisture stress[ix].

The projected increases in average temperatures in spring, summer and fall will result in increases in both the length and the warmth of the growing season in Beaver County. By the 2050s, Beaver County is projected to experience an increase of approximately 306 (growing) degree days, on average (see Figure 12); growing degree days are a measure of the length and warmth of the growing season[x]. Put another way, the average growing season in Beaver County by the middle of the century will be more like the growing season experienced around Lethbridge, Alberta in today's climate.

A reduction in available moisture and an extended growing season are projected consequences of climate change common to most of the Alberta boreal and prairie regions[xi]. Because of its more northern location relative to much of the rest of the prairie region, the benefit for agriculture of the projected longer growing season in Beaver County may be greater than the potential negative impacts of the projected reduction in available moisture[xii].

Figure 12: (A) Historic (1961-1990) and (B) projected distribution of Growing Degree Days in Beaver County Region by the 2050s (2041-2070)[xiii]



➡ Regional ecosystems

Alberta's natural sub-regions, which are defined by unique combinations of vegetation, soil and landscape features, represent the diversity of ecosystems in the province. Beaver County is currently located at the interface between the Central Parkland and the Dry Mixedwood Forest regions (see Figure 13). The Central Parkland ecosystem is a mosaic of grasslands and deciduous (aspen) forests, which, at higher elevations (such as in Elk Island National Park and the Beaver Hills) and further north, transition to a more continuous aspen forest with spruce stands—the Dry Mixedwood Forest ecosystem[xiv].

The warmer and drier conditions projected for the Beaver County area will have consequences for these regional ecosystems. The projected climate for the 2050s will be more favourable for Mixed Grassland ecosystems and less favourable for the Central Parkland and Dry Mixedwood Forest ecosystems (as shown in Figure 13)[xv]. As a result, natural spruce and aspen forests in the area may be less likely to recover from disturbances like fire or insect outbreaks, leading to an expansion of grasslands at the expense of forests in natural areas[xvi,xvii]. The changes in regional ecosystems will also have consequences for the diversity of species that reside in the natural areas in and around Beaver County.

➡ Wildfire

The warmer and drier climate projected for Beaver County by the 2050s will create conditions more favourable for wildfires. A longer fire season with weather conditions more conducive to heightened fire risk in the future is likely to result in fires that are more difficult to control and in an increase in the average area burned[xviii, xix].

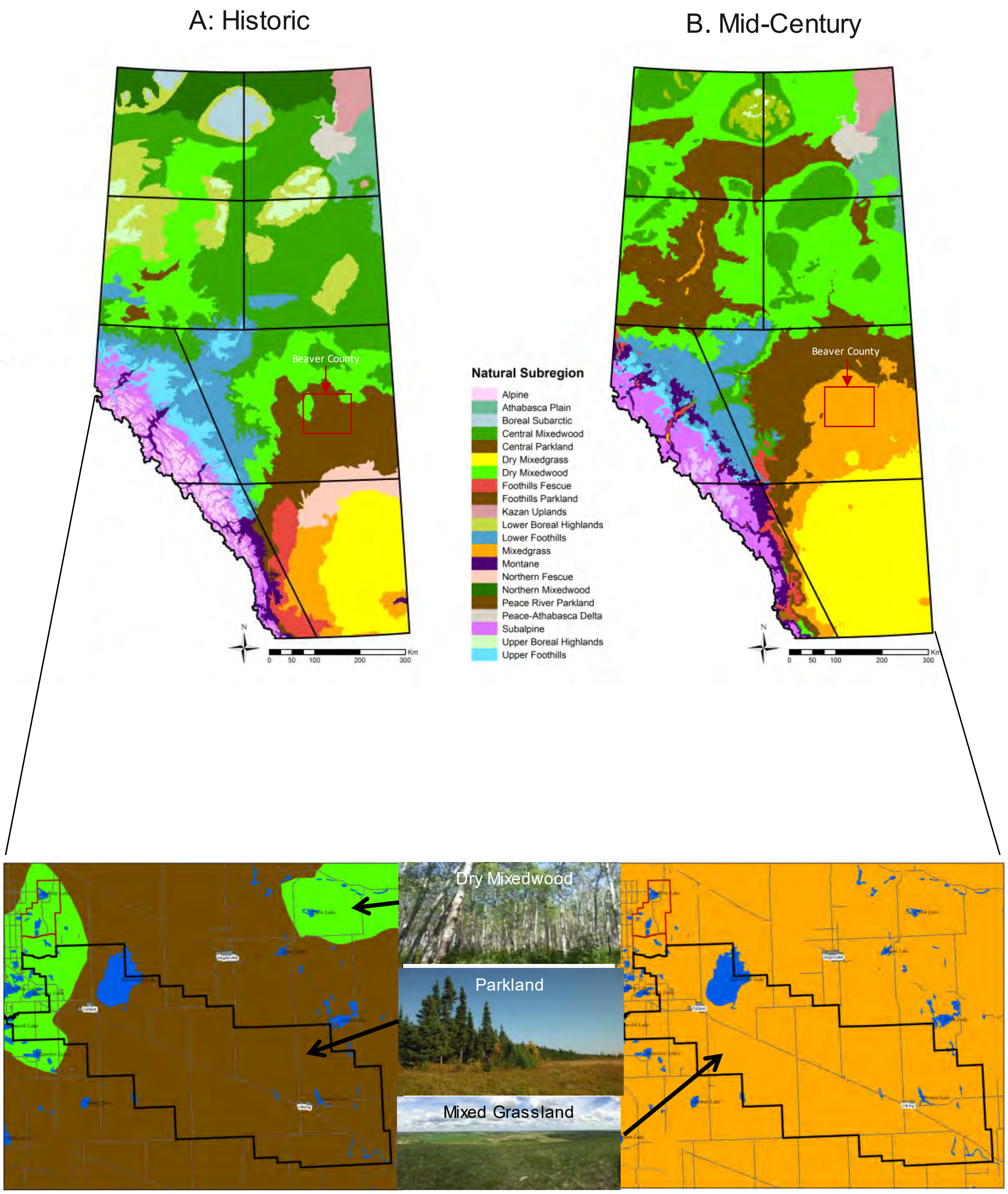
➡ Streamflow

Streamflow in the North Saskatchewan River depends on both snowmelt runoff from the eastern Rocky Mountains and glacial meltwater[xx]. Warmer winter temperatures, an increased proportion of rain versus snow in winter months, and earlier snowmelt will all influence winter snow pack, and consequently streamflow in the river[xxi]. Streamflow in the North Saskatchewan River is projected to increase in winter, peak earlier in the spring, and decrease in the summer[xxii]. Meltwater from glacial sources will become increasingly less reliable in the future: as glaciers in the eastern Rockies continue to melt, the North Saskatchewan River will experience a decrease in glacier-derived streamflow.

➡ Wetlands

Wetlands in the Beaver County region and in the prairie region more broadly are highly sensitive to climate change and variability[xxiii]. Projected declines in summer precipitation and overall available moisture, and more frequent drought conditions in the future will lead to reductions in wetland area and depth, and will reduce wetland permanence[xxiv,xxv].

Figure 13: (A) Historic (1961-1990) and (B) projected (2050s) distribution of natural sub-regions in Alberta and in Beaver County[xxvi]



4. Climate Risks and Opportunities for Beaver County

Session 3 at the workshop invited participants to:

1. Identify how projected climate or environmental changes for the 2050s could impact Beaver County; and

2. Translate the identified impacts into risks and opportunities to establish priorities for action planning.

Potential Climate Impacts

Workshop participants identified a range of climate-related impacts for the local economy, property and infrastructure, the natural environment, and residents' health and lifestyles. The list of identified impacts is provided in Table 2.

Table 2: Potential climate change impacts with mainly negative (-) or mainly positive (+) consequences for Beaver County

• Heat stress on people (-)	• Loss of winter recreation (-)
• Road damage (-)	• Pest infestation (-)
• Damage to land (-)	• Heat stress-damage to crops (-)
• Wildland fire (-)	• Flooding of communities (-)
• Vegetation loss (-)	• Dust storms (asthma and health impacts) (-)
• Reduced water availability (-)	• Freeze-thaw cycles (-)
• Change in wind seasonality) (-)	• Increased crop varieties / types (+)

PRIORITY CLIMATE RISK AND OPPORTUNITIES

The potential impacts listed in Table 2 served as a starting point for the risk and opportunity assessment. Following plenary discussion at the workshop, some impacts were merged, and the descriptions modified. Other impacts were deemed not particularly relevant to Beaver County or had positive and negative consequences that were judged to cancel out; these are not considered further. This produced a smaller list of the most important potential impacts for Beaver County.

Workshop participants were invited to translate these impacts into risks (impacts with mainly negative consequences) and opportunities (impacts with mainly positive consequences), and to prioritize the risks and opportunities. Priorities are assigned to impacts by scoring, first, the severity of potential consequences, and second, the likelihood of those consequences at that level of severity being realized. Participants assigned scores to impacts using the consequence scales found at Appendix B (for risks) and Appendix C (for opportunities), and the likelihood scale found at Appendix D.

➡ Potential risks

Table 3 provides a description of the potential climate change risks facing Beaver County. The description includes a selection of key consequences, along with the label used to identify the impact in the “risk map” shown in Figure 14.

The risk map is a two-dimensional representation of the average level of adverse consequence assigned each impact by workshop participants, plotted against the average level of likelihood assigned each impact. Impacts in the upper right corner of the map have relatively larger adverse consequences combined with a relatively higher likelihood of occurrence. These impacts represent priorities for action.

Table 3: Climate change risks facing Beaver County by the 2050s

Potential local risks		Key consequences for Beaver County
Label for risk map	**Description**	
"Heat stress"	Increased risk of heat stress on vulnerable populations (aging demographic) due to more extreme heat events	• Increased health care costs • Increased potential for human (mental and physical) illness and mortality • Increased cost to municipalities to support impacted residents
"Road damage"	Damage to roads because of excessive moisture and precipitation	• Increased road maintenance costs • Decrease in property values (because of ongoing poor access to properties) • Increased taxes (to cover repair costs) • Social impact (from transport interruption) and resident frustration • Reduced access to land
"Damage to land"	Damage to land because of excessive moisture and precipitation	• Decrease in property values • Increased taxes • Reduced access to land (for agriculture) • Decreased productivity of crops (lower yields) • Delayed crop seeding • Increased potential for crop disease • Social impact and resident frustration
"Wildland fire"	Increased wildland fire risk caused by increased summer temperatures and less precipitation in summer	• Negative impacts to agriculture industry – damage to crops and fencing • Increased fire fighting and protection costs to municipalities • Damage to property and buildings • Potential health impacts • Loss of wildlife habitat
"Vegetation loss"	Negative impacts to local vegetation, crops and natural areas, due to reduced soil moisture	• Economic impacts for agricultural sector from reduced productivity • Loss of biodiversity • Increased water consumption
"Reduced water availability"	Potential water supply shortage due to decreased summer stream flows and less available moisture	• Lack of water supply for fire fighting • Reduced water availability for crops and agriculture – economic and social consequences
"Wind seasonality"	Change in the seasonality and predictability of wind	• Increased uncertainty for agricultural sector

Potential local risks		Key consequences for Beaver County
Label for risk map	**Description**	
"Loss of winter recreation"	Reduced opportunities for traditional winter recreation due to warmer winter temperatures and less precipitation falling as snow	• Economic impacts – residents seeking recreation opportunities elsewhere • Negative impact on quality of life for residents
"Pest infestation"	Increased potential for pest infestation due to increased summer temperatures, less precipitation in summer, and increased drought potential	• Lower agricultural yields and production • Economic impacts for agricultural sector from reduced productivity – spinoff impacts to local communities and businesses
"Damage to crops"	Damage to agricultural crops and production from increased summer temperatures, less precipitation in summer, and increased drought potential	• Lower agricultural yields and production • Economic impacts for agricultural sector from reduced productivity – spinoff impacts to local communities and businesses • Increased potential for pest/crop infestations
"Flooding"	Increased risk of flooding in low-lying areas of communities from extreme precipitation events and storms	• Damage to homes, buildings and property • Increased erosion and infrastructure damage
"Dust storm"	Increased potential for dust storms because of drier conditions from increased temperatures and less precipitation in summer	• Increased public health impacts, particularly for those with asthma
"Freeze-thaw"	Frost heave and damage to roads and infrastructure from freeze-thaw cycles	• Increased road maintenance costs • Increased taxes • Increased risk of water main breaks, and potential flooding • Increased cracking and stress on building foundations

Figure 14: Risk map for climate change impacts with mainly negative consequences for Beaver County

CONSEQUENCES						
	(5) Major					Higher priorities for action
	(4)			Vegetation loss Flooding	Freeze-thaw Wildland fire Reduced water availability	
	(3) Moderate			Heat stress Dust storm Damage to land Pest infestation Damage to crops	Road damage Wind seasonality	
	(2)			Loss of winter recreation		
	(1) Negligible	Lower priorities for action				
		(1) Low	(2)	(3) Moderate	(4)	(5) High
		LIKELIHOOD				

Impacts in the red and yellow zones are priorities for further investigation or management. Impacts in the red zone are the highest priorities for action. Impacts in the green zone represent broadly acceptable risks at this time; no action is required now for these impacts beyond monitoring of the risk level as part of periodic reviews (see Section 6).

➡ Potential opportunities

One potential climate change opportunity was identified for Beaver County – an increased agricultural growing season. Potential local benefits of an increased growing season were identified as:

- An increase in crop varieties that can be grown, including the introduction of new, higher value-added crops;
- Extended harvesting and planting windows; and
- Extended grazing seasons.

5. CLIMATE RESILIENCE ACTIONS

The next step is to formulate an initial set of actions (a) to increase resilience to priority risks and (b) to increase capacity to capitalize on priority opportunities.

For the priority risks and opportunities, Session 5 at the workshop invited participants to devise a list of recommended adaptation actions. Ideally, actions should be devised for all priority risks and priority opportunities. However, within the time constraints of the one-day workshop used by Climate Resilience Express, action planning focuses on subset of priority risks and opportunities, chosen by workshop participants. The three priorities selected for action planning are:

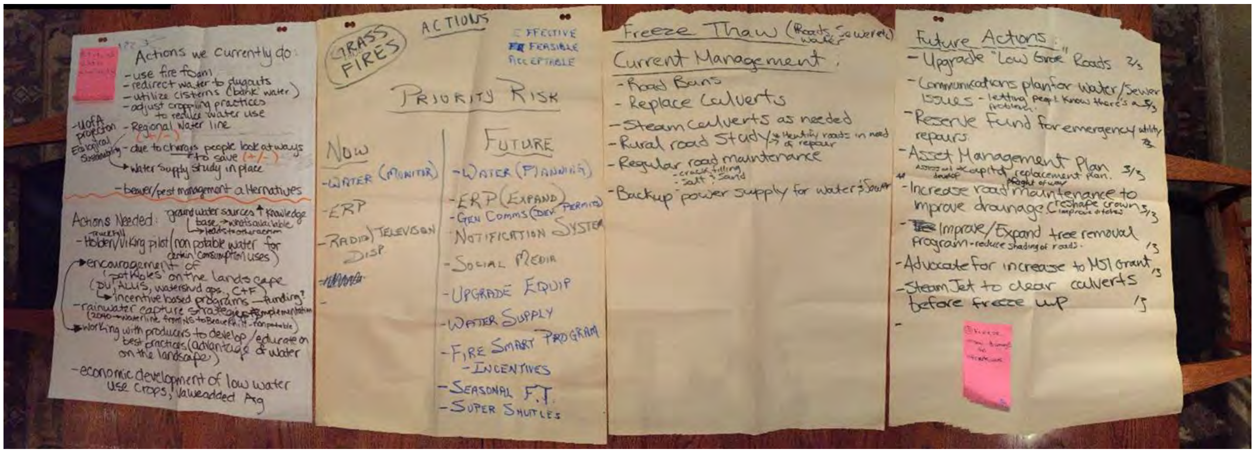
1. Wildland fire;
2. Reduced water availability; and
3. Freeze-thaw cycles.

For each of these three priorities, a starter action plan is developed by, first, addressing the following two questions:

1. What actions are currently being taken to manage the risk or opportunity?
2. What new actions, or improvements to existing actions, are needed to more effectively manage the risk or opportunity in the future?

Second, the resulting long-list of potential actions (shown in Figure 15) is screened to identify three to five of the most promising actions for inclusion in the starter action plan for each priority risk or opportunity. When screening actions, participants considered: the effectiveness of the action in mitigating the risk; how feasible it would be to implement (in terms of available funding and human resources); and how generally acceptable it would be to stakeholders, including elected officials.

Figure 15: Brainstorming climate resilience actions for Beaver County



To inform decision-making and support implementation of the recommended actions, workshop participants also provided information on:

1. Total implementation costs;
2. The timeframe for implementation (i.e., how long before the action is operational); and
3. The lead department or organization.

These three factors are key inputs to the development of an implementation strategy. Table 4 was used to help participants provide approximations for (1) and (2).

Starter action plans for each of the four selected priority risks are provided below. It is important that the other priority risks and opportunities are put through a similar action planning exercise as soon as it is practical to do so.

Of note, Beaver County is already committed to numerous actions that will help manage the risks and opportunities of climate change identified in Section 4. Some of these actions were identified during Session 5 of the workshop and include:

- An existing emergency response plan and collaboration with adjacent jurisdictions;
- Identification and monitoring of water availability for firefighting;
- Use of fire foam, rather than water, for firefighting;
- Agricultural producers are adjusting practices to reduce water use;
- Utilization of cisterns to bank water for use during dry spells;
- Collaboration on a water supply study to determine feasibility of a regional water line;

- Exploration of options for beaver management to improve water availability;
- Ongoing road maintenance including crack filling, salting and sanding;
- Ongoing stormwater management activities including culvert steaming (cleaning), and replacement when necessary;
- A rural road study to identify roads in need of repair; and
- Back-up power supplies for critical water and sewer system infrastructure.

It is important that the County continue to support the implementation of these important initiatives that will also serve to enhance the County's climate resilience.

Table 4: Climate resilience actions—definitions for total implementation costs and implementation timeframe

Information	Descriptor	Description
Total implementation costs	Low	Under $10,000
	Moderate	$10,000 to $49,999
	High	$50,000 - $99,999
	Very high	$100,000 or more
Timeframe to have action implemented (operational)	Ongoing	Continuous implementation
	Near-term	Under 2 years
	Short-term	2 to 5 years
	Medium-term	5 to 10 years
	Long-term	More than 10 years

Wildland Fire

Action	Cost	Timeframe	Lead
Implement a County-wide FireSmart Program	Moderate	Short-term	Beaver Emergency Services Commission (BESC)
Develop a fire risk communication system, including through social media	Moderate	Near-term	BESC / Beaver County
Upgrade firefighting equipment, with emphasis on equipment for wildland fires	Very high	Short-term	BESC / Beaver County
Conduct a regional water planning process to identify future water supply needs	Very high	Long-term	BESC / Highway 14 Regional Water Services Commission
Continue expansion and improvement of the Emergency Response Plan	Low	Near-term	BESC

Freeze-Thaw Cycles

Action	Cost	Timeframe	Lead
Develop a communications plan to inform and communicate with the public on water and sewer issues	Low	Near-term	Highway 14 Regional Water Services Commission
Increase road right-of-way maintenance to improve drainage	Very high	Ongoing	Beaver County (Public Works)
Develop an Asset Management Plan	Moderate	Near-term	Beaver County (Administration)

REDUCED WATER AVAILABILITY

Action	Cost	Timeframe	Lead
Conduct a study to increase knowledge and determine sources of groundwater	High	Near-term	Municipality in partnership with Watershed Alliances
Implement a truck fill pilot program in Holden-Viking for non-potable water	Very high	Short-term	Municipality (Agricultural Services Board) + Highway 14 Regional Water Services Commission
Develop a wetland protection incentive program, including producer education and communication, best practices and incentives	Very high	Ongoing	Municipality in partnership with Watershed Alliances and groups
Implement rainwater capture strategies across the County	Very high	Long-term	Municipality (Agricultural Services Board)
Support planting of low water use crops as economic development and value-added for producers	Very high	Long-term	Beaver County Battle River Alliance for Economic Development
Install a water line from the North Saskatchewan River to Beaverhill	Very high	Long-term	For profit corporation (Government approval needed)

6. Implementation and Next Steps

> Writing a plan and leaving it on the shelf is as bad as not writing the plan at all. If this Action Plan is to be an effective tool, it must be implemented and reviewed periodically.

Acting

The recommended actions listed in Section 5 serve as a 'shopping-list'. County staff should establish priorities from the listed actions and begin implementation as soon as practical. Consideration should be given to forming a cross-departmental and cross-community implementation team from among workshop participants to oversee implementation of the Action Plan. Several actions can be implemented quickly with minimal investment, whereas other actions have longer-term timeframes, require a higher level of investment, and may require a more detailed implementation strategy with specific budgets and funding sources, timelines and milestones for specific activities, and defined roles and responsibilities for specific stakeholders and groups.

Effective communication with the public and other community stakeholders about climate change impacts can be valuable in helping them understand why certain measures are needed. Community outreach, for example through the County website or at public events, can be an effective way to both:

- Gather input from community members on the content of the Action Plan; and
- Promote the County's efforts to make the community more resilient.

Mainstreaming

This Action Plan is developed as a 'stand-alone' document. However, it is important that climate resilience is integrated (i.e., 'mainstreamed')—as a matter of routine—into the County's strategies, plans, policies, programs, projects, and administrative processes. For example:

- Climate resilience should be considered in all future land use and development decisions, including administrative processes such as bids, tenders and contracts for planning and development work;
- Strategic plans (e.g., the Municipal Development Plan) and neighborhood scale plans should consider potential future climate change impacts; and

- Decisions related to the design, maintenance, and upgrading of long-life infrastructural assets and facilities should likewise consider future climate changes and impacts.

Review and Update

Building resilience to climate change is not a static process. The priority risks and opportunities identified in this Action Plan, along with the recommended actions to address them, should be viewed as the first step in Beaver County's journey towards a climate resilient future.

The climate resilience action planning process is dynamic. For a start, the rapidly changing scientific knowledge about the physical impacts of climate change means that climate change risk and opportunity assessments are not one-off activities, but rather need to be reviewed and updated regularly. This Action Plan should be reviewed and updated every 5 years to ensure it remains relevant and effective, taking account of:

- Lessons learned from the implementation of actions;
- New scientific information about climate projections and corresponding impacts; and
- Changes to the County's goals and policies.

Keeping the Action Plan relevant may only involve a few minor adjustments, or it may require revisiting some of the steps in the climate resilience planning process and preparing a new Action Plan.

7. Appendices

Appendix A: Workshop participants

Name	Title
Mike Hoffman	Regional Emergency Manager, Beaver Emergency Services Commission
Mara Erickson	Extension & Stewardship Coordinator – North Saskatchewan Watershed Alliance; Vermilion River Watershed Alliance
Sarah Skinner	Watershed Planning Coordinator – Battle River Watershed Alliance
Al Harvey	CAO – Highway 14 Water Commission
Doug Hanson	Deputy Mayor – Village of Holden
Terry Magneson	Mayor – Village of Ryley, Agricultural Service Board Producer at Large
Brent Christensen	Agricultural Service Board Producer at Large, Seed Cleaning Plant Board Member
Jordan Nakonechny	Augustana Research Team, County Resident
Jim Kallal	Reeve, Beaver County
Kevin Smook	Councillor, Beaver County
Aimee Boese	Agricultural Fieldman, Beaver County
Mike Bates	Agricultural Fieldman, Beaver County
Darby Dietz	Superintendent of Public Works, Beaver County

Appendix B: Scale for scoring the consequences of risks

Score	Description
(1) **Negligible**	• Negligible impact on health & safety and quality of life for residents • Very minimal impact on local economy • Insignificant environmental disruption or damage • Slight damage to property and infrastructure, very short-term interruption of lifelines, or negligible cost to municipality
(2)	
(3) **Moderate**	• Some injuries, or modest temporary impact on quality of life for some residents • Temporary impact on income and employment for a few businesses, or modest costs and disruption to a few businesses • Isolated but reversible damage to wildlife, habitat or and ecosystems, or short-term disruption to environmental amenities • Damage to property and infrastructure (including critical facilities and lifelines), short-term interruption of lifelines to part of community, localized evacuations, or modest costs to municipality
(4)	
(5) **Major**	• Many serious injuries or illnesses, some fatalities, or long-term impact on quality of life for most residents • Long-term impact on businesses and economic sectors, major economic costs or disruption • Widespread and irreversible damage to wildlife, habitat and ecosystems, or long-term damage, disruption to environmental amenities • Widespread damage to property & infrastructure (including critical facilities and lifelines), extensive and long-term interruption of services, widespread evacuations, or major cost to municipality

Appendix C: Scale for scoring the consequences of opportunities

Score	Description
(1) **Negligible**	• Increase in income / jobs for a *few* businesses • Lifestyle improvement for *some* residents • Cost savings for municipality, businesses or residents
(2)	
(3) **Moderate**	• Increase in income / jobs for a *sector* • Lifestyle improvement for a *select group* of residents • Cost savings for municipality, businesses or residents • *Short-term* boost to reputation and image of municipality
(4)	
(5) **Major**	• Increase in income / jobs for *key sectors* of local economy • Lifestyle improvement for a *majority* of residents • Cost savings for municipality, businesses or residents • *Long-term* boost to reputation of municipality

Appendix D: Scale for the scoring the likelihood of consequences

Score	Recurring impact	Trending impact
(1) **Low**	Once in 50 years or more	*Very unlikely* – less than 5% chance of occurrence in next 50 years
(2)	Once in 10 to 50 years	*Unlikely* – 5% to 35% chance of occurrence in next 50 years
(3) **Moderate**	Once in 5 to 10 years	*Possible* – 35% to 65% chance of occurrence in next 50 years
(4)	Once in 1 to 5 years	*Likely* – 65% to 90% chance of occurrence in next 50 years
(5) **High**	Up to once per year	*Almost certain* – 95% or greater chance of occurrence in next 50 years

ENDNOTES

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[i] Participating communities include: Banff, Beaver County, Big Lakes County, Black Diamond, Brazeau County, Bruderheim, Canmore, Lacombe County, Mackenzie County, Okotoks, Spruce Grove, Sylvan Lake and Turner Valley.

[ii] Environment Canada's Adjusted and Homogenized Canadian Climate Data (AHCCD) are quality controlled climate data that incorporate a number of adjustments applied to the original meteorological station data to addresses any inaccuracies introduced by changes in instruments and observing procedures.

[iii] The significance of the trends was determined using the Mann-Kendall test after removing lag-1 autocorrelation with the Zhang (1999) method (described in Wang and Swail, 2001).

[iv] In figures 6 through 11, light red lines show individual 'Business as Usual' scenario model runs for the Pacific Climate Impacts Consortium (PCIC) downscaled ensemble. Heavy red lines show the ensemble mean for 'Business as Usual' scenario model runs. Light yellow lines show individual 'Strong Mitigation' scenario model runs for the PCIC downscaled ensemble. Heavy yellow lines show the ensemble mean for 'Strong Mitigation' scenario model runs. Purple lines show the observed record based on data from the Climate Data Guide: ERA-Interim (Dee, Dick & National Center for Atmospheric Research Staff (Eds). 2017) available at: https://climatedataguide.ucar.edu/climate-data/era-interim

[v] Seasons are defined by the standard meteorological definitions of Winter (Dec-Jan-Feb), Spring (Mar-Apr-May), Summer (Jun-Jul-Aug), and Fall (Sep-Oct-Nov).

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[ix] Ibid. (same as previous reference)

[x] Specifically, they are a measurement of heat accumulation, calculated by determining the total number of degrees by which average daily temperature exceeds a threshold temperature (in this case 5°C) over the course of a growing season.

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[xvi] Ibid.

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Email: helen@allonesky.ca
Phone: 403.471.6247

809 49th Ave SW, PO Box 19012, Calgary, AB T2S 1A0, Canada