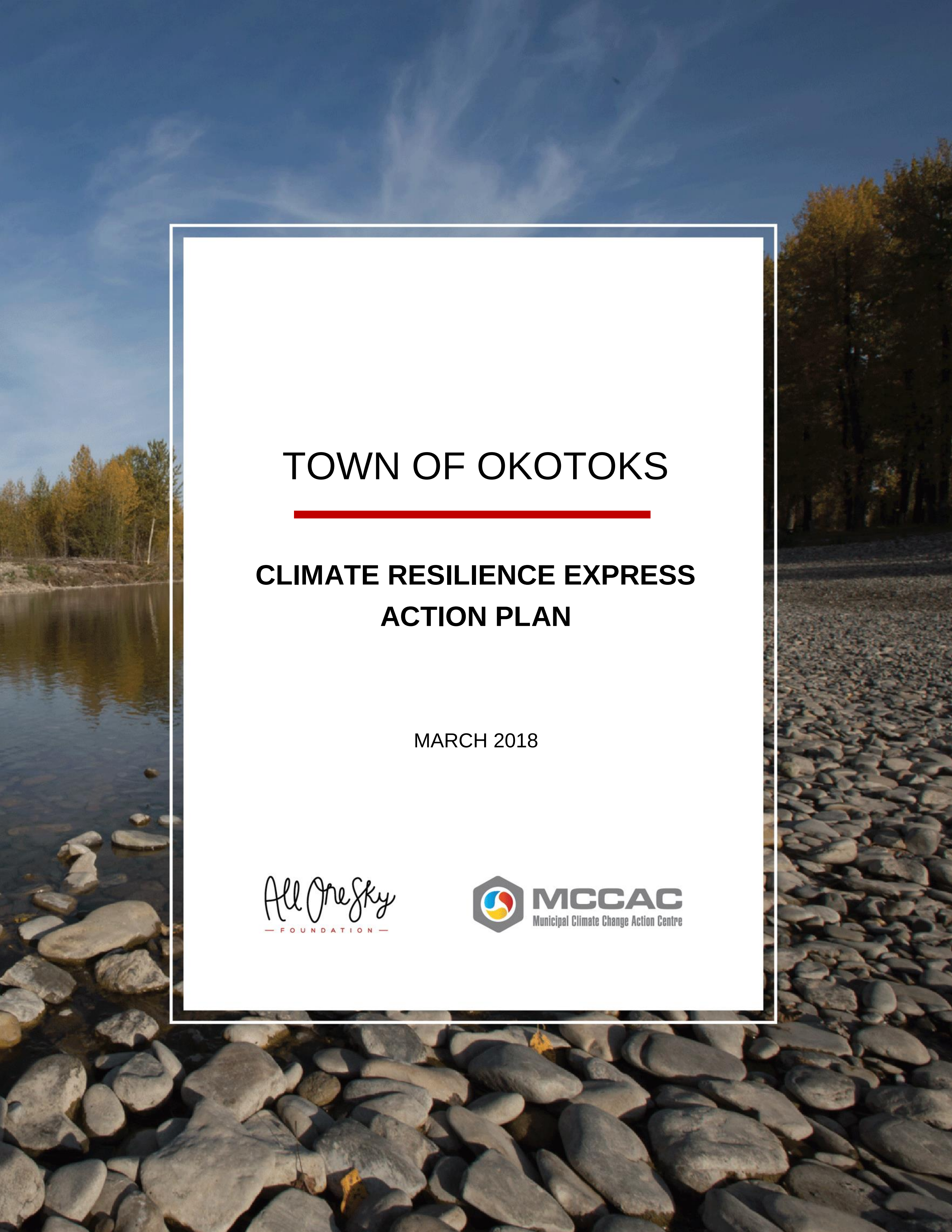


TOWN OF OKOTOKS

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 the Town of Okotoks[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 Okotoks, with observable changes in temperature, precipitation, and extreme weather events over the last century. The impacts of climate change on the Town 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, Okotoks 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, seventeen climate-related risks and six climate-related opportunities were identified by participants at a workshop in the Town of Okotoks on December 7th, 2017. Three risks were judged to be priorities requiring immediate action:

1. Water supply shortage;
2. Drought; and
3. River flooding

Starter action plans were developed for these priority risks at the workshop.

Okotoks is already committed to numerous actions that help manage the above priority risks, including: floodplain mapping, data and research for the Sheep River; floodplain development regulations; structural and non-structural flood mitigation infrastructure; emergency response planning; universal water metering and pricing; water conservation measures, including an outdoor watering schedule, rebate programs and education programs; landscaping standards and xeriscaping to promote water conservation; use of non-potable water for outdoor watering; and development of a Water Shortage Management Plan.

In addition to existing actions that help mitigate he consequences of the priority risks, sixteen further actions were identified for consideration to help Okotoks 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 Okotoks 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 Okotoks, with observable changes in temperature, precipitation, and extreme weather events over the last century. The average annual temperature in the Okotoks area has increased by about +1.4°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 interconnected 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.

Okotoks, 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;

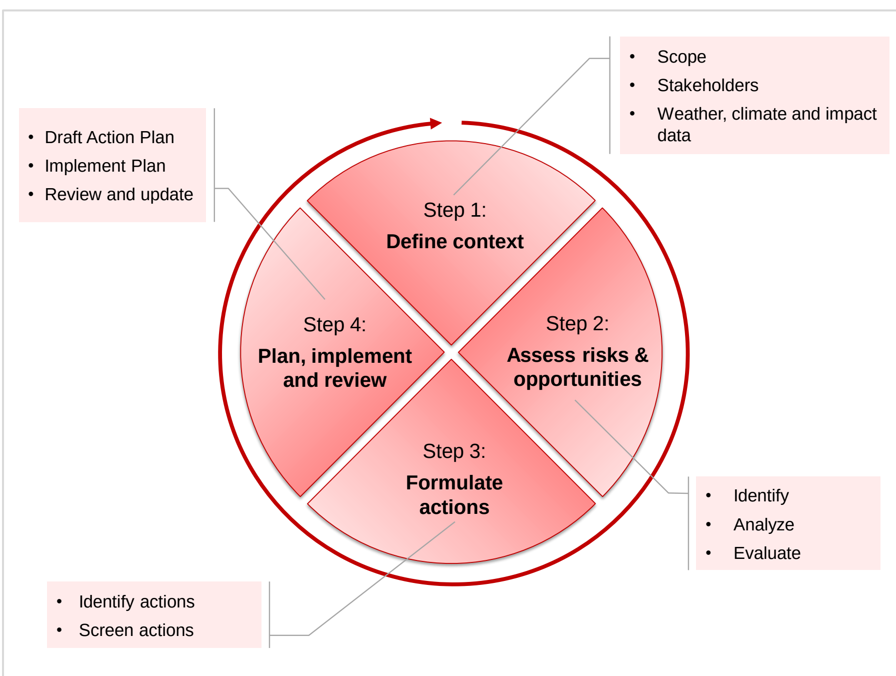
Step 2: Assess potential climate-related risks and opportunities to establish priorities for action;

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 Okotoks is established. This involves:

- **Defining the spatial scope**

  The spatial scope is limited to direct impacts within the geographic boundaries of the Town of Okotoks.

- **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 Okotoks 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 Okotoks 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 Okotoks, and second, to prioritize the identified impacts 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, however, 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 Okotoks has been affected by weather-related events in the 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

- ✓ Freeze-thaw cycles can lead to increased transportation system maintenance needs, infrastructure damage, and increased injuries from slips and falls (ice)
- ✓ Increased presence of pests and diseases vectors
- ✓ Increased wildlife presence in Town (deer)
- ✓ Drought can lead to increased fire risk, low water supply, increased tree mortality
- ✓ Water availability issues cause water restrictions and planning challenges (e.g., placing limits on growth)
- ✓ Nearby wildfires cause poor air quality and health issues
- ✓ Severe thunderstorms cause significant property damage
- ✓ Flooding has increased in intensity and severity
- ✓ Summer storms (wind, hail) cause tree and infrastructure damage
- ✓ Increased winter temperatures reduce opportunities for winter tourism

Local Climate Trends

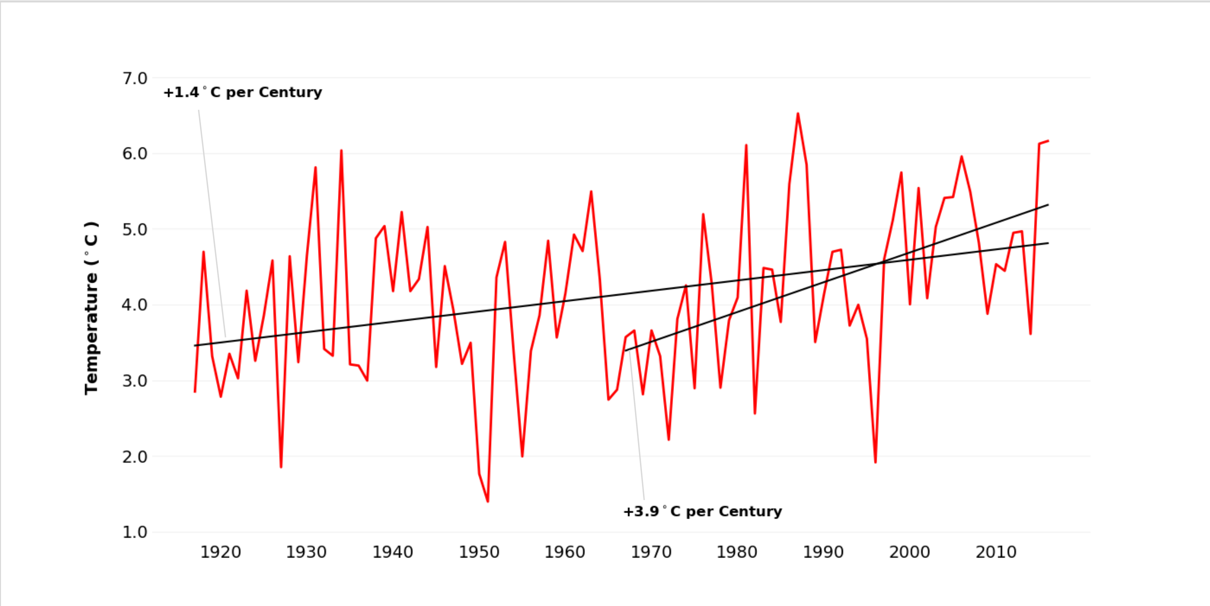
To provide a perspective of historic climate trends in Okotoks, data was collected and analyzed from four climate stations in the region (Olds, Calgary, Gleichen, and Lethbridge)[ii]. These climate stations were selected because the data cover multiple decades, are high quality, and the stations span an area that is comparable to the same area for which climate projections are available.

Climate records of temperature and precipitation for Okotoks are assembled by averaging the individual records from these four 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 +1.4 °C per century (Figure 2), which is approximately 50% faster than the observed global rate of warming over the same period. The rate of warming observed over the last 50 years is higher still at +3.9°C per century.

Figure 2: Mean annual temperature in Okotoks area (1917-2016)



The largest seasonal increase in temperature in Okotoks occurred during the winter (December-February). The observed rate of warming in winter over the last 100 years is +3.2°C per century (Figure 3). Over the last 50 years mean winter temperature increased at a rate of +8.9°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 +0.4°C per century, and +1.1°C per century over the last 50 years (Figure 4). Trends in summer temperature, however, are not statistically significant.

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 Okotoks area (1917-2016)

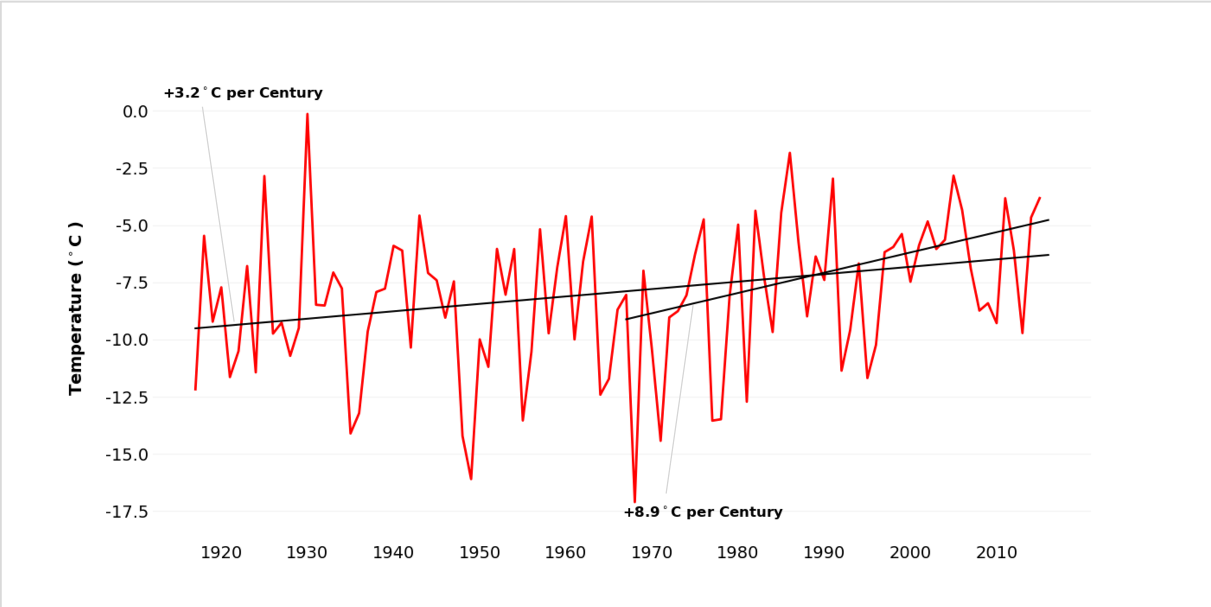
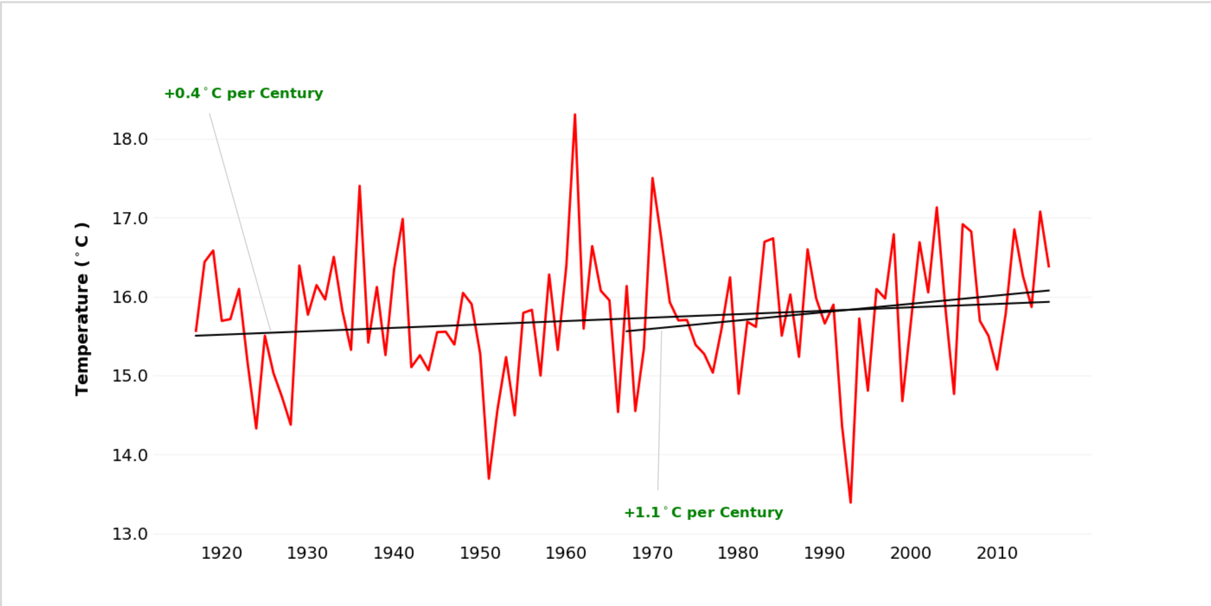


Figure 4: Mean summer temperature in Okotoks area (1917-2016)



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

➡ Precipitation records

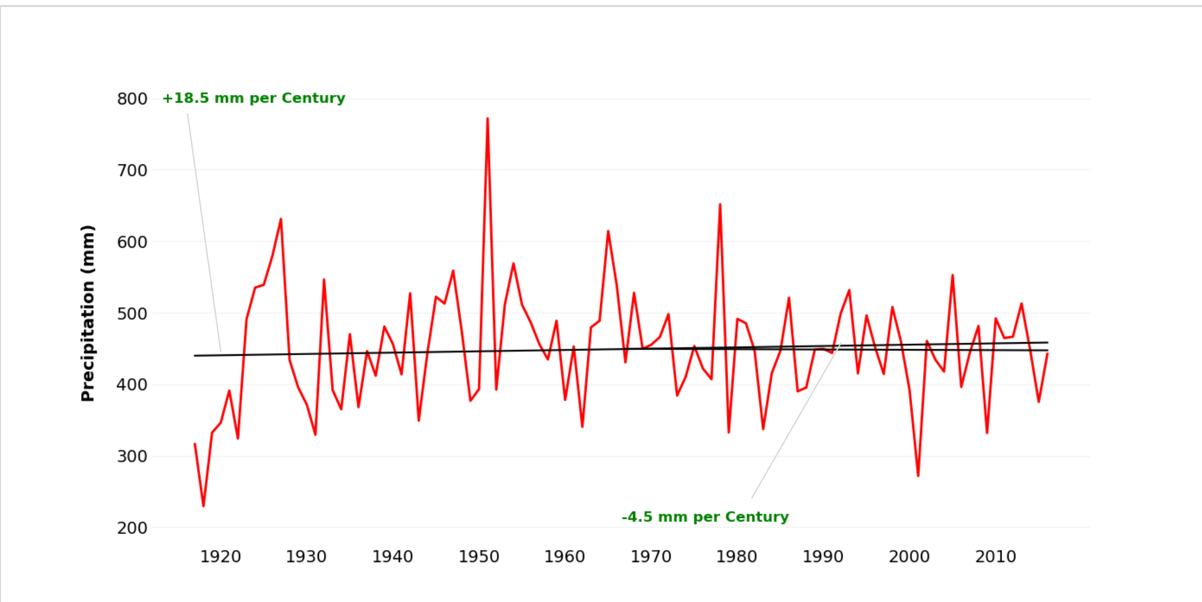
Over the last 100 years, mean annual precipitation in Okotoks increased at a rate of 19 mm per century, and over the last 50 years, mean annual precipitation has declined at a rate of -5 mm per century (Figure 5). However, neither trend in precipitation is statistically significant.

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

- -7 mm per century in spring;
- -21 mm per century in fall;
- +48 mm per century in summer; and
- -54 mm per century in winter.

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

Figure 5: Mean annual precipitation in Okotoks area (1917-2016)



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

CLIMATE PROJECTIONS FOR OKOTOKS AREA

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 the Town of Okotoks.

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 the Okotoks area 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.

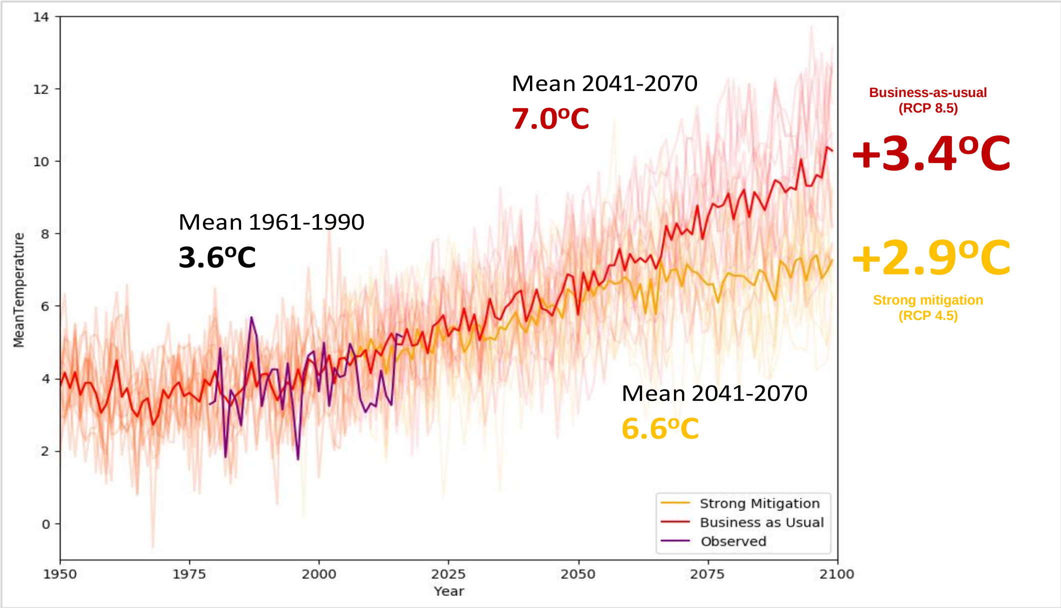
Both scenarios will result in significant changes to the local climate by mid-century, necessitating the development of robust adaptation strategies. However, changes projected under RCP 8.5. (business-as-usual) represent a worst-case scenario for adaptation planning.

- **Temperature projections**

Mean annual temperature in Okotoks is anticipated to increase by between +2.9°C (yellow line, 'strong mitigation' or RCP 4.5 scenario) and +3.4°C (red line, 'business-as-usual' or RCP 8.5 scenario) above the 1961-1990 baseline, which will increase the absolute mean annual temperature in the 2050s to between +6.6°C and +7.0°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 Okotoks over the last 50 years.

Projected increases in mean winter temperature are +3.7°C and +3.6°C for the 'strong mitigation' (RCP 4.5) and 'business-as-usual' (RCP 8.5) scenarios, respectively (Figure 7). In summer, mean temperatures are projected to increase by +2.7°C and +3.7°C for the 'strong mitigation' and business-as-usual' scenarios, respectively (Figure 8).

Figure 6: Projected mean annual temperature in Okotoks



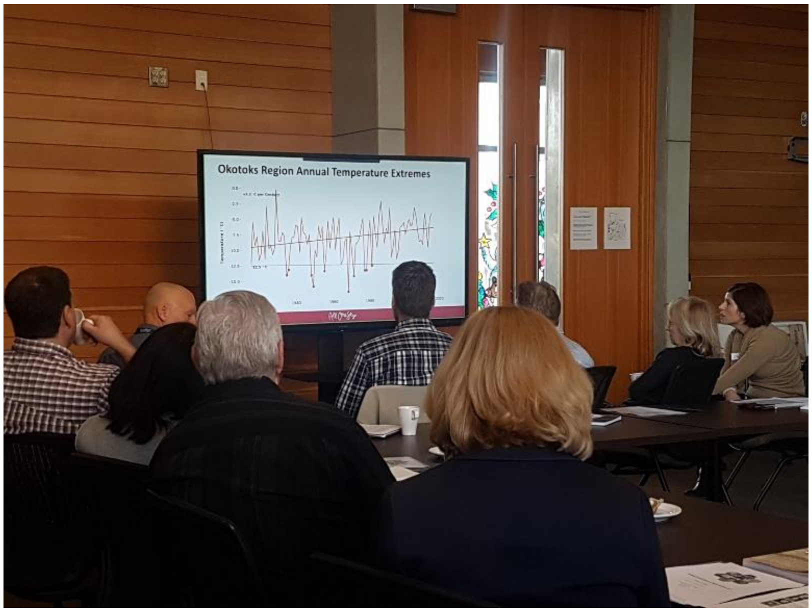


Figure 7: Projected mean winter temperature in Okotoks

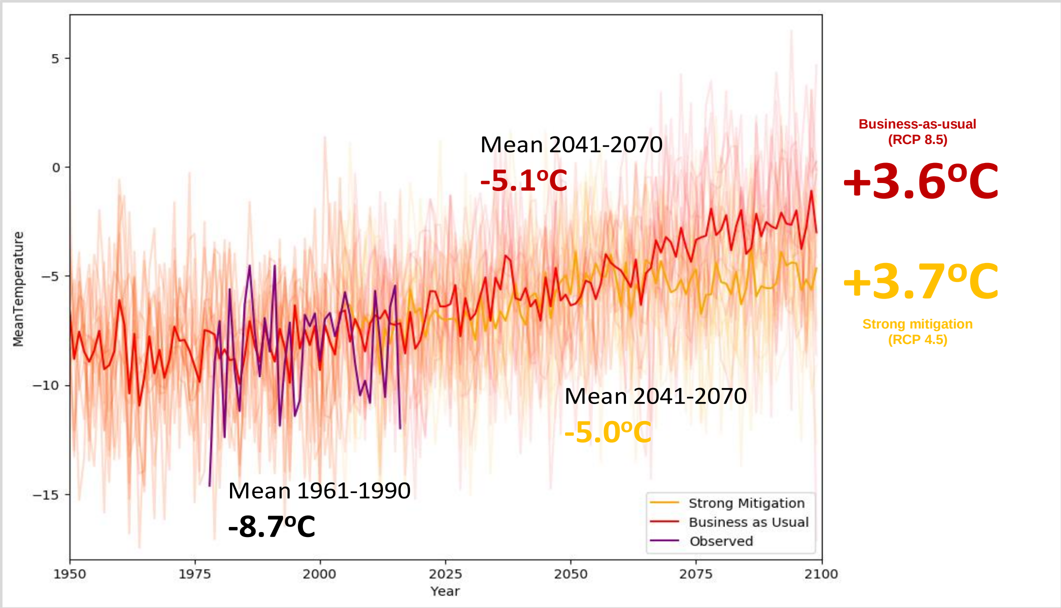
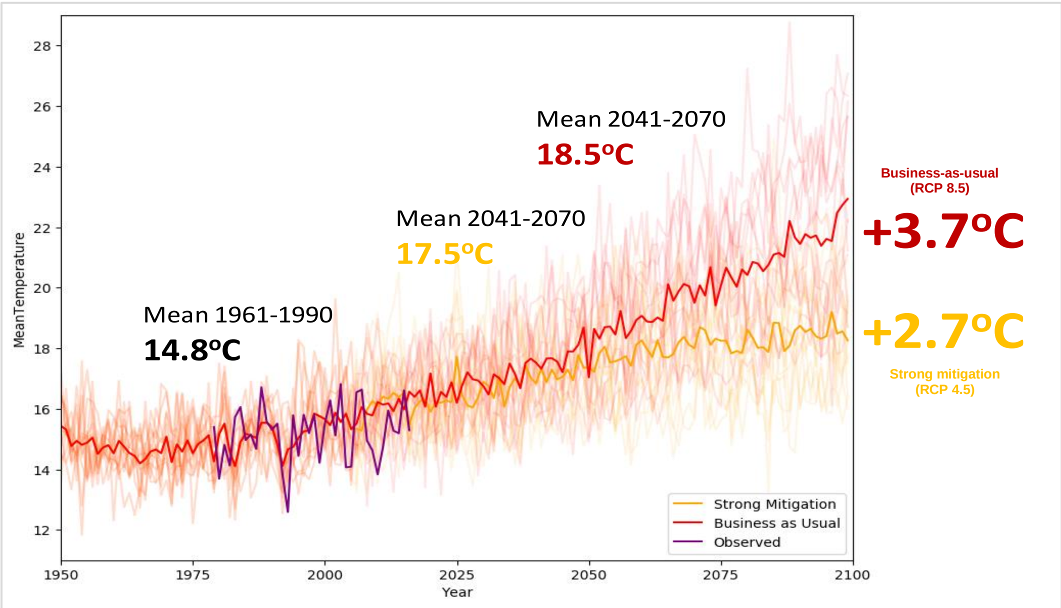


Figure 8: Projected mean summer temperature in Okotoks



➡ Precipitation projections

While precipitation declined across most seasons (annual, winter, spring and fall) over the last 50 years, precipitation is projected to increase overall 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 10% for the 'strong mitigation' (RCP 4.5) and 'business-as-usual' (RCP 8.5) scenarios, 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 9: Projected mean annual precipitation in Okotoks

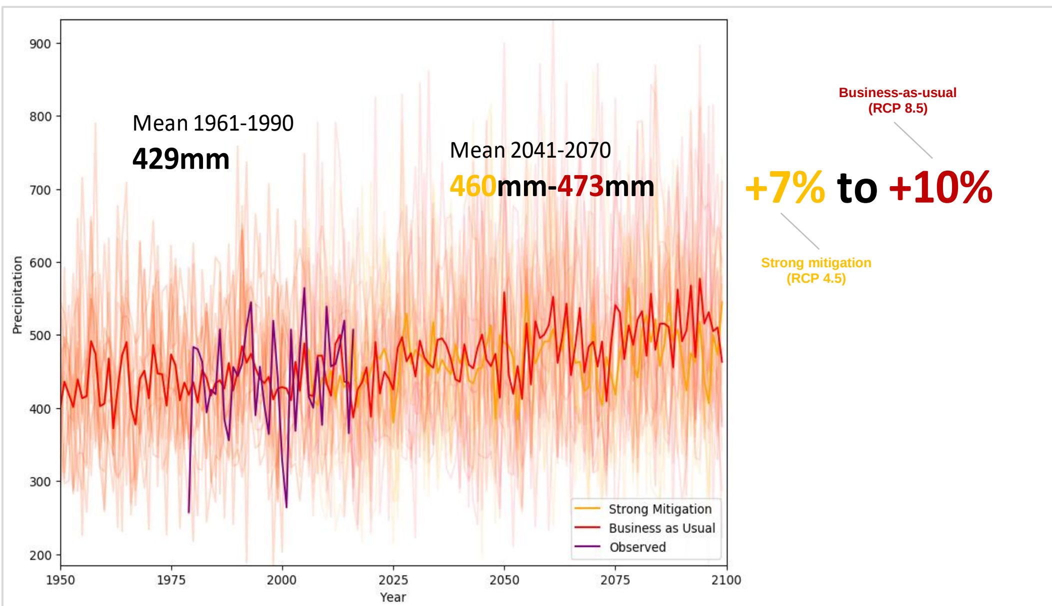


Figure 10: Projected mean winter precipitation in Okotoks

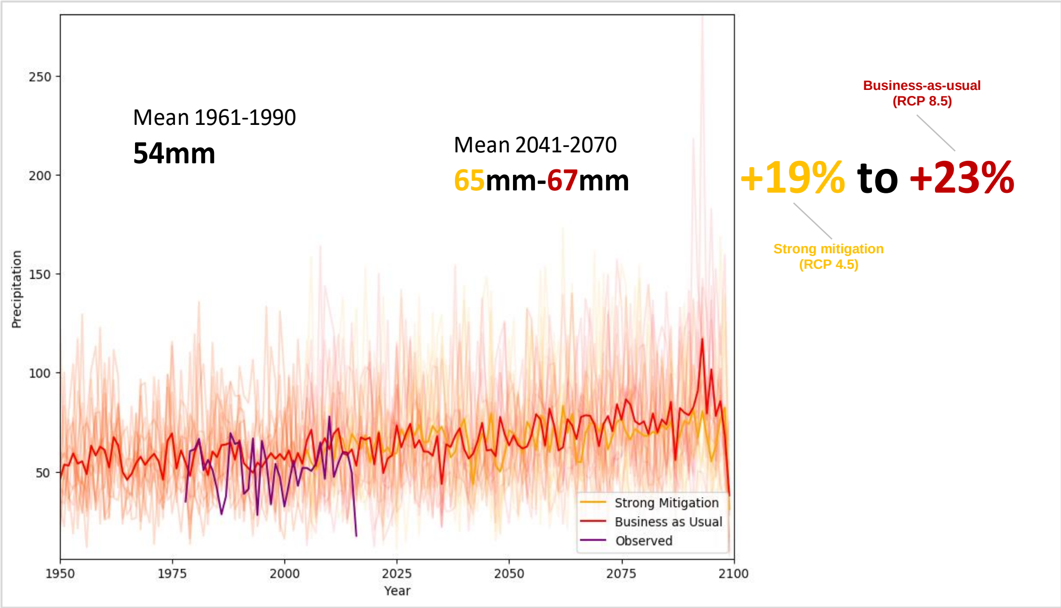


Figure 11: Projected mean summer precipitation in Okotoks

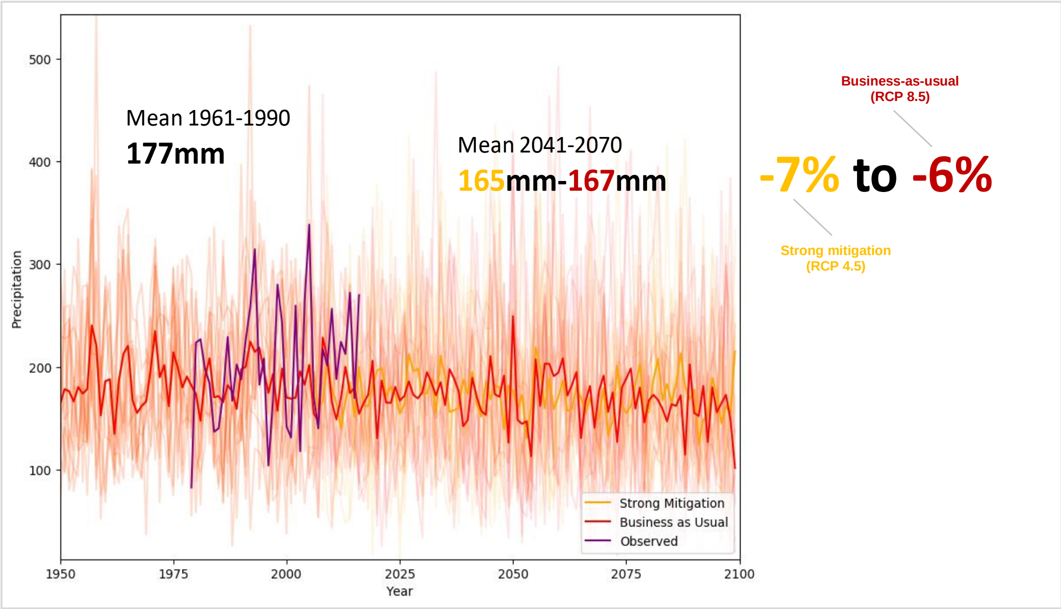


Figure 12: Maximum one-day Precipitaiton

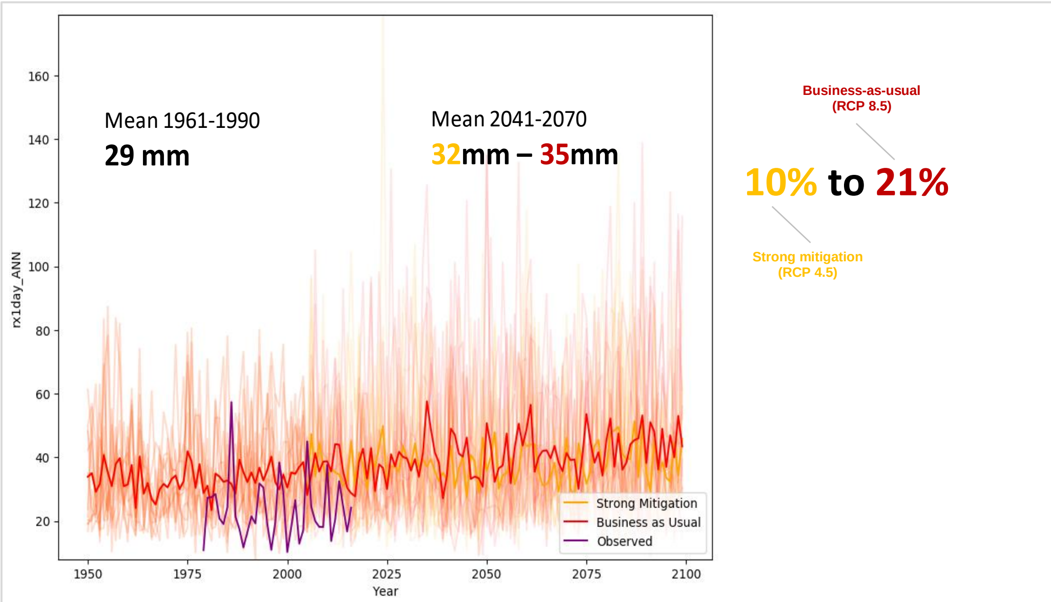


Table 1 presents a summary of projected climate changes for Okotoks by the 2050s.

Table 1: Summary of projected cliamte changes for Okotoks

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	+3.6	+2.9	+6.6	+3.4	+7.0
	Winter	-8.7	+3.7	-5.0	+3.6	-5.1
	Spring	+3.5	+2.8	+6.3	+2.9	+6.5
	Summer	+14.8	+2.7	+17.5	+3.7	+18.5
	Fall	+4.3	+2.5	+6.9	+3.8	+8.1
Precipitation (mm)	Annual	429	+7%	460	+10%	473
	Winter	54	+19%	65	+23%	67
	Spring	111	+30%	144	+22%	135
	Summer	177	-7%	165	-6%	167
	Fall	74	+9%	80	+10%	81

➡ Precipitation extremes

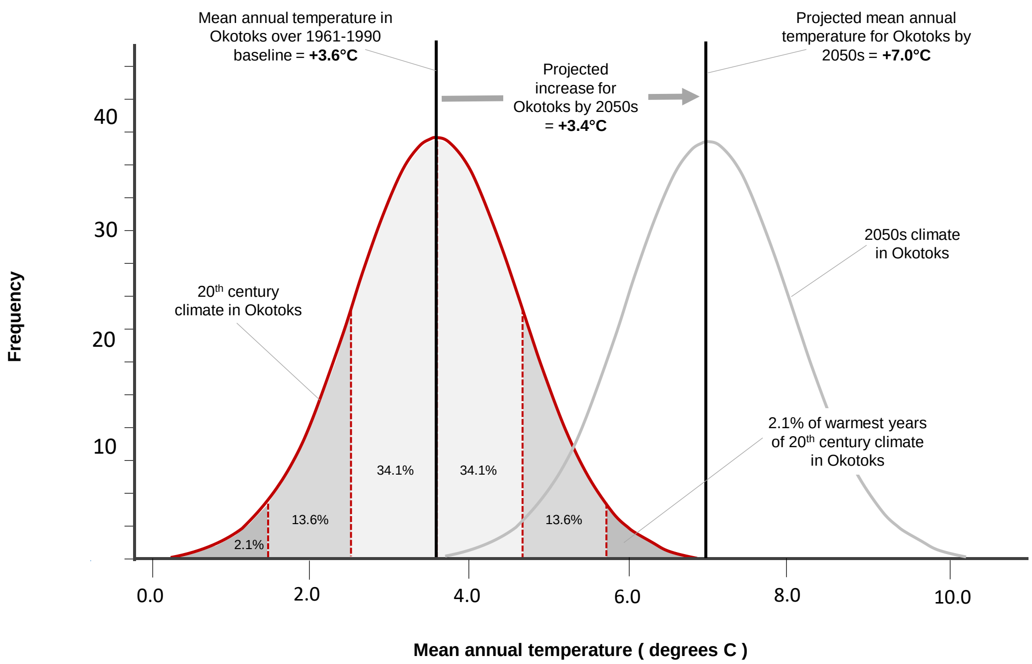
In recent years, numerous extreme precipitation events have occurred at various locations globally; several have occurred in western Canada with serious consequences, notably the 2013 flood that affected southern Alberta. Recent studies have demonstrated that extreme rainfall intensity increases by about 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, Okotoks is projected to see more extreme precipitation events as the climate continues to warm in the coming decades. Projections indicate a potential increase in maximum one-day precipitation of between 10% and 21% for the 'strong mitigation' (RCP 4.5) and 'business-as-usual' (RCP 8.5) scenarios, respectively (Figure 12).

Box 2: Putting projected changes in mean annual temperature in context

To place the magnitude of the projected temperature changes by the 2050s into context, the 20th century climate of Okotoks (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 +3.4°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 Okotoks will be just higher than the warmest 1-2% of 20th century climate.

Although a change in mean annual temperature of +3.4°C may not appear to be a large absolute shift in climate, when compared with the probability distribution of 20th century climate in Okotoks, a shift of this magnitude is substantial. By analogy, the projected shift in mean annual temperature will replace the climate of Okotoks with the historical climate (1961-1990) of Great Falls, Montana.



PROJECTED ENVIRONMENTAL CHANGES

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

➡ Available moisture and growing season

Although mean annual precipitation is projected to increase in Okotoks 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 Okotoks. By the 2050s, the area surrounding Okotoks is projected to experience an increase of approximately 285 (growing) degree days (from 909 to 1,194), on average (see Figure 13); growing degree days are a measure of the length and warmth of the growing season[x]. Put another way, the average growing season in Okotoks 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 Okotoks may be greater than the potential negative impacts of the projected reduction in available moisture[xii].

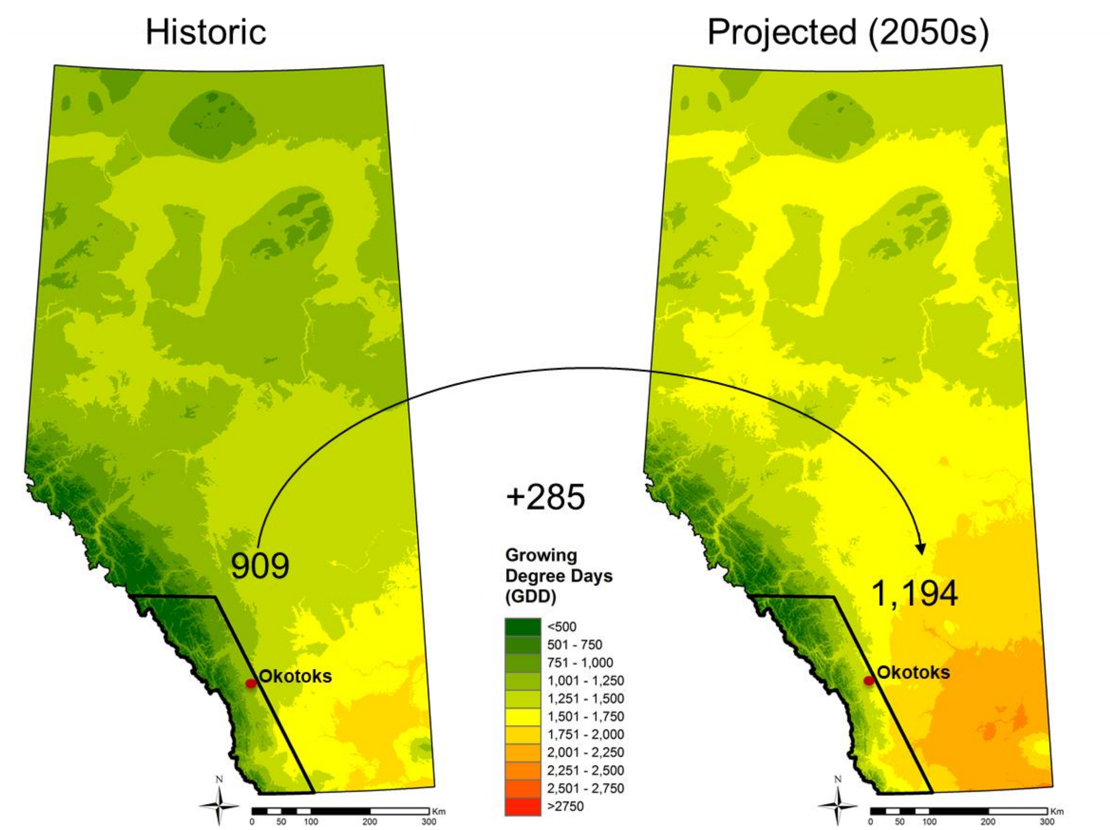
➡ Regional ecosystems

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. Okotoks is currently located in the Foothills Parkland region, with Foothills Fescue to the East (see Figure 14). The Foothills Parkland ecosystem is a mosaic of grasslands and deciduous (aspen) forests, which, at higher elevations and further north, transition to a more continuous aspen forest with spruce stands—the Dry Mixedwood Forest ecosystem[xiii].

The warmer and drier conditions projected for the Okotoks 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 Foothills Parkland ecosystem (as shown in Figure 14)[xiv]. 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[xv,xvi]. The changes in regional ecosystems will also have consequences for the diversity of species that reside in the natural areas in and around Okotoks.

Figure 13: (A) Historic (1961-1990) and (B) projected distribution of Growing Degree Days in Okotoks Region by the 2050s (2041-2070)[xvii]



➡ Wildfire

The warmer and drier climate projected for Okotoks by the 2050s will create conditions more favourable for wildfires. In particular, a longer fire season with more severe fire weather conditions 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].

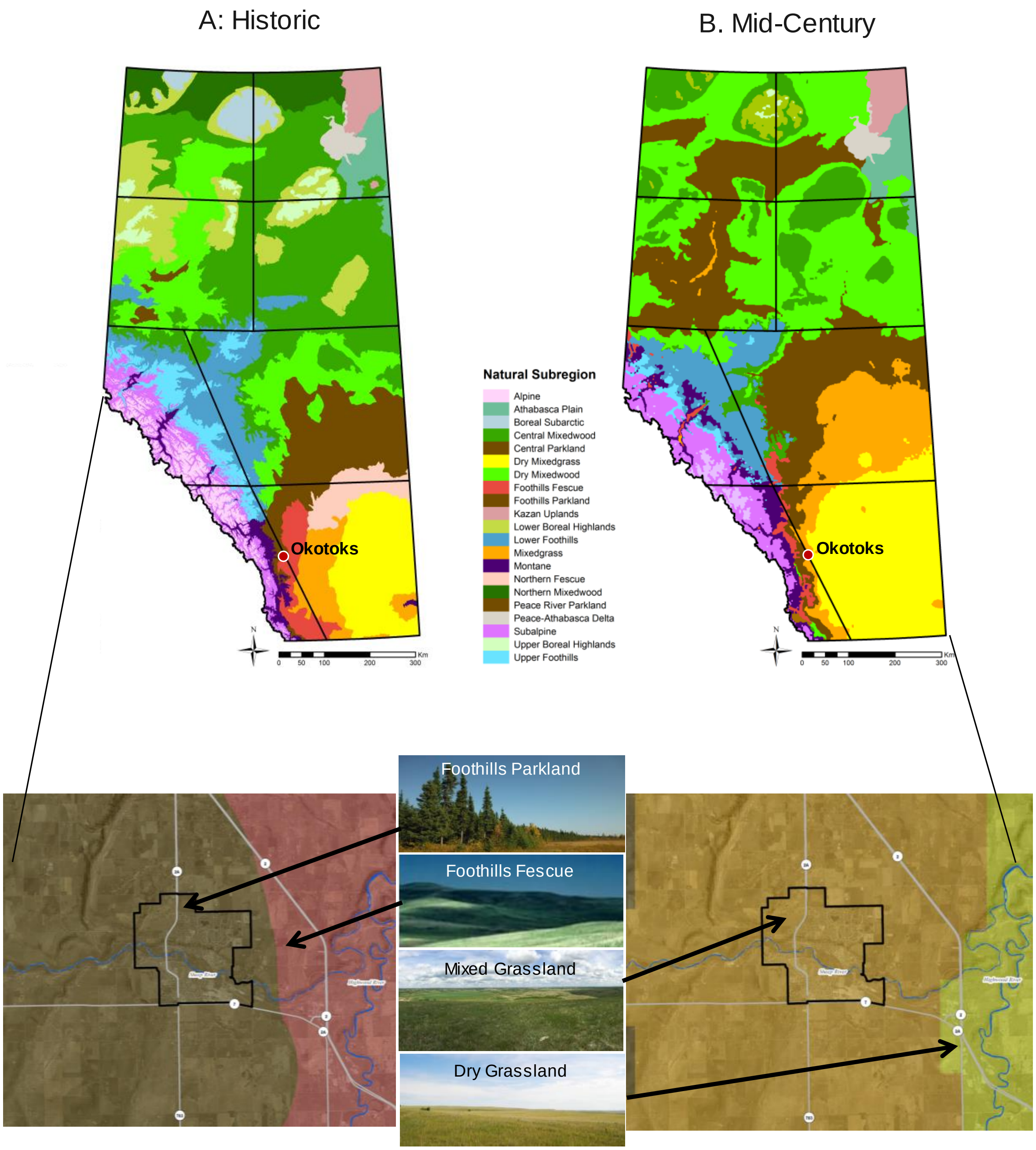
➡ Streamflow

Streamflow and rivers in Alberta depend 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 South 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 South Saskatchewan River will likely experience a decrease in glacier-derived streamflow.

➡ Lakes and Wetlands

Lakes and wetlands in the Okotoks 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 14: (A) Historic (1961-1990) and (B) projected (2050s) distribution of natural sub-regions in Alberta and in Okotoks[xxvi]



4. Climate Risks and Opportunities for Okotoks

Session 3 at the workshop invited participants to:

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

• River flooding (-)	• Low flow in river (-)
• Overland flooding (-)	• Decreased wetlands (-)
• Lightning (-)	• Strong winds (-)
• Grass fire (-)	• Hail (-)
• Water supply shortage (-)	• Water-borne illness (-)
• Heat stress on people (-)	• Longer growing season (+)
• Increased space cooling demand (-)	• Increased winter tourism and recreation (+)
• Increase in forest pests (-)	• Renewable (wind) energy opportunities (+)
• Ice storm (-)	• Increased water storage opportunities (+)
• Blizzard (-)	• Reduced space heating costs (+)
• Freeze-thaw cycles (-)	• Extended summer recreation season (+)
• Drought (-)	• Solar energy opportunities (+)

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 Okotoks 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 Okotoks.

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 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 Okotoks. The description includes a selection of key consequences, along with the label used to identify the impact in the “risk map” shown in Figure 15.

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 Okotoks by the 2050s

Potential local risks		Key consequences for Okotoks
Label for risk map	**Description**	
"River flooding"	Flooding of the sheep river caused by increased precipitation in spring, winter, fall, and extreme precipitation events	• Damage to property and infrastructure • Potential impacts to health and safety (injuries, fatalities) • Increased insurance costs • Lost productivity for local businesses • Negative impact on social well-being (psychological) • Increased maintenance and management for flood mitigation • Reduced water quality in river – increased treatment costs, negative environmental impacts • Potential impact to water and wastewater treatment plants
"Overland flooding"	Overland flooding caused by extreme precipitation	• Damage to property and infrastructure • Mudslides and erosion • Damage to vegetation • Potential impacts to health and safety (injuries) • Lost productivity for local businesses • Negative impact on social well-being (psychological)
"Lightning"	Lightning, associated with an increase in intensity of summer storms	• Power outage, lost productivity for local businesses, potential health and safety impacts • Increased potential for grassfire
"Grassfire"	Increased risk of grass fire from increased temperatures, extreme heat, and drier conditions overall	• Damage to property and infrastructure • Increased costs for fire protection services • Reduced air quality (smoke) • Higher insurance premiums • Negative impacts for tourism (closures)
"Water supply"	Increased risk of water supply shortage due to increased temperatures, drier conditions, and increased water demand	• Water restrictions • Inability to meet water demand requirements • Negative environmental impacts • Potential limitation on future growth
"Heat stress"	Increased incidence of heat-related illness (stress, exposure) from increased temperatures	• Increase health care costs • Negative health impacts on vulnerable people (seniors)
"Energy demand"	Increased space cooling demand due to increased summer temperatures and extreme heat	• Increased costs to local residents, businesses and the Town • Increase in greenhouse gas emissions

Potential local risks		Key consequences for Okotoks
Label for risk map	**Description**	
“Forest pests”	Increase in pests and disease not previously native to our area due to fewer extreme cold periods	• Damage to trees • Impact on terrestrial and aquatic wildlife and ecosystems
“Ice storm”	Increased likelihood of ice storms and freezing rain, due to increased temperatures and less precipitation as snow	• Power outage, lost productivity for local businesses, potential health and safety impacts • Damage to trees • Potential drainage issues, surface flooding • Transportation disruption – vehicle accidents and poor travel conditions
“Blizzard”	Potential for blizzards from increased winter precipitation	• Impacts to health and safety • Transportation disruption – vehicle accidents and poor travel conditions
“Freeze-thaw”	Potential increase in freeze-thaw cycles, in certain seasons, form increasing precipitation in fall, winter and spring	• Negative impact on surface and underground infrastructure
“Drought”	Extended dry period from increased temperatures and reduced precipitation in summer	• Lost productivity for local crops • Increase in crop and forest pests • Increased fire risk • Reduced water supply reliability • Reduced quality of turf for sports
“Low flow”	Extended periods of low flow in the Sheep River	• Loss or negative impact to fish habitat • Reduced river recreation opportunities • Reduced assimilation capacity
“Wetlands”	Reduction in local wetlands due to increased temperatures and reduced precipitation in summer	• Negative impacts to local species dependent on wetlands • Reduced capacity for storm water capture (reduced permeability of land)
“Wind”	Wind storm, associated with an increase in intensity of summer storm	• Damage to property and infrastructure • Power outage, lost productivity for local businesses, potential health and safety impacts
“Hail”	Hail storm, associated with an increase in intensity of summer storm	• Damage to property and infrastructure
“Water-borne illness”	Increased potential for water-borne illnesses related to increased water temperatures	• Impacts to health and safety

Figure 15: Risk map for climate change impacts with mainly negative consequences for Okotoks

CONSEQUENCES						
	(5) Major				Water supply	Higher priorities for action
	(4)		Ice storm		River flooding Drought	
	(3) Moderate		Grass fire	Strong winds Freeze-thaw	Hail Low flow	
	(2)		Heat stress Water-borne illness	Forest pests Energy demand Lightning	Blizzard Wetlands	Overland flooding
	(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

Table 4 provides a description of the potential climate change opportunities for Okotoks. The description includes a selection of potential benefits, along with the label used to identify the impact in the opportunity matrix shown in Figure 16. Impacts in the upper right corner of the map offer greater potential benefits combined with a relatively high likelihood of being realized.

Table 4: Climate change opportunities for Okotoks by the 2050s

Potential local opportunities		Key benefits for Okotoks
Label for opportunity map	**Description**	
"Longer growing season"	Longer growing season for agriculture and local producers from increased temperatures in summer, spring and fall	• Economic benefits for local food producers • Social benefits for residents – increased opportunities for gardening • Earlier, increased use of fields • Opportunities may be offset by lack of precipitation
"Winter recreation"	Increased opportunities for winter tourism and recreation resulting from fewer periods of extreme cold	• Increased social interaction • Increased active transportation and physical activity – improved health and quality of life
"Wind energy"	Potential opportunities for renewable (wind) energy	• Increased local economic opportunities in renewable energy sector, including solar and wind
"Water storage"	Increased ability and opportunities to store water for future uses	• Potential to mitigate impacts of water supply shortages – utilize stored water for non-consumptive use
"Space heating"	Reduced space heating demand due to increased winter temperatures and fewer extreme cold spells	• Reduced heating costs for local residents, businesses and the Town • Reduced greenhouse gas emissions
"Summer recreation"	Increased opportunities for summer and shoulder season tourism and recreation from increased temperatures	• Increased social interaction • Increased active transportation and physical activity – improved health and quality of life

Figure 16: Opportunity map for climate change impacts with mainly positive consequences for Okotoks

CONSEQUENCES	LIKELIHOOD: (1) Low	(2)	(3) Moderate	(4)	(5) High
(5) Major					Higher priorities for action
(4)				Water storage	
(3) Moderate		Longer growing season	Wind energy Winter recreation		
(2)				Summer recreation Space heating	
(1) Negligible	Lower priorities for action				

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:

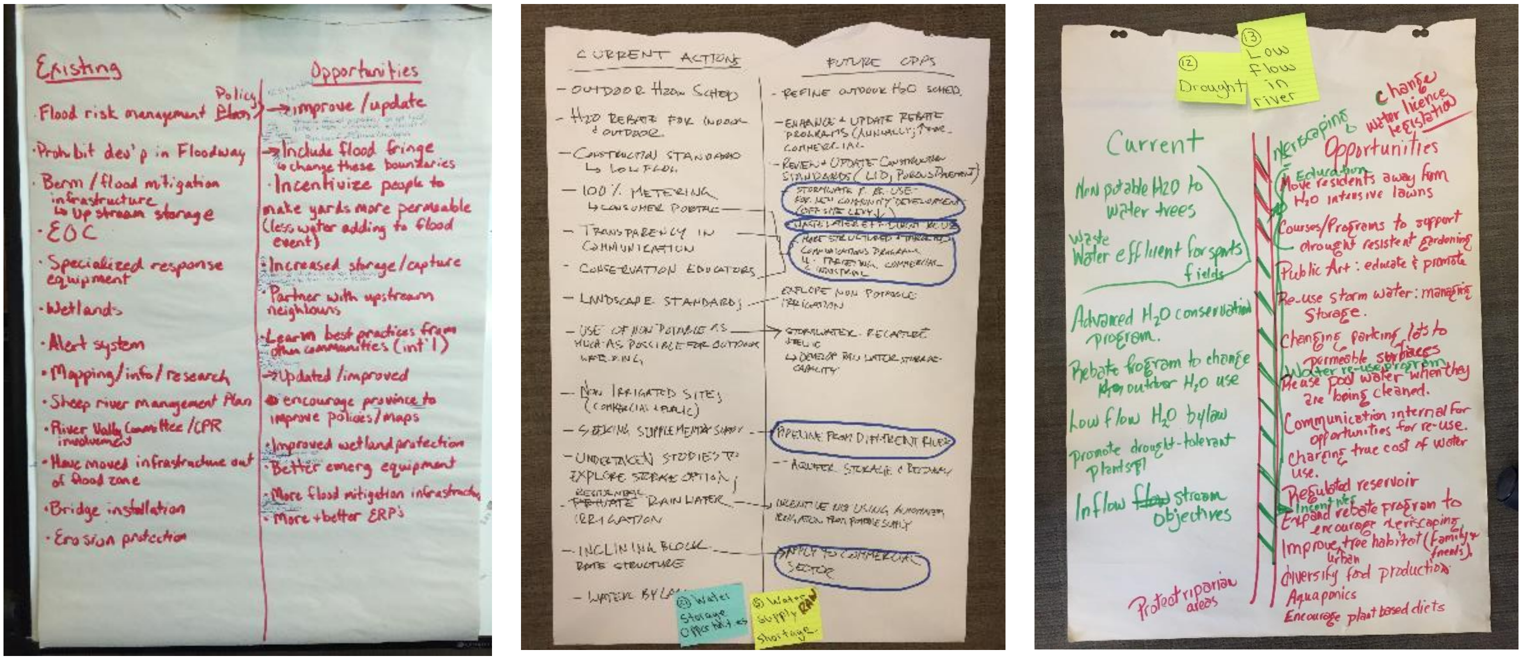
1. Water supply shortage;
2. Drought; and
3. River flooding

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 17) 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 17: Brainstorming actions to mitigate priority risks in Okotoks



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 5 was used to help participants provide approximations for (1) and (2).

Starter action plans for each of the three 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, Okotoks 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:

- A flood risk management policy;
- Floodplain mapping, data and research for the Sheep River, as well as floodplain development regulations;

- Structural and non-structural flood mitigation infrastructure;
- Emergency response planning and systems for emergency management;
- Universal water metering and pricing;
- Water conservation measures including an outdoor watering schedule, rebate programs and education programs;
- Landscaping standards and xeriscaping to promote water conservation;
- Use of non-potable water for outdoor watering, including for sports fields;
- Exploration of new options for the municipal water supply;
- Research on enhanced water storage options;
- A low flow water bylaw requiring low flow construction standards; and
- Development of a Water Shortage Management Plan, as required by Alberta Environment and Parks.

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

Table 5: 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

Due to time constraints at the workshop, climate resilience actions are necessarily defined at a coarse level. As consideration is given to initiating any of the identified actions (listed in the tables below), it is expected that they will be further developed to support decision-making and enable implementation (see Section 6).

Water Supply Shortage

Action	Cost	Timeframe	Lead
Install a water pipeline from an adjacent watershed to establish a secure future water supply to meet current and future population needs	Very high ($30 million)	Short-term	Engineering
Implement stormwater re-use for new developments, through an off-site levy on developers	Very high ($250,000)	Short-term	Operations
Re-use wastewater, including grey water and stormwater, for non-consumptive uses	Very high ($500,000)	Near-term	Operations
Apply the inclining block rate water pricing structure to the commercial sector	Low	Near-term	Operations & Finance
Enhance water conservation education and communications programs, targeting commercial and industrial sectors	Medium	Ongoing	Environment and Sustainability / Operations

River Flooding

Action	Cost	Timeframe	Lead
Update Sheep River floodplain mapping, policy and regulations based on flood mapping developed by Alberta Environment and Parks	Low	Near-term	Planning / GIS
Increase utilization of natural areas and open spaces for water storage and capture	Very high	Long-term	Engineering / Operations

Action	Cost	Timeframe	Lead
Initiate a study to better understand best practices (regionally, nationally, internationally) for flood management	Low	Near-term	Engineering / Planning / Environment and Sustainability
Improve wetland protection	High	Short-term	Planning / Engineering / Parks
Install flood mitigation infrastructure where needed to reduce risk (e.g. higher berms, inflatable berms)	Very high	Long-term	Engineering / Parks / Fire

DROUGHT

Action	Cost	Timeframe	Lead
Develop a xeriscaping program to support drought resistant planting and gardening and enhance public engagement on water conservation	Medium	Near-term	Environment and Sustainability / Parks / Communications
Implement a water re-use program to utilize stormwater ponds and wastewater effluent for vegetation	Very high	Short-term	Operations / EPCOR / Engineering
Restrict potable water use for non-essential (vegetation) residential use	Medium	Long-term	Environment and Sustainability
Encourage agricultural sector crop diversification, using drought resistant crops	Very high	Long-term	Province (Urban Agriculture Strategy) / 4H clubs / Partnerships with post-secondary institutions, farm producers
Improve urban tree habitat and ecosystems to enhance water storage and capture	High	Medium-term	Parks / Transportation / Environment and Sustainability
Expand reservoir water storage capacity to increase water availability during drought conditions	Very high	Long-term	Engineering

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'. Town 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 Town 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 Town'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 Town'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 Okotoks'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 Town'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
Dawn Smith	Environment & Sustainability Coordinator (Corporate and Strategic Services)
Tom Jacks	GIS/Mapping Technician (Information/Business Solutions)
Marley Oness	Engineering Manager
Darren Peel	EPCOR
Chris Radford	Infrastructure and Operations Director
Christa Michailuck	Parks Manager
Bridget Couban	Landscape Inspector (Parks)
Nancy Weigel	Corporate and Strategic Services Director
Brian Courrone	Facilities Maintenance Manager
James Greenshields	Transportation Manager
Susan Laurin	Community Services Director
Amanda Brinda	Senior Planner
Allan Boss	Culture and Heritage Manager
Janette Messer	Programs and Events Manager
Joan Botkin	Communications Manager
Quincy Brown	Economic Development Manager
Rob Mueller	Permit/Inspection/Assessment Manager
Jinny Toffelmire	Environment and Sustainability Specialist

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	Descriptor	Interpretation
(1)	**Low**	*Very unlikely* - to see that level of consequences
(2)	↕	*Unlikely* – to see that level of consequences
(3)	**Moderate**	*Possible* – to see that level of consequences
(4)	↕	*Likely* – to see that level of consequences
(5)	**High**	*Almost certain* – to see that level of consequences

8. ENDNOTES

[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).

[vi] Westra, S., Alexander, L.V., Zwiers, F., 2013. Global increasing trends in annual maximum daily precipitation. J Clim 26(11) 3904–3918.

[vii] Trenberth, K.E., 2011. Changes in precipitation with climate change. Clim Res., 47, 123-138.

[viii] Schneider, R.R. 2013. Alberta's Natural Subregions under a changing climate: past, present and future. Biodiversity Management and Climate Change Adaptation Project, Alberta Biodiversity Monitoring Institute, Edmonton, AB. Available at: http://biodiversityandclimate.abmi.ca/

[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.

[xi] Sauchyn, D. and S. Kulshreshtha. 2008. Prairies; *in* From Impacts to Adaptation: Canada in a Changing Climate 2007, *edited by* D.S. Lemmen, F.J. Warren, J. Lacroix, and E. Bush; Government of Canada, Ottawa, ON. pp. 275-328.

[xii] Nyirfa, W.N. and B. Harron. 2004. Assessment of Climate Change on the Agricultural Resources of the Canadian Prairies. Prepared for the Prairies Adaptation Regional Collaborative, Regina, SK. 27p. Available at http://www.parc.ca/

[xiii] Natural Regions Committee. 2006. Natural Regions and Subregions of Alberta. Compiled by D.J. Downing and W.W. Pettapiece. Government of Alberta. Pub. No. T/852. Edmonton, AB.

[xiv] Schneider, R.R. 2013. Alberta's Natural Subregions under a changing climate: past, present and future. Biodiversity Management and Climate Change Adaptation Project, Alberta Biodiversity Monitoring Institute, Edmonton, AB. Available at: http://www.biodiversityandclimate.abmi.ca

[xv] Ibid.

[xvi] Qualtiere, E. 2011. Impacts of climate change on the western Canadian southern boreal forest fringe. Saskatchewan Research Council Publication No. 12855-3E11. Saskatoon, SK. 129pp. Available at: http://www.parc.ca/

[xvii] Maps created with climate data available at http://ualberta.ca/~ahamann/data/climatewna.html (Hamann et al. 2013). The mid-century growing degree days projection based on the German ECHAM5 global climate model and the A2 emissions scenario (IPCC 2000).

- Hamann, A.T., Wang, D.L. Spittlehouse and T.Q. Murdock. 2013. A comprehensive, high-resolution database of historical and projected climate surfaces for western North America. *Bulletin of the American Meteorological Society* 94:1307–1309
- IPCC. 2000. Special Report on Emissions Scenarios - Summary for Policy Makers. Intergovernmental Panel on Climate Change Working Group III.

[xviii] De Groot, W.J., M.D. Flannigan and A.S. Cantin. 2013. Climate change impacts on future boreal fire regimes. *Forest Ecology and Management* 294:35-44.

[xix] Flannigan, M.D., M.A. Krawchuk, W.J. de Groot, B.M. Wotton, and L.M. Gowman. 2009. Implications of changing climate for global wildland fire. *International Journal of Wildland Fire* 18:483-507.

[xx] Sauchyn, D. J. St. Jacques, E. Barrow, S. Lapp, C.P. Valdivia, and J. Vanstone. 2012. Variability and trend in Alberta climate and streamflow with a focus on the North Saskatchewan River Basin. Final Report for the Prairies Regional Adaptation Collaborative. Regina, SK. Available at http://www.parc.ca/

[xxi] Ibid.

[xxii] Ibid.

[xxiii] Liu, G. and F.W. Schwartz. 2012. Climate-driven variability in lake and wetland distribution across the Prairie Pothole Region: from modern observations to long-term reconstructions with space-for-time substitution. *Water Resources Research* 48: W08526

[xxiv] Ouyang, Z., R. Becker, W. Shaver, and J. Chen. 2014. Evaluating the sensitivity of wetlands to climate change using remote sensing techniques. *Hydrological Processes* 28:1703-1712

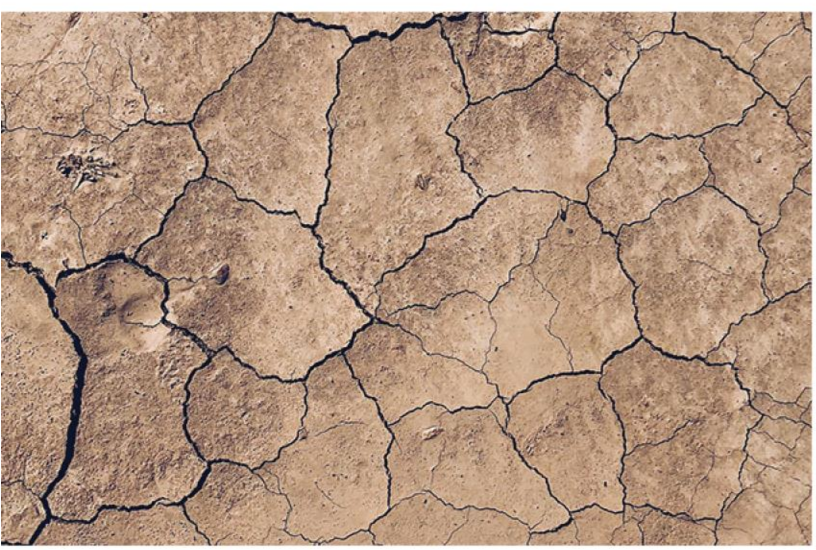
[xxv] Johnson, W.C., B. Werner, G.R. Guntenspergen, R.A. Voldseth, B. Millett, D.E. Naugle, M. Tulbure, R.W.H. Carroll, J. Tracy, and C. Olawsky. 2010. Prairie wetland complexes as landscape functional units in a changing climate. *BioScience* 60:128-140.

[xxvi] Maps created with data available at http://biodiversityandclimate.abmi.ca/. The mid-century Natural Subregion projection from Schneider (2013) is based on the German ECHAM 5 global climate model and the A2 emissions scenario (IPCC 2000).

- Schneider, R.R. 2013. Alberta's Natural Subregions under a changing climate: past, present and future. Biodiversity Management and Climate Change Adaptation Project, Alberta Biodiversity Monitoring Institute, Edmonton, AB. Available at: http://biodiversityandclimate.abmi.ca/
- IPCC. 2000. Special Report on Emissions Scenarios - Summary for Policy Makers. Intergovernmental Panel on Climate Change Working Group III.

All One Sky
FOUNDATION

The ALL ONE SKY FOUNDATION is a not-for-profit, charitable organization established in 2010 to help vulnerable populations at the crossroads of energy and climate change. We do this through education, research and community-led programs, focusing our efforts on adaptation to climate change and energy poverty. Our vision is a society in which ALL people can afford the energy they require to live in warm, comfortable homes, in communities that are able to respond and adapt to a changing climate.



www.allonesky.ca | email: helen@allonesky.ca | phone: 403.471.6247
809 49th Ave SW, PO Box 19012, Calgary, AB T2S 1A0, Canada