Attachment 1

Sturgeon County's Climate Adaptation Action Plan

May 2022

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TREATY/TERRITORIAL ACKNOWLEDGEMENTS

We acknowledge that we are on Treaty 6 territory, a traditional meeting grounds, gathering place, and travelling route to the Cree, Saulteaux, Blackfoot, Métis, Dene and Nakota Sioux. We acknowledge all the many First Nations, Métis, and Inuit whose footsteps have marked these lands for centuries.

GENERAL ACKNOWLEDGEMENTS

We would like to thank Sturgeon County municipal staff and committee members for their support in the creation of this Climate Adaptation Plan. Their participation was essential to the assessment of priority climate impacts facing Sturgeon County, as well as the generation of ideas to manage these impacts. County support was provided by Tim Osborne, Sturgeon County's Corporate Operations Advisor.

This Climate Adaptation Action Plan was led by Elise Renchko, Project Assistant, Alberta Municipalities. Specific support was provided from the following organizations:

- All One Sky Foundation: Project Delivery and Technical Expertise
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EXECUTIVE SUMMARY

Climate change is causing current and future impacts. In Alberta, these changes include hotter summers, shorter winters, and increasingly frequent and severe extreme weather– all of which impact our heath, environment and economy. The impacts of climate change are already affecting Sturgeon County and will be felt more strongly in the coming decades. Creating a Climate Adaptation Action Plan (CAAP) helps Sturgeon County's local environment, economy, and residents to thrive in the face of climate change.

This Climate Adaptation Action Plan is meant to be a guide for Sturgeon County in building climate resilience for its community. The vision of the CAAP is as follows:

The Climate Adaptation Action Plan promotes responsible stewardship by reducing the impacts of climate change on Sturgeon County while honouring our rural roots, promoting prosperity, and dreaming big.

The CAAP was created using climate science research, consultation with various County departments, and public engagement. The CAAP shows how climate change has affected the County in the past and how it may affect the County in the future.

Climate impacts that could cause harm to the County are known as **climate risks**, whereas those that offer benefits are known as **climate opportunities**. Through the CAAP process, seven priority risks and one priority opportunity were identified for the County:

Climate Risks	Climate Opportunities
Heat Wave	Increased Agricultural Productivity
Seasonal Drought	
Wildland/Cropland Fire	
Wildfire Smoke	
Outbreak of Invasive Agricultural Pests	
Water Supply Shortage	
Lowland Flooding due to Precipitation	

There are 4 themes for development and implementation each with specific goals and objectives. Each theme contains specific actions that can be implemented to benefit the County in the long-term.

The implementation of this plan is the responsibility of Sturgeon County. However, the role of climate adaptation extends beyond the County and will extend to partnerships, synergies and alignment to external initiatives and funding from other orders of government.

Resilient Water Management

Goal	Enhance water management practices to reduce risks from lowland flooding and water shortage events
Objectives	Consider climate change in stormwater management Protect local water supplies to reduce the severity of water shortages Increase water use efficiency

Health and Wellbeing

Goal	Reduce negative health impacts as a result of extreme heat and wildfire smoke
Objectives	Increase public awareness of the health risks associated with heat waves and wildfire smoke Improve air quality and cooling systems at public facilities Increase naturalization of public spaces Increase air quality monitoring capacity

Strong and Resilient Economy

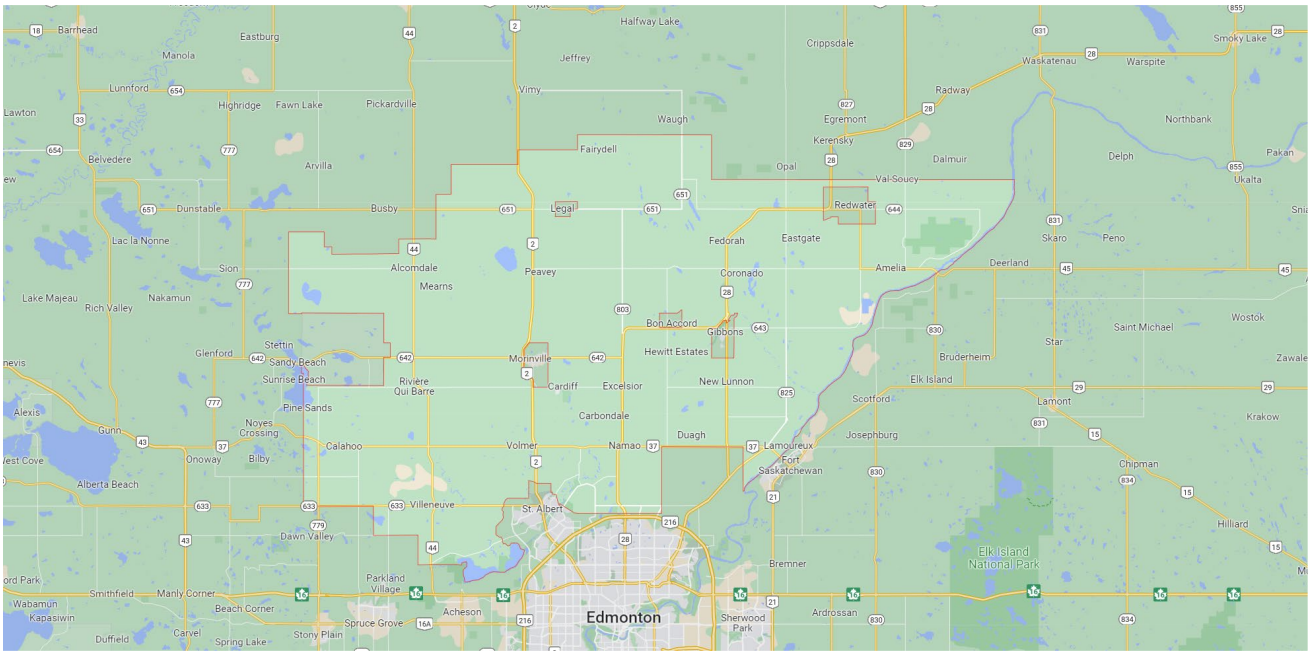
Goal	Support economic prosperity within the agricultural sector
Objectives	Increase public education and awareness of alternative methods of farming that are resilient to climate change Explore potential opportunities to support/increase local food production

Disaster Resilience

Goal	Build capacity to prepare for and respond to increased extreme events
Objectives	Update emergency response plans to consider the potential future impacts of climate change to the County Support practices that reduce the severity of wildland/cropland fires Support practices that reduce the severity of water shortages

INTRODUCTION

Sturgeon County covers more than 2,300 square kilometers of land, located within proximity to several large urban centers, and serves a population of more than 20,000 residents. Agriculture and industry are established sectors within the County and are continuing to expand. The County is the home of the Industrial Heartland, with an abundance of natural resources found in the area.



Municipalities within Alberta are at the forefront of climate change impacts. As a response to current and future climate conditions, local climate adaptation planning can increase the resiliency and prosperity of local communities.

This Climate Adaptation Action Plan (CAAP) supports Sturgeon County in further developing the County's climate adaptation work, which will help reduce the direct negative impacts of climate change to the community. The CAAP has been prepared to reduce potential negative climate-related impacts such as damage from flooding, reduction in crop yields, increased morbidity, and mortality due to extreme heat and smoke, as well as property damage from severe storms, etc. As the climate changes, this Climate Adaptation Action Plan can help support the County's long-term vision and path, as well as aid in meeting the needs of current and future residents.

This Climate Adaptation Action Plan is a result of Sturgeon County taking part in the Climate Adaptation Challenge (CAC), in partnership with the Municipal Climate Change Action Centre and the All One Sky Foundation. The Climate Adaptation Challenge program helps create a greater understanding of the risks that municipalities may face as a result of climate change.

All One Sky Foundation

All One Sky Foundation is a not-for-profit, charitable organization established to help vulnerable populations at the crossroads of energy and climate change. They do this through education, research and community-led programs, and focusing their efforts on adaptation to climate change and energy poverty. Their vision is a society in which all people can afford the energy they require to live in warm, comfortable homes, in communities that are resilient and adaptive to a changing climate.

Municipal Climate Change Action Centre

The Municipal Climate Change Action Centre was established in 2009 as a partnership initiative between Alberta Municipalities, Rural Municipalities of Alberta, and the Government of Alberta, including assistance, and funding programs to implement energy efficiency and renewable energy projects that reduce greenhouse gas emissions and energy costs, while increasing community resilience.

Understanding Climate Adaptation

The average global temperature is on pace to increase by 3.2°C by 2100, in comparison to an 1850 baseline (IPCC, 2014). This increase is higher than the scientifically recommended maximum global temperature increase of 1.5°C (IPCC, 2014). While the exact amount of change to the climate could vary from scientific projections, some climate change has already occurred and will continue to occur in the coming decades. These changes are expected to have large, mostly negative impacts to the health and well-being of people across the planet.

In response to this change, there is a collective responsibility to take action. There are two ways in which we can do this: climate mitigation and climate adaptation, as seen in Figure 1.

Climate mitigation actions refer to human interventions to reduce the sources or enhances the sinks of greenhouse gases (IPCC, 2014).

Climate adaptation refers to the process of adjustment to actual or expected climate and its effects (IPCC, 2014).

Climate adaptation and climate mitigation are different, but equally as important, responses to climate change. Climate mitigation strategies focus on addressing the root cause of the problem; reduce greenhouse gas emissions from human-based activities. Climate adaptation actions focus on addressing the effects caused by the problem; minimizing the consequences that come from a changing climate.

This action plan is focused on climate adaptation, preparing Sturgeon County for change a changing climate. Specifically, this Climate Adaptation Action Plan identifies climate risks and opportunities for the community, projects the future impacts of climate change, and prioritizes actions that can be taken to reduce the impacts of climate change in Sturgeon County.

Climate adaptation refers to anticipating the effects of climate change and taking appropriate action to manage adverse effects and take advantage of the opportunities that may arise as a result of climate change. These actions reduce the direct impacts of climate change to the community.

Adaptation Examples

Extreme weather emergency response plans

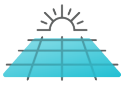
Zoning measures (e.g., building away from flood plains.)

Updating vulnerable infrastructure

FireSmart Programs

Mitigation Examples

Installing solar panels



Reducing building energy usage

Composting

Converting carbon into new products

Climate mitigation refers to reducing greenhouse gas emissions into the atmosphere, and the storage of carbon through carbon sinks. Carbon sinks include ways that carbon dioxide is captured, stored or re-purposed, forming it into new compounds. Natural carbon sinks include forests, native grasslands, and the ocean. Human-made forms of carbon capture can include storing carbon underground or converting it to another product such as concrete.

Figure 1: *Climate adaptation vs. climate mitigation*

Scope

The scope of this project is defined at a community-wide level. This included the following:

- All municipal assets, services, and operations (e.g., parks, transportation networks, civic buildings and infrastructure, etc.)
- All homes, private buildings and infrastructure, the local economy, ecosystem functions and services, and the health and well-being of residents across the entire community of Sturgeon County

The scope of the Climate Adaptation Action Plan does not include impacts to infrastructure or services outside of Sturgeon County's municipal boundaries such as supply chains and transportation systems, etc.

Equity and Climate Adaptation

Applying an 'equity lens' to climate action means ensuring that the benefits and burdens of climate change and climate action are distributed fairly throughout a community, and that they account for future generations. It means only asking for people to make changes that are manageable for them, while reducing potential costs for those who are already challenged in making ends meet. It also means ensuring that community members who are most vulnerable to climate change are better protected, and that the positive outcomes of climate action can be enjoyed by all for years to come. The CAAP addresses equity by ensuring that all residents of Sturgeon County were taken into consideration in adaptation planning, so that everyone could benefit from this process.

Climate Adaptation Planning Process

The CAAP utilized the Climate Resilience Express – Community Climate Adaptation Planning Guide (Climate Resilience Express, 2021) and toolkit as a framework for adaptation planning. This framework provided a flexible approach to climate adaptation planning that can be tailored to community needs and achieves the following:

- Gains an understanding of how the climate and natural environment in the region is projected to change in the future.
- Prioritizes climate change impacts affecting the local economy, municipal infrastructure and services, the natural environment, and the health and lifestyle of residents.
- Identifies and implements local actions to manage climate risks and opportunities to ensure the community is resilient and adapted to future climate change.

Creation of the CAAP followed a 4-step process from the Climate Resilience Express Planning Guide (Climate Resilience Express, 2022). The process is shown in Figure 2 below. Step 4, Implementation, is the responsibility of Sturgeon County, and is not included in this document.

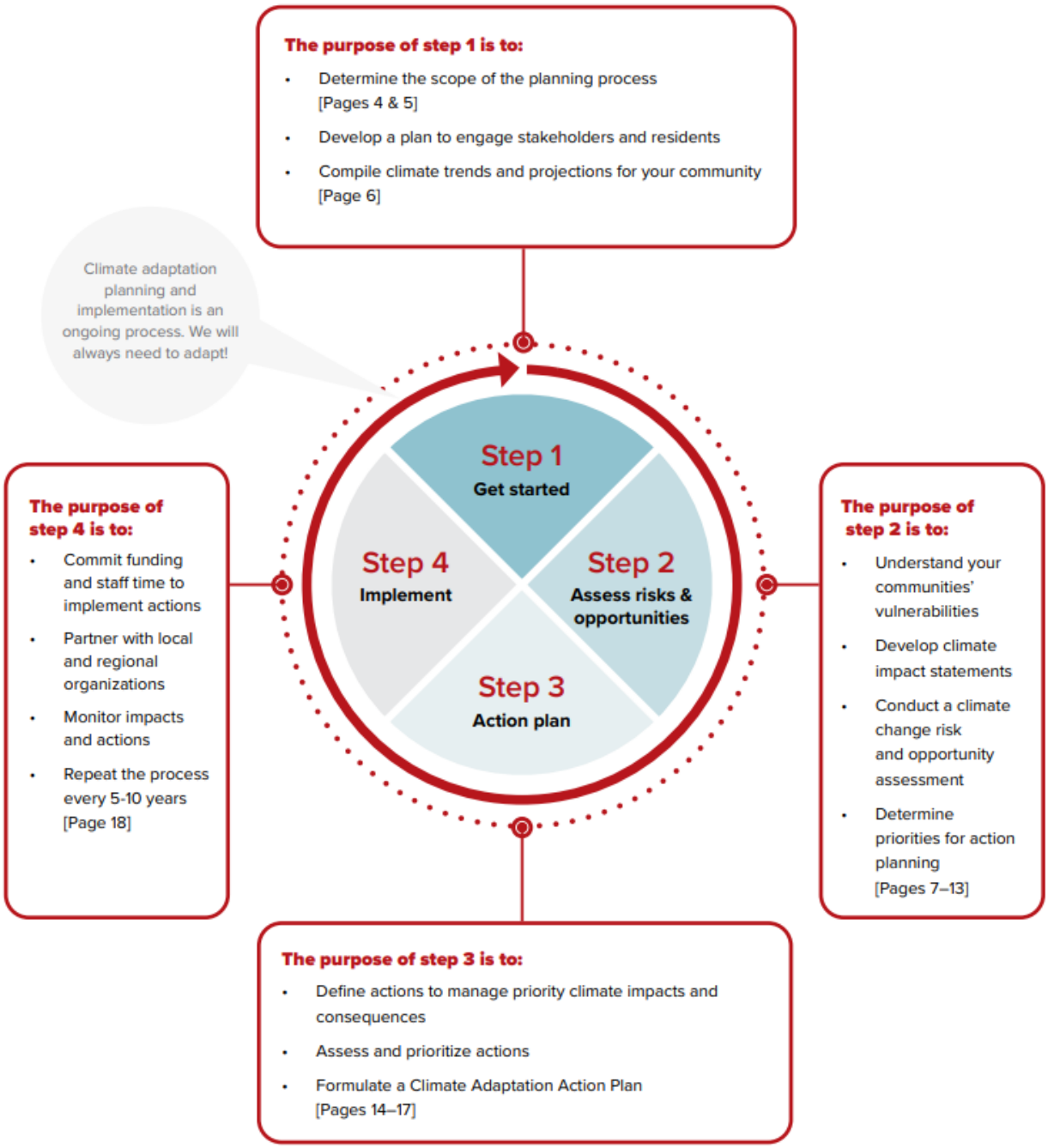


Figure 2: *Climate Resilience Express Action Guide 4 Step Process (All One Sky Foundation)*

EXISTING PLANS, POLICIES AND INITIATIVES

The County has already included many actions relevant to climate adaptation within existing plans, policies and initiatives. Many of the recommendations from this Climate Adaptation Action Plan can be incorporated into previously existing documents. The following are particularly relevant to adaptation planning:

Strategic Plan 2022-2025

This plan supports priorities such as planned growth, encouraging thriving communities, supporting collaborative governance, striving for operational excellence, and promoting environmental stewardship. All of these topics are relevant to adaptation planning, as communities require strong social networks, economic systems, governance systems and environmental stewardship measures to adapt to the impacts of climate change.

Sturgeon County Infrastructure Master Plan

This plan focuses on key linear infrastructure components including water, wastewater, stormwater, and transportation/road systems. It examines the effects of potential growth scenarios on each component of infrastructure. Climate change can pose risks to County infrastructure; however, effective infrastructure can help buffer the negative impacts of climate change to the community.

Sturgeon Regional Emergency Management Partnership Emergency Action Guide and Sturgeon Regional Emergency Management Plan

These plans cover emergency response, management, governance, administration and partnerships and guidelines about what the public can do in various emergency situations. As climate-related emergencies strike, it will become increasingly important to incorporate climate considerations into emergency response plans and guidelines. Actions that the County has already taken to respond to emergencies can be further built on to improve resilience.

Drainage Master Plan Final Report 2019

This plan provides a framework for prioritizing maintenance works and capital projects to help meet the County's goals for meeting the needs of residents and businesses for reliable infrastructure. Climate change increases the likelihood of heavy rainfall, which can increase community's dependence on effective drainage systems.

Website: Agriculture Corner and Agricultural Services' Pest Management Program

The County provides publicly accessible agricultural information aimed at helping farmers produce their best products. The County additionally aids residents in controlling large pests, using a trap rental program. Agricultural patterns are expected to alter as a result of climate change, and pests are expected to be on the rise. These programs can help residents deal with the evolving challenges of climate change.

Alternative Land Use Services (ALUS) Program

This program provides expertise, resources and direct financial support to communities where farmers and ranchers build nature-based solutions on their land to deliver ecosystem services to sustain agriculture, help build community resilience and fight climate change and biodiversity loss for the benefit of future generations.

CLIMATE TRENDS AND PROJECTIONS

Climate projections for this plan were accessed from the Canadian Climate Atlas. The reference period for the 'recent past' used a baseline time frame of 1976-2005. Projections were accessed for changes that are expected by approximately the 2060s (2051-2080), since it is important for municipalities to plan decades into the future to protect the interests and wellbeing of their community, and to ensure a viable local environment.

Table 1 provides a summary of climate change projections for Sturgeon County. The projections show changes from the 1976-2005 baseline period to the 2060s (2051-2080), and for a 'high carbon' climate change scenario. This scenario, known as RCP 8.5, assumes that world greenhouse gas emissions continue to increase at current rates through the end of the century.

For more information on climate projections for Sturgeon County, see appendix A.

Table 1 Notes:

- *A Summer Day is a day when the temperature rises to at least 25°C.*
- *Growing Degree Days (GDD) are used to assess the ability of the climate to support crops and insects at different temperatures. the growth of canola and forge crops can be assessed using 5 °C GDDs; 10 °C GDDs assesses the growth of corn and beans; and 15 °C GDDs assesses the growth and development of insects and pests.*

Climate projections from baseline period (1976-2005) to the 2060s		Example Impacts
Temperature 	• Mean annual temperature increase from 2.7°C to 7°C • Spring and fall experience greatest changes to the annual mean 3.2°C to 7.1°C (spring), 3.4°C to 7.4°C (fall)	• Shifts in ecoregions, causing changes to the types of plants and animals found in the area
Precipitation 	• Heavy precipitation (at least 20mm of rain or frozen precipitation days) increase from 2 days per year to 3 days/year	• Transportation disruptions due to flooded roadways • Increased stress on County drainage systems • Flooding causing property damage • Heavy snowfall in winter
Longer and Hotter Summers 	• The number of days per year that are ≥30°C increases from 2.5 days to 22 days/year • Heat waves expected to increase from 0.3/year to 3 per year • The number of summer days* per year increases from 26 days to 70 days	• Heat-related illness and death • Longer dry seasons, leading to drought • Increased demand for potable water
Shorter and Milder Winters 	• Days -30°C or below decreases from 9 to 1.5 days/year • Days -15°C or cooler decreases from 60.8 to 31.7 days/year • Mild winter days (-5°C or cooler) decreases from 133 to 92 days/year	• Reduced winter recreation • Invasive species that normally die in winter persist into the warmer seasons • Reduced cold-related morbidity and mortality
Agricultural Changes 	• Length of frost- free season increases from 125 to 164 days/year • The number of 5 °C GDDs* increases from 1421 to 2190 • 15 °C GDD will increase from 170.2 - 547.2	• Increased growing season • The potential to grow new types of crops • Increased outbreak of invasive agricultural pests and spread of agricultural diseases
More Extreme Weather 	• As a result of the variables described above, climate change could lead to more extreme weather	Increased frequency and/or intensity of storms and natural disasters including windstorms, wildland fires, hail, and ice storms

***Table 1**: Climate projections and example impacts showing expected changes from baseline (1976-2005) to the 2060s.*

VULNERABILITY AND RISK ASSESSMENT METHODS

International Standards

The approach to the vulnerability and risk assessment (VRA) is based on the Intergovernmental Panel on Climate Change (IPCC) latest model of climate risk and can be viewed as a risk assessment with a vulnerability assessment portion. It is consistent with the recently published International Organization for Standardization (ISO) guidelines for climate vulnerability and risk assessments (ISO 14091) and adaptation planning for local governments and communities (ISO14092).

Participatory Approach

The VRA was informed by a bottom-up, participatory approach that recognizes the skills and experiences of County staff and a range of community stakeholders, who were engaged throughout in the co-production of outcomes at each stage. This approach-built momentum for successful adaptation planning and implementation by including County staff and key stakeholders in all aspects of the planning process.

Defining Climate Impacts

Climate change risk assessments involves 3 steps, the results of which are discussed below:

Identify Potential Impacts

Changes to the local climate could affect the County in several ways, both positive and negative. A list of potential climate impacts was developed through:

- a review of climate projection data using the Canadian Climate Atlas,
- input from Sturgeon County staff and committee members,
- examination of municipal plans and policies,
- and additional external research.

A total of 19 direct climate impacts were identified. Impacts that could cause harm to the County are known as climate risks, whereas those that offer benefits are known as climate opportunities. The final climate risks are shown in the Table 2 below in orange, and climate opportunities are shown in blue. Each climate impact statement uses a proxy indicator, which defines how each climate impact is measured.

A complete list of all 19 climate impact scenarios explored during research process of this Plan, as well as climate projections for Surgeon County can be found in appendix B and C.

Assess Impacts

A Vulnerability and Risk Assessment (VRA) workshop was delivered in January. The benefit of conducting a VRA workshop is to focus the efforts of the Climate Adaptation Action Plan on the highest risks that face the County. County staff and stakeholders assessed the consequences and benefits of each of the 19 climate impact scenarios.

To rank the climate impacts from most to least likely to affect the County, a predetermined 'Likelihood Score' to derive an overall Risk or Opportunity Score, was utilized as seen in appendix D. This was achieved by multiplying the likelihood of a climate impact by the perceived consequence that staff and stakeholders thought each climate impact would have on the County. The consequence score for each climate impact was determined using the average ranking of staff and stakeholders.

The consequence scale ranges from 1-5, with 1 being a climate impact with very low consequence, and 5 being an impact with very high consequence (appendix D). The likelihood of each climate impact scenario was determined using scientific projections and research based on how likely each climate impact was to occur and was established before the Vulnerability and Risk Assessment Workshop.

The likelihood scoring criteria can be found in appendix D and ranges from1-5, with 1 being a climate impact that is very unlikely to occur, and 5 being a climate impact that is very likely to occur.

Evaluate Results

After the Vulnerability and Risk Assessment Workshop, Risk and Opportunity Scores for all climate impacts were verified with County staff and stakeholders to determine if any impacts were being underestimated or overestimated in comparison to one another. This resulted in minor re-adjustment of the final priority climate risks identified, which are shown below in Table 3 and 4. The cut-off for considering each climate impact for action planning was a score of 15 or greater.

Although wildfire smoke, wildland/cropland fire and flooding due to precipitation did not score above 15 initially, in a post-workshop evaluation of the results of the VRA workshop voting and likelihood scoring, it was concluded that these 3 climate impacts should be considered for action planning since they have had significant effects on the community in the past and are expected to become a growing threat in the future. It was decided that freezing rain should be moved below 15 due to this being a threat that the County felt confident dealing with. As for climate opportunities, increased agricultural productivity was moved above 15 because staff and stakeholders expressed that this would be a significant benefit for the County's agricultural sector. Reduced road maintenance was moved below 15.

Final Results

A total of 19 potential direct climate impacts to the County were identified. Table 2 shows the results of the VRA workshop and post-workshop evaluation, as well as climate impact descriptions and their respective proxy indicators. A total of 8 climate impacts are recommended for action planning, comprising of 7 climate risks and 1 climate opportunity. This does not mean that the lower priority risks should not be addressed, but rather that increased focus above and beyond existing initiatives may not be required at this time.

Climate Risks	Climate Impact Description	Proxy Indicator
Heat Wave	Three or more consecutive days of +30°C temperatures or hotter	3 heat waves occur in any given year
Seasonal Drought	A period of anomalously low moisture during the frost-free season	A class D3 drought occurs in any given year
Wildland/Cropland Fire	A wildland or cropland fire, small or large, that occurs in an area where there is little development, except for roads, railroads, power lines and other linear infrastructure	A wildland/cropland fire occurs within the municipal boundary in any given year
Wildfire Smoke	Smoke from wildfires enters into municipal boundaries	The maximum Air Quality Health Index (AQHI) is 10 in any given year
Outbreak of Invasive Agricultural Pests	An outbreak of invasive plant and insect pests, such as Bertha Armyworm and Grasshopper, etc.	Growing Degree Days of 547 GGD (Base 15 Degrees) in any given year
Water Supply Shortage	Extreme low flow conditions in the North Saskatchewan River, endangering local water supply	North Saskatchewan River flow rate is 25 m^3 per second or lower in any given year
Lowland Flooding due to Precipitation	Heavy precipitation of 10mm or more rain in a day causes flooding within County boundaries	11.4 heavy precipitation days (10mm or more) in any given year

Climate Opportunities	Climate Impact Description	Proxy Indicator
Increased Agricultural Productivity	A warmer growing season for plants and crops, providing favorable conditions for agriculture	Growing Degree of 1243 GDDs (Base 10 degrees) in any given year

Table 2: *Final Climate Impact Scenarios (Risks and Opportunities)*

Climate Risks

A total of 15 climate impacts that could negatively impact Sturgeon Count were identified. **Action planning was recommended for the 7 Climate Impact Scenarios above the black line,** as shown in Table 3 since they fall into the high and very high-risk category according to the Action Planning Status Table (appendix D). For impacts below the black line, that have a Risk Score of less than 15, no additional action is recommended at this time beyond monitoring and consideration as part of regular reviews.

Climate Impacts Scenarios with negative consequences	Likelihood	Consequence	Risk Score
Water Shortage	5	4.3	**21.5**
Heat Wave	5	3.3	**16.7**
Invasive Agricultural Pests	5	3.3	**16.4**
Seasonal Drought	4	3.9	**15.6**
Wildfire Smoke	4	3.8	**15.2**
Wildland/Cropland Fire	4	3.8	**15.2**
Flooding due to Precipitation	4	3.8	**15.2**
Freezing Rain	5	2.9	**14.5**
Crop Pathogens	4	3.1	**12.5**
Increased Space Cooling Demand	4	3	**12.0**
Windstorm	4	3	**11.7**
Sturgeon River Flooding	3	2.9	**8.8**
Heavy Snowfall	3	2.9	**8.8**
Hailstorm	3	2.8	**8.3**
North Saskatchewan River Flooding	3	2.7	**8.0**

Table 3. *Climate Impacts (Risks) recommended for action planning*

Climate Opportunities

A total of 4 climate impacts that could present positive opportunities for Sturgeon Count were identified**. Action planning is recommended for all Climate Impacts Scenarios above the black line**, as shown in table 4 since they fall into the high and very high opportunity category according to the Action Planning Status Table (appendix D). For impacts below the black line, that have an Opportunity Score of less than 15, no additional action is recommended at this time beyond monitoring and consideration as part of regular reviews.

Climate Impacts Scenarios with positive consequences	Likelihood	Consequence	Opportunity Score
Increased Agricultural Productivity	4	3.8	**15.2**
Longer Summer Recreation Season	4	3.7	**14.7**
Reduced Road Maintenance	5	2.9	**14.5**
Longer Construction Season	4	3.5	**14.1**

***Table 4**. Climate Impacts (Opportunities) recommended for action planning*

PUBLIC SURVEY

Implementing the Climate Adaptation Action Plan requires knowledge of the public acceptability of certain actions that can be used to address the priority climate risks and opportunities. Although an estimation of the level of public acceptability was included the action planning criteria (appendix D), the survey gives further insights to the public's opinions on the matter.

Questions comprised of which of the actions mentioned during Action Planning Workshop the public would find most helpful for action planning for each of the 8 priority climate risks/ opportunities. The survey had a question about which of the 8 priority climate risks/ opportunities would most affect the respondents' lives. There was the opportunity to write open-ended comments as to why respondents voted a certain way, and any other insights or comments they wanted to share.

The survey was distributed via the Sturgeon County website, with the goal of residents and business owners of the County to respond to the survey. The survey was open for approximately 1 week. Seven survey responses were received. Because of the low response rate, this survey may not provide a representative sample of the perspectives of the public.

Summary of findings

Water supply shortage had the highest number of "extremely impactful" votes for response to how much each climate impact would affect the respondent's lives, and heat waves was second for the most "extremely impactful" votes.

Overall, the public respondents felt that the following actions from the survey were most important for the County to implement:

- Analyze and identify water saving options at County facilities
- Increase the amount of water stored in tanks for use during low-water periods
- Update the emergency response program to help vulnerable populations suffering from heat-related illness
- Install air conditioning in public buildings
- Help farmers reduce invasive weeds in forage and feed products
- Increase the responsibilities of the County to better serve local farmers
- Update existing drainage systems such as culverts, pipes, drainage on roads etc.
- Use natural ways for water to be diverted (e.g., wetlands, culverts, ponds)
- Increase water retention through the use of natural areas
- Promote soil health education so that current crops can better tolerate droughts
- Ensure facilities that serve vulnerable populations have air filtration systems
- Provide public spaces with indoor air filtration
- Use drone technology to assist fire fighters
- Increase fire breaks by using natural elements such as ponds, fire resistant plants, etc.
- Help farmers use waste products from agricultural processes to create other useful products
- Provide information about alternative farming methods e.g., permaculture, vertical farming, planting crops alongside photovoltaics, etc.

The results of the public survey are shown in appendix E.

CLIMATE ADAPTATION ACTION PLANNING

A series of Action Planning Sessions were conducted with various County departments and stakeholders. During these sessions, participants brainstormed ideas that the County could take to address each of the priority climate risks and opportunities. Similar ideas that were expressed were grouped together and organized to generate an initial list of 29 actions. These initial actions were evaluated using a simple cost-benefit analysis framework to determine which actions provide the most benefit for the least cost (appendix D). Only the final 26 priority actions that were evaluated as a high or medium level of benefit are included in the Climate Adaptation Action Plan.

Priority actions were organized into the following climate resilience themes that aim to reduce the collective impact on the environment and make the most of opportunities. The themes are shown below:

Each of the climate resilience themes can be implemented using the following types of actions by the County:

> **Plan:** Incorporating the action into a statutory document that is created by the municipality.
>
> **Policy:** Writing a new policy or amending an existing policy for the action.
>
> **Program:** Launching an official program for the public that is centered around the action.
>
> **Infrastructure:** Enhancing transportation, water, and public service facilities, etc. to support the action.
>
> **Education and Awareness:** Launching or expanding upon existing education and awareness initiatives that inform the public about specific topics.
>
> **Naturalization:** Utilizing nature-based solutions as an alternative to hard infrastructure e.g., restoring a wetland to absorb excess water, rather than a storm drain.
>
> **Research and Monitoring:** Gathering information and monitoring aspects of an action.
>
> **Partnership:** Creating or building upon an existing agreement between two parties to implement an action.
>
> **Operations:** Modifying the County's daily operations to account for the action.

Sturgeon County's Climate Adaptation Action Plan is presented below and describes a variety of recommended priority actions that the County can take to further adapt to the impacts of climate change. Each of the actions are informed by the scientific data, the Vulnerability and Risk Assessment Workshop and the Action planning workshop. The tables below summarize the goals, objectives and actions under each of the four themes, and include the action type, and the scoring for each action.

All recommended actions within this Plan are proposed to be initiated between 2022-2027.

RESILIENT WATER MANAGEMENT

	**Water is one of our most important natural resources. As the climate changes, the availability of water can fluctuate greatly. In some instances, there may be too little water due to droughts and increased water demand from hot weather. In other situations, flooding may cause an over-abundance of water and damage to property and the natural environment.**
Goal	**Enhance water management practices to reduce risks from lowland flooding and water shortage events**
Objectives	• **Consider climate change in stormwater management** • **Protect local water supplies to reduce the severity of water shortages** • **Increase water use efficiency**

Table 5: Resilient water management climate actions

Action	Action Type	Priority Level
Stormwater management		
Update and/or enhance the Drainage Master Plan to ensure that low-impact development is adopted for future developments, not only for open-spaces but for entire communities. Consider projected changes to extreme rainfall, update stormwater design standards accordingly	Plan	High
Conduct a tree and environmental reserve inventory of the age, type, condition and density of vegetation to help quantity the difference that naturalization makes for reducing the negative impacts of flooding	Research and Monitoring	High
Protect water supply		
Develop a long-term water supply plan	Plan	High
Add more large holding tanks to collect water to prepare for water shortages	Infrastructure	High
Increase water use efficiency		
Research using reclaimed water for non-potable purposes	Research and Monitoring	High

HEALTH AND WELLBEING

	**The health and well-being of residents are already adversely affected by climate change, increasing exposures to extreme heat events, floods, droughts, and other extreme events; vector-, food- and water-borne infectious diseases; changes in air and water quality and stresses to mental health and well-being generally. Extreme heat in the summer and exposure to wildfire smoke are linked with increased risk of a range of illnesses and death. Those particularly at risk include older adults, pregnant women, children, people with chronic health conditions, and populations with increased social vulnerability with less access to information, resources, healthcare, and other means to prepare for and avoid the risks.**
Goal	**Reduce negative health impacts of extreme heat and wildfire smoke**
Objectives	• **Increase public awareness of the health risks associated with heat waves and fire smoke.** • **Improve air quality and cooling systems at public facilities** • **Increase naturalization of public spaces** • **Increase air quality monitoring capacity**

Table 6: Health and wellbeing climate actions

Action	Action Type	Priority Level
Enhance education and awareness of health risks associated with extreme heat and poor air quality		
Increase public education and awareness of what they can do about poor air quality due to wildfire smoke. Important points to include: • Raise public awareness of the AQHI (Air Quality Health Index), this information could be added to the County website • Provide education about types of air filters that are best suited for homes • Provide information for residents about any available grants and funding for air filtration systems	Education and Awareness	High

Improve air quality and cooling systems at public facilities			
	Create partnerships with towns across the County to use large public buildings as clean air facilities for the public on smoky days. These assets should have indoor air filtration that the public can access when the AQHI indicates dangerous conditions	Partnership	High
	Retrofit existing public buildings with air conditioning and filtration systems	Infrastructure	Medium
	Ensure that new public buildings have air conditioning and filtration systems	Policies	High
	Provide funding assistance for homeowners to improve their air filtration systems	Program	High
	Partner with Alberta Capital Airshed to expand air quality monitoring • Increase engagement with Alberta Capital Airshed to have more types of air quality factors monitored and published • Advocate for building new air monitoring stations within the County	Partnership	Medium
	Research to understand how best to improve heat wave management and update local educational programs, plans and procedures • Assess the need for additional outdoor cooling areas such as shaded areas or water parks • Research if there is a need for more natural landscaping in public outdoor spaces so that there is more shade (e.g., planting more trees over walking paths, parks, and high-use public spaces)	Research and Monitoring	High

STRONG AND RESILIENT ECONOMY

	**The agricultural sector is a key part of the local economy and is particularly sensitive to weather and climate conditions. Climate change has the potential to adversely impact agricultural productivity in Sturgeon County through changes in rainfall patterns, more frequent climate extremes (including high temperatures and drought), increased stress from pests and disease, as well as increased heat-stress on animals. Risks arising from climate change depend on the ability of producers to adapt to projected changes. Climate change may also present opportunities for the agriculture sector, such as the potential to grow new varieties or types of crops, or exploring alternative agricultural practices, such as growing crops that are more resistant to drought and pests, permaculture and utilizing autonomous agriculture technology, etc.**
Goal	**Support economic prosperity within the agricultural sector**
Objectives	• **Increase public education and awareness of alternative methods of farming that are resilient to climate change** • **Explore potential opportunities to support/increase local food production**

Table 7: Strong and resilient economy climate actions

Action	Action Type	Priority Level
Education and awareness		
Support local farming community with climate change related information, which could include: • Encouraging local farmers to alter farming practices, such as growing drought resistant plants, permaculture, holistic farming, planting crops alongside photovoltaics (AgroPV), year-round indoor farming, and utilizing autonomous crop technology for agriculture • Promoting soil health education and amendments so that current crops can better tolerate droughts • Encouraging water retention through utilizing natural areas on private properties • Encouraging the growth of new crop varieties that are resistant to drought and pests • Encouraging alternative agricultural practices such as permaculture or using natural methods such as	Education and Awareness	High

	promoting species that eat pests e.g., native insects that eat invasive insects, goats to eat invasive weeds, etc. • Increase monitoring and information sharing with farmers and neighboring municipalities about local drought-related metrics such as precipitation, soil moisture etc. • Providing information on funding opportunities for farmers to manage pests • Increasing public education and awareness about the risk or effects of heat stress on livestock and ways to reduce risk • Increase agricultural data accessibility for local farmers, which could include, using Agriculture Alberta to report precipitation and drought trends in a public-friendly manner • Utilize existing technology to measure soil moisture levels locally		
Increase/support local food production			
	Create partnerships with local community groups to utilize open spaces and parks for community gardens or a food forest, with some funding provided	Partnership	**Medium**

DISASTER RESILIENCE

	As climate change intensifies, we can anticipate more natural disasters. Climate change can increase the intensity of flooding, severe storms, and wildfires, all of which have been experienced by the County. The County has well-established protocols for emergency management. Further enhancing disaster resilience can help increase public safety, protect economic assets, and prevent sensitive ecological areas from being damaged.
Goal	**Build capacity to prepare for and respond to increased extreme events such as wildland/cropland fires and floods**
Objectives	**Update emergency response plans to consider the potential future impacts of climate change to the County** **Support practices that reduce the severity of wildland/cropland fires** **Support practices that reduce the severity of water shortages**

Table 8: Disaster resilience climate actions

Action	Action Type	Priority Level
Emergency response		
Update the Sturgeon Regional Emergency Management Plan to consider flooding risk and other climate change-related hazards • Update emergency flood management procedures using predictive rainfall information for stormwater infrastructure • Update 72hr home emergency kits to include items such as masks that reduce smoke exposure, etc. • Prioritize responses for local vulnerable populations including the elderly, the very young, individuals with pre-existing health conditions, and individuals living in poorly insulated homes without access to air conditioning • Incorporate agriculture disaster considerations into existing plans	Plan	High

Wildland/cropland fire management			
	Develop an urban-interface fire risk assessment and management plan • Utilize Indigenous knowledge about fire management practices by partnering with local Indigenous groups • Increase fire breaks through using natural and design elements such as ponds, fire resistant plants in high fire risk areas • Assess the viability of doing prescribed burns in public areas with heavy debris		High
	Have County staff inspect large piles of debris before burning to reduce unintentional spread of fire from overuse of gasoline, lack of control while burning and burning too close to other flammable materials	Operations	**Medium**
	Enhance public education of fire risk and mitigation: • public education for residents about how to reduce the risk of a wildland/cropland fire occurring on their property (FireSmart) • Increase education about the influence of fire on grasslands and the effects of wind, peat moss fires, advantages of clearing leaves	Education and Awareness	High
	Increase ditch mowing during high fire risk periods	Operations	High
	Develop an aerial monitoring program: • Use drone technology, unmanned aerial vehicle) (UAVs) to assess the impact of a fire before fire crews arrive in order to speed up the firefighting process • Use drone and satellite technology to look at the health or moisture content of an area to identify its risk - could deal with it right away or prevent fires from starting thermal imaging	Program	**Medium**
	Create a debris/fallen tree removal program to help residents to remove debris from their properties, especially focusing on those who live in high fire-risk areas of the County	Program	**Medium**
	Lobby province for resources to improve wildfire management and response	Partnership	**Medium**

	Flood protection		
	Discourage future development in flood zones through the County's Land Use Bylaw, taking the risk of changing flood zones to the climate change into consideration	Policy	Medium
	Increase public education and awareness of ways to reduce susceptibility to flooding, which could include: • Education about what types of practices farmers can adopt to protect their topsoil from loss during a flooding event • Increase education and awareness about the benefits of minimum tillage for water retention and erosion management • Increase public education and awareness about what residents and landowners can do to protect their property from flooding • Further promote wetland conservation by educating the public about the importance of natural wetlands • Further promote the ALUS program to encourage flood protections on farming property	Education and Awareness	High
	Update the environmentally sensitive areas study (1989) to consider climate change and explore if any additional natural infrastructure or wetland restoration would be of benefit to reduce flooding	Research and Monitoring	High
	Update Land Use Bylaw to encourage developments that minimize the removal of trees and other natural assets	Policy	Medium

NEXT STEPS

This Plan is meant to provide a proactive guide to increasing capacity on climate adaptation and increasing climate resiliency in Sturgeon County. This plan focuses on climate change impacts that have the highest likelihood of occurring, and the largest consequences to Sturgeon County, which will allow the County to prioritize the response to specific impacts. Action in the Plan are also prioritized as the cost benefit analysis, action where prioritized based on the projected upfront costs, operating costs, negative side-effects, human capital costs, acceptability and effectiveness.

The success of this Climate Adaptation Action Plan will require the commitment and support of Council members, County staff, and key local stakeholders who helped shape the vision, principles, and actions of this report.

It is recommended that the suggestions of the Climate Adaptation Action Plan are integrated into future County strategic plans and initiatives. All priority actions should be initiated between 2022-2027, and the plan should be updated and reviewed every 5 years. The County may find additional ways to adapt in the future, which can be added to the recommend actions in this plan.

CONCLUSION

It is essential that the recommendations in this Plan are implemented in order to best serve the interests and well-being of the community and to protect the vitality of the local economy and environment. The way ahead for Sturgeon County can be one that pursues resilience. The adaptation actions within this Climate Adaptation Action Plan provide direction for the County's climate resilience journey. However, the climate is constantly changing and will continue to introduce new impacts. Adapting to these changes successfully cannot be done by the County alone. It will require unity from all orders of governments, residents, and businesses to invest in solutions that equip the county to withstand the forces of nature. With diligent work and collaboration, the County can thrive in the midst of a changing climate.

BIBLIOGRAPHY

All One Sky Foundation. (n.d.). *Climate Resilience Expresss: A Community Climate Adaptation Planning Guide.* Municipal Climate Change Action Centre.

IPCC. (2014). *Climate Change 2014: Impacts, Adaptation, and Vulnerability.* Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press.

IPCC. (2014). *Summary for Policymakers. In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge, United Knigdom and New York, NY, USA: Cambridge University Press.

Relevant Sturgeon County Plans, Policies and Bylaws

- Sturgeon County Municipal Development Plan Bylaw 1313/13
- Sturgeon County Land Use Bylaw 1385/17
- Strategic Plan 2022-2025
- Sturgeon County Infrastructure Master Plan
- Sturgeon Regional Emergency Management Partnership Emergency Action Guide
- Sturgeon Regional Emergency Management Plan
- Drainage Master Plan Final Report 2019
- County Website- Agriculture Corner
- Agricultural Services' Pest Management Program
- ALUS Program

APPENDICES

Appendix A: Climate Trends and Projections

Since the 1976-2005 baseline time period, a number of climate variables have significantly been affected by climate change. The changes in these variables may spur new climate events or increase the magnitude and duration of current climate events within the community. This could result in significant impacts to the municipality if appropriate measures and preparation are not taken to build resiliency.

The following section identifies and analyzes climate trends in Sturgeon County that have been observed between the historical baseline (1976-2005) and projections up until the 2060s. The Climate Atlas grid in which Morinville is situated was used for this research. Results are expressed in absolute terms as well as percentage changes.

The climate projections described in this report are from the Canadian Climate Atlas, which presents summary results from 24 different climate models. The climate projects are based on the RCP 8.5 scenario, which is a 'business as usual scenario where greenhouse gas emissions continue to rise at existing rates over the coming decades. In the graphs from the Climate Atlas, baseline data is presented in blue, and future projections are presented in red.

Temperature and Precipitation Patterns

The climograph below compares average precipitation and temperature patterns between baseline (1976-2005) and 2060s climate models. The temperature in Sturgeon County is projected to increase for every month of the year except August by the 2060s, with the greatest differences being experienced during the winter and summer seasons. Precipitation levels are expected to increase slightly for all months except the month of August. The months of April and May will experience the greatest percentage increases in precipitation.

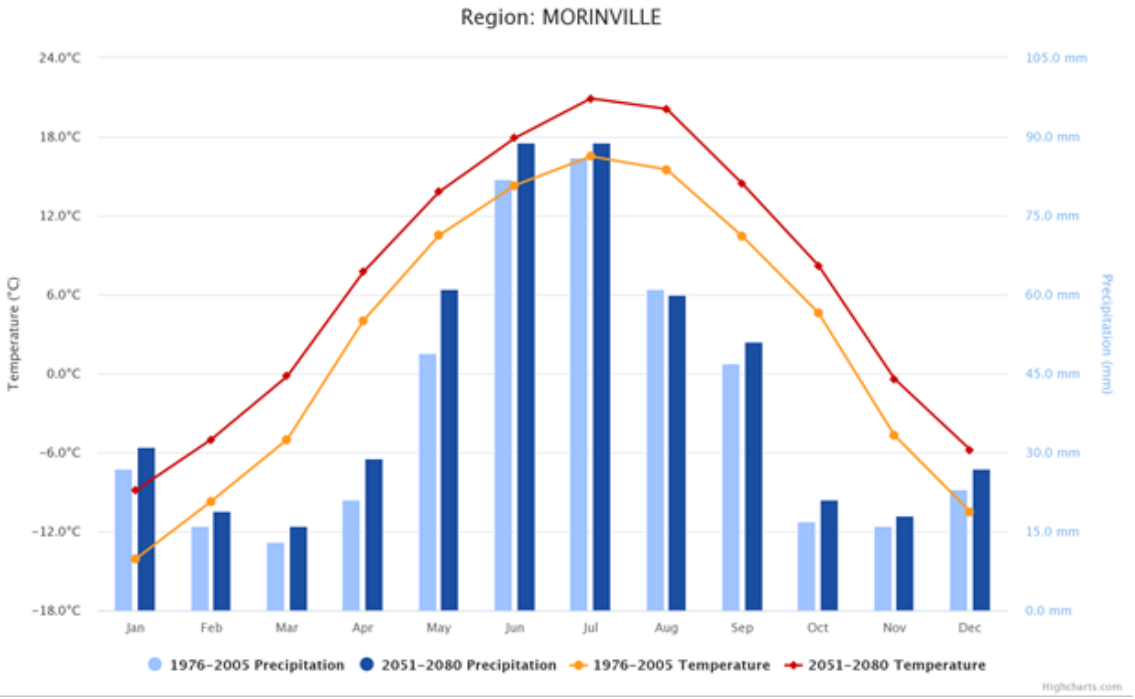


Figure 3: Predicted Changes to Average Annual Temperature and Precipitation Patterns in Sturgeon County between the baseline and the future.

This climograph compares average annual precipitation and temperature patterns. Historical monthly mean precipitation (light blue), future projected mean precipitation, (dark blue), historical monthly mean temperature (orange), and future projected mean precipitation (red) are shown.

Temperature

The mean annual temperatures in Sturgeon County are expected to increase from a baseline annual temperature of 2.7°C to 7°C. The spring and fall seasons will experience the greatest changes in mean temperature, with an increase from 3.2 to 7.1°C and 3.4 to7.4°C, respectively.

Average annual minimum temperatures will follow a similar pattern. Minimum annual temperatures are expected to rise by 2060s from -2.9 to °C 1.95°C. The spring and fall will experience the greatest changes to minimum temperatures, warming from -2.7 to1.3°C and -2 to 2.1°C.

Precipitation

Precipitation levels are expected to remain relatively consistent between the baseline (1976-2005) and 2060 climate models. The greatest change that Sturgeon County can expect a change from 2.2-2.8 days in the number of heavy precipitation days, where at least 20mm of rain or frozen precipitation falls in a single day. This may increase the risk of lowland/overland flooding and increase the water level of the North Saskatchewan River and Sturgeon River. All other precipitation variables are expected to increase slightly, with the exception of a change in the number of dry days from 232 to 231 days/year.

Specific Climate Impacts

Longer and Hotter Summers

According to the Climate Atlas (2021), a summer day occurs when temperatures reach a minimum of 25°C. The number of summer days is expected to increase from 25.6 to 69.8 days annually. This could result in new opportunities for a longer summer recreation season, agricultural growth, and construction seasons. Alternatively, this could increase the frequency of invasive species, agricultural pests, and crop pathogens.

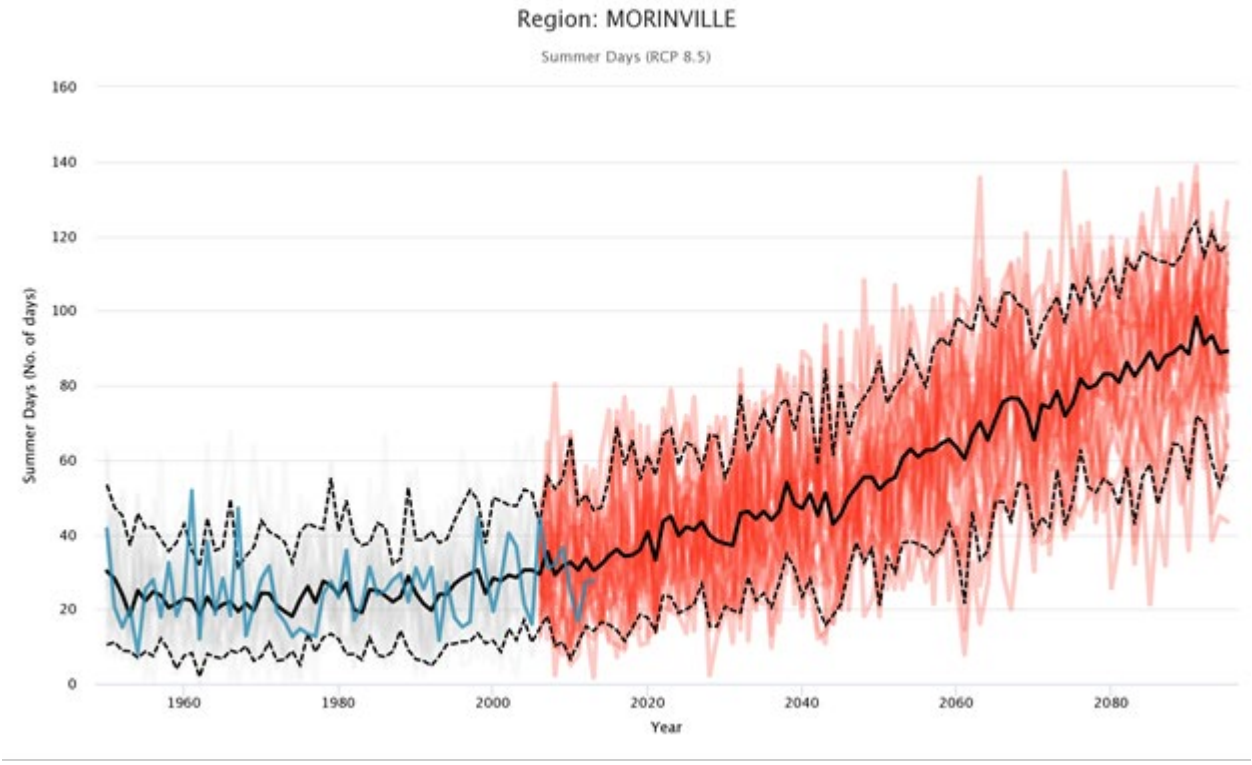


Figure 4: Annual Number of Summer Days in Sturgeon County

The average number of +30°C days annually in Sturgeon County is projected to increase from 2.5 to 22 days by the 2060s. This can influence a variety of local impacts on health, economy, recreation, agriculture, and infrastructure. The intensity and frequency of heat-related climate events may increase. Examples include heat waves, cropland fires/wildfires, wildfire smoke days, extreme weather events, and droughts. Additionally, very hot days increase heat stress on the elderly, very young and vulnerable populations.

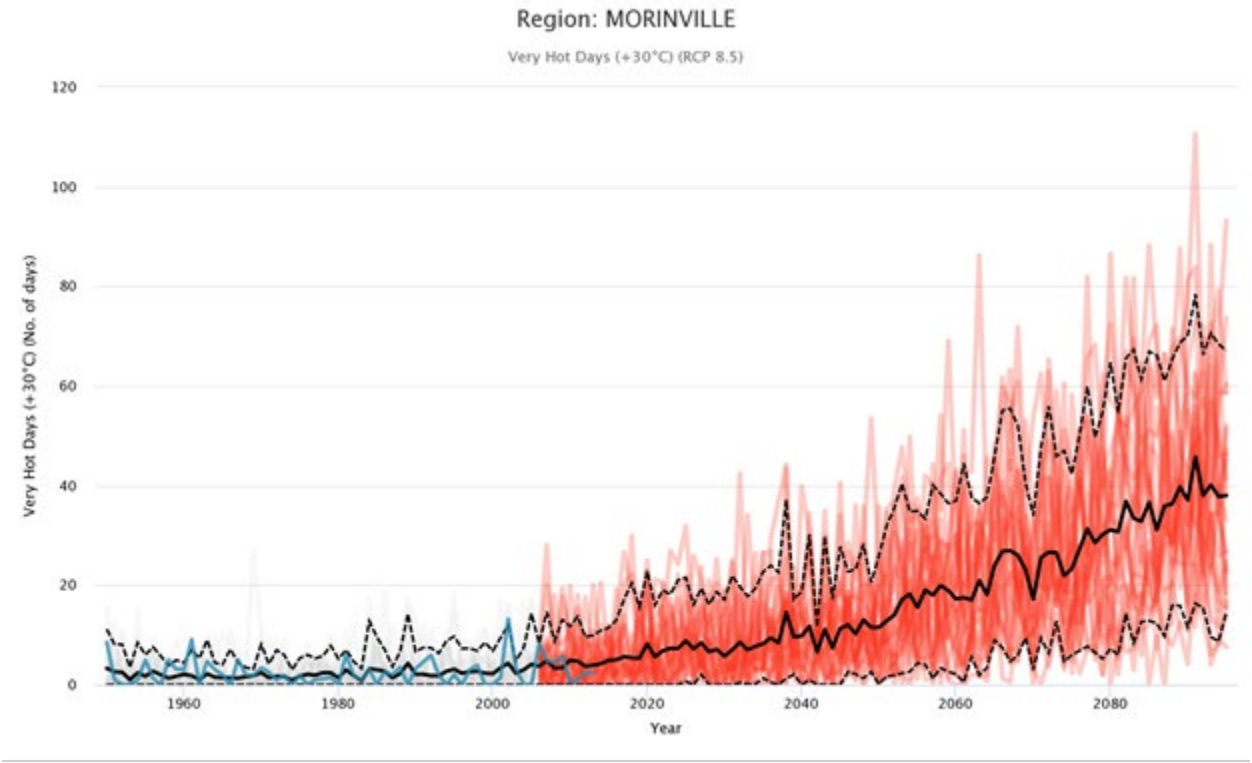


Figure 5: Annual Number of Very Hot Days (+30°C) in Sturgeon County

By the 2060s, the number of extremely hot days annually with temperatures reaching 32°C and 34°C are expected to increase dramatically by the 2060s. Temperatures reaching 32°C are expected to rise from 0.5 to 11.6 days annually, and temperatures reaching 34°C are expected to rise from 0.1 to 5.5 days annually. The need for air conditioning and other cooling measures may become more prevalent.

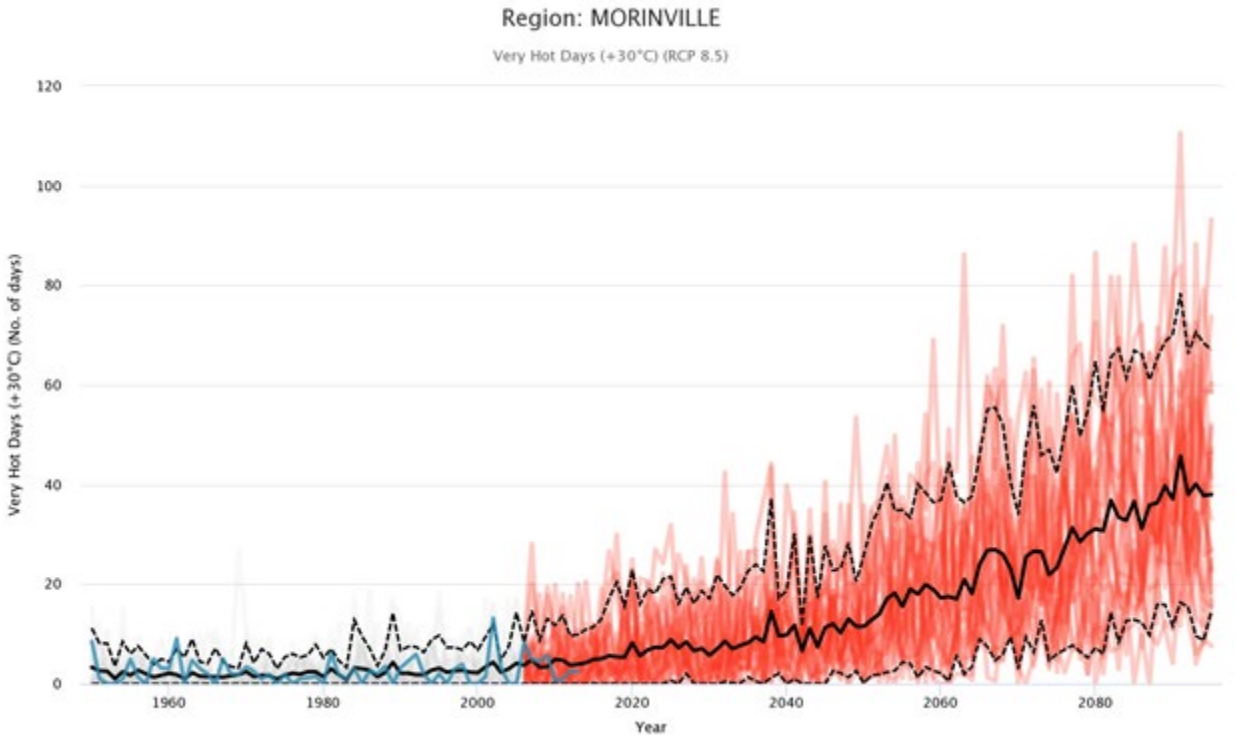


Figure 6: Annual Number of Extremely Hot Days (+34°C) in Sturgeon County

Furthermore, Sturgeon County may experience tropical nights – a climate event that has rarely occurred in the municipality. Tropical nights occur when the minimum temperature in a day does not drop below 20°C (Climate Atlas, 2021).

Shorter and Milder Winters

The winter season in Sturgeon County is expected to become shorter as temperatures continue to warm. All variables related to cold weather are projected to decline, with the number of very cold days (-30°C or below) experiencing the greatest decrease from the historical mean of 9.3 days below -30°C to 1.5 days. This may, however, increase opportunities for winter recreation as temperatures become safer to venture outdoors. On the other hand, the number of winter days, which is defined as days when the temperature is 15°C or cooler, is expected to decrease from 60.8 to 31.7 days annually. Shorter winter seasons could also result in decreased usage of indoor heating.

On the other hand, decreased winter days when the temperature does not reach -30°C can negatively affect some forms of wildlife and agriculture by allowing the spread of invasive species that could not otherwise withstand the cold weather.

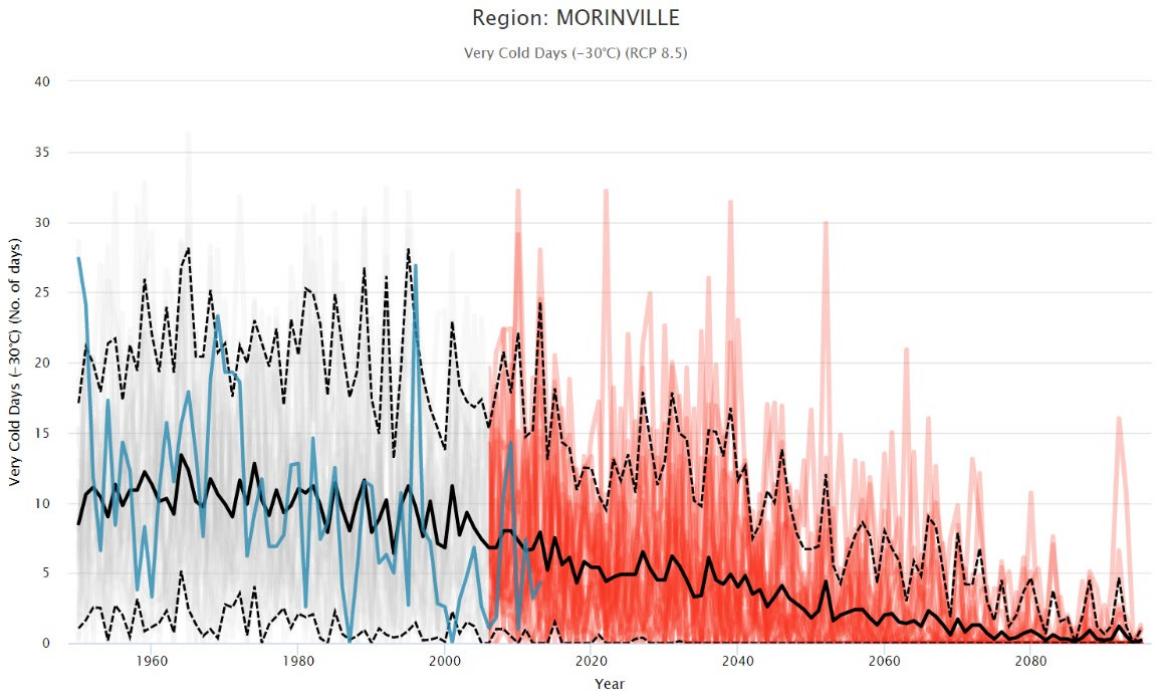


Figure 7: Annual Number of Very Cold Days (-30°C) in Sturgeon County

As the winters become milder, it is expected that the frequency of freeze-thaw cycles will change. Freeze-thaw cycles are a count of days when the air temperature fluctuates between freezing and non-freezing temperatures. Under these conditions, it is likely that some water at the surface was both liquid and ice at some point during a 24-hour period. It is projected that freeze-thaw cycles will decrease from a baseline of 87.1 days annually to 68.2days.

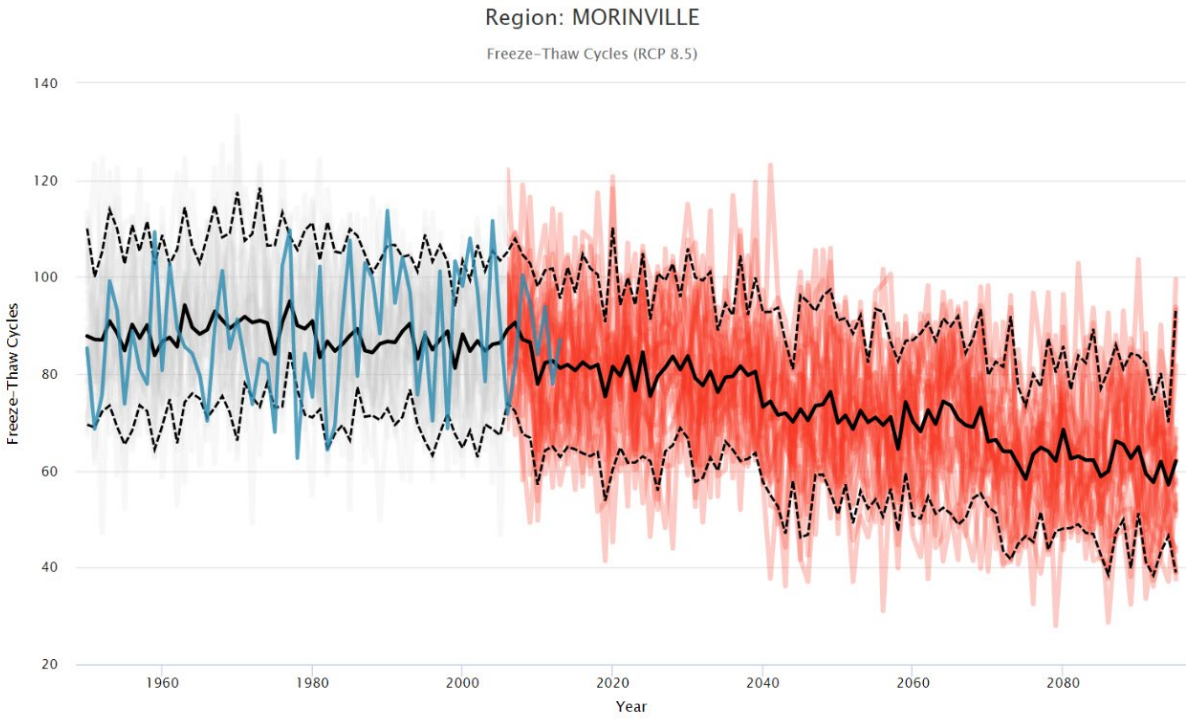


Figure 8: Annual Number of Freeze Thaw Cycles in Sturgeon County

More Extreme Weather

As the climate becomes more unpredictable, the intensity and frequency of extreme weather events is projected to increase into the 2060s. A notable example is the number of heat waves that occur, where temperatures of 30°C or hotter are experienced in the county for three consecutive days or more. The number of heat waves in Sturgeon County is expected to rise from 0.3 per year to 3 per year by the 2060s. This could also trigger a number of other heat-related extreme weather events, such as droughts, wildfires, wildfire smoke, and stronger thunderstorms.

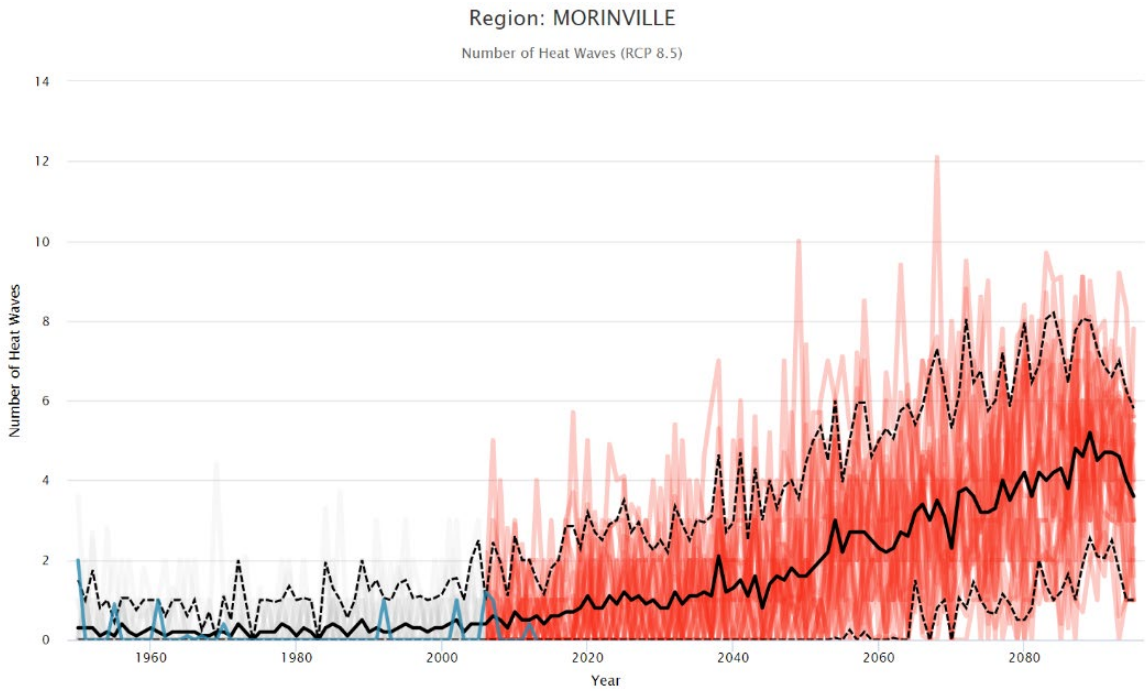


Figure 9:Annual Number of Heat Waves in Sturgeon County

Importantly, stronger thunderstorms can produce high winds, lightning strikes, hail, tornadoes, and extreme rainfall. The number of heavy precipitation days where at least 20mm of rain or frozen precipitation falls in a single day is estimated to increase from 2.2 to 2.8 days by the 2060s. This could intensify flooding in lowland areas.

Agricultural Variables

Growing Degree Days (GDD) are used to assess the ability of the climate to support crops and insects at different temperatures. The growth of canola and forge crops can be assessed using 5 °C GDDs for example. 10 °C GDDs assesses the growth of corn and beans, and 15 °C GDDs assesses the growth and development of insects and pests. Current climate projections indicate that all GDDs will increase by the 2060s, creating opportunities for enhanced agricultural productivity and the potential to diversify crop species. 5 °C GDDs will rise from 1421-2190 and 10 °C GDDs will rise from 653.6-1243. 15 °C GDD will experience the largest percent increase, from 170.2 - 547.2 GGDs. Additionally, 4 °C GDD is expected to increase from 1605-2409. The large increase in the 15 °C GDD can result in an increase of invasive species across the region, which may negatively affect some types of agriculture.

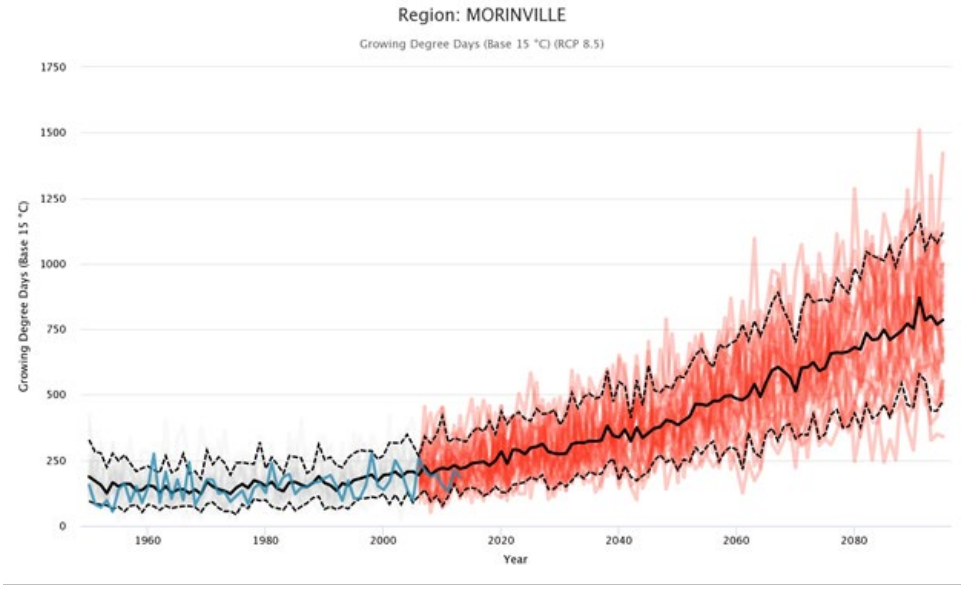


Figure 10: Annual Growing Degree Days (Base 15°C) in Sturgeon County

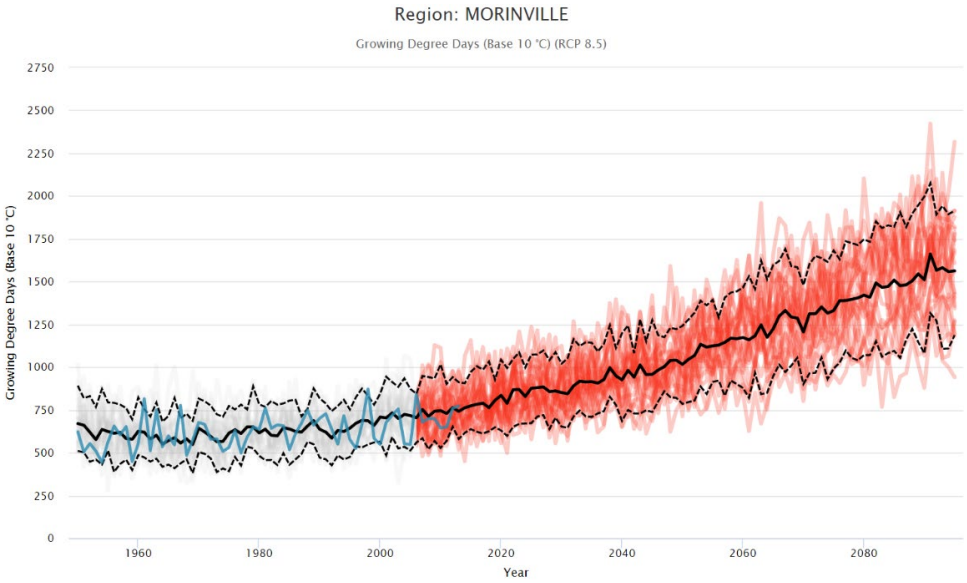


Figure 11: Annual Growing Degree Days (Base 10°C) in Sturgeon County

The length of the frost-free season is expected to increase from 125.2 to 163.9 days annually. The date of the first fall frost is expected to change from approximately September 19th to October 9th by the 2060s, and the date of the last spring frost is expected to change from May 14th to April 24th. This increase in the frost-free season would result in a longer growing season.

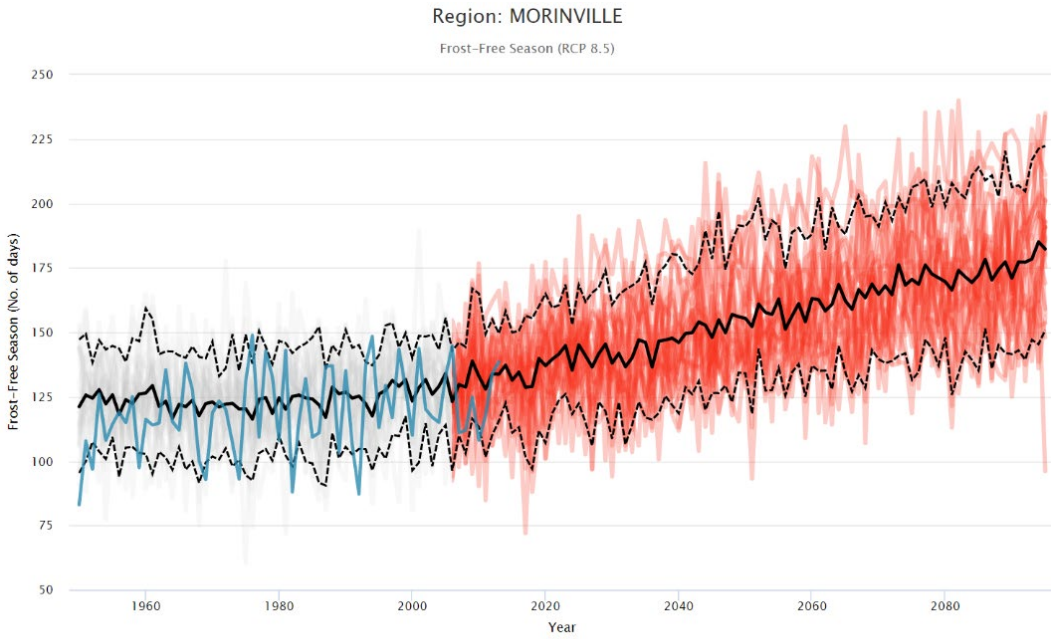


Figure 12: Annual Length of Frost-Free Season in Sturgeon County

Corn Heat Units (CHU) is a temperature-based index often used by farmers and agricultural researchers. It is used to estimate whether the climate is warm enough (but not too hot) to grow corn. A minimum of 2200 CHUs are required to mature most varieties of corn. CHU is expected to increase in Sturgeon County from 2062 to 3176 by the 2060s, meaning that other forms of agriculture that are not currently suited for Sturgeon County's climate could potentially become an opportunity in the future.

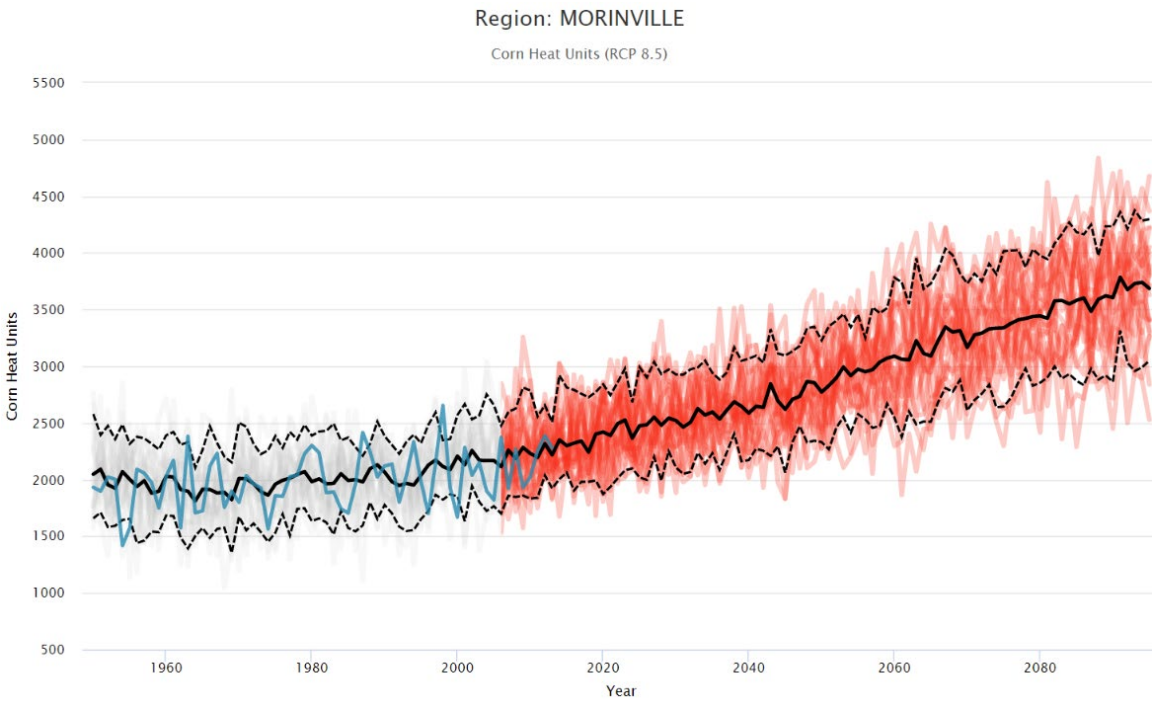


Figure 13: Annual Corn Heat Units in Sturgeon County

Complete Summary of Projected Climate Changes for Sturgeon County

The table below displays complete data from the Climate Atlas of Canada for five climate variable categories: Hot Weather, Cold Weather, Temperature, Precipitation, and Agriculture. Comparisons are made between the baseline (1976-2005) and 2060s (2051-2080) mean values. The variables highlighted in green have the greatest percent change between the historical baseline mean and future projections. This is more detailed information that compliments the climate trends and projections listed above.

Climate Variable	Baseline Mean (1976-2005)	2051-2080 Projections ('2060s')			
		Low (10th percentile)	Mean	High (90th percentile)	Mean % Change
Hot Weather					
Number of Very Hot Days (+30 degrees days)	**2.5**	5	**22**	44	780%
Tropical Nights	**0**	0	**1.6**	5.8	N/A
Average warmest max temp	**30.6**	31.5	**35.3**	39.4	15%
Summer Days	**25.6**	43.3	**69.8**	96.1	173%
Cooling Degree Days (CDD)	**45.1**	117.1	**264.6**	436.5	487%
Number of Heat Waves	**0.3**	0.4	**3**	5.9	900%
Average Length of Heat Waves (days)	**0.8**	1.2	**5**	9	525%
Longest Spell of +30 Degree Days	**0.9**	1.3	**6.9**	15.3	667%
Number of expected +30-degree days ("Hot Season")	**12.9**	23.1	**71.9**	118.7	457%
Extremely Hot Days (+32 degrees)	**0.5**	0.7	**11.6**	28.3	2220%
Extremely Hot Days (+34 degrees or hotter)	**0.1**	0	**5.5**	16.6	5400%
Cold Weather					
Number of very cold days (-30-degree days	**9.3**	0	**1.5**	5.5	-84%
Freeze Thaw Cycles (days)	**87.1**	50.6	**68.2**	86.1	-22%
Frost Days	**193.9**	125.5	**149.9**	174.5	-23%
Icing Days	**93.8**	44.4	**68**	92.5	-65%
Climate Variable	**Baseline Mean (1976-2005)**	**2051-2080 Projections ('2060s')**			

		Low (10th percentile)	Mean	High (90th percentile)	Mean % Change
Coldest Minimum Temperature (degrees Celsius)	**-36.2**	-34.4	**-28.3**	-21.9	-22%
Heating Degree Days (HDD)	**5620**	3626	**4292**	4956	-24%
Freezing Degree Days (FDD)	**1448**	475.7	**845.3**	1270	-41%
Mild Winter Days (-5 degrees or colder)	**133.2**	65.4	**92.4**	118.1	-31%
Winter Days (-15 degrees or colder)	**60.8**	11.3	**31.7**	54.8	-48%
Temperature					
Annual Mean Temperatures (degrees)	**2.7**	4.9	**7**	9	159%
Spring Mean Temperature	**3.2**	3.9	**7.1**	10.5	122%
Summer Mean Temperature	**15.4**	17.5	**19.6**	21.8	27%
Fall Mean Temperature	**3.4**	5.2	**7.4**	9.7	118%
Winter Mean Temperature	**-11.5**	-11	**-6.6**	-2.5	-43%
Annual Max. Temperature	**8.3**	10.3	**12.4**	14.6	49%
Spring Max. Temperature	**9.1**	9.4	**12.9**	16.8	42%
Summer Max. Temperature	**21.6**	23.4	**26.1**	28.8	21%
Fall Max. Temperature	**8.8**	10.1	**12.7**	15.5	44%
Winter Max. Temperature	**-6.6**	-6.6	**-2.5**	1.7	-62%
Annual Min. Temperature	**-2.9**	-0.5	**1.5**	3.5	-152%
Spring Min. Temperature	**-2.7**	-1.6	**1.3**	4.3	-148%
Summer Min. Temperature	**9.2**	11.4	**13.2**	15	43%
Fall Min. Temperature	**-2**	0.1	**2.1**	4	-205%
Winter Min. Temperature	**-16.4**	-15.4	**-10.8**	-6.5	-34%
Climate Variable	**Baseline Mean (1976-2005)**	**2051-2080 Projections ('2060s')**			

		Low (10th percentile)	Mean	High (90th percentile)	Mean % Change
Precipitation					
Heavy Precipitation Days (10 mm)	**9.4**	5.9	**11.4**	17.5	21%
Heavy Precipitation Days (20 mm)	**2.2**	0.5	**2.8**	5.7	27%
Wet Days	**132.5**	114.2	**133.2**	152.5	0.53%
Dry Days	**232.2**	212.1	**231.4**	250.5	-0.34%
Max 1-Day Precipitation (mm)	**33**	20	**37**	59	12%
Max 3-Day Precipitation (mm)	**46**	28	**52**	83	13%
Max 5-Day Precipitation (mm)	**57**	36	**64**	103	12%
Length of Frost-Free Season	**125.2**	135.4	**163.9**	195.3	31%
Date of First Fall Frost	**Sept. 19**	Sept. 21	**Oct. 9**	Oct. 28	
Date of Last Spring Frost	**Ma. 14**	Apr. 1	**Apr. 24**	Ma. 13	
Corn Heat Units (CHU)	**2062**	2633	**3176**	3727	54%
Growing Degree Days (Base 5 Degrees)	**1421**	1809	**2190**	2562	54%
Growing Degree Days (Base 10 Degrees)	**653.6**	942.4	**1243**	1540	90%
Growing Degree Days (Base 15 Degrees)	**170.2**	331.4	**547.2**	772.8	22%
Growing Degree Days (Base 4 Degrees)	**1605**	2014	**2409**	2797	50%

Figure 14: Summary of Projected Climate Changes for Sturgeon County

Climate Variable Definitions

Below is a list of climate variable definitions that are relevant to the above climate trends and projections and complete summary of projected climate changes for Sturgeon County.

Hot Weather Variables:

- **Average Length of Heat Waves**: The average length of a heat wave. A heat wave occurs when at least three days in a row reach or exceed 30°C.
- **Cooling Degree Days:** Cooling Degree Days (CDD) are equal to the number of degrees Celsius a given day's mean temperature is above 18°C. For example, if the daily mean temperature is 21°C, the CDD value for that day is equal to 3°C. If the daily mean temperature is below 18°C, the CDD value for that day is set to zero.
- **Extremely Hot Days (+32°C):** A day when the temperature rises to at least 32°C.
- **Extremely Hot Days (+34°C):** A day when the temperature rises to at least 34°C.
- **Hot (+30°C) Season:** The number of days when +30°C temperatures can be expected.
- **Longest Spell of +30°C Days:** The maximum number of days in a row with temperatures 30°C or higher.
- **Number of Heat Waves:** The average number of heat waves per year. A heat wave occurs when at least three days in a row reach or exceed 30°C.
- **Summer Days:** A Summer Day is a day when the temperature rises to at least 25°C.
- **Tropical Nights:** A Tropical Night occurs when the lowest temperature of the day does not go below 20°C.
- **Very Hot Days:** A Very Hot Day is a day when the temperature rises to at least 30°C.
- **Warmest Maximum Temperature:** The highest temperature of the year.

Cold Weather Variables:

- **Coldest Minimum Temperature:** The very coldest temperature of the year.
- **Freeze-Thaw Cycles:** This is a simple count of days when the air temperature fluctuates between freezing and non-freezing temperatures. Under these conditions, it is likely that some water at the surface was both liquid and ice at some point during the 24-hour period.
- **Freezing Degree Days:** Freezing degree days (FDD) begin to accumulate when the daily mean temperature drops below freezing: if a day's mean temperature is -21°C, for example, it increases the annual FDD value by 21. Days when the mean temperature is 0°C or warmer do not contribute to the annual sum.
- **Frost Days:** A frost day is one on which the coldest temperature of the day is lower than 0°C. Under these conditions frost might form at ground level or on cold surfaces.
- **Heating Degree Days:** Heating Degree Days (HDD) are equal to the number of degrees Celsius a given day's mean temperature is below 18°C. For example, if the daily mean temperature is 12°C, the HDD value for that day is equal to 6°C. If the daily mean temperature is above 18°C, the HDD value for that day is set to zero.
- **Icing Days:** An Icing Day is a day on which the air temperature does not go above freezing (0°C).
- **Mild Winter Days (-5°C):** A Mild Winter Day is a day when the temperature drops to at least 5°C.
- **Very Cold Days (-30°C):** A Very Cold Day is a day when the temperature drops to at least 30°C.
- **Winter Days (-5 °C):** A Winter Day is a day when the temperature drops to at least -15°C.

Temperature Variables:

- **Maximum Temperature:** The highest temperature of the day.
- **Mean Temperature:** The average temperature of the day.
- **Minimum Temperature:** The lowest temperature of the day.

Precipitation Variables:

- **Dry Days:** The number of days in a year without rain/snow.
- **Heavy Precipitation Days:** A Heavy Precipitation Day (HPD) is a day on which at least a total of 10mm (or 20mm) of rain or frozen precipitation falls. Frozen precipitation is measured according to its liquid equivalent: 10cm of snow is usually about 10mm of precipitation.
- **Max 1-Day Precipitation:** The amount of precipitation that falls on the wettest day of the year.
- **Max 3-Day Precipitation:** The wettest three-day period.
- **Max 5-Day Precipitation:** The wettest five-day period.
- **Mean Annual Precipitation:** The average amount of precipitation that falls in a year.
- **Mean Growing Precipitation:** The average amount of precipitation that falls during the growing season.
- **Precipitation:** The total amount of rain, drizzle, snow, sleet, etc. Frozen precipitation is measured according to its liquid equivalent: 10cm of snow is usually about 10mm of precipitation.
- **Wet Days:** The number of days in a year with rain/snow.

Agriculture Variables:

- **Corn Heat Units:** Corn Heat Units (CHU) is a temperature-based index often used by farmers and agricultural researchers to estimate whether the climate is warm enough (but not too hot) to grow corn. A minimum of 2200 CHUs are required to mature most varieties of corn.
- **Date of First Fall Frost:** The date of the first fall frost, which marks the approximate end of the growing season for frost-sensitive crops and plants.
- **Date of Last Spring Frost:** The date of the last spring frost, which marks the approximate beginning of the growing season for frost-sensitive crops and plants.
- **Frost-Free Season:** The Frost-Free Season is the approximate length of the growing season, during which there are no freezing temperatures to kill or damage plants.
- **Growing Degree Days:** Growing Degree Days (GDD) provide an index of the amount of heat available for the growth and maturation of plants and insects. Different base temperatures (5, 10 and 15°C) are used to capture results for organisms that demand different amounts of heat.

Note from Climate Atlas on Data Sources

Where did this data come from?

Global Climate Models (GCMs) are used to depict how the climate is likely to change in the future. Since no one climate model can be considered 'correct', it is important to use many GCMs to capture a range of possible conditions. The GCM Climate Atlas data were obtained from the Pacific Climate Impacts Consortium (PCIC). PCIC collected temperature and precipitation data produced by 24 different models and used advanced statistical techniques to create high-resolution (daily, 10km) versions of the data for all of Canada (for more information visit pacificclimate.org). Data used in this workshop was from the 'Morinville' grid.

What are the RCP 8.5 and RCP 4.5 future climate scenarios?

One of the most important inputs into GCM simulations of the future climate is the expected concentration of greenhouse gases (GHGs; especially carbon dioxide) in the atmosphere as a result of human activity. In the scientific literature these future GHG concentrations are used to calculate Representative Concentration Pathways (RCPs). The High Carbon scenario (RCP8.5) assumes that humans continue to emit very large amounts of carbon dioxide from the burning of fossil fuels; the Low Carbon scenario (RCP4.5) assumes that drastic reductions of emissions in the coming decades will stabilize the concentration of GHGs in the atmosphere by the end of this century. The Climate Atlas did not use RCP2.6, an even lower emissions scenario.

How are the minimum, mean, and maximum calculated?

The Climate Atlas used an ensemble of 24 different GCMs to analyze the future climate. The mean values are the average values of this ensemble over the 1976-2005, 2021-2050 and 2051-2080 periods. The range of values in each time period is indicated by the High (90th percentile) and Low (10th percentile) values in the

tables. This means about 10% of the predicted values are above the "High" value, and 10% are lower than the "Low" value.

Appendix B: Climate Risk Scenarios

Heat Wave

Projected climate change	Hotter summer temperatures, and more extreme heat
Impact event description	A heat wave occurs when temperatures reach +30°C or hotter for at least 3 consecutive days
Potential consequences	• Injuries and fatalities related to heat exhaustion and heat stroke • Impacts exacerbated for vulnerable populations, including the young, elderly, disabled and long-term sick, as well people experiencing homelessness or living in poor-quality homes. • Increased water demand for potable water, agricultural animals, irrigation, demands on water infrastructure • Heat-related illness animals • Road and sidewalk damage • Impacts to local vegetation, crops, and outdoor community gardens due to dehydration • More work for emergency services • Impact on soil quality, agriculture, natural systems
Proxy indicator / threshold	3 heat waves in any given year occur

Historic value (1976-2005)	**Future value (2060s)**
0.3 heat waves per year	*3 heat waves per year* (900% increase)

Annual probability		**Likelihood score**	
Historic	**Future**	**Historic**	**Future**
1%	*63%*	*1*	*5*
Consequence score	3.3	**Final risk score**	16.7

Data notes:

- Threshold indicator and climate projections from Climate Atlas, 2021

Seasonal Drought

Projected climate change	Reduced summer precipitation, increased summer temperatures
Impact event description	Anomalously low moisture during the frost-free season
Potential consequences	• Stress on natural systems • Reduced crop yields, decreased livelihood for farmers • Increased need for irrigation • Damage to green infrastructure • Increased operational costs for the County • Increased risk of wildland/cropland fires • Decreased underground water for wells • Water shortage
Proxy indicator / threshold	Canadian Drought Monitor (CDM) D3 occurs in any given year

Historic value (2003-2021)	**Future value (2060s)**
5 D3 droughts were reported between 2003 and 2021	*Not modelled*

Annual probability		**Likelihood score**	
Historic	**Future**	**Historic**	**Future**
28%	*>28%*	*4*	*4*
Consequence score	3.9	**Final risk score**	15.6

Data notes:

- Annual probability calculation: 5 events/18 years= 0.2778x 100= 27.78%
- The Canadian Drought Monitor (CDM) uses a variety of federal, provincial, and regional data sources to establish a single drought rating based on a five-category system (i.e., D0 – D4) (Government of Canada, 2019). A D3 drought is classified as an extreme drought that occurs every 20-25 years (Government of Canada, 2014).
- Threshold and historic values are obtained from the Canadian Drought Monitor (CDM). A D3 drought is classified as an extreme drought or a 1 in 20-year drought event (Government of Canada, 2019).
- Historic annual probability estimate based on the average historic value.
- Future annual probability and likelihood estimates based on research from Bonsai et al. (2013). Drought in the Canadian prairies is expected to become longer and more frequent in the 21st century.
- Although precipitation is projected to increase in Alberta, higher temperatures along with longer warm seasons increase the risk of drought (climatedata.ca)
- A very severe drought affected much of Canada, reaching from British Columbia to the Atlantic between 1999 and 2005 (climate data.ca)

Wildfire/Cropland Fire

Projected climate change	Reduced summer precipitation, increased summer temperatures
Impact event description	A wildland or cropland fire, small or large, that occurs in an area where there is little development, except for roads, railroads, power lines and other linear infrastructure
Potential consequences	• Damage to property and infrastructure • Loss of recreation assets and opportunities – social impact • Loss of agricultural resources/crops, financial burden/instability for farmers • Increased costs and municipal resources required • Increased air pollution • Increased demand for water to put out fires • Increased work for emergency services
Proxy indicator / threshold	Wildland/cropland fire occurs within the county boundary, causing damage to property in any given year

Historic value	**Future value (2060s)**
*There have been several fires over the past years due to lightning strikes and human activity**	*Not modelled*

Annual probability		**Likelihood score**	
Historic	**Future**	**Historic**	**Future**
Unknown	≥30% increase in historical frequency^	4	*5*
Consequence score	3.8	**Final risk score**	15.2

Data notes:

- *There have been several fires over the years associated with lighting strikes (Communications with Pat Mahoney, Manager/Fire Chief at Sturgeon County)
- ^Future annual probability estimate is based on a projected 33% increase in wildfire activity in central Alberta (NRCan, 2017).
- The warmer and drier climate projected for the 2060s will create conditions more favorable for wildfires. 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, increasing wildfire smoke in the region (De Groot et al., 2013; Flannigan et al., 2019)

Wildfire Smoke

Projected climate change	Reduced summer precipitation, increased summer temperatures
Impact event description	Smoke from wildfires enters the municipal boundary
Potential consequences	• Negative health outcomes related to smoke inhalation and poor air quality • Reduced visibility • Impacts exacerbated for vulnerable populations • Poor air quality at civic facilities, potential disruption of services • Cancellation of local and outdoor events • Increased break cycles for employees • Reduced crop quality
Proxy indicator / threshold	The maximum Air Quality Health Index (AQHI) is 10 in any given year

Historic value	**Future value (2060s)**
2016-2021 records show 3 years where AQHI values were 10 or higher (Average = 1 event every 1.5 years)	*Not modelled*

Annual probability		**Likelihood score**	
Historic	**Future**	**Historic**	**Future**
60%	*80%*	*5*	*5*
Consequence score	3.8	**Final risk score**	15.2

Data notes:

- Threshold obtained from Government of Alberta (2019). An AQHI index of 10+ is labelled as "Very High" and occurs during a forest fire smoke event.
- Historic value obtained from the Alberta Capital Airshed staff (2022).
- Historic annual probability estimate based on the average historic value.
- Future annual probability estimate based on wildfire activity across Canada. The data projects a 33% increase in wildfire activity in central Alberta (NRCan, 2017).
- The warmer and drier climate projected by the 2060s will create conditions more favorable 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 an increase in the average area burned, increasing wildfire smoke in the region (De Groot et al., 2013; Flannigan et al., 2019).

Outbreak of Invasive Agricultural Pests

Projected climate change	Longer, hotter summers
Impact event description	An outbreak of invasive plant and insect pests, such as Bertha Armyworm and Grasshopper, etc.
Potential consequences	• Negative impacts to farmers, loss of crop yields • Decreased livelihood for farmers • Increased use of chemicals to control pests • Increased operational agricultural pest management costs • Change in food prices, food shortage • Increased erosion • Changes to natural systems
Proxy indicator / threshold	Growing Degree Days (Base 15 Degrees) of 547 in any given year

Historic value (1976-2005)	**Future value (2060s)**
170.2 GDDs Base 15	*547.2 GDDs Base 15* (221% increase)

Annual probability		**Likelihood score**	
Historic	**Future**	**Historic**	**Future**
<1%	*37%*	*1*	*4*
Consequence score	3.3	**Final risk score**	16.4

Data notes:

- Historic and future climate projections from the Climate Atlas, 2021.
- Main agricultural pest of concern in Sturgeon County are Bertha Armyworm and Grasshopper (Communication with Angela Veenstra, Manager of Agriculture Services).
- Insects affecting crops typically thrive in hot, dry weather (Dixon, 2012).
- Bertha Armyworms eggs can survive up until approximately -10 degrees Celsius (Province of Manitoba, Agriculture and Resource Development).
- Grasshopper eggs can survive Alberta winters and excel in hot, dry conditions (Government of Alberta, Grasshoppers-Best Management Practices).

Outbreak of Crop Pathogens

Projected climate change	Longer growing season
Impact event description	Increased outbreak of agricultural diseases affecting crops
Potential consequences	• Negative impacts to farmers, loss of crop yields • Increased operational agricultural disease management costs • Outbreak of invasive agricultural pathogens such as clubroot of canola, virulent blackleg of canola and fusarium head blight in cereals • Increased use of chemicals to control crop pathogens
Proxy indicator / threshold	Length of frost-free season is 164 days annually

Historic value (1976-2005)	**Future value (2060s)**
125.2 days	*163.9 days* (31% increase)

Annual probability		**Likelihood score**	
Historic	**Future**	**Historic**	**Future**
>1%	*48%*	*1*	*4*
Consequence score	3.1	**Final risk score**	12.5

Data notes:

- Historic and future climate projections from Climate Atlas, 2021.
- Crop type trends and crop yield trends in Alberta (Government of Alberta, 2019 Agriculture Statistics Yearbook).
- The main crop diseases in Sturgeon County are Clubroot of Canola, Virulent Blackleg of Canola and Fusarium Head Blight in Cereals (Communication with Angela Veenstra, Manager of Agriculture Services).
- A longer growing season increase the chances of crop pathogens. Additionally, levels of precipitation are another factor that have a significant impact on the development of crop pathogens, with greater levels of precipitation increasing crop pathogen spread (Dixon 2012).

Water Supply Shortage

Projected climate change	Hotter summer temperatures, more extreme heat, and drier summer conditions
I Impact event description	Extreme low flow conditions of the North Saskatchewan River endangering local water supply
Potential consequences	• At risk water supply, with potential water restrictions • Impacts to aquatic ecosystems • Reduced water quality, increased need for treatment and filtration • Increased costs of water • Increased demand for alternative water sources (e.g., Bottled water, potable water, etc.) • Increased utility costs for businesses and residents • Increased price of crops/feed for livestock • Increased operating costs for municipality • Reduced crop production • Reduced water for emergency services
Proxy indicator / threshold	North Saskatchewan River flow rate is 25 m^3/s in any given year (1:100-year flooding)

Historic value	**Future Value (2060s)**
In the past 100 years there were two times when flow volumes fell below the 245 m^3/s threshold	*Not modelled*

Annual probability		**Likelihood score**	
Historic	**Future**	**Historic**	**Future**
2%	*5%*	*2*	*3*
Consequence score	4.3	**Final risk score**	21.5

Data notes:

- Historic value and historic annual probability estimate from Boyd et al. (2018) with data from the Water Survey of Canada Hydrometric data for Edmonton (2019).
- Future annual probability estimates from Boyd et al. (2018).
- Most of Sturgeon County's crops are dryland crops and do not require irrigation that. For crops that do require irrigation, residents are predominantly reliant on Water licenses to draw from surface water bodies including drainage ways and rivers (ex. Sturgeon River, North Saskatchewan River) and dugouts (Communications at Sturgeon County).
- Livestock operations typically rely on groundwater wells and dugouts. A small number have access to County-owned and operated water lines or haul water from County/ Regional water truck fill stations (Communications at Sturgeon County).

Sturgeon River Flooding

Projected climate change	Increased precipitation in spring, summer, and fall seasons
Impact event description	Higher water levels in the Sturgeon River causes local flooding
Potential consequences	• Damage to nearby property, infrastructure, and utilities located in low-lying areas or floodplains • Damage to riparian areas and recreational trails • Increased capital costs for flood mitigation • Transportation disruption • Increased insurance costs • Increased runoff and erosion • Impacts to water quality (turbidity) – increased water treatment costs
Proxy indicator / threshold	Sturgeon River rate is 90 m^3/s in any given year (1:100-year flood)

Historic value	**Future Value (2060s)**
1-3 m^3/s	*Not modelled*

Annual probability		**Likelihood score**	
Historic	**Future**	**Historic**	**Future**
1%	7%	1	3
Consequence score	2.9	**Final risk score**	8.8

Data notes:

- Threshold and historical value obtained from Government of Alberta, Alberta Floods Portal.
- Historic annual probability estimate based on the average historic value.

North Saskatchewan River Flooding

Projected climate change	Increased precipitation in spring, and increased heavy rainfall
Impact event description	Elevated flow conditions in the North Saskatchewan River (NSR)
Potential consequences	• Disruption of drinking water supply • Damage to riparian areas and recreational trails • Damage to nearby infrastructure, agricultural productions and residences • Lowland/cropland flooding
Proxy indicator / threshold	North Saskatchewan River flow rate is 5800m3 per second (approximately 1:00 year flood occurrence)

Historic value (1976-2005)	**Future Value (2060s)**
5,800 m^3 per second is the largest volume ever recorded on the NSR at Edmonton during the 1915 flood	*Not modelled*

Annual probability		**Likelihood score**	
Historic	**Future**	**Historic**	**Future**
0.6%	*1.5%*	*2*	*2*
Consequence score	2.7	**Final risk score**	8.0

Data notes:

- Historic annual probability estimates from Eng et al. (2017) with data from the Water Survey of Canada Hydrometric data for Edmonton (daily discharge).
- Future annual probability estimates from Boyd et al. 2018.
- Threshold based on the flow rate above which the water treatment plant at Rossdale in Edmonton would sustain damage and be unable to reliably provide water
- In response to projected climate changes, the seasonal pattern of river flow will shift. River flows in June to August will be, on average, lower than in the past. As a warming climate amplifies the hydrological cycle, the range of river levels will expand, with larger departures from a shifting baseline of higher winter flows and lower summer flows (Kerr, et al., 2019).

Lowland Flooding due to Precipitation

Projected climate change	Heavy precipitation of 10mm or more rain in a day causes flooding within County boundaries
Impact event description	Lowland flooding due to precipitation occurs
Potential consequences	• Flooding damage to property and infrastructure, including basement flooding and road damage • Topsoil loss • Transportation disruption • Increased insurance costs • Increased runoff and erosion • Impacts to water quality (turbidity) – increased water treatment costs, pollution from runoff, decreased water quality • Increased stress on storm drains and related storm water infrastructure
Proxy indicator / threshold	11.4 heavy precipitation days (10mm or more) in any given year

Historic value (1976-2005)	**Future Value (2060s)**
9.4 days	*11.4 days* (21% increase)

Annual probability		**Likelihood score**	
Historic	**Future**	**Historic**	**Future**
25%	*47%*	*3*	*4*

Consequence score	3.8	**Final risk score**	15.2

Data notes:

- Historic and future climate projections from Climate Atlas, 2021.

Hailstorm

Projected climate change	Increased storm intensity
Impact event description	Hailstorm producing hail stones of 27 mm ("loonie-sized") or greater in diameter
Potential consequences	• Power outage – disruption to county operations and services • Damage to property and infrastructure, including trees, signs, roofs, siding, automobiles, etc. • Increased insurance costs for repair and replacement of damaged property • Cancellation of outdoor events • Damages to crops influencing increased agricultural insurance costs
Proxy indicator / threshold	A hailstorm with loonie-sized (27mm) hailstones occur in any given year

Historic value	Future value (2060s)
2 hail events with loonie-sized hail or greater were reported in Sturgeon County between 1982-2020 (Average = 1 hailstorm every 19 years)	*Not modelled*

Annual probability		Likelihood score	
Historic	**Future**	**Historic**	**Future**
5%	*5%*	*3*	*3*
Consequence score	2.8	**Final risk score**	8.3

Data notes:

- Threshold value based on a study from Marshall et al. (2002). The study indicates that 32mm (Toonie-sized) hail incrementally damaged the greatest number of roofing products. Loonie-sized hail is used for the threshold value as it is the most similar in size for which data is available.
- Historic value based on Alberta hail data from ECCC
- The amount of hailstorms in North America is expected to decrease (Brimelow et al., 2017; Raupach et al., 2021), however, the size of hail is expected to increase, therefore causing greater damage (Brimelow et al., 2017).
- Future annual probability estimate based on data from Allen (2018). The number of hailstorms is projected to be less frequent across Alberta overall. However, when a hailstorm does occur, larger hail stone sizes between 20mm-40mm are expected.
- The localized and short duration nature of hailstorms makes it difficult to accurately predict future changes in frequency with meaningful confidence.

Windstorm

Projected climate change	Increased storm intensity
Impact event description	A windstorm with gusts of 90km/h or greater
Potential consequences	• Power outage – disruption to county operations and services • Damage to property and infrastructure, including trees, signs, roofs, siding, automobiles, etc. • Costs for repair and replacement of damaged property • Cancellation of outdoor events • Crop seedlings blowing away, tearing of crops, removal of topsoil • Transportation disruption (especially highways)
Proxy indicator / threshold	A windstorm with gusts of 90km/h occur in any given year

Historic value (1976-2005)	**Future value (2060s)**
9 high wind events were reported between 1976-2005 (Average = 1 high wind event every 3 years)	*Not modelled*

Annual probability		**Likelihood score**	
Historic	**Future**	**Historic**	**Future**
31%	*≥31%*	*4*	*4*
Consequence score	3	**Final risk score**	11.7

Data notes:

- Annual Probability calculation:
  - 9/29 years =0.3103 x 100= 31.03%
- Threshold based on data from Environment and Climate Change Canada (ECCC) for wind warning criteria
- Historic value based on data from weather station (Namao Station).
- Future annual probability estimate based on study from Cheng (2014), which suggests that 50-60% of extreme wind gust events (i.e., 90km/h wind speeds or greater) are associated with warmer temperatures. Future temperatures in Canada are projected to be higher than they were in the past.

Increased Summer Electricity Demand for Space Cooling

Projected climate change	Increased summer temperatures and extreme heat
Impact event description	Increased demand for space cooling
Potential consequences	• Increased space cooling and operating costs for municipality to retrofit and upgrade buildings and facilities • Increased need for space cooling for emergency services • Utilities affected/overloaded • Increased space cooling costs for businesses and residents • Impacts exacerbated for vulnerable populations and low-income populations
Proxy indicator / threshold	Cooling Degree Days in any given year are 264 CDDs

Historic value (1976-2005)	**Future value (2060s)**
45.1 CDDs	*264.6 CDDs* (486% increase)

Annual probability		**Likelihood score**	
Historic	**Future**	**Historic**	**Future**
1%	*43%*	*1*	*4*
Consequence score	3	**Final risk score**	12.0

Data notes:

- Cooling Degree Days (CDD) are equal to the number of degrees Celsius a given day's mean temperature is above 18 °C. For example, if the daily mean temperature is 21 °C, the CDD value for that day is equal to 3. If the daily mean temperature is below 18 °C, the CDD value for that day is set to zero.
- CDD indicator threshold from the Climate Atlas, 2021.
- Historic and future climate projections from the Climate Atlas, 2021.

Heavy Snowfall

Projected climate change	Increased precipitation in winter
Impact event description	A heavy snowfall event
Potential consequences	• Structural damage to buildings (roof collapse) • Public safety risk of injuries from slips, falls and heart attacks from shoveling snow • Increased road and sidewalk maintenance costs • Transportation disruption • Damage to trees • Damage to electrical/ communications systems – disruption to municipality operations and services
Proxy indicator / threshold	Snowfall accumulation of 10cm within 24 hours or less in any given year

Historic value	**Future value (2060s)**
36 days annually	*Not modelled*

Annual probability		**Likelihood score**	
Historic	**Future**	**Historic**	**Future**
10%	<=10%	*3*	*3*
Consequence score	2.9	**Final risk score**	8.8

Data notes:

- Annual probability calculation
    - 36days/365days= 0.09863x100= 9.86%
- Threshold based on data from Environment and Climate Change Canada (ECCC)
- Historic value based on data from weather station (Namao Station).
- Generally, increasing humidity increases the intensity of snowfall, however, increased temperatures decrease the likelihood of snowfall. The intensification of extreme snowfall is expected in North America (Quante et al., 2021)

Freezing Rain

Projected climate change	Increased average temperatures and precipitation in fall, winter, and spring
Impact event description	Precipitation event in which rain freezes on impact to form a coating of clear ice on the ground and on exposed objects
Potential consequences	• Public risk of injuries from slips, trips and falls • Increased road and sidewalk maintenance costs • Risk to emergency response and services • Higher insurance costs from increased risk of traffic accidents and property damage • Transportation disruption and mobility impacts, particularly for people with accessibility challenges. Vulnerable groups disproportionately affected. • Power outage – disruption to municipality operations and services
Proxy indicator / threshold	Level of freezing rain that meets the criteria for ECCC warning; A freezing rain event in a year

Historic value	Future value (2060s)
0.4 events per year	*Not modelled*

Annual probability		Likelihood score	
Historic	**Future**	**Historic**	**Future**
40%	*<99%*	*4*	*5*
Consequence score	2.9	**Final risk score**	14.5

Data notes:

- Historic value from Boyd et al. (2018) is based on results from the Edmonton area. No information specific to Sturgeon County was available.
- Historic annual probability estimates from Boyd et al. (2018) with data from Environment and Climate Change Canada (ECCC) for issuance of freezing rain warnings in Alberta.
- The ECCC warning criteria is defined as "When freezing rain is expected to pose a hazard to transportation or property, or when freezing rain is expected for at least two hours." (ECCC, 2020).
- Future annual probability estimates from Boyd et al. (2018).
- Data on freezing rain events indicate an increasing trend for parts of Alberta (e.g., Cheng et al., 2011), but no specific estimates of future projections were available for the Sturgeon County area.

Appendix C: Climate Opportunity Scenarios

Increased Agricultural Productivity

Projected climate change	Warmer spring, summer and fall temperatures
Impact event description	A warmer growing season for plants and crops, providing favorable conditions for agriculture
Potential consequences	• Increased economic benefits for local agriculture (increased yield potential) • Increased economic benefits from growing new varieties of crops, such as soybeans, faba beans, mustards, lentils • Green energy opportunities • New methods of growing crops
Proxy indicator / threshold	Greater Growing Degree Days (Base 10 °C) is 1243GDDs Base 10 in any given year

For Historic value (1976-2005)	Future Value (2060s)
653.6 GDDs	*1243 GDDs* (90% increase)

Annual probability		Likelihood score	
Historic	**Future**	**Historic**	**Future**
<1%	*48%*	*1*	*4*
Consequence score	3.8	**Final opportunity score**	15.2

Data notes:

- Growing Degree Days: Growing Degree Days (GDD) provide an index of the amount of heat available for the growth and maturation of plants and insects. Different base temperatures (5, 10 and 15 °C) are used to capture results for organisms that demand different amounts of heat.
- Growing Degree Days (GDD) provide an index of the amount of heat available for the growth and maturation of plants and insects (Climate Atlas, 2021). 10 °C GDDs assess the growth of corn and beans, which are generally more difficult to grow compared to other crops.
- The benefits of warmer average temperatures could be offset by dry conditions and/or insufficient access to water.
- Potential future crop opportunities may include soybeans, faba beans, mustards and lentils (Communication with Angela Veenstra, Manager of Agriculture Services).

Longer Construction Season

Projected climate change	Warmer spring and fall temperatures
Impact event description	Longer construction season
Potential consequences	• Increased efficiency of summer construction projects such as road repairs and underground utility work (more projects completed, more opportunities) • Economic benefits for local businesses • Longer employment terms for construction workers • Faster municipal development
Proxy indicator / threshold	Frost-Free Season is 163 days (5.4 months) in length

Historic value (1976-2005)	Future value (2060s)
125.2 days	*163.9 days* (31% increase)

Annual probability		Likelihood score	
Historic	**Future**	**Historic**	**Future**
<1%	*48%*	*1*	*4*
Consequence score	3.5	**Final opportunity score**	14.1

Data notes:

- The Frost-Free Season is the length of time (number of days) during which there are no freezing temperatures (Climate Atlas of Canada, 2021).
- Historic and future climate projections from the Climate Atlas, 2021.

Reduced Road Maintenance

Projected climate change	Warmer spring and fall temperatures
Impact event description	Reduced need for road maintenance
Potential consequences	• Economic benefits for local businesses • More opportunity to maintain existing infrastructure • Faster municipal development
Proxy indicator / threshold	Frost-Free Season is 163 days (5.4 months) in length

Historic value (1976-2005)	Future value (2060s)
125.2 days	*163.9 days* (31% increase)

Annual probability		Likelihood score	
Historic	**Future**	**Historic**	**Future**
<1%	*48%*	*1*	*4*
Consequence score	2.9	**Final opportunity score**	14.5

Data notes:

- Historic and future climate projections from the Climate Atlas of Canada, 2022.

Longer Summer Recreation Season

Projected climate change	Warmer weather in spring and fall
Impact event description	Longer recreation season for summer outdoor recreation activities
Potential consequences	• Increased opportunities for outdoor activities for residents, such as, golfing, softball, hiking, walking, cycling, ATV, hunting etc. • Increased opportunity for summer festivals and events
Proxy indicator / threshold	Frost-Free Season equal to or greater than 163 days (5.4 months) in length

Historic value (1976-2005)	**Future value (2030s)**
125.2 days	*163.9 days* (31% increase)

Annual probability		**Likelihood score**	
Historic	**Future**	**Historic**	**Future**
<1%	*48%*	*1*	*4*

Consequence score	3.7	**Final risk score**	14.7

Data notes:

- The Frost-Free Season is the length of time (number of days) during which there are no freezing temperatures (Climate Atlas of Canada, 2022).
- Historic and future climate projections from the Climate Atlas of Canada, 2022.

Appendix D: Climate Impact Assessment Scales

Likelihood Scale

Score	Description	Climate Event
1	**Rare**	Event is expected to happen less than once every 100 years (Annual probability < 1% in the 2060s)
2	**Unlikely**	Event is expected to happen about once every 51-100 years (1 - 2% annual probability in the 2060s)
3	**Possible**	Event is expected to happen about once every 11-50 years (2 - 10% annual probability in the 2060s)
4	**Likely**	Event is expected to happen about once every 3-10 years (10 - 50% annual probability in the 2060s)
5	**Almost Certain**	Event is expected to happen once every two years or more frequently (Annual probability > 50% in the 2060s)

Consequence Scales for Climate Risks

Criteria	Very Low (1)	Low (2)	Medium (3)	High (4)	Very High (5)
Public Health & Safety	No directly related loss of life No directly related injuries, illnesses, diseases or need to access healthcare services Minimal short-term reaction of fear or anxiety, or disruption to daily life	⟷	No directly related deaths A few people injured or experiencing illness, some requiring hospital treatment Widespread moderate, temporary feelings of fear and anxiety	⟷	Any directly related deaths Many more people injured, many seriously, or experiencing illness, many requiring hospital treatment Widespread and severe disturbance resulting in chronic psychological effects, like PTSD
Social Functioning	Minimal disruption to daily life Minimal or no change in community cohesion and trust in others No self-evacuations Minimal or no impact on cultural resources, recovering full functionality within days	⟷	Week-long disruption to daily life Moderate erosion of community cohesion and trust in others Small areas of the City (1 block) seeing temporary self-evacuations Moderate damage to cultural resources, with full recovery taking months	⟷	Months long disruption to daily life (e.g., inability to access schools, recreation) Severe, widespread erosion of community cohesion and trust in others Large areas of some neighbourhoods requiring temporary evacuations, with some permanent displacement High damage to cultural resources, full recovery may not be possible or could take years
Economic Vitality	Little or no potential direct and indirect economic losses Minimal or no disruption to economic sectors, jobs and livelihoods Minimal or no impact to infrastructure services Negligible impact on existing disparities, inequalities, or deprivation	⟷	Notable potential direct and indirect economic losses Week-long disruption to an important economic sector and associated jobs & livelihoods Week-long disruption to infrastructure services Moderate, temporary exacerbation of existing disparities, inequalities, or deprivation	⟷	Significant potential direct and indirect economic losses Long-term disruption or loss of an important economic sector and associated job & livelihood losses Months long disruption to infrastructure services Significant, prolonged exacerbation of existing disparities, inequalities, or deprivation

Natural Environment	Minimal or no environmental disruption or damage Affected resources recovering full functionality within days	Isolated but reversible damage to wildlife, habitat or and ecosystems, or short-term disruption to environmental amenities Full restoration of function possible, but could months	Widespread and irreversible damage to wildlife, habitat and ecosystems, or long-term damage, disruption to environmental amenities Full restoration of function is not possible, or could take decades
City Services	Little or no expected additional costs to City Minimal or no impact on operations and delivery of services Public reaction is minimal-little or no erosion of trust in City (council & staff)	Added costs are near or equivalent to available contingency / extreme weather reserves Operations and services temporarily interrupted for weeks before backlog is cleared Public reaction is moderate -negative view of City (council & staff) is held by several community groups or a neighbourhood	Added costs far exceed contingency and extreme weather reserves Operations and services severely interrupted – additional resources required to clear backlog, taking months Public reaction is significant -negative view of City (council & staff) is widespread, spanning the majority of population

Consequence Scale for Climate Opportunities

Very Low [1]	Low [2]	Medium [3]	High [4]	Very High [5]
Minimal or no increase in jobs and economic activity, benefiting a few businesses		Moderate direct and indirect economic gains, and/or modest increases in employment opportunities in a sector of the local economy		Significant direct and indirect economic gains, and/or large increases in employment opportunities in key sectors of the local economy, or the creation of a new sector
Minimal improvement to the lifestyle, and/o physical and emotional well-being of some residents		Modest improvements to the lifestyle, and/or physical and emotional well-being of specific population groups (e.g., outdoor recreationalists) in St. Albert		Noteworthy improvements to the lifestyle, and/or physical and emotional well-being of the majority of residents in St. Albert
Existing disparities, inequalities and deprivation across the community is unchanged	⟷	Moderate reduction in existing disparities, inequalities and deprivation for some marginalized groups	⟷	Large reductions in existing disparities, inequalities and deprivation for majority of marginalized groups
Minimal or no improvement in the City's annual operating surplus (revenues less expenses)		Modest improvement in the City's annual operating surplus (revenues less expenses)		Significant improvement in the City's annual operating surplus (revenues less expenses)

Action planning cost-benefit analysis evaluation criteria

Cost (inputs)/ Benefit (outputs)	Criteria	1	2	3	4	5
Cost	**Upfront Costs**	Upfront investment cost of action <$100,000	$100,000 to $200,000	Upfront investment cost of action $300,000 to $400,000	$400,000 to $500,000	Upfront investment cost of action >$500, 000
Cost	**Operating Costs**	Annual costs of action <$10,000	$11,000 to $20,000	Annual costs of action $21,000 to $30,000	$31,000 to $40,000	Annual costs of action > $41,000
Cost	**Negative Side-effects**	Little to no unintentional negative impacts and consequences for Sturgeon County		Unintentional negative impacts with moderate consequences for Sturgeon County		Unintentional negative impacts with significant consequences for Sturgeon County
Cost	**Human Capital Costs**	Little to no technological, knowledge, staff or training required to implement the action		Moderate technological, knowledge, staff or training required to implement the action		Significant technological, knowledge, staff or training required to implement the action
Cost	**Acceptability**	Majority (>50%) of community and Council supports the action		Modest (up to 50%) community and Council support for the action		No or limited community and Council support for the action
Benefit	**Effectiveness**	Minor reduction in priority climate risk or minimal potential to realize projected climate opportunities		Moderate reduction in priority climate risk or moderate potential to realize projected climate opportunities		Significant reduction in priority climate risk or significant potential to realize projected climate opportunities

Appendix E: Survey Results Data

The results of the public survey are shown in 9 and 10 below. The ranking is scored according from the highest concern for action to least concern for action. Climate Actions with the same ranking number were tied for ranking.

Climate actions with an asterisk * were mentioned in initial action planning sessions, but did not make it into action planning priorities.

Table 9: Climate Impacts (Risk and Opportunities) ranked from highest to lowest according to survey

Climate Impacts (Risks and Opportunities)	Weighted Average
Water supply shortage	4.1
Heat waves	3.8
Seasonal drought	3.6
Outbreaks of invasive agricultural pests	3.3
Flooding due to precipitation	3.1
Wildfire smoke	3
Wildland/cropland fires	3
Increased agricultural productivity	2.9

Table 10: Climate actions ranked from highest to lowest according to survey

Climate Actions	Weighted Average
Water shortage	
Analyze and identify water saving options at County facilities	3.5
Increase the amount of water stored in tanks for use during low-water periods	3.3
Provide incentives for water efficient home water systems (e.g., low flow fixtures, irrigation) *	3.3
Encourage use of recycled/non-potable water e.g., toilet flushing and crop watering	3
Identify ways to reduce water use in agriculture	3.2
Identify alternative water supply options such as groundwater or water purchases from other communities	2.5

Climate Actions	Weighted Average
Heat Waves	
Install air conditioning in public buildings	5
Update the emergency response program to help vulnerable populations suffering from heat-related illness	3.3
Increase public education about the risk of heat stroke and ways to reduce this risk	3
Reduce outdoor employee work times during extreme heat*	2.8
Provide air conditioning in some public places	2.7
Increase natural landscaping to provide more shade in public areas	2.7
Update the emergency response program to include measures for livestock heat-related illness	2.5
Investigate creating local thresholds for safe and unsafe outdoor activity during hot temperatures*	2.3
Invasive agricultural pests	
Help farmers reduce invasive weeds in forage and feed products*	3.6
Increase the responsibilities of the County to better serve local farmers	3.5
Encourage alternative agricultural practices such as permaculture or using natural methods such as promoting species that eat pests	3.3
Encourage planting types of crops that are more resistant to pests	3.2
Increase public education about what can be done to reduce the impacts of agricultural pests	3.2
Lowland flooding due to precipitation	
Update existing drainage systems such as culverts, pipes, drainage on roads etc.	3.7
Use natural ways for water to be diverted (e.g., wetlands, culverts, ponds)	3.5
Suggest practices farmers can use to protect against topsoil loss during flooding	3.3
Discourage future development in areas that flood often	3.3
Increase public education about what residents can do to protect their property from flooding	3
Reduce the amount of runoff from storms by using non-concrete surfaces (e.g., permeable surfaces)	2.7
Seasonal drought	
Increase water retention through the use of natural areas	3.5
Promote soil health education so that current crops can better tolerate droughts	3
Supply farmers with additional resources to deal with drought	3
Increase research about precipitation levels, soil moisture, etc.	3
Encourage local farmers to alter farming practices (e.g., growing drought resistant plants, permaculture)	2.7
Wildfire smoke	
Ensure facilities that serve vulnerable populations have air filtration systems	3.8
Provide public spaces with indoor air filtration	3.2
Increase public education about how to reduce wildfire smoke exposure at home	3
Increase the number of local air quality monitoring stations	2.9
Provide funding assistance for homeowners to improve air filtration systems	2.8

Climate Actions	Weighted Average
Wildland/cropland fire	
Use drone technology to assist fire fighters	3.5
Increase fire breaks through using natural elements such as ponds, fire resistant plants, etc.	3.5
Use satellite technology to predict which areas are most prone to fires occurring	3.3
Increase mowing of long grass in ditches	3.2
Increase public education for residents about how to reduce the risk of a wildland/cropland fire occurring on their property	3.2
Provide resources for residents to remove debris from their properties	2.3
Incorporate Indigenous knowledge into fire management practices	2.2
Increased Agricultural Productivity	
Help farmers use waste products from agricultural processes to create other useful products	3.8
Provide information about alternative farming methods e.g., permaculture, vertical farming, planting crops alongside photovoltaics, etc.	3.3
Grow new crop varieties	3.3
Incorporate changes to the climate into agricultural planning for the future	3.2