TOWN OF EDSON – CLIMATE VULNERABILITY AND RISK ASSESSMENT REPORT

A multi-hazard vulnerability, risk identification and resiliency assessment

September 21, 2023

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Town of Edson

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Executive Summary

Climate change poses risks due to extreme weather events that can influence the quality of life for Edson residents by impacting infrastructure, impeding economic development and growth, while leading to higher capital and operational costs for the Town and surrounding communities. To address the potential impacts from a changing climate, a Climate Vulnerability and Risk Assessment (CVRA) has been completed. The purpose of the CVRA is to expand the Town's understanding of how the municipal assets, infrastructure and operations are vulnerable to climate change and recommend ways to increase resiliency.

The first step in the CVRA involved completing a vulnerability assessment on the following Town of Edson asset systems.

- Administration and Operation Centers
- Recreation and Community Centers
- Roads
- Ecological Assets and Parks
- Stormwater Conveyance and Drainage Systems
- Water Storage, Treatment and Conveyance Systems
- Wastewater Treatment, Storage and Conveyance Systems

The climate vulnerability assessment which evaluates the extent to which the Town's assets are vulnerable to climate-related hazards as a function of exposure, sensitivity, and adaptive capacity, can be expressed by the following formula.

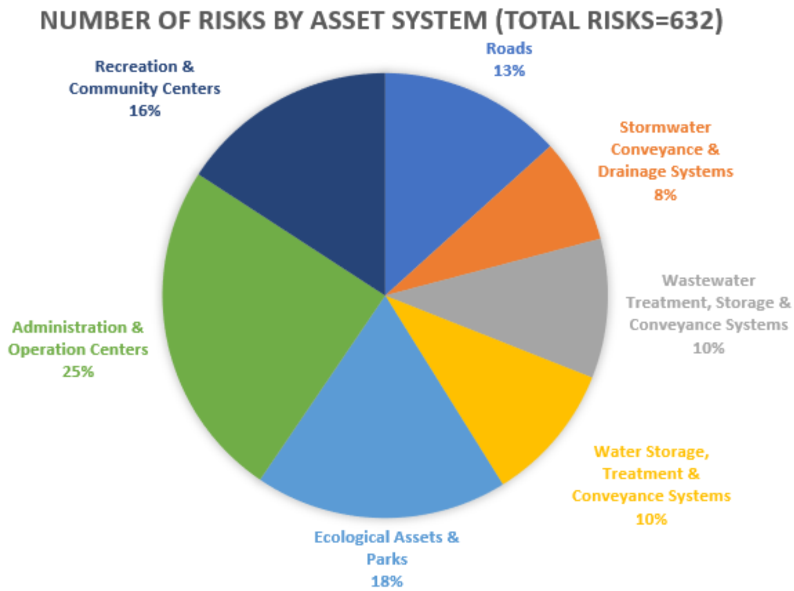
$V = E \times S \times D$

Where: V = Vulnerability; E = Exposure; S = Sensitivity; and D = Adaptive Capacity

The results of the vulnerability assessment determined that four of the seven asset systems were highly vulnerable to climate impacts. Only water storage, treatment and conveyance systems were determined to have a low vulnerability.

Select Asset Group	Roads	Stormwater Conveyance & Drainage Systems	Water Storage, Treatment & Conveyance Systems	Wastewater Treatment, Storage & Conveyance Systems	Ecological Assets & Parks	Administration & Operation Centers	Recreation & Community Centers
Average Age of Asset Group	20-50 years	20-50 years	10-20 years	20-50 years	20-50 years	20-50 years	20-50 years
Average Condition of Asset Group	Fair	Good	Good	Fair	Poor	Poor	Fair
Sensitivity Rating Assessment	3 - High	2 - Medium	1 - Low	3 - High	3 - High	3 - High	3 - High
Adaptive Capacity Rating Assessment	3 - High	2 - Medium	2 - Medium	2 - Medium	2 - Medium	2 - Medium	2 - Medium
Overall Vulnerability Rating	Medium Vulnerability	Medium Vulnerability	Low Vulnerability	High Vulnerability	High Vulnerability	High Vulnerability	High Vulnerability

The second part of the CVRA involved the completion of a multi-hazard climate risk assessment on the Town's assets and infrastructure components. Risks were calculated for selected infrastructure components for each of the seven asset systems which previously assessed for vulnerability. Risks scores were derived for each infrastructure component-climate interaction based on consequence scores and likelihood of occurrence of each climate hazard, under current climate and future climate periods (2030s, 2050's and 2080s).



A total of 632 risks were identified across the seven asset systems over three climate periods. Administration and operations centers, comprised largely of built assets, had the largest number of risks, followed by ecological assets and parks and recreation and community centers. These three asset systems were also identified as being highly vulnerable.

Risks within each asset system ranged from low to high, with no extreme risks identified. The highest risks associated with each climate hazard and asset system are shown in Table E-1 and discussed below. Adaptations measures for identified risks as well as potential barriers to implementation of the adaptations for each asset system are provided in the report.

- Administration and Operations Centers had the largest number of high risks associated with extreme heat, extreme cold affecting the building controls, HVAC and air handling systems. The building control and HVAC systems will struggle to maintain temperature set points under future climate (2050s and 2080s).
    - Extreme heat and cold resulted in high risk had similar impacts for recreation and community centers, affecting the building controls, HVAC and air handling systems.
- The highest risks identified (R=20) was caused by extreme cold impacts on the water storage, treatment and conveyance system and wildfires on the ecological assets and parks.
    - Ice-build-up on the interior walls of water storage tanks can result in tanks collapsing under the additional weight of ice, and extreme cold can also cause water mains to freeze and rupture.
    - Wildfires can destroy trees and other assets in parks – this happened during the wildfires this summer that burned the overflow campground area.
- Intense rainfall resulted in a high risk to the stormwater and drainage conveyance system, which can overload the system resulting in sever flooding in the Town.

Table E-1. Highest Risks by Asset System and Climate Hazard

Risk Rating: Extreme | High | Medium | Low | Special Case

Asset Systems / Climate Hazard	Highest Risk per Asset	Extreme Heat	Higher Average Temperatures	Wildfire	Drought	Intense Rainfall	Riverine Flooding	Heavy Snowfall	Severe Thunderstorms	High Winds	Extreme Cold	Winter Freeze-Thaw	Freezing Rain
Highest Risk per Hazard													
Roads		5				8	8	10	8	12	10	8	10
Stormwater & Drainage Conveyance System						16		10	8		10	8	10
Water Storage, Treatment & Conveyance Systems		10	5	10	15				12	8	20	4	10
Wastewater Treatment, Storage & Conveyance Systems		10				8			8	8	5	4	10
Ecological Assets & Parks		10	5	20	15	8	12	10	4	8	10	8	10
Administration & Operation Centers		15	5	10	15	8		10	8	8	15	8	10
Recreation & Community Centers		15	5	10		8		10	8	8	15	8	10

Climate adaptation is becoming an essential aspect of proactively managing assets and infrastructure that can result in significant avoidance of climate related costs. While the most cost-effective time to implement climate change mitigation and adaptation measures for nearly any building or facility will be at the time of scheduled capital replacements or renewals, with the unpredictable nature of climate change, not proactively upgrading facility components could result in a wide range of unintended financial and non-financial impacts.

This CVRA has identified the potential vulnerabilities and risks to the Town's assets, infrastructure, and the services these assets provide to the community. Specific adaptation measures are provided to reduce the risks and build resilience into these assets systems and components. The following recommendations have been provided to assist the Town or Edson in their ongoing climate resilience and adaptation planning efforts.

1. Incorporate Climate Considerations into Key Levels of Decision-making

- Integrate climate change considerations into financial decision-making processes.
- Consider climate change in the development of business continuity plans.
- Review health and safety (H&S) protocols to include possible work-related impacts from climate change.
- Develop and Build staff capacity and resources to support climate risk in capital and operational planning.

2. Continually Monitor and Improve Climate Projections and Expectations.
    - Review climate projections and vulnerability studies.
    - Continue to monitor the outcomes of disaster and emergency events and integrate actions into operations and maintenance (O&M) plans.
    - Continue to provide funding for wildfire protection, detection, preparedness, and forest fuel management.
3. Assess Climate-Resiliency for Infrastructure
    - Develop a climate risk assessment program for at-risk infrastructure.
    - Review and revise design standards to account for and minimize the impacts of climate change.
    - Investigate Opportunities for infrastructure renewal and capital projects funding.
4. Build and Develop Climate-Based Communication and Collaboration Opportunities
    - Share the results of this Climate Vulnerability and Risk Assessment with internal audiences.
    - Continue to conduct post-disaster event analyses to identify lessons learned.
    - Review and refine existing communication processes as they relate to climate change and extreme weather.
5. Develop an Implementation Plan

Acronyms / Abbreviations

CADC	Climate Adjusted Design Criteria
CRA	Climate Change Physical Risk Assessment
ECCC	Environment and Climate Change Canada
GCM	Global Climate Model
GHG	Greenhouse Gas
GISTM	Global Industry Standards on Tailings Management
HVAC	Heating, Ventilation and Air Conditioning
IDF	Intensity, Duration and Frequency
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
O&M	Operations and Maintenance
NOAA	National Oceanic and Atmospheric Administration
NRCAN	Natural Resources Canada
PCIC	Pacific Climate Impacts Consortium
PIEVC	Public Infrastructure Engineering Vulnerability Committee
PMP	Probable Maximum Precipitation
RCM	Regional Climate Model
RCP	Representative Concentration Pathway
SOP	Standard Operating Procedure

SSP	Shared Socioeconomic Pathway
UNEP	United Nations Environment Programme
WMO	World Meteorological Organization

Glossary

Adaptation	Adjustments in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects or impacts. It refers to changes in processes, practices, and structures to moderate potential damages or to benefit from opportunities associated with climate change. Actions/measures that reduce the negative impacts of climate change, while taking advantage of potential new opportunities.
Adaptive Capacity	The IPCC defines adaptive capacity as the ability of a system to adjust to climate change (including climate variability and extremes) to moderate damages, to take advantage of opportunities, or to cope with the consequences.
Adaptive Management	A structured, iterative process of robust decision-making with the aim of reducing uncertainty over time via system monitoring. It includes the implementation of mitigation and management measures that are responsive to changing conditions, including those related to climate change, and the results of monitoring throughout the tailings facility lifecycle. The approach supports alignment on decisions about the tailings facility with the changing social, environmental and economic context and enhances opportunities to develop resilience to climate change in the short and long term (GISTM, 2020).
Climate	The average, or expected weather and related atmospheric, land, and marine conditions for a particular location. In statistical terms, it is the mean and variability of relevant measures over a period ranging from months to thousands or millions of years. The classical period for averaging these variables is 30 years, as defined by the World Meteorological Organization.
Climate Change	A persistent, long-term change in the state of the climate, measured by changes in the mean state and/or its variability. Climate change may be due to natural internal processes, natural external forcings such as volcanic eruptions and modulations of the solar cycle, or to persistent anthropogenic changes in the composition of the atmosphere or in land use.

Climate Change Resilience	The ability of a system (built, natural, social or economic) to anticipate, withstand, recover, adapt to and transform in response to a climate-related hazard.
Climate Hazard	The potential occurrence of a natural or human-induced physical event or trend, or physical impact that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, and environmental resources. In this report, the term hazard refers to climate-related physical events or trends or their physical impacts.
Climate Impact	The effects on natural and human systems of extreme weather, climate events and climate change. Impacts generally refer to effects on lives, livelihoods, health status, ecosystems, economic, social, and cultural assets, services (including environmental), and infrastructure due to the interaction of climate changes or hazardous climate events occurring within a specific time period and the vulnerability of an exposed society or system. The impacts of climate change on geophysical systems, including floods, droughts, and sea level rise, are a subset of impacts called physical impacts.
Climate Model	A numerical representation of the climate system based on the physical, chemical, and biological properties of its components, their interactions and feedback processes, and accounting for all or some of its known properties.
Climate Projection	An estimate of longer-term future climate.
Confidence	The validity of a result is based on the type, amount, quality, and consistency of evidence (e.g., mechanistic understanding, theory, data, models, expert judgment) and the degree of agreement across multiple lines of evidence. Confidence is expressed qualitatively. Five qualifiers are used to express assessed levels of confidence in findings (very low, low, medium, high, and very high) in IPCC (2013) and in Canada's Changing Climate Report (Bush and Lemmen, 2019).
Consequence Score	A rating (0 to 5) used to define the severity of the consequences of a climate hazard or weather event impacting a particular infrastructure component.

Global Climate Model (GCM)	Complex computer simulation of the climate system usually including interacting simulations of the atmosphere, ocean, ice and land surface. The climate system can be represented by models of varying complexity. Climate models are developed and used at climate research institutions around the world to make projections of future climate, based on future scenarios of greenhouse gas and aerosol forcing.
Infrastructure Component	One of several physical features, processes, procedures and/or human resources that comprise the infrastructure.
Infrastructure Response	The generally anticipated effects arising from the climate and other change parameters interacting with the infrastructure components.
Infrastructure Threshold Value	A value representing an infrastructure specific weather event or climate trend that triggers an undesirable infrastructure response.
Interaction	The interface between weather events and/or climate trends and infrastructure components.
ISO	International Organization for Standardization
Likelihood (in quantifying climate change uncertainty)	The chance of a specific outcome occurring, where this might be estimated probabilistically. The likelihood of a result occurring is based on quantified measures of uncertainty expressed probabilistically (based on statistical analysis of observations or model results, or expert judgment). Likelihood is expressed quantitatively.
Likelihood (in risk analysis)	The chance of an event or an incident happening (i.e., a Climate related hazard), whether defined, measured or determined by qualitative or quantitative means.
Professional Judgment	The application of training, knowledge, experience, and skills gained over a prolonged period of professional practice.
Regional Climate Model (RCM)	Regional climate models (RCMs) provide climate projections on a smaller grid scale than GCMs. They are based on GCMs to initiate the model process then produce parameters on the smaller scale using a process called dynamic downscaling.

Representative Concentration Pathway (RCP)	Scenario of future greenhouse gas concentrations, and other anthropogenic forcings, based on various possible levels of human emissions. Representative Concentration Pathways (RCPs) are identified by a number indicating the change in radiative forcing by the end of the 21st century. RCP 2.6 represents a low emission pathway with a radiative forcing of roughly 2.6 W/m2, RCP 4.5 and RCP 6 represent intermediate emission pathways, and RCP 8.5 represents a pathway with continued growth in greenhouse gas emissions, leading to a radiative forcing of roughly 8.5 W/m2 at the end of the century. The word representative signifies that each RCP provides only one of many possible scenarios that would lead to the specific radiative forcing characteristics. The term pathway emphasizes that not only the long-term concentration levels are of interest, but also the trajectory taken over time to reach that outcome.
Resiliency	Resiliency is the elasticity, or adaptability of buildings to ‘endure’ and maintain operations in changed climate conditions or recover from a climate change related disruption or impact. It requires designers to identify hazards and vulnerabilities local to a given site, before projecting impacts and implementing measures that reduce risk and increase flexibility to adapt.
Risk Assessment	The overall process of risk identification, risk analysis and risk evaluation.
Scenario (forcing scenario, emission scenario)	A plausible representation of the future based on a coherent and internally consistent set of assumptions. A forcing scenario is a possible future evolution of greenhouse gas concentrations and other anthropogenic forcings. An emission scenario describes a possible future evolution of emissions of greenhouse gases, and other climate drivers. They assist in climate change analysis, including climate modelling and the assessment of impacts, impacts, adaptation, and mitigation. The likelihood of any single emissions path described in a scenario is highly uncertain.
Shock Event	An acute natural or human-made event or phenomenon threatening major loss of life, damage to assets and a building or community’s ability to function and provide basic services, particularly for poor or vulnerable populations. Examples include heat waves, extreme storms and storm surge.

Stress Event	An ongoing or cyclical natural or human-made event or phenomenon that renders an organization, asset/infrastructure, or community less able to function and provide basic services. Examples include prolonged droughts, increasing temperatures, and rising sea levels.
Vulnerability	The degree to which a system is susceptible to, or unable to cope with, adverse effects of changing climate, including climate variability and extreme weather.
Weather	The state of the atmosphere at a given time and place, with respect to variables such as temperature, moisture, wind velocity, and barometric pressure.

1 Introduction

Climate change and extreme weather affects not only the immediate area of the hazard, but also has potential to adversely impact the surrounding area. The Town of Edson has recently experienced some of the devastating impacts of climate-change like forest fires, which twice caused the evacuation of the Town's residents and severe flooding during the spring of 2023.

The Town of Edson (the Town) is completing a Climate Vulnerability and Risk Assessment (CVRA) on the Town's corporate engineered and built infrastructure, operations, and natural assets that together support the services provided by the Town.

This report summarizes the findings of the climate vulnerability and risk assessment (CVRA) completed on the Town's assets and infrastructure and provides a basis for developing and planning adaptation measures. The Town of Edson Climate Risk and Resiliency Report should be considered a living document, with regular periodic reviews and updates to maintain and enhance the Towns resilience to a continuously changing climate.

1.1 Project Overview

The Town of Edson is located in west-central Alberta, approximately 192 kilometres west of Edmonton along the Yellowhead Highway (Highway 16). During the 1930's, Edson was a major supply depot for the railroad as it was developed to serve western Canada. It has seen several development booms related to upgrading of the Yellowhead highway in the 1950's, the development of the petroleum industry in the 1960's, the revitalization of the coal industry in the 1970's and the development of the lumber and forestry industries in the 1980's, which remains major employers in the Town to date.

Climate change poses risks due to extreme weather events that can influence the quality of life for Edson residents by impacting infrastructure, impeding economic development and growth, while leading to higher capital and operational costs for the Town. To address the potential impacts from a changing climate, the Town of Edson (the Town) is completing a Climate Vulnerability and Risk Assessment (CVRA) on the Town's corporate engineered and built infrastructure, operations, and natural assets that together support the services provided by the Town.

The intention of the Town in undertaking this assessment is to identify potential climate and community-related vulnerabilities as well as identifying actions to reduce exposure to these vulnerabilities for both the Town's built and natural infrastructure. The assessment is intended to:

- Expand the Town's understanding of its vulnerability to climate change and extreme weather events.
- Determine the assets and corporate operations with the highest risk to climate impacts, and
- To provide recommendations on ways the Town can increase its resiliency under a changing climate.

1.2 Responding to the Impacts of Climate Change

Responding to climate change involves a two-pronged complementary approach between mitigation and adaptation as illustrated in Figure 1. Hazard mitigation reduces loss of life and property damage by minimizing the impact of disasters (FEMA, 2021). In hazard mitigation planning, a community identifies natural disaster/climate hazard risks and vulnerabilities that are common in their area and develops long-term strategies for protecting people and property from similar events. Mitigation plans are key to breaking the cycle of disaster/climate hazard related damage and reconstruction.

Resiliency planning is the ability to adapt to changing conditions and prepare for, survive, and rapidly recover from hazard-based disruptions. Resiliency planning is risk management. Resiliency reduces the impact of the natural environment on buildings, operations, and the community, balancing efficiency with redundancy and adapting to climate change instead of responding to it. It protects the functionality and asset value of the built environment and derived income or public benefits. The benefits of community resilience are many and include:

- Preventing loss of life and injury.

- Reducing property damage to homes and businesses.
- Reducing business interruption and revenue loss.
- Helps lower emergency response and disaster recovery costs.
- Protecting cultural and historical assets.
- Reduces environmental damage.
- High return on Investment – for every $1.00 invested in resiliency it is estimated that 10-times or more can be saved in future damages required to address these risks[1].

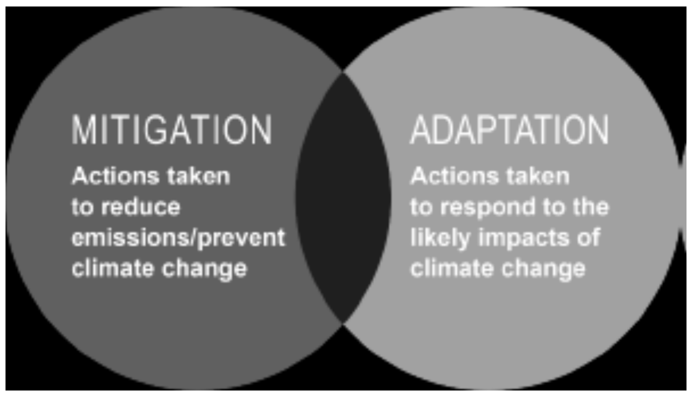


Figure 1: Resilience Components

Hazard mitigation uses planning tools and strategies to reduce or mitigate risks to natural and man-made hazards. **Resiliency planning** links together the environment, social, and economic sectors to holistically improve communities by being adaptable to changing conditions, adapting to the causes of climate change rather than mitigating its effects.

Proactive prevention/ mitigation measures are used to eliminate, reduce, or adapt to risks. These activities include structural mitigation measures (e.g., construction of floodways and dykes) and non-structural mitigation measures (e.g., building codes, land-use planning, and insurance incentives). The return-on-investment for these activities, while dependent on hazard type and location, can generate savings of $10 for every $1 invested in prevention. These activities support opportunities to build more resilient infrastructure while integrating environmental protection and sustainable development concepts[2].

Future climate uncertainty and associated influence on extreme weather events represent significant risks for the Town of Edson. Without action, these threats could impact the quality of life of residents by disrupting the infrastructure necessary to deliver services, impeding economic development, and leading to higher operational and capital costs for the Town of Edson and surrounding communities.

1.3 Purpose of Climate Vulnerability and Risk Assessment

The Town of Edson recognizes that changes in climate, as reflected in long-term trends and in increases in both frequency and intensity of extreme weather events, are expected to cause a greater range of potentially costly and disruptive impacts to the Town's assets and infrastructure systems, services, and operations. The inevitability of these climatic changes has prompted the Town to complete a Climate Vulnerability and Risk Assessment (CVRA) to determine the exposure of their assets and services to the impacts from a changing climate and use the study to prioritize future operational and capital expenditures on their assets and infrastructures to increase their resilience, reduce vulnerability and limit the damage that extreme weather events can cause.

The purpose of this assessment report is to expand the Town's understanding of how the municipal assets, infrastructure and operations are vulnerability to climate change and recommend ways to increase resiliency. The CVRA involves completing a vulnerability and risk screening level assessment on the following Town of Edson asset systems.

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[1] Investing in Resilience, 2019: Center for Climate and Energy Solutions, https://www.c2es.org/wp-content/uploads/2019/11/investing-in-resilience_Brief.pdf
[2] Emergency Management for Canada; Toward a Resilient 2030. https://www.publicsafety.gc.ca/cnt/rsrcs/pblctns/mrgncy-mngmnt-strtgy/mrgncy-mngmnt-strtgy-en.pdf

- Administration and Operation Centers
- Recreation and Community Centers
- Roads
- Ecological Assets and Parks
- Stormwater Conveyance and Drainage Systems
- Water Storage, Treatment and Conveyance Systems
- Wastewater Treatment, Storage and Conveyance Systems

A more detailed risk assessment was completed for the infrastructure assets and components within each asset system. Climate adaptation recommendations were developed based on the outcome of the full climate vulnerability and risk assessment.

2 Methodology and Approach

Stantec's Climate Vulnerability and Risk methodology uses similar risk assessment approaches as those of the Institute for Catastrophic Loss Reduction (ICLR) Public Infrastructure Engineering Vulnerability Committee (PIEVC) Protocol, Infrastructure Canada's Climate Lens General Guidance[3], and aligns with the following international standards:

- ISO 31000:2019 – Risk Management – Principles and Guidelines
- ISO 14090:2019 – Adaptation to climate change — Principles, requirements and guidelines
- ISO 14091:2021 – Adaptation to climate change — Guidelines on vulnerability, impacts and risk assessment.

The CVRA identifies vulnerabilities and risks and assesses how the Town of Edson's infrastructure and operations will respond when exposed to selected climate hazards and extreme weather events, under current and future climate conditions. Selected climate hazards are specific to the location of the facility or building being assessed and can include gradual changes in climate conditions (e.g., gradual warming) and/or extreme climate changes and weather events (e.g., extreme temperature, extreme precipitation, high wind events). To assess the vulnerability and risks of an asset and its components to the effects of climate change, the following steps are undertaken:

- Vulnerability assessment
- Exposure and impacts assessment
- Consequence scoring
- Risk assessment
- Adaptation recommendations

These steps are described in more detail in the following sections.

2.1 Vulnerability Assessment

Climate change vulnerability is generally defined as the susceptibility or propensity of a system or resource to the negative effects of climate change and other stressors, and includes three components: exposure (E), sensitivity (S), and adaptive capacity (D) as shown in Figure 2.

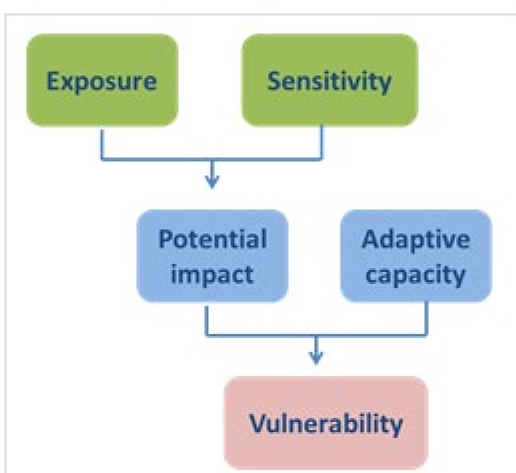

Figure 2: Vulnerability Assessment Flowchart (Glick et al., 2011)

[3] Infrastructure Canada Climate Lens Guidance - https://www.infrastructure.gc.ca/pub/other-autre/cl-occ-eng.html

Vulnerability can be expressed by the following formula.

$$V = E \times S \times D$$

Where: V = Vulnerability; E = Exposure; S = Sensitivity; and D = Adaptive Capacity.

Exposure is the amount and rate of change that a system experiences from the direct (e.g., extreme temperature, precipitation) or indirect (e.g., habitat shifts due to changing vegetation composition) impacts of climate change.

Sensitivity refers to the attributes of the asset or infrastructure that make it more or less reactive to a climate hazard interaction, and the degree to which the asset is likely to be affected by climate change. Sensitivity for the Edson CVRA is based on several factors such as the design of the asset, its age, condition, location, materials of construction, maintenance history and experience of the staff with the asset operations and upkeep. Sensitivity is rated from 1-low to 3-high.

Adaptive Capacity refers to the ability of the facility and City to respond and recover from the climate hazard interactions when they occur. The Town's adaptive capacity is based on Emergency Response and Preparedness plan, experience in dealing with climate hazards impacting assets and services, access to supply chains and resources to support recovery activities. Adaptive capacity is rated from 1-low to 2-medium or 3-high.

High vulnerability is defined as a situation where the exposure to climate risks is high, the sensitivity of the system is high, and the adaptive capacity is low. The interaction between sensitivity and adaptive capacity is presented in Table 1.

Table 1: Vulnerability Matrix

		Sensitivity		
		Low	**Medium**	**High**
Adaptive Capacity	**High**	Low Vulnerability	Low Vulnerability	Medium Vulnerability
	Medium	Low Vulnerability	Medium Vulnerability	High Vulnerability
	Low	Medium Vulnerability	High Vulnerability	High Vulnerability

2.2 Exposure & Impacts Assessment

The exposure and impacts assessment evaluates how current and future climate-related hazards might materialize as impacts to assets, operations, or users at the facility. By evaluating the range of possible impacts, consequences can be assessed, priority risks identified, and appropriate adaptive responses established to reduce risks. This involves identifying the asset systems and components and defining the climate hazards that have occurred or are expected to occur in the Edson area over the next century.

The first of two workshops was completed on March 23, 2023. The workshop focused on assessing the Town's experience and level of awareness about climate change and developing an understanding of the impacts climate change and extreme weather event have and can have on the Towns asset systems, infrastructure, and services. The exposure and resulting impacts for specific asset systems and components were discussed and a climate hazard-infrastructure impacts spreadsheet developed. A copy of the impacts developed for the CVRA are included in Appendix A for reference.

The Town' assets and infrastructure were divided into the following seven asset systems for the purpose of the vulnerability and risks assessments.

- Administration and Operation Centers
- Recreation and Community Centers
- Roads
- Ecological Assets and Parks

- Stormwater Conveyance and Drainage Systems
- Water Storage, Treatment and Conveyance Systems
- Wastewater Treatment, Storage and Conveyance Systems

2.3 Risk Assessment

As part of the CVRA, a more detailed multi-hazard climate risk assessment was completed on the Town of Edson asset systems and infrastructure components. The risk assessment starts by screening each individual infrastructure components in each asset system to determine if the climate hazard may affect the asset/component in any way. If no climate hazard / infrastructure element interaction is deemed to occur, the relationship is no longer considered. If an interaction is established, then the assessment moves forward to likelihood (probability) and consequence (severity) scoring, and ultimately calculating the risk associated with each climate hazard / infrastructure element interaction. The risk assessment process is illustrated in Figure 3.

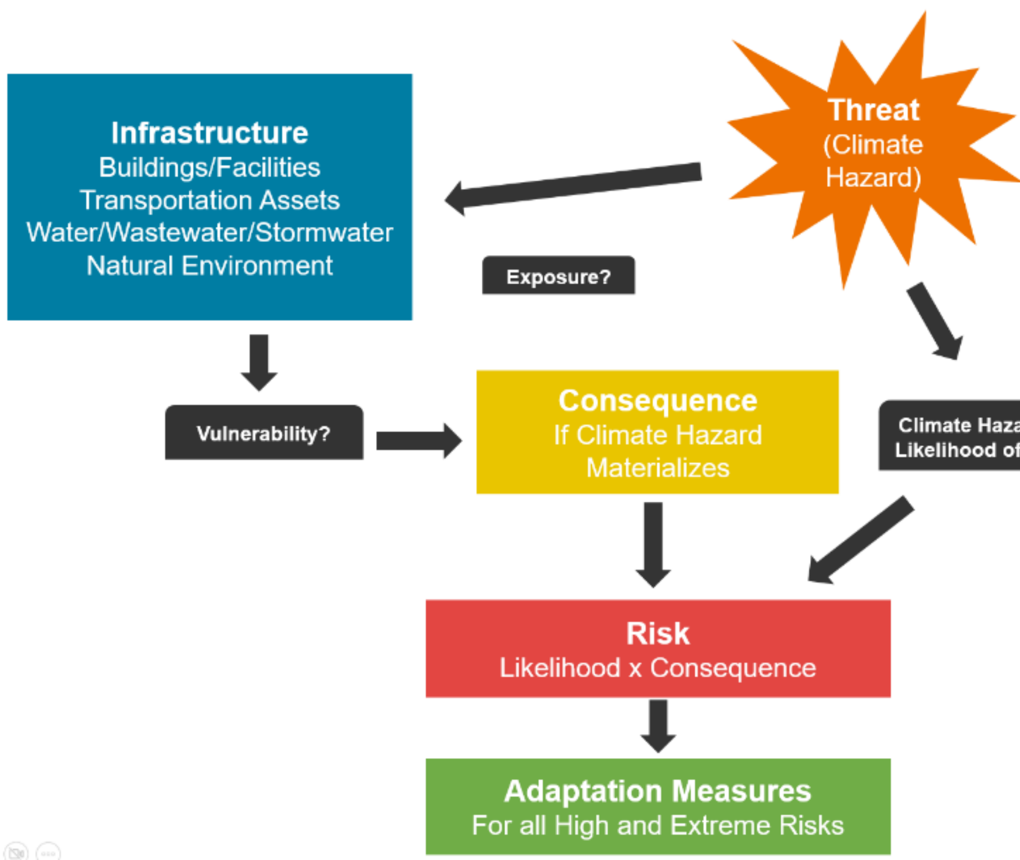

Figure 3: CVRA Risk Assessment Process

A risk rating is developed for each climate hazard / infrastructure component interaction by assigning each interaction a consequence rating and multiplying the consequence score by the likelihood of the climate hazard exceeding the defined climate threshold. The risk rating is defined as the product of two ratings as illustrated in the following equation:

Risk = Likelihood of Climate Hazard Occurring x Consequence of Impact of Occurrence

Likelihood represents the estimated occurrence of a climate hazard above an identified threshold which is expected to negatively impact the asset or infrastructure component. Likelihood scores range from 1 (Very Rare) to 5 (Almost Certain)

Consequence of Impact Rating is a measure of the expected impact/damage/loss of service to the infrastructure component should the climate event occur. The impacts of the climate exposure on the Town's assets and infrastructure components were assessed under five consequence categories. Each severity of each climate hazard – infrastructure interaction was assessed against each consequence category.

- **Structural Integrity/Condition** - Interaction with climate hazards or extreme weather events can result in physical damage to the infrastructure requiring repairs or replacement and/or result in a loss or reduction of services.
- **Availability / Accessibility** - Interaction with climate hazards or extreme weather events can result in a change in service delivery of the infrastructure system or components below the intended level of service.
- **Sustainability** - A measure of the impacts of climate hazards on energy use, GHG generation, and water use or efficiency.
- **Recovery/Resilience** - A measure of the length of time required for the facility to return to basic functionality.
- **Health and Safety** - A measure of medical, health, or safety impacts to users (occupants, staff, residents) of the Town's assets and infrastructure.

Consequence scores range from 1 (Very Low) to 5 (Very High). Using Consequence scores of 1 to 5 and Likelihood ratings of 1 to 5 produces a 5x5 risk matrix with risk ratings ranging from 1 to 25 as shown in Table 2. Risks are rated from "Low" (risk ratings of 1 to 6) to "Extreme" (risk ratings = 25). Generalized recommended risk adaptation and mitigation responses are provided in Table 3.

Table 2: Risk Ratings – Evaluation Matrix

Consequence							
	5	Very High	5	10	15	20	25
	4	High	4	8	12	16	20
	3	Moderate	3	6	9	12	15
	2	Low	2	4	6	8	10
	1	Very Low	1	2	3	4	5
			1	**2**	**3**	**4**	**5**
			Very Unlikely	**Possible**	**Occasional**	**Frequent**	**Almost Certain**
			Likelihood				

Table 3: Risk Classifications and Adaptation/Mitigation Responses

	Risk Rating	Adaptation/Resilience Response
Extreme	**25**	Risks require Immediate controls
High	**15 - 20**	Risks require high priority control measures.
Moderate	**8 - 12**	Some controls required to reduce risks to lower levels
Low	**1 - 6**	Controls not likely, monitor risks
Special Case	**5**	Monitor Risks: Further analysis may be required
	5* (L=1 and C=5)	Shock Event - Very Rare Likelihood but Very High Consequence
	5 (L=5 and C=1)	Stress Event - Very Low consequence but Almost Certain Likelihood

Adaptation and mitigation recommendations were developed for all moderate, high and extreme risks identified. Risks with a consequence score of 5 have the potential to produce catastrophic damage to infrastructure components, so are a significant concern despite the low likelihood or frequency of occurrence. Risks with rating of 5 are treated as special cases and are classified as either shock or stress events.

- **Shock events** have a very low likelihood of occurrence (L=1) but have a very high consequence of impact (C=5). Should the event occur, the damage to the infrastructure may be extreme. A tornado is a good example of a stress-type of event.
- **Stress events** have a very high likelihood of occurrence (L=5) but have a very low consequence of impact (C=1). However, the repetition of stress events can have a cumulative effect over time leading to increased risk of damage to or failure or loss of services associated with the infrastructure component. Freeze-thaw events are a typical stress event.

2.3.1 ASSET SYSTEMS AND INFRASTRUCTURE COMPONENTS

To support the completion of the risk portion of the assessment, each asset system was broken down into components to better define how the climate hazards are affecting the infrastructure. The asset systems and associated components using in the risk assessment are shown in Table 4.

Table 4: Asset System Categories and Components Assessed in the CVRA

Asset System	Infrastructure Component
Roads	Paved
	Gravel
	Drainage Systems
	Lights & Signage
Stormwater and Drainage Conveyance Systems	Catch Basins & Pipes
	Culverts
	Oil Grit Separators
	Overland Systems (raingardens, bioswales, etc.).
	Ditches
Water Storage, Treatment & Conveyance Systems	Wells/Treatment Facility
	Reservoirs
	Distribution Pipes
	Flow Control Structures & Monitors
	Electrical & Communication Systems
	Utilities & Backup Power
	Raw Water Source
Wastewater Treatment, Storage & Conveyance Systems	Sanitary Sewer / Combined Sewer Gravity Mains
	Sanitary Sewer / Combined Sewer Designated Force Mains
	Outfalls
	Wastewater Treatment Plant
	Flow Control Structures & Monitors
	Electrical & Communication Systems
	Utilities & Backup Power
Ecological Assets & Parks	Sports Fields
	Play Areas (playgrounds)
	Other (skate park, water parks, courts, etc.)
	Recreational & Non-Recreational Lakes
	Beaches
	Campground
Administration & Operation Centers	Roof & Associated Drainage Systems
	Foundation & Structural Elements
	Building Envelope & Insulation
	Windows & Doors
	Building Controls, HVAC & Air Circulation Systems
	Utilities & Backup Power

Asset System	Infrastructure Component
	Hardscape & Associated Drainage Systems
	Trees & Vegetation
	Building Occupants & Public Users
Recreation & Community Centers	Roof & Associated Drainage Systems
	Foundation & Structural Elements
	Building Envelope & Insulation
	Windows & Doors
	Building Controls, HVAC & Air Circulation Systems
	Pools & Associated Mechanical Systems
	Electrical, Communication & Emergency Systems
	Utilities & Backup Power

2.4 Adaptation Development

Recommended resilience and adaptation measures were developed by the Stantec Team for all medium, high and extreme risks. The adaptations were presented during Workshop #2, which allowed an opportunity for the Project Team to validate, review and refine the findings of the CVRA, and to brainstorm additional adaptation response options, and to determine any barriers to implementing the recommended adaptation measures. The adaptations developed focused on reducing the climate vulnerabilities and risks to the Town's infrastructure and assets, and on documenting ways the Town can build resilience to the impacts of future climate change and extreme weather events.

2.5 Climate Hazard Identification

To understand anticipated future climate conditions in the area, current and historical data from regional weather stations was analyzed in relation to projected global climate trends. These projections were then used to assess potential extreme weather events and general long-term patterns and trends that could be expected to be experienced in the Town of Edson. A full climate profile for the Edson area is included in Appendix B for reference. The following is a summary of some of the key findings from the climate profile report.

2.5.1 HISTORICAL CLIMATE

A climate profile was developed for the Edson area to assess the climate risks to the Town. The climate profile for the area required a review of available historical observed weather data and climate projection data for the area. As shown in Figure 4, five Environment and Climate Change Canada (ECCC) weather stations were identified with records covering recent historical climate for the area. The Edson A (Station ID: 3062244) and Edson Climate (Station ID: 3062246) weather stations were used as the primary data sources to establish the baseline climate for the area (1981-2010 and 1991-2020).

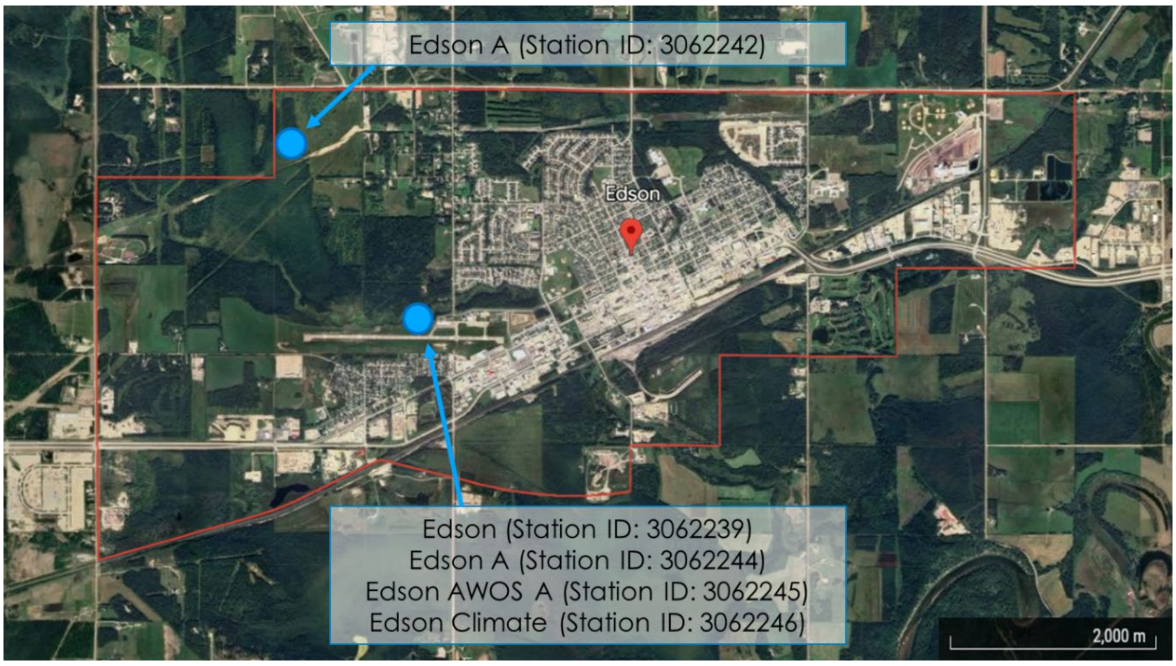

Figure 4: Weather Monitoring Stations in Edson (Modified Figure from Google Earth)

2.5.2 CLIMATE MODEL DATA

Future climate projections use internationally recognized greenhouse gas (GHG) emissions scenarios published by the Intergovernmental Panel on Climate Change (Intergovernmental Panel on Climate Change, n.d.) The Intergovernmental Panel on Climate Change (IPCC) is the international body for assessing the science related to climate change. The IPCC was set up in 1988 by the World Meteorological Organization (WMO) and United Nations Environment Program (UNEP) to provide policymakers with regular assessments of the scientific basis of climate change, its impacts and future risks, and options for adaptation and mitigation. IPCC assessments provide a scientific basis for governments at all levels to develop climate related policies, and they underlie negotiations at the UN Climate Conference – the United Nations Framework Convention on Climate Change (UNFCCC). The assessments are policy-relevant but not policy-prescriptive. They may present projections of future climate change, the risks posed, and the implications of response options, but they do not tell policymakers what actions to take.

Climate projections are descriptions of plausible future climate and are most often generated by Global Climate Models (GCMs). There are nearly 40 GCMs that have contributed to the Fifth Coupled Model Intercomparison Project (CMIP5) (Taylor); which forms the basis of IPCC Fifth Assessment Report (Climate Change 2013, 2013). The IPCC recommended best practices advice using the mean of several GCMs instead of relying only on one or two GCMs to give a more reliable estimate of future climate.

A large source of uncertainty in all future climate projections is based in the ultimately unknown future trajectory of global GHG emissions as well as the international progress towards meeting GHG emissions targets. There are four Representative Concentration Pathways (RCP) scenarios adopted by the IPCC for its Fifth Assessment Report (IPCC, 2013) that are based on various future greenhouse gas concentration scenarios (van Vuuren et al., 2011). The RCPs range from low emissions (RCP2.6) to moderate emissions (RCP4.5 and RCP6.0) to high emissions (RCP8.5) trajectories (See Figure 5). Of the four RCPs, current global greenhouse gas emissions are closer to following the RCP 8.5 trajectory (Smith, (2018))..

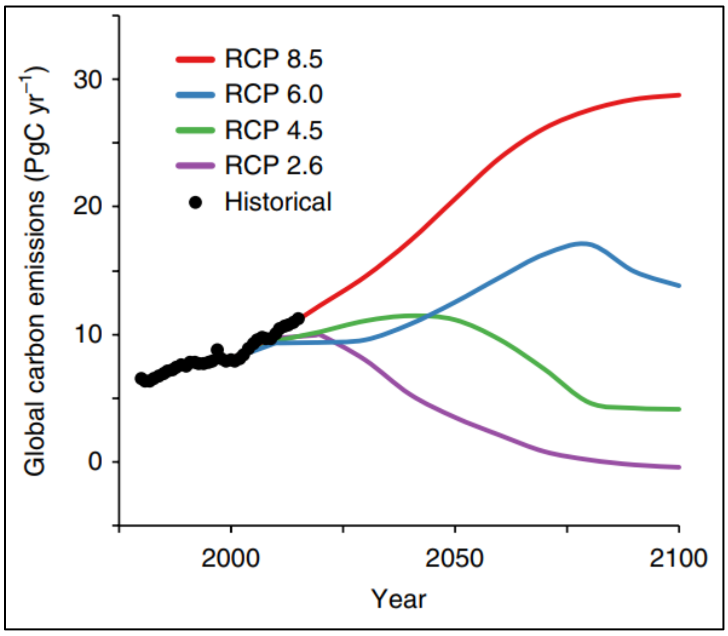

Figure 5: **Historical and Projected CO2 Emissions Trajectories for Four RCP Scenarios[4].**

2.5.3 TIMESCALE FOR ASSESSMENT

To cover the climate risks associated with the expected service life of the Town's assets and infrastructure, the following time horizons have been selected for the Climate Risk Assessment (See Table 2).

- Historical data for the time periods from 1981-2010 and 1991-2020 were selected to determine the current climate baseline conditions for the Edson area.
- Short term projections include the period 2011-2040. Referred as the 2030s, short term projections help inform climate risks during the short-term operating and planned renewal phases of the Town's assets.
- Mid-century projections include the period from 2041-2070. Referred to as the 2050s, they help inform an understanding of the climate trends and emergent and potentially increasing urgency for adaptation and risk mitigation measures during the remaining service life of many of the Town's assets.
- End-of-century projections (2071-2100) referred to as the 2080s, allow for longer term forward planning activities related to emergent risks and the urgency of design adaptation and risk mitigation needed to address the longer-term impacts of climate change.

2.5.4 GENERAL CLIMATE TRENDS FOR THE EDSON AREA

A summary of climate trends and projections for the Edson area is presented below. Detailed historical climate data and future climate projections (including charts and graphs displaying the data) for the area are presented in the climate profile attached as Appendix B.

- The area has experienced (and is projected to continue experiencing) temperature increases for annual mean daily temperature, annual mean daily minimum temperature, and annual maximum daily temperature. This trend applies to all seasons. ***By the 2080s, the average annual mean daily temperature is projected to increase by 5.1°C under RCP8.5.***
- The number of extreme heat temperature events is projected to increase. During the 1981 to 2020 period, no days with temperatures greater than 35°C were recorded. During the June 2021 heat dome event, the Edson Climate weather station recorded daily maximum temperatures of 36.2°C, 38.6°C, and 38.8°C on June 28-30, respectively. ***By the 2080s, the number of days over 35°C is projected to increase to 4.4 days/year under RCP8.5.*** This change is also expected to increase the

[4] Source: Figure from Smith and Meyers 2018

number of cooling degree days (based on an 18°C threshold), which translates into an increase in cooling loads on building HVAC systems.

- The number of extreme cold temperature events is projected to decrease. ***Days with temperatures below -30°C are expected to decline from 8.7 days per year (1981-2010) to 0.1 days/year by 2080 under RCP8.5.*** This translates to an expected decline in the number of heating degree days (based on an 18°C threshold), which will result in a decrease in heating needs in the area.
- ***Total annual precipitation in the area is projected to increase by 9.9% under RCP8.5 for the 2080s from the 1981-2010 baseline.*** Seasonal precipitation (winter, spring and fall) is projected to increase in the area with the largest percentage changes in spring (+26.7% in the 2080s relative to 1981-2010), while the summer precipitation is projected to remain constant or decrease slightly (-1.3% in the 2080s relative to 1981-2010) under future climate.
- ***Short duration high intensity precipitation events are projected to become 9.2% to 41.2% more intense under RCP8.5 for all design storms ranging from 5 minute to 24-hour duration and 2 to 100-year return frequency,*** based on historic and projected Intensity-Duration-Frequency (IDF) curves. This translates to increased overland flooding risks due to the overwhelming of stormwater and drainage systems.
- Despite the projected overall decrease in the annual number of freeze-thaw cycles under the effects of climate change, ***the number of freeze-thaw cycles during the winter (December-January-February) is projected to increase***. With warmer winter conditions projected under climate change, temperature fluctuations around 0°C are projected to become more common during the winter months.
- The effects of climate change with respect to wind are not as well understood as other variables such as temperature. ***The percentage increases in future daily wind gust events of ≥90 km/h from the current baseline condition in central Alberta could be 60% (Cheng et al., 2014).***
- Under climate change projections, research has shown that warming temperatures in a future climate may influence the timing, duration, and magnitude of freezing rain events. Under a +3°C global warming scenario (roughly corresponding with RCP8.5***), the average annual number of hours of freezing rain is projected to increase by up to 10 hours per year (McCray et al., 2022) and the 1-in-20-year ice thickness is projected to increase up to 40 to 60% (Cannon et al., 2020).***
- Historical annual total snowfall shows a decreasing trend in the area. Under climate change scenarios, ***warming temperatures are expected to diminish the total annual snowfall, however, large snowfall events will remain possible due to cold air outbreaks and storm tracks***.
- Using the Canadian Wildland Fire Information System (NRCan, 2017), at least 39 separate large (< 200 ha) wildfires were observed within a 100 km radius of Edson during the 1981-2020 period. Due to the predicted warmer temperatures, change in precipitation and intensification of drought events, ***fire occurrences are expected to increase by approximately 10 to 25% by 2080 in the Edson area*** (Wotton et al., 2010).
- Severe thunderstorms are a frequent occurrence and are often associated with high intensity but short duration impacts, which may include heavy rainfall, high winds, lightning, hail, and/or tornadoes. ***An increase in severe thunderstorm potential (number of days with favourable conditions for the development of a severe thunderstorm) is projected under a warming climate*** (Diffenbaugh et al., 2013).

2.5.5 CLIMATE HAZARD LIKELIHOODS

The likelihood of occurrence rating of each climate hazard (Acute / Chronic) is based on the expectation a climate event will exceed a defined threshold above which the event is expected to result in damage or interruption of service provided by the infrastructure component. The likelihood for the climate hazard is defined as the expected recurrence of a climate event as described in Table 5 and Table 6 for acute and chronic hazards, respectively. As shown in Table 6, the “middle-baseline” approach is used to translate chronic hazard frequency/intensity to a likelihood score, based on the relative changes compared to the baseline period.

Table 5: Acute Climate Hazards Rating Table

Score	Qualitative Descriptor	Descriptor	Occurrence
1	Very Low	Not likely to occur within period	**> 1:50 year**
2	Low	Likely to occur at least once between 30-50 years	**1:30-50 year**
3	Moderate	Likely to occur at least once every 10 to 30 years	**1:10-30 year**
4	High	Likely to occur at least once per decade	**1:1-10 year**
5	Very High	Likely to occur once or more annually	**>1/year**

Table 6: Chronic Climate Hazards Rating Table

Score	Change in Event Frequency/Intensity Compared to Baseline Climate	Descriptor
1	50-100% reduction compared to baseline	Likely to occur much less frequently than baseline climate
2	10-50% reduction compared to baseline	Likely to occur slightly less frequently than baseline climate
3	Within +/-10% compared to baseline	Likely to occur about as frequently as in the baseline climate
4	10-50% increase compared to baseline	Likely to occur slightly more frequently than baseline climate
5	50-100% increase compared to baseline	Likely to occur much more frequently than baseline climate

The likelihood of occurrence for selected climate hazards was established based on the historical climate conditions and future climate projections. The likelihood scores for each climate hazard and time horizon used in the CVRA are presented in Table 7. The projected trend in frequency of occurrence for each climate hazard (increasing, decreasing, or steady) from current climate to the 2080s is also provided for reference. It should be noted the trend (increasing, decreasing, constant) can change while the likelihood score may not. For example, a climate hazard may have a likelihood score of 4 for all three-time horizons but with an increasing frequency of occurrence from 1-in-8 years in the baseline climate to 1-in-5 years in the 2050s to 1-in-2 years in the 2080s.

Table 7: Current and Future Likelihood Scores for Selected Climate Hazards

Climate Parameter	Climate Hazard	Threshold	Likelihood Score			Trend
			Baseline Climate (1981-2010)	2050s (2041-2070)	2080s (2071-2100)	
Temperature	Annual mean temperature (gradual warming)	Baseline average annual mean temperature	3	4	5	Increasing
	Extreme heat	Days with T_{max} ≥ 35°C	4	5	5	Increasing
	Heat wave	Humidex > 40 for Two or More Days	5	5	5	Increasing
	Extreme cold	Days with T_{min} ≤ -28°C	5	4	1	Decreasing
	Temperature swing (proxy for HDD and CDD)	HDD ≥ 4 and CDD ≥ 4 in Two Consecutive Days in April, May, September, October, and November	4	4	4	Increasing
	Flash freeze	Rapid temperature change, +3°C to -12°C or more within 24 hours	5	5	4	Decreasing
	Freeze-thaw cycles	Occurrence of 30 freeze-thaw cycles per year	5	5	5	Decreasing
Precipitation	Extreme rainfall - short duration high intensity	45 mm in 1 hour	2	3	4	Increasing
	Extreme rainfall - long duration	100 mm in 24 hours	2	3	3	Increasing
	Heavy snow	15 cm in 12 hours	5	5	5	Stable
	Freezing rain	10-15 mm ice accumulation in 24 hours	4	4	4	Increasing
	Winter rain (proxy for rain-on-snow events)	30 mm in 24 hr rainfall event in January-March	4	4	4	Increasing
High Winds	Wind gusts	Gusts ≥ 90 kph	4	4	4	Increasing

Note: The trend in frequency of occurrence can change while the likelihood score remains constant. For example, a climate hazard may have a likelihood score of 4 for all three-time horizons but with an increasing frequency of occurrence from 1-in-8 years in the baseline climate to 1-in-5 years in the 2050s to 1-in-2 years in the 2080s.

2.6 Assumptions and Limitations

The climate profile for the Project was completed using the best information available to the assessment team at the time of the study. The climate profile presents data and discussions for the current climate (1981-2010 and 1991-2020) and future climate for the 2020s (2011-2040), 2050s (2041-2070) and 2080s (2071-2100). The climate data and trends (current and future projections) used in the climate profile were obtained through various sources. Cross-verification between climate information sources was conducted where possible to identify potential discrepancies between the data sources used.

Historical climate data and trends are based on observational data from Environment and Climate Change Canada (ECCC) weather stations. Data availability of ECCC weather stations is considered in the analysis. Extreme weather events, such as convective heavy rainfall, are often very localized, so it is possible the weather stations utilized in this analysis may not have captured or provide representative measurement of the intensity of some of these events. This uncertainty is considered during the Climate Risk Assessment analysis. The ECCC weather station records were also supplemented with gridded NRCANmet data as necessary. Although observational data from a weather station is preferable, the NRCANmet data is interpolated from quality-controlled but unadjusted station data from the National Climate Data Archive of Environment and Climate Change Canada, which is widely used by industry and researchers (Hutchinson et al., 2009).

Future climate projections used in this study are based on the Fifth Coupled Model Intercomparison Project (CMIP5) climate projections data. The Pacific Climate Impacts Consortium (PCIC) has taken a subset of 27 of the CMIP5 models and produced reliable, high-resolution (~10 km) downscaled climate projections for Canada, referred to as Canadian Downscaled Climate Scenarios – Univariate (CMIP5) or CanDCS-U5 for short (Cannon, 2015; Cannon et al., 2015). The CanDCS-U5 projections, for the RCP8.5 emissions scenario, provide the climate projections utilized in this study. All climate models have inherent shortcomings in fully and accurately representing the real climate system. Therefore, it is not recommended to rely only on one or two GCMs to estimate future climate. Instead, an average of several GCMs (a multi-model mean) tends to give a more reliable estimate of future climate (IPCC, 2013; 2021). The use of ensembles and multi-model means is common in climate science and is strongly encouraged as “best practice” (IPCC, 2013; 2021). Using ensembles and multi-model means provide insight into uncertainties in the climate model projections.

3 CVRA Results

3.1 Vulnerability Assessment Results

For the purposes of the vulnerability assessment, seven asset systems were chosen which reflect the infrastructure and components essential to the day-to-day operation of the Town. For each of the seven systems, specific asset infrastructure components were defined which have been included in the more detailed risk assessment potion of the CVRA (See Section 4).

The vulnerability of each of the asset systems was determined by assessing several factors that can impacts an asset system ability to respond to a climate impact. The ratings of the following criteria combine to determine the overall vulnerability of the asset. Information used in the vulnerability assessment was based on documents provided by the Town (i.e., Asset Management Plan) and information collected during workshops.

Average age of the asset: Each asset system is comprised of several components, with the age of each component considered in determining the average age for the asset group. Ages were classified into four age grouping, <10 years, 10-20 years, 20-50 years and > 50 years. Newer assets are generally less vulnerable than old ones.

Condition of Asset Group: The condition of the assets was largely based on information from the Town's Asset Management Plan (2018). Scoring was determined using the Canadian Infrastructure Report card system as shown in Table 8.

Table 5 Canadian Infrastructure Report Card - Rating Scale for Asset Condition

Condition Rating	Description	Criteria
Very Good	Fit for the future	Well maintained, good condition, new or recently rehabilitated
Good	Adequate for now	Acceptable, generally approaching mid-stage of expected service life
Fair	Requires attention	Signs of deterioration, some elements exhibit significant deficiencies
Poor	Increasing potential of affecting service	Approaching end of service life, condition below standard, large portion of system exhibits significant deterioration
Very Poor	Unfit for sustained service	Near or beyond expected service life, widespread signs of advanced deterioration, some assets may be unusable

Table 8: Condition Rating Table

Sensitivity Rating was determined by considering the condition of the asset and the age of the asset as shown in Table 9. Sensitivity is classified as low, medium, or high, where low sensitivity means the asset group is less responsive to climate hazards. The sensitivity of an asset is based on several factors such as the asset design, age, materials of construction, maintenance, system complexity and previous exposure to climate impacts.

		Asset Age			
		<10	10-20 years	20-50 years	>50 years
Asset Condition	A	1 - Low	1 - Low	2 - Medium	3 - High
	B	1 - Low	1 - Low	2 - Medium	3 - High
	C	2 - Medium	2 - Medium	3 - High	3 - High
	D	3 - High	3 - High	3 - High	3 - High
	F	3 - High	3 - High	3 - High	3 - High

Table 9: Sensitivity Rating Matrix

Adaptive Capacity, as discussed in Section 2.1and shown in Table 1, refers to the ability of the asset system to respond and recover from climate hazard interactions. Adaptive capacity is rated as low medium, or high, where a low adaptive capacity means a low ability to respond and recover from a climate hazard interaction. Adaptive capacity can be influenced by emergency response/emergency preparedness plans, experience of the staff/staff training in dealing with the impacts of climate hazards, continuity planning, and access to multiple supply chains to support recovery efforts.

The results of the Vulnerability Assessment are shown in Table 10. The results were presented during Workshop #2 for review and confirmation by the Town.

Four of the seven asset systems were found to have a high vulnerability to climate impacts. These assets tended to be older and in fair to poor condition, with a high sensitivity and medium adaptive capacity rating. The Town's Water Treatment, Storage and Conveyance Systems have a low vulnerability, largely due to a lower average age and low sensitivity to climate impacts. Roads and Stormwater Conveyance and Drainage systems both have a vulnerability rating of medium.

Table 10: Vulnerability Assessment Results

Select Asset Group	Roads	Stormwater Conveyance & Drainage Systems	Water Storage, Treatment & Conveyance Systems	Wastewater Treatment, Storage & Conveyance Systems	Ecological Assets & Parks	Administration & Operation Centers	Recreation & Community Centers
Average Age of Asset Group	20-50 years	20-50 years	10-20 years	20-50 years	20-50 years	20-50 years	20-50 years
Average Condition of Asset Group	Fair	Good	Good	Fair	Poor	Poor	Fair
Sensitivity Rating Assessment	3 - High	2 - Medium	1 - Low	3 - High	3 - High	3 - High	3 - High
Adaptive Capacity Rating Assessment	3 - High	2 - Medium	2 - Medium	2 - Medium	2 - Medium	2 - Medium	2 - Medium
Overall Vulnerability Rating	Medium Vulnerability	Medium Vulnerability	Low Vulnerability	High Vulnerability	High Vulnerability	High Vulnerability	High Vulnerability

3.2 Multi-Hazard Risk Assessment Results

Risks were derived for each infrastructure component-climate interaction based on consequence scores and likelihood of occurrence scores. Risks scores were calculated for the infrastructure components for each of the seven asset systems which were previously assessed for Vulnerability. A total of 632 risks were identified across the seven asset systems as shown in Figure 6. Administration and operations centers, comprised largely of built assets, had the largest number of risks, followed by ecological assets and parks, and recreation and community centers.

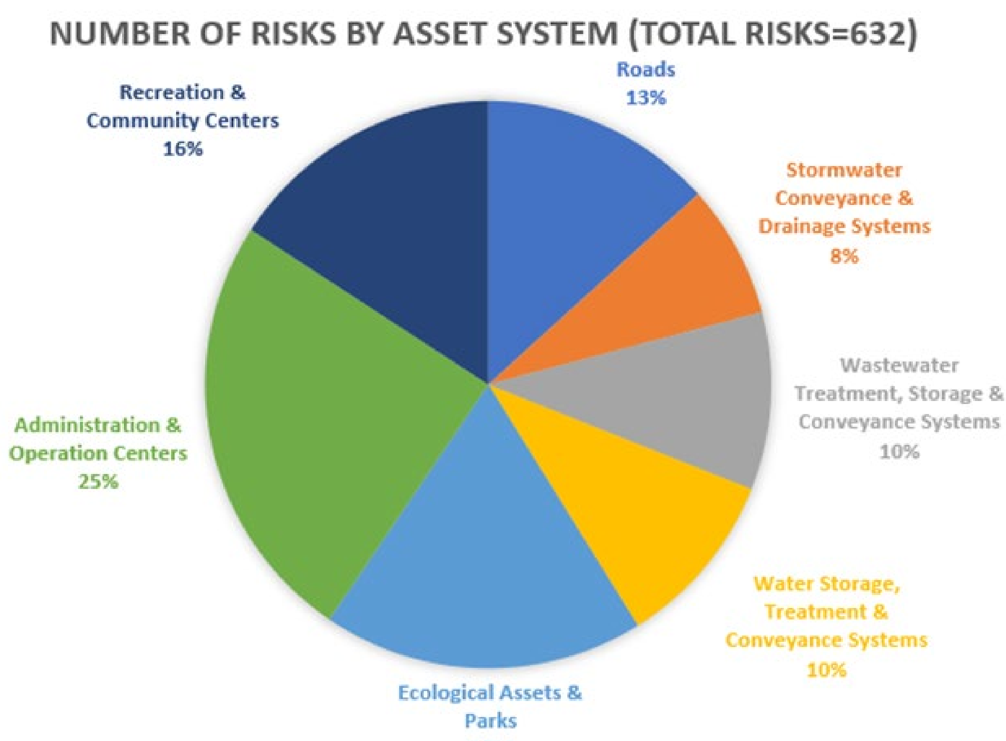

Figure 6: Number of Risks by Asset System

Risks within each asset system ranged from low to high, with no extreme risks identified. The highest risks associated with each climate hazard and asset system are shown in Table 11 and discussed below.

- Administration and Operations Centers had the largest number of high risks associated with extreme heat, extreme cold affecting the building controls, HVAC and air handling systems. The building control and HVAC will struggle to maintain temperature set points under future climate (2050s and 2080s), with a lower risk for extreme cold in the 2080s.

- Extreme heat and cold resulted had similar high risks impacts for recreation and community centers, affecting the building controls, HVAC and air handling systems.
- The highest risks identified (R=20) was caused by extreme cold impacts on the water storage, treatment and conveyance system and wildfires on the ecological assets and parks.
  - Ice-build-up on the interior walls of storage tanks can result in tanks collapsing under the additional weight of ice, and extreme cold can also cause water mains to freeze and rupture.
  - Wildfire can destroy trees and other assets in parks – this happened during the wildfires this summer that burned the overflow campground area.
- Intense rainfall resulted in a high risk to the stormwater and drainage conveyance system, which can overload the system resulting in sever flooding in the Town.

Table 11: Highest **Risks by Asset System and Climate Hazard**

Risk Rating: Extreme | High | Medium | Low | Special Case

Asset Systems / Climate Hazard	Highest Risk per Asset	Extreme Heat	Higher Average Temperatures	Wildfire	Drought	Intense Rainfall	Riverine Flooding	Heavy Snowfall	Severe Thunderstorms	High Winds	Extreme Cold	Winter Freeze-Thaw	Freezing Rain
Highest Risk per Hazard													
Roads		5				8	8	10	8	12	10	8	10
Stormwater & Drainage Conveyance System						16		10	8		10	8	10
Water Storage, Treatment & Conveyance Systems		10	5	10	15				12	8	20	4	10
Wastewater Treatment, Storage & Conveyance Systems		10				8			8	8	5	4	10
Ecological Assets & Parks		10	5	20	15	8	12	10	4	8	10	8	10
Administration & Operation Centers		15	5	10	15	8		10	8	8	15	8	10
Recreation & Community Centers		15	5	10		8		10	8	8	15	8	10

The risk for the infrastructure components in each asset system are further discussed in the following sections.

3.2.1 ROADS SYSTEM

Medium Vulnerability

The roads systems were assessed across four major asset groups: paved roads, gravel roads, drainage systems and lights and signage (Figure 12). A total of 84 risks were identified – 55% high risks, 42% low risk and 3% special case (stress events – very high likelihood and very low severity). No high or extreme risks were identified.

The highest risks (R=12) were related to wind impacts on the condition of lights and signage. High (R=10) risks were generally associated with condition/accessibility and safety concerns for paved and gravel roads associated with heavy snowfall and freezing rain. Extreme cold also posed a high safety risk (R=10) to paved and gravel roads, with a slightly lower risks in the 2080s due to a warming climate. Intense rainfall and riverine flooding pose moderate to high risks to paved and gravel roads and drainage systems, with risks lower in the 2020s peaking in the 2050s and 2080s.

RECOMMENDED ADAPTATIONS:

- Apply dust suppressant to gravel roads on regular basis to minimize dust during high wind events.
- Maintain and clean ditches to improve drainage and reduce the occurrence of frost heaving and pothole development.
- Crown road surfaces to allow proper drainage of road surfaces, shoulders and drainage structures (culverts, storm drains, etc.).
- Develop a policy to repair and seal cracks and holes in asphalt surfaces early, when first detected. Speed up asset inspection cycles for transportation assets deemed to be in poor or critical condition or are at a significant risk to the effects of climate change.
- Grade gravel roads to maintain adequate surface cover to prevent damage to road subgrade.
- Create Flexible Transportation Networks that include low-cost, low-emission travel options such as active transportation and transit options that minimize reliance on vulnerable transportation networks and create multiple travel options in the event of a disruption. Consider possible synergies between and co-location of transportation networks with infrastructure designed to address resilience priorities such as storm water management and flooding.
- Keep abreast of latest developments in resilient asphalt and modify procurement specifications accordingly.
- Use flexible poles for signage, to reduce structural damage in high winds.

BARRIERS TO IMPLEMENTATION:

- Limited financial resources to replace and repair roads, leads to chronic repair cycles. Continuously seek new sources of funding to support ongoing infrastructure repairs and renewals.
- Limited manpower to maintain the roadways in a good state of repair.

3.2.2 STORMWATER & DRAINAGE CONVEYANCE SYSTEM

Medium Vulnerability

The stormwater and drainage conveyance systems were assessed across five major asset groups: catch basins and pipes, culverts, oil and grit separators, overland systems (rain gardens, bioswales, etc.) and ditches (Figure 13). A total of 48 risks were identified – 4% high, 56% medium risks, 29% low risk and 10% special case (stress events). No extreme risks were identified.

Catch basins and culverts were impacted by the largest number (36 of 48) of risks exposures, with the highest risk scores (R=10) related to heavy snowfall, extreme cold and freezing rain. Snow and freezing rain can cause blockage resulting in localized flooding around catch basis and culverts. Extreme cold was noted during the workshops as causing stormwater pipes to heave and shift.

The highest risk scores (R=16) were associated with intense rainfall impacting drainage ditches. The Towns' stormwater drainage system, comprised of a complex network of culverts, ditches and creeks (Wase and Bench Creeks) flowing through the Town, frequently flood during intense rainfall events.

RECOMMENDED ADAPTATIONS:

- Design stormwater systems (pipes, ditches, ponds, etc.) using climate adjusted IDF curves. Complete trade off study to optimum increased pie size versus increased cost.

- Implement green infrastructure (bioswales, permeable asphalt, rain gardens, etc.) to reduce surface run off volumes. Limit hardscape to help reduce water runoff velocities. Incorporate green stormwater infrastructure, such as permeable pavements and plant vegetation to reduce run off and promote infiltration.
- Consider installing high volume pumps at strategic locations in stormwater system to reduce flooding risks during extreme rainfall events by removing water from the current creek-based stormwater system. This option is best considered with the development of additional stormwater storage facilities.
- Consider developing a system of stormwater ponds/reservoirs to increase the capacity of the storm water drainage system and to manage overland flows, and decrease the risk of flooding during extreme rainfall events.
- Inspect and clean stormwater pipes to maintain maximum design flows and reduce localized flooding.
- Develop a green infrastructure strategy and policies that requires / encourages onsite stormwater retention and infiltration and discourages runoff (e.g., green streets, etc.).
- Update stormwater infrastructure design standard to account for the effects and risks related to climate change.
- Explore opportunities for upstream flow diversion / water management.

BARRIERS TO IMPLEMENTATION:

- Provincial environmental permitting impacts development of drainage system (Wase and Bennett creeks).
- Culverts and parts of system under provincial highway control. Investigate developing partnerships with the province / advocating for the province to do risk assessments on stormwater systems.
- Land ownership and conservation authorities impacts permitting. Consider developing a policy to purchase properties subject to flooding. This may also reduce insurance claims.
- Fisheries and species at risk concerns and requirements. Work with the ministries to develop construction schedules to minimize impacts of species at risk.

Legend	
Extreme	25
High	15 - 20
Moderate	8 - 12
Low	1 - 6

Table 12: Summary of Highest Risk Ratings - Roads Systems

Roads System	Extreme Heat				Higher Average Temperatures				Wildfire				Drought				Intense Rainfall				Riverine Flooding				Heavy Snowfall				Severe Thunderstorms (including Lightning/Hail)				High Winds				Extreme Cold				Winter Freeze-Thaw				Freezing Rain			
	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080
Paved	1	2	4	5	-	-	-	-	-	-	-	-	-	-	-	-	6	6	8	8	6	8	8	8	10	10	10	10	-	-	-	-	-	-	-	-	10	10	10	8	6	8	8	8	6	8	10	10
Gravel	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	6	8	8	6	8	8	8	10	10	10	10	-	-	-	-	4	4	4	4	10	10	10	8	3	4	4	4	6	8	10	10
Drainage Systems	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	6	8	8	6	8	8	8	-	-	-	-	6	6	8	8	-	-	-	-	-	-	-	-	3	4	4	4	-	-	-	-
Lights & Signage	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	4	4	12	12	12	12	-	-	-	-	-	-	-	-	3	4	5	5

Table 13: Summary of Highest Risk Ratings - Stormwater & Drainage Conveyance System

Stormwater & Drainage Conveyance System	Extreme Heat				Higher Average Temperatures				Wildfire				Drought				Intense Rainfall				Riverine Flooding				Heavy Snowfall				Severe Thunderstorms (including Lightning/Hail)				High Winds				Extreme Cold				Winter Freeze-Thaw				Freezing Rain			
	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080
Catch Basins & Pipes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	6	8	8	-	-	-	-	10	10	10	10	6	6	8	8	-	-	-	-	5	5	5	4	6	8	8	8	6	8	10	10
Culverts	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	6	8	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	10	10	8	6	8	8	8	-	-	-	-
Oil Grit Separators	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Overland Systems (raingardens, bioswales, etc.).	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	6	8	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	4	5	5
Ditches	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	12	12	16	16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 14: Summary of Highest Risk Ratings - Water Storage, Treatment & Conveyance Systems

Water Storage, Treatment & Conveyance Systems	Extreme Heat				Higher Average Temperatures				Wildfire				Drought				Intense Rainfall				Riverine Flooding				Heavy Snowfall				Severe Thunderstorms (including Lightning/Hail)				High Winds				Extreme Cold				Winter Freeze-Thaw				Freezing Rain			
	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080
Wells/Treatment Facility	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	4	4	4	4	4	4	10	10	10	8	3	4	4	4	-	-	-	-
Reservoirs	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20	20	20	16	-	-	-	-	-	-	-	-
Distribution Pipes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15	15	15	12	-	-	-	-	-	-	-	-
Flow Control Structures & Monitors	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Electrical & Communication Systems	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	9	12	12	8	8	8	8	-	-	-	-	-	-	-	-	6	8	10	10
Utilities & Backup Power	2	4	8	10	-	-	-	-	8	10	10	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	6	8	8	8	8	8	8	-	-	-	-	-	-	-	-	6	8	10	10
Raw Water Source	-	-	-	-	3	4	5	5	-	-	-	-	9	9	15	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

3.2.3 WATER STORAGE, TREATMENT & CONVEYANCE SYSTEMS

Low Vulnerability

Water storage, treatment and conveyance systems were assessed across seven major asset groups: wells and treatment facilities, reservoirs, distribution piping, flow control structure and monitoring, electrical and communication systems, utilities and back-up power and raw water source (Figure 14). A total of 64 risks were identified – 14% high risks, 52% medium risks, 31% low risk and 3% special case (stress events). No extreme risks were identified.

Electrical and communication systems, and utilities and back-up power were impacted by the largest number (32 of 64) of risks exposures, with the highest risk scores occurring in the 2050s and 2080s related to severe thunderstorms (R=12), wildfires (R=10) and freezing rain (R=10). Wildfires, high winds (R=8) and freezing rain have the potential to damage transmission lines and poles resulting in power outages. Sever thunderstorms can result in physical damage and power surges that can damage communication equipment (SCADA and PLC-based control systems) used to operate the potable water supply and treatment system.

The highest risk scores(R=20) were associated with extreme cold impacting distribution pipes and reservoirs. Water pipes are at risk of freezing and breaking, and ice-build-up on the interior walls of storage tanks can result in tanks collapsing under the additional weight of ice. The risk of collapse increases if tank vents become clogged with frost or ice build-up. The risks were highest under current climate and the 2030s, decreasing in the 2080s under a generally warming climate.

RECOMMENDED ADAPTATIONS:

- Install permanent generators to power wells and treatment during power outages. Purchase stand-by generators if permanent option is not viable in the near term.
- Consider installing solar/battery powered/natural gas powered (low carbon option) fire pumps to reduce reliance on generator power.
- Consider redundant wells and operate wells on alternating schedule to increase recharge rates.
- Inspect water tank vents during extreme cold events for frost and ice build-up. Consider installing heating cables to reduce or eliminate frost/ice build-up.
- Modify/adjust water levels in storage tanks during icing conditions to minimize ice build-up during winter and extreme cold outbreaks.

BARRIERS TO IMPLEMENTATION:

- Under current system, shortage of available of portable generators, especially during extended power outages.
- Limits on volume of water extracted from aquifers.
- Limited number of aquifers available for raw water sources.

3.2.4 WASTEWATER TREATMENT, STORAGE & CONVEYANCE

High Vulnerability

Wastewater treatment, storage and conveyance systems were assessed across seven major asset groups: sanitary sewer/combined sewer gravity and force mains, outfall structures, wastewater treatment plant, flow control structures and electrical and communication systems and utilities and backup. (Figure 15). A total of 64 risks were identified - 34% medium risk, 56% low risk and 10% special case (stress events). While no extreme risks were identified, the wastewater treatment, storage and conveyance asset system as a group are at an elevated risks due to the high vulnerability rating. Moderate and high risks can increase to extreme risks under a changing climate given the vulnerable state of these assets.

The highest risks (R=10) were related to extreme heat and freezing rain, and severe thunderstorms and high winds (R=8) impacting electrical and communication systems, utilities and back-up power and the water treatment plant. Most of these climate hazard interactions can result in power outages affecting the operation of the wastewater treatment operations. Intense rainfall had the largest number of risks (16 of 64), affecting the sanitary sewers and gravity and force mains, wastewater treatment plant and flow control structures and monitors. Intense rain can cause surge charging of the system, resulting in sewer backups and localized flooding.

RECOMMENDED ADAPTATIONS:

- Inspect and clean pipe mains to maintain optimum flows and reduce risk of sewage backups.
- For areas at elevated risks to sewer backups, install back-flow prevention valves.
- Eliminate combined sewage/stormwater piping in the sanitary system.
- Investigate funding sources to complete sanitary upgrades related to climate events like extreme rainfall (i.e., DMAF, https://www.infrastructure.gc.ca/dmaf-faac/index-eng.html)
- Enforce a policy of disconnecting all sump pumps systems connected to the sanitary system.

BARRIERS TO IMPLEMENTATION:

- High capital allocation required to replace aging sanitary infrastructure system.
- Wastewater billing rates are capped and/or rate increased do not meet the costs required to maintain the sanitary handling and treatment requirements of the Town. Investigate options other municipalities use to address financial shortages. Encourage water reduction use which can reduce treatment costs.

3.2.5 ECOLOGICAL ASSETS & PARKS

High Vulnerability

Ecological assets and parks were assessed across six major asset groups: sports fields, play areas (playgrounds), recreational and non-recreational lakes, beaches, campgrounds, and other assets (skate park, water park, courts, etc.) (Figure 16). A total of 116 risks were identified – 5% high risks, 48% moderate risks, 43% low risk and 3% special case (stress events). While no extreme risks were identified, these assets are still at an elevated risk due to the high vulnerability ring. While no extreme risks were identified, the ecological assets and parks as a group are at an elevated risks due to the high vulnerability rating. Moderate and high risks can increase to extreme risks under a changing climate given the vulnerable state of these assets. Moderate and high risks can increase to extreme risks under a changing climate given the vulnerable state of these assets.

The highest risks (R=20) were associated with wildfires potentially causing catastrophic loss of the trees and facilities in the campground. Unfortunately, wildfires during the summer of 2023 damaged part of the campground (overflow campground loop) most of the campground. Wildfire smoke was a major issue for the entire town this summer due to the proximity of several wildfires that resulted in multiple evacuations of the Town's residents. The campground was also at moderate risk (R=12) related to potential impacts from riverine flooding.

The other ecological and park assets were affected by a large number of climate hazards (8 of the 12 hazards impacted these assets). High risks (R=15) were associated with drought, primarily impacting the water park, resulting in the park closing due to insufficient water in the municipal system to operate the park. Moderate risks were caused by interaction with high winds, extreme cold, freeze-thaw and freezing rain events, which affected the availability of these assets and the safety of the users. Risks were highest in the 2080s, except for extreme cold which showed a decrease in risk in the 2080s.

Sports fields and play areas (playgrounds) were also at moderate risk (R=10) associated with heavy snowfall, extreme cold and freezing rain, with similar impacts as indicated for the other assets. Extreme heat and drought caused moderate risks (R=10) to the recreational and non-recreational lakes, with risks peaking in the 2080s. The combination of extreme heat and drought can increase the likelihood of algae blooms, which can impact the use of the lakes and/or cause the closing of local beaches.

Table 15: Summary of Highest Risk Ratings - Wastewater Treatment, Storage & Conveyance

Wastewater Treatment, Storage & Conveyance Systems	Extreme Heat				Higher Average Temperatures				Wildfire				Drought				Intense Rainfall				Riverine Flooding				Heavy Snowfall				Severe Thunderstorms (including Lightning/Hail)				High Winds				Extreme Cold				Winter Freeze-Thaw				Freezing Rain			
	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080
Sanitary Sewer / Combined Sewer Gravity Mains	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	6	8	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sanitary Sewer / Combined Sewer Designated Force Mains	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	6	8	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Outfalls	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Wastewater Treatment Plant	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	4	4	-	-	-	-	-	-	-	-	6	6	8	8	8	8	8	8	5	5	5	4	3	4	4	4	-	-	-	-
Flow Control Structures & Monitors	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	4	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Electrical & Communication Systems	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	6	8	8	4	4	4	4	-	-	-	-	-	-	-	-	6	8	10	10
Utilities & Backup Power	2	4	8	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	6	8	8	4	4	4	4	5	5	5	4	-	-	-	-	6	8	10	10

Table 16: Summary of Highest Risk Ratings - Ecological Assets & Parks

Ecological Assets & Parks	Extreme Heat				Higher Average Temperatures				Wildfire				Drought				Intense Rainfall				Riverine Flooding				Heavy Snowfall				Severe Thunderstorms (including Lightning/Hail)				High Winds				Extreme Cold				Winter Freeze-Thaw				Freezing Rain			
	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080
Sports Fields	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	6	8	8	-	-	-	-	10	10	10	10	3	3	4	4	-	-	-	-	-	-	-	-	-	-	-	-	6	8	10	10
Play Areas (playgrounds)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	6	8	8	-	-	-	-	10	10	10	10	3	3	4	4	8	8	8	8	-	-	-	-	-	-	-	-	6	8	10	10
Other (skate park, water parks, courts, etc.)	2	4	8	10	-	-	-	-	-	-	-	-	9	9	15	15	6	6	8	8	-	-	-	-	-	-	-	-	3	3	4	4	8	8	8	8	10	10	10	8	6	8	8	8	6	8	10	10
Recreational & Non-Recreational Lakes	2	4	8	10	3	4	5	5	-	-	-	-	6	6	10	10	-	-	-	-	-	-	-	-	-	-	-	-	3	3	4	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Beaches	2	4	8	10	3	4	5	5	-	-	-	-	6	6	10	10	-	-	-	-	-	-	-	-	-	-	-	-	3	3	4	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Campground	-	-	-	-	-	-	-	-	16	20	20	20	-	-	-	-	6	6	8	8	9	12	12	12	-	-	-	-	3	3	4	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

RECOMMENDED ADAPTATIONS:

- Continue to enforce wildfire prevention regulations to ensure consistency in fire prevention rules so the number of human-caused fires is minimized. Consider reviewing and adapting the '*National guide for wildland-urban-interface fires: guidance on hazard and exposure assessment, property protection, community resilience and emergency planning to minimize the impact of wildland-urban interface fires'*[5].
- Continue to restrict use of open fires during periods of elevated wildfire fire activity or high fire danger.
- Conduct regular testing of recreational lakes and beach areas during periods of extreme heat/heat waves to measure the water is safe to use.
- Develop berms along Wase and Bench Creeks to reduce the amount of flooding in the parks. Top of berms could be part of the Towns recreational trails network.
- Consider low flow water/sprinkler hears in the water park to reduce amount of water consumed.
- Consider recycling water in the water park, to reduce strain on municipal potable water system.

BARRIERS TO IMPLEMENTATION:

- Competition for financial resources impacts.
- Costs to maintain trails safe can be high (coast of de-icing materials, snow removal, insurance, etc.).
- Barriers to obtaining insurance and increased liability to the Town (i.e., campground) related to increased risks from climate hazards.

3.2.6 ADMINISTRATION & OPERATION CENTERS

High Vulnerability

Administration and operation centers were assessed across nine major asset groups: roof and associated drainage systems, foundation and structural elements, building envelope and insulation, windows and doors, building controls, HVAC and air circulation systems, utilities and back-up power, hardscape and associated drainage systems, trees and vegetation and building occupants and public users (Figure 17). A total of 156 risks were identified – 4% high risks, 40% moderate risks, 42% low risk and 13% special case (stress events). While no extreme risks were identified, the administration and operations centers as a group are at an elevated risks due to the high vulnerability rating. Moderate and high risks can increase to extreme risks under a changing climate given the vulnerable state of these assets.

High risks (R=15) were associated with extreme heat and extreme cold affecting the building controls, HVAC and air circulation systems and the ability of these systems to maintain building temperature set-points for occupant comfort. Highest risks for extreme heat were in the 2080s, while the risk for extreme cold was highest under current climate and the 2020s, declining to a moderate risk in the 2080s due to a generally warming climate. High risks (R=15) were also associated with drought impacts on trees and vegetation in the 2050s and 2080s.

Freezing rain had a broad impact affecting 7 of the 9 asset groups. Moderate risks (R=10) occurred in the 2050s and 2080s, impacting the roof and hardscape drainage systems, windows and doors, utilities and backup power, and building occupants and public users. Freezing rain can directly restrict or plug drainage systems, impact the operation of building envelope components like windows and doors, and create health and safety risks (slip and fall) for building occupants and public users accessing the buildings. Power can be interrupted by ice accumulation on power lines and towers in extreme freezing rain events.

Moderate risks (R=8/10) were also associated with the following interactions.

- Wildfire and associated smoke impacting the building controls, HVAC and air circulation systems.
- Heavy snow impacts roof and hardscape drainage systems, causing blockages and increasing the risks of localized flooding. Intense rainfall was found to be a moderate risk overwhelm roof and hardscape drainage systems.

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[5] National guide for wildland-urban-interface fires: guidance on hazard and exposure assessment, property protection, community resilience and emergency planning to minimize the impact of wildland-urban interface fires (canada.ca)

- High winds have the potential to damage roof systems on buildings as well as trees and vegetation. The public and building users can be harmed by wind-driven debris.

RECOMMENDED ADAPTATIONS:

- Size HVAC equipment at time of renewal using the latest climate data/future weather files. Install filters with the appropriate MERV rating on the HVAC/air handling equipment to facilitate removal of particulate from wildfire smoke.
- Increase insulation in the walls and attics of buildings, replace weather seals and weather stripping, upgrade windows to facilitate the reduction of heating and cooling loads.
- Maintain or add natural and built shade structures around buildings, to reduce solar heating.
- Develop policies and operating procedures to guide building occupants on practices to keep cool, including closing windows after noon and opening them at night.
- Incorporate passive solar cooling and ventilation systems when possible.
- Use high albedo or "cool" roofing materials or consider vegetated or green roof systems to reduce internal heat gains. Use light-coloured building materials to reduce envelope surface temperatures and lower thermal transfer.
- Use drought resistant vegetation to reduce water requirements. Consider developing a rain harvesting system to reduce municipal water requirements.
- Develop O & M policy to inspect and clean roof drains, catchment basins and other drainage systems to prevent localized flooding.
- Install occupancy sensors and programmable thermostats to reduce heating and cooling loads.

BARRIERS TO IMPLEMENTATION:

- Age of many buildings make some resilience retrofits cost prohibitive or minimally effective.

3.2.7 RECREATION & COMMUNITY CENTERS

High Vulnerability

Recreation and community centers were assessed across eight major asset groups: roof and associated drainage systems, foundation and structural elements, building envelope and insulation, windows and doors, building controls, HVAC and air circulation systems, pools and associated mechanical systems, electrical, communication and emergency systems and utilities and back-up power (Figure 18). A total of 100 risks were identified – 4% high risks, 37% moderate risks, 48% low risk and 11% special case (stress events). While no extreme risks were identified, the recreation and community centers as a group are at an elevated risks due to the high vulnerability rating. Moderate and high risks can increase to extreme risks under a changing climate given the vulnerable state of these assets.

High risks (R=15) were associated with extreme heat and extreme cold affecting the building controls, HVAC and air circulation systems and the ability of these systems to maintain building temperature set-points for occupant comfort. Highest risks for extreme heat were in the 2080s, while the risk for extreme cold was highest under current climate and the 2020s, declining to a moderate risk in the 2080s due to a generally warming climate.

Freezing rain affecting 5 of the 8 asset groups. Moderate risks (R=10) occurred in the 2050s and 2080s, impacting the roof and drainage systems, windows and doors, utilities and backup power, and building occupants and public users. Freezing rain can directly restrict or plug drainage systems, impact the operation of building envelope components like windows and doors, and create health and safety risks for building occupants and public users accessing the buildings. Power and communication systems can be interrupted by ice accumulation on power lines and towers in extreme freezing rain events.

Severe thunderstorms also impacted 5 of the 8 asset groups, but only heavy rain impacting roof and associated drainage systems we classified as a high risk (R=8), The remaining interactions were classified as low risks across all time periods.

Moderate risks (R=8/10) were also associated with the following interactions.

- Wildfire and associated smoke impacting the building controls, HVAC and air circulation systems.

- Heavy snow impacts roof and drainage systems, causing blockages and increasing the risks of water retention on the roof, which could lead to water infiltration.
- High winds have the potential to cause uplift and damage roof systems on buildings. Roof mounted equipment can be damaged by high winds and wind-driven debris.
- Winter freeze-thaw can damage building foundations and structural elements, by cracking concrete structures increasing the risk of water infiltration.

RECOMMENDED ADAPTATIONS:

- Size HVAC equipment at time of renewal using the latest climate data/future weather files. Install filters with the appropriate MERV rating on the HVAC/air handling equipment to facilitate removal of particulate from wildfire smoke.
- Increase insulation in the walls and attics of buildings, replace weather seals and weather stripping, upgrade windows to facilitate the reduction of heating and cooling loads.
- Maintain or add natural and built shade structures around buildings, to reduce solar heating.
- Develop policies and operating procedures to guide building occupants on practices to keep cool, including closing windows after noon and opening them at night.
- Incorporate passive solar cooling and ventilation systems when possible.
- Use high albedo or “cool” roofing materials or vegetated roof systems to reduce internal heat gains. Use light-coloured building materials to reduce envelope surface temperatures and lower thermal transfer.
- Develop O & M policy to inspect and clean roof drains, catchment basins and other drainage systems to prevent localized flooding.
- Install occupancy sensors and programmable thermostats to reduce heating and cooling loads and reduce electrical costs.

BARRIERS TO IMPLEMENTATION:

- Age of many buildings make some resilience retrofits cost prohibitive or minimally effective.

Table 17: Summary of Highest Risk Ratings – Administrative and Operations Centers

Administration & Operation Centers	Extreme Heat				Higher Average Temperatures				Wildfire				Drought				Intense Rainfall				Riverine Flooding				Heavy Snowfall				Severe Thunderstorms (including Lightning/Hail)				High Winds				Extreme Cold				Winter Freeze-Thaw				Freezing Rain			
	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080
Roof & Associated Drainage Systems	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	6	8	8	-	-	-	-	10	10	10	10	6	6	8	8	8	8	8	8	-	-	-	-	-	-	-	-	6	8	10	10
Foundation & Structural Elements	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	4	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	8	8	8	-	-	-	-
Building Envelope & Insulation	-	-	-	-	3	4	5	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	4	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Windows & Doors	2	4	8	10	3	4	5	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	4	4	-	-	-	-	5	5	5	4	-	-	-	-	6	8	10	10
Building Controls, HVAC & Air Circulation Systems	3	6	12	15	3	4	5	5	8	10	10	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15	15	15	12	-	-	-	-	3	4	5	5
Utilities & Backup Power	2	4	8	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	4	4	4	4	4	4	-	-	-	-	-	-	-	-	6	8	10	10
Hardscape & Associated Drainage Systems	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	6	8	8	-	-	-	-	10	10	10	10	-	-	-	-	-	-	-	-	-	-	-	-	3	4	4	4	6	8	10	10
Trees & Vegetation	1	2	4	5	-	-	-	-	-	-	-	-	9	9	15	15	-	-	-	-	-	-	-	-	-	-	-	-	3	3	4	4	8	8	8	8	-	-	-	-	-	-	-	-	3	4	5	5
Building Occupants & Public Users	2	4	8	10	-	-	-	-	4	5	5	5	-	-	-	-	-	-	-	-	-	-	-	-	5	5	5	5	6	6	8	8	8	8	8	8	-	-	-	-	6	8	8	8	6	8	10	10

Table 18: Summary of Highest Risk Ratings – Recreation and Community Centers

Recreation & Community Centers	Extreme Heat				Higher Average Temperatures				Wildfire				Drought				Intense Rainfall				Riverine Flooding				Heavy Snowfall				Severe Thunderstorms (including Lightning/Hail)				High Winds				Extreme Cold				Winter Freeze-Thaw				Freezing Rain			
	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080	Present	2030	2050	2080
Roof & Associated Drainage Systems	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	6	8	8	-	-	-	-	10	10	10	10	6	6	8	8	8	8	8	8	-	-	-	-	-	-	-	-	6	8	10	10
Foundation & Structural Elements	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	4	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	8	8	8	-	-	-	-
Building Envelope & Insulation	-	-	-	-	3	4	5	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	4	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Windows & Doors	2	4	8	10	3	4	5	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	4	4	-	-	-	-	5	5	5	4	-	-	-	-	6	8	10	10
Building Controls, HVAC & Air Circulation Systems	3	6	12	15	3	4	5	5	8	10	10	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15	15	15	12	-	-	-	-	3	4	5	5
Pools & Associated Mechanical Systems	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Electrical, Communication & Emergency Systems	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	4	4	-	-	-	-	-	-	-	-	-	-	-	-	6	8	10	10
Utilities & Backup Power	2	4	8	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	4	4	4	4	4	4	-	-	-	-	-	-	-	-	6	8	10	10

4 Recommended Actions and Next Steps

Planning to adapt to climate change is not simply a one-size-fits-all approach. Just as the changes in climate are likely to vary, so are the impacts likely to materialize and the adaptation and resilience measures vary across different infrastructure classes, communities, and regions. As climate change is a growing factor for most Towns, Cities and Municipalities, change adaptation and resilience measures should be considered throughout the municipal planning, operations and maintenance, and renewal lifecycles for Town's assets and infrastructure as illustrated in Figure 7.

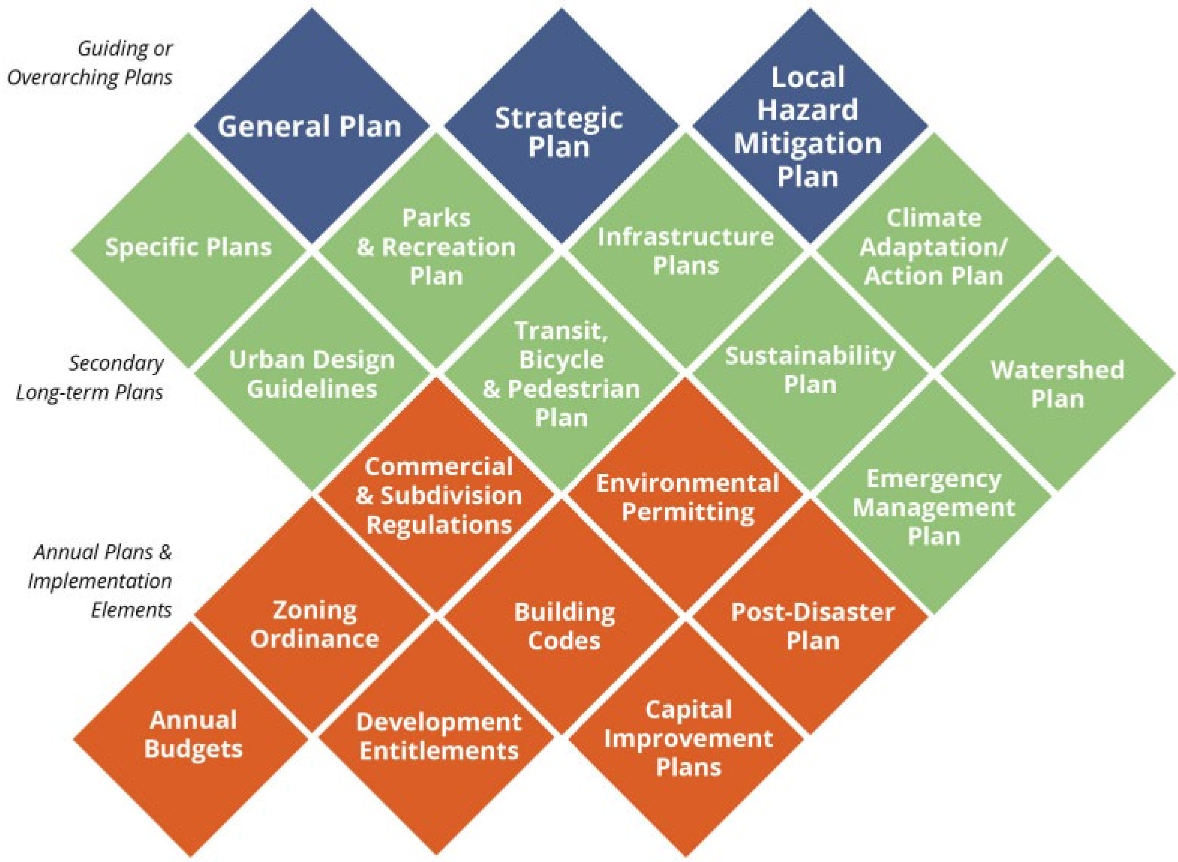

Figure 7: Cascading Plans that can be Influenced by Resilience Planning[6]

Effective climate change adaption requires leadership, cooperation, collaboration, and information sharing between departments, regulators, and various levels of governments to increase funding, incorporate policy changes and develop timely climate adaptation responses. Based on these discussions and the outcomes of this climate vulnerability and risk assessment, a series of recommendations are presented in the following sections to best address the impacts of climate change and extreme weather, and help

[6] Regional Resilience Toolkit , Environmental Protection Agency 2019. Retrieved from https://www.epa.gov/sites/default/files/2019-07/documents/areaal_resilience_toolkit.pdf

facilitate the Town of Edson as they work to develop low carbon resilience to meet the net zero challenges of the future.

4.1 Incorporate Climate Considerations into Key Levels of Decision-making

Strategic planning priorities need to be consistent with the challenges of climate change adaptation which requires flexibility in planning systems to capture new information as it becomes available. The following actions primarily refer to integrating climate change considerations into existing and the development of future plans, policies, and frameworks relating to the management of asset systems. This is one of the most important ways the Town can adapt to a changing climate in a sustainable, cost-effective, and low carbon resilience manner as these actions require climate change be a core consideration across the Town’s management and operational systems and processes.

4.1.1 INTEGRATE CLIMATE CHANGE CONSIDERATIONS INTO FINANCIAL DECISION-MAKING PROCESSES

This could involve the development and implementation of a decision-making process that considers the change in infrastructure lifecycle and services levels based on climate change and other environmental factors. This would require cross-organizational integration and leadership, and the development of tools to evaluate the effectiveness of resiliency actions (e.g., triple bottom line – social, environmental, and environmental). With these tools, staff can identify financial implications and incorporate climate adaptation-related costs into short and long-term financial budgets and projections.

4.1.2 CONSIDER CLIMATE CHANGE IN THE DEVELOPMENT OF BUSINESS CONTINUITY PLANS

Business continuity planning involves developing a plan to increasing asset and service resiliency to a variety of impacts, and when there is a disruption, getting the asset or service back up and operating as quickly as possible. The business continuity plans may consider climate change impacts which may affect the ability of the service to recover from an event (e.g., relocation, potential for flooding, etc.). Consider establishing a climate fund to be used specifically to address climate impacts and develop climate-based adaptation and resilience measures to address climate impacts.

4.1.3 REVIEW HEALTH AND SAFETY (H&S) PROTOCOLS TO INCLUDE POSSIBLE WORK-RELATED IMPACTS FROM CLIMATE CHANGE.

Changes in climate are expected to have a significant impact on staff, contractor, and public health and safety (e.g., heat stress, working in extreme temperature, high wind and storm events). Review current policies for gaps that fail to address climate-related hazards to staff, contractors, and public health and safety. The following could be considered:

- Develop a policy to limit outdoor work during peak heat hours or extreme weather events (i.e., thunderstorms and lightning).

- Develop a work from home plan to eliminate commuting during extreme weather events.
- Create a policy that supports more localized decision making (e.g., closing centers when there are weather events) or opening of cooling centers during extreme heat/heat waves.
- Build programs that support the Towns vulnerable populations during heatwaves or periods of extreme temperatures.

4.1.4 DEVELOP AND BUILD STAFF CAPACITY AND RESOURCES TO SUPPORT CLIMATE RISK IN CAPITAL AND OPERATIONAL PLANNING

Investigate avenues to increase staff capacity to oversee or aid staff in coordinating or streamlining the capital planning process across the organization. This action would better oversee project management activities and support the broad adoption of incorporating climate risks throughout the planning-design-construct-operate-maintain asset life cycle.

Capacity can be developed through climate change training for staff so that impacts and risks are considered as part of the Town's risk management framework.

4.2 Continually Monitor and Improve Climate Projections and Expectations.

Historical weather events have had an unavoidable impact on Town operations and assets, none more evident that this year where climate has resulted in multiple wildfire-based evacuations and flooding by extreme rainfall events. The following actions are ways the Town's staff can help reduce operations and maintenance risks associated with a changing climate.

4.2.1 REVIEW CLIMATE PROJECTIONS AND VULNERABILITY STUDIES.

Climate change projections are developed using a combination of climate models, historical weather data, and GHG emission trajectories. As the climate models are updated over time, climate models will improve and change based on new data. Reviewing new future climate data on a regular basis will provide the Town's decision makers with the best available science, research, and evidence to support climate-based policies, procedures and operating/management decisions. It is recommended this climate vulnerability and risk assessment be treated as live document, reviewed and updated on a regular basis, to continue to build and maintain resilience in the Towns assets and systems to the impacts of climate change and extreme weather. Consider updating the CVRA at least every 5 years, or when IPCC releases new climate assessment reports (current release is the Sixth Assessment Report, 2023).

4.2.2 CONTINUE TO MONITOR THE OUTCOMES OF DISASTER AND EMERGENCY EVENTS AND INTEGRATE ACTIONS INTO OPERATIONS AND MAINTENANCE (O&M) PLANS.

The Town already reviews the outcomes of disaster and emergency events and their effect on Town infrastructure and assets, staff, and service delivery to residents. Track and record data on damages experienced and identify recommended mitigation strategies and response protocols for future similar events. Consider the impact of climate change on the following:

- Winter cleaning and surface control practices.
- O& M practices to ensure assets operate at their design capacity.
- Emergency and back-up power requirements, and critical facilities to operate key building systems (i.e., air conditioning).
- Creeks and stormwater infrastructure to minimize flood risks.
- Necessary staffing for emergency management activities.
- Multi-departmental efforts to address high risk weather events (wildfire, floods), such as interactions with emergency and community services, external agencies, and the community.
- Develop redundant communication protocols to be used before, during and after extreme weather events, including back-up communication systems when regular communications may be disrupted (i.e., loss of cellular communications).

4.2.3 CONTINUE TO PROVIDE FUNDING FOR WILDFIRE PROTECTION, PROTECTION, DETECTION, PREPAREDNESS, AND FOREST FUEL MANAGEMENT.

The Town's natural assets provide a host of ecosystem goods and services that can be impacted by climate change. Providing funding for wildfire protection, detection, preparedness, forest fuel management and urban fire preparedness can help mitigate risk of hotter and drier climate on parks and ecological assets.

4.3 Assess Climate-Resiliency for Infrastructure

The Town has experienced the direct impacts of a changing climate which have manifested as more frequent extreme weather events, heat waves, and wind events. These changing conditions are already affecting existing infrastructure designed and constructed on standards that are outdated. The following list of actions aim to reduce the risk of climate change when designing and building new infrastructure.

4.3.1 DEVELOP A CLIMATE RISK ASSESSMENT PROGRAM FOR AT-RISK INFRASTRUCTURE.

Complete design reviews for at risk assets to insure resilience against climate impacts. The outcome of this action may be a policy to identify resilience options and implement them. Several asset systems have been identified as being at risk and have been / could be at an increasing risk from climate change. It is recommended the Town consider the effects of climate when completing assessments or retrofitting the following assets:

- trails (e.g., slope failure, erosion, flooding, and material degradation).
- bridges (e.g., scouring erosion, side-slope failure, foundation settlement and material degradation).
- buildings identified as critical or strategic properties that could serve as emergency support centers during times of crisis (e.g., need for reliable backup power, fuel supply issues with third party fuel suppliers).
- water supply and treatment systems and the need to operate during power outages.
- existing stormwater assets at risk or known to be undersized (e.g., monitor and prioritize opportunities to increase the capacity of the system, to address flooding risks from future climate impacts).

4.3.2 REVIEW AND REVISE DESIGN STANDARDS TO ACCOUNT FOR AND MINIMIZE THE IMPACTS OF CLIMATE CHANGE.

Review infrastructure design and construction-related policies and procedures for requirements against projected climate change to identify and inventory areas where future conditions could surpass current thresholds. Consider implementing climate adjusted climate criteria based on the current version of the applicable building code to increase the resilience of the Towns assets and infrastructure.

4.3.3 INVESTIGATE OPPORTUNITIES FOR INFRASTRUCTURE RENEWAL AND CAPITAL PROJECTS FUNDING

Funding is and continues to be a major concern for towns, communities, and municipalities. Adding the impacts of climate change only increases the need for additional funding to an already unfunded system. Federal and provincial levels of government are key players in supporting climate actions in the face of a changing climate and will need to support municipalities in their efforts to locally address climate impacts. Work with provincial and federal governments to access funding to financially support climate change mitigation, resilience adaptation practices to minimize the effects of climate change. Consider creating a climate change officer position to lead the strategic development of the Towns climate change action plan and finding sources of new funding.

4.4 Build and Develop Climate-Based Communication and Collaboration Opportunities

Engaging Town staff, Local Governments, businesses, and residents in a dialogue about how to achieve resiliency is extremely important. This involves sharing best practices and lessons learned, collaborating with, and informing these groups on progressive measures as it relates to improving infrastructure and community climate resilience. Consider creating a climate action officer or position to champion the need to build climate resilience into the Towns policies, process, and procedures. One of the key roles will be finding Federal and Provincial funding opportunities to support climate actions in the Town. Work with local communities to lobby the governments to access climate change related funding.

4.4.1 SHARE THE RESULTS OF THIS CLIMATE VULNERABILITY AND RISK ASSESSMENT WITH INTERNAL AUDIENCES

It is recommended that the Town communicate this report's results with key audiences to build awareness of specifically how climate change will impact the Town's assets and operations. This will also provide an opportunity to review, verify, and update the condition of the Town's asset systems by looking through a climate lens focus.

4.4.2 CONTINUE TO CONDUCT POST-DISASTER EVENT ANALYSES TO IDENTIFY LESSONS LEARNED

Continue to comprehensively review the outcomes of disaster and emergency events and their effect on Town assets and service delivery. Consider the following activities:

- Track and report data on climate related damages and impacts and develop mitigation strategies and response protocols for future similar events.
- Consider whether events will warrant strategic decisions for Town assets (e.g., hardening, replacement, relocation, etc.).
- Distribute findings to all relevant staff and leadership via standardized reports. Follow-up by developing action plans to address the most pressing issues. Obtain support from senior levels of management to build and maintain climate change support at all levels on governance.
- Review funding opportunities to support developing resilient climate adaptation measures to address climate disasters affecting the Town.

4.4.3 REVIEW AND REFINE EXISTING COMMUNICATION PROCESSES AS THEY RELATE TO CLIMATE CHANGE AND EXTREME WEATHER

There are several opportunities to improve communication practices. Consider the following activities:

- Assess existing cross-departmental communications plans to notify the public of any climate-induced disruptions or cancellations to services and programs, as well as post-event clean-up and safety risks.

- Continuously review and refine communication tools and information delivery mechanisms to rapidly inform staff, residents, businesses, and organizations of service-level changes required because of climate-related events (e.g., closure of parks because of extreme heat/heat waves, wildfire and flooding impacts, beach closures die to algae blooms, etc.).
- Incorporate the impacts of extreme climate events and risks into health and safety communication and training materials.
- Include the risk of climate-based hazards in the Town's Emergency Response Plan.
- Develop broad climate risk awareness campaigns to educate and engage staff and public about the impacts of climate on the community and the services provided by the Town.

4.5 Develop an Implementation Plan

Using a list of prioritized and actionable strategies, the next step is to develop an implementation plan. Implementation can be the most challenging part of any planning effort and it will be a critical part in sustaining resilience over the long-term, ensuring ongoing support and funding for future projects and initiatives. In moving toward resilience strategy implementation, the Town of Edson should consider:

- Developing a long-range regional resilience masterplan which creates a vision for the Town and surrounding communities how to address the impacts of climate change.
- Review operational strategies to oversee resilience efforts. Update or create new climate-focused department guidance, programs, and policies.
- Evaluate department and program budgets to assess the need to include resilience considerations in infrastructure improvement and operation funding. Include climate change consideration in your Asset Management Plan.
- Develop timelines for capital and renewal projects which address vulnerable critical assets identified in the CVRA process.
- Create an educational and awareness campaign for adaptation and mitigation needs. Hold public open houses to build community support.
- Look for opportunities to create private, municipal and government development and business partnerships which support climate resilience initiatives.

The implementation plan should directly link resiliency action strategies to annual budgets, grant funding cycles, capital improvement plans, and daily operation and maintenance activities. Integration of financing will assist in routine Town decision making while still maintaining the long-term vision of the Town of Edson Climate Resiliency Objectives. Short-term staff level working plans should be developed to detail each step or tactic necessary to achieve those longer-term goals and vision in a manageable time frame.

Implementation of the strategies presented in this document are intended to serve as a primer to facilitate long-term climate action plans to guide future local and community-based resilience efforts. It is a higher-level planning tool that connects regional planning documents, programs and efforts into a multi-hazard stakeholder driven risk assessment. The Town of Edson Regional Resiliency Report should be shared with neighbouring communities and regional stakeholders and decision makers, to facilitate the development of broader regional climate resiliency plan which can better leverage resources to build resilience to the benefit of everyone.

The Town of Edson's Climate Vulnerability and Resilience Report and the process used in its development and subsequent implantation strategy should be used as a template to assist neighboring communities and municipalities to create their own climate action plans. This increased collaboration and communication could lead to greater community resilience and support stronger and more competitive applications for external resilience adaptation and mitigation funding.

5 Adopting the CVRA Framework

Implementation of the strategies presented in this document are intended to serve as a primer to facilitate long-term climate action plans to guide future local and community-based resilience efforts. It is a higher-level planning tool that connects regional planning documents, programs and efforts into a multi-hazard stakeholder driven risk assessment. The Town of Edson Climate Vulnerability and Risk Assessment Report should be shared with neighbouring communities and regional stakeholders and decision makers, to facilitate the development of broader regional climate resiliency plan which can better leverage resources to build resilience to the benefit of everyone.

The Town of Edson's Climate Vulnerability and Resilience Report and the process used in its development and subsequent implantation strategy should be used as a template to assist neighboring communities and municipalities to create their own climate action plans. This increased collaboration and communication could lead to greater community resilience and support stronger and more competitive applications for external resilience adaptation and mitigation funding by following the simplified resilience-focused plan illustrated in Figure 8.

Figure 8: Five Steps to Building Resilience (Regional Resilience Toolkit 2019)

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APPENDICES

Appendix A – Edson Climate Hazard Exposure and Impacts

Asset	Major Infrastructure Components	Subcomponents	Average Condition	Remaining Service Life	Asset Condition Notes and Workshop Comments	Seasonal Change (Higher Average Temperatures) & Extreme Heat	Extreme Cold and Freeze Thaw	Heavy Rainfall & Riverine/ Overland Flooding	Extreme Events (Severe Storms, High Winds & Heavy Snowfall)	Drought & Wildfires	Other Climate Hazards and Impacts	Planned Asset Condition Assessment
Municipal Services	Stormwater Systems	Catch Basins	Fair	49%	• spring and fall clearing	• There is the potential during heat waves for stormwater management facilities to lose significant volumes of retained water resulting in a reduction of mosquito breeding conditions	• Freezing can cause blockages of catch basins.	• Debris from runoff blocks catch basin causing overflows/flooding.	• Ice and snow can clog storm drains, resulting in localized flooding	•		
		Collection/Retention Ponds	Very Good	84%	• 30 cm wide creek; Bench Creek turns into a retention pond south of town Retention pond on Bench Creek in town (56st south of 2nd ave) only pond with engineering retention (interlocked sheet piling re-enforcement) due to erosion problems		• May damage concrete structures.	• Ponds may overflow/creeks backup/flood due to extreme precipitation events.	• Ponds may overflow/creeks backup/flood due to extreme precipitation events/spring melt.	•		
		Ditches	Fair		•		• Re-freezing of meltwater may obstruct the site's drainage system.	• Ditches are overwhelmed and causes local flooding.	• May result in increased localized / downstream flooding if system is overwhelmed	•		
		Stormwater Mains And Pipes, Grates	Very Good	82%	• freeze-thaw cycles impact pipes, a lot of issues, PVC pipes particularly impacted (expand/contract more easily)		• Can cause heaving of SW piping. • May damage concrete structures. • Re-freezing of meltwater may obstruct the site's drainage system.	• Extreme rainfall can overload SW system causing local flooding.	• Extreme rainfall and spring melt can overload SW system causing local flooding.	•		
	Drinking Water Network	Water Treatment Plant			• Newest WTP should be online in April or May 2023. WTP includes the removal of manganese from water. Most other pump stations just chlorinate water for disinfection.	• Generators may shutdown due to overheating under extreme heat events.	• May damage concrete structures.	•	• Storms cause power outages • WTP requires back-up power to maintain water pressure. • In-ability to access WTP and associated systems.	•		
		Boiler/Valve House	Very Poor	14%	•	•		•		•		
		Degasification Plant	Fair	48%	• well with high methane gas, plant will be upgraded in coming years to also deal with chlorine	•		•		•		
		Distribution Pumphouse	Poor	34%	• pumping station to help increase pressure	•		•		•		
		Glenwood Reservoir And Building	Very Poor	19%	• in-ground reservoir	•		•		•		
		Water Wells, Well Pumps, Buildings (On Concrete Pads, Steel Roofs)	Good to Very good	65%-91%	• 'pumps/well function (on/off) depends on how much water is in the reservoir wells can't meet the demands during the summer	• Warmer temperatures increase demand which exceeds the capacity of the wells.		•		• Potential to affect the availability of GW in wells.		

Asset	Major Infrastructure Components	Subcomponents	Average Condition	Remaining Service Life	Asset Condition Notes and Workshop Comments	Seasonal Change (Higher Average Temperatures) & Extreme Heat	Extreme Cold and Freeze Thaw	Heavy Rainfall & Riverine/ Overland Flooding	Extreme Events (Severe Storms, High Winds & Heavy Snowfall)	Drought & Wildfires	Other Climate Hazards and Impacts	Planned Asset Condition Assessment
					(demand exceeds production)							
		Water Mains, Pipes, Valves, Fire Hydrants	Very Good	86%	• water hydrant failure due to plugged vent (now has a heat tracer) - pulled down the ceiling of reservoir	•	• Risk of frozen pipes/pipe breaks. Use of bleeders to limit freezing.	•		•		
		Reservoirs 1 And 2			• Two above ground reservoirs, Capacity of 750,000 and 500,000 gallons	• Extreme heat can increase the water temperature, increasing the potential for bacteria growth. • Reduced recharge of groundwater sources. • Increased demand on water sources, increased pumping and treatment requirements, and faster depletion of water storage.	• Risk of collapse - ice buildup inside tanks?	•		•		
Municipal Services		Treatment Plant			• New WWTP	• Dry spells may result in a reduction of water consumption and wastewater volumes which may impact operational efficiencies.	•	• Increases in rainfall could increase stormwater flows resulting in a temporary inability to meet local conveyance and treatment demands.	• Increased potential for power outages, although backup generators are in place for key systems. • Lack of access to facilities if there is an issue.	• Fires can impact power sources and impact level of service.		
		Lagoon	Very Poor	2%	• Lagoons still in service. One accepts municipal sewage	• Warmer temperatures increase bacteria growth.	•	•	•	•		
	Sanitary Sewer Network	Lagoon Blower House, Influent Shack	Poor	34%	•	•	•	•	•	•		
		Waste Fill Station	Very Good	93%	•	•	•	•	•	•		
		Manholes	Fair	46%	• average condition	• Increased average temperatures could enhance wastewater fermentation in the collection system, in turn producing more hydrogen sulphide (H_2S) and result in corrosion and H&S concerns.	• Extreme cold/freeze thaw can loosen pipe connections in manholes.	•	•	•		
		Sanitary Mains, Pipes, Valves	Very Good	81%	• Existing Municipal Servicing Plan (MSP) Update Report completed in 2018.		• May damage concrete structures.	• Extreme rainfall can overload combine SW/WW system causing local flooding.	•	•		

Asset	Major Infrastructure Components	Subcomponents	Average Condition	Remaining Service Life	Asset Condition Notes and Workshop Comments	Seasonal Change (Higher Average Temperatures) & Extreme Heat	Extreme Cold and Freeze Thaw	Heavy Rainfall & Riverine/ Overland Flooding	Extreme Events (Severe Storms, High Winds & Heavy Snowfall)	Drought & Wildfires	Other Climate Hazards and Impacts	Planned Asset Condition Assessment
	Roads / Transportation Network	Roads (Paved And Gravel)	Good (Paved)	61%	• freeze-thaw causes heaving - lots of cracks, potholes - lots of maintenancefreeze-thaws are accounted for in the design (900mm below asphalt)	• Higher temperatures can cause pavement to soften and expand which can create rutting and potholes, particularly in high-traffic areas and can place stress on bridge joints. • Increase in the frequency of the maintenance / replacement cycle.	• Can cause heaving of roads. Increased pothole formation.Edson built on muskeg. • Ice may form on the surfaces, which become slippery and dangerous for pedestrians and vehicles.	• Increased potential for water issues on roads with improper crowning, sloping, and ditching. • Potential for soft shoulders that could lead to vehicles slipping off the road. • Potential for inadequately sized drainage structures to become overwhelmed. • An increase in the potential for drainage structures below roads to become blocked with debris washed into and transported by streams. • An increase in the potential for failures of slopes with stability issues above or below roads.	•	• Wildfires and associated smoke can close roads/highways restricting access in/out of Town. • Potential damage to roads in burned over areas and roads used for emergency response by heavy vehicles and equipment.		
Municipal Services		Alleys	Poor	21%	• gravel (helps reduce flow of water into stormwater system)	•	•	• Gravel slows the flow of water.	•	•		
		Bridges	Poor	33%	• Steel. Bridge and culvert inspection planned 1 ped. Bridge decommissioned, all ped. bridges are poor condition (all to be assessed as part of parks assessment). Centennial Park ped bridge is in good condition	• Heat-induced damage to asphalt pavements can increase the risk of vehicle accidental loads, rutting, potholes, and place stress on bridge joints. • Increase in the frequency of the maintenance / replacement cycle	• May damage concrete structures. • Increase in the frequency of the maintenance / replacement cycle. • Ice may form on the surfaces, which become slippery and dangerous for pedestrians and vehicles.	• Great potential for ponding issues. • Greater potential for debris accumulations on bridge to be washed into watercourses. • Higher risk of scouring, erosion, bridge side-slope failure, and foundation settlement.	•	•		
		Culverts	Fair	46%	• concrete, corrugated steel pipe (some under capacity - many designed in the 1930s/40s)	•	• Heaving of culverts • Possible localized flooding due to plugged catch basins.	• Potential for overtopping of culverts.	•	•		
		Sidewalks	Good	60%	• safe-sidewalks assessment - 95% are broken heaving sidewalks concrete (some asphalt parkways for parks, in poor conditions to be assessed as of park assessment)	•	• Freeze-thaw can cause heaving and accelerated deterioration of sidewalks. • Risk of spalling and cracking of	•	•	•		

Asset	Major Infrastructure Components	Subcomponents	Average Condition	Remaining Service Life	Asset Condition Notes and Workshop Comments	Seasonal Change (Higher Average Temperatures) & Extreme Heat	Extreme Cold and Freeze Thaw	Heavy Rainfall & Riverine/ Overland Flooding	Extreme Events (Severe Storms, High Winds & Heavy Snowfall)	Drought & Wildfires	Other Climate Hazards and Impacts	Planned Asset Condition Assessment
							roads, parking lot and sidewalk surfaces. • Ice may form on the surfaces, which become slippery and dangerous for pedestrians and vehicles.					
		Signs	Very Good	83%		•	•	• Wind loads may affect stability of fence, poles, signage and equipment connected to the building.	•	•		
Municipal Services	**Solid Waste Management**				•	• Increased site management to reduce the risk of subsidence and slope instability from drying out of soils and wetting due to heavy rainfall. • Increased hot weather events (summer) will increase fires at the landfill. • Increased solar exposure can decrease material and equipment life expectancy. • Extreme hot temperatures could overwhelm the capacity of the cooling systems needed to support the building user demands and will result in increased energy consumption. • Excessively high temperatures could cause failure of on-site electrical components including transformers.	• May damage concrete structures.	• Extreme rainfall can cause excess leachate unable to be managed by treatment system.	• Snow accumulation could hinder operations and maintenance activities. • High winds can pull up garbage and deposit it in neighboring communities.	•		

Asset	Major Infrastructure Components	Subcomponents	Average Condition	Remaining Service Life	Asset Condition Notes and Workshop Comments	Seasonal Change (Higher Average Temperatures) & Extreme Heat	Extreme Cold and Freeze Thaw	Heavy Rainfall & Riverine/ Overland Flooding	Extreme Events (Severe Storms, High Winds & Heavy Snowfall)	Drought & Wildfires	Other Climate Hazards and Impacts	Planned Asset Condition Assessment
Municipal Assets	**Ecological Assets & Parks**	Urban forest, parkland, wetlands, etc.	Good		•	• Higher temperatures will result in increased water demand for managed vegetation around facilities. • Combined with lower summer precipitation hotter temperatures could result in increased vegetation mortality and need for replacement. • Warmer temperatures could increase the potential for insect outbreaks that could negatively affect trees and other vegetation. • An increase in vegetation mortality will result in increased woody debris accumulations on the ground and an increase in forest fuel hazard. • Warmer temperatures in water bodies will increase the duration of conditions where algal blooms occur.	• Freeze thaw events can damage vegetation and increase slope stability issues in susceptible areas.	• May result in increased localized flooding and closure of parks. • Increased soil saturation associated with flooding can make trees more vulnerable to mortality and windthrow. • Higher stream flows resulting from major precipitation events can entrain woody debris, scour channels, and lead to erosion, sediment deposition and flooding downstream. • Stream channels containing large accumulations of woody debris and sediment could release suddenly during high flows and damage bridge and culvert structures downstream. • Periods of prolonged rain and saturated soils can lead to slope failures in susceptible areas. Such failures can introduce considerable amounts of woody debris and sediment to watercourses • Scouring of stream channels and the deposition of fine sediments entrained during storms can damage habitat for fish and other aquatic species.	• Snow accumulation can increase loading on trees resulting in falling trees and branches. • Extensive snow and ice damage can change the structure and composition of forest stands. • Snow damage can lead to a buildup of woody debris and increase forest fuel hazard. • Potential for high stream flows and flooding if rapid melt due to rain on snow event. • Snow hampers wildlife movement and foraging.	• Potential increase in the conditions (hot temperatures, low humidity, dry fuels, and high winds) that lead to large damaging wildfires. • A major impact on natural assets is the direct loss of forests and vegetation and impacts to affected wildlife species including the loss of the habitat of species at risk. • An increase in the potential for impacts to natural areas during emergency response (pumping from water bodies, clearing of areas for fire lines or staging areas, impacts on wells from retardant use/drops).		
Municipal Assets	**Parks**	Spray Parks			• Water park, quite popular with residents	• Operations shutdown because of high water demand.	•	•	•	• Drought may impact availability of park due to water restrictions.		
	Cemeteries	Edson And Greenwood Cemeteries			• Lots of trees, Provincial requirement of municipality to maintain graves. Municipality needs to have insurance for cemeteries?	• Extreme temperatures increase risk of plant and tree morbidity.	•	•	• Risk of damage to trees can result in damage to headstones.	• Drought increases risk of plant and tree morbidity.		

Asset	Major Infrastructure Components	Subcomponents	Average Condition	Remaining Service Life	Asset Condition Notes and Workshop Comments	Seasonal Change (Higher Average Temperatures) & Extreme Heat	Extreme Cold and Freeze Thaw	Heavy Rainfall & Riverine/ Overland Flooding	Extreme Events (Severe Storms, High Winds & Heavy Snowfall)	Drought & Wildfires	Other Climate Hazards and Impacts	Planned Asset Condition Assessment
	Supporting Systems	Operations & Maintenance		•	•	• Extreme weather working conditions may lead to delay of regularly scheduled maintenance procedures. • Reduction of productivity of operations staff due to heat stress. • Droughts can impact fire suppression abilities.	• Increased slip and fall hazards.	• Flooding and extreme weather events are likely to create access issues	• Increased snowfall could lead to increase snow removal needs and could challenge accessibility. • Snow and ice accumulation can impact employees getting to locations as needed. • Snow / ice loads can impact communication systems (e.g., tree falling). • Climatic emergencies cause strain on resources such as staffing and budgets. • Power outages and associated impacts.	• Fires tie up operational staff as their projects are temporarily delayed as many of them attend to fighting or managing the fire response.	•	•
Buildings Built Assets	**Airport**	Maintenance Garage, Shed And Terminal	Terminal - very poor	19%	• trying to acquire a new hanger, would move maintenance garage if acquired	• Increased solar exposure can decrease material and equipment life expectancy. • Extreme hot temperatures could overwhelm the capacity of the cooling systems needed to support the building user demands and will result in increased energy consumption. • Excessively high temperatures could cause failure of on-site electrical components including transformers. • Increased use of fans at workspaces in inadequately cooled buildings could overload electrical systems.	• Winter freeze thaw damages concrete and mortar structures.	• Increased potential for roof leaks and drainage issues in gutters and around building envelope. • Increased rain increases the wear on exterior membranes and envelope systems which leads to more frequent repair and replacement. • May result in access issues. • Increased ground water could result in greater hydrostatic pressure on foundation walls resulting in increased below grade water ingress.	• Potential for wind and lightning damage. • Wind driven rains cause water to enter under bay doors into the building. • High winds can damage roof mounted equipment (grilles, ducts, filters, HVAC equipment) • Heavy snow accumulation increases loading on roof structures. • Snow accumulation could hinder operations and maintenance activities. • Snow accumulation on large trees can caused limb failure and building damage if close proximity to structures. • Snow accumulation on roof can become a falling snow hazard.	• Smoke limits visibility at airports. • Poor air quality in building, health concerns. • Increased likeliness of wildfire events, could result in evacuations, closures or damage to buildings.		X
Buildings Built Assets	**Firehall**		Fair	59%	• 30-yr old, bays face west - high wind driven rain can lead to water coming under doors; no issues with freezing shut					• Poor air quality in building, health concerns. • Increased likeliness of wildfire events, could result in evacuations, closures or damage to buildings.		X
	Civic Centre		Poor	39%	• town hall; aging (beyond designed lifecycle); roof surface near end of life (flat roof, roof drains) major issues with one of the drains; boiler upgrade in 2022; AC (not central)							
	Public Works Shop		Poor/Fair	59%	• flat roof, redone last year							X
Buildings Built Assets	**Library**		Poor/Fair	26%	• Aging, nearing end of life but renovation and expansion has been approved (including HVAC/AC)							

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	Medical Centre		Poor	38%	• replaced a furnace							X
	Museum		Fair	59%	• new furnaces							X
	Old RCMP Building		Poor	39%	• roof needs to be replaced (next year is the aim); home of the food bank (interior renos)							X
	Garages	Transfer Station And Willmore Park	Fair	59%	• used as storage buildings							
	Griffith's Park Centre		Poor	39%	• HVAC system, AC upgrades completed; no current issues with roof but at end of life							X
	Pavilion		Good	79%	• open air stage	• Increased solar exposure can decrease material and equipment life expectancy.	• Winter freeze thaw damages concrete and mortar structures.	• Increased potential for roof leaks and drainage issues in gutters and around building envelope. • May result in access issues.	• Possible uplift to stage cover by high winds. • Snow accumulation on large trees can caused limb failure and building damage if close proximity to structures. • Snow accumulation on roof can become a falling snow hazard.	• Increased likeliness of wildfire events, could result in evacuations, closures or damage to buildings		
	Picnic Shelter		Very Poor	0%	• a couple of gazebos on the parks land							
	Glenwood Park Changing Rooms		Good	78%	• community on the far end of the west side of town							
	Salt And Sand Shed		Fair	59%	•	• Increased solar exposure can decrease material and equipment life expectancy. • More dust control by water trucks may be needed to prevent particulate matter from leaving the site as material piles dry in larger quantity and frequency. • Warmer air has a higher holding capacity for moisture and therefore a higher relative humidity which can increase the amount of salt in a soluble state and speed up the degradation process on asphalt structures.	• Increased potential for roof leaks and drainage issues in gutters and around building envelope.	• Increased potential for roof leaks and drainage issues in gutters and around building envelope. • May result in increased site runoff and loss of sand / salt.	•	•		

Appendix B – Edson Area Climate Profile

Climate Profile – Edson, Alberta

August 30, 2023

Prepared For:

Town of Edson, Alberta

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1.0 INTRODUCTION

1.1 DESCRIPTION OF CLIMATE PROFILES

Climate is usually defined as the "average weather," or more rigorously, as the statistical description in terms of the mean and variability of meteorological variables such as temperature, precipitation and wind over a period of time. Climate profiles are important tools that describe what climate trends have been occurring in recent history (i.e., over the last 30 years or longer), and also describe future climate conditions to help inform planners, stakeholders and decision makers in managing the climate change risks and planning for appropriate adaptation measures. Climate profiles rely on historical climate records (usually in the form of meteorological data measured at weather stations) to describe climate from recent history, and on climate projections (developed by global climate models or GCMs). The historical climate profile puts future climate projections into context: the performance of the infrastructure from the past can be compared to both historical and future climate to better understand what (if any) adaptation measures should be implemented to ensure better performance in the future.

When developing a profile of the historic climate of an area, the most valuable data is typically temperature, precipitation, and wind. Meteorological data from the last 30 years is preferred to help provide a representative estimate of the climate of recent history at a given location – though longer periods are of benefit in that they add even more to the story of an area's historical climate. Environment and Climate Change Canada (ECCC) provides the largest database of observational historical climate data in Canada. In addition to assembled climate data from weather stations, gridded data products are available and provide additional climate data resources. These gridded data products include the NRCANmet gridded dataset, produced by Natural Resources Canada (NRCan), which provides daily maximum and minimum temperature and total precipitation data on a ~10 km grid resolution over Canada for the 1950-2013 time period (Hopkinson et al., 2011; McKenney et al., 2011). Although observational data from a weather station is preferable, the NRCANmet data is interpolated from quality-controlled but unadjusted station data from the National Climate Data Archive of Environment and Climate Change Canada, which is widely used by industry and researchers (Hutchinson et al., 2009).

Projections of future climate are based on data produced by GCMs. It is not recommended to rely only on one or two of these GCMs to estimate future climate. Instead, an average of several GCMs tends to give a more reliable estimate of future climate. There are nearly 40 GCMs that have contributed to the Fifth Coupled Model Intercomparison Project (CMIP5; Taylor et al., 2012), which forms the basis of Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (IPCC, 2013). CMIP5 model performance have undergone evaluation and validation, both individually and collectively (IPCC, 2013). When possible, model evaluations are completed by comparing model output with observations and analyzing the resulting difference. In cases when observations are not available or insufficient, model evaluations are completed through intercomparison of model results, providing quantification of model uncertainty via inter-model spread. The Pacific Climate Impacts Consortium (PCIC) has taken a subset of 27 of the CMIP5 models and produced reliable, high-resolution (~10 km) downscaled climate projections for Canada, referred to as Canadian Downscaled Climate Scenarios – Univariate (CMIP5) or CanDCS-U5 for short (Cannon, 2015; Cannon et al., 2015). These PCIC downscaled CanDCS-U5 projections provide the climate projections utilized in this climate profile.

> The IPCC is the international body for assessing the science related to climate change. The IPCC was set up in 1988 by the World Meteorological Organization (WMO) and United Nations Environment Programme (UNEP) to provide policymakers with regular assessments of the scientific basis of climate change, its impacts and future risks, and options for adaptation and mitigation.
>
> IPCC assessments provide a scientific basis for governments at all levels to develop climate related policies, and they underlie negotiations at the UN Climate Conference – the United Nations Framework Convention on Climate Change (UNFCCC). The assessments are policy-relevant but not policy-prescriptive: they may present projections of future climate change based on different scenarios and the risks that climate change poses and discuss the implications of response options, but they do not tell policymakers what actions to take.

Future climate conditions will depend on the concentration of greenhouse gases (GHGs) in the atmosphere. Various scenarios have been developed to estimate GHG emission concentrations into the future. These GHG concentration trajectories provide the driving conditions used by Global Climate Models. There are four emission scenarios, the Representative Concentration Pathways (RCPs; van Vuuren et al., 2011)[1], which were adopted by the IPCC for its Fifth Assessment Report (IPCC, 2013). These RCPs are based on various future greenhouse gas concentration scenarios, ranging from low emissions (RCP2.6) to moderate emissions (RCP4.5 and RCP6.0) to high emissions (RCP8.5) trajectories. This climate profile will focus on the high emissions RCP8.5 greenhouse gas concentrations scenario. Of the four RCPs, current global cumulative CO_2 emissions are closer to following the RCP8.5 pathway (Smith and Myers, 2018; Schwalm et al., 2020), despite global agreements/targets for GHG emissions reductions.

1.1.1 Levels of Confidence in Projections

Future climate conditions presented in this climate profile are retrieved from climate projections produced by downscaled GCMs, specialized literature, and professional judgement of Stantec's climate scientists. Some climate variables can be projected into the future with more confidence than others. The level of confidence in climate projections is dependent on the understanding of the processes involved in the climate phenomena, ability of climate models to simulate the phenomena, degree of agreement among the climate models (e.g., range of uncertainty), and the supporting evidence (e.g., theory, specialized literature, expert judgement, etc.). For example, projections based on GCMs and downscaling of such models are considered:

- Adequate (high confidence) for general temperature and precipitation projections,

[1] RCP: Representative Concentration Pathways – a greenhouse gas concentration (not emissions) trajectories adopted by the Intergovernmental Panel on Climate Change (IPCC) for its fifth Assessment Report (AR5) in 2013/2014.

Introduction

- Less adequate (moderate confidence) for extreme parameters, such as extreme rainfall, and
- Inadequate for combined events (low confidence) such as freezing rain.

Combined or complex climate variables are normally inferred from other climate variables and result in lower confidence for projections. For example, freezing rain is a complex process and the projected prevalence of freezing rain events under future climate conditions is not as well understood as other variables such as temperatures.

1.2 CLIMATE PROFILE FOR EDSON

A climate profile was required for the Edson region to assess the climate risks to the Town. The climate profile for the region required a review of available historical observed weather data and climate projection data for the region. As shown in Table 1 and Figure 1, five Environment and Climate Change Canada (ECCC) weather stations were identified with records covering recent historical climate for the region. The Edson A (Station ID: 3062244) and Edson Climate (Station ID: 3062246) weather stations were used as the primary data sources to establish the baseline periods for the region (1981-2010 and 1991-2020).

Table 1: Summary of Weather Monitoring Stations in Edson Region

Weather Monitoring Station	Station ID	Latitude, Longitude	Elevation	Complete Observational Record (Daily Data)	Data Availability (% of record)
Edson	3062239	53°34'44.000" N, 116°27'54.000" W	926.9 m	2010-2023	Temperature: 91% Precipitation: 91% Snow: 0% Wind: 76%
Edson A	3062242	53°35'42.000" N, 116°28'51.000" W	925.4 m	1992-2007	Temperature: 88% Precipitation: 85% Snow: 66% Wind: 21%
Edson A	3062244	53°35'00.000" N, 116°28'00.000" W	927.2 m	1970-1998	Temperature: 86% Precipitation: 86% Snow: 86% Wind: 80%
Edson AWOS A	3062245	53°34'44.000" N, 116°27'54.000" W	926.9 m	2006-2010	Temperature: 97% Precipitation: 92% Snow: 0% Wind: 94%
Edson Climate	3062246	53°34'49.007" N, 116°27'12.007" W	927.0 m	1996-2023	Temperature: 99% Precipitation: 87% Snow: 40% Wind: 34%

Introduction

Figure 1: Weather Monitoring Stations in Edson (Modified Figure from Google Earth)

The time horizon of 1981-2010 was selected for establishing baseline climate conditions for the Edson region. The climate for the 1991-2020 time horizon is also presented in this climate profile to provide insight into current conditions and recent climate changes for the Edson region. The climate for the 2030s (time horizon of 2011 to 2040) is presented to evaluate how recent trends correlate with the projections in the near future. The 2050s (2041 to 2070) and 2080s (2071 to 2100) time horizons are presented as longer-term climate projections, which will highlight the variation between the various future GHG scenarios presented to help inform stakeholders and decision-makers of the climate risks to the infrastructure in the region. The projected climate values represent the projected average over a 30-year time period in the future.

2.0 ASSUMPTIONS AND LIMITATIONS

The climate profile for the Project was completed using the best information available to the assessment team at the time of the study. The climate profile presents data and discussions for the current climate (1981-2010 and 1991-2020) and future climate for the 2030s (2011-2040), 2050s (2041-2070) and 2080s (2071-2100). The climate data and trends (current and future projections) used in this climate profile were obtained through various sources. Cross-verification between climate information sources was conducted where possible to identify potential discrepancies between the data sources used.

Historical climate data and trends are based on observational data from Environment and Climate Change Canada (ECCC) weather stations. Data availability of ECCC weather stations is considered in the analysis. Extreme weather events, such as convective heavy rainfall, are often very localized, so it is possible the weather stations utilized in this analysis may not have captured or provide representative measurement of the intensity of some of these events. This uncertainty is considered during the analysis. The ECCC weather station records were also supplemented with gridded NRCANmet data as necessary. Although observational data from a weather station is preferable, the NRCANmet data is interpolated from quality-controlled but unadjusted station data from the National Climate Data Archive of Environment and Climate Change Canada, which is widely used by industry and researchers (Hutchinson et al., 2009).

Future climate projections used in this study are based on the Fifth Coupled Model Intercomparison Project (CMIP5) climate projections data. The Pacific Climate Impacts Consortium (PCIC) has taken a subset of 27 of the CMIP5 models and produced reliable, high-resolution (~10 km) downscaled climate projections for Canada, referred to as Canadian Downscaled Climate Scenarios – Univariate (CMIP5) or CanDCS-U5 for short (Cannon, 2015; Cannon et al., 2015). The CanDCS-U5 projections, for the RCP8.5 emissions scenario, provide the climate projections utilized in this climate profile. All climate models have inherent shortcomings in fully and accurately representing the real climate system. Therefore, it is not recommended to rely only on one or two GCMs to estimate future climate. Instead, an average of several GCMs (a multi-model mean) tends to give a more reliable estimate of future climate (IPCC, 2013; 2021). The use of ensembles and multi-model means is common in climate science and is strongly encouraged as “best practice” (IPCC, 2013; 2021). Using ensembles and multi-model means provide insight into uncertainties in the climate model projections.

3.0 MEAN TEMPERATURE

3.1 ANNUAL AND SEASONAL AVERAGE

Summaries of mean historical temperature averaged for the baseline periods of 1981-2010 and 1991-2020 for Edson and projected average change in mean temperature from the baseline under RCP8.5 are shown in Table 3.

Annual and seasonal temporal averages for daily mean temperature in Edson are shown in Figure 2 and Figure 3. Annual and seasonal mean temperature is projected to increase from the 1981-2010 baseline, with the greatest change (+5.6°C) occurring in the summer season.

Table 2: Historical and Projected Mean Temperature under RCP8.5 in Edson

Season	Average Mean Temperature 1981-2010 (°C)	Average Mean Temperature 1991-2020 (°C)	Projected Mean Temperature (Change in Mean Temperature from 1981-2010 Baseline) (°C)		
			2030s	2050s	2080s
Annual	2.6	2.7	3.9 (+1.3)	5.6 (+3.0)	7.7 (+5.1)
Winter	-9.4	-9.4	-8.0 (+1.4)	-6.2 (+3.2)	-4.2 (+5.2)
Spring	3.1	3.0	4.3 (+1.2)	5.7 (+2.6)	7.6 (+4.5)
Summer	14.1	14.3	15.5 (+1.4)	17.4 (+3.3)	19.7 (+5.6)
Autumn	2.4	2.6	3.6 (+1.2)	5.4 (+3.0)	7.4 (+5.0)

Mean Temperature

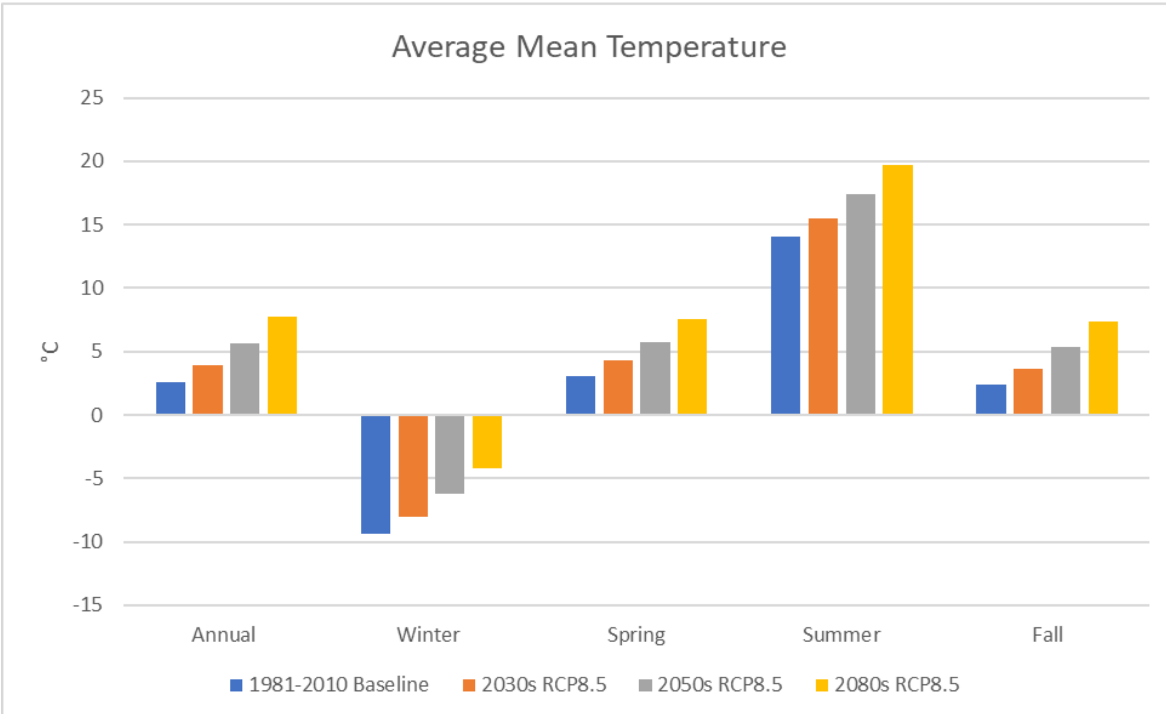

Figure 2: Annual and Seasonal Temporal Averages – Historical and Projected (RCP8.5) Average Mean Temperature in Edson

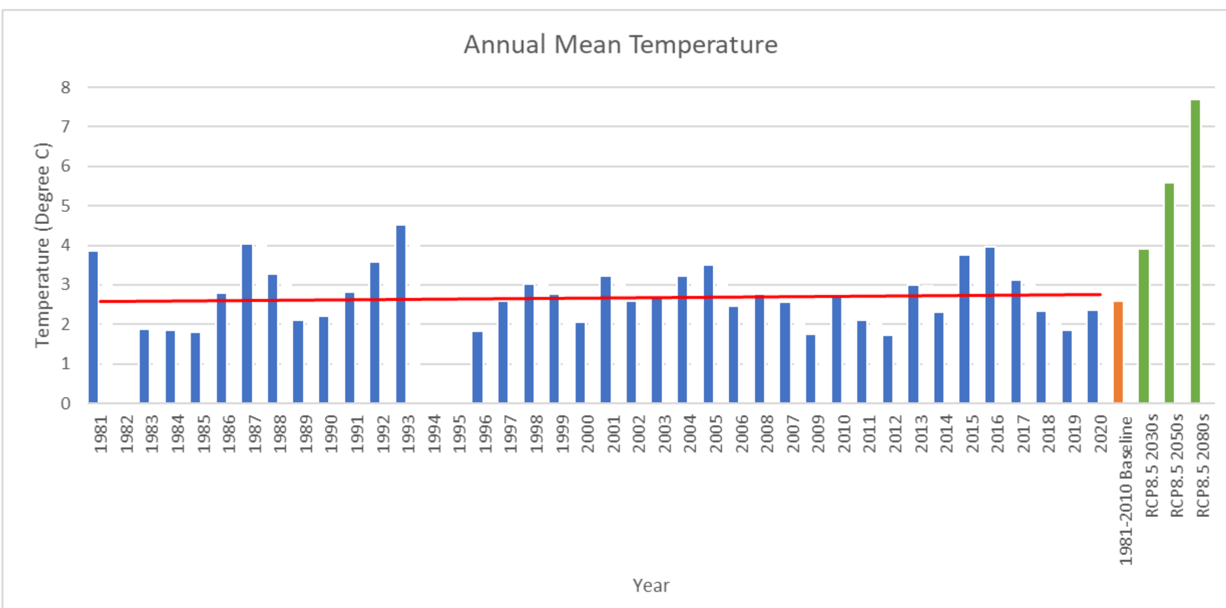

Figure 3: Average Annual Mean Temperature (1981-2020) and Projected Average Mean Temperature (RCP8.5) in Edson (Note: Annual Mean Temperature for 1982 is 0°C. 1994 and 1995 have insufficient data for analysis.)

4.0 MAXIMUM TEMPERATURE

4.1 ANNUAL AND SEASONAL AVERAGE

Summaries of maximum historical temperatures averaged from the baseline periods of 1981-2010 and 1991-2020 for Edson and average change in maximum temperature from the baseline are shown in Table 3.

Annual and seasonal temporal averages for daily maximum temperature in the region are shown in Figure 4 and Figure 5. The maximum annual and seasonal temperature is projected to increase from the 1981-2010 baseline, with the greatest increase occurring in the summer season (+5.9°C).

Table 3: Historical and Projected Maximum Temperature under RCP8.5 in Edson

Season	Average Maximum Temperature 1981-2010 (°C)	Average Maximum Temperature 1991-2020 (°C)	Projected Maximum Temperature (Change in Maximum Temperature from 1981-2010 Baseline) (°C)		
			2030s	2050s	2080s
Annual	9.4	9.3	10.7 (+1.3)	12.3 (+2.9)	14.3 (+4.9)
Winter	-2.7	-2.9	-1.5 (+1.2)	-0.1 (+2.6)	1.7 (+4.4)
Spring	10.2	9.9	11.3 (+1.1)	12.7 (+2.5)	14.6 (+4.4)
Summer	20.9	21.1	22.4 (+1.5)	24.3 (+3.4)	26.8 (+5.9)
Autumn	8.9	8.9	10.0 (+1.1)	11.7 (+2.8)	13.8 (+4.9)

Maximum Temperature

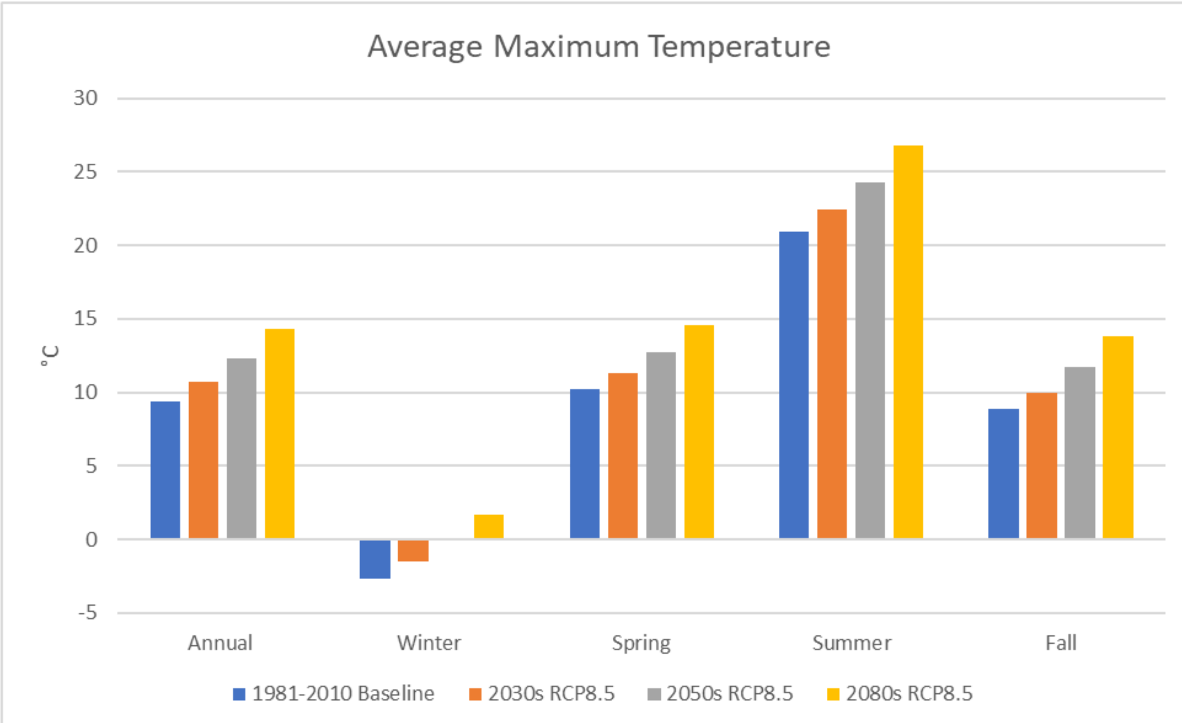

Figure 4: Annual and Seasonal Temporal Averages – Historical and Projected (RCP8.5) Average Maximum Temperature in Edson

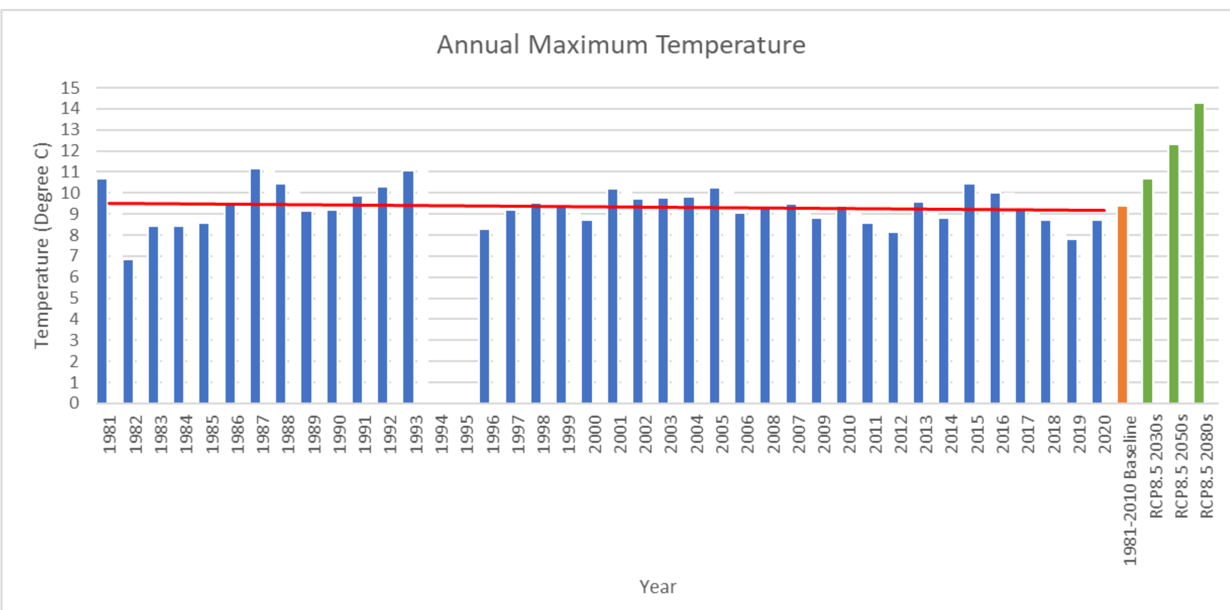

Figure 5: Average Annual Maximum Temperature (1981-2020) and Projected Average Maximum Temperature (RCP8.5) in Edson (Note: 1994 and 1995 have insufficient data for analysis)

4.2 EXTREME MAXIMUM TEMPERATURE FREQUENCY

Extreme heat can negatively affect some infrastructure. The average number of days with daily maximum temperatures greater than 30°C and 35°C in Edson is shown historically and for future time periods in Table 4 and Table 5, respectively. The frequency of extreme high temperatures is projected to increase for the region across all time periods.

Table 4: Occurrence of Maximum Daily Temperature > 30°C, Edson (RCP8.5)

	Average Annual Number of Days with Max. Temp > 30°C				
	1981-2010	1991-2020	2030s	2050s	2080s
Days/year	2.1	2.0	5.0	13.5	30.5

Table 5: Occurrence of Maximum Daily Temperature > 35°C, Edson (RCP8.5)

	Average Annual Number of Days with Max. Temp > 35°C				
	1981-2010	1991-2020	2030s	2050s	2080s
Days/year	0	0	~0	0.3	4.4

*During the June 2021 heat dome event, the Edson Climate weather station record daily maximum temperatures of 36.2°C, 38.6°C, and 38.8°C on June 28-30, respectively.

Maximum Temperature

4.3 HEAT WAVES

A heat wave can be defined as three (3) or more consecutive days with a daily maximum temperature greater than 30°C. Alternatively, a heat wave can also be defined as two (2) or more consecutive days with a daily maximum temperature greater than 29°C and a daily minimum temperature greater than 14°C, aligning with ECCC heat warning criteria. The historical and projected frequency of heat waves as previously defined are presented in Table 6 and Table 7, respectively. The number of heat waves are projected to increase for Edson over all time periods.

Table 6: Average Annual Number of Heat Waves (3 or More Consecutive Days with Tmax > 30°C) for Edson (RCP8.5)

	Average Annual Number of Heat Waves (3 or More Consecutive Days with Tmax > 30°C)				
	1981-2010	**1991-2020**	**2030s**	**2050s**	**2080s**
Days/year	0.1	0.3	0.6	1.7	3.4

Table 7: Average Annual Number of Heat Waves (2 or More Consecutive Days with Tmax > 29°C and Tmin > 14°C) for Edson (RCP8.5)

	Average Annual Number of Heat Waves (2 or More Consecutive Days with Tmax > 29°C and Tmin > 14°C)				
	1981-2010	**1991-2020**	**2030s**	**2050s**	**2080s**
Days/year	~0.0	~0.0	0.1	1.2	3.8

5.0 MINIMUM TEMPERATURE

5.1 ANNUAL AND SEASONAL AVERAGE

Summaries of mean minimum historical temperature averaged for the baseline periods of 1981-2010 and 1991-2020 for Edson and projected average change in minimum temperature from the baseline are shown in the Table 8.

Annual and seasonal temporal averages for daily minimum temperature in the region are shown in Figure 6 and Figure 7. The minimum annual and seasonal temperature is projected to increase from the 1981-2010 baseline, with the greatest increase (+6.1°C) occurring in the winter season.

Table 8: Historical and Projected Minimum Temperature (RCP8.5) in Edson

Season	Average Minimum Temperature 1981-2010 (°C)	Average Minimum Temperature 1991-2020 (°C)	Projected Minimum Temperature (Change in Minimum Temperature from 1981-2010 Baseline) (°C)		
			2030s	2050s	2080s
Annual	-4.2	-3.9	-2.8 (+1.4)	-1.0 (+3.2)	1.1 (+5.3)
Winter	-16.1	-15.9	-14.4 (+1.7)	-12.2 (+3.9)	-10.0 (+6.1)
Spring	-3.9	-3.9	-2.7 (+1.2)	-1.1 (+2.8)	0.7 (+4.6)
Summer	7.1	7.5	8.4 (+1.3)	10.2 (+3.1)	12.3 (+5.2)
Autumn	-4.2	-3.6	-2.9 (+1.3)	-1.1 (+3.1)	0.9 (+5.1)

Minimum Temperature

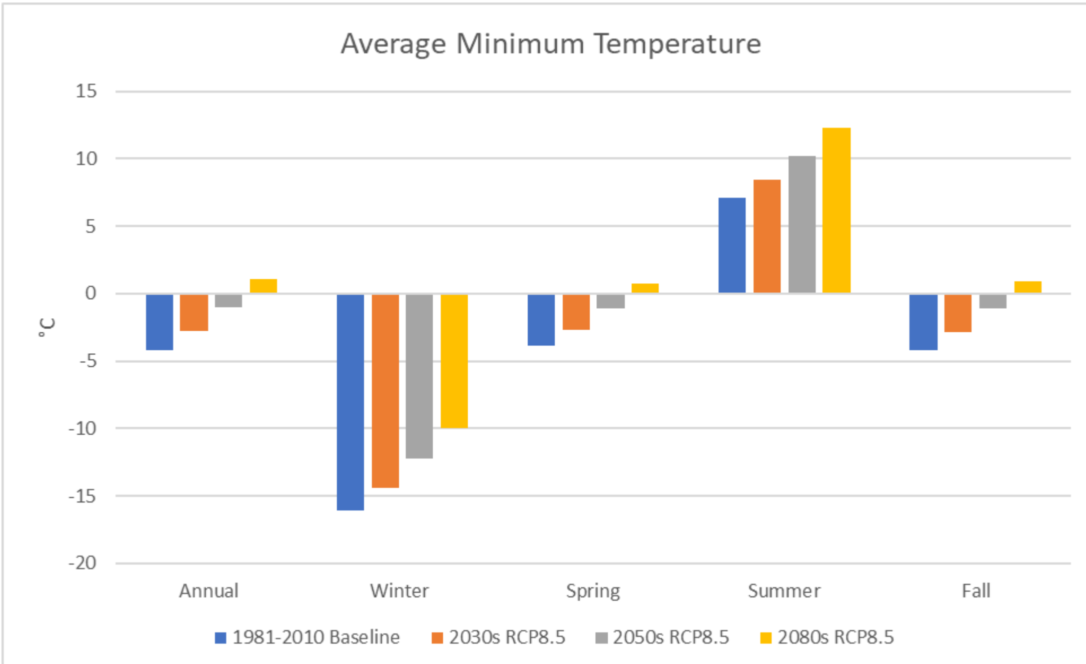

Figure 6: Annual and Seasonal Temporal Averages – Historical and Projected (RCP8.5) Average Minimum Temperature in Edson

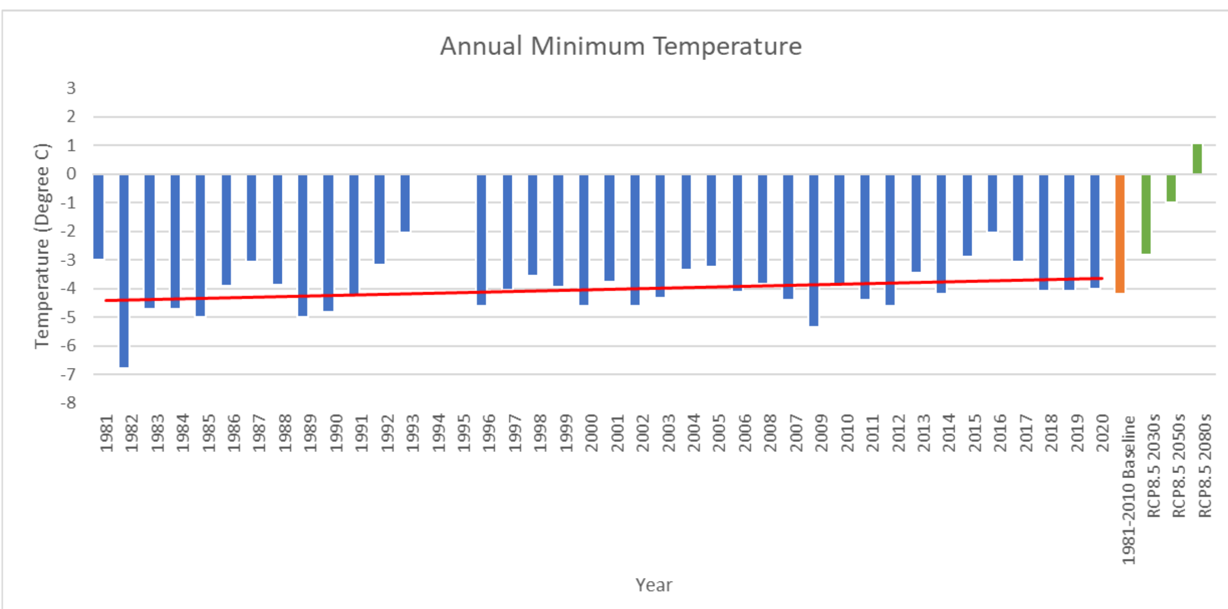

Figure 7: Average Annual Minimum Temperature (1981-2020) and Projected Average Minimum Temperature (RCP8.5) in Edson (Note: 1994 and 1995 have insufficient data for analysis)

5.2 EXTREME MINIMUM TEMPERATURE FREQUENCY

It can also be useful to view projected increases in temperatures as the change in the occurrence of days with a temperature lower than a certain extreme cold threshold. The climate projections for the occurrence of days with temperatures less than -25°C and -30°C are presented in Table 9 and Table 10, respectively. The frequency of extreme minimum temperatures is projected to decrease for Edson over all time periods.

Table 9: Occurrence of Minimum Temperature < -25°C, Edson (RCP8.5)

	Average Annual Number of Days with Min. Temp < -25°C				
	1981-2010	1991-2020	2030s	2050s	2080s
Days/year	16.6	15.5	11.5	6.1	1.8

Table 10: Occurrence of Minimum Temperature < -30°C, Edson (RCP8.5)

	Average Annual Number of Days with Min. Temp < -30°C				
	1981-2010	1991-2020	2030s	2050s	2080s
Days/year	8.7	7.2	4.5	1.8	0.1

While the number of days with a minimum temperature colder than -30°C are projected to become rarer under climate change, the occurrence of extreme cold events is not expected to vanish completely. The amplified warming in the Arctic under climate change has been linked to a more unstable Polar Vortex and the occurrence of extreme weather in mid-latitudes (30 – 60°N) (Francis and Vavrus, 2012; Coghlan, 2014; Kretschmer et al., 2018). Subsequent wintertime southward dips in the Polar Vortex have the potential to result in extreme cold events such as those in recent winters (2012-13, 2013-14, 2017-18, 2018-19, and 2020-2021) and could impact the Edson region. Furthermore, the effects of Polar Vortex events under climate change (Mitchell et al., 2012) are not well captured by climate models, meaning the future frequency of extreme cold events may be underestimated.

6.0 PRECIPITATION

6.1 TOTAL ANNUAL & SEASONAL ACCUMULATION

Total annual and seasonal precipitation in Edson for the recent historical periods of 1981-2010 and 1991-2020 and the percent change in total precipitation from the 1981-2010 baseline are shown in Table 11.

Total annual and seasonal precipitation in the region for future climate periods is shown in Figure 8 through Figure 10. Annual, winter, spring and fall precipitation is projected to increase in Edson with the largest percentage changes (+26.7%) in the spring season. Summer precipitation, however, is projected to remain steady overall.

Table 11: Historical Total Precipitation and Projected Percent Change from Baseline (RCP8.5) in Edson

Season	Mean Total Precipitation 1981-2010 (mm)	Mean Total Precipitation 1991-2020 (mm)	Projected Total Precipitation (mm) (Percent Change in Total Precipitation from 1981-2010 Baseline (%))		
			2030s	2050s	2080s
Annual	494.1	474.8	502.0 (+1.6%)	531.2 (+7.5%)	543.0 (+9.9%)
Winter	49.9	56.0	52.4 (+5.0%)	54.9 (+10.1%)	59.6 (+19.4%)
Spring	90.1	98.3	97.8 (+8.5%)	106.1 (+17.8%)	114.2 (+26.7%)
Summer	238.0	216.3	237.8 (-0.1%)	239.9 (+0.8%)	234.9 (-1.3%)
Autumn	103.5	96.4	104.4 (+0.9%)	110.8 (+7.1%)	116.3 (+12.4%)

Precipitation

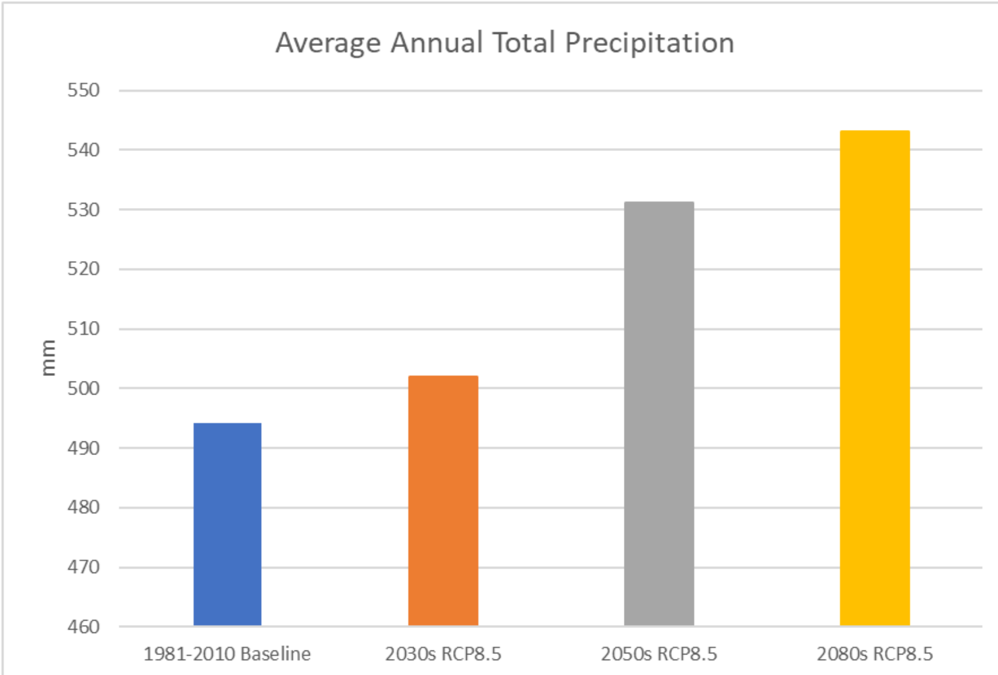

Figure 8: Average Annual Total Precipitation – Historical and Projected (RCP8.5) in Edson

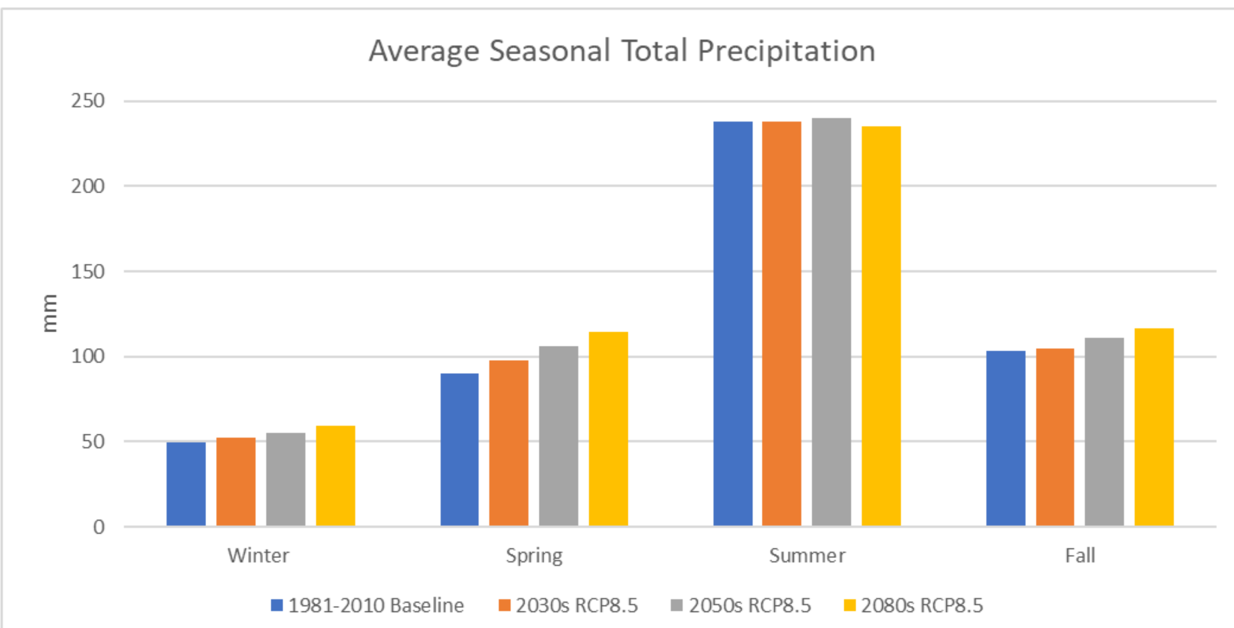

Figure 9: Average Seasonal Total Precipitation – Historical and Projected (RCP8.5) in Edson

Precipitation

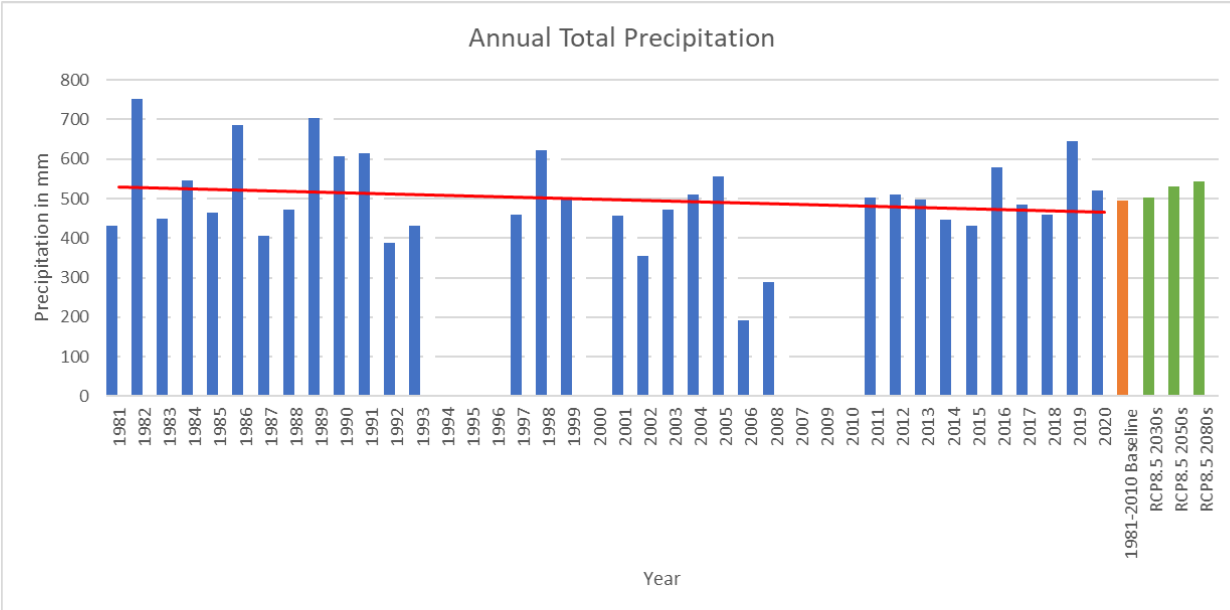

Figure 10: Average Annual Precipitation (1981-2020) and Projected Average Total Precipitation (RCP8.5) in Edson (Note: 1994-1996 and 2007-2010 have insufficient data for analysis)

6.2 INTENSITY-DURATION-FREQUENCY (IDF)

Evaluating historic and projected intensity-duration-frequency (IDF) rainfall data provides insight into how the intensity, duration, and frequency of precipitation events will change under future climate conditions. IDF data relates short-duration, high intensity rainfall with its frequency of occurrence. The Edson Climate (Station ID: 3062246) weather station provides 35 years of record of IDF data, over the 1970-2020 time period, and is provided to evaluate the future changes in intensity, duration, and frequency of precipitation events.

The Canadian Standards Association's (CSA) Rainfall Intensity-Duration-Frequency Guide (CSA PLUS 4013:19) and ECCC (2020) recommend using the Clausius-Clapeyron (C-C) relation method for estimating projected changes to short duration, high intensity precipitation events. The C-C relation is founded on the atmospheric physics theoretical relationship between air temperature and the holding capacity of the atmosphere (*i.e.,* the amount of water the air could potentially contain). The C-C relation indicates that there is, on average, a 7% increase in the air's holding capacity per 1°C of local warming. A similar or greater rate of increase in precipitation amounts is likely under a warming climate, dependent on the event duration. Rainfall vs. temperature relationships close to the C-C relation have been detected globally and regionally in observational studies (Westra et al., 2013; Panthou et al., 2014; Prein et al., 2016; Barbero et al., 2017). Therefore, the IDF projections presented in this assessment are calculated following the C-C relation method.

Precipitation

Total precipitation amount (mm) in specific time intervals (5 minutes to 24 hours) for various return periods (2 years to 100 years), are provided in Table 12 to Table 15. Under the RCP8.5 scenario, short-duration, high intensity precipitation events are projected to increase 9.2% for the 2030s, 22.5% for the 2050s, and 41.2% for the 2080s, relative to the historical data.

Table 12: Historical Precipitation Event Accumulation IDF Data (mm) – Edson Climate (Station ID: 3062246), 1970-2020

T (years)	2	5	10	25	50	100
5 min	6.6	9.1	10.8	13.0	14.5	16.1
10 min	9.8	12.8	14.9	17.5	19.4	21.3
15 min	11.9	15.4	17.7	20.6	22.8	25.0
30 min	14.3	18.7	21.6	25.2	27.9	30.6
1 h	16.1	21.3	24.7	29.0	32.2	35.4
2 h	18.9	25.2	29.3	34.6	38.5	42.3
6 h	25.3	31.8	36.1	41.6	45.6	49.6
12 h	32.1	41.4	47.5	55.3	61.0	66.7
24 h	42.2	54.7	63.0	73.5	81.3	89.0

Table 13: Projected Precipitation Event Accumulation IDF Data (mm), Edson Climate (Station ID: 3062246), RCP8.5, 2030s

T (years)	2	5	10	25	50	100
5 min	7.2	9.9	11.8	14.2	15.8	17.6
10 min	10.7	14.0	16.3	19.1	21.2	23.3
15 min	13.0	16.8	19.3	22.5	24.9	27.3
30 min	15.6	20.4	23.6	27.5	30.5	33.4
1 h	17.6	23.3	27.0	31.7	35.2	38.7
2 h	20.6	27.5	32.0	37.8	42.0	46.2
6 h	27.6	34.7	39.4	45.4	49.8	54.2
12 h	35.1	45.2	51.9	60.4	66.6	72.8
24 h	46.1	59.7	68.8	80.3	88.8	97.2

Table 14: Projected Precipitation Event Accumulation IDF Data (mm), Edson Climate (Station ID: 3062246), RCP8.5, 2050s

T (years)	2	5	10	25	50	100
5 min	8.1	11.1	13.2	15.9	17.8	19.7
10 min	12.0	15.7	18.3	21.4	23.8	26.1
15 min	14.6	18.9	21.7	25.2	27.9	30.6
30 min	17.5	22.9	26.5	30.9	34.2	37.5
1 h	19.7	26.1	30.3	35.5	39.4	43.4
2 h	23.2	30.9	35.9	42.4	47.2	51.8
6 h	31.0	39.0	44.2	51.0	55.9	60.8
12 h	39.3	50.7	58.2	67.7	74.7	81.7
24 h	51.7	67.0	77.2	90.0	99.6	109.0

Table 15: Projected Precipitation Event Accumulation IDF Data (mm), Edson Climate (Station ID: 3062246), RCP8.5, 2080s

T (years)	2	5	10	25	50	100
5 min	9.3	12.8	15.3	18.4	20.5	22.7
10 min	13.8	18.1	21.0	24.7	27.4	30.1
15 min	16.8	21.7	25.0	29.1	32.2	35.3
30 min	20.2	26.4	30.5	35.6	39.4	43.2
1 h	22.7	30.1	34.9	41.0	45.5	50.0
2 h	26.7	35.6	41.4	48.9	54.4	59.7
6 h	35.7	44.9	51.0	58.7	64.4	70.0
12 h	45.3	58.5	67.1	78.1	86.1	94.2
24 h	59.6	77.2	89.0	103.8	114.8	125.7

6.3 1-, 3-, AND 5-DAY ACCUMULATION

Record 1-, 3-, and 5-day precipitation accumulations from the Edson A (Station ID: 3062244) and Edson Climate (Station ID: 3062246) weather stations for the years from 1981 to 2020 are shown in Table 16.

Projections of precipitation extremes have higher uncertainty. Since climate model grid box precipitation projections are usually interpreted as spatially averaged values, the outputs tend to reduce extreme precipitation magnitudes (Chen and Knutson, 2008; Seneviratne et al., 2012), contributing to the systematic underestimation of precipitation. Considering the Clausius-Clapeyron relation, it is probable an increasing trend in precipitation accumulation would extend to longer rainfall duration events, similar to those projected for IDF data (see Section 6.2).

Table 16: Historical Precipitation Event Accumulation (mm) – Edson A (Station ID: 3062244) and Edson Climate (Station ID: 3062246)

	Record Maximum Precipitation Accumulation in Edson (1981-2020)		
	1-day	**3-day**	**5-day**
Precipitation (mm)	72.7	92.7	136.5
Event End Date	17-July-86	17-July-86	17-July-86

6.4 SNOW

The historical occurrences of snowfall in the Edson region, based on the observations of ECCC weather stations for 1981-2010 time period are shown in Table 17. While historical annual total snowfall over the 1981-2005 time period shows a steady trend in the region (Figure 11), annual total snowfall over the 1971-2005 time period shows a declining trend for the region (Figure 12).

Table 17: Days with Snowfall - Edson A (Station ID: 3062244) and Edson Climate (Station ID: 3062246)

Snowfall	Days/year
≥ 0.2 cm	50.4
≥ 5 cm	9.0
≥ 10 cm	2.6
≥ 25 cm	0.1

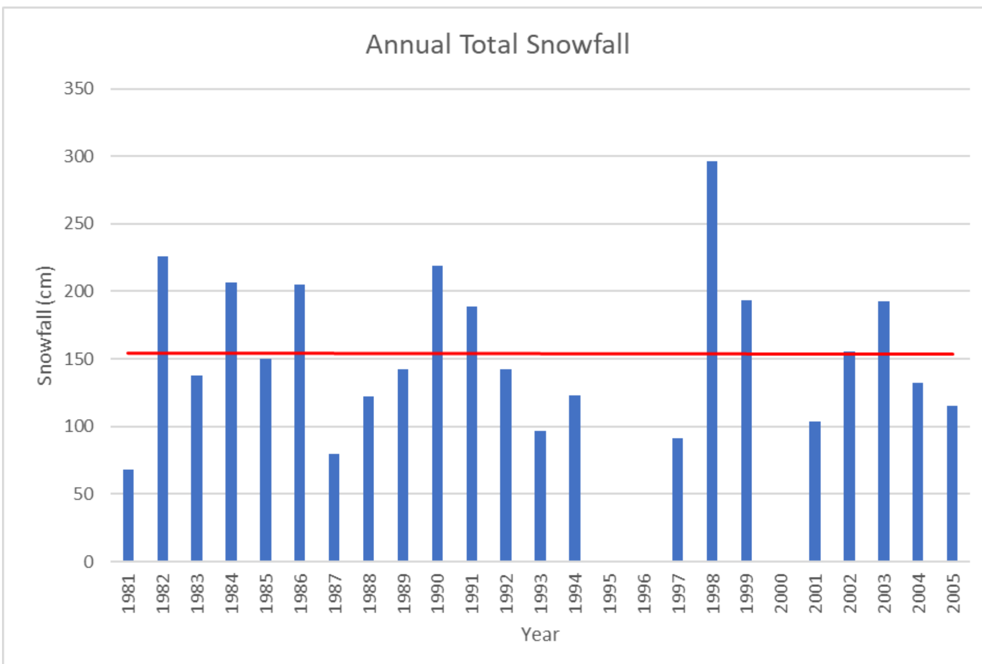

Figure 11: Total Annual Snowfall from Edson A (Station ID: 3062244) and Edson Climate (Station ID: 3062246) Weather Stations for 1981-2005 (Note: 1995, 1996, and 2000 have insufficient data for analysis)

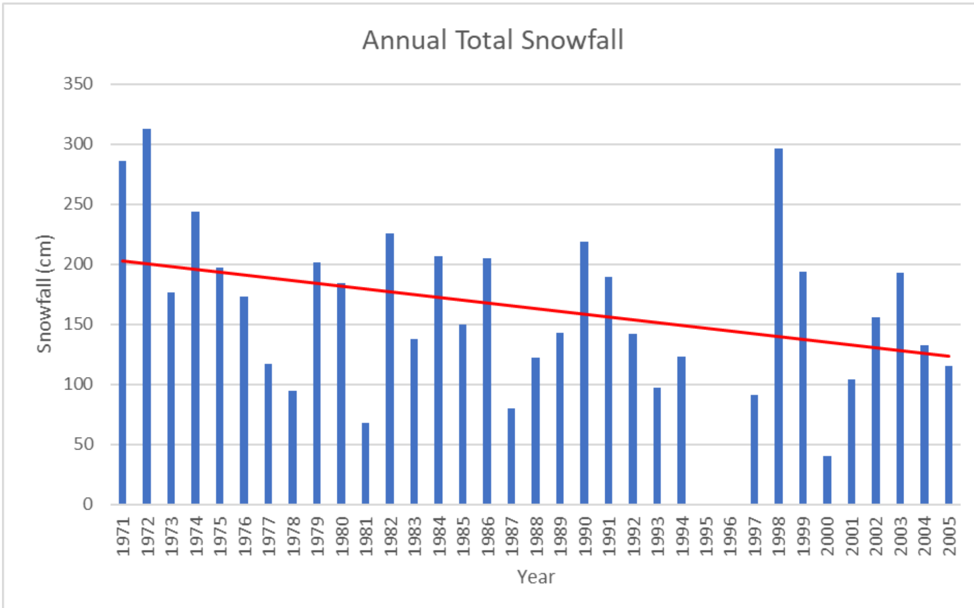

Figure 12: Total Annual Snowfall from Edson A (Station ID: 3062244) and Edson Climate (Station ID: 3062246) Weather Stations for 1971-2005 (Note: 1995, 1996, and 2000 have insufficient data for analysis)

Annual snowfall is projected to decrease under a warming climate, with less precipitation falling as snow under the warmer temperatures. Nevertheless, large snowfall events will remain possible under climate change due to cold air outbreaks and storm tracks and it is likely that the frequency of larger snowfall events will remain steady. Meteorological principles, such as the Clausius-Clapeyron relation, dictate that warmer temperatures allow for more moisture to be contained within an air mass, and if the mean temperature remains below freezing during an event, precipitation will continue to fall as frozen precipitation such as snow.

6.5 FREEZING RAIN

Freezing rain is described as supercooled rain that freezes on impact to form a coating of clear ice on the exposed surfaces. Depending on the intensity of the event, ice accretion can accumulate and cause significant structure damages by exceeding its designed load capacity. Currently, ECCC warning criteria does not include a threshold for total ice accretion amount. Therefore, while numerous freezing rain events have impacted the Edson region, it is difficult to quantify the impacts of freezing rain events on the region. In the Edson region, historically there has been an average of 4 to 8 hours of freezing rain annually, occurring typically in the winter, fall or spring (Kochtubajda et al., 2017; Mekis et al., 2020).

High resolution climate models and specialized studies are necessary to investigate how freezing rain events may change in the future. Under a warming climate, the average annual number of hours of freezing rain and resulting ice thickness are projected to increase. Under a +3°C global warming scenario, the average annual number of hours of freezing rain is projected to increase by up to 10 hours per year

(McCray et al., 2022) and the 1-in-20-year ice thickness is projected to increase up to 40 to 60% for the Edson region (Cannon et al., 2020). The timing of events such as freezing rain may also shift under a warming climate. Freezing rain requires complex meteorological conditions and projections of freezing rain frequency and amount differ depending on the climate scenario (e.g., RCP4.5 vs. RCP8.5).

While there is high uncertainty and low confidence in projections due to the complexity of freezing rain events, it would be prudent to continue preparing for freezing rain extremes in the future.

7.0 FREEZE-THAW CYCLES

Freeze-thaw cycles are days (24-hr periods) when the air temperature fluctuates between freezing and non-freezing temperatures. A freeze-thaw cycles is therefore a day with the maximum temperature greater than 0°C and the minimum temperature equal to or less than -1°C. A minimum temperature threshold of -1°C (instead of 0°C) is used to increase the likelihood that water present at the surface freezes. The historic and projected annual number of freeze-thaw cycles in Edson are presented in Table 18. The annual number of freeze-thaw cycles is projected to decrease under future climate conditions in Edson.

Table 18: Historical and Projected Annual Freeze-Thaw Cycles (Days with Maximum Temperature > 0°C & Minimum Temperature ≤ -1°C) under RCP8.5 in Edson

	Average Annual Number of Freeze-Thaw Cycles				
	1981-2010	1991-2020	2030s	2050s	2080s
Cycles/year	116.9	115.1	110.0	97.9	85.3

Despite the projected overall decrease in the annual number of freeze-thaw cycles, the number of freeze-thaw cycles during the winter (December-January-February) is projected to increase (Table 19). With warmer winter conditions projected under climate change, temperature fluctuations around 0°C are projected to become more common during the winter months.

Table 19: Historical and Projected Winter Freeze-Thaw Cycles (Days with Maximum Temperature > 0°C & Minimum Temperature ≤ -1°C) under RCP8.5 in Edson

	Average Number of Winter (Dec-Jan-Feb) Freeze-Thaw Cycles				
	1981-2010	1991-2020	2030s	2050s	2080s
Cycles/year	33.8	34.3	37.6	40.1	43.9

8.0 HEATING DEGREE DAYS

Heating Degree Days (HDD) are equal to the number of degrees Celsius the daily mean temperature is below 18°C. For example, if the daily mean temperature is 15°C, 3°C HDD are accrued. HDD are accumulated over a time period (e.g., monthly, seasonally, or annually). HDD provide an indication of the heating capacity required to maintain comfortable building conditions during cooler months. The historic and projected HDD values provided in Table 20 demonstrates a decrease in heating needs under future climate conditions in the Edson region.

Table 20: Average Annual Heating Degree Days for Edson (RCP8.5)

	Average Annual Heating Degree Days				
	1981-2010	1991-2020	2030s	2050s	2080s
HDD/year	5629.6	5493.3	5162.9	4635.3	4006.0

9.0 COOLING DEGREE DAYS

Cooling Degree Days (CDD) are equal to the number of degrees Celsius the daily mean temperature is above 18°C. For example, if the daily mean temperature is 20°C, 2°C CDD are accrued. CDD are accumulated over a time period (e.g., monthly, seasonally, or annually). CDD provide an indication of the cooling capacity required to maintain comfortable building conditions during warmer months. The historic and projected CDD values provided in Table 21 demonstrates an increase in cooling needs under future climate conditions in the Edson region.

Table 21: Average Annual Cooling Degree Days for Edson (RCP8.5)

	Average Annual Cooling Degree Days				
	1981-2010	1991-2020	2030s	2050s	2080s
CDD/year	19.0	24.7	43.3	116.5	265.3

10.0 WILDFIRES

For this assessment, the wildfire hazard threshold is the occurrence of large fires (≥ 200 ha) within 100 km of Edson. However, it is important to note that wildfires outside the 100 km radius can still affect the visibility and air quality of the Edson region. Using the Canadian Wildland Fire Information System

(NRCan, 2017), for the 1981-2020 period, 39 separate large wildfires were observed within a 100 km radius of Edson, with 22 fires caused by lightning/atmospheric discharge and 17 fires caused by human activity (Figure 13). Figure 14 presents large (≥ 200 ha) wildfire locations across Canada during the 1980-2020 time period.

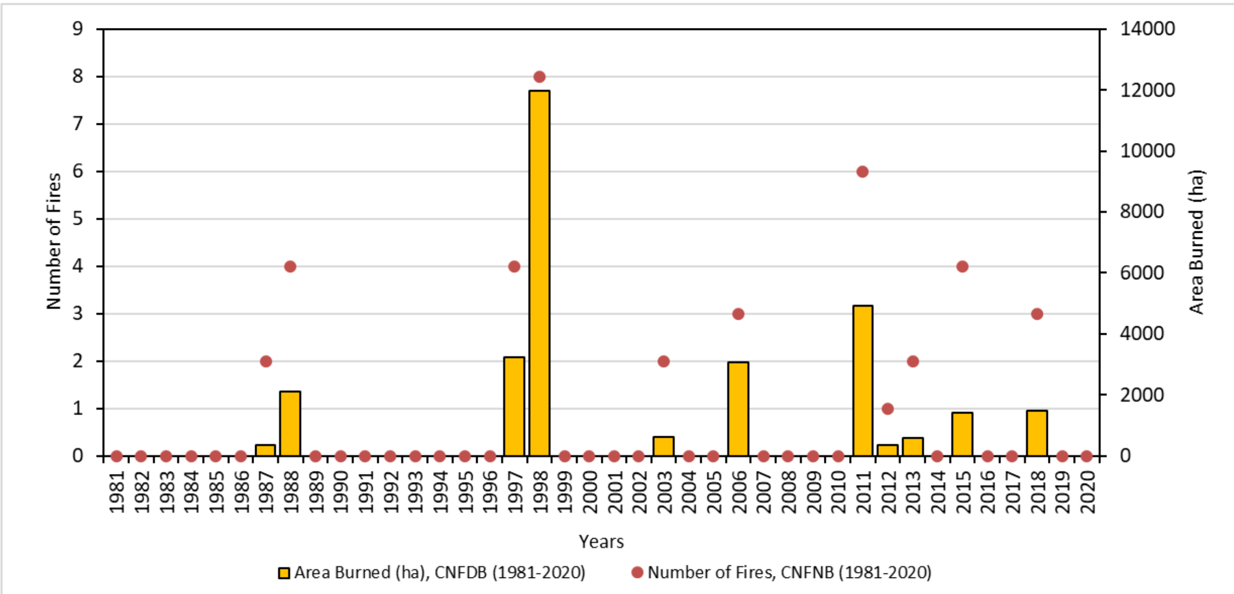

Figure 13: Number of Large Fires (≥ 200 ha) within 100 km of Edson and Area Burned during 1981-2020

Wildfires

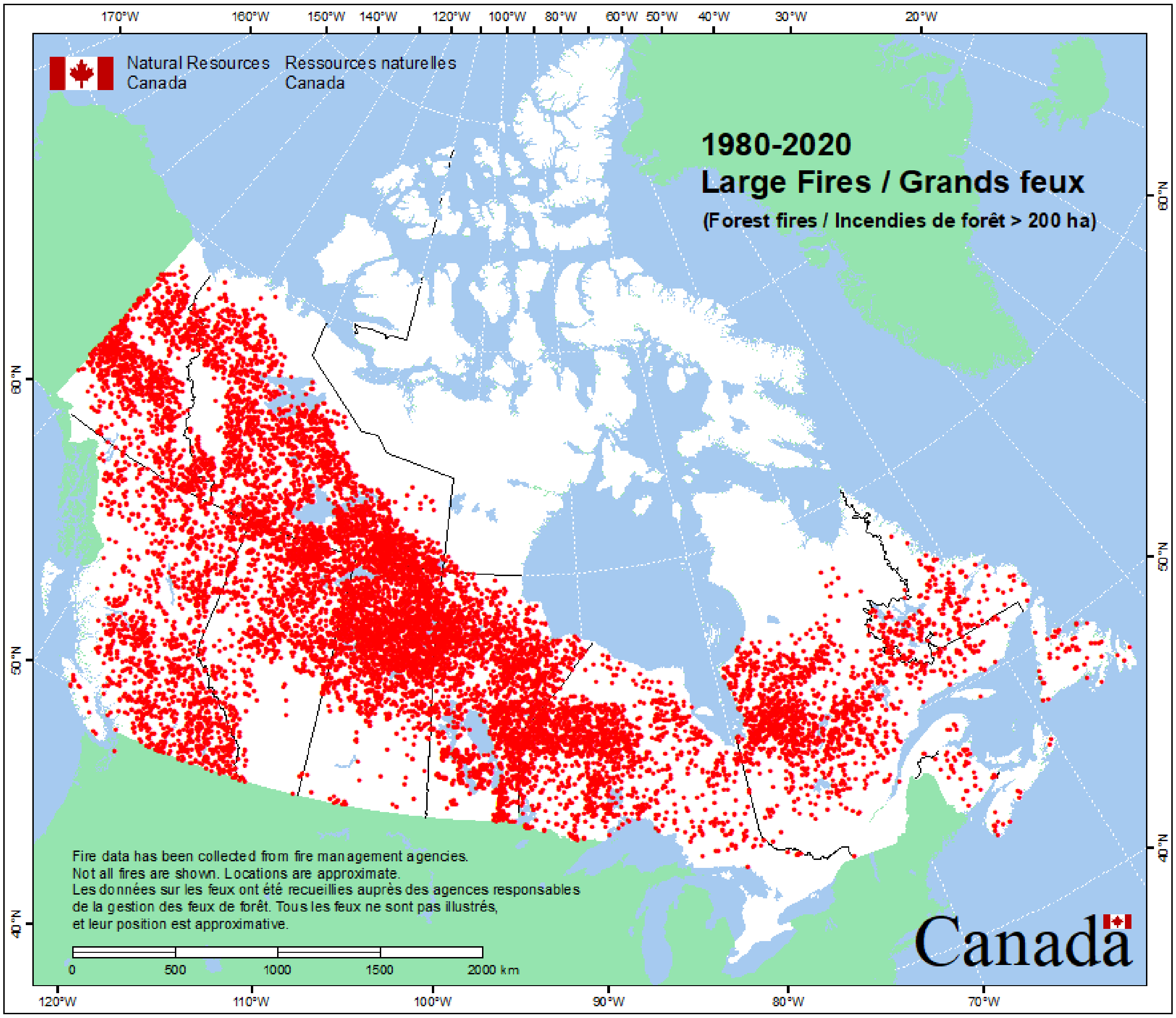

Figure 14: 1980-2020 Large Fire (> 200 ha) Locations (Figure source: Canadian Forest Service)

Under the RCP8.5 climate change projections, the area burnt by wildfires are expected to increase gradually from 2020 to 2050 and exponentially from 2050 to 2100 (Balshi, 2009). Due to the predicted warmer temperatures, change in precipitation and intensification of drought events, fire occurrences are expected to increase by approximately 10 to 25% by 2090 in the Edson region (Flannigan et al., 2009; Wotton et al., 2010) using the Canadian Climate Center GCMs. Edson is located in the Southern Cordillera (SC) homogeneous fire regime of Canada (Boulanger et al, 2012; 2014). In the Southern Cordillera homogeneous fire regime, the annual area burned (AAB) is projected to increase 3 to 4 times while fire occurrence (FireOcc) is projected to increase 0.75 to 0.9 times by the end of the century, relative to the 1961-1990 baseline (Boulanger et al., 2014) (Figure 15). The number of spread day is also projected to increase by the end of the century, with a median number of spread days per year increasing from 0-5 historically (1981-2010) and during the 2030s to 5-10 spread days in the 2050s and 2080s (Figure 16) (Wang et al., 2015; 2017). Additionally, temperature has also shown a strong positive correlation with lightning, humidity, and fire season. Therefore, warmer temperatures may result in longer fire seasons, and more frequent and intense wildfires. Wildfire projections are subject to a moderate amount of uncertainty due to the complex nature of wildfires and dependence on numerous variables including temperature and precipitation, which influence moisture/dryness conditions, ignition sources (including lightning/atmospheric discharge activity), fuel type and characteristics, and fire management actions.

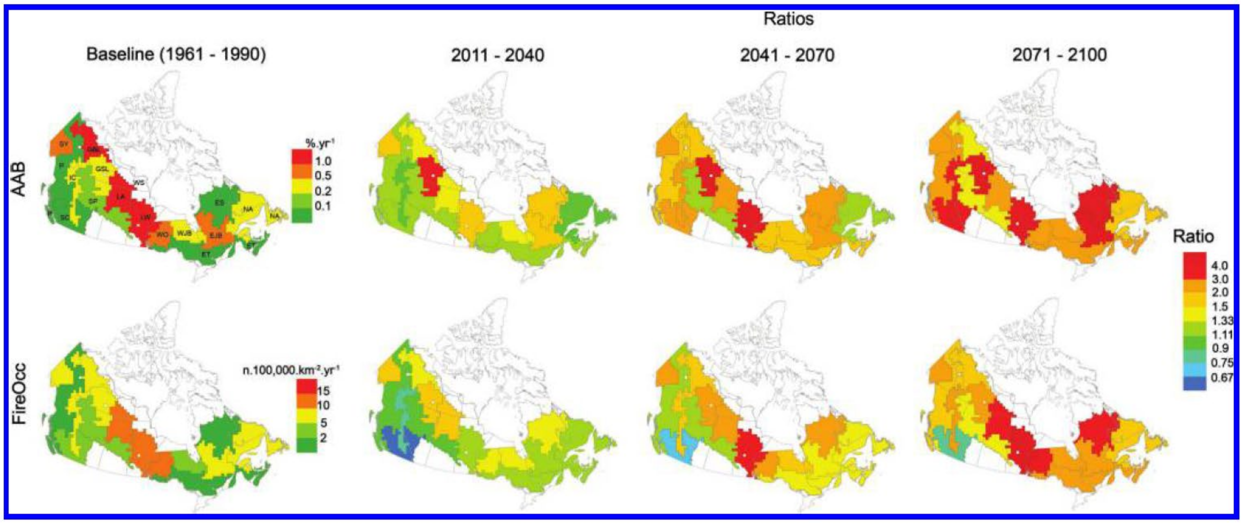

Figure 15: Projected Changes in Annual Area Burned (AAB) and Fire Occurrence (FireOcc) Compared with the Baseline (1961-1990). (Figure source: Boulanger et al., 2014)

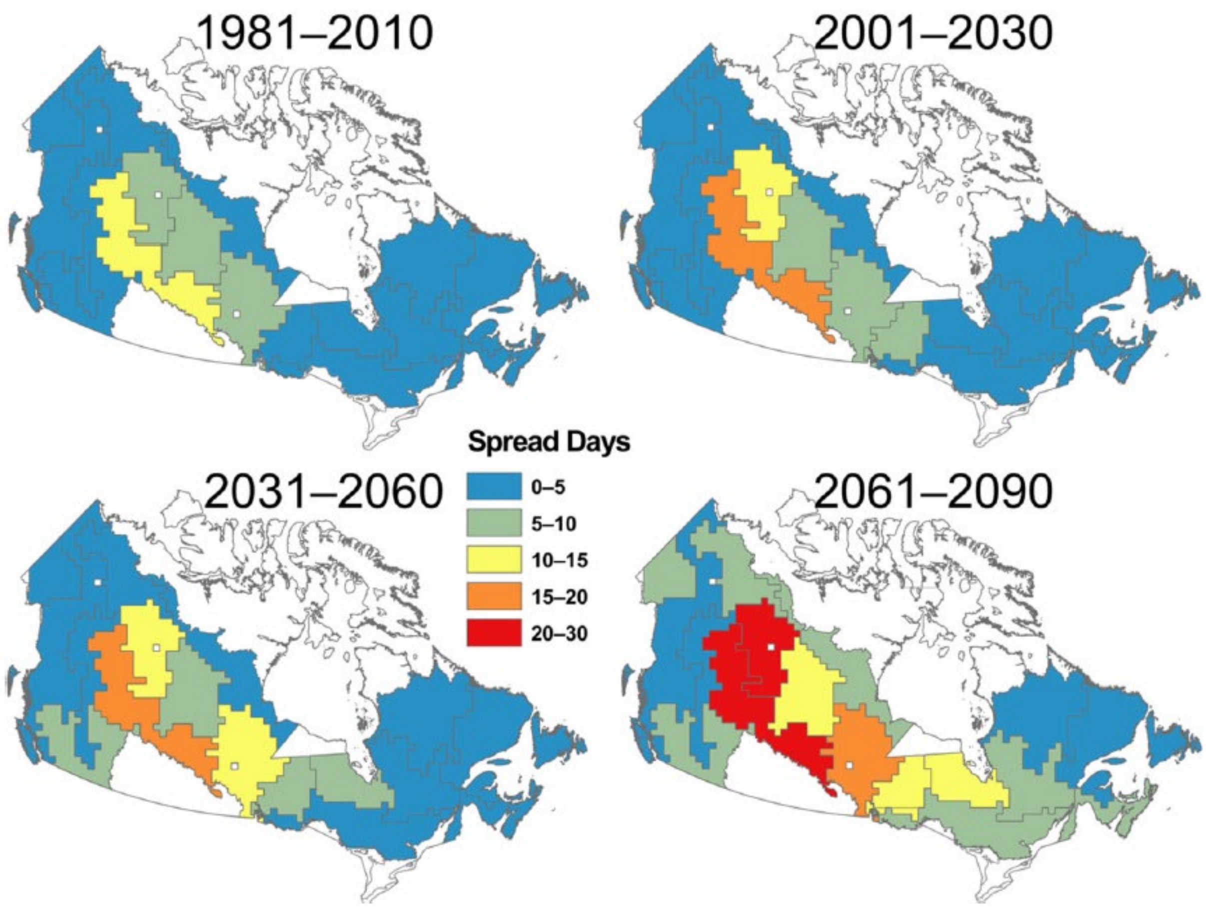

Figure 16: Median Number of Spread Days Per Year by Homogeneous Fire Regime. (Figure source: Wang et al., 2015)

11.0 DRY SPELLS AND DROUGHT

A dry spell is a measure of the number of consecutive days with precipitation less than 1 mm/day. The average annual maximum number of consecutive dry days is presented in Table 22. It should be noted that there may be more than one dry spell of significant length in a given year but Table 22 only displays the longest dry spell. Table 23 presents the average annual number of periods with more than 5 consecutive dry days. Prolonged dry periods can result in drought conditions which can cause significant agricultural, economic, and environmental damage. The impacts of drought conditions can vary and depend on the timing of the drought conditions (onset and end) and drought duration. The frequency and duration of dry spells in Edson are projected to remain steady under climate change.

Dry Spells and Drought

Table 22: Average Annual Maximum Number of Consecutive Dry Days for Edson (RCP8.5)

	Average Annual Maximum Number of Consecutive Dry Days				
	1981-2010	1991-2020	2030s	2050s	2080s
Days/year	24.2	24.5	24.0	23.7	23.2

Table 23: Average Annual Number of Periods with More than 5 Consecutive Dry Days for Edson (RCP8.5)

	Average Annual Number of Periods with More than 5 Consecutive Dry Days				
	1981-2010	1991-2020	2030s	2050s	2080s
Periods/year	14.7	14.8	14.6	14.7	14.7

Drought can cause major agriculture, economic and environmental damage. As their effects are only apparent after a long period of dry conditions, it is generally very difficult to determine their onset, extent and end. Canada has experienced frequency and severe drought over its history, especially in the western regions. However, under the impacts of climate change, new areas across the country will be affected and recurring severe droughts will occur more often. To quantitatively measure and project the magnitude, duration and spatial extent of droughts, the Standardized Precipitation Evapotranspiration Index (SPEI) is considered. The SPEI drought index is based on the difference between precipitation and potential evapotranspiration and can be used to monitor and analyze droughts and identify their characteristics in the context of climate change. A positive SPEI value indicates wetness at the land surface, while a negative value indicates dryness. Figure 17 shows the historical and projected 12-month SPEI for the Edson region[2].

[2] SPEI-12 calculated for the month of September. SPEI-12 describes the SPEI of the month selected and the previous 11 months.

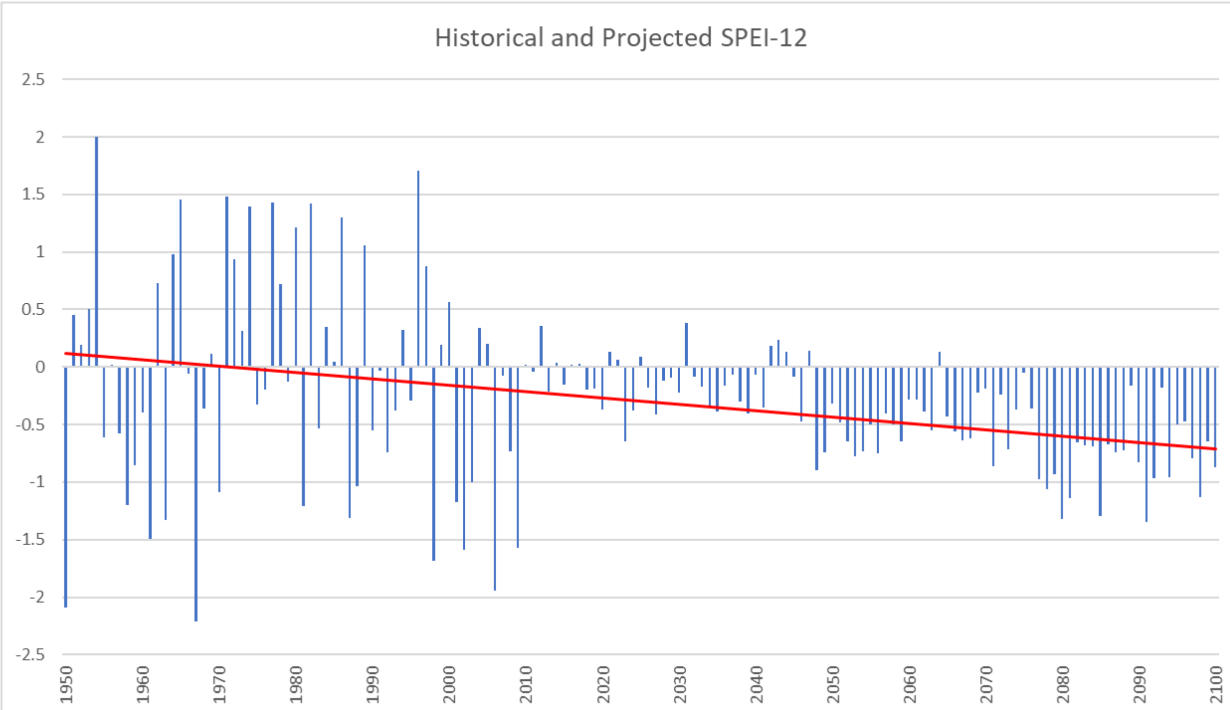

Figure 17: Historical and Projected SPEI-12 for the Edson Region (1950-2100)

12.0 WIND

The Edson (Station ID: 3062239), Edson A (Station ID: 3062244), and Edson Climate (Station ID: 3062246) weather stations (all located at Edson Airport) were used to obtain hourly and daily wind data for the period of 1970-2023. The available wind data for the 1970-2023 time period is used to generate windroses for the Edson region. A windrose shows the distribution of wind direction (direction from which the wind is blowing) observed at a particular location over a time period. The length of each line represents the frequency of the wind from that direction and, therefore, windroses provide information on the prevailing wind direction(s) at a given location. Figure 18 and Figure 19 display hourly and daily mean wind speed and direction observed at the Edson Airport, respectively.

Wind

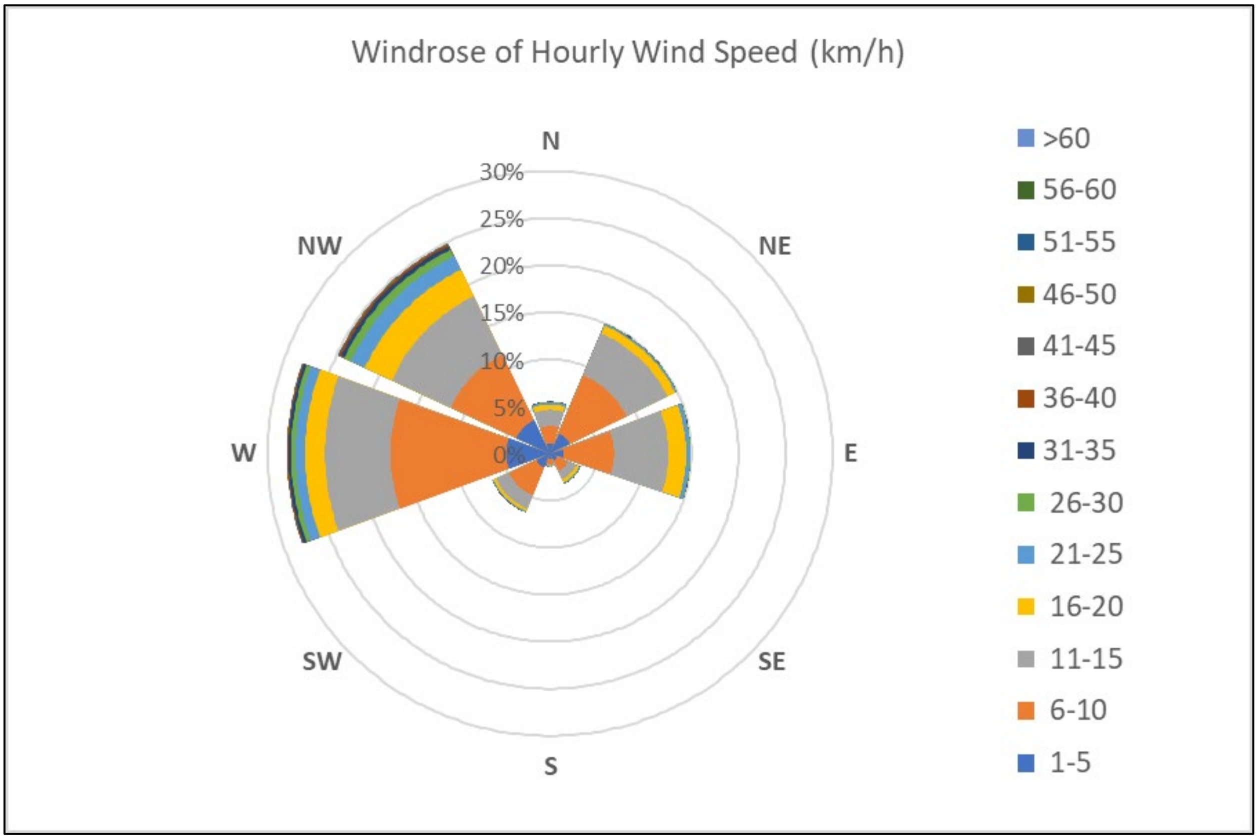

Figure 18: Hourly Mean Wind Speed and Direction from 1977-2023 observed at Edson Airport (Station IDs: 3062239 and 3062244)

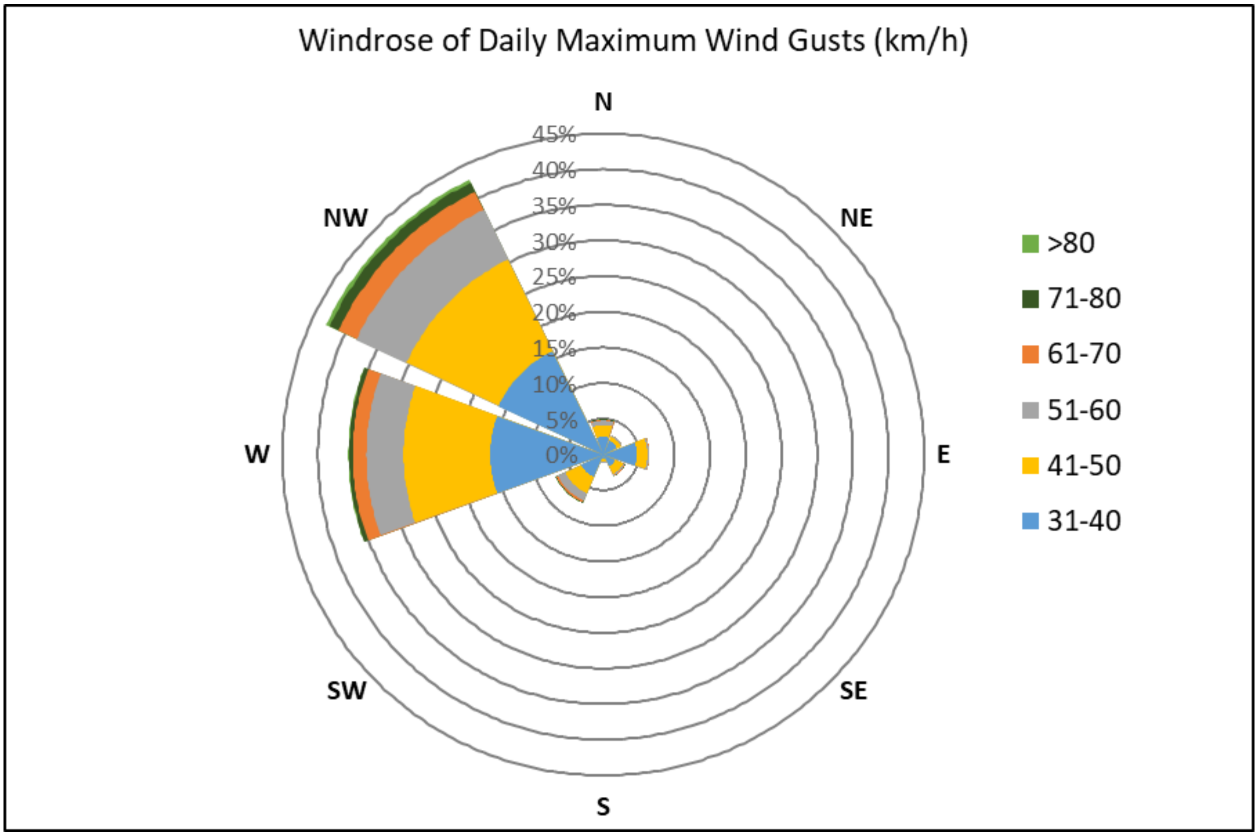

Figure 19: Daily Maximum Wind Gust Speed and Direction from 1970-2023 observed at the Edson Airport (Station IDs: 6032244 and 6032246)

The projected changes in wind frequency and intensity have considerable uncertainty compared to other climate variables. However, some general trends that have been estimated from specialized research. For example, an analysis of 57 years (1953–2009) of wind gusts at 104 weather stations across Canada indicated that for every 1°C increase in the daily temperature anomaly, the speed of daily wind gust events (≥ 50 km/h) increased by more than 0.2 km/h over most regions in Canada (Cheng, 2014). Another study indicates the percentage increase in the frequency of future daily wind gust events of ≥ 70 km/h from the current conditions could be up to 25% in central Alberta by the end of the century (Cheng et al., 2014). Cheng et al. (2014) also indicates an approximately 60% increase in the frequency of daily wind gust events of ≥ 90 km/h by the end of the century, relative to the current conditions, for central Alberta.

13.0 SEVERE THUNDERSTORMS-RELATED HAZARDS

Severe thunderstorms are a frequent occurrence and are often associated with high intensity but short duration impacts, which may include heavy rainfall, high winds, lightning, hail, and/or tornadoes. Specialized studies on severe thunderstorm activity provide some indication of the potential effects of climate change. Specialized studies on severe thunderstorms typically analyze key ingredients necessary for severe thunderstorm development, such as convective available potential energy (CAPE) and atmospheric wind shear (e.g., Trapp et al., 2007; Brooks, 2013; Diffenbaugh et al., 2013). CAPE is a measure of the amount of energy available for convection and is directly related to the maximum potential updraft of thunderstorms. The greater the CAPE, the greater the potential for severe weather. Strong vertical wind shear – a significant increase in wind speed and change of wind direction with height – is important for severe thunderstorm development; Vertical wind shear aids storm organization (including keeping the storm updraft and downdraft separate), storm longevity, and the development of a rotating updraft (required for tornadic activity).

Brooks (2013) investigated CAPE and wind shear independently and found that possible changes in CAPE under a warming climate will result in more favourable conditions for severe thunderstorms. However, while CAPE value provides possible insight into severe thunderstorm development, a combination of thunderstorm ingredients[3] are necessary to result in severe thunderstorm-related hazards such as hail and/or tornadoes.

Diffenbaugh et al. (2013) assessed the potential effects of climate change on severe thunderstorm activity by looking at CAPE and wind shear together, investigating the change in conditions on individual days. Results of Diffenbaugh et al.'s study indicate an overall *increase* in the number of days with combination of high values of both potential energy and wind shear, especially for days with strong wind shear in the lowest portions of the atmosphere. Diffenbaugh et al. (2013), therefore, further supports the projection of increased severe thunderstorm potential, including for Alberta. Diffenbaugh et al.'s study also found an increase in severe thunderstorm potential is projected under both the RCP8.5 emission scenarios and the lower emissions RCP4.5 scenario.

Due to the complexity of severe thunderstorms and localized natural of the related hazards, very-high resolution (e.g., 1 km) models are required to investigate the possible effects of climate change and there is low confidence in projections.

[3] https://www.weather.gov/source/zhu/ZHU_Training_Page/thunderstorm_stuff/Thunderstorms/thunderstorms.htm

13.1 LIGHTNING

Environment and Climate Change Canada has developed a map of Canada's lightning "hot spots" using lightning data over the 1999-2018 time period (Figure 20). The Edson region has an average lightning flash density of 1.2 flashes per square kilometre, per year.

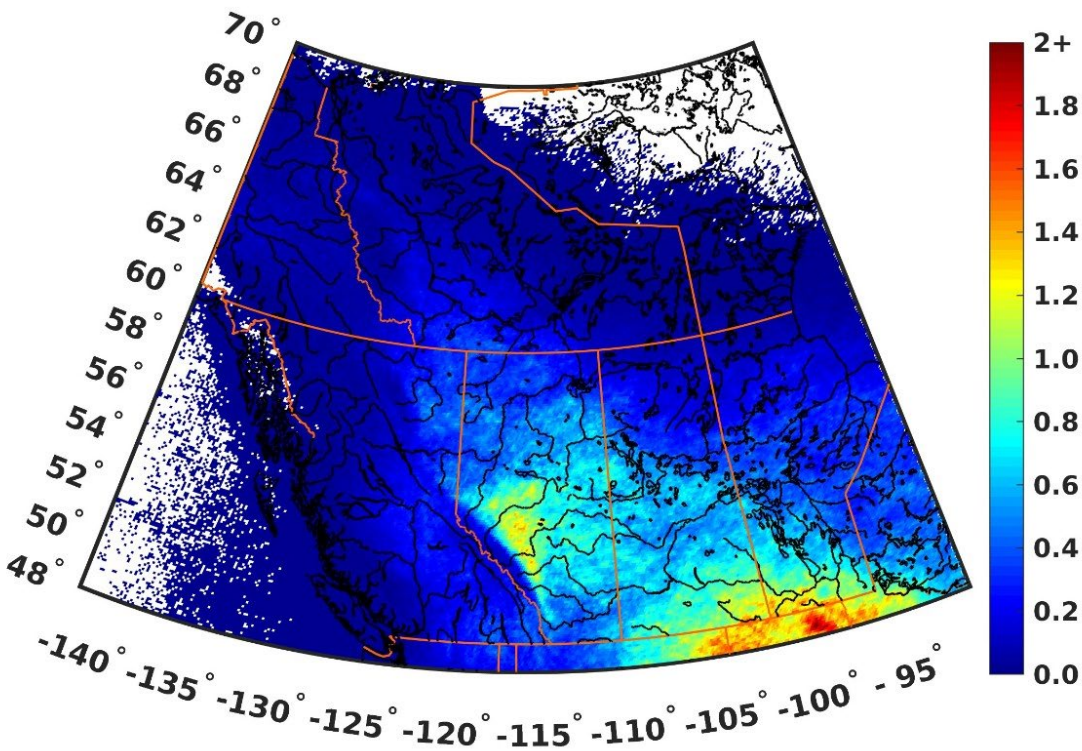

Figure 20: Average lightning flash density (flashes per square kilometre, per year) in Western Canada (1999-2018). (Image source: https://www.canada.ca/en/environment-climate-change/services/lightning/statistics/maps-hotspots.html)

Lightning/atmospheric discharge activity is projected to increase across most of North America under a warming climate (Romps et al., 2014; Finney et al., 2018). Finney et al. (2018) investigated projected changes in flash rate under the RCP8.5 emissions scenario using two approaches – based upon cloud ice flux and cloud-top height – and found a projected increase in flash rate of up to 10 flashes per square kilometre, per year between the 2000s and 2100s for the Edson region.

13.2 HAIL

Hail is described as precipitation consisting of ice particles, in various shapes, which are generally observed during thunderstorms, with a minimum diameter of 5 mm (AMS, 2017). Depending on their size, hail can be destructive to buildings and infrastructure, costing insurers millions of dollars. Historical data was obtained from hail observing station of the ECCC for the period of 1977 to 2006 (Figure 21). Hail days averaged over the province of Alberta shows a mean frequency of 0.37 hail days/station for the months of May-September (Etkin, 2018). Etkin (2018) also developed a hail climatology for Canada using hail days data from the Digital Archive of Canadian Climatological Data, Environment Canada and reports a warm months (May-September) hail frequency of ~3.2 days per year for the Edson region (Figure 22).

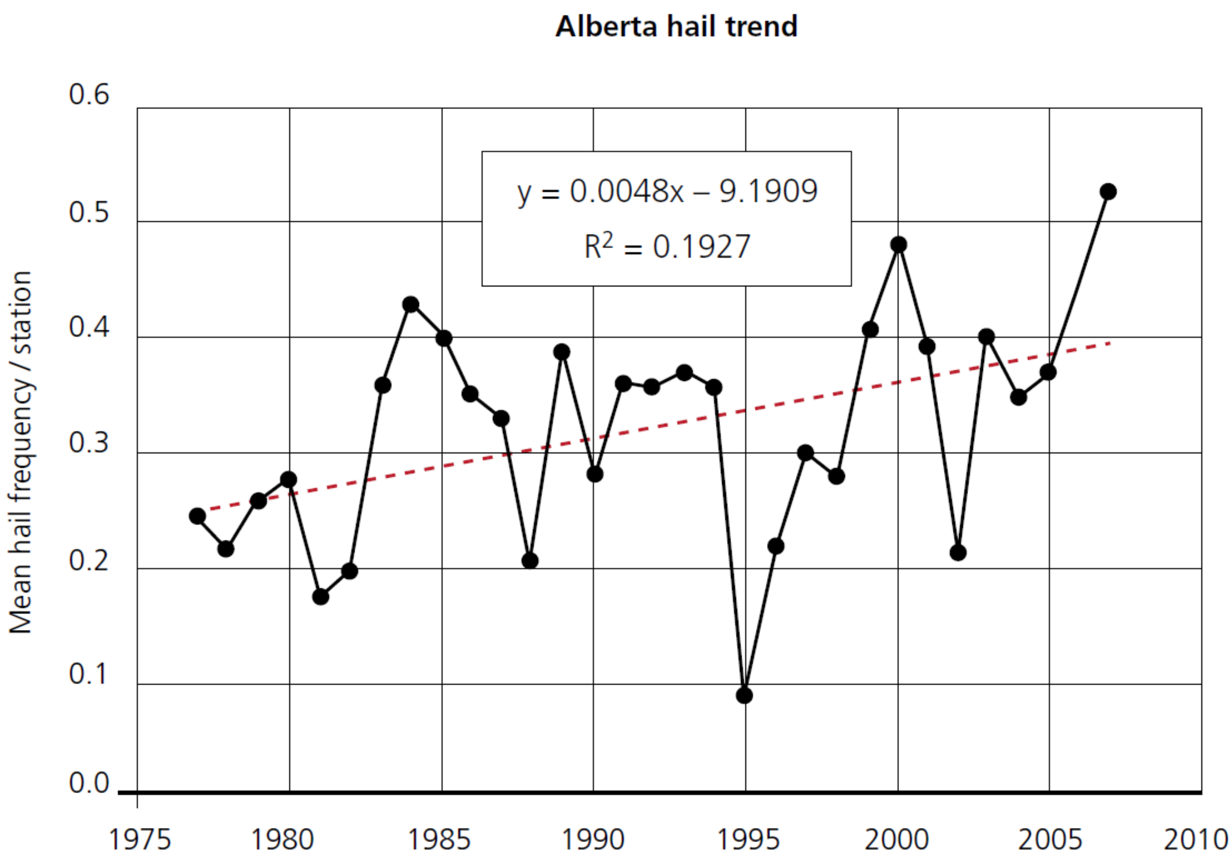

Figure 21: Alberta Hail Trend from 1977-2007 (Figure source: Etkin, 2018)

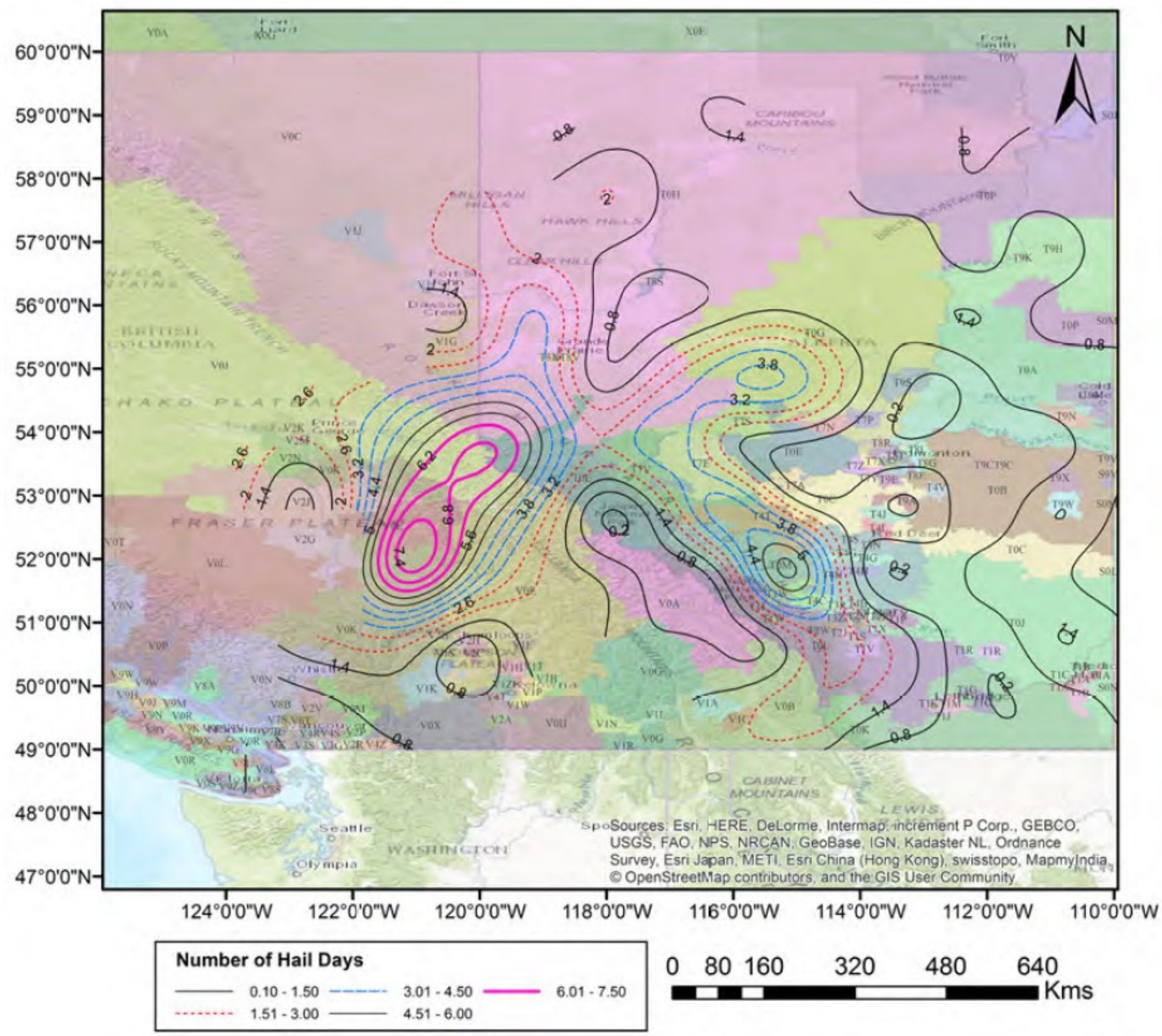

Figure 22: Warm months (May-September) hail frequency in Western Canada (Figure source: Etkin, 2018)

A recent study by Brimelow et al. (2017) attempted to quantify the effects of climate change on large hail events in North America, assessing hail frequency and size for the mid-century (2041-2070). Brimelow et al. (2017) suggest an increased large hail activity under climate change. By mid-century, the number of days with hail exceeding 4 cm in diameter during the summer months for the Edson region is projected to increase by approximately 0.1 to 1 days per season and maximum hail diameter is projected to increase between 0.15 cm and 0.3 cm. Due to the complex, localized and short duration nature of hailstorms, projections of hail activity have high uncertainty and there is low confidence in the projections. The

Northern Hail Project[4], founded in 2022 at Western University, provides a new additional source of information on recent hail events and possible changes under climate change.

13.3 TORNADOES

Based on the Canadian Tornado Database, during the period of 1980-2009, 8 tornadoes were observed in the Whitecourt/Edson/Fox Creek/Swan Hills region, including an F2 tornado in August 1989 (Table 25). This number, however, is likely an underestimate of tornadic activity in the region. The number of tornado observations in Canada is considered to be a significant underestimate of the number of actual tornado occurrences, particularly in rural and remote regions (Cheng et al., 2013). It is not possible to document all tornado occurrences – many tornadoes are not observed or recorded due to the relatively localized nature and short duration of tornado events and the absence of observes, structures, or daylight (Cheng et al., 2013). Cheng et al. (2013) calculated the probability of tornado occurrence and found that the probability of tornado occurrence would be significantly higher than reported, particularly in sparsely populated areas. Cheng et al. (2013) indicates a tornado occurrence of approximately 0.5 tornadoes per 10,000 km^2 per year for the Edson region. The Northern Tornadoes Project[5], founded in 2017 at Western University, provides an additional source of information on recent tornadic events. The Northern Tornadoes Project database includes information on a EF1 tornado[6] reported east of McLeod Valley in April 2019.

Table 24: Historical Tornado Occurrences in the Whitecourt/Edson/Fox Creek/Swan Hills Region (1980-2009)

Intensity	F0	F1	F2	F3	F4	F5
Occurrence	7	0	1	0	0	0

Historical data on tornado occurrence in Canada are insufficient to develop strong conclusions regarding the potential trends in tornado activity.

Diffenbaugh et al. (2013) indicates a projected increase in severe thunderstorm potential for Alberta. Additionally, Diffenbaugh et al. (2013) indicates an overall *increase* in the number of days with combination of high values of both potential energy and wind shear, ingredients required for tornadic

[4] The Northern Hail Project (https://uwo.ca/nhp/) "aims to improve knowledge of damaging hail storms and the detection of hail occurrence across Canada [and] endeavour to improve severe convective storm prediction, mitigate against harm to people and property, and investigate future implications due to climate change."

[5] The Northern Tornadoes Project (https://www.uwo.ca/ntp/) "aims to better detect tornado occurrence throughout Canada, improve severe and extreme weather understanding and prediction, mitigate against harm to people and property, and investigate future implications due to climate change."

[6] ECCC adopted the updated "Enhanced Fujita" or EF-Scale in April 2013 for the purposes of rating the intensity of severe thunderstorm winds and tornadoes based on their resulting damage (https://www.canada.ca/en/environment-climate-change/services/seasonal-weather-hazards/enhanced-fujita-scale-wind-damage.html). However, the historical dataset under the old "F-Scale" was maintained, and modern intensity ratings have been scaled to be roughly equivalent to historical events of similar intensity.

activity. Diffenbaugh et al. (2013) therefore, suggests a possible increase in storms capable of producing tornadic activity. Nevertheless, while the overall chance of storms producing tornadic activity are likely to increase, the probability of site-specific impacts remains low. Projections of tornadic activity, however, have high uncertainty and, due to the complexity of these events, there is low confidence in the projections.

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