



CLIMATE RESILIENT EDMONTON

ADAPTATION STRATEGY AND ACTION PLAN

The City's Climate Change Adaptation
Plan under the City Charter

**CHANGE
FOR CLIMATE**



ACKNOWLEDGEMENTS

Climate Resilient Edmonton: Adaptation Strategy and Action Plan was prepared with the support of Edmonton's academic, business, public institution, and government communities. The City of Edmonton is grateful for the involvement of these communities; their collective knowledge and insight was critical to understanding the specific impacts expected in coming decades due to climate change and lay out the five priority paths towards climate resilience. This publication is a major milestone in our journey towards creating a more climate resilient Edmonton, but it is only the first step. As we move ahead with implementation we look forward to further collaboration with these and other impacted communities.

We acknowledge the contributions from:

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			Zizzo Strategy

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FOREWORD

We commit to and call upon all national, state and local governments to undertake climate risk and vulnerability assessments to guide their planning and investment decisions, increase climate resilience and minimize the exposure of people and assets to the impacts of climate change. EXCERPT FROM THE EDMONTON DECLARATION, 2018

Cities around the world are working swiftly to develop and implement plans in response to climate change. Edmonton has worked judiciously to ensure that city operations and the wider community have a well-researched, scientifically sound and stakeholder-validated strategy and action plan to follow. As host of the inaugural IPCC Cities and Climate Change Science Conference in March 2018, Edmonton had the distinct pleasure of interacting with scientists from around the world who emphasized the need for urgent action on reducing greenhouse gas (GHG) emissions to lessen the most extreme consequences of climate change. Edmonton's plan for reducing GHGs is being implemented, but there remains a need to prepare our city for the repercussions of a warming planet. The Edmonton Declaration that resulted from the conference was a call to the global scientific community to advance its efforts in support of evidence-based climate action in cities, enabling ambitious climate action plans.

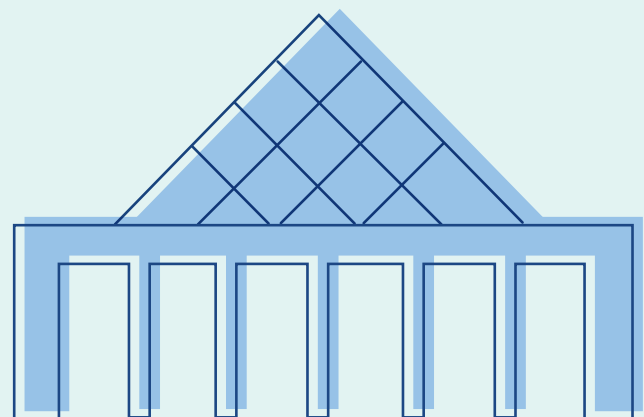
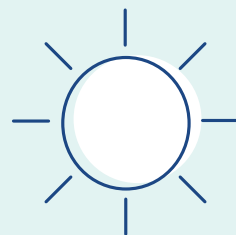
I have said this before, and it bears repeating, that the city needs the participation of scientists, researchers, business, civil society, artists and students – a whole village – to tackle the challenges of climate adaptation and resilience. Climate Resilient Edmonton: Adaptation Strategy and Action Plan illustrates not only the gravity and urgency of climate change and the impacts for which Edmonton must prepare itself, but a well-considered plan for taking on this challenge – a plan that involves the “whole village.”

To leave this work to others is irresponsible and would put Edmonton in a vulnerable and unsustainable position. Around the world, people are calling on their leaders to transition their cities to low-carbon living and, at the same time, to adapt to a changing climate and move ourselves toward resilience. Climate Resilient Edmonton is a science and evidence-based plan that puts Edmonton on this path.

Mayor Don Iveson



DON IVESON
MAYOR



MESSAGE FROM THE CITY OF EDMONTON'S ENVIRONMENTAL ADVISORY COMMITTEE

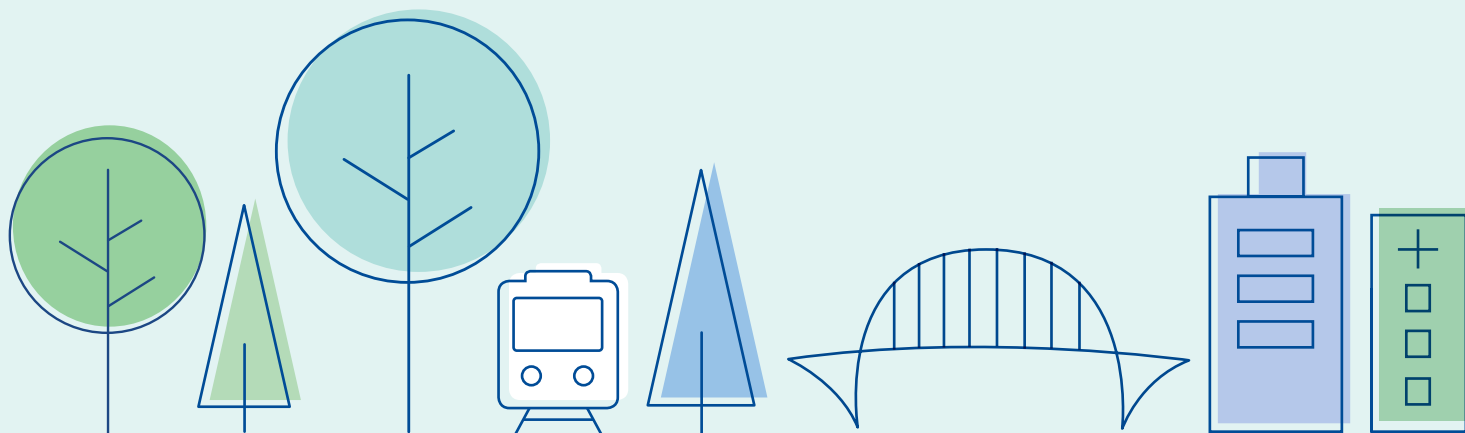
The City of Edmonton is pleased to be supported by a volunteer committee of citizens that provides Administration with strategic advice on environmental programs and topics. For over 22 years, the City's Environmental Advisory Committee (EAC) has provided a critical public perspective on environmental issues, and the current membership is no exception, demonstrating its commitment to improving the City's environmental performance.

Membership on the Committee is comprised of nine citizens-at-large and one representative from each of Alberta Health Services, Alberta Environment and Parks, MacEwan University and Concordia University of Edmonton. The EAC was actively involved in the evolution of Climate Resilient Edmonton: Adaptation Strategy and Action Plan by asking probing questions, providing guidance over the course of its development, responding to discussion papers and advising on public communications. Following is the Committee's response to Climate Resilient Edmonton.

The Environmental Advisory Committee (EAC) endorses this strategy and action plan based on: the process employed to develop the plan, the range of stakeholders consulted, efforts to raise awareness among the public, membership and oversight of the Climate Resilient Edmonton Strategy Stakeholder

Committee, the diligence shown by the project working team and, perhaps most importantly, the EAC recognizes the significant and serious nature of this work. Leaders at the City of Edmonton are being proactive with this strategic approach to climate change, creating momentum across the region. This plan will help to provide citizens with a sense of security that leadership is committed to addressing future changes in climate, even in times of uncertainty.

Climate Resilient Edmonton: Adaptation Strategy and Action Plan is the first climate change resilience plan for Edmonton. Due to the complex nature of this strategy, it was developed primarily with input from the scientific and expert community. However, since June 2016 when the plan was in very early stages of being formulated, the City has engaged the EAC with progress updates and sought feedback on ongoing and upcoming work.



Message from the City of Edmonton's Environmental Advisory Committee [continued]

The EAC points out the following considerations from the Action Plan, each of which requires adequate funding to enable successful implementation:

- Ongoing climate resilience research: Given that actions for resilience are relatively new for municipalities around the world, there will be a need for all pieces of the implementation plan to be reflective of scientifically-sound understanding. This includes the monitoring and incorporation of new practices and learning from other municipalities, and the most current developments in research. The integration of new information will enable evidence-based decision-making, and allow for this initial strategy to be revised over time.
- Climate resilience of infrastructure and green spaces: Infrastructure, in all its forms, must be newly developed or retrofitted to meet a new climate future. From placement of utility infrastructure, to (permeable) materials for hard surfaces, integration of public cooling stations and potable water, design of bridges and buildings, policies that advance climate-proofing in new

neighbourhoods, vegetation choices for green spaces and parkland, and so on—all forms of infrastructure need to be thoughtfully and skillfully designed now for a new climate reality.

- Climate resilience of people: citizens will need to be prepared in advance for climate shocks and develop skills for adapting their spaces and lifestyles for a changing climate. This in-depth engagement will obviously include emergency preparedness, but must also build capacity that will activate citizens, neighbourhoods and communities to becoming climate resilient.

The EAC is pleased that the City has taken on this work and supports the City's commitment to adapting its operations for resilience in the greater community. Preparedness for the potential impacts of climate change is the best way forward. The City must move forward with research, policy changes and support for citizens and stakeholders to ensure that Edmonton will thrive and be a leader in a new climate future. This strategy and action plan is a commendable first step to a resilient Edmonton.



INTRODUCTION

Our climate is already changing, both globally and locally. It's affecting our weather, environment, economy and health. Unless significant global efforts to reduce greenhouse gas (GHG) emissions occur, climate change will have serious and continued impacts on Edmonton.

The good news is that we can position ourselves to be better able to withstand and adapt to these changes. We can create and follow a pathway that will help us manage the risks of climate change. We can increase our knowledge, adjust our lifestyles and adapt to changes that have already taken place. This document—Climate Resilient Edmonton: Adaptation Strategy and Action Plan—will help set Edmonton on this path so that we can be prepared for and respond to anticipated climate change impacts.

While climate change efforts are underway at both national and provincial levels, cities are often leaders in climate change mitigation and adaptation initiatives. Edmonton is one of those cities. The City of Edmonton is already in the process of implementing our Community Energy Transition Strategy, which aims to reduce greenhouse gas emissions in Edmonton. Our Climate Resilient Edmonton: Adaptation Strategy and Action Plan is complementary to those efforts. It's also part of City Council's Initiative on Energy Transition and Climate Resilience and the City of Edmonton's overall leadership on climate change issues. The plan focuses on understanding how the climate impacts we are already experiencing may shift in the future due to ongoing climate change. It looks at what this means for our community and provides insight into how we can build resilience for those impacts.

There is international recognition that climate change is an urgent threat and that global pursuits are needed to reduce GHG emissions and limit global warming. Ninety-seven percent of actively publishing climate scientists agree that the world is experiencing a change in climate caused by humans (Cook et al. 2016). Historical climate records also show the world is warming at unprecedented rates. These climate records indicate that Edmonton is warming at a faster rate than the global average. Scientists predict that Edmonton will be exposed to higher temperatures, drier summers, more extreme precipitation events,

more variable extreme weather events, and an overall warmer and drier climate (see Chapter 3). Without action, these impacts can exacerbate existing climate pressures on our economic, social, infrastructure, and environmental systems.

How will Edmonton adapt to these effects of climate change? We need to work towards becoming a climate resilient city—a city in which our institutions, communities, businesses, and individuals have the capacity to function, survive, adapt and thrive in response to any sudden and short disruption they may experience. This plan will guide us, through its paths, goals, strategies and actions.

In 2016, we began an investigation to understand how Edmonton's climate has already changed and how it might change in the future. We conducted an Edmonton-specific climate risk and vulnerability assessment. We also determined the potential risks and opportunities these changes could present for our communities. Climate Resilient Edmonton: Adaptation Strategy and Action Plan is the result of this work. With its foundation in science and evidence, it sets a pathway towards climate resilience. It's our way towards a bright future as we face the effects of climate change.

As part of our research and knowledge gathering, we spoke with Edmontonians. They told us that they're worried about the changing climate—a 2018 poll of residents indicates that 73% are concerned about climate change and 72% think that we need to act now to respond to climate change. Our residents are critical to helping us become more adaptable and resilient, which is why we included their opinions in forming a vision for our strategy.

We also consulted with other stakeholders and subject matter experts to develop this plan. The knowledge these experts shared with us formed an important part of our learning and evidence gathering process.

In 2018, Edmonton hosted the first ever Intergovernmental Panel on Climate Change's (IPCC) Cities and Climate Change Science Conference. The event established a global research agenda focused on the science of cities and climate change. This ongoing research and knowledge sharing between world-wide cities will help inform future versions of this document.

The Change for Climate Global Mayors Summit was held alongside the conference. There, the Edmonton Declaration was developed. It recognizes the expert consensus that cities, towns and regions must play a central role in adapting to and mitigating the effects of climate change to reduce GHG emissions, given that more than half of the world's population live in urban areas and produce more than 70% of energy-related GHG emissions. The Edmonton Declaration calls upon cities to take bold action on climate change. To date, over 3,000 cities have endorsed the declaration. This strategy delivers on adaptation commitments from the Edmonton Declaration.

Climate Resilient Edmonton: Adaptation Strategy and Action Plan is Edmonton's Climate Change Adaptation Plan under section 615.5 of the City Charter. The strategy outlines how the City of Edmonton will plan and invest resources to increase our communities' climate resilience, minimize the exposure of people and assets to the impacts of climate change, and take advantage of new opportunities as they arise. It begins with an examination of climate change adaptation and leads into an outline of the methods Edmonton used for its adaptation planning. An overview of Edmonton-specific climate change science and a brief discussion on the primary impacts that predicted climate changes will have on Edmonton follows. It's capped with a synopsis of the adaptation actions needed to respond to those impacts.

This document represents the first iteration of Edmonton's climate change adaptation journey. It will be a living document, to be revisited and updated as new information becomes available and as adaptation planning and actions evolve. We invite every Edmontonian to join us on the path towards Edmonton's climate change adaptation and resilience.

Qualities of a Resilient City [100 Resilient Cities]

REFLECTIVE:

People and institutions reflect and learn from past experiences and leverage this learning to inform decision making.

ROBUSTNESS:

Urban physical assets are designed, constructed and maintained in anticipation of high-impact climate events.

REDUNDANCY:

Spare capacity is built into the system to account for disruptions and surges in demand. It also involves multiple ways of fulfilling a need or function.

FLEXIBLE:

Refers to the willingness and ability to adopt alternative strategies in response to changing circumstances or sudden crises. This can be achieved through new knowledge and technologies.

RESOURCEFULNESS:

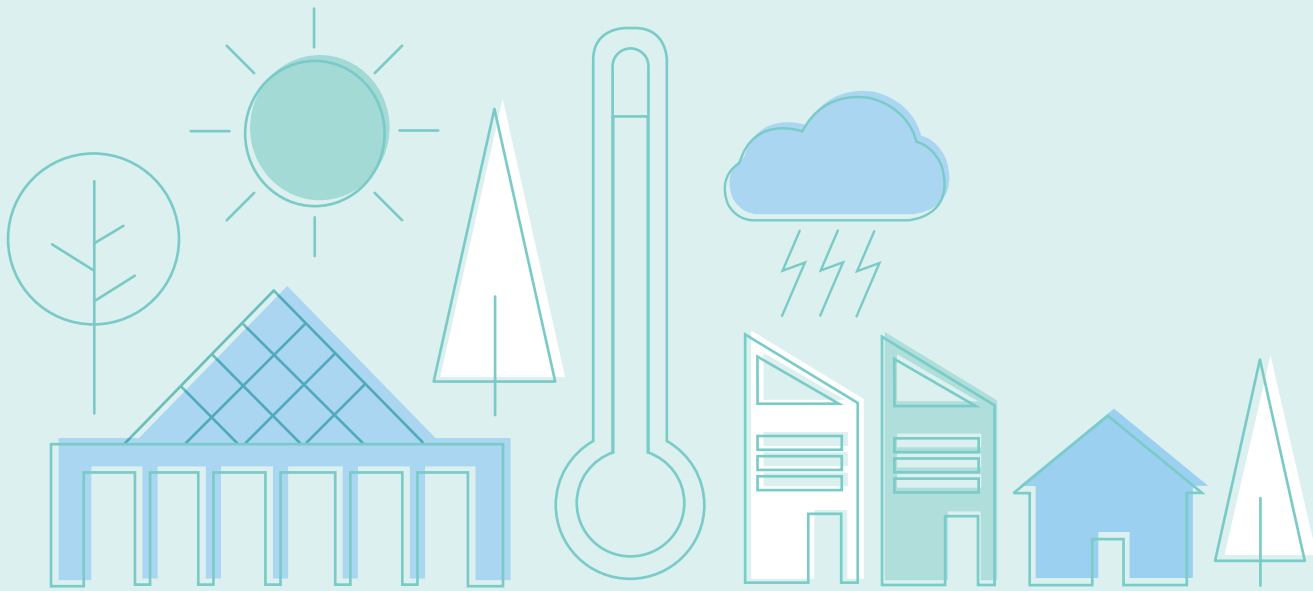
Citizens and institutions are aware of climate risks, able to adapt to shocks and stresses and can quickly respond to a changing environment.

INCLUSIVE:

Inclusive processes emphasize the need for broad consultation and many views to create a sense of shared ownership of a joint vision to build city resilience.

INTEGRATED:

Integrated processes bring together and align city systems to promote consistency in decision making and investments. Exchange of information between components of the system enables them to function collaboratively and respond rapidly.



1

CLIMATE CHANGE ADAPTATION AND RESILIENCE IN THE EDMONTON CONTEXT

CLIMATE CHANGE ADAPTATION AND RESILIENCE IN THE EDMONTON CONTEXT

The Earth's climate is changing. While it has changed throughout the history of the planet, the current rate of change is unprecedented (IPCC Fifth Assessment Report, Summary for Policymakers 2014). The earth's temperature has risen approximately 1.1 degrees Celsius [$^{\circ}\text{C}$] since the late 1800s (NASA 2018). Most of the warming has occurred in the past 35 years. This warming trend is projected to continue throughout the next century onwards. The effects of global climate change can be seen in the warming and acidification of oceans in addition to sea level rise; shrinking of ice sheets and glacial retreat; decreased snow cover; and changes in the frequency and intensity of extreme events (NASA 2018).

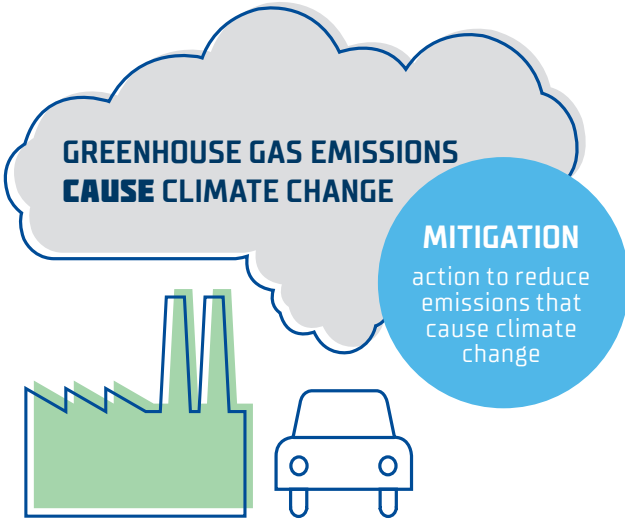
Organizations and governments worldwide can take "mitigation" and "adaptation" actions in response to climate change. Mitigation refers to actions taken to address the causes of climate change, namely actions to reduce the concentration of greenhouse gases in the atmosphere. Adaptation refers to actions taken to address the impacts of climate change and to respond to the local risks and opportunities climate change may bring. The City of Edmonton's Community Energy Transition Strategy, passed unanimously by City Council and currently being implemented, is the path forward for Edmonton to mitigate climate change and reduce greenhouse gas emissions produced by our community. Climate Resilient Edmonton: Adaptation Strategy and Action Plan, sets a path to respond to the impacts Edmonton will face from a changing climate.

While climate change is a global issue, impacts are being felt at a local scale and will differ depending on the local context. To be successful climate change adaptation efforts must be taken at a local scale, including government action. Local governments

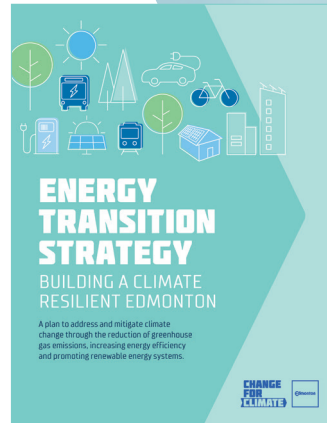
typically have many of the planning and policy tools available to address climate change impacts such as land use planning and zoning, design guidelines for infrastructure and development, and emergency management.

While this adaptation strategy and action plan focuses on impacts to Edmonton, the City of Edmonton recognizes that global climate changes could have specific impacts on Edmonton. For example these changes could impact the global food system and increase climate migration. Determining what these impacts might be will require further detailed studies than what was conducted to inform this strategy. This strategy focuses on local impacts, but it will be important going forward to monitor global trends and gain a better understanding of what global impacts will mean for Edmonton.

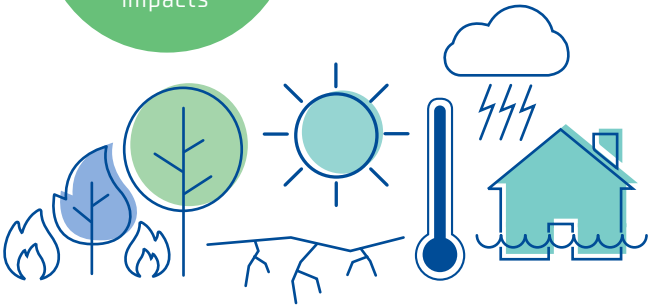
MITIGATION AND ADAPTATION DIAGRAM



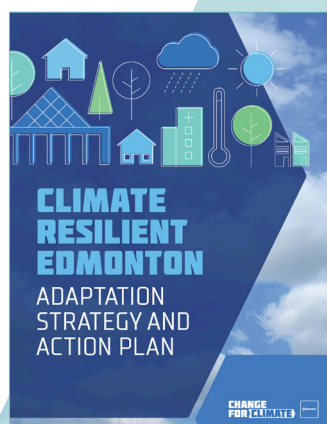
Energy Transition Strategy and Civic Operations Greenhouse Gas Management Plan

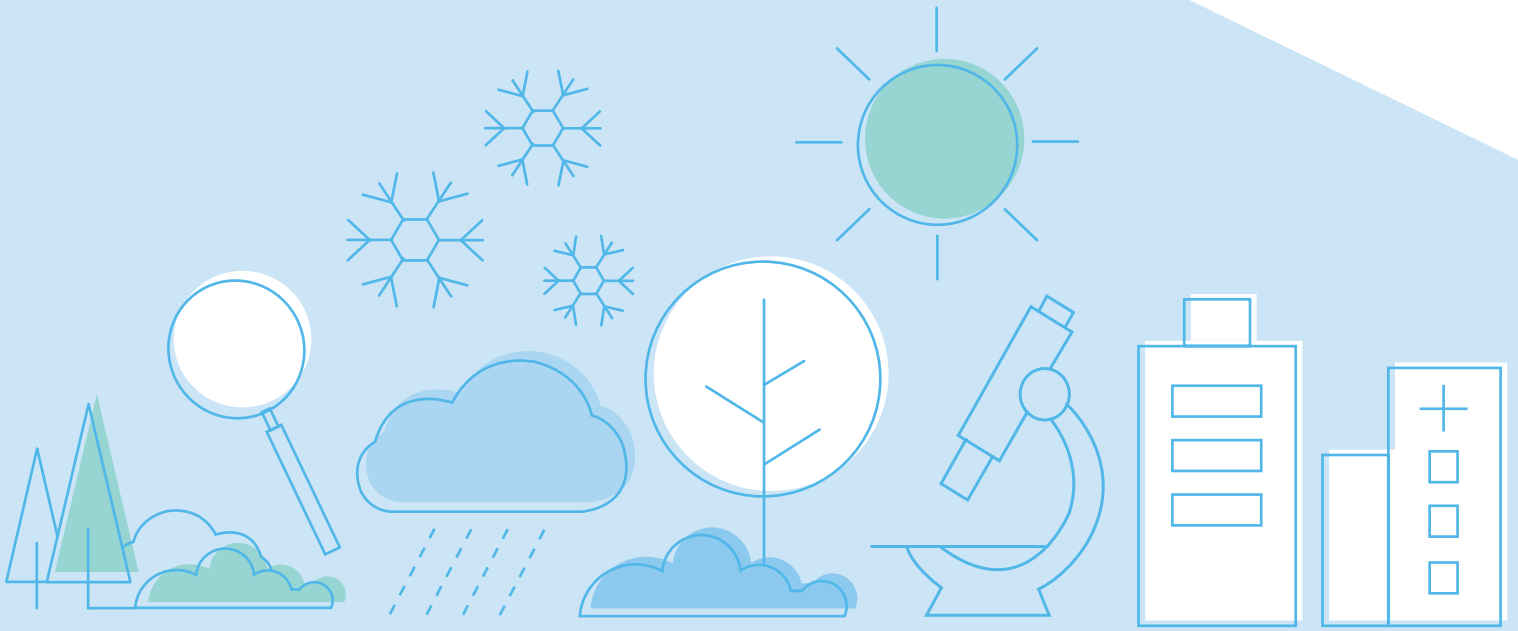


CLIMATE CHANGE IMPACTS EDMONTON



Climate Resilient Edmonton:
Adaptation Strategy and Action Plan





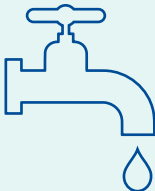


METHODS

METHODS: OVERVIEW

Climate change adaptation planning is complex, and requires analysis of climate science and research as well as expertise in analyzing climate change impacts. The City of Edmonton has followed adaptation planning best practices including methodology and commitments from the International Council for Local Environmental Initiatives (ICLEI) Canada's Building Adaptive and Resilient Communities program and the Global Covenant of Mayors for Climate and Energy. Edmonton has taken a broad approach in developing a climate change adaptation strategy for the community, including both City-owned and community assets and services. Table 1 identifies the asset and service area themes and descriptions included in this strategy development.

TABLE 1. ASSET AND SERVICE AREA THEMES AND DEFINITIONS

Asset and Service Area Theme	Asset and Service Area Description
<p>People</p> 	<p>Health and Safety: The physical and mental health of Edmontonians, including mortality (premature death) and morbidity (injuries, illnesses/disease, stress and anxiety) outcomes.</p> <hr/> <p>Community and Culture: Heritage, cultural, amenity (including recreation) and place-making (including access to food, education, transport, medical services) aspects of the community that affect the well-being or quality of life of residents.</p> <hr/> <p>Emergency Management: The organization and management of resources and roles for dealing with all aspects of emergencies including preparedness, response and recovery (e.g. fire, ambulance, police, etc.).</p>
<p>Food</p> 	<p>The growing of food and raising of animals for food and other uses within and around the city, including related activities such as the production and delivery of inputs and the processing and marketing of products, where relevant.</p>
<p>Water</p> 	<p>Stormwater: The stormwater management system, including roads and sidewalks, stormwater pipes and natural drainage areas.</p> <hr/> <p>Drinking Water: the withdrawal and treatment of raw water, and the supply of potable water to industrial, commercial and residential end-users.</p> <hr/> <p>Wastewater: The collection, treatment and disposal of wastewater.</p>

Infrastructure



Buildings and Property: Commercial, residential, industrial and public buildings (schools, hospitals, recreation facilities, etc.), as well as land and property.

Waste Management: The collection, treatment and disposal of solid waste, including recycling facilities and landfills.

Roads: The road network (including highways and bridges).

Rail: The light rail transit (LRT) network.

Air: Edmonton International Airport.

Active Transportation: Biking and walking trails and infrastructure.

Information and Communications Technology: Information and communications infrastructure, including telephone lines, cable, fibre-optics and related infrastructure.

Electricity: The electricity system, including transmission lines, substations and distribution lines.

Fuel Supply: Infrastructure to support the supply of light and heavy fuel oils.

Places



Natural Environment: Natural areas such as the urban forest in the river valley, manicured parks, trees, terrestrial habitats and ecosystems, aquatic habitats and ecosystems, air quality and soil quality.

Built Environment: The planning and design of the city.

Economy



Small, medium and large enterprises in both goods producing (e.g., construction, manufacturing) and service producing (e.g., finance, banking, insurance and real estate, wholesale and retail trade, tourism, etc.) sectors of the local economy.



Edmonton's Science and Evidence Based Approach

Due to the important and complex nature of this work, community stakeholder and partner perspectives were needed to steer this work. The City of Edmonton partnered with community stakeholders in the development of Climate Resilient Edmonton: Adaptation Strategy and Action Plan, using a multi-stakeholder approach to climate change adaptation planning. This included:

- A strategy stakeholder committee made up of subject matter experts who represented the strategy's asset and service areas themes. The committee was formed at the beginning of this work and met throughout the planning process to provide input, analysis and subject matter advice on all aspects of the work.
- Over 50 organizations participated by sharing their knowledge and expertise in assessing climate change risks and opportunities.

Edmonton's adaptation strategy development can be grouped into three phases: investigation, direction setting and taking action.

INVESTIGATION PHASE

This phase involved research and analysis, including:

- Conducting a current state assessment of Edmonton's level of risk to current climate conditions using the C40 Cities Climate Leadership Group's climate hazard taxonomy.
- Understanding how Edmonton's climate has changed over the past 100 years.
- Developing future climate change projections and scenarios (see Chapter 3).
- Assessing Edmonton's climate change risks and vulnerabilities (see Chapter 4).

- Engaging various local and regional stakeholders and subject matter experts at more than ten workshops to assess the levels of risks and vulnerabilities that climate change may have on identified asset and service areas.
- Conducting an economic analysis to provide an understanding of an overall measure of economic cost of climate change to Edmonton, in the absence of additional planned adaptation.
- Hosting a workshop to identify potential economic opportunities that may arise for Edmonton because of climate change.
- Learning from the first ever IPCC Cities and Climate Change Science conference.
- Partnering with the City of Calgary to commission a series of papers to understand the qualities of climate resilient cities.
- Conducting climate change adaptation and resilience case studies.

DIRECTION SETTING PHASE

This phase involved identifying pathways to a climate resilient Edmonton. It was informed by the knowledge gained and evidence gathered in the investigation phase, as well as through direction from other key guiding work, including:

- The City of Edmonton Charter Regulation which requires the City to establish, review and update a plan for adapting to the effects of climate change. The climate change adaptation plan must be based on an assessment of the exposure, risk and vulnerability of systems within Edmonton to effects of climate change over the short, medium and long term.

- The Edmonton Declaration, which commits local governments (from an adaptation perspective) to:
 - » Undertake climate risk and vulnerability assessments to guide their planning and investment decision, increase climate resilience and minimize the exposure of people and assets to the impacts of climate change.
 - » Establish formal, science-based policy and decision-making processes within their organizations.
- Edmonton's 2050 Vision and Council's Strategic Plan (2019-2028), which contains the climate resilient goal:
 - » Edmonton is a city transitioning to a low-carbon future, has clean air and water and is adapting to a changing climate.
- Public input to further define a vision for a climate resilient Edmonton.

City staff and key collaborators were consulted to develop the action plan and the strategy stakeholder group was engaged to evaluate identified actions. The main output of this phase of work is this document.

TAKING ACTION PHASE

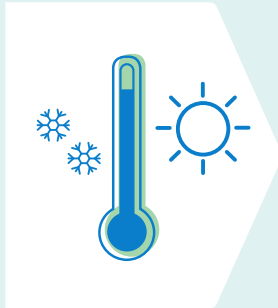
This phase will be the ongoing implementation of the work to date. To be successful, implementation will require engagement with residents and implementation partners. The strategy will be

reviewed and updated at least every five years, to ensure that the best available science and evidence is being used in adaptation planning. Ongoing measurement and reporting of Edmonton's vulnerabilities is required to assess the success of adaptation actions and to determine any changes to vulnerabilities. A monitoring plan and evaluation process that reviews the implementation and progress of Climate Resilient Edmonton: Adaptation Strategy and Action Plan will be developed.

As part of the science and evidence based approach, several climate variables and associated impacts were considered in the assessment. Two types of climate related impacts were included in Edmonton's assessment: sudden onset and slow onset. Sudden onset are discrete, short term events that typically last minutes, hours, or days (UNFCCC 2012). These events already occur, however climate change is altering their frequency, intensity and distribution (Siegele 2012). Slow onset events are caused entirely by climate change (Siegele 2012 and UNFCCC 2012). These events are sometimes called chronic, as the impacts occur gradually over long term timeframes such as decades. The consequences from the slow onset climate change variables can be very significant as they can affect more assets, services and people than sudden onset events, and over a longer timeframe. Table 9 in Appendix B identifies the climate variables that were assessed for the vulnerability and risk assessment.



CLIMATE VARIABLES ASSESSED



CHANGING TEMPERATURES

- Warm Nights
- Cooling Degree Days
- Hot days
- Hottest day
- Accumulated Moisture
- Heat wave frequency
- Heat wave magnitude
- Ice days
- Cold nights
- Coldest night
- Heating degree days
- Extreme heat
- Cold snap frequency
- Drought
- Extreme cold
- Cold snap magnitude
- Frost days
- Freeze-thaw cycles



CHANGING PRECIPITATION

- Precipitation as snow
- Maximum 1-day precipitation
- Maximum 5-day precipitation
- Very heavy precipitation days
- River flooding



CHANGING WEATHER EXTREMES

- Wildland-urban interface fire (wildfire)
- Heavy snow
- Rain-on-snow
- Freezing rain
- Blizzard (winter storm)
- Low-flow in the North Saskatchewan River
- High winds
- Hail
- Lightning Strikes
- Tornado



CHANGING ECOSYSTEMS

- Frost free season length
- Timing of frost free period
- Growing degree days
- Growing season
- Maximum dry spell length
- Frost free season
- Maximum snowpack

Vulnerability refers to the susceptibility of assets and services to be impacted by climate change; it is the function of the nature and magnitude of the impact the asset or service is exposed to, the sensitivity to that exposure, and the adaptive capacity of the asset or service (see Glossary for definitions).

Vulnerability and Risk Assessment

While multiple inputs were used to develop this strategy, one of the primary tools was the stakeholder-led vulnerability and risk assessment. This assessment helped to define Edmonton's adaptation needs by identifying areas of highest vulnerability (see Chapter 4).

Edmonton took an evidence based quantitative approach to the vulnerability and risk assessment. To understand the risks associated with climate change, both the likelihood as well as the consequence of

climate variables were evaluated. The consequence levels of the impacts caused by climate variables were determined by quantifying physical damages and service losses to the specific asset and service areas. This was done by using published damage curves, quantitative vulnerability indices scales, and professional judgement of subject matter experts.

Consequences were quantified across four different categories:

<p>1</p> <hr/> <p>HEALTH AND SAFETY of individuals, families, workers, and vulnerable groups in Edmonton. This category includes physical and mental illness and disease, injuries, and fatalities.</p>	<p>2</p> <hr/> <p>ECONOMY including both goods and service-producing sectors of Edmonton's local economy.</p>	<p>3</p> <hr/> <p>SOCIAL WELLBEING derived from social interactions, sense of place, and community connectedness in addition to access to and the preservation of resources, buildings, activities and events of significant cultural or heritage value.</p>	<p>4</p> <hr/> <p>NATURAL ENVIRONMENT including Edmonton's urban forest and parks, terrestrial and aquatic habitat and ecosystems.</p>
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The definitions and thresholds of the different climate variables were based on a combination of stakeholder input and historical evidence of these variables occurring, and not on the theoretical worst case scenarios. The future likelihood of a specific climate

variable was determined based on climate science modeling, research and statistical analysis. The combination of quantified consequence and likelihood was used to assess the overall risk of each climate variable.

Adaptation Action Planning

The vulnerability and risk assessment identified priority areas for adaptation action planning. Workshops with groups of subject matter experts were conducted to identify potential actions that could be taken to reduce risks or take advantage of new opportunities. These actions were supplemented with actions identified during the practice review, case study and discussion paper research. This list

of actions was then taken forward to the strategy stakeholder committee for evaluation. Criteria from ICLEI's Canadian Communities' Guidebook for Adaptation to Climate Change was used to evaluate the actions. Table 2 identifies the criteria used in this evaluation. The results of this evaluation informed this strategy and action plan.

TABLE 2. ADAPTATION ACTION EVALUATION CRITERIA

Category	Criteria	Low	Medium	High
Sustainability	Mitigation Co-Benefits	Will increase GHG Emissions	Will not affect GHG emissions	Will reduce GHG emissions
	Equity	Benefits few people	Benefits many people	Significantly benefits many people
	Implementation Cost	High cost relative to cost of inaction	Moderate cost relative to cost of inaction	Low cost relative to cost of inaction
Effectiveness	Robustness	Effective for a narrow range of plausible future scenarios	Effective across many plausible future scenarios	Effective across a wide range of plausible future scenarios
Risk and Uncertainty	Urgency	Impacts likely to occur in the long term	Impacts likely to occur in the near to medium term	Impacts are already occurring
Opportunity	Ancillary Benefits	Contributes little or not at all to other City goals and programs	Will contribute moderately to other City goals and programs	Will contribute significantly to other City goals and programs
	No Regret	Will have little or no benefit if climate change doesn't occur	Will have some benefit regardless of climate change	Will have significant benefits regardless of climate change
	Window of Opportunity	There is no window currently	A window could be created	A window exists to implement

Engagement and Outreach Approach

A stakeholder and subject matter expert approach to engagement was the main source of advice and expertise used in the creation of this plan. Other various engagement and outreach efforts occurred as well in order to inform citizens about the strategy's development:

- A Strategy Stakeholder Committee that contributed knowledge, guidance and partnership since adaptation planning work began.
- The City's Environmental Advisory Committee members were provided with multiple opportunities to offer feedback and advice on the strategy development since the work began.
- A series of stakeholder workshops to identify and understand the impacts of current climate hazards.
- A series of stakeholder workshops to conduct a vulnerability and risk assessment of future climate change impacts.
- A stakeholder workshop to identify potential economic opportunities for Edmonton related to climate change.
- A mixed-topic Edmonton Insight Community Survey that attracted over 1600 respondents, indicating that Edmontonians have a wide range of knowledge and understanding about climate change adaptation.

- Pop-up conversations at various events and locations in Edmonton.
- Informational "Climate Change is Here" and "To What Degree?" displays were placed at highly visited recreation venues.
- Public open houses at six locations engaged over 750 citizens in conversations about a climate resilient Edmonton.
- A 2018 general population survey of 1000 Edmontonians that showed 73% of residents are concerned about climate change and that 72% of residents believe action is required now to address climate change.

While subject matter experts and climate scientists were the main source of advice and guidance in developing the strategy, residents, staff, and the City's partners at EPCOR will be at the forefront of readying Edmonton, its homes, businesses and communities for a changing climate. Deeper engagement opportunities for residents will be provided during implementation.





CLIMATE SCIENCE AND PROJECTIONS

CLIMATE SCIENCE AND PROJECTIONS

Countries and communities around the world are already experiencing the impacts of climate change including droughts, floods, and an increase in storm surges (IPCC 2014). Our weather and climate systems are naturally variable, and events such as El Niño and La Niña oscillations contribute to year-to-year fluctuations. Climate change, however, assesses the changes in climate once those fluctuations have been accounted for. An important distinction to make is the difference between weather and climate.

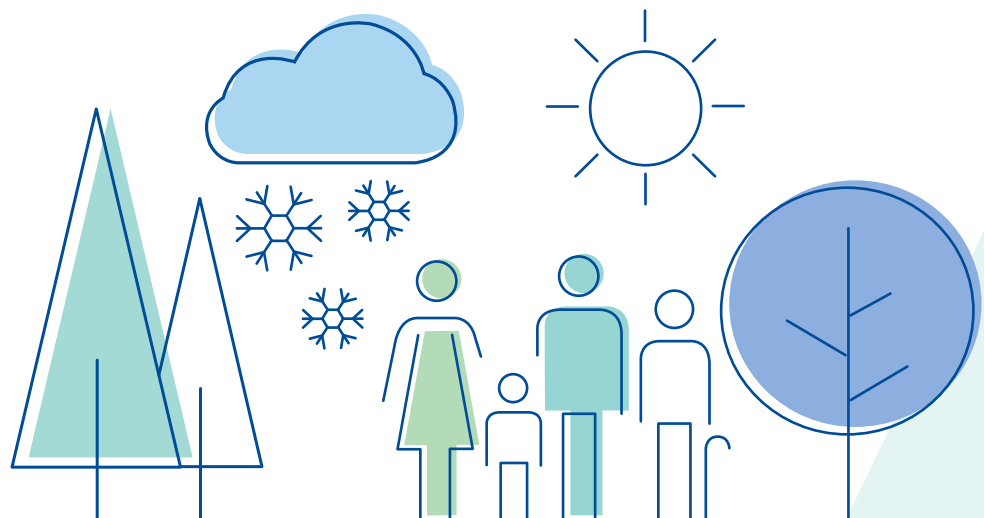
Weather refers to the atmospheric conditions we are all familiar with, including events such as rain, snow, and temperature that occur over a short period of time, such as days, and change rapidly. Climate describes the atmospheric conditions over longer periods of time, such as months, years or decades.

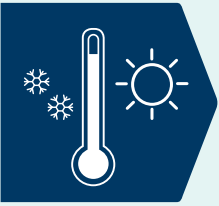
Climate change refers to long-term changes to climate variables, typically assessed over 30 year periods. The IPCC has concluded that many of the observed changes in the global climate since the 1950s are unprecedented. These changes are attributed to the global increase of greenhouse gases in the atmosphere and changes in land use.

In Canada, observations indicate that changes to temperature, precipitation, snow and ice cover and extreme weather events are already occurring (ECCC 2016). Environment and Climate Change

Canada has estimated that the average rate of warming across Canada is double that of the global average (ECCC 2016).

To assess potential climate changes in the Edmonton region, climate change models used by the Intergovernmental Panel on Climate Change combined with a variety of scientific research studies were conducted to determine climate change projections for specific climate variables and impacts of those variables relevant to Edmonton. These studies identified four major climate change impact themes for Edmonton: 1) Changing Temperatures, 2) Changing Precipitation, 3) Changing Weather Extremes, and 4) Changing Ecosystems. Summaries of the main findings within these themes are provided below.





Changing Temperatures

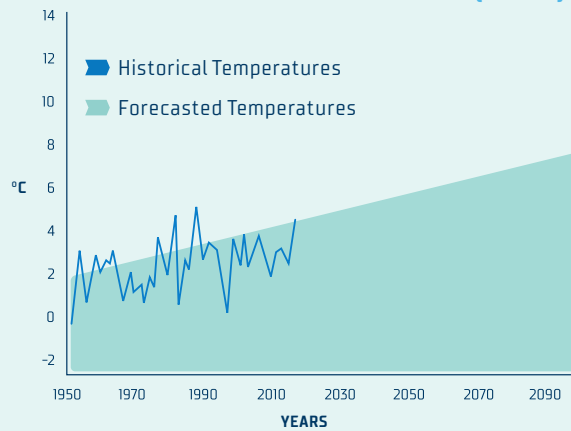
Edmonton can expect average temperatures to increase in the future, across all seasons, with the largest increases happening in the winter. By the 2050s, on average it is expected that Edmonton's annual average temperature of +2.1°C will increase by 3.5°C to 5.6°C and by approximately 6°C to 8°C by the 2080s. In winter, however, the average temperature of -13°C is expected to increase by 4.5°C by the 2050s to -8.5°C and by 7°C to -6°C by the 2080s. Edmonton can also expect maximum temperatures that are hotter than previously experienced. Table 4 presents other climate variables that were modeled; they indicate changing temperatures for Edmonton.

It is important to note that, even though temperatures are expected to increase and minimum temperatures may not be as cold as previously experienced or occur as often, Edmonton will continue to experience periods of cold weather.

Increasing temperature in the Edmonton region is expected to have an impact on drought conditions. One climate variable that can be used to assess potential drought conditions is the Accumulated Moisture Index, which takes into account both

precipitation and evapotranspiration (which increases as temperature increases). It is expected that annual accumulated moisture will increase slightly, but will decrease during summer months. This will result in an increased likelihood of drought conditions during the summer.

FIGURE 1. AVERAGE MEAN DAILY TEMPERATURE (ANNUAL)



BUSINESS AS USUAL

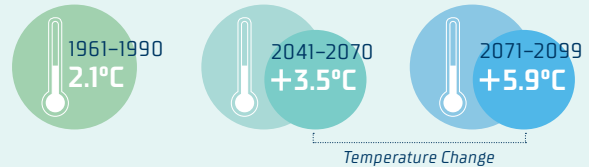
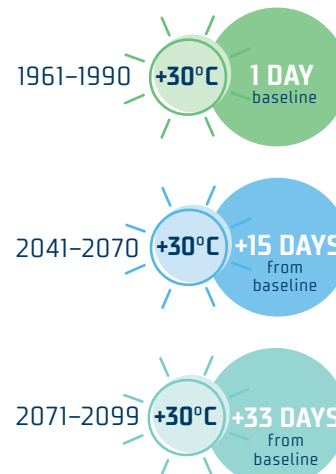


TABLE 4. CHANGING TEMPERATURE CLIMATE VARIABLES

Climate Variable	Historical Baseline	Projected Change by 2050s	Projected Change by 2080s
Warm nights <i>(Nighttime temperatures above 10°C)</i>	31 days/year	78 days/year	108 days/year
Hot Days <i>(Daytime temperatures above 30°C)</i>	1 day/year	16 days/year	34 days/year
Hottest Day	30°C	35°C	38°C
Cold Nights <i>(Nighttime temperatures below -20°C)</i>	43 days/year	22 days/year	11 days/year
Coldest Night	-38°C	-31°C	-27°C

BUSINESS AS USUAL

A "Hot Day" is defined as the annual number of days with maximum daytime high temperatures over 30 degrees.





Changing Precipitation

Edmonton's precipitation patterns are expected to change in the future. While temperature is expected to increase in all seasons, precipitation may increase in some seasons, but change very little in others. On average, Edmonton's annual precipitation of approximately 458 millimeters (mm) is expected to increase by 40 mm by the 2050s and 54 mm by the 2080s. The biggest seasonal increase of precipitation is expected to occur in the spring, while precipitation is expected to decrease during the summer months.

Edmonton can expect more heavy rainfall events in the future. Maximum one-day precipitation and maximum five-day precipitation are two variables

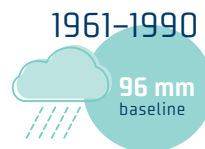
used to assess the maximum amount of precipitation that falls in one and five days, respectively. Both variables indicate that the maximum amounts of precipitation received at one time are likely to increase (see Table 5). This is likely to lead to an increase in both urban and river flooding events. Studies show that the likelihood of urban flooding events occurring will almost double by the 2050s, and the likelihood of river flooding events will double by the same time. It is important to note, however, that the likelihood of river flooding events remains low.

Overall, Edmonton should prepare for drier summers, wetter winters, and more heavy rainfall events.

TABLE 5. CHANGING PRECIPITATION CLIMATE VARIABLES

Climate Variable	Historical Baseline	Projected Change by 2050s	Projected Change by 2080s
Maximum One-Day Precipitation	28 mm	31 mm	32 mm
Maximum Five-Day Precipitation	43 mm	51 mm	51 mm
Total Annual Precipitation from Very Heavy Rain	96 mm	118 mm	127 mm

BUSINESS AS USUAL



"Precipitation from very heavy rain" is the annual sum of the daily precipitation from the top 5% heavy rain events.

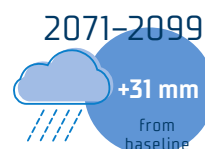
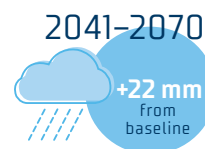


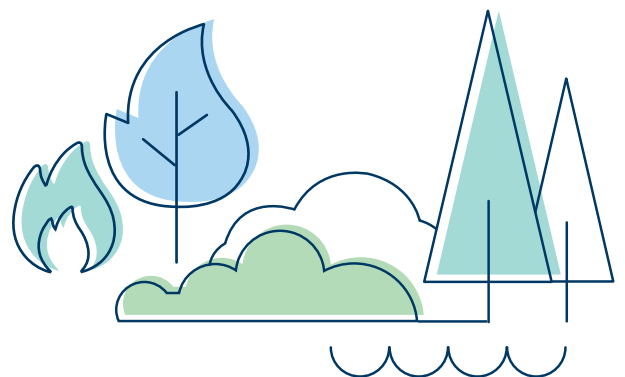


TABLE 6. EXTREME WEATHER TRENDS

Extreme Weather Event	Trend in Frequency of Event
Wildfire	Increasing
Low Flow in River	Increasing
Rain on Snow	Increasing
Freezing Rain	Increasing
High Winds	Increasing
Heavy Snow	Unknown
Blizzard	Unchanged
Hail	Unknown
Lightning	Increasing
Tornado	Unknown

Changing Weather Extremes

As temperature rises and there is more energy in the atmosphere, it is expected that atmospheric conditions will be more conducive to producing more frequent and intense extreme weather events. Where climate models are unable to predict specific weather events, supplemental research was conducted to establish the expected trend of the frequency of an event arising. Table 6 presents the likely trend in frequency of extreme weather events for Edmonton.





Changing Ecosystems

In addition to the temperature, precipitation, and extreme weather event changes described above, changes in other climate variables, like those listed

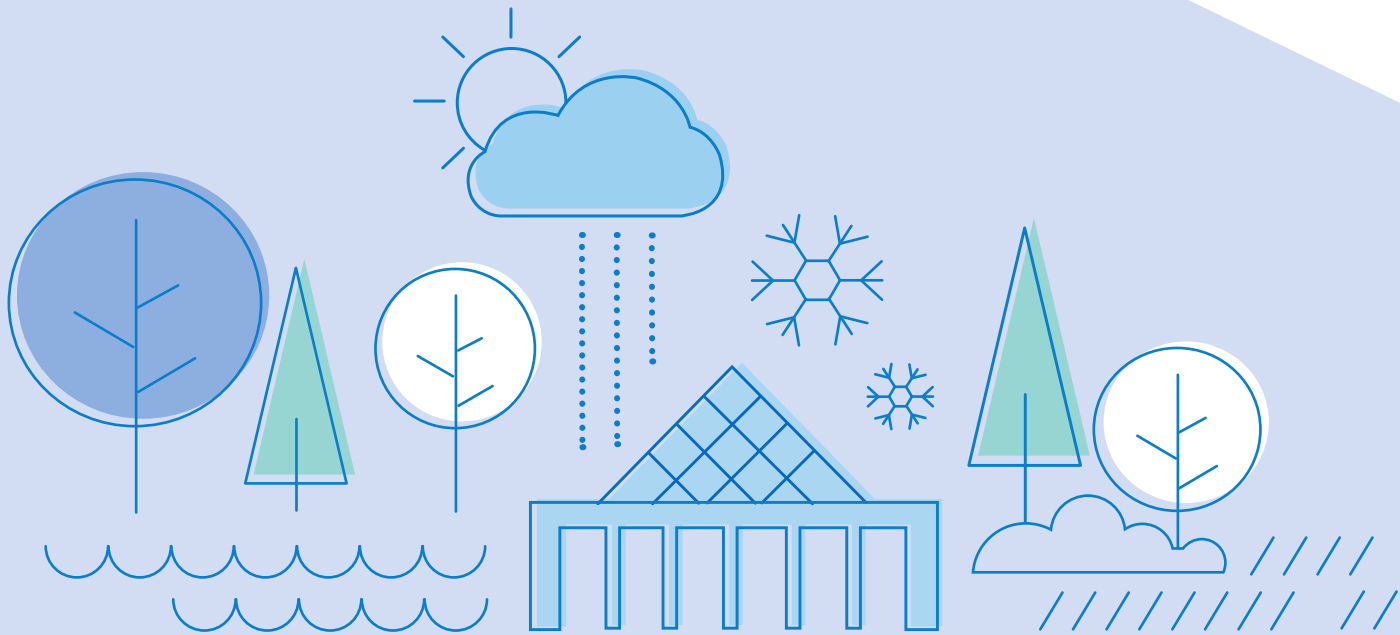
in Table 7, will also contribute to long term ecological change.

TABLE 7. LONG TERM CLIMATE CHANGE VARIABLES

Climate Variable	Historical Baseline	Projected Change by 2050s	Projected Change by 2080s
Frost Free Season	211 days	232 days	243 days
Growing Season Length	178 days	202 days	220 days
Frost Days (days with minimum temperature less than 0)	204 days	170 days (limited to changes in the spring and fall seasons)	151 days (limited to changes in the spring and fall seasons)
Maximum Snow Pack	52 mm snow water equivalent (SWE)	47 mm SWE	41 mm SWE

These variables indicate that there will be a long term overall trend of warming and drying in our climate. Research from the Alberta Biodiversity Monitoring Institute predicts that, by the 2050s, Edmonton's climate will be more conducive to supporting

grassland ecosystems (similar to what is currently present in southern Alberta) than the Boreal/Aspen Parkland transition ecosystems currently supported (Schneider 2013).



4

IMPACTS AND OPPORTUNITIES

IMPACTS AND OPPORTUNITIES

The modeled and projected changes to Edmonton’s climate conditions as presented in Chapter 3 will have impacts across Edmonton. These impacts were determined through research and the work of the vulnerability and risk assessment. This assessment identified relative climate-related risk categories for Edmonton grouped into the following categories: changing temperatures; changing precipitation patterns; more frequent and intense weather events; and changing ecosystems due to the overall warming and drying of Edmonton’s climate.

- 1**

CHANGING TEMPERATURES
- 2**

CHANGING PRECIPITATION PATTERNS
- 3**

CHANGING EXTREME WEATHER
- 4**

CHANGING ECOSYSTEMS

These climate changes will have varying impacts on the different asset and service areas. The following discusses the consequences of the impacts that require adaptation planning.

Human Health and Social Welfare Consequences

Globally, climate change is expected to impact public health, primarily by amplifying health concerns that are already present (IPCC 2014). As examples, a greater likelihood of injury and death is expected due to more intense heat waves and wildfires. As well it is projected that health risks from waterborne and vector borne diseases will increase globally because of climate change.

Climate Change is also expected to have direct physical and mental health impacts in Edmonton. Even without accounting for population growth, an additional 22,000 adverse health episodes are anticipated annually by the 2050s (compared to baseline). Disability-Adjusted Life Years (DALYs) is one metric commonly used to measure health impacts in a population in terms of the loss of years of healthy life. One DALY is equivalent to one lost year of healthy life. The vulnerability and risk assessment conducted for Edmonton estimated total DALYs anticipated for different climate changes. The 22,000 additional health episodes per year anticipated in Edmonton by the 2050s results in 2,400 DALYs in the population. This is primarily related to physical and mental health effects associated with higher temperatures and an increase in frequency and severity of both drought and freezing rain events.

Economic Consequences

Climate change has implications for global, national and local economies. The IPCC has stated that throughout the 21st century, climate-change impacts are projected to erode food security, slow down economic growth and make poverty reduction more difficult (IPCC 2014). In 2018, three of the top five global risks identified by the World Economic Forum are related to climate change: extreme weather events, natural disasters, and failure of climate change mitigation and adaptation.

Climate change impacts, such as damages and disruption from extreme weather events, adverse health effects, and direct and indirect lost productivity and services, can have significant financial, economic, and social implications for municipalities and local economies. As Edmonton grows and the climate continues to change, economic analysis indicates that climate impacts on the city could increase by \$8.0 billion by the 2050s and \$18.2 billion by the 2080s (compared to today). These 'social' costs include health costs, environmental costs and financial losses. Looking solely at the gross domestic product (GDP) component, Edmonton's GDP would be \$3.2 billion and \$7.4 billion lower by the 2050s and 2080s, respectively (compared to today). Social and GDP costs for Edmonton increase with each degree of additional warming.

Investment in climate resilience reduces exposure to climate risks, lowers social and GDP costs, and improves investor confidence and credit ratings. In turn, improving urban resilience to climate change will promote economic resilience. The National Round Table on the Environment and the Economy stated that the cost to build a new house, bridge or transmission line that is adapted to climate change for its lifecycle will only add 0% to 5% to construction costs, which is more economical than restoring infrastructure post damage, retrofitting, rebuilding or increasing maintenance costs for the remaining life of an asset.

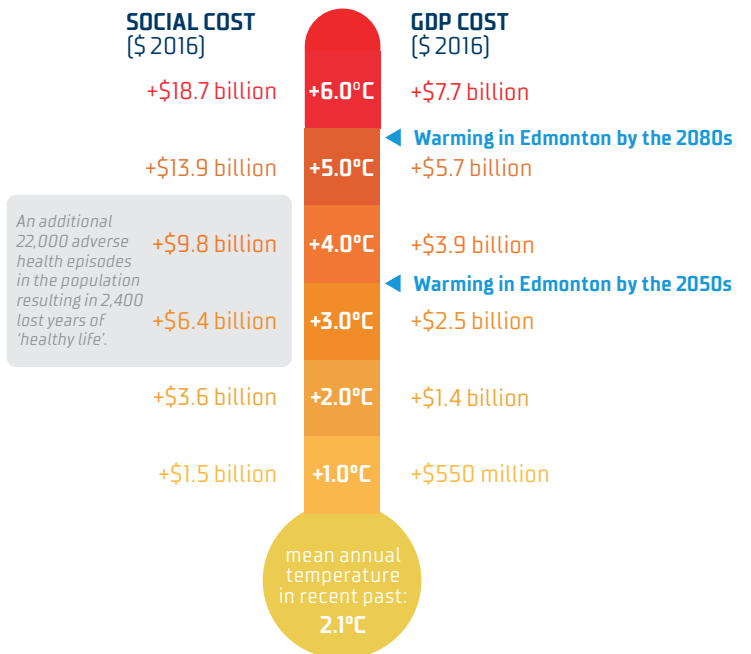
Urban Infrastructure Consequences

Modern cities have become increasingly dependent on our built infrastructure systems, including transportation, buildings, water and sanitation, electricity, and information communication technology systems. In urban areas, climate change is likely to increase risks to these assets, including risks from heat stress, storms, extreme precipitation events, flooding, air pollution, drought and water scarcity (IPCC 2014).

Infrastructure developments are a key area for adaptation. Typically infrastructure assets have long life spans in which they are likely to be exposed to future climate conditions. Infrastructure in Canada (including Alberta and Edmonton) is vulnerable to climate changes due to age and over use from population growth. At the same time reinvestment efforts have not been sufficient to maintain infrastructure (Canada Infrastructure Report Card 2016).

Direct changes to weather patterns can impact infrastructure by accelerating chemical (corrosion), biological (mould), and other (snow loading, heavy wind, etc.) weathering. Changing precipitation that leads to urban or river flooding can have a direct impact on facilities such as the water treatment system as well as residential or commercial buildings.

FIGURE 2. SOCIAL AND ECONOMIC LOSSES



Conversely, dry conditions can lead to damage to foundations and linear assets such as water distribution pipes and underground electricity cables. More intense and frequent weather events such as high winds, blizzards, and tornadoes can cause disruptions to electricity supply and information and communications systems. These direct damages can also result in service disruption.

Environment Consequences

Climate change will have global impacts on the natural environment and ecosystems. In many regions around the world, climate change is already impacting the hydrological cycle. Changing precipitation patterns and melting snow and/or ice are affecting water resources, both in terms of quality and quantity (IPCC 2014).

Edmonton is fortunate to be located along the North Saskatchewan River; however impacts to glaciers and snowpacks in the headwaters could change the timing and volume of flows in the river. This can have consequences for potable water treatment and supply, particularly as the North Saskatchewan River is Edmonton's only source of drinking water.

As summers become drier, and drought conditions become more frequent and severe, the availability of water could change, as could the types of plants that are viable in Edmonton. Already, many species (terrestrial, freshwater, and marine) have shifted their geographic ranges, migration patterns, and interactions in response to climate change (IPCC 2014). As climate changes continue, a large fraction of species face a higher risk of extinction during and beyond the 21st century (IPCC 2014). Most plant species cannot naturally shift their ranges fast enough to keep pace with the rate of change that is occurring (IPCC 2014). Specific to Edmonton, the shift to a warmer and drier climate overall is likely to become more conducive to supporting grassland ecosystems, instead of the forested and parkland ecosystems present today.

Opportunities

Climate change consequences are often at the forefront of adaptation planning, however Edmonton is uniquely positioned to pursue various opportunities.

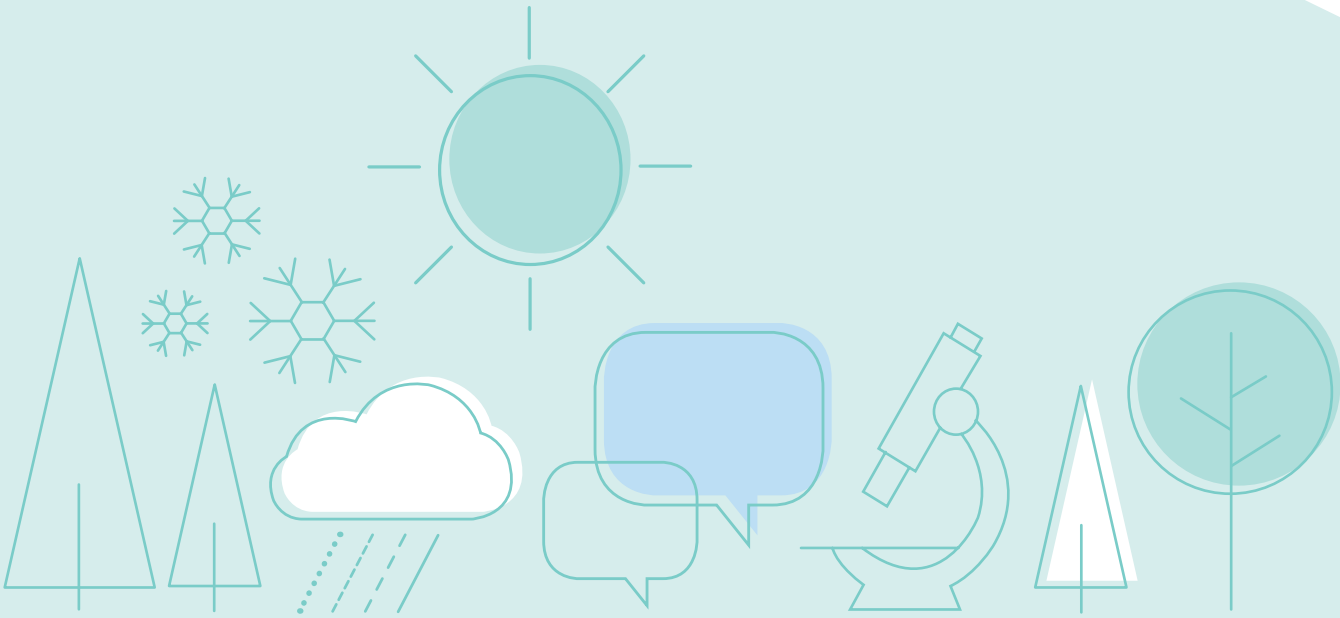
Warmer temperatures could:

- reduce the number of cold-related injuries and illnesses
- encourage more people to use active modes of transportation more frequently
- increase tourism and recreation opportunities
- increase the viable construction season in Edmonton
- lengthen the growing and frost free seasons which could have various benefits, including for local agriculture.

Increasing resilience can help attract businesses, talent and residents, particularly as other regions may see more severe and negative impacts from climate change. There are also opportunities to leverage existing capabilities in the region such as data analytics and machine intelligence to combine data and improve climate related analysis.

Both consequences and opportunities were considered during the development of climate resilient pathways for Edmonton.





**PATH TO
A CLIMATE
RESILIENT
EDMONTON**

PATH TO A CLIMATE RESILIENT EDMONTON

Edmonton’s journey to becoming a climate resilient city involves five comprehensive and interconnected pathways. Each path is needed and will guide us as we work to make scientific and evidence-based decisions and prepare for changes to our temperatures, precipitation, weather extremes and ecosystems.

To establish these five paths, we consulted many stakeholders and subject matter experts. We also engaged with and listened to Edmontonians’ vision for a climate resilient Edmonton. These conversations were meant to expand upon the aspirational vision for the year 2050 included in City Council’s Strategic Plan 2019–2028. Vision 2050 sees Edmonton as a city transitioning to a low-carbon future, has clean air and water, and is adapting to a changing climate. Open house attendees helped to create a complementary

vision for a climate resilient Edmonton for this strategy: *Edmonton is a safe, healthy, sustainable community that grows in harmony with nature while adapting to and prepared for a changing climate.*

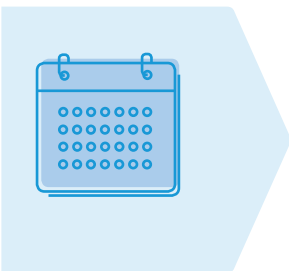
The fulfillment of this vision will require effort, change and adaptation from all of us. It will require that actions taken for implementation follow seven underlying strategic principles for Edmonton’s adaptation journey.



STRATEGIC PRINCIPLE 1:

The City of Edmonton will apply a climate science and evidence based decision making approach to becoming a climate resilient city.

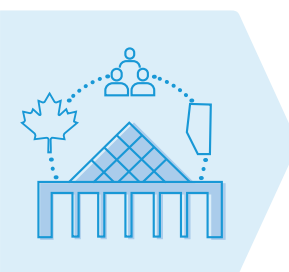
The complex social, economic and environmental adaptation challenges facing Edmonton necessitates science-based approaches and solutions. The path forward to a climate resilient Edmonton requires decision making based on the best available science, research and evidence.



STRATEGIC PRINCIPLE 2:

The City of Edmonton will take into account short, medium and long term changing climate conditions, vulnerabilities, risks and opportunities in decision making, recognizing that decisions made today can impact the long term climate resilience of Edmonton.

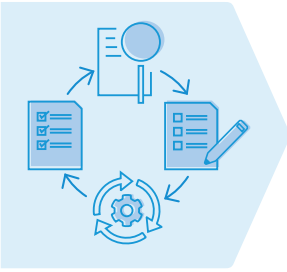
The long term health and climate resilience of Edmonton and its residents is critical. We can plan for this to happen, in part, through the decisions we make today. The path forward to a climate resilient Edmonton requires a scientific climate resilience lens be applied to planning, development, asset and service decisions.



STRATEGIC PRINCIPLE 3:

The City of Edmonton will engage and partner with Federal/Provincial governments, regional municipalities, Indigenous communities and key stakeholders to achieve Edmonton’s climate resilience goals.

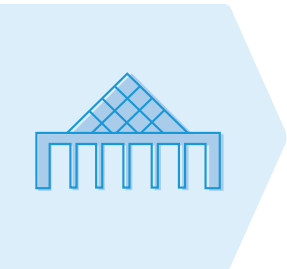
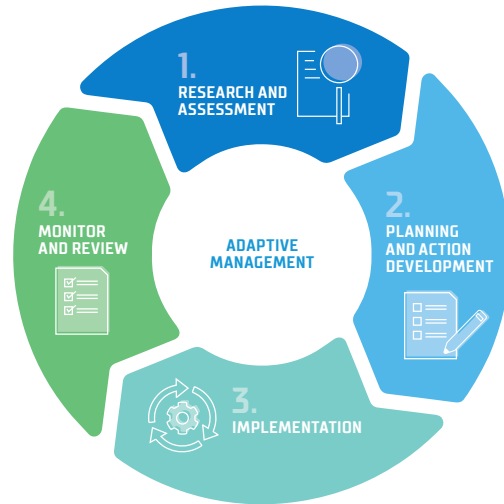
Adapting to climate change requires partnership and coordination between all levels of government, we need to work together in research and action initiatives. We can become collectively stronger by working with federal and provincial levels of government, regional neighbours, academic and other research institutions, and community partners.



STRATEGIC PRINCIPLE 4:

The City of Edmonton will pursue Edmonton’s climate resilience goals by using an adaptive management approach supported by measurement, monitoring and analysis.

The adaptive management approach recognizes that there is an element of “learning by doing”. This includes piloting initiatives, reflecting on and adjusting them, and sharing adaptation lessons. This flexibility in adaptation approaches allows for continual learning, improvement of our understanding of local, regional, national and international issues and solutions, and adjustment to adaptation planning and actions.



STRATEGIC PRINCIPLE 5:

The City of Edmonton will take a lead role in supporting Edmonton’s resilience and adaptation efforts. In doing so, it will lead by example in its own civic operations.

The City of Edmonton plays a central role in adapting Edmonton to the effects of climate change. We can prepare our own civic assets and services and lead the community on the journey towards a climate resilient Edmonton.



STRATEGIC PRINCIPLE 6:

The City of Edmonton will engage with citizens to deepen their understanding of climate change, involve them in decisions that affect them, and build their capacity for strengthening climate resilience within themselves and their communities.

We recognize that communities might be defined in different ways. They can be place-based geographic locations, organizations, special interest groups, etc. Pathways to resilience and adaptation will be different for each community. It follows that engagement initiatives will differ depending on the relevant climate impacts to each community.



STRATEGIC PRINCIPLE 7:

The City of Edmonton will take socially inclusive approaches to adaptation and climate resilience.

Edmonton is only resilient when its residents are also resilient. This requires an inclusive approach that considers the unique needs of different communities, including vulnerable populations.

Five Paths to Climate Resilience


Climate Resilient Edmonton: Adaptation Strategy and Action Plan is a journey that involves five interconnected paths. The paths connect science-based decision making with the primary climate change impacts identified during our research. Each path is an important part of Edmonton’s journey to climate resilience.

Within each path, specific goals have been determined and specific adaptation actions are identified to achieve the goal(s). Each action is an “umbrella” under which smaller actions (including supporting actions and actions that are already in progress) reside. These are the actions that need to be initiated in the next four years; they represent the priority actions of the strategy. The actions mainly reflect activities that the City of Edmonton must undertake, however, some actions recognize activities that are being led by other partners. Specific

details of each action will be determined during the implementation phase.

We understand the need for broader regional collaboration on some aspects of climate change adaptation planning. We are just starting to embark on this journey, and like any journey we will have to regularly reflect on our progress and adjust our plans as needed to successfully reach our goals. As such, this plan and the actions within will be reviewed and revised as needed (see Appendix A).

PATH 1: SCIENCE AND EVIDENCE BASED DECISIONS



This path is the underlying foundation of Edmonton’s approach to climate change adaptation; it influences all other strategy pathways. This path is directional in Edmonton’s climate resilience efforts. This path sets forward goals and actions to support: science and evidence based decision making; climate resilient infrastructure and built form; and communities, households, institutions and residents who are more prepared for impacts and opportunities from our changing climate.

GOAL 1:

The City of Edmonton uses formal climate science and evidence based policy and decision making processes

ACTION 1:

The City of Edmonton develops and implements a climate science and evidence based decision-making framework

Description: We will create a formal mechanism for both City Administration and Council to integrate climate science and evidence into their decision-making processes. This includes the consideration of science and evidence as it relates to our health, economy, environment, infrastructure and climate. Implementation of this action will provide our decision makers with the most up-to-date and best available science, research and evidence. This will affect all five of the climate change adaptation paths and will require cross-organizational integration and leadership to be successful.

ACTION 2:

The City of Edmonton develops and implements a vulnerability risk assessment, resilience and adaptation planning, measurement and reporting program

Description: This ensures the ongoing review and update of Climate Resilient Edmonton: Adaptation Strategy and Action Plan to reflect any updated understanding of risks and vulnerabilities. It will also ensure we meet the City of Edmonton Charter Regulation's adaptation planning requirements. It will identify data requirements, monitoring data, tracking and assessing trends in data, reporting on measures that monitor the success of adaptation actions and goals, and overall community resilience.

ACTION 3:

The City of Edmonton leads by example by continuing to pilot, evaluate, share results and implement science based adaptations

Description: We recognize the City of Edmonton must be a community leader on climate change adaptation. Through piloting and sharing the results of adaptation interventions, we will lead other community members to take similar actions.

GOAL 2: Edmonton is planned, designed, developed and built to be climate resilient today and for future Edmontonians

ACTION 4:

The City of Edmonton in partnership with community stakeholders develops and integrates climate adaptation and resilience standards into urban and strategic planning, design, and development approval processes

Description: To increase the resilience of our built urban environment, we will integrate climate adaptation and resilience into key city planning and development processes, policies and standards. This includes participation in federal and provincial initiatives such as building code updates.

ACTION 5:

The City of Edmonton conducts climate change impact assessments on existing assets, ongoing maintenance programs, planned retrofits, and new infrastructure developments

Description: We will develop a process for Edmonton to apply a climate lens risk management approach so that we can then access federal infrastructure funding. Beyond that, this action includes asset level climate resilient assessments and improvements to support climate resilient infrastructure.

GOAL 3: Edmonton's communities, businesses and institutions are aware, connected, and prepared for climate change

ACTION 6:

The City of Edmonton in partnership with community stakeholders develops and implements a community scale and household climate change readiness program

Description: We will work with communities to develop community scale climate resilience plans; they will focus on community-specific assets, risks and vulnerabilities, and support of households as they become more climate resilient.

ACTION 7:

The City of Edmonton develops and implements a local business and institution climate change readiness program

Description: We will help support local businesses and institutions prepare for climate change. Initiatives under this action will also explore economic opportunities in which Edmonton could potentially capitalize upon changes to the climate.

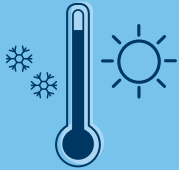
ACTION 8:

The City of Edmonton in partnership with community stakeholders develops and implements a community “Resilience Hubs” program that provides support and resources for residents to improve their capacity to cope with climate changes and extreme weather

Description: We will identify the need for (and subsequently identify partnerships to provide) community amenities that can be used in the event of an emergency or as a climate change innovation and demonstration facility.

PATH 2:

PREPARING FOR CHANGING TEMPERATURES



This path sets forward goals and actions to support adapting to increasing temperature and preparing for more frequent drought conditions.

GOAL 4: Edmonton's communities and urban environment are resilient to changing temperatures

ACTION 9:

The City of Edmonton develops and implements a “Cool Edmonton” program to reduce the impacts of urban heat island effect

Description: We will work with partners to incorporate actions that reduce the impacts of the urban heat island effect in the built environment and provide accessible information to those who may need to locate cooling amenities.

GOAL 5: Edmonton is proactive in drought management to minimize social, economic and environmental impacts

ACTION 10:

The City of Edmonton in partnership with EPCOR and other stakeholders develops and implements a drought management program

Description: We will work with partners to support Edmonton as it prepares for, responds to and recovers from drought conditions.

PATH 3:**PREPARING FOR CHANGING PRECIPITATION**

This path sets forward goals and actions to support adapting to potential changes to our water supply and to flooding impacts that changing precipitation may bring.

GOAL 6:

Edmonton's water supply is secure and safe for current and future Edmontonians

ACTION 11:

The City of Edmonton in partnership with EPCOR and other stakeholders enhances long term source water security and protection planning for water quantity and quality

Description: We will work with partners to integrate climate change into source water protection approaches, including water conservation/re-use and identification of potential future water sources.

GOAL 7:

Edmonton is a flood resilient community

ACTION 12:

The City of Edmonton in partnership with the Province of Alberta and other stakeholders researches, develops and implements a river and ravine flooding resilience program

Description: We will identify partnership opportunities with the provincial government to understand the vulnerabilities and risks to communities and infrastructure should the North Saskatchewan River and connected ravines flood. We will also implement resilience actions, while keeping in mind the role that natural wetlands have in flood resilience.

ACTION 13:

The City of Edmonton in partnership with EPCOR develops and implements an urban flooding resilience program

Description: We will work with partners to make Edmonton more resilient to urban flooding events, and integrate changes to our climate into stormwater management approaches.

PATH 4: PREPARING FOR CHANGING WEATHER EXTREMES



This path sets forward goals and actions to increase the resilience of our electricity and fuel systems, and to support Edmontonians prepare for, respond to and recover from changing weather extremes.

GOAL 8: Edmontonians with regional partners are informed, prepared for, can respond to and recover from increasing frequency and severity of extreme weather events

ACTION 14:

Integrate changing climate extremes into coordinated emergency management programs including preparedness, prevention, response and recovery

Description: Climate change considerations will be integrated into emergency management planning and priority backup power locations will be identified and evaluated.

GOAL 9: Edmonton has resilient energy systems

ACTION 15:

The City of Edmonton identifies and assesses opportunities to increase the resilience of Edmonton's energy systems

Description: We will investigate the resilience of energy systems within Edmonton and identify priority areas susceptible to disruption or increased demand due to climate impacts inside and outside the city's boundaries.

PATH 5: PREPARING FOR CHANGING ECOSYSTEMS



This path sets forward goals and actions to support the protection of ecosystem goods and service we rely on for maintaining our quality of life, and to improve the resilience of our food systems and urban agriculture.

GOAL 10: Edmonton's natural ecosystems continue to provide essential ecosystem goods and services such as clean air, clean water, and biodiversity

ACTION 16:

The City of Edmonton in partnership with stakeholders enhances integrated pest management policies and practices on public and private lands

Description: Changes to our climate may introduce new pests and invasive species to Edmonton. We will adapt our integrated pest management practices to respond.

ACTION 17:

The City of Edmonton develops and implements an ecosystem services based program, that includes ecological restoration, that supports climate resilience

Description: To ensure Edmonton's natural ecosystems are resilient to climate change impacts, we will establish an integrated ecosystem services team to conduct comprehensive ecological and environmental planning. This will maintain healthy ecosystems as part of a healthy and resilient city and will preserve, conserve, and foster wellbeing of the environment.

GOAL 11: Edmonton's food systems are resilient, reliable and secure

ACTION 18:

The City of Edmonton will research, develop and integrate climate change food resilience and agribusiness program into Edmonton's food and urban agriculture strategy

Description: We will integrate climate change resilience into plans, programs, policies and actions related to Edmonton's food system, as well as explore agribusiness opportunities.

Implementation and Monitoring

Implementation of these 18 actions will set Edmonton on a path towards becoming resilient to expected climate changes. Some actions will be achieved through existing City of Edmonton projects and programs. Other actions rely on partner organizations responsible for the specific asset or service. Where needed, new projects and programs will be developed in partnership with stakeholders.

The City of Edmonton intends to review and evaluate progress on the strategy annually. This will occur with

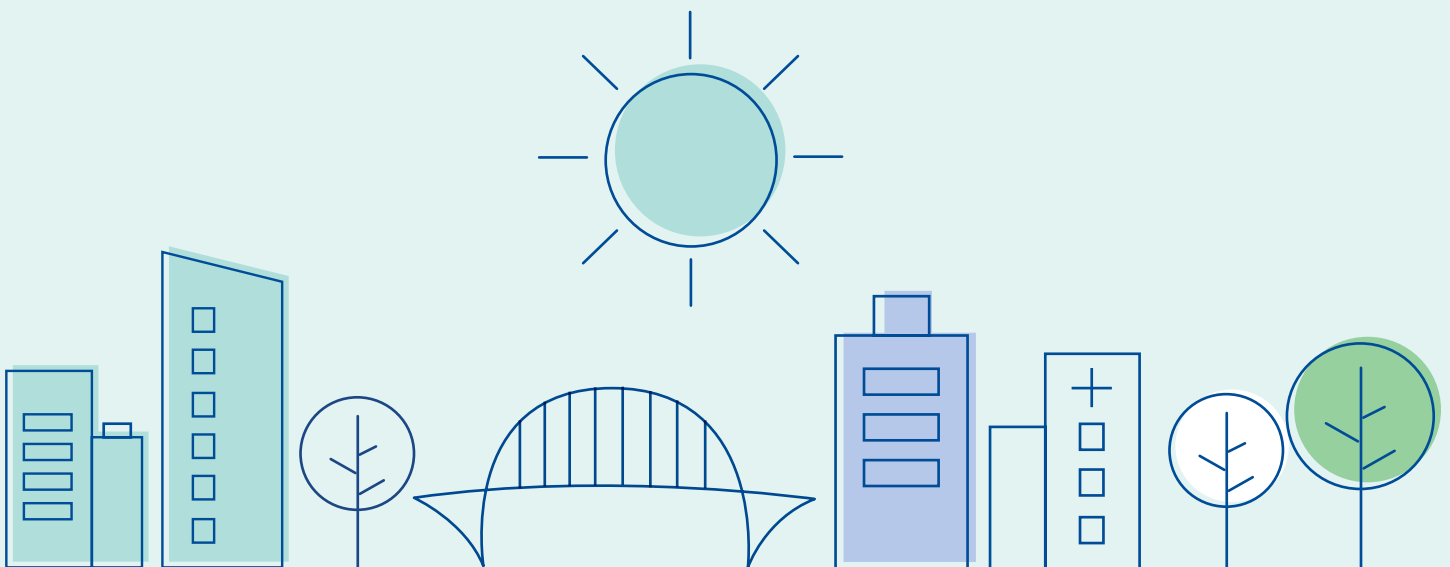
the use of evaluation measures (to be developed) and through a community indicator on resilience. This will require extensive monitoring of adaptation actions, as well as conditions and responses of those actions in the climate, environment, social and economic systems of Edmonton. The associated data analytics will provide evidence for updates. Climate Resilient Edmonton: Adaptation Strategy and Action Plan will be updated every five years, at a minimum.

CONCLUSION

Edmonton can become a climate resilient city. We understand that to become an adaptive and resilient city, we must plan for and respond to the climate change impacts arising today and those we anticipate will occur in the future.

We already started this journey; we have guiding work like Edmonton's Community Energy Transition Strategy, City Council's Initiative on Energy Transition and Climate Resilience and, now, the Climate Resilient Edmonton: Adaptation Strategy and Action Plan. Edmonton is quickly becoming a leader in climate change mitigation and adaptation initiatives and we intend to continue down this path.

Though we have created this plan and will work towards implementing the actions contained within it, we know we can't do it alone. We need to continue to engage with Edmontonians, as well as local and global subject matter experts and partners. We need to ensure that our City Council can make decisions with a climate change lens, using the most up-to-date science and evidence. We need Edmontonians to ready their homes, businesses and communities for our shifting climate. Together, we can take this journey towards creating a Climate Resilient Edmonton.



GLOSSARY

ADAPTATION

Lowering the risks and negative impacts and embracing potential opportunities associated with climate change so that communities and ecosystems are prepared to cope with new climate conditions.

ADAPTIVE CAPACITY

The ability of built, natural and social systems to adjust to climate change (including climate variability and extremes), to reduce risks or to take advantage of opportunities.

ADAPTIVE MANAGEMENT

A systematic process for continually improving policies and management practices by learning from the outcomes of policy and management practice implementations.

ASSET AND SERVICE AREAS

Terms often used when describing how climate change might impact Edmonton, or any other community. Assets are the infrastructure, or physical pieces of equipment and buildings required for the city to run smoothly (ex., roads, street lights, power lines, pipes, and so on). Service areas refers to how a city functions, such as ensuring social services are accessible, people have access to recreation, access to clean drinking water, and so on.

BASELINE

A climatological baseline is a reference period, typically 30 years, that is used to compare fluctuations of climate between one period and another.

CLIMATE

The weather of a location averaged over a period of time, typically 30 years.

CLIMATE CHANGE

Long term change in weather patterns (for example, an increase or decrease in extreme weather events such as hurricanes, droughts or floods) over periods of time ranging from decades to millions of years.

EVAPOTRANSPIRATION

The process by which water is transferred from land to the atmosphere by evaporation from soil and other surfaces, and by transpiration from plants (sum of evaporation and plant transpiration).

GLOBAL CLIMATE MODELS (GCM)

Based on physical laws and physically-based empirical relationships. These are mathematical representations of the atmosphere, ocean, ice caps and land surface processes. They are the only tools that estimate changes in climate due to increased greenhouse gases for a large number of climate variables.

GREENHOUSE GAS (GHG)

Gases that absorb and trap heat in the atmosphere. Carbon dioxide (CO₂) is the main naturally-occurring GHG. The most common human produced GHGs are CO₂, methane (CH₄), and nitrous oxide (N₂O).

MALADAPTATION

Process that results in increased vulnerability to climate variability and change, directly or indirectly, and/or significantly undermines capacities or opportunities for present and future adaptation.

MITIGATION

Efforts that slow climate change by reducing or preventing the release of greenhouse gases to the atmosphere.

RESILIENCE

Capacity of a system to survive and thrive under changing conditions, and to maintain its functions during change.

SUDDEN-ONSET

Sometimes called acute, short term shocks, or climate "hazards" are severe weather events that already occur, but may happen more frequently and with greater intensity as a result of climate change such as flooding, freezing rain, hail, high winds or tornados.

SLOW-ONSET

Sometimes called chronic stresses, are gradual impacts to the environment that occur only because of climate change, and include such impacts as glacial retreat (melting glaciers) and ecosystem shifts (change in habitats, species type, migration, etc.).

WEATHER

The day to day state of the atmosphere, changes quickly over days to weeks.

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APPENDIX A

TABLE 8. CLIMATE RESILIENT EDMONTON: ACTION PLAN

SCIENCE AND EVIDENCE BASED DECISIONS	The City of Edmonton uses formal climate science and evidence based policy and decision making processes	Action #1: The City of Edmonton develops and implements a climate science and evidence based decision-making framework	» Create formal processes, committees and tools for City Administration and Council to integrate climate and ecosystem science and evidence into decision making » Consider the impacts of climate change in review of Financial Stabilization Reserve balance » Support the Cities IPCC conference's "Global Research and Action Agenda on Cities and Climate Change Science" to improve local understanding » Conduct adaptation assessment, planning and updating per City Charter requirements » Develop, track and report Vulnerability and Resilience measures » Support the establishment of a regional municipal adaptation and mitigation working group to support regional climate change initiatives » Identify potential climate change adaptation demonstration/piloting opportunities » Explore international partnership opportunities for new adaptation pilot projects and additional resources	Urban Form and Corporate Strategic Development
		Action #2: The City of Edmonton develops and implements a vulnerability risk assessment, resilience and adaptation planning, measurement and reporting program		Urban Form and Corporate Strategic Development
		Action #3: The City of Edmonton leads by example by continuing to pilot, evaluate, share results, and implement science based adaptations		Urban Form and Corporate Strategic Development
Edmonton is planned, designed, developed and built to be climate resilient today and for future Edmontonians		Action #4: The City of Edmonton in partnership with community stakeholders develops and integrates climate adaptation and resilience standards into urban and strategic planning, design, and development approval processes	» Integrate climate adaptation and resilience into City Plan and Zoning by law updates » Continue implementing Breather, Green Network Strategy, the Ribbon of Green strategy, and the Natural Connections Strategic Plan to adapt to long term climate changes » Develop planning tools to integrate climate change resilience into planning processes » Integrate climate resilience into development permitting and approval processes » Identify priority considerations for building code updates » Implement a Climate Lens risk management approach to access federal infrastructure funding » Pilot the Public Infrastructure Engineering Vulnerability Committee protocol » Integrate climate projections into condition assessment criteria for existing infrastructure programs » Develop or integrate climate change adaptation and resilience into infrastructure design and construction standards	Urban Form and Corporate Strategic Development
		Action #5: The City of Edmonton conducts climate change impact assessments on existing assets, ongoing maintenance programs, planned retrofits, and new infrastructure developments		Integrated Infrastructure Services & Urban Form and Corporate Strategic Development
Edmonton's communities, businesses and institutions are aware, connected and prepared for climate change		Action #6: The City of Edmonton in partnership with community stakeholders develops and implements a community scale and household climate change readiness program	» Develop and incorporate climate change resilience education and awareness materials into the Change for Climate marketing program » Develop and pilot community scale adaptation planning and engagement approach » Develop household climate resilience program » Develop and share climate change resources for local businesses and institutions » Establish a working group to further explore climate change economic opportunities	Urban Form and Corporate Strategic Development
		Action #7: The City of Edmonton develops and implements a local business and institution climate change readiness program	» Conduct a Resilience Hub needs assessment and develop a Resilience Hub program	Urban Form and Corporate Strategic Development, Citizen Services & Integrated Infrastructure Services
Edmonton's communities and urban environment are resilient to changing temperatures		Action #8: The City of Edmonton in partnership with community stakeholders develops and implements a "Cool Edmonton" program to reduce the impacts of urban heat island effect	» Conduct urban heat island effect assessment and identify priority areas and mitigations » Develop a resilient vegetation shading and eco/cool roof program » Develop accessible information for cooling amenities	Urban Form and Corporate Strategic Development & City Operations
Edmonton is proactive in drought management to minimize social, economic and environmental impacts		Action #9: The City of Edmonton develops and implements a "Cool Edmonton" program to reduce the impacts of urban heat island effect	» Support Alberta Water Council's Municipal Drought Management Project and apply learnings to develop a drought management program for Edmonton » Continue to work with EPDOR on water conservation initiatives	EPDOR & Urban Form and Corporate Strategic Development
Edmonton's communities and urban environment are resilient to changing temperatures		Action #10: The City of Edmonton in partnership with EPDOR and other stakeholders develops and implements a drought management program		

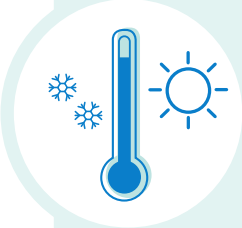




TABLE 8. CLIMATE RESILIENT EDMONTON: ACTION PLAN CONTINUED


THEME	GOALS	ACTIONS	2019-2022	LEAD DEPARTMENTS
 <p>PREPARING FOR CHANGING PRECIPITATION</p>	Edmonton's water supply is secure and safe for current and future Edmontonians	<p>Action #11: The City of Edmonton in partnership with EPCOR and other stakeholders enhances long term source water security and protection planning for water quantity and quality</p>	<ul style="list-style-type: none"> » Continue implementation of actions in EPCOR's Source Water Protection Plan » Work with EPCOR to align long term water programs with Climate Resilient Edmonton » Support options/tools for upstream watershed interventions for source water protection » Improve understanding of climate change impacts on headwaters and watershed of the North Saskatchewan River 	EPCOR & Urban Form and Corporate Strategic Development
	Edmonton is a flood resilient community	<p>Action #12: The City of Edmonton in partnership with the Province of Alberta and other stakeholders researches, develops and implements a river and ravine flooding resilience program</p>	<ul style="list-style-type: none"> » Participate in update of North Saskatchewan River flood risk mapping » Scope detailed river valley vulnerability assessment » EPCOR undertake vulnerability assessments of water treatment and wastewater treatment plants to identify required resilience measures » Complete ravine risk mapping for all creeks and ravines within the City of Edmonton » Continue to maintain appropriate waterbody flood and pollution buffers 	EPCOR & Urban Form and Corporate Strategic Development
	Edmontonians with regional partners are informed, prepared for, can respond to and recover from increasing frequency and severity of extreme weather events	<p>Action #13: The City of Edmonton in partnership with EPCOR develops and implements an urban flooding resilience program</p> <p>Action #14: Integrate changing weather extremes into coordinated emergency management programs including preparedness, prevention, response and recovery</p>	<ul style="list-style-type: none"> » Continue to work with EPCOR to align the City's Climate Adaptation plan with the implementation and update of the Stormwater Integrated Resource Plan (SIRPP) » Integrate climate change considerations into stormwater and urban flooding management practices » Integrate wetlands into the urban environment and implement the City of Edmonton's Wetland Strategy » Integrate climate change into the Regional Emergency Response Plan and continue to enhance regional coordination of emergency management » Undertake wildfire vulnerability and risk study under future climate conditions » Inventory the City of Edmonton's emergency notification system and identify gaps » Identify back-up power priorities 	EPCOR & Urban Form and Corporate Strategic Development
 <p>PREPARING FOR CHANGING WEATHER EXTREMES</p>	Edmonton has resilient energy systems	<p>Action #15: The City of Edmonton identifies and assesses opportunities to increase the resilience of Edmonton's energy systems</p>	<ul style="list-style-type: none"> » Continue monitoring and evaluating energy system performance » Identify new partnerships, feasibility assessments, and prioritization for increasing resilience in Edmonton's energy systems (ex. low carbon district energy systems, heating/cooling options) » Continue to develop and learn from projects such as Blatchford » Continue to motivate new local renewable energy generation to increase resilience to grid disruptions (ex. Edmonton's Solar Program) 	Urban Form and Corporate Strategic Development & Integrated Infrastructure Services
	Edmonton's natural ecosystems continue to provide essential goods and services such as clean air, clean water, and biodiversity	<p>Action #16: The City of Edmonton in partnership with stakeholders enhance integrated pest management policies and practices on public and private lands</p> <p>Action #17: The City of Edmonton develops and implements an ecosystem services based program, including ecological restoration, that supports climate resilience</p>	<ul style="list-style-type: none"> » Incorporate climate change and ecosystem service evaluations, in coordination with Action #17, into pest management policies/practices/etc. » Establish an integrated ecosystem services team to undertake comprehensive ecological and environmental planning » Research climate change impacts on Edmonton's ecological goods and services and develop a Climate Change Resilience and Ecosystem Services Management Program » Conduct a food self-sufficiency study that incorporates global climate change impacts 	Citizen Services, City Operations, Urban Form and Corporate Strategic Development
 <p>PREPARING FOR CHANGING ECOSYSTEMS</p>	Edmonton's food systems are resilient, reliable and secure	<p>Action #18: The City of Edmonton will research, develop and integrate climate change food resilience and agribusiness program into Edmonton's Food and Urban Agriculture Strategy</p>	<ul style="list-style-type: none"> » Define prioritized actions to prepare Edmonton's food system for climate change » Develop food and urban agricultural standards for urban development » Expand and support the development of agribusiness opportunities 	Urban Form and Corporate Strategic Development

APPENDIX B

TABLE 9. CLIMATE VARIABLES ASSESSED

 <p>Changing Temperatures</p>	Sudden Onset	Warm Nights	Number of days with nighttime low temperatures above 10°C
	Sudden Onset	Cooling Degree Days	Annual sum of the number of degrees by which daily mean temperatures exceed 18°C
	Sudden Onset	Hot days	The annual sum of days with maximum daytime high temperatures over 30°C
	Sudden Onset	Hottest day	The hottest maximum daytime temperatures recorded in a particular year
	Sudden Onset	Accumulated Moisture	The total net precipitation minus the potential evapotranspiration at the end of the season. A positive value means that more rain fell than was evaporated, and a negative value means that there was more evapotranspiration than precipitation
	Sudden Onset	Heat wave number	The annual number of heat waves that occur each summer. A heatwave is defined as 3 or more days when maximum temperature exceeds the 90th percentile of temperatures
	Sudden Onset	Heat wave magnitude	The mean temperature of all summer heat waves, as identified by the heat wave number
	Sudden Onset	Ice days	Annual sum of days with maximum daytime temperatures below 0°C
	Sudden Onset	Cold nights	Annual sum of days with minimum nighttime low temperatures below -20°C
	Sudden Onset	Coldest night	Lowest minimum nighttime temperature recorded over a year
	Sudden Onset	Heating degree days	Index of the annual sum of the daily mean temperatures that are less than 18°C
	Sudden Onset	Extreme heat	A period of extreme hot weather creating hazardous thermal conditions
	Sudden Onset	Cold snap number	The annual number of cold snaps that occur each winter, defined as 3 or more days when minimum temperature is below the 10th percentile of temperatures
	Sudden Onset	Drought	One year of anomalously low moisture during the frost free season, expressed by a drought severity index
<p>Changing Temperatures continued</p>	Sudden Onset	Extreme cold	A period of extreme cold creating hazardous thermal conditions for the population, including those with insufficient shelter and/or access to heating
	Sudden Onset	Cold snap magnitude	The mean temperature of all winter cold snaps as identified by the cold snap number

Climate Change Theme	Type of Variable	Variable	Definition
 <p>Changing Precipitation</p>	Sudden Onset	Frost days	Annual number of days with minimum temperature below 0°C
	Sudden Onset	Freeze-thaw cycles	The number of days with minimum temperature below -5°C and maximum temperature above +5°C
	Sudden Onset	Precipitation as snow	The percentage of total precipitation that falls as snow (mm water equivalent)
	Sudden Onset	Maximum 1-day precipitation	An index of the maximum amount of precipitation that falls in one day over the course of one year
	Sudden Onset	Maximum 5-day precipitation	An index of the maximum amount of precipitation that falls during a 5-day period over the course of one year
	Sudden Onset	Very heavy precipitation days	The annual sum of the daily precipitation when daily precipitation exceeds the 95th percentile precipitation amount for the 1961-1990 base period
	Sudden Onset	Urban Flooding	Precipitation that creates a hazardous and intense short-duration rainfall in the urban environment, resulting in overland or more localized flash flooding conditions
 <p>Changing Weather Extremes</p>	Sudden Onset	River flooding	Elevated flow conditions resulting in a water body overtopping its banks and creating hazardous conditions, typically driven by large scale watershed conditions
	Sudden Onset	Wildland-urban interface fire [wildfire]	A grass, bush or forest fire in the wildland-urban interface
	Sudden Onset	Heavy snow	A snowfall which is heavy enough to cause significant inconvenience
	Sudden Onset	Rain-on-snow	The occurrence of heavy rainfall when snow has already accumulated on the ground
	Sudden Onset	Freezing rain	Rain [supercooled] that freezes on impact to form a coating of clear ice [ice accretion] on the ground and on exposed objects
<p>Changing Weather Extremes continued</p>	Sudden Onset	Blizzard [winter storm]	A severe weather condition characterized by high winds and reduced visibilities due to falling or blowing snow
	Sudden Onset	Low-flow in the North Saskatchewan river	Low flow conditions in the North Saskatchewan river creating adverse impacts to aquatic ecosystems or endangering water supply

Climate Change Theme	Type of Variable	Variable	Definition
	Sudden Onset	High winds	Straight-line winds including thunderstorm associated winds (downbursts, microbursts) and winds from large scale low pressure systems, of sufficient strength to cause damage to exposed vegetation, buildings and infrastructure
	Sudden Onset	Hail	Precipitation consisting of ice particles, in various shapes, which are generally observed during thunderstorms, with a minimum diameter of 5 millimeters
	Sudden Onset	Lightning Strikes	Occurrence of lightning strikes, within the City of Edmonton with the potential to contact and cause harmful effects to people, infrastructure and the environment
	Sudden Onset	Tornado	A rotating column of air, in contact with the surface, and often visible as a funnel cloud and/or circulating debris/dust at the ground
 <p>Changing Ecosystems</p>	Slow Onset	Frost free season	The annual sum of days between the last occurrence of a nighttime low temperature below 0°C in the spring and the first occurrence of a nighttime low temperature below 0°C in the fall
	Slow Onset	Timing of frost free period	Change in the timing and duration of the frost free season resulting in potential impacts to plants, agriculture, river flows and disease and illness
	Slow Onset	Growing degree days	Index of the annual sum of the number of degrees by which daily mean temperatures exceed 5°C
	Slow Onset	Growing season	Index of the annual number of days between the first occurrence of 6 consecutive days with average daily temperature > 5°C and the first occurrence of 6 consecutive days with average daily temperature < 5°C
	Slow Onset	Maximum dry spell length	The maximum number of consecutive days with precipitation less than 1 mm in a year
	Slow Onset	Frost free season	The annual sum of days between the last occurrence of a nighttime low temperature below 0°C in the spring and the first occurrence of a nighttime low temperature below 0°C in the fall
	Slow Onset	Maximum snowpack	An index of accumulated precipitation as snow which assumes that snow accumulates when mean temperatures are below 0°C and melts when temperatures are above 2°C



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