CLIMATE PROJECTIONS & POSSIBLE IMPACTS

LOCAL ACTIONS:
Saskatoon's Adaptation Strategy (Part One)

Official Community Plan
Climate Action Plan
Local Actions Strategy

City of Saskatoon

Climate CHANGE

saskatoon.ca/**localactions**

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Photo courtesy of Tourism Saskatoon

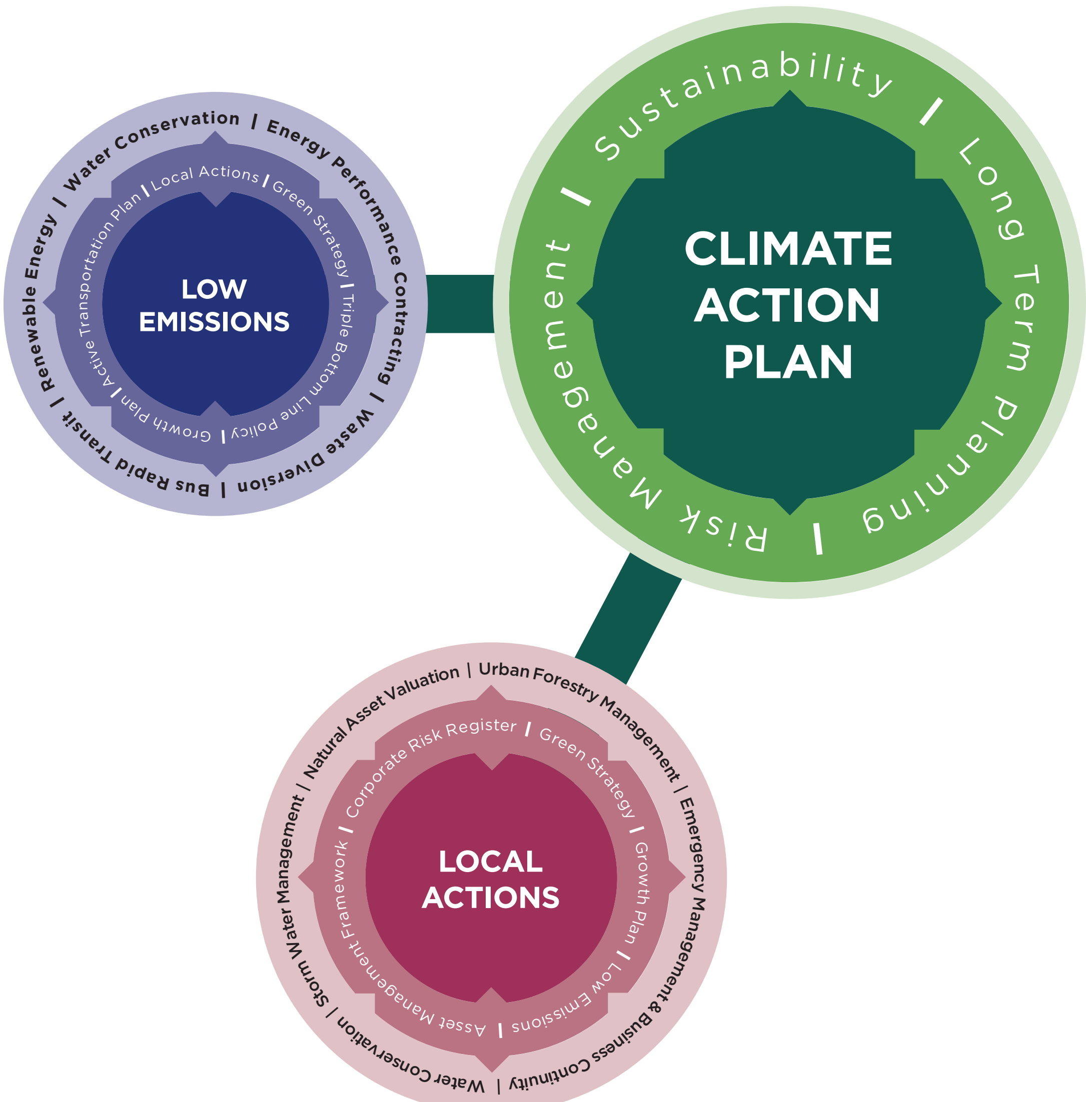
INTRODUCTION

Saskatoon's future outcome hinges on the actions we make today, as we attempt to save our planet from the effects of climate change. Climate change will impact the way our current and future generations live, work and prosper in the community. The strategy to address climate change requires a dual approach to address the causes and effects.

- **"Mitigation"** focuses on decreasing the severity of future climate change effects through actions to reduce and store greenhouse gas (GHG) emissions.
- **"Adaptation"** focuses on increasing the ability of a location to prepare for, withstand, and rebound from the impacts of changing climate patterns already occurring as a result of emissions.

At the City of Saskatoon (City), the Administration is undertaking work on mitigation and adaptation through the *"Low Emissions Community Plan"* and *"Local Actions Strategy"*. Together the two strategies form the City's Climate Action Plan. Figure 1 presents an illustration of this connection along with links to other key civic projects and programs.

Figure 1: *Climate Action Plan*



OUR COMMITMENTS TO CLIMATE ACTION

The City of Saskatoon's (City) Climate Action Plan is founded in the 2018-2021 Corporate Strategic Plan through the Strategic Goal of Environmental Leadership. Specifically, a key activity includes *"the effects of climate change on civic services are proactively addressed."*

Consistent with the Strategic Goal of Environmental Leadership, the City signed an agreement with the Global Covenant of Mayors for Climate and Energy in November 2015. As a signatory, the City committed to becoming an active contributor to global climate change solutions by reducing emissions and building resiliency against climate change impacts. Recent civic efforts to comply with this agreement have focused mainly on climate change mitigation. Highlights from this work include an emissions inventory, setting emissions reduction targets for both the City as a corporation and the Saskatoon community, and thorough reporting on potential options for achieving the targets over time. A report focused on options for financing sustainability, including climate action, is scheduled for completion in 2019.

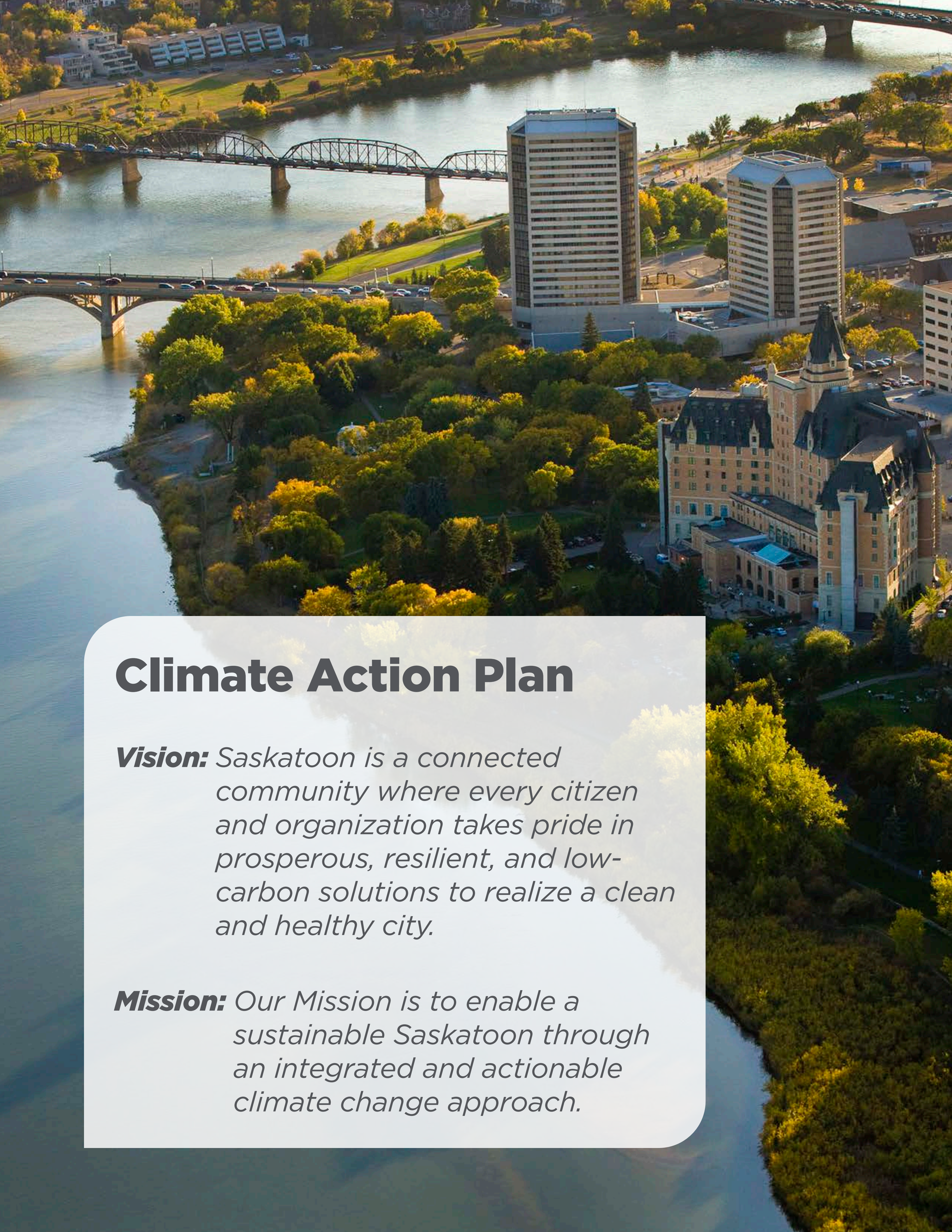
The Corporate Strategic Risk Register identifies that *"the City may not be prepared for the effects of climate change"* as a medium level risk to the overall corporation. A risk of this nature requires action to limit the City's exposure and improve resiliency planning in order to reduce unexpected disruptions and hardships in resident's lives.

Increasingly, people in cities and rural locations are being impacted by progressively frequent and severe heat waves, sudden and unexpected flooding, and unseasonable weather patterns causing social, economic and environmental impacts and at times possibly devastation.

In June 2017 a survey was conducted with residents and the industrial-commercial-institutional (ICI) sector to better understand perceptions of current environmental activities and climate change.

- The majority of resident respondents believed that climate change would have a negative impact on Saskatoon in the future and that the City is somewhat prepared for the effects of climate change. The climate change impacts topping the list of concerns included "higher food and energy costs", "higher costs for public services", and "damage to infrastructure."
- The majority of ICI respondents believed that climate change would have an impact on their business. The climate change impacts topping the list of concerns are similar to those of residents and also include "higher insurance costs" and "reductions in drinking water availability."

As a result of these drivers for climate action the Climate Action Plan was created. Efforts and activities within the Climate Action Plan are focused on the following vision and mission.



Climate Action Plan

Vision: *Saskatoon is a connected community where every citizen and organization takes pride in prosperous, resilient, and low-carbon solutions to realize a clean and healthy city.*

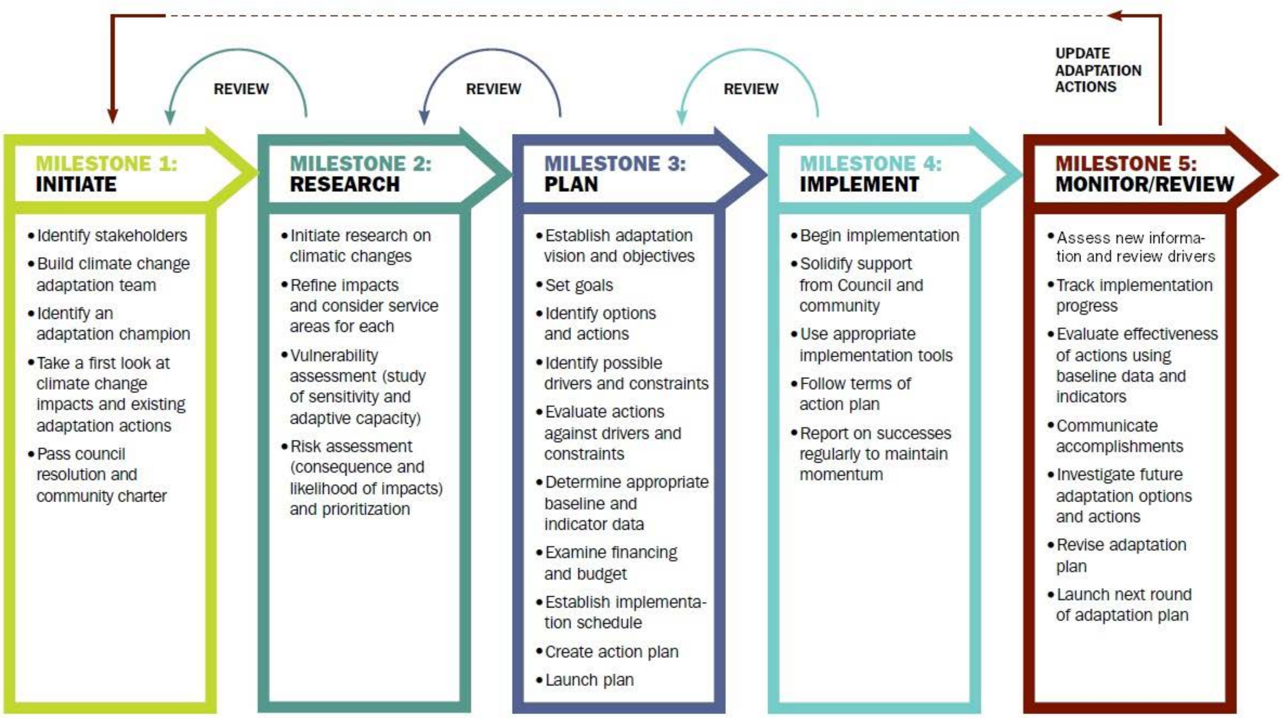
Mission: *Our Mission is to enable a sustainable Saskatoon through an integrated and actionable climate change approach.*

CLIMATE CHANGE ADAPTATION

Climate change adaptation includes all activities that reduce the negative impacts of climate change and take advantage of new opportunities that may be presented. Adaptation actions that are taken prior to experiencing specific climate change trends are called "anticipatory or proactive" and those taken after a trend or event has been experience are considered "reactive". Generally understood that planned proactive adaptation actions will incur lower long-term costs and be more effective than reactive adaptations.[1]

Local Actions: Saskatoon's Adaptation Strategy (Local Actions) is focused on proactive adaptation and preparing the City for changing climate trends in order to limit disruptions and negative impact on our citizens, services, and infrastructure. The development of Local Actions is following the iterative five milestone approach from the International Council for Local Environmental Initiatives (ICLEI) Canada organization. Figure 2 presents a diagram of the adaptation process.

Figure 2: *ICLEI Canada 5 Milestone Approach to Climate Adaptation*[2]



Currently, work on the first two milestones is completed. Activities within Milestone 3 will be completed in September 2019. The final Local Actions report will be presented to City Council in October 2019. Implementation and progress tracking efforts related to Milestones 4 and 5 are dependent on decisions and funding allocations made by City Council later in 2019.

1 Natural Resources Canada. (2009). **What is adaptation?** Retrieved from https://www.nrcan.gc.ca/environment/impacts-adaptation/adaptation-101/10025
2 ICLEI Canada. (2015). Adaptation methodology. Retrieved from http://www.icleicanada.org/resources/item/79-adaptation-methodology

OUR CHANGING CLIMATE

Canada's climate is changing now and is expected to continue to change into the future. But what conditions can we actually expect? To paraphrase David Phillips, a Climatologist with Environment and Climate Change Canada, we can expect warmer, wetter, and wilder weather.

What can we expect locally? This section of the report will outline climate change expectations for both Canada and Saskatoon.

Climate projections were gathered from the Canadian Centre for Climate Services[3] and the Climate Atlas of Canada[4], using data from 30 global climate models adjusted to produce locally specific results[5]. Global climate models consider many factors including temperature, precipitation, land uses, and emissions scenarios. Climate projection data gathered by the Administration works with three emissions scenarios: "status quo emissions production"; "moderate emissions reduction"; and "major emissions reduction". See Appendix 1 for emissions scenario assumptions.

WARMER

In 2018, the Canadian Centre for Climate Services reported that between 1948 and 2016 the average annual temperature in Canada rose by 1.7^0C. This is more than double that of the total warming experienced globally since 1880 (0.8^0C)[6]. Northern Canada (north of 60^0 latitude) realized average annual temperature warming higher still, at 2.3^0C from 1948 to 2016. All territorial communities will see considerably higher warming impacts and more quickly than the majority of the Canadian population. The provincial city closest to this region is Edmonton, Alberta.

Under current emissions rates, climate models project Canada's average annual temperature increase to be approximately 4^0C by 2100, with some models projecting even higher increases.[2] Figure 3 provides a visualization of average annual temperature change projected for Canada over the next 80 years.

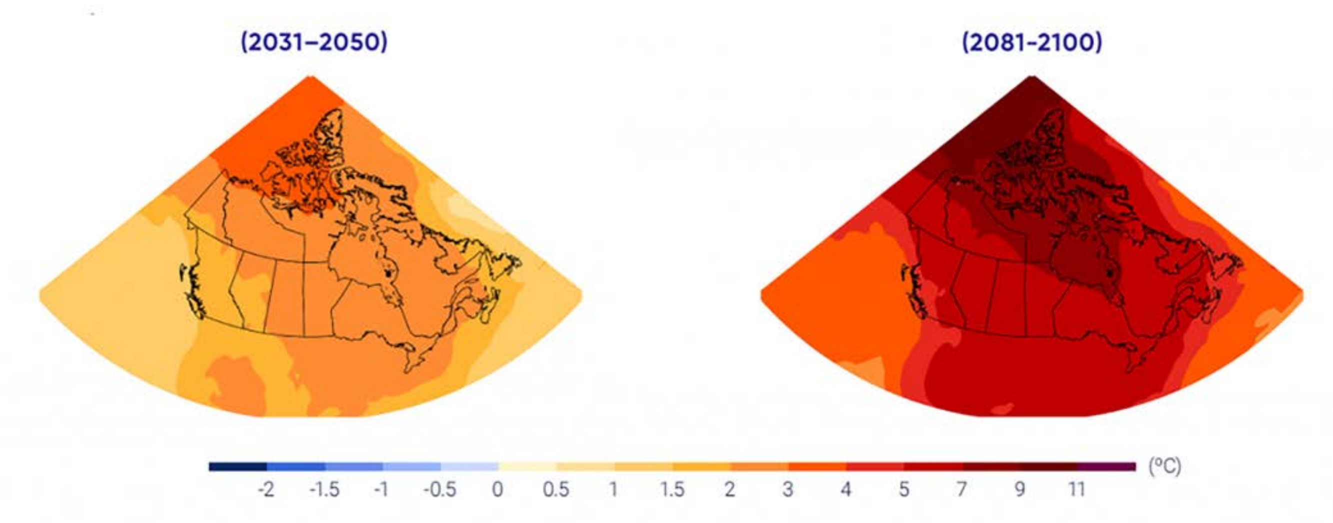
3 Government of Canada. (2018). Canadian Centre for Climate Services. Retrieved from https://www.canada.ca/en/environment-climate-change/services/climate-change/canadian-centre-climate-services.html

4 Climate Atlas of Canada (2018). Retrieved from https://climateatlas.ca/

5 Local climate projections in this report attachment were produced using statistical downscaling methodology. Statistical downscaling takes data from global climate models and refines it from a large spatial resolution (200 or more kilometres) to a smaller resolution (10-25 kilometres) using well documented steps and mathematical processes.

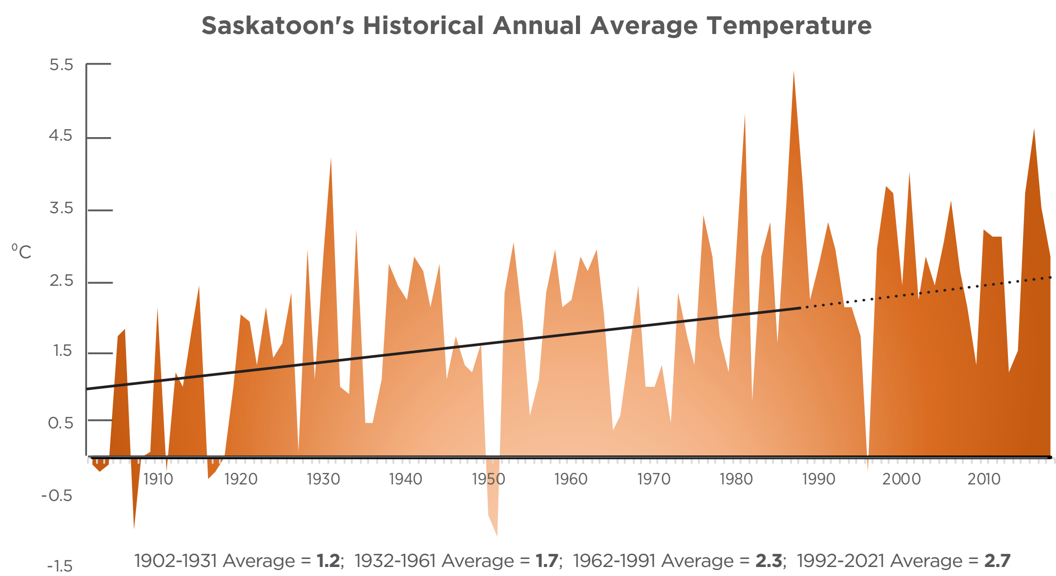
6 Global temperatures. (2011, January). Retrieved from https://earthobservatory.nasa.gov/world-of-change/DecadalTemp

Figure 3: *Average annual temperature change variation for Canada under current emissions rates for 2031-2050 (left) and 2081-2100 (right)*[7]



Annual average temperature data for Saskatoon is available from 1902 to 2018 using a combination of two sources: the Saskatoon Climate Station #4057165 and the Saskatchewan Research Centre (SRC) Climate Reference Station Summary[8]. Figure 4 presents a visual highlighting the warming trend over time.

Figure 4: *Saskatoon's Average Annual Temperature from 1902 - 2018*



Saskatoon's seasonal temperature trends from 1902-2017 suggest that average daily temperatures in all seasons have increased 1 to 4°C. More specifically, average daily temperatures since 1902 have warmed by

- 1.2°C in summer;
- 1.2°C in fall;
- 2.8°C in spring, and;
- 3.8°C in winter.

7 Images from the Canadian Centre for Climate Services.

8 Wittrock, V. (2019.) Climate reference station Saskatoon annual summary 2018. Saskatchewan Research Council. Publication No. 10440-1E19

Saskatoon's average annual temperature rise is projected to increase by almost 7⁰C by the end of the century under current emissions production rates as compared to the historical baseline from 1976-2005 (1.8⁰C). Under the moderate emissions reduction scenario this increase shrinks to just over 3⁰C. Under the major emissions reduction scenario, the increase in average annual temperature is reduced again to 1.9⁰C above baseline. Figure 5 depicts each of the emissions scenarios and their projected increase in average annual temperature for Saskatoon.

Figure 5: *Saskatoon's average annual temperature change under status quo emissions, a moderate emissions reduction, and a major emissions reduction*

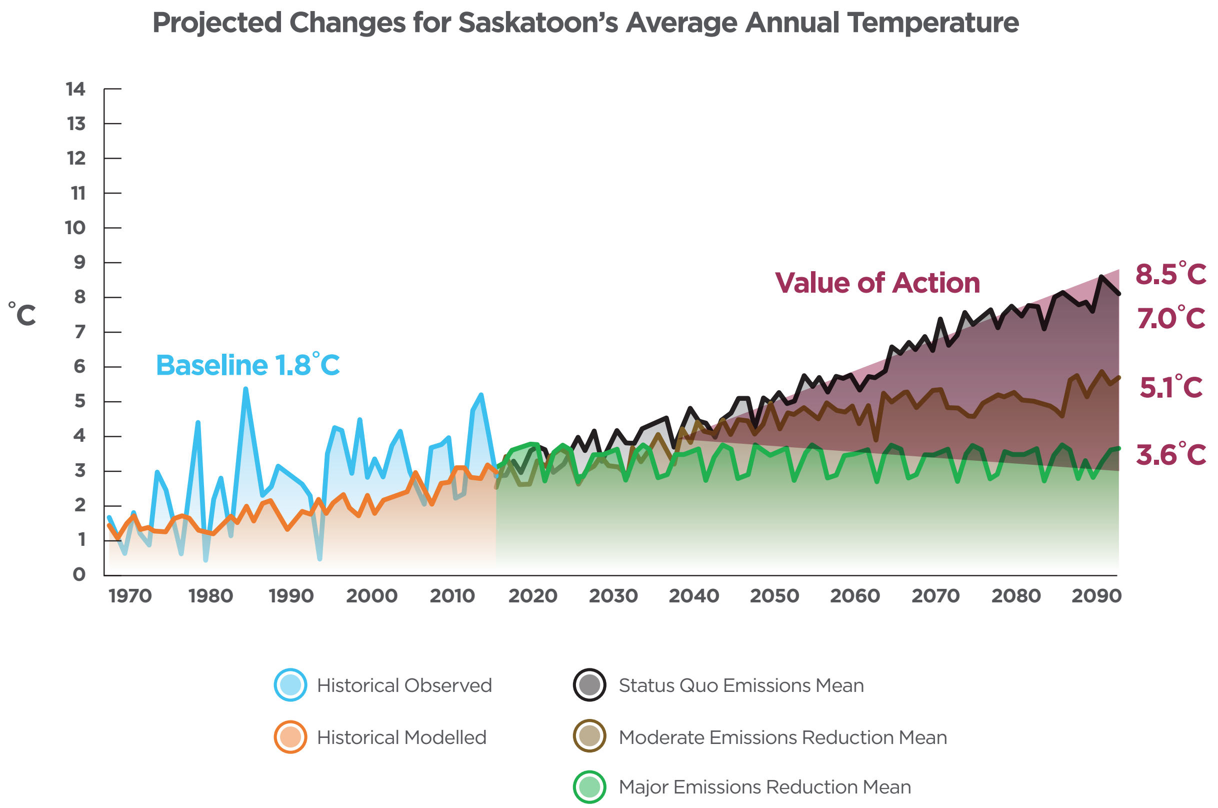


Figure 5 highlights the "value of action" or the cost of inaction. This concept outlines the relationship between emissions rates and adaptation needs. The higher the emissions rates are, the larger the increase in average annual temperature becomes and, in turn, the larger the cost and magnitude needed for adaptive actions grows over time.

Photo courtesy of Tourism Saskatoon

WARMER BY 2100

Projections show Saskatoon will have double the number of days 25°C or more and six times the number of days at 30°C annually under status quo emissions rates.

Other warming trends expected for Saskatoon under current emissions rates by 2100 include:

- An increase in the number of days per year where the temperature reaches above 25°C (an average of 106 per year up from 46 as a baseline);
- An increase in the number of days per year where the temperature reaches above 30°C (an average of 55 per year up from 9 as a baseline);
- An increase in the number of growing degree days at base 15°C (an average of 882 per year up from a 258 as a baseline);
- A decrease in the number of days per year at or colder than -30°C (an average of 1 per year down from 13 as a baseline); and
- A longer frost-free season (47 days per year longer on average).
- Changes in river flow patterns in snow melt-fed river basins, like the Saskatchewan River Basin, where peak flows come earlier in the spring and summer flows are reduced due to warmer winter temperatures, loss of glacier ice, and a smaller snow pack.

Available data for all three emissions scenarios is presented in Appendices 2, 3, and 4.

A NOTE ABOUT BASELINES

Baselines tell us what time period climate information is from and what the average outcome was during that time period, allowing changes to be tracked over time. For example, a baseline includes information such as "the average annual temperature for Saskatoon was 1.8°C during 1976-2005". The baseline for the Paris Agreement is "pre-industrial" which is often referred to as 1850 -1900 but has not been definitively stated (see Appendix 1 for more details on the Paris Agreement). The baseline for Saskatoon's climate projection data in this report is 1976 - 2005. Climate information for national projections uses baselines as described throughout the report. The choice of baseline period in climate science is governed by the availability of climate data. In order to be reliable a baseline must include roughly 30 years of data.

WETTER

When considering "wetter" conditions, two distinct projections are most frequently utilized for proactive future planning: total changes in average annual precipitation and changes in the frequency of short duration and heavy intensity precipitation events.

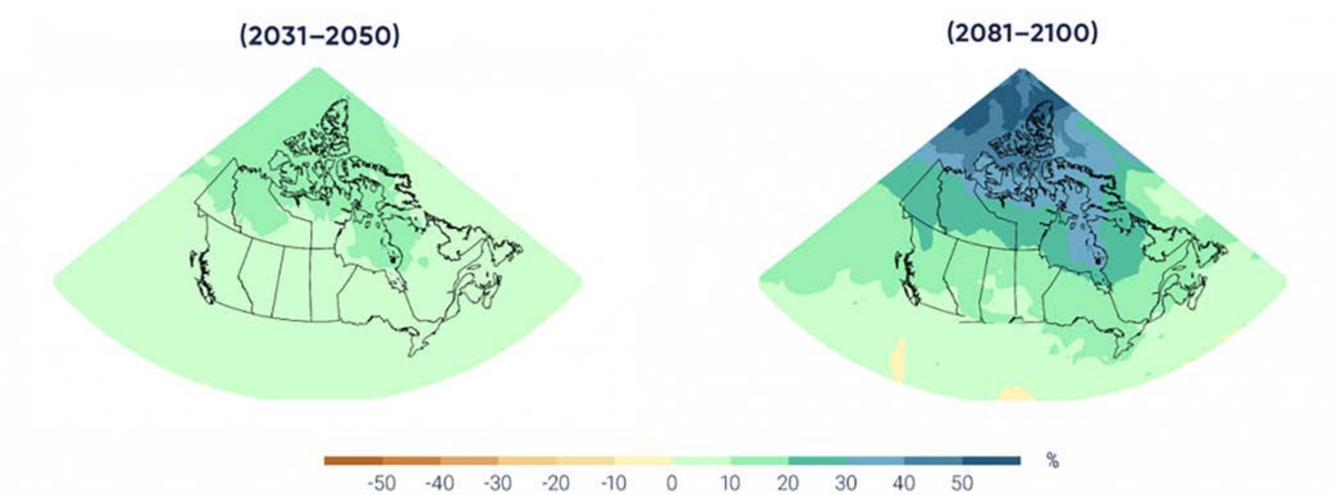
AVERAGE ANNUAL PRECIPITATION

Between 1948 and 2012 average annual precipitation (including rain, snow, freezing rain, hail, and drizzle) increased in Canada overall. Seasonal and regional variation in this trend is high. For example, over the same period (1948 – 2012) Kugluktuk, Nunavut saw a 170% increase in winter precipitation and Kelowna, British Columbia saw a 40% reduction.

Average overall winter precipitation is projected to continue to increase between 9.1% and 37.8% in Canada by 2100. Although the changes experienced will be regionally dependent, with northern regions of Canada expected to see higher increases and southern Canada expected to see smaller increases.

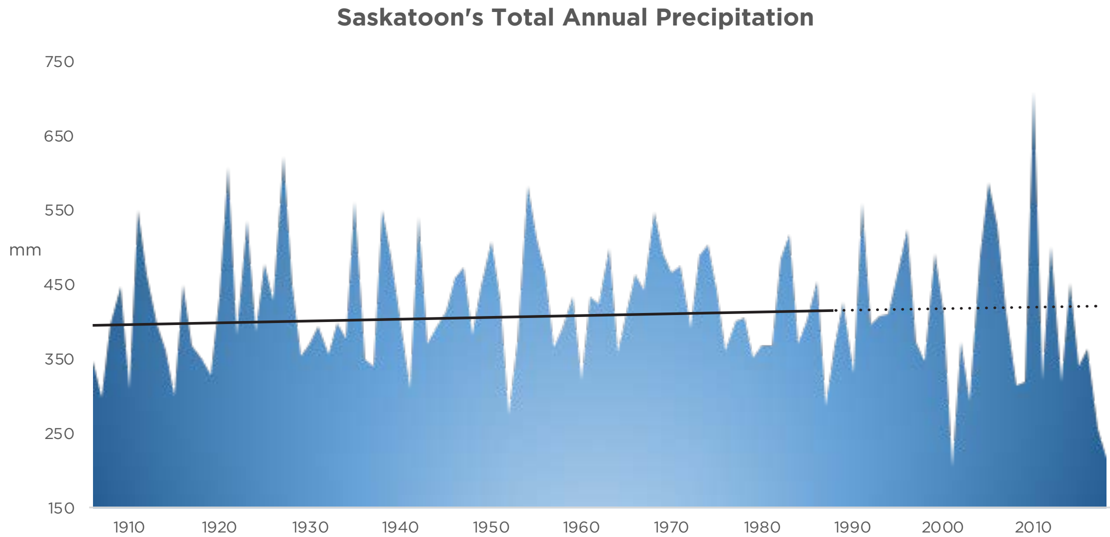
Additionally, with warmer overall temperatures in winter months, more precipitation will likely be realized as freezing rain or sleet during this season. Increased freezing rain and sleet will also impact overall snow cover levels seen nationally, as snow often melts when interacting with warmer precipitation. Figure 6 provides a visualization of average annual precipitation changes projected for Canada under current emissions rates.

Figure 6: *Average annual precipitation change variation for Canada under current emissions rates for 2031-2050 (left) and 2081-2100 (right)*[5]



Annual precipitation total records are available for Saskatoon from 1906 to 2018 from the combination of two sources: the Saskatoon International Airport and the Saskatoon Research Council Climate Reference Station Summary[9]. Figure 7 presents a visual highlighting the wetter trend over time.

Figure 7: *Saskatoon's Total Annual Precipitation from 1906 - 2018*



1906-1395 Total = **417**; 1936-1965 Total = **424**; 1966-1995 Total = **432**; 1996-2026 Total = **440**

Under current emissions rates the projected increase in average annual precipitation in Saskatoon is approximately 12% by 2100. For the moderate emissions reductions scenario the increase in annual precipitation shrinks to 7% by 2100. And for the major emissions reductions scenario the increase in annual precipitation declines slightly further to 6% by 2100.

However, Saskatoon will see a general shift in the timing of the majority of precipitation. Today precipitation totals are generally highest during the late spring and summer months (May to August) enabling a green and vibrant city. Under both current emissions rates and moderate reduction scenarios:

- The timing of the majority of precipitation moves earlier in the year (March to June) and;
- July and August are projected to have reductions in average precipitation.

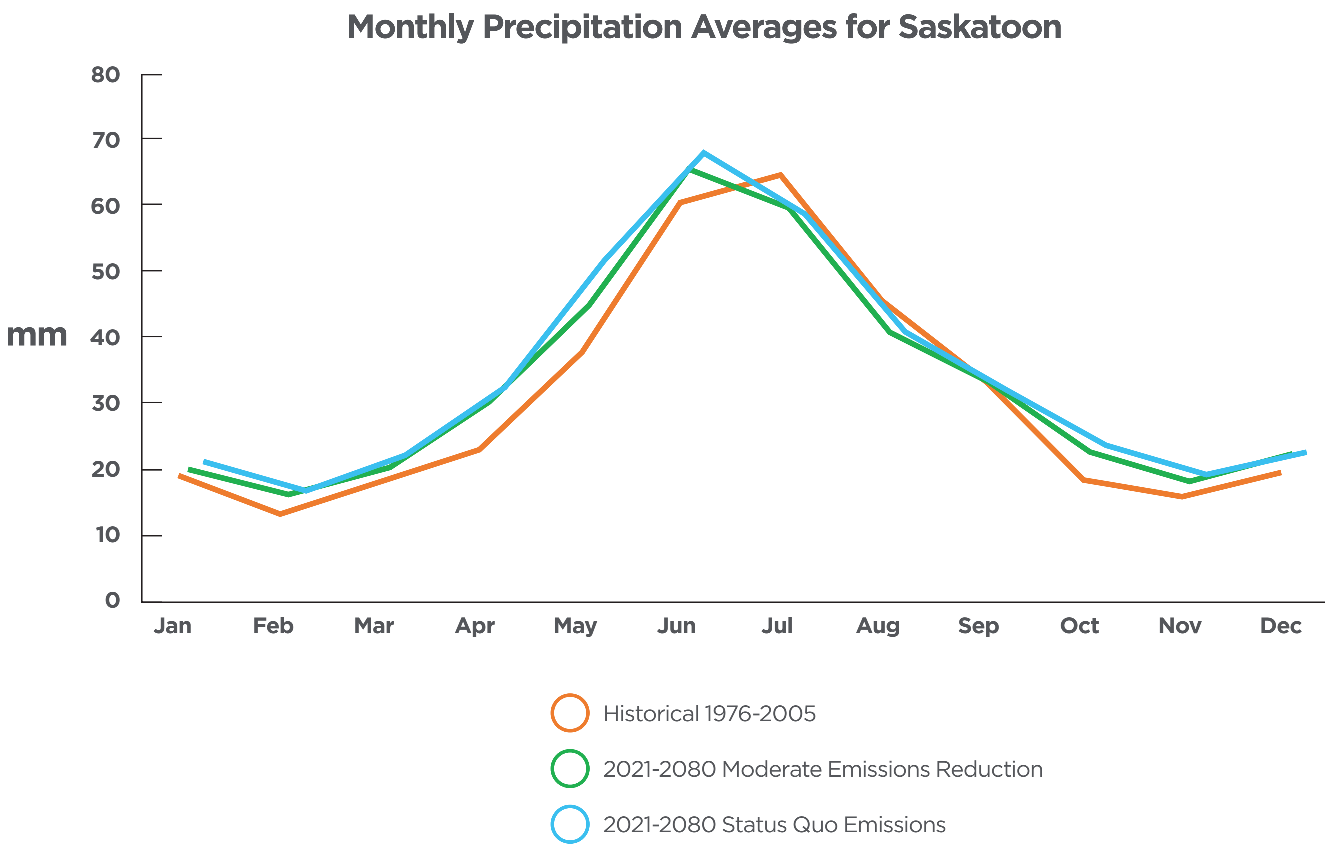
WETTER BY 2100

Projections show Saskatoon will see a 24% increase in winter precipitation, such as freezing rain and snow, and that total spring precipitation is expected to increase by more and 30% under status quo emissions rates.

9 Saskatoon Water produces an Annual Rainfall report using information collected from seven gauges throughout the Saskatoon from April 1 to September 30th. This information was not used as "average annual precipitation total" data includes all precipitation types falling throughout the entire year.

Temporal shifts in precipitation combined with generally warmer temperatures and an increasing number of very hot days (30°C or more) are likely to increase the risk of drought conditions for the city, increase the cost of green space watering, and could create demand stress on the water and waste water treatment facilities and their delivery networks. Figure 8 displays a visual of the expected total annual precipitation trends.

Figure 8: *Saskatoon's average monthly precipitation change under current emissions rates and a moderate emissions reductions*[10]



HEAVY RAINFALL EVENTS

Moving beyond annual total precipitation changes, under current emissions and moderate reduction scenarios rainfall event projections for Saskatoon call for small increases (one more day per year or less) in heavy precipitation days (totalling 10 mm or 20 mm over 24 hours)[11]. Although the City's storm water system performance often depends on the intensity and duration of rain events. While 20 mm over 24 hours is not likely to cause flooding in Saskatoon, 20 mm over 30 minutes will likely cause flooding issues.

10 Data used for Figure 8 comes from the Climate Atlas of Canada. No "major emissions reduction" scenario data was available at the monthly rate from consulted sources at the time of reporting as result it is not included in the analysis.

11 Climate Atlas of Canada. (2018). Retrieved from https://climateatlas.ca/.

The likelihood of 1-in-10 year rain events (36.5 mm over 1 hour) is expected to increase by 13.4% from 2041 to 2070.12 The City's storm water infrastructure design standards for new neighbourhoods, adopted in 1989, include streets as part of the "major system" which effectively handle run-off for up to a 1-in-100 year rain event. Storm water infrastructure in older neighbourhoods, however, was not developed to the same standards, and some neighbourhoods are subject to flooding during lower intensity rain events. A Flood Control Strategy was approved in 2018 to add storm water capacity in ten areas that are subject to frequent flooding.

Saskatoon Water also has begun a project to refine climate projections regarding the intensity, duration, and frequency (IDF) of rainfall events in Saskatoon. This action is one of the most common recommendations in municipal climate adaptation plans. The IDF Curve project will update current information and explore the potential impacts to storm water design standards moving forward. The project is a joint venture between the City of Saskatoon, the University of Saskatchewan, and Concordia University. Final results from the project are expected in 2020. For more information on this project see Appendix 5.

WILDER

Climate models are not yet able to reliably project changes in the occurrence rates for extreme weather events. As a result, formal extreme weather projections for Saskatoon are not present in this section. Instead the discussion in this section focuses on wind projections, observed trends in extreme weather event occurrences, and future risk projections.

WIND

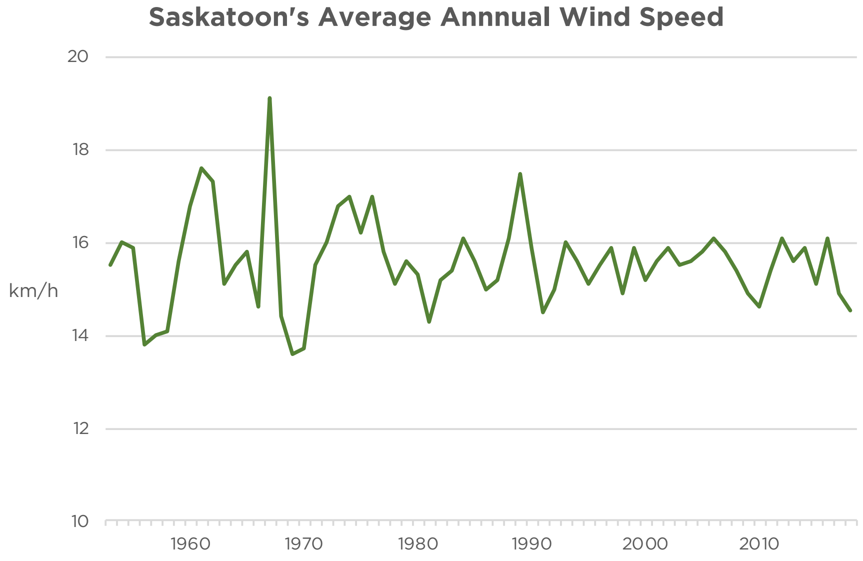
High winds can create dangerous incidents including downed power lines, tree limb failures, and sudden debris movement. The southern region of Saskatchewan has up to 10 days per year with winds reaching at least 63 kilometers per hour (km/h). Between 2008 and 2016 more than 200 wind events were reported in Saskatchewan, often occurring with other elements of severe summer storms[13]. Environment and Climate Change Canada issues wind warnings in Saskatchewan when winds are sustained at 70 km/h or gusting to 90 km/h or more.

In Saskatoon average annual wind speed data is available through the Saskatoon International Airport records from 1953 to 2018. The average wind speed from the available period of record is 15.6 km/h. Figure 9 presents wind speed data over time.

Figure 9: *Saskatoon's Average Annual Wind Speed 1953 – 2018*

12 As cited in Saskatoon Water's Flood Control Strategy: Hazards and Return on Investment. Increase in 1-in-10 Year daily extreme rainfall in Saskatoon at 25 km by 25 km scale is 13.4% from 2041 to 2070 based on an average from 21 Global Climate Models and Representative Concentration Pathway (RCP) 8.5 (or current state emissions scenario) which assumes emissions continue to rise throughout the 21st century.

13 Wittrock, V., Halliday, R. A, Corkal, D. R., Johnston, M., Wheaton, E., Lettvenuk, J., Stewart, I., Bonsal, B., and Geremia, M. (2018, December). Saskatchewan flood and natural hazard risk assessment. Prepared for Saskatchewan Ministry of Government Relations. Saskatchewan Research Council Publication No. 14113-2E18. Saskatoon, SK.



Historical data from the Canadian Centre for Climate Services suggests that average annual wind speeds are staying relatively consistent over time. However, seasonal wind speeds are changing with slight increases in the winter and spring seasons (up to 1 km/hr on average) and decreases in summer and fall (roughly 0.5 km/h on average).

EXTREME WEATHER EVENTS TRENDS AND FUTURE RISK

Many climate scientists agree that warmer and wetter settings will increase the likelihood and severity of extreme weather events, as the conditions that generate large and intense storms become present more frequently.

Extreme weather events (or natural hazards) such as drought, wildfire, and flooding are part of Saskatchewan's history and have significant economic repercussions for the region. The 2001-2002 drought caused a reduction in agricultural production of more than $1.6 billion[18]. The forest fires in Saskatchewan in 2015 cost in excess of $100 million, destroyed over 1.7 million hectares, and forced more than 10,000 people to evacuate their homes in northern communities[18].

A 2018 report from the Saskatchewan Research Council completed a province-wide risk analysis of natural hazards in Saskatchewan[18]. The report plots the overall risk (consequences severity and likelihood) of a plausible worst-case scenario for each type of natural hazard under current and projected future climate conditions. The plausible worst-case scenarios come from actual experiences within the province's last 100 years. Results from the report suggest changing climate conditions will slightly increase the risk of experiencing natural hazards throughout the province. See the movement of plotted items in Appendix 6 for more details. Management and Fire Safety Office, aimed at building resiliency to natural hazards/extreme weather events already in place.

Moving beyond the climate science sector, the insurance industry has additional evidence on increasingly wild weather in Canada. Since 2008, the Insurance Bureau of Canada has reported an increase in annual claims related to extreme weather events of approximately 150% ($400M to $1B)[14]. Additionally, climate projections (related to annual average temperature and precipitation) and claim growth cost forecasting suggests the insurance industry in Canada can expect a further $675M will be spent on flooding costs alone in the next five years[15].

Many local and national insurance providers started offering overland flooding protection products in 2015. New product availability is contributing to the increase in annual claims and total cost of claims nationally. New flood protection products are often "add-ons" for an additional cost which will increase the total amount of household and organization budget spent on insurance.

Uninsured losses have also been adding up. Between 1970 and 2014 the three Prairie Provinces, received the largest payouts from the federal Disaster Financial Assistance Arrangements program both per capita and in aggregate. From 2005 to 2014 Saskatchewan received 20% of national payouts with the majority of payouts being flooding related[16]. On the provincial side, Provincial Disaster Assistance Program (PDAP) expenditures have been rising since 2002 with costs ranging from $10.4M to more than $157M over the last ten years[17].

14 Hodgson, G. (2018, May 15). The costs of climate change are rising. Retrieved from https://www.theglobeandmail.com/business/commentary/article-the-costs-of-climate-change-are-rising/

15 De Pruis, R. (2018, September 19). Prairie Regional Adaptation Collaborative presentation. [PowerPoint slides]. Retrieved from https://www.prairiesrac.com/wp-content/uploads/2018/10/Rob-de-Pruis-IBC-Prairies-Regional-Adaptation-Collaborative-2018.pdf

16 Wittrock, V., Halliday, R. A, Corkal, D. R., Johnston, M., Wheaton, E., Lettvenuk, J., Stewart, I., Bonsal, B., and Geremia, M. (2018, December). Saskatchewan flood and natural hazard risk assessment. Prepared for Saskatchewan Ministry of Government Relations. Saskatchewan Research Council Publication No. 14113-2E18. Saskatoon, SK.

17 As cited in Prebble, P., Asmuss, M., Coxworth, A., and Halliday, B. (2018). "Prairie Resilience" is not enough. Retrieved from http://environmentalsociety.ca/wp-content/uploads/2018/12/Prairie-Resilience-Is-Not-Enough-Full-Report-Final.pdf PDAP statistics citation #48.

CLIMATE RISK AND CIVIC OPERATIONS

Collaborative risk analysis workshops were held throughout February 2019 with staff from the following divisions: storm water management; corporate risk; asset management; parks management; emergency management and preparedness; sustainability; facilities management; power generation; and emissions reduction. Given the internal scope of the Local Actions project, items within the risk analysis focus on service areas we are currently responsible for.

The intent of the risk assessment is to connect each of the identified "climate change impacts on civic operations" with estimated "consequence severity" and "likelihood of occurrence over the next 25 years" through the Overall Risk Level (ORL)[18]. The ORL has a four point scale: high, medium, low, and very low. Figure 10 outlines details for the ORL scale.

Figure 10: *Overall Risk Level Scale*

High	• Consequences: "Major to Catastrophic" - Service area functionality would get worse and/or become unmanageable. Significant ($$$$) and/or substantial ($$$$$) staff and cost interventions would be required for correction. • Likelihood: "Likely to Almost Certain" – Event should occur about once per year and/or could occur multiple times per year.
Medium	• Consequences: "Minor to Major" – Service area functionality could stay the same or become worse. Slight ($$) to significant ($$$$) staff and cost interventions would be required for correction. • Likelihood: "Possible to Almost Certain" – Event should occur once every ten years and/or could occur multiple times per year.
Low	• Consequences: "Minor to Moderate" – Service area functionality could stay the same or become slightly worse. Slight ($$) to some ($$$) staff and cost interventions would be required for correction. • Likelihood: "Unlikely to Likely" – Event could occur once in the next 10 to 25 years and/or about once per year.
Very Low	• Consequences: "Insignificant to Moderate" – Service are functionality will stay the same or become slightly worse. Little ($) to some ($$$) staff and cost interventions would be required for correction. • Likelihood: "Rare to Unlikely" – Event only occurs in exceptional circumstances within the next 25 years and/or could occur once in the next 10 to 25 years.

Figure 11, on the following page, presents the ranked risk analysis results. The ranked results highlight the importance of heat strategies into the future as the majority of high and medium risks are driven by warmer overall temperatures and more frequent extreme heat. However, the Administration notes that all risk estimates for identified climate impacts would likely increase over time if actions to address conditions were delayed or avoided.

18 The risk analysis presented does not consider "perfect storm scenarios" or "risk velocity". Perfect storm scenarios are those where a number of events considered 'rare' and having 'catastrophic' consequences occur together. Risk velocity adds a third dimension to traditional approaches and tracks "the speed at which exposure can impact an organization". Siew Quan, N.G. and Chiang, A. (2017). Risk management at the speed of business.

Figure 11: *Ranked risk analysis results*

Rank	Climate Change Driver	Impact on Civic Operations	Overall Risk Level
1	**Warmer**	Increased demand on the water and waste water utility and delivery system	High
2	**Warmer**	Increased heat stress on plants and the urban forest	
3	**Wetter**	Increased demand on the storm water management system	
4	**Wilder**	Increased demand on the power utility and delivery system under highly variable and extreme conditions	
5	**Warmer**	Reductions in plant health overall and winter survival rates due to increasingly frequent freeze-thaw cycles	
6	**Wilder**	Increased stress on vulnerable populations in increasingly frequent heat waves, severe cold snaps, and declining air quality scenarios	Medium
7	**Warmer**	Increased heat stress for outdoor workers	
8	**Warmer**	Increases in vector borne diseases or illnesses due to increases in pest populations and diversity of species	
9	**Wilder**	Increased presence of conditions that can create convective summer storms (i.e. tornados, hail, strong plough winds and severe thunderstorms)	
10	**Warmer**	Loss of plant and urban wildlife diversity due to heat stress, water availability reductions and habitat losses	
11	**Wetter**	Severe heavy precipitation events could overwhelm the storm water management system and cause water to infiltrate the sanitary sewer system causing health concerns, property damage, environmental damage, and regulatory fines or consequences including and up to prosecution	
12	**Wilder**	Added stress on those without access to (or appropriately sized) heating, cooling and ventilation systems under more variable and extreme weather conditions	
13	**Warmer**	Drought conditions	
14	**Wetter**	Increased demand for civic staff and equipment to manage spring drainage challenges	
15	**Warmer**	Increased loss of plant and tree species due to larger and more diverse pest populations	
16	**Warmer**	Longer annual operation and maintenance periods for outdoor pools, golf courses, the Saskatoon Forestry Farm Park and Zoo, campgrounds, parks, green spaces, public lands, and right of way areas	
17	**Wilder**	Increased absenteeism and lower staff productivity due to heat waves, severe cold snaps, and declining air quality	
18	**Wetter**	Increased need for roadway and sidewalk salt and sanding due to increasingly frequent freezing rain or safe citizen mobility may be compromised	
19	**Warmer**	Increased instances of freezing rain can create challenges for tree limb stability and power line functionality	
20	**Wetter**	Public and private property damage due to overland flooding due to heavy precipitation events	Low
21	**Warmer**	Increased demand for Saskatoon Fire Department services in fighting grass, forest, brush fires in and around the municipality	
22	**Warmer**	Increased cost to maintain winter spaces in warmer weather (i.e. ice rinks, ski trails, Optimist Hill, etc.)	
23	**Wetter**	Increased demand for civic staff to respond to precipitation events (i.e. manage flooded intersections/roadways, address manhole cover displacements, operations when responding to severe precipitation events, etc.)	

Figure 11: Ranked risk analysis results (continued)

24	**Wetter**	Increased opportunity for mosquito and other water-borne pests to thrive in standing water	Low
25	**Warmer**	Potential need for alternative locations for outdoor playground programming with the frequency of daily temperatures reaching 30°C and higher more often	
26	**Warmer**	Increased risk of heart attack and heart disease in vulnerable populations	
27	**Wilder**	Increases in calls for civic tax dollar support for those suffering property damage due to wind and rain event related infrastructure failures	
28	**Wetter**	Improved drainage planning and standards may be required to support park, public space, and sport field use more quickly after heavy rain events	
29	**Wilder**	Risk of revenue loss if civic buildings are impacted by increasingly frequent and extreme storms	
30	**Wilder**	Increased fleet and facility operation costs due to more frequent use of (and change in) air conditioning and heating needs especially in fringe seasons	
31	**Wilder**	Increases in use of leisure centres and sports complexes for persons displaced/evacuated from their home communities due to extreme weather events and/or natural hazards	
32	**Wilder**	Increased need for inspection and clean-up services "post-storm"	
33	**Warmer**	Reduced availability of water resources impacting quality and cost of water treatment	
34	**Wilder**	Increased presence of conditions that can create severe winter storms, freezing rain, and blizzard conditions	
35	**Wilder**	Forest, bush and grass fire conditions are present more often	
36	**Warmer**	Increased rate of deterioration for built (grey) infrastructure due to increases in freeze-thaw cycles	
37	**Warmer**	Increased percentage of household and business dollars going to cover health and heating/cooling costs	
38	**Wetter**	Slope stability concerns around river valley	
39	**Wilder**	Increase in civic building insurance costs	
40	**Warmer**	Reductions in soil health	
41	**Wilder**	Reduced availability of goods and services procured from regions experiencing sea level rise challenges or transportation network outages due to extreme weather events	
42	**Warmer**	Increased demand all emergency services as instances of violence increase with temperature rise	
43	**Wilder**	Loss of critical infrastructure or civic service delivery ability (power, water, sewer, transit, etc.)	
44	**Warmer**	Reduction in local food production capacity under extreme heat and dry conditions	
45	**Wetter**	Ground water level and frost line changes impacting the continued stability and depth of burial for subsurface assets (i.e. water lines, sanitary sewer lines, and other utilities)	Very Low
46	**Wetter**	High river levels creating water seepage into waste water treatment plant through storm water outfalls	
47	**Wetter**	Public and private property damage due to riverine flooding from heavy precipitation and/or early/intense mountain runoff	

OUR NEXT STEPS

The next steps for the Administration will focus on digging deeper into the risk assessment outcomes and completing additional internal and key external engagement and collaboration events.

Digging further into the risk assessment outcomes will allow prioritization to occur in order to focus adaptive capacity building activities and limited resources in areas where focused attention is warranted. The Administration's approach will include discussing climate projections and risk rankings for all risk items in more concrete terms with a larger group of internal stakeholders, asking questions such as "what levels of increased demand can the water, waste water, storm water, and power utilities currently meet", "what climate change and other conditions might impair this ability to provide service", and "what emergency management and redundancy plans are in place to manage risk within these operations". Green space and urban forestry questions could include "at what level of heat exposure do plant and tree species in the city become stressed to the point where recovery is unlikely" and "how might additional watering protocols fit into the Urban Forestry Management Plan". Digging deeper in this way will allow the Administration to plot the difference between the "inherent", "residual", and "target residual risk" of each item within the complete Local Actions, similar to the process used for the Corporate Risk Registers.

- Inherent risk refers to the level of risk an item presents without intervention.
- Residual risk refers to the level of risk an item presents after considering existing risk management and adaptive capacity building activities already underway.
- Target residual risk refers to the acceptable level of risk that is "left over" after existing work and proposed new activities, coming from the Local Actions, are considered. Final decisions made on target residual risk levels will be made by City Council.

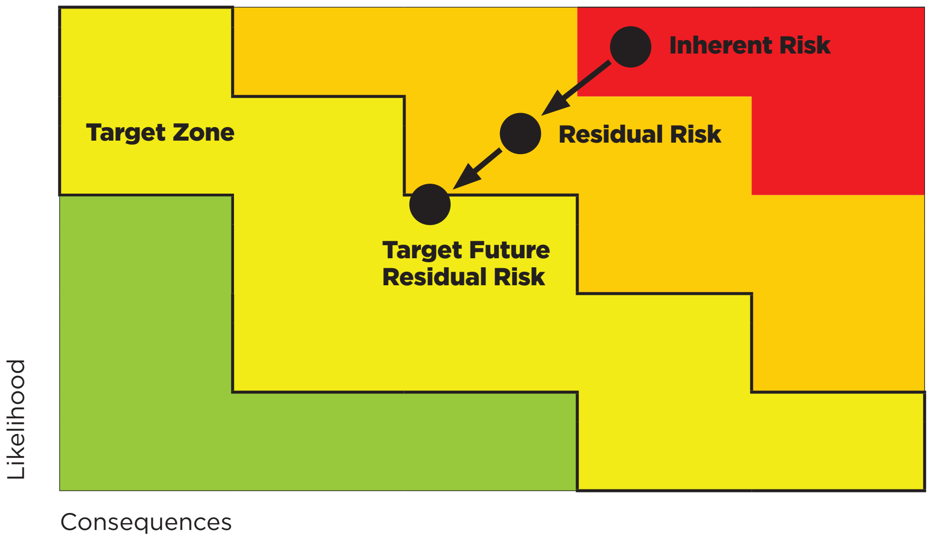


Figure 12: *presents a simplified version of the climate adaptation risk analysis visual to highlight the risk management path as described above.*

Moving beyond the risk assessment, the remaining project focus between May and August will be collaborative engagement events with internal staff and key external stakeholders. Internal staff events will focus on creating potential ideas to improve the City's resilience to climate change now and into the future. Events with key external stakeholders will ask for feedback on the potential ideas and solicit additional ideas based on best practices and expert opinions.

Moving beyond the creation of Local Actions, implementation and progress tracking efforts related to Milestones 4 and 5 are dependent on decisions and funding allocations made by City Council later in 2019.

Not all weather experienced in our city over the next 80 year will be “on-trend” due to natural climate variability. However, collaborative ideas today can build and improve Saskatoon’s resiliency through local actions tomorrow.

APPENDIX 1:

Emissions Scenario Assumptions

The Government of Canada signed on to the Paris Agreement in December 2015. The latest Intergovernmental Panel on Climate Change[1] report explains each emission scenario relative to the Paris Agreement pre-industrial global temperature rise goals.

The assumptions underlying each of the emissions scenarios are as follows:

GHG Scenario	Assumptions[2]	Is this scenario likely to achieve compliance with the Paris Agreement?
Status Quo or Current Emission Rates	Land use, population and economic growth, energy consumption, and emissions production continue at currently increasing rates.	**No**
Minor Reduction	Emissions double by 2060 then dramatically fall, but remain well above current levels. Population growth peaks around 10 billion. Energy consumption increases until 2060 then stabilizes. Oil consumption remains high and other sources play a smaller role than in the moderate and major reduction scenarios.	**No**
Moderate Reduction	Emissions peak around 2050 and at 50% more than 2000 levels, with a decline over 30 years to stabilize at half of than 2000 levels. Total energy consumption is slightly higher than the major reduction emissions scenario but the sources are more diverse including renewables, nuclear power, and fossil fuels. Change in land use patterns include cropping and grassland area declines and increases in reforestation.	**No**
Major Reduction	Emissions peak by 2020 and all countries, developing and developed, initiate climate policies and concentrated actions to reduce fossil fuel reliance in the next few years. Global population increases to a peak of just over 9 billion and global economic growth is high. Oil use declines, but other fossil fuel uses increase offset by capture and storage of carbon dioxide. Renewable energy sources increase, but remain a lower percentage of the global energy mix.	**Yes**

1 Intergovernmental Panel on Climate Change. (2014). **Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change** [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp.

2 Furphy, D. (2013) **What on earth is an RCP? A quick guide to the carbon dioxide** emissions scenarios used by the IPCC Assessment Report 5.Retrieved from https://medium.com/@davidfurphy/what-on-earth-is-an-rcp-bbb206ddee26

APPENDIX 2:

Saskatoon's Climate Projections under Status Quo Emissions Rates[1,2,3,4]

				2021-2050			2051-2080			2081-2100		
	Variable	**Timeframe**	**Baseline Mean**	**Low**	**Mean**	**High**	**Low**	**Mean**	**High**	**Low**	**Mean**	**High**
Primary Impacts	Precipitation *(mm)*	Annual	370	273	395	546	272	409	573	N/A	415	N/A
		Spring	78	44	91	159	50	106	196	N/A	103	N/A
		Summer	171	97	174	278	82	167	276	N/A	171	N/A
		Fall	68	32	73	125	32	75	130	N/A	77	N/A
		Winter	51	31	57	86	31	61	95	N/A	63	N/A
	Mean Temperature *(ºC)*	Annual	1.8	1.9	4.1	6.1	3.7	6.2	8.9	N/A	8.5	N/A
		Spring	2.3	0.4	4.2	7.8	2.3	5.8	9.5	N/A	7.6	N/A
		Summer	16.8	16.7	18.8	20.9	18.3	21	23.7	N/A	23.7	N/A
		Fall	3	2.2	5.1	7.6	4.5	7.3	10.3	N/A	9.1	N/A
		Winter	-15.3	-17.1	-12.1	-6.9	-14.8	-9.6	-4.5	N/A	-8.1	N/A
Secondary Impacts	Mean Minimum Temperature *(ºC)*	Annual	-3.1	-5.4	-1.8	2.5	-3.5	0.4	5	-1.7	2.1	3.6
	Mean Maximum Temperature *(ºC)*	Annual	8.4	5.6	9.9	13.9	8	12	17.1	9	13.5	19
	Summer Days *(≥ +25ºC)*	Annual	46	16	66	112	36	88	137	51	106	151
	Tropical Nights *(Lowest temp. does not go below 20ºC)*	Annual	0	0	0	3	0	3	14	1	8	23
	Very Hot Days *(≥ +30ºC)*	Annual	9	8	18	41	14	37	67	6	55	104
	Very Cold Days *(≤ -30ºC)*	Annual	13	1	4	20	0	2	13	0	1	16
	Date of Last Spring Frost	Annual	22-May	1-May	12-May	26-May	24-Apr	5-May	18-May	N/A	N/A	N/A
	Date of First Spring Frost	Annual	14-Sep	11-Sep	24-Sep	1-Oct	22-Sep	3-Oct	12-Oct	N/A	N/A	N/A
	Frost-Free Season *(Days)*	Annual	115	113	135	150	130	151	169	135	162	222
	Growing Degree Days at Base 15ºC *(Temp. at which many insects and pests can grow and mature)*	Annual	258	199	425	867	284	661	1399	459	882	1568
	Freeze-Thaw Cycles *(Count)*	Annual	71	28	65	109	28	65	92	26	57	80
	Heavy Precipitation Days *(10 mm within 24 hours)*	Annual	8	0	9	20	2	9	23	2	9	19
	Heavy Precipitation Days *(20 mm within 24 hours)*	Annual	2	0	2	7	0	2	9	0	2	7

APPENDIX 3:

Saskatoon's Climate Projections under Moderate Emissions Reductions

				2021-2050			2051-2080			2081-2100		
	Variable	**Timeframe**	**Baseline Mean**	**Low**	**Mean**	**High**	**Low**	**Mean**	**High**	**Low**	**Mean**	**High**
Primary Impacts	Precipitation *(mm)*	Annual	370	275	396	548	280	394	533	N/A	398	N/A
		Spring	78	43	93	167	49	95	168	N/A	93	N/A
		Summer	171	88	172	264	90	166	264	N/A	166	N/A
		Fall	68	36	75	129	33	74	121	N/A	71	N/A
		Winter	51	32	57	86	33	59	90	N/A	57	N/A
	Mean Temperature *(ºC)*	Annual	1.8	1.3	3.6	5.6	2.7	4.9	7	N/A	5.1	N/A
		Spring	2.3	0.5	4	7.5	1.7	5	8.3	N/A	5.4	N/A
		Summer	16.8	16.4	18.3	20.6	17.2	16.9	22	N/A	19.9	N/A
		Fall	3	1.6	4.7	7.2	3.1	5.9	8.8	N/A	6	N/A
		Winter	-15.3	-17.5	-12.9	-7.7	-16.4	-11.3	-6.7	N/A	-11.2	N/A
Secondary Impacts	Mean Minimum Temperature *(ºC)*	Annual	-3.1	-6.5	-2.3	1.4	-4.7	-1	2.2	-4.2	-0.5	3
	Mean Maximum Temperature *(ºC)*	Annual	8.4	4.9	9.5	13.3	7	10.7	15	7.7	11.1	15.2
	Summer Days *(≥ +25ºC)*	Annual	46	24	61	121	26	74	125	29	80	123
	Tropical Nights *(Lowest temp. does not go below 20ºC)*	Annual	0	0	0	2	0	1	5	0	1	15
	Very Hot Days *(≥ +30ºC)*	Annual	9	5	15	37	9	25	53	3	26	86
	Very Cold Days *(≤ -30ºC)*	Annual	13	1	5	20	1	3	17	0	2	28
	Date of Last Spring Frost	Annual	22-May	2-May	13-May	28-May	29-Apr	9-May	23-May	N/A	N/A	N/A
	Date of First Spring Frost	Annual	14-Sep	10-Sep	23-Sep	1-Oct	16-Sep	27-Sep	7-Oct	N/A	N/A	N/A
	Frost-Free Season *(Days)*	Annual	115	109	133	148	121	141	158	107	141	185
	Growing Degree Days at Base 15ºC *(Temp. at which many insects and pests can grow and mature)*	Annual	258	140	382	885	200	504	981	212	543	1083
	Freeze-Thaw Cycles *(Count)*	Annual	71	38	65	96	35	67	76	27	64	100
	Heavy Precipitation Days *(10 mm within 24 hours)*	Annual	8	1	9	20	1	9	19	2	9	21
	Heavy Precipitation Days *(20 mm within 24 hours)*	Annual	2	0	2	8	0	2	9	0	2	10

APPENDIX 4:

Saskatoon's Climate Projections under Major Emissions Reductions[5]

	Variable	Timeframe	Baseline Mean	2021-2040 Mean	2041-2060 Mean	2061-2080 Mean	2081-2100 Mean
Primary Impacts	Precipitation *(mm)*	Annual	370	389	389	399	391
		Spring	78	83	86	90	86
		Summer	171	178	172	179	173
		Fall	68	72	72	72	71
		Winter	51	53	55	54	56
	Mean Temperature *(ºC)*	Annual	1.8	3.6	3.8	3.7	3.7
		Spring	2.3	3.8	4.2	3.8	4.1
		Summer	16.8	18.2	18.2	18.2	18
		Fall	3	4.5	4.8	4.7	5
		Winter	-15.3	-13.6	-12.5	-12.5	-12.9
	Mean Minimum Temperature *(ºC)*	Annual	-3.1	-1.4	-1	-1.2	-1.2
	Mean Maximum Temperature *(ºC)*	Annual	8.4	10.1	10.2	10.2	10.2

APPENDIX 5:

Updated Intensity-Duration-Frequency Curve Project

The City uses Intensity-Duration-Frequency (IDF) curves to provide estimates for rainfall intensities for storms of different durations, which are used for the design of new storm water infrastructure. A rain event which is rated as a 1-in-2 year design storm has a 50% chance of occurring in any given year. A 1-in-100 year rain event has a 1% chance of occurring in any given year.

The City's current IDF curves were used to create the storm water infrastructure design standards adopted in 1987. These IDF curves were based on rainfall data from 1926 to 1986. Since 2010, Saskatoon has had three of the top 10 highest seasonal rainfalls on record. Between 2012 and 2018, the City recorded 34 days with rain events exceeding the 1-in-2 year return period. Climate change modelling indicates that increased extreme rainfall intensities can be expected over the next century.

The Government of Canada, through the National Disaster and Mitigation Fund, has approved $100,000 towards a $212,000 project for the City. The project's main components are:

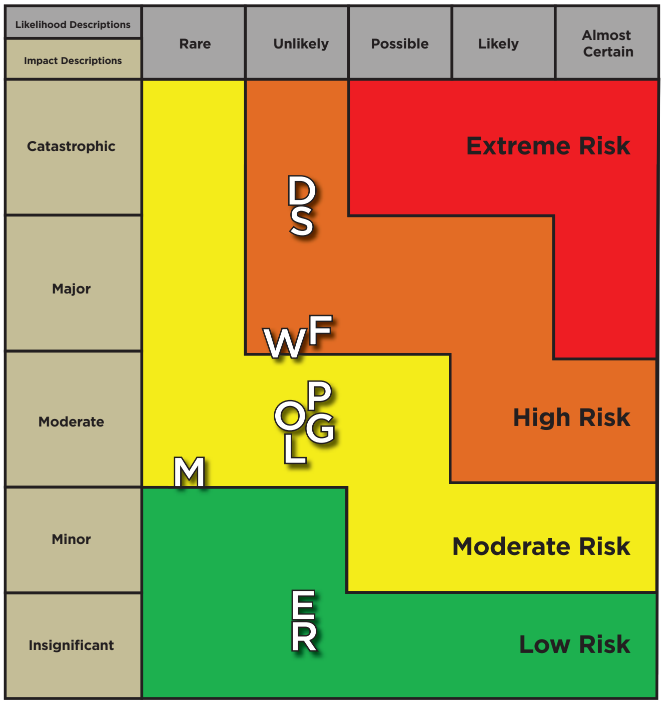
- Secure new LiDAR data where there are gaps for use in storm water modelling;
- Update IDF curves to include more recent available rainfall;
- Evaluate the risk of climate change on future extreme rainfall events;
- Identify international state-of-art practices that municipalities are using to assess and design their storm water collection systems in response to climate change; and
- Develop a cost-risk assessment framework based on storm water infrastructure standards and flood cost impacts for sample neighbourhoods.

The project will inform design standards for storm water infrastructure. Understanding flood risks, flood damage and the cost of infrastructure for different risk levels will enable more informed decisions about optimal resource allocation for new storm water management infrastructure for neighbourhood resiliency.

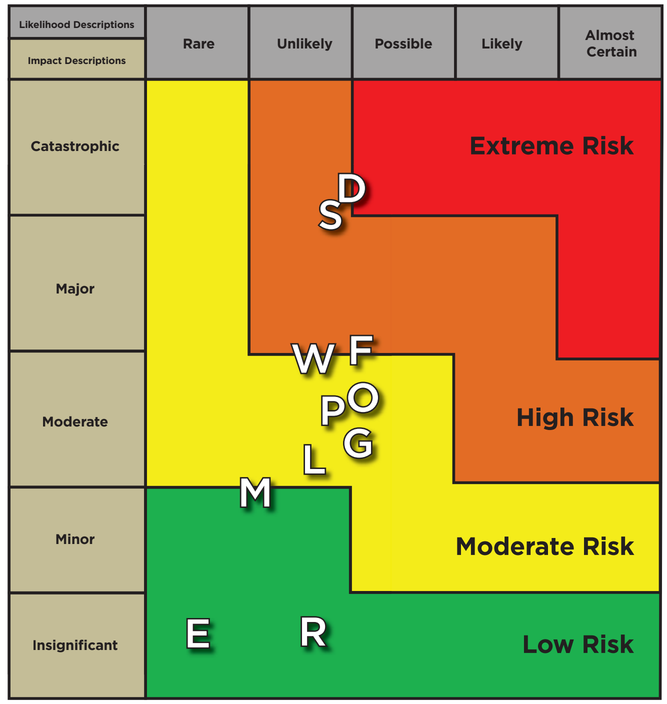
APPENDIX 6:

Natural Hazard/Extreme Weather Event Risk Analysis for Saskatchewan[6]

Risk Today under Current Conditions



Risk in 2050s under Changing Climate Conditions



Natural Hazard Key

D - Drought
S - Summer Convective Storms
F - Forest Fires
G - Grass Fires
W - Severe Winter Weather
E - Earthquakes
L - Lake Flooding
O - Overland Flooding
M - Mountain Runoff Flooding
R - Groundwater Flooding
P - Plains Runoff Flooding

Endnotes

1 Appendix 2 and Appendix 3 data and all table styles are adapted from the Climate Atlas of Canada's **Climate Atlas Report Region: Saskatoon.** (2018). Retrieved from https://climateatlas.ca

2 In Appendices 2-4 spring refers to March, April, and May; summer refers to June, July, and August; fall refers to September, October, and November; winter refers to December, January, and February.

3 In Appendices 2-4 the baseline mean data is from observed historical data from 1976-2005.

4 Where data fields are marked "N/A" or are missing in Appendix 1-3 this means these items were not available from the resources consulted. Often secondary impact and long-term data is only available through contracted research services. No "minor emissions reduction" scenario data (or Representative Concentration Pathway 6.0) data was available through any of the resources consulted. The Administration chose not to contract any research services for this stage of the capital project due to their high cost and generally long turnaround time. The need to "fill in data gaps" with specialized contracted research services will be considered within the business plan for the Local Actions strategy.

5 Climate projection data in Appendix 4 is from the Canadian Centre for Climate Services. (2018). Retrieved from https://climate-viewer.canada.ca/climate-maps.html#/.

6 Graphics from the Saskatchewan Research Council's **Saskatchewan Flood and Natural Hazard Risk Assessment**. (Wittrock et al., 2018; as cited in footnote #8).

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