CORPORATE CLIMATE ADAPTATION STRATEGY

LOCAL ACTIONS:
Saskatoon's Adaptation Strategy (Part Two)
December, 2019

Official Community Plan
Climate Action Plan
Local Actions Strategy

City of Saskatoon

Climate CHANGE

saskatoon.ca/**localactions**

LOCAL ACTIONS

CONTENTS

Vision: *The City of Saskatoon is a climate ready and resilient organization.*

Mission: *We implement climate change adaptation actions as planned and on purpose in order to limit disruptions and negative impacts on our staff, services, and assets, allowing us to continue to deliver high quality services to the residents of Saskatoon.*

EXECUTIVE SUMMARY

Adaptation involves activities that increase the ability to prepare for, withstand, and recover from the impacts of changing climate conditions. Daily, media coverage includes extreme weather events, more intense rain, and longer and hotter heat waves, indicating that the impacts of climate change are no longer a concern restricted to future generations. Climate change impacts have been increasingly widespread globally, with severe devastation to homes, businesses, the environment, and the social fabric of neighbourhoods; leading to many communities declaring a climate crisis or emergency.

Municipalities are working to develop and implement adaptation plans which consider the areas of city control and oversight, and the broader community. The Local Actions Strategy focuses on understanding how Saskatoon will be impacted by climate change and what the City of Saskatoon (City) can do to build resilience into municipal operations and assets.

Municipal climate adaptation planning encourages early consideration of the possible impacts on land use practices, design requirements, programming, and standards for construction. These plans typically consider:

- Conserving natural areas as providers of ecosystem services, including carbon sequestration, storm water management, and urban heat island reduction
- Using nature-based adaptation whenever possible, such as naturalized storm ponds and park spaces
- Incorporating traditional knowledge of Indigenous peoples into land management practices as a way to recognize their deep understanding of climate adaptation

The City has committed to preparing for changing climate conditions and resulting impacts to assets, programs, and services through the Strategic Goal of Environmental Leadership within the *Strategic Plan (2018-2021)* and as a signatory to the Global Compact of Mayors for Climate and Energy initiative. City Council approved the development of a corporate climate adaptation strategy on August 27, 2018. The project is jointly funded through capital and a grant from the Federation of Canadian Municipalities' (FCM) Municipal Climate Innovation Program.

In April 2019, **Climate Projections and Possible Impacts** was delivered to City Council. This report outlined projected climate changes for the Saskatoon region between 2020 and 2100 and presented a climate risk assessment for corporate operations. Portions of this report are included in Appendix A. Adaptation planning is complementary to the climate change mitigation roadmap described in Saskatoon's ***Low Emissions Community (LEC) Plan***. The LEC Plan and Local Actions Strategy work together to focus on both the causes and effects of climate change to create a comprehensive approach for the City's **Climate Action Plan.**

The **Corporate Climate Adaptation Strategy** outlines tangible actions and initiatives for corporate climate adaptation that are organized into four resiliency focus areas: Decisions, Staff, Services, and Assets. Initiatives are further prioritized as:

1. Near-term: 1-2 years to start
2. Mid-term: 3-6 years to start
3. Long-term: 7-10 years to start

Preparation of the corporate strategy has followed the International Council for Local Environmental Initiatives (ICLEI) five milestone approach: initiate, research, plan, implement and monitor/review. Research findings on adaptation practices are provided, as well as emerging initiatives from other municipalities. Internal and key external experts were engaged, resulting in approximately 125 interactions between September 2018 and September 2019.

Performance reporting is required in order to effectively manage adaptation planning. Annual key performance indicators will be reported publicly through the Carbon Disclosure Project website and Saskatoon's Environmental Dashboard site.

Adaptation best practice repeatedly demonstrates that a planned, proactive approach delivers the best value for investment over time. For the City of Saskatoon, the municipal actions and initiatives presented in this report represent a shift from a largely reactionary approach to managing corporate climate risk to a city-wide planned and proactive approach that is intended to limit disruptions and negative impacts to City staff, services, and assets.

The *Corporate Climate Adaptation Strategy* does not include broader community actions. Some community focused initiatives are underway through various divisions, such as Saskatoon Water, Emergency Management Office, Saskatoon Fire Department, Community Development and Sustainability. Preparation of a comprehensive community adaptation plan could be considered as a third phase to the Local Actions Strategy that can be completed at a later date.


City of
Saskatoon

RESILIENCE:

"Resilience is the capacity of individuals, communities, institutions, businesses and systems to survive, adapt and thrive, no matter what kinds of chronic stresses and acute shocks they experience."

THE STRATEGY

Introduction

Early project planning highlighted the need to advance corporate adaptation action beyond an ad hoc, reactive approach that addresses issues only after they arise. Project team members framed a planned risk management approach as a way to ensure the best value for investment and greatest **RESILIENCE** improvement over time.

Actions identified in the *Corporate Climate Adaptation Strategy* are specific to increasing resilience for corporate operations and are organized into four focus areas:

- Decisions: Thinking Strategically about Tomorrow, Today
- Staff: A Safe, Healthy, and Productive Culture
- Services: Prepared for Change and Ready to Serve
- Assets: Designing and Building for Tomorrow's Saskatoon

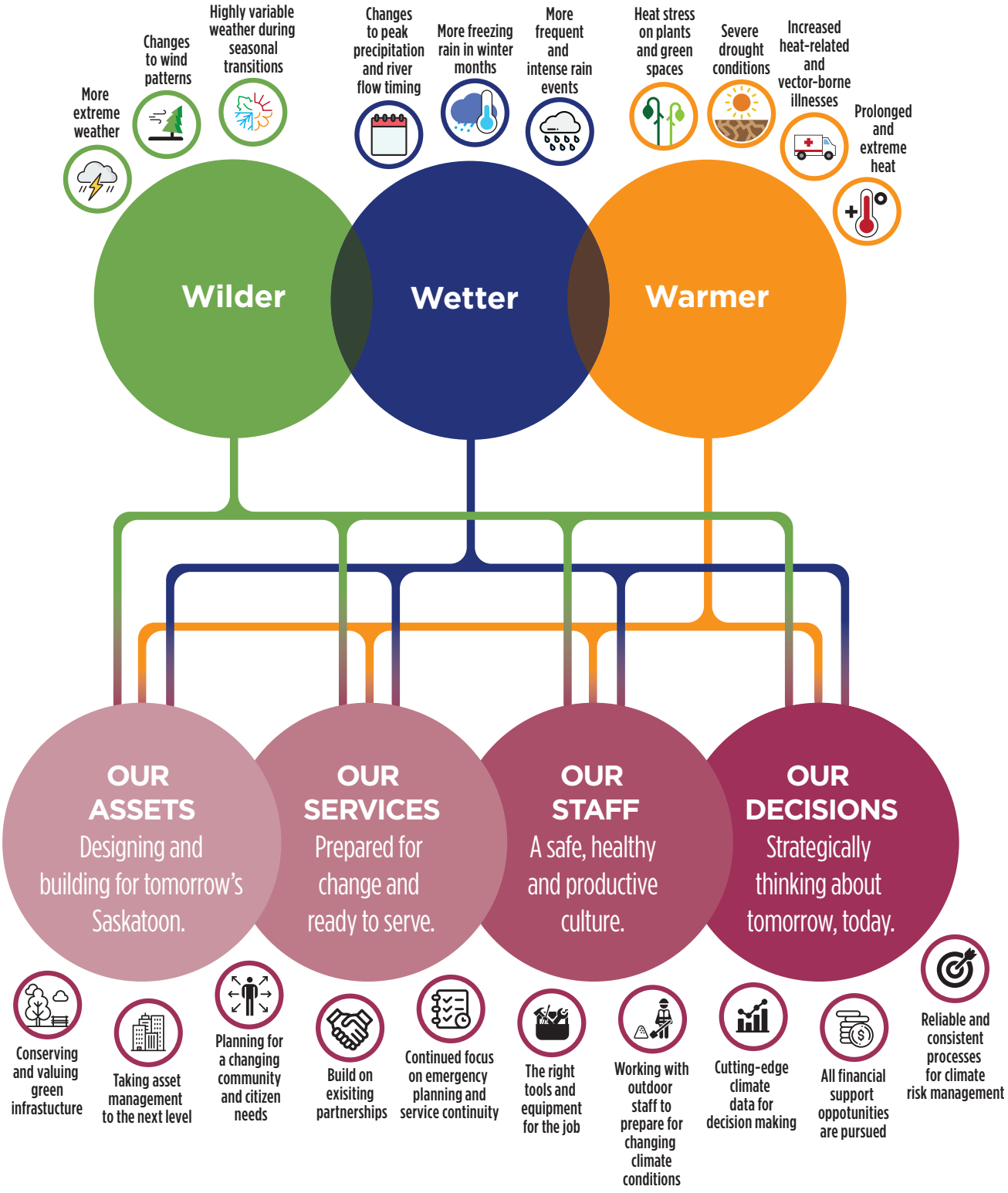
Each focus area includes actions as well as prioritized initiatives for planning and budgeting purposes. Prioritization categories are:

1. Near-term: 1-2 years to start
2. Mid-term: 3-6 years to start
3. Long-term: 7-10 years to start

Prioritization is based on the risk analysis previously presented in Climate Projections and Possible Impacts (Figure 11, Appendix A). Priority is given to those actions that will address the greatest number of risks, or that will address the risks with the potential for highest impact.

Figure 1 presents the connections between identified local climate change impacts and the four focus areas.

Figure 1. *Local Impacts Require Local Actions*



Decisions: Thinking Strategically about Tomorrow, Today

Decision-Making and Adaptation Planning Issues

Strategic planning and risk management processes are ever evolving due to the fast pace at which societal needs are changing and technological advancement occurs. It is a challenge to develop strategic priorities while also managing new and changing risks quickly and flexibly. Planning must be integrated, future-focused, and scalable to optimize success.

Climate change is just one of the risks facing Saskatoon. Given the wide reach and great uncertainty associated with the anticipated impacts, however, there is high potential to affect the City's vision to be "a great place to live, work, learn, and play." Failure to consider a range of changing climate conditions for long-term urban development, design, and strategic planning could result in asset damage, unexpected expenses, societal and economic suffering, and missed opportunity. Efforts to ensure climate risk management is considered in all corporate strategic decision-making and long-term planning processes is a critical component of building substantive resilience.

Did you know?

Current funding requests for actions in support of "proactively addressing the effects of climate change" do not fall under one umbrella. To date, funds to support climate resiliency projects have come from dedicated user fees (e.g. storm water utility fees), dedicated reserves (e.g. Major Natural Event Reserve and Pest Management Reserve), or one-off capital expenditures (e.g. Local Actions Strategy project).

Current Approaches to Decision-Making and Adaptation

At the City, strategic decision-making and long-term planning is guided by a combination of documents, programs and processes including:

- Strategic Plan,
- Official Community Plan (OCP) Bylaw 8759,
- Corporate Risk Management Program, and
- Multi-year business plan and budget process.

Recent work has been carried out to integrate climate change adaptation and climate risk management into these documents, programs, and processes.

The Strategic Plan provides high level direction for the Administration from 2018 to 2021. Updates are timed to align with City Council election cycles and internal multi-year business plan and budgeting processes in order to better link decisions on prioritization, resourcing and long-term strategic direction continuity. The Strategic Goal of Environmental Leadership contains language mandating the importance of "proactively addressing the effects of climate change" over the next four years.

The OCP provides the policy framework to define, direct and evaluate development in Saskatoon to a population of 500,000. In 2019, Planning and Development led a collaborative process to update this bylaw. Conservation of natural areas to improve biodiversity and mitigate greenhouse gas emissions as well as changes in administrative practices to improve resiliency are just two items that will strengthen the City's policy commitment to both mitigation and adaptation actions.

The Corporate Risk Management Program, supported by the Corporate Financial Services department, outlines and prioritizes significant risks to the City and ensures risks are being managed in a positive, systematic and productive manner. The program is based on the International Organization of Standardization's Standard for Risk Management (31000). Since 2016, the Corporate Risk Annual Report has included "*the City may not be prepared for the effects of climate change*" as a medium priority risk to the corporation as a whole. Some projects and programs have been implemented in response to this risk, however, work has been conducted in an ad hoc manner due to resourcing challenges and different levels of perceived (and real) urgency throughout the Administration. This was a driving factor in the creation of the Local Actions Strategy.

A new factor in the City's strategic decision-making is the Triple Bottom Line policy. Effective January 2020, the policy and its accompanying decision-making tool outline the approach to evaluate new projects and programs using indicators from the following areas:

- environmental health and integrity,
- social equity and cultural wellbeing,
- economic prosperity and fiscal responsibility, and
- good governance.

The desired outcome is balanced decisions about projects and programs that consider strategic priority areas and competing interests over the long-term. Climate change adaptation and mitigation measures have been included in the decision-making tool to ensure new projects and programs consider and support (where possible) reducing greenhouse gas emissions, innovative repurposing of greenhouse emissions and/or their by-products and reducing corporate and community exposure to climate risks, such as extreme heat and changing precipitation patterns.

Actions to Improve Decision-Making

Action	Initiative	Priority (1,2,3)
A) Adaptation Lens Document a process to support the consideration of adaptation for all new projects, programs and assets in a reliable and consistent manner.	**1. Administrative Procedures** Create Administrative Procedure and Standard Work documents to support the consideration of climate change projections, positive and negative risk to operations, and resiliency options creation as part of the implementation of the Triple Bottom Line Policy.	**1**
	2. Training Create internal training sessions that can be delivered on demand to support workgroups as they build climate change impact understanding and adaptation innovation capacity.	**1**
	3. Tracking and Data Management Create internal processes and dashboard for climate adaptation strategy key performance indicator tracking. Create a digital historical and future climate data hub to support reliable internal use and updating. Work with internal stakeholders to document what additional climate data points would be useful in decision-making related to asset management and service/program planning.	**1**
B) External Funding Explore and document existing municipal, provincial, federal, and international mechanisms for financing resiliency building that look beyond mill-rate increases and capital expenditure.	**4. Funding Research** Create and maintain a list of existing programs that fund resiliency building projects (include application process and requirements).	**1**
C) Corporate Alignment Look to partners across departments to support and integrate resilience planning into current and future work.	**5. Pilot Adaptation Initiatives** Review major upcoming projects (such as Bus Rapid Transit, Saskatoon Forestry Farm Park & Zoo Master Plan, Winter City Strategy, the new central library, and downtown arena) that may be good candidates for piloting resiliency building options.	**1**
	6. City Planning for Resilience Continue to work with Planning & Development to review current land use, zoning, and urban/regional design practices to ensure current requirements provide adequate flexibility to support resiliency building.	**1**
D) External Relationships Continue to develop relationships with external organizations that produce high quality historical and future climate data for use in data-driven decision-making.	**7. Share Knowledge and Nurture Partnerships** Work with the Global Institute for Water Security, Global Water Futures, Saskatchewan Research Council, Prairie Climate Atlas, and Canadian Centre for Climate Services to define ways to visualize climate change projection data to improve corporate impact and risk assessment discussions, inform user-driven science, and aid in public education campaigns.	**1**

Staff: Safe, Healthy, and Productive

Staff Adaptation Planning Issues

Changing climate conditions impact outdoor staff, residents, the environment, and ecosystems in Saskatoon. **Climate Projections and Possible Impacts** anticipates that warmer average annual temperatures will bring larger, more diverse insect and pest populations, increasing the risk of vector-borne disease as well as the need for pest management practices. The longer, more frequent heat waves predicted in the report will impact outdoor staff through increased risk of heat stroke, dehydration, and exhaustion. Warmer winter temperatures where more precipitation falls as freezing rain and slushy snow will create additional transportation challenges for staff moving around the city. More frequent extreme storm events require planned emergency responses, including timely, clear instructions so staff know what to do and where to go.

The City employs approximately 5,400 people; roughly a third are seasonally employed from April to October. Many seasonal staff work partly or completely outdoors to support public works functions, manage parks and green space maintenance, and facilitate outdoor recreation.

Ensuring that all staff have what they need to be safe, healthy, and productive at work is one of the City's core corporate values. Continued commitment to this value will require comprehensive consideration of the risks posed by changing climate conditions.

Current Approaches to Staff and Adaptation

Safety is part of everything we do at the City. Major initiatives driving safety performance relative to extreme weather events and changing climate conditions include organizational practices that support Saskatchewan Occupational Health and Safety (OHS) regulations and the maturation of internal emergency response and service continuity planning.

The Occupational Health and Safety division within the Human Resources department leads development and coordination of the Health and Safety Management System (HSMS) at the City. The HSMS is based on eight elements:

- leadership
- hazard identification
- assessment and control
- education and communication
- incident investigation
- inspections
- emergency response
- health and wellness and
- program administration

Changing climate conditions have the potential to influence all elements of the HSMS. Working in partnership with other internal groups, the Occupational Health and Safety division has created internal training modules, safe work practices, and toolbox talks to manage safety risks posed by changing climate conditions. On high heat days, for example, staff are trained to take more frequent breaks and drink more water. The rate of required breaks is determined by OHS regulations and takes into account air temperature, humidity, effort level required by task, and radiant heat.

The Saskatoon Emergency Management Organization (EMO) is responsible for coordinating the City's emergency preparedness and service continuity. This includes preparedness, planning, response and recovery in the event of a natural disaster, severe weather event, and human caused threats. It is important that essential City services continue during and after these events. The EMO has been focused on supporting the development of internal and external emergency response plans, building internal and external capacity through emergency preparedness and Incident Command System training, and completing a multi-year exercise[1] process. *Notifynow* is the EMO's targeted public mass notification system. The service allows all residents and staff to subscribe to receive location-specific or city-wide emergency alerts by phone, email or text message.

Did you know?

Inclusivity is a top priority for the City. Notifynow can be used by people who are deaf, hard of hearing, or speech-impaired through a TTY (teletypewriter). A TTY is a special device that allows spoken messages to be converted to text.

Service continuity refers to the ability of an organization to maintain essential services and functions during and after a disaster or unexpected event. It is an essential component of a resilient city. Service continuity planning activities are currently underway for prolonged power outages, pandemic, and technological threats. The increasing frequency of extreme weather events and extreme heat/cold will require further attention as the program develops.

1 An exercise in the emergency management context refers to the simulation of an event that triggers the use of an emergency response plan. Exercise complexity can range from a simple "tabletop" meeting, where the simulation is talked through, to a "full-scale" practice, where multiple groups are performing response plan activities as if a real-world event is taking place.

Actions to Improve Resiliency for Staff

Action	Initiative	Priority (1,2,3)
E) Review anticipated work impacts Begin proactive discussions with outdoor staff, labour units, and leadership on climate change impacts, risk to current operations, and potential adaptive strategies.	**8. Identify work impacted by climate change** Review and inventory all job descriptions and collective bargaining agreements of workgroups with outdoor staff to identify existing language and requirements regarding work in hot/cold conditions.	**2**
	9. Condition assessments Conduct a staff safety and productivity assessment of outdoor activities under extreme heat and extreme cold in order to define potential thresholds where non-essential services are stopped until favourable climate conditions return.	**3**
	10. Alternate duties for extreme conditions Create a list of extreme heat and extreme cold tasks that could be completed by outdoor staff instead of regular duties to increase employee safety and minimize negative salary impacts of non-essential work stoppages.	**3**
	11. Safety and training processes Ensure pest preparedness and extreme heat/cold internal safety training and processes consider the diversity of the City's workforce.	**3**
	12. Work hours Explore and define alternative scheduling options to reduce the exposure of outdoor staff to the "hottest hours of the day" based on learnings and practices in other municipalities where extreme heat is prevalent.	**3**
	13. Seasonal work terms Discuss current seasonal hiring practices with outdoor staff to meet the needs of more variable seasonal transitions and a potentially longer summer season.	**3**
F) Pilot initiatives to mitigate staff exposure Define pilot project opportunities for extreme heat/cold management and pest preparedness through new equipment procurement.	**14. Pilot development** Work with outdoor staff to explore potential pilot projects for extreme heat and cold management and pest preparedness equipment. Examples could include lawn mower canopies, pop-up shade tents, and mosquito netting.	**3**

Services: Prepared for Change and Ready to Serve

Services Adaptation Planning Issues

As climate becomes more variable, the amount of useable space in landfills or airspace, can be consumed more quickly than planned. Cities in Puerto Rico saw 6.2 million cubic yards of debris sent to landfills after Hurricane Maria hit in 2017; that is enough to fill 43 football stadiums.[2] Alberta faced a similar situation after 2013 flooding caused water damage in more than 4,000 businesses and 3,000 buildings in downtown Calgary, with repairs ranging from minor to full demolition and rebuild.[3] In October 2018, the City of Edmonton sent 30 snowplows to Calgary to help clean-up after a severe early season snowstorm.[4]

More frequent extreme heat and intense storms can impact the ability for recreation staff to consistently provide safe outdoor play opportunities. Globally, changing climate conditions may increase the rate of immigration to Saskatoon as other areas become unsafe or undesirable. Increased seasonal variability can impact the ability of staff to meet defined service levels. As a result, delivering climate-ready, resilient services under changing climate conditions requires proactive planning and cross-departmental collaboration.

Current Approach to Services Adaptation Planning

The City has a number of initiatives underway and in place to prepare for changing climate conditions. Examples are listed below.

The Saskatoon North Partnership for Growth supports a coordinated approach to land use, development, asset management, and governance in five municipalities. Opportunities to build resiliency to intense rainfall events and riverine flooding as well as coordination enhancements to emergency management and mutual aid have been discussed through this work. Additional resiliency building discussion will be included as regional planning documents and bylaws are created.

Within the Automated Traffic Management System, alternative traffic signal plans are being created to accomplish specific goals, such as clearing the downtown core and/or bypassing major corridors due to unexpected disturbances and weather events.

The Low Impact Development Guidelines provide onsite storm water management options for those developing property in Saskatoon. Some methods outlined in the document include raingardens, rainwater reuse, green roofs, permeable pavements, storm water box planters, and naturalization of drainage ways.

Mobility management processes (e.g. sanding, salting) during snow events and freezing rain are deployed through well-defined response plans already in place. Improved real-time weather and road condition data will further refine management processes through the Roadway and Weather Information System, a continuous improvement project underway through Roadways, Fleet, and Support.

Communications and Public Engagement uses service alerts, news releases, social media channels, and news conferences to support timely communication with internal staff and the public. These activities occur in collaboration with the EMO *Notifynow* system. Communications and Public Engagement and the EMO participated in a relationship building initiative with Environment and Climate Change Canada that has further improved the severe weather alert process.

2 Kennedy, M. and Migaki, L. (2017). After Maria, Puerto Rico struggles under the weight of its own garbage. National Public Radio. Retrieved on September 3, 2019 from https://www.npr.org/sections/thetwo-way/2017/12/14/570927809/after-maria-puerto-rico-struggles-under-the-weight-of-its-own-garbage

3 Environment and Climate Change Canada. (2017). Canada's top ten weather stories of 2013. Retrieved on September 3, 2019 from https://www.ec.gc.ca/meteo-weather/default.asp?lang=En&n=5BA5EAFC-1&offset=2&toc=hide

4 Antoneshyn, A. (2018). Edmonton to help dig Calgary out of snowstorm. CTV News Edmonton. Retrieved on September 3, 2019 from https://edmonton.ctvnews.ca/edmonton-to-help-dig-calgary-out-of-snowstorm-1.4118725

As part of the 2017 Internal Audit Plan, PricewaterhouseCoopers completed an audit of the City's ability to "quickly and effectively resume operations in the event of a serious incident, accident, disaster, or emergency". The audit proposed 26 recommendations, grouped into six phases of work, to support the continued development of a robust service continuity management system. Prioritized implementation of these recommendations is ongoing.

Actions to Improve Resiliency for Services

Action	Initiative	Priority (1,2,3)
G) Services and Emergencies Continue discussions to define points that trigger a change in service level and/or require public communication.	**15. Climate change scenarios and responses** Define worst-case climate change scenarios and graduated administrative responses with core service providers, including water, electricity, waste management, transit, parks management, recreation, and mobility management.	**2**
	16. Communications planning Proactively define communication tools, key messaging, and delivery mechanisms to rapidly inform residents, businesses, and organizations of service level changes required due to administrative responses to extreme heat/cold/wind, intense summer/winter storms, prolonged drought, increasing pest populations, and intense precipitation events.	**2**
	17. Flexibility in seasonal transitions Define options to increase flexibility in seasonal equipment turnover practices to improve readiness for highly variable weather and emergencies.	**3**
	18. Plan for post-event emergency resourcing Explore opportunities to use cross-training and/or temporary staff reassignments, mutual aid agreements and/or private-sector contractors, when appropriate, to add capacity to post-weather event administrative responses as part of emergency management and service continuity.	**2**
	19. Plan for water security Engage with the Water Security Agency to better understand Gardiner Dam operating procedures in order to clearly define resiliency needs. Identify and analyze other water security risks.	**2**
H) Evacuation Planning Continue work with internal staff and external partners to improve evacuation processes.	**20. Define appropriate evacuation and shelter procedures** Continue to work with the Saskatchewan Public Safety Agency City stakeholders, external partners, and at-risk communities to define efficient, culturally appropriate evacuation processes and suitable temporary housing locations that balance the needs of those in unsafe situations with the needs of Saskatoon residents.	**1**
I) Social Impacts of Climate Change Engage with internal staff to better understand how community needs may be impacted by climate change.	**21. Utility affordability and energy poverty** Analyze the affordability of corporate utilities from a social-equity lens and define options to improve affordability.	**3**
	22. New services Identify potential new services or changing service levels required due to exacerbated social inequities.	**3**
	23. Climate change migration Analyze the impacts of "climate refugee" migration to Saskatoon on population growth and service demand.	**2**

Assets: Designing and Building with the Future in Mind

Asset Adaptation Planning Issues

Current design practices are typically based on historical climate information with added safety factors. Climate change is increasing expected maximum temperatures, intensifying rainfall events of rainfall events, and heightening storm severity. As a result, aging and recently built assets are being pushed beyond design limits and failures are occurring. When Hurricane Dorian made landfall in the Bahamas, it decimated structures indiscriminately—hospitals, roadways, homes—and left more than 2,500 people missing.[5] In December 2018, unprecedented levels of frost accumulation on SaskPower lines caused wide-spread and lengthy power outages to "tens of thousands" of people. In February 2019, prolonged extreme cold and low snow cover in Saskatoon contributed to frost depths reaching eight feet and beyond, causing a spike in water service interruptions due to frozen water service connections.

The cost of continuing to design and build using only historical or current climate information is likely to result in, at best, a faster deterioration rate and higher insurance premiums and, at worst, asset failure and destruction of lives, property, and the environment

5 Reuters for Global News Saskatoon. (2019). Over 2,500 registered as missing as death toll of hurricane Dorian rises to 50 in Bahamas. Retrieved on September 11, 2019 from https://globalnews.ca/news/5889274/2500-missing-death-toll-hurricane-dorian/

Did you know?

The World Bank's recently released Lifelines study concludes that building more resilient infrastructure can increase upfront project costs by 3%, but often improves utility returns by 300% or more over the duration of the asset's lifecycle. Utility returns in this sense refer to the total value of avoiding asset downtime and damage as well as lost wages and revenue likely to occur in "non-resilient or status quo infrastructure".[6]

Current Approach to Asset Adaptation Planning

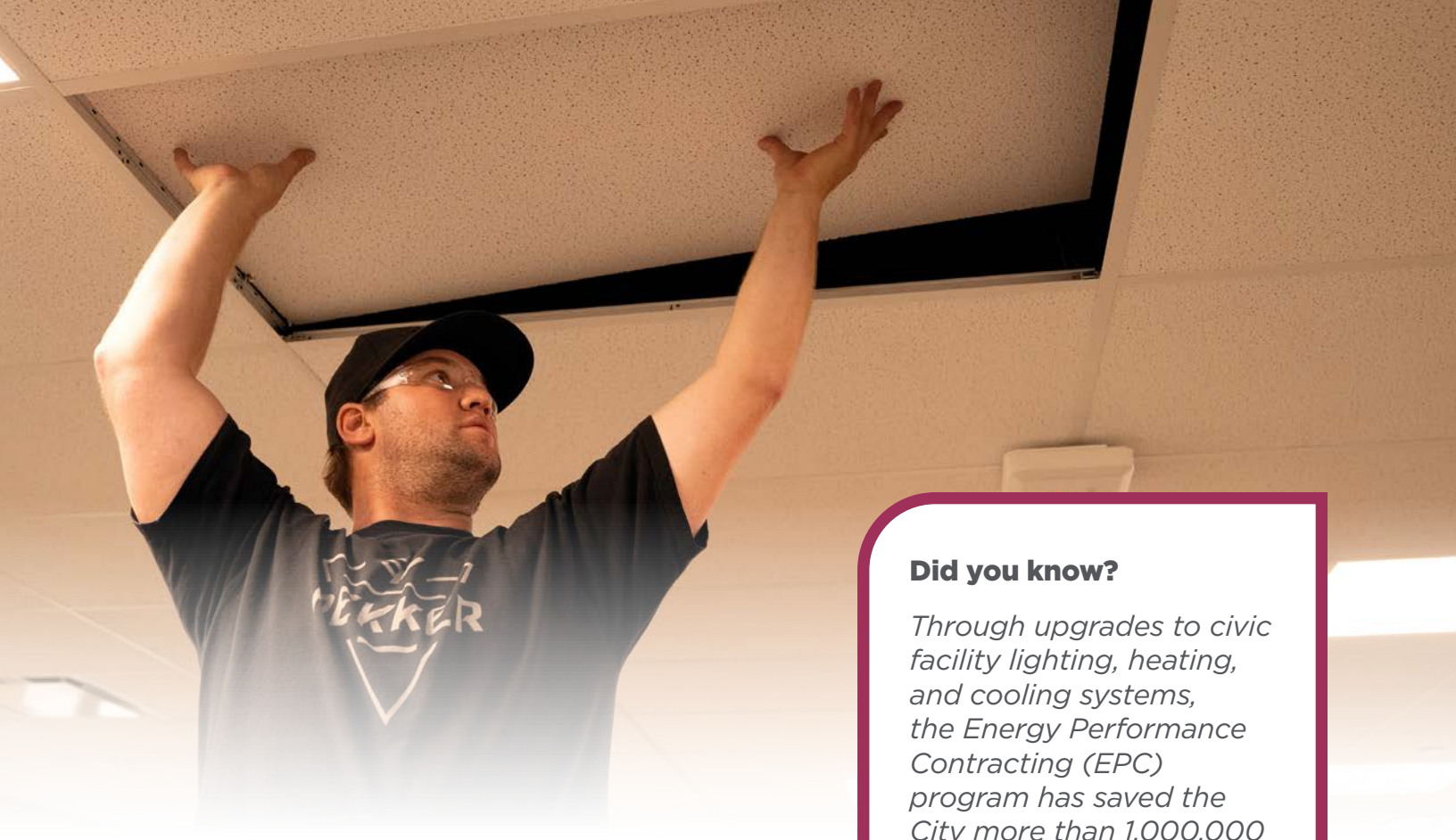
Operationalizing the City's Asset Management Policy and Framework will include the integration of climate projection data and adaptation options. The new policy and framework is set to support a more holistic discussion of renewal and maintenance funding. Implementation is set to be completed over the next three years. All assets and existing asset management plans will benefit from this enhanced process.

Saskatoon Water and Saskatoon Light & Power are undergoing long-term demand planning. Saskatoon Water is reviewing design curves for storm water assets through a climate change lens in partnership with the University of Saskatchewan and Concordia University. At Saskatoon Light & Power, climate risk management and adaptation planning are guided by ISO 31000 as recommended by the Canadian Electricity Association. SaskPower has also recently begun developing a climate adaptation strategy using this guide. Saskatoon EMO is guiding the two utility providers through interdependency documentation and contingency planning.

Additionally, Saskatoon Light & Power is contributing to a climate ready city by installing energy efficient technology, such as Light Emitting Diode (LED) streetlights, in all new neighbourhoods and in older neighbourhoods as part of the asset management process. Energy efficiency contributes to resiliency by lowering energy demand. This allows current supply to meet potential future demand growth (e.g. due to increased air conditioner use) for longer. To date, approximately 2,500 LED streetlights have been installed around Saskatoon, reducing total energy consumption by an estimated 950,000 kilowatt-hours annually.

Energy and resource efficiency are important components of holistic asset management as well as resilient (and low carbon) cities. Additional energy and resource efficiency actions, such as the Energy Performance Contracting program, are described and guided through *the* **Low Emissions Community (LEC) Plan**. The LEC Plan and Local Actions Strategy work together to focus on both the causes and effects of climate change to create a comprehensive approach for the City's **Climate Action Plan**.

6 Hallegatte, S., Rentschler, J., and Rozenberg, J. (2019). Lifelines: The Resilient Infrastructure Opportunity Washington, DC: World Bank.



Did you know?

Through upgrades to civic facility lighting, heating, and cooling systems, the Energy Performance Contracting (EPC) program has saved the City more than 1,000,000 kilowatt-hours of energy, equalling approximately $150,000 in utility cost savings. Looking ahead, the EPC program will provide further, significant utility cost savings as retrofits are completed on additional civic facilities.

Initiatives to develop and implement standards, guidelines and opportunities to support green assets (e.g. parks and wetlands) are also underway at the City. The Green Infrastructure[7] Strategy places importance on all residents having access to a network of high quality, multifunctional, and integrated green spaces. As part of this Strategy, a project to develop Natural Area Standards is currently underway. The project focuses on identifying natural areas within Saskatoon and collaboratively developing a list of compatible uses in order to create a predictable process for integrating natural areas into development areas.

The Wetland Policy (C09-041) presents guidance for land use and development decisions related to wetland and riparian areas[8] in a manner that is sensitive to the ecological integrity of wetlands and the ability of the City to achieve compact, sustainable, and economically viable growth patterns.

The Parks Division is set to present an Urban Forestry Management Plan (UFMP) to City Council in 2020. The UFMP focuses on minimizing the impacts of urban growth on the urban forest, redevelopment in established areas, invasive pests and diseases, weather events, and aging trees. A number of graduated response plans for invasive pests, such as Dutch Elm Disease and Cottony Ash Psyllid, have been developed as part of the UFMP. Other key elements include water conservation through naturalization of park space, smart irrigation technology, and an emphasis on native and drought-resistant plant species.

7 Green infrastructure is defined as a system of green spaces and techniques that provide municipal and ecosystem services by protecting, restoring, or emulating nature. Green infrastructure spans a wide range of asset types, from natural (e.g. existing wetlands and grasslands) to engineered (e.g. dry storm water ponds constructed within green park spaces).

8 Riparian areas are the interface between land and water bodies, such as rivers and lakes. These areas are important as they form a corridor allowing animals to travel between different biomes.

Actions to Improve Asset Resiliency

Action	Initiative	Priority (1,2,3)
K) Asset Management for Climate Change Integrate climate risk consideration and resiliency building options in the development of the Corporate Asset Management Program.	**24. Design assets in alignment with climate projections** Develop and document processes that allow future climate projections to be considered in the design of new and upgraded corporate assets.	1
	25. Review standards for resiliency Review all corporate design/construction standards and building code requirements against projected climate change in order to identify and inventory areas where future conditions could surpass current thresholds.	2
	26. Regional collaboration Network and share information with other municipalities that will likely experience Saskatoon's projected climate conditions.	1
	27. Division collaboration Continue to participate in Saskatoon Water's design curve update project to inform climate projection and risk management through asset design.	1
L) Consider Green Infrastructure on Par with Grey Infrastructure Support increased integration of green infrastructure into all available aspects of urban development and through implementation of the Green Infrastructure Strategy and Urban Forestry Management Plan.	**28. Species selection for resiliency** Support increased use of drought and pest-resistant and native plant species to reduce watering requirements, pest impact and improve biodiversity.	2
	29. Retain moisture Support increased soil and mulch/compost cover in planted areas to improve storm water retention and enhance plant viability.	2
	30. Local food production Define opportunities to expand and diversify local food production to improve biodiversity and reduce reliance on distant food producing areas also facing significant climate risk.	2

Did you know?

Public engagement conducted as part of the Green Infrastructure Strategy noted stakeholder interest in seeing an increased focus on adaptation at the City. Stakeholder feedback from the Green Infrastructure Strategy has been integrated into the Local Actions Strategy where possible.

From mid-May to early September, the Urban Biological Services team (Parks division) conducts weekly mosquito counts using eight traps located across Saskatoon. Data informs population management activities and helps partner organizations such as the Saskatchewan Health Authority track West Nile Virus risk. Mosquito counts from 2019 suggests mosquito numbers were lower than the previous 10-year average.

PERFORMANCE REPORTING

Annual

Annual key performance indicators will be reported publicly through two sources: the **Carbon Disclosure Project** website and the City's **Environmental Dashboard** website.

The Carbon Disclosure Project (CDP) is an international platform used by municipalities and other levels of government to publicly disclose their progress towards existing climate action commitments. The City is required to report annually through CDP in order to maintain satisfactory status with the Global Covenant of Mayors for Climate and Energy. The City has reported to CDP since 2015.

Reporting through the City's Environmental Dashboard will focus on implementation and impact. Implementation indicators will track progress on objective funding and completion rates. Impact indicators will measure the effect of completing initiatives on climate risk management practices. Figure 3 presents a list of recommended key performance indicators.

Figure 2. *Recommended Key Performance Indicators*

Implementation
› Funding status of all initiatives (e.g. unfunded, partially funded, fully funded)
› Funding source for all initiatives (e.g. capital, operating, external grant, external loan, etc.)
› Status of all initiatives tasks (e.g. not started, underway, complete)
Impact
Decisions:
› Number of internal training or subject matter expert support sessions delivered to support corporate capacity building related to climate projection data use and resiliency building
› Number of new projects, programs, initiatives that included climate risk management and/or adaptation options
› Number of available climate data points
Services:
› Number of internal and external inquiries related to climate change preparedness and/or adaptation activities
› Number, duration, and location of service interruptions related to climate events
Staff:
› Number of staff engaged to discuss climate change impacts and preparedness options for managing climate risk
› Number of pilot projects completed
Assets:
› Total cost of corporate asset insurance premiums over time
› Percent of total design standards and building code regulations flagged as "may need adjustment" given future climate projections[9]
› Percent of asset management plans that consider historical and future climate information
› Ratio of total investment in green and grey infrastructure across all corporate operations
› Total cost of asset damage/repairs after climate events

9 The intention of reviewing current corporate design standards and building code regulations is not to change the City of Saskatoon's requirements before provincial, federal, or international mandating organizations make changes. The intention is to use future climate projection data available to the City today to review the future suitability of current codes and standards in order to prepare internal staff to bring any concerns to their higher-level counterparts.

Long-Term

Public policy decisions, behaviour changes, and technological advances will impact the severity of climate change experienced globally and locally. As a result, global climate model projections are updated on a five-year cycle with new assumptions.

To align with global climate model updates, it is recommended that climate projection data, hazard-risk-vulnerability assessment information, and resiliency building actions and initiatives be updated in a report to City Council every five years. Using the most recent climate science is important to building and maintaining useful resilience strategies because the actual pace of some global changes often outpace projection rates.[10]

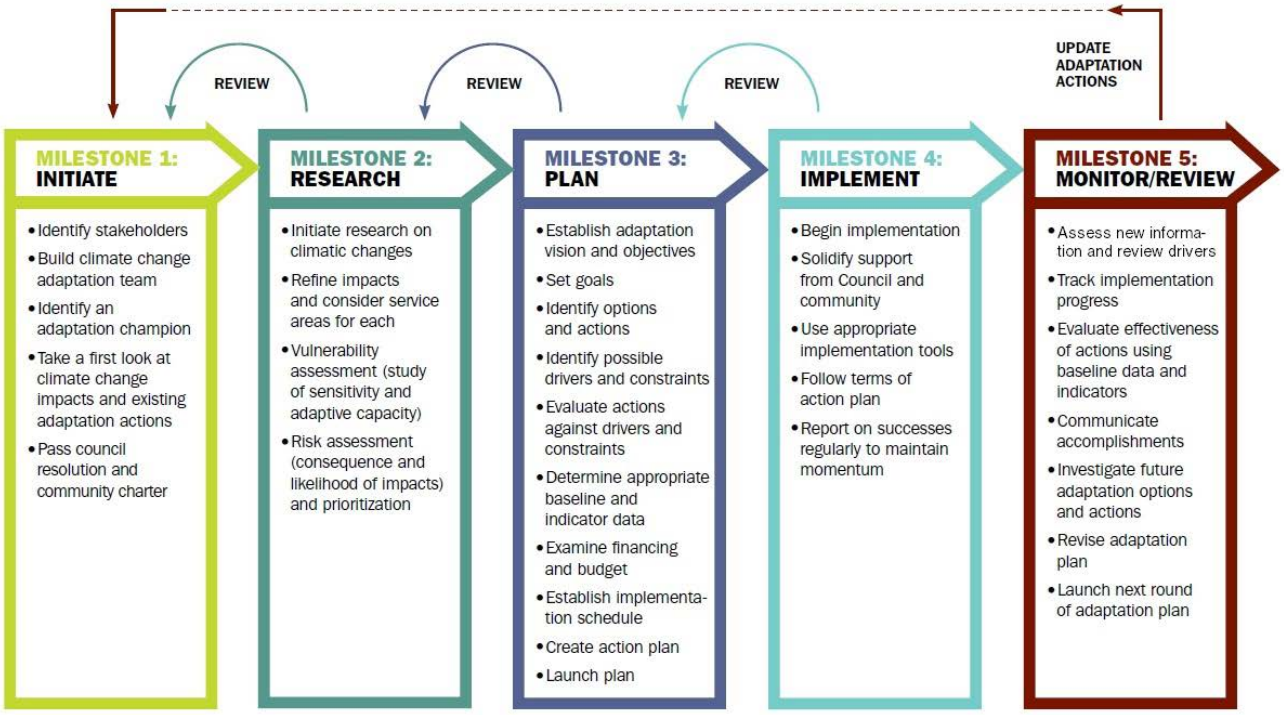
By regularly updating the *Corporate Climate Adaptation Strategy* as a living document, the City can improve and re-prioritize actions and initiatives based on new information, access to technologies, resource availability and stakeholder and community readiness.

10 Lindsey, R. (2019). Climate change: Global sea level. Retrieved on October 3, 2019 from https://www.climate.gov/news-features/understanding-climate/climate-change-global-sea-level Intergovernmental Panel on Climate Change. (2019). IPCC special report on the ocean and cryosphere in a changing climate: Summary for policymakers. Retrieved on October 3, 2019 from https://www.ipcc.ch/site/assets/uploads/sites/3/2019/09/SROCC_SPM_HeadlineStatements.pdf

Framework

The Local Actions Strategy is based on the International Council for Local Environmental Initiatives (ICLEI) Canada's five milestone approach. Major activities are summarized in the following figure.

Figure 3. *ICLEI Canada's 5 Milestone Approach to Climate Adaptation*[11]



Activities within Milestones 1 and 2 were completed and presented in administrative reports sent to City Council in 2018 and 2019.

- **Milestone 1** – City Council unanimously passed the resolution to create a corporate climate adaptation strategy through joint municipal capital and federal grant funding (from the Federation of Canadian Municipalities) on August 27, 2018. The resolution was guided by the following factors:
    - "*The effects of climate change on civic services are proactively addressed*" is one of the Things We are Striving For under the Strategic Goal of Environmental Leadership in the Strategic Plan 2018-2021
    - "*The City may not be prepared for the effects of climate change*" is identified in the 2018 Corporate Risk Annual Report as a strategic risk facing the City (this risk was first identified in 2015)
    - The City's signatory status with the Global Covenant of Mayors for Climate and Energy requires the City to create a climate adaptation strategy to remain in good standing. Former Mayor Don Atchison signed the agreement in late 2015.

11 ICLEI Canada. (2015). Adaptation methodology. Retrieved on Aug. 13, 2019 from http://www.icleicanada.org/resources/item/79-adaptation-methodology

- **Milestone 2** – The *Climate Projections and Possible Impacts* report outlined results of the climate projection research phase of the corporate climate adaptation strategy project. Projected changing climate conditions were used to lead staff through a hazard-risk-vulnerability assessment in order to outline risk levels posed to assets, services, and programs over the next 80 years. High risk impacts include changing utility demands, heat stress on outdoor staff, vulnerable populations and green spaces, as well as increases in pest populations and vector-transmission incidence rates. See Appendix B for a short summary of climate change projections and possible impacts facing Saskatoon.

The *Corporate Climate Adaptation Strategy* fulfills the requirements of Milestone 3. A vision, mission, actions, initiatives, and scorecard for measuring the effectiveness of the strategy have been developed.

Decision-making authority for resourcing Milestone 4 (implementation) and Milestone 5 (review and update) lies with City Council. Implementation options for the corporate adaptation strategy will be presented to City Council in alignment with the multi-year business plan and budget process.

Research

Adaptation, an Emerging Practice

Preparation of the *Corporate Climate Adaptation Strategy* was informed by a literature review and a comparative analysis of other municipal and provincial/state level adaptation documents. See Appendix C for a list of documents reviewed.

Climate change adaptation is an emerging field of practice. Until about a decade ago, it often drew heavy scorn from individuals focused on promoting climate change mitigation (e.g. reduction and management of greenhouse gas emissions). The rationale for this divide is linked to the perception that funding adaptation activity gave decision makers a reason to avoid or delay greenhouse gas emission management and reduction actions. In his 1992 book, *Earth in the Balance*, Al Gore called adaptation, "A kind of laziness, an arrogant faith in our ability to react in time to save our skins."

However, a shift in this philosophical debate began when the realities of changing climate conditions moved from an issue of the future to an issue on the nightly news.[12] Headlines such as "Record heat wave linked to climate change killed 1,500 people in France this summer" and "Quebec: Flooding turns fatal, military to provide assistance" demonstrate the devastation changing climate conditions are bringing to our world.[13] Reflecting this change in climate action best practice, the City has expanded its Climate Action Plan to focus on a two-prong approach dedicated to both reducing and managing greenhouse gas emissions as well as preparing for local impacts with local actions.

12 Ball, J. (September 2018). With climate change no longer in the future, adaptation speeds up. New York Times. Retrieved on September 13, 2019 from https://www.nytimes.com/2018/09/21/climate/climate-change-adaptation.html.

13 Lemon, J. (September 2019). Record heat wave linked to climate change killed 1,500 people in France this summer. Newsweek. Retrieved on September 13, 2019 from https://www.newsweek.com/summer-heat-wave-climate-change-killed-1500-france-1458205
The Weather Network. (2019). Quebec: Flooding turns fatal, military to provide assistance. Retrieved on September 13, 2019 from https://www.theweathernetwork.com/ca/news/article/quebec-days-of-rain-flood-threat

The Process of Adaptation

Generally, research aligns climate adaptation with risk management.[14] In this sense, actions taken to build resiliency against or adapt to changing climate conditions are designed to ensure organizations are better prepared for any negative impacts and can quickly take advantage of any new opportunities.

The review of municipal adaptation plans and strategies focused on adaptation action types that lessened the impact of "worst-case" scenarios and increased the benefits of "best-case" scenarios. Worst-case scenario adaptations focus on harm reduction to human, economic, and environmental systems. For example, the Thames Barrier protects 125 square kilometres of central London, amounting to tidal surge and flood protection for millions of people and billions of dollars in real estate.[15] Best-case scenario adaptations focus on taking advantage of changing climate conditions, such as prairie farmers experimenting with growing longer season crop varieties.[16]

Implementation methods for resiliency and climate adaptation depend on the severity and likelihood of impacts and the rate of climatic change an area expects. Implementing adaptation action prior to experiencing specific conditions is considered proactive or anticipatory. Action taken after an event or trend has occurred is considered reactive. Planned and proactive adaptation is often more effective and occurs at a lower cost than reactive adaptation.[17] However, proactive adaptation can increase the risk of overinvestment if projected conditions are not realized. Municipal adaptation documents reviewed as part of this project tend to balance planned and reactive adaptation action, realizing in an uncertain and resource-constrained world that not all things can be anticipated and not all initiatives can be funded.

Academic research suggests that decision makers face challenges in resourcing and implementing climate action today, given the uncertainty inherent in climate projection data and the urgency with which some constituents are demanding climate action. Incremental or flexible adaptation action types offer a way forward.[18] These are planned actions that do not need to be deployed all at once, which increases readiness while limiting overinvestment risk. In the City of Phoenix *2005 Water Resources Plan Update,* the Water Services department used scenario planning to consider climate change within its strategic plan. Climate projection data showed an increased risk of water insecurity. In order to prepare for the worst-case scenario, the organization purchased land with access to sustainable ground water resources but did not begin installing pumping infrastructure. This type of adaptation action takes advantage of the ground water option to meet future demands without requiring resources until a specific predetermined threshold or trigger is hit.[19] Taking a higher level approach, the Hungarian Parliament created a special position, the "Ombudsman for Future Generations," in 2007. The role is directed to "protect and mandate the interests of future generations" in conversations regarding program development and spending prioritization.[20]

Matching the type of adaptation action with an appropriate (planned or reactive) response depends on the risk it is intended to manage. Action design was an important consideration in all long-term adaptation strategies reviewed in this research.

14 Thomalla, F., Downing, T. Spanger-Siegfried, E., Han, G., and Rockström. (2006). Reducing hazard vulnerability: towards a common approach between disaster risk reduction and climate adaptation. Disasters, 30(1). Storbjörk, S. (2007). Governing climate adaptation in the local arena: Challenges of risk management and planning in Sweden. Local Environment, 12(5). Jones, R.N. and Preston, B. L. (2011). Adaptation and risk management. Interdisciplinary Reviews Climate Change, 2(2).

15 Government of United Kingdom. (2019). The Thames barrier. Retrieved on September 16, 2019 from https://www.gov.uk/guidance/the-thames-barrier

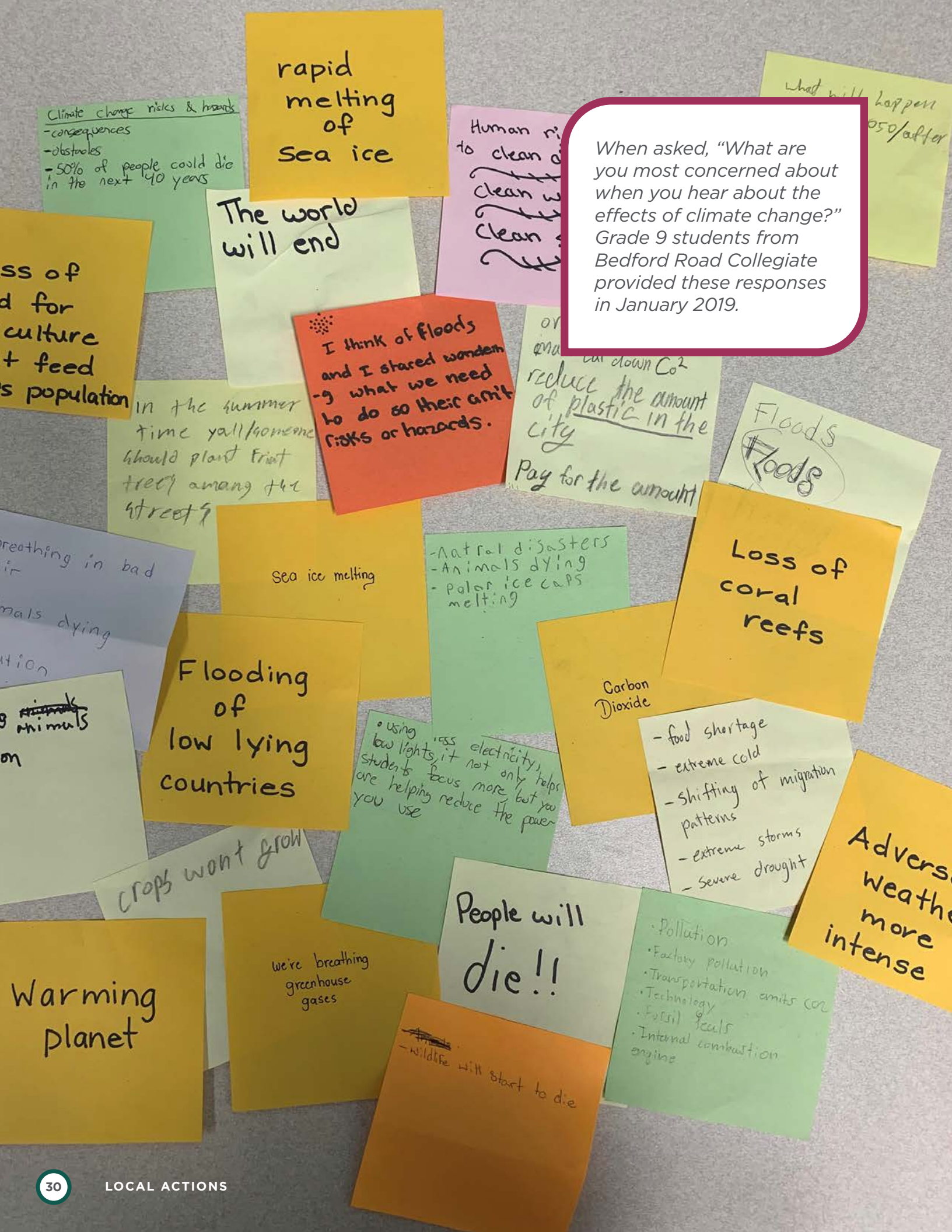
16 Bunge, J. (November 2018). A warming climate brings new crops to frigid zones. The Wall Street Journal. Retrieved on September 16, 2019 from https://www.wsj.com/articles/a-warming-climate-brings-new-crops-to-frigid-zones-1543168786

17 Natural Resources Canada. (2009). What is adaptation? Retrieved on August 14, 2019 from https://www.nrcan.gc.ca/climate-change/impacts-adaptations/what-adaptation/10025

18 Migone, A. and Howlett, M. (2016). Charles E. Lindblom, "The science of muddling through". In The Oxford Handbook of Classics in Public Policy and Administration.

19 Quay, R. (2010). Anticipatory governance: A tool for climate change adaptation. Journal of the American Planning Association. 76(4).

20 Environmental Rights Database. (2010). Hungary's Ombudsman for future generations. Retrieved on September 26, 2019 from http://environmentalrightsdatabase.org/hungarys-ombudsman-for-future-generations/.



When asked, "What are you most concerned about when you hear about the effects of climate change?" Grade 9 students from Bedford Road Collegiate provided these responses in January 2019.

Engagement

The engagement process focused on two audiences: internal staff and key external stakeholders, resulting in approximately 125 interactions between September 2018 and September 2019.

- For internal staff, a combination of workshops, meetings, and digital communications gathered contextual knowledge and supported climate risk analyses and resiliency building action generation. Participants represented 16 divisions and workgroups across the organization.
- For external experts, a combination of workshops, meetings, and digital communications gathered feedback and enhancements on early strategy design and resiliency building actions. Target expert groups included professionals from climate change and adaptation fields as well as key business and community stakeholder groups. Input from Insurance groups that was collected through engagement for a related project was also used to inform strategy design and resiliency building actions.

External stakeholders were asked to review and enhance the climate risk inventory and potential adaptation actions inventory created by internal stakeholders. External stakeholders also offered feedback on the perceived risks to success of implementing an adaptation strategy, potential partnership opportunities, available research, and advice on communicating the Local Actions Strategy.

The majority of the feedback received from external stakeholders focused on implementation planning and the need for consideration of community resiliency as well as corporate adaptation planning.

As adaptation initiatives are moved to implementation, a review of the engagement report is advised and additional public engagement is recommended to inform decisions around actions with the potential to impact the public.

To address the demand for consideration of community resilience in adaptation planning, opportunities for development of a Community Adaptation Strategy will be considered in future.

WHAT ABOUT OUR COMMUNITY?

Local Actions is currently a corporate strategy. This means the resiliency building actions and initiatives outlined in this document are focused on things the City can do to limit disruptions and negative impacts on staff, services, and assets, allowing us to continue to effectively deliver services to the residents of Saskatoon.

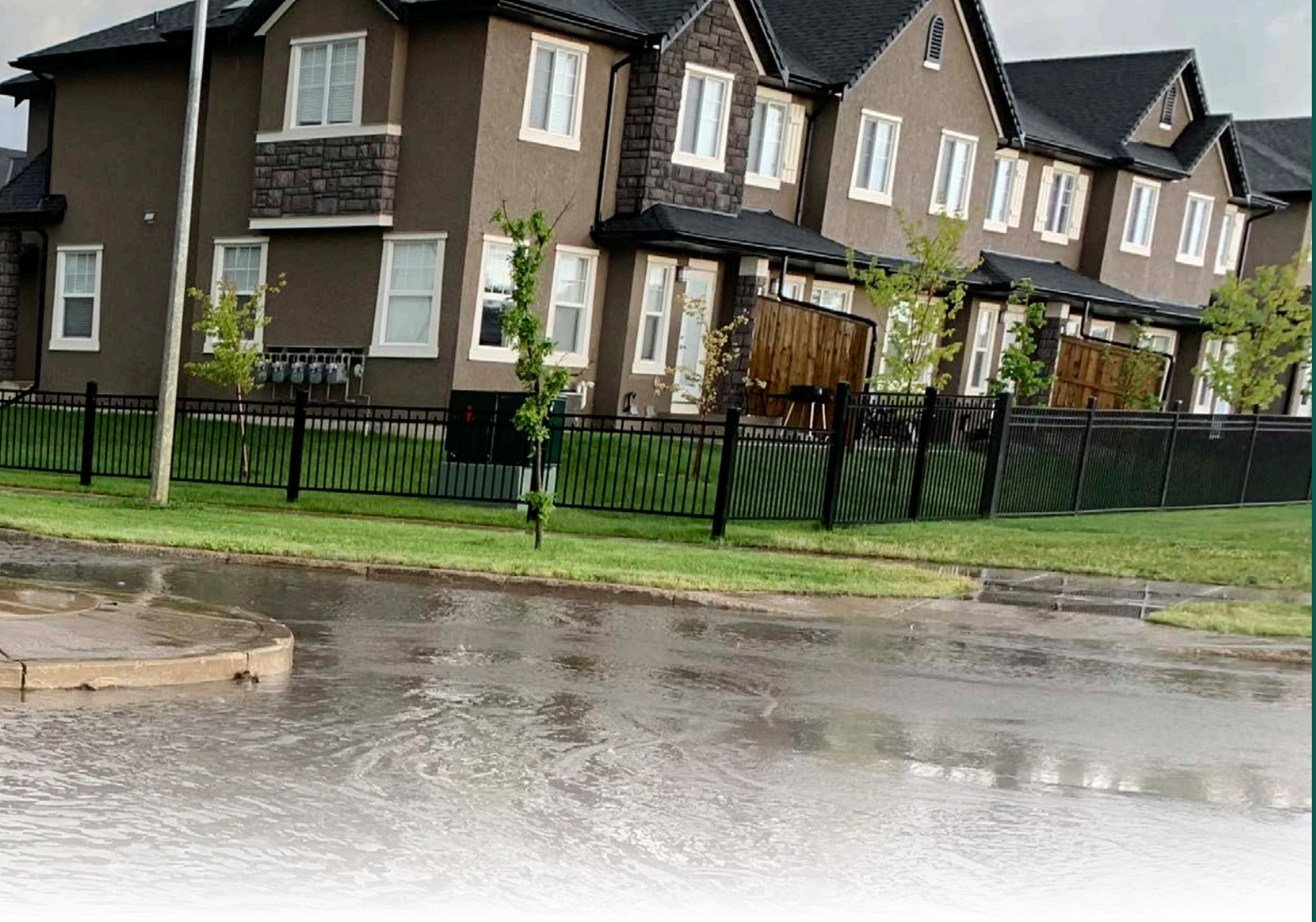
Our research does show that a corporate-only strategy is not the norm for municipal adaptation documents. Of all the adaptation documents we reviewed, no others were solely focused on corporate actions.

The purpose of the corporate strategy is two-fold. First, by focusing on "organizing our own house first", the City intends to show leadership on climate adaptation without prescribing corresponding activities or targets for residents, businesses, and organizational sectors. Second, by scoping strategy development activities on corporate operations only, the project team was able to meet the one-year deliverable timeline as required by the granting organization (Federation of Canadian Municipalities).

Climate Projections and Possible Impacts presented climate change projections and their likely impacts on corporate operations. Changing climate will also present significant risk to residents and businesses, physical and mental health, and quality of life. Recent research suggests changing climate conditions are likely to impact communities unevenly and can exacerbate existing social inequities.

The City's work in providing local governance and public service delivery blurs the line between corporate actions and community actions. As a result, the current mandate of some workgroups does include aspects of community resiliency building. Examples are provided below.

- Saskatoon Water annually supports a number of resiliency building programs.
    - Be Water Wise is a public education campaign focused on informing residents about reducing water use through mindful landscaping practices (e.g. rain gardening and rain barrels) and home renovations(e.g. low-flow fixtures and appliances).
    - The Storm Water Management Credit Program provides opportunities for multi-unit residential and non-residential property owners to lower storm water utility fees through implementation of onsite storm water management and/or water quality (e.g. oil and grit separators) best practices.
    - In 2018, the division partnered with the Intact Centre for Climate Adaptation to provide a 50-point home inspection with customized recommendations for residents in flood prone areas to increase their flood resiliency. More than 100 residents took part in the program; free flood risk reduction resources continue to be available online on the City's website.



- The EMO provides emergency coordination services and service continuity supports for internal and external partners. It manages notifynow and supports extreme heat and cold weather response strategies for vulnerable populations with external partner organizations as well as incident command and emergency management training for external partner organizations.
- The Saskatoon Fire Department devotes resources annually to public education on fire, water, and life safety through presentations, programs, and fire hall tours for school-aged children and other targeted audiences.
- Community Development and Recreation focuses on building quality of life in Saskatoon through support for community associations, non-profit organizations, community gardening, local sport, and special events, all of which are key drivers of strong communities. In turn, strong communities respond with more innovative and collaborative solutions to all types of challenges, and residents are more likely to check on and have relationships with their neighbours. All these factors contribute to climate resiliency, because they reduce the time it takes for a community to "bounce-back" after unexpected shocks (climate-related or otherwise).
- Sustainability supports resiliency-focused public education through Healthy Yards, Student Action for a Sustainable Future, waste diversion campaigns, and a compost-coaching programming.
- Saskatoon Transit supports existing extreme heat (above 30°C) and cold (below -30°C) weather responses through a Safe Bus Program that sees buses open their doors to anyone needing a ride to a community cooling or warming station free of charge.

NEXT STEPS

The City of Saskatoon has committed to preparing for changing climate conditions and the resulting impacts to assets, programs, and services through the Strategic Goal of Environmental Leadership (Strategic Plan 2018–2021) and as a signatory to the Global Compact of Mayors for Climate and Energy initiative. Achieving the actions and initiatives presented in this report will begin the corporate climate resiliency journey. It will set an official direction for action and start the transformation from a disconnected, reactionary approach to a planned, proactive approach. Adaptation best practice repeatedly demonstrates a planned and proactive approach delivers the best value for investment over time.

Local food production through Saskatoon's 50+ community gardens, builds resiliency against food supply chain and transportation network disruptions due to climate change impacts in other regions and in turn lowers our city's carbon footprint. Other co-benefits of local food production include community building and knowledge sharing. Demand for plots within existing community garden locations exceeds current supply in many cases.

APPENDIX A:

Climate Projections and Possible Impacts

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[21] and the Climate Atlas of Canada[22], using data from 30 global climate models adjusted to produce locally specific results[23]. 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^{0}C. This is more than double that of the total warming experienced globally since 1880 (0.8^{0}C)[24]. Northern Canada (north of 60^0 latitude) realized average annual temperature warming higher still, at 2.3^{0}C 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^{0}C 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.

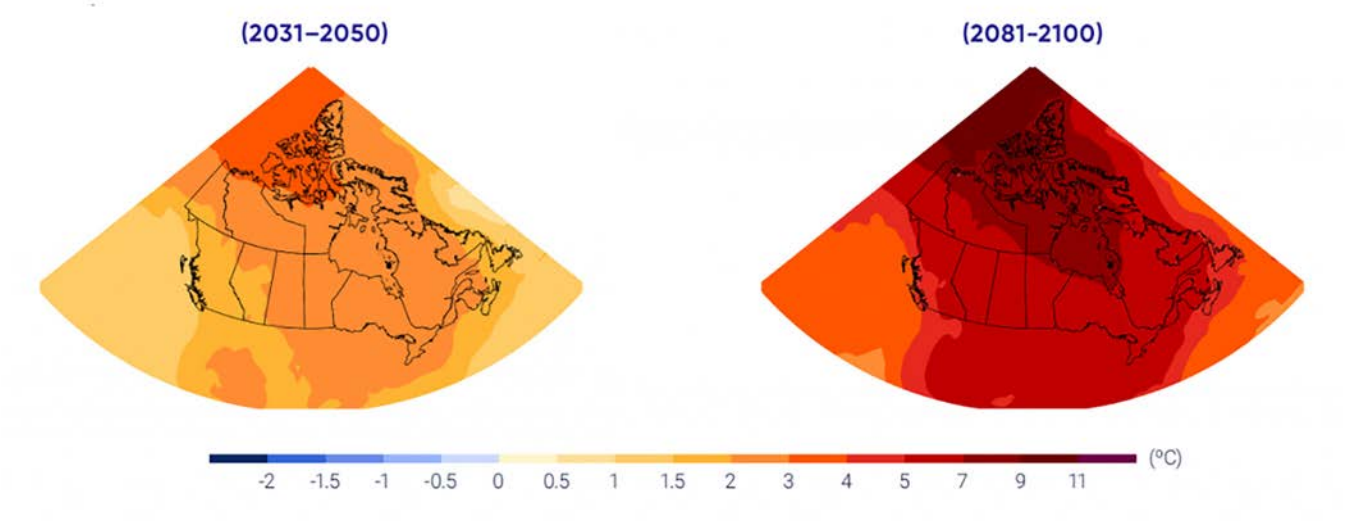
21 Government of Canada. (2018). Canadian Centre for Climate Services. Retrieved from https://www.canada.ca/en/environment-climate-change/services/climate-change/canadian-centre-climate-services.html

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

23 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.

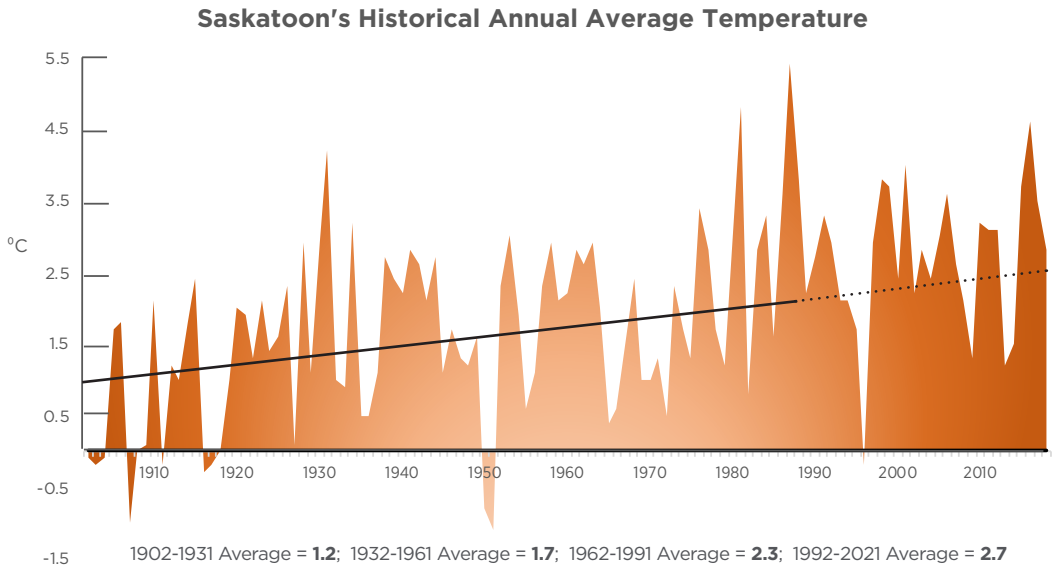
24 Global temperatures. (2011, January). Retrieved from https://earthobservatory.nasa.gov/world-of-change/DecadalTemp

Figure 4: *Average annual temperature change variation for Canada under current emissions rates for 2031-2050 (left) and 2081-2100 (right)*[25]



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[26]. Figure 5 presents a visual highlighting the warming trend over time.

Figure 5: *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.

25 Images from the Canadian Centre for Climate Services.
26 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 7^{0}C by the end of the century under current emissions production rates as compared to the historical baseline from 1976-2005 (1.8^{0}C). Under the moderate emissions reduction scenario this increase shrinks to just over 3^{0}C. Under the major emissions reduction scenario, the increase in average annual temperature is reduced again to 1.9^{0}C above baseline. Figure 6 depicts each of the emissions scenarios and their projected increase in average annual temperature for Saskatoon.

Figure 6: *Saskatoon's average annual temperature change under status quo emissions, a moderate emissions reduction, and a major emissions reduction*

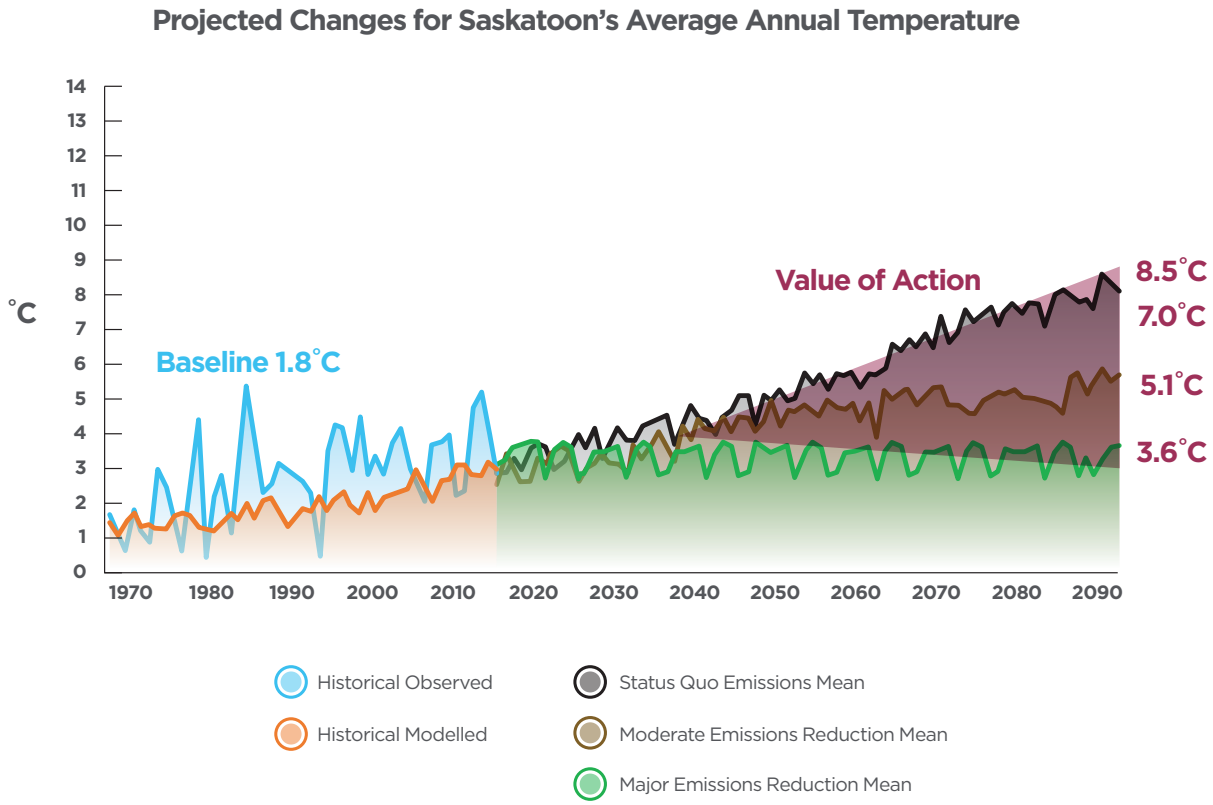


Figure 6 highlights the "value of action" or the cost of inaction. This concept outlines the relationship between emissions rates and adaptation needs. The higher the emissions rates are, the larger the increase in average annual temperature becomes and, in turn, the larger the cost and magnitude needed 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.

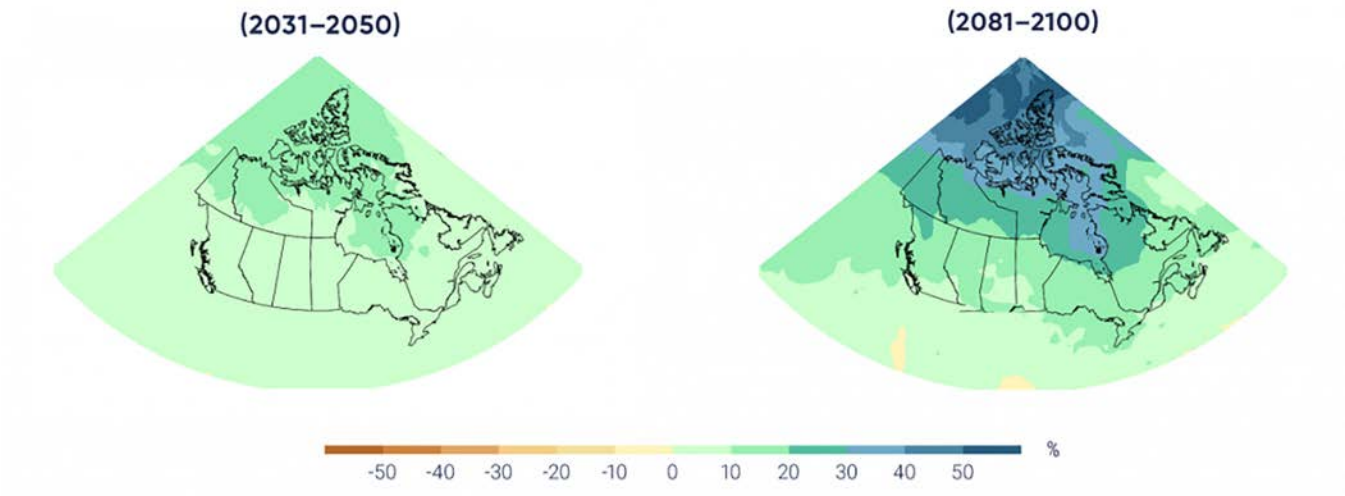
Average Annual Precipitation

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.

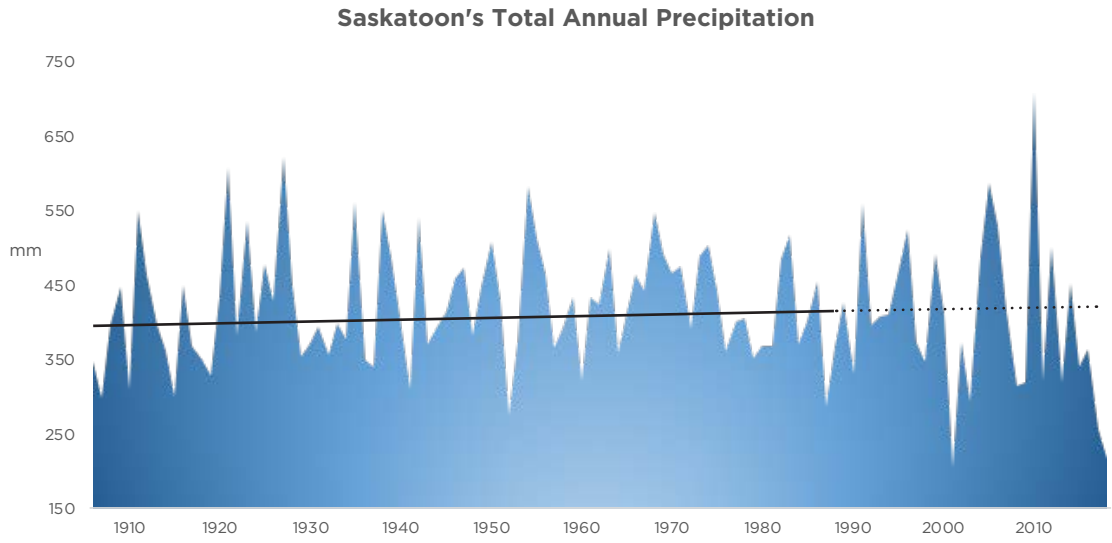
Additionally, with warmer overall temperatures in winter months, more precipitation will likely be realized as freezing rain or sleet during this season. Increased freezing rain and sleet will also impact overall snow cover levels seen nationally, as snow often melts when interacting with warmer precipitation. Figure 7 provides a visualization of average annual precipitation changes projected for Canada under current emissions rates.

Figure 7: *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[27]. Figure 8 presents a visual highlighting the wetter trend over time.

Figure 8: *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.

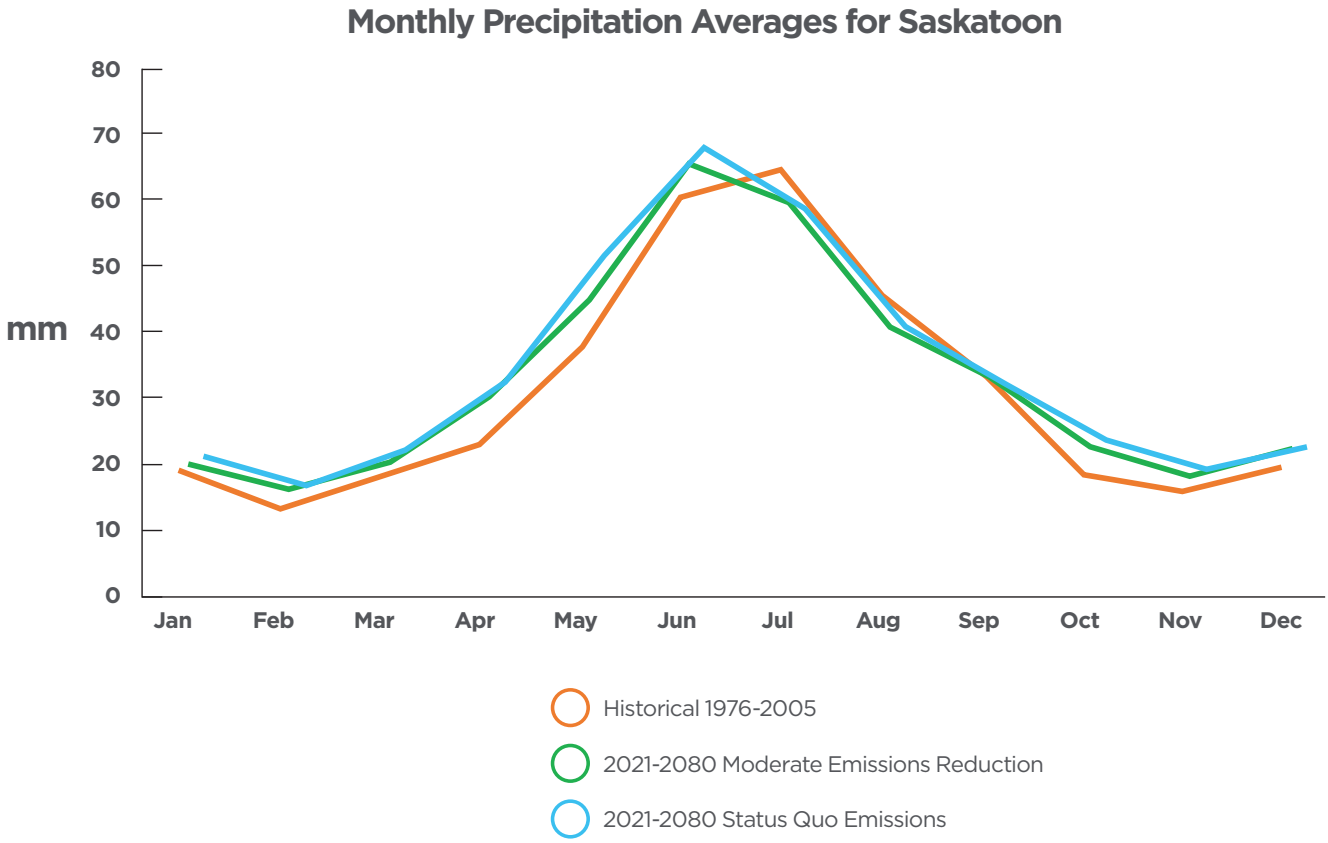
WETTER BY 2100

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.

27 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^{0}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 9 displays a visual of the expected total annual precipitation trends.

Figure 9: *Saskatoon's average monthly precipitation change under current emissions rates and a moderate emissions reductions*[28]



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)[29]. 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.

28 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.

29 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 2070.30 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

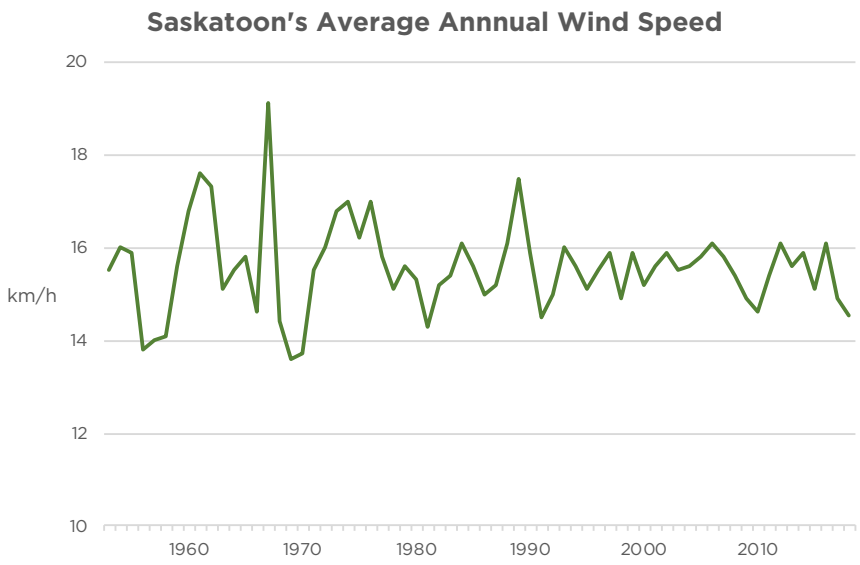
High winds can create dangerous incidents including downed power lines, tree limb failures, and sudden debris movement. The southern region of Saskatchewan has up to 10 days per year with winds reaching at least 63 kilometers per hour (km/h). Between 2008 and 2016 more than 200 wind events were reported in Saskatchewan, often occurring with other elements of severe summer storms[31]. 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 11 presents wind speed data over time.

30 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.

31 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.

Figure 10: *Saskatoon's Average Annual Wind Speed 1953 – 2018*



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)[32]. 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[33].

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[34]. 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[35].

32 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/

33 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

34 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.

35 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)[36]. The ORL has a four point scale: high, medium, low, and very low. Figure 11 outlines details for the ORL scale.

Figure 11: *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 12, 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.

36 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 12: *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 12: *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	

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.

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.

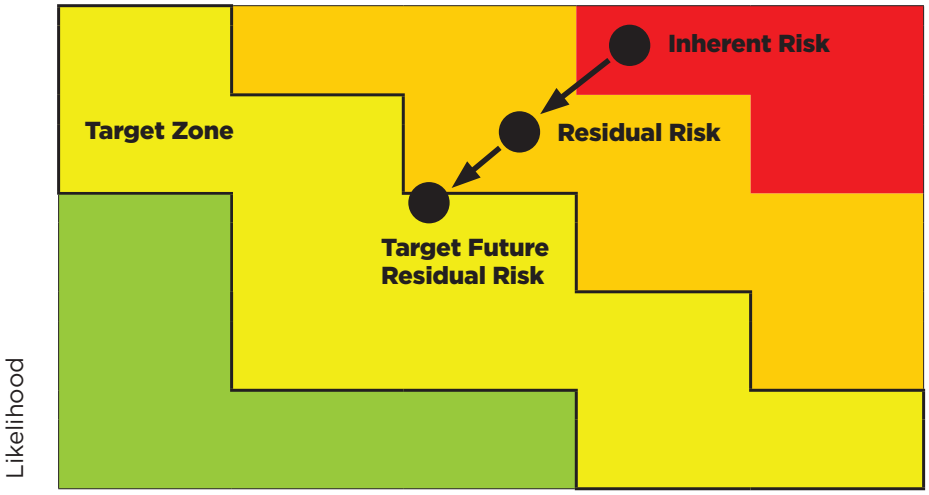


Figure 13: *presents a simplified version of the climate adaptation risk analysis visual to highlight the risk management path as described above.*

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.

APPENDIX 1F

Emissions Scenario Assumptions

The Government of Canada signed on to the Paris Agreement in December 2015. The latest Intergovernmental Panel on Climate Change [37] 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[38]	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**

37 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.

38 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
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
Secondary Impacts											
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
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
Secondary Impacts											
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]

Primary Impacts

Variable	Timeframe	Baseline Mean	2021-2040 Mean	2041-2060 Mean	2061-2080 Mean	2081-2100 Mean
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:

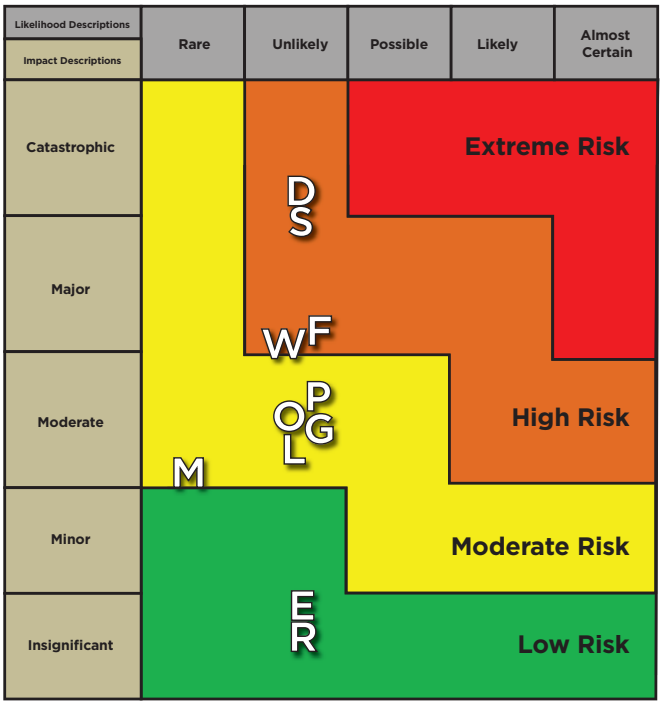
- Secure new LiDAR data where there are gaps for use in storm water modelling;
- Update IDF curves to include more recent available rainfall;
- Evaluate the risk of climate change on future extreme rainfall events;
- Identify international state-of-art practices that municipalities are using to assess 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.

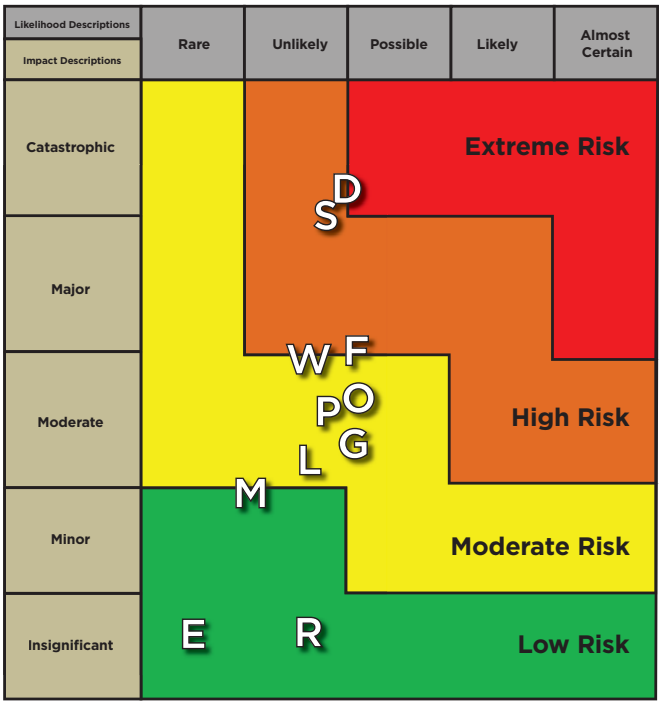
APPENDIX 6:

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).

APPENDIX B:

Summary of Projected Climate Change and Possible Impacts for Saskatoon

Category	Climate Factor	Projection Range for 2021-2050	Possible Impacts to Corporate Operations
Warmer	Annual and seasonal temperature changes	No change to +4^{0}C[1]	- Increased demand for water for public and private uses in warmer conditions. - Increased demand for electricity for building and home cooling in warmer conditions. - Rapid melt and drainage challenges during the spring. - Outdoor skating ponds, ski-trails, etc. require more maintenance in warmer conditions. - A longer season to enjoy green spaces, outdoor recreation, and active transportation options. - Watering and maintenance needs may increase for plants, green spaces, and urban forest. - Higher evapotranspiration[2] rates increase risk of bush and grass fires. - Increasing demand on emergency services.
	Frequency extreme (≥30^{0}C) heat days per year	No change to 4x more	- Increased risk of heat-related health risks for outdoor staff and vulnerable populations. - Increasing demands on emergency services. - Increasing need for indoor play and recreation opportunities during very hot weather. - Increased watering needs for plants, green spaces, and urban forest.
	Warmest maximum temperature	3^0 Reduction (31.5^{0}C) to 10^0 Increase (44.8^{0}C)	
	Longest spell of +30^{0}C days	1 day to 22 days [3]	
	Average number of heat waves annually[4]	No change to 8 per year	
	Frost-free season length	No change to +35 days	- More people enjoying green spaces, outdoor recreation, and choosing active transportation options. - Longer outdoor maintenance period for plants, green spaces, and urban forest. - New plant species may thrive in warmer and longer frost-free conditions. - Longer road construction and maintenance season.
	Pest and insect season[5] length	Slightly shorter to 3.5x longer	- New pest species may thrive, increasing management resource needs. - Increasing risk of vector-borne disease, with particular concern for outdoor staff and vulnerable populations.
	Annual peak river flows	Occurring in June/July to occurring in May/June	- Potential impact to operations and maintenance protocols at water and wastewater treatment plants. - Less water in South Saskatchewan River in summer months for municipal and recreation usage.

1 The largest increase in seasonal temperatures is projected to occur in winter.
2 Evapotranspiration refers to the process by which water is transferred from the land to the atmosphere by evaporation from the soil, other surfaces and from the transpiration of plants.
3 Average data from the Saskatchewan Research Council Annual Climate Summaries 2008-2018 states that Saskatoon usually gets +30 ° C temperatures for approximately 2.5 days in a row 2-3 times per summer season.
4 A heat wave is defined as a period of three consecutive days where the temperature reaches or exceeds 30 ° C.
5 The pest and insect season is defined by "degree days above base 15 ° C" as this is the minimum temperature many pests and insects need for survival.

Category	Climate Factor	Projection Range for 2021-2050	Possible Impacts to Corporate Operations
Wetter	Annual and seasonal precipitation changes	26% reduction to 150% increase	- Road icing likelihood increases with more frequent rain and slush in winter months. - Changes to timing of peak precipitation too early in the year may increase watering needs in late summer.
	Rainfall event characteristics	*Data coming soon*	- Saskatoon Water is completing a project with University of Saskatchewan and Concordia University to provide data on projected changing characteristics of rainfall events in Saskatoon now and in the future.
Wilder	Seasonal variability Summer storms Winter storms Strong winds	Frequency of occurrences likely to increase as conditions that create these events are present more often.	- Seasonal program turnover and deployment challenges in highly variable shoulder seasons. - Potential for storm debris to quickly use up air space in landfills, reducing asset lifecycle. - Highly variable wind creates asset failure risk for tree limbs and power lines. - Increased wind may improve wind turbine power generation business case. - Increased demand on emergency services. - Potential for core service level disruptions, as crews and equipment are diverted to disaster relief or unable to operate.

APPENDIX C:

Adaptation Documents Reviewed

Canada

1. City of Edmonton. (2018). *Climate Resilient Edmonton: Adaptation Strategy and Action Plan*
2. City of Windsor. (September 2012). *Climate Change Adaptation Plan*
3. City of Vancouver. (2019). *Resilient Vancouver*
4. City of Toronto. (2019). *Toronto's First Resiliency Strategy*
5. City of Montréal. (2018). *Montreal's Resilient City Strategy*
6. Government of Saskatchewan. (2019). *Climate Resilience in Saskatchewan*
7. Halifax Regional Municipality. (2013). *Municipal climate change action planning*
8. Regional District of Nanaimo. (2006). *Hazard risk and vulnerability assessment*

United States of America

1. City of San Antonio. (January 2019) *SA Climate Ready: A pathway for climate action & adaptation* [Draft for Public Discussion]
2. City of New York. (2018). *Resilient Industry: Mitigation and preparedness in the City's industrial floodplain*
3. City of Madison. (2011). *The Madison Sustainability Plan: Fostering environmental, economic and social resilience*
4. State of California. (2009). *California Climate Adaptation Strategy*
5. City of Berkeley. (2016). *Resilience Strategy: A strategic preparedness plan for Berkeley, a community known for inclusiveness and innovation*
6. City of Oakland. (2016). *Resilient Oakland: It takes a town to thrive*
7. City of Boulder. (2016). *Resilience strategy*

Global

1. City of Amman. (2017). *Amman Resilience Strategy*
2. City of Sydney. (2018). *Resilient Sydney: A strategy for city resilience 2018*
3. City of Thessaloniki. (2018). *Resilient Thessaloniki: A strategy for 2030*
4. City of Glasgow. (2017). *Resilient Glasgow: A city strategy*
5. City of Christchurch. (2017). *Greater Christchurch resilience strategy*
6. City of Melbourne. (2016). *Resilient Melbourne*
7. City of London. (2017). *An urban resilience summit.*

APPENDIX D:

Adaptation Actions in Other Municipalities

Many municipal adaptation documents reviewed as part of this project were part of one of the following networks and peer-to-peer learning groups: ICLEI Canada's Building Adaptive and Resilient Cities (BARC) Network, 100 Resilient Cities, and Urban Sustainability Directors Network. Resiliency building goals or adaptation actions proposed as part of these documents were often related to four themes: leadership and strategy, health and well-being, economy and society, and infrastructure and the environment. Highlights are presented below.

Leadership and Strategy

Mainstreaming climate risk management into all strategic planning processes was present in all adaptation documents reviewed.[6] The City of Edmonton is working to mainstream climate risk management into its existing risk management and strategic decision-making processes by adopting an adaptive management framework.[7] Denver Water and the cities of Phoenix and New York use scenario planning and anticipatory governance to guide climate risk management mainstreaming efforts.[8]

Health and Well-being

Resilience to climate shocks, such as severe storms, is a common theme throughout municipal adaptation plans and strategies. The National Adaptation Forum, an internationally focused conference, dedicated an entire conference stream to "Before and After Extreme Events". Discussions focused on municipal attempts to build adaptive capacity by increasing collaboration with emergency management professionals and organizations in their regions.

In Greece, the City of Thessalonikihas committed to completing a full review of current municipal administration processes in relation to disaster risk and response as part of its resilience plan. The City of Vancouver highlights the Vancouver Emergency Management Agency's internal training and exercise program as critical elements in its resilience approach. Vancouver is also working to expand its understanding of what "recovery" means as part of the emergency management cycle. The idea is that after a shock or extreme event, areas are "building back better" through designs intended to minimize chronic stresses. Building back better is a key principle within Public Safety Canada's *Emergency Management Strategy for Canada: Toward a Resilient* 2030.[9] In Scotland, the City of Glasgow is working to develop an employee toolkit to support staff in using climate projection data and risk assessment processes to build resilience into existing organizational procedures.

6 Mainstreaming refers to the integration of climate change adaptation information into related government policies, programs and documents according resources from the European Union's Climate Policy Hub, Natural Resources Canada, and the Canadian Institute of Planners.

7 Allen. C, R., Fontaine, J.J., Pope, K.L., & Garmestani, A.S. (2011). Adaptive management for a turbulent future. Journal of Environmental Management, 92 (1339-1345).

8 Quay, R. (2010). Anticipatory governance: A tool for climate change adaptation. Journal of the American Planning Association, 76 (496-511).

9 Public Safety Canada. (2018). Emergency management strategy for Canada: Toward a resilient 2030.

Economy and Society

Exploring mutual aid agreements with neighbouring municipalities, reviewing zoning and land use regulations to ensure new developments are designed to withstand and continue to deliver value under changing climate conditions, and building redundancy into long-term utility growth plans are all common activities other municipalities are implementing to better prepare for climate change.

The City of Phoenix recently engaged community members and business owners in its downtown core to ask, "How might we update zoning regulations to better support heat management and walkability?" Overwhelming feedback showed the number one concern was "current building code restrictions prohibiting businesses from installing permanent and/or temporary canopies or structure over their entry doors in order to create shade and a sense of place for customers on sidewalks".[10]

A recent Intergovernmental Panel on Climate Change report, *Climate Change and Land*, presents the importance of land use planning in climate change mitigation and adaptation. The report focused on the need to proactively drive toward sustainable land management practices, because after development occurs the new "use" of the area is often fixed and large-scale retroactive changes can present challenges. Recommendations relevant to the City include:

- Conservation of natural areas as providers of multiple ecosystem services (e.g. carbon sequestration, storm water management, urban heat island reduction)
- Using nature-based adaptation whenever possible (e.g. naturalized storm ponds and park spaces)
- Incorporating the traditional knowledge of Indigenous peoples into land management practices as a way to recognize their deep understanding of climate adaptation.

The report also focused on the importance of including local stakeholders, especially those most vulnerable to climate shocks, in the selection, evaluation, implementation and evaluation of policy options to increase proactive sustainable land use planning.[11] A land use planning assessment aimed at reducing climate risk is part of the Greater Christchurch Region, City of Montreal, City of Toronto, City of Edmonton, and City of Vancouver resilience strategies.

The Government of Saskatchewan's climate action document, *Climate Resilience in Saskatchewan*, focuses on the importance of planning for possible water scarcity and drought in the future to maintain high levels of well-being in Saskatchewan communities. Saskatoon was listed as one of 26 communities vulnerable to drought in the report due to having had "below normal" or "well below normal" precipitation amounts in the spring of 2018.[12]

10 Hartman, M. (2019). Moving from assessments to action: Innovative projects to address urban heat. 4th National Adaptation Forum. [Personal Communication].
11 Intergovernmental Panel on Climate Change. (2019). Climate change and land: Summary for policymakers.
12 Government of Saskatchewan. (2018). Climate resilience in Saskatchewan.

Infrastructure and Environment

Municipalities across Canada are grappling with aging infrastructure and changing climate conditions. CanInfra reports the current infrastructure deficit in Canada is between $110-270 billion, depending on the source of the analysis.[13] Asset management practices and increasing the use of green infrastructure[14] were key pieces in all municipal climate adaptation documents reviewed.

In 2019, Anne Hidalgo, the Mayor of Paris, made international news with a plan to cover up to 50% of the city's urban space (including treasured landmarks) with trees and greenery by 2030 in an attempt to improve air quality, manage storm water runoff, and reduce the urban heat island effect. [15] The urban heat island effect is cause by the combination of closely packed buildings, abundant paved surfaces, and waste heat from vehicles and buildings, all of which amplify and trap heat in urban spaces, making them feel hotter than rural areas or cities with larger green spaces.

The City of Seattle published a strategy dedicated to the use of green infrastructure to meet changing storm water management needs.[16] The City of Phoenix developed an urban heat management plan focused on increasing tree canopy cover, green roofs, planted spaces, and cool pavements to attract foot traffic to downtown service and shopping districts.

Asset management is widely recognized as an effective and efficient method to respond to and prepare for climate change through adaptation and mitigation efforts.[17] In 2018, Infrastructure Canada released the Climate Lens, an assessment that requires all applications to consider both greenhouse gas emissions mitigation and climate change adaptation within projects in order to qualify for funding under the Investing in Canada, Disaster Mitigation and Adaptation Fund, and Smart Cities Challenge.[18] The City of Edmonton's climate resilience strategy speaks to planning, designing, developing, and building to ensure climate resilience today and in the future through asset management and integrating resilience standards into urban development processes. The Federation of Canadian Municipalities is offering workshops and resources to support municipalities in integrating climate risk assessments with asset management processes.

13 CanInfra. (2019). Estimates of Canada's infrastructure deficit vary widely. Retrieved on September 10, 2019 from https://www.caninfra.ca/insights-6

14 Green infrastructure is defined as a system of green spaces and techniques that provide municipal and ecosystem services by protecting, restoring, or emulating nature. Green infrastructure spans a wide range of asset types from natural (such as existing wetlands and grasslands) to engineered (such as dry storm water ponds constructed within green park spaces).

15 O'Sullivan, F. (2019). Paris wants to grow 'urban forests' at famous landmarks. CityLab. Retrieved on September 11, 2019 from https://www.citylab.com/environment/2019/06/paris-trees-famous-landmarks-garden-park-urban-forest-design/591835/

16 City of Seattle. (2015). Green stormwater infrastructure Seattle: Implementation strategy 2015-2020.

17 Asset Management British Columbia. (2018). Climate change and asset management: A sustainable service delivery primer. Rayner, R. (2010). Incorporating climate change with asset management. Retrieved on September 11, 2019 from http://www.lse.ac.uk/newsletters/CATS/pdfs/Asset%20Management%20-%20Final%20Proof.pdf

18 Infrastructure Canada. (2019). Climate Lens – general guidance. Retrieved on September 16, 2019 from https://www.infrastructure.gc.ca/pub/other-autre/cl-occ-eng. html#1.1.

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Project Team:

Kristin Bruce,
Project Manager

Twyla Yobb,
Environmental Protection Manager

Jeanna South,
Director Sustainability

Angela Gardiner,
General Manager, Utilities & Environment

Leighland Hrapchak,
Marketing Consultant

Katie Suek,
Public Engagement Consultant

Moe Al-Mahdawe
Lesley Anderson
Konrad Andre
Hossein Azinfar
Chelsey Bartlett
Tanya Bell
Trevor Bell
Jessie Best
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