City of Calgary ReCAP

Recommendations for Climate Adaptation Planning

February, 2023

Introduction

Background

In an effort to reduce the risk that climate change poses, the City of Calgary's (hereafter referred to as the "City") Planning Department embarked on a research project to identify climate adaptation planning interventions to reduce risks from extreme weather and changing temperatures, while prioritizing assets, places, and people who are most vulnerable. With the support of ICLEI Canada, the *Recommendations for Climate Adaptation Planning project* (hereafter referred to as "*ReCAP*") was developed as a resource to help inform the City's Planning Department in developing, reviewing, and approving land use planning approaches to address climate impacts and build local resilience.

The City's mandate to foster climate resilience is set in the 2022 *Calgary Climate Strategy – Pathways to 2050* and Council's 2021 mandate through the Climate Emergency Declaration.

City Climate Strategy and Implementation Plan:

- Calgary Climate Strategy – Pathways to 2050
- 2023-2026 Climate Implementation Plan

Community Climate Risk

The City's climate adaptation work acknowledges that climate risk is not evenly distributed across communities. The City has developed Community Climate Risk Profiles, describing which communities have the highest relative risk, what climate hazards pose the greatest risk currently and in the future, and what factors in the community are driving that risk. Among the datasets integrated into the profiles are:

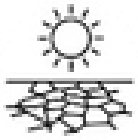
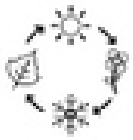
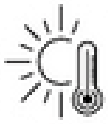
- The Community Climate Risk Index (CCRI), a dataset analysing the intersection of climate and community factors;
- An urban heat island map that shows where temperatures are highest in the city;
- An natural asset map that shows the location of natural infrastructure, which can serve a number of climate resilience benefits, including permeable areas that can absorb rainwater, reducing local temperatures, and as a wind break; and
- The Calgary Equity Index, which assesses a number of socio-economic factors in Calgary, which can amplify or ameliorate climate risk.

Further information about climate risk in Calgary:

- Community Climate Risk Index: Summary Report
- Climate Projections for Calgary

How to Use the Guide

This resource is a natural next step to continue the work done to date by the City. Connecting to the Community Climate Risk Reports, ReCAP details a variety of adaptation options that aim to tackle the six identified climate hazards that are and will continue to impact Calgary's residents, built infrastructure, and the natural environment. These are:

	Meteorological drought: Meteorological drought occurs when there is a lack of rainfall over a prolonged period of time. The lack of rain can cause the loss of agriculture activity, damage to natural areas and land, and socio-economic impacts from water restrictions in Calgary.
	Higher Average temperatures: Temperatures in Calgary have steadily risen and are projected to continue to increase as climate change continues. Rising temperatures will cause changes to the ecosystems in Calgary and cause long term wear on infrastructure.
	Extreme heat: As temperatures continue to increase, Calgary will experience more intense periods of extreme heat, or heatwaves, over summer months. Extreme heat damages buildings and infrastructure, impacts ecosystems, and threatens the health and wellbeing of Calgarians, including increasing mortality.
	Severe storms: Climate projections suggest that Calgary will experience more storms that bring lightning, high winds, hail, and heavy rains. Hailstorms are projected to increase, with the stones getting larger and more dangerous. These events will cause physical damage to buildings, vehicles, and threaten physical health and safety.
	River flooding: Due to changes to the temperatures and rainfall, climate change will increase the likelihood and magnitude of river flooding, where the amount of water in the river exceeds the size of the channel and spills over into the city.
	Short Duration High Intensity precipitation (SDHI precipitation): Climate projections anticipate that rainfall patterns will change so that Calgary will experience heavier rain (more total water over a shorter period of time). This kind of rainfall is more likely to cause flooding.

There are a total of 16 adaptation options outlined in the Guide with an additional 8 outlined in an accompanying *Options Matrix* document.

Climate change will impact us across all our social, built, economic, and natural systems. As such, it is imperative we continue to take a systems approach to identify relevant adaptation options. The adaptation options are numbered from 1 to 24 in the accompanying *Options Matrix* document. The 16 options in the Guide will follow the same numbering system.

The 16 climate adaptation options are organized into three themes:

- Built Environment: including our built assets and infrastructure (e.g. roads, homes, buildings, private assets, etc.)
- Natural Environment: this includes our ecological systems (e.g. rivers, lakes, forests/green areas, wildlife, etc.)
- Socio-Economic: this includes our social systems (e.g. public health and safety) and economic systems (e.g. tourism, business, transportation networks, etc.)

For each option, ReCAP will identify (where available):

- Relevant climate hazard(s): the climate hazards the adaptation option addresses
- Description: a description of the adaptation option - how it works, how it builds resiliency, etc.
- Role of Planning: how planning can implement, enable, and/or support this option through a number of roles, tools, instruments, and/or approaches
- Effectiveness: benefits of the measure to produce the intended adaptation outcomes. This also includes how well this option performs in addressing the risks associated with climate hazard(s). Evidence from other jurisdictions related to the effectiveness of the policy or program to date will also be included, if available.
- Barriers: insights into barriers or challenges in the design or implementation related to physical infrastructure, local regulations, economic concerns, and/or resident attitudes and practices. Suggested solutions will be included, if available.
- Costs: financial costs associated with the implementation of this option (e.g. capital costs, staffing etc.)
- Co-Benefits: an outline of any potential mitigation and/or other co-benefits. This includes unintended outcomes, qualitative and quantitative determinants, and any “win-win” gains associated with the option.
- Equitable Engagement and Outcomes: if and how equity-deserving groups were considered in any or all aspects of the options development process (e.g. how they were engaged, design and development process, implementation, etc.)
- Additional Implementation Considerations: any other information pertaining to the implementation of the options that was gathered through the jurisdictional interviews or research (this will vary by option).
- Example(s) of where this action has been implemented: examples of other communities or entities that have implemented the adaptation option or a similar option.

Use with Community Climate Risk Profiles

ReCAP enables the use of climate adaptation options that address the specific drivers of climate risk in a community. Planners are encouraged to consult the Community Climate Risk Profile for the area of Calgary they are working in and note the climate hazards projected to be the greatest risk and which factors drive climate risk in each system. Planners should then consult this document to find options that best target those hazards and drivers to most effective address foster climate resilience.

Methodology

The project methodology centred around a literature review and a series of interviews. Jurisdictions and agencies were selected to provide the best available information on options that have been implemented to reduce impacts from the six identified climate hazards.

Summary of the methodological process:

Literature review (peer-reviewed and grey)

Grey literature, including local government reports and plans, bylaw documents, briefing documents, among others, were reviewed to analyze options implemented by jurisdictions and to provide details related to the municipal climate adaptation landscape. Peer-reviewed literature was also analyzed to provide supporting information on implementation and promising practices. Fact checking was performed throughout to ensure the information was reliable.

Options review and shortlisting

An initial long list of 81 adaptation options was identified by ICLEI Canada with examples of communities or entities that have implemented these action options. In creating this long list, ICLEI Canada cross-referenced both the climate hazards and the vulnerability indicators identified in the City's Community Climate Risk Profiles to ensure the long list addressed all the hazards and as many vulnerability indicators as possible. This longlist was then reviewed, discussed, and edited by the City's project team to produce a shortlist of 28 options. From this shortlist, ICLEI Canada continued to conduct further desktop research as well as schedule jurisdictional interviews and merge options to produce a final list of 24 options (16 included in this guide, and an additional 8 in the *Options Matrix* (see below).

Interview preparation, scheduling, and summary

With a shortlist of adaptation options, key interviewees from each selected jurisdiction were identified and telephone interviews were scheduled. A standardized list of questions was developed to identify and/or confirm relevant implementation information and data to complete the ReCAP summaries. The list of questions formed the basis for all interviews, however, questions were adapted and/or added as needed in order to collect the best available

information or to suit the expertise of the interviewee. Please refer to the Appendix below for the questionnaire and a complete list of interviewees.

In conducting the interviews, ICLEI Canada ensured to ask interviewees about any equity-related considerations pertaining to their identified project. In many cases, findings from these interviews as well as the literature reviews suggests that integration of equity-related considerations or engagement of equity-deserving groups in the implementation of adaptation options did not take place.

Options Matrix

Once all the relevant information was collected, an *Options Matrix* was developed to both gather and store relevant information for easy comparison of the various options. The additional 8 options included in the matrix represent options that are still very much in the promising practice phase and offer opportunities innovation and piloting.

Adaptation Options for the Built Environment

Option # 1: Climate Resilient Building Materials and Design

Relevant Climate Hazard(s)

Description

- Climate resilient building materials is a catch all term for materials (e.g. insulation, high performance glass and energy efficient windows, impact resistant shingles, hurricane clips, exterior cladding rated for high winds and hail) which together can increase a building's resilience to climate impacts
- Climate resilient building design includes aspects of passive cooling, building shape, shading, orientation, ventilation, and internal layout

- These materials and designs can decrease the likelihood of damage to property and indirectly to human health during extreme weather events and heatwaves
- Municipalities can use a number of tools and incentives to encourage the use of these materials in new developments and retrofits including
    - Implementing regulatory measures (e.g. bylaws and standards)
    - Design guidelines outlining how buildings can become more resilient to climate change impacts
    - Education and awareness initiatives directed at developers, homeowners and property managers, contractors, and roofers
    - Incentive programs for new and existing buildings

Role of planning

- The Toronto Green Standard and the Vancouver Green Homes Program outline updated design standards to better cope with the impacts of extreme heat and severe storms.
- The City of Vancouver's Rezoning Policy for Sustainable Large Developments outlines requirements for site design, food systems, rainwater and groundwater management, zero waste planning, and climate resilience.
- The City of Vancouver's Passive Design toolkit identifies a number of building materials and designs that can increase resilience to the impacts of extreme heat including passive design practices, as well as window glazing, insulation, thermal mass, and air tightness.
- Incentive programs across the country have been utilized to increase uptake of climate resilient materials, including Dufferin County's Hurricane Clip Rebate Program, the City of Calgary's Resilient Roofing Rebate Program, and Victoriaville's Sustainable Housing Grant Certification Program

Effectiveness

The benefits considered here include a sample of the materials and designs that can be used to create climate resilient buildings that may be of interest to the City of Calgary.

- Passive cooling utilizes design to harness natural heating and cooling mechanisms to better regulate temperature and airflow within buildings and reduce the need for mechanical systems.
- Impact resistant shingles and exterior cladding rated for high winds can reduce damage to buildings from severe storms. Class 4 rated shingles for wind and impacts can withstand ~97 km/h winds for two hours and remain unscathed under a barrage of steel balls simulating the energy hailstones could have (2 inch diameter), ~ 95% of all hail storms experienced (Porter, 2022).

- Hurricane clips can prevent and reduce damage caused by roof structures being torn from buildings during severe storms and reduce risk of injury during severe storms. Hurricane clips are rated to withstand tornados with wind speeds up to ~EF2 (180-220 km/h). ~90% of tornado events in Canada are EF2 or less (Sandink, et al., 2019).
- High performance glass and higher insulation requirements can significantly improve indoor air temperatures and reduce heat transfer into buildings. The efficacy of high performance glass is dependent on the type of glass installed as well as where windows are located, but can significantly reduce thermal transfer into buildings.
- Materials such as concrete or brick have higher thermal mass and require more energy to be heated or cooled, and can provide better passive heating and cooling than materials with a lower thermal mass such as timber.

Barriers

- Many of these materials, such as hurricane clips, upgraded shingles, insulation materials, and glass can increase the cost of development or retrofits.
- Incentivizing or requiring design standards/new materials not standardized in the Alberta Building Code can result in push back from developers and/or homeowners.
- Updating bylaws or incentivizing the use of these materials and designs will require multi-departmental and stakeholder engagement (e.g. BILD)

Costs

- A benefit-cost analysis of impact resistant asphalt shingles conducted by the Institute for Catastrophic Loss Reduction estimates that impact resistant shingles can increase roofing costs by 50%, but reduce the chance of damage by 15 times, provide a benefit-cost ratio of 3:1 or $10 000 over the life of a standard roof, and will pay for themselves in five years (Porter, 2022).
- Hurricane clips are relatively inexpensive ~$1/clip plus labor (Dufferin County, 2023).
- High performance glass/glazing can be expensive to install and upgrade. Cost is dependent on the number of panes, U-Factor, and size.
- A number of insulation materials are available with differing R values and costs to purchase and install.

Co-benefits

- High performance glass and insulation materials can reduce energy costs and GHG emissions, reduce thermal transfer, and keep buildings cooler during extreme heat days.

- Passive cooling design systems can reduce energy costs and GHG emissions, reduce thermal transfer, and keep buildings cooler during extreme heat days. The most rigorous European passive design standard (PassivHaus) can reduce energy consumption by 3000kWh of electricity annually (City of Vancouver, 2019).

Equitable Engagement and Outcomes

- Equity considerations are not widely identified in implementation of climate resilient materials and designs particularly for severe weather.
- However, improving design standards can reduce the impacts of severe storms low-income communities.
    - E.g. Rebate programs that prioritize low-income communities/residents.
- Protection of vulnerable populations to the impacts of extreme heat is however often identified as a municipal priority within climate plans and community health strategies
    - E.g. Toronto Public Health - Heat Options for Multi-Residential Units
        - Provides recommendations on design and cooling technologies to reduce heat risks for vulnerable populations.

Additional Implementation Considerations

- Regulation and incentives can increase the likelihood of uptake.
- Demonstrating and communicating cost savings and benefits to homeowners is an important aspect of uptake.
- Internal collaboration between various municipal services are key to implementation.
- A unified voice through construction code, building services, insurance providers, and land use planning can increase efficacy and uptake of climate resilient building materials.

Examples of Implementation

- City of Vancouver, British Columbia - Passive Design Toolkit for Homes
- Victoriaville, Quebec - Sustainable Housing Grant Certification Program
- Dufferin County, Ontario - Hurricane Clip Rebate Program
- City of Calgary, Alberta - Resilient Roofing Rebate Program
- City of Barrie, Ontario - Building Services Bulletin in support of exceeding Ontario Building Code minimums to include hurricane clips

Option # 2: Integrate Climate Data into Adaptive Stormwater Management

Relevant Climate Hazard(s)

Description

- Integrating climate change data into stormwater management is a increasingly common best practice implemented by Canadian and international municipalities that supports resilience in infrastructure and flood risk reduction.
- Up-to-date global and regional climate model data and projections, across multiple Representative Concentration Pathways (RCP) (e.g. RCP4.5 (moderate) and RCP 8.5 (high)), are available to municipalities through a number of sources:
    - Canadian Centre for Climate Services (CCCS)
    - ClimateData.ca
    - Climate Atlas of Canada
    - Climate West
    - Prairie Adaptation Research Collaborative (PARC)
    - Prairie Climate Centre (PCC)
- The City of Calgary has collaboratively developed a regionally specific set of climate data, including climate projected IDF curves for the 2050s and the 2080s.
- The City of Ottawa has identified key components for integrating climate change data into stormwater management planning, including:
    - Updating Intensity-Duration-Frequency (IDF) Curves
        - IDFs are a critical tool in stormwater management planning and design
        - The City of Ottawa is exploring options to reconcile current climate data and projections with their 'stress test' practice of increasing rainfall intensity in the City's stormwater design curves by 20%.
        - Most current IDF curves use historical data to generate IDF curves, however municipalities are increasingly using climate models and future scenarios to anticipate changes in climate, extreme precipitation events and risks to infrastructure.

        - There are a number of available tools and guidelines available to municipalities that considers climate change, including:
            - The Standards Council of Canada's Technical Guide Development, interpretation, and use of rainfall intensity-duration-frequency (IDF) information: Guideline for Canadian water resources practitioners
            - University of Wester Ontario: IDF_CC Tool ver. 6.0
    - Updating Floodplain maps
        - Floodplain maps are most often based on 20 and 100-year floods return periods (Wang, 2015). However, these are also often based on historic data.
        - Floodplain maps need to be updated to reflect flood impacts anticipated in the future and allow evaluation under varying climate scenarios.
        - The Province of Alberta has released draft updated floodplain maps, but at this time there is no timeline for final floodplain maps.

Role of planning

- Updated IDF curves and floodplain maps are important tools for a climate-informed risk and vulnerability assessment used to identify necessary stormwater system upgrades (e.g. increasing culvert size, depth) and regulate urban development, such as buildings in floodplains
    - E.g. integrating IDF curves, Max 1-, 2-, 5-Day, and other projected climate indicators into the development approvals process can ensure that new developments are resilient to extreme precipitation events (20, 50, 100-year events)
- This approach will further support a more integrated stormwater management framework within other municipal policies, plans and programs that apply a climate change lens.
- For example, the City of Ottawa's Official Plan, Infrastructure Master Plan both contain policies and directions, informed by climate change, that support an adaptive approach to stormwater management.
- The City of Ottawa's also has a number of planning tools, informed by climate change, that support their stormwater management approach (City of Ottawa, 2013):
    - Subwatershed planning and community design plans directed to consider and advise on stormwater management adaptation issues and opportunities;
    - Zoning bylaws which consider built form and lot coverage issues;

- Urban design guidelines which promote or require consideration of stormwater management adaptation measures;
- Sewer design guidelines which provide specific direction or advise consideration of stormwater adaptation measures;
- Infrastructure inventory programs including data collection and work planning which considers climate impacts and stormwater management adaptation opportunities;
- Tax and rate incentive tools as motivators for property owners and developers to align and help achieve stormwater management adaptation objectives.

Effectiveness

- Integrating climate projections into stormwater management and design principles is a necessary and proactive step to ensure existing stormwater infrastructure is sized properly to prevent flooding on public and private property due to the increased risk of short duration high-intensity precipitation events.
- Using multiple climate scenarios will also more robust testing of existing stormwater infrastructure.
- This process will also support the financial basis and technical/engineering decision-making requirements for new and existing stormwater infrastructure.
- The City of Ottawa found applying a climate factor to their risk and vulnerability assessment process has allowed them to find aspects of their stormwater system that was at risk that the City was not aware of.

Barriers

- Justifying the costs of stormwater system upgrades based on climate projections when there is already a infrastructure backlog and when municipal budgets are already stretched presents a significant challenge.
    - Increasingly, municipalities are assessing the costs of doing nothing to build the business case for infrastructure upgrades with estimate demonstrating that the cost of inaction is far greater.
        - Recent examples of flood disasters ranking amongst the costliest in terms of economic damages: BC Floods ~$17 billion (2021), Southern Alberta/City of Calgary Floods ~$5 billion, Toronto Flood ~$1 billion
- Adapting stormwater management based on climate considerations may impact many municipal functions and the “costs and benefits” will vary across municipal responsibilities and will require corporate-wide and multi-departmental planning processes which can be challenging.

    - The City of Ottawa notes that municipalities will need to decide how best to apply climate data based on their context and risk factors
- While there is some uncertainty in predicting the exact scope and timing of future extreme precipitation events, the City of Ottawa reports climate uncertainty is similar to other uncertainties dealt with in municipal planning such as population and economic growth.

Costs

- The City of Prince George estimated the costs of stormwater system renewals and upgrades to reflect a stormwater management plan that factors in climate projections
    - Existing renewal costs of stormwater system (e.g. sewers, culverts, and pumping stations) are determined based on replacement of like-for-like. They determined that if infrastructure needs to be larger due to climate change projections, then the costs will be considered as upgrades and will increase accordingly.
    - Estimates of upgrades to infrastructure have been determined based on a 15% climate change factor.
- The City of Welland used climate data within the stormwater infrastructure risk assessment to assess the costs of adaptation measures
- City of Ottawa Recommendations and Costs of Adaptation Measures:

Recommendation	Cost
Determine the effect of climate change on achievable flow reduction through separation and I/I programs	$100-500k
Applicability of updated IDF curves for sewer design	<$100k
Applicability of green infrastructure as an adaptation measure	<$100k
Assess impact of excess heat on SWM facility functions	<$100k
Assess impact of reduced efficiency of oil grit separators on receiving streams (more frequent storms will reduce efficiency)	<$100k

(From City of Ottawa, 2013)

Co-benefits

- For stormwater management, many existing measures that address stormwater generated environmental degradation are the same measures which may contribute climate resilience to stormwater systems.
- Many of the measures promoted to address stormwater management in a changing climate are cross-cutting and may be less costly
    - E.g. Nature-based solutions to stormwater management can be less expensive than engineered hard infrastructure solutions, and provide significant community and environmental benefits.

Equitable Engagement and Outcomes

- The City of Ottawa has considered social vulnerability to infrastructure vulnerability as part of their stormwater adaptation planning process.
    - E.g., Municipalities can include the social risks and costs associated with a period of infrastructure failures.
    - E.g., Municipalities can inventory where electrical substations may fail in flood prone areas and consider the demographic characteristics of the population in the affected area and their ability to manage without electricity.
- The City of Welland recommends working closely with stormwater maintenance and operations to determine how infrastructure has performed under previous storm events.

Additional Implementation Considerations

- The City of Ottawa recommends careful selection of a framework and methodology for integrating climate data and projections into the stormwater management and design tools. Municipalities need to decide their approach based on their own context and risk factors
- It is important to consider that existing curves may be conservative. Therefore an update to IDF curves based on climate projections may not necessarily result in an increase in the curves.
- The City of Welland recommends that municipalities collect asset data (e.g. condition/state of repair, operation and maintenance data) and storm event data. Combining this data with climate projection data will ensure the review of stormwater adaptation planning is the most accurate.

Examples of Implementation

- The City of Ottawa has engaged in a integrated approach to stormwater management as part of their broader climate adaptation planning process. The City of Ottawa Adaptative Stormwater Management Plan
- The City of Prince George has recommended integration of future climate change projections into the design of the stormwater system, by updating their design guidelines to consider future rainfall projections. City of Prince George Integrate Stormwater Management
- In 2007, the City of London worked with the University of Western Ontario to assess their climate risks and vulnerabilities and update their existing IDF curves to reflect climate change. This work formed the bases of their adaptation planning work and identify the various stormwater infrastructure elements (floodways, culverts, dikes, bridges, street and sewer design, etc.) that will be impacted and to determine appropriate stormwater system upgrades and management strategies. City of London updated IDF Curves for climate change

Option # 3: Water Demand Management and Conservation Regulation

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Relevant Climate Hazard(s)

Description

- Water demand management and conservation regulations seek to monitor water consumption, identify high water users and inefficiencies in the system, identify opportunities to collect rainwater and greywater, and implement restrictions for public and private usage.
- Municipalities can utilize several tools to reduce or restrict water consumption or incentivize reduced consumption:
    - Implementing regulatory measures (e.g. bylaws and standards)
    - Metering to monitor public and private water consumption

- Education and awareness initiatives directed at the public and business owners

Role of planning

- In the case of the Sunshine Coast Regional District (SCRD), they employ a series of water conservation regulations and fines through bylaws to restrict water consumption at the private and business level. Of note are Stage 4 restrictions that restrict water usage for non-essential high consumption businesses such as concrete and construction businesses, spas, and breweries.
- SCRD requires all irrigation systems to utilize Drip Irrigation conservation technology to limit water usage and pressure, and all irrigation systems to employ Rain Sensors to prevent watering in the rain.
- The SCRD also requires all new developments and retrofits to include water metering to track water consumption at the private and business level.
- The SCRD provides monitoring services and check-ins with higher than average water users to identify inefficiencies or leaks in water services at the private and business level.
- The SCRD provides educational information and water conservation tips to residents on how to better conserve water during summer months.
- The Capital Regional District in British Columbia developed a handbook aimed at homeowners, engineers, architects, contractors, and developers outlining guidelines for residential rainwater harvesting systems.
- The City of Guelph has created a Greywater rebate program to incentivize the installation of greywater reuse systems.

Effectiveness

- Water restrictions can be applied in progressive phases and on a need-to-need basis, considering forecasting and weather conditions. Data from Sunshine Coast Regional District demonstrates reduced water consumption in relation to implementation of water restrictions.
- Metering provides both users and municipalities with water data to support restrictions and to identify inefficiencies in the system.
- Graduated rates for water consumption can be time-specific and targeted at specific users or industries.
- Rainwater and greywater harvesting can reduce demand and consumption of water for non-potable purposes such as gardening, landscaping, and toilets.

- Rainwater harvesting at the residential level can provide homeowners with enough water for short-term (~one month) outdoor water needs (i.e. lawns, gardens, vehicles, etc.) if water restrictions are in place.
- Implementation of low flow toilets and fixtures as well as greywater recapture can significantly reduce water consumption. Greywater systems can result in up to 30% less water consumption.

Barriers

- Enforcement of outdoor water restrictions can be challenging and resource intensive.
- Revision of rate structure can be publicly unpopular.
- Pushback from large water using business (e.g. construction, breweries, spas)
- Wastewater regulation and recycling at large scales requires engineering approval and professional expertise to install and implement.

Costs

- Costs to local businesses who rely on high levels of water consumption can be prohibitive if forced to reduce or eliminate water usage.
- Low flow toilets and fixtures are relatively inexpensive to install.
- Greywater systems vary in capacity and cost, but can be prohibitive for homeowners looking to retrofit.

Co-benefits

- Rainwater and greywater capture can reduce water consumption outside of drought conditions, reduce strain on municipal infrastructure and reduce costs for businesses and households.

Equitable Engagement and Outcomes

- Equity considerations were not expressly identified in the implementation of the option.
- However, removing financial barriers can support the implementation
    - E.g. subsidy programs can increase uptake of water metering and greywater retrofits

Additional Implementation Considerations

- In the SCRD, educational information and community engagement are considered to be a major factor in reducing water consumption at the property and community level.

Examples of Implementation

- Sunshine Coast Regional District, British Columbia:
    - Comprehensive Regional Water Plan
    - Water Rates and Regulations Bylaw
    - Water Meter Installations Project Loan Authorization Bylaw
    - Water Demand Analysis
- Capital Regional District, British Columbia - Guidelines for Residential Rainwater Harvesting Systems Handbook
- Guelph, Ontario - Greywater System Rebate
- City of Calgary - Water Utility Bylaw

Option # 4: Power and Information Communication Technologies Redundancy

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Relevant Climate Hazard(s)

Description

- Climate shocks such as heat waves and severe storms can cause stress on the power grid and can damage critical infrastructure such as power distribution and telecommunications.
- Building backup power generation paired with energy storage systems and infrastructure redundancy can reduce the risks caused by power outages during extreme weather events and flooding.
- Renewable energy generation and storage and ICT systems can be decentralized and can increase resilience to climate related emergencies.
- Municipalities can use a number of tools and incentives to encourage the use of these materials in new developments and retrofits including:
    - Implementing regulatory measures (e.g. bylaws and standards)
    - Design guidelines outlining how buildings can become more resilient to climate change impacts

    - Incentive programs for new and existing buildings
    - Education and awareness initiatives directed at developers, homeowners and property managers, contractors, and roofers

Role of planning

- The Waterfront Toronto Green Building Requirements outline conditions for climate resilience of all developments along Toronto's waterfront, and include measures to include climate risk modeling and impacts to building structures and systems, requirements for back-up power/emergency generators, and a resilience assessment that includes a number of items related to building design, high-risk impacts, and strategies to increase resilience.
- The City of Edmonton passed their Climate Resilient Design and Construction of City Buildings Procedure which requires (among a number of climate mitigation and GHG reduction items) all new construction of city buildings to be designed to mitigate the risks of climate change through Resilient Design Credits in the LEED Certification program.
- The City of Surrey utilized the Engineers Canada Public Infrastructure Engineering Vulnerability Committee (PIEVC) High Level Screening Tool to assess the infrastructure in the Mud Bay Study Area to assess flood vulnerability of the various infrastructure types affected by flooding in the lowlands.
- The National Building Code requires emergency generators for health-care facilities, life-safety systems, and emergency building services.
- The Prairie Climate Centre identifies several best practices for infrastructure and ICT redundancy at the municipal level:
    - Adopting the PIEVC protocol for energy and ICT infrastructure and design to identify climate related risks
    - Adopting the Canadian SmartGrid Standards Roadmap and compatibility with the Alberta Microgeneration Regulation

Effectiveness

- Protection of key infrastructure from increasing climate vulnerability.
- Redundancy decreases the likelihood of key systems failures in the event of climate related impacts, severe storms, and flooding.
- Smart grids can monitor and alter energy distributions and pricing based on energy availability and can disconnect high-load discretionary appliances.

- Identifying and fortifying critical infrastructure against identified climate hazards can save municipalities money and resources in the long-term in the face of more frequent heatwaves, severe storms, and SDHI precipitation.
- Fortifying assets and critical infrastructure can help to ensure service delivery and key responsibilities are resilient to climate impacts.
- CTI redundancy features now in place in the US following Hurricane Sandy to allow emergency roaming would have largely left mobile users across 10 states unaffected by outages.

Barriers

- Systems to create redundancy, such as backup power generation and storage, cooling systems, etc. may have an additional installation cost and may reduce efficiency in buildings.
- Identifying increased standards may require engineering sign off, tech industry partnerships and collaboration to provide consulting services and expertise.
- Incentivizing or requiring design standards/new materials that go above the Alberta Building Code is not standardized, nor is there current legislative ability for the City of Calgary to require above Code standards. This can result in pushback from developers/homeowners.
- Updating bylaws or incentivizing the addition of redundancy measures can require multi-departmental and stakeholder engagement (e.g. Buildings home builders associations, Roofing Contractors Association)

Costs

The costs of these systems are highly specific to the type of redundancy being introduced. Below are estimates relating to backup power generation and backup information systems at the site level:

- Generators (approximately $100 to $6,000+, for 1,000-7,000 watt hours per unit)
    - Powered by natural gas or diesel energy source
    - Natural gas generators are preferred for backup power systems for several reasons, in particular their reduced operational emissions, simpler maintenance, and, critical to resilience, the fact that no refueling is necessary.
    - Although natural gas engines tend to be more expensive than diesel units as they increase in size, the liquid fuel handling systems for diesel units also become larger and the costs tend to even out.

    - Larger natural gas generators need load management systems in order to be able to meet the code-required 15 second start up time for emergency loads. While this equipment adds costs, it also allows for selection of loads to power, which can reduce the required generator size and cost.
- Battery backup (approximately $1,000 - $3,000+ for 700 -1,500+ watt hours)
    - Easy to use
    - No associated emissions
    - Re-chargeable
- ICT infrastructure redundancy:
    - Physical appliance provides on-site storage as networked appliance with optional hardware-based encryption. (approximately $20,000 upfront, $7,000 monthly)
    - Virtual appliance runs backup software on municipality's own hardware on premises or in the cloud. (approximately $4,500 upfront, $2,000 monthly
    - Managed Service Provider (MSP) provides a fully managed cloud-based service. (approximately $7,500 upfront, $1,000 monthly)

Co-benefits

- A pilot program in Austin Texas employing smart metering for both energy and water systems has experienced significant energy and water savings, and has attracted considerable investment from the tech sector.
- Investing in renewables to support redundancy, such as solar power generation, can support climate change mitigation goals such as GHG reduction.
    - However, renewable backup systems in Alberta are currently rare and back up power generation is more likely to be fossil fuel powered and produce emissions.

Equitable Engagement and Outcomes

- Equity considerations were not expressly identified in the implementation of the option.
- However, removing financial barriers can support the implementation
    - E.g. subsidy programs can increase uptake of water metering and greywater retrofits

Additional Implementation Considerations

- Including redundancy features in municipal assets, buildings, and infrastructure can demonstrate leadership and accountability to other sectors such as homebuilders, telecommunications operators, etc.

- When considering adding a new generator or replacing an existing one in a building without separated loads, coordinating with other electrical work can help reduce electrical distribution costs.
- If at-grade spaces are anticipated to host important community services, consider designing the backup power system to also provide backup power to this part of the building.
- Instead of one large generator, consider multiple smaller ones in order to reduce costs and provide some redundancy – if one fails there is still some available power.

Examples of Implementation

- City of Toronto Waterfront Toronto Green Building Requirements
- The City of Edmonton Climate Resilient Design and Construction of City Buildings Procedure
- City of Austin Pecan Street Project

Option # 5: Fortify Existing Buildings and Assets

Relevant Climate Hazard(s)

Description

- Relocating existing at-risk buildings, infrastructure, and assets can often be costly and unfeasible for municipalities. Fortifying these assets can include addressing climate impacts through risk assessments, upgrades, and retrofits to increase resilience
- A number of nationally identified codes and standards exist to fortify Canada's buildings and assets against the impacts of climate change. Canada's Climate-Resilient Buildings and Core Public Infrastructure Initiative seeks to protect buildings, bridges, roads, water and wastewater systems, energy transmission, and transit infrastructure by integrating climate resilience into building and infrastructure design, guides, and codes.
- A number of resources and methodologies have been created by third parties in insurance, risk reduction, climate change adaptation and mitigation, industry, and infrastructure to better protect buildings and assets from climate change impacts.

- Standards, guides, and risk assessment methodologies that seek to build resilience in municipal buildings, assets, and infrastructure include:
    - The Canadian Standards Association has created numerous standards to protect buildings and assets from flooding, extreme heat, high winds and severe storms, and other climate impacts.
    - Risk assessment methodologies, including HIRA, ISO 31000:2018, the PIEVC Engineering Protocol, and the Building Adaptive and Resilient Communities Framework seek to identify climate hazards and impacts and develop and prioritize actions to mitigate the risk of climate related impacts.
    - The Intact Centre on Climate Adaptation, The Institute for Catastrophic Loss Reduction, The Climate Risk Institute, the International Institute for Sustainable Development, ICLEI Canada, and more, have created a host of resources to identify climate related vulnerability and actions to increase the resilience of infrastructure, buildings, and assets.

Role of planning

- Numerous cities across the country have undertaken Climate Change Risk Assessments to better prepare for climate related impacts. Planning can support the identification of City-owned at-risk assets and buildings through floodplain mapping, risk assessments, and resilience research to inform long-term climate resilience infrastructure and asset strategies.
- The City of Edmonton passed their Climate Resilient Design and Construction of City Buildings Procedure requiring (among a number of climate mitigation and GHG reduction items) all new construction of city buildings to be designed to mitigate the risks of climate change through Resilient Design Credits in the LEED Certification program
- The mid- to long-range perspective employed by planning departments provides a flexible approach to implementing actions that increase resilience.
- The land-use planning framework provides Planning Departments with a framework to facilitate collaboration and engagement between municipal departments.

Effectiveness

- Identifying and fortifying public builds against identified climate hazards can save municipalities money and resources in the long-term in the face of more frequent severe storms and SDHI precipitation. Proactive investment in infrastructure adaptation is the most cost-effective way to protect municipal assets, infrastructure, and services (Warren, Lulhan, 2021).

- Fortifying assets and buildings can ensure service delivery and key responsibilities are resilient to climate emergencies.
- The inclusion of a climate lens to identifying at-risk infrastructure and assets can better inform the land-use planning and development approvals process in the future.
- Natural Resources Canada's National Issues Report estimates that investments in adaptation have an average return of 5.6:1, though the economic performance of adaptation actions is highly site and context specific (Warren, Lulham, 2021).

Barriers

- Fortifying existing buildings and assets can be costly and prohibitive.
- Identifying hazards and developing standards for resiliency upgrades often requires multi-departmental and stakeholder engagement.
- Uncertainty related to climate related risk and impacts can conflict with competing priorities and financing.
- A lack of policy direction can hinder the implementation of resiliency efforts.
- Existing building code is often behind in relation to climate-related risk assessment and standards.
- Nationally, Canada has an infrastructure investment deficit of $250 billion indicating that much of Canada's infrastructure is already in need of retrofit, upgrade, or replacement.

Costs

- The costs of fortifying infrastructure is highly site and context specific
- The City of Selkirk developed its climate adaptation strategy by assessing seasonal and annual impacts of climate change across municipal assets and services. The costs of actions were calculated and integrated in the City's budgeting process to support implementation.

Co-benefits

- Fortification of buildings and assets can integrate low-carbon resilience opportunities that meet other municipal priorities and goals such as equity, stormwater management, GHG reductions, and clean energy improvements.

Equitable Engagement and Outcomes

- As part of the Building Adaptive and Resilient Communities Framework, the risk and vulnerability analysis builds in equitable engagement and identifies how vulnerable

populations will be impacted by the impacts of climate change, and identifies actions that seek to increase the resilience of these populations.

Additional Implementation Considerations

- Focusing on public buildings and assets provides municipalities the opportunity to demonstrate leadership and accountability in the face of climate change and the associated impacts.
- Municipalities have an opportunity to involve a multitude of businesses, industry leaders, community organizations, and partners when completing this work.

Examples of Implementation

- City of Selkirk Asset Management Plan
- The City of Edmonton Climate Resilient Design and Construction of City Buildings Procedure
- City of Surrey Mud Bay Infrastructure Flood Vulnerability Assessment

Option # 6: Install and Maintain Backwater Valves/Sump Pumps

Relevant Climate Hazard(s)

Description

- Backwater valves and sump pumps are flood prevention devices that can protect homes during extreme rainfall events or overland flooding.
- Backwater valves, or backflow prevention devices prevent sewers from backing up into basements during heavy rain events, and are typically required when storm sewers and sanitary sewers are combined.
- Sump pumps seek to combat overland flooding by pumping excess water out of the basement and away from the property

- Municipalities can use a number of tools and incentives to mandate or encourage the use of sump pumps and backwater valves to reduce flood risk:
    - Implementing regulatory measures (e.g. bylaws and standards)
    - Incentive or subsidy programs
    - Education and awareness measures directed at the public, property owners and managers, and developers

Role of planning

- The City of Winnipeg developed bylaws mandating the installation of sump pumps and backwater valves that included subsidy programs for both backwater valves and sump pump systems.
- In 2016, the Town of Halton Hills launched the Enhanced Basement Flooding Prevention Subsidy Program, which contained measures for a host of flood mitigation measures including sump pump and backwater valve devices, but also sewer lateral lining and repair, a flood mitigation education page, and door-to-door outreach in high-risk areas.
- In 2005, The City of Ottawa passed the Residential Protective Plumbing Bylaw granting rebates for the installation of protective plumbing to reduce the risk of basement flooding from sewer backup, and in 2009 passed an amendment to the City's Sewer Design Guidelines requiring the installation of backwater valves on all new sanitary sewer connections. The current program focuses on high-risk areas and subsidizes between 50-100% in areas that experience basement flooding.
- The City of Saskatoon has implemented a backwater valve incentive program to encourage homeowners to protect their homes from the risk of sewer backup. The City mapped the basements that had flooded as a result of sewer backup to locate vulnerable areas, and conducted hydraulic modeling to provide more precise information on locations more prone to sewer backups and basement flooding.
- The Town of Collingwood and their Chief Building official, seeking to avoid the complexity of developing a bylaw mandating backwater valves on new builds, issued a public statement to developers indicating that backwater valves were required in all new home construction.

Effectiveness

- These are relatively inexpensive mechanisms to significantly limit the risk of damage to homes during severe storms and short duration high intensity precipitation.
- These are particularly cost effective when installed in new homes.
- ~28% of houses in Winnipeg have installed a backwater valve, and 15% have installed a sump pit system (Kovacs, et al., 2014)

- City of Saskatoon experienced over 50% uptake of targeted households following three major flooding events. 85% of those who installed backwater valves had no further flood issues (Kovacs, et al., 2014).
- City of Ottawa has subsidized the installation of over 900 backwater valves since the 2005 subsidy program was implemented (Kovacs, et al., 2014).
- Halton Hills increased subsidy uptake from ~18/year to over ~250/year by through targeted outreach and by leveraging previous flood events.

Barriers

- Lack of knowledge and education for homeowners could lead to limited uptake.
- Can be difficult to convince homeowners to take action.
- Can be administratively intensive to manage the subsidy/incentive programs.
- Maintenance is required by homeowners to ensure the proper function of these devices

Costs

- In 2014, the Town of Halton Hills set aside $24.7 million over 10 years to fund their backwater valve subsidy program and subsidizes ~250 devices per year.
- The City of Saskatoon offered residents $3000 to install backwater valves on their sanitary sewer laterals and has subsidized the installation of nearly 700 devices (between 2005 and 2010) (Kovacs, et al., 2014).

Co-benefits

- Installing sump pumps and backwater valves can help reduce the risk of basement flooding, which can reduce energy consumption and greenhouse gas emissions by preventing damage to homes and the need for energy-intensive repair and cleanup processes.

Equitable Engagement and Outcomes

- Offering a subsidy program can significantly reduce costs to homeowners for the installation of backwater and sump pump devices.
- Targeted programming in high-risk neighborhoods can increase uptake amongst those who are more vulnerable to basement flooding.

Additional Implementation Considerations

- Monitoring of stormwater and sewer flow is an important aspect of identifying high-risk areas prone to backup or basement flooding and can identify infrastructure in need of upgrades or replacement.
- Door-to-door canvassing can be particularly effective but can be time consuming and resource intensive. Canvassing should take place in neighbourhoods at high-risk of backup or flooding.
- Leveraging previous flood events can significantly increase program uptake.
- Efforts should be made to include access to education materials for homeowners around flood vulnerability, flood mitigation techniques, access to contractors, and the maintenance required to keep devices operational

Examples of Implementation

- City of Winnipeg Building By-law
- City of Ottawa Residential Protective Plumbing Bylaw, Sewer Design Guidelines
- City of Saskatoon Backwater Valve Rebate Program
- Town of Halton Hills Enhanced Basement Flooding Prevention Subsidy Program
- Town of Collingwood Backwater Valve: Mandatory Installation Building Bulletin

Option # 7: "Cool"/Reflective Walls and Pavement

Relevant Climate Hazard(s)

Description

- Incorporating high-albedo materials to reduce thermal gains and increase cooling for buildings, structures and pavements to reduce the impacts for extreme heat.
- The materials that make up city roadways have a very low albedo and so absorb far more incident shortwave radiation than natural vegetation does. Further, these materials often have high heat capacities that cause the release of absorbed daytime thermal energy at night. (Wang & Akbari, 2016)

- The use of cool or reflective surfaces, including light-coloured materials, can reflect more solar radiation and sunlight and absorb less heat than conventional dark, heat-retaining materials which results in a lower temperature.

- There are a two primary materials for cool or reflective surfaces (not inclusive of roofs, nor vegetated options)
  - **Cool Paints:** White or light coloured elastomeric paint is specifically made to protect masonry surfaces, when applied it hardens into a flexible, watertight covering.
  - **Cool Pavements:** Paving materials that reflect more solar energy, enhance water evaporation, and remain cooler than conventional pavements. This can include interlocking concrete pavers, light coloured pavers)
    - E.g. CoolSeal is an asphalt coating designed to protect, seal, and cool asphalt surfaces through increased solar reflectivity.

Role of planning

- The City of Toronto's Green Standard - Four development standards with development features relating to the reduction of heat island at grade:
  - Low-Rise Residential
  - Mid to High-Rise Residential Non-Residential
  - City Agency, Corporation & Division-Owned Facilities
  - Energy Modelling Guidelines
- These include voluntary and required provisions:
  - Voluntary:
    - Use any combination of the following strategies to treat at least 75% of the site's non- roof hardscape (including driveways, walkways, courtyards, parking areas, artificial turf and other on-site hard surfaces):
    - High-albedo surface materials with an initial reflectance of at least 0.3 or SRI of 291
    - Open grid pavement with at least 50% perviousness
  - Required:
    - Use a combination of the following strategies to treat at least 50% of the site's non-roof hardscape (including driveways, walkways, courtyards, surface parking areas, artificial turf and other on-site hard surfaces):
      - High-albedo surface materials with an initial reflectance of at least 0.3 or SRI of 291
      - Open grid pavement with at least 50% perviousness2
      - Shade from existing tree canopy or within 5 years of landscape installation

        - Shade from structures covered by solar panels.
    - Non-residential uses option:
        - Select one or a combination of the above strategies OR
        - Place a minimum of 50% of required parking spaces under cover. Any roof used to shade or cover parking must have an SRI of at least 29, be green roof or be covered by solar panels that produce energy to offset some non-renewable resource use.5,6
- Can be combined with LEED credit certification. International certification schemes that may be useful in urban planning for heat- resilience include the LEED (Leadership in Energy and Environmental Design) rating system for buildings.

Effectiveness

- Directly reduces heat gain through the building envelope resulting in reduced internal building temperatures.
- Lowers the urban air temperature in the area surrounding building, structure or pavement, reducing the urban heat island effect.
- Standard or dark surfaces can reach temperatures of 150°F (or 65.6°C) or more in the summer sun. A cool surface under the same conditions could stay more than 50°F (or 10°C) cooler (U.S. Environmental Protection Agency. 2008).
- The City of New York Cool Roof Program shows that their cool roof painting program reduces 10 to 30% in cooling energy use within a building.
- Calculations done for Los Angeles, USA, for if all pavements and roofs in downtown were to include cool walls and pavementsit would increase the albedo by 25 and 35 percent, and air temperatures would drop by nearly 3 degrees Fahrenheit. (Pomerantz, et al., 1998).

Barriers

- Consideration of the following disadvantages can be considered (Sophia et al, 2022):
    - Waste generated by removal of existing surfaces if needed.
    - Waste material associated with the application or installation of coat or surface.
    - Potential wear and tear, and glare on roads.
- Modelling studies have predicted that reflected energy could be absorbed by pedestrians, and in hot, dry cities, make people feel warmer (Mohegh et al, 2017)

Costs

- The cost of cool pavements to conventional paving materials can be difficult to estimate as the cost varies by:
    - region, contractor, time of year, materials chosen, accessibility of the site, local availability of materials, underlying soils, size of the project, expected traffic, desired life of the pavement
- The City of Phoenix, USA, tested the spray method, versus the squeegee method as it can be applied quickly with lower labour costs. The cost of the cool pavement sealant itself is about $0.60(US) more per sq yd compared with typical asphalt sealants ($4.40 per sq yd). (Fortner, 2021)
- New York City's Cool Roof program estimates that the cost to install as part of their program is as low as 30 to 40 (US) cents per square foot. Outside of the program they estimate that the cost per square foot would include:
    - Contractor ($0.65-1.00(US))
    - Painter ($0.17-0.45(US))
    - Workforce group ($0.25-0.45 (US))

Co-benefits

- According to the US Environmental Protection Agency (US Environmental Protection Agency 2008), reflective surfaces can:
    - extend the life of the surface by (re-)sealing the surface
    - address multiple climate hazards if traditional pavement is replaced with cool permeable pavements there can be:
        - Reduced stormwater runoff and improved water quality (filtering pollutants and lowering temperature of runoff)
        - Lower tire noise (open pores reduce by 2-8 decibels)
        - Enhanced safety (reduced water spray and increased traction with better water drainage)
    - improve local comfort in parking lots or other areas where people congregate or children play.
    - Can improve nighttime visibility with reflective pavements, potentially reducing lighting requirements and saving both money and energy.
- An increase in urban albedo will reduce energy consumption, reduce electricity demand, improve air quality, reduce risk of heat-related discomfort and mortality, and change precipitation patterns (in non- snow cover regions/seasons). (Yang, Wang & Kaloush 2015)

Equitable Engagement and Outcomes

- The risk of heat-related illness and death is greatest for older adults, infants, young children, people with chronic illnesses, those who are physically disabled, and people living alone and is greatest when temperatures are higher than normal and sustained over several days. Addressing extreme heat can reduce challenges for vulnerable populations. (The Institute for Catastrophic Loss reduction, 2020)
- The City of Toronto's Green Roof Construction Standard provides a similar example of developing a bylaw and did so with public consultation as part of its development.

Additional Implementation Considerations

- Providing shading, often with trees, in addition to cooling surfaces can make the largest difference (Taleghani, 2016)

Examples of Implementation

- The BNQ 3019-190 Guidelines – Reducing the Urban Heat Island Effect – Parking Lot Development – Design Guidance (Bureau de normalisation du Québec)
    - This certification program in Quebec includes standards and guidelines that encourage uptake such as "Eco-Responsible Parking (Stationnement écoresponsable)," for businesses to promote their efforts to customers.
- Los Angeles, California, USA, has adopted and is undertaking a reflective pavements program.
- City of Toronto, Canada - China City parking lot is an example of implementing the City's Green Standards.

Option # 8: Adopt Nationally Recognized Flood Resilience Codes and Standards

Relevant Climate Hazard(s)

Description

- Pluvial flooding in urban areas is one of the most significant drivers of disaster loss in Canada. Damages during pluvial flood events are associated with overwhelmed urban drainage (stormwater and wastewater) systems (Moudrak & Feltmate, 2020).
- Municipalities are increasing the adoption of nationally recognized codes and standards into municipal policy and regulations, including in land use, urban planning and in design requirements for existing and new developments.
- Once adopted into practice they will serve to strengthen existing municipal policies, management plans, and programs that build resilience to floods.
- There are a wide range of national guidelines and standards for flood risk-reduction:
    - CSA Z800: Guideline on basement flood protection and risk reduction
    - CSA W200: Design of Bioretention Systems
    - CSA W201: Construction of Bioretention Systems
    - CSA W204: Flood resilient design for new residential communities
    - CSA W210: Prioritizing flood resilience work in existing residential communities (under development)
    - CSA 211: Management Standard for Stormwater Systems (under development)
    - CSA PLUS 4013: Technical guide: development, interpretation and use of rainfall intensity-duration frequency (IDF) information: guideline for Canadian water resources practitioners. This is a resource for understanding the derivation, and application in water system planning and design, of rainfall IDF information. IDF information is meant to describe the frequency (in terms of probability of occurrence) of extreme rainfall events of various rates and durations.

Role of planning

- Municipalities can adopt and integrate the codes and standards developed in compliance with the National Standards Council of Canada, published by CSA Group, and compliant with the National Building Code of Canada (NBCC) to mitigate flood hazards for:
    - New builds
    - Existing buildings
    - Water and stormwater systems
- A number of municipalities have incorporated these guidelines and standards into urban-planning policies and zoning by-laws such as:
    - Barrie Stormwater Management Master Plan
        - (p. 152) - Technical guide on development and use of IDF information was reviewed for this Plan
    - Flood Reduction Master Plan of City Peterborough
        - (p.4) - Action to update City's engineering standards to promote/require LID to assist with climate adaptation
    - Thunder Bay Stormwater Management Plan
        - (p. 160, 172) - References to Federal and Provincial policies and programs and guiding documents to support this Plan
    - Toronto Wet Weather Flow Master Plan
        - (p.4) - Action to update City's engineering standards to promote/require LID to assist with climate adaptation
    - Waterloo Sanitary Servicing Master Plan
        - (p. 22) - References importance to consider and modify IDF curves in relation to climate change and use most up-to-date climate data to generate IDF curves

Effectiveness

- Guidelines and standards help engineering firms and contractors carry out flood-resilience work more efficiently by identifying the specific design approaches, optimal methods of construction, and most appropriate materials.
- Incorporated design guidelines and standards can help to reduce project risks and improve transparency in performance monitoring.
- Adoption of nationally recognized guidelines and standards will help align flood risk-reduction efforts in jurisdictions across the country.

- These regulations and standards limit the potential for flood damages, reduce insurable losses, and minimize the probability of flood-related lawsuits and downgraded credit ratings in the aftermath of a flood.
- Enhancing planning tools and flood infrastructure is key to effective flood impact reduction. (Diordjević et al., 2011).
    - This includes policy, legislation, land-use management, emergency response planning, and community participation (Kundezewicz, 2009)
- The City of Edmonton has adopted flood resilient codes and standards and is implementing these effective measures.

Barriers

- Reducing the risk of flooding is reliant upon not only the adoptions of codes and standards into City planning policies and plans but also the interpretation of the codes and standards, public engagement on the adopted codes and standards, the ensuing enforcement, consistent design, development and installation, and the maintenance of the resulting infrastructure. (Sandink & Binns, 2021)
- There are also jurisdictional challenges as elements of the water and stormwater systems are under the control of the homeowner. (Sandink & Binns, 2021)
- Similarly, institutional fragmentation related to flood resilience that results in a lack of clarity on roles and responsibilities and competing mandates can reduce the effectiveness to prevent and recover from flooding events. (Morrison, Noble & Westbrook, 2018)

Costs

- Flood resilience implementation requires financial investment (Asrat, 2015)
- Information related to the costs of integrating national flood resilience standards and codes was not available and will vary per location and implementation.
    - There are minimal costs (~$100) for annual subscription to the CSA group standards, codes and guidelines.

Co-benefits

- Better prepares cities for ability to adapt to current flows and conditions, build another level of resilience to the watershed and build resilience to climatic changes (Sturgess, 2016).

Equitable Engagement and Outcomes

- Equity considerations are not widely identified in implementation of this adaptation option from a municipal standpoint.
- However, the Manitoba Water Strategy integrates engagement with stakeholders, including opportunities to participate and to leverage local and traditional knowledge in water management planning and adaptation measures.

Additional Implementation Considerations

- Adopting these measures can reduce insurable losses, and minimize the probability of flood-related lawsuits and downgraded credit ratings in the aftermath of a flood. (Moudrak & Feltmate, 2020)

Examples of Implementation

- City of Edmonton - Stormwater Integrated Resource Plan
    - Worked with CSA to develop and test CSA standards as part of their stormwater planning process.
- City of Québec - Réaménagement de l'espace Roland-Beaudin project
    - This project used the CSA W200: Design of bioretention systems and CSA W201: Construction of bioretention systems to design and construct phases of the project, helping to provide additional relief for sewer systems located downstream.
- City of Vancouver- The Vancouver Building Bylaw (VBBL) was updated in 2014 to include floodplain standards and requirements for floodplain areas
- Ontario - Provincial Policy Statement and Flooding Strategy
    - The development of policies and codes are significant tools to protect vulnerable lands and apply flood preventative measures such as flood zoning regulations and which will ensure sustainable communities and long-term resilience planning.

Option #9: Increase Riparian Buffer Zones

Relevant Climate Hazard(s)

Description

- Riparian buffer zones are areas of land near rivers, streams, lakes, or other bodies of water that serve as a protective barrier to maintain the health and stability of the aquatic ecosystem. They are designed to reduce the impact of human activities, such as agriculture, development, or logging, on these water bodies.
- By absorbing pollutants, preventing soil erosion, providing habitat for wildlife, and stabilizing stream banks, riparian buffer zones help maintain water quality, prevent flooding, and preserve biodiversity (*Riparian Forest Buffers*, n.d.).
- Municipalities can encourage or require increased riparian buffer zones through:
    - Implementing regulatory measures (e.g. bylaws and standards)
    - Design guidelines or best management practices
    - Education and awareness initiatives directed at private landowners on the importance of riparian buffers and what they can do better protect these areas if they are adjacent to them.

Role of planning

- Zoning regulations and other policies can be created/updated to regulate land use activities in riparian areas. In general, land adjacent to riparian areas should be zoned for non-intensive uses that will minimize disturbance or pollution to the riparian area (e.g. floodplain, park and open space, commercial recreation, residential, managed livestock grazing, etc.) (Government of Manitoba, n.d.)
    - The City of Toronto's Ravine and Natural Feature Protection policy restricts development in areas adjacent to sensitive aquatic ecosystems to protect water quality and wildlife habitats.
- Municipalities can work with land trusts and other conservation organizations to establish conservation easements on riparian buffer zones. These easements can

ensure that the areas are permanently protected from development and other harmful activities.
    - The Land Conservancy of British Columbia (TLC) - TLC has established several conservation easements for riparian areas in British Columbia, including the Sooke River riparian corridor, the Cowichan River conservation corridor, and the Cottonwood Island Nature Park along the Nechako River in Prince George.
- Municipalities can require streamside setbacks to protect riparian areas and prevent encroachment. Streamside setbacks require a specified distance between the edge of a watercourse and the location of any new development or construction.
- Planning and design guidelines: Municipalities can develop planning and design guidelines that encourage/ensure the conservation/expansion of riparian buffer zones in new development projects or that all subdivision proposals meet a minimum design standard (enforced through zoning or development agreements). (Government of Manitoba, n.d.)
    - The Toronto and Region Conservation Authority's Guideline for Ecosystem Compensation (after a decision for compensation has been made) aims to provide a clear and repeatable method for determining compensation for lost or altered ecosystems, once it has been established that compensation is necessary.
        - It is designed to help professionals such as planners, ecologists, landscape architects, landowners, and others understand how to implement compensation for ecosystem loss. With the goal of promoting efficient and effective compensation restoration, the guideline provides a consistent and science-based approach, drawing on extensive experience in natural heritage planning and ecological restoration.
    - The Province of Manitoba's Planning Resource Guide on Planning for the Protection of Riparian Areas provides guidance on how to enforce riparian policies to secure and preserve riparian areas on both public and private properties

Effectiveness

- Vegetation in buffer zones can help slow down and absorb water runoff, reducing the risk of downstream flooding (Climate Adapt, 2015).
- Buffer zones help to filter pollutants and sediments from runoff, improve water quality and reduce the risk of erosion (Climate Adapt, 2015).
- The width needed for a riparian buffer to be effective depends on a number of factors, but, in general, the wider the buffer, the greater the benefits delivered.

    - In the experience of TRCA, they utilize a standard 30 meter buffer around all watercourses to identify riparian areas.
- Several factors can impact the effectiveness of riparian forest buffers in achieving their goals. These factors include site conditions such as adjacent agricultural practices and crop varieties, stream size, topography, and soils; landscape conditions such as position in the watershed, adjacent land use, and buffer continuity. Careful planning and design of riparian forest buffers is crucial in maximizing their effectiveness (*Riparian Forest Buffers*, n.d.).
- In the experience of TRCA, they highlighted that being able to monitor, go back to sites to evaluate whether riparian plantings have made improvements to the area is an excellent measure of their success.

Barriers

- In the case of the Toronto and Region Conservation Authority:
    - Given how urbanized their jurisdiction is, finding adequate available space within existing public ownership was a challenge
    - Finding willing private landowners was also a key challenge.
        - **Solution:** Providing incentives (e.g. tax breaks) for property owners who voluntarily establish riparian buffer zones on their land can help this.
        - **Solution:** Outreach and education to property owners and developers about the importance of riparian buffer zones and how they can be established and maintained.
    - Securing funding for ongoing maintenance and monitoring efforts
    - Coordinating between various divisions within a municipality can be cumbersome as work is being bridged across silos.
    - Residual post-pandemic impacts on labor and sourcing.

Costs

- Through an interview with staff from the Toronto and Region Conservation Authority, they have estimated costs based on different aspects of the work, including project management, site preparation, planting a mix of large and small stock, and also installing structural habitat for wildlife. The riparian compensation costs are estimated to be anywhere between $140,000 to $195,000 per hectare.

Co-benefits

- Riparian buffer zones can act as carbon sinks, sequestering carbon and mitigating the impacts of climate change.

- Trees and vegetation in buffer zones can provide shade, reduce water evaporation and regulate water temperature, which is beneficial for aquatic species.
- Riparian areas provide habitat and food sources for a variety of wildlife species, and buffer zones help to protect and enhance these habitats (Climate Adapt, 2015).
- Buffer zones can provide opportunities for recreation and education, such as hiking, bird-watching, and fishing.
- When working to expand or protect existing riparian zones, the Toronto and Region Conservation Authority (TRCA) recommends the protection hierarchy as follows: the most important component is to avoid impacts to natural features and areas altogether. If this is not possible, minimize this impact and then compensate for this impact if natural areas and features are negatively affected or lost due to development.
    - The TRCA's Guideline for Ecosystem Compensation (after a decision for compensation has been made) is available online. This Guideline aims to provide a clear and repeatable method for determining compensation for lost or altered ecosystems, once it has been established that compensation is necessary. It is designed to help professionals such as planners, ecologists, landscape architects, landowners, and others understand how to implement compensation for ecosystem loss. With the goal of promoting efficient and effective compensation restoration, the guideline provides a consistent and science-based approach, drawing on extensive experience in natural heritage planning and ecological restoration.

Equitable Engagement and Outcomes

- Equity considerations are not widely identified in implementation of this adaptation option from a municipal standpoint.
- However, in the experience of TRCA's restoration team, they do engage community groups who partner on plantings from time-to-time, funding partners, landowners (if the plantings are on private land), and municipalities who own any public land that is not owned/ managed by TRCA. Developers are also engaged if there is a role for them to be offsetting their impacts. In terms of general stakeholder outreach, this is more limited unless the site requires an environmental assessment.

Additional Implementation Considerations

- From an interview with staff from the Toronto and Region Conservation Authority, they undertake a strategic approach to prioritizing riparian zone plantings. In doing so, they identified areas that would be most suited to or where there is the most need for

ecological restoration. They also conduct desktop and field investigations to thoroughly identify where restoration opportunities could exist in order to prioritize projects.
    - Also integrated are results from a TRCA wide climate change vulnerability assessment of terrestrial ecosystems to integrate that climate change vulnerability.
- In general, riparian plantings tend to be easier to plant than other types of land uses (e.g. private land or farmland) as it tends to be in public ownership with lesser development and/or potential to change.

Examples of Implementation

- The City of Edmonton's Natural Area Management Plan outlines several strategies to support vegetated (including riparian) buffers. A few of these include:
    - Maintain the natural condition of the buffer zone surrounding the natural area wherever possible (e.g., reduced mowing and/or no mow zones) in order to provide the required transition between the natural area and surrounding land uses.
    - Native vegetation plantings (shrubs and native seed mixes) should be applied in disturbed areas within the natural area (including the buffer zone and in areas where informal trails have developed) as identified through understory assessments or other natural area monitoring processes. Replanting should mimic surrounding native vegetative structure and should provide a diversity of plant species
- Regional District of Okanagan-Similkameen Riparian Areas Regulation: This regulation requires the protection and enhancement of riparian areas in the region. The regulation includes setback requirements, vegetation management guidelines, and requirements for the creation of buffer zones around waterways.
- The Province of British Columbia - Riparian Areas Protection Regulation and easy fact sheet
- City of Abbotsford, British Columbia - Guidelines for the City of Abbotsford's
- Streamside Protection Bylaw
- District of Squamish, British Columbia - Riparian and Aquatic Protection: development, streamside protection and enhancement areas, and more
- Ducks Unlimited Canada (DUC) - DUC has established several conservation easements for riparian buffer zones in different regions of Canada, including the Beaver River in Alberta, the Qu'Appelle River in Saskatchewan, and the St. Lawrence River in Quebec.

Adaptation Options for the Natural Environment

Option # 11: Eco-roofs (Green and 'Cool' Roofs) Bylaw and Incentive Program

Relevant Climate Hazard(s)

Description

- Eco-roof is the collective term for the category of climate resilient roofing systems that includes green (vegetated) roofs, 'cool' (reflective) roofs, or a combination of both types.
- Eco-roofs provide a number of public and private benefits over standard roofing materials and have been implemented successfully in jurisdictions across Canada and internationally.
- Municipalities can use a number of tools and incentives to encourage the implementation of eco-roofs and stimulate the local market and increase implementation across the community (Lawlor et al., 2006). These include:
    - Implementing regulatory measures (e.g. bylaws and standards)
    - Direct and indirect incentive programs for new and existing buildings
    - Education and awareness initiatives directed at the public, property managers and owners, and the roofing sector
- In 2009, the City of Toronto passed the Green Roof Bylaw which mandates the installation of green roofs on new commercial, institutional and residential buildings with greater floor area of 2,000 m^2.
- In tandem with their Green Roof Bylaw, the City of Toronto launched an Eco-roof incentive program directed at existing residential, industrial, commercial and institutional buildings; new buildings with less than 2,000 m^2 of floor area; and all new construction projects by Toronto School Boards and not-for-profit organisations.

Role of planning

- The cities of Toronto and Montreal have both been successful in passing and implementing bylaws which mandate the installation of green and cool roofs in their jurisdictions.
- The City of Toronto's Green Roof bylaw requires all new commercial, institutional, and residential buildings with a floor area larger than 2,000m^2 to install green roofs (City of Toronto, n.d.).
- The bylaw requirements range from 20-60% of available roof spaces being covered with green roofs depending on the size of the roof.
- Developers can opt to pay \$200/m^2 to the City in lieu of meeting the above requirements, with funds directed to the Eco-Roof Incentive Program.
- The bylaw also includes minimum design and engineering requirements that meet the City's objectives and Ontario Building Code requirements.

Effectiveness

- Adopting a bylaw and a complementary incentive program allows for improved coverage and uptake across buildings sectors, types and sizes.
- This approach also increases the strength of the signal to the market lowering costs and encouraging changes in the roofing sector
- An incentive program removes a number of significant financial barriers by providing direct funding to property owners not mandated through a bylaw.

City of Toronto

- The combined approaches of a bylaw and an incentive program has resulted in a successful implementation of over eco-roofs across the city.
    - Between 2009 and 2016, the incentive program has supported the installation of 176 eco-roof projects with a combined area of 375,000 square metres. The combined outcomes of these projects include 9 million litres of diverted stormwater, a reduction of energy usage of 1000 megawatts annually, and a reduction of 120 tonnes of GHG emissions (ICLR, 2016).
- The combined total of mandated and incentivized eco-roofs completed to date is 500.
- The innovative funding mechanism has allowed the incentive program to run for over 10 years and is self-sustaining.
- Esri Canada, in Toronto, chose to build a green roof as a result of a Ryerson University study that concluded that the increased greening of roofs in the City of Toronto could reduce the City's ambient air temperatures by up to 2 degree Celsius. The result was an extensive green roof that now diverts 393,353 L of stormwater from municipal systems and reduces an estimated 88 kilograms of CO2 equivalent from the air each year.

City of Montreal

- As of 2016, 2000 green roofs have been retrofitted since the implementation of the bylaw, or roughly 10% of the flat roofs in the neighbourhood.
- Homeowners participating in the program have reported both decreased temperatures and reduction in energy use (ICLR 2016).

Barriers

- The City of Toronto identified lack of education as a significant barrier to implementation and uptake, especially for residential sector. Residential owners also often struggle to understand how to get approved for the incentive program.
    - A solution to overcome this challenge has been to work closely with the roofing industry and property owners.
    - The City has focused education on the roofing sector who then work with individual building owners. At the time of replacing a new roof, the roofing sector professional will recommend the installation of an eco-roof and direct owners towards the incentive program.
- A challenge with this approach is that there is no one association or other governing body for roofers so outreach and engagement (to reach individual roofers) presents a capacity issue
- Another challenge has been that eager homeowners often want a list of 'preferred' roofers which is not something the City can provide. Currently, the City includes a list of specific criteria and material types that are required within the incentives program, but this isn't as useful for homeowners.
    - A solution the City is working on is to start a 'certification' training for roofers, that will educate them about the program, how to be successful in applying, materials used etc.
    - The City would then create a list of certified roofers that they could share with property owners (only of those roofers who had completed their training).
- Paying for and understanding the engineering requirements for the installation of an eco-roof was also identified as a significant barrier, particularly for residential uptake
    - In 2015, the City of Toronto added a Structural Assessment Grant to the Eco-roof Incentive Program, which provides $1000 towards an engineering assessment to determine if older buildings can support the added weight of a green roof

Costs

- The City of Toronto piloted their green roof incentive program for 2-years with an initial budget of $200,000 for grants. The pilot provided grants of $10/$m^2$ up to $20,000. The program was open to all private property owners.
- The City of Toronto's permanent Eco-Roof incentive program expanded to include industrial, commercial and residential buildings. Property owners can apply to receive $100 per square metre up to a maximum of $100,000 for green roofs, and $2 to $5 per square metre up to a maximum of $50,000 for cool roofs. The City also provides an additional incentive of up to $1000 for structural assessments.
- The green roof installed by Esri Canada in Toronto, Ontario costed just under $200,000 and spans 704 m^2. Over time, the design of the green roof is also expected to reduce heating and cooling costs, provide improved sound and weather insulation, and improve employee productivity and well-being. (Green Infrastructure Ontario Coalition, 2020)
- Estimate for the installation of green roofs range from $10-$24 (USD) per square foot (Green Roofs for Healthy Cities, n.d.)
    - It is important to note that initial costs for the installation of green roofs are greater, one of the benefits of green roofs is extended service life of roof membranes and decreased heating and cooling costs.

Co-benefits

- There are a number of direct environmental, economic and social benefits and co-benefits to the install of green and cool roofs, including:
    - Reduced urban heat
    - Improved stormwater management and retention
    - Improved air quality
    - Reduced energy consumptions in increased energy savings for property owners
    - Reduced GHG emissions
    - Habitat creation for pollinators, birds and other wildlife
    - Improved building aesthetics
    - Extended service life of waterproof roof membranes and heating and cooling systems (through decreased use)
    - Increased green and recreational spaces
    - Opportunities for job creation and urban agriculture
    - Improved quality of life for residents including heat moderation and noise reduction

Equitable Engagement and Outcomes

- The City of Toronto identified consultation with multiple stakeholders as a critical element for the successful implementation of an incentives program. This in particular was helpful in overcoming a number of barriers to implementation and increasing access and update to the program.
- The City of Toronto has consulted with roofing sector, property managers/owners, school boards multiple times
- The roofing industry in particular has played a huge part as they work with clients and understand why things will /won't work.
- The City of Toronto has worked extensively with the University of Toronto, which they noted working with academic research has been very helpful in shaping their technological, materials, engineering and design requirements for the bylaw and incentives program.

Additional Implementation Considerations

- Careful consideration should be made for the selection of permissible materials included in the eco-roofs incentives program (e.g. Montreal amended their bylaw to include a white polymer membrane instead of white gravel due to increased reflection and decreased absorption.
- The City of Toronto created the Green Roof Construction Standard which outlines key design, engineering and maintenance standards for eco-roofs built under the bylaw and incentives program.
    - E.g. The City requires a five-year maintenance plan for both cool and green roofs to ensure their continued environmental performance.
- The City of Toronto identified the importance of maintaining ongoing harmony between their bylaw and incentives program. As chances are made to one, it is critical that these changes are reflected in the other. This will make sure any gaps are filled.

Examples of Implementation

City of Toronto

- The City of Toronto launched a Green Roof incentives pilot program in 2006, which became a permanent Eco-Roof (green and 'cool' roof) program in 2009.
- A critical component of the success of the Eco-roof program was the supportive policy and regulatory context. A Green Roof bylaw was approved by council in 2009. The bylaw requires green roofs to be installed in all new commercial, institutional and residential developments with roof areas larger than 2000 metres.

- City of Toronto Green Roof Bylaw
- City of Toronto Eco-roof Incentive Program

City of Montreal

- In the Rosemont-La Petite-Patrie neighbourhood, revised their zoning bylaw to mandate property owners that were replacing or building a new roof to install a green or 'cool' (reflective material) roof or a combination of these different types of eco-roofs. This initiative was implemented in an effort to mitigate the urban heat island effect in the City and has since been adopted by several other neighbourhoods across the City.
- Rosemont-La Petite-Patrie Mandatory cool roofs

Option # 12: Increase Minimum Topsoil Depth and Quality for New Development

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Relevant Climate Hazard(s)

Description

- Topsoil depth and quality can aid in water conservation and rainwater management by increasing the soil capacity to absorb and retain rainwater and stormwater runoff.
- Increasing minimum topsoil depth in development standards can reduce the impacts of higher average temperatures and meteorological drought, reduce the need for irrigation in summer months, and reduce the effects of Short Duration High Intensity storms by providing increased capacity to absorb runoff.
- Municipalities can encourage or require increased levels of topsoil depth through:
    - Implementing regulatory measures (e.g. bylaws and standards)
    - Design guidelines or best management practices

Role of planning

- The City of Calgary Parks Department mandates topsoil depth and quality in its Development Guidelines and Standard Specifications: Landscape Construction document, this is specific to City park areas, but does not include private land.

- The City of Vancouver Green Bylaws, Stewardship Bylaws, and Groundwater Bylaws mandate minimum requirements for topsoil depth and have increased minimum topsoil depths to meet water conservation and rainwater management goals.
- Bylaws in Surrey, Vancouver, Maple Ridge, and Kelowna have increased minimum topsoil depth to meet a number of goals and strategies including stormwater management control, erosion control, and watercourse protection policies
- The British Columbia Landscape and Nursery Association Standards, Master Municipal Construction Documents, the Metro Vancouver Stormwater and Source Control Guidelines, and the city of Vancouver Water Wise Landscape Guidelines all provide guidance on specifications for topsoil depth and content and best practices for before and after development.
- Increasing topsoil depths could be included as part of the Sustainable Development Inventory or the Sustainable Buildings Permitting Matrix to encourage uptake by developers.

Effectiveness

- Increased absorptive capacity can reduce need for irrigation during dry periods.
- Deeper topsoil can absorb higher levels of rainwater and runoff reducing strain on stormwater infrastructure and the likelihood of flooding.
- Deeper topsoil can increase plant health and reduce evapotranspiration during extended periods of higher average temperatures, extreme heat, or drought, and can result in cooler air temperatures than densely packed soil or concrete.
- Good quality soil has 20% water holding capacity (Cook, 2016). It is estimated that irrigation requirements in summer months can be significantly reduced by increasing topsoil depth and soil quality.

Barriers

- Depending on implementation levers, this can require cross-departmental collaboration with stormwater, engineering, and parks.
- Changes to development standards, bylaws, guidelines can result in pushback from developers, and/or landscapers.
- Sourcing high-quality topsoil can be a challenge for developers, landscapers, and the City.

Costs

- Metro Vancouver estimated that the cost for approximately 250m^3 of absorbent topsoil at 450mm deep, was $6,500 (2012 value). This is for engineered topsoil, as opposed to native topsoil, which would be more affordable (Cook, 2016).

Co-benefits

- Increased soil health and depth supports biodiversity
- Increased soil health and depth support increased filtration of stormwater runoff

Equitable Engagement and Outcomes

- Equity considerations were not expressly identified in the implementation of the option.
- However, municipal climate risk assessments often identify several top risk communities that suffer from low riparian health, underperforming park areas, low public tree conditions, and sensitivity to drought.
    - Increasing topsoil depth can support efforts to create healthier greenspaces and reduce the effects of severe weather events.

Additional Implementation Considerations

- Slope grade and stability should be considered when requiring topsoil requirements to avoid the risk of erosion.
- Topsoil 'settling' can result in sinking lawns and garden beds. It is recommended that 15% more soil is applied to the recommended depths to ensure it settles to desired levels.
- The City of Vancouver regulates soil removal to protect existing topsoil.

Examples of Implementation

- City of Vancouver - Green Bylaws, Stewardship Bylaws, Groundwater Bylaws: Topsoil Requirements in Vancouver
- District of Saanich - Absorbent Landscape Best Management Practice
- City of Surrey - Stormwater and Drainage Regulation and Charges Bylaw
- City of Coquitlam - Rainwater Management Design Requirements and Guidelines
- City of Port Coquitlam - Development Permit Areas
- City of Maple Ridge - Watercourse Protection Bylaw

Option # 13: Climate Resilient and Native Vegetation Management

Relevant Climate Hazard(s)

Description

- Climate-resilient native species are plant species that are native to a specific region and have evolved over time to adapt to its unique climate conditions, including local weather patterns, temperature fluctuations, and precipitation levels. These species have a higher likelihood of survival and growth in the face of changing climate conditions, making them more resilient to extreme weather events, drought, and other climate-related stressors.
- Urban Forestry depends on successful programs and initiatives in jurisdictions south of the management area to provide species seed sources. In urban settings, cities are also using the knowledge to plant the best seedlings within their programs. More and more nurseries are sharing regional and species-specific information and selling nursery stock to their customers.
- Species-specific models and maps from the Federal government provide potential range maps for individual species of trees, shrubs and perennial herbs
- This tool returns a list of species whose climatic range, based on ANUCLIM models, overlaps a selected location.
- This tool from the Federal government returns a list of species whose climatic range, based on ANUCLIM models, overlaps a selected location. Three future periods are available for a Composite of the fifth assessment RCP 8.5 scenario.
- Alberta's Invasive Species Council's 'Grow Me Instead' guide to native plant species to grow as alternatives to some common invasive species. A list of locally approved species and maintenance criteria should be provided.

Role of planning

- The Prairie Climate Center's Building a Climate-Resilient City: Urban Ecosystems document highlights how cities can use zoning amendments, tradable development rights, natural asset management systems, support for land acquisition and securement, and provide opportunities for active civic engagement through projects

such as: community gardens, residential gardening, greening programs, land acquisition and restoration, and advisory committee participation.

- The Waterfront Toronto Green Building Requirements has a 75% native or biodiverse planting requirement. Landscaping standards could be updated to include language requiring climate resilient species.
- As seen in the Sustainable Development Codes, local governments can amend planning codes to:
    - Allow or require landscaping with native plant species;
    - Label native species and not being 'nuisance';
    - Require landowners to meet specific minimums of native plant species in field borders, buffers, and other landscaping improvements;
    - Encourage their use in landscaping plans;
    - Enforce maintenance criteria and setback distances to adequately maintain public safety and discourage unmanaged growth;
    - Include minimum area threshold and require conservation of any existing native plant species where possible;
    - Reduce requirements for plan approvals and permit flexibility in landscape design if landscaping will incorporate native plant species.

Effectiveness

- Native species are adapted to local conditions, and support a diversity of wildlife, insects and other plants. This helps to maintain a healthy ecosystem, which provides a range of benefits, such as improved air and water quality.
- Climate-resilient native species are more likely to be able to withstand the impacts of a changing climate, including droughts, heatwaves, and changes in precipitation patterns.
- Unlike non-native species, which often require extensive maintenance, climate-resilient native species are adapted to local conditions and are typically low maintenance.
- Climate-resilient native species can enhance the natural beauty of an area and create a more inviting and attractive environment. They can also provide habitat value to improve urban biodiversity encouraging native species back into cities.
- Climate Change species atlases, such as that for the United States Department of Agriculture provide researched estimates of species location into the near future (100 years) given different climate change models. The success of species in a region, given the unpredictability of climate change can not be guaranteed.

Barriers

- Guidelines can lack prescription and enforcement
- Reliable source of native and locally sourced plants, as may are difficult to propagate
- Restrictive plant choices
- May require choosing species or varieties of plants that withstand salt conditions and compacted soil due to the urban environment.
    - In urban areas with high heat, air pollution, and limited planting space, a non-native, non-invasive species might be tougher and better able to survive and provide benefits such as shading and cooling, but it may not support native wildlife as well as a native species, for example. (https://extension.umd.edu/resource/planting-trees-our-changing-climate)
- Native plants, like all plants, have specific environmental conditions in which they thrive, and may not be suitable for all locations.

Costs

- There are no costs to the municipality for integrating these considerations into planning.
- An incentive or subsidy can support the planting of climate-resilient native species, such as Toronto's Neighborhood Planting Program
- Native species are often easier to establish and maintain than non-native species, which can be more expensive and require more resources.

Co-benefits

Planting climate-resilient native species can:

- Absorb more water during periods of rain resulting in less runoff into storm sewers and rivers.
- Can reduce water consumption needs during extended periods of hot or dry weather.
- Require very little additional water or maintenance (no fertilizer or pesticides) once established.
- Roots retain and stabilize soil, reduce erosion, and prevent soil from being washed away during severe storms and short duration high intensity precipitation.

Equitable Engagement and Outcomes

- Equity considerations are not widely identified in implementation of planting climate-resilient plant species from a municipal standpoint.
- However, the work done by the Kootenay Native Plant Society is an example of how additional engagement has encouraged people–plant connections in the West Kootenay

region of British Columbia, Canada, over a 10-year period (Beckwith, B. R., Johansson, E. M., & Huff, V. J., 2022).

- They employed place-based and interactive initiatives (i.e. wildflower walks and school programmes) and coupled this with their approach to showcase a flagship native species called Camassia quamash, itxwa. They also developed more specialized programmes that trained participants in native plant propagation and gardening, where they gained competence and contributed to a social group linked by community-based conservation efforts and a passion for native plants.

Additional Implementation Considerations

- As the climate changes, some individual trees or even whole local populations may not be adapted, nor have the capacity or time to evolve to adapt to climate change. In some cases populations may not be able to migrate to more favorable conditions due to forest fragmentation and the rapid changes predicted. Practitioners, landowners, policy makers, can undertake assisted migration that involves moving seed or material from a known location to an area with a similar climate to what the tree may be exposed to under climate change.
- British Columbia: Climate Based Seed Transfer (CBST) helps promote healthy, resilient and productive forests and ecosystems through the matching of seedlings/seedlots to future (projected) planting site climates.
- The use of native and climate resilient species should also consider opportunities to create low maintenance natural spaces that reduce operational costs and GHG emissions.

Examples of Implementation

- City of Minneapolis, Minnesota, USA
  - Encourages and permits the use of native plant species by making installation and maintenance of natural landscapes a right with no application required.
  - Removed the improper classification of native plant species as nuisances when properly maintained.
  - Formally defined managed natural landscape as “a planned, intentional and maintained planting of native or non-native grasses, wildflowers, forbs, ferns, shrubs or trees, including but not limited to rain gardens, meadow vegetation, and ornamental plantings.” Natural landscaping is allowed to exceed maximum height and maintenance requirements of traditional turf landscapes.
  - Species used are required to be non-invasive and proven adaptable to the local climate.

- City of Toronto Green Low-Rise Standard requires new developments to include native species in the following areas:
    - "Shade is measured may be provided by existing tree canopy, new shade trees or shade structures. For examples of native shade trees, refer to Forestry Facts & Native Plant Lists."
    - In choosing drought-tolerant tree species, "preference should always be given to
    - those native to the area."
    - In planting the landscaped site area, use "a minimum of 50% native species (including trees, shrubs and herbaceous plants)."

Option # 14: Low Impact Development and Community Greening

Relevant Climate Hazard(s)

Description

- Low Impact Development (LID) is an approach to land use and development that emphasizes the use of techniques that mimic natural hydrologic processes in order to manage stormwater and reduce the impact of development on the environment.
- LID techniques typically involve the use of green infrastructure, such as vegetated swales, rain gardens, green roofs, and permeable pavement. These features are designed to capture, treat, and infiltrate stormwater, allowing it to recharge groundwater and reducing the amount of runoff that enters nearby streams, rivers, and other bodies of water.
- LID also emphasizes the preservation and protection of natural features, such as wetlands and stream corridors, and the use of compact, walkable development patterns that reduce the need for automobile travel.
- In an interview with City of Montreal staff, the Parc Pierre-Dansereau project was discussed. The Pierre-Dansereau Park was implemented as part of the MIL Montreal project and is located in the northern part of the City of Montreal's Outremont borough. The park came as an opportunity to incorporate green infrastructure to collect

rainwater and delay its transportation to the sewer system, which tends to be overwhelmed by large amounts of water during severe precipitation.

- The redevelopment project for the former Outremont marshalling yard represented an opportunity to consolidate the urban and social fabric of the area by creating a network of public spaces that respect its railway and industrial heritage. The objective of the park was to provide a space for leisure and play, increase green infrastructure and improve biodiversity in the area.
    - The park includes typical elements such as a children's playground and a water play area; a multipurpose area; benches and picnic tables; a pedestrian walkway linking the site from east to west; as well as the many pieces of green infrastructure to retain stormwater including rain gardens, permeable pavements, and a naturalized dry steam.
    - The park also proposes a greening strategy focusing on the creation of new wildlife and plant habitats by planting abundant and varied vegetation. The maximization of these planted spaces also contributes to the infiltration of light rains, thus allowing a reduction in the number of civil drainage infrastructures in the park.

Role of planning

- Policies can be developed that promote sustainable development practices, including LID and greening projects. These policies may include zoning regulations, building codes, and stormwater management regulations that require or incentivize developers to incorporate LID practices.
    - The City of Vancouver, British Columbia: Vancouver has a Green Buildings Policy for Rezonings, which requires new developments to achieve LEED Gold certification and implement LID practices, as well as a Rainwater Management Plan that sets targets for managing rainwater runoff through LID. This is also part of their larger Integrated Rainwater Management Plan
- Provide technical assistance and guidance to developers, community groups, and property owners interested in implementing LID and greening projects. This may include providing information on the best practices, technical specifications, and design standards for LID and green infrastructure projects.
    - The City of Toronto, Ontario has a Green Development Standard that encourages LID practices in new developments.
    - The City of Edmonton, Alberta provides a Low Impact Development Best Management Practices Design Guide

- Coordinate with other departments and stakeholders such as engineering, public works, and community groups, to plan and implement LID and greening projects effectively. This may involve facilitating partnerships, communication, and collaboration to ensure that projects are well-designed and executed.

Effectiveness

- LID techniques help to reduce the volume of stormwater runoff that is generated by developed sites. This can help to reduce the risk of flooding and erosion, as well as improve water quality by reducing the amount of pollutants that are carried into nearby bodies of water.
- They can help to improve the quality of water in nearby streams, rivers, and other bodies of water. By infiltrating stormwater and filtering out pollutants, LID features can help to reduce the amount of sediment, nutrients, and other pollutants that enter our waterways.
- LID features such as green roofs and trees can help to reduce the urban heat island effect
- LID projects can help to manage stormwater by infiltrating it on site, reducing the risk of flooding and erosion. This can protect local infrastructure and reduce the cost of flood damage.
- In the case of Pierre-Dansereau Park, the benefits described were as follows:
    - Reduces flows and volumes sent to the sewer, and therefore reduces the risk of flooding.
    - Pools the infrastructure needed to manage stormwater while meeting the recreational needs of citizens.
    - Makes the municipal investments and interventions required for ecological stormwater management visible and in a way that raises awareness and educates experts and the public.
    - Strengthen the resilience of Montreal's MIL area while improving the quality of life of its citizens.
- The effectiveness of low impact development (LID) projects can vary depending on the specific project and its scope, as well as the location and other factors.
- The Green City, Clean Waters program in Philadelphia, Pennsylvania USA is a comprehensive stormwater management plan that aims to use green infrastructure to reduce the amount of runoff that enters Philadelphia's combined sewer system. The program includes the installation of rain gardens, green roofs, and permeable pavement, among other strategies. A study of the program's effectiveness found that it

reduced combined sewer overflows by 1.5 billion gallons between 2011 and 2015 and is on track to meet its long-term goal of reducing overflows by 85%.

Barriers

- LID projects can require significant upfront costs, including design, construction, and ongoing maintenance.
- LID projects require specialized technical knowledge, which may not always be available within staff.
- Municipalities may face some opposition from residents or other stakeholders who are sceptical of the benefits of LID projects and community greening projects.
- These projects may require significant upgrades to infrastructure, such as drainage systems, water supply systems, and transportation networks.
- LID practices, such as rain gardens or green roofs, require space that may not be available on smaller or densely developed sites. This can make it challenging to implement LID practices in urban areas with limited available land.
- In the case of Park Pierre-Dansereau, city staff interviewed discussed the following challenges:
    - The development of a resilient public space with a participative approach required constant compromise between the technical objectives for water retention and the recreational needs of the community. The benefits of the consultation would have had more of an impact if the focus had been on the views and desired ambience of the landscape, rather than the finer details of the design.
    - This new type of infrastructure could create maintenance challenges. Providing information on how to better care for the space is crucial for the park's long-term conservation.

Costs

- The cost of implementing low impact development (LID) projects can vary depending on the specific project and its scope, as well as the location and other factors.
    - Stormwater/infiltration planter boxes (typically located in transportation corridors or parking areas) cost between CAD $50-108 per m2 of IA (Green Infrastructure Ontario Coalition, 2020)
    - Permeable pavement (Different types: porous, asphalt, permeable concrete, permeable pavement, open matrix pavement) costs between CAD $70-98 per m2 of IA (Green Infrastructure Ontario Coalition, 2020)

    - Bioswales (Different types: Roadside and Parking Lot, collects runoff, including stormwater Water absorption, and filtration) costs between CAD$210.47/m2 (Green Infrastructure Ontario Coalition, 2020)
    - Rain gardens can cost around CAD $26.70/m2 (Green Infrastructure Ontario Coalition, 2020)
    - Rain barrels can cost around CAD $98.24/m2 (Green Infrastructure Ontario Coalition, 2020)
- In the case of Montreal's Pierre-Dansereau Park, staff discussed how designing a park that improved stormwater management capacity for the neighbouring areas allowed the City to mutualize its investment. Building new stormwater infrastructure independently from the construction of the park would have been more expensive for the municipality.

Co-benefits

- LID measures can help to improve the resilience of homeowners to extreme weather events and climate change. By reducing the risk of flooding and erosion, these projects can help to protect infrastructure and reduce the costs of post-disaster recovery.
- Trees and other vegetation can help to improve air quality by absorbing carbon dioxide and other pollutants from the air.
- LID projects can help to enhance the aesthetic and recreational value of communities, which can lead to increased property values.
- By incorporating green infrastructure features into development projects, LID can help to create more hospitable environments for a variety of plant and animal species.

Equitable Engagement and Outcomes

- As part of the Pierre-Dansereau Park project, a citizen participation process was carried out to involve the community in the park's design.
    - During the consultation, citizens were asked to express their views on two design options. The outcome of this consultation led to a design that took aspects from both options into account. The choices endorsed by inhabitants were ambitious and proved to be a challenge in practice, namely the curved steps.
    - The project's technical committee included the city's technical services, the borough of Outremont and the University of Montreal. The community was closely involved in the design stage of the project and was considered a key player in terms of gaining information, awareness and support.
- Equity considerations were not expressly identified in the implementation of the option.

- However, the Equity Guide for Green Stormwater Infrastructure Practitioners developed by the Green Infrastructure Leadership Exchange (GILEx) is a resource that can provide some guidance to help green infrastructure practitioners incorporate equity considerations into their work.
    - The guide provides information on how green infrastructure can advance equity goals and provides guidance on how to engage with communities to ensure that their needs and perspectives are incorporated into green infrastructure planning and implementation.
    - The guide includes a variety of tools and resources, including case studies, checklists, and worksheets, to help practitioners address equity issues in their work. It covers a range of topics, such as identifying equity considerations in project planning, engaging with community stakeholders, and evaluating the equity impacts of green infrastructure projects.

Additional Implementation Considerations

- In regards to the Pierre-Dansereau Park, the team planned to integrate natural infiltration and retention zones that could collect stormwater for small and large rainfall events with return periods ranging from three months to 50 years.
    - The various infiltration zones designed within the park created interesting variations in elevation that were then used to create interesting multi-functional spaces that serve the community. For instance, a dry stream acting as a retention basin was integrated within the design and the space has become very popular among the neighbourhood's children who use the area to play with rocks and vegetation.
- Education and outreach are important components of any LID or community greening project to help increase public support and participation in LID and community greening projects.
- Maintenance and monitoring are critical components of any LID or community greening project to ensure the ongoing functionality and effectiveness of green infrastructure.

Examples of Implementation

- City of Toronto, Ontario -
    - Green Roof Bylaw - requires new developments to include green roofs,
    - Eco-Roof Incentive Program - provides grants to support the installation of green roofs and cool roofs on homes and buildings.

- City of Victoria, British Columbia - rebates and credits for low density residential properties; multi-family, business, and institutional properties; and existing rainwater management systems
- City of Austin, Texas - Water's WaterWise Rainscape Rebate helps residents and schools install landscape features to keep rainwater on the property.

Option # 15: Integrate Natural Asset Management and Valuation into Asset Management Plans

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Relevant Climate Hazard(s)

Description

- Integration of natural assets within asset management plans is not yet standard practice in all jurisdictions, however momentum is growing, and examples and resources are becoming more widely available. For example,
    - Municipal Natural Assets Initiative (MNAI) provides guidance on natural asset valuation and asset management: https://mnai.ca/resources-and-reports/
    - Green Municipal Fund Tool for Measuring the Value of Natural Assets
- The City of London and the Town of Gibsons are among the leading examples of how to integrate natural assets within asset management plans.
    - They have both taken an approach that aligns natural assets with standard practices in asset management.
- Steps to integrating natural assets within asset management plans include:
    - Inventorying natural assets
    - Assessing natural asset conditions
        - important to assess the infrastructure backlog / gap - to understand what natural assets already require attention
    - Assessing the value
    - Assessing levels of service (LOS)
        - E.g. determine metrics to quantify how well an infrastructure system is meeting expectations.

    - Determining an asset lifecycle strategy (i.e., strategies to enable continued and sustainable levels of service, while managing risks at the lowest costs
        - Actions include operational and maintenance considerations and plans and costs for natural asset - e.g. invasive species management, mulching etc.
        - Risks include loss of natural assets due to climate change - drought, flooding, pollution
- Many municipalities have conducted natural asset evaluations which is an important step in understanding and assessing their value, building recognition of their importance, and ultimately integrating them within broader asset management plans. For example,
    - City of Calgary Natural Asset Valuation
    - District of West Vancouver Natural Assets
    - City of Oshawa Value of Natural Assets for Stormwater Management
    - City of Saskatoon Natural Capital Asset Valuation
    - Town of Okotoks Natural Assets Inventory and Valuation
    - Assessing the value of natural assets have most often followed the determination of the value of Ecosystem Services provided by the assets. However, the City of London and Town of Gibsons completed their valuations based on the total replacement value (see *Barriers* for more details).
- Natural assets can be integrated into an asset management plan.
    - E.g. The City of London integrated their natural assets within different program areas alongside traditional grey infrastructure:
        - Water, wastewater/stormwater services (e.g. green infrastructure drywells, bioretention)
        - Environmental services (e.g. on-site buffers)
        - Parks and Recreation
        - Social and Health Services
        - Preparing and implementing plans to maintain and/or replace the assets
- By integrating natural assets in this approach allows for the comparison between services areas and asset categories.

Role of planning

- The District of West Vancouver identified that planning departments can have a major role in preserving and/or restoring natural assets. Their planning department is leading the urban forest management plans, and is utilising a number of planning tools including:

    - Zoning bylaws – best avenue to dictate/manage natural assets (Specifically for - New developments)
    - Regulations - Ensuring density on a lot
        - Retain/re-plant
    - Zoning permits – development permits
        - Maintaining trees on tree roads
        - Land-use planning on new subdivisions
- The City of Victoria, British Columbia has a tree protection bylaw that requires property owners to obtain a permit before removing or injuring trees on private property. The bylaw also establishes fines for unauthorized tree removals.
- Planning departments can further support the integration and valuation of natural assets by defining them within municipal plans and policies
    - The City of London made sure to align their asset plans with the Provincial regulatory landscape, meeting specific requirements of Green Infrastructure Assets defined in O.Reg 588/17.

Effectiveness

- Integrating natural assets into management plans help municipalities:
    - Understand of the services they provide
    - Take stock of existing assets
    - Prioritise at-risk assets and maintenance and operational requirements
    - Increase the priority of natural infrastructure relative to grey infrastructure
    - Support with decision-making and strategic management to enhance green infrastructure
    - Defend budgets
    - Increase opportunities for federal and provincial infrastructure funding:
        - Green Municipal Fund
        - Natural Infrastructure Fund
- Natural assets are one of the many tools municipalities can leverage to build resilience against multiple climate hazards (e.g. extreme heat, drought, flooding), while also providing a number of co-benefits and services (e.g. carbon sequestration, air quality improvements, recreation, cultural significance).
- Integrating natural assets within broader asset management plans ensures adequate resources are allocated to maintaining and managing these assets.

Barriers

- The City of London identified that determining the replacement value for natural assets can be challenging as there are limited standards or frameworks that can be applied to any jurisdiction.
    - They noted that this approach needs to be developed locally within the context of the municipality and their methodologies that align with their own asset management approaches
- The District of West Vancouver noted it can be challenging getting buy in from asset managers and council – as they do not yet understand the value of natural assets (especially through an ecosystems services approach)
    - They noted that there is a need to educate and build value proposition
- Getting buy in from the community can also be challenging if the view of natural assets are divided/polarised
    - E.g. in some cases, the community may want to cut down trees as some see trees as risks to lives and properties (danger from extreme weather)

Costs

- Information related to the costs associated with the integration and valuation of natural assets was not available
    - There are two emerging approaches to assessing the value of natural assets which will determine the broader costs within asset management planning
- The ecosystem services valuation approach assigns an economic value to the services provided by natural assets
    - This approach is useful for making the business case for protecting and managing natural assets
- The City of London found the ecosystem services valuation approach presents a challenge to the integration of natural assets within asset management plans as it does not align with the valuation method used for traditional assets
    - Their solution was to apply an asset valuation approach for asset planning
        - Includes current replacement costs
        - Is asset focused
        - Is important for keeping consistent across all asset classes in the asset management plans
        - City of London's estimates and methods used to calculate replacement costs as part of the corporate asset management plan

- The District of West Vancouver has focused their costing assessments on replacement costs versus avoided costs with hard infrastructure
    - Recreational value – travel costs
    - Water supply /filtration vs avoided costs of reservoir/filtration
    - Habitats – natural resources produced - values
    - Restoration costs vs self-maintaining
        - Cost benefits analysis - Costs of naturalisation vs management natural infrastructure
- Recommend starting with low hanging fruit, for example one asset class like urban canopy and forests
    - E.g. Can connect to existing urban forest management plans

Co-benefits

- Natural assets provide a number of core municipal services (ecosystem services: cultural, regulating, supporting, provisioning) that aligns with a number of other municipal strategies and policies:
    - Removes carbon that drives climate change while also increasing resilience to the climate change impacts.
    - Reduces flood risk and provides enhanced stormwater management - supports water quantity and quality improvements e.g. bioretention
    - Reduces urban heat - through reduced heat absorption and retention, direct shading

Equitable Engagement and Outcomes

- Integrating natural assets into asset management plans will ensure they remain a priority
    - Natural assets provide a number of key services to underserved communities
- The City of Windsor has included a number of actions as part of their environment Master Plan that relate to equitable engagement:
    - Develop an engagement strategy to improve community acceptance of naturalisation programs, as well as using parks for short term rainwater storage.
    - Promote the health benefits of using green spaces for accessible and safe physical activity.
- In the City of London's asset management strategy they engaged local residents as part of citizen science to assess the inventories/conditions of assets
    - Community member engagement will be important in developing the natural asset inventories and assessing the condition of the assets

    - They also have equity considerations built directly into their asset management plans which include natural assets
        - Accessibility
        - Capacity building
        - Availability
- The District of West Vancouver council have also prioritised community engagement as part of their urban forest management strategy, which is aligned with their natural assets and asset management strategy.
    - Community members were engaged through:
        - Visioning exercises
        - Education and awareness
        - Surveys
        - Community events
        - Vulnerability scoring related to climate change and urban forests
    - Findings included feedback on understanding concerns around the risks trees pose to homes, property and safety; Better ways to maintain urban tree assets under changing climate hazards
    - Findings informed planning for better urban tree regulations for developments

Additional Implementation Considerations

- The City of London noted that in assessing the condition of natural assets, it is important to use standardise definitions of natural asset condition
    - E.g. health and structural form
- Depending on the feasibility to assess the replacement value of specific groups of natural assets, municipalities can treat these assets differently within the asset management plan, for example:
    - Full asset management approach (assess inventory and replacement value): urban parks and tree canopy, bioswales, pools, rain gardens, stormwater management
    - Inventory only: soils, wetlands, rivers, creeks
    - No inventory: green roofs/walls, permeable pavements

- In assessing the value of natural assets, it is important to note that natural assets (unlike traditional engineered assets) may appreciate in value as time goes on, with appropriate care and maintenance practices
    - E.g. Mature trees vs young trees
        - more carbon sequestration
        - Increase biodiversity

        - Increase shade
- The City of London noted a number of other important considerations for their asset management plan, including:
    - Determining the optimal costs of the asset lifecycle activities required to ensure the infrastructure systems provide service levels that meet community expectations.
    - Establishing a financial strategy to fund the expenditures that are required to complete the optimal lifecycle activities for Council's approval.
    - Prepare conclusions and provide recommendations resulting from the data analysis performed

Examples of Implementation

- City of London
    - Corporate Asset Management Plan
    - City of London Green Infrastructure
- Town of Gibsons
    - Asset Management Plan
    - Natural asset management recommendations
- City of Windsor
    - Integrated Asset Management Plan - Integrated green infrastructure within their asset management plan (specifically, urban tree canopy and forests)
        - Integrating these green assets within their asset management plan allowed them to link to their urban forest management plan
        - Identifying risks to this asset including: vulnerable to severe weather such as wind and ice storms
- District of West Vancouver
    - Natural Asset Valuation
    - Natural Assets Inventory and Council Report

Adaptation Options for Social Systems

Option #18: Community Cooling Centres/Spaces

Relevant Climate Hazard(s)

Description

- Heating and cooling centres provide safe spaces for the public in the event of extreme weather events such as severe storms, heatwaves, and cold snaps. They can be operationalized in the event of heatwaves or extreme heat days, cold snaps, or power outages caused by increased strain on the power grid or severe storms.
- Existing community spaces such as libraries, recreation centres, pools, splash pads, etc. can be utilized in the event of climate-related emergencies
- Municipalities can use a number of tools and incentives to encourage the creation or expansion of these spaces in new developments and retrofits including:
    - Implementing regulatory measures (e.g. bylaws and standards)
    - Design guidelines outlining how buildings can become more resilient to climate change impacts
    - Incentive programs for new and existing buildings
    - Education and awareness initiatives directed at developers, homeowners and property managers, contractors, and roofers

Role of planning

- The City of Toronto's Green Standards require all new residential development to include community centres/institutional buildings for residents seeking refuge from extreme weather events, and outlines the minimum operational requirements for these centres, including backup power generation and access to basic amenities
- The City of Toronto temporarily expands access to public pools during Heat Warnings and provides access to Warming Centres when an Extreme Cold Weather Alert is issued.

Toronto also operates the Heat Relief Network, comprising over 300 locations across the City, and provides an online map to identify the location and amenities available.

- The City of Vancouver has identified and mapped a variety of free-to-enter spaces for residents to cool down on hot days, including community centres, libraries, misting stations, spray parks, wading pools, partner cooling centres, and more.
- The City of Toronto's Community Benefits Charge (CBC) Bylaw (formerly Section 37) is a planning tool the City uses to ensure new development funds development-related capital infrastructure needs. The CBC Bylaw has been used to fund a number of community amenities, including recreational centres, park improvements, affordable housing, and more.
- The City of Vancouver, in their Updates to Extreme Heat Response Plans for 2022; identify expanding partnerships and coordinated response; increasing access to indoor cooling; expanding access to water, washrooms, and outdoor cooling; and updating communications and alerting, as recommendations to improve their Extreme Heat Response Plan.
- The City of Montreal has completed vulnerability mapping based on factors that contribute to Urban Heat Islands to better reduce the impacts of heatwaves and to increase public access to indoor and outdoor 'cool areas'
- The Climate Change and Health Vulnerability Assessment for Waterloo Region, Wellington County, Dufferin County, and the City of Guelph, identified key vulnerable populations exposed to extreme heat, analyzed heat-related emergency visits within the region, mapped tree canopy coverage to identify where heat-related exposure is anticipated to be the greatest, and mapped the presence of cooling centres (including air conditioned spaces, public pools, and splash pads) by transit accessibility throughout the region.

Effectiveness

- As extreme heat days, heatwaves, and tropical nights (i.e. lowest temperature of the day does not go below 20℃) become more frequent, access to these services can provide refuge from those without adequate access to air conditioned spaces.
- Many of these spaces (libraries, recreational centres, public pools, splash pads) already exist in some capacity and may only require programming and staffing modification to either increase accommodation or more accommodate community members during extreme weather events.
- Urban Heat mapping and vulnerability mapping can provide a targeted approach to increasing access to heating and cooling centres and increase the resilience of at-risk communities or neighbourhoods.

- Specific data related to cooling centre efficacy (e.g., attendance, operation budgets) was not available.
- Urban Heat mapping can identify at-risk communities or neighbourhoods but will have to be paired with additional actions to increase the resilience of at-risk communities/neighborhoods to extreme heat.

Barriers

- Many of the identified vulnerable populations (e.g., seniors, low-income populations, mobility status, access to transit, language barriers, etc.) experience barriers to access these services.
- Access to online information related to cooling centre maps, hours of operation, etc., requires internet access and could be a barrier for some (especially in the event of an emergency/extreme weather event)
- Retrofitting existing buildings with increased cooling capacity (such as air conditioning) can be cost prohibitive.
- Expanding operating hours of existing spaces can be staff and resource intensive
- Private spaces are unwelcoming to those that are low-income and/or unhoused.

Costs

- Information related to costing for the extension, improvement, or expansion of cooling centre operations was not available.
- Retrofitting existing public spaces with air conditioning is dependent on a number of factors including building size, age, and capacity.
- Costing for the construction of new buildings such as recreational centres and libraries is highly context specific.

Co-benefits

- Mapping urban heat islands provides an opportunity to identify communities that lack access to green space, parks, and tree canopy coverage

Equitable Engagement and Outcomes

- Working to increase and/or improve cooling centre operations to service those that are typically more vulnerable to the impacts of extreme weather events (i.e. youth, seniors, those with mobility-related concerns, those that are socially isolated, those that are unhoused, those with preexisting conditions, etc.) can be done through a variety of methods:

    - Work directly with landlords and property owners/managers in low-income neighborhoods/high rises to implement community cooling rooms on the property
    - Explore data collection (e.g. surveys) after extreme weather events/emergencies to understand who was able to access the service, what their experience was like and what could be improved (e.g. providing activities to keep children entertained, adequate seating and charging stations, books available, free passes to indoor spaces like galleries/museums, public transportation to and from cooling centres, etc.).

Additional Implementation Considerations

- Vulnerability mapping can better identify communities, neighbourhoods, and populations at-risk of extreme heat

Examples of Implementation

- City of Vancouver Extreme Heat Response Plan and Cooling Centre Mapping
- City of Toronto Heat Relief Network, Waterfront Toronto Green Standards
- City of Montreal Extreme Heat Vulnerability Mapping
- Waterloo Region, Wellington County, Dufferin County, and the City of Guelph Climate Change and Health Vulnerability Assessment

For more information on cooling centres, please see the following sections in Irreversible Extreme Heat: Protecting Canadians and Communities from a Lethal Future:

- Vancouver - Cooling Centres
- Sherbrooke - Cooling Options
- Sudbury - Accessible Cooling Stations

Option # 21: Indoor Cooling Requirements

Relevant Climate Hazard(s)

Description

- The World Health Organization states that a comfortable indoor temperature range is between 18–24 °C with a maximum range of 25–32 °C. (WHO. 2018)
- With an increase in extreme heat occurrences in Canada individuals, organizations and building owners are looking to reduce related health risks. (Climate Atlas of Canada)
- Heat-related fatalities in Canada often increase with temperatures above 25°C, and increase significantly when the temperature is above 35°C. Over the next 25 years it is projected that Canadians will experience more frequent high temperatures dangerous to their health. (ICLR. 2020)
    - An unprecedented heat dome between June 25 to July 1, 2021, in British Columbia led to 619 deaths. Many of these individuals were elderly and living alone without air conditioning or proper cooling measures.
- The Canadian Center for Occupational Health and Safety provides a jurisdictional summary of working temperature limits and exposure limits for heat stress
- Cooling (and heating) by-laws can be used to outline the responsibilities of landlords and tenants for regulating indoor temperatures for commercial occupancies. These can include measures to provide mechanical cooling, outline dates when cooling is provided, etc.
- Indoor cooling requirements for multi-unit buildings can be incorporated into the City's planning processes, such as the development application approval process, to require air conditioning, heat pumps, common-space cool rooms, and/or shade structures.
- Development policy options can include ways to mitigate extreme temperatures through infrastructure improvements that minimally affect rent, which could include grant-based retrofit incentives.
- The installation of "smart" thermostats can automatically activate air conditioning and ventilation systems when the temperature reaches a certain threshold, and avoid energy waste when not required. They can also alert people to extreme heat conditions so that they can take action to protect themselves and others.

Role of planning

- Toronto's Municipal Code- Property standards, sections 629-38 address heating and air conditioning, and section 629-39 address ventilation.
    - It includes the requirement that air-conditioning systems be operated between June 2 to September 14 to maintain a temperature of less than 26℃. This requirement is only in effect where AC is available. There are also provisions to ensure that where AC is provided, it's installed in a safe manner.
- Toronto's Municipal Code - Property Standards, section 497 on heating requirements.
    - It includes that landlords are asked to use their judgment and turn heat off during the shoulder season when outdoor temperatures may cause indoor temperatures to increase above 21℃, but it is not a requirement.
- Toronto's Municipal Code - Property Standards, Chapter 354, addresses apartment building requirements.
    - It includes that landlords post information on their Tenant Notification Board about the nearest cooling centre and any areas on the property to keep cool in extreme heat.
    - The RentSafeTO program also enables regular communication with landlords to discuss roles and responsibilities related to heating and cooling.
- Ontario Provincial Regulation Residential Tenancies Act, 2006 (O.Reg. 516/06) requires that landlords shall provide heat and maintain a minimum temperature of 20C between September 1 and June 15.
    - The Municipal Licensing and Standards (MLS) regulations mostly mimic the O.Reg.
    - The MLS Division at the City of Toronto is responsible for the enforcement of RentSafeTO including requirements related to heat/cooling.
    - Disincentivizing through fines of $100k
- The City of Toronto has a 'Heat in Apartments Working Group', that reports to the Tenant Issues Committee
- City of Toronto's Mitigating the Negative Impacts of Extreme Heat in Apartment Buildings, includes requirements that:
    - all existing apartment buildings provide air-conditioned units or an air-conditioned cool room in the building;
    - all new apartment buildings have air conditioning and add measures that enable passive cooling; and
    - all apartment buildings undergo retrofits, such as new windows, heavy-duty screens, cladding and other passive and active cooling systems, and updated heating systems to mitigate the negative health impacts of heat on tenants.

- effective communication is increased to landlords and the public as per City Council's direction related to Heat Relief related to flexibility when above 21℃ in the heating systems in apartment units requirement between September 15 and June 1.

- As part of the Green Vancouver Climate Change Adaptation Strategy the City of Vancouver is partnering with Health Canada, SFU and UBC to complete Urban Heat Island Effect maps and explore options for cooling for older buildings not designed for hotter weather
- BC Housing Guidelines state that:
  - All residential units should be designed to maintain a temperature no higher than 21°C during periods of high outdoor temperatures. For common areas (excluding corridors), design cooling and ventilation systems to maintain a maximum indoor temperature of 24°C.
    - "For residential suites, design systems to maintain indoor operative temperatures within 80% acceptable limits as per the current edition of ASHRAE Standard 55 "Thermal Environmental Conditions for Human Occupancy". It shall be demonstrated that 80% acceptability limits are not exceeded for more than 20 hours per year for any climate zone."
    - "For any projects without or with only partial (living room only) mechanical cooling provided for the residential suites, the comfort acceptability limits must be confirmed by the summer overheating analysis modelling using the CWEC 2020 weather file. A sensitivity analysis is also required to assess future overheating potential."
- The City of Calgary works on indoor cooling for dwelling units that are being built:
  - For spaces that do not use any mechanical cooling, temperatures cannot exceed "80% acceptability limits" (as per ASHRAE Standard 55) for more than 200 hours during the summer months. For spaces that make use of mechanical cooling, design teams must demonstrate that each space will experience less than 100 "unmet cooling hours" (as per NECB) per year. The design and the modelling conducted for the project should leverage The City of Calgary's future climate design tools to ensure that comfort and performance targets are achievable today and over the design life of the building.

Effectiveness

- By cooling indoor spaces during extreme heat and increasing ventilation homeowners and tenants can feel more comfortable and reduce the health impacts to residents from overheating such as heat edema, heat exhaustion, heat strokes, and higher mortality rates, especially amongst vulnerable populations.

- When considering the effectiveness of indoor cooling requirements, a study of seven Canadian cities determined that the mortality rate of humans increases by 2.3% for each degree above 20℃ (Smoyer-Tomic et al. 2003).

Barriers

- Staff capacity to update City policies and the resulting education/awareness and by-law enforcement.
- Lack of municipal legislative authority, in Canada, it is the Province's authority to determine and implement building code and related maximum temperatures.
- Installing air conditioners can pose a huge strain on the power grids and increase the likelihood of having a blackout or a brownout. Electricity use can also increase the burning of greenhouse gasses depending on the energy source (Climate Atlas of Canada).
- Setting indoor temperature limits can be limited by relying on out-of-date climate data and modelling data of occupancy (City of Vancouver, 2022).

Costs

- As seen in Toronto, disincentivizing non-compliance with the indoor cooling requirements is $100k.
    - Fail to maintain a minimum air temperature of 21° Celsius in a rented dwelling unit (By-Law:497-1.2A). $500.00
    - Hinder/obstruct official in the performance of authorized duties (By-law: 497-3.1C(1)). $500.00
    - Hinder/obstruct or delay an officer conducting an inspection. (By-Law:4 97-1.3B) $500.00
    - Knowingly provides false information (By-Law: 497-3.1C(3). $400.00
    - Collected funds could be used towards financing the communication and education around related indoor cooling requirements.
- Incentivize indoor cooling through offsets, grant-based retrofits, variances or planning assistance incentives to developers and consultations with insurance providers.
- Cost estimate of mechanical cooling construction depends on the project size, location and cooling system
- Cost estimates for Vancouver mechanical cooling were determined by comparing the costs of cooling scenarios against the costs of the heating-only baseline scenario. The lowest-cost option with full mechanical cooling was the packaged terminal heat pump (PTHP) scenario, with incremental costs over the heating-only scenario of $8-10 per square foot, depending on the archetype. Other cooling system designs cost more, and some developers have communicated that their own studies of the cost of adding

cooling showed significantly higher incremental costs than the $8-10 per square foot range.

- More affordable cooling designs include passive design and ventilation air to distribute cooling. This approach had incremental capital costs of only $1.5-1.8 per square foot. (City of Vancouver. 2021)

Co-benefits

- Using natural ventilation can encourage air circulation in buildings using passive measures to reduce overheating, provide fresh oxygen, improve air quality, reduce pathogens and alleviate odours. Natural ventilation can include:
  - Natural-draft ventilation: allow cooler air to enter a building at its base, or north side, and let hotter air exit through an opening at the top of the building. Especially effective at night.
  - Cross-ventilation: open doors or windows on opposite walls to encourage air currents.

Equitable Engagement and Outcomes

- The World Health Organization identifies that heat-related health concerns begin to increase for infants, the elderly, and those with significant health problems, at a minimum of 20°C (WHO. 2018).
- In Montreal, in 2018, temperatures remained high for eight days resulting in the deaths of 66 people from heat. Most of the victims were older men living alone showing that some people are more vulnerable than others. (CANICULE, 2018).
  - The City of Montreal has identified the following populations as being more vulnerable to extreme heat:
    - Children under 4
    - People aged 65 and over who do not have air conditioning
    - People chronically ill with diabetes or cardiovascular, cerebrovascular, respiratory or neurological illness
    - People experiencing mental health problems (especially schizophrenia) or problems of alcoholism or drug addiction
    - People living alone and experiencing reduced autonomy
    - Workers or athletes involved in strenuous physical activity
- A person's ability to manage the effects of heat relates closely to their ability to access resources such as adequate housing, air-conditioning, and drinking water. (Banks. 2014)
- Individuals who are socially isolated, have mobility issues, have difficulty accessing or understanding public health information such as heat warnings, and people

experiencing mental health issues are at higher risk of experiencing heat-related illnesses or death. (Climate Atlas of Canada).

- Toronto Community Housing Corporation follows the direction of using flexibility with heating systems during shoulder seasons where temperatures exceed 21C and to implement cooling options, including air conditioning, common cool rooms, and/or shade structures. Updates are on as repairs are done and during new construction.
- Vancouver sets limits on the number of hours a new building can overheat, with more stringent limits for buildings with vulnerable populations. (City of Vancouver, 2022).

Additional Implementation Considerations

- The heating/cooling regulations must also balance other priorities, including but limited to:
    - Windows and child safety - require that windows have safety devices that restrict the opening to no more than 10 cm.
- Consideration should be given to reliance on power supply and its relative carbon emissions to operate air conditioners and opportunities for passive air ventilation and shading
- Using a thermostat that can be programmed to control temperature and air conditioning can reduce energy requirements and may result in cost savings.

Examples of Implementation

- City of Hamilton, Ontario delivered a pilot project to address extreme heat in City housing
- Vancouver's Climate Emergency-Bylaw and Policy Updates Applicable to New Buildings Changes include:
    - Require cooling for new multi-family homes beginning in 2025.
        - Include the existing overheating limits in the by-law.
        - Including all dwelling units in new Part 3 buildings (which in B.C. means they're taller than three storeys or exceed 600 square metres in area) be served by active mechanical cooling capable of maintaining 26°C or less, with windows closed.
- City of Montreal, Quebec - Extreme Heat Response Plan
    - This plan comes into effect when there is a three-day forecast with daytime highs of 33°C or greater and nighttime lows of 20°C or higher, or when nighttime temperatures are higher than 25°C for two consecutive nights. The plan lists shopping malls that are air-conditioned as places to go to cool down.
- City of Toronto, Ontario - Heat Relief Strategy. see information under 'role of planning' section.

- Includes public access to certain air-conditioned facilities during heat waves. (CBC, 2018).

Option #22: Integrate Source Water Protection into Planning

Relevant Climate Hazard(s)

Description

- Source water protection refers to efforts aimed at protecting the sources of drinking water from contamination. The goal of source water protection is to maintain the quality of the water that comes from natural sources, such as rivers, lakes, or underground aquifers, before it enters the treatment facility.
- There are a variety of ways to integrate source water protection into planning, including identifying potential sources of contamination, creating policies and regulations, implementing best management practices, educating the public, and working with stakeholders to protect the quality of the water.
- One method utilized by the Toronto and Region Conservation Authority (TRCA) was a land use planning policy to protect groundwater recharge through managing activities that reduce recharge to an aquifer.
    - A specific example discussed with staff from the TRCA is the "REC-1 policy" in the TRCA's Source Protection Plan (jointly created with the Credit Valley Conservation Authority and the Central Lake Ontario Conservation Authority). The intent of the policy is to ensure the Planning Approval Authority makes decisions that do not result in a recharge reduction from new development becoming a significant drinking water threat within a Wellhead Protection Area.
    - In doing so, the policy requires water balance assessments and recharge mitigation for most land development applications in Wellhead Protection Areas for drinking water source quantity. (Credit Valley Conservation et al., 2022)

Role of planning

- Wellhead protection policies can be implemented to protect groundwater drinking water sources from contamination. These policies can prevent or regulate activities that may contaminate the groundwater, such as hazardous waste storage or disposal, as well as requirements for monitoring and reporting on groundwater quality.
    - The City of Fredericton, New Brunswick passed a resolution requesting that the New Brunswick Minister of the Environment and Local Government protect the groundwater supply under the *Wellfield Protected Area Designation Order - Clean Water Act* (Order). This Order ensures maximum protection of Fredericton's water supply while minimizing the impact to property owners, residents, and businesses.
- Policies can be implemented to protect riparian areas from development and other activities that may disturb their ecological function. These areas can be important for protecting the quality of source water by filtering pollutants and providing habitat for wildlife.
    - For more information on how this can be done, please refer to the adaptation action, “Increase riparian buffer zones.”
- Source water assessment(s) and mapping can be done to understand the vulnerability of source water to contamination. These assessments help to identify potential sources of contamination and to prioritize actions to protect the water supply.
    - The Regional Municipality of York, Ontario completed a Source Water Assessment to evaluate the quality and quantity of its water resources, and used this information to develop a Source Water Protection Plan for the region.
- Policies to regulate the storage and disposal of hazardous materials can be implemented. These policies may include requirements for spill response plans, secure storage facilities, and regular inspections.
    - Information on spill response plans has been provided by the B.C. Ministry of Environment and Climate Change Strategy. This includes information about industrial spill response plans, a First Nations Guide to Environmental Emergencies, and example actions to undertake to prevent risks of hazardous materials during spring freshet.
- Bylaws around drinking water protection can be implemented to prevent or regulate activities that may contaminate the water supply.
    - The City of Winnipeg, Manitoba has a Water Bylaw that regulates the use of the municipal water supply, including activities that may impact water quality, such as cross-connections and backflow prevention.

Effectiveness

- Protect the quality and quantity of drinking water sources.
- Assist in avoiding costly treatments that would otherwise be necessary to remove contaminants from water.
- Encourage better land use planning by promoting practices that reduce the impact of development on water resources, such as limiting land use in areas that are more vulnerable to contamination.
- Integration of these policies into planning can allow for community engagement opportunities and participation in decisions related to water resources, promoting a sense of ownership and responsibility for the protection of local water resources.

- The specific policies adopted will depend on local conditions and the nature of the water supply being protected, as well as on the regulatory and planning frameworks in place.
- In the case of the TRCA, the effectiveness of their "REC-1 policy" to better manage development activities that reduce groundwater recharge depends on various factors such as the accuracy and completeness of the assessments, the level of detail in the recharge mitigation plan, the implementation and enforcement of the plan, and the effectiveness of the recharge mitigation techniques used.
    - In TRCA's experience, continuing to demonstrate through monitoring of land development applications and estimating volumes of artificial recharge and benefits of retention, shows that this policy measure is very effective.

Barriers

- Integrating source water protection policies into planning can require significant staff time.
- Source water protection planning may not be a priority for all elected officials or decision-makers, particularly if they do not see the immediate benefits of investing in this area.
- Some members of the public may not be aware of the importance of protecting source water or the benefits of source water protection planning. This can make it more difficult to build support for implementing source water protection planning policies.
    - **Solution**: conduct thorough engagement with various community members and groups to build buy-in. See section on 'Equitable Engagement and Outcomes' for resources that could support this.
- Balancing competing land use planning objectives such as economic development or housing, may conflict with source water protection planning objectives.

- In the experience of TRCA, they found that there can be site-specific challenges depending on the nature of the proposed development. Specifically, they found that there has been a significant challenge in the trend towards lot line to lot line underground parking with multiple levels especially in an urbanized area such as Toronto, where adequate space is hard to find. This, in turn, really precludes on-site recharge.
    - **Solution**: to remedy this, an offsite Recharge Mitigation Program has been initiated in partnership with a neighboring Conservation Authority, with this program having seen some success.

Costs

- In the case of TRCA's "REC-1 policy", the cost of the assessments would be part of the overall land development cost framework and therefore paid for by the developers.
- For the implementation of other types of policies, staff time will be required.

Co-benefits

- Source water protection planning can help reduce the impacts of floods and storms by promoting the use of green infrastructure and low impact development, such as rain gardens, permeable pavement, and bioswales, that can absorb and filter stormwater, reducing the risk of contamination to water sources.
    - The TRCA has seen that their REC-1 policy has been greatly effective in driving implementation of low impact development measures.

Equitable Engagement and Outcomes

- Equity considerations were not expressly identified in the implementation of the option.
- However, Conservation Ontario provides a Resource Catalogue for Education and Outreach Policies, including "Campaign in a Box Toolkit" provides tools to support education, outreach, communications and engagement for policy implementing bodies. These resources can be used to further engage different stakeholders.
- TRCA did engage with both the land development community and municipal partners during the initial implementation stage of their REC-1 policy. This continues even though the policy and the Source Protection Plan has been in place since 2015. Currently municipal planning departments are responsible for implementation.

Additional Implementation Considerations

- Additional implementation considerations are dependent on the type of policy or action undertaken.

Examples of Implementation

- City of Saskatoon, Saskatchewan - Water Utility Bylaw
- City of Edmonton, Alberta - Source Water Protection Plan
- City of Guelph, Ontario - Source Water Protection Program (which includes their Source Water Protection Plan, Water Budget Study, and Annual Reports)

Option # 23: Neighbourhood-based Flood Mitigation Plans

Relevant Climate Hazard(s)

Description

- Neighbourhood-based flood mitigation plans are strategies and actions designed to reduce the risk of flooding in a specific area or neighbourhood.
- These plans are often initiated by a flood mitigation study for the neighbourhood. The goal of these studies is to identify and evaluate potential flood mitigation measures that can reduce the risk and impact of flooding in the neighbourhood.
- Then, a tailored flood mitigation plan is created to suit the needs and characteristics of the neighbourhood. They can outline a wide range of measures and actions that need to be undertaken. Some example of these include:
    - Stormwater management: The implementation of practices and infrastructure to reduce runoff and improve drainage, such as green roofs, rain gardens, and permeable pavement.
    - Floodplain management: The establishment of regulations and land-use controls to prevent development in flood-prone areas.
    - Elevation and relocation: The raising of buildings or the relocation of homes and businesses to higher ground.

    - Flood warning systems: The installation of sensors and other equipment to provide advance warning of potential flooding and alert residents to take protective actions.
    - Education and outreach: The dissemination of information about flood risk, preparedness, and response to residents and business owners in flood-prone areas.
- In an interview with City of Mississauga staff, two key projects were discussed:
    - Malton Flood Mitigation Study
        - Goal of this study was to mitigate urban flooding risks to people, property and infrastructure and involved identifying and evaluating various alternative solutions to help mitigate flooding including a preferred solution that was presented at a Public Information Centre (PIC).
        - Study is not complete and the City is slowly implementing the recommendations from this study into a plan.
    - Port Credit Storm Drainage Master Plan (ongoing)
        - The City is in the process of creating the plan, starting with an environmental assessment study. Through the study, the City will confirm potential drainage system issues within Port Credit. It will also assess the impacts of infill and intensification development and climate change in the study areas.
        - The SDMP is a long term plan that will outline practical ways to manage Port Credit's storm drainage system. It will:
            - Enable the City to address current and future storm drainage infrastructure requirements
            - Allow the City to establish stormwater infrastructure requirements related to the City's Level of Service

Role of planning

- Conducting a comprehensive analysis of the physical and environmental characteristics of the neighbourhood, such as topography, soil conditions, and existing infrastructure.
    - Accurate floodplain mapping can help municipal planners and other stakeholders identify high-risk areas and inform land-use planning and other decision-making.
        - The City of Mississauga completed their Little Etobicoke Creek Flood Evaluation Study in 2021.

        - The City of Ottawa conducted flood plain mapping for 1-in-50 year, 1-in-100 year and 1-in-350 year flooding events that could occur with climate change. They've provided an interactive map to display these results.
- Land-use planning and zoning can be adjusted to guide development away from flood-prone areas and ensure that new construction and infrastructure is built to withstand potential flooding.
    - The City of Ottawa Flood Plain Overlay is a set of zoning provisions that regulate development within areas of potential flooding. To acknowledge reduced flood risk in areas with flood mitigation infrastructure or other similar features, there are two zoning overlay categories:
        - Flood Plain: Development not permitted other than limited additions to existing buildings. Intensification is generally not supported.
        - Area Specific Flood Plain: Limited development is permitted subject to flood proofing, protection works, and access standards. Intensification in these areas is not encouraged. Despite the underlying zoning, severances in these areas are not supported under Official Plan policies.
    - The City of Vancouver revised its bylaws to raise flood construction levels
- Incorporating green infrastructure, such as rain gardens, bioswales, and green roofs, can help to reduce runoff and increase infiltration of rainwater, which can reduce the likelihood of flooding.
- Implementing stormwater management practices, such as the construction of detention ponds and the use of permeable pavement, to reduce the amount of water that enters the sewer system and overloads it during heavy rain events.
    - Please see adaptation options "Low Impact Development and Community Greening" and "Eco-roofs (Green and 'Cool' Roofs) Bylaw and Incentive program" in the Guide for more information on how this can be achieved.
- Offering incentives, such as tax breaks or grants, to encourage property owners to invest in flood mitigation measures, such as elevating buildings or installing flood-resistant materials.
    - The City of Edmonton offers a Backwater Valve Subsidy Program that offers financial assistance to homeowners by providing up to $800 for the installation of an interior or exterior backwater valve
- Educating residents and business owners about the risks of flooding, preparedness, and response can help them to take proactive measures to reduce their vulnerability to floods.
    - The City of Edmonton provides a suite of resources on their website tailored to educate homeowners on flood prevention and maintenance.
    - The City of Vancouver provides this information on their website as well.

Effectiveness

- Developing flood mitigation plans that are tailored to specific neighbourhoods, municipalities can help to minimize the impact of floods on the community, and reduce the need for emergency response and recovery efforts.
- Investing in flood mitigation measures can help to reduce the cost of flood damage and related emergency response efforts.
- In the experience of the City of Mississauga, staff discussed that even though the Province has suggested a move to watershed-based planning, their intention is to be more focused on neighborhood-based drainage studies and plans, as they have found it to be the most prudent way to approach flood mitigation, in terms of investment and implementation.
- In the experience of the City of Mississauga, staff highlighted that internal relationships and external partnerships (i.e. with their neighboring conservation authority) were crucial in the success of these projects.

Barriers

- Flood risks can cross jurisdictional boundaries, making it difficult for municipalities to coordinate and collaborate with neighbouring jurisdictions or other stakeholders.
- Challenges experienced by the City of Mississauga as identified through interviews with staff:
    - Resident resistance to change on the ground
        - **Solution:** thoroughly engage with residents in that neighbourhood to drive home that the improvements being made are going to be a communal benefit. Making sure that the area's respective City Councillor is on board as this will assist in making the case to residents.
    - Studies will typically find overland or surface ponding areas or overland flow routes that are blocked and provide no relief points. Solving those problems may require considerable grading. In addition to being quite costly, at times the physical constraints don't allow for that fix (i.e., might have to regrade roads, driveways, etc. and it changes a lot of above-ground utility)
        - **Solution:** Where possible, the City of Mississauga identifies priority areas that really require the investment.
    - Sometimes there is a lack of space to employ the mitigation solutions. What limited or 'premium' space might be available could be costly as it is located in established settlement areas.

Costs

- The cost of neighborhood-based flood mitigation studies and plans can vary depending on several factors, such as the size of the neighborhood, the scope of the study, the level of community involvement, and the specific flood risks and vulnerabilities of the area.
- In the experience of the City of Mississauga staff, costs for both the aforementioned studies were between $150,000 - $250,000, depending on the consultant assisting with the study.

Co-benefits

- These plans can help to improve public safety by reducing the risk of injury or death due to flooding.
- These plans can help reduce the impact of floods and minimize the need for emergency response and recovery efforts. In turn, avoiding or reducing the emissions required for emergency response, rebuilding and repair.

Equitable Engagement and Outcomes

- Equity considerations were not expressly identified in the implementation of the option.
- However, in general, conducting thorough community engagement with those residing in the area or neighborhood is crucial for the successful long-term implementation of these plans. The following resources can better support these efforts:
    - ICLEI Canada's Engaging Meaningfully: Leveraging Community Engagement to Advance Implementation resource: aims to guide municipalities on engaging with multiple institutions and stakeholders to help find and capitalize on outside resources to better leverage implementation efforts. It aids users in distinguishing between stakeholders, partners, and target audiences while also providing guidance on how to effectively build and maintain meaningful partnerships.
    - United States Environmental Protection Agency's Public Participation Guide: designed with government agencies in mind, to help those who must manage the process where public participation is important for decision-making, while incorporating fair treatment, meaningful involvement and social inclusion of all people regardless of race, colour, national origin, sexual orientation or income.
- In the experience of the City of Mississauga:
    - The Malton Flood Mitigation Study was a technical study and therefore did not involve stakeholder participation or engagement.

- The Port Credit Storm Drainage Master Plan is going through an environmental assessment process, and therefore requires public consultation within the neighborhood. This is ongoing.
- In general, however the City regularly engages with a core group of Indigenous peoples and nations in the area as part of their projects.

Additional Implementation Considerations

- Municipal planners should work closely with other departments and agencies involved in flood management and emergency response to ensure that the proposed flood mitigation strategies align with other relevant plans and programs.

Examples of Implementation

- City of Toronto - Taylor Creek Park Management Plan
  - It is intended to provide guidelines and direction to coordinate management actions in an effort to effectively and efficiently protect and enhance sensitive natural environmental features, address flood and drainage issues and improve safety along the trail system within Taylor Creek Park.
- City of Calgary Community Drainage Improvement Project: Northwest Inner-City Community Drainage Improvements

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Appendix A – Options Matrix Table

This table provides a list of all the options in the Guide and options matrix and the corresponding climate hazards they address

Adaptation Option	Hazard					
	Extreme Heat	**Drought**	**Higher Average Temperatures**	**Severe Storms**	**River Flooding**	**SDHI Precipitation**
1. Climate Resilient Building Materials and Designs						
2. Integrate Climate Change Data into Adaptive Stormwater Management						
3. Demand Management and						

Conservation Regulations						
4. Power and Information Communication Technologies Infrastructure Redundancy						
5. Fortify Existing Public Buildings and Assets						
6. Install and Maintain Backwater Valves/Sump Pumps						
7. "Cool" /Reflective Walls and Pavement						
8. Adopt Nationally						

Recognized Flood Resilience Codes and Standards						
9. Increase Riparian Buffer Zones						
10. Permeable Surfaces						
11. Eco-Roof Bylaw and Incentive Program						
12. Increase Minimum Topsoil Depth and Quality for New Development						
13. Climate Resilient and Native						

Vegetation Management						
14. Low Impact Development and Community Greening						
15. Integrate Natural Asset Management and Valuation into Asset Management Plans						
16. Vegetated Facades and Vertical Greenery Systems						
17. Wetland Restoration						
18. Community Cooling						

Centeres/ Spaces						
19. Flood Risk Disclosures						
20. Home Flood Assessment						
21. Indoor Cooling Requirements						
22. Integrate Source Water Protection Approaches into Planning						
23. Neighbourhood-based Flood Mitigation Plans						
24. Water and Rain Harvesting						

Appendix B – Interview List

Jurisdiction, Agency/Organization	Name	Role/Position
City of Toronto, Ontario	David Macleod	Senior Environmental Specialist, Environment and Climate Division
City of Toronto, Ontario	Annemarie Baynton	Program Manager, Environment and Climate Division
City of Toronto, Ontario	Mitchell Thibault	Policy Development Officer, Municipal Licensing and Standards
City of Toronto, Ontario	Janet Stoeckl	Manager RentSafeTO, Investigation Services, Municipal Licensing and Standards
Toronto Public Health, Ontario	Dr. Howard Shapiro	Associate Medical Officer of Health, Healthy Environments
City of Ottawa, Ontario	Hiran Sandanayake	Senior Engineer, Water Resources, Asset Management Branch
City of Ottawa, Ontario	Julia Robinson	Project Manager, Environment Program
District of West Vancouver, British Columbia	Heather Keith	Senior Manager, Climate Action and Environment
Toronto and Region Conservation Authority, Ontario	Sharon Lam	Project Manager, Ecosystem and Climate Science

City of Mississauga, Ontario	Muneef Ahmad	Manager, Stormwater Projects & Approvals, Environmental Services Section
Town of Halton Hills, Ontario	Lisa Kohler	Executive Lead - Climate Change Response and Sustainability
Town of Halton Hills, Ontario	Trish Holden	Manager of Systems Planning & Customer Service, Public Works
City of Edmonton, Ontario	Danielle Koleyak	Environmental Project Manager
Sunshine Coast Regional District, British Columbia	Raphael Shay	Manager, Sustainable Development
Sunshine Coast Regional District, British Columbia	Sierra Rempel	Strategic Planning Technician
Sunshine Coast Regional District, British Columbia	Mia Edbrook	Manager, Strategic Initiatives
Institute for Catastrophic Loss Reduction	Dan Sandink	Director of Research
City of Montréal, Québec	Alexandre Guilbaud	Conseiller en aménagement - Division des projets urbains -Direction des projets d'aménagement urbain - Service de l'urbanisme et de la mobilité
City of Montréal, Québec	Remi Haf	Conseiller en planification - Direction de la gestion des actifs - Service de l'eau

City of Montréal, Québec	Irène Cloutier	Conseillère en planification - Division Mobilisation, Biodiversité et Résilience - Bureau de la transition écologique et de la résilience - Direction générale adjointe – Qualité de vie

Appendix C – Interview Questionnaire

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1. Describe the _____ measure that was implemented including scale (e.g., number and size of buildings, communities) and timing (year).

2. In which context was the measure implemented? Private or public space? City-led or partner-led? New-build or retrofit?

3. Was the measure effective in reducing risks / impacts to _____ [relevant climate hazards] (quantitative if possible)?
   a. Why or why not?

4. What was the cost of implementing this measure?

5. What have you found to be the most effective ways to finance the identified measures? (e.g., bundling into already planned upgrades, local improvement charges, other incentive programs, partnership programs, third party funding, etc.)

6. Did the implemented measure require broader stakeholder / partner engagement for its initial implementation or for ongoing operation / maintenance?
   a. Where is the measure housed within the corporation (e.g., department/division)?
   b. Has this worked? Have there been any issues with ongoing maintenance or support?

7. What were the barriers to implementing the measure? How were they/would they be overcome?

8. Would you recommend Calgary undertake this measure to address _____ (insert the hazard here)? What factors would be required to ensure the success/effectiveness of this measure?

9. For actions not led by planning: What guidance do you have for how planning can support this action?

Note: This project is led by the planning department at Calgary, so they are interested specifically in the role of planning