DISCUSSION PAPER

New Official Plan

Climate Adaptation and Resiliency

City of Ottawa
Planning, Infrastructure, and Economic Development

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Climate Adaptation and Resiliency

OP Discussion Paper

Table of Contents

1 Introduction of theme - What is Climate Resiliency? 2
2 Global Context 2
2.1 Ottawa's changing climate 3
2.2 The impacts of a changing climate and extreme weather events 4
2.3 The costs of climate change 4
2.4 City of Ottawa's current climate adaptation initiatives 5
2.5 Provincial and federal drivers and opportunities 5
3 Specific challenges and opportunities for Ottawa 6
3.1.1 Flooding 6
3.1.2 Temperature shifts and extreme heat 7
3.1.3 Infrastructure 8
3.1.4 Natural environment 8
4 Moving Forward - Building Climate Resiliency in Ottawa 9
4.1 Possible Strategic Directions 10
4.1.1 Flood risk reduction 10
4.1.2 Mitigating extreme heat 10
4.1.3 Infrastructure resilience 11
4.1.4 Natural resilience 12
4.2 Relationships with other themes 13
4.3 Building climate resilience beyond the Official Plan 14

Appendices 15
Appendix 1 – Ottawa Next: Beyond 2036 - Drivers and Planning Considerations 15
Appendix 2 – Climate projections for Ottawa 16
Appendix 3 – Examples of climate-resilient practices 18

1 Introduction of theme - What is Climate Resiliency?

Climate change is a major driver of change identified in *Ottawa Next: Beyond 2036.* Responding to climate change requires two complementary sets of actions – mitigation and adaptation. Mitigation involves lowering our contribution to climate change by reducing our greenhouse gas emissions. A discussion on how Ottawa can change energy consumption and reduce emissions is covered in the Energy Discussion Paper. Adaptation is how we manage the risks of climate change impacts and build resilience to future change. It is the focus of this paper.

The realities of climate change are upon us. Changing weather patterns and extreme weather impact our health and safety, infrastructure, the economy and the environment. They touch our day-to-day lives as well as the natural and built systems that support the city's liveability and prosperity. While parallel efforts are required to curb Ottawa's contribution to climate change by reducing our greenhouse gas emissions[1], Ottawa must adapt to the changes we're already experiencing and prepare for further change to come.

Resiliency is the capacity of individuals, communities, institutions, businesses and systems within a city to survive, adapt and grow, no matter what chronic stresses and acute shocks they experience [Source: 100 Resilient Cities]

Climate resiliency focuses on the capacity to adapt and thrive in response to current and future climate conditions – including extreme weather such as heavy rains or windstorms and gradual shifts in temperature and precipitation.

Building climate resiliency means investing in forward-looking decisions that make our communities, infrastructure and environment less vulnerable to projected change and more capable of recovering from extreme events. While action is needed at all levels – including individuals, organizations and businesses - local governments play a fundamental role in shaping the liveability of cities through community design and land use planning, environmental assessments, management of infrastructure and delivery of community services.

As the key plan that guides Ottawa's growth and development, the Official Plan influences the health and well-being of our communities for generations. This paper provides an overview of the potential impacts of projected climate change in Ottawa, and outlines a series of planning considerations to build climate resiliency.

2 Global Context

Ottawa Next: Beyond 2036 identified several environmental forces related to climate change that could shape Ottawa over the next century, including rising temperature, increased storm events, and greater pressures on public health and emergency response. Climate change also exacerbates several other drivers including greater pressures on Ottawa's natural environment and agriculture, as well as increased costs associated with drinking water, wastewater, and solid waste management (Appendix 1).

This section provides an overview of Ottawa's changing climate, the impacts and costs, and the current policy context.

2.1 Ottawa's changing climate

Ottawa is experiencing warmer, wetter and more unpredictable weather. On average, summers are getting hotter and winters less cold. While total annual precipitation has increased on average[2], precipitation varies greatly both in terms of where and when it falls[3]. Overall, Ottawa's weather is more variable and unpredictable, and we have experienced extreme heat, wind, rain and snow in recent years. In July 2018, for example, six days of extreme heat and low-water conditions were followed by a four-day record rainfall that caused flooding in several areas of the city. Persistent rains combined with melting snow in the spring of 2017 led to severe flooding along the Ottawa River. While total snowfall has decreased, a record-breaking snowstorm in February 2016 dropped 51 cm of snow in one day. Ottawa has also experienced extended low water conditions, such as the drought in the summer of 2016, and felt the destructive forces of high winds. The 265 km/h winds during the September 2018 tornados left behind extensive damage and power outages, as did wind gusts of up to 100 km/h in fall 2017 and spring 2018, including winds in April that were accompanied by freezing rain.

Climate scientists anticipate Ottawa will continue to get warmer, with significant increases in extreme heat events, and more variable and unpredictable precipitation (droughts and heavy rains) and other extreme weather (Figure 1 and Appendix 2)[4].

Figure 1: Ottawa Climate Projections from www.climateatlas.ca[5]

Change	1976-2005 Mean	2051-2080 Low	2051-2080 Mean	2051-2080 High
Typical hottest summer day	33.1 °C	34.7 °C	**37.7°C**	41.6 °C
Typical coldest winter day	-30.7 °C	-31.0 °C	**-24.9 °C**	-21.5 °C
Number of +30 °C days per year	10	20	**49**	78
Number of +20 °C nights per year	3	10	**27**	51
Number of below-zero days per year	160	91	**114**	136
Annual precipitation	910 mm	815 mm	**995 mm**	1204 mm
Frost-free season (days)	156	164	**195**	217

2.2 The impacts of a changing climate and extreme weather events

Climate change impacts our health and well being, economy and environment. Heat waves, flooding and storms put communities at risk. Heat related illnesses and deaths increase with rising temperatures, especially among older adults, young children, people with chronic illnesses and those without air conditioning[6].

Climate change exacerbates many of the environmental stresses already affecting urban areas. For example, stormwater systems were not designed to cope with the higher volumes of water seen in intense or prolonged rainfall events, especially with the extent of hardened surfaces and loss of trees and green space.

Flooding is now the most costly type of natural disaster in Canada. Floods damage property, threaten infrastructure and erode shorelines. Wind and ice storms damage communication and power lines, disrupting lives, straining emergency response and impairing local businesses. Buildings and infrastructure are at risk from extreme heat, water and winds that they were not designed to withstand.

Extreme events are not the only cause of climate impacts. Higher temperatures and more frequent freeze-thaw cycles stress our roads and other infrastructure. Gradual warming and more variable precipitation also impact the natural environment, affecting which plants and animals survive and thrive[7]. Shifting species increases the risk of vector-borne diseases, such as West Nile virus and Lyme disease[8], as well as invasive species that can alter local ecosystems, like the Emerald Ash Borer that has drastically affected our forest canopy.

Climate variability is as important as overall trends. Temperature fluctuations impact seasonal tourism, such as outdoor skating or winter festivals. Farmers must cope with unpredictable water patterns that can inundate their fields or cause drought. While overall snowfall amounts may be declining, heavy snowstorms are still expected, and so is winter flooding, when rain falls on frozen ground. This affects operations and maintenance practices and costs, for everything from roads and sidewalks to forestry and stormwater assets.

2.3 The costs of climate change

Not surprisingly, there is a cost to all these impacts. Costs can be measured in insurance claims, disaster relief, lost productivity, compromised health, and infrastructure maintenance and repair.

Disaster relief costs related to flooding have risen drastically in Canada, as have insurance claims[9]. Claims for climate hazards have exceeded $1 billion per year since 2008, compared to average annual costs of $400 million in the previous 30 years. A single storm in Toronto in 2013 cost more than $1 billion in insured losses from flooding[10]. The spring 2017 flooding in Ontario and Quebec resulted in $223 million in insured damage. The September 2018 tornados cost $295 million in claims[11]. Additional uninsured costs are borne by governments, individuals and businesses.

While the cost of climate adaptation may be high, the costs of not preparing are estimated to be much higher. Climate change could cost Canada $21 to $43 billion per year by 2050[12]. A U.S. study estimates that every dollar invested in building resilient infrastructure saves $6 in future costs, including from economic disruptions, property damages, public health crises, and deaths caused by extreme weather disasters[13].

2.4 City of Ottawa's current climate adaptation initiatives

The City's current Official Plan recognizes the potential impacts from a changing climate and includes policies to develop an adaptation plan, integrate climate in environmental management plans and subwatershed plans, ensure development avoids impacts from extreme weather events, and reduce the urban heat island effect through landscaping and green buildings[14].

The City of Ottawa`s *Air Quality and Climate Change Management Plan* (2014) outlines the City`s long-term goals and objectives to reduce greenhouse gas emissions and adapt to climate change. The plan includes four goals related to adaptation:

- Reduce risks to public health, such as vector-borne diseases and heat stress.
- Increase infrastructure resiliency, including through back-up power and flood protection.
- Reduce risks to structures by wind, flooding, or other natural forces.
- Ensure effective emergency management.

City departments work together to understand and reduce the impacts of climate change. Current climate resiliency initiatives include emergency preparedness and response, extreme temperature warning and response programs, updating flood risk analyses for urban and riverine flooding, designing stormwater infrastructure to accommodate increased flows, and protecting and enhancing the urban forest canopy. Increasingly, the City uses a climate lens in planning and project design, for example through environmental assessments or infrastructure risk assessments.

In 2016, the City joined the Global Covenant of Mayors for Climate and Energy, which committed the City to develop targets and action plans to mitigate greenhouse gas emissions and reduce the impacts of climate change. This work includes conducting a climate vulnerability assessment and developing a climate adaptation and resiliency plan. An initial step is to consolidate information on past and future climate projections. The Characterization of Ottawa's Watersheds includes a historical analysis of climate data. Future projections are being prepared in collaboration with the National Capital Commission, Public Services and Procurement Canada and Ville de Gatineau. This project will develop climate information for the National Capital Region to support risk assessments and climate resiliency planning, communication and action.

2.5 Provincial and federal drivers and opportunities

The 2014 Provincial Policy Statement strengthened requirements for municipalities to consider the potential impacts of climate change and reduce risks from climate events, such as flooding or droughts. Specific policies in the Provincial Policy Statement that build climate resilience include strengthening stormwater management and encouraging

green infrastructure, implementing climate change adaptation measures such as planting trees for shade, and managing increased risks from natural hazards such as flooding.

The Province is developing tools on how to consider climate change, and has released Asset Management regulations and guidelines for environmental assessments. They are currently developing guidelines on how to integrate climate change in watershed planning and stormwater management planning.

Amendments to the Municipal Act in 2017 (Bill 68) strengthened the authority of municipalities to pass by-laws related to the economic, social and environmental well-being of the municipality. By-laws may include responding to climate change including for example requiring the construction of green roofs or alternative roof surfaces.

Another key tool for municipalities is the Building Code. The Province started consultations in 2017 to examine potential changes, including measures to build resiliency of new houses to extreme weather events. These include requiring hurricane straps to protect buildings from extreme winds and backwater valves to prevent basement flooding from over-filled municipal sewer systems during severe rainstorms.

At a federal level, the Pan-Canadian Framework on Clean Growth and Climate Change includes actions to support climate adaptation and resilience across Canada, such as updating building codes and design standards and investing in climate-resilient infrastructure. Municipalities are required to apply a climate lens to federal funding requests and demonstrate how climate mitigation and adaptation are considered.

3 Specific challenges and opportunities for Ottawa

As outlined above, Ottawa must prepare for our main climate risks - flooding, increased heat and other extreme weather - and their impacts on communities, infrastructure and the natural environment. The next sections map out the key challenges and opportunities for each of these key risks.

3.1.1 Flooding

Floods are now the leading cause of damage to homes in Canada. Damage from sewer back ups and basement flooding has been steadily increasing and now exceeds $2 billion annually[15]. Many homeowners are unaware that sewer backup and overland flooding insurance are not standard coverages, and property owners located in regulatory floodplains face additional risk as they may not be eligible for flood insurance.

Communities are protected from flooding in two main ways:

- Conservation Authorities regulate land use and development in flood-prone areas along watercourses using floodplain mapping[16]. Municipalities use this mapping when reviewing planning applications and have policies that restrict development in such areas.
- Municipalities use stormwater and drainage plans to manage runoff through a combination of both infrastructure, such as storm sewers, ditches and swales, and overland routes, such as along streets and through parks.

Changing rainfall and snowmelt patterns affect the risks of both riverine and urban (basement or overland) flooding. While critical to understanding flood risks, precipitation is one of the hardest climate parameters to measure and predict. While total annual precipitation is projected to increase, especially in the spring and winter[17], understanding the likelihood and location of extreme rain events is much more difficult. Most rainfall events happen in localized areas and the lack of comprehensive monitoring stations makes long-term analysis and modeling of rainfall patterns challenging. That said, the intensity of both wet and dry extremes is expected to increase because of higher temperatures and changes to hydrological cycles[18]. While we cannot predict when or where extreme rainfall events will happen, we need to prepare for them.

Ottawa was rated as the most flood-proof city in Canada in 2015[19]. Through its Wet Weather Plan the City has implemented mitigation measures in response to severe flood events in the last decades, successfully reducing the risk of basement flooding in many older neighbourhoods. Stormwater systems in new communities are designed to accommodate a potential 20 per cent increase in rainfall. Backwater valves are required in all new residential and commercial properties as a second line of defence, and rebates are available for existing properties through the Residential Protective Plumbing Program. Rebates are also available for back-up power for sump pumps, to protect homes from flooding during power outages. Additional flood risk analyses are examining the impacts of more intense or prolonged rainfall events on both floodplains and wet weather flow.

While urban flood risks will be exacerbated by more variable and extreme precipitation expected as a result of climate change, a core challenge relates to the volume of stormwater runoff created through development pressures and the associated increases in impermeable or hard surfaces. Low impact development measures such as rain gardens, bio-retention and vegetated swales are effective at reducing and treating runoff from frequent, smaller rainfall events when implemented widely, but additional stormwater infrastructure is required to deal with runoff from large, infrequent storms[20]. Natural infrastructure such as wetlands, forests and vegetated watercourses, also provide key ecological services such as mitigating floods and protecting water quality.

3.1.2 Temperature shifts and extreme heat

Average temperatures in Ottawa increased by 1.3℃ between the 1940s and mid-2010s[21]. Ottawa's mean annual temperature is projected to increase by another 4℃ by the 2050s, with pronounced increases in the number of extreme heat days (Appendix 2).

The impacts of higher temperatures are exacerbated by urban heat islands, which are areas with temperatures much higher than their surroundings[22]. Heat islands typically form as a result of urban development where roads, buildings and parking lots absorb and retain heat. The lack of mature trees and other vegetation means there is less cooling from shade and evapotranspiration[23]. Heat islands have negative health, social, economic and environmental impacts. Vulnerable populations including the elderly, the young, those with health conditions, or those living without air conditioning are particularly at risk. High heat also increases peak energy demands, potentially

overloading electricity grids and contributing more greenhouse gases[24]. The risks are greatest during heat waves when prolonged high temperatures occur over many days and there is limited cooling at night.

3.1.3 Infrastructure

The City of Ottawa manages $42 billion worth of public infrastructure including roads, bridges and pathways, buildings and facilities, buses, trains and other vehicles, water, wastewater and stormwater infrastructure, waste management infrastructure, and trees, forests and natural areas[25]. The Infrastructure Discussion Paper includes a discussion of infrastructure challenges and opportunities. This section examines challenges related to climate change.

Most existing infrastructure was not designed to withstand future climate conditions and extremes. Older stormwater systems, for example, were not built to handle the volume of runoff resulting from extreme rainstorms, especially given the impermeability of urban development, and the lack of overland flow routes designed to for flows exceeding sewer capacity. Buildings, bridges and transit infrastructure need to withstand rising temperatures, more frequent and intense rainfall, and higher wind, snow or ice loads. Roads and pipes are weakened by high heat or more frequent freeze-thaw cycles. Infrastructure that services water supply and wastewater management must withstand power disruptions[26].

Comprehensive Asset Management is the process the City of Ottawa uses to plan and manage the City's infrastructure assets to ensure safe and sustainable services are delivered to our communities in a cost effective way. A key part of risk management is to understand the likelihood and consequence of climate risks, both from incremental change and from extreme weather events.

Asset management planning prioritizes the use of City resources to build, operate, maintain and replace infrastructure. Like many cities, Ottawa faces a significant deficit in repairing and replacing existing infrastructure. Our roads, pipes, buildings and other infrastructure are designed to last up to 100 years. Current infrastructure investments must reflect future climate conditions to ensure they perform under these new conditions and deliver the services our community needs. An additional challenge is how to pay for upgrades required to service our communities as they grow and intensify.

3.1.4 Natural environment

Our trees, forests, wetlands and watercourses not only provide quality of life and biodiversity, they serve as a buffer against climate impacts. Trees and other greenery provide shade, retain and filter stormwater, and provide habitat for birds and pollinators. Wetlands absorb and release water to recharge streams or groundwater. Forests naturally store carbon and reduce our greenhouse gas emissions[27].

Protecting the natural environment is seen as a first response to safeguard the services that underpin healthy resilient communities. While the Official Plan includes measures to protect Ottawa's natural heritage, the city's natural assets will face considerable added pressure as Ottawa grows. Natural and agricultural areas are vulnerable to expanding development. Trees lack adequate space to thrive. Urbanization leaves

limited space for water to naturally infiltrate. See the Natural Ottawa paper for a full discussion of the pressures facing Ottawa's natural assets.

These pressures will intensify under future climate conditions. Trees are vulnerable to high winds and freezing rain. Shifting temperatures and more variable precipitation affect the composition and range of plants and animals and create opportunities for invasive species and vector-borne diseases to spread. Linkages between natural areas are critical to enable species to adapt to changing conditions.

4 Moving Forward - Building Climate Resiliency in Ottawa

How do we prepare as a city to adapt to and thrive under future climate conditions? What policies and practices will help us mitigate the effects of gradual changes like increased temperature and more variable precipitation, as well as extreme weather including heat waves, intense rain, high winds and freezing rain?

Ottawa's next Official Plan is an opportunity to respond to stronger direction in the Provincial Policy Statement and set clear directions to guide Ottawa's growth and development under future climate conditions. The way we design our built and natural environments is a powerful tool in building resilient communities where people can live, work and play in all climate conditions. Resiliency is strengthened through robust design, creating redundancy and encouraging resourcefulness[28].

There are several overarching questions to keep in mind as we explore strategies to build a climate-resilient Ottawa:

- How can we meet our goals of compact, complete communities that reduce the urban footprint while simultaneously building climate resilience? How can intensification avoid exacerbating urban heat and flood risks?
- How do we reduce climate risk in the face of uncertainty? We know the past no longer represents the future, yet predicting what will happen is an imperfect science. What are the "no-regrets" solutions that prepare us for gradual climate shifts and more variable extremes?
- How do we weigh the benefits of investing in climate preparedness while facing significant costs of aging infrastructure and delivering quality community services?
- What provisions are needed to protect vulnerable populations like the elderly, the young, the health-impaired, the isolated and those with low incomes?
- How can Ottawa take the necessary steps to manage risks and build resilience in advance of provincial and/or federal direction?

The OP must consider our main climate risks - flooding, increased heat and other extreme weather events - and their impacts on communities, infrastructure and the natural environment. The following sections outline a series of planning considerations and draw on climate-resilient policies and practices across Canada (see Appendix 3 for more detail).

4.1 Possible Strategic Directions

4.1.1 Flood risk reduction

Ottawa's Infrastructure Master Plan, Wet Weather Management Implementation Plan and supporting programs provide a strong foundation for managing runoff and mitigating the impacts of floods. Given the complexities in understanding future rainfall, many municipalities and research groups are examining best practices to manage additional rainfall and reduce flood risks (Appendix 3).

How do we ensure Ottawa's communities – both new and existing – can withstand more frequent or severe flooding? Some planning considerations include:

- How may flood-prone areas shift under future climate conditions and what are the potential impacts on property, infrastructure and services including emergency access? What strategies can safeguard against larger flood events? How can we work with other regulatory agencies like Conservation Authorities and the province to ensure a consistent approach to flood risk analysis and regulation?
- Do our current stormwater design standards provide adequate flood protection against future anticipated rainfall? If not, how can they be strengthened?
- How can Ottawa encourage new homes and communities to be built to withstand more frequent or severe flooding?
- How can low impact development techniques, such as rain gardens, bio-retention and other permeable surfaces be encouraged to increase infiltration, reduce harmful runoff and reduce the pressures on stormwater systems?
- How we can ensure that our trees, wetlands and vegetated watercourses – our natural green infrastructure – continue to provide key ecological services to mitigate floods and protect water quality?

4.1.2 Mitigating extreme heat

The health impacts of extreme heat can be mitigated through two main ways - response and prevention. Heat alert and response systems include issuing targeted warnings, opening cooling centres, providing access to water at public pools, splash pads or beaches, and distributing water during heat events[29]. Some municipalities have introduced requirements for maximum temperature standards for residential units to complement minimum temperature standards. Ottawa Public Health has a well-established heat alert and response plan and is planning a more detailed assessment of climate-related health risks and vulnerable populations.

Preventive actions include retaining and planting trees and other vegetation, installing green or cool roofs and using reflective paving materials on sidewalks, parking lots and streets to reflect heat, and strengthening local social networks, especially among vulnerable populations[30]. Smaller connected green spaces with mixed trees have been shown to improve thermal comfort and relieve heat stress at the street level and neighbourhood scale[31]. Many actions that reduce heat also increase building comfort and lower energy demands. Durham Region's heat reduction strategy, Toronto's Green

Standard and Rosemont-La Petite-Patrie's By-law are concrete examples of municipal action to reduce the impacts of heat (Appendix 3).

How can we ensure Ottawa's current and future communities are healthy and liveable in warmer temperatures and extreme heat conditions?

Some planning considerations include:

- Where are Ottawa's hot spots? Who is most vulnerable to heat stress? What combination of preventative and responsive actions will best mitigate the effects of heat in these areas?
- What are our best strategies to make sure new communities are designed for a warmer future? How can we ensure adequate shade or cooler surfaces to encourage walking, biking and outdoor recreation in warmer temperatures?
- As the City continues to intensify and redevelop especially around transit hubs, how can we avoid exacerbating urban heat islands? How do we mitigate extreme heat in areas where walking, cycling and transit are prioritized?
- Given the multiple benefits of trees and vegetation, how can we protect and enhance existing trees and small networks of urban green space along streets, and on public and private property as part of Ottawa's growing green infrastructure network?
- How can we align efforts to reduce heat impacts with other ways to build resilience such as managing higher rainfall and reducing greenhouse gases?

4.1.3 Infrastructure resilience

Many municipalities are grappling with ways to build resilience in their existing and future infrastructure. The Transportation and Infrastructure Master Plans guide Ottawa's investments in our transportation, water, wastewater and stormwater services. While the City does not have jurisdiction over the Building Code, the federal government has committed to revising building codes and infrastructure design standards by 2020.

Municipalities such as New York have developed design guidelines on how to build resilience to increased heat, precipitation and rising sea levels for capital projects. Toronto's Green Standard includes guidance for city-owned as well as private development. Tools such as the Public Infrastructure Engineering Vulnerability Committee (PIEVC) protocol assess risks to infrastructure from incremental change and extreme events and identify options to build robustness and redundancies (Appendix 3).

How can Ottawa's buildings, roads, bridges, pathways, fleet, and water, wastewater, stormwater and waste infrastructure become more resilient to future climate conditions?

Some planning considerations to strengthen infrastructure resilience include:

- How is our critical infrastructure, such as water and wastewater infrastructure, vulnerable to changing climate conditions, extreme weather events and power disruptions? What are the priorities for building resilience and redundancy into existing infrastructure?

- Do infrastructure design standards need to be revised to build additional resilience against projected future conditions including increased temperatures, high winds, increased freeze-thaw cycles and higher rainfall?
- How can we apply a climate resiliency lens to asset management planning, to ensure the long-term planning, operation and renewal of infrastructure assets considers future climate scenarios?
- Building denser communities around our transit system helps reduce the urban footprint and protects green space and agricultural lands. How do we ensure our older water and sewer systems have the capacity to support denser communities? And how do we cover the costs of these upgrades?
- How can the City encourage the installation of green infrastructure, such as rain gardens, green roofs, swales and permeable surfaces, on public and private lands to reduce pressure on stormwater systems by managing rainwater where it falls?
- How can we ensure our active transportation infrastructure - sidewalks, bike lanes and transit - can be used it in all temperatures and during extreme rain or storms?
- How can Ottawa encourage provincial and national building codes account for future increased temperatures and extreme weather events?

4.1.4 Natural resilience

Ottawa's trees, wetlands, forests, watercourses and floodplains are a critical part of our green infrastructure. The City's Urban Forest Management Plan and Greenspace Master Plan outline the City's commitment to protecting a healthy urban tree canopy and natural heritage system, supported by policies and regulatory tools to address site alteration, tree conservation, significant woodlands and conservation area planning. The City's Source Protection Plans, Infrastructure Master Plan and Water Environment Strategy protect Ottawa's groundwater, rivers and streams.

How can we strengthen natural resilience to safeguard the services that underpin healthy resilient communities? Some planning considerations include:

- How can we strengthen our existing Official Plan policies to protect and connect our natural areas, including wetlands, forests, watercourses and floodplains? How can we retain a network of smaller vegetated green space in more urban areas? Which guidelines or tools can best support the implementation of policies and apply a climate resilience lens to protect our natural green infrastructure?
- How do we protect existing trees along streets, in public areas and on private property, in light of their shade, biodiversity and runoff services? How do we value the services provided and ensure adequate space for survival amidst the many competing demands for space?

- How can we prioritize tree planting in areas most affected by heat, with poor canopy or at risk of canopy loss? What species are most suitable for new climate conditions and how can we build resilience against disease?
- Do we understand the risks to our ravines, watercourses and groundwater from changing temperature and rainfall, and extreme weather?
- How can we better reflect the full value of services provided by trees, wetlands, watercourses and other natural assets as Ottawa grows and develops? What can we learn from communities like the Town of Gibsons on managing aquifers, forests and streams in the same way we manage traditional infrastructure assets?

4.2 Relationships with other themes

Climate change affects all facets of life – health and well-being, the economy and the environment. Initiatives that build climate resiliency also enhance liveable and prosperous communities. Examples of climate-resilient planning considerations with multiple benefits in other areas of the Official Plan include:

- **Infrastructure** – Adopting a climate lens in asset management will ensure that investments in infrastructure will consider their performance over the full life-cycle of these assets. How can we build greater energy resilience, including back-up power for critical infrastructure, and prepare for and mitigate increased cooling demands? Redundancy also improves reliability of service to residents, and is important for health and safety, and a stable economy. How do we ensure green infrastructure becomes a key element of infrastructure planning and asset management?
- **Mobility** - Complete communities with well-serviced transportation networks give people viable options to walk, bike or take transit during increased heat or extreme weather. This contributes to green mobility, improved health and maintains access to essential services in times of power outages. Mobility infrastructure that supports light rail transit, cycling and walking – and that is designed to encourage use even during warmer or colder temperatures and extreme weather events – also contributes to meeting active transportation goals.
- **Natural Ottawa** – How can the value of ecosystem services such as urban heat island mitigation, stormwater runoff, improved physical and mental health, as well as carbon capture and reduced greenhouse gas emissions be reflected in policies that protect green space and the urban tree canopy and enhance our green infrastructure?
- **Energy** – Energy efficient buildings that reduce greenhouse gas emissions are also more comfortable in extreme temperatures. Measures to reduce urban heat impacts, such as cool or green roofs, or shading from trees, reduce energy demands during peak summer energy times. Policies to encourage improved energy performance, such as green development standards, density bonuses or Development Charge rebates, can also consider climate resilience measures.
- **Healthy Ottawa** – Climate-resilient community design that reduces the impacts of extreme heat and flooding also supports healthy communities with less

physical and mental illness. Heat mitigation measures are particularly important for vulnerable populations, such as the old and young, those living with chronic conditions, and low-income residents.

- **Housing** – Community, low-income or seniors' housing needs to be built or retrofitted to withstand higher temperatures and electrical disruptions, and mitigate heat stress for residents.
- **Rural Ottawa** – Protecting agricultural land, which serves as a carbon sink, and supporting agricultural innovation help farmers adapt to a changing climate, builds resilience into our economy and supports local food security. Food security can be strengthened by allowing food to be grown in all areas of the city.

4.3 Building climate resilience beyond the Official Plan

The Official Plan sets policies that will guide Ottawa's growth and development and influence the health and well being of our communities for generations. Many other policies, practices and investments that build climate-resilient communities are beyond the scope of the Official Plan. A comprehensive vulnerability assessment and climate resiliency strategy would also consider:

- Emergency response and recovery, including coordination with stakeholders responsible for critical infrastructure, such as power and telecommunications.
- Operations and maintenance of infrastructure, such as roads, trees, stormwater infrastructure, facilities, and transit.
- Asset management and capital planning – applying a climate lens to maintaining, repairing/retrofitting and replacing existing infrastructure.
- Public outreach and education to ensure individuals, institutions and businesses understand the projected impacts of climate change, the steps they can take to protect their homes, property and businesses and what to expect during a flood.
- Community services such as health, recreation and programs to support more vulnerable residents.
- Monitoring invasive species and vector-borne diseases such as Lyme disease and West Nile virus, and taking steps to manage these species and/or the associated public health risks where possible.
- Programs to build economic resilience and prosperity. These include working with the agricultural community to prepare for seasonal shifts and unpredictable water availability, supporting adaptability and innovation in seasonal businesses such as winter recreation and tourism, or supporting businesses to prepare for and recover from productivity loss during extreme events.
- Coordination with other levels of government and stakeholders on building and infrastructure standards, affordable and comprehensive insurance and fair cost-sharing amongst levels of government.
- Steps to build financial resilience and reduce legal risk.

Appendices

Appendix 1 – Ottawa Next: Beyond 2036 - Drivers and Planning Considerations

Ottawa Next: Beyond 2036 identified the following forces and planning considerations related to climate resiliency that may shape Ottawa over the next century.

Environmental Drivers of Change	Planning Considerations
Greater Pressure on Ottawa's Natural Environment from Urban Development	• Natural heritage protection, restoration, and enhancement within existing natural areas and in emerging and existing urban areas, and the ability to integrate environmental considerations in accordance with each planning context (urban, suburban, rural) • Integrated watershed management programs with social, economic, and environmental benefits • Retention of existing tree canopy into both urban infill and suburban development • Diversification, protection, and enhancement of natural systems as a means to capture larger percentages of stormwater • Stewardship programs to protect and enhance private natural assets (urban and rural) • Environmental planning built into healthy community development • Mitigation of heat island effect
Rising Temperature	• Infrastructure design standards to meet new climate conditions • Sustainable infrastructure operation and maintenance in light of increasing need and cost • Building technologies and development approaches that maximize energy efficiencies and reduce emissions • Protection and establishment of connected natural habitat for wildlife and plant systems • Climate resistant design of public and private spaces • Building resiliency into all facets of City planning and operations • Retention and maintenance of urban forest • Appropriate responses to invasive species
Increased Storm Events	• Coordinated response capacity • Ice, wind and flood-resistant design for buildings and energy distribution networks • Natural, or more resilient, storm water infrastructure • Storm and sewer management resilience • Appropriate restrictions on the use of flood plains to mitigate future impacts of flooding • Enhanced weather monitoring • Urban tree retention • Building resiliency into emergency management response
Greater Pressure on Agriculture and Food Sources	• Promotion of local food sources and protection of agricultural land through land use policy and zoning • Precision agriculture opportunities • Agricultural low water management • Nutrient management to protect rivers and lakes • Local and coordinated food systems • Access to affordable nutritious food

Greater Pressure on Public Health and Emergency Response	• Enhanced emergency event response capacity • Public education and protection in regard to climate change • Urban design that supports public health, including greater access to tree-shaded public spaces and streets across the city • Monitoring and surveillance of the health impacts of climate change

Appendix 2 – Climate projections for Ottawa

The following climate projections are taken from the Climate Atlas of Canada (www.climateatlas.ca). The Climate Atlas was developed by the Prairie Climate Centre based at the University of Winnipeg and provides climate data for cities across Canada. It uses modeling from the Pacific Climate Impacts Consortium, a regional partner of Environment Canada and Climate Change's (ECCC) recently launched Canadian Centre for Climate Services portal.

The full Ottawa Fact Sheet and supporting data and graphs are available at www.climateatlas.ca together with a description of the methodology.

Prairie Climate Centre
From Risk to Resilience

Municipality Ottawa
45.4°N, 75.73°W

Climate Atlas Report

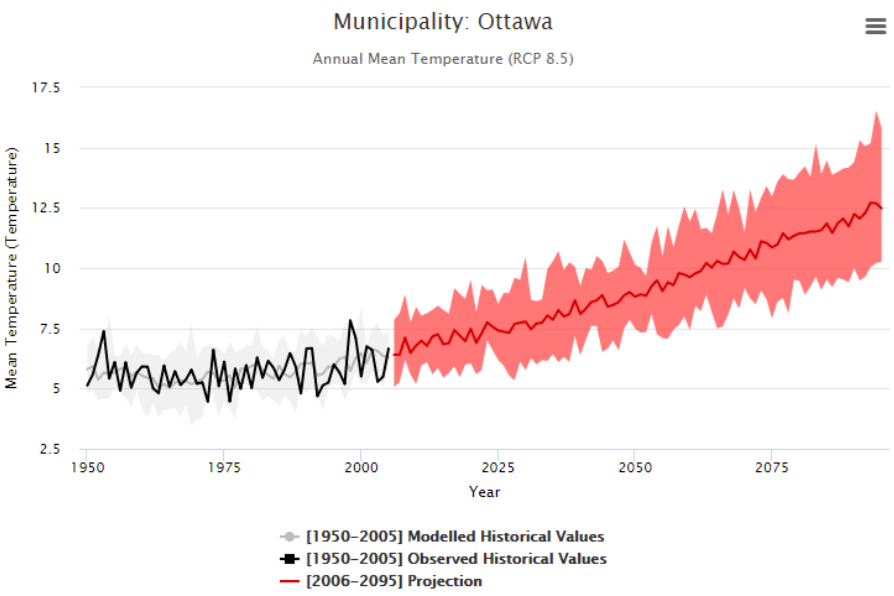
RCP 8.5: "Status quo" climate future
GHG emissions continue to increase at current rates

			2021-2050			2051-2080		
Variable	Period	1976-2005	Low	Mean	High	Low	Mean	High
Precipitation (mm)	Annual	910	768	959	1124	815	995	1205
Precipitation (mm)	Spring	205	150	228	319	156	240	343
Precipitation (mm)	Summer	251	167	252	339	158	248	350
Precipitation (mm)	Fall	247	156	249	346	170	257	365
Precipitation (mm)	Winter	205	147	231	327	167	251	343
Mean Temperature (°C)	Annual	5.9	6.5	8	9.7	8.2	10.2	12.3
Mean Temperature (°C)	Spring	5.1	4.4	6.9	9.5	6	8.8	11.6
Mean Temperature (°C)	Summer	19.2	19.4	21.2	23.1	20.8	23.5	25.9
Mean Temperature (°C)	Fall	8	8.1	10.1	12.1	9.7	12.1	14.7
Mean Temperature (°C)	Winter	-8.9	-9.4	-6.3	-3.4	-7.4	-3.7	-0.5
Tropical Nights	Annual	3	3	10	25	10	27	51
Very hot days (+30°C)	Annual	10	12	25	48	20	49	78
Very cold days (-30°C)	Annual	1	0	0	3	0	0	1
Date of Last Spring Frost	Annual	May 4	April 13	April 24	May 11	April 7	April 15	May 6
Date of First Fall Frost	Annual	Oct. 6	Oct. 4	Oct. 15	Nov. 2	Oct. 10	Oct. 27	Nov. 13
Frost-Free Season	Annual	156	151	174	197	164	195	217

Annual Mean Temperature (RCP 8.5)

Mean value

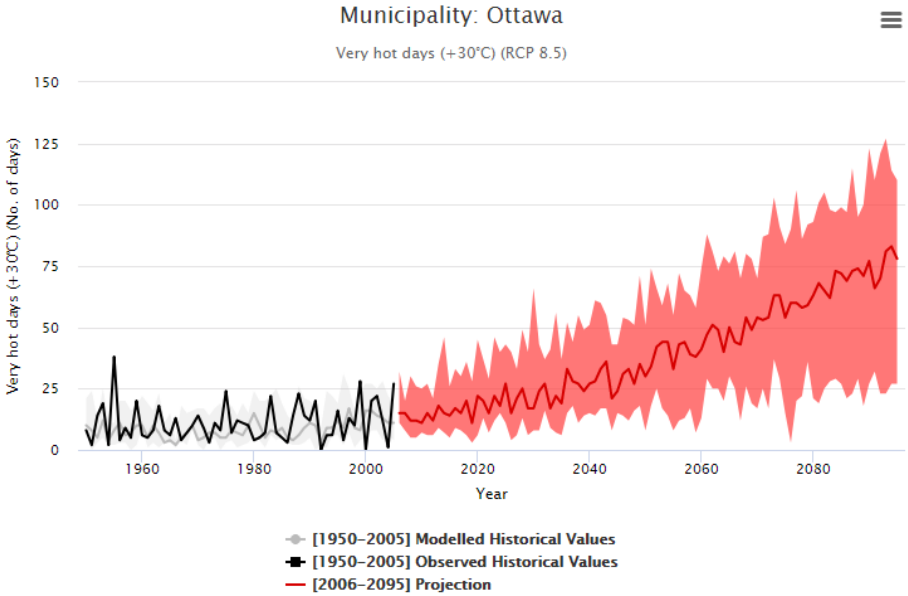
Recent past 1976-2005	Immediate future 2021-2050	Near future 2051-2080
5.9 °C	8.0 °C	10.2 °C



Very hot days (+30°C) (RCP 8.5)

Mean value

Recent past 1976-2005	Immediate future 2021-2050	Near future 2051-2080
9.6	24.8	49.0



Appendix 3 – Examples of climate-resilient practices

Ottawa can learn from the experience of other municipalities. Some examples of policies and practices to build resilience against climate change are included here.

Flood-resilient community design

- Given the uncertainty about future rainfall patterns, there are no standard methods to integrate rainfall projections into flood risk management. A recent report by the Intact Centre for Climate Adaptation is examining possible standards for designing flood-resilient communities in Canada[32]. Some jurisdictions are updating Intensity Duration Frequency curves with projected rainfall, others are using more severe storm events based on historical data, and others are adding safety factors or buffers to flood-proofing requirements or floodplain development limits. Toronto Region Conservation Authority, for example, adds buffers to freeboard height (a safety factor above the projected water level to protect against flooding). Stratford has designed its overland stormwater management system to cope with 250 year storms[33].
- In terms of new development, the community of Rosemont-La Petite-Patrie in East Montréal sets minimum requirements for open ground landscaping for building sites and parking lots in its Zoning By-law[34]. Markham prohibits reverse-slope driveways.
- Many municipalities use education and incentives to encourage homeowners to protect their houses from flooding by installing backwater valves and reduce runoff by directing downspouts to lawn or gardens, installing rain gardens and using permeable driveways, patios or walkways[35].
- Vancouver amended its Building Bylaw to increase flood construction levels in designated flood plains to respond to the increased risk of flood damage due to climate change[36]

Urban heat reduction

- The Zoning By-law passed by the community of Rosemont-La Petite-Patrie in East Montréal also includes measures to reduce the impact of urban heat islands including: cool or green roofs; minimum greening requirements for building sites and parking lots; and reflective standards for paving materials[37]. About 2,000 roofs have been replaced since the implementation of the By-Law (~10% of flat roofs in the municipality) and has led to co-benefits including thermal comfort and reduced energy use[38].
- The Cool Durham Heat Reduction Program aims to reduce air temperatures during heat waves by adopting cooling measures such as reflective roofs, vegetated roofs, increasing urban tree cover, shading structures in parks and public spaces, light coloured pavement and buildings, energy efficiency and passive cooling design, and water features in landscaping such as rain gardens. They also amended their Property Standards By-law to limit maximum temperatures in apartments to reduce risks to tenants due to extreme heat[39].
- Heat maps are used in Durham to identify vulnerable populations such as seniors` residences, daycares and social housing, as well as cooling centres such as pools,

community facilities and malls[40]. The Region of Peel uses urban heat maps as one criterion to prioritize tree planting[41]. Surrey's comprehensive tree protection program protects private and public property shade trees. New York City uses Heat Vulnerability Index maps to guide the design of capital projects[42].

- Toronto's Green Standard outlines the sustainable design requirements for new private and City-owned developments. It sets minimum and voluntary high performance standards to reduce environmental impacts (including greenhouse gases) and build resiliency to climate change. Climate resiliency standards include green and cool roofs, reducing the heat impacts of hardscaping through reflective materials, onsite stormwater management, drought-tolerant landscaping, minimum soil requirements for trees, shade trees for parking lots and refuge areas with back-up power. Projects that demonstrate higher levels of performance may be eligible for a refund on development charges[43].
- Halton Hills' Green Development Standard includes measures to reduce stormwater runoff through low impact development, drought-tolerant landscaping, and tree shading for streets and parking lots[44].

Building Infrastructure Resilience

- Tools such as the Public Infrastructure Engineering Vulnerability Committee (PIEVC) protocol assess risks to infrastructure from incremental change and extreme events and identify options to build robustness and redundancies.
- Triple bottom line accounting or climate resilience scorecard and rating systems can help apply a climate lens to asset management.
- Natural Resources Canada is updating the national assessment of climate change impacts and adaptation, and examining the implications for engineering systems such as design rainfall intensity, drainage and wastewater systems, and Low Impact Development.
- Toronto is undertaking cascade risk assessments for critical infrastructure independencies including sectors such as utilities, transportation, buildings, economy, health and the natural environment[45].
- New York City's Climate Design Guidelines provide guidance on designing City capital projects to withstand increased heat, precipitation and sea level rise. Projects located in moderate to high Heat Vulnerability Index areas should implement multiple strategies to reduce the heat island effect and reduce vulnerability. The guidelines recommend using the current 50-year Intensity Duration Frequency curve as a proxy for the future 5-year storm[46].
- The Credit Valley Conservation Authority installs Low Impact Development measures to mitigate stormwater runoff and reduce flood risk and pollution loads. Research showed significant benefits including 80% reduction in runoff volumes, 80% reduction in total suspended solids and phosphorus, 50-90% reduction in heavy metals, and up to 5 degrees cooling of water[47].

Building Natural Resilience

- The Town of Gibsons, British Columbia was North America's first community to experiment with strategies to integrate natural assets into asset management and financial planning. The Town's Eco-Asset Strategy values and manages its aquifers, forests, streams and foreshores based on the services they provide such as stormwater management, flood protection, and provision of drinking water[48]. The Municipal Natural Assets Initiative is working with other municipalities to examine ways to identify, value and account for natural assets in their financial planning and asset management programs.
- The Town of Ajax recognizes the value of the tree canopy and natural environment to build resilience to climate change. Its Official Plan includes policies on planting shade trees, selecting climate-resilient species and requiring reimbursement for all healthy trees removed during development.

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